The Sinclair QL

(and other Sinclair products)

A Wikipedia-Generated Book

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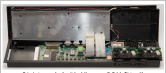
Sinclair QL

Sinclair QL

Release date	January 12, 1984
Discontinued	April 1986
Units sold	150,000
Operating system	Sinclair QDOS
CPU	Motorola 68008 @ 7.5 MHz
Memory	128 KB (640 KB max.)

The **Sinclair QL** (for *Quantum Leap*), was a personal computer launched by Sinclair Research in 1984, as the successor to the Sinclair ZX Spectrum. The QL, based on the Motorola 68008 microprocessor, was aimed at the hobbyist and small business markets, but failed to achieve commercial success.

Description


QL internals (with Minerva ROM fitted)


QL rear view

The QL was originally conceived in 1981 under the code-name *ZX83*, as a portable computer for business users, with a built-in ultra-thin flat-screen CRT display (similar to the later TV80 pocket TV), printer and modem. As development progressed, and *ZX83* became *ZX84*, it eventually became clear that the portability features were over-ambitious and the specification was reduced to a conventional desktop configuration.[1 2] It was designed to be more powerful than the IBM Personal Computer, and comparable to Apple's Macintosh.[3]

Based on a Motorola 68008 processor clocked at 7.5 MHz, the QL included 128 kB of RAM (officially expandable to 640 kB) and could be connected to a monitor or TV for display.[4] Two built-in ZX Microdrive tape-loop cartridge drives provided mass storage, in place of the more expensive floppy disk drives found on similar systems of the era. Microdrives had been introduced for the Sinclair ZX Spectrum in July 1983, although the QL used a different logical tape format. Interfaces included an expansion slot, ROM cartridge socket, dual RS-232 ports, proprietary QLAN local area network ports, dual joystick ports and an external Microdrive bus. Two video modes were available, 256×256 pixels with 8 RGB colours and per-pixel flashing, or 512×256 pixels with four colours (black, red, green and white). Both screen modes used a 32 kB framebuffer in main memory. The hardware was capable of switching between two different areas of memory for the framebuffer, thus allowing double buffering. However, this would have used 64 KB of the standard machine's 128 kB of RAM and there is no support for this feature in the QL's original firmware. The alternative and much improved operating system Minerva does provide full support for the second framebuffer. When connected to a normally-adjusted TV or monitor, the QL's video output would overscan horizontally. This was reputed to have been due to the timing constants in the ZX8301 chip being optimised for the flat-screen CRT display originally intended for the QL.[5]

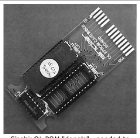
Internally, the QL comprised the CPU, two ULAs, (ZX8301 and ZX8302) and an Intel 8049 microcontroller (known as the IPC, or "Intelligent Peripheral Controller"). The ZX8301 or "Master Chip" implemented the video display generator and also provided DRAM refresh. The ZX8302, or "Peripheral Chip", interfaced to the RS-232 ports (transmit only) Microdrives, QLAN ports, real-time clock and the 8049 (via a synchronous serial link). The 8049 (included at late stage in the QL's design, the ZX8302 originally being intended to perform its functions[6]) ran at 11 MHz and acted as a keyboard/joystick interface, RS-232 receive buffer and audio generator.[7]

A multitasking operating system, *QDOS*, primarily designed by Tony Tebby, was included on ROM, as was an advanced BASIC interpreter, named SuperBASIC designed by Jan Jones. The QL was also bundled with an office suite (word processor, spreadsheet, database, and graphics) written by Psion. Sinclair had commissioned GST Computer Systems to produce an operating system for the machine, but switched to QDOS, developed in-house, before launch. GST's OS, designed by Tim Ward, was later made available as 68K/OS, in the form of an add-on ROM card.[8 9] The tools developed by GST for the QL would later be used on the Atari ST, where GST object format became standard.

Physically, the QL was the same black colour as the preceding ZX81 and Sinclair ZX Spectrum models, but introduced a new angular styling theme and keyboard design which would later be seen in the ZX Spectrum+. Unusually, the QL used BS 6312 type 630W sockets for the RS-232 and joystick ports, except for QLs built by Samsung for export markets, which had DE-9 sockets.

History

Bundled Psion application software on Microdrive cartridges



Sinclair QL ROM "dongle" - needed to expand internal 32 kB ROM in early QLs

The QL was the first mass-market personal computer based on the Motorola 68000-series processor family. Rushed into production, the QL beat the Apple Macintosh by a month, and the Atari ST by a year. While clock speeds were comparable, the 8-bit databus and cycle stealing of the ZX8301 ULA limited the QL's performance. However, at the time of launch, on January 12, 1984, the QL was far from being ready for production, there being no complete working prototype in existence. Although Sinclair started taking orders immediately, promising delivery within 28 days, first customer deliveries only started, slowly, in April. This provoked much criticism of the company and the attention of the Advertising Standards Authority.[10]

Due to its premature launch, the QL was plagued by a number of problems from the start. Early production QLs were shipped with preliminary versions of firmware containing numerous bugs, mainly in SuperBASIC. Part of the firmware was held on an external 16 kB ROM cartridge (also known as the "kludge" or "dongle"), until the QL was redesigned to accommodate the necessary 48 kB of ROM internally, instead of the 32 kB initially specified.[11] The QL also suffered from reliability problems of its Microdrives. These problems were later rectified, by Sinclair engineers, especially on Samsung produced models, as well as by aftermarket firms such as Adman Services and TF Services — to the point where several QL users report their Microdrives working perfectly even after almost 17 years of service (for Samsung QLs) — but in any case much too late to redeem the negative image they had already created.

Although the computer was hyped as being advanced for its time, and relatively cheap, it failed to sell well, and UK production was suspended in 1985, due to lack of demand. After Amstrad acquired Sinclair's computer products lines in April 1986, the QL was officially discontinued. Apart from its reliability issues, the target business market was becoming wedded to the IBM PC platform, whilst the majority of ZX Spectrum owners were uninterested in upgrading to a machine which had a minimal library of games. Sinclair's persistence with the non-standard Microdrive and uncomfortable keyboard did not endear it to the business market; coupled with the machine's resemblance to a ZX Spectrum, they led many to perceive the QL as something akin to a toy. Software publishers were also reluctant to support the QL due to the necessity of using Microdrive cartridges as a distribution medium.

ICL One Per Desk

The QL's CPU, ZX8301 and ZX8302 ULAs and ZX Microdrives also formed the basis of International Computers Limited's (ICL's) One Per Desk (OPD) - also marketed by British Telecom as the Merlin Tonto and by Telecom Australia as the Computerphone. The result of a three-year collaboration between Sinclair Research, ICL and British Telecom, the OPD had the intriguing addition of a telephone handset on one end of the keyboard, and rudimentary Computer-Telephony Integration (CTI) software.[12] This curious machine interested a number of high-profile business customers, including certain divisions of the former UK Customs and Excise Department, but its success was generally limited. In the late eighties they were used in bingo halls to allow a country wide networked bingo game.[13]

Clone systems

Hardware

After Amstrad abandoned the QL in 1986, several companies previously involved in the QL peripherals market stepped in to fill the void. These included CST and DanSoft, creators of the Thor line of compatible systems; Miracle Systems, creator of the Gold Card and Super Gold Card processor/memory upgrade cards and the QXL PC-based hardware emulator; and Qubbesoft, with the Aurora, the first replacement QL mainboard, featuring enhanced graphics modes.[14]

In the late 1990s, two partly QL-compatible motherboards named Q40 and Q60 (collectively referred to as Qx0) were designed by Peter Graf and marketed by D&D Systems. The Q40 and Q60, based on the 68040 and 68060 CPUs respectively, were much more powerful than the original QL and have the ability among other things (such as multimedia, high resolution graphics, Ethernet networking etc.) to run the Linux operating system.[15]

Hardware add-ons were still being produced for the original QL mainly by TF Services until early 2009, when it was passed to RWAP Software, who supply various hardware and software upgrades.

Software

A few patched versions of QDOS were produced, most notably Minerva which gradually evolved into a completely rewritten operating system, offering improved speed, with multitasking SuperBASIC interpreters. Tony Tebby went on to produce another updated operating system, SMSQ/E, which has continued to be developed for the Sinclair QL and emulators, offering many more features.[16]

External links

- Dilwyn Jones's QL pages - General QL information and software downloads
- Thierry Godefroy's Sinclair QL and QDOS compatible systems site
- The QL chronology (1981 until today)
- Binary Dinosaurs: QL peripherals gallery
- Sinclair QL Service Manual, issue 3, October 1985
- QL-Users Mailing List
- QL User Forum
- QUANTA - the QL Users and Tinkerers Association

Emulators and support

- RWAP Software - Software, second hand items and keyboard membranes
- RWAP Adventures - Adventure programs for the Sinclair QL and ZX Spectrum
- Jochen Merz Software
- TF Services (Tony Firshman) Spares, repairs and addons for the QL
- Davide Santachiara web page
- Q-emuLator Sinclair QL emulator for Windows and Mac OS
- QPC emulator for DOS and Windows (uses QDOS successor SMSQ/E)
- uQLx emulator for Unix
- QL2K - Sinclair QL Emulator for Windows 2000/XP

Quantum Leap

Quantum leap may refer to:

- Atomic electron transition or similar transitions between quantum states, which are scientific phenomena
- *Quantum Leap* (TV series), a science-fiction television series
- Sinclair QL, a 1980s personal computer made by Sinclair Research
- In popular discourse, the term "quantum leap" refers to a large increase

SuperBASIC

- *This article is about the **SuperBASIC** interpreter which was included in Sinclair QDOS. **SuperBasic** was also the name of Tymshare's unrelated BASIC system.*

SuperBASIC was an advanced variant of the BASIC programming language with many structured programming additions. It was developed at Sinclair Research by Jan Jones during the early 1980s. Originally SuperBASIC was intended for a home computer, code-named *SuperSpectrum*, then under development. This project was later cancelled, however, SuperBASIC was subsequently included in the ROM firmware of the Sinclair QL personal computer (launched in January 1984), also serving as the command interpreter for the QL's Qdos operating system.

External links

- SuperBASIC
- *The Quantum Leap - to where?* — a chapter from *Sinclair and the 'Sunrise' Technology*

The Operating System

Sinclair QDOS

QDOS (sometimes written as **Qdos** in official literature; the name is not regarded as an acronym; also see the identically-pronounced word kudos) is the multitasking operating system found on the Sinclair QL personal computer and its clones. It was designed by Tony Tebby whilst working at Sinclair Research, as an in-house alternative to 68K/OS, which was later cancelled by Sinclair, but released by original authors GST Computer Systems.

QDOS was implemented in Motorola 68000 assembly language, and on the QL, resided in 48 kB of ROM, consisting of either three 16 kB EPROM chips or one 32 kB and one 16 kB ROM chip. These ROMs also held the SuperBASIC interpreter, an advanced variant of BASIC with structured programming additions. This also acted as the QDOS command line interpreter.[17]

Facilities provided by QDOS included management of processes (or "jobs" in QDOS terminology), memory allocation, and an extensible "redirectable I/O system", providing a generic framework for filesystems and device drivers. Very basic screen window functionality was also provided. This, and several other features, were never fully implemented in the released versions of QDOS, but were improved in later extensions to the operating system produced by Tebby's own company, QJUMP.

Rewritten, enhanced versions of QDOS were also developed, including Laurence Reeves' Minerva, and Tebby's SMS2 and SMSQ/E. The latter is the most modern variant and is still being improved.

Versions

QDOS versions were identified by numerical version numbers. However, the QL firmware ROMs as a whole (including SuperBASIC) were given two- or three-letter alphabetic identifiers (returned by the SuperBASIC function *VER$*).
The following version of QDOS were released (dates are estimated first customer shipments):

- **0.08**: the last pre-production version.
- **1.00**: corresponded to the *FB* version QL ROMs, released in April 1984.
- **1.01**: corresponded to the *PM* version ROMs. This was faster and had improved Microdrive support.
- **1.02**: corresponded to the *AH* ROM version released in June 1984. This fixed many bugs and was the first ROM version to be produced in quantity.
- **1.03**: included in ROM versions *JM* and *TB*; a minor bug-fix release issued in late 1984.
- **1.10**: corresponded to the *JS* and *JSU* (US export version) ROMs, released in early 1985. This was the last version used in QLs manufactured for the UK market.
- **1.13**: corresponding to the *MG*x series of ROM versions for European export markets. Included a significant number of bug fixes. The following localised versions of the *MG* firmware are known to exist:
  - *MGE*: Spanish
  - *MGF*: French
  - *MGG*: German
  - *MGI*: Italian
  - *MGS*: Swedish

The localised versions of QDOS were identified by the "." in the version number being replaced by the ROM version suffix letter used to identify the territory, eg. the *MGE* ROMs contained QDOS version 1E13. All *MG* firmware versions shared the same bottom 32 kB ROM chip.
Qdos 1.13 was also reported to be included in a Greek localised ROM version, known as *ΣFP* (marked on the ROMs as *EFP*).

References

- Andrew Pennell (1985). *The Sinclair QDOS Companion: a guide to the QL operating system*. London: Sunshine Books. ISBN 0-946408-69-6
- Simon Goodwin. "Bugging the ROM", *Sinclair QL World*, August 1987.
- QL History FAQ: Firmware

External links

- QDOS Internals Dokuwiki established by Norman Dunbar
- SMSQ/E Source Code
- QL ROM Versions list by Dilwyn Jones
- Minerva Source Code

Minerva (QDOS reimplementation)

Written by Laurence Reeves in England, **Minerva** was a reimplementation of Sinclair QDOS, the built-in operating system of the Sinclair QL line of personal computers. Minerva incorporated many bug fixes and enhancements to both QDOS and the SuperBASIC programming language. Later versions also provided the ability to multi-task several instances of the SuperBASIC interpreter, something not supported by QDOS.

Minerva was distributed as a ROM chip on a daughterboard which replaced the QL's original ROM chips. A Minerva Mk. II daughterboard was also produced which also incorporated an I²C interface and non-volatile real-time clock. As of version 1.89, the Minerva source code is licenced under the GNU General Public License.

Other reimplementations of QDOS include SMS2 and SMSQ/E.

External links

- Laurence Reeves' page, includes complete Minerva source code
- TF Services Minerva page

SMS2

SMS2 ("Small Multitasking System 2") was a computer operating system developed for the Atari ST by Tony Tebby, the designer of the Qdos operating system for the Sinclair QL personal computer. SMS2 evolved from Qdos but was not intended to provide full Qdos compatibility.

Later, Tebby developed SMSQ and SMSQ/E, which added Qdos (and SuperBASIC) compatibility and ran on various QL-emulating and Atari platforms.

References

- QL History FAQ part 2: Firmware

SMSQ/E

SMSQ/E is a computer operating system originally developed in France by Tony Tebby, the designer of the original QDOS operating system for the Sinclair QL personal computer. It began life as **SMSQ**, a QDOS-compatible version of SMS2 intended for the Miracle Systems QXL emulator card for PCs. This was later developed into an extended version, SMSQ/E, for the Atari ST. It consists of a QDOS compatible SMS kernel, a rewritten SuperBASIC interpreter called SBasic, a complete set of SuperBASIC procedures and functions and a set of extended device drivers originally written for the QL emulator for the Atari ST.

It also integrates many extensions previously only available separately for the QL, like Toolkit II (quite essential SuperBASIC add-on), the Pointer Environment (the QL's mouse and windowing system) and the Hotkey System 2.

While SMSQ/E does not run on any unmodified QL, it runs on all of the more advanced QL compatible platforms, from the Miracle Systems (Super)GoldCard CPU plug-in cards to the Q60 motherboard.

In late 1995 a German author, Marcel Kilgus, acquired the SMSQ/E sources for adaptation to his QL emulator QPC, which from then on did not emulate any specific QL hardware anymore but employed specially adapted device drivers to achieve a tighter integration and faster emulation.

In 2000, version 2.94 was the first QL operating system that broke free of the bounds of the QL 8 colour screen, introducing GD2 (Graphic Device Interface Version 2), a QL compatible 16-bit high colour graphics sub-system.

Up to version 2.99 the system was exclusively developed by Tony Tebby and Marcel Kilgus. In 2002, Mr Tebby released all of his source code (which doesn't include most QPC specific parts), albeit under a license which is not Open Source under the Open Source Definition. With this step Tony Tebby finally left the QL scene, but development by volunteers continues to this day.

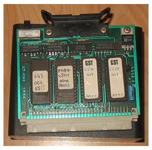
Currently SMSQ/E consists of approximately 2000 68k assembler source files containing about 222,000 lines of code.

External links

- A Brief History of SMSQ/E
- Official SMSQ/E source code site
- QPC: a software emulator for DOS/Windows that employs SMSQ/E
- Q40/Q60: a 68040/68060 based motherboard for SMSQ/E
- Article on OSnews about this wiki article

68K/OS

68K/OS



68K/OS EPROM expansion card

Company / developer	GST Computer Systems
OS family	Disk operating systems
Working state	Discontinued
Source model	Closed source
Initial release	1984
Default user interface	CLI or menu

68K/OS was a computer operating system developed by GST Computer Systems for the Sinclair QL microcomputer.

It was commissioned by Sinclair Research in February 1983. However, after the official launch of the QL in January 1984, 68K/OS was rejected, and production QLs shipped with Sinclair's own Qdos operating system.

GST later released 68K/OS as an alternative to Qdos, in the form of an EPROM expansion card, and also planned to use it on single-board computers based on the QL's hardware.

The operating system was developed by Chris Scheybeler, Tim Ward, Howard Chalkley and others.

The few ROM cards that were made mean that surviving examples now fetch a high price: On Feb 04, 2010 one sold for £310 on eBay.[18]

References

- Leon Heller (September 1984). "QL Affairs". *Your Spectrum* (7). Retrieved 2009-03-26.
- "SinclairWatch". *Your Spectrum* (8). October 1984. Retrieved 2009-03-26.
- "Sinclair QL". *Binary Dinosaurs*. Retrieved 2009-03-26.

External links

- GST Assembler, Adder Assembler - *Sinclair User*, April 1985
- QL Pictures Gallery
- 68k/OS manuals and documentation

Computer multitasking

In computing, **multitasking** is a method where multiple tasks, also known as processes, share common processing resources such as a CPU. In the case of a computer with a single CPU, only one task is said to be *running* at any point in time, meaning that the CPU is actively executing instructions for that task. Multitasking solves the problem by scheduling which task may be the one running at any given time, and when another waiting task gets a turn. The act of reassigning a CPU from one task to another one is called a context switch. When context switches occur frequently enough the illusion of parallelism is achieved. Even on computers with more than one CPU (called multiprocessor machines), multitasking allows many more tasks to be run than there are CPUs.

Operating systems may adopt one of many different scheduling strategies, which generally fall into the following categories:

- In *multiprogramming* systems, the running task keeps running until it performs an operation that requires waiting for an external event (e.g. reading from a tape) or until the computer's scheduler forcibly swaps the running task out of the CPU. Multiprogramming systems are designed to maximize CPU usage.
- In *time-sharing* systems, the running task is required to relinquish the CPU, either voluntarily or by an external event such as a hardware interrupt. Time sharing systems are designed to allow several programs to execute apparently simultaneously. The expression 'time sharing' was usually used to designate computers shared by interactive users at terminals, such as IBM's TSO, and VM/CMS
- In *real-time* systems, some waiting tasks are guaranteed to be given the CPU when an external event occurs. Real time systems are designed to control mechanical devices such as industrial robots, which require timely processing.

The term *time-sharing* is no longer commonly used, having been replaced by simply *multitasking*, and by the advent of personal computers and workstations rather than shared interactive systems.

Multiprogramming

In the early days of computing, CPU time was expensive, and peripherals were very slow. When the computer ran a program that needed access to a peripheral, the Central processing unit (CPU) would have to stop executing program instructions while the peripheral processed the data. This was deemed very inefficient. The first computer using a multiprogramming system was the British *Leo III* owned by J. Lyons and Co.. Several different programs in batch were loaded in the computer memory, and the first one began to run. When the first program reached an instruction waiting for a peripheral, the context of this program was stored away, and the second program in memory was given a chance to run. The process continued until all programs finished running.

Multiprogramming doesn't give any guarantee that a program will run in a timely manner. Indeed, the very first program may very well run for hours without needing access to a peripheral. As there were no users waiting at an interactive terminal, this was no problem: users handed on a deck of punched cards to an operator, and came back a few hours later for printed results. Multiprogramming greatly reduced wait times when multiple batches were being processed.

Cooperative multitasking/time-sharing

When computer usage evolved from batch mode to interactive mode, multiprogramming was no longer a suitable approach. Each user wanted to see his program running as if it were the only program in the computer. The use of time sharing made this possible, with the qualification that the computer would not seem as fast to any one user as it really would be if it were running only that user's program.

Early multitasking systems used applications that voluntarily ceded time to one another. This approach, which was eventually supported by many computer operating systems, is known today as cooperative multitasking. Although it is now rarely used in larger systems, cooperative multitasking was once the scheduling scheme employed by Microsoft Windows (prior to Windows 95 and Windows NT) and Mac OS (prior to Mac OS X) in order to enable multiple applications to be run simultaneously. Windows 9x also used cooperative multitasking, but only for 16-bit legacy applications, much the same way as pre-Leopard PowerPC versions of Mac OS X used it for Classic applications. The network operating system NetWare used cooperative multitasking up to NetWare 6.5. Cooperative multitasking is still used today on RISC OS systems.

Because a cooperatively multitasked system relies on each process regularly giving up time to other processes on the system, one poorly designed program can consume all of the CPU time for itself or cause the whole system to hang. In a server environment, this is a hazard that makes the entire network brittle and fragile. All software must be evaluated and cleared for use in a test environment before being installed on the main server, or a misbehaving program on the server slows down or freezes the entire network.

Despite the difficulty of designing and implementing cooperatively multitasked systems, time-constrained, real-time embedded systems (such as spacecraft) are often implemented using this paradigm. This allows highly reliable, deterministic control of complex real time sequences, for instance, the firing of thrusters for deep space course corrections.

Preemptive multitasking/time-sharing

Preemptive multitasking allows the computer system to more reliably guarantee each process a regular "slice" of operating time. It also allows the system to rapidly deal with important external events like incoming data, which might require the immediate attention of one or another process.

Operating systems were developed to take advantage of these hardware capabilities and run multiple processes preemptively. For example, preemptive multitasking was implemented in the earliest version of Unix[19] in 1969, and is standard in Unix and Unix-like operating systems, including Linux, Solaris and BSD with its derivatives.

At any specific time, processes can be grouped into two categories: those that are waiting for input or output (called "I/O bound"), and those that are fully utilizing the CPU ("CPU bound"). In primitive systems, the software would often "poll", or "busywait" while waiting for requested input (such as disk, keyboard or network input). During this time, the system was not performing useful work. With the advent of interrupts and preemptive multitasking, I/O bound processes could be "blocked", or put on hold, pending the arrival of the necessary data, allowing other processes to utilize the CPU. As the arrival of the requested data would generate an interrupt, blocked processes could be guaranteed a timely return to execution.

The earliest preemptive multitasking OS available to home users was Sinclair QDOS on the Sinclair QL, released in 1984, but very few people bought the machine. Commodore's powerful Amiga, released the following year, was the first commercially-successful home computer to use the technology, and its multimedia abilities make it a clear ancestor of contemporary multitasking personal computers. Microsoft made preemptive multitasking a core feature of their flagship operating system in the early 1990s when developing Windows NT 3.1 and then Windows 95. It was later adopted on the Apple Macintosh by Mac OS 9.x [20] as an additional API, i.e. the application could be programmed to use the preemptive or cooperative model, and all legacy applications were multitasked cooperatively within a single process. Mac OS X, being a Unix-like system, uses preemptive multitasking for all native applications, although Classic applications are multitasked cooperatively in a Mac OS 9 environment that itself is running as an OS X process (and is subject to preemption like any other OS X process).

A similar model is used in Windows 9x and the Windows NT family, where native 32-bit applications are multitasked preemptively, and legacy 16-bit Windows 3.x programs are multitasked cooperatively within a single process, although in the NT family it is possible to force a 16-bit application to run as a separate preemptively multitasked process.[21] 64-bit editions of Windows, both for the x86-64 and Itanium architectures, no longer provide support for legacy 16-bit applications, and thus provide preemptive multitasking for all supported applications.

Real time

Another reason for multitasking was in the design of real-time computing systems, where there are a number of possibly unrelated external activities needed to be controlled by a single processor system. In such systems a hierarchical interrupt system is coupled with process prioritization to ensure that key activities were given a greater share of available process time.

Multithreading

As multitasking greatly improved the throughput of computers, programmers started to implement applications as sets of cooperating processes (e.g. one process gathering input data, one process processing input data, one process writing out results on disk). This, however, required some tools to allow processes to efficiently exchange data.

Threads were born from the idea that the most efficient way for cooperating processes to exchange data would be to share their entire memory space. Thus, threads are basically processes that run in the same memory context. Threads are described as *lightweight* because switching between threads does not involve changing the memory context.

While threads are scheduled preemptively, some operating systems provide a variant to threads, named *fibers*, that are scheduled cooperatively. On operating systems that do not provide fibers, an application may implement its own fibers using repeated calls to worker functions. Fibers are even more lightweight than threads, and somewhat easier to program with, although they tend to lose some or all of the benefits of threads on machines with multiple processors.

Some systems directly support multithreading in hardware.

Memory protection

When multiple programs are present in memory, an ill-behaved program may (inadvertently or deliberately) overwrite memory belonging to another program, or even to the operating system itself.

The operating system therefore restricts the memory accessible to the running program. A program trying to access memory outside its allowed range is immediately stopped before it can change memory belonging to another process.

Another key innovation was the idea of privilege levels. Low privilege tasks are not allowed some kinds of memory access and are not allowed to perform certain instructions. When a task tries to perform a privileged operation a trap occurs and a supervisory program running at a higher level is allowed to decide how to respond.

Memory swapping

Use of a swap file or swap partition is a way for the operating system to provide more memory than is physically available by keeping portions of the primary memory in secondary storage. While multitasking and memory swapping are two completely unrelated techniques, they are very often used together, as swapping memory allows more tasks to be loaded at the same time. Typically, a multitasking system allows another process to run when the running process hits a point where it has to wait for some portion of memory to be reloaded from secondary storage.

Programming in a multitasking environment

Processes that are entirely independent are not much trouble to program. Most of the complexity in multitasking systems comes from the need to share computer resources between tasks and to synchronize the operation of co-operating tasks. Various concurrent computing techniques are used to avoid potential problems caused by multiple tasks attempting to access the same resource.

Bigger systems were sometimes built with a central processor(s) and some number of I/O processors, a kind of asymmetric multi-processing.

Over the years, multitasking systems have been refined. Modern operating systems generally include detailed mechanisms for prioritizing processes, while symmetric multiprocessing has introduced new complexities and capabilities.

List of Sinclair QL software

- *This list is incomplete.*

. This is a list of software titles produced for the Sinclair QL personal computer.
Notation: **Program name** (purpose), publisher, first release

Utilities

#

- **3D Precision**, High-Precision Imaging System, Digital Precision

A

- **Abacus** (Spreadsheet), Psion (Sinclair), 1984
- **APL Interpreter**
- **ArcED**, coWo
- **Archive** (Database), Psion (Sinclair), 1984
- **Archivist** database (Std and MP), A.R.K. (Richard Howe), 1984
- **Assembler and Linker**, Computer One
- **Assembler**, GST Computer Systems
- **Assembler**, Metacomco
- **Assembler Workbench**, Talent

B

- **Banks of Plants**, Toby Hodd, 1986
- **BASIC TO CPORT**, Translator from SuperBASIC to Kernighan & Ritchie C, Digital Precision
- **BCPL Compiler**, Metacomco
- **Beule Tools**, Peter Beule

C

- **C Compiler** (Small C), GST
- **C Compiler**, Metacomco
- **Cad Pak**, Datalink
- **Cardfile** database (128K and 256K), A.R.K. (Richard Howe), 1986
- **Cartridge Doctor**, Talent
- **Cosmos**, Talent
- **CST Disk Utilities** (Backup, Convert, Filed, Disced, Ramdrive), Cambridge Systems Technology

D

- **Data Design** (Database), The Progs
- **Desktop Publisher**, Digital Precision
- **Desktop Publisher Special Edition**, Digital Precision
- **Digital C** (Small C), Digital Precision
- **Digital C Special Edition** (~~K&R C), Digital Precision
- **DISA** (Intelligent Disassembler), JO
- **Disktool & Quickdisk**, Ultrasoft (Martin Berndt)
- **DJ Toolkit** (DJTK)

E

- **Easel** (Business Graphics), Psion (Sinclair), 1984
- **EasyPTR**, Albin Hessler
- **Eye-Q**, Graphics System, Digital Precision
- **Eye-Q Special Edition**, Graphics System, Digital Precision

F

- **Ferret** (File Search Utility), Sector Software
- **Fibu** (Accounting), eTo soft
- **Flashback** (Database), Sector Software
- **Forth**, Computer One
- **Fortran 77**, Prospero

G

- **Giga-BASIC**, Giga-Soft (ABC Electronic)
- **Giga-Chroma**, Giga-Soft (ABC Electronic)
- **Giga-Disassembler with Monitor**, Giga-Soft (ABC Electronic)
- **Grafix III**, Digital Precision
- **Graphics Toolkit**, Ultrasoft (Martin Berndt)
- **GraphiQL**, Talent
- **GST Assembler**

I

- **Ice Toolkit**, Eidersoft (on eprom)
- **IDIS** (Intelligent disassembler), Digital Precision
- **IDIS Special Edition** (Intelligent disassembler), Digital Precision
- **Image D**, PDQL

L

- **Librarian** database (128K and 256K), A.R.K. (Richard Howe), 1986
- **Lightning**, Text/Graphics/Maths Accelerator, Digital Precision
- **Lightning Special Edition**, Digital Precision
- **Lisp Interpreter**, Metacomco

M

- **Macro Assembler**, GST
- **Mailfile** database (128K and 256K), A.R.K. (Richard Howe), 1986
- **Mailmerge**, A.R.K. (Richard Howe), 1986
- **Master Spy** editor, A.R.K. (Richard Howe), 1988
- **Mega Dictionary for Perfection**, 360K word Spellchecker, Digital Precision
- **Menu Extension**, JMS
- **M-Paint**, Medic
- **Monitor**, Computer One
- **Mon QL**, Hisoft

N

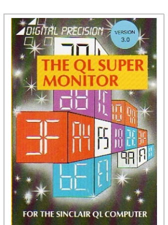
- **Nucleon**, Pyramide

P

- **Page Designer**, Sector Software
- **Page Designer 2**, Sector Software
- **Page Designer 3**, Sector Software
- **Paint Master**, Shadow Games
- **Pascal Compiler**, Computer One
- **Pascal** (ISO 7185/ANSI 770×3.97), Prospero
- **PC Conqueror** (IBM PC emulator, supports MS-DOS v.3,4,5,6), Digital Precision
- **PCB1**, Talent
- **PCB CAD**, Lear Data Systems
- **Peintre**, Pyramide
- **Perfect Pointer Tools**, Digital Precision
- **Perfection**, Word Processor, Digital Precision
- **Perfection Special Edition**, Word Processor, Digital Precision
- **Pointer's & Writer's Toolkit**, JMS
- **Professional Monitor**, Compware
- **Professional Publisher**, Digital Precision

Q

- **QD**, JMS
- **Q-Draw**, Psion, 1985
- **QKick**, Ultrasoft (Martin Berndt)
- **QMATHS**, Digital Precision
- **QMATHS II**, Digital Precision
- **QMon**, QJump
- **QLOAD** (SuperBASIC fast save/load), Liberation
- **QL Cadette** drafting system, Bestmalt Ltd (Mark Mansell), 1987
- **QL Cash Trader** (Cash Accounting Package), RWAP Software
- **QL Cosmos** (Astronomy Program), Talent available from RWAP Software (Programmer: G. F. Cornwell)
- **QL Gardener**, GCS (Sinclair)
- **QL ICE**, Eidersoft
- **QL Paint** (an edition of *GraphiQL*), Talent (Sinclair)
- **QL Pascal Development Kit**, Metacomco, 1985
- **QL Payroll**
- **QL Super Monitor**, Digital Precision
- **QL Toolbox**, Ultrasoft (Martin Berndt)
- **QLiberator Basic Compiler**, Liberation
- **QLone+**, Ultrasoft (Martin Berndt)
- **QPAC**, QJump
- **QPAC 2**, QJump
- **QPTR**, QJump
- **QRAM**, QJump
- **QREF** (SuperBASIC Cross Reference), Liberation
- **QTop** (Desk, clock, demos, animator, index, snap), coWo, 1989
- **QTYP**, QJump
- **Quick Layout**, Gollmann
- **Quill** (Word processor), Psion, (Sinclair), 1984
- **QZ II**, Sector Software



Cover of QL Super Monitor

R

- **RPM Resident Procedure Manager**, Liberation

S

- **S-Edit**, Ralf Reköndt/Ultrasoft (Martin Berndt)
- **Sideways**
- **Spellbound Interactive Spelling Checker**, Sector Software, 1987
- **Spy** editor, A.R.K. (Richard Howe), 1988
- **SToQL**
- **Stripper** file filter, A.R.K. (Richard Howe), 1986
- **SuperBASIC Extension**, Hisoft
- **SuperCharge** SuperBASIC compiler with Lenslok, Digital Precision
- **SuperCharge Special Edition**, Digital Precision
- **SuperForth**, (with Reversi/Othello game), Digital Precision
- **Super Media Manager**, Digital Precision
- **Super Sprite Generator**, Digital Precision
- **SuperToolkit II**, QJump (Care)
- **SuperToolkit III**, Ultrasoft (Martin Berndt)

T

- **Task Master** (Multitasking front end), Sector Software, 1987
- **TechniQL** (CAD software), Talent
- **Text87 plus4** (Word processor), Software87
- **The Painter by The Progs**, 1988/1990
- **Thing & EPROM Manager**, JMS
- **Thor-Desk**, coWo, 1988
- **Toolkit III**, Ultrasoft (Martin Berndt)
- **Touch Typist** (Typing tutor), Sector Software, 1985
- **Transfer Utility**, Digital Precision
- **TURBO** (SuperBASIC compiler), Digital Precision, 1987
- **TURBO TOOLKIT**, Digital Precision, 1987

U

- **USCD Fortran-77**, TDI
- **USCD Pascal**, TDI
- **USCD Toolkit**, TDI

X

- **XCHANGE** (Office), Psion (Cambridge Systems Technology)

Z

- **Zapper**, Eidersoft
- **Z88 Transfer**, Mark Pfizenmazer

Games

#

- **3D Slime**

A

- **Assault & Battery**, Kaos Software
- **Arcanoid**
- **Alien Hijack**, Chisoft - On QL Wiki

B

- **BJ in 3D Land**, Eidersoft - On QL Wiki
- **BJ Returns**, Eidersoft - On QL Wiki
- **Blocklands Warrior**, Digital Precision
- **Brain Smasher**, JMS
- **Breakout**

C

- **Cavern**
- **Chess**, Psion (Sinclair)
- **Citadel**, Eidersoft - on QL Wiki
- **Crazy Painter**, Microdeal

D

- **Deathstrike**
- **Diamonds**, JMS
- **Double Block** (Tetris-style game), CGH
- **Dragonhold**
- **Dreamlands**, CGH Services
- **Droidzone**
- **D-Day**, CGH

E

- **Eagle**, Eidersoft
- **Executive Adventure**, Gemini

F

- **Fleet Tactical Command**, DI-REN
- **Flightdeck**, Deltasoft
- **Flight Simulator**, Ekotek
- **Funfear**, Talent - Never released (Author: Mert)

H

- **Horrorday**
- **Hyperdrive**

J

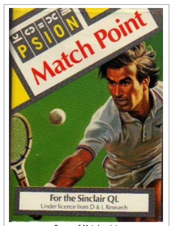
- **Jungle Eddi**

K

- **Karate**, Eidersoft
- **Knight Flight**, Realtime Software

L

- **Lands of Havoc**
- **Lost Kingdom of Zkul**
- **Lost Pharaoh**



Cover of Matchpoint

M

- **Matchpoint**, Psion - on QL Wiki
- **Metropolis**, Medic Datasystems - on QL Wiki
- **MicroBridge**, Contract Bridge player, Digital Precision
- **Mortville Manor**, Pyramide
- **M-Cosmic**, Medic Datasystems - on QL Wiki
- **M-Crunch**, Medic Datasystems - on QL Wiki
- **M-Treasure**, Medic Datasystems - on QL Wiki

N

- **Nebula II**, Pyramide
- **Nemesis MKII**, RWAP Software

O

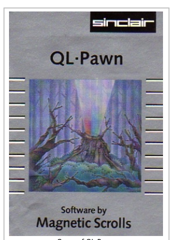
- **Othello**, Pyramide
- **Oxford Trivia**

P

- **Pengi**, RWAP Software - on QL Wiki
- **Pirate**
- **QL Pawn**, Magnetic Scrolls - on QL Wiki
- **The Prawn** RWAP Software (Author: Mert) - on QL Wiki

Q

- **QBert**
- **QL Adventure**, Optimus Software
- **QL Bounder**, Brian Kelly - on QL Wiki
- **QL Fantasy** (World 2000, Golf Plus, Fireball Plus, Satellites, Marine, Leonardo, Amadeus, Q-Prints), RB Software, 1986
- **QL Fictionary**
- **QL Jabber**, Sinclair (programmer: Arrakis)
- **QL Monopoly**
- **QL Quboids**, Sinclair (programmer: AJS)
- **QShang**, Stefan Kühne
- **QWord**, RWAP Software (programmer: Rich Mellor, Geoff Wicks and Phoebus Dokos)



Cover of QL Pawn

R

- **Return to Eden**
- **Reversi**

S

- **Scrabble**
- **Spook**, Eidersoft (Programmer: Damon Chaplin) - on QL Wiki
- **Speedfreaks**, Kaos Software
- **Super Arcadia** (BMX Burner and Grid Racer), Digital Precision
- **SuperGames Pack** (Arcanoid II, Pengi, Firebirds, Ion Gold, Doppel Ion), JMS

T

- **The Talisman**
- **Tankbusters**
- **Type 22**, Type 22 frigate simulator by John G. Burns for Talent Software

V

- **Vroom**, Pyramide

W

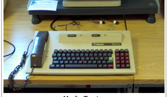
- **War in the East**
- **West**
- **Wanderer**, Pyramide

Compatibles And Derivatives

One Per Desk

The **One Per Desk**, or **OPD**, was an innovative hybrid personal computer/telecommunications terminal based on the hardware of the Sinclair QL. The One Per Desk was built by International Computers Limited (ICL) and launched in the UK in 1984. It was the result of a collaborative project between ICL, Sinclair Research and British Telecom begun in 1981, originally intended to incorporate Sinclair's flat-screen CRT technology.

Rebadged versions of the OPD were sold in the United Kingdom as the **Merlin Tonto** and in Australia as the **Telecom Australia Computerphone**.


Merlin Tonto

Hardware

From the QL, the OPD borrowed the 68008 CPU, ZX8301/8302 ULAs, 128 KB of RAM and dual Microdrives (re-engineered by ICL for greater reliability) but not the 8049 Intelligent Peripheral Controller. Unique to the OPD was a "telephony module" incorporating an Intel 8051 microcontroller (which also controlled the keyboard), two PSTN lines and a V.21/V.23 modem, plus a built-in telephone handset and a TI TMS5220 speech synthesiser (for automatic answering of incoming calls).[22 23]

The OPD was supplied with either a 9-inch monochrome (white) monitor or a 14-inch colour monitor. Both monitors also housed the power supply for the OPD itself.

Later, 3.5" floppy disk drives were also available from third-party vendors.

Software

The system firmware (BFS or "Basic Functional Software") was unrelated to the QL's Qdos operating system, although a subset of SuperBASIC was provided on Microdrive cartridge. The BFS provided application-switching, voice/data call management, call answering, phone number directories, viewdata terminal emulation and a simple calculator.

The Psion applications suite bundled with the QL was also ported to the OPD as *Xchange* and was available as an optional ROM pack.

Other optional application software available on ROM included various terminal emulators such as Satellite Computing's ICL7561 emulator, plus their Action Diary and Presentation Software, address book, and inter-OPD communications utilities.[24]

An ICL supplied application was used to synchronise a national bingo game across hundreds of bingo halls in the UK. The integral V.23 dialup modem was used to provide remote communications to the central server.

Several UK ICL Mainframe (Series 39) customers, in Local Government and Ministry of Defence sectors, used statistics applications on OPD systems to view graphical representations of mainframe reports. Once again, the integral V.23 modem was used to download from the mainframe.

Merlin Tonto

British Telecom Business Systems sold the OPD as the Merlin M1800 Tonto.[25] BT intended the Tonto to be a centralised desktop information system able to access online services, mainframes and other similar systems through the BT telephone network. It is said that the power supply unit was unreliable and often failed on most units. The Tonto retailed at £1,500 at launch. OPD peripherals and software ROM cartridges were also badged under the Merlin brand. BT withdrew support for the Tonto in February 1993. The name Tonto was derived from "**T**he **O**utstanding **N**ew **T**elecoms **O**pportunity" .

MegaOPD

An enhanced version of the OPD was produced in small numbers for the United States market. This had a 68008FN CPU, 256 KB of RAM as standard, an RS-232 port and enhanced firmware.[26] [27]

External links

- OPD page at www.SinclairComputers.com
- Description of Merlin Tonto from BT Engineering
- ICL One Per Desk page at rwapsoftware.co.uk including a floppy disk project

CST Thor

The **CST Thor** series of personal computers were Sinclair QL-compatible systems designed and produced by Cambridge Systems Technology during the late 1980s.

Thor PC

The original **Thor PC** (also called **Thor 1**, sometimes also retrospectively referred to as the **Thor 8**), was launched in 1986, as a logical progression of CST's QL peripheral business after production of the QL was halted. The remaining stock of QL parts were purchased from Sinclair, and the standard QL motherboard (including a 7.5 MHz Motorola 68008 CPU and 128 KiB of RAM) was augmented with a CST-designed expansion board providing 512 KiB of additional RAM, extra ROMs, a non-volatile real-time clock, floppy disk, SCSI, Centronics parallel, IBM PC/AT-style keyboard and mouse interfaces enclosed in a low-profile metal desktop case with a built-in power supply. Mass storage options consisted of one (Thor 1F) or two (Thor 2F) 3.5-inch floppy drives or one floppy drive and one 20 MB Rodime RO652 SCSI hard disk (Thor 2WF). The ROMs contained Eidersoft's ICE GUI and some QDOS extensions. Also supplied with the Thor was a specially-commissioned version of the Psion Xchange application software suite (an enhanced edition of the Psion applications bundled with the QL).

Prices for the Thor PC ranged from £599 to £1399, excluding monitor, mouse and VAT. An upgrade service for existing QLs was also available.

Total production of the Thor PC ran to around 1100 units.

Thor 20/21

The **Thor 20** and **Thor 21** were variants of the Thor PC launched in April 1987, fitted with a 68020 processor on a daughterboard in place of the original CPU. The new processor ran at 12.5 MHz, a 16.67 MHz option also being offered at higher cost. The Thor 21 was also fitted with the 68881 floating-point co-processor, running at the same speed as the CPU. Performance was significantly better than the Thor 1, but handicapped by the use of the 8-bit memory of the base system.

The Thor 20 and 21 were shipped with a 68020 macro assembler and linker, plus Motorola processor documentation. They were intended as a vehicle for the development of software for a projected enhanced 68020-based model, later shelved.

The Thor 20 and 21 were very expensive (a 12.5 MHz Thor 21 costing around twice as much as a Thor 1F) and were mainly placed on loan to the software development community.

Thor XVI

The **Thor XVI** was developed in collaboration with the Danish company DanSoft and was announced at the *Personal Computer World* Show in September 1987. Unlike the previous models, the Thor XVI's hardware was of a completely new design, based around an 8 MHz 68000 processor plus a 2 MHz 68B02 co-processor for audio and I/O processing. 512 KiB of RAM was included as standard (expandable to 2 MiB, later 6.5 MiB). The video hardware provided QL-compatible video modes as well as a new 16-colour mode. Floppy disk, SCSI, Centronics, dual RS-232, PC/AT keyboard, mouse, QL expansion bus and QLAN network interfaces were provided. Mass storage options were similar to the previous Thors, plus 40 MB hard disk and diskless network workstation configurations. The Thor XVI was housed in a case similar to that of the Thor PC.

The Thor XVI included in ROM a QDOS-compatible operating system derived from QDOS 1.13, called *Argos*. Like its predecessors, the XVI was bundled with Xchange.

Production started in early 1988, and around 250 Thor XVIs were built in the UK. Prices were slightly higher than the Thor PC. Later in 1988, a joint CST/DanSoft marketing operation, Thor International, was formed in Denmark in an attempt to increase sales to the European market. The Thor XVI hardware was revised slightly and production was moved to Brüel & Kjær in Denmark. Plans were also made to build Thors under license in Russia, but this came to nothing.

The following year, Thor International (and CST) collapsed amid acrimony and legal action over the disputed transfer of assets from the UK by the partners.

References

- "Thor", *Sinclair QL World*, July 1986.
- "Under the Hammer", *Sinclair QL World*, July 1987.
- "CST Thor — Euro-68000?", *Computer Shopper*, August 1988.
- "QL Corner", *Computer Shopper*, September 1989.
- "Thor saga labours on", *Computer Shopper*, October 1989.
- "Valhalla Revisited", *Sinclair QL World*, March 1991

External links

- Binary Dinosaurs page about the CST Thor
- Sinclair QL Hardware FAQ
- Sinclair QL Computer Wiki
- Description of Thor series on Thierry Godefroy's Sinclair QL and QDOS compatible systems site

Q40 (motherboard)

The **Q40** and **Q60** (sometimes known generically as the **Qx0** series) are computer motherboards designed in the late 1990s, based on the Motorola 68040 and 68060 microprocessors respectively and intended to be partially compatible with the Sinclair QL microcomputer. They were by designed by Peter Graf of Germany and manufactured by D&D Systems of the United Kingdom.

Hardware

The Q40 consists of a sub-AT form factor board comprising a 40 MHz 68040 processor, 1 MiB of video RAM, and several PLDs implementing a QL-compatible video display generator, an ISA bus, stereo 20 kHz audio DACs and an AT keyboard interface. Floppy disk, ATA hard disk, RS-232 and Centronics printer port interfaces are provided by an ISA "multi-I/O" card in one of the two ISA slots provided. Up to 32 MiB of FPM or EDO RAM can be installed in two 72-pin SIMM slots. Also included are sockets for two ROM devices, 2 kiB of non-volatile RAM and a real-time clock.

Both of the QL's standard video modes are supported, plus two extended modes: 512×256 or 1024×512 pixels with 16-bit colour.

The Q60 is a revised board with a 66 MHz 68060 or 80 MHz 68LC060 processor and support for up to 128 MiB of RAM.

The Q40 board was produced in limited quantities before being superseded by the **Q40i**; essentially a Q60 board with a 40 MHz 68040.

Software

Three operating systems are available for the Q40/Q60; these comprise QDOS Classic (an enhanced version of Qdos 1.10), SMSQ/E and a custom Linux distribution.

External links

- Official Q40/Q60 website

Sinclair

Cambridge Consultants Ltd

Cambridge Consultants

Type	Private (Private company)
Industry	Product and technology development and consultancy
Founded	1960
Headquarters	Cambridge, England, UK Cambridge, USA
Employees	300
Website	www.cambridgeconsultants.com

Cambridge Consultants is an international technology development and consultancy company, providing outsourced Research and Development to clients - from start-ups to blue-chip multinationals - who need to develop innovative, technologically novel, breakthrough products. The company also provides business consulting services in the areas of innovation management, market strategy and technical due diligence.

As of mid-2008, the company employs about 300 engineers, scientists, mathematicians, consultants, analysts and support staff in both Cambridge, UK and Cambridge, USA. In addition to their client work, staff at Cambridge Consultants are free to develop their own intellectual property, either for licensing to clients or as the basis for a spin-out business.

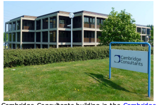
History

Founded in 1960[28] by two Cambridge graduates – Tim Eiloart [29] and David Southward – to "put the brains of Cambridge University at disposal of the problems of British industry",[30] Cambridge Consultants was one of the UK's first technology transfer businesses. Their early work laid the foundations for what is now known as the Cambridge Phenomenon or Silicon Fen. Indeed, many of the high-tech companies in and around the city of Cambridge can trace their roots back to Cambridge Consultants. Inspired by the service and business model of CCL several engineering and innovation companies like Technology partnership (www.ttp.com), Verhaert Masters in Innovation (www.verhaert.com), Sentec Limited (www.sentec.co.uk) and Sagentia (www.sagentia.com) came to life.

Initially, the company was privately run. However, in January 1972, it became part of Arthur D. Little, the large American management consultancy, gaining professional management support and access to international markets. Cambridge Consultants remained part of Arthur D. Little until 2001. In 2002 the management team at Cambridge Consultants acquired the company, backed by Altran, Europe's largest technology consultancy.

Despite the early difficulties witnessed by many technology companies at the turn of the millennium, Cambridge Consultants has continued to grow since 2000, and now has a reputation as one of the world's most innovative product development companies.

Current business



Cambridge Consultants building in the Cambridge Science Park in April 2011.

Cambridge Consultants' work spans a range of different industry sectors, and its structure is designed to mirror these:

The company's **Medical Technology** Division develops products and technology for drug delivery (respiratory, transdermal, injection, etc), diagnostics (both lab-based and point-of-care devices), and surgical and interventional device manufacturers. The company is also working to develop a new generation of wireless medical products.

The **Wireless** Division develops chips through to complete products and is active in the majority of wireless technologies available today, including satellite and WiMAX to ZigBee, UWB and NFC. Cambridge Consultants is responsible for many 'world-firsts' in wireless communication, including:

- The first single-chip Bluetooth device, which was spun out to create Cambridge Silicon Radio, now the market leader in Bluetooth chips
- The digital radio used to manage the majority of the US airspace
- The world's first GSM videophone for Orange
- The world's first digital wireless patient monitoring system operating in the WMTS medical frequency band, which the company developed for its client Philips Medical Systems

The **Products & Systems** division within Cambridge Consultants develops CleanTech, industrial and consumer products, transport technologies, and ASICs and FPGAs. Many ASIC projects use Cambridge Consultants' XAP processor core. The Division also developed the Prism 200, an advanced handheld through-wall radar and the open standard Universal Metering Interface for smart metering.

The **Consulting** Division at Cambridge Consultants advises companies on market strategy, transaction support and innovation management, especially where complex technology is involved. The Division's consultants and analysts carry out technical and commercial due diligence for clients around the world, and provide Expert Reports for companies listing on the UK stock market. Using a range of bespoke consulting tools, the teams also assist organisations to better manage ideas, and to prepare more effectively for future market scenarios.

Spin-outs

Cambridge Consultants has created over twenty new ventures in the past twenty-five years, several of which have gone on to achieve listing on the London Stock Exchange, namely Domino, Xaar, Prelude Trust, CSR plc and Vivid (sold to Vectura Group). Other successful spin-offs include Alphamosaic and Inca, who have subsequently been acquired by Broadcom for US$123 million and Dainippon Screen for €43.8 million, respectively. Both sales were achieved within five years of the companies being formed.

In a new approach to venturing, Cambridge Consultants established a joint £10-million joint venture fund with the technology venture capitalist Esprit Capital Partners. The fund will be used to invest exclusively in Cambridge Consultants' own spin-outs.[0]

Further reading

- Dale, Rodney (1979) *From Ram Yard to Milton Hilton: A History of Cambridge Consultants Ltd, 1960-1979*, 36 pp. Cambridge: Cambridge Consultants Ltd
- Dale, Rodney (2010) *From Ram Yard to Milton Hilton: Cambridge Consultants - the early years*, 120 pp. Haddenham, Cambridgeshire: Fern House Publishing, ISBN 978-1-902702-24-7

External links

- Cambridge Consultants – Official website
- Cambridge Network – Cambridge Consultants is a founder member of the Cambridge Network and regularly posts news and jobs here

Sinclair Radionics

Sinclair Radionics Ltd

Type	Limited company
Industry	Electronics Hi-fi equipment
Fate	Renamed Sinclair Electronics Ltd. (September 1979)
Founded	Cambridge, England (1961)
Key people	Sir Clive Sinclair, Founder Nigel Searle
Products	Sinclair Executive Sinclair Scientific Black Watch
Revenue	£6.3 million GBP (1975)

Sinclair Radionics Ltd was a company founded by Sir Clive Sinclair in Cambridge, England which developed hi-fi products, radios, calculators and scientific instruments.

History

After raising funds to start the business by writing articles for *Practical Wireless* magazine, Clive Sinclair founded Sinclair Radionics Ltd. on 25 July 1961.

Radios and Hi-Fi


Sinclair Micromatic pocket radio.

Radionics initially developed hi-fi equipment; it released its first product, the Sinclair Micro-amplifier, in December 1962. The assembly and distribution of this product were contracted out to Cambridge Consultants Ltd. In 1963 Sinclair Radionics introduced their first radio with the "Sinclair Slimline" in kit form at forty-nine shillings and sixpence. A year later in 1964 Sinclair released the "Micro-6", match-box size radio which the company claimed was the "world's smallest radio". It could also be worn on your wrist with the "Transrista". In 1965 the "Micro-FM" debuted as "the world"s first pocket-size FM tuner-receiver", but was unsuccessful due to technical difficulties. Despite problems, illegal clones were produced in the far-east. Sinclair's final 1960s radio kit was the 1967 "Micromatic", billed as "the world's smallest radio" like Sinclair's earlier radios. The "Micromatic" was a reasonable success and was sold until 1971. In May 1971 Sinclair Radionics made £85,000 profit on £563,000 turnover; the following year profit increased to £97,000 on turnover of £761,000.

In 1966 Sinclair Radionics entered the hi-fi market with the "Stereo 25", a low-cost pre-amp control system. Production was halted in 1968 due to low supply of transistors which had been purchased in 1964 as rejects from other manufacturers. In 1969 it was replaced by the "Stereo Sixty". This soon became Sinclair's most successful audio product, being the second product of the "Project 60" range. The "Project 60" products sold well and were supplemented by the "Project 605" kit in 1972. It was eventually superseded by the more advanced "Project 80" kit in 1974.[31] In May 1973 Sinclair Radionics generated £1.8m turnover. The last Sinclair Radionics hi-fi product was the System 4000, in 1974.

Another Sinclair Radionics product that was introduced in 1964 and failed was the first class D amplifier kit rated at 10 watt RMS. A class D switching amplifier that was good in theory but sadly ahead of its time and available technology. The amplifier used low frequency germanium transistors as pulse width modulators and switches and wrongly relied on the loudspeaker's inductance to filter the class D signal into audio. Most often this would short out the output transistors. When it did work the power level was far below 10 watts and Sinclair's main advertising channel, Wireless World Magazine, was so deluged with complaints that it supposedly refused to take further advertisements form Sinclair.

Calculators and test equipment


Sinclair Executive calculator

In 1972 Radionics launched its first electronic calculator, the *Executive*, which was considerably smaller than its competitors since it had been possible to use hearing-aid-sized batteries. It had been discovered that there was considerable latency in the display and memory and that, with the addition of a timer, power could be withheld from these battery-draining components for much of the time.

During the majority of the 1970s Sinclair focused on building the most affordable pocket calculators with the best design. In 1972 Sinclair released the world's first slim-line pocket calculator, the Sinclair Executive, for £79.95. The calculator only included basic maths functions, and the LED display required lots of power. It is often credited as being the world's first attractively-styled calculator that didn't require mains power to be used like prior calculators. The Executive was a phenomenal success, earning Sinclair £1.8m in profit. In 1973 the slightly larger Sinclair Cambridge was introduced at a far cheaper price of £29.95 + VAT. A cheaper Executive was also launched shortly after. In addition to expanding the Cambridge range, the Sinclair Cambridge Scientific was launched in 1975. It was a scientific pocket calculator for the very competitive price of £49.95. In 1977 a revised model, the "Scientific Programmable", was released at £29.95.[32] The Scientific Programmable Mark 2 was later released, reducing the price to £17.22.

In 1975 Sinclair Radionics launched the Oxford range of briefcase calculators. Sinclair also attempted to capture the top-end calculator market with the Sinclair Sovereign, available in plated gold or silver. The calculator was critically acclaimed for its excellent engineering and design and enjoyed short success. A final attempts at the mass-market for calculators, the Sinclair Enterprise and the President did not sell well.

In 1974, Radionics launched the DM1 digital multimeter.[33] Such scientific instruments were to form a quiet backbone of Radionics business for the rest of its existence. In marked contrast to the rest of the Sinclair range, the instruments gained a reputation for reliable conventionality rather than often unreliable idiosyncrasy.[34]

Black Watch


Sinclair Black Watch

In August 1975 Sinclair introduced the Black Watch digital watch at £17.95 in kit form and £24.95 ready-built, although this wasn't available to buy until January 1976.[35] Including a five-digit LED display, it suffered from technical flaws related with the design of the case, the chip, the battery and accuracy. Not only was the watch unreliable, Radionics was not able to fulfil the orders it had taken. As a result, Radionics made its first loss in the financial year April 1974-April 1975. The Black Watch fiasco had a devastating effect on Sinclair's finances and the company would have gone bankrupt had not the Government, through the National Enterprise Board, stepped in to support it.[36]

Portable televisions

In 1966 Sinclair Radionics developed the world's first portable television, the "Microvision", but never attempted to sell it because development costs would have been too high based on the complicated design the Microvision used.

In April 1976, the National Enterprise Board bought a 43% stake in Sinclair Radionics for £650,000, and in October the National Research and Development Council agreed to provide £1m for a revived portable TV project, which was finally launched in January 1977 as the Microvision TV1A and MON1A at £99.95. Supply exceeded demand, and 12,000 units were left unsold until they were sold off cheaply. This resulted in a £480,000 loss for Sinclair. Sir Clive Sinclair was certain that the TV1B model released in 1978 would be more successful, but sales were disappointing.

	Turnover	Profit	Loss	%
1971	563,000	85,000	—	15%
1972	761,000	97,000	—	13%
1973	1,800,000	?	—	?
1974	4,000,000	240,000	—	6%
1975	6,300,000	45,000	—	1%
1976	5,600,000	?	355,000	N/A
1977	?	?	820,000	N/A
1978	6,390,000	?	1,980,000	N/A

Financial performance of Sinclair Radionics 1971—1978

Demise

In July 1977 the NEB increased its stake in Radionics to 73%. By June 1978 Sinclair Radionics was working on the NewBrain microcomputer project, which was later taken over by Newbury Laboratories.

In May 1979 the NEB announced that it intended to sell Radionics' calculator and TV interests; they were bought by the ESL Bristol group (as **Radionic Products Ltd.**) and Binatone respectively. In July Clive Sinclair resigned with a £10,000 golden handshake. In September the NEB renamed what was left of Radionics (i.e. the scientific instrument business) as **Sinclair Electronics Ltd.**; in January 1980 this was changed to **Thandar Electronics Ltd**. As of 2008 this business continues, now called **Thurlby Thandar Instruments**.

Sinclair Instrument and Science of Cambridge

When it became clear that Radionics was failing, Clive Sinclair took steps to ensure that he would be able to continue to pursue his commercial goals: in February 1975, he changed the name of **Ablesdeal Ltd.** (an off-the-shelf company he bought in September 1973 for just such an eventuality) to **Westminster Mail Order Ltd.**; this was changed to **Sinclair Instrument Ltd.** in August 1975.

Finding it inconvenient to share control after the NEB became involved in Radionics, Sinclair encouraged Chris Curry, who had been working for Radionics since 1966, to leave and get Sinclair Instrument up and running.

Sinclair Instrument developed the "Wrist Calculator" to generate cash, which soon became a commercial success selling in surprising figures. In July 1977 Sinclair Instrument Ltd was renamed to **Science of Cambridge Ltd**. Around about the same time Ian Williamson showed Chris Curry a prototype microcomputer based around a National Semiconductor SC/MP microprocessor and some parts taken from an earlier Sinclair calculator. This was sold as the MK14 microcomputer kit. Science of Cambridge ultimately became **Sinclair Research Ltd.**

References

- Sinclair: A Corporate History
- Nigel Tout. *Clive Sinclair and the Pocket Calculator*, 2003.

External links

- Thurlby Thandar Instruments Limited (successor to Thandar Electronics Ltd)

Sinclair Research

Sinclair Research Ltd

Type	Limited company
Industry	Computing Electronics
Founded	Cambridge, England (1973)
Headquarters	London, England
Key people	Sir Clive Sinclair, Founder Nigel Searle, Director (1979 to 1986) Jim Westwood Rick Dickinson, Designer
Products	Sinclair ZX Spectrum Sinclair QL
Revenue	£102 million GBP (1985)
Employees	140 (1980s) 3 (1990) 1 (1997)
Website	Sinclair Research

Sinclair Research Ltd is a British consumer electronics company founded by Sir Clive Sinclair in Cambridge. Originally incorporated in 1973 as Ablesdeal Ltd., it remained dormant until 1976, and did not adopt the name Sinclair Research until 1981.

In 1980, Clive Sinclair entered the home computer market with the ZX80 at £99.95, at the time the cheapest personal computer for sale in the UK. In 1982 the ZX Spectrum was released, later becoming Britain's best selling computer, competing aggressively against Commodore and Amstrad. At the height of its success, and largely inspired by the Japanese Fifth Generation Computer programme, the company established the "MetaLab" research centre at Milton Hall (near Cambridge), in order to pursue artificial intelligence, wafer-scale integration, formal verification and other advanced projects. The combination of the failures of the Sinclair QL computer and the TV80 led to financial difficulties in 1985, and a year later Sinclair sold the rights to their computer products and brand name to Amstrad.[37] Sinclair Research Ltd still exists today as a one man company, continuing to market Sir Clive Sinclair's newest inventions.

History

Period	Profit	Turnover
1980	£131,000	£640,000
1981	£818,000	£4.6m
1982	£8.55m	£27.17m
1983	£13.8m	£54.53m
1984	£14.28m	£77.69m
1985	-£18m	£102m
1988 to 1989	-£183,015	£7,825
1989 to 1990	£618,389	£4,754
1989 to 1990	-£271,734	£5,486
1991 to 1992	-£592,600	£1,115
1992 to 1993	-£169,197	£379,836
1993 to 1994	-£194,826	£510,943
1994 to 1995	-£303,630	£435,742
1995 to 1996	-£122,873	£255,826

*All profit and turnover data from [38]

Founding and early years

On 25 July 1961, Clive Sinclair founded his first company, Sinclair Radionics Ltd. in Cambridge. Sinclair Radionics developed hifi products, radios, calculators and scientific instruments. When it became clear that Radionics was failing, he took steps to ensure that he would be able to continue to pursue his commercial goals: in February 1975, he changed the name of Ablesdeal Ltd. (an off-the-shelf company he bought in September 1973 for just such an eventuality) to Westminster Mail Order Ltd; this was changed to Sinclair Instrument Ltd in August 1975.

Finding it inconvenient to share control after the National Enterprise Board became involved in Radionics in 1976, Sinclair encouraged Chris Curry, who had been working for Radionics since 1966, to leave and get Sinclair Instrument up and running. The company's first product was a watch-like Wrist Calculator.

Development of the ZX80

In July 1977, Sinclair Instrument Ltd was renamed as Science of Cambridge Ltd. Around the same time Ian Williamson showed Chris Curry a prototype microcomputer based around a National Semiconductor SC/MP microprocessor and some parts taken from an earlier Sinclair calculator. Curry was impressed and encouraged Sinclair to adopt this as a product; an agreement was reached with Williamson but no contract was ever signed. National Semiconductor had offered to redesign the project so that it used only their components and they also offered to manufacture the boards.

In June 1978, Science of Cambridge launched the microcomputer in kit form, marketed as the MK14. In May 1979, Jim Westwood started a project to design a new microcomputer based on the Zilog Z80 microprocessor at Science of Cambridge. This was launched as the ZX80 in February 1980 in two forms: kit and ready-built.[39] In November of the same year Science of Cambridge was renamed Sinclair Computers Ltd.

Commercial success and home computers


ZX Spectrum (1982)

In March 1981, Sinclair Computers was renamed **Sinclair Research Ltd** and the Sinclair ZX81 was launched. In February 1982 Timex Corporation obtained a license to manufacture and market Sinclair's computers in the USA under the name Timex Sinclair. In April the ZX Spectrum was launched. In July Timex launched the TS 1000 (a version of the ZX81) in the United States. In March 1982 Sinclair made an £8.55m profit on turnover of £27.17m, including £383,000 government grants for flat screen.

In 1982 Clive Sinclair converted the Barker & Wadsworth mineral water bottling factory at 25 Willis Road, Cambridge, into the company's new headquarters. It was sold to Cambridgeshire County Council in December 1985 due to Sinclair's finance troubles.

In January 1983 the ZX Spectrum personal computer was presented at the Las Vegas Consumer Electronics Show. In September the Sinclair TV80 pocket television was launched, but was a commercial failure.

In 1983 the company bought Milton Hall in the village of Milton, Cambridgeshire, for £2m, establishing their *MetaLab* research and development facility there.

In late 1983 Timex decided to pull out of the Timex Sinclair venture, which had failed to break the United States market as expected due to strong competition. However Timex computers continued to be produced for several years in other countries. Timex Portugal launched improved versions, the TS 2048 and 2068. They also developed and launched the FDD 3000, a floppy disk system, that was not well received by the market.

Mid-1980s developments

The Sinclair QL was announced on 12 January 1984, shortly before the Apple Macintosh actually went on sale.[40] It suffered from several design flaws,[41] and *Your Sinclair* noted that it was "difficult to find a good word for Sinclair Research in the computer press".

Fully working QLs were not available until late summer; complaints against Sinclair regarding delays were upheld by the Advertising Standards Authority in May of the year (in 1982 it had upheld complaints about delays in shipping Spectrums). Especially severe were allegations that it was cashing cheques months before machines were shipped. The QL was nowhere near as successful as Sinclair's earlier computers. In the autumn Sinclair were still publicly predicting it would be a "million seller", with 250,000 sold by the end of the year.[42] QL production was suspended in February 1985, and the price was halved by the end of the year.[43]

The ZX Spectrum+, a repackaged ZX Spectrum with a QL-like keyboard, was launched in October 1984 and appeared on W H Smith's shelves the day after release. Retailers stocked the machine in large numbers in expectation of good Christmas sales. However the machine did not sell in the numbers expected and, because retailers still had unsold stock, Sinclair's income from orders dipped alarmingly in January. The Spectrum+ had the same technical specifications as the original Spectrum. However, an enhanced model, the ZX Spectrum 128, was launched in Spain in September 1985, with development funded by the Spanish distributor Investronica.[44] However, the UK launch was delayed until January 1986, due to large unsold stocks of previous models held by retailers.[45]

At the January 1985 Las Vegas Consumer Electronics Show, Sinclair re-entered the United States market, announcing the "FM Wristwatch Radio", an LCD wristwatch with a radio attached.[46] However, the watch had several usage problems and never went into full production.

Sir Clive had long held an interest in electric vehicles and during the early 1980s worked on the design of a single-seater "personal vehicle", eventually starting a company called Sinclair Vehicles Ltd in March 1983, and launching the Sinclair C5 electric vehicle on 10 January 1985. It was a commercial disaster, selling only 17,000 units and losing Sinclair £7m, Sinclair Vehicles going into liquidation later the same year. The C5, combined with the failures of the QL and the TV80, caused investors to lose confidence in Sir Clive.

Amstrad acquisition of assets

On 28 May 1985, Sinclair had announced that it wanted to raise an extra £10m to £15m to restructure Sinclair Research. Given the loss of confidence in the company, this proved hard to find. In June 1985, the business magnate Robert Maxwell announced a takeover of Sinclair Research, through Hollis Brothers, a subsidiary of his Pergamon Press business.[47] However the deal was aborted in August 1985.[48]

Sinclair Research's future remained uncertain, until 7 April 1986, when the company sold its entire computer product range and the "Sinclair" brand name to Amstrad.[49 50] This deal did not involve the company, merely its name and products.

Sinclair Research was reduced to an R&D business and holding company, with shareholdings in several new "spin-off" companies, formed to exploit technologies developed by the company. These included Anamartic Ltd. (wafer-scale integration), Shaye Communications Ltd. (CT2 mobile telephony) and Cambridge Computer Ltd. (Z88 portable computer and satellite TV receivers).[51]

Return to invention


Inventors of the A-bike, Sir Clive Sinclair and Alexander Kalogroulis

Since 1986 the company has continued to exist, but in a completely different form than it did in the early 1980s. In 1993, 1994 and 1995 Sinclair made continuing losses on decreasing turnover, and began to worry investors since Clive Sinclair himself was using his own personal wealth to fund his inventions. By 1990 Sinclair's entire staff had been reduced to Sinclair himself, a salesperson/administrator, and an R&D employee. By 1997 reportedly only Sinclair on his own was working at his company.

In 1992 the "Zike" electric bicycle was released, Sinclair's second attempt at changing means of transportation. The "Zike" was a commercial failure much like the C5 was, and only sold a total of 2,000 units. It had a maximum speed of 10 mph (16 km/h), and was only available through mail order.

In 2003 the Sinclair "ZA20 Wheelchair Drive Unit" was introduced, designed and manufactured in conjunction with Hong Kong's Daka Designs, a partnership which also led to the SeaDoo Sea Scooter underwater propulsion unit. In 1999 Sinclair released the world's smallest radio with the "Z1 Micro AM Radio".

On 12 July 2006, the A-bike, a folding bicycle invented by Sir Clive Sinclair, was released and went on sale for £200. It had been originally announced two years previously, in 2004.

In November 2010 Sinclair Research announced [52] the X-1 electric vehicle, to be launched in July 2011 in the UK.[53]

Products

- **Wrist Calculator**

The Wrist Calculator was released by Sinclair Instrument in 1977.[54]

- **MK14**

The MK14 (Microcomputer Kit 14) was a computer kit sold by Science of Cambridge of the United Kingdom, first introduced in 1977 for UK£39.95.

- **ZX80**

The ZX80 home computer was launched in February 1980 at £79.95 in kit form and £99.95 ready-built.[55] In November of the same year Science of Cambridge was renamed Sinclair Computers Ltd.


Timex Sinclair 1000, a U.S. version of the Sinclair ZX81

- **ZX81**

The ZX81 (known as the TS 1000 in the United States) was priced at £49.95 in kit form and £69.95 ready-built, by mail order.


ZX Spectrum (1982)

- **ZX Spectrum**

The ZX Spectrum was launched on 23 April 1982, priced at £125 for the 16 KB RAM version and £175 for the 48 KB version.

- **TV80**

The TV80 was a pocket television. Launched in September 1983. It used a flattened CRT unlike Sinclair's previous portable televisions. The TV80 was a commercial failure selling only 15,000 units and not covering its development costs of £4m.

- **Sinclair QL**

The Sinclair QL was announced in January 1984,[56] priced at £399. Marketed as a more sophisticated 32-bit microcomputer for professional users, it used a Motorola 68008 processor. Production was delayed by several months, due to unfinished development of hardware and software at the time of the QL's launch.[57] Hardware reliability problems and software bugs resulted in the QL acquiring a poor reputation from which it never really recovered.

- **ZX Spectrum+**

The ZX Spectrum+ was a repackaged ZX Spectrum 48K launched in October 1984.

- **ZX Spectrum 128**

The ZX Spectrum 128, with RAM expanded to 128 kB, a sound chip and other enhancements, was launched in Spain in September 1985 and the UK in January 1986, priced at £179.95.[58]

- **Computer peripherals**

Sinclair created various peripherals for their computers including memory expansion modules, the ZX Printer, and the ZX Interface 1 and ZX Interface 2 add-ons for the ZX Spectrum. A number of QL peripherals were developed by other companies but marketed under the Sinclair brand. External storage for the Spectrum was usually on cassette tapes, as was common in the era. Rather than an optional floppy disk drive, Sinclair instead opted to offer their own mass storage system, the ZX Microdrive, a tape-loop cartridge system that was rather unreliable. This was also the primary storage device for the QL.


X1 Button Radio (1997)

- **X1 Button FM Radio**

In June 1997 Sinclair Research released the X1 radio for £9.50. This miniature mono FM radio, powered by a CR2032 battery was inserted in the ear and had a fixed volume. The X1 radio had three buttons, an on/off switch, a *Scan* button and a *Reset* to restart the scanning process. It came with a short length of aerial and a detachable ear hook. [59]

- **Sinclair X-1**

In November 2010 Sinclair told *The Guardian* newspaper that he was working on a new prototype electric vehicle, called the X-1, to be launched within a year. "Technology has moved on quite a bit, there are new batteries available and I just rethought the thing. The C5 was OK, but I think we can do a better job now."[60 61] The X-1 will be available on July 2011 at the price of £595.[62]

Cancelled projects

The following computer products were under development at Sinclair Research during the 1980s but never reached production:

- **LC3**

Standing for "Low Cost Colour Computer", the *LC3* was developed during 1983 by Martin Brennan and was intended to be a cheap Z80-based games console implemented in two chips, using ROM and (non-volatile) RAM cartridges for storage. A multi-tasking OS for the *LC3* with a full windowing GUI was designed by Steve Berry. It was cancelled in November 1983 in favour of the QL.[63]

- **SuperSpectrum**

Intended to be a 68008-based home computer, equipped with built-in ZX Microdrive, joystick, RS-232 and ZX Net ports. Sinclair's SuperBASIC programming language was originally intended for this model but was later adopted for the QL. *SuperSpectrum* was cancelled in 1982 after the specification of the *ZX83* (QL) had converged with it.[64] This project is not to be confused with *Loki*, which was described as the "SuperSpectrum" in an article in the June 1986 issue of *Sinclair User* magazine.

- **Pandora**

This was to be a portable computer with an integral flat-screen CRT display. Initially to be ZX Spectrum-compatible with a faster Z80 CPU, a built-in ZX Microdrive and a new 512×192-pixel monochrome video mode. Due to the limited size of flat CRT that could be manufactured, a series of folding lenses and mirrors were necessary to magnify the screen image to a usable size. The project was cancelled after the Amstrad take-over; however, the *Pandora* concept eventually transformed into the Cambridge Computer Z88.[65 66 67]

- **Loki**

This project was intended to create a greatly enhanced ZX Spectrum, possibly rivalling the Commodore Amiga. *Loki* was to have a 7 MHz Z80H CPU, 128 KiB of RAM and two custom chips providing much enhanced graphics and audio capabilities. After the Amstrad buy-out in 1986, two engineers who had worked on the project, John Mathieson and Martin Brennan, founded Flare Technology to continue their work.[68]

- **Bob/Florin**

According to Rupert Goodwins, this was a project to produce an add-on floppy disk drive for the ZX Spectrum.[69]

- **Tyche**

This codename was assigned to a QL follow-on project running from 1984 to 1986. Among the features associated with *Tyche* were increased RAM capacity, internal floppy disk drives, the Psion *Xchange* application suite on ROM, and possibly the GEM GUI.[70]

- **Janus**

This name has been associated with a design concept for a "Super QL" based on wafer-scale integration technology.[71 72]

- **Proteus**

This was rumoured to be a hypothetical portable version of the QL similar to *Pandora*.[73]

External links

- Sinclair Research Corporate website
- Sinclair Nostalgia Products
- Sinclair Heaven website
- *The Sinclair Story* book extract
- Planet Sinclair
- 'Pocket TVs failed before. What's changed?', BBC News Magazine article
- ZX81 Online Museum
- www.1000bit.net, 1000BiT Sinclair's section
- Sinclair Research at World of Spectrum

Further reading

Books

- Adamson, Ian; Kennedy, Richard (1986). *Sinclair and the "Sunrise" Technology*. London: Penguin Books. 224 pp. ISBN 0-14-008774-5.
- Dale, Rodney (1985). *The Sinclair Story*. London: Duckworth. 184 pp. ISBN 0-7156-1901-2.
- Tedeschi, Enrico (1986). *Sinclair Archaeology: The Complete Photo Guide to Collectable Models*. Portslade: Hove Books. 130 pp. ISBN 0-9527883-0-6.

Magazines

- *CRASH*
- *Everyday Electronics*, various issues
- *Practical Electronics*, various issues
- *Practical Wireless*, various issues
- *Radio Constructor, The*, various issues
- *Sinclair Programs*, various issues
- *Sinclair Projects*, various issues
- *Sinclair User*
- *Your Sinclair*

Timex Sinclair

Timex Sinclair was a joint venture between the British company Sinclair Research and Timex Corporation in an effort to gain an entry into the rapidly-growing early-1980s home computer market in the United States. The choice of partnership was natural as Timex was already the main contractor for manufacture of Sinclair's ZX81 and ZX Spectrum computers at its Scottish plant in Dundee.

It was Timex of Portugal, though, that took on the R&D and the local manufacturing of the models to be exported to the U.S. Although both Timex of Scotland and Timex of Portugal were full subsidiaries of Timex, internal rivalry, whether unintended or purported, meant there were no contacts nor experiences shared between the two plants. Timex of Portugal also sold the Timex Sinclair models in Portugal and Poland under the Timex Computer brand.

Products

Timex Sinclair released four computers, all of them based (to some extent) on Sinclair Research's existing machines. In chronological order:

- TS1000, essentially a modified ZX81 with 2 KiB RAM
- TS1500, a TS 1000 with 16 KiB RAM and a ZX Spectrum-like case and keyboard

- TS2068, a ZX Spectrum-based machine with enhancements, namely a cartridge port to make it compete with videogame consoles, which resulted in poor compatibility with software developed for the original. Its European sibling, the TC2068, featured improved compatibility with the ZX Spectrum.
- TC2048, a ZX Spectrum-based machine with a TS 2068-like keyboard. Not sold in the US.

The Timex Sinclair 2068
Although a similar shape to the +3, the box on the right is not a floppy disk drive but a front-loading cartridge port.

In July 1982, Timex Sinclair introduced the first computer touted to cost under $100 marketed in the U.S. (TS 1000). In spite of the flaws in the early versions, half million units were sold in the first 6 months alone.

Overall, the machines were nowhere near as successful as their UK progenitors; in contrast with the ZX Spectrum, which was the best-selling computer in Britain at the time, the TS2068 was a relative failure.

Timex Corporation withdrew from the U.S. home computer market in February 1984 but Timex of Portugal continued to manufacture, sell and develop hardware in Portugal and Poland for another ten years.

The next computer, the TC3256, was the third generation of Timex Computer Technology, but it vanished when Timex of Portugal shut down its production line.

Timex of Portugal also produced a Z80-based CP/M-compatible computer, the Timex FDD or FDD 3000. Most people only know it as a floppy disk drive controller but in fact, it is a computer without graphics circuitry. The FDD or FDD 3000 could be used in three different ways:

- as a disk drive controller for a TC2048/2068 or ZX Spectrum, running TOS (Timex Operating System)
- as a CP/M system, using a TC2048/2068 computer running the Timex Terminal Emulator as a console.
- as a CP/M system, using the Timex Terminal 3000, a terminal keyboard, as a console.

Peripherals

Timex Sinclair produced the following peripherals for the Timex computer line:

- TS1016 - Timex 16K RAM Pack for use on a TS1000. Can be used on a TS1500.
- TS1050 - Not a real peripheral, but a "suitcase" to carry TS1000, tapes and peripherals
- TS1510 - A cartridge player for TS1500. It can be used on TS1000 with a 16K RAM Pack
- TS2020 - Analog Tape Recorder
- TS2040 - Thermal Printer
- TS2050 - Communications Modem
- TS2060 - Bus Expansion Unit (vaporware)
- TS2065 - Timex Microdrives (vaporware)
- TS2080 - 80 column dot matrix printer (vaporware)
- TS2090 - Joystick to be used on TS2068 internal ports

Timex Computer (TMX Portugal) produced the following peripherals for the Timex computer line:

- TS1040 - A multi-voltage power supply (printer + tape recorder (TS2020) + TS1000 + TC2048/2068)
- TC2010 - A digital tape recorder
- TC2080 - A serial 80 column dot matrix printer
- Timex FDD - A "cut down" computer that can be used as a floppy disk controller
- Timex FDD3000 - A "cut down"computer that can be used as a floppy disk controller (an upgraded Timex FDD)
- Timex Terminal 3000 - A "cut down"computer to be used as a CP/M terminal with FDD3000
- Timex RS232 - A serial RS232 interface
- Sound/Joystick Unit - A sound amplifier for SLCD sounds and Kempson(?) Joystick Interface

TMX Portugal also sold the TS2040 and later renamed it to Timex Printer 2040.
To export the Timex Computer to Poland, Timex of Portugal had to be paid in goods. It chose to import the Neptun 156 12" green monochrome monitor, manufactured in Poland by Unimor company. Based on the Vela TV receiver, it proved very popular in Portugal and was frequently sold in bundles with the TC computers.


Neptun 156 monitor. It came in matching black or grey colours.

Software

TMX Portugal sold/developed the following software:

- TOS - Operating system for the FDD/FDD3000 known as Timex Operating System
- CP/M for FDD3000 - Advanced operating system for the FDD3000
- Basic 64 - Basic extensions for the extra video modes
- Timeword - A word processor in cartridge that can save to TOS disks or to a tape recorder

External links

- TIMEXsinclair Showcase

Timex Group

Timex Group B.V.

Timex Group Logo

Type	Privately Held
Industry	Watch manufacturing, Luxury Goods
Headquarters	Hoofddorp, Netherlands
Owner(s)	Fred. Olsen & Co.[74]
Employees	5,000+
Website	timexgroup.com

Timex Group B.V., or **Timex Group**, is a Dutch holding company headquartered in Hoofddorp, the Netherlands, and the corporate parent of several watchmaking companies around the globe including Timex Group USA, Inc.,[75] TMX Philippines, Inc., and Timex Group India Ltd. Businesses and exclusive worldwide licenses include the Timex Business Unit (Timex, Timex Ironman, Opex, TX, Nautica, Marc Eckō), Timex Group Luxury Watches (Valentino, Salvatore Ferragamo), Sequel (Guess, Gc), Vertime (Versace, Versus) and Giorgio Galli Design Lab.[76] Today, Timex Group B.V.'s products are manufactured in the Philippines, Hong Kong, China, France, India and Switzerland, often based on technology that continues to be developed in the United States and in Germany. The group has operations in a number of countries in Europe, the Americas, Asia and Australia.

Companies and brands

Timex Business Unit, A division of Timex Group USA, Inc.

- Timex
- Opex
- Nautica
- Marc Eckō
- TX

Sequel AG

- Guess
- Gc

Vertime SA

- Versace
- Versus

Timex Group Luxury Watches

- Salvatore Ferragamo Timepieces
- Valentino Timeless

Giorgio Galli Design Lab

External links

- Timex Group Corporate website
- Timex Brand website

Timex Group USA

Timex Group USA, Inc.

Timex Group Logo

Type	Privately held company
Industry	Watch manufacturing, luxury goods
Founded	1854 as Waterbury Clock Company
Headquarters	Middlebury, Connecticut, USA with various operations in Europe, the Americas, and Asia
Owner(s)	Timex Group B.V.
Employees	2,000
Website	timexgroup.com

Timex Group USA, Inc. (formerly known as **Timex Corporation**), a subsidiary of Timex Group B.V. and its US headquarters, is based in Middlebury, Connecticut. The company is the current day successor to the Waterbury Clock Company, founded in 1854 in nearby Waterbury, Connecticut.

History

Waterbury Clock Company (1854–1944)

In 1854 Waterbury, CT-based brass manufacturer Benedict & Burnham created Waterbury Clock Company to manufacture clocks using brass wheels and gears. Waterbury Clock Company was legally incorporated on March 27, 1857 as an independent business with $60,000 in capital.[77 78] The American clock industry, with scores of companies located in Connecticut's Naugatuck Valley, was producing millions of clocks, earning the region the nickname, "Switzerland of America".[79] The Waterbury Clock Company was one of the largest producers for both domestic sales and export, primarily to Europe.[80] Today its successor, Timex Group USA, Inc. is the only remaining watch company in the region.

Ingersoll Watch Company

Originally, the company produced clocks as less expensive alternatives to the high-end European counterparts of the time.[81] In 1887 the company began experimenting with its product line leading to the creation of the large *Jumbo* pocket watch invented by Archibald Bannatyne – named after the famous P. T. Barnum elephant.[82] The *Jumbo* was put on the market in New York City on a trial basis catching the attention of Robert H. Ingersoll, a salesman and eventual marketing pioneer.[83] During the turn of the century, Waterbury Clock Company produced millions of pocket watches for the newly created partnership of Robert and his brother Charles, Robert H. Ingersoll & Bro., under their own brand name.[84] In 1896, Ingersoll introduced the *Ingersoll Yankee*, a dollar pocket watch supplied by Waterbury Clock Company.[85] These watches gained such great popularity that they became known as *"the watch that made the dollar famous."*[86]

Waterbury Watch Company

In 1877, a new prototype was introduced to Benedict and Burnham for an inexpensive pocketwatch made of 58 parts, mostly made of punched sheet brass. They immediately set aside an unused portion of their machine shop and began producing the *Long Wind* at a rate of 200 per day by 1878. The department quickly outgrew its space in the plant, so with a capital of $400,000 Waterbury Clock's sister company Waterbury Watch Company was incorporated by Benedict & Burnham in 1880 to manufacture and sell inexpensive watches and other timepieces.[87 88] Waterbury Watch started out very successfully in its early days, employing hundreds of women for their "slender fingers" and "delicate manipulation," having become the largest volume producer of watches in the world by 1888.[89]

Due to poor sales techniques, where *jobbers* and salesmen gave away much of the Waterbury Watch products as loss-leaders with little regard to the company's future – thereby cheapening the products' perceived value – Waterbury Watch quickly fell into bankruptcy.[90] In a last attempt to salvage the company, Waterbury Watch began to produce higher-end watch models which only created more demand on a workforce unable to keep up with the complexity of the new watches using several hundred parts. The company was finally reorganized as the New England Watch Company in 1898 as its London sales office was placed into liquidation.[91] The company continued to focus on high-priced watch models and eventually fell into receivership, discontinuing business in July 1912. Robert H. Ingersoll & Bro. bought the Waterbury plant and began manufacturing Ingersoll Watches there in 1914.[92]

Advent of the wristwatch

With the beginning of World War I there were new demands for timepiece design. Artillery gunners needed an easy way to calculate and read time while still being able to work the guns. The Waterbury Clock Company met this need by modifying the small Ingersoll ladies' *Midget* pocket watch to become military-issue wristwatches – lugs were added for a canvas strap, the crown was repositioned to 3 o'clock, hands and numbers were made luminescent for nighttime readability – thus making one of the first wrist watches.[93 94]

In 1922, Waterbury Clock Company purchased the Robert H. Ingersoll & Bro. for $1,500,000 which had gone bankrupt the previous year due to the post-war recession, thereby inheriting all of Ingersoll's and Waterbury Watch's assets and facilities.[95 96] Unable to deliver on Ingersoll's guarantee of quality in Europe due to the Great Depression, Waterbury Clock sold the London-based Ingersoll, Ltd. to its Board of Directors in 1930, making it a wholly British-owned enterprise. The "powerful Ingersoll brand name" was continued in the United States by Waterbury Clock into the 1950s.[97] No longer part of Waterbury Clock Company, Ingersoll Ltd. continued to produce the Ingersoll watch brand independently for the European and other international markets.

Following the Great Depression and a period of hardship for the company, Waterbury Clock Company regained its identity in the consumer market. In 1930, a license agreement was reached with Walt Disney, resulting in the production of the famous Mickey Mouse watches and clocks under the Ingersoll brand name. The new Mickey Mouse timepieces were introduced to the public at the Chicago World's Fair in June 1933 and quickly became the company's first million dollar line saving it from financial disaster.[98 99]

In 1940, Thomas Olsen (owner and operator of Fred. Olsen Shipping Co.) and Joakim Lehmkuhl fled Norway with their families because of the Nazi invasion.[100] Eventually they came to the United States seeking investments to assist in the war effort. In 1941, Olsen and Lehmkuhl purchased controlling interest in Waterbury Clock Company, Thomas Olsen became Chairman.[101 102 103] Though the company had fallen on hard times during the Great Depression it still had the manufacturing capability to make large numbers of timing devices. Mr. Lehmkuhl, who had studied business and engineering at Harvard and MIT, was appointed President by Olsen and, under his direction, the company became the largest producer of fuse timers for precision defense products in the United States.[104] A new concrete plant was built in nearby Middlebury, CT in 88 days in 1942 for the high-volume production of precision timers.[105] In August 1943, the Army-Navy 'E' Award for excellence was awarded by the United States Under-Secretary of War to Waterbury Clock Company for the "Anglo-American fuse". As a result of this success shareholders in the following December voted to rename the company to United States Time Corporation.[106]

United States Time Corporation (1944–1969)

Following the end of the Korean War, sales declined because of diminishing defense orders. United States Time Corporation President Lehmkuhl was convinced that an inexpensive watch that was both accurate and durable would be a marketing success. He felt that low cost could be accomplished through the combination of automation, precision tooling techniques used in making fuse timers, and a simpler design than that of higher-priced Swiss watches. Durability was accomplished through a new hard alloy, *Armalloy*, developed through wartime research. *Armalloy* was used to produce long wearing bearings, replacing the expensive jewels traditionally used in a watch's movement.[107] These innovations led to the eventual public debut of the Timex brand in 1950, though the name was first used on a small trial shipment of nurses' watches in 1945.[108] The X suffix was used to "convey U.S. Time's technological expertise and innovation".[109]

Slogan: It takes a licking and keeps on ticking

The new watch movement design faced resistance from traditional jewelers. Lehmkuhl made two more decisions that proved pivotal to the company's long-term success. The company would go on to, or continue to pursue innovative marketing programs and develop new channels of distribution. A marketing decision was made to use the most credible newsman in the United States at that time, John Cameron Swayze, as a spokesperson for live *torture tests* on television with the tag line, "Timex – Takes a Licking and keeps on Ticking" – a well-recognized campaign in advertising history.[110 111] These commercials were developed by Hirshon Garfield as elaborations on tests originated by United States Time Corporation salesmen. The commercials included high-divers, water skiers, a dolphin, dishwashers, jackhammers, paint mixers and the propeller of an outboard motor, all torturing a Timex watch.[112]

Despite resistance from jewelers because of the low 50% markup, consumer demand increased and new distribution channels were opened to include department stores, cigar stands, drug stores and a host of other mass market outlets.[113] By 1962, the Timex brand held the number one market share position in the United States where one out of every three watches sold was a Timex.[114 115] Foreign markets were added with company sales offices in Canada, Mexico, France, Great Britain, Germany and Portugal as well as with distributors in about twenty other countries. Plants were built in the United States, Europe, and Asia.[116]

Edwin H. Land, co-founder of Polaroid Corporation, contacted United States Time Corporation in 1948 in search of a manufacturer for his cameras. A strong relationship was forged between the companies in 1950 resulting in United States Time becoming the exclusive manufacturer of all Polaroid cameras worldwide through the 1970s, totaling more than 44 million cameras.[117]

In recognition of the Timex brand's worldwide success, United States Time Corporation was renamed Timex Corporation on July 1, 1969.[118]

Timex Corporation (1969–2008)

In the 1970s and early 1980s, the American watch and clock industry was devastated by the arrival of cheap mechanical watches from the Far East, as well as the development of digital quartz watches pioneered by Japanese companies. Lehmkuhl retired in 1973 with no clear successor. Polaroid ended its contract with Timex in 1975 resulting in a layoff of 2,000 employees.[119] New technology, in the form of electronic digital watches and quartz analog watches, was developing very rapidly, making Timex's mechanical watchmaking production facilities obsolete. Timex closed and consolidated worldwide operations, cutting the 30,000 employee workforce to 6,000.[120] New competition, including Japanese companies, low-cost Hong Kong producers and large American companies such as Gillette, Texas Instruments and National Semi-Conductor were aggressively entering the business.[121] The Disney license had expired and John Cameron Swayze retired from his role as spokesperson. The subcontracting business was rebuilt with new customers such as IBM, Hugin-Sweda and General Electric. In a joint venture with Sinclair Research Ltd., the company entered the home computer business, selling such computers as the Timex Sinclair 1000 and succeeding machines, modeled on the ZX81 and ZX Spectrum. In 1984 after declining sales, the company decided not to compete in the market any longer.[122]

Timex Corporation transformed itself again in the mid-1980s as it abandoned its development of various consumer products and refocused efforts specifically on timepieces.[123] Product quality and fashionable design became essential to success in the mass market. Although Timex had a solid reputation for durable products, increased efforts were put behind quality improvement. Longer battery life, more durable gold plating, greater accuracy and more water resistant styles were some of the many improvements that were implemented. New quartz analog movements were created using fewer components, reducing overall production time and costs.[124] Top athletes assisted in the design of sports watches for specific sports which led to the introduction of the Ironman Triathlon in 1986. Named for the Hawaiian triathlon the company had sponsored since 1984, the Ironman Triathlon became the most successful Timex watch in the post-mechanical watch era. Within its first year, Timex Ironman became the best-selling watch in the United States, and the world's largest selling sport watch for the next decade.[125]

Following on the success of the Ironman Triathlon line, Timex introduced the Indiglo night light during the Christmas shopping season in 1992. By January 1993 Indiglo had made headlines as a result of the bombing of the World Trade Center in which an office worker wearing a Timex with an Indiglo night light used its light to guide a group of evacuees down 40 dark flights of stairs. Sales immediately took off leading to an increase in Timex's American market share.[126]

Timex Corporation acquired Callanen International, the producer of Guess? Watches, in 1991 as part of its "multi-brand strategy".[127] Timex and Disney reunited in 1993 to produce a new line of character watches called *Disney Classics Collection*.[128] In 1994, Timex acquired the Nautica Watches license and introduced Timex Data Link. The Data Link PDA-type watch could receive contact and scheduling information from a sequence in a computer monitor's light using software developed with Microsoft.[129] 1997 saw the introduction of the successful Timex Expedition brand, designed for rugged outdoor sports. Timex and Motorola introduced Beepwear in 1998, a watch with an integrated pager.[130]

The new millennium led to further growth of Timex Corporation and its parent, Timex Group B.V., by way of brand acquisition, brand introduction and licensing partnerships. In 2000, Timex Corporation purchased the French fashion watch brand Opex.[131] Under its Callanen subsidiary, Timex acquired the watch license for urban fashion designer Marc Ecko in 2002.[132]

The company entered the luxury market in 2005 when Timex's parent company acquired Swiss-based Vertime SA. Vertime is responsible for the design, manufacturing and distribution of Swiss-Made watches and jewelry for the Versace and Versus brands.[133]

Timex launched a new brand In 2006 called TX, marketed around innovative technology and affordable luxury.[134] During the same year, Timex Group B.V. acquired the ultra-luxury hand-made Swiss brand Vincent Bérard.[135 136]

In 2007, Timex Group B.V. established Sequel AG as a separate company devoted to the design, manufacturing and distribution of the Guess? and the Swiss-Made Gc watch brands. The Sequel AG business is headquartered in Zug, Switzerland.[137 138] Timex Group B.V. purchased the Italian design studio Giorgio Galli Design Lab in 2007.[139]

Timex Group USA, Inc. (2008–present)

The company was restructured in early 2008, establishing the Timex Business Unit as a separate business function for the Timex brand with its own president. Until then, past Timex Group CEOs had managed the Timex Group and brand, which had contributed to the brand's less-than-stellar earnings in the previous five years. While Timex Group's Sequel division, which houses the Guess collections, had grown tremendously to rival Timex as the firm's top earner, the signature brand had been flat, as of August 2008.[140] Since this change, Timex has introduced GPS enabled watches, heart rate monitor exercise watches and similar high tech devices.

In 2008, Timex Group USA signed a four-year agreement making Timex the first official timekeeper of the ING New York City Marathon.[141] Meanwhile, parent company Timex Group B.V. launched two new Swiss-Made luxury watch brands – Salvatore Ferragamo Timepieces and Valentino Timeless – under the Timex Group Luxury Watches business.[142 143]

As the year closed, construction commenced on the second-largest ground mounted solar array in the northeastern United States at Timex Group USA's Middlebury, CT headquarters. The 800-panel solar array was inaugurated on February 5, 2009 during a press event held at the headquarters.[144] A few months later Timex Group USA purchased ownership of the Marc Ecko watch trademark it had licensed since 2002.[145] At the same time, the Callanen International business unit merged with the Timex Business Unit bringing the Timex, Opex, TX, Nautica and Marc Ecko brands all under one house.[146]

In an agreement announced on June 16, 2009, Timex Group USA became an official sponsor of the NFL's New York Giants new headquarters and practice facility called the Timex Performance Center. Further details of the sponsorship include Timex being an official equipment provider to the Giants and working closely with the team to develop new products.[147]

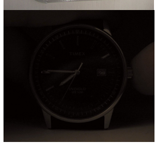
In honor of Timex's 50th anniversary, the company re-released their classic Timex 80 watch. The iconic retro design of this basic digital watch made it a hit with both fashion lovers and retro watch enthusiasts, and the range has since expanded to jumbo sizes, silver and gold metallic finishes and calculator watches.

Timex Group B.V.

Timex Group B.V., a Dutch holding company, is the corporate parent of several watchmaking companies around the globe including Timex Group USA, Inc.[148] Businesses and exclusive worldwide licenses include the Timex Business Unit (Timex, Timex Ironman, Opex, TX, Nautica, Marc Eckō), Timex Group Luxury Watches (Valentino, Salvatore Ferragamo), Sequel (Guess, Gc), Vertime (Versace, Versus), Vincent Bérard and Giorgio Galli Design Lab.[149 150] Today, Timex Group B.V.'s products are manufactured in the Far East and in Switzerland, often based on technology that continues to be developed in the United States and in Germany. The group has operations in a number of countries in Europe, the Americas, and Asia.

Products


TIMEX
DATA-LINK
WATCH
Notebook Adapter
Use your Timex Data Link Watch with your PC Notebook!
Just plug the adapter into a serial port on your notebook and send info to any Timex Data Link Watch... it's like magic!
All the software you need is included.



External links

- Timex Group Corporate website
- Timex Brand website

Personalities At Sinclair

Clive Sinclair

Sir Clive Sinclair

Sinclair meeting young inventors in Bristol, England in 1992

Born	Clive Marles Sinclair 30 July 1940 near Richmond, Surrey
Nationality	English
Ethnicity	Caucasian
Citizenship	British
Occupation	Inventor, entrepreneur
Partner	Angie Bowness
Children	Belinda, Crispin, Bartholomew
Parents	George William Carter Sinclair Thora Edith Ella Marles

Sir Clive Marles Sinclair (born 30 July 1940) is a British entrepreneur and inventor, most commonly known for his work in consumer electronics in the late 1970s and early 1980s.

After spending several years as assistant editor of *Practical Wireless* and *Instrument Practice*, Sinclair founded Sinclair Radionics in 1961, where he produced the first slim-line electronic pocket calculator in 1972 (the Sinclair Executive). Sinclair later moved into the production of home computers and produced the Sinclair ZX80, the UK's first mass-market home computer for less than GB£100, and later, with Sinclair Research, the ZX81 and ZX Spectrum; the latter is widely recognised for its importance in the early days of the British home computer industry. Sinclair stated in 2010 that he does not use computers himself, using the telephone in preference to email.[5]

Knighted in 1985, Sinclair formed Sinclair Vehicles and released the Sinclair C5, a battery electric vehicle which was a commercial failure. Since then Sinclair has concentrated on personal transport, including the A-bike, a folding bicycle for commuters that weighs 5.5 kilograms (12 lb) and folds down small enough to be carried on public transport.

Early life, family and education

Sinclair's father and grandfather were engineers; both had been apprentices at Vickers the shipbuilders. His grandfather George Sinclair was an innovative naval architect who got the *paravane*, a mine sweeping device, to work. George Sinclair's son Bill Sinclair wanted to take religious orders or become a journalist. His father suggested he train as an engineer first; Bill became a mechanical engineer and remained in the field. At the outbreak of World War II in 1939 he was running his own machine tools business in London and later worked for the Ministry of Supply.[152]

Clive Sinclair was born to George William Carter Sinclair (known as *Bill*) and Thora Edith Ella Marles in 1940 near Richmond, then in Surrey. He and his mother left London to stay with an aunt for safety in Devon, where they eventually travelled to Teignmouth. A telegram arrived shortly afterwards, bringing the news that their home in Richmond had been bombed. Clive's father found a house in Bracknell in Berkshire. Sinclair's brother Iain was born in 1943 and his sister Fiona in 1947.[153]

Clive enjoyed the freedom of holidays and swimming and boating. At an early age he designed a submarine, possibly influenced by his grandfather George. During holidays he could pursue his ideas and teach himself what he wanted to know. Sinclair had little interest in sports and found himself out of place at school. He preferred the company of adults, which he got only from his family.[154]

Sinclair attended Box Grove preparatory school. He excelled in mathematics. By the time Clive was ten, his father Bill had financial problems. He had branched out from machine tools and planned to import miniature tractors from the U.S.; he had to give up the business.[155] Because of his father's problems, Sinclair had to move school several times. Sinclair took his O-levels at Highgate School in London in 1955 and A-levels in physics, pure maths, and applied maths at St. George's College, Weybridge.[156]

During his early years, Sinclair earned money mowing lawns and washing up, and earned 6d (old pence) more than permanent staff in a cafe. Later he went for holiday jobs at electronic companies. At Solatron he enquired about the possibility of electrically propelled personal vehicles. Sinclair applied for a holiday job at Mullard and took one of his circuit designs; he was rejected for theoretical precociousness. While still at school he wrote his first article for *Practical Wireless*.[157]

Sinclair did not want to go to university when he left school just before his 18th birthday; he wanted to sell miniature electronic kits by mail order to the hobby market.[158]

Career

Sinclair Radionics

Sinclair's Micro Kit was formalised in an exercise book dated 19 June 1958 three weeks before his A-levels. Sinclair drew a radio circuit, Model Mark I, with a components list: cost per set 9/11 (49½p), plus coloured wire and solder nuts and bolts, plus celluloid chassis (drilled) for nine shillings (45p). Also in the book are advertisement rates for *Radio Constructor* (9d (3¾p)/word, minimum 6/- (30p)) and *Practical Wireless* (5/6 (27½p) per line or part line).[159]

Sinclair estimated producing 1,000 a month, placing orders with suppliers for 10,000 of each component to be delivered.[160]

Sinclair wrote a book for Bernard's Publishing, *Practical transistor receivers Book 1*, which appeared in January 1959. It was re-printed late that year and nine times subsequently. His practical stereo handbook was published in June 1959 and reprinted seven times over 14 years. The last book Sinclair wrote as an employee of Bernard's was *Modern Transistor Circuits for Beginners*, published in May 1962.[161] At Bernard Babani he produced 13 constructors' books.

In 1961 Sinclair registered Sinclair Radionics Ltd. His original choice, *Sinclair Electronics*, was taken; *Sinclair Radio* was available but didn't sound right. Sinclair Radionics was formed on 25 July 1961.

Sinclair made two attempts to raise startup capital to advertise his inventions and buy components. He designed PCB kits and licensed some technology. Then he took his design for a miniature transistor pocket radio and sought a backer for its production in kit form. Eventually he found someone who agreed to buy 55% of his company for £3,000 but the deal didn't go through.

Sinclair, unable to find capital, joined United Trade Press (UTP) at 9 Gough Square, just off Fleet Street, as technical editor of *Instrument Practice*. Sinclair appeared in the publication as an assistant editor in March 1962. Sinclair described making silicon planar transistors, their properties and applications and hoped they might be available by the end of 1962. Sinclair's obsession with miniaturisation became more obvious as his career progressed. Sinclair undertook a survey for *Instrument Practice* of semiconductor devices, which appeared in four sections between September 1962 and January 1963.[162]

His last appearance as assistant editor was in April 1969. Through UTP, Sinclair had access to thousands of devices from 36 manufacturers. He contacted Semiconductors Ltd (who at that time sold semiconductors made by Plessey)[163] and ordered rejects to repair. He produced a design for a miniature radio powered by a couple of hearing aid cells and made a deal with Semiconductors to buy its micro-alloy transistors at 6d (2½p) each in boxes of 10,000. He then carried out his own quality control tests, and marketed his renamed MAT 100 and 120 at 7s 9d (38¾p) and 101 and 121 at 8s 6d (42½p).[164]

Sinclair Radionics lasted until 1979, with various products and company spin-offs. Beginning with a mini-amplifier, the company earned a name for design, quality and pioneering. The vision was to produce in bulk and sell cheaply. This risky but potentially profitable approach made fortunes before but carries the risk of bankruptcy. In the early days one strategy essential to this policy for Sinclair Radionics was production in kit form.

Science of Cambridge

Sinclair had formed another company, initially called Ablesdeal Ltd, in 1973. This changed name several times, eventually becoming *Science of Cambridge Ltd* in July 1977.[165]

In June 1978 Science of Cambridge launched a microcomputer kit, the MK14, based on the National SC/MP chip. By July 1978, a personal computer project was under way. When Sinclair learnt the NewBrain could not be sold at below £100 as he envisaged, he turned to a simpler computer. In May 1979 Jim Westwood started the ZX80 project at Science of Cambridge; it was launched in February 1980 at £79.95 in kit form and £99.95 ready-built. In November, Science of Cambridge was renamed Sinclair Computers Ltd.

Sinclair Research


ZX Spectrum (1982)

In March 1981, Sinclair Computers was renamed again as Sinclair Research Ltd and the Sinclair ZX81 was launched at £49.95 in kit form and £69.95 ready-built, by mail order. In February 1982 Timex obtained a license to manufacture and market Sinclair's computers in the United States under the name Timex Sinclair. In April the ZX Spectrum was launched at £125 for the 16 kB RAM version and £175 for the 48 kB version. In March 1982 the company made an £8.55 million profit on turnover of £27.17 million, including £383,000 government grants for the TV80 flat-screen portable television.

In 1982 Sinclair converted the Barker & Wadsworth mineral water bottling factory at 25 Willis Road, Cambridge, into the company's headquarters. (This was sold to Cambridgeshire County Council in December 1985 owing to Sinclair's financial troubles.) The following year, he received his knighthood[166] and formed Sinclair Vehicles Ltd. to develop electric vehicles. This resulted in the 1985 Sinclair C5.

In 1984, Sinclair launched the Sinclair QL computer, intended for professional users. Development of the ZX Spectrum continued with the enhanced ZX Spectrum 128 in 1985.

In April 1986, Sinclair Research sold the Sinclair trademark and computer business to Amstrad for £5 million.[167] Sinclair Research Ltd. was reduced to an R&D business and holding company, with shareholdings in several spin-off companies, formed to exploit technologies developed by the company. These included Anamartic Ltd. (wafer-scale integration), Shaye Communications Ltd. (CT2 mobile telephony) and Cambridge Computer Ltd. (Z88 portable computer and satellite TV receivers).

By 1990, Sinclair Research consisted of Clive Sinclair and two other employees,[168] and its activities have since concentrated on personal transport, the Zike electric bicycle, Zeta bicycle motor and the A-bike folding bicycle.

In November 2010 Sinclair told *The Guardian* newspaper that he was working on a new prototype electric vehicle, called the X-1, to be launched within a year. "Technology has moved on quite a bit, there are new batteries available and I just rethought the thing. The C5 was OK, but I think we can do a better job now."[169 170] The X-1 will be available on July 2011 at the price of £595.[171]

Personal life

Sinclair married Ann Trevor-Briscoe in 1962, and has three children: Belinda, Crispin and Bartholomew. Clive and Ann divorced in 1985.[172] In 2010 Sinclair married Angie Bowness, who also has an only son called Marcus Thornton. Despite his involvement in computing, he does not use the Internet, stating that he does not like to have "technical or mechanical things around me" as it distracts from the process of invention.[173 174]

Sinclair has become a poker player. He appeared in the first three seasons of the *Late Night Poker* television series in Britain. He won the first season final of the *Celebrity Poker Club* spin-off, defeating Keith Allen.

Sinclair is a member of British Mensa, and was Chairman for 17 years from 1980 to 1997.[175]

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External links

- Sinclair Research website
- Sinclair in 1966 in Life magazine
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- Sinclair bows out. John Gilbert, *Sinclair User*, Issue 51, June 1986
- 'Move over Segway, I'm planning the C6'. Jonathan Duffy, BBC News Online, 5 August 2003
- British Mensa biography of Clive Sinclair
- I don't use a computer at all. Observer interview, 28 February 2010, with Simon Garfield.

Tony Tebby

Tony Tebby is probably most famous for designing Qdos, the computer operating system used in the Sinclair QL personal computer, whilst working as an engineer at Sinclair Research in the early 1980s.[176] He left Sinclair Research in 1984 in protest at the premature launch of the QL,[177] and formed QJUMP Ltd., a software house specializing in system software and utilities for the QL, based in Rampton, Cambridgeshire, England.[178]

Prior to this he worked at the Philips Research Laboratories in Redhill, Surrey where he worked on realtime image processing, using electronic hardware rather than software. At that time, software would have been either a batch program on the PRL mainframe computer or, within the departmental laboratory, the Commodore PET.

Among the software developed by QJUMP was SuperToolkit II, a collection of extensions to Qdos and SuperBASIC; a Qdos floppy disk driver which became the *de facto* standard for the various third-party floppy disk interfaces sold for the QL; and the QJUMP Pointer Environment, which extended the primitive display windowing facility of Qdos into something approaching a full GUI. Tebby also received a commission to write a Qdos-like operating system for the Atari ST; this was called SMS2.

Tebby later moved to Le Grand-Pressigny, France, but continued his involvement in the QL user community. In the early 1990s, he developed SMSQ, a new Qdos-compatible OS, based on SMS2, for the Miracle Systems QXL, a QL emulator card for PCs. An enhanced version of SMSQ was ported to the Atari ST and various other QL emulators, being renamed SMSQ/E.[179] He has also worked on Stella, an embedded operating system for 68000-series and ColdFire processors.

Jan Jones (novelist)

Jan Jones (born 1955) is a British former software engineer, now a writer of romantic fiction and short stories. In her previous career, she achieved some fame as the architect of the SuperBASIC programming language for the Sinclair QL personal computer while working at Sinclair Research in the early 1980s. Before joining Sinclair Research, she worked at British Gas and the Royal School of Mines as a programmer and lecturer. Her first novel, *Stage By Stage*, was published in July 2005 and won the Romantic Novelists' Association Joan Hessayon Award the same year.

External links

- Jan Jones's personal website
- Works by or about Jan Jones (novelist) in libraries (WorldCat catalog)

Jim Westwood

Jim Westwood was the chief engineer at Sinclair Research Ltd in the 1980s, starting at the company in 1963. Westwood was the technical mastermind behind many of Sinclair's products and worked there for more than twenty years. Sir Clive Sinclair and Westwood shared a connection even before they met when Westwood had previously worked at an electronics store in London which was owned by Bernard Babani, Sinclair's publisher. This gave Westwood a good degree of familiarity with Sinclair's designs, which prompted him to join Sinclair's fledgling company, Sinclair Radionics. Westwood subsequently had a hand in most of the company's products, including the calculators, audio equipment, ZX Spectrum computers and TV80. Jim is still designing hardware for Amino Communications, and is a partner in Cambridge Electronics Consultancy.

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- Dale, Rodney (1985). *The Sinclair Story*. London: Duckworth. 184 pp. ISBN 0-7156-1901-2.

External links

- Cambridge Network listing for Westwood
- Planet Sinclair: Sinclair: Key People: Jim Westwood

Rick Dickinson

Rick Dickinson is a British industrial designer.

Early life

Dickinson graduated from Newcastle Polytechnic (now Northumbria University) in 1979 with a First Class Bachelor of Arts Honours degree in Design for Industry. The 'Design for Industry' degree was the first of its kind, formerly a three-year 'Industrial Design' degree. The new course with two additional terms for industrial placements, extended the degree to four years and the introduction of the term "sandwich".

The ZX81 personal computer. Dickinson holds a patent for its design

Sinclair

Dickinson joined Sir Clive Sinclair's Sinclair Research Ltd in December 1979, replacing John Pemberton who was leaving Sinclair to head up a new design centre for ITT in Harlow. Sinclair Research offices were at 6 Kings Parade, Cambridge.

Rick Dickinson was the in-house industrial designer of Sinclair Research Ltd. He designed the ZX80 and ZX81 home computers,[180] including the touch-sensitive keyboard, as well as the rubber keyboard of the ZX Spectrum. He also designed the TV80 casing and Sinclair QL. Dickinson is a graduate of Newcastle Polytechnic, and worked for Sinclair as a student on one of his industrial placements from Newcastle Polytechnic before he had completed his degree.

The ZX81 won a British Design Council award in 1981. It won a Haus Industrieform award and is in a permanent collection in Essen. The Sinclair QL won an Italian design award at the Smau Industrial Design Award.

Post-Sinclair

In 1986, he founded *Dickinson Associates*, an industrial design consultancy based in Cambridge. That year he produced the industrial design for an early laptop computer, the Cambridge Z88. In 1987 he was commissioned by Sir Alan Sugar to create the industrial design concept for Amstrad's first portable computer.

In 1989 Rick Dickinson, Christopher Curry (Acorn Computers), and Keith Dunning had a re-think of the famous MacArthur field microscope and Rick designed the **Lensman microscope**, a portable field microscope. In 1991 the Lensman microscope won the BBC design awards, The Prince Of Wales Award For Industrial Innovation And Production, Archimedes award for Engineering Excellence.

He produced the industrial design concepts and models of the first 'Broad Band phone', for AT&T. Dickinson Associates created the industrial design, mechanical design, and production engineering design for the first GSM mobile phone 'reference phone' design, for Rockwell. Dickinson Associates were also the designers of the Gizmondo handheld console (originally the Gametrac).

External links

- Rick Dickinson interview: The Enigma of Design Part 1
- Rick Dickinson interview: The Enigma of Design Part 2
- Rick Dickinson interview: The Enigma of Design Part 3
- Planet Sinclair - Rick Dickinson
- Sinclair User magazine, *Modest award winner sets the pace in micro design*, August 1982
- Rick Dickinson's photos on Flickr
- ZX80 patent
- ZX81 patent

Ben Cheese

Ben Cheese (1955 – 21 January 2001) was the engineer who got Sinclair's ZX Microdrives to work. Authors Ian Adamson and Richard Kennedy, in their book *Sinclair and the "Sunrise" Technology*, writes that "*it seems only fair to note that it was the tenacity and imagination of R&D staffer Ben Cheese that got the product [i.e., the Microdrive] to the market*".

When Sinclair sold up, Cheese formed a company called Flare Technology with two other ex-Sinclair engineers, John Mathieson and Martin Brennan. Brennan and Mathieson went on to form Flare II, and to develop the Atari Jaguar console. Meanwhile, Cheese worked with Argonaut Software and Nintendo to develop the Super FX chip used in SNES games such as *Star Fox*.[181]

Besides his engineering work, Ben Cheese also did some mildly subversive cartoons for the Sinclair in-house newsletter ("*WHAM!*", or "*What's Happening At Milton*").

Martin Brennan (engineer)

Martin Brennan is a computer engineer who developed pioneering personal computers such as the Loki (for Sinclair Research) and the Atari Jaguar video game console.

A physics graduate of Cambridge University, he was a co-founder of Flare Technology,[182] a design house involved in the design of the ill-fated Konix Multisystem.

Brennan initially worked for Sinclair Research where he designed the digital electronics and software in ZX Interface 1 before going on to found Flare with ex-Sinclair colleagues John Mathieson and Ben Cheese. After working at Flare on the *Flare 1* and its development into the Konix Multisystem he went on to work for Atari developing the Atari Panther and the Atari Jaguar.

In 1997 Brennan founded the "Cheap & Cheerful Chip Company" which later went on to become Global Silicon Limited[183]

In 2007 Brennan designed the Brennan JB7 digital jukebox[184] produced by 3GA Ltd (Third Generation Audio)

External links

- http://www.konixmultisystem.co.uk
- http://www.brennan.co.uk

John Mathieson (computer scientist)

John Mathieson is a Computer Science graduate who initially worked for Sinclair Research before going on to found Flare with fellow ex-Sinclair colleagues Martin Brennan and Ben Cheese.

After working at Flare on the *Flare 1* and its development into the Konix Multisystem, he went on to work for Atari developing the Atari Jaguar with Martin Brennan. John moved to California and worked on the Jaguar 2 which never saw the light of day.

He led the development of the ill-fated NUON media processor at VM Labs. He moved to work for NVIDIA at the end of 2001.

External links

- http://www.chez.com/toxicmag/real/articles/mathieson.htm - Interview with Mathieson discussing the Jaguar
- http://www.vmlabs.de/team.htm - List of VM Labs team with picture of John

Rupert Goodwins

Rupert Goodwins	
Born	May 23, 1965
Nationality	British
Occupation	Writer, Broadcaster and Technology journalist

Rupert Goodwins (born May 23, 1965) is a British writer, broadcaster and technology journalist.

He began his career as a programmer for Sinclair Research in the early 1980s, working on the ZX Spectrum ROM. He moved to Amstrad after it bought the rights to the Sinclair name and range of products.

He has written for a number of UK computer publications, including:

- Sinclair User
- Personal Computer World
- MacUser UK
- PC Magazine (UK)
- IT Week
- Nature
- The Daily Telegraph

Rupert also wrote the 64-page novella accompanying the game Weird Dreams by Rainbird.

He is editor of ZDNet UK. His most notable contribution to the site is Rupert's Diary, which preceded the blogging phenomenon by some years. He occasionally appears on CNet UK's technology podcast, Crave, and the Dialogue Box video series.

In addition to journalism, he also writes short stories, often with a technological theme to them. He is a regular contributor to radio and television news and current affairs programmes on business and technology issues.

Rupert is also a keen amateur radio operator with the call sign G6HVY.

Christopher Curry

Christopher Curry	
Born	Christopher Curry 28 January 1946
Ethnicity	Caucasian
Citizenship	British
Occupation	Inventor, Entrepreneur

Christopher Curry (born 28 January 1946 in Cambridge) is the co-founder of Acorn Computers, with Hermann Hauser and Andy Hopper.

Early life

He went to school initially in St Neots in Cambridgeshire, then later went to the independent Kimbolton School, also in Cambridgeshire. He gained two A levels, in Maths and Physics. He thought about going to university at the University of Southampton, but was keener to be earning some money whilst learning.

Early career

He joined Pye in Cambridge in 1964. He stayed for a few months, then left for the Royal Radar Establishment in Worcestershire. He worked on the radar for the proposed BAC TSR-2. The RRE had been the site of many technological advances such as the integrated circuit in 1952. He stayed for nine months. He moved to the W.R. Grace Laboratories, run by ITT, and stayed for six months.

Sinclair Radionics

In April 1966, Curry joined Sinclair Radionics, a company founded by Clive Sinclair in 1961. Curry was to play an important role in getting Sinclair interested in both calculators and computers in his thirteen years with the company.

Curry was at first involved with Sinclair's hifi products, which included amplifiers and speakers, and he also worked on Sinclair's electric vehicle, a project that would turn into the C5 some years later.

In 1972, Sinclair Radionics launched its first electronic calculator, the *Executive*, which was considerably smaller than its competitors since it used hearing-aid-sized batteries. Curry and Jim Westwood had discovered that it was possible to exploit persistence in the diode displays and memory and introduced a timer that removed the power from these components for most of the time. This discovery dramatically improved the lasting-power of the batteries.

Until 1976 Sinclair Radionics had enjoyed 15 years of strong turnover and profit growth. However, the company sustained losses related to difficulties with chip supplies for the Black Watch. As a result there were insufficient internal funds available for the final stages of the pocket TV project Sinclair had been working on for some 10 years. In August 1976 the National Enterprise Board (NEB) provided £650,000 in return for 43 per cent stake in Sinclair Radionics. Sinclair did not like sharing control of his company. Thus, he converted a company he had purchased in 1973, Ablesdeal Ltd, into Westminster Mail Order Ltd, which was itself renamed to Sinclair Instrument Ltd. In this way, he maintained control of his most important projects.

Science of Cambridge

Shortly after the NEB took control Sinclair encouraged Curry to leave Sinclair Radionics to get Sinclair Instruments off the ground. Curry borrowed some money and rented offices at 6 King's Parade, Cambridge. To raise cash, Sinclair Instruments released the Wrist Calculator, designed by John Pemberton, in February 1977. The product was successful, selling 15,000 units.

In July 1977, the company was renamed to *Science of Cambridge Ltd*. Around the same time Ian Williamson showed Curry a prototype computer based around a National Semiconductor SC/MP and some parts scavenged from a Sinclair *Cambridge* calculator. Curry was impressed and encouraged Sinclair to adopt this as a product; an agreement was reached with Williamson but no contract was ever signed - Nat Semi had offered to redesign the project so that it used only their components and they also offered to manufacture the boards.

Curry took Nat Semi up on its offer and in June 1978 Science of Cambridge launched a microcomputer kit (marketed as the MK14) based around the National SC/MP chip. Curry wanted to further develop the MK14 but Sinclair was working on the NewBrain. Sinclair's reluctance to develop the MK14 led Curry to consider his options. Throughout the MK14 project he had been discussing it with his friend, physics researcher Hermann Hauser, who had also helped by seeking out advice from the many computer experts on hand in Cambridge University.

Cambridge Processor Unit Ltd

Curry and Hauser had become increasingly interested in the idea of selling their own computers and so, on 5 December 1978, they set up Cambridge Processor Unit Ltd (CPU). From the mathematics (Curry started working for Sinclair in 1966 and worked for him for 13 years) it is clear that Curry was still working for Sinclair at this time, and indeed CPU was "borrowing" a room at Science of Cambridge to provide computer consultancy services in order to raise money to finance the development of their own hardware. Their first customer was Ace Coin Equipment Ltd, who needed controllers for their fruit machines.

Acorn Computer

The Acorn Microcomputer (later to be called the System 1) was launched as the first product of a new company, Acorn Computers Ltd, founded in March 1979. Curry said that they "chose the word Acorn because it was going to be an expanding and growth-oriented system." It is also said that they wanted a name that would appear before "Apple" in a directory.

After becoming a millionaire as a result of Acorn's success with the BBC Micro project, in 1983 Curry co-founded Redwood Publishing with Michael Potter (former publisher of advertising trade weekly Campaign) and Christopher Ward (former editor of Daily Express newspaper). The company bought the Acorn User title.

GIS

At the time of the Olivetti takeover of Acorn in 1985 Curry founded General Information Systems Ltd (GIS),[185] based on Acorn's Communications Group, and he remains a director.

GIS specialises in Smart Card technologies for access control and electronic money.

Bibliography

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- Perry, James (1985). "Britain's Sir Clive Sinclair Keeps Bouncing Back With New Inventions." *Wall Street Journal*. June 6.
- Pesola, Maija (2005). "The Fertile Soil of Silicon Fen." *Financial Times*. February 9.

Other Companies

GST Computer Systems

GST was a group of computer companies based in Cambridge, England, founded by Dr Jeff Fenton in June 1979. The company worked with Sinclair Research, Torch Computers, Acorn Computers, Monotype Corporation and Kwik-Fit, amongst others.

The group included:

- **GST Computer Systems**: the original name of the company.
- **GST Professional Services**: a software consultancy that was sold and became OTIB A.T.
- **GST Software Products**: produced retail software, most notably Timeworks Publisher.
- **GST Training Centre**: a class based software training provider in Cambridgeshire, UK.
- **Electric Software**: a games software label, producing titles for home computers such as the Commodore 64, Sinclair ZX Spectrum and MSX-compatible models in the early 1980s.[186]

GST Computer Systems started as a contract software development company. In 1983, it became involved with Sinclair Research, producing the 68K/OS operating system (later rejected by Sinclair) and development software for the Sinclair QL.[187] In 1985 it was approached by Atari to port products from the QL on to the just to be launched Atari ST. The word processing package *1st Word* was bundled with every Atari ST for the first two years of its life and GST became the leading software supplier for the Atari ST platform.

In 1987 GST developed its first desktop publishing application, Timeworks Publisher. This was sold in the USA by Timeworks, Inc. (a Chicago based software publisher) as Publish-It!. This product went on to become the world-leading budget DTP product until competition from Microsoft Publisher in 1993 caused the eventual demise of Timeworks, Inc. The product was sold under new names including NEBS PageMagic (changed after objections from Adobe), Macmillan Publisher, Canon Publisher, and many other brands, distinguished by use of the .DTP file extension. The latest version was sold as Greenstreet Publisher 4 and is upwards file compatible with earlier versions.

In 2001 GST merged with eGames Europe as a new company, **Greenstreet Software**. It remains a developer and publisher of computer software for Windows operating systems. In July 2008 the company was reconstructed and now trades as **Greenstreet Online** Limited.

External links

- Greenstreet Online website
- greenstreet Softwrap product announcement

Psion

Psion	
Type	Public (LSE: PON)
Industry	Computers
Founded	1980
Headquarters	London, England, UK
Key people	John Hawkins, (Chairman) John Conoley (CEO)
Products	Workabout Pro 3, NEO, Ikôn, Omnii XT10, EP10, 8500 Series vehicle mount devices
Revenue	£170 million (2009)
Employees	900 (2010)
Website	psion.com

Psion is a designer and manufacturer of rugged mobile handheld computers for commercial and industrial applications. The company is headquartered in London, England with major operations in Mississauga, Ontario, Canada and additional company offices in Europe, the United States, Asia, Latin America, and the Middle East. It is a public company listed on the London Stock Exchange (LSE: PON) and was once a constituent of the FTSE 100 Index.

Psion's current operational business was formed in September 2000 from a merger of Psion and Canadian-based Teklogix Inc. and is a global provider of solutions for mobile computing and wireless data collection. The Group's products and services include rugged mobile hardware, secure wireless networks, robust software, professional services and exceptional support programs. Psion works with its clients in the area of new and emerging technologies, including image capture, voice recognition and RFID. Psion has customers in more than 80 countries around the world, as well as operations in 14 countries.

Formed in 1980, Psion achieved its first successes as a consumer hardware company that developed the revolutionary Psion Organiser as well as a whole range of more advanced, clamshell-design Personal Digital Assistants. Psion closed, or disposed of, all its previous operations and is now focused on rugged mobile computing solutions. It withdrew from the consumer devices marketplace in 2001.

History

Early development

Psion was established in 1980 as a software house with a close relationship with Sinclair Research. The company developed games and other software for the ZX81 and ZX Spectrum home computers, released under the Sinclair/Psion brand. Psion's games for the ZX Spectrum included Chess, Chequered Flag, Flight Simulator and the Horace series.[188]

The company name is an acronym standing for "Potter Scientific Instruments", after the company's founder, David Potter. The acronym PSI was already in use elsewhere in the world so "ON" was added to make the name PSION unique. David Potter remained managing director until 1999 and was chairman of the company until late 2009. In early 1983, Sinclair approached Psion regarding the development of a suite of office applications for the forthcoming Sinclair QL personal computer. Psion were already working on a project in this area and the QL was launched in 1984, bundled with *Quill*, *Archive*, *Abacus* and *Easel*; respectively a word processor, database, spreadsheet and business graphics application. These were later ported to MS-DOS, collectively called *PC-Four*, or *Xchange* in an enhanced version.[189]

The Psion Organiser

1984 also marked Psion's first foray into hardware; the Psion Organiser, the world's first handheld computer, in appearance resembling early games machines. In 1986, the vastly improved Psion Organiser II was released. Its success led the company into a decade long period of "Psion" Computer and operating system development. It included a simple-to-use database programming language, OPL, which sparked a large independent software market. In 1987, Psion began development of its "SIBO" ("SIxteen Bit Organiser") family of devices and its own new multitasking operating system called EPOC to run its PDA products.[190] It is often rumoured that EPOC stands for "Electronic Piece Of Cheese" however Colly Myers, who was Symbian's CEO from founding until 2002,[191] said in an interview that it stood for 'epoch' and nothing more. This development effort produced the Psion Series 3 (1993–98) and the Psion MC-series laptops.

A second effort, dubbed Project Protea, produced the Series 5 Psion for sale in 1997, a completely new product from the 32-bit hardware upwards through the OS, UI, and applications.[192] It is still remembered for its high quality, especially its keyboard which despite its size allowed for touch-typing. But the entirely new feel of the product, and the removal of certain familiar quirks, alienated the loyal Series 3 userbase — who tended to stick with their robust PDAs rather than upgrade. Psion was also challenged by the arrival of cheaper devices running Microsoft's Windows CE and the lower functionality approach of the Palm Pilot.

The Software Legacy

The 32-bit EPOC developed by Project Protea resulted in the eventual formation of Symbian Ltd. in June 1998 in conjunction with Nokia, Ericsson and Motorola.[193] The OS was renamed the Symbian Operating System and was envisioned as the base for a new range of smartphones. Psion gave 130 key staff to the new company and retained a 31% shareholding in the spun-out business. The Symbian operating system as of 2007 powered around 125 million mobile phones such as the Sony Ericsson P900 series.

The development of new and updated products by Psion slowed after the Symbian spin-off. Other products failed or had limited success — a Psion Siemens' GSM device, a Series 5 based STB, the Wavefinder DAB radio, an attempt to add Dragon's speech recognition software to a PDA, Ericsson cancelled a Series 5MX derived smartphone project in 2001.

Psion had sold its sole manufacturing plant in 1999 and started to withdraw from its PDA markets in late 2001,[194] shedding 250 of 1,200 staff and writing-off £40 million. The PDA, which was once a niche market, had become a global horizontal marketplace where it was difficult for Psion to compete. The final blow for Psion's Organiser and PDA business came in January 2001 when Motorola pulled out of a joint project with Psion, Samsung, and Parthus, to create "Odin", an ARM-based PDA-phone.[195]

In 2000 Psion acquired Teklogix in Canada for £240 million, and merged its business-to-business division, Psion Enterprise, with the newly acquired company. Teklogix was re-branded Psion Teklogix. This division now forms the core of Psion Plc's business.[196]

In 2002 Psion created a new division called Psion Software. This business developed push email solutions for Symbian smartphones, Microsoft Exchange and Lotus Notes. This business was sold to Visto (USA) in 2003.

In 2004, Psion announced its intention to dispose of the company's remaining Symbian shareholding to Nokia, as they no longer regarded it as a core part of their strategy.[197]

2010 onwards

Through its open innovation business model, Psion works with its customers and partners to design and build modular and customisable variants of its mobile hardware, software and services to address the needs of specific markets and industries. This collaborative development process happens via the company's open, online community, www.ingenuityworking.com. Launched in March 2010, Ingenuity Working achieved more than 35,000 visitors per month within its first six months.[198]

In January 2011, the company refreshed its corporate identity and developed a new logo, that it describes as an icon. It claims it did this to "demonstrate its new business model in action and to signal that it is no longer a consumer products company, which was symbolized by the old Psion logo".[199]

At the same time it removed Teklogix from its operating company name to create a "clear, unifying, global identity".[200]

Psion and the term Netbook

Psion registered the trademark *NETBOOK* in various territories, including European Union Community Trade Mark 000428250 and U.S. Trademark 75215401, which was applied for on 18 December 1996 and registered by USPTO on 21 November 2000. They used this trademark[201] for the Psion netBook product, discontinued in November 2003,[202] and from October 2003, the NETBOOK PRO, later also discontinued.[203]

Intel started using the term *netbook* in March 2008 as a generic term to describe "small laptops that are designed for wireless communication and access to the Internet", believing they were "not offering a branded line of computers here" and "see no naming conflict".[204]

In response to the growing use of the term, on 23 December 2008 Psion Teklogix sent cease and desist letters[205] to various parties including enthusiast website(s) demanding they no longer use the term "*netbook*".[206][207]

In early 2009 Intel sued Psion Teklogix (US & Canada) and Psion (UK) in the Federal Court, seeking a cancellation of the trademark and an order enjoining Psion from asserting any trademark rights in the term "netbook", a declarative judgement regarding their use of the term, attorneys' fees, costs and disbursements and "such other and further relief as the Court deems just and proper".[208][209] The suit was settled out of court, and on June 2, 2009 Psion announced that the company was withdrawing all of its trademark registrations for the term "Netbook" and that Psion agreed to "waive all its rights against third parties in respect of past, current or future use" of the term.[210]

Similar marks have been recently rejected by the USPTO citing a "likelihood of confusion" under section 2(d), including 'G NETBOOK' (U.S. Trademark 77527311 rejected 31 October 2008), MSI's 'WIND NETBOOK' (U.S. Trademark 77580272) and Coby Electronics' 'COBY NETBOOK' (U.S. Trademark 77590174 rejected 13 January 2009)

Psion and Linux

Psion PLC had a lengthy, but distant, interest in Linux as an operating system on its electronic devices. In 1998, it supported the Linux7K project that had been initiated by Ed Bailey at Red Hat, which was to port Linux to its Series 5 personal computer.[211 212 213] The project was named after the Cirrus Logic PS-7110 chip of the Series 5. Although this project was one of the earliest attempts to port Linux to a handheld computer,[214] it did not come to fruition for Psion. The project soon transitioned to an informal open source project at Calcaria.net that kept the name Linux7K. After the project transitioned again to sourceforge.net, the project's name was changed to a more general name "PsiLinux", and more recently to " OpenPsion". The project has developed Linux kernels and filesystems for the Revo, Series 5 and 5MX, and Series 7 and netBook.

In 2003–4, Psion Teklogix and its founder David Potter expressed interest in Linux as the operating system for its devices as it divested from Symbian.[215 216 217] However, the only result of that interest was Linux as the operating system on a limited number of custom NetBook Pro's designed for a hospital setting.[218]

The Embeddable Linux Kernel Subset project has produced a small subset of Linux that runs on Psion Series 3 PDAs.[219]

PDAs

- Psion Organiser and Psion Organiser II
- Psion Series 3, 3a, 3c & 3mx
- Psion Siena
- Psion Series 5, 5mx & 5mx Pro
- Psion Revo
- Psion netBook
- Psion Netpad
- Psion Series 7
- Psion Teklogix Netbook Pro (Windows CE)
- Psion Workabout

All these PDAs except the Psion netpad have a small keyboard, which excepting the Organiser and Workabout was of the standard QWERTY layout, or a regional variation thereof.

Laptops

- Psion MC 200
- Psion MC 400
- Psion MC 400 WORD
- Psion MC 600 (DOS)

External links

- A Brief History Of Psion's Machines
- A detailed history of Psion around the time of the Series 5
- Abandoned Psion software collected
- OpenPsion: A project to port linux to Psion Handhelds!
- Psion shareware library and tips/articles
- Psion website
- Psion's online community - ingenuityworking.com
- The History of Psion
- Unofficial Psion F.A.Q

David Potter

David Edwin Potter, CBE, FREng (born 1943) is the founder and chairman of the microcomputer systems company Psion PLC., and Psion Teklogix after Psion's acquisition of Teklogix in the year 2000.

Early life

Potter was born in East London, South Africa in 1943 and brought up in Cape Town. In 1963 he took up a Beit scholarship to read Natural Sciences at Trinity College, Cambridge. In 1966 he was awarded a Commonwealth Scholarship to study for a doctorate in mathematical physics at Imperial College London where he was subsequently appointed to the staff. As an academic during the 1970s he taught at the University of London and at the University of California, consulted and wrote a number of academic papers and a book on the use of computers in physics.

Career at Psion

Potter founded Psion in 1980. In its early years, Psion became a leader in software for home microcomputers. Notably, Psion's first real success, a flight simulation game for the ZX Spectrum, used actual physical algorithms that were probably simplified versions of those Potter had devised professionally.

In 1984 using radical technology, Psion invented 'The Organiser', the world's first volume hand-held computers for personal use and information. Over the next sixteen years and through many product introductions, Psion led the creation of the Organiser, Palmtop and PDA markets as a new market segment.

In 1988, David led Psion's flotation on the London Stock Exchange and saw Psion's scale and value multiply many times. The Company expanded further into data-communications and mobile corporate solutions. In 1998, using Psion's talented team and experience in small mobile operating systems, David led the creation of Symbian Limited in partnership with Nokia, Ericsson, Motorola and Matsushita to create the operating system standard for mobile wireless devices - now known as Symbian.

In 1999, Potter stood down as Chief Executive of the Company and assumed the role of Chairman, and retired as Chairman in September 2009.

Other activities

Potter has been a member of the London Regional Council of the CBI, a Board member of the London First Centre and co-Chairman of the London Manufacturing Group. David served on the 1997 National Committee of Inquiry into Higher Education (The Dearing Committee) and continued his involvement in higher education policy as a Board Member of the Higher Education Funding Council for England. From 1999 to 2003 he was a member of The Council for Science and Technology reporting to the Cabinet. Potter has also had extensive involvement with educational establishments as a Visiting Fellow of Nuffield College, Oxford, Honorary Fellow of Imperial College, London and Honorary Fellow and Governor of The London Business School. In 1993 he received the Mountbatten Medal from the Institution of Electrical Engineers and has received Honorary Doctorate Degrees from a number of universities including Warwick, Sheffield, Edinburgh and York. He has written and lectured widely on technology and the new economy, including the Stockton Lecture at London Business School in 1998, one of the Millennium Lectures at 10 Downing Street in 1999, and the Tacitus Lecture, 2000 at the Guildhall.

Honours

In the 1997 New Year's Honours list, David was awarded the CBE for services to the manufacturing industry[220] and in 2001 he was elected a Fellow of the Royal Academy of Engineers. In 1999, David Potter was chosen as Entrepreneur of the Year in the annual UK PLC Awards. In June 2003, David was appointed a non-Executive Director to the Bank of England, stepping down in 2009.

Family

David is husband of journalist and writer, Elaine Potter and they have three sons. His interests include his family, farming, education, science and economics, reading and ideas, tennis, golf and music. With their involvement in education and the developing world, the family created The David and Elaine Potter Foundation to support projects in education, research and third world development. He serves on the South African President's Committee on Communication and Information Technology.

Cambridge Systems Technology

Cambridge Systems Technology (CST) were a company formed in the early 1980s by ex-Torch Computers engineers David Oliver and Martin Baines, to produce peripherals for the BBC Micro, and later, with Graham Priestley, Sinclair QL microcomputers. Products included IEEE 488, floppy disk and SCSI interfaces. Following the demise of the Sinclair QL in 1986, CST began producing the Thor series of QL-compatible personal computers. These had limited commercial success, and CST had ceased trading by the end of the decade.

References

- News items from *The Micro User*, January 1984 mentioning CST
- Binary Dinosaurs page about the CST Thor

Miracle Systems

Miracle Systems Ltd. were a manufacturer of personal computer peripherals and upgrades, specializing in the Sinclair QL, in the 1980s and early 1990s.

The company was incorporated in February 1983. Initially, they produced simple peripherals such as an RS-232 to Centronics parallel printer interface adapter. Later, they designed the *Expanderam* series of RAM expansion cards for the QL, which lead to the *Trump Card* combined RAM expansion and floppy disk interface. This was notable in that it mapped RAM into memory space reserved for external peripheral devices, thus allowing the QL's RAM to be expanded to 768 kB rather than the official limit of 512 kB.

The Trump Card was later superseded by the *Gold Card* processor upgrade card. This replaced the QL's 68008 CPU with a 16 MHz 68000 and included 2 MB of RAM, a floppy disk interface (supporting DD, HD, and ED density 3.5 in drives) and a non-volatile real-time clock. Gold Card plugged into the QL expansion slot and required no internal modifications to the host QL.

The follow-up *Super Gold Card* had a 24 MHz 68020 CPU, 4MB of RAM, and added a Centronics parallel printer interface.

In 1993, Miracle launched the *QXL* QL emulator card for PCs. This comprised a 20 MHz (later 25 MHz) 68EC040 processor, up to 8 MB of RAM and an FPGA on an ISA card. The QXL ran the SMSQ Qdos-compatible operating system and used the host PC's disks, screen, keyboard, serial and parallel ports via an MS-DOS "server". Two QLAN-compatible network ports were also provided on the QXL card.

The company was finally wound up in August 2004.

Amstrad

Amstrad Limited

Amstrad logo

Type	Private limited company[1]
Industry	Electronics
Founded	1968
Headquarters	Brentwood, Essex, United Kingdom
Area served	UK and Ireland
Key people	Lord Sugar, Founder Alun Webber, Managing Director
Revenue	£91.65 million (2006)
Operating income	£26.94 million GBP (2006)
Net income	£15.08 million GBP (2006)
Employees	85 (2005)
Parent	BSkyB
Website	amstrad.com

Amstrad is a British electronics company, now wholly owned by BSkyB. As of 2006, Amstrad's main business is manufacturing Sky Digital interactive boxes.

Amstrad was founded in 1968 by Alan Sugar. The name is a contraction of ***A****lan* ***M****ichael* ***S****ugar* ***Trad****ing*. It was first listed on the London Stock Exchange in 1980. During the late 1980s, Amstrad had a substantial share of the PC market in the UK. Amstrad was once a FTSE 100 Index constituent but is now wholly owned by BSkyB.

The company is based in Brentwood, Essex.

History


Amstrad 7070 tape deck

1960s and 1970s

Amstrad was founded in 1968 by Lord Sugar. Amstrad entered the market in the field of consumer electronics. During the 1970s they were at the forefront of low-priced hi-fi, TV and car stereo cassette technologies. Lower prices were achieved by injection moulding plastic hi-fi turntable covers, undercutting competitors who used the vacuum forming process.

Amstrad expanded to the marketing of low cost, low quality audio amplifiers and tuners, imported from the Far East and badged with the Amstrad name for the UK market.

1980s


The Amstrad CPC 464 personal microcomputer

In 1980, Amstrad went public trading on the London Stock Exchange, and doubled in size each year during the early '80s. Amstrad began marketing their own home computers in an attempt to capture the market from Commodore and Sinclair, with the Amstrad CPC range in 1984. The CPC 464 was launched in the UK, France, Australia, New Zealand, Germany, Spain and Italy. It was followed by the CPC 664 and CPC 6128 models. Later "Plus" variants of the 464 and 6128, launched in 1990, increased their functionality slightly.


Amstrad PCW8512 word processor

In 1985, the popular Amstrad PCW range was introduced, which were principally word processors, complete with printer, running the LocoScript word processing program. They were also capable of running the CP/M operating system. The Amsoft division of Amstrad was set up to provide in-house software and consumables.

On 7 April 1986 Amstrad announced it had bought from Sinclair Research *"...the worldwide rights to sell and manufacture all existing and future Sinclair computers and computer products, together with the Sinclair brand name and those intellectual property rights where they relate to computers and computer related products."*[221] which included the ZX Spectrum, for £5 million. This included Sinclair's unsold stock of Sinclair QLs and Spectrums. Amstrad made more than £5 million on selling these surplus machines alone. Amstrad launched two new variants of the Spectrum: the ZX Spectrum +2, based on the ZX Spectrum 128, with a built-in tape drive (like the CPC 464) and, the following year, the ZX Spectrum +3, with a built-in floppy disk drive (similar to the CPC 664 and 6128), taking the 3" disks that many Amstrad machines used.


The ZX Spectrum +2. This was the first new Spectrum model released by Amstrad after their purchase of the range.

The company produced a range of affordable MS-DOS-based, but with the GEM graphics interface, and later Windows-based personal computers, the first of which was the PC1512, priced at £399 in 1986. It was a success, capturing more than 25% of the European computer market. In 1988 Amstrad attempted to make the first affordable portable personal computer with the PPC512 and 640 models, introduced a year before the Macintosh Portable. They ran MS-DOS on an 8 MHz processor, and the built-in screen could emulate the Monochrome Display Adapter or Color Graphics Adapter. Amstrad's final (and ill-fated) attempts to exploit the Sinclair brand were based on the company's own PCs; a compact desktop PC derived from the PPC 512, branded as the Sinclair PC200, and the PC1512 rebadged as the Sinclair PC500.


Amstrad PPC 512 portable PC

Amstrad's second generation of PCs, the PC2000 series, were launched in 1989. However, due to a problem with the Seagate ST277R hard disk shipped with the PC2386 model, these had to be recalled and fitted with Western Digital controllers. Amstrad later successfully sued Seagate, but following bad press over the hard disk problems, Amstrad lost its lead in the European PC market.[222]

1990s

In the early 1990s, Amstrad began to focus on portable computers rather than desktop computers. In 1990, Amstrad tried to enter the video game console market with the Amstrad GX4000, similar to what Commodore did at the same time with the C64 GS. The console, based on the Amstrad 464 Plus hardware, was a commercial failure, because it used 8-bit technology unlike the 16-bit Mega Drive and Super Nintendo.

In 1993, Amstrad was licenced by Sega to produce a system which was similar to the Sega TeraDrive, going by the name of the Amstrad Mega PC, to try to regain their image in the gaming market. The system didn't succeed as well as expected, mostly due to its high initial retail price of £599. In that same year, Amstrad released the PenPad, a PDA similar to the Apple Newton, and released only weeks before it. It was a commercial failure, and had several technical and usability problems. It lacked most features that the Apple Newton included, but had a lower price at $450.

As Amstrad began to concentrate less on computers and more in communication, they purchased several telecommunications businesses including Betacom, Dancall Telecom, Viglen Computers and Dataflex Design Communications during the early 1990s. Amstrad has been a major supplier of set top boxes to UK satellite TV provider Sky since its launch in 1989. Amstrad was key to the introduction of Sky, as it was the only manufacturer producing receiver boxes and dishes at the system's launch, and has continued to manufacture set top boxes for Sky, from analogue to digital and now including Sky's Sky+ digital video recorder.

In 1997, Amstrad PLC was wound up, its shares being split into Viglen and Betacom instead. Betacom PLC was then renamed Amstrad PLC.

The same year, Amstrad supplied set top boxes to Australian broadcaster Foxtel, and in 2004 to Italian broadcaster Sky Italia.

Recent times

In 2000, Amstrad released the first of its combined telephony and e-mail devices, called the *E-m@iler*. This was followed by the *E-m@iler Plus* in 2002, and the *E3 Videophone* in 2004. Amstrad's UK E-m@iler business is operated through a separate company, Amserve Ltd which is 89.8% owned by Amstrad and 10.2% owned by DSG International plc (formerly Dixons plc).

Amstrad has also produced a variety of home entertainment products over their history, including hi-fi, televisions, VCRs, and DVD players. Recently, Amstrad has also started producing animatronic Alan Sugar heads.[223]

BSkyB takeover

In July 2007, BSkyB announced a takeover of Amstrad for £125m,[224] a 23.7% premium on its market capitalisation. BSkyB had been a major client of Amstrad, accounting for 75% of sales for its 'set top box' business. Having supplied BSkyB with hardware since its inception in 1988, market analysts had noted the two companies becoming increasingly close in recent years.

Sugar commented that he wished to play a part in the business, saying: "I turn 60 this year and I have had 40 years of hustling in the business, but now I have to start thinking about my team of loyal staff, many of whom have been with me for many years."

2008

It was announced on 2 July 2008 that Sugar had stepped down as Chairman of Amstrad, which had been planned since BSkyB took over in 2007.[225] [226] The former Amstrad headquarters building in Brentwood was subsequently sold by Sugar's property arm Amsprop and reopened in 2010 as a Premier Inn hotel.

Computer product lines

Home computers

- **CPC464** (64 KB RAM, cassette drive)
- **CPC472** (same as CPC464 but with 72 KB instead of 64 KB)
- **CPC664** (3 inch internal disk variant of CPC464)
- **CPC6128** (128 KB version of the CPC664 with 3 inch disk)
- **464 Plus** (CPC464 with enhanced graphics and sound)
- **6128 Plus** (CPC6128 with enhanced graphics and sound)
- **GX4000** (games console based on 464 Plus)
- **Sinclair ZX Spectrum +2** (Re-engineered ZX Spectrum 128 with tape drive)
- **Sinclair ZX Spectrum +3** (as ZX Spectrum +2 but with 3 inch disk drive instead of tape drive)

Word processors

- **PCW8256** (Z80, 3.5 MHz, 256 KB RAM, single 180 KB 3" floppy drive, dot-matrix printer, green screen)
- **PCW8512** (same as PCW8256 but with 512 KB RAM, 180 KB 3" A: drive, 720 KB 3" B: drive)
- **PCW9512** (Z80, 3.5 MHz, 512 KB RAM, single or dual 720 KB 3" floppy drives, daisywheel printer, "paper white" screen)
- **PcW9256** (Z80, 3.5 MHz, 256 KB RAM, single 720 KB 3.5" floppy drive, dot-matrix printer, "paper white" screen)
- **PcW9512+** (same as PCW9512 but with single 3.5" 720 KB floppy drive)
- **PcW10** (same as PcW9256 but with 512 KB RAM and a built-in parallel port)
- **PcW16** (Z80, 16 MHz, single 1.44 MB 3.5" floppy drive, new machine not directly compatible with old PCWs)

Notepad computers

- **NC100** (Z80, 64 KB RAM, 80×8 character LCD)
- **NC150** (NC100 with 128 KB RAM, floppy disk interface and NC200 firmware — sold in France and Italy)
- **NC200** (Z80, 128 KB RAM, adjustable 80×16 character LCD, 3.5 in floppy disk drive)

PC compatibles

- **PC1512** (Intel 8086, 8 MHz, 512 KB RAM, CGA graphics) - Marketed in the United States as the PC5120
- **PC1640** (Intel 8086, 8 MHz, 640 KB RAM, MDA/Hercules/CGA/EGA colour graphics) - Marketed in the United States as the PC6400
- **PPC512** (Portable using NEC V30 processor, 512 KB RAM, non-backlit supertwist CGA, one or two 720 KB 3.5" floppy drives) - released around the same time as the PC1512.
- **PPC640** (Portable using NEC V30 processor, 640 KB RAM, non-backlit supertwist CGA, one or two 720 KB 3.5" floppy drives, internal modem) - released around the same time as the PC1640.
- **Sinclair PC200** (integral desktop PC for home computer market based on PPC512)
- **PC-20** the Australian version of the Sinclair PC200
- **Sinclair PC500** (rebadged PC1512)
- **PC1286**
- **PC1386** (Intel 80386SX CPU, 20 MHz, 1 MB RAM)
- **PC2086** (Intel 8086 CPU, 8 MHz, 640 KB RAM, VGA graphics) launched 1989
- **PC2286** (Intel 80286 CPU, 12.5 MHz, 1 MB RAM, VGA graphics) launched 1989
- **PC2386** (Intel 80386DX CPU, 20 MHz, 4 MB RAM, VGA graphics) launched 1989.
- **PC3086** (8 MHz 8086 CPU, 640 KB RAM)
- **PC3286** (16 MHz 80286 CPU, 1 MB RAM)
- **PC3386SX** (20 MHz 80386SX CPU, 1 MB RAM)
- **PC4386SX** (20 MHz 80386SX CPU, 4 MB RAM)
- **PC5086** (8 MHz 8086 CPU, 640 KB RAM)
- **PC5286** (16 MHz 80286 CPU, 1 MB RAM)
- **PC5386SX** (20 MHz 80386SX CPU, 2 MB RAM, VGA graphics) launched 1991
- **PC6486SX**
- **PC7000** series: PC7286, PC7386SX, PC7486SLC
- **PC8486**
- **PC9486** (25 or 33 MHz 80486SX)
- **PC9555i** (120 MHz Pentium)

- **ALT286** (laptop; 16 MHz 80286 CPU, 1 MB RAM)
- **ALT386SX** (laptop; 16 MHz 80386SX CPU, 1 MB RAM)
- **ACL386SX** (laptop; 20 MHz 80386SX CPU, 1 MB RAM, colour TFT LCD)
- **ANB386SX** (notebook; 80386SX CPU, 1 MB RAM)

PC accessories

- **Amstrad DMP1000** 9-pin dot matrix printer
- **Amstrad DMP3000, DMP3160, DMP3250di** 9-pin dot matrix printer (different printing speed), the special model 3250*di* (dual interface) having both serial and parallel ports
- **Amstrad SM2400** 2400 baud internal modem (came with Mirror software)

PDA

- **PDA 600 Pen Pad** (1993, Z8S180 CPU)

Set-top box

- **Amstrad Sky+ box** 2003

Further reading

- Sugar, Alan. *What You See Is What You Get - My Autobiography* (2010) hardback ISBN 978-230-74933-7
- Thomas, David. *Alan Sugar — the Amstrad Story* (1991), paperback ISBN 0-330-31900-0.

External links

- Official website
- Amstrad CPC464 Java emulator

Chips

Motorola 68000 family

Motorola 68000	
Designer	Motorola
Bits	16/32-bit
Introduced	1979
Design	CISC
Endianness	Big
Registers	
General purpose	16x32-bit

The Motorola **680x0**/**m68000**/**68000** is a family of 32-bit CISC microprocessors. During the 1980s and early 1990s, they were popular in personal computers and workstations and were the primary competitors of Intel's x86 microprocessors. They were most well known as the processors powering the early Apple Macintosh, the Commodore Amiga, the Sinclair QL, the Atari ST, SEGA Megadrive and several others. Although no modern desktop computers are based on the 68000, derivative processors are still widely used in embedded applications.

Family members

- Generation one (internally 16/32-bit, and produced with 8-, 16-, and 32-bit interfaces)
  - Motorola 68000
  - Motorola 68EC000
  - Motorola 68HC000
  - Motorola 68008
  - Motorola 68010
  - Motorola 68012

- Generation two (fully 32-bit)
  - Motorola 68020
  - Motorola 68EC020
  - Motorola 68030
  - Motorola 68EC030

- Generation three (pipelined)
  - Motorola 68040
  - Motorola 68EC040
  - Motorola 68LC040

- Generation four (superscalar)
  - Motorola 68060
  - Motorola 68EC060
  - Motorola 68LC060

- Others
  - Freescale 683XX (CPU32 aka 68330, 68360 aka QUICC)
  - Freescale ColdFire
  - Freescale DragonBall

Improvement roadmap

Note that the 68000 family does not possess a CPUID instruction like the x86 family does. So determining what 68k CPU is running requires other detection methods.

68010

- Virtual memory support (restartable instructions).
- 'loop mode' for faster string and memory library primitives.

68020

- 32-bit address & ALU.
- 3 stage pipeline.
- Instruction cache of 256 bytes.
- Unrestricted word and longword data access (see alignment).
- 8 x multiprocessing capability.
- Larger multiply (32×32 -> 64 bits) and divide (64÷32 -> 32 bits quotient and 32 bits remainder) instructions, and bit field manipulations.
- Addressing modes added scaled indexing and another level of indirection.
- Low cost, EC = 24-bit address.

68030:

- Split instruction and data cache of 256 bytes each
- On-chip MMU (68851).
- Low cost EC = No MMU.

68040:

- Instruction and data caches of 4 kilobytes each
- 6 stage pipeline.
- FPU lacks IEEE transcendental functions capability.
- FPU emulation works with 2E71M and later chip revisions.
- Low cost LC = No FPU.
- Low cost EC = No FPU & MMU.

68060:

- Instruction and data caches of 8 kilobytes each
- 10 stage pipeline.
- Two cycle integer multiplication unit.
- Branch prediction.
- Dual instruction pipeline.
- Instructions in the address generation unit (AGU) and thereby supply the result two cycles before the ALU.
- Low cost LC = No MMU.
- Low cost EC = No MMU & FPU.

Main uses

The 68000 line of processors has been used in a variety of systems, from modern high-end Texas Instruments calculators (the TI-89, TI-92, and Voyage 200 lines) to all of the members of the Palm Pilot series that run Palm OS 1.x to 4.x (OS 5.x is ARM-based), and even radiation hardened versions in the critical control systems of the Space Shuttle. However, they became most well known as the processors powering desktop computers such as the Apple Macintosh, the Commodore Amiga, the Sinclair QL, the Atari ST, and several others. The 68000 was also the processor of choice in the 1980s for Unix workstations and servers from firms such as Sun Microsystems, NeXT and Silicon Graphics. There was a 68000 version of CP/M, which received almost no notice, and almost no sales.

Additionally, and perhaps most significantly, the first several versions of Adobe's PostScript interpreters were 68000-based. A fast 68000 in the Apple LaserWriter and LaserWriter Plus, also the LaserWriter IInt (all 300 dpi). A fast 68030 in later PostScript interpreters, including the standard resolution LaserWriter IIntx, IIf and IIg (also 300 dpi), the higher resolution LaserWriter Pro 600 series (usually 600 dpi, but limited to 300 dpi with minimum RAM installed) and the very high resolution Linotronic imagesetters, the 200PS (1500+ dpi) and 300PS (2500+ dpi). Thereafter, Adobe generally preferred a RISC for its processor, as its competitors, with their PostScript clones, had already gone with RISCs, often an AMD 29000-series. The early 68000-based Adobe PostScript interpreters and their hardware were named for cold war U.S. rockets and missiles: Atlas, Redstone, etc.

Today, these systems are either end-of-line (in the case of the Atari and Amiga), or are using different processors (in the case of Macintosh, Sun, and SGI). Since these platforms had their marketshare peak in the 1980s, their original manufacturers are unlikely to support an operating system for this hardware or are even out of business. However, the Linux, NetBSD and OpenBSD operating systems still include support for 68000 processors.

The 68000 processors were also used in the Sega Mega Drive/Sega Genesis and SNK Neo Geo consoles as the main CPU. Other consoles such as the Sega Saturn used the 68000 for audio processing and other I/O tasks, while the Atari Jaguar included a 68000 which was intended for basic system control and input processing, but due to the Jaguar's unusual assortment of heterogeneous processors was also frequently used for running game logic. Many arcade boards also used 68000 processors including boards from Capcom, SNK, and Sega.

Microcontrollers derived from the 68000 family have been used in a huge variety of applications. For example, CPU32 and ColdFire microcontrollers have been manufactured in the millions as automotive engine controllers.

Architecture

People who are familiar with the PDP-11 or VAX usually feel comfortable with the 68000. With the exception of the split of general purpose registers into specialized data and address registers, the 68000 architecture is in many ways a 32-bit PDP-11.

The instruction set was much more "orthogonal" than those of many processors that came before (e.g., 8080) and after (e.g., x86). That is, it was typically possible to combine operations freely with operands, rather than being restricted to using certain addressing modes with certain instructions. This property made programming relatively easy for humans, and also made it easier to write code generators for compilers.

The 68000 instruction set can be divided in the following broad categories:

- Load and store (Move.B, Move.W, Move.L)
- Arithmetic (Add, Sub, Mul, Div)
- Bit shifting (left or right, logical or arithmetical)
- Bit rotation (ROR, ROL, ROXL, ROXR)
- Logic operations (And, Or, Not, EOr)
- Type conversion (byte to word and *vice versa*)
- Conditional and unconditional branches (Bra, BCS, BEq, BNE, BHI, BLO, BMI, BPL, etc.)
- Subroutine invocation and return (BSR, RTS)
- Stack management (pea / move x,(sp) / move (sp),x)
- Causing and responding to interrupts
- Exception handling
- There is no equivalent to the x86 CPUID instruction to determine what CPU or MMU or FPU is present.

68050 and 68070

There was no 68050, though at one point it was a project within Motorola. Odd-numbered releases had always been reactions to issues raised within the previous even numbered part; hence, it was generally expected that the 68050 would have reduced the 68040's power consumption (and thus heat dissipation), improved exception handling in the FPU, used a smaller feature size and optimized the microcode in line with program use of instructions. Many of these optimizations were included with the 68060 and were part of its design goals. For any number of reasons, likely that the 68060 was in development, that the Intel 80486 wasn't progressing as quickly as Motorola assumed it would, and that 68060 was a demanding project, the 68050 was cancelled early in development.

There is also no revision of the 68060, as Motorola was in the process of shifting away from the 68000 and 88k processor lines into its new PowerPC business, so the 68070 was never developed. Had it been, it would have been a revised 68060, likely with a superior FPU (pipelining was widely speculated upon on Usenet).

Motorola mainly used even numbers for major revisions to the CPU core such as 68000, 68020, 68040 and 68060. The 68010 was a revised version of the 68000 with minor modifications to the core, and likewise the 68030 was a revised 68020 with some more powerful features, none of them significant enough to classify as a major upgrade to the core.

There was a CPU with the 68070 designation, which was a licensed and somewhat slower version of the 16/32-bit 68000 with a basic DMA controller, I²C host and an on-chip serial port. This 68070 was used as the main CPU in the Philips CD-i. This CPU was, however, produced by Philips and not officially part of Motorola's 680x0 lineup.

Last generation

The 4th generation 68060 shared most of the features of the Intel P5 architecture. Had Motorola decided to continue the 680x0 series, the next processor (68080) would likely have resembled Intel P6 architecture.

Other variants

After the mainline 68000 processors' demise, the 68000 family has been used to some extent in microcontroller/embedded microprocessor versions. These chips include the ones listed under "other" above, i.e. the CPU32 (aka 68330), the ColdFire, the QUICC and the DragonBall.

Competitors

Desktop

During the 1980s and early 1990s, when the 68000 was widely used in desktop computers, it mainly competed against Intel's x86 architecture, which to this day — other than a small minority of Transmeta VLIW processors — remains the only architecture used in IBM Compatible PCs. Generation 1 68000 CPUs primarily competed against the 16-bit 8086/8088 and 80286. Generation 2 competed against the 80386 (the first 32-bit x86 processor), and generation 3 against the 80486. The fourth generation competed with the P5 Pentium line, but it was not nearly as widely used as its predecessors, since much of the old 68000 marketplace was either defunct or nearly so (as was the case with Atari, Amiga and NeXT), or converting to newer architectures (PowerPC for the Macintosh, SPARC for Sun, and MIPS for SGI).

Embedded

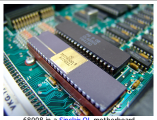
There are dozens of processor architectures that are currently successful in embedded systems. Some are microcontrollers which are much simpler, smaller, and cheaper than the 68000, while others are relatively sophisticated and capable of running complex software. Embedded versions of the 68000 often compete with processors derived from the PowerPC, ARM, MIPS, and SuperH architectures, among others.

Bibliography

- Howe, Dennis, ed. (1983). *Free On-Line Dictionary of Computing*. Imperial College, London. http://foldoc.org. Retrieved September 4, 2007.

Motorola 68008

Motorola MC68008.



68008 in a Sinclair QL motherboard

The **Motorola 68008** is an 8/16/32-bit microprocessor made by Motorola. It is a version of the Motorola 68000 with an 8-bit external data bus, as well as a smaller address bus.

The original 68000 had a 24-bit address bus and a 16-bit data bus. These relatively large buses made it hard to design a low-cost system around the 68000; they were difficult to lay out on a circuit board and needed a lot of supporting circuitry. A 16-bit data bus also required twice as many memory chips as an 8-bit one.

The 68008, introduced in 1982, was designed to work with low-cost 8-bit memory systems. Because of its smaller data bus, it was only about half as fast as a 68000 of the same clock speed. However, it was still faster than competing 8-bit microprocessors, because the 68008's internal architecture was based around a 32-bit architecture.

Except for its smaller data and address buses, the 68008 behaved identically to the 68000 and had the same internal organization and microarchitecture.

The 68008 was an HMOS chip with about 70000 transistors; it came in 8 and 10 MHz speed grades. There were two distinct versions of the chip. The original version came in a 48-pin dual in-line package and had a 20-bit address bus, allowing it to use up to 1 megabyte of memory. A later version came in a 52-pin plastic leaded chip carrier; this version provided a 22-bit address bus and could support 4 megabytes of memory.

Very few computer systems used the 68008 as the main processor; the Sinclair QL personal computer is the best known of these. However, the 68008 was popular in embedded systems.

Motorola ended production of the 68008 in 1996.[227]

External links

- A small 68008 design
- M68000 8-/16-/32-Bit Microprocessors User's Manual, Ninth Edition

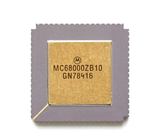
Motorola 68000

Motorola 68000	
Designer	Motorola
Bits	16/32-bit
Introduced	1979
Design	CISC
Endianness	Big
Registers	
General purpose	8 × 32-bit + 7 address registers also usable for most operations + stack pointer

The **Motorola 68000** is a 16/32-bit [228] CISC microprocessor core designed and marketed by Freescale Semiconductor (formerly Motorola Semiconductor Products Sector). Introduced in 1979 with HMOS technology as the first member of the successful 32-bit m68k family of microprocessors, it is generally software forward compatible with the rest of the line despite being limited to a 16-bit wide external bus. After 30 years in production, the 68000 architecture is still in use.


Pre-release XC68000 chip manufactured in 1979.

History


Motorola MC68000 (CLCC package)

Motorola MC68000 (PLCC package)

The 68000 grew out of the **MACSS** (Motorola Advanced Computer System on Silicon) project, begun in 1976 to develop an entirely new architecture without backward compatibility. It would be a higher-power sibling complementing the existing 8-bit 6800 line rather than a compatible successor. In the end, the 68000 did retain a bus protocol compatibility mode for existing 6800 peripheral devices, and a version with an 8-bit data bus was produced. However, the designers mainly focused on the future, or forward compatibility, which gave the M68K platform a head start against later 32-bit instruction set architectures. For instance, the CPU registers are 32 bits wide, though few self-contained structures in the processor itself operate on 32 bits at a time. The MACSS team drew heavily on the influence of minicomputer processor design, such as the PDP-11 and VAX systems, which were similarly microcoded.

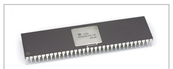
In the mid 1970s, the 8-bit microprocessor manufacturers raced to introduce the 16-bit generation. National Semiconductor had been first with its IMP-16 and PACE processors in 1973-1975, but these had issues with speed. The Intel 8086 in 1977 quickly gained popularity. The decision to leapfrog the competition and introduce a hybrid 16/32-bit design was necessary, and Motorola turned it into a coherent mission. Arriving late to the 16-bit arena afforded the new processor more transistors (roughly 40000 active versus 20000 active in the 8086), 32-bit macroinstructions, and acclaimed general ease of use.

The original MC68000 was fabricated using an HMOS process with a 3.5-micron feature size. Formally introduced in September 1979[229], Initial samples were released in February 1980, with production chips available over the counter in November.[230] Initial speed grades were 4, 6, and 8 MHz. 10 MHz chips became available during 1981, and 12.5 MHz chips by June 1982.[231] The 16.67 MHz "12F" version of the MC68000, the fastest version of the original HMOS chip, was not produced until the late 1980s. Tom Gunter, retired Corporate Vice President at Motorola, is known as the "Father of the 68000."

The 68000 had many high-end design wins early on. It became the dominant CPU for Unix based workstations including Sun workstations and Apollo/Domain workstations, found its way into heralded computers such as the Amiga, Atari ST, Apple Lisa and Macintosh, and was used in the first generation of desktop laser printers including the original Apple Inc. LaserWriter and the HP LaserJet. In 1982, the 68000 received an update to its ISA allowing it to support virtual memory and to conform to the Popek and Goldberg virtualization requirements. The updated chip was called the 68010. A further extended version which exposed 31 bits of the address bus was also produced, in small quantities, as the 68012.

To support lower-cost systems and control applications with smaller memory sizes, Motorola introduced the 8-bit compatible MC68008, also in 1982. This was a 68000 with an 8-bit data bus and a smaller (20 bit) address bus. After 1982, Motorola devoted more attention to the 68020 and 88000 projects.

Second-sourcing


Hitachi HD68000


Thomson TS68000

Several other companies were second-source manufacturers of the HMOS 68000. These included Hitachi (HD68000), who shrank the feature size to 2.7-microns for their 12.5 MHz version[232], Mostek (MK68000), Rockwell (R68000), Signetics (SCN68000), Thomson/SGS-Thomson (originally EF68000 and later TS68000), and Toshiba (TMP68000). Toshiba was also a second-source maker of the CMOS 68HC000 (TMP68HC000).

CMOS versions

The 68HC000, the first CMOS version of the 68000, was designed by Hitachi and jointly introduced in 1985.[233] Motorola's version was called the MC68HC000, while Hitachi's was the HD68HC000. The 68HC000 was eventually offered at speeds of 8-20 MHz. Except for using CMOS circuitry, it behaved identically to the HMOS MC68000, but the change to CMOS greatly reduced its power consumption. The original HMOS MC68000 consumed around 1.35 watts at an ambient temperature of 25 °C, regardless of clock speed, while the MC68HC000 consumed only 0.13 watts at 8 MHz and 0.38 watts at 20 MHz. (Unlike CMOS circuits, HMOS still draws power when idle, so power consumption varies little with clock rate.) Apple selected the 68HC000 for use in the Macintosh Portable.

Motorola replaced the MC68008 with the MC68HC001 in 1990.[234] This chip resembled the 68HC000 in most respects, but its data bus could operate in either 16-bit or 8-bit mode, depending on the value of an input pin at reset. Thus, like the 68008, it could be used in systems with cheaper 8-bit memories.

The later evolution of the 68000 focused on more modern embedded control applications and on-chip peripherals. The **68EC000** chip and SCM68000 core expanded the address bus to 32 bits, removed the M6800 peripheral bus, and excluded the MOVE from SR instruction from user mode programs.[235] In 1996, Motorola updated the standalone core with fully static circuitry drawing only 2 μW in low-power mode, calling it the MC68SEC000.[236]

Motorola ceased production of the HMOS MC68000 and MC68008 in 1996,[237] but its spin-off company, Freescale Semiconductor, is still producing the MC68HC000, MC68HC001, MC68EC000, and MC68SEC000, as well as the MC68302 and MC68306 microcontrollers and later versions of the DragonBall family. The 68000's architectural descendants, the 680x0, CPU32, and Coldfire families, are also still in production.

As a microcontroller core

After being succeeded by "true" 32-bit microprocessors, the 68000 was used as the core of many microcontrollers. In 1989, Motorola introduced the MC68302 communications processor.[238]

Applications

Two Hitachi 68HC000 CPUs being used on an arcade game PCB

At its introduction, the 68000 was first used in high-priced systems, including multiuser microcomputers like the WICAT 150 [6], early Alpha Microsystems computers, Sage II / IV, Tandy TRS-80 Model 16, and Fortune 32:16; single-user workstations such as Hewlett-Packard's HP 9000 Series 200 systems, the first Apollo/Domain systems, Sun Microsystems' Sun-1, and the Corvus Concept; and graphics terminals like Digital Equipment Corporation's VAXstation 100 and Silicon Graphics' IRIS 1000 and 1200. Unix systems rapidly moved to the more capable later generations of the 68k line, which remained popular in that market throughout the 1980s.

By the mid-1980s, falling production cost made the 68000 viable for use in personal and home computers, starting with the Apple Lisa and Macintosh, and followed by the Commodore Amiga, Atari ST, and Sharp X68000. The 68008, on the other hand, was only used in a few home computer systems. The Sinclair QL (though the QL was a sister machine to the ICL One Per Desk, which also used a 68008) was the most commercially important. Helix Systems (in Missouri, United States) designed an extension to the SWTPC SS-50 bus, the SS-64, and produced systems built around the 68008 processor.

While the rapid pace of computer advancement quickly rendered the 68000 obsolete as desktop/workstation CPU, the processor found substantial use in embedded applications. By the early 1980s, quantities of 68000 CPUs could be purchased for less than $30 USD per part. Video game manufacturers used the 68000 as the backbone of many arcade games and home game consoles: Atari's Food Fight, from 1982, was one of the first 68000-based arcade games. Others included Sega's System 16, Capcom's CP System and CPS-2, and SNK's Neo Geo. By the late 1980s, the 68000 was inexpensive enough to power home game consoles, such as Sega's Mega Drive (Genesis) console. The 1993 multi-processor Atari Jaguar console used a 68000 as a support chip, although some developers used it as the primary processor due to familiarity.

The 68000 also saw great success as an embedded controller. As early as 1981, laser printers such as the Imagen Imprint-10 were controlled by external boards equipped with the 68000. The first HP LaserJet—introduced in 1984—came with a built-in 8 MHz 68000. Other printer manufacturers adopted the 68000, including Apple with its introduction of the LaserWriter in 1985, the first PostScript laser printer. The 68000 continued to be widely used in printers throughout the rest of the 1980s, persisting well into the 1990s in low-end printers.

The 68000 also saw success in the field of industrial control systems. Among the systems which benefited from having a 68000 or derivative as their microprocessor were families of Programmable Logic Controllers (PLCs) manufactured by Allen-Bradley, Texas Instruments and subsequently, following the acquisition of that division of TI, by Siemens. Users of such systems do not accept product obsolescence at the same rate as domestic users and it is entirely likely that despite having been installed over 20 years ago, many 68000-based controllers will continue in reliable service well into the 21st century.

The 683XX microcontrollers, based on the 68000-architecture, are used in networking and telecom equipment, television set-top boxes, laboratory and medical instruments, and even handheld calculators. The MC68302 and its derivatives have been used in many telecom products from Cisco, 3com, Ascend, Marconi, Cyclades and others. Past models of the Palm PDAs and the Handspring Visor used the DragonBall, a derivative of the 68000. AlphaSmart uses the DragonBall family in later versions of its portable word processors. Texas Instruments uses the 68000 in its high-end graphing calculators, the TI-89 and TI-92 series and Voyage 200. Early versions of these used a specialized microcontroller with a static 68EC000 core; later versions use a standard MC68SEC000 processor.

A modified version of the 68000 formed the basis of the IBM XT/370 Hardware emulator of a System 370 processor.

Architecture

Address bus

The 68000 has a 23-bit external address bus and two byte-select signals "replaced" A0. These 25 lines could therefore reach 16 MB of physical memory with byte resolution. Address storage and computation used 32 bits, however, with the high-order byte ignored due to the physical lack of pins. This allowed it to run software written for a flat 32-bit address space. Motorola's intent with the internal 32-bit address space was forward compatibility, making it feasible to write 68000 software that would take full advantage of later 32-bit implementations of the 68000 instruction set.[239]

However, this did not prevent programmers from writing forward incompatible software. "24-bit" software that discarded the upper address byte, or used it for purposes other than addressing, could fail on 32-bit 68K implementations. For example, early (pre-7.0) versions of Apple's Mac OS used the high byte of memory-block master pointers to hold flags such as locked and purgeable. Later versions of the OS moved the flags to a nearby location, and Apple began shipping computers which had "32-bit clean" ROMs beginning with the release of the 1989 Mac IIci.

Internal registers

The CPU has eight 32-bit general-purpose data registers (D0-D7), and eight address registers (A0-A7). The last address register is the stack pointer, and assemblers would accept the label SP as equivalent to A7. This was a good number of registers in many ways. It was small enough to allow the 68000 to respond quickly to interrupts (because if all 8 Data registers DO - D7 and 7 Address registers A0 - A6 have to be saved, 15 Registers in total), and yet large enough to make most calculations fast. Note that an Exception routine in supervisor Mode could also have saved the User Stack Pointer A7, which would make it 8 Address registers)

Having two types of registers was mildly annoying at times, but not hard to use in practice. Reportedly, it allowed the CPU designers to achieve a higher degree of parallelism, by using an auxiliary execution unit for the address registers.

Integer representation in the 68000 family is big-endian.

Status register

The 68000 comparison, arithmetic and logic operations set bit flags in a status register to record their results for use by later conditional jumps. The bit flags were "zero" (Z), "carry" (C), "overflow" (V), "extend" (X), and "negative" (N). The "extend" (X) flag deserves special mention, because it was separated from the carry flag. This permitted the extra bit from arithmetic, logic, and shift operations to be separated for the carry for flow-of-control and linkage.

Instruction set

The designers attempted to make the assembly language orthogonal. That is, instructions were divided into operations and address modes, and almost all address modes were available for almost all instructions. Some programmers disliked the "near" orthogonality, while others were grateful for the attempt.

At the bit level, the person writing the assembler would clearly see that these "instructions" could become any of several different op-codes. It was quite a good compromise because it gave almost the same convenience as a truly orthogonal machine, and yet also gave the CPU designers freedom to fill in the op-code table.

With only 56 instructions, the minimum instruction size was huge for its day at 16 bits. Furthermore, many instructions and addressing modes added extra words on the back for addresses, more address-mode bits, etc.

Many designers believed that the MC68000 architecture had compact code (High code density) for its cost, especially when produced by compilers. This belief in more compact code led to many of its design wins, and much of its longevity as an architecture through updated CPUs.

Privilege levels

The CPU, and later the whole family, implemented exactly two levels of privilege. User mode gave access to everything except the interrupt level control. Supervisor privilege gave access to everything. An interrupt always became supervisory. The supervisor bit was stored in the status register, and visible to user programs.

A real advantage of this system was that the supervisor level has a separate stack pointer. This permitted a multitasking system to use very small stacks for tasks, because the designers did not have to allocate the memory required to hold the stack frames of a maximum stack-up of interrupts.

Interrupts

The CPU recognized seven interrupt levels. Levels 1 through 7 were strictly prioritized. That is, a higher-numbered interrupt could always interrupt a lower-numbered interrupt. In the status register, a privileged instruction allowed one to set the current minimum interrupt level, blocking lower priority interrupts. Level 7 was not maskable—in other words, an NMI. Level 1 could be interrupted by any higher level. Level 0 means no interrupt. The level was stored in the status register, and was visible to user-level programs.

Hardware interrupts are signalled to the CPU using three inputs that encode the highest pending interrupt priority. A separate interrupt controller is usually required to encode the interrupts, though for systems that do not require more than three hardware interrupts it is possible to connect the interrupt signals directly to the encoded inputs at the cost of additional software complexity. The interrupt controller can be as simple as a 74LS148 priority encoder, or may be part of a VLSI peripheral chip such as the MC68901 Multi-Function Peripheral (used in Atari TT030), which also provided a UART, timer, and parallel I/O.

The "exception table" (interrupt vector addresses) was fixed at addresses 0 through 1023, permitting 256 32-bit vectors. The first vector was the starting stack address, and the second was the starting code address. Vectors 3 through 15 were used to report various errors: bus error, address error, illegal instruction, zero division, CHK & CHK2 vector, privilege violation, and some reserved vectors that became line 1010 emulator, line 1111 emulator, and hardware breakpoint. Vector 24 started the **real** interrupts: spurious interrupt (no hardware acknowledgement), and level 1 through level 7 autovectors, then the 16 TRAP vectors, then some more reserved vectors, then the user defined vectors.

Since at a minimum the starting code address vector must always be valid on reset, systems commonly included some nonvolatile memory (e.g. ROM) starting at address zero to contain the vectors and bootstrap code. However, for a general purpose system it is desirable for the operating system to be able to change the vectors at runtime. This was often accomplished by either pointing the vectors in ROM to a jump table in RAM, or through use of bank-switching to allow the ROM to be replaced by RAM at runtime.

The 68000 did not meet the Popek and Goldberg virtualization requirements for full processor virtualization because it has a single unprivileged instruction "MOVE from SR", which allowed user-mode software read-only access to a small amount of privileged state.

The 68000 was also unable to easily support virtual memory, which requires the ability to trap and recover from a failed memory access. The 68000 does provide a bus error exception which can be used to trap, but it does not save enough processor state to resume the faulted instruction once the operating system has handled the exception. Several companies did succeed in making 68000-based Unix workstations with virtual memory that worked by using two 68000 chips running in parallel on different phased clocks. When the "leading" 68000 encountered a bad memory access, extra hardware would interrupt the "main" 68000 to prevent it from also encountering the bad memory access. This interrupt routine would handle the virtual memory functions and restart the "leading" 68000 in the correct state to continue properly synchronized operation when the "main" 68000 returned from the interrupt.

These problems were fixed in the next major revision of the 68K architecture, with the release of the MC68010. The Bus Error and Address Error exceptions pushed a large amount of internal state onto the supervisor stack in order to facilitate recovery, and the MOVE from SR instruction was made privileged. A new unprivileged "MOVE from CCR" instruction was provided for use in its place by user mode software; an operating system could trap and emulate user-mode MOVE from SR instructions if desired.

Instruction set details

The standard addressing modes are:

- Register direct
  - data register, e.g. "D0"
  - address register, e.g. "A6"
- Register indirect
  - Simple address, e.g. (A0)
  - Address with post-increment, e.g. (A0)+
  - Address with pre-decrement, e.g. -(A0)
  - Address with a 16-bit signed offset, e.g. 16(A0)
  - Indexed register indirect with 8-bit signed offset e.g. 8(A0, D0) or 8(A0, A1)

Note that with (A0)+ and -(A0), the actual increment or decrement value is dependent on the operand size: a byte access increments the address register by 1, a word by 2, and a long by 4.

- PC (program counter) relative with displacement
  - Relative 16-bit signed offset, e.g. 16(PC). This mode was very useful for position-independent code.
  - Relative with 8-bit signed offset with index, e.g. 8(PC, D2)
- Absolute memory location
  - Either a number, e.g. "$4000", or a symbolic name translated by the assembler
  - Most 68000 assemblers used the "$" symbol for hexadecimal, instead of "0x" or a trailing H.
  - There were 16 and 32-bit version of this addressing mode
- Immediate mode
  - Data stored in the instruction, e.g. "#400"
- Quick Immediate mode
  - 3 bit unsigned (or 8 bit signed with moveq) with value stored in Opcode
  - In addq and subq, 0 is the equivalent to 8
  - e.g. moveq #0,d0 was quicker than clr.l d0 (though both made d0 equal 0)

Plus: access to the status register, and, in later models, other special registers.
Most instructions have dot-letter suffixes, permitting operations to occur on 8-bit bytes (".b"), 16-bit words (".w"), and 32-bit longs (".l").
Most instructions are **dyadic**, that is, the operation has a source, and a destination, and the destination is changed. Notable instructions were:

- Arithmetic: ADD, SUB, MULU (unsigned multiply), MULS (signed multiply), DIVU, DIVS, NEG (additive negation), and CMP (a sort of subtract that set the status bits, but did not store the result)
- Binary Coded Decimal Arithmetic: ABCD, and SBCD
- Logic: EOR (exclusive or), AND, NOT (logical not), OR (inclusive or)
- Shifting: (logical, i.e. right shifts put zero in the most significant bit) LSL, LSR, (arithmetic shifts, i.e. sign-extend the most significant bit) ASR, ASL, (Rotates through eXtend and not:) ROXL, ROXR, ROL, ROR
- Bit test and manipulation in memory: BSET (to 1), BCLR (to 0), BCHG (invert Bit) and BTST (set the Zero bit if tested bit is 0)
- Multiprocessing control: TAS, test-and-set, performed an indivisible bus operation, permitting semaphores to be used to synchronize several processors sharing a single memory
- Flow of control: JMP (jump), JSR (jump to subroutine), BSR (relative address jump to subroutine), RTS (return from subroutine), RTE (return from exception, i.e. an interrupt), TRAP (trigger a software exception similar to software interrupt), CHK (a conditional software exception)
- Branch: Bcc (a branch where the "cc" specified one of 16 tests of the condition codes in the status register: equal, greater than, less-than, carry, and most combinations and logical inversions, available from the status register).
- Decrement-and-branch: DBcc (where "cc" was as for the branch instructions) which decremented a D-register and branched to a destination provided the condition was still true *and* the register had not been decremented to -1. This use of -1 instead of 0 as the terminating value allowed the easy coding of loops which had to do nothing if the count was 0 to begin with, without the need for an additional check before entering the loop. This also facilitated nesting of DBcc.

68EC000

Motorola 68EC000 controller

The 68EC000 is a low-cost version of the 68000, designed for embedded controller applications. The 68EC000 can have either a 8-bit or 16-bit data bus, switchable at reset.[240]

The processors are available in a variety of speeds including 8 and 16 MHz configurations, producing 2,100 and 4,376 Dhrystones each. These processors have no floating point unit and it is difficult to implement an FPU coprocessor (MC68881/2) with one because the EC series lacks necessary coprocessor instructions.

The 68EC000 was used as a controller in many audio applications, including Ensoniq musical instruments and sound cards where it was part of the MIDI synthesizer.[241] On Ensoniq sound boards, the controller provided several advantages compared to competitors without a CPU onboard. The processor allowed the board to be configured to perform various audio tasks, such as MPU-401 MIDI synthesis or MT-32 emulation, without the use of a TSR program. This improved software compatibility, lowered CPU usage, and eliminated host system memory usage.

The Motorola 68EC000 core was later used in the m68k-based DragonBall processors from Motorola/Freescale.

It also was used as a sound controller in the Sega Saturn game console, and as a controller for the HP JetDirect Ethernet controller boards for the mid-90s LaserJet printers.

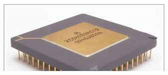
References

- Motorola MC68000 Family Programmer's Reference Manual
- comp.sys.m68k FAQ
- CAST, Inc. (68000 IP provider)

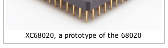
External links

- Descriptions of assembler instructions
- 68000 images and descriptions at cpu-collection.de
- 'Chips : Of Diagnostics & Debugging' Article
- The Vintage Mac Museum: 9inch/mono Display 68000 ONLY
- EASy68K, an open-source 68k assembler for Windows.
- CAST, Inc. (68000 IP provider)
- Digital Core Design (68000 IP provider)

Motorola 68020



The **Motorola 68020** is a 32-bit microprocessor from Motorola, released in 1984. It is the successor to the Motorola 68010 and is succeeded by the Motorola 68030. A lower cost version was also made available, known as the **68EC020**. In keeping with naming practices common to Motorola designs, the 68020 is usually referred to as the '020, pronounced *oh-two-oh* or *oh-twenty*".


XC68020, a prototype of the 68020

Description

Motorola 68020

The 68020 had 32-bit internal and external data and address buses, compared to the early models with 16-bit data and 23-bit address busses. Newer packaging methods allowed the '020 to feature more external pins without the large size that the earlier dual in-line package method required. The 68EC020 lowered cost through a 24-bit address bus. The 68020 was produced at speeds ranging from 12 MHz to 33 MHz.

Improvements over 68010

The 68020 added many improvements to the 68010 including a 32-bit arithmetic logic unit (ALU), external data bus and address bus, and new instructions and addressing modes. The 68020 (and 68030) had a proper three-stage pipeline. Though 68010 had a "loop mode", which sped loops through what was effectively a tiny instruction cache, it had only two memory location and was thus little used. The 68020 replaced this with a proper instruction cache of 256 bytes, the first 68k series processor to feature true onboard cache memory.

The previous 68000 and 68010 processors could only access word (16 bit) and longword (32 bit) data if it were word-aligned (located at an address that is evenly divisible by 2). The 68020 had no alignment restrictions on data access. However, unaligned longword accesses were often much slower than aligned accesses.

Coprocessor support

The 68020 has a coprocessor interface supporting up to eight coprocessors. The main CPU recognizes "F-line" instructions (with the four most significant opcode bits all one), and uses special bus cycles to interact with a coprocessor to execute these instructions. Two types of coprocessors were defined, the floating point unit (MC68881 or MC68882 FPU) and the paged memory management unit (MC68851 PMMU). Only one PMMU can be used with a CPU. In principle multiple FPUs could be used with a CPU, but it was not commonly done. The coprocessor interface is asynchronous, so it is possible to run the coprocessors at a different clock rate than the CPU.

Multiprocessing features

Multiprocessing support was implemented externally by the use of a RMC pin[242] to indicate an indivisible read-modify-write cycle in progress. All other processors had to hold off memory accesses until the cycle was complete.[243] Software support for multiprocessing included the TAS, CAS and CAS2 instructions.

In a multiprocessor system, coprocessors could not be shared between CPUs. To avoid problems with returns from coprocessor, bus error, and address error exceptions, it was generally necessary in a multiprocessor system for all CPUs to be the same model, and for all FPUs to be the same model as well.

Instruction set

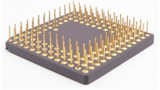
The new instructions included some minor improvements and extensions to the supervisor state, several instructions for software management of a multiprocessing system (which were removed in the 68060), some support for high-level languages which did not get used much (and was removed from future 680x0 processors), bigger multiply (32×32→64 bits) and divide (64÷32→32 bits quotient and 32 bits remainder) instructions, and bit field manipulations.

While the 68000 had 'supervisor mode', it did not meet the Popek and Goldberg virtualization requirements due to the single instruction 'MOVE from SR' being unprivileged but sensitive. Under the 68010 and later, this was made privileged, to better support virtualization software.

Addressing modes

The new addressing modes added scaled indexing and another level of indirection to many of the pre-existing modes, and added quite a bit of flexibility to various indexing modes and operations. Though it was not intended, these new modes made the 68020 very suitable for page printing; most laser printers in the early '90s had a 68EC020 at their core.

The 68020 had a minimal 256 byte direct-mapped instruction cache, arranged as 64 four-byte entries. Although small, it still made a significant difference in the performance of many applications. The resulting decrease in bus traffic was particularly important in systems relying heavily on DMA.



bottom view of a Motorola XC68020

Usage

The 68020 was used in the Apple Macintosh II and Macintosh LC personal computers, as well as Sun 3 workstations and the Hewlett Packard 8711 Series Network Analyzers, and the Alpha Microsystems AM-2000.

It is also the processor used on board TGV trains to decode signalling information which is sent to the trains through the rails. It is further being used in the flight control systems of the Eurofighter Typhoon combat aircraft.

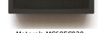
For more information on the instructions and architecture see Motorola 68000.

Variant

The **68EC020** is a microprocessor from Motorola. It is a lower cost version of the Motorola 68020. The main difference between the two is that the 68EC020 only has a 24-bit address bus, rather than the 32-bit address bus of the full 68020, and thus is only able to address 16 MB of RAM.

The Commodore Amiga 1200 computer and the Amiga CD32 games console used the cost-reduced 68EC020; the Namco System 22 arcade board has also used this processor. It also found use in laser printers. Apple used it in the QMS PS 410 and the LaserWriter II-NTX. Kodak used it in the Ektaplus 7016PS, and Dataproducts used it in the LZR 1260.

Technical data


Motorola MC68EC020.

Formal name	MC68020[244]
Work frequency	12.5 , 16.67 , 20 , 25 , 33 MHz (minimum 8 MHz, no on-chip clock generation)[245]
Voltage supply	5 V
Maximum power	1.75 W[246]
Production process	HCMOS, 3/8" silicon piece[247]
Chip carrier	PGA 169 (114 pins used) 34.16 x 34.16 mm[248] (53 °C/W without heatsink)[249]
Address bus	32-bit (4 GB directly linear accessible)[250]
Data bus	32-bit
Instruction set	101 instructions CISC
Cache	256 byte ICache[251 252]
Register	• 7 for Address operations (32-bit)[253] • 8 for Data operations (32-bit)[254]
Transistors	~200 000[255]
Performance	5.36 MIPS @ 33MHz[256]

Bibliography

External links

- 68020 images and descriptions at cpu-collection.de

Motorola 68040

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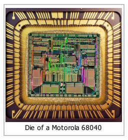
A Motorola 68040 microprocessor



Die of a Motorola 68040

The **Motorola 68040** is a microprocessor from Motorola, released in 1990. It is the successor to the 68030 and is followed by the 68060. There was no 68050. In keeping with general Motorola naming, the 68040 is often referred to as simply the '040 (pronounced *oh-four-oh* or *oh-forty*).

In Apple Macintosh computers, the 68040 was found mainly in the Macintosh Quadra, which was named for the chip. The fastest 68040 processor was clocked at 40 MHz and it was only used in the Quadra 840AV. The more expensive models in the (short-lived) Macintosh Centris line also used the 68040, while the cheaper Quadra, Centris and Macintosh Performa used the 68LC040. The 68040 was also used in other personal computers, such as the Amiga 4000 and Amiga 4000T, as well as a number of Workstations and later versions of the NeXT computers.

The 68040 was the first 680x0 family member with an on-chip Floating-Point Unit (FPU). It thus included all of the functionality that previously required external chips, namely the FPU and Memory Management Unit (MMU), which was added in the 68030. It also had split instruction and data caches of 4 kilobytes each. It was fully pipelined, with six stages.

Unfortunately, the 68040 ran into the transistor budget limit early in design. While the MMU did not take many transistors — indeed, having it on the same die as the CPU actually saved on transistors — the FPU certainly did. Motorola's 68882 external FPU was known as a very high performance unit and Motorola did not wish to risk integrators using the "LC" version with a 68882 instead of the more profitable full "RC" unit. (For information on Motorola's multiprocessing model with the 680x0 series, see Motorola 68020.) The FPU in the 68040 was thus made incapable of IEEE transcendental functions, which had been supported by both the 68881 and 68882 and were used by the popular fractal generating software of the time and little else. The Motorola floating point support package (FPSP) emulated these instructions in software under interrupt. As this was an exception handler, heavy use of the transcendental functions caused severe performance penalties.

Heat was always a problem throughout the 68040's life. While it delivered over four times the per-clock performance of the old-when-released 68020 and 68030, the chip's complexity and power requirements came from a large die and large caches. This affected the scaling of the processor and it was never able to run with a clock rate exceeding 40 MHz. A 50 MHz variant was planned, but canceled. Overclocking enthusiasts reported success reaching 50 MHz using a 100 MHz oscillator instead of an 80 MHz part and the then novel technique of adding oversized heat sinks with fans.

The 68040 offered the same features as the Intel 80486, but on a clock-for-clock basis could significantly outperform the Intel chip.[257] [258] However, the 80486 had the ability to be clocked significantly faster without suffering from overheating problems. In late 1991, as the higher-end Macintosh desktop lineup transitioned to the '040, Apple was unable to offer the newer processor in their top-of-the-line PowerBooks until early 1994. With PowerBooks being restricted to 68030s for several years, Macworld reviewers conceded that the best choice for power users was the PC compatible Texas Instruments 80486 notebook, rather than the top-of-the-line PowerBook 180.

Versions of the 68040 were created for specific market segments, including the 68LC040, which removed the FPU, and the 68EC040, which removed both the FPU and MMU. Motorola had intended the EC variant for embedded use, but embedded processors during the 68040's time did not need the power of the 68040, so EC variants of the 68020 and 68030 continued to be common in designs.

Motorola produced several speed grades. The 16 MHz and 20 MHz parts were never qualified (XC designation) and used as prototyping samples. 25 MHz and 33 MHz grades featured across the whole line, but until around 2000 the 40 MHz grade was only for the "full" 68040. A planned 50 MHz grade was canceled after it exceeded the thermal design envelope.

For more information on the instructions and architecture, see Motorola 68000.

Variants

68EC040

The *68EC040* is a version of the Motorola 68040 microprocessor, intended for embedded controllers (EC). It differs from the 68040 in that it has neither an FPU nor an MMU. This makes it less expensive and it draws less power.

68LC040

The *68LC040* is a *low cost* version of the Motorola 68040 microprocessor with no FPU. This makes it less expensive and it draws less power. Although the CPU now fits into a feature chart more like the Motorola 68020, it continues to include the 68040's caches and pipeline and is thus significantly faster than the 68020.

Some mask revisions of the 68LC040 contained a bug that prevents the chip from operating correctly when a software FPU emulator is used. According to Motorola's errata,[9] any chip with a mask set 2E71M or later does not contain the bug. This new mask was introduced in mid-1995 and converted the 68LC040 chip to MC status.[10]

The buggy revisions are typically found in 68LC040-based Apple Macintosh computers. Chips with mask set 2E23G (as used in the LC 475) have been confirmed to be faulty. The fault relates to pending writes being lost when the F-line exception is triggered.[11] The 68040 cannot update its microcode in the manner of modern x86 chips. This means that the only way to use software that requires floating-point functionality is to replace the buggy 68LC040 with a later revision, or a full 68040.

External links

- MC68040 Product Summary Page
- MC68040V Third-Generation 32-Bit Low-Power Microprocessor (PDF)
- M68040 Microprocessors User's Manual (PDF)

Motorola 68060

The **Motorola 68060** is a 32-bit microprocessor from Motorola released in 1994.[259] It is the successor to the Motorola 68040 and is the highest performing member of the 680x0 family. Two derivatives were produced, the **68LC060** and the **68EC060**.

A Motorola 68EC060 microprocessor

Architecture

There is an **LC** (Low-Cost) version, without an FPU[260] and **EC** - Embedded Controller, without MMU and FPU. The 68060 design was led by Joe Circello.

The 68060 shares most architectural features with the P5 Pentium. Both have a very similar superscalar in-order dual instruction pipeline configuration,[261] and an instruction decoder which breaks down complex instructions into simpler ones before execution. However, a significant difference is that the 68060 FPU is not pipelined and is therefore up to three times slower than the Pentium in floating point applications. In contrast to that, integer multiplications and bit shifting instructions are significantly faster on the 68060. An interesting feature of the 68060 is the ability to execute simple instructions in the address generation unit (AGU) and thereby supply the result two cycles before the ALU. Another point of interest is that large amounts of commercial compiled code were analyzed for clues as to which instructions would be the best candidates for performance optimization.

Against the Pentium, the 68060 could perform better on mixed code, Pentium's decoder could not issue an FP instruction every opportunity and hence the FPU wasn't superscalar as the ALUs were. If the 68060's non-pipelined FPU could accept an instruction, it could be issued one by the decoder. This meant that optimizing for the 68060 was easier, no rules prevented FP instructions from being issued whenever was convenient for the programmer other than well understood instruction latencies. However, with properly optimized and scheduled code, the Pentium's FPU was capable of double the clock for clock throughput of the 68060's FPU.

The 68060 was the last development of the 680x0 series for general purpose use, abandoned in favour of the PowerPC chips. It saw use in some late-model Amiga machines and Amiga accelerator cards as well as some Atari ST clones and a Falcon accelerator board (CT060), and very late models of the Alpha Microsystems multiuser computers before their migration to x86, but Apple Inc. and the Unix world had moved onto various RISC platforms by the time the '060 was available. The 68060 was introduced at 50 MHz on Motorola's 0.6 µm manufacturing process. A few years later it was shrunk to 0.42 µm and clock speed raised to 66 MHz and 75 MHz.

Developments of the basic core continue, intended for embedded systems. Here they are combined with a number of peripheral interfaces to reduce the overall complexity and power requirements of a design. A number of chips, each with different sets of interfaces, are sold under the name ColdFire and DragonBall.

History

The even numbers (68000, 680**2**0, 680**4**0, 680**6**0) were reserved for major revisions to the 680x0 core architecture. The odd numbers (680**1**0, 680**3**0, 680**5**0, 680**7**0) were reserved for upgrades to the architecture of the previous chip. No 68050[262] or 68070 was ever produced by Motorola.

For example, the Motorola 68010 (and the obscure 68012) was a 68000 with improvements to the loop instruction and the ability to suspend then continue an instruction in the event of a page fault, enabling the use of virtual memory with the appropriate MMU hardware. There were, however, no major overhauls of the core architecture. Similarly, the Motorola 68030 was a process improvement on the 68020 with the MMU and a small data cache (256 bytes) moved on-chip. The 68030 was available in speed ratings up to 50 MHz.

The jump from the 68000/68010 to the 68020/68030, however, represented a major overhaul, with too many individual changes to list here.

By the time the 68060 was in production, Motorola had abandoned development of the 680x0-type chips in favour of PowerPC. The 68060 was the last 680x0-type processor from Motorola.

There was a so-called 68070 processor, produced by Signetics (Philips), and was a modestly improved 68000 series processor, with a simple, on-chip MMU and I²C bus support. It came out long before the 68060, and was used mostly as an embedded processor in some consumer electronics items.

Usage

Perhaps its most memorable use was in American broadcast television graphics. Chyron's Infinit!, Max!, and Maxine! series of television character generators used the 68060 as the main processor. These character generators were a fixture on many American television networks' affiliate stations.

In desktops, the 68060 was used in some variants of the Amiga 4000T produced by Amiga Technologies,[263] and available as a third party upgrade for other Amiga models. It was also used in the Amiga clone DraCo non-linear video system.[264]

The 68060 was also used in Nortel Meridian 1 Option 51, 61 and 81 large office PBX systems, powering the CP3 and CP4 core processor boards. A pair of these boards each sporting a 68060 could be used to make the PBX fault tolerant. This was a logical application as previous Meridian 1 cores used other Motorola chips. Nortel has since changed the architecture to use Intel processors.

Also the Motorola Vanguard 6560 multiprotocol router used a 50 MHz 68EC060 processor.

Motorola MVME-17x and Force Computer SYS68K VMEbus systems also used a 68060 CPU.

Variants

- 68060 – CPU with MMU and FPU.
- 68LC060 – CPU with MMU but without FPU.
- 68EC060 – CPU with neither MMU nor FPU.

Technical data

Work frequency	50, 60, 66, 75 MHz
Voltage supply	• Vcore 3.3 V • I/O 5 V
Temperature	−40 °C .. 70 °C (85 °C with the current mask)
Production process	Static-CMOS 0.6 µm and later 0.42 µm
Chip carrier	PGA 206 (compatible with 68040), TBGA 304 31*31*1.7P1.27
Address bus	32 Bit
Data bus	32 bit
Instruction set	CISC
Cache	• 8 kB DCache (4-way associative) • 8 kB ICache (4-way associative) • 96 byte FIFO Instruction Buffer • 256 Entry Branch Cache • 64 Entry ATC MMU Buffer (4-way associative)
Register	• 8 for Address operations • 8 for Data operations
Transistors	~2 500 000
Performance	• ~88 Mips @ 66 MHz • ~110 Mips @ 75 MHz • ~36 MFlops @ 66 MHz

Bibliography

External links

- A paper describing the 68060 architecture

RomDisq

The **RomDisQ** is a fast, solid-state mass storage device that is meant to plug in the **ROM port** of a Sinclair QL or Aurora motherboard. It is a very elegant design and extremely durable and comes in 2, 4 and 8 mebibyte capacities. The RomDisq's firmware was designed by Stuart Honeyball of Miracle Systems for TF Services and its software written by the QL Operating System designer Tony Tebby. The PCB was designed by TF Services.

ZX8301

The **ZX8301** was a ULA integrated circuit designed for the Sinclair QL microcomputer. Also known as the "Master Chip", it provided a Video Display Generator, the division of a 15 MHz crystal to provide the 7.5 MHz system clock, ZX8302 register address decoder, DRAM refresh and bus controller. The ZX8301 was IC22 on the QL motherboard.

The Sinclair Research business model had always been to work toward a maximum performance to price ratio (as was evidenced by the keyboard mechanisms in the QL and earlier Sinclair models). Unfortunately this focus on price and performance often resulted in cost cutting in the design and build of Sinclair's machines. One such cost driven decision (failing to use a hardware buffer IC between the IC pins and the external RGB monitor connection) caused the ZX8301 to quickly develop a reputation for being fragile and easy to damage, particularly if the monitor plug was inserted or removed while the QL was powered up. Such an action resulted in damage to the video circuitry with the ZX8301 almost always requiring replacing.

The ZX8301, when subsequently used in the ICL One Per Desk featured hardware buffering and as a direct result, the ZX8301 ULA was proven to be much more reliable.

External links

- http://www.worldofspectrum.org/qlfaq/Hardware

ZX8302

The **ZX8302** was a ULA integrated circuit designed for the Sinclair QL microcomputer. Also known as the QL's "Peripheral Chip", it interfaced the CPU to the Microdrives, QLAN local area network interface and RS-232 ports (transmit only) and also provided a real-time clock. The ZX8302 was IC23 on the QL motherboard.

External links

- http://www.worldofspectrum.org/qlfaq/Hardware

Gate array

A **gate array** or **uncommitted logic array** (**ULA**) is an approach to the design and manufacture of application-specific integrated circuits (ASICs). Using a prefabricated chip with active devices like AND-gates etc. That is later interconnected according to a custom order by adding metal layers in the factory environment.

Sinclair ZX81 ULA

Design

A gate array circuit is a prefabricated silicon chip circuit with no particular function in which transistors, standard NAND or NOR logic gates, and other active devices are placed at regular predefined positions and manufactured on a wafer, usually called a *master slice*. Creation of a circuit with a specified function is accomplished by adding a final surface layer or layers of metal interconnects to the chips on the master slice late in the manufacturing process, joining these elements to allow the function of the chip to be customized as desired. This layer is analogous to the copper layer(s) of a printed circuit board (PCB).

Gate array master slices are usually prefabricated and stockpiled in large quantities regardless of customer orders. The design and fabrication according to the individual customer specifications may be finished in a shorter time compared with standard cell or full custom design. The gate array approach reduces the mask costs since fewer custom masks need to be produced. In addition manufacturing test tooling lead time and costs are reduced since the same test fixtures may be used for all gate array products manufactured on the same die size. Gate arrays were the predecessor of the more advanced structured ASIC; unlike gate arrays, structured ASICs tend to include predefined or configurable memories and/or analog blocks. Structured ASICs are still sold by companies such as ChipX, Inc.

An application circuit must be built on a gate array that has enough gates, wiring and I/O pins. Since requirements vary, gate arrays usually come in families, with larger members having more of all resources, but correspondingly more expensive. While the designer can fairly easily count how many gates and I/Os pins are needed, the amount of routing tracks needed may vary considerably even among designs with the same amount of logic. (For example, a crossbar switch requires much more routing than a systolic array with the same gate count.) Since unused routing tracks increase the cost (and decrease the performance) of the part without providing any benefit, gate array manufacturers try to provide just enough tracks so that most designs that will fit in terms of gates and I/O pins can be routed. This is determined by estimates such as those derived from Rent's rule or by experiments with existing designs.

Drawbacks

The main drawbacks of gate arrays are their somewhat lower density and performance compared with other approaches to ASIC design. However this style is often a viable approach for low production volumes.

History

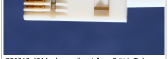
Sinclair Research ported an enhanced ZX80 design to a ULA chip for the ZX81, and later used a ULA in the ZX Spectrum. A compatible chip was made in Russia as T34VG1.[265] Acorn Computers used several ULA chips in the BBC Micro, and later managed to compress almost all of that machine's logic into a single ULA for the Acorn Electron. Many other manufacturers from the time of the home computer boom period used ULAs in their machines. Ferranti in the UK pioneered ULA technology, then later abandoned this lead in semi-custom chips. The IBM PC took over much of the personal computer market, and the sales volumes made full-custom chips more economical.

Designers still wished for a way to create their own complex chips without the expense of full-custom design, and eventually this wish was granted with the arrival of the field-programmable gate array (FPGA), complex programmable logic device (CPLD), and structured ASIC. Whereas a ULA required a semiconductor wafer foundry to deposit and etch the interconnections, the FPGA and CPLD had programmable interconnections.

British telephone sockets

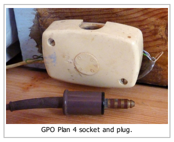
British telephone sockets were introduced in their current plug and socket form on 19 November 1981 by British Telecom to allow subscribers to connect their own telephones. They are governed by British Standard **BS6312.**

They are similar to modular connectors (as used in RJ11), but feature a side-mounted hook, rather than a bottom-mounted one, and are physically incompatible.



BS6312 431A plug; colloquially, a British Telecom plug.

History



GPO Plan 4 socket and plug.

Standard sockets were introduced, as part of the 'New Plan' wiring policy, to allow customers to easily purchase their own telephones, as required by Oftel, the phone regulator. Thus any phone whose plug conformed to BS6312 and met certain other regulatory standards, such as BABT, could be connected to the network, rather than British Telecom controlling the market. The 'New Plan' was only new to the UK and was based extensively on systems which had been available elsewhere for many years, especially in the US.

The new system replaced the older hard-wired system, which came in many 'flavours', e.g. Plans 1, 1A, 1B, 1C, 2, 2A, 105, 107 etc, which could be very complicated and required the attendance at the premises of a GPO telephone-engineer, who needed a complete set of 'N' (wiring) Diagrams, which was very extensive and ran to over 15 volumes of little, black, ring binders. N diagrams also had their own numbering system e.g. a Plan 1A had an N diagram of N4502, and were frequently updated.

From the early years of the 1900's, the GPO (subsequently British Telecom) did have a plug and socket system available for rent (See Plate 3 in the 1909 edition of the Post Office Telegraphs 'Connections of Telephonic Apparatus and Circuits' 1909 edition) It was later called a "Plan 4" (N762 - first edition not later N762!), and employed a heavy-duty, four-way jack plug 404, (circular in cross-section), on the end of the standard, plaited, cotton covered instrument cord. It also had to have a separate Bell-Set which was permanently in-circuit to provide ringing if there were no telephones plugged in. This system survived through various models of telephones from the 'candlestick', 200 and 300 type bakelite phones until the introduction of the 700 series in 1959 when a smaller 'Plug 420' was introduced. The separate bell-set, with its on-board capacitor and coils, also provided a testing circuit for remote engineers, by providing the mandatory 1000ohm, capacitive loop-back. Rental had to be paid on each telephone and on all the sockets, and hence was not that common.

Sockets

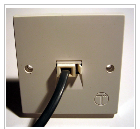
Master socket and NTE-5 Line Box

A domestic single British telephone line installation will have a single master socket or line box in the premises, which is provided by BT or another service provider: this socket is the demarcation point between the customer-owned and maintained on-premises wiring, and the telephone network. For installations using the NTE-5 line box (NTE = network termination equipment), the demarcation point is actually *within* the socket: the lower half of the front plate and associated wiring is the customer's, while the permanent wiring on the non-removable section behind this, remains the responsibility of the service provider. Customers are not permitted to access the wiring in a master socket without a removable lower section. Plug-in extension kits are available for customers with this type of installation.

This master socket contains a high voltage surge protection (SP1) to suppress high voltage spikes etc, a 1.8 µF capacitor (Bell Circuit) to feed the AC ringing and a 470 kΩ resistor (R1 Out of Service Resistor) to provide remote testing when no telephones are plugged into any sockets. Additional internal extension (secondary) sockets are wired off the master socket (connected in parallel using the IDC system) and do not contain the surge protector, bell circuit capacitor and the out-of-service resistor.

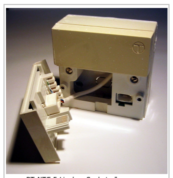
Old style: Fixed plate

The 'old style' fixed master socket (see image at right) had only one set of terminals on the back and customers were supposed to use extension kits plugged into the front socket, however many customers hard-wired their own extensions anyway for neatness and robustness reasons which was a poor arrangement since it provided no way to isolate the customer's internal extension wiring from BT's wiring.



A fixed BT Master Socket front LJ 2/1A that does not allow disconnection of internal wiring with previous 1980-1991 BT "T" logo - surface mounted

New style: Removable plate (NTE5)

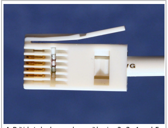


BT NTE 5 Linebox Socket allows easy disconnection of the internal wiring shown with cable attached (internal test jack visible) - surface mounted. Note the previous 1980-1991 BT "T" logo, used from the NTE5's introduction to 1991

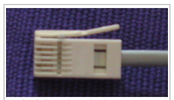
In recent years NTE5 sockets (see image at left) have been fitted in place of master sockets. These have a front plate where the lower-half is removable so allowing customer's access to the terminals required for connecting internal extension sockets; it also provides access to a test jack, to determine if line faults are due to the customer's wiring or BT's. The removable panel also allows the external telephone line to be easily disconnected from the internal wiring, provided the wiring of the premises has been correctly carried out. The terminals on the back part are large screw terminals allowing direct connection to many types of external phone cable; cable companies use a similar socket with insulation-displacement connectors (IDCs) instead of screw terminals on the back piece, known as a CTE5.

Now that BT does not have a monopoly of internal wiring, they make a substantial charge if a fault reported to them turns out to be in the customer's internal/domestic wiring. It is therefore important for the customer to have the facility to check whether any problem or fault is in their internal wiring/equipment or externally in BT's cabling or systems. Since the NTE5 socket represents the official demarcation point between the internal/domestic wiring (at the removable front of the socket which is the customer's responsibility) and the external telephone line/cabling fixed at the rear (which is BT's responsibility) the physical disconnection of the two wirings (made possible by the NTE5's removable front plate) is crucial in identifying faults and allocating responsibility for their rectification.

Plugs



A British telephone plug, with pins 2, 3, 4 and 5.



British telephone plug with only two pins present (2 and 5), from a modem cable

There are two types of modern British Telecom plugs – 431A and 631A.

431A is 4-way and 631A 6-way. They fit a standard "Type 600" telephone socket. There are also plugs with only two contacts commonly seen on modem leads. These are a recent introduction and do not seem to be easily available as separate parts.

The Sinclair QL and 128k ZX Spectrum home computers used type 630W connectors for their serial ports (on the Spectrum 128 and +2, MIDI signals could also be sent from the port). These closely resemble standard 631A connectors but the keying slots on the back of the plug have a different size and position.

The 430A and 630A plugs had the latch on the opposite side of the plug, and were used as headset plugs on some switchboards and as handset connectors on some telephones, eg Ambassador.

The 631A and 630A plugs are also used for connecting sensors to interfaces for computer based measurements in educational environments, the former for connecting analogue sensors and the latter for digital sensors. Companies using these plugs include Vernier, TI and Casio, for interfaces connecting to their graphical calculators, and in the Netherlands CMA. They all use the same pinning.

Connector on phone

The connector on the phone is not standardized: the connector at the wall is standardized by regulation, to allow individuals to use their own phones (interconnection), but the wire from the phone to the wall may be hard-wired to the phone, or use various connectors.

Typically it will have a 6P4C or 6P2C modular connector at the telephone end: this latter may be wired as per the RJ11 standard (with pins 3 and 4), or it may be wired with pins 2 and 5, as a straight through cable from the BT plug (which uses pins 2 and 5 for the line, unlike RJ11, which uses pins 3 and 4). Thus cables are not in general compatible between different phones, as the phone base may have a socket with pins 2 and 5 (requiring a straight through cable), or have an RJ11 socket (requiring a crossover cable).

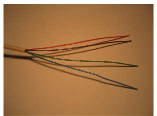
Use in other countries

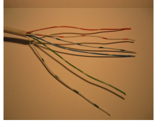
The BS 6312 jack has been used in New Zealand since the 1980s, replacing a number of other connectors and hard-wired connections, and was subsequently replaced by a "2-wire" version suited to daisy chain wiring that eliminated the 3rd ringing voltage wire. The "BT Jack" is still the most common phone jack in use, although many installations in business use structured cabling with "RJ45" 8p8c modular connectors for telephone as well as data services. Since 2010 the TCF Premises Wiring Code of Practice[266] has deprecated BT jacks in favour of "RJ45" modular jacks for all new residential and SOHO phone/data networks, although not yet a mandatory standard in 2011.

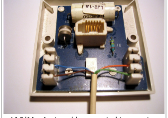
It is also used in Bahrain, Bangladesh, Belize, Botswana, Brunei, Cyprus, Eritrea, the Falkland Islands, Ghana, Gibraltar, Israel, Jordan, Kenya, Kuwait, Lesotho, Malawi, Malta, Myanmar (Burma) , Nigeria, Oman, Qatar, Saudi Arabia, Swaziland, Tanzania, the United Arab Emirates, Zambia, and Zimbabwe. The jack is still found in Hong Kong, where new installations ceased in 1998, while in Saint Vincent and the Grenadines, new installations ceased in 2001, with RJ11 now used instead.

Making the connections

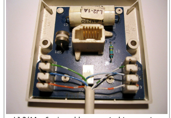
As previously mentioned the actual connections are made using Insulation-displacement connectors (IDC). A punch down tool is required to do this and two sorts are available. One is of plastic construction and only intended for occasional use. The other is a tool manufactured by Krone and is of more robust construction : an example is shown in the photograph. It also comes with a tool for removing wires from sockets. The outer sheath of the cable is removed but the insulation from each wire is left and just placed in the connector. The Krone tool both inserts the wire into the connector and cuts off the excess wire in one action. The action of pushing the wire into the connector cuts into the insulation and makes contact with the wire. A maximum of three wires can be attached to each connector but it is best to stick to two if possible as the third is not usually a good connection.







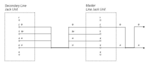
LJ 2/1A - 4 wire cable connected to a master socket - surface mounted

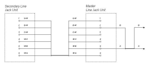


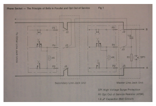
LJ 2/1A - 6 wire cable connected to a master socket - surface mounted

Cabling arrangements

Shown below are the cabling arrangements for both 4-wire and 6-wire cable. Initially 4 wire was used and many older installations still use it, until recent months however the 6-wire was the new standard, but the 4-wire, has now been reissued to all Openreach engineers as part of cost savings. The modern 4 wire is however the same diameter as 6 wire to allow engineers to use existing tacking guns and cable clips. Note that the wires in the 6-wire cable are coloured with two colours in a ratio of four to one in length, with the first colour mentioned being the predominant colour, e.g. if the colour of the wire is W-B then the wire will be coloured White for 12mm, then Blue for 3mm and so on. In other words it looks like a white wire with blue patches on it.







Strictly speaking, a textbook installation will only actually use pins 2, 5 (for the voice) and 3 (for the ringer). Having said this, most modern telephones contain their own ringing capacitor, to cater for badly wired extensions, which means you can usually run your extension wiring with only pins 2 and 5. Often where multi-core cable is used, the remaining cables are used for wiring extensions on additional incoming telephone lines.

Broadband


Replacement face plate for an NTE5 containing a built-in ADSL filter

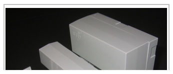

DSL Filter

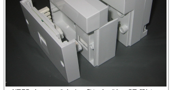
In order to use Broadband internet services simultaneously with voice telephony, it is necessary to use a DSL filter. This is basically two filters, which divide the single line into two discrete channels. Enough bandwidth is retained for voice telephony and the majority is used for high speed data. All phones must be connected via a filter (either a separate filter for each phone or one filter covering multiple phones) to avoid interference between the phones and the DSL signal. Where the data transmission is still unduly audible, using two DSL filters, daisychained in tandem, will eliminate the problem. The DSL modem connects directly to the phone line (most DSL filters have a socket marked DSL that just connects directly through to the incoming phone line). The ringer wire is unnecessary in unfiltered parts of the wiring and its removal can often improve performance and reliability of the broadband service.

When ADSL was first introduced in the UK it was installed by an engineer who replaced the front part of the NTE5 (if the property still had an old style master socket it would be replaced with an NTE5) with one containing a filter. Any hardwired phone extensions were disconnected from the original front part and connected to filtered terminals on the back of the filter. The DSL modem (which at the time was also BT supplied) and, if present, a phone or plug-in extension, could then be plugged into the front. If it was desired to locate the DSL modem away from the master socket a plug-in ADSL extension kit could be purchased.

BT also offered "wires only" ADSL service and promoted the technique of using a separate plug-in filter on every socket.[267] While both technically inferior and far less tidy than the solution BT engineers had used, it was usually adequate and was simple enough for a non technical householder to understand. The more discerning customer can purchase a variety of hardwired filtering products, including replacement front plates for the NTE5, some of which have unfiltered as well as filtered terminals on the back to avoid the need to plug in the extension wiring that leads to the DSL modem.

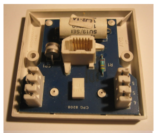
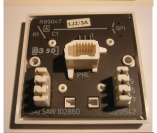
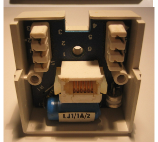
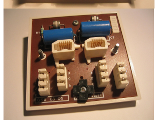
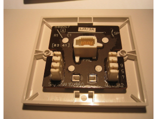
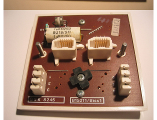
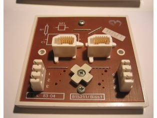
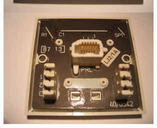
In 2008 BT trialed and launched their 'IPlate'; the "I" is for interstitial, as it is fitted between the socket and the front panel. This plate is fitted by the consumer inside the NTE 5 and reduces interference carried by the 3rd (bell) wire. The reduced interference allows faster broadband speeds - BT claim a speed improvement of up to 1.5 Mbit/s with a theoretical 4 Mbit/s. By November 2009 BT were calling the I-plate a "BT Broadband Accelerator".

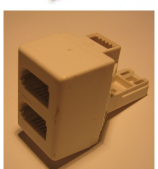
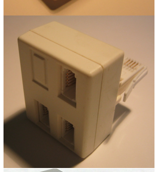
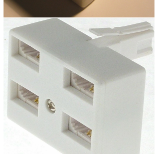




NTE5 showing it being fitted with a BT IPlate. The IPlate is the part in the middle of the sandwich

Socket and adapter gallery

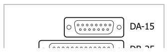
External links

- Wiring diagram
- UK plug and socket telephones
- Using ADSL with extension telephone sockets
- The RJ System of telephone plugs and sockets is gradually replacing the BT System in Hong Kong, Office of the Telecommunications Authority (OFTA), Hong Kong Special Administrative Region Government

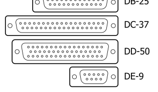
Notes

- "BT claims UK broadband boost breakthrough". The Register. 2008-10-01. Retrieved 2008-10-01.
- *This article was originally based on material from the Free On-line Dictionary of Computing, which is licensed under the GFDL.*

D-subminiature

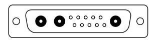


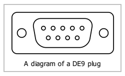
The **D-subminiature** or **D-sub** is a common type of electrical connector. They are named for their characteristic D-shaped metal shield. When they were introduced, D-subs were among the smaller connectors used on computer systems.



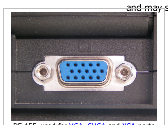
DA, DB, DC, DD, and DE sized connectors

Description, nomenclature, and variants


The DB13W3 Connector with 3 coaxial connections and ten ordinary pins


A diagram of a DE9 plug


Male 13W3 Plug


DE-15F, used for VGA, SVGA and XGA ports

A D-sub contains two or more parallel rows of pins or sockets usually surrounded by a D-shaped metal shield that provides mechanical support, ensures correct orientation, and may screen against electromagnetic interference. The part containing pin contacts is called the *male connector* or *plug*, while that containing socket contacts is called the *female connector* or *socket*. The socket's shield fits tightly inside the plug's shield. The plug also may have screws on either side of the shield that fasten into holes in the socket (although sometimes the screws are on the socket: see the DE9 pictured to the left). When screened cables are used, the shields are connected to the overall screens of the cables. This creates an electrically continuous screen covering the whole cable and connector system.

The D-sub series of connectors was invented by ITT Cannon, part of ITT Corporation, in 1952.[268] Cannon's part-numbering system uses *D* as the prefix for the whole series, followed by one of *A*, *B*, *C*, *D*, or *E* denoting the shell size, followed by the number of pins or sockets, followed by either *P* (plug) or *S* (socket) denoting the gender of the part. Each shell size usually (see below for exceptions) corresponds to a certain number of pins or sockets: A with 15, B with 25, C with 37, D with 50, and E with 9.[269] For example, *DB25* denotes a D-sub with a 25-position shell size and a 25-position contact configuration. The contacts in either row of these connectors are spaced 326/3000 of an inch apart, or approximately 0.109 inches (2.77 mm), and the rows are spaced 0.112 inches (2.84 mm) apart (the pins in the two rows are offset by half the distance between adjacent contacts in a row).[270] The suffixes *M* and *F* (for male and female) are sometimes used instead of the original *P* and *S*.

This naming pattern is not always followed, however. Because personal computers first used DB25 connectors for their serial and parallel ports, when the PC serial port began to use 9-pin connectors, they were often labeled as DB9 instead of DE9 connectors, due to an ignorance of the fact that *B* represented a shell size. It is now common to see DE9 connectors sold as DB9 connectors. *DB9* nearly always refers to a 9-pin connector with an E size shell. The non-standard 23-pin D-sub connectors for external floppy drives and video output on most of the Amiga computers are usually labeled *DB23*, even though their shell size is two pins smaller than ordinary DB sockets.

There are now D-sub connectors which have the original shell sizes, but more pins, and their names follow the same pattern. For example, the DE15, usually found in VGA cables, has 15 pins in three rows, all surrounded by an E size shell. The pins are spaced at 0.090 inches (2.3 mm) horizontally and 0.078 inches (2.0 mm) vertically.[271] The other connectors with the same pin spacing are the DE15, DA26, DB44, DC62, and DD78. Reflecting the same confusion of the letters *DB* with just *D* as mentioned above, these connectors are also often called DB15HD (or even DB15 or HD15), DB26HD, DB44HD, DB62HD, and DB78HD connectors, respectively, where *HD* stands for "high density". They all have three rows of pins, except the DD78, which has four. The "double density" series of D-sub connectors features even denser arrangements and consists of the DE19, DA31, DB52, DC79, and DD100. These each have four rows of pins.

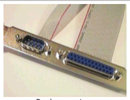
Cannon also produced "hybrid" D-subs with larger contacts in place of some of the normal contacts that could be used for high-current, high-voltage, or co-axial inserts. The DB13W3 variant was commonly used for high-performance video connections; this variant provided 10 regular (#20) pins plus three coaxial contacts for the red, green, and blue video signals. Hybrid D-subs are currently being manufactured in a broad range of configurations by other companies, including Amphenol, Conec, Teledyne Reynolds, Assmann Electronics, Norcomp, Cinch, 3M, and Tyco. Some variants have current ratings up to 40A or operating voltages as high as 13,500V; others are waterproof and meet IP67 standards.

A smaller type of connector derived from the D-sub is called the microminiature D, or micro-D, which is a trademark of ITT Cannon. It is about half the length of a D-sub.

There is yet another similar family of connectors that is easy to confuse with the D-sub family. These connectors have names like *HD50* and *HD68*, and have a D-shaped shell that is about half the width of a DB25. They are common in SCSI attachments.

The original D-sub connectors are now defined by an international standard, IEC 60807-3 / DIN 41652. The United States military also maintains another specification for D-subminiature connectors, the MIL-DTL-24308 standard.[272]

Typical applications



D-sub connectors.
The connector on the left is a 9-pin male (DE9M) connector plug, and the one on the right is a 25-pin female (DB25F) socket. The hexagonal pillars (4-40 bolt) at either end of each connector have a threaded stud (not visible) that passes through flanges on the connector, fastening it to the metal panel. They also have a threaded hole that receives the jackscrews on the cable shell, to hold the plug and socket together.

Communications ports

The widest application of D-subs is for RS-232 serial communications, though the standard did not make this connector mandatory. RS-232 devices originally used the DB25, but for many applications the less common signals were omitted, allowing a DE9 to be used. The standard specifies a male connector for terminal equipment and a female connector for modems, but many variations exist. IBM PC-compatible computers tend to have male connectors at the device and female connectors at the modems. Early Apple Macintosh models used DE9 connectors for RS-422 serial interfaces (which can operate as RS-232). Later Macintosh models use 8-pin miniature DIN connectors instead.

On PCs, 25-pin and (beginning with the IBM-PC/AT) 9-pin plugs are used for the RS-232 serial ports; 25-pin sockets are used for the parallel printer ports (instead of the Centronics socket found on the printer itself).

Many uninterruptible power supply units have a DE9F connector on them in order to signal to the attached computer via an RS-232 interface. Often these do not send data serially to the computer but instead use the handshaking control lines to indicate low battery, power failure, or other conditions. Such usage is not standardized between manufacturers and may require special cables.

Network ports

DE9 connectors were used for some token ring networks as well as other computer networks.

The Attachment Unit Interfaces that were used with 10BASE5 "thick net" in the 1980s and 1990s used DA15 connectors for connectivity between the Medium Attachment Units and (Ethernet) network interface cards, albeit with a sliding latch to lock the connectors together instead of the usual hex studs with threaded holes. (The sliding latch was intended to be quicker to engage and disengage and to work in places where jack screws could not be used for reasons of component shape.

Computer video output

A male DE9 connector.

A female 9-pin connector on an IBM compatible personal computer may be a video display output such as MDA, Hercules, CGA, or EGA (rarely VGA or others). Even though these all use the same DE9 connector, the displays cannot all be interchanged and monitors or video interfaces may even be damaged if connected to an incompatible device using the same connector.

Later analog video (VGA and later) adapters generally replaced these connectors with DE15 high-density sockets (though some early VGA devices still used DE9 connectors). DE15 connectors are similar to DE9 connectors (see above).

Many Apple Macintosh models (beginning with the Macintosh II) used DA15 sockets for analogue RGB video out. Just prior to this, the Apple IIgs used the same connector for the same purpose, but in a non-compatible way. A digital (and thus also incompatible) RGB adapter for the Apple IIe also used a DA15F. And the Apple IIc used a DA15F for an auxiliary video port which was not RGB, but provided the necessary signals to derive RGB.

Game controller ports

Starting in the late 1970s the Atari 2600 game console used DE9 connectors without the pair of fastening screws (male on the system, female on the controller) for its game controller connectors. In the years following, various video game consoles and home computers adopted the connector for their own game ports, though they were not all interoperable. The common wirings supported digital connections for up, down, left, and right buttons along with one or two others. Some systems supported connecting a pair of analog potentiometers, or paddles, and on some computers a computer mouse or a light pen was also supported via the game port. Like joysticks, these devices were not typically interchangeable between different systems.

Systems utilizing the DE9 connector for their game port included the Atari 8-bit and ST lines; the Commodore VIC-20, 64, 128, and Amiga; the Amstrad CPC (which employed daisy-chaining when connecting two Amstrad-specific joysticks); the MSX, Sharp X68000, and FM-Towns, predominantly used in Japan; the Sega Master System and Sega Genesis; and the Panasonic 3DO. The Sinclair ZX Spectrum lacked a built-in joystick connector of any kind but aftermarket interfaces provided the ability to connect DE9 joysticks.

Many Apple II computers also used DE9 connectors for joysticks, but they had a female port on the computer and a male on the controller, used analog rather than digital sticks, and the pin-out was completely unlike that used on the aforementioned systems. DE9 connectors were not used for game ports on the Apple Macintosh, Apple III, IBM PC systems, or most newer game consoles.

DA15S connectors are used for PC joystick connectors, where each DA15 connector supports two joysticks each with two analog axes and two buttons. In other words, one DA15S "game adapter" connector has 4 analog potentiometer inputs and 4 digital switch inputs. This interface is strictly input-only, though it does provide +5V DC power. Some joysticks with more than two axes and/or more than two buttons use the signals designated for both joysticks. Conversely, Y-adapter cables are available that allow two separate joysticks to be connected to a single DA15 game adapter port; if a joystick connected to one of these Y-adapters has more than two axes or buttons, only the first two of each will work.

The IBM DA15 PC game connector has been modified to add a (usually MPU-401 compatible) MIDI interface, and this is often implemented in the game connectors on third-party sound cards, for example the Sound Blaster line from Creative Labs. The "standard" straight game adapter connector (introduced by IBM) has three ground pins and four +5V power pins, and the MIDI adaptation replaces one of the grounds and one of the +5V pins, both on the bottom row of pins, with MIDI In and MIDI Out signal pins. (There is no MIDI Thru provided.) Creative Labs introduced this adaptation.

Other

25-pin sockets on Macintosh computers are typically SCSI connectors (again in contrast to the Centronics C50 connector typically found on the peripheral), while older Sun hardware uses DD50 connectors for FastSCSI equipment.

The complete range of D-sub connectors also includes DA15s (one row of 7 and one of 8), DC37s (one row of 18 and one of 19), and DD50s (two rows of 17 and one of 16); these are often used in industrial products, the 15-way version being commonly used on rotary and linear encoders.

The early Macintosh and late Apple II computers used an obscure 19-pin D-sub for connecting to external floppy disk drives. The Commodore Amiga used an equally unusual 23-pin version for both its video output and connection to an external floppy disk drive.

TASCAM used DB25 connectors for their multi-track recording audio equipment (TDIF), and Logitek Audio later did the same for its broadcast consoles, though with different pinouts.[273] Roland used DB25 connectors for their multi-track recording audio equipment (R-BUS). A few patch panels have been made which have the DB25 connectors on the back with phone jacks (or even TRS jacks) on the front, however these are normally wired for TASCAM, which is more common outside of broadcasting.

In broadcast and professional video, "parallel digital" is a digital video interface that uses DB25 connectors, per the SMPTE 274M specification adopted in the late 1990s. The more common SMPTE 259M "serial digital interface" (SDI) uses BNC connectors for digital video signal transfer.

Wire-contact attachment types


A male PCB-mounting DD50 connector

There are at least five different methods used to attach wires to the contacts in D-sub connectors.

- *Solder-bucket* (or *solder-cup*) contacts have a cavity into which the stripped wire is inserted and hand-soldered.
- *Insulation displacement* contacts (IDCs) allow a ribbon cable to be forced onto sharp tines on the back of the contacts; this action pierces the insulation of all the wires simultaneously. This is a very quick means of assembly whether done by hand or automatically.
- *Crimp* contacts are assembled by inserting a stripped wire end into a cavity in the rear of the contact, then crushing the cavity using a crimp tool, causing the cavity to grip the wire tightly at many points. The crimped contact is then inserted into the connector where it locks into place. Individual crimped pins can be removed later by inserting a special tool into the rear of the connector.
- *PCB pins* are soldered directly to a printed circuit board and not to a wire. These connectors are frequently mounted at a right angle to the PCB, allowing a cable to be plugged into the edge of the PCB assembly.
- *Wire wrap* connections are made by wrapping solid wire around a square post with a wire wrap tool. This type of connection is usually used in prototyping.

Usage

The 25-pin D-sub connector is occasionally used in recording studios for multi-channel analog audio and AES digital audio.

The D-sub connector family is now in decline for general usage in the computer industry, due to size and cost. For portable devices such as PDAs, MP3 players or mobile phones, the D-sub connector is usually too large to fit. In the laptop computer sector, where weight and size are crucial, many models no longer include D-subs. Even small form factor desktop PCs may find D-sub connectors too large for their value.

Because of its relative complexity (the D-shaped metal shield, the screws and nuts), D-sub connectors are now quite expensive compared to other, mostly simpler, common connectors. In the retail PC world where margins are very thin, these connectors are a natural target for removal.

The physical design of D-sub connectors is ill-suited for consumer plug-and-play applications. Thin metal pins, especially in higher-density connectors, are easily bent or broken, particularly if frequently plugged in by touch behind equipment. The need to tighten screws for a secure connection is cumbersome. Although ESD- and EMI-resistant D-sub connectors exist, the fundamental design was never intended to protect from electrostatic discharge or electromagnetic interference or facilitate very high frequency interconnections.

For video purposes, the DE15HD connector is in the process of being replaced by DVI and HDMI connectors. A notable exception to this replacement is on the many analog CRT monitors still in use: the analog version of the DVI connector is similar in price and more complex than the D-sub, so the shift away from D-subs is slow in this case. For the majority of other consumer applications, D-sub serial and parallel connectors have been replaced by the physically much simpler and cheaper IEEE 1394 (FireWire), SATA, USB, or modular connectors.

See also

- Gender of connectors and fasteners
- RS-232 Technical Manual
- Micro ribbon
- MMJ
- Game port

External links

- Comprehensive DB25 wiring diagrams: Tascam, Apple, SCSI, etc..
- Ishmael Stefanov-Wagner's web page on D-Subminiature Nomenclature at the Wayback Machine (*archived January 11, 2009*)
- A list of common computer connectors, including most D-sub
- Devices with DE-9 connectors
- DE-9 Connector RS-232 Pinout

Other Sinclair Computers

Sinclair BASIC

Sinclair BASIC	
Appeared in	1979
Developer	Nine Tiles Networks, Sinclair
Platform	ZX80, ZX81, ZX Spectrum
License	Proprietary

Sinclair BASIC (taking its name from innovator Sir Clive Sinclair) is a dialect of the BASIC programming language used in the 8-bit home computers from Sinclair Research and Timex Sinclair. The Sinclair BASIC interpreter was made by Nine Tiles Networks Ltd.[274]

Originally developed in 1979 to fit in the 4 kB ROM of the ZX80, it was initially an incomplete implementation of the 1978 ANSI minimal BASIC standard and evolved through the 8 kB ROM ZX81 and TS1000 to be an almost complete version in the 16 kB ROM ZX Spectrum.

Original Sinclair BASIC

Reserved words

On the ZX Spectrum, there are 86 reserved words in Sinclair BASIC, denoting commands (of which there were 50), functions (31), and *other keywords* (5). They are entered via Sinclair's somewhat unorthodox keyword entry system. The most common commands require just a single keystroke; for example, pressing P causes the entire command PRINT to appear. Less frequent commands require more complex key sequences: BEEP (for example) is keyed by pressing CAPS SHIFT plus SYMBOL SHIFT to access extended mode (later models include an EXTENDED MODE key), keeping SYMBOL SHIFT held down and pressing Z. Keywords are colour-coded on the keyboard to indicate which SHIFT-sequence is required.

- ABS, ACS, AND[1], ASN, *AT*, ATN, ATTR, BEEP, BIN, BORDER, BRIGHT[7], CAT[2], CHR$[3], CIRCLE, CLEAR, CLOSE#[2], CLS, CODE[3], CONTINUE, COPY, COS, DATA, DEF FN, DIM, DRAW, ERASE[2], EXP, FLASH[7], FN, FOR, FORMAT[2], GO SUB, GO TO, IF[4], IN, INK[7], INKEY$[3], INPUT, INT, INVERSE[7], LEN, LET[5], *LINE*, LIST, LLIST, LN, LOAD, LPRINT, MERGE, MOVE[2], NEW, NEXT, NOT[1], OPEN#[2], OR[1], OUT, OVER[7], PAPER[7], PAUSE, PEEK, PI, PLOT, POINT, POKE, PRINT, RANDOMIZE, READ, REM, RESTORE, RETURN, RND, RUN, SAVE, SCREEN$[3], SGN, SIN, SQR, *STEP*, STR$[3], *TAB*, TAN, *THEN* [4], TO, USR, VAL[3, 6], VAL$[3], VERIFY

Commands found exclusively on the ZX81 and its clones, the TS1000 and TS1500 are:

- FAST, SCROLL, SLOW, UNPLOT, GOSUB, GOTO (vs the Spectrum's functionally identical GO SUB, GO TO)

On the ZX Spectrum each reserved word was assigned a character code between 165 and 255 in the latter half of the system character set, and expanded by referencing a token table held in ROM. As a result, any reserved word in a program listing occupied just one byte of memory, a significant saving over traditional letter-by-letter storage. This also meant that the BASIC interpreter could quickly determine any command or function by evaluating a single byte.
The 128k Spectrum models—the ZX Spectrum 128, +2, +3, +2A, and +2B—introduced a conventional letter-by-letter BASIC input system, and two new commands, neither of which was present in or recognised by the machine's legacy version of 48k BASIC:

- PLAY (which operated the 128k models' AY-3-8910 music chip)
- SPECTRUM (which switched the 128k Spectrum into a 48k Spectrum compatibility mode)

The original Spanish ZX Spectrum 128 included four additional commands in Spanish,[275] one of which was undocumented. These can be translated as:

- EDIT (to edit a line number or invoke the full screen string editor)
- RENUM (to renumber the program lines)
- DELETE (to delete program lines)
- WIDTH (to set the column width of the RS232 device, but undocumented as the code was broken)

Notes

1. The AND, NOT, and OR functions are logical operators.
2. CAT, ERASE, FORMAT and MOVE were originally designed to be used with peripherals, but at the launch of ZX Spectrum, they had not been completely implemented, such that their use generated an error message (Invalid Stream). Later with the aid of the ZX Interface 1 shadow ROM, they were used for the ZX Microdrive. (The shadow ROM was paged when the BASIC interpreter detected a syntax error, which is why most ZX Microdrive commands use a "*").
3. String variable names must consist of only one alphabetical character.
   Thus, LET A=5, LET Apples=5, and LET A$="Hello" are all good, while LET APPLES$="Fruit" is not.
4. Unlike most other BASIC dialects, Sinclair Basic did not include the ELSE operator in the IF–THEN(–ELSE) clause.
   Thus, instead of
   ```
   10 IF V=5 THEN GO TO 50 ELSE GO TO 100
   ```
   it is
   ```
   10 IF V=5 THEN GO TO 50
   20 GO TO 100
   ```
5. LET is compulsory (i.e., LET A=1 but never A=1). This practice is also different from most other BASIC dialects.
6. The VAL function does not just evaluate numbers, but also evaluates full expressions. For example, PRINT VAL(A$) will output 14 when given an A$ of "3*3+4+COS(0)". VAL$ does the same but returns a string.
7. INK, PAPER, FLASH, BRIGHT, OVER and INVERSE set attributes for outputting text and graphics to the screen. They can be used either as commands, to apply to all subsequent output until set again, or within a PRINT statement, to apply only from that point until the end of the statement.
8. Machine code could be executed using the USR function, the value provided being the start address of the machine code to execute and the return value being the contents of the BC register pair (unlike most other Z-80 based computers that returned the value of the HL register pair). thus:
   ```
   LET A=USR 30000
   ```
   would jump to and begin executing the machine code starting at memory address 30000, and on successful completion would store the value of the BC register pair into the variable A which can then be used by the programmer.

Unlike the LEFT$(), MID$() and RIGHT$() functions used in the ubiquitous Microsoft BASIC dialects for home computers, parts of strings in Sinclair BASIC are accessed in a manner similar to arrays. For example, A$ (5 TO 10) will give a substring starting with the 5th and ending with the 10th character of A$. As with modern programming languages such as Python, it was therefore possible to replace the LEFT$() and RIGHT$() commands simply by omitting the left or right array position respectively; for instance A$ (TO 5) is equivalent to LEFT$(A$,5).

Timex BASIC

The **Timex BASIC** dialect, used on the Spectrum-compatible TS2068, but not the TC2048, which used the ordinary Sinclair BASIC, has the following six keywords as well as the ordinary Sinclair BASIC ones:

- DELETE deletes BASIC program line ranges. SHIFT + 0 with the K cursor produces the command DELETE.
- FREE is a function that gives the amount of free RAM. PRINT FREE will show how much RAM is free.
- ON ERR is an error detection function mostly used as ON ERR GO TO or ON ERR CONT.
- RESET can be used to reset the behaviour of ON ERR. It was also intended to reset peripherals.
- SOUND controls the AY-3-8192 sound chip.
- STICK is a function that gives the position of the internal joystick (Timex Sinclair 2090).

Timex of Portugal released a software extension called BASIC64 to allow better Basic programming with the advanced 512x192 graphic mode available only on Timex 2000 series computers. This extension added commands and do a complete memory remap to avoid the system to overwrite the extended screen memory area. Two versions existed: a version for TC2048 and a version for TS/TC2068 because they have different memory map.

References

- **Notes**

- Vickers, Steven (1982). *Sinclar ZX Spectrum BASIC Programming*. Sinclair Research.
- Ardley, Neil (1984). *Sinclair ZX Spectrum+ User Guide*. Dorling Kindersley in association with Sinclair Research. ISBN 0-86318-080-9.

External links

- Sinclair ZX Spectrum BASIC Programming — The original 1982 manual by Steven Vickers (referenced above)
- Sinclair ZX81 Basic Programming — also by Vickers
- The History of Sinclair BASIC — By Andrew Owen
- Timex Computer World — Basic 64 user manual for Timex Computer 2048

ZX Spectrum

An issue 2 1982 ZX Spectrum

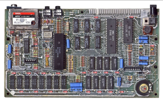
Release date	April 23, 1982
Discontinued	1992[276]
Media	Cassette tape
Operating system	Sinclair BASIC
CPU	Z80 @ 3.5 MHz and equivalent
Memory	16 kB / 48 kB / 128 kB
Predecessor	ZX81
Successor	QL

The **ZX Spectrum** (the "Z" is pronounced "Zed" from its original British English branding) is an 8-bit personal home computer released in the United Kingdom in 1982 by Sinclair Research Ltd. Referred to during development as the *ZX81 Colour* and *ZX82*,[277 278] the machine was launched as the *ZX Spectrum* by Sinclair to highlight the machine's colour display, compared with the black-and-white of its predecessor, the Sinclair ZX81.[279] The Spectrum was ultimately released as eight different models, ranging from the entry level model with 16 kB RAM released in 1982 to the ZX Spectrum +3 with 128 kB RAM and built in floppy disk drive in 1987; together they sold in excess of 5 million units worldwide (not counting clones, which were numerous).[280]

The Spectrum was among the first mainstream audience home computers in the UK, similar in significance to the Commodore 64 in the USA. The introduction of the ZX Spectrum led to a boom in companies producing software and hardware for the machine,[281] the effects of which are still seen;[282] some credit it as the machine which launched the UK IT industry.[283] Licensing deals and clones followed, and earned Clive Sinclair a knighthood for "services to British industry".[284]

The Commodore 64, BBC Microcomputer and later the Amstrad CPC range were major rivals to the Spectrum in the UK market during the early 1980s. Over 20,000 software titles have been released since the Spectrum's launch and new titles continue to be released, with over 90 new ones in 2010.

Hardware



ZX Spectrum 48K motherboard (Issue 3B — 1983, heat sink removed)

The Spectrum is based on a Zilog Z80A CPU running at 3.5 MHz (or NEC D780C-1 clone). The original model Spectrum has 16 kB (16×1024 bytes) of ROM and either 16 kB or 48 kB of RAM. Hardware design was by Richard Altwasser of Sinclair Research, and the machine's outward appearance was designed by Sinclair's industrial designer Rick Dickinson.[285]

Video output is through an RF modulator and was designed for use with contemporary portable television sets, for a simple colour graphic display. Text can be displayed using 32 columns × 24 rows of characters from the ZX Spectrum character set or from a set provided within an application, from a palette of 15 shades: seven colours at two levels of brightness each, plus black.[286] The image resolution is 256×192 with the same colour limitations.[287] To conserve memory, colour is stored separate from the pixel bitmap in a low resolution, 32×24 grid overlay, corresponding to the character cells. Altwasser received a patent for this design.[288]

An "attribute" consists of a foreground and a background colour, a brightness level (normal or bright) and a flashing "flag" which, when set, causes the two colours to swap at regular intervals.[289] This scheme leads to what was dubbed *colour clash* or *attribute clash* with some bizarre effects in the animated graphics of arcade style games. This became a distinctive feature of the Spectrum and an in-joke among Spectrum users, as well as a point of derision by advocates of other systems. Other machines available around the same time, for example the Amstrad CPC, did not suffer from this limitation. The Commodore 64 used colour attributes in a similar way, but a special multicolour mode, hardware sprites and hardware scrolling were used to avoid attribute clash.

Sound output is through a beeper on the machine itself. This is capable of producing one channel with 10 octaves. The machine also includes an expansion bus edge connector and audio in/out ports for the connection of a cassette recorder for loading and saving programs and data.

Firmware

The machine's Sinclair BASIC interpreter is stored in ROM (along with fundamental system-routines) and was written by Steve Vickers on contract from Nine Tiles Ltd. The Spectrum's chiclet keyboard (on top of a membrane, similar to calculator keys) is marked with BASIC keywords, so that, for example, pressing "G" when in programming mode would insert the BASIC command GOTO.[290]

The BASIC interpreter was developed from that used on the ZX81 and a ZX81 BASIC program can be typed into a Spectrum largely unmodified, but Spectrum BASIC included many extra features making it easier to use. The ZX Spectrum character set was expanded from that of the ZX81, which did not feature lower-case letters. Spectrum BASIC included extra keywords for the more advanced display and sound, and also supported multi-statement lines. The cassette interface was also much more advanced, saving and loading around four times faster than the ZX81, and much more reliably. As well as being able to save programs, the Spectrum could in addition save the contents of arrays, the contents of the screen memory, and the contents of any defined range of memory addresses.

Sinclair Research models

ZX Spectrum 16K/48K (Dimensions (mm): 233×144×30 (W×H×D) @ ~552 grams).[291]

ZX Spectrum+ (Dimensions (mm): 319×149×38 (W×H×D))[292]

ZX Spectrum 128

Pre-production designs

Rick Dickinson came up with a number of designs for the "ZX82" project before the final ZX Spectrum design. A number of the keyboard legends changed during the design phase including *ARC* becoming *CIRCLE*, *FORE* becoming *INK* and *BACK* becoming *PAPER*.[293]

ZX Spectrum 16K/48K

The original ZX Spectrum is remembered for its rubber keyboard, diminutive size and distinctive rainbow motif. It was originally released in 1982 with 16 kB of RAM for £125 Sterling or with 48 kB for £175;[294] these prices were later reduced to £99 and £129 respectively.[295] Owners of the 16 kB model could purchase an internal 32 kB RAM upgrade, which for early "Issue 1" machines consisted of a daughterboard. Later issue machines required the fitting of 8 dynamic RAM chips and a few TTL chips. Users could mail their 16K Spectrums to Sinclair to be upgraded to 48 kB versions. To reduce the price, the 32 kB extension used eight faulty 64 kilobit chips with only one half of their capacity working and/or available. Links on the PCB were configured accordingly so as to place these faulty memory locations in the other (unused) half of each IC.[296] External 32 kB RAM packs that mounted in the rear expansion slot were also available from third parties. Both machines had 16 kB of onboard ROM.

About 60,000 "Issue 1" ZX Spectrums were manufactured; they can be distinguished from later models by the colour of the keys (light grey for Issue 1, blue-grey for later models).[297]

ZX Spectrum+

Planning of the **ZX Spectrum+** started in June 1984,[298] and the machine was released in October the same year.[299] This 48 kB Spectrum (development code-name *TB*[300]) introduced a new QL-style case with an injection-moulded keyboard and a reset button that was basically a switch that shorted across the CPU reset capacitor. Electronically, it was identical to the previous 48 kB model. It was possible to change the system boards between the original case and the Spectrum+ case. It retailed for £179.95.[301] A DIY conversion-kit for older machines was also available. Early on, the machine outsold the rubber-key model 2:1;[302] however, some retailers reported a failure rate of up to 30%, compared with a more usual 5-6%.[303]

ZX Spectrum 128

Sinclair developed the **ZX Spectrum 128** (code-named *Derby*) in conjunction with their Spanish distributor Investrónica.[304] Investrónica had helped adapt the ZX Spectrum+ to the Spanish market after the Spanish government introduced a special tax on all computers with 64 kB RAM or less,[305] and a law which obliged all computers sold in Spain to support the Spanish alphabet and show messages in Spanish.[306]

The appearance of the ZX Spectrum 128 was similar to the ZX Spectrum +, with the exception of a large external heatsink for the internal 7805 voltage regulator added to the right hand end of the case, replacing the internal heatsink in previous versions.

New features included 128 kB RAM, three-channel audio via the AY-3-8912 chip, MIDI compatibility, an RS-232 serial port, an RGB monitor port, 32 kB of ROM including an improved BASIC editor, and an external keypad.

The machine was simultaneously presented for the first time and launched in September 1985 at the SIMO '85 trade show in Spain, with a price of 44,250 pesetas. Because of the large number of unsold Spectrum+ models, Sinclair decided not to start selling in the UK until January 1986 at a price of £179.95.[307] No external keypad was available for the UK release, although the ROM routines to use it and the port itself remained.

The Z80 processor used in the Spectrum has a 16-bit address bus, which means only 64 kB of memory can be directly addressed. To facilitate the extra 80 kB of RAM the designers used bank switching so that the new memory would be available as eight pages of 16 kB at the top of the address space. The same technique was also used to page between the new 16 kB editor ROM and the original 16 kB BASIC ROM at the bottom of the address space.

The new sound chip and MIDI out abilities were exposed to the BASIC programming language with the command *PLAY* and a new command *SPECTRUM* was added to switch the machine into 48K mode, keeping the current BASIC program intact (although there is no way to switch back to 128K mode). To enable BASIC programmers to access the additional memory, a RAM disk was created where files could be stored in the additional 80 kB of RAM. The new commands took the place of two existing user-defined-character spaces causing compatibility problems with some BASIC programs.

The ZX Spectrum 128 had no internal speaker like its predecessors. The sound was produced from the television speaker instead.

The Spanish version had the "128K" logo in white while the English one had the same logo in red.

Amstrad models

ZX Spectrum +2

ZX Spectrum +2A

ZX Spectrum +3

ZX Spectrum +2

The **ZX Spectrum +2** was Amstrad's first Spectrum, coming shortly after their purchase of the Spectrum range and "Sinclair" brand in 1986. The machine featured an all-new grey case featuring a spring-loaded keyboard, dual joystick ports, and a built-in cassette recorder dubbed the "Datacorder" (like the Amstrad CPC 464), but was in most respects identical to the ZX Spectrum 128. The main menu screen lacked the Spectrum 128's "Tape Test" option, and the ROM was altered to account for a new 1986 Amstrad copyright message. These changes resulted in minor incompatibility problems with software that accessed ROM routines at certain addresses. Production costs had been reduced and the retail price dropped to £139–£149.[308]

The new keyboard did not include the BASIC keyword markings that were found on earlier Spectrums, except for the keywords *LOAD*, *CODE* and *RUN* which were useful for loading software. This was not a major issue however, as the +2 boasted a menu system, almost identical to the ZX Spectrum 128, where one could switch between 48k BASIC programming with the keywords, and 128k BASIC programming in which all words (keywords and otherwise) must be typed out in full (although the keywords are still stored internally as one character each). Despite these changes, the layout remained identical to that of the 128.

The ZX Spectrum +2 power supply was a grey version of the ZX Spectrum + and 128 power supply.

ZX Spectrum +2A

The **ZX Spectrum +2A** was produced to homogenise Amstrad's range in 1987. Although the case reads "ZX Spectrum +2", the +2A/B is easily distinguishable from the original +2 as the case was restored to the standard Spectrum black.

The +2A was derived from Amstrad's +3 4.1 ROM model, using a new motherboard which vastly reduced the chip count, integrating many of them into a new ASIC. The +2A replaced the +3's disk drive and associated hardware with a tape drive, as in the original +2. Originally, Amstrad planned to introduce an additional disk interface, but this never appeared. If an external disk drive was added, the "+2A" on the system OS menu would change to a +3. As with the ZX Spectrum +3, some older 48K, and a few older 128K, games were incompatible with the machine.

The ZX Spectrum +2A had a more substantial power supply compared to previous models. This powers supply was slightly larger with air vents and a DIN plug to supply +/- 5 volts and +/- 12 volts. This supply could also be used with the +2B and +3. However, the power supply purchased with the +2A/B had "Sinclair +2" written on the case.

ZX Spectrum +2B

Early Black +2 case mouldings bear the legend "128K Spectrum +2A Made in Taiwan", but in later examples this changed to "128K Spectrum +2B Made in China".

ZX Spectrum +3

The **ZX Spectrum +3** looked similar to the +2 but featured a built-in 3-inch floppy disk drive (like the Amstrad CPC 6128) instead of the tape drive, and was in a black case. It was launched in 1987, initially retailed for £249[309] and then later £199[310] and was the only Spectrum capable of running the CP/M operating system without additional hardware.

The +3 saw the addition of two more 16 kB ROMs. One was home to the second part of the reorganised 128 ROM and the other hosted the +3's disk operating system. This was a modified version of Amstrad's AMSDOS, called +3DOS. These two new 16 kB ROMs and the original two 16 kB ROMs were now physically implemented together as two 32 kB chips. To be able to run CP/M, which requires RAM at the bottom of the address space, the bank-switching was further improved, allowing the ROM to be paged out for another 16 kB of RAM.

Such core changes brought incompatibilities:

- Removal of several lines on the expansion bus edge connector (video, power, and IORQGE); caused many external devices problems; some such as the VTX5000 modem could be used via the "FixIt" device.
- Dividing ROMCS into 2 lines, to disable both ROMs
- Reading a non-existent I/O port no longer returned the last attribute; caused some games such as *Arkanoid* to be unplayable
- Memory timing changes; some of the RAM banks were now contended causing high-speed colour-changing effects to fail
- The keypad scanning routines from the ROM were removed
- move 1 byte address in ROM

Some older 48K, and a few older 128K, games were incompatible with the machine. The ZX Interface 1 was incompatible due to differences in ROM and expansion connector; therefore it was not possible to connect and use the Microdrive units.

The ZX Spectrum +3 had an identical power supply to the +2A/B. This supply could also be used with the +2A/B. However, the power supply purchased with the +3 had "Sinclair +3" written on the case.

Production of the +3 ceased in December 1990. Although still accounting for one third of all home computer sales in the UK at the time, production of the model was ceased by Amstrad at that point.

Clones


Didaktik M

Sinclair licensed the Spectrum design to Timex Corporation in the United States. An enhanced version of the Spectrum with better sound, graphics and other modifications was marketed in the USA by Timex as the Timex Sinclair 2068. Timex's derivatives were largely incompatible with Sinclair systems. However, some of the Timex innovations were later adopted by Sinclair Research. A case in point was the abortive *Pandora* portable Spectrum, whose ULA had the high resolution video mode pioneered in the TS2068. *Pandora* had a flat-screen monitor and Microdrives and was intended to be Sinclair's business portable. After Amstrad bought the computer business of Sinclair Research, Sir Clive retained the rights to the *Pandora* project, and it evolved into the Cambridge Computer Z88, launched in 1987.[311]

In the UK, Spectrum peripheral vendor Miles Gordon Technology (MGT) released the SAM Coupé as a potential successor with some Spectrum compatibility. However, by this point, the Commodore Amiga and Atari ST had taken hold of the market, leaving MGT in eventual receivership.

Many unofficial Spectrum clones were produced, especially in the former Eastern Bloc countries (e.g. in Romania, several models were produced (Tim-S, HC85, HC91, Cobra, Junior, CIP, CIP 3, Jet), some featuring CP/M and a 5.25"/3.5" floppy disk) and South America (e.g. Microdigital TK 90X and TK 95). In the Soviet Union, ZX Spectrum clones were assembled by thousands of small start-ups and distributed through poster ads and street stalls. Over 50 such clone models existed.[312] Some of them are still being produced, such as the *Pentagon* and *ATM Turbo*. In India, Decibells Electronics introduced a licensed version of the Spectrum+ in 1986. Dubbed the "db Spectrum+", it did reasonably well in the Indian market and sold quite a few thousand until 1990 when the market died away.

Peripherals

Several peripherals for the Spectrum were marketed by Sinclair: the ZX Printer was already on the market,[313] as the ZX Spectrum expansion bus was backwards-compatible with that of the ZX81.

The ZX Interface 1 add-on module included 8 kB of ROM, an RS-232 serial port, a proprietary LAN interface (called ZX Net), and an interface for the connection of up to eight ZX Microdrives – somewhat unreliable but speedy tape-loop cartridge storage devices released in July 1983.[314] [315] These were later used in a revised version on the Sinclair QL, whose storage format was electrically compatible but logically incompatible with the Spectrum's. Sinclair also released the ZX Interface 2 which added two joystick ports and a ROM cartridge port.[316]

There were also a plethora of third-party hardware addons. The better known of these included the Kempston joystick interface, the Morex Peripherals Centronics/RS-232 interface, the Currah Microspeech unit (speech synthesis),[317] Videoface Digitiser,[318] RAM pack, the Cheetah Marketing SpecDrum,[319] a drum machine, and the Multiface,[320] a snapshot and disassembly tool from Romantic Robot. Keyboards were especially popular in view of the original's notorious "dead flesh" feel.[321]

There were numerous disk drive interfaces, including the Abbeydale Designers/Watford Electronics SPDOS, Abbeydale Designers/Kempston KDOS and Opus Discovery. The SPDOS and KDOS interfaces were the first to come bundled with Office productivity software (*Tasword* Word Processor, *Masterfile* database and *OmniCalc* spreadsheet). This bundle, together with OCP's Stock Control, Finance and Payroll systems, introduced many small businesses to a streamlined, computerised operation. The most popular floppy disk systems (except in East Europe) were the DISCiPLE and +D systems released by Miles Gordon Technology in 1987 and 1988 respectively. Both systems had the ability to store memory images onto disk *snapshots* could later be used to restore the Spectrum to its exact previous state. They were also both compatible with the Microdrive command syntax, which made porting existing software much simpler.[322]

During the mid-1980s, Telemap Group Ltd launched a fee-based service allowing users to connect their ZX Spectrums via a Prism Micro Products VTX5000 modem to a viewdata service known as Micronet 800, hosted by Prestel. This service pre-dated the World Wide Web, but offered many of the services now considered commonplace.

Software


The space exploration game *Elite*

The Spectrum family enjoys a very large software library of more than 20,000 titles[323] which is still increasing. While most of these are games, the library is very diverse, including programming language implementations, databases (e.g. *VU-File*[324]), word processors (e.g. *Tasword II*[325]), spreadsheets (e.g. *VU-Calc*[326]), drawing and painting tools (e.g. *OCP Art Studio*[327]), and even 3D-modelling (e.g. *VU-3D*[328] [329]) and archaeology software[330] amongst many other types.[331]

The hardware limitations of the Spectrum imposed a special level of creativity on video game designers, and so many Spectrum games are very creative and playable even by today's standards.[332] The early Spectrum models' great success as a games platform came in spite of its lack of built-in joystick ports, primitive sound generation, and colour support that was optimised for text display.[333]

Distribution

Most Spectrum software was originally distributed on audio cassette tapes. The Spectrum was intended to work with a normal domestic cassette recorder,[334] and despite differences in audio reproduction fidelity, the software loading process was quite reliable, if somewhat slow (by today's standards).

Although the ZX Microdrive was initially greeted with good reviews,[335] it never took off as a distribution method due to worries about the quality of the cartridges and piracy.[336] Hence the main use became to complement tape releases, usually utilities and niche products like the *Tasword* word processing software and *Trans Express*, (a tape to microdrive copying utility). No games are known to be exclusively released on Microdrive.

Despite the popularity of the DISCiPLE and +D systems, most software released for them took the form of utility software. The ZX Spectrum +3 enjoyed much more success when it came to commercial software releases on floppy disk. More than 700 titles were released on 3-inch disk from 1987 to 1997.[337]

Software was also distributed through print media; magazines[338] and books.[339] The reader would type the Sinclair BASIC program listing into the computer by hand, run it, and could save it to tape for later use. The software distributed in this way was in general simpler and slower than its assembly language counterparts. Magazines also printed long lists of checksummed hexadecimal digits with machine code games or tools.

Another software distribution method was to broadcast the audio stream from the cassette on another medium and have users record it onto an audio cassette themselves. In radio or television shows in many European countries, the host would describe a program, instruct the audience to connect a cassette tape recorder to the radio or TV and then broadcast the program over the airwaves in audio format.[340] Some magazines distributed 7" 33⅓ rpm *flexidisc* records, a variant of regular vinyl records which could be played on a standard record player.[341] These disks were known as *floppy ROMs*.

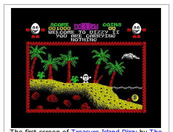
Copying and backup software

Many copiers—utilities to copy programs from audio tape to another tape, microdrive tapes, and later on diskettes—were available for the Spectrum.[342] As a response to this, publishers introduced copy protection measures to their software, including different loading schemes.[343] Other methods for copy prevention were also used including asking for a particular word from the documentation included with the game—often a novella like in Silicon Dreams trilogy—or another physical device distributed with the software—e.g. Lenslok as used in Elite. Special hardware, such as Romantic Robot's Multiface, was able to dump a copy of the ZX Spectrum RAM to disk/tape at the press of a button, entirely circumventing the copy protection systems.

Most Spectrum software has, in recent years, been converted to current media and is available for download. One popular program for converting Spectrum files from tape is *Taper*; it allows connecting a cassette tape player to the line in port of a sound card, or—through a simple home-built device—to the parallel port of a PC.[344] Once in files on a host machine, the software can be executed on one of many emulators, on virtually any platform available today.

The largest on-line archive of ZX Spectrum software is World of Spectrum, with more than 21,000 titles. The legality of this practice is still in question and while a number of copyright holders have explicitly objected to the posting of their software, others have given their permission for their games to be archived as part of the preservation project.[345]

Notable developers


The first screen of Treasure Island Dizzy by The Oliver Twins

A number of current leading games developers and development companies began their careers on the ZX Spectrum, including David Perry of Shiny Entertainment, and Tim and Chris Stamper (founders of Ultimate Play The Game, now known as Rare, maker of many famous titles for Nintendo and Microsoft game consoles). Other prominent games developers include Julian Gollop (*Chaos*, *Rebelstar*, *X-COM* series), Matthew Smith (*Manic Miner*, *Jet Set Willy*), Jon Ritman (*Match Day*, *Head Over Heels*), The Oliver Twins (the *Dizzy* series), Clive Townsend (*Saboteur*), Pete Cooke (*Tau Ceti*), Mike Singleton (*The Lords of Midnight*, *War In Middle Earth*), and Alan Cox.[346]

Although the Spectrum's audio hardware was not as capable as chips in other popular 8-bit home computers of the era, computer musicians David Whittaker and Tim Follin produced notable multi-channel music for the machine.

Jeff Minter ported some of his Commodore VIC-20 games to the ZX Spectrum.[347]

Oliver Twins

Community

The ZX Spectrum enjoyed a very strong community early on. Several dedicated magazines were released including *Sinclair User* (1982), *Your Sinclair* (1983) and *CRASH* (1984). Early on they were very technically oriented with type-in programs and machine code tutorials. Later on they became almost completely game-oriented. Several general contemporary computer magazines covered the ZX Spectrum in more or less detail. They included *Computer Gamer*, *Computer and Video Games*, *Computing Today*, *Popular Computing Weekly*, *Your Computer* and *The Games Machine*.[348]

The Spectrum is affectionately known as the *Speccy* by elements of its fan following.[349]

More than 80 electronic magazines existed, many in Russian. Most notable of them were *AlchNews* (UK), *ZX-Format* (Russia), and *Spectrofon* (Russia).

External links

- ZX Spectrum at the Open Directory Project
- Online Games
- World of Spectrum
- Page on site VRCP Soft for ZX Spectrum
- Planet Sinclair
- ZXF magazine
- The Incomplete Spectrum ROM Assembly and actual assembly listing
- Sinclair Spectrum development
- The Anatomy/Dissection of a Spectrum +2B
- ZX Spectrum online emulator in Java (Symbol Shift -> Windows; Edit -> Escape)
- ZX Spectrum Basic Handbook
- iSpeccy. Online ZX Spectrum emulator in Javascript for iOS devices (iPhone, iPad, iPod Touch)

ZX Interface 1

The ZX Interface 1 with the ZX Microdrive connected

A peripheral from Sinclair Research for its ZX Spectrum home computer, the **ZX Interface 1** was launched in 1983. Originally intended as a local area network interface for use in school classrooms, it was revised before launch to also act as the controller for up to eight ZX Microdrive high-speed tape-loop cartridge drives. It also included a DE-9 RS-232 interface capable of operating at up to 19.2 kbit/s — a rare instance of Sinclair using an industry-standard connector. At hardware level it was mainly a voltage adapter, the serial protocol being implemented in software by bit-banging. This led to problems when receiving data, but not when transmitting.

A wedge-shaped device fitting underneath the ZX Spectrum, ZX Interface 1 contained 8 kB of ROM comprising the control software for the Microdrives, RS-232 port and network interface. This extended the error handler in the Sinclair BASIC to allow extra keywords to be used. As this became an official standard, other developers quickly used this mechanism to create language extensions to Sinclair BASIC.

The device offered two network ports, allowing up to 64 ZX Spectrums to be daisy-chained using network leads up to 3 m (10 ft) long. The network, called **ZX Net**, used a proprietary CSMA-like protocol. Data could be sent or received at 100 kbit/s either to or from a numbered workstation, or broadcast to all nodes, allowing one machine to act as a server.

Two further revisions of the device's firmware were made following launch.[350] These aimed to improve ZX Microdrive cartridge formatting and access time, printing functions via the RS-232 interface, and other bugs in the firmware held in device's internal 8K ROM. Machine code software which used the officially documented entry points ('hook codes') would experience few incompatibility issues, however programs using non-standard entry points risked incompatibility due to presence of revised entry points.

The same protocol, renamed **QLAN**, was later used on the Sinclair QL. This was intended to be interoperable with ZX Net, but due to timing differences interoperability was found to be problematic.

The ZX Interface 1 was incompatible with some of later ZX Spectrum models such as the +2 and +3, due to differences in ROM and expansion connector, therefore wasn't possible to connect and use the Microdrive units.

External links

- Information at Planet Sinclair
- Hardware feature from Sinclair User - October 1983

ZX Microdrive

The **ZX Microdrive** is a magnetic tape data storage system launched in July 1983 by Sinclair Research for their ZX Spectrum home computer. The Microdrive technology was later also used in the Sinclair QL and ICL One Per Desk personal computers.

ZX Microdrive unit

Microdrive cartridge

Opened microdrive cartridge

Development

It is claimed the Microdrive was originally proposed by Andrew Grillet at an interview with Sinclair Research for what was to become the ZX81. Grillet proposed "a version of the Learjet Stereo 8 system, modified to allow two 64k core images per track for roll-out roll-in swapping using the KUTS protocol". The ZX81 had only 1k of RAM. Mr Grillet was offered better pay by Xerox Corporation, and never worked on the ZX81 or the Spectrum. The primary engineer involved in the development of the Microdrive was Ben Cheese.

Products

Typically of Sinclair Research, the ZX Microdrive was comparatively cheap (£49.95 at launch) and technologically innovative but also rather limited. Connecting a ZX Microdrive to a ZX Spectrum required the ZX Interface 1 unit - which cost £49.95 - although this could be bought packaged with a Microdrive for £79.95. Later, in March 1985, the *ZX Spectrum Expansion System* was launched for £99.95. This consisted of Interface 1, a Microdrive, a blank cartridge and several cartridges with content: the *Tasword Two* word processor plus *Masterfile* filing system, Quicksilva's *Games Designer* and *Ant Attack* game, and an introductory cartridge. A total of eight ZX Microdrive units could be connected to the Interface 1 by daisy chaining one drive to the next via an electrical connector block.

Technology

Microdrives used tiny (44 × 34 × 8 mm including protective cover) cartridges containing a 5 m (200 inch) endless loop of magnetic tape, 1.9 mm wide, driven at 76 cm/second (30 in/second); thus performing a complete circuit in approximately 8 seconds. The cartridges held a minimum of 85 kB when formatted on a ZX Microdrive (exact capacity depended on the number of "bad" sectors found and the precise speed of the Microdrive motor when formatting). The data retrieval rate was 15 kB/s (i.e., 120 kbit/s). It is possible to 'expand' the capacity of a fresh microdrive cartridge by formatting it several times. This causes the tape to stretch slightly, increasing the length of the tape loop so that more sectors can be marked out on it. This procedure was widely documented in the Sinclair community magazines of the 1980s.

Unfortunately, the system acquired a reputation for unreliability.[351] The tapes stretched during use (giving them a short life span) eventually rendering the data stored unreadable. Also the "write protection" was software based so that a computer crash could erase the data on an entire tape in 8 seconds. The cartridges were relatively expensive (initially sold for £4.95 each, later reduced to £1.99). Similar technology was used in other devices, such as the Rotronics Wafadrive, and was sometimes known as a "stringy floppy".

QL Microdrive

Microdrives were also used as the native storage medium of the Sinclair QL, which incorporated two internal drives. These were very similar to the ZX Microdrive, but used a different logical format, allowing each cartridge to hold at least 100 kB. Mechanically the drives were similar however they ran slightly slower, and had a take-up acceleration start instead of the instant start of the ZX Spectrum drives - putting less strain on the cartridges themselves. The QL also included a Microdrive expansion bus allowing the attachment of up to six external QL Microdrives. These were never produced, probably due to lack of demand. It was however possible to connect ZX Microdrives to a QL by putting a twist in the cable.

In addition to the QL versions, dual internal Microdrives were included in the related ICL One Per Desk system (also badged as the Merlin Tonto and Telecom Australia Computerphone). These drives were re-engineered by ICL for greater reliability, and used a format incompatible with both ZX and QL Microdrives.

External links

- ZX Microdrive information – At Planet Sinclair
- *Sinclair User*, April 1985, News section

ZX Printer


The Sinclair ZX Printer

The Sinclair **ZX Printer** is a spark printer which was produced by Sinclair Research for its ZX81 home computer. It was launched in 1981, with a recommended retail price of £49.95.

The ZX Printer used special 4-inch (100 mm) wide black paper which was supplied coated with aluminium oxide, this was electrically marked during the printing process to reveal its black under-surface. The printer's horizontal resolution was the same as the ZX81's video display, ie. 256 dots (pixels) or 32 characters (using the standard character definition). The print quality was crude, but no other printer was compatible with the ZX81 without the use of additional software and interface hardware.

The ZX Printer was also compatible with the earlier ZX80 computer (when fitted with the 8kB ROM upgrade) and the later ZX Spectrum, and plugged directly into the expansion bus connector via a short cable. The printer drew its power directly from the expansion bus, and was sold with a larger (1-2A) power supply for the ZX81 to accommodate the additional power drain.[352] The Spectrum's user manual noted that this was not needed for the Spectrum as its default 1.1A power supply was sufficient.

ZX Interface 2

The **ZX Interface 2** was a peripheral from Sinclair Research for its ZX Spectrum home computer released in September 1983. It had two joystick ports and a ROM cartridge slot, which offered instant loading times. The joystick ports were not compatible with the popular Kempston interface, and thus did not work with most Spectrum games released prior to the launch of the ZX Interface 2. In addition, the pass-through expansion bus provided was stripped, only allowing a ZX Printer to be attached.

ZX Interface 2

Compatible titles

Availability of cartridge software was very limited: The cost was almost twice as much as the same game on cassette tape, and each cartridge could only hold 16 KiB, making it almost immediately obsolete as the majority of Spectrums sold were 48K-models, which the software publishers targeted.

Only ten games were commercially released:

1. Jetpac
2. PSSST
3. Cookie
4. Tranz Am
5. Chess
6. Backgammon
7. Hungry Horace
8. Horace and the Spiders
9. Planetoids
10. Space Raiders

Paul Farrow has demonstrated that it is possible to produce custom ROM cartridges, including the ability to exceed the 16 KiB design limitation of the ROM cartridges [353].

Joystick ports

The interface two came with two joystick ports that (unlike the Kempston which used the IN31 command) were mapped to actual key presses. Player 1 was mapped to 1-5 and player 2 was mapped to 6-0. This initially seemed at odds with Sinclair's own keyboard layout, given that the keyboard itself had the cursor keys mapped to 5-8 with 0 typically being used by games as a fire button. Joystick interfaces that mapped to the cursor keys were available, but like the popular Kempston interface they were limited to supporting a single joystick only. It was the twin joystick feature of the ZX Interface 2 that turned out to be its major selling point[354].

External links

- Detailed information on Interface 2
- List of ROM cartridges available for Interface 2
- Information at Planet Sinclair
- Hardware feature from Sinclair User - December 1983

ZX81

Sinclair ZX81	
Developer	Sinclair Research
Manufacturer	Timex Corporation
Release date	5 March 1981[355]
Introductory price	£49.95 kit, £69.95 assembled (in 1981)[356] (equivalent to £143 – £200 in 2012[357]).
Discontinued	1984
Units sold	More than 1.5 million[358]
Operating system	Sinclair BASIC[359]
CPU	Z80 at 3.25 MHz[360]
Storage capacity	External cassette tape recorder at 250 baud[361]
Memory	1 kB (64 kB max. 56 kB usable)[362]
Display	Monochrome display on UHF television[363]
Graphics	24 lines x 32 characters or 64 x 48 pixels graphics mode[364]
Dimensions	167 millimetres (6.6 in) deep by 40 millimetres (1.6 in) high[365]
Weight	350 grams (12 oz)[366]
Predecessor	ZX80
Successor	ZX Spectrum
Related articles	Timex Sinclair 1000, Timex Sinclair 1500

The **ZX81** was a home computer produced by Sinclair Research and manufactured in Scotland by Timex Corporation. It was launched in the United Kingdom in March 1981 as the successor to Sinclair's ZX80 and was designed to be a low-cost introduction to home computing for the general public. It was hugely successful and more than 1.5 million units were sold before it was eventually discontinued. The ZX81 found commercial success in many other countries, notably the United States, where Timex manufactured and distributed it under licence. Timex later produced its own versions of the ZX81 for the US market – the Timex Sinclair 1000 and Timex Sinclair 1500. Unauthorised clones of the ZX81 were produced in a number of countries.

The ZX81 was designed to be small, simple, and above all cheap, using as few components as possible to keep the cost down. Video output was to a television set rather than a dedicated monitor. Programs and data were loaded and saved onto audio tape cassettes. It had only four silicon chips on board and a mere 1 kB of memory. The machine had no moving parts – not even a power switch – and used a touch-sensitive membrane keyboard for manual input. The ZX81's limitations prompted the emergence of a flourishing market in third-party peripherals to improve its capabilities. Such limitations, however, achieved Sinclair's objective of keeping the cost of the machine as low as possible. Its distinctive design won awards in the UK and abroad.

The ZX81 could be bought by mail order in kit form or pre-assembled. In what was then a major innovation, it was the first cheap mass-market home computer that could be bought from high street stores, led by W.H. Smith and soon many other retailers. The ZX81 marked the first time that computing in Britain became an activity for the general public, rather than the preserve of businesspeople and electronics hobbyists. It inspired the creation of a huge community of enthusiasts, some of whom founded their own businesses producing software and hardware for the ZX81. Many went on to play a major role in the British computer industry in later years. The ZX81's commercial success made Sinclair Research one of Britain's leading computer manufacturers and earned a fortune and an eventual knighthood for the company's founder, Sir Clive Sinclair.

Features

Close-up view of the ZX81's keyboard

The ZX81 came with 1 kB of on-board memory that could be expanded externally to 16 kB. Its single circuit board is housed inside a wedge-shaped plastic case measuring 167 millimetres (6.6 in) deep by 40 millimetres (1.6 in) high. The memory is provided by either a single 4118 (1024 bit × 8) or two 2114 (1024 bit × 4) RAM chips. There are only three other chips on board: a 3.5 MHz Z80A 8-bit microprocessor from Nippon Electric (now NEC), an uncommitted logic array (ULA) chip from Ferranti and a 8 kB ROM providing a simple BASIC interpreter. The entire machine weighs just 350 grams (12 oz).[367] The memory can be expanded externally to a maximum of 16 kB. Early versions of the external cartridge contained 15 kB of memory using an assortment of memory chips, while later versions contained 16 kB of chips but the lowest addressed kilobyte was disabled.

The front part of the case is occupied by an integrated 40-key membrane keyboard displaying 20 graphic and 54 inverse video characters.[368] Each key has up to five functions, accessed via the SHIFT and FUNCTION keys or depending on context. For example, the P key combined the letter 'P', the " character and the BASIC commands PRINT and TAB. The ZX81 uses a standard QWERTY keyboard layout, with some extra keys that are unfamiliar to modern eyes, such as a RUBOUT key (instead of DELETE) and a NEW LINE key rather than RETURN or ENTER. The keyboard is mechanically very simple, consisting of 40 pressure-pad switches and eight diodes under a plastic overlay, connected in a matrix of eight rows and five columns.[369]

The ZX81's primary input/output is delivered via four sockets on the left side of the case. The machine uses an ordinary UHF television set to deliver a monochrome picture via a built-in RF modulator. It can display 24 lines of 32 characters each, and by using the selection of 2x2 block character graphics from the machine's character set offered an effective 64 × 48 pixel graphics mode, also directly addressible via BASIC using the PLOT and UNPLOT commands. Two 3.5 mm jacks connect the ZX81 to the EAR (output) and MIC (input) sockets of an audio cassette recorder, enabling data to be saved or loaded at a rate of 250 baud. This provides a somewhat temperamental storage medium for the machine, which has no built-in storage capabilities. The ZX81 requires 420 mA of power at 7–11 V DC, delivered via a custom 9 V Sinclair DC power supply.[370]

The ULA chip, described by the ZX81 manual as the "dogsbody" of the system, has a number of key functions that competing computers shared between multiple chips and integrated circuits. These comprise:

- Synchronising the screen display;
- Generating a 6.5 MHz clock, from which a 3.25 MHz clock is derived for the processor;
- Outputting an audio signal to a cassette recorder in SAVE mode;
- Processing the incoming cassette audio signal in LOAD mode;
- Sensing keystrokes;
- Using memory addresses provided by the CPU to decide when ROM and RAM should be active;
- Controlling general system timing.[371]

The ZX81's built-in RF modulator can output a video picture to either a UHF 625-line colour or monochrome television (used in the UK, Australia, and most western European countries). France required a slightly modified version of the machine to match the positive video modulation of their sets. The USA and Canada required a different ULA chip and modulator to cope with their 525-line VHF television systems. Both the ZX81 and its predecessor, the ZX80, have a significant drawback in the way that they handle visual output. Neither machine has enough processing power to run at full speed and simultaneously maintain the screen display. On the ZX80, this means that the screen goes blank every time the machine carries out a computation and causes an irritating flicker whenever a shorter computation – such as processing a keystroke – takes place.[372]

Left side and rear views of the ZX81, showing its edge connector, the three input/output sockets (TV, EAR, MIC) and the 9 V DC power socket.

The ZX81's designers adopted an improved approach, involving the use of two modes called SLOW and FAST respectively. In SLOW mode, also called "compute and display" mode, the ZX81 concentrates on driving the display. It runs the current program for only about a quarter of the time – in effect slowing the machine down fourfold, although in practice the speed difference between FAST and SLOW modes depends on what computation is being done.[373] In FAST mode processing occurs continuously but the display is abandoned to its own devices – equivalent to the ZX80's standard operating mode.[374]

Another hardware quirk produced one of the most distinctive aspects of the ZX81's screen display – during loading or saving, moving zigzag stripes appear across the screen. The same pin on the ULA is used to handle the video signal as well as the tape output, producing the stripes as an interference pattern of sorts. As well as this, the ULA cannot maintain the display during SAVE and LOAD operations, as it has to operate continuously to maintain the correct baud rate for data transfers.[375]

The unexpanded ZX81's tiny memory presented a major challenge to programmers. Simply displaying a full screen takes up 768 bytes, the system variables take up another 125 bytes and the program, input buffer and stacks need more memory on top of that.[376] Nonetheless, ingenious programmers were able to achieve a surprising amount with just 1 kB. One notable example was *1K ZX Chess* by David Horne, which is somewhat misnamed as it managed to squeeze most of the rules of chess into just 672 bytes. The ZX81 conserved its memory to a certain extent by representing entire BASIC commands as one-byte tokens, stored as individual "characters" in the upper reaches of the machine's unique (non-ASCII) character set.[377]

The edge connector or external interface at the rear of the ZX81 is an extension of the main printed circuit board. This provides a set of address, control, and data lines that can be used to communicate with external devices.[378] Enthusiasts made use of this facility to create a wide range of add-ons for the ZX81.

Comparisons between ZX81 and other computing devices

The following table provides a comparison between the capabilities of the ZX81 and various other competing microcomputers that were already on the market at the time of the ZX81's launch. The prices given are as of December 1982.[379]

Device	RAM standard	Expandable to	CPU	Storage	Upper- and lower case	List price	Number of colours	Maximum resolution	Sound
Apple II Plus	16 kB	48 kB	MOS Technology 6502 @ 1 MHz	Cassette tape / floppy disk (up to 143 kB per drive)	No	$1330	16	280 × 194 pixels	Clicks via speaker
Atari 800	16 kB	48 kB	MOS Technology 6502 @ 1.78 MHz	Cassette tape / floppy disk (up to 92 kB per drive)	Yes	$899.95	256	320 × 192 pixels	4-voice / 4-octave effects
Commodore PET	16 or 32 kB	32 kB	MOS Technology 6502 @ 1 MHz	Cassette tape / floppy disk (up to 1024 kB per drive)	Yes	$995	monochrome	80 × 50 pixels	1 voice / 3 octaves
Commodore VIC-20	5 kB	32 kB	MOS Technology 6502 @ 1.02 MHz	Cassette tape / floppy disk (up to 170 kB per drive)	Yes	$260	16	176 × 184 pixels	3 voices / white noise
IBM PC	16 kB	512 kB	Intel 8088 @ 4.77 MHz	Cassette tape / floppy disk (up to 320 kB per drive)	Yes	$1265	16	640 × 200 pixels	1 voice
Radio Shack TRS-80 III	16 kB	48 kB	Zilog Z80 @ 1.78 MHz	Cassette tape / floppy disk (up to 175 kB per drive)	Yes	$699	Monochrome	128 × 96 pixels	Basic sound via cassette interface
Texas Instruments TI-99/4A	16 kB	48 kB	TI TMS9900 @ 3.0 MHz	Cassette tape / floppy disk (up to 90 kB per drive)	Yes	$299	16	256 × 192 pixels	3 voices / white noise
ZX81 / TS1000	1 kB / 2 kB	64 kB	Zilog Z80 @ 3.25 MHz or NEC Z80 @ 3.25 MHz	Cassette tape	No	$99.95	Monochrome	64 x 48 pixels	None

History

Background


The Sinclair Executive "slimline" pocket calculator (1972)

Clive Sinclair's first company Sinclair Radionics, established in 1962, made its name producing a wide range of cheap electronics aimed at the hobbyist market. Its products included amplifiers, radios, multimeters and other items generally sold in kit form to hi-fi enthusiasts and other electronics hobbyists.[380] The company entered a new market in 1972 when it launched the first "slimline" pocket calculator, the Sinclair Executive.[381] It was a major success that Radionics followed up by launching a wide range of pocket calculators. The company's subsequent expansion made it Europe's biggest calculator manufacturer by 1975.[382]

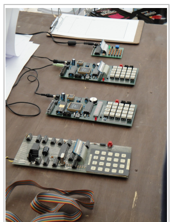
By the late 1970s, however, Sinclair Radionics was in serious difficulties. It lost its ability to compete effectively in the calculator market following the launch of a new generation of Japanese-produced calculators with liquid crystal displays, which were much more capable and power-efficient than Sinclair's LED calculators.[383] Projects to develop a pocket television and digital watch turned out to be expensive flops. The company made losses of over £350,000 in 1975–76, bringing it to the edge of bankruptcy.[384] In July 1977 Radionics was rescued by a state agency, the National Enterprise Board (NEB), which recapitalised it, provided a loan facility and took effective control of the company by acquiring a 73% stake.[385]

Clive Sinclair's relationship with the NEB was fraught due to conflicting notions about which direction the company should go. Radionics had begun a project to develop a home computer but the NEB wanted to concentrate on the instrument side of the business, which was virtually the only area where Radionics was profitable. Sinclair disagreed vehemently with what he characterised as the view "that there was no future in consumer electronics".[386] This and other disputes led to Sinclair resigning from Radionics in July 1979.[387]

While he was struggling with the NEB, Clive Sinclair turned to a "corporate lifeboat" in the shape of an existing corporate shell under his exclusive control – a company called Ablesdeal Ltd, which he had established in 1973 and later renamed Science of Cambridge. It became a vehicle through which he could pursue his own projects, free of the interference of the NEB.[388] Despite his later success in the field, Sinclair saw computers as merely a means to an end. As he told the *Sunday Times* in April 1985, "We only got involved in computers in order to fund the rest of the business", specifically the development of the ultimately unsuccessful TV80 pocket television and C5 electric vehicle.[389] In an interview with *Practical Computing*, Sinclair explained:

I make computers because they are a good market, and they are interesting to design. I don't feel bad about making them or selling them for money or anything, there is a demand for them and they do no harm; but I don't think they are going to save the world.[390]

Precursors: the MK14 and ZX80


Science of Cambridge MK14 (1978) – Sinclair's first computer, sold in kit form and assembled by the user.

By the late 1970s, American companies such as Apple were producing simple home computer kits. This aroused interest among electronics hobbyists in the UK but relatively high prices reduced the appeal of the American products. Off-the-shelf personal computers were also available for the high end of the market but were extremely expensive; Olivetti's offering cost £2,000, and the Commodore PET, launched in 1979, sold for £700. There was nothing for the hobbyist at the low end of the market. Sinclair realised that this provided a useful commercial opportunity.[391]

Sinclair's first home computer was the MK14, which was launched in kit form in June 1978.[392] It was a long way from being a mass-market product. Its very name – MK standing for "Microcomputer Kit" – was indicative of its origins as a product developed by, and for, hobbyists. It had no screen but instead used an LED segment display (though Science of Cambridge did produce an add-on module allowing it to be hooked up to a UHF TV); it had no case, consisting of an exposed circuit board; it had no built-in storage capabilities and only 256 bytes of memory; and input was via a 20-key hexadecimal keyboard.[393] Despite the limitations of the machine it sold a respectable 10–15,000 units;[394] by comparison, the much more expensive Apple II had only sold 9,000 units in the United States, a much bigger market, in 1978.[395] This success convinced Clive Sinclair that there was an untapped market for low-cost computers that could profitably be exploited.

Sinclair followed up the MK14 by producing the ZX80, at the time the world's smallest and cheapest computer, which was launched in January 1980 costing £99.95 (equivalent to £319 at 2009 prices.[396]) The company conducted no market research whatsoever prior to the launch of the ZX80; according to Clive Sinclair, he "simply had a hunch" that the general public was sufficiently interested to make such a project feasible and went ahead with ordering 100,000 sets of parts so that he could launch at high volume.[397]


The Sinclair ZX80 (1980). It was the immediate predecessor of the ZX81 and shared many of the same design features.

The ZX80's design introduced many key features that were carried over to the ZX81; as Sinclair himself later said, "the ZX80 was very much a stepping stone to the ZX81".[398] The design was driven entirely by the desired price point – the machine had to cost less than £100 but still make a healthy profit.[399] Its distinctive wedge-shaped white case concealing the circuitry and the touch-sensitive membrane keyboard were the brainchild of Rick Dickinson, a young British industrial designer who had recently been hired by Sinclair. As he later recalled of Sinclair's approach, "Everything was cost driven. The design was the face of the machine."[400] The unconventional keyboard was the outcome of Sinclair's cost-cutting. It made use of a sheet of plastic, on which the keys were printed, overlaying a metallic circuit that registered when a key was pressed. This avoided the expense of providing a typewriter-style keyboard, though the design had many drawbacks when it came to usability and "feel".[401]

Inside the case, there were many more similarities with the ZX81. Like its successor, it used the Z80A microprocessor and had only 1 kB of on-board RAM. It came with a specially written BASIC interpreter on a dedicated ROM chip and could use a television as a display. It relied on an ordinary cassette tape recorder for data storage. The main difference between the two machines lay in the internal software; when the ZX81 was released, ZX80 owners were able to upgrade by the relatively simple expedient of plugging a new ROM onto the circuit board.[402]

The ZX80 was an immediate success, selling 20,000 units over the following nine months.[403] Science of Cambridge was producing ZX80s at the rate of 9,000 a month by the end of 1980[404] and within 18 months of its launch the company had sold 100,000 units.[405] The commercial success of the ZX80 made a follow-up product inevitable. The company was renamed Sinclair Computers in November 1980, reflecting its new focus, and became Sinclair Research in March 1981.[406]

The BBC Micro affair

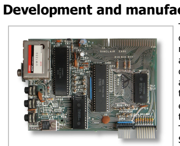
The launch of the ZX81 was catalysed in part by the British Broadcasting Corporation's plan to produce a TV series, to be broadcast in 1982, aimed at popularising computing and programming. The BBC intended to commission an existing manufacturer to provide it with a BBC-branded home computer to tie in with the series. When Sinclair got wind of the project in December 1980, he wrote to the BBC informing them that he would be announcing a new version of the ZX80, to be called the ZX81, in the spring of 1981. It would remedy some of the ZX80's deficiencies and would be both cheaper and more advanced.[407] Sinclair naturally wanted the ZX81 to be a candidate for the BBC contract and lobbied for its adoption. He pointed out that there were already 40,000 users of the ZX80 and that by the time the series was broadcast there were likely to be upwards of 100,000 ZX81 users (which turned out to be an underestimate by over 400,000 – an indication of how the ZX81's success exceeded even Sinclair's expectations).[408]

A prototype ZX81 was demonstrated to BBC representatives in January 1981,[409] while Sinclair's local rival Acorn Computers put forward their proposed Proton computer, a design – of which a prototype did not yet exist – based on the Acorn Atom.[410] To Sinclair's dismay, the contract to produce the BBC Microcomputer went to Acorn, which launched the machine in January 1982.[411] Paul Kriwaczek, the producer of *The Computer Programme*, explained his reservations in a March 1982 interview with *Your Computer*:

I would have been very reluctant for the BBC to sell something like the Sinclair [ZX81] because it is so limited. The Sinclair cannot be expanded; it is fundamentally a throw-away consumer product. Its usefulness lies in learning about programming, but I do not believe that the future of computers lies in everyone learning to program in BASIC.[412]

Sinclair was bitterly critical of the BBC's decision, accusing it of incompetence and arrogance.[413] Shortly after Acorn won the BBC contract the Government issued a recommended list of computers that schools could purchase, with the aid of a grant, for half price. Sinclair's computers were not included on the list. Sinclair responded by launching his own half-price deal, offering schools the chance to buy a ZX81 and 16 kB RAM pack for £60, plus a ZX Printer at half price, for a total cost of £90. As the cheapest Government-approved system was £130, this was an attractive offer for many schools and about 2,300 bought Sinclair's package.[414]

Development and manufacture


The ZX81 motherboard, Issue One version. The Ferranti ULA is on the left of the image and the NEC Z80 processor is in the centre. The TV output modulator is on the top left. At the bottom right is a ribbon cable connecting to the membrane keyboard.

The development of the ZX81 got underway even before the ZX80 had been launched. Sinclair's chief engineer, Jim Westwood, was given the task of improving the ZX80's hardware to reduce the number of components and thus bring down the cost. He also sought to fix some of the more annoying problems with the ZX80. Westwood and his colleagues found that the component count could be reduced greatly by combining eighteen of the ZX80's chips into a single uncommitted logic array (ULA), a type of general-purpose chip that allowed manufacturers to reprogram it to meet their particular requirements rather than having to develop their own customised chip at greater expense.[415] Ferranti produced the new chip for Sinclair,[416] who hailed Westwood's design as a triumph of innovation: "The ZX81 had four chips when our nearest competitor in this respect, the TRS-80, had 44."[417] Only 70% of the logic gates on the ULA were supposed to be used, but Sinclair decided to obtain maximum benefit by using them all. This resulted in the machine becoming uncomfortably warm during usage.[418] Computing folklore held that the ZX81 had to be refrigerated by balancing a carton of cold milk on top of the case.[419] [420]

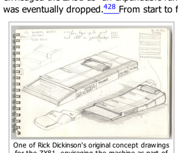
The ZX81's ROM was doubled to 8 kB, from the ZX80's 4 kB ROM. This enabled a fuller implementation of a version of ANSI Minimal BASIC (termed Sinclair BASIC by the company). Clive Sinclair re-commissioned a company called Nine Tiles, which had produced the ZX80 ROM, to develop the new ROM software for the ZX81.[421] The code was written by John Grant, the owner of Nine Tiles, and Steve Vickers, who had joined the company in January 1980. Grant concentrated on the software that drove the ZX81's hardware, while Vickers developed the new BASIC and the accompanying manual. Sinclair's brief to the pair was fairly non-specific but primarily concerned remedying a key defect of the ZX80 so that the new machine could be used for practical programming and calculations. Vickers later recalled:

As far as Clive was concerned, it wasn't a question of what the machine ought to be able to do, but more what could be crammed into the machine given the component budget he'd set his mind on. The only firm brief for the '81 was that the '80's math package must be improved.[422]

The new ROM incorporated trigonometric and floating point functions, which its predecessor had lacked – the ZX80 could only deal with whole numbers. Grant came up with one of the ZX81's more novel features, a syntax checker that indicated errors in BASIC code as soon as it was entered (rather than, as was standard at the time, only disclosing coding errors when a program was run).[423] Unfortunately for Vickers, he introduced a briefly notorious error – the so-called "square-root bug" that caused the square root of 0.25 to be returned erroneously as 1.3591409 – as a result of problems with integrating the ZX Printer code into the ROM. Although it was eventually fixed, the bug became the subject of controversy and Sinclair was forced to replace some of the ZX81s sold to early customers.[424] On a more positive note, Vickers' work on the manual was received favourably, being described in 1983 as "one of the classic texts on BASIC".[425] Max Phillips commented in a *What Micro?* retrospective:

It does a reasonable job and sensibly provides lots for the reader to do. It's quite honest about the [ZX81]'s shortcomings and provides hints and tips for ways round them ... Best of all, the manual is complete and comprehensive. There's some fairly advanced and often undisclosed information in there. The beginner won't understand it for a long time but if he or she learns some more advanced ideas, the manual is ready for them.[426]

The task of designing the ZX81's case again fell to Rick Dickinson, who produced an updated version of the ZX80's wedge-shaped case. This time round, the design team were able to use injection moulding,[427] which enabled them to deliver a higher-quality case. Dickinson originally envisaged the ZX81 as "an expandable range of boxes following a vaguely modular approach with a common width", though this approach was eventually dropped.[428] From start to finish, the design process took about six months.[429]


One of Rick Dickinson's original concept drawings for the ZX81, envisaging the machine as part of "an expandable range of boxes following a vaguely modular approach".

The ZX81 was launched on 5 March 1981 in two versions (though with identical components) – a pre-assembled machine or a cheaper kit version, which the user could assemble himself. Both versions were manufactured in Dundee, Scotland by Timex Corporation[430] at the company's Dryburgh factory.[431] Timex had not been an obvious choice of manufacturing subcontractor, as the company had little previous experience in assembling electronics. It was a well-established manufacturer of mechanical watches but was facing a crisis at the beginning of the 1980s. Profits had dwindled to virtually zero as the market for mechanical watches stagnated in the face of competition from the digital and quartz watches. Recognising the trend, Timex's director, Fred Olsen, determined that the company would diversify into other areas of business.[432]

This shift by Timex came at an ideal time for Sinclair. The ZX80 had proved more popular than expected and Sinclair's existing manufacturer, a small electronics company in St Ives, lacked the resources to deal with the demand. Timex took over production of the ZX80 late in 1980.[433] The arrangement worked well for both companies and Timex took on the manufacture of the ZX81, aided by capital investment in its Dundee plant.[434] Sinclair initially planned to produce 10,000 ZX81s a month, rising to 30,000 a month within a year.[435] However, Timex initially had significant problems in producing enough ZX81s to satisfy demand. As a consequence, it took up to nine weeks for ZX81s to be delivered by mail order. It was not until September 1981, five months after the launch of the ZX81, that the delivery times finally came down to the promised twenty-eight days.[436] Those who already owned or had recently ordered the ZX80 were not left out in the cold. Anyone who had ordered a ZX80 in the two weeks before the ZX81's launch would receive the newer machine, while existing owners were able to upgrade their ZX80s by soldering an extra £20 ROM chip into the circuit board.[437]

The reliability of the ZX81 was a somewhat controversial issue. W.H. Smith, one of the machine's key distributors, had a company policy of ordering a third more ZX81s than were actually required for sale, so that it would have enough replacements for faulty machines.[438] Similar problems were reported in the US market, where contemporary reports suggested that only a third of the ZX81s shipped actually worked.[439] However, figures released by Sinclair claimed that only 2.4 per cent of pre-assembled machines were returned, although 13 per cent of kits were returned.[440] Clive Sinclair strongly denied any problem with reliability:

We have a lower rate of failure on our computers than anybody else in the world, and the reason for that is that we do everything to keep the quality right. The ZX81 production line is a miracle of efficiency; after all, one is made every 10 seconds. They go through the most amazing quality control. Also we have a far lower component count than anyone else. We have only four chips where everyone else has 40.[441]

The higher failure rate of the kits was put down to customers breaking the components by inserting or soldering them the wrong way, though Sinclair admitted that there was a persistent problem with power supplies that affected both kits and pre-assembled ZX81s.[442] The bigger problem was perhaps Sinclair's after-sales service, or rather the lack thereof, which Robin Clarke of *New Scientist* described as "one of the worst after-sales performance records of any company ever established."[443] The *Financial Times* observed that "Clive Sinclair's offices are filled with returned computers which can take months to be repaired."[444] The company's slowness in replacing returns and delivering freshly ordered machines meant that Sinclair Research gained an unenviable reputation for poor customer service.[445]

Marketing

The marketing of the ZX81 was handled by Sinclair's long-standing marketing agency Primary Contact (now part of Ogilvy & Mather), which had provided marketing services for Sinclair since 1971 and was to continue doing so until 1985. Sinclair's entry into the nascent home computing market gave Primary Contact a major challenge – how to market a product simultaneously at hobbyists and at the "man on the street", who probably had little or no computer literacy.[446] The answer was to pursue what the journalist David O'Reilly of *MicroScope* magazine described as a single-minded "user-friendly strategy." Chris Fawkes, one of Primary Contact's directors, explained: "We brought personal computers to the mass market by showing that you didn't have to be a whizzkid to use one."[447] As Clive Sinclair put it in a 1982 interview with *Your Computer*,

There are two big markets. There is the hobbyist and the man in the street. The hobbyist was a dead certainty. We knew we could sell to him because we have so much experience of it and we were offering a better product. The much less certain prospect was the man in the street. There the view was that if we offered him a computer plus a self-training book at a keen enough price he would buy by mail order – which, of course, he has.[448]

According to the US market analyst Ben Rosen, by pricing the ZX81 so low, "Sinclair has opened up a completely new market among people who had never previously considered owning a computer." Clive Sinclair acknowledged the role that guesswork had played in his decision to launch the ZX81 on such a large scale: "It was a surmise that the man in the street would want such a computer. He does, and our information is that a lot of people are using the machines avidly."[449] A *New Scientist* retrospective published in 1986 commented:

Sir Clive's marketing achievement was to downgrade the "concept" of a computer to the point where he could claim to provide one for less than the magical £100 mark. To this end, efficient keyboards and monitors, useful amounts of memory, efficient filing and storage systems and the like were stripped away, to leave an affordable facsimile of a "computer". The market image was more important than what the computer could do, but the burgeoning industry in computer games provided an application which adolescents – young and old – eagerly seized on as the *raison d'être* for their new gadget. In the main, it was ignorance of genuine computer technology that fired the success of the ZX range, despite the availability of accessories that, albeit inefficiently, turned the Z80 processor chip at the heart of these up-market toys into the core of a useful machine.[450]

Sinclair Research's launch advertising for the ZX81. High-profile advertisements such as this were used to promote the benefits and value for money of the ZX81.

High-profile advertising was central to the marketing campaign. Although Sinclair Research was a relatively small company, it had a long-standing policy of using large-scale advertisements that stood out in stark contrast to the more muted advertisements of other manufacturers. Superlatives, exhortations, appeals to patriotism, testimonials, eye-catching drawings and photographs on double-page spreads, varying from month to month, were used to drum up mail order business for Sinclair.[451] The launch advertising for the ZX81 illustrates this approach. A photograph of the ZX81 alongside the official Sinclair peripherals dominated the centre of a double-page spread. The value for money of Sinclair's products was emphasized by the prices being printed in larger type than any other text on the spread. The ZX81's benefits were promoted with the aspirational slogan "Sinclair ZX81 Personal Computer – the heart of a system that grows with you". The advertisement highlighted *ZX81 BASIC Programming*, the manual written by Steve Vickers, as "a complete course in BASIC programming, from first principles to complex programs." The educational benefits of the ZX81 were stressed ("it's still very simple to teach yourself computing") and its technical advantages were explained in relatively non-technical terms. For instance, the ZX81's idiosyncratic method of typing commands with a single keystroke – the result of the memory-saving method of using one-byte tokens to represent keywords[452] – was presented as "eliminat[ing] a great deal of tiresome typing". The ZX81's British character was emphasized; it was "designed by Sinclair and custom-built in Britain."[453] Sinclair's advertising in the United States provides an illustration of how the company perceived the ZX81's purpose:

For less than $100, the Sinclair ZX81 will get you started in personal computing right now. Your children will gain an understanding of computers that will benefit them for the rest of their lives. And you will be prepared to make informed decisions about using and buying computers, both in your career and in your home.[454]

This approach to advertising was driven by Sinclair's reliance on mail-order marketing. It came with a high up-front cost in terms of purchasing space in publications but it had the advantage of ensuring that all sales were firm and pre-paid. A big splash on launch produced a large influx of cash at the outset of a campaign, though it did also depend on the advertiser having enough product to satisfy the initial surge in demand. The advertisements served an additional purpose of priming the market for over-the-counter sales by "getting the story across", as Clive Sinclair put it: "Not that big a proportion do buy on mail order, but they see the ads, and that helps to prepare them for buying when the item appears in the shops."[455]

Sinclair himself became a focal point for the marketing campaign, putting a human face on the business, while Sinclair Research was portrayed in the media as a plucky British challenger taking on the technical and marketing might of giant American and Japanese corporations. As David O'Reilly noted, "by astute use of public relations, particularly playing up his image of a Briton taking on the world, Sinclair has become the best-known name in micros."[456] The popular press soon latched onto the image. His "Uncle Clive" persona is said to have been created by the gossip columnist for *Personal Computer World*,[457] while the media praised Sinclair as a visionary genius (or even, in the words of *The Sun*, "the most prodigious inventor since Leonardo.") As Ian Adamson and Richard Kennedy put it, Sinclair outgrew "the role of microcomputer manufacturer and accepted the mantle of pioneering boffin leading Britain into a technological utopia."[458]

Pricing was central to the marketing strategy, as it had been through Sinclair's career. The ZX81 had been designed to meet a £70 price point and was launched at a price of £69.95 (built) or £49.95 (kit). One Sinclair brochure presented a side-by-side comparison of the ZX81 with the four machines that Sinclair considered its main rivals – the Acorn Atom, Apple II Plus, Commodore PET and TRS-80. The comparison highlighted the vast differences in cost, from £630 in the case of the Apple II Plus to just £70 for the ZX81, though even by Sinclair's own comparison the Apple was by far the more capable machine.[459]

According to Sinclair himself, the £69.95 price was chosen after applying the "experience curve" developed by the Boston Consulting Group. Sinclair's prior experience in the calculator market had highlighted the fact that a product will be more profitable selling at (for instance) twice the manufactured cost than at three times. He could have launched the ZX81 at a higher price, marketing it in a more traditional way as a premium product, but chose not to. In effect, he used the lower price to establish an unassailable lead before the competition moved in.[460]

An essential part of Sinclair's marketing strategy was to use regular cost-cutting at strategic intervals to maintain market share. Ian Adamson and Richard Kennedy comment that Sinclair's approach was "to secure and extend [his] market lead and panic the competition. While most companies reduce prices when their products are in steep decline, Sinclair tends to discount shortly after sales have peaked. The advantage of his approach is that vacillating customers are drawn into the fold while the product's promotion retains a commercial urgency, and the costings of the competition are thrown into utter disarray."[461]

This tactic proved highly successful. When sales of the ZX81 fell in the wake of the launch of its successor, the ZX Spectrum, Sinclair reduced the price of the pre-assembled version to £49.95 in May 1982. It was cut by another £10 the following April. Despite the increased competition from much more capable computers, the ZX81 was still shipping in excess of 30,000 units a month even as late as July 1983, more than two years after it had been launched.[462] By that time, over 1.5 million ZX81s had been sold.[463]

Distribution

The kit version of the ZX81, sold by Sinclair through mail-order.

The ZX81's distribution arrangements were an essential part of its success and marked a watershed in the way that computers were sold in the UK. Sinclair had previously made its name as a mail-order retailer – the ZX81 was initially available only through mail-order – but the only truly effective way to reach the mass market was via high street stores. Fortunately for Sinclair, an opportunity to do just that was provided by W.H. Smith, a venerable book- and magazine-seller and stationery chain. The company had stagnated in the 1970s and was looking for ways to revitalise its image and expand its product range.[464]

Smith's had begun selling audio and photographic equipment and calculators at the end of the 1970s, with a modest degree of success. In 1980 its marketing development manager, John Rowland, hit upon the idea of creating "Computer Know-How" sections in major branches to sell computer books and magazines. Most of the items on display were imports from the United States but their relatively high cost reduced their attractiveness to the casual buyer.[465] The commercial success and mass market potential of the ZX80 caught Rowland's interest; he approached Sinclair, saw a prototype ZX81 and agreed to market the machine through Smith's on an exclusive basis for the first six months after launch.[466] As Rowland put it, "what we've done now is bring the computer-orientated publications together with an actual computer, to create the Computer Know-How section of the store", alongside computer software and blank cassette tapes. The ZX81 would be sold in 112 stores around the UK and would serve as the centrepiece of the "Computer Know-How" sections.[467]

Selling the ZX81 over the counter was seen as something of a gamble and Rowland's colleagues were initially unenthusiastic about the scheme. Branch buyers thought that the ZX81 was unlikely to sell more than 10–15 units per branch at launch.[468] Rowland himself thought that the ZX81 would sell about 10,000 units during the first five months of the retail agreement, equivalent to one month's mail order sales by Sinclair.[469] In the event, the ZX81 was a massive success for Smith's. The "Computer Know-How" sections were swamped with eager customers, overwhelming the 300 staff who had been trained to demonstrate the machines; a *Financial Times* correspondent wrote of being "dazed and bewildered by the crowds of schoolchildren clustered round the ZX81 in your local branch of W.H. Smith."[470] Within a year, Smith's had sold 350,000 ZX81s, making an estimated net profit of £10 million. Sales of peripherals, software, books and magazines netted even more profit.[471]

Other distributors soon joined the act. The British chain stores Boots, John Menzies and Currys began selling the ZX81 as soon as Smith's exclusive distribution deal expired[472] and a number of companies secured overseas distribution rights for the ZX81, which was being sold in 18 countries by March 1982.[473] Sinclair launched the ZX81 in the United States in November 1981 at a price of $149.95 assembled and $99.95 in kit form, initially selling directly to the American market by mail order.[474] Sales reached 15,000 a month by January 1982, while American Express sold thousands more to its own customers. In February 1982 Timex obtained a licence from Sinclair to sell the ZX81 directly through thousands of retail outlets in the US, paying Sinclair Research a 5 per cent royalty on all Sinclair hardware and software sold by Timex.[475] The company was later to produce its own licensed clones and variants of the ZX81.[476] In December 1981 Mitsui obtained rights to distribute the ZX81 in Japan, selling it by mail order for ¥38,700 (equivalent to £83 in 1982 prices), and had sold 5,000 units by July 1982. The Japanese market's favourable reaction to the ZX81 led Mitsui to begin selling the ZX81 over the counter in large bookshops from September 1982, with annual sales of 20,000 units predicted.[477]

The ZX81 was also sold for a while in duty-free shops at UK airports. However, this fell foul of government export restrictions aimed at preventing the Soviet bloc countries from obtaining Western high technology goods. It was not uncommon for visitors from the Soviet Union and other eastern European countries to pick up gadgets in Western countries with the aim of transferring their technology to their own states' industries. In 1983 the government ordered that the ZX81s were to be withdrawn from sale at airports.[478] There was no such restriction on sales to communist China and in November 1983 Sinclair Research announced that it had signed an agreement to export ZX81 kits to a factory in Guangzhou, where they would be assembled for the Chinese market.[479]

In the Netherlands, the regular Sinclair ZX81 was for sale as well as a Bang & Olufsen branded version called *Beocomp*.[480]

Reception


A typical ZX81 setup including cassette recorder and black-and-white Ferguson television set.

Reviews of the ZX81 highlighted the great value for money offered by the machine but noted its technical shortcomings. As Tim Hartnell put it in *Your Computer*, "the ZX81 is both a delight and a disappointment". He applauded the improvements that had been made over the ZX80, such as a much better manual, display and string handling, and called the ZX81 "a very good first computer" that "will open the world of computing to many who would be denied access to it by cost." However, the built-in memory was so small that use of a memory expansion pack was "mandatory for any worthwhile use". He also found the ZX81 to be alarmingly unreliable, having to have his first two test machines replaced before getting one that worked properly.[481]

New Scientist's Malcolm Peltu commented that it was "great technical value for money particularly for computing enthusiasts" but thought that others were "likely to be bored very quickly by the basic system". He highlighted weaknesses in the manual and Sinclair's accompanying software, criticising them for "a misconceived design and sloppiness in execution which make the machine seem harder to use and more limited than it should" and questioned whether it might be more worthwhile to save up for a more powerful computer such as Acorn or Commodore's offerings. Overall, he concluded, the ZX81 might have a limited value in helping to teach BASIC programming and overcoming psychological barriers to computing, but "the Sinclair systems have a long way to go before they raise the quality and level of understanding of the nature and use of computer-based information systems among compute unbelievers."[482]

While *Personal Computer World* editor Derek Cohen was on holiday in May 1981, his colleagues publicised the magazine's review of the ZX81 with a cover showing a chimpanzee with the machine above the strapline "Editor benchtests the ZX81". (The chimp returned in later issues to "benchtest" all of Sinclair's subsequent computers.) The review, which was actually written by *PCW* staffer Dave Tebbutt, acknowledged that the machine had significant shortcomings but nonetheless represented "absolutely amazing value for money". He described the ZX81 as "a lovely product which will have enormous appeal to people wanting to find out more about computers, but without it costing them an arm and a leg" and concluded: "If you know nothing about computers and you want to enjoy finding out about them, then this machine offers a value for money way of doing just that. Children will love the ZX81, there can be no question about that, and I suspect that more than a few people who are already familiar with computers will buy one, just to have a bit of fun."[483]

Paul Taylor of the *Financial Times* found the ZX81 to be "a powerful and flexible little computer ideally suited as a fun introduction to the mysteries of home computing" but cautioned readers about its limitations. It lacked ready-made software, the keyboard was not easy to use, it did not have sufficiently advanced graphics to be able to replicate arcade-style games and its built-in memory was inadequate. Even so, he suggested, "the ZX81 is a unique British product, part toy, part puzzle, part learning tool and I think that, provided one accepts its limitations and recognises that any computer will only do what it is told to do, it is good value as an introduction to the hobby of home computing."[484]

David Babsky described the ZX81 as "a wonderfully brainy little micro which won't let you waste your time and make a fool of yourself". In a comparison between the ZX81 and IBM PC published in *Which Micro?*, he commended the ZX81's user-friendliness and its on-the-fly syntax checking of BASIC programs, which he described as "the feature that I, as a newcomer to computing, want to see incorporated into every micro."[485]

Peripherals and software


A ZX81 connected to Sinclair's official peripherals – the notoriously wobbly 16 kB RAM pack and the ZX Printer.

The success of the ZX81 led almost immediately to enthusiasts producing a huge variety of peripherals and software. Clive Sinclair was "amused and gratified" by the attention the machine received[486] but made little effort to exploit the demand, effectively ceding a very lucrative market to third party suppliers – a decision that undoubtedly forfeited a lot of potential earnings. W.H. Smith, for instance, was able to exploit a peculiarity of the ZX81; owners found that technically obsolete low-fidelity mono tape cassette recorders actually worked better as storage devices than higher-quality music systems. Smith's cashed in by buying up stocks of cheap "shoebox" cassette recorders in the Far East, sticking the W.H. Smith logo on them and selling them with a generous mark-up as "data recorders". Over 100,000 were sold in eighteen months.[487]

Sinclair released only two official peripherals for the ZX81 – a 16 kB RAM pack (actually the same one previously released for the ZX80, but rebadged) and the ZX Printer, both of which plugged into the edge connector at the rear of the ZX81. They retailed at a launch price of £49.95 each but both had notable flaws. The RAM pack was top-heavy and was supported only by the edge connector. It had a habit falling out of its socket at crucial points and crashing the ZX81, losing anything that the user had typed in. Users turned to using sticky lumps of chewing gum, double-sided tape or Blu-Tack to cure what became known as the "RAM pack wobble" problem.[488] The ZX Printer was a tiny spark printer that used two electrically charged styli to burn away the surface of aluminium-coated paper to reveal the black underlay. It worked reasonably well at first but its output deteriorated rapidly after a time.[489]

Many peripherals aimed to remedy the ZX81's flaws and provide many new capabilities that Sinclair had not tackled. These included proper typewriter-style keyboards, wobble-free RAM packs providing up to 64 kB of extra memory, more advanced printers and sound generators[490] – and even a hard disk interface, which Clive Sinclair thought was "quite overgilding the lily".[491] A wide range of software was also published. Within only a year of the ZX81's launch, around 200 independent companies had been established to manufacture and sell Sinclair-compatible hardware.[492] The people behind the ZX81 cottage industry were very often not computer professionals but were, as the *Financial Times* noted, "school teachers, civil servants, electrical engineers and technicians [who] have set up small operations in their own time."[493]

A dramatic illustration of the ZX81's explosive popularity came in January 1982, when civil servant Mike Johnstone organised a "ZX Microfair" at Westminster Central Hall. Seventy exhibitors set up their stalls with only a few hundred visitors expected in a hall with a capacity of 650 people. In the event, more than 12,000 people turned up and the police had to be called to control the crowd. Thousands of people, many of whom had travelled long distances to get there, queued outside for up to three hours to get into the hall. The exhibitors found themselves selling thousands of pounds' worth of software and hardware, "as fast as three pairs of hands on each stall could hand them over and stuff the fivers into improvised overflowing cash boxes."[494 495]

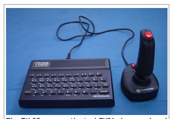
Many ZX81 owners replaced the machine's touch-sensitive keyboard with more usable add-on keyboards produced by third-party suppliers.

Thousands of ZX81 programs were published, either as printed listings that could be typed in or as ready-made applications that could be loaded from cassette tape. Many computer magazines featured ZX81 program listings – some, such as *Sinclair Programs*, were dedicated entirely to listings – while many individuals became the archetypal "bedroom programmers", producing games and applications which they produced, marketed, recorded and sold from their own homes. Some went on to found their own software houses, employing teams of programmers – some of whom were still at school – to produce programs for the ZX81 and other computers. Existing companies jumped on the bandwagon as well, to profitable effect; Psion produced a series of ZX81 programs in close association with Sinclair, including a flight simulator,[496] while ICL's range of ZX81 programs sold over 100,000 cassettes in less than three months.[497] Psion's success with the ZX81 had a profound effect on the future of the company. Its work on the ZX81 database program *Vu-File* led to Psion switching its focus to the development of personal digital assistants, which resulted in the launch in 1984 of the Psion Organiser, the world's first handheld personal computer.[498] Some of the most popular ZX81 games (Psion's *Flight Simulation* being an example) were rewritten for the Spectrum to take advantage of the newer machine's colour and sound capabilities.

Enterprising programmers were able to produce games for the ZX81 using nothing more than text characters and the machine's limited number of inverse video graphical blocks. Some ZX81 games achieved lasting fame, such as *3D Monster Maze*, a tense first-person perspective game that involved the player escaping a labyrinth with a Tyrannosaurus rex in pursuit. Written in a combination of BASIC and machine code, its innovative design led it to be hailed as the first home computer 3D game and a landmark in the history of computer and video games.[499]

One of the more bizarre software products for the ZX81 came about as a result of music companies attempting to capitalise on the popularity of Sinclair's computers. In 1983, EMI released a single by Chris Sievey that had a ZX81 program recorded on the B-side. Island Records responded with *XL1* by Buzzcocks frontman Pete Shelley, packaged with a program for the ZX Spectrum.[500]

Clones and variants



The TK 85, an unauthorised ZX81 clone produced by Microdigital Eletronica of Brazil.

The Timex Sinclair 1000, a licensed ZX81 variant produced for the US market by Timex in 1982–83. It was initially highly successful but sales soon collapsed.

Sinclair's licensing agreement with Timex enabled the American company to produce three clones or offshoots of Sinclair machines for the US market. These were the Timex Sinclair 1000, Timex Sinclair 1500 (both variants of the ZX81) and the Timex Sinclair 2068 (a variant of the ZX Spectrum). The TS1000 was launched in July 1982 and sparked a massive surge of interest; at one point, the Timex phoneline was receiving over 5,000 calls an hour, 50,000 a week, enquiring about the machine or about microcomputers in general.[501] It was virtually identical to the ZX81 save for rebranding and the addition of an extra 1 kB of memory, making for a grand total of 2 kB. In the five months following the TS1000's launch, the company sold 550,000 machines, earning Sinclair over $1.2 million in royalties.[502]

Timex produced a second version of the ZX81 in the form of the TS1500, essentially an Americanised ZX81 launched in August 1983. It dispensed with the membrane keyboard and used a case similar to that of the ZX Spectrum, incorporating 16 kB of on-board memory.[503] It was effectively a stopgap between the ZX81 and Spectrum. However, it was unsuccessful due to increased competition from rival US machines and the after-effects of Timex's botched marketing of the TS1000. Although the TS1000 had initially been a great success, Timex failed to provide the essential RAM pack upgrades to the market for two or three months after it launched the TS1000. Consumers would take the machine home, plug it in and find that it would not do anything useful due to the lack of memory.[504]

In addition, consumers' attitude in the US was quite different to that in the UK. Clive Sinclair told *Informatics* magazine in June 1981 that "our competitors thought that consumers didn't want to learn programming. We [Sinclair Research] think they failed because of this and because of price."[505] Timex evidently shared this belief but events proved it to be a false assumption. The TS1000/ZX81's price advantage was erased when its main rivals – the Texas Instruments TI99/4A and the Commodore VIC 20 – had their prices cut to below the all-important $100 mark.[506] Competitors such as Apple, Atari, Commodore and Texas Instruments promoted their machines as being for business or entertainment rather than education, highlighting the value of computers with ready-made applications and more advanced features such as graphics, colour and sound.[507]

Consumers deserted the TS1000 once its novelty value had worn off and, as publishers of programming guides found to their cost, the American public showed little interest in using the machine to learn about computer programming. American retailers were left with large stocks of unsold machines. Burned by this experience, many were unwilling to stock the later Timex Sinclair machines in large numbers and the big chain stores dropped the Timex Sinclair line altogether.[508]

Some companies outside the US and UK produced their own "pirate" versions of the ZX81 and Timex Sinclair computers, aided by weak intellectual property laws in their countries of origin. Several Brazilian companies produced ZX81 clones, notably the TK series (such as the TK 85) from Microdigital Eletronica of Brazil)[509] and Prológica's CP-200. Czerweny Eletronica of Argentina produced the CZ1000 and CZ1500, clones of the ZX81 and TS1500 respectively. Lambda Electronics of Hong Kong produced the Lambda 3000, based on the ZX81, which was itself widely copied by other Chinese manufacturers.

The machines were not all straight copies of the ZX81; some, such as the CP-200, came with extra memory and a larger case (often with a chiclet keyboard in place of the original membrane keyboard). One clone, the TL801 from TELLAB of Italy, could emulate either the ZX80 or ZX81 and switch between the two machines via a jumper.

Impact and legacy

The ZX81 had an immediate impact on the fortunes of Sinclair Research and Clive Sinclair himself. The company's profitability rose enormously, from a pretax profit of £818,000 on a turnover of £4.6 million in 1980–81 to £8.55 million on a turnover of £27.17 million in 1981–82. Clive Sinclair became one of the UK's highest-profile businessmen and a millionaire, receiving a £1 million bonus on top of a salary of £13,000.[510] He received a knighthood in the Queen's Birthday Honours and the Young Businessman of the Year award in 1983.[511]

The machine also had a widespread and lasting social impact in the United Kingdom. According to Clive Sinclair, purchasers of the ZX81 came from "a reasonably broad spectrum" that ranged from readers of the upmarket *Observer* and *Sunday Times* newspapers to the more downmarket but numerous *Sun* readers. The largest age group was around 30 years old.[512] The *Financial Times* reported in March 1982 that most Sinclair computers were being bought for educational purposes, both for adults and children, though the children were usually able to learn much more quickly.[513] Ian Adamson and Richard Kennedy note that the popularity of the ZX81 was "subtly different from the run-of-the-mill social fad"; although most enthusiasts were in their teens or early twenties, many were older users – often parents who had become fascinated by the ZX81s that they had bought for their children. On the downside, the ZX81 boom was overwhelmingly male-dominated.[514]

One of the ZX81's key legacies was that it spurred huge numbers of people to try programming for the first time. This gave the UK a computing culture that was perhaps unequalled anywhere else and gave rise to a generation of expert programmers. The ZX81 plays a significant part in the plot of William Gibson's 2003 novel *Pattern Recognition*. One character, an artist using old ZX81s as a sculptural medium, explains the cultural and intellectual impact that the machine had on British society:

Walking on, he explains to her that Sinclair, the British inventor, had a way of getting things right, but also exactly wrong. Foreseeing the market for affordable personal computers, Sinclair decided that what people would want to do with them was to learn programming. The ZX81, marketed in the United States as the Timex 1000, cost less than the equivalent of a hundred dollars, but required the user to key in programs, tapping away on that little motel keyboard-sticker. This had resulted both in the short market-life of the product and, in Voytek's opinion, twenty years on, in the relative preponderance of skilled programmers in the United Kingdom. They had their heads turned by these little boxes, he believes, and by the need to program them...

..."But if Timex sold it in the United States," she asks him, "why didn't we get the programmers?"

"You have programmers, but America is different. America wanted Nintendo. Nintendo gives you no programmers. Also, on launch of product in America, RAM-expansion unit did not ship for three months. People buy computer, take it home, discover it does almost nothing. A disaster."[515]

Among those whose first experience of home computing was provided by the ZX81 are Terry Pratchett (who used it for "very primitive word processing"),[516] Edward de Bono[517] and – perhaps proving William Gibson's point – many video game developers including Charles Cecil,[518] Raffaele Cecco,[519] Pete Cooke,[520] David Perry[521] (whose first published game, a driving game, involved "a black blob avoiding other black blobs"[522]), Rhianna Pratchett,[523] and Jon Ritman.[524]

Even though 2011 has seen the 30th anniversary of the ZX81, its legacy continues with active user forums in German [525] and in English.[526]

New hardware and software continues to be developed for the ZX81, including:

- a ZX81-based webserver;[527]
- the ZXpand, a combined SD card interface, 32K configurable memory expansion, and optional joystick port and AY sound interface;[528] and
- new games such as a port of the classic game, *Nanako in Classic Japanese Monster Castle* by the Mojon Twins[529] and *Virus* by Bob Smith.[530]

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- "From Science of Cambridge: the new MK14" (advertisement). Cambridge, England: Science of Cambridge (1978)
- *ZX81 Operating Supplement*. Cambridge, England: Sinclair Research (1982)
- *Sinclair ZX81 Personal Computer* (brochure). Cambridge, England: Sinclair Research (undated, *circa* March 1981)
- Sinclair Research advertisement. *Everyday Electronics*, April 1981, pp. 284–285
- Sinclair Research advertisement. *Popular Science*, October 1982, pp. 284–285
- Sinclair ZX81 Home Computer, with "Mapsoft" keyboard attached." McManus Galleries, Dundee. Accessed 13-1-2011
- TK85. Museu da Computação e Informática. Accessed 2-1-2011
- ZX81DES1. Rick Dickinson, 24 August 2007. Accessed 2-1-2011.
- Sinclair ZX81. Sinclair Research. Accessed 5-1-2011.

External links

- ZX81 at the Open Directory Project
- Sinclair ZX80/ZX81 Discussion Forums
- ZX81 Download Page
- ZX81 Online Museum
- ZX81 Java emulator
- Sinclair ZX81 Teardown - a detailed look at the ZX81's hardware

ZX80

ZX80	
Release date	1980
Introductory price	£99.95 (£319 at 2012 prices)
Discontinued	1981
Units shipped	100,000[53]
Media	Cassette tape
Operating system	Sinclair BASIC
CPU	Z80 @ 3.25 MHz (most machines used the NEC μPD780C-1 equivalent)
Memory	1 KB (16 KB max.)
Successor	ZX81

The **Sinclair ZX80** is a home computer brought to market in 1980 by Science of Cambridge Ltd. (later to be better known as Sinclair Research). It is notable for being the first computer (unless you consider the MK14) available in the United Kingdom for less than a hundred pounds (£99.95). It was available in kit form, where purchasers had to assemble and solder it together, and as a ready-built version at a slightly higher cost for those without the skill or inclination to build their own unit. The ZX80 was very popular straight away, and for some time there was a waiting list of several months for either version of the machine.

Description

Name

The ZX80 was named after the Z80 processor with the 'X' for "the mystery ingredient".[532]

Hardware

Internally, the machine was designed by Jim Westwood around a Z80 central processing unit with a clock speed of 3.25 MHz, and was equipped with 1 kB of static RAM and 4 kB of read-only memory (ROM). The ZX80 was designed around readily available TTL chips; the only proprietary technology was the firmware. While the successor ZX81 used a semi-custom chip (a ULA or Uncommitted Logic Array), this merely combined the functions of the earlier hardware onto a single chip — the hardware and system programs (except the BASIC versions) were very similar, with the only significant difference being the NMI-generator necessary for slow mode in the ZX81. (See ZX81 for technical details.) Both computers can be made by hobbyists using commercially available discrete logic chips or FPGAs.

Firmware

The ROM contained the Sinclair BASIC programming language, editor, and operating system. BASIC commands were not entered by typing them out but were instead selected somewhat similarly to a scientific calculator - each key had a few different functions selected by both context and modes as well as with the shift key.

Case

The machine was mounted in a tiny white plastic case, with a one-piece blue membrane keyboard on the front; it owed its distinctive appearance to industrial designer Rick Dickinson. There were problems with durability, reliability and overheating (despite appearances, the black stripes visible on the top rear of the case are merely cosmetic, and are not ventilation slots).

Video output

Display was over an RF connection to a household television, and simple offline program storage was possible using a cassette recorder. The video display generator of the ZX80 used minimal hardware plus a combination of software to generate a video signal. This was an idea that was popularised by Don Lancaster in his 1978 book The TV Cheap Video Cookbook and his "TV Typewriter".[533] As a result of this approach the ZX80 could only generate a picture when it was idle, i.e. waiting for a key to be pressed. When running a BASIC program, or even when pressing a key for any input, the display would, therefore, black out momentarily while the processor was busy. This made moving graphics difficult since the program had to introduce a pause for input to display the next change in graphical output. The later ZX81 improved on this somewhat because it could run in a "slow" mode while creating a video signal, or in a "fast" mode without generating a video signal (typically used for lengthy calculations). Another issue was that the main RAM was used to store the screen display, with the result that the available screen size would gradually decrease as the size of a program increased (and vice versa) - with 1kB RAM, running a 990 byte program would result in only one row of characters being visible on the screen; a full screen (32*24) would leave only 384 bytes to the programmer.

Video output was strictly black-and-white, character-based. However, the character set included some simple block-based graphics glyphs, allowing crude graphics to be accomplished, with some effort. One advantage to using monochrome video is that different colour broadcast standards (e.g. PAL, NTSC) simply weren't an issue when the system was sold outside the UK.

Expansion

Other than the built-in cassette and video ports, the only provided means of expansion was a slot opening at the rear of the case, which exposed an expansion bus edge connector on the motherboard. The same slot bus was continued on the ZX81, and later the ZX Spectrum, which encouraged a small cottage industry of expansion devices, including memory (Sinclair produced RAM expansion packs for the ZX80: the original ZX80 RAM Pack held either 1, 2 or 3 KB of static RAM; a later model held 16 KB, using dynamic RAM chips (DRAM)), printers, and even floppy drives.

Following the ZX81's release, a ZX81 8 KB ROM was available to upgrade the ZX80 at a cost of around 20% of a real ZX81. It came with a thin keyboard overlay and a ZX81 manual. Simply taking off the top cover of the ZX80 and prying the old ROM from its socket and carefully inserting the new ROM and adding the keyboard overlay, the ZX80 would now function almost identically to the proper ZX81 - except for SLOW mode, due to the differences in hardware between the two models. The process was easily reversed to get the ZX80 back to its old self.

One of the most common modifications by hobbyist users was to move the motherboard into a larger case, with a full-size keyboard. This had the dual advantages of making the machine easier to type on, while increasing ventilation to the motherboard (reducing the likelihood of overheating).

Versions

The UK version of the machine was the standard, and only changes that were *absolutely* necessary to sell units in other markets were made. In fact, the only real change made in most markets involved the video output frequency (the ZX80 used an external power transformer, so differences in AC line frequency and outlet were not an issue to the machine itself). One outcome of this is that the machine had some keyboard keys and characters that were distinctly British: "Newline" was used instead of "Enter", "Rubout" instead of "Backspace" or "Delete", and the character set and keyboard included the Pound symbol, relatively unusual for its day.

Reception

Sales of the ZX80 reached about 50,000 — an unheard of number for the day which contributed significantly to the UK leading the world in home computer ownership through the 1980s. Owing to the unsophisticated design and the tendency for the units to overheat, surviving machines in good condition are quite uncommon and can fetch high prices by collectors.

The primary audience for such computers at the time was hobbyists, and the ZX80 was primarily marketed towards that end. In the US, the ZX80 was available in two forms: a prebuilt unit for US$199.95, or a "kit" version, which provided all the parts but required assembly, for US$149.95. Capitalizing on the price, the system was advertised (in computing and electronics magazines) with the slogan "The first personal computer for under $200".[534]

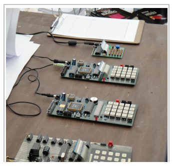
Clones

There were also unauthorised clones of the ZX80, such as the MicroAce (produced in the USA), and from Brazil the Nova Eletrônica/Prológica NE-Z80 and the Microdigital TK82.[535 536]

External links

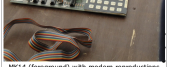
- Planet Sinclair:ZX80
- Review of Sinclair ZX80 from 1980
- Showcase of Sinclair ZX80
- Scot's ZX80 site

MK14



The **Microcomputer Kit 14**, or **MK14** was a computer kit sold by Science of Cambridge of the United Kingdom, first introduced in 1977 for UK£39.95. The MK14 eventually sold over 50,000 units. It used a National Semiconductor SC/MP CPU (INS8060), 256 bytes of random access memory (RAM) which was directly expandable to 640 bytes on board and 2170 bytes total. It used an 8 or 9 red light-emitting diode (LED) seven segment display, there was also optional VDU supporting 32×16 text or 64×64 graphics. Input and output was a 20 key keyboard and reset switch, with an optional 128 bytes of RAM and 16 I/O lines available by adding an INS8154N RAM/IO chip. Cassette-based and PROM storage were optional extras, a sound card was not included but a design for one was provided.

The MK14 could address up to 64kB of memory space by adding a few chips (the NADS address strobe indicated when the most significant 4 bits of address were available to be captured by an external latch); many pioneering home-brew computer magazines such as *Personal Computer World*, and *Practical Electronics* carried details of user modifications.


MK14 (foreground) with modern reproductions behind.

External links and references

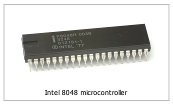
- Planet Sinclair - MK14 articles
- Planet Sinclair - MK14 photo gallery
- The Sinclair / Science of Cambridge MK14 Web Site, includes emulator software
- Making a reproduction MK14 - includes original manuals/schematics
- MK14 on a PIC
- MK14 NIBL basic on a pic

Intel MCS-48

The **MCS-48**


USSR KM1816BE48, an Intel 8748 clone.


The 8749 with UV EPROM


Intel 8048 microcontroller

microcontroller (µC) series, Intel's first microcontroller, was originally released in 1976. Its first members were 8048, 8035 and 8748.

The MCS-48 series has a Modified Harvard architecture, with internal or external program ROM and 64–256 bytes of internal (on-chip) RAM. The I/O is mapped into its own address space, separate from programs and data. The 8048 is probably the most prominent member of Intel's MCS-48 family of microcontrollers. It was inspired by, and is somewhat similar to, the Fairchild F8 microprocessor.

Though the MCS-48 series was eventually replaced by the very popular Intel MCS-51, even at the turn of the millennium it remains quite popular, due to its low cost, wide availability, memory efficient one-byte instruction set, and mature development tools. Because of this it is much used in high-volume consumer electronics devices such as TV sets, TV remotes, toys, and other gadgets where cost-cutting is essential.

Variants

The *8049* has 2 KB of masked ROM (the *8748* and *8749* had EPROM) that can be replaced with a 4 KB external ROM, as well as 128 bytes of RAM and 27 I/O ports. The µC's oscillator block divides the incoming clock into 15 internal phases, thus with its 11 MHz max. crystal one gets 0.73 MIPS (of one-clock instructions). Some instructions are single byte/cycle ones, but a large amount of opcodes need two cycles and/or two bytes, so the raw performance would be closer to 0.5 MIPS.

Another variant, the ROM-less *8035*, was used in Nintendo's arcade game Donkey Kong. Although not being a typical application for a microcontroller, its purpose was to generate the background music of the game.

The Intel *8748* has on-chip clock oscillator, 2 8-bit timers, 27 I/O ports, 64 bytes of RAM and 1 KB of EPROM. A version with 2 KB EPROM and 128 bytes RAM was also available under the *8749* number.

Device	Internal	Memory	Remarks
8020	1K x 8 ROM	64 x 8 RAM	Subset of 8048, 20 pins, Only 13 I/O Lines
8021	1K x 8 ROM	64 x 8 RAM	Subset of 8048, 28 pins ,21 I/O Lines
8022	2K x 8 ROM	64 x 8 RAM	Subset of 8048, A/D-converter
8035	none	64 x 8 RAM	
8039	none	128 x 8 RAM	
8040	none	256 x 8 RAM	
8048	1K x 8 ROM	64 x 8 RAM	
8049	2K x 8 ROM	128 x 8 RAM	
8050	4K x 8 ROM	256 x 8 RAM	
8748	1K x 8 EPROM	64 x 8 RAM	
8749	2K x 8 EPROM	128 x 8 RAM	
8648	1K x 8 OTP EPROM	64 x 8 RAM	Factory OTP EPROM

Device	Internal	Memory	Remarks
8041	1K x 8 ROM	64 x 8 RAM	Universal Peripheral Interface (UPI)
8041AH	1K x 8 ROM	128 x 8 RAM	UPI
8741A	1K x 8 EPROM	64 x 8 RAM	UPI, EPROM version of 8041
8741AH	1K x 8 OTP EPROM	128 x 8 RAM	UPI, OTP EPROM version of 8041AH
8042AH	2K x 8 ROM	256 x 8 RAM	UPI
8742	2K x 8 EPROM	128 x 8 RAM	UPI, EPROM version
8742AH	2K x 8 OTP EPROM	256 x 8 RAM	UPI, OTP EPROM version of 8042AH

Uses

The 8048 was used in the Magnavox Odyssey² video game console, the Korg Trident series, the Korg Poly-61[537], Roland Jupiter-4 and Roland ProMars[538] analog synthesizers.

The original IBM PC keyboard used an 8048 as its internal microcontroller.[539] The PC AT replaced the PC's Intel 8255 peripheral interface chip at I/O port addresses 0x60-63 with an 8042 accessible through port addresses 0x60 and 0x64.[540] As well as managing the keyboard interface the 8042 controlled the A20 line of the AT's Intel 80286 CPU, and could be commanded by software to reset the 80286 (unlike the 80386 and later processors, the 80286 had no way of switching from protected mode back to real mode except by being reset). Later PC compatibles integrate the 8042's functions into their super I/O devices.

Literature

- **MCS-48**

- *MCS-48™ Single Component Microcomputer*, Applications Seminar Notebook, 1978, Intel Corporation.
- *MCS-48™ MICROCOMPUTER USER'S MANUAL*, 1978, Intel Corporation.
- Lionel Smith, Cecil Moore: *Serial I/O and Math Utilities for the 8049 Microcomputer*, Application Note AP-49, January 1979, Intel Corporation.
- *A High-Speed Emulator for Intel MCS-48™ Microcomputers*, Application Note AP-55A, August 1979, Intel Corporation.
- Phil Dahm, Stuart Rosenberg: *Intel MCS-48™ and UPI-41A™ Microcontrollers*, Reliability Report RR-25, December 1979, Intel Corporation.
- *Microcontroller Handbook*, Intel 1984, Order number 210918-002.
- *8-Bit Embedded Controllers*, Intel 1991, Order number 270645-003.

- **UPI-41**

- *UPI-41A User's Manual*, Intel 1980, Order number 9800504-02 Rev. B.
- *Microprocessor Peripherals UPI-41A/41AH/42/42AH User's Manual*, October 1993, Order number 231318-006, Intel Corporation.
- Johan Beaston, Jim Kahn: *An 8741A/8041A Digital Cassette Controller*, Application Note AP-90, May 1980, Intel Corporation.

External links

- MCS-48 family architecture
- Coprolite 8048 Projects
- Computer History Museum, Intel 8048 Microcontroller Oral History Panel
- Microcontroller NEC 8741 (image of the Silicium-Chip)
- HSE-49 Emulator

References

Cambridge Z88

Cambridge Z88	
Release date	1988
Operating system	OZ
CPU	CMOS Z80A @ 3.2768 MHz
Memory	32 KiB RAM, 128 KiB EPROM (internal memory) as standard

The **Cambridge Computer Z88** is an A4-size, lightweight, portable Z80-based computer with a built-in combined word processing/spreadsheet/database application called *PipeDream*, along with several other applications and utilities, such as a Z80-version of the BBC BASIC programming language.

The Z88 evolved from Sir Clive Sinclair's *Pandora* portable computer project which had been under development at Sinclair Research during the mid-1980s. The machine was launched at the *Which Computer?* Show on February 17, 1987.[541]

Technical description

The Z88 is a portable computer weighing 0.9 kg, based on a low-power CMOS version of the popular Zilog Z80 microprocessor. It comes with 32 KiB of internal pseudo-static RAM and 128 KiB of ROM containing the operating system (called *OZ*). The memory can be expanded up to 3.5 MiB of RAM, the contents of which are preserved across sessions. An integrated capacitor prevents the Z88 from losing its data for the limited amount of time it takes to change the batteries.

The machine uses a membrane keyboard, which is almost silent in use; an optional electronic "click" can be turned on to indicate keystrokes. The Z88 is powered by four AA batteries, giving up to 20 hours of use. It has three memory card slots, which accommodate proprietary RAM, ROM or EPROM cards, the third slot being equipped with a built-in EPROM programmer. Card capacities range from 32 KiB to 1 MiB.

The Z88 has a built-in eight-line, "super-twisted" LCD display, which has greater contrast than conventional twisted nematic LCDs.

Memory map

The 64 KiB addressable by the Z80 processor are divided in four banks of 16 KiB each. The maximum memory of 4 MiB for the system is also divided in 256 segments of 16 KiB each. The hardware can map any of the 16 KiB blocks to any of the four banks. The first 512 KiB are reserved for ROM; the next 512 KiB are reserved for internal RAM. The next 3 MiB are assigned to each one of the three memory slots.

The Z88 used an 8-line LCD display

Current status

The Z88 had something of a cult following, and is still used by a few enthusiasts. A variety of software is available including games and utilities. Since 1998, a 1 MiB Flash memory card is available which provides convenient non-volatile storage. Once written to the card, files are safe and not reliant on a power supply. Unlike traditional EPROM cards (erased with an external ultraviolet light), this one can be electrically erased in the computer's slot. The first generation of card only worked in slot 3 where a 12V signal (Vpp) is available. The later generation is based on AMD chips and runs with 5V for erasure. It is possible to read, write and erase flash cards in the three slots and the internal one.

It is also possible for an experienced user to replace the built-in 32 KiB RAM chip with a bigger 128 or 512 KiB static RAM chip. However, the latter requires some extra board modifications, and 512 KiB is the biggest size that can be addressed by the Z88 for the internal RAM. A similar modification is possible for the internal EPROM slot. A 512 KiB flash chip can replace the original ROM, allowing an upgrade of the operating system.

External links

- Cambridge Z88 at the Open Directory Project
- Rick Dickinson's "Pandora to Z88" gallery on Flickr
- Z88 Project Development
- Z88 Forever enthusiast site
- Lots of informations and utilities for the Z88
- Rakewell - the 1MiB flash EPROM producer
- RWAP Software - Z88 sales and support
- PipeDream book
- Z88Transfer, a program to transfer files between a Z88 and a PC

Grundy NewBrain

The **Grundy NewBrain** was a microcomputer sold in the early 1980s by **Grundy Business Systems Ltd** of Teddington and Cambridge, England.


GBS Newbrain AD with a French keyboard. On display at the Musée Bolo, EPFL, Lausanne.


View of the connectors of the same machine.

Beginnings

The NewBrain project was started in 1978 when Sinclair Radionics began design work with Mike Wakefield as the designer and Basil Smith as the software engineer. This project was intended to provide competition for Apple and hardly fitted in with Sinclair's focus on inexpensive consumer-oriented products. When it became obvious to Sinclair that the NewBrain could not be made for the sub-£100 price he envisaged his thoughts turned to the ZX80 that was to be developed by his other company, Science of Cambridge Ltd.

The NewBrain project was moved to Newbury Laboratories by the National Enterprise Board (NEB), the owner of both Sinclair Radionics and Newbury Labs, following the closure of Sinclair Radionics. In 1980 Newbury announced the imminent release of three NewBrain models, including a battery-powered portable computer.

BBC micro project

An English AD model, clearly showing the 16-character display, on show at The National Museum of Computing

In early 1980, the British Broadcasting Corporation (BBC) Further Education department conceived the idea of a computer literacy programme, principally in response to the impact of a 1979 six-part ITV documentary series, *The Mighty Micro*, in which Dr Christopher Evans from the UK National Physical Laboratory predicted the coming (micro)computer revolution. It was a very influential documentary — so much so that questions were asked in parliament. BBC Engineering was instructed to attempt to draw up an objective specification.

As a result of the questions in Parliament, the Department of Industry (DoI) became interested in the programme, as did BBC Enterprises, which saw an opportunity to sell a machine to go with the series.

Eventually, under some pressure from the DoI to choose a British system, the BBC 'chose' the NewBrain. The BBC specification was closely written around the NewBrain specification, with (presumably) the expectation that Newbury Laboratories would tender and win. It was not to be. Although the NewBrain was under heavy development by Newbury, it soon became clear that Newbury was not going to be able to produce it. Newbury did not tender, so opening the door for other companies. The BBC's programmes, initially scheduled for Autumn 1981, were moved back to Spring 1982. After Chris Curry and Clive Sinclair found out about the BBC's plans, the BBC allowed other manufacturers to submit their proposals. Chris Curry visited the BBC and persuaded them to change the specification so that Acorn could submit their design.

The BBC eventually chose a computer from Acorn Computers Ltd.

As a result of the BBC's decision, the British Technology Group, which had replaced the NEB, sold the final design and production to Grundy. Grundy had been looking for an entrant into the personal computer business, as they were already producing a CP/M 2.2-based machine, built into a 'dumb terminal' as a virtual clone of the Intertec Superbrain.

Available models

Detail of the screen of an AD (one-line integrated display) model. On display at the Musée Bolo, EPFL, Lausanne.

Two main models were released. The model 'A' had display to either a TV or a monitor. The model 'AD' also included a one-line, 16-character, vacuum fluorescent (VF) display on the unit which permitted operation with or without a TV screen or monitor - the VF display responded to the cursor keys and scrolled around the screen display area. One additional model was released, but this was a custom version for a pharmaceutical chain, with no screen display - only the VF display - and was never generally discussed.

An expansion chassis was released, providing additional paged memory of 64Kb. The Z80 can only address 64Kb of memory at a time. The paged memory system added the NewBrain to take advantage of several 64Kb modules. The expansion module included a parallel printer port and two hardware based serial ports and an expansion through bus for further modules such as the 8 and 16 way serial modules under development. The expansion module included Series 2 software, replacing those in the processor module as well as software for the new devices.

CP/M 2.2 was also available. Under CP/M 2.2 the internal BASIC ROM was paged out for the CP/M ROM but this gave only 32Kb memory to CP/M. With the expansion module fitted the three 8Kb ROMS of the processor module were paged out to give the NewBrain one of the highest available TPA (Transient Program Area - memory left after the OS demands are satisfied) to CP/M. Grundy Business Systems released two 5.25" drive formats, 40 track 200Kb single sided and 80 track 800Kb double sided. Several independent dealers provided 40 track 400Kb double sided drive. In 1983 the Sony 3.5" was becoming available and single and paired units were being supplied to dealers in the NewBrain cream cases. The 3.5" 800Kb discs also got a more effective format allowing the files from 4x200Kb floppies to be stored on one 800Kb disc.

Commercial Application

Over 50,000 NewBrain units were sold to educational, scientific, industry, small business and banking sectors; as well as to home users. Scientific use was strong because of the unusually high precision of the NewBrain's floating point computations and its very high-resolution graphics. Business use was also proportionally high due to the availability of CP/M based software. The main industrial use was within the pharmaceutical industry.

Software

The unexpanded NewBrain contains software provided in ROM, primarily BASIC, a full screen editor and device drivers. Other packages were also included within the ROM (e.g. maths and graphics packages) and were accessible to BASIC and any other software.

All I/O was stream-based, and orthogonal: any device could be replaced by an alternative, although the manual did warn that devices had to be chosen with care. This approach did make it easy to write programs that could swap between input and output coming from a screen, keyboard or a tape.

The maths package[542] had 12 figures of accuracy and a dynamic range of 10^{-150} to 10^{150}, compared to most common machines having 6 figure accuracy and a dynamic range of 10^{-38} to 10^{+38}. This was achieved by using base 256 for the floating point format, rather than the more common base 2, and using 6 bytes for storing numbers, rather than the more common four. Five bytes stored the basic number, with the last byte storing the sign in the first bit, and the remaining seven bits storing the exponent. For example, Pi was stored as 3.14159265358.

Benchmarks show that even though the NewBrain performed double accuracy calculations, it was one of the fastest 8-bit computers available for several years, completing PCW Benchmark 8 in 7.0 seconds.[543] For comparison against other contemporary machines, the Sinclair Spectrum took 25.3 seconds, the BBC Micro took 5.1 seconds, but with fewer significant digits. The 16-bit IBM PC took 3.5 seconds.

The graphics screen was separate to the text screen, and was opened as a new output stream that shared space with the text screen. The graphics commands were based on 'turtle' keywords and provided a flexible means of drawing. The last two generations of NewBrain ROMs included new graphics commands - ROM 1.9 had two more commands, and ROM 2.0 some more. But to ensure compatibility little software would use these additional commands. The programmers were working on version 2.2 as well as versions for different keyboards, including Greek and Swedish as well as French and German. Grundy had been considered offering the Series 2 ROMS to existing users. This required the existing soldered in ROMS to be removed from the circuit board and a socket soldered in. The tight fit and labour cost was high on this retro fitting, and the failure of the company in 1983 meant that users were never aware that this was being considered.

The version of BASIC was an extended version of ANSI BASIC, the facilities of which were similar to those in Microsoft BASIC. The graphics package included commands that could draw dots, lines, arcs, filled-in areas and annotated axes.

Grundy offered a 'Software Technical Manual'. This manual documented various routines that could be called in the ROM and the calling parameters. It was left to the NewBrain user groups to publish the details of how to access these routines through the indirect call (a low-memory address was called with the relevant routine parameters, and this address would call the ROM-specific location of a jump table which, in turn, then called the final routine.) Even screen access required this indirect use, as the screen location would change as new input and output streams were created, including high-resolution (for the time) graphic streams. Memory maps and other technical information were included in numerous technical notes which were supplied to dealers and owners free of charge. The Technical Manual had a retail price of £50.

HiSoft produced NewBrain versions of their Pascal compiler and editor. A number of CP/M applications were converted to using the NewBrain's CP/M terminal and made available on NewBrain 5.25" and 3.5" formatted diskettes. These included Z80 Assemblers and debuggers, Pro Pascal and Pro Fortran, TCL Pascal, dBase II, Wordstar 3.3, Peach Tree accounts and business applications and Superfile database and CP/M versions of Hisoft Pascal, Modula-2, Z80 Assembler and text editor.

Many third party software houses (e.g. IEL, MicroMart, Black Knight Computers) provided independent software for the NewBrain, which was supplied to users such as the British Ministry of Defence, and Cambridge University.

The end

Tradecom purchased Grundy Business Systems in 1983 in order to fulfill a contract to supply microcomputers to schools and training centres in the Netherlands. They created a server to which several NewBrains could use its floppy discs to load programs down the serial cable and simple switching enabled the teacher to view the screen of the students. They also demonstrated a keyboard with predictive text laid out in a non-QWERTY fashion. They were given television coverage, but the NewBrain's part in this was not mentioned.

Tradecom's NewBrains were supplied entirely by existing stock. A press release was made of a new factory in India to provide NewBrains for the Indian market and to supply Europe, but nothing materialised.

What remains

The Dutch NewBrain user group has PDF downloads of various publications, and a link to a Greek website that contains a PC-based emulator.
The Dutch website has many of the programs that were available for the NewBrain, and these can be run on the emulator.

Specifications

Pricing:	Model AD 229.00 GBP, Model A 199.00 GBP (United Kingdom, 1982), 48,000.00 GRD (Greece, 1985)
Emphasis:	Education, Portable computing, Programming, Small business
Timeline:	Released: 1982
CPU type:	Zilog Z80A
CPU word length:	8 bits
CPU clock rate:	4 MHz
ROM Size:	24 KiB
RAM Size:	32 KiB
Maximum RAM Size:	2 MiB
Number of keys:	62
Keyboard and one-line VF display chip:	COP420 MCU
Graphics modes:	256×256, 320×256, 512×256, 640×256×2
Text modes:	32×25, 32×30, 40×25, 40×30, 64×25, 64×30, 80×25×2, 80×30×2
Total number of colours:	2
I/O Ports:	2× Tape recorder (1,200 Baud), Composite video, Expansion, 2x RS-232 (to 19,000 Baud), UHF TV output

References

NewBrain Handbook
NewBrain Model AD, Serial # 610802
Personal Computer World, 1982 review.
The Computer Programme, BBC Television Programme.
NBUG magazines

External links

- Binary Dinosaurs' History of Grundy Business Systems - an inside view
- A second history, plus photographs
- Press release on the sale of the NewBrain to Grundy
- Old Computers Museum's entry on the NewBrain
- Dutch NewBrain user group
- More NewBrain photos
- The current Newbrain emulator website
- The Newbrain emulator website -- an older version
- Grundy Newbrain Repair Information

On TV!

"Micro Men"

Micro Men

Micro Men title card.

Genre	Documentary Drama
Written by	Tony Saint
Directed by	Saul Metzstein
Country of origin	United Kingdom
Language(s)	English
Production	
Producer(s)	Andrea Cornwell
Running time	84 mins
Broadcast	
Original channel	BBC Four
Original airing	8 October 2009[544]
External links	
Website	

Micro Men is a one-off BBC drama television show set in the late 1970s and 1980s, about the rise of the British home computer market, particularly the rivalry between Sir Clive Sinclair who developed the ZX Spectrum, and Chris Curry - the man behind the BBC Micro; played by Alexander Armstrong and Martin Freeman respectively.

It was produced as a BBC Drama, shot in the UK, with some scenes shot in and around the colleges of Cambridge on 15 July 2009.

The opening title's theme tune is called 'Pulstar' which is on the 1976 album Albedo 0.39 by Vangelis.

Plot

The drama is centred on two of the leading players and their respective companies in the home computer market of the late 1970s and early 80s focusing on the race to become the provider of a home computer for the BBC's programming for schools. Certain parts of the drama are based on historical fact whilst others are mere dramatisation and a version of events at the time.

Release

It was first shown on the UK channel BBC Four on 8 October 2009. The programme was directed by Saul Metzstein and produced by Andrea Cornwell. The programme was created by independent production company Darlow Smithson and was written by Tony Saint. It originally had the working title ***Syntax Era***.

Cameo appearances

Sophie Wilson, part of the Acorn development team, played the part of the pub landlady calling time (around 1h 21m).
Jim Westwood can be seen reading a magazine behind Martin Freeman in WH Smith.

Props

The computers and technical props including the Sinclair C5 were supplied by The Centre for Computing History in Haverhill which is just outside Cambridge.

Factual Errors

In the pub at 5:20, it shows someone playing a *Tempest* arcade machine, which would not be released until 1981, 3 years after the scene is meant to be set in. At the computer show, where Curry is promoting the Acorn Atom and Clive Sinclair is promoting the ZX80, library footage at 27:04 shows visitors using Amstrad CPCs, embedded in a counter, with their distinctive coloured keyboards and integrated cassette decks. However, Amstrad had not entered the computer market at that time and the Amstrad CPC would not be introduced until 1984. Throughout the show, they call the Z80A processor the ZX80A processor. In the advert where Clive Sinclair announces the ZX Spectrum, it shows MIDI OUT port, the MIDI standard would not be published until 1983, one year after the Spectrum's release, however the MIDI OUT port would be part of the Sinclair Spectrum 128 model.

Cast

- Alexander Armstrong: Clive Sinclair
- Martin Freeman: Chris Curry
- Edward Baker-Duly: Hermann Hauser
- Sam Phillips: Steve Furber
- Stefan Butler: Roger Wilson
- Colin Carmichael: Jim Westwood
- Derek Riddell: Nigel Searle
- Rhona Croker: Valerie
- Jason Fitzpatrick: David Johnson-Davies
- Amy Beth Hayes: Cynthia
- Nicola Harrison: Ann Sinclair
- Peter Davison: Bank Manager
- Michael Keating: Holley
- Jon Glover: Radcliffe
- Theo Barklem-Biggs: Ralph
- Renny Krupinski: Foreman
- James Garnon: Journalist
- James Fleet: Kenneth Baker
- Rasmus Hardiker: Luke
- Alison Dowling: Shopper
- Perdita Avery: Susan
- Elizabeth Bower: Mindy
- Tim Downie: Tony Wood Rogers
- Mark Mansfield: Rick Dickinson
- Sophie Wilson (uncredited): Pub Landlady
- Louise Wilkinson (uncredited): Barbara

External links

- *Micro Men* at BBC Online
- *Micro Men* on the British Comedy Guide
- *Micro Men* at the Internet Movie Database
- The Guardian: Battle between ZX Spectrum and BBC Micro to be BBC4 comedy drama
- TechRadar article
- BitterWallet blog entry by Andy Dawson (09.10.2009, just a day after Micro Men was broadcasted first)

Some Other Products

Sinclair Executive

The **Sinclair Executive** was Clive Sinclair's first venture into the pocket calculator market. The Executive was the world's first "slimline" pocket calculator. It was variously described as "a piece of personal jewelry" (*New Scientist*) and "at once a conversation piece, a rich man's plaything and a functional business machine" (*Design Magazine*). An example of the calculator is displayed at the Museum of Modern Art in New York.

History

The Executive was launched in August 1972 at the price of GB£79.95 plus VAT, which at that time was about two or three times the average weekly wage.

Sinclair Executive calculator

Design

The Executive weighed only 2.5 ounces (71 g) and measured 5.5 × 2.25 × 0.4 inches (14 × 5.7 × 1.0 cm).

The Executive was remarkably thin for its time, made possible by the first use of button-type batteries to power a calculator. To do this, Sinclair had to overcome the problem of the power hungry calculator electronics and LED display. It was common to pulse the power to the LED display to reduce power consumption, but Sinclair's engineers found that it was also possible to rapidly pulse the main calculator integrated circuit (chip). This method of operation relied on the capacitance of the devices in the chip to retain information during a calculation, and it was claimed that the power consumption of the chip was reduced from 350 milliwatts to about 20 milliwatts. Texas Instruments, the manufacturer of the chip, said it had not tested them operating like this, but Sinclair said that it tested all the chips before it used them.[545 546 547] This had the effect of extending battery life to about 20 hours of continuous use.

External links

- Planet Sinclair—Sinclair Executive information
- Planet Sinclair—Sinclair Executive photo gallery
- Clive Sinclair and the Pocket calculator

Sinclair Cambridge

Sinclair Cambridge

A Sinclair Cambridge calculator with its case. As a sense of scale, the tiles in the background have 5-centimetre (2.0 in) long edges

Manufacturer	Sinclair Radionics
Release date	August 1973
Introductory price	GB£43.95
CPU	General Instruments Microelectronics GI-C550 (Cambridge),[548] National Semiconductor MM5799EHY/N and DS7784N (Programmable)[549]
Display	8-digit LED character display
Dimensions	50x111x28mm
Weight	3.5 ounces (99 g)
Predecessor	Sinclair Executive

The **Sinclair Cambridge** was a small pocket-sized calculator manufactured from summer 1973 by UK company Sinclair Radionics. It was available both as a kit to be assembled by the purchaser, and assembled. The range ultimately comprised seven models, the original "four-function" Cambridge, which carried out the four basic mathematical functions of addition, subtraction, multiplication, and division, being followed by the Cambridge Scientific, Cambridge Memory, two versions of Cambridge Memory %, Cambridge Scientific Programmable and Cambridge Universal.[550]

History

The Cambridge had been preceded by the Sinclair Executive, Sinclair's first pocket calculator, in the summer of 1972. At the time the Executive was smaller and noticeably thinner than any of its competitors, at 56x138x9mm, fitting easily into a shirt pocket.[55]

Design

The Cambridge was extremely small for a calculator of the time:[552] it weighed less than 3.5 ounces (99 g) and its size was 50x111x28mm.

A major factor in the Cambridge's success was its low price; the Cambridge was launched in August 1973, selling initially for GB£43.95.[553] In January 1974 the Cambridge was priced at £32.95 (£29.95 + VAT) fully assembled or £27.45 (£24.95 +VAT) as a kit,[554] bundled with an extensive manual detailing how to calculate functions such as trigonometry, n-th root extraction and compound interest on the device.[555] Initially power was supplied by 4xAAA batteries.[556]

The use of cheap components was an important contributor to the unit's cost. A common failure mode was breakage of the battery contacts,making it impossible to switch the calculator off, due to the use of switch contacts made of nickel coated with tin, rather than the gold; tin, unlike gold, produces an oxide layer when exposed to air which spreads across the insulation over time as the switch is operated, short-circuiting the switch.[557]

The Cambridge used light-emitting diodes for its display. On later scientific variants the power draw for the display required a larger PP3 battery, creating a bulge in the lower rear casing of the appliance.[558]

Display

Numbers were displayed on the 8-digit LED display (made by National Semiconductor[559]) in scientific format with a 5-digit mantissa and a 2-digit exponent.[560]

Close-up of a powered-on Cambridge, showing the illuminated display

Variants

A later model, the Sinclair Cambridge Scientific, was developed, and launched in March 1974 at a price of £49.95 (£5 cheaper than its nearest rival from Hewlett-Packard). As the name suggests, it was a development of the Cambridge, using the same case, with the addition of some common scientific functions (sin, cos, tan, etc).[561]

The other calculators in the range were the Cambridge Memory, Cambridge Memory % (which came in two different versions), Cambridge Programmable (marketed in the United States as the Radio Shack EC-4001), Cambridge Scientific, Cambridge Scientific Programmable and Cambridge Universal.[562]

The Cambridge Programmable (sold in the U.S as the Radio Shack EC-4001[563]) was released in 1975.[564] It lacked accuracy in many of its scientific functions, some yielding only four significant digits. It featured a single memory register and a limit of 36 program steps, along with a conditional jump instruction.[565] The Programmable came with a program library consisting of 4 books, covering general functions, finance & statistics, mathematics, physics & engineering and electronics.[566]

The Cambridge Programmable was superseded by the Sinclair Enterprise, which allowed 80 program steps.[567]

References

568 569 570 571 572 573 574 575 576

Sinclair Scientific

Sinclair Scientific calculator photographed circa 1974

The **Sinclair Scientific** calculator was a 12-function, pocket-sized calculator, selling for about $100 in the USA and around £45 in the UK.

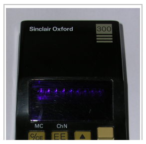
The Sinclair Scientific first appeared in a case derived from that of the Sinclair Cambridge, but it was not part of the same range. At the time it was launched, in August 1975, it was a highly unusual calculator. It displays only in scientific notation - 5 digit mantissa, 2 digit exponent. Because of the way its processor (a custom chip from Texas Instruments) is designed, it relies on reverse Polish notation (RPN). This unusual method of mathematical problem solving meant that, for instance, to add 2 and 4, one had to enter 2, then 4, then the + symbol. There was no = key. The Scientific Programmable was an advanced version launched in 1977, again using reverse Polish notation. It could handle programs of up to 24 steps and cost £29.95. It used four AAA batteries.

The Scientific Programmable Mark 2 was powered either by a 9V battery or a mains adaptor and cost £17.22. It came with twelve sample programs, with another 294 contained in an additional four-volume library which could be bought for £4.95. Each volume was dedicated to a different application: finance and statistics, mathematics, physics and engineering, and electronics. It also used RPN.

An ingenious aspect of the design which showed Sinclair's inventiveness was that the machine made use of what was originally a 4-function calculator chip. Sinclair realised that by using RPN and allowing a reduced precision of 4 or 5 significant figures displayed in scientific notation, the algorithms for scientific functions could be redesigned and compacted to fit in the same programmable space on the chip. This allowed Sinclair to adapt the relatively low-cost processor and produce an 'electronic slide rule' that fitted easily in a shirt pocket, at a price that even impecunious students could afford.

As a consequence of the compacted logical design and in common with many ground-breaking inventions, operation was a little idiosyncratic, but amazingly flexible with familiarity. Keys trebled up on functionality, important constants were printed on the case below the display, and the instruction book contained many useful keystroke sequences for common functions that were otherwise absent from the device - thus making the calculator much more versatile than the keyboard at first suggests. The log/antilog functions used natural logs and the trignometric functions used radians. The constants printed on the case were useful when converting between radians and degrees, and between log base 10 and log base e.

Sinclair Oxford

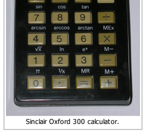


Sinclair Oxford was a range of low-cost scientific calculators manufactured and sold by Sinclair Radionics in England from 1975 until 1976. The first model was the *Oxford 100*, launched in Spring 1975 for GB£12.95; this model was based on the *Gillette GPA* from late 1974 that was made by Sinclair for Gillette in a slightly different case. Both the Gillette GPA and Oxford 100 models used 8 digit displays with red light-emitting diodes (LEDs), 4 functions, 9 volt PP3 batteries. Both models measured 73 x 155 x 34 mm (2.9 x 6.1 x 1.3 inches).

All the Oxford models were similar in appearance; the 150 was introduced in 1975 introducing the ability to calculate percentages and square roots. The *Oxford 200* included memory and sold for £19.95. The *Oxford 300* was a scientific model with a limited number of functions (such as sin, cos, tan), which sold for £29.95, much lower than the competition. The last two models, the *Oxford Scientific* (1976) and *Oxford Universal* were the most advanced of the range.

External links and references

- vintagecalculators.com - Gillette GPA / Sinclair Oxford 100
- vintagecalculators.com - Sinclair Oxford 150
- vintagecalculators.com - Sinclair Oxford 200
- vintagecalculators.com - Sinclair Oxford 300
- vintagecalculators.com - Sinclair Oxford Scientific
- vintagecalculators.com - Sinclair Oxford Universal
- Planet Sinclair - Sinclair Oxford information
- Planet Sinclair - Sinclair Oxford photo gallery



Sinclair Oxford 300 calculator.

Sinclair Sovereign

The **Silver Sovereign** was a high-end calculator introduced by Sinclair Research Ltd of the United Kingdom in 1976, it was one of the last Sinclair calculators. The Sovereign came in silver and gold plated models, with leather pouches and fitted wooden cases. The display can view 8 digits using red light-emitting diodes (LEDs), and includes four functions for percentage, memory, square root and square. It uses two 2.5 volt button cells and uses a Mostek MK50321N main integrated circuit (IC). Similar to other Sinclair products and calculators, the Sovereign was small and slim measuring 36 x 141 x 12 mm (1.4 x 5.6 x 0.5 inches).

The Sovereign was unusual because the casing was made from pressed steel. This allowed a variety of paint and plating options, including black painted, bright chrome plated, silver plated, and gold plated. A small number of solid gold ones were made. In 1976, the chrome plated version cost GB£30 (US$60) and the gold plated version cost twice as much. A limited edition silver plated version, inscribed to commemorate the Silver Jubilee of Queen Elizabeth II in 1977 was produced.

External links and references

- vintagecalculators.com - Sinclair Sovereign
- Planet Sinclair - Sinclair Sovereign calculator
- Planet Sinclair - Sinclair Sovereign photo gallery

Sinclair President

The **Sinclair President** is a calculator that was made by [Sinclair Research Ltd.] It was launched in 1978. Writing embossed in the black plastic on the back of the calculator states that they were assembled in Hong Kong and designed in Great Britain.

It requires two size AA 1.5 volt batteries or it can be powered by a 3 volt DC external adapter via a socket on the side of the calculator.

External links

- Vintage Calculators Web Museum

A Sinclair President calculator (on a grid of 5cm squares)

Watch

Early wrist watch by Waltham, worn by soldiers in World War I (Deutsches Uhrenmuseum, Inv. 47-3352)

A **watch** is a small timepiece, typically worn either on the wrist or attached on a chain and carried in a pocket, with wristwatches being the most common type of watch used today. They evolved in the 17th century from spring powered clocks, which appeared in the 15th century. The first watches were strictly mechanical. As technology progressed, the mechanisms used to measure time have, in some cases, been replaced by use of quartz vibrations or electromagnetic pulses and are called quartz movements.[577] The first digital electronic watch was developed in 1970.[578]

Before wristwatches became popular in the 1920s, most watches were pocket watches, which often had covers and were carried in a pocket and attached to a watch chain or watch fob.[579] In early 1900s, the wristwatch, originally called a Wristlet, was reserved for women and considered more of a passing fad than a serious timepiece. Real gentlemen, who carried pocket watches, were actually quoted as saying they would "sooner wear a skirt as wear a wristwatch". This all changed in World War I when soldiers on the battlefield found using a pocket watch to be impractical, so they attached the pocket watch to their wrist by a cupped leather strap. It is also believed that Girard-Perregaux equipped the German Imperial Navy in a similar fashion as early as the 1880s, which were used while synchronizing naval attacks and firing artillery.[580]

Most inexpensive and medium-priced watches used mainly for timekeeping are electronic watches with quartz movements.[581] Expensive, collectible watches valued more for their workmanship and aesthetic appeal than for simple timekeeping, often have purely mechanical movements and are powered by springs, even though mechanical movements are less accurate than more affordable quartz movements. In addition to the time, modern watches often display the day, date, month and year, and electronic watches may have many other functions. Watches that provide additional time-related features such as timers, chronographs and alarm functions are not uncommon. Some modern designs even go as far as using GPS technology or heart-rate monitoring capabilities.

Movement

Different kinds of movements move the hands differently as shown in this 2 second exposure. The left watch has a mechanical 21,600 bph movement, the right one has a quartz movement

A Russian mechanical watch movement

A movement in watchmaking is the mechanism that measures the passage of time and displays the current time (and possibly other information including date, month and day). Movements may be entirely mechanical, entirely electronic (potentially with no moving parts), or a blend of the two. Most watches intended mainly for timekeeping today have electronic movements, with mechanical hands on the watch face indicating the time.

Mechanical movements

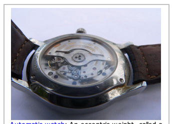
Compared to electronic movements, mechanical watches are less accurate, often with errors of seconds per day, and they are sensitive to position, temperature[582] and magnetism.[583] They are also costly to produce, require regular maintenance and adjustment, and are more prone to failure. Nevertheless, the craftsmanship of mechanical watches still attracts interest from part of the watch-buying public. Skeleton watches are designed to leave the mechanism visible for aesthetic purposes.

Mechanical movements use an escapement mechanism to control and limit the unwinding and winding parts of a spring, converting what would otherwise be a simple unwinding into a controlled and periodic energy release. Mechanical movements also use a balance wheel together with the balance spring (also known as a hairspring) to control motion of the gear system of the watch in a manner analogous to the pendulum of a pendulum clock. The tourbillon, an optional part for mechanical movements, is a rotating frame for the escapement, which is used to cancel out or reduce the effects of gravitational bias to the timekeeping. Due to the complexity of designing a tourbillon, they are very expensive, and only found in "prestige" watches.

The pin-lever escapement (called the Roskopf movement after its inventor, Georges Frederic Roskopf), which is a cheaper version of the fully levered movement, was manufactured in huge quantities by many Swiss manufacturers as well as Timex, until it was replaced by quartz movements.[584][585][586]

Tuning-fork watches use a type of electromechanical movement. Introduced by Bulova in 1960, they use a tuning fork with a precise frequency (most often 360 hertz) to drive a mechanical watch. The task of converting electronically pulsed fork vibration into rotary movement is done via two tiny jeweled fingers, called pawls. Tuning-fork watches were rendered obsolete when electronic quartz watches were developed, because quartz watches were cheaper to produce and even more accurate.

Traditional mechanical watch movements use a spiral spring called a mainspring as a power source. In *manual watches* the spring must be rewound periodically by the user by turning the watch crown. Antique pocketwatches were wound by inserting a separate key into a hole in the back of the watch and turning it. Most modern watches are designed to run 40 hours on a winding and thus must be wound daily, but some run for several days and a few have 192-hour mainsprings and are wound weekly.



Automatic watch: An eccentric weight, called a rotor, swings with the movement of the wearer's body and winds the spring

A *self-winding* or *automatic* watches is one that rewinds the mainspring of a mechanical movement by the natural motions of the wearer's body. The first self-winding mechanism was invented for pocketwatches in 1770 by Abraham-Louis Perrelet,[587] but the first "self-winding", or "automatic", wristwatch was the invention of a British watch repairer named John Harwood in 1923. This type of watch allows for constant winding without special action from the wearer; it works by an eccentric weight, called a winding rotor, which rotates with the movement of the wearer's wrist. The back-and-forth motion of the winding rotor couples to a ratchet to automatically wind the mainspring. Self-winding watches usually can also be wound manually so they can be kept running when not worn or if the wearer's wrist motions are inadequate to keep the watch wound.

Electronic movements

Electronic movements have few or no moving parts, as they use the piezoelectric effect in a tiny quartz crystal to provide a stable time base for a mostly electronic movement. The crystal forms a quartz oscillator which resonates at a specific and highly stable frequency, and which can be used to accurately pace a timekeeping mechanism. For this reason, electronic watches are often called *quartz watches.* Most quartz movements are primarily electronic but are geared to drive mechanical hands on the face of the watch in order to provide a traditional analog display of the time, which is still preferred by some consumers.

Prototype of a Quartz Wristwatch, CEH Switzerland, 1967

In 1959 Seiko gave an order to Epson (a daughter company of Seiko and the actual brain behind the quartz revolution) to start developing a quartz wristwatch. The project was codenamed 59A and by the 1964 Tokyo Summer Olympics, Seiko had a working prototype of a portable quartz watch which took part in time measurements throughout the event.

The first prototypes of an electronic quartz wristwatch (not just *portable* quartz watches as the Seiko timekeeping devices at the Tokyo Olympics in 1964) were made by the CEH research laboratory in Neuchâtel, Switzerland. From 1965 through 1967 pioneering development work was done on a miniaturized 8192 Hz quartz oscillator, a thermo-compensation module and an inhouse-made, dedicated integrated circuit (unlike the hybrid circuits used in the later Seiko Astron wristwatch). As a result, the BETA 1 prototype set new timekeeping performance records at the International Chronometric Competition held at the Observatory of Neuchâtel in 1967.[588]

Quartz Movement of the Seiko Astron, 1969 (Deutsches Uhrenmuseum, Inv. Inv. 2010-006)

The first quartz watch to enter production was the Seiko 35 SQ Astron, which hit the shelves on December 25, 1969. One particularly interesting decision made by Seiko at that time was to not patent the whole movement of the quartz wristwatch, thus allowing other manufacturers to benefit from the Seiko technology. This played a major role in the popularity and quick development of the quartz watch, which in less than a decade was dominant in the watch market, nearly ending an almost 100 years of mechanical wristwatch heritage. The modern quartz movements are produced in very large quantities, and even the cheapest wristwatches typically have quartz movements. Whereas mechanical movements can typically be off by several seconds a day, an inexpensive quartz movement in a child's wristwatch may still be accurate to within half a second per day —ten times better than a mechanical movement.[589]

After a consolidation of the mechanical watch industry in Switzerland during the 1970s, mass production of quartz wristwatches took off under the leadership of the Swatch Group of companies, a Swiss conglomerate with vertical control of the production of Swiss watches and related products. For quartz wristwatches, subsidiaries of Swatch manufactured watch batteries (Renata), oscillators (Oscilloquartz) and integrated circuits (Ebauches Electronic SA). The launch of the new SWATCH brand in 1983, was marked by bold new styling, design and marketing. Today, the Swatch Group is the world's largest watch company.

Seiko's efforts to combine the quartz and mechanical movements bore fruit after 20 years of research, leading to the introduction of the Seiko Spring Drive, first in a limited domestic market production in 1999 and to the world in September 2005. The Spring Drive manages to keep time within quartz standards without the use of a battery, using a traditional mechanical gear train powered by a spring, while at the same time doesn't have the need of a balance wheel either.

Radio time signal watches are a type of electronic quartz watch which synchronizes (time transfer) its time with an external time source such as in atomic clocks, time signals from GPS navigation satellites, the German DCF77 signal in Europe, WWVB in the US, and others. Movements of this type may -among others- synchronize not only the time of day but also the date, the leap-year status of the current year, and the current state of daylight saving time (on or off). However, other than the radio receiver these watches are normal quartz watches in all other aspects.

Electronic watches require electricity as a power source. Some mechanical movements and hybrid electronic-mechanical movements also require electricity. Usually the electricity is provided by a replaceable battery. The first use of electrical power in watches was as a substitute for the mainspring, in order to remove the need for winding. The first electrically powered watch, the Hamilton Electric 500, was released in 1957 by the Hamilton Watch Company of Lancaster, Pennsylvania.

Watch batteries (strictly speaking cells, as a battery is composed of multiple cells) are specially designed for their purpose. They are very small and provide tiny amounts of power continuously for very long periods (several years or more). In most cases, replacing the battery requires a trip to a watch-repair shop or watch dealer; this is especially true for watches that are designed to be water-resistant, as special tools and procedures are required to ensure that the watch remains water-resistant after battery replacement. Silver-oxide and lithium batteries are popular today; mercury batteries, formerly quite common, are no longer used, for environmental reasons. Cheap batteries may be alkaline, of the same size as silver-oxide cells but providing shorter life. Rechargeable batteries are used in some solar powered watches.

Some electronic watches are also powered by the movement of the wearer of the watch. For instance, Seiko's Kinetic powered quartz watches make use of the motion of the wearer's arm turning a rotating weight which causes a tiny generator to supply power to charge a rechargeable battery that runs the watch. The concept is similar to that of self-winding spring movements, except that electrical power is generated instead of mechanical spring tension.

Solar powered watches are powered by light. A photovoltaic cell on the face (dial) of the watch converts light to electricity, which in turn is used to charge a rechargeable battery or capacitor. The movement of the watch draws its power from the rechargeable battery or capacitor. As long as the watch is regularly exposed to fairly strong light (such as sunlight), it never needs battery replacement, and some models need only a few minutes of sunlight to provide weeks of energy (as in the Citizen Eco-Drive). Some of the early solar watches of the 1970s had innovative and unique designs to accommodate the array of solar cells needed to power them (Synchronar, Nepro, Sicura and some models by Cristalonic, Alba, Seiko and Citizen). As the decades progressed and the efficiency of the solar cells increased while the power requirements of the movement and display decreased, solar watches began to be designed to look like other conventional watches.[590]

A rarely used power source is the temperature difference between the wearer's arm and the surrounding environment (as applied in the Citizen Eco-Drive Thermo).

Display

Analog

Poljot chronograph

Traditionally, watches have displayed the time in analog form, with a numbered dial upon which are mounted at least a rotating hour hand and a longer, rotating minute hand. Many watches also incorporate a third hand that shows the current second of the current minute. Watches powered by quartz usually have a second hand that snaps every second to the next marker. Watches powered by a mechanical movement have a "sweep second hand", the name deriving from its uninterrupted smooth (sweeping) movement across the markers, although this is actually a misnomer in most cases; the hand merely moves in smaller steps, typically 1/5 of a second, corresponding to the beat (half period) of the balance wheel. In some escapements (for example the *duplex* escapement), the hand advances every two beats (full period) of the balance wheel, typically 1/2 second in those watches, or even every four beats (two periods, 1 second), in the *double duplex* escapement. A truly sweeping second hand is achieved with the *tri-synchro regulator* of Spring Drive watches. All of the hands are normally mechanical, physically rotating on the dial, although a few watches have been produced with "hands" that are simulated by a liquid-crystal display.

Analog display of the time is nearly universal in watches sold as jewelry or collectibles, and in these watches, the range of different styles of hands, numbers, and other aspects of the analog dial is very broad. In watches sold for timekeeping, analog display remains very popular, as many people find it easier to read than digital display; but in timekeeping watches the emphasis is on clarity and accurate reading of the time under all conditions (clearly marked digits, easily visible hands, large watch faces, etc.). They are specifically designed for the left wrist with the stem (the knob used for changing the time) on the right side of the watch; this makes it easy to change the time without removing the watch from the wrist. This is the case if one is right-handed and the watch is worn on the left wrist (as is traditionally done). If one is left-handed and wears the watch on the right wrist, one has to remove the watch from the wrist to reset the time or to wind the watch.

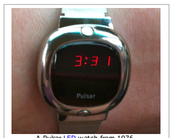
Analog watches as well as clocks are often marketed showing a display time of approximately 10:09 or 10:10. This creates a visually pleasing smile-like face on upper half of the watch, in addition to enclosing the manufacturer's name. Digital displays often show a time of 12:08, where the increases in the numbers from left to right culminating in the fully lit numerical display of the 8 also gives a positive feeling.[591] [592]

Analog watch displays can be used to indicate cardinal direction due to the relation between the position of the hour hand and the position of the Sun in the sky. By rotating the watch so that the hour hand points toward the Sun, the point halfway between the hour hand and 12 o'clock will indicate south when observing from a position in the Northern hemisphere. In the Southern hemisphere, the point halfway between the hour hand pointed at the sun and 12 o'clock on the dial indicates North.

Digital

Cortébert digital mechanical pocket watch. 1890s


Cortébert digital mechanical wristwatch. 1920s



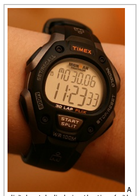
A Pulsar LED watch from 1976.

A digital display simply shows the time as a number, *e.g.*, *12:08* instead of a short hand pointing towards the number 12 and a long hand 8/60 of the way round the dial. The digits are usually shown as a seven-segment display.

The first digital *mechanical* pocket watches appeared in late 19th century. In the 1920s the first digital mechanical wristwatches appeared.

The first digital *electronic* watch, a Pulsar LED prototype in 1970, was developed jointly by Hamilton Watch Company and Electro-Data. John Bergey, the head of Hamilton's Pulsar division, said that he was inspired to make a digital timepiece by the then-futuristic digital clock that Hamilton themselves made for the 1968 science fiction film *2001: A Space Odyssey*. On April 4, 1972, the Pulsar was finally ready, made in 18-carat gold and sold for $2,100. It had a red light-emitting diode (LED) display.

Digital LED watches were very expensive and out of reach to the common consumer until 1975, when Texas Instruments started to mass produce LED watches inside a plastic case. These watches, which first retailed for only $20,[593] reduced to $10 in 1976, saw Pulsar lose $6 million and the Pulsar brand sold to Seiko.



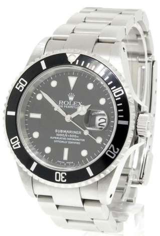
A digital watch displaying the time (with seconds) and date

Most watches with LED displays required that the user press a button to see the time displayed for a few seconds, because LEDs used so much power that they could not be kept operating continuously. Usually the LED display color would be red. Watches with LED displays were popular for a few years, but soon the LED displays were superseded by liquid crystal displays (LCDs), which used less battery power and were much more convenient in use, with the display always visible and no need to push a button before seeing the time. The first LCD watch with a six-digit LCD was the 1973 Seiko 06LC, although various forms of early LCD watches with a four-digit display were marketed as early as 1972 including the 1972 Gruen Teletime LCD Watch, and the Cox Electronic Systems Quarza.[594] In Switzerland, Ebauches Electronic SA presented a prototype eight-digit LCD wristwatch showing time and date at the MUBA Fair, Basle, in March 1973, using a Twisted Nematic LCD manufactured by Brown, Boveri & Cie, Switzerland, which became the supplier of LCDs to Casio for the *CASIOTRON* watch in 1974.[595]

From the 1980s onward, digital watch technology vastly improved. In 1982 Seiko produced a watch with a small television screen built in, and Casio produced a digital watch with a thermometer as well as another that could translate 1,500 Japanese words into English. In 1985, Casio produced the CFX-400 scientific calculator watch. In 1987 Casio produced a watch that could dial your telephone number and Citizen revealed one that would react to your voice. In 1995 Timex released a watch which allowed the wearer to download and store data from a computer to his wrist. Some watches, such as the Timex Datalink USB, feature dot matrix displays. Since their apex during the late 1980s to mid 1990s high technology fad, digital watches have mostly become simpler, less expensive time pieces with little variety between models.

Despite these many advances, almost all watches with digital displays are used as timekeeping watches. Expensive watches for collectors rarely have digital displays since there is little demand for them. Less craftsmanship is required to make a digital watch face and most collectors find that analog dials (especially with complications) vary in quality more than digital dials due to the details and finishing of the parts that make up the dial (thus making the differences between a cheap and expensive watch more evident).

Functions



The Rolex Submariner, an officially certified chronometer

All watches provide the time of day, giving at least the hour and minute, and usually the second. Most also provide the current date, and often the day of the week as well. However, many watches also provide a great deal of information beyond the basics of time and date. Some watches include alarms. Other elaborate and more expensive watches, both pocket and wrist models, also incorporate striking mechanisms or repeater functions, so that the wearer could learn the time by the sound emanating from the watch. This announcement or striking feature is an essential characteristic of true clocks and distinguishes such watches from ordinary timepieces. This feature is available on most digital watches.

A *complicated watch* has one or more functions beyond the basic function of displaying the time and the date; such a functionality is called a complication. Two popular complications are the **chronograph** complication, which is the ability of the watch movement to function as a stopwatch, and the **moonphase** complication, which is a display of the lunar phase. Other more expensive complications include Tourbillon, Perpetual calendar, Minute repeater, and Equation of time. A truly complicated watch has many of these complications at once (see Calibre 89 from Patek Philippe for instance). Some watches can both indicate the direction of Mecca and have alarms that can be set for all daily prayer requirements. Among watch enthusiasts, complicated watches are especially collectible. Some watches include a second 12-hour display for UTC (as Pontos Grand Guichet GMT).

The similar-sounding terms **chronograph** and **chronometer** are often confused, although they mean altogether different things. A chronograph has a stopwatch complication, as explained above, while a chronometer watch has a high quality mechanical or a thermo-compensated movement that has been tested and certified to operate within a certain standard of accuracy by the COSC (Contrôle Officiel Suisse des Chronomètres). The concepts are different but not mutually exclusive; so a watch can be a chronograph, a chronometer, both, or neither.

Timex Datalink USB Dress edition from 2003 with a dot matrix display; the *Invasion* video game is on the screen

Many computerized wristwatches have been developed, but none have had long-term sales success, because they have awkward user interfaces due to the tiny screens and buttons, and a short battery life. As miniaturized electronics became cheaper, watches have been developed containing calculators, tonometers, barometers, altimeters, a compass using both hands to show the N/S direction, video games, digital cameras, keydrives, GPS receivers and cellular phones. In the early 1980s Seiko marketed a watch with a television in it. Such watches have also had the reputation as unsightly and thus mainly geek toys. Several companies have however attempted to develop a computer contained in a wristwatch (see also wearable computer).

Braille watches have analog displays with raised bumps around the face to allow blind users to tell the time. Their digital equivalents use synthesised speech to speak the time on command.

Uses

Fashion

A sapphire cabochon on the crown of a men's dress watch

Wristwatches are often appreciated as jewelry or as collectible works of art rather than just as timepieces. This has created several different markets for wristwatches, ranging from very inexpensive but accurate watches (intended for no other purpose than telling the correct time) to extremely expensive watches that serve mainly as personal adornment (featuring jewel bearings to hold gemstones) or as examples of high achievement in miniaturization and precision mechanical engineering.

Traditionally, men's dress watches appropriate for informal (business), semi-formal, and formal attire are gold, thin, simple, and plain, but recent conflation of dressiness and high price has led to a belief among some that expensive rugged, complicated, or sports watches are also dressy because of their high cost. Some dress watches have a cabochon on the crown and many women's dress watches have faceted gemstones on the face, bezel, or bracelet. Some are made entirely of facetted sapphire (corundum).

Many fashion and department stores offer a variety of less-expensive, trendy, "costume" watches (usually for women), many of which are similar in quality to basic quartz timepieces but which feature bolder designs. In the 1980s, the Swiss Swatch company hired graphic designers to redesign a new annual collection of non-repairable watches.

Most companies that produce watches specialize in one or some of these markets. Companies such as Patek Philippe, Blancpain and Jaeger-LeCoultre specialize in simple and complicated mechanical dress watches; companies such as Omega SA, Ball Watch Company, TAG Heuer, Sinn, Breitling, Panerai and Rolex specialize in rugged, reliable mechanical watches for sport and aviation use. Companies such as Casio, Timex, and Seiko specialize in watches as affordable timepieces or multifunctional computers.

Counterfeit watches which mimic expensive fashions watches are estimated to cost the watchmaker industry US$1 billion per year.[596]

Space


The Omega Speedmaster, selected by U.S. space agencies

Zero gravity environment and other extreme conditions encountered by astronauts in space requires the use of specially tested watches. On April 12, 1961, Yuri Gagarin wore a Shturmanskie (a transliteration of Штурманские which actually means "navigator's") wristwatch during his historic first flight into space. The Shturmanskie was manufactured at the First Moscow Factory. Since 1964, the watches of the First Moscow Factory have been marked by the trademark "ПОЛЕТ", transliterated as "POLJOT", which means "flight" in Russian and is a tribute to the many space trips its watches have accomplished. In the late 1970s, Poljot launched a new chrono movement, the 3133. With a 23 jewel movement and manual winding (43 hours), it was a modified Russian version of the Swiss Valjoux 7734 of the early 1970s. Poljot 3133 were taken into space by astronauts from Russia, France, Germany and Ukraine. On the arm of Valeriy Polyakov, a Poljot 3133 chronograph movement-based watch set a space record for the longest space flight in history.[597]


Astronaut Nancy J. Currie wears the Timex Ironman Triathlon Datalink model 78401 during STS 88.

During the 1960s, a large range of watches were tested for durability and precision under extreme temperature changes and vibrations. The Omega Speedmaster Professional was selected by NASA, the U.S. space agency. Heuer became the first Swiss watch in space thanks to a Heuer Stopwatch, worn by John Glenn in 1962 when he piloted the Friendship 7 on the first manned U.S. orbital mission. The Breitling Navitimer Cosmonaute was designed with a 24-hour analog dial to avoid confusion between AM and PM, which are meaningless in space. It was first worn in space by U.S. astronaut Scott Carpenter on May 24, 1962 in the Aurora 7 mercury capsule.[598] Since 1994 Fortis is the exclusive supplier for manned space missions authorized by the Russian Federal Space Agency. China National Space Administration (CNSA) astronauts wear the Fiyta[599] spacewatches. At BaselWorld, 2008, Seiko announced the creation of the first watch ever designed specifically for a space walk, Spring Drive Spacewalk. Timex Datalink is flight certified by NASA for space missions and is one of the watches qualified by NASA for space travel.Both the Casio G-Shock DW-5600C and 5600E are Flight-Qualified for NASA space travel.[600 601 602 603] The various Datalink models were used both by cosmonauts and astronauts.

Scuba diving

Seiko 7002-7020 Diver's 200 m on a 4-ring NATO style strap

Watches may be crafted to become water resistant. These watches are sometimes called diving watches when they are suitable for scuba diving or saturation diving. The International Organization for Standardization issued a standard for water resistant watches which also prohibits the term "waterproof" to be used with watches, which many countries have adopted.

Water resistance is achieved by the gaskets which forms a watertight seal, used in conjunction with a sealant applied on the case to help keep water out. The material of the case must also be tested in order to pass as water resistant.[604]

None of the tests defined by ISO 2281 for the Water Resistant mark are suitable to qualify a watch for scuba diving. Such watches are designed for everyday life and must be water resistant during exercises such as swimming. They can be worn in different temperature and pressure conditions but are under no circumstances designed for scuba diving.

The standards for diving watches are regulated by the ISO 6425 international standard. The watches are tested in static or still water under 125% of the rated (water)pressure, thus a watch with a 200 metre rating will be water resistant if it is stationary and under 250 metres of static water. The testing of the water resistance is fundamentally different from non-dive watches, because every watch has to be fully tested. Besides water resistance standards to a minimum of 100 metre depth rating ISO 6425 also provides eight minimum requirements for mechanical diver's watches for scuba diving (quartz and digital watches have slightly differing readability requirements). For diver's watches for mixed-gas saturation diving two additional requirements have to be met.

Watches are classified by their degree of water resistance, which roughly translates to the following (1 metre = 3.281 feet):[605]

Water resistance rating	Suitability	Remarks
Water Resistant 30 m or 50 m	Suitable for washing hands. 50 m suitable for showering and light swimming.	not suitable for swimming or diving.
Water Resistant 100 m	Suitable for recreational surfing, swimming, snorkeling, sailing and water sports.	not suitable for diving. This is the standard for children's digital watches.
Water Resistant 200 m	Suitable for professional marine activity and serious surface water sports.	suitable for diving.
Diver's 100 m	Minimum ISO standard (ISO 6425) for scuba diving at depths not requiring helium gas.	Diver's 100 m and 150 m watches are generally old(er) watches.
Diver's 200 m or 300 m	Suitable for scuba diving at depths not requiring helium gas.	Typical ratings for contemporary diver's watches.
Diver's 300+ m helium safe	Suitable for saturation diving (helium enriched environment).	Watches designed for helium mixed-gas diving will have additional markings to point this out.

Some watches use bar instead of meters, which may then be multiplied by 10, and then subtracted by 10. This is because 1 bar is equal to one atmosphere or 10 metres of water (therefore 1 bar at the surface and one more each 10 metres). to be approximately equal to the rating based on metres. Therefore, a 5 bar watch is equivalent to a 40 metre watch. Some watches are rated in atmospheres (atm), which are roughly equivalent to bar.

Sport

One of the fastest growing segments of the Watch industry is the "Sport" watch. Made for both function and style these watches often contain extra features like compasses, altimeters, barometers, and thermometers. Some of the higher end sport watches will even have a heart rate monitor.

Further reading

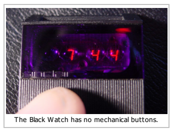
- De Carle, Donald, (Illustrations by E. A. Ayres), *Practical Watch Repairing*, 3rd edition, New York : Skyhorse Pub., 2008. ISBN 9781602393578

External links

- Philadelphia Exhibition 1876 Report to the Federal High Council by Ed. Favre-Perret (1877)
- American and Swiss Watchmaking in 1876 by Jacques David
- The Watch Factories of America Past and Present by Henry G. Abbott (1888)
- Watchmaking and the American System of Manufacturing (2009)
- Federation of the Swiss Watch Industry FH
- UK patent GB218487, Improvements relating to wrist watches, 1923 patent resulting from John Harwood's invention of a practical self-winding watch mechanism.
- The Most Expensive Watches

Black Watch (wristwatch)

The **Black Watch** is an electronic wristwatch launched in September 1975 by Sinclair Radionics. It cost £24.95 ready-built, but was also available for £17.95, as a kit.[606]



The Black Watch has no mechanical buttons.

The Black Watch was a financial disaster for Sinclair Radionics.

The Black Watch is equipped with a red LED display, which is illuminated only when the watchcase's surface is pressed; two resilient spots display hours and minutes or minutes and seconds, respectively.

The product was beset by technical problems including low battery life, variable accuracy and a very sensitive integrated circuit which could be rendered useless by a static shock from a nylon shirt. In spite of this, Sinclair's advertising still claimed:

- *If that sounds technical, think of the outcome: a watch with no moving parts, a watch with nothing to go wrong, a watch which gives accuracy never achievable by the most precise mechanical engineering.*[607]

References

- Planet Sinclair: The Black Watch

Relevant articles

- Wristwatch

TV80

The Sinclair **TV80**, also known as the **Flat Screen Pocket TV** or **FTV1**, was a pocket television launched by Sinclair Research in 1984. Unlike Sinclair's earlier attempts at a portable television, the TV80 used a flat CRT with a side-mounted electron gun instead of a conventional CRT; the picture was made to appear larger than it was by the use of a Fresnel lens. It was a commercial failure, and did not recoup the £4m it cost to develop; only 15,000 units were sold. New Scientist warned that the technology used by the device would be short-lived, in view of the liquid crystal display technology being developed by Casio.

External links

- Sinclair TV80 Information and Pictures

Sinclair X-1

The **Sinclair X-1**, is an electric vehicle invented by Sir Clive Sinclair and marketed by his company Sinclair Research. The X-1 was announced in November 2010.[608 609] As of April 2011, the X-1 is expected to be available on July 2011 at the price of £595.[610]

Electric Transport

Sinclair Vehicles

Sinclair Vehicles Ltd was a company formed in March 1983 by Sir Clive Sinclair as a focus for his work in the field of electric vehicles. The initial investment was £8.6m, which came from the proceeds of the sale of some of Sir Clive's shares in Sinclair Research. Barrie Wills, formerly of the DeLorean Motor Company, was appointed as managing director.

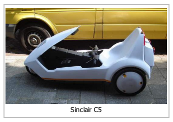
The first (and only) Sinclair Vehicles production model was the single-seater Sinclair C5, launched on 10 January 1985. Larger models were planned, including the C15, a four-seater car capable of speeds of up to 80 mph (130 km/h). The generally poor reception given to the C5 by the press and public meant that these models would never reach production.

In August 1985, Hoover, the manufacturer of the C5, announced that production would be stopped due to a financial dispute with Sinclair Vehicles. The following month, Sinclair Vehicles were renamed as **TPD Ltd**. On 15 October 1985, it was announced that TPD were in receivership and the company entered voluntary liquidation on 4 November 1985.

References

- Excerpt from *Sinclair and the 'Sunrise' Technology*
- Excerpt from *The Sinclair Story*

Sinclair C5


Sinclair C5

The **Sinclair Research C5** is a battery electric vehicle invented by Sir Clive Sinclair and launched by Sinclair Research in the United Kingdom on 10 January 1985. The vehicle is a battery-assisted tricycle steered by a handlebar beneath the driver's knees. Powered operation is possible making it unnecessary for the driver to pedal. Its top speed of 15 miles per hour (24 km/h), is the fastest allowed in the UK without a driving licence. It sold for £399 plus £29 for delivery.

It became an object of media and popular ridicule during 1980s Britain and was a commercial disaster, selling only around 17,000 units, although according to Sinclair, "it currently remains the best selling electric vehicle of all time,"[611] however as of Novermber 2011 the Nissan Leaf has sold over 20,000 units.[612]

History

Sir Clive Sinclair started to think about electric vehicles as a teenager, and it was an idea he toyed with for decades. In the early 1970s Sinclair Radionics was working on the project. Sinclair had Chris Curry work on the electric motor. However, the company focus shifted to calculators and no further work was done on vehicles until the late 1970s. Development began again in 1979 and progressed erratically until, in 1983, it became apparent new legislation would alter the market and make it possible to sell a vehicle closely resembling development efforts.

As time went on, the Sinclair Research C5 development cost gradually increased. In March 1983, Sinclair sold some of his shares in Sinclair Research and raised £12 million to finance vehicle development. In May a new company, Sinclair Vehicles Ltd, was formed out of Sinclair Research and a development contract entered with Lotus to take the C5 design to production. At the same time, the Hoover Company at Merthyr Tydfil contracted to manufacture the C5. This, together with the fact that the motors were made by Polymotor in Italy, started the urban myth that the C5 was powered by a washing machine motor.[613] In 1984, Sinclair Vehicles set up head office at the University of Warwick Science Park.

Reaction

Despite promotion involving former formula one racing driver Stirling Moss, the reaction upon its release was that the C5 was impractical in the British climate meaning it was only comfortably usable in southern England in the spring and summer, and possibly dangerous on busy roads.

A court case involving a drunk driver of a C5 ruled that the vehicle was a tricycle (not a car).

On 13 August 1985, the Hoover Company announced the end of production. Only around 17,000 C5s had been sold.[614] Sinclair Vehicles was put into receivership on 12 October 1985.

Design problems

A C5 at the Museum of Science and Industry in Manchester

The C5 suffered from problems: cold weather shortened battery life, the driver was exposed to the weather, and because it was low to the ground, doubts were raised about the safety in traffic. The problems were addressed with a second battery, side screens for bad weather and a reflector on tall poles - all available as extras from the launch.[615] The problems were expressed in a cartoon showing a C5 and a juggernaut approaching each other at a blind corner, the C5 being occupied by lemmings. Users of recumbent tricycles and a study by the Department of Transport suggested visibility fears were largely unfounded, but the weight, lack of seat-to-pedal adjustment, lack of gears, short pedal cranks, and that the motor overheated on long hills were serious problems;[616] indeed the motor was essentially useless for climbing hills, with even mild gradients necessitating significant pedal assistance.

Modified C5s

A heavily modified C5 reached a top speed of 150 miles per hour (240 km/h) and accelerated from 0 to 60 mph in 5 seconds taking the speed record for an electric vehicle.[617] The C5 also became the world's first electric stunt vehicle when it was driven through a 70ft tunnel of fire.[618]

A "turbo conversion" converting the C5 to 24 volts and boosting the speed to 27–30 miles per hour (43–48 km/h) is available.[619]

During the Swiss Tour de Sol in the early 1990s, several C5s were solarised and modified to provide more range and speed. Plans were made available for these conversions, required to use the C5 legally in Switzerland.

Sinclair C5s have also been converted to jet engine power.[620]

In 2006 another Sinclair C5 was fitted with a hybrid rocket engine for an episode of Sky TV's Brainiac science show. After evaluating the performance of three different fast foods as rocket fuels (combined with nitrous oxide), the winning fuel was used to propel the C5 in a drag race with an electric scooter.[621]

Sinclair X-1

In November 2010 Sinclair told The Guardian he was working on a new prototype that should be launched within a year. "Technology has moved on quite a bit, there are new batteries available and I just rethought the thing. The C5 was OK, but I think we can do a better job now." He said the prototype was called the X1.[622][623] The X-1 will be available in July 2011 at the price of £595.[624]

References

- Adamson, Ian; Kennedy, Richard (1986). *Sinclair and the "Sunrise" Technology*. London: Penguin Books. 224 pp. ISBN 0-14-008774-5.
- Dale, Rodney (1985). *The Sinclair Story*. London: Duckworth. 184 pp. ISBN 0-7156-1901-2.

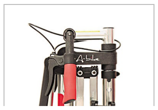
External links

- Enthusiasts forum
- Sinclair C5 at the Open Directory Project
- Old Merthyr Tydfil: Sinclair C5 Production - Historical Photographs showing the Production of the Sinclair C5 at Hoover, Merthyr Tydfil.
- 'Move over Segway, I'm planning the C6', BBC News article

A-bike

The **A-bike** is a type of folding bicycle invented by Sir Clive Sinclair in the United Kingdom and released on 12 July 2006. It weighs 5.5 kilograms (12 lb) and folds to 67×30×16 cm, small enough to fit in a rucksack.

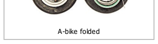
The A-bike was designed by a team at Daka, Hong Kong and Sinclair Research Ltd over 5 years, and was originally announced in 2004. Clive Sinclair envisioned the A-bike, and Alex Kalogroulis was the main design engineer.



Characteristics

The A-bike's telescoping structure reduces its apparent volume to about 25% in its collapsed state. A twin-chain system enables the bike to travel about 3.2 metres (10 ft) per crank rotation despite the bicycle's small-diameter wheels (6 inches (15 cm)). The crankcase housing completely encloses the drive mechanism, protecting it and preventing oil stains on clothing or floor surfaces.

Media appearances



A-bike folded

A-bike

In November 2006, A-bike was featured on UK television programme *The Gadget Show*, alongside the Strida.[625] The distribution company behind the A-bike was featured on the UK Television programme Badger or Bust broadcast on the 5 June 2007. In the *Top Gear epic race* Car vs. Train 2. Richard Hammond and James May carried A-bikes in their suitcases and unfolded them to bike from a ferry dock to a cable car. The magazine *A to B* described the A-bike as a "fabulous folder, but almost unrideable".[626]

Series

- A-bike
  - Nigel Bike / Nigel A-bike (Sanctioned Chinese version of the A-bike) [627] [628]
- A-bike Plus (Refined version of the A-bike) [629]
- A-bike Smart (Authorised versions of the A-bike in China) [630]
  - AS530
  - AS530I
  - AS530S
  - AS530L
  - AS530X
  - AS730
  - AS800S
  - AS830
  - AS850
- A-bike City (8" wheeled version of the A-bike) [631]
  - AE-bike (Electric version of the A-bike) [632]

External links

- Official A-bike website
- Sinclair Research - A-bike
- Chief Design Engineer Alexander Kalogroulis explains the folding unfolding procedure (YouTube video)
- BBC Review of the A-bike

Sinclair Zike

The **Zike**, or **Sinclair Zike**, was a light-weight electric bicycle invented by Sir Clive Sinclair and marketed by his company Sinclair Research Ltd in 1992. It was a commercial failure, selling only 2,000 units while originally intended to be produced at the rate of 10,000 a month. It was ended six months after introduction.[633 634]

External links

- Planet Sinclair — Zike

Some Distant Relatives

Loki (computer)

Loki (computer)	
Release date	Never
Operating system	SuperBASIC variant
CPU	Z80 @ 7 MHz and equivalent
Memory	128 KB

Loki was the codename for a home computer under development at Sinclair Research during the mid-1980s. The name came from the Norse god Loki, god of mischief and thieves. *Loki* was based on the ZX Spectrum, but intended to rival the Commodore Amiga as a games platform. When Amstrad bought out Sinclair's computer business in 1986, the project was cancelled. *Loki* is sometimes confused with two earlier aborted Sinclair Research projects; the *LC3* games console (cancelled in 1983) and the *SuperSpectrum*, a 68008-based home computer very similar to the Sinclair QL (cancelled in 1982).[635]

Martin Brennan and John Mathieson, two Sinclair engineers, took the *Loki* technology with them and founded Flare Technology. There they worked on an abortive games console project on the Konix Multisystem, later working with Atari on the Panther and Jaguar systems. According to Jaguar developer Andrew Whittaker, two other Sinclair employees, Bruce Gordon and Alan Miles, who went on to form Miles Gordon Technology, also used some of the designs in the SAM Coupé.[636]

According to an article published in *Sinclair User* magazine (which is likely to have been, at least in part, speculative), *Loki* was to have a 7 MHz Z80H CPU, a minimum of 128 KiB of RAM and two custom chips providing much enhanced video and audio capabilities compared to the ZX Spectrum, but with a compatibility mode. The video chip, referred to as the "Rasterop" chip, would have blitter-type functionality and three different modes: 512×256 pixels with 16 colours, 256×212 with 256 colours, or 256×212 with 64 colours and two bits per pixel used for "blitter objects". Comprehensive peripheral support was also claimed, including MIDI, lightpen, joystick and floppy disk.

A version of the SuperBASIC language from the Sinclair QL was to be provided in place of the old ZX Spectrum BASIC and support for the CP/M operating system was also intended. On top of this, the computer would cost as little as £200.[637]

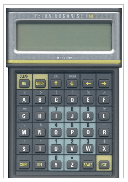
Another Spectrum magazine, *Crash*, poured scorn on the report in Sinclair User, dismissing the design as a "dreamware" in the opinion of an ex-Sinclair designer they consulted, analysing the implied components and costs, and adding, "It may be fun to dream about Loki, but the fact is that it won't appear, and nor will anything like it." This was the rationale, according to Crash Technical Editor Simon Goodwin:

> Being blessed with lots of headed typing paper and very little money, the Thinkers at Sinclair were invited to make a big list of trendy computer features. That list, embellished with a few charts and tables but a noticeable lack of circuit diagrams and real detail, finally escaped into the hands of the computer press. Despite six years of agonising experience of the difference between Sinclair specifications and reality they swallowed it whole. Technical know-how has never been a strong point in magazines that still - indeed, the same month - print Commodore 64 screen shots in their Spectrum software preview section.[638]

External links

- USENET posting by Rupert Goodwins in comp.sys.sinclair mentioning *Loki*

Psion Organiser



The **Psion Organiser** was the brand name of a range of pocket computer developed by the British company Psion in the 1980s. The Organiser I (launched in 1984) and Organiser II (launched in 1986) had a characteristic hard plastic sliding cover protecting a 6x6 keyboard with letters arranged alphabetically.

Early Psions are very robust (as witnessed by tech support people who were able to retrieve data from machines run over by cars and even forklift trucks) and they have been sold in very large numbers (about a million). Some continue to be used commercially, although the firmware of the two-line models fails to acknowledge dates after the end of 1999. However, there is a patch available. The Organiser had an independent user group (IPSO) for nine years, with a worldwide following, until the establishment of the Series 3 made it largely redundant.

Production of consumer hand-held devices by Psion has now ceased; the company, after corporate changes, now concentrates on hardware and software for industrial and commercial data collection applications.

On an episode of The Gadget Show (first aired on 30 March 2009), the Psion was pitted against the BlackBerry for a place on the show's Hall of Fame.[639] Whilst the Psion was highly praised as a device that pioneered portable computing, the accolade was ultimately given (by host Jon Bentley) to the BlackBerry.

Psion Organiser II

Organiser I

The Psion Organiser I model, launched in 1984 was the **"World's First Practical Pocket Computer"**[640]. Based on an 8-bit Hitachi 6301-family processor, with 4KB of ROM and 2KB of battery-backed RAM, and had a single-row monochrome LCD screen. The size in **mm** with the case closed is **142 x 78 x 29.3**, and the weight is 225 grams.

The machine provided a simple flat-file database, calculator and clock, and had no operating system. The Organiser I supported removable storage write-once devices which used EPROM storage. The machine could host two of these so-called DATAPAKS (or simply PAKs), to which it could write data but which needed to be removed from the machine and erased by being exposed to ultraviolet light before they could be re-used. As Psion had patented the use of EPROMS as storage device it was impossible for other device manufacturers to copy this innovative approach to mobile storage.

The original 1984 cost was **£99** (GBP) and **$199** (CAD) and included one Datapak and one Utility pack.

Organiser II


Psion Organiser II with cover


Memory modules for the Psion Organiser - (on 5cm squares)


Psion Organiser II (open & closed) - Models XP & LZ are shown on 5cm squares

In 1986, the successful Organiser II introduced a number of hardware improvements, a better keyboard and display, a much larger ROM and either 8K or 16K of battery-backed RAM, and featured a capable newly-designed single-tasking operating system. The first Organiser II models featured a two-line display. The new model supported a number of different types of improved DATAPAKs containing either EPROM or battery-backed RAM storage each storing between 8k and 128k of data. Later flashpaks (EEPROM) and RAMpaks were added to the range, capable of storing up to 256k on each extension slot.

The machine had vastly more application functionality, including a number of built-in application programs, a diary and alarm clock, and featured end-user programmability in the form of the successful Organiser Programming Language (OPL), a BASIC-like language which was compiled to intermediate code, in contrast to the interpreters which were commonly available for other consumer computers of the time. More advanced users could reach into the system machine code routines either via direct machine code, or via calls from OPL.

The Organiser II was widely used for commercial applications in companies such as Marks and Spencer, where it was used on the shop floor, and in the world's first large scale application of mobile technology in government where over 3000 were used for benefit calculations by the Employment Services department of the UK government.

The Organiser II also had an external device slot into which various plug-in modules could be fitted, including a device which providing an RS232 port (called 'CommsLink') to enabling it to communicate with other devices or computers. This "top slot" also supported various other hardware additions, such as telephone dialers, a speech synthesiser, barcode reader and even a dedicated thermal printer. This latter was used by several banks as a counter-top exchange rate calculator for some years. As it was easy to get hardware specifications, numerous bespoke devices were developed by small companies such as A/D converters and even an interface to the entire range of Mitutoya measuring equipment, allowing it to be used in quality control for various car manufacturers. Later models in the Organiser II range offered other hardware improvements, with 4-line displays, and also models were introduced with 32, 64 and 96KB RAM.

Subsequent hand-held devices

The name "Organiser" was not used for later Psion handhelds, such as the "SIBO" family Psion Series 3 and the 32-bit Psion Series 5 machines which were of a clamshell design with a QWERTY keyboard. In terms of hardware architecture and operating system had no links to the earlier "Organiser" range, other than the end user programming language which shared a great deal of structure with OPL.

The "SIBO" family name stood for "**SI**xteen **B**it **O**rganiser" and the improved version of the OPL language (with window and focus controls) was at the root of what is now sold as the Symbian operating system, currently the most widely used OS in smartphones. This change was more significant than appeared at the time. The consumer level 'high' programming language still shares features with OPL, but the developer toolkits were from then on focused on programmers familiar with C and only the Symbian operating system remains.

The first similar device made in the USA didn't appear until 1985 and was manufactured by **Validec**.[641]

External links

- The Psion Organiser II Homepage - Everything you ever wanted to know about the Psion Organiser II, and more...
- Psion website - the operational division of Psion PLC.
- Psion Organiser History - website by Steve Litchfield.
- A detailed history of Psion around the time of the Series 5
- Psion Organiser Files to Download

Jupiter Ace

Jupiter Ace

Release date	1982
Discontinued	1984
Operating system	ACE Forth
CPU	Z80 @ 3.25 MHz
Memory	1 KB (Max=49 KB)

The **Jupiter Ace** was a British home computer of the early 1980s, produced by a company, set up for the purpose, named Jupiter Cantab.
The Ace differed from other microcomputers of the time[642] in that it used FORTH instead of the more common BASIC.

Introduction

Jupiter Cantab was formed by Richard Altwasser and Steven Vickers.[643] Both had been on the design team for the Sinclair ZX Spectrum. Altwasser did some work on the development of the ZX-81 and in the design of the hardware of the Spectrum. Vickers adapted and expanded the 4K ZX-80 ROM to the 8K ZX-81 ROM and wrote most of the ROM for the Spectrum. The Jupiter Ace was named after the early British computer, the ACE. The name was chosen to emphasize the "firsts" of using FORTH environment as more efficient for personal computers.

FORTH is a threaded code programming language that also acted as operating system. As such, "Forth was developed as the world's first and, at that time, only practical, fully Integrated (and explicitly Interactive) software Development Environment (IDE)"[644]

The Jupiter Ace system was adapted to the disk-less tape-using home computer hardware. On average, and for similar programs, ACE's FORTH was 5 times faster and used half the memory (which was a costly luxury at the time) of an equivalent program written in interpreted BASIC.[645] Forth programs tend to be more memory efficient than the bigger programs; as they become bigger, they reuse more previously-defined code.[646]

For such reasons FORTH was chosen to deliver better performance and [structured programming] flexibility.[647]

System characteristics


A small Jupiter ACE system

The Jupiter ACE is often compared with ZX81 due to its similar size, low cost, and similar form factor, although internally it is an independent design. The ZX81 used 75% of its Z80 CPU time to drive the video. In ACE the Z80 CPU was fully used for running programs. The ACE used dedicated video memory of 2 KB, leaving the 1 KB main memory free for user programming.

The Jupiter ACE was new to the market and the designers couldn't afford to use an uncommitted logic array (ULA), which were common in other computers (such as the ZX 81) to reduce component count, because these weren't economical in small quantities. Instead they reduced the number of chips required via clever design.

Like the Spectrum, the Ace used black rubber keys. Audio capabilities were CPU controlled with programmable frequency and duration. Sound output was through a small built-in speaker. A television was needed as a display - which was in black and white only.

Programs and data storage was by means of a common cassette tape, which was typical of home computers of the time.

Specifications

- Processor: Zilog Z80A clocked at 3.25 MHz.[648]
- Memory: 1 KB, expandable up to 49 KB (Video SRAM excluded).
- Video: Independent sub-system using dedicated 2 banks of 1 KB making a total of 2 KB of extra SRAM.
- Sound: Internal Speaker.
- Keyboard: 40 keys.
- Expansion: 2 connectors: One CPU related similar to the one in the ZX-81, the other connecting to the Video sub-system.

References to the ACE RAM usually include the separate 2 KB video memory, which is not available for user programs, thus leading to some confusion.

Hardware

- **Video**

One 1K bank allowed redefinition of most of its 128 characters ASCII based characters in 8×8 pixel bitmap format. The other 1K bank stored the full screen display of 24 rows x 32 columns of characters in black and white. So while the Ace had only one text video mode, redefinition of the character shapes could provide graphics in a low resolution of 64x48, and a higher resolution mode of 256x192 graphics, limited by the 128 available (definable) 8x8 chars. Both graphics and text could be displayed at the same time.

The font of the character set is identical to that of the Spectrum, but the display is white on black whereas the Spectrum has colour hardware. Although a colour graphics board was designed[649] none was ever produced commercially.

- **Sound**

An internal speaker was directly controlled by the CPU in single task mode, with control of sound frequency and its duration in milliseconds.

- **External Storage**

Storage was through a cassette tape interface at 1500 baud.

- **Add-ons**

Originally developed to receive ZX-81 add-ons, with a compatible expansion slot, it was actually delivered in a different configuration. A simple rewiring adapter could be used, but not very effectively due to power losses. Dedicated add-ons were needed and built by external companies, after the initial 16 KB by Jupiter Cantab.

- **RAM**[650]
  1. Pack 16 KB by Jupiter Cantab.
  2. Pace 16 KB and 32 KB by Stonechip Electronics.
  3. Pack 48 KB by Boldfield (new Jupiter ACE owner after Jupiter Cantab).

- **Keyboard**[651]
  - Memotech Keyboard, by Memotech.

- **Sound**[652]
  - SoundBoard (1983) by Essex Micro Electronics,

- **Storage**[653]
  1. Jet-Disc Disc Drive System (1983) by MPE (control up to four 3", 5", or 8" drives).
  2. "Deep Thought" Disc interface with a 4K AceDOS in an EPROM (1986) by J Shepherd & S Leask.

- **Printer Adapters**
  - ADS Centronics Interface Machine (1983), by Advanced Digital Systems,[654]
  - RS232 & Centronics PrinterCard (1984) by Essex Micro Electronics.[655]

- **Graphics Card**
  1. Gray Scale card - 4 shades of gray by S Leask (1986)

Firmware

The ACE had an 8 KB ROM containing the Forth kernel and operating system, and the predefined dictionary of Forth words in about 5KB. The remaining 3KB of ROM were used for tape control, floating point numbers library and character definitions table.[656] Some of the ROM was written in Z80 machine code, but some was also coded in Forth.

The next 8 KB were split in 2 blocks of 4KB each. The video subsystem access allowing two different priorities by the user to the 2KB VRAM, *Regular* or *Overriding* video. The 1 KB of user RAM was only partially decoded, so it echoed in the full 4 kB block address space it resides. So a 16 KB space was used for ROM, VIDEO, and USER, leaving free a 16 KB space for RAM extension plus 32KB space free for all possible usages.

Forth


ACE's Forth Vocabulary

The major visible difference from previous introductory computers, was Forth as its default programming language. Forth was considered well adapted to microcomputers with small memory and relatively low-performance processors. Forth allowed control structures to be nested to any level, limited only by available memory. Forth allowed implementation of machine code routines, if needed for a particular task. Forth also allowed recursive programming, if desired. On the downside, the usage of a data stack and the associated Reverse Polish notation were as unfamiliar as was structured programming.

ACE's Forth was based mostly on Forth-79, with some relevant differences.[657] Runtime error checking could be turned off to raise speed by 25% to 50%. A few extra words were named similar to known BASIC sound, video and tape commands, as behavior was the same. The implementation lacked less frequently used Forth words, but these were easily implemented if needed.

The ACE's dialect of FORTH introduced several innovations. It simplified usual Forth definer and compiler words creation, replacing the CREATE .. DOES>,[658] creation pair with:

1. DEFINER .... DOES> : Create new Defining words, usually used to define and build data data structures. Similar to CREATE..DOES usage in standard FORTH.[659] (Examples: Arrays, Records, ...).
2. COMPILER .. RUNS> : Create new Compiling words, less frequently used to extend the language with compiler words where CREATE..DOES> is FORTH implementation dependent.[660] (Examples: control structures like Case, Infinite-Loop, ...).

As an operating system, it was adapted to Tape usage, saving/loading user vocabularies instead of the usual numbered programming blocks used in diskette systems.

The ACE's Forth could decompile its programs, unlike usual Forth systems. This decompiling ability had several advantages as a solution to the absence of the more flexible disk system used by Forth. It did not store the text of a Forth program, instead it compiled the code after editing and stored it in ready-to-run format. While this saved computer memory it also saved time in reading and writing programs from cassette tape. This tape-friendly and RAM-saving solution was unique to the Jupiter ACE Forth.

Commercial

Though Forth delivered several advantages over the interpreted BASIC used on all other contemporary home computers, the weak box and small initial memory kept the sales low despite technical interest.[661]

Models

1982 - Original Jupiter ACE in a yogurt-pot type of case - Reported 8000 units built.[662]
1983 - Jupiter ACE 4000 on stronger injection moulded case - Reported 800 units built.[663]

Sales

Sales of the machine were never very large; as of the early 2000s, surviving machines are quite uncommon, fetching high prices as collector's items. One main reason for low sales seems to have been the need to buy an extra 16 KB RAM-extension which almost doubled the ACE's price. It happened that the designed 4 KB of base RAM was not built in favour of the less costly 1 KB delivered. The absence of colour kept the ACE squarely in a niche market of programming enthusiasts.

Jupiter ACE 4000

External links

- Jupiter Ace Resource Site: The Jupiter Ace restoration and preservation project.
- ACE-ROM-PROJECT: latest e-book with hardware considerations (Zip file).

Miles Gordon Technology

Miles Gordon Technology logo

Miles Gordon Technology, known as **MGT**, was a small British company, initially specialising in high-quality add-ons for the Sinclair ZX Spectrum home computer. It was named for its founders, Alan Miles and Bruce Gordon and was founded in Cambridge, England in June 1986, by the two ex-Sinclair Research employees after Sinclair sold the rights for the Spectrum to Amstrad. In May they moved to Swansea, Wales, became a public company in July 1989 and went into receivership in June 1990.

The DISCiPLE and +D

As the ZX Spectrum became hugely popular, the lack of a mass storage system became a problem for more serious users and while Sinclair's response, the ZX Interface 1 and ZX Microdrive, while very cheap and technologically innovative, was also rather limited. Many companies developed interfaces to connect floppy disk drives to the ZX Spectrum, one of the most successful being the Opus Discovery, however these were all to some degree incompatible with Sinclair's system.

MGT's approach was different. It produced two different floppy-disk interfaces for the Spectrum, first the DISCiPLE (marketed by Rockfort Products) and later the cut-down +D interface (marketed by MGT themselves). Both, however, shared certain features:

- A Shugart-compatible port for connecting one or two floppy diskette drives (the *de facto* standard created by Shugart Associates)
- A parallel printer port
- A "magic button"

The latter generated a non-maskable interrupt, freezing any software running on the Spectrum and allowing it to be saved to disk. This made it simple to store tape-based games on disk, to take screenshots and to enter cheat codes. A duplicate expansion connector at the back allowed other peripherals to be daisy chained, although the complexity of the DISCiPLE meant that many would not work correctly.

However, the real innovation was in the ROM. Unlike most of the competing systems, this was compatible with the Sinclair's extended ROM, meaning that the same BASIC commands used to operate Microdrives or the ZX Printer now could control floppy disk drives or a standard parallel printer. As well as being BASIC-compatible, though, it also mimicked the machine code entry points in the ZX Interface 1 - the so-called "hook codes". This meant that any Microdrive-specific software could use floppy disk drives connected to MGT interfaces instead, without modification provided the hook codes were used. The floppy drives simply appeared to Microdrive-aware applications to be very big, fast Microdrives.

Sinclair's Microdrive command syntax was so complex that a selling point of many disk interfaces was that their commands were simpler. While loading from tape required a simple:

```
LOAD "progname"
```

the equivalent Microdrive syntax was:

```
LOAD *"m";1;"progname"
```

Given the complexity of entering punctuation on the Spectrum's tiny keyboard, this was cumbersome. In addition to supporting the Sinclair syntax, MGT's code reduced the command to:

```
LOAD d1"progname"
```

Later, MGT produced the Lifetime Drive range of floppy disk drives (later named Universal Drive after concerns about warranty expectations). The drive was advertised as being compatible with major systems on the market at the time and comprised four models (3.5" and 5.25", with and without their own power supplies). Compatibility with various machines was achieved using a DIP switch and computer-specific cables.

The SAM Coupé

MGT started working their own home computer, the SAM Coupé, early on, while profits from MGT's other product financed its development. The SAM was essentially a ZX Spectrum 48K-compatible system with enhanced graphics and sound, more interfaces, expanded memory and a new BASIC interpreter. The machine was eventually launched late in 1989. Unfortunately, while technically advanced, it arrived too late to establish a market and resulted in the company's demise. The rights to the +D interface were sold to Datel Electronics Limited in an effort to finance the SAM Coupé. Alan Miles and Bruce Gordon bought the assets of MGT to form Sam Computers. However that was a temporary repreive and thhat company also ceased in 1992.

External links

- World of Spectrum: Hardware Feature #35
- MGT Lifetime/Universal Disc Drive FAQ
- DISCiPLE/+D Technical Guide

SAM Coupé

SAM Coupé

Release date	1989
Discontinued	1992
Operating system	SAM BASIC
CPU	Zilog Z80B @ 6 MHz
Memory	256 KB/512 KB (4.5 MB max.)

The **SAM Coupé** (Pronounced: *"Sam Koo-Pay"* from its original British English branding) is an 8-bit British home computer that was first released in late 1989. It is commonly considered a clone of the Sinclair ZX Spectrum computer, since it features a compatible screen mode and emulated compatibility, and it was marketed as a logical upgrade from the Spectrum. It was originally manufactured by Miles Gordon Technology (MGT), based in Swansea in the United Kingdom.

Hardware overview


A profile of the SAM Coupé, illustrating the origin of its car themed name

The machine is based around a Z80B CPU[664] clocked at 6 MHz, and contains an ASIC that is comparable to the Spectrum's ULA. Memory is accessible within the 64 KB range of the Z80B CPU by slicing it into 16 KB blocks and accessing IO ports to switch which blocks appeared in the 4 slots available to the CPU. The basic model has 256 KB of RAM, upgradable internally to 512 KB and externally with an additional 4 MB (added in 1 MB packs). The computer's primary storage medium is a cassette tape, though one or two 3.5 inch floppy disk drives can be installed internally as well. Six channel, 8 octave stereo sound is provided by a Philips SAA 1099 chip. The ASIC also includes a line triggered interrupt counter, allowing video effects to be synchronised to specific display positions with little effort.

The SAM Coupé provides four graphics modes:

- *Mode 4* — 256×192, linear framebuffer, 4 bits per pixel (16 colours) = 24 KB
- *Mode 3* — 512×192, linear framebuffer, 2 bits per pixel (4 colours) = 24 KB
- *Mode 2* — 256×192, linear framebuffer, 1 bit per pixel with 32×192 separate attributes for each 8×1 block of pixels = 12 KB
- *Mode 1* — 256×192, separate attributes, non-linear framebuffer arranged to match the display of the ZX Spectrum = 6.75 KB

All modes are paletted, with a 16-entry CLUT selecting from a palette of 128 colours. Palette entries consist of 2 bits for each of the red, green and blue components as well as an extra bit which slightly increases the intensity of all three components. The machine's non-standard SCART connector includes signals to drive a TTL-style monitor, in which case the total palette of colours is reduced to 16.

In order to match the display speed of the ZX Spectrum, the Coupé introduces extra wait states to reduce the CPU speed while in Display Mode 1.

The Motorola MC1377P RGB to PAL/NTSC encoder creates a composite video signal from the machine's RGB- and Sync-signals (output by the ASIC) for the RF modulator.

SAM Coupé bootup screen

The machine shipped with 32 KB of ROM containing code to boot the machine and a BASIC interpreter (SAM BASIC) written by Andrew Wright and heavily influenced by his earlier Beta BASIC for the ZX Spectrum. No DOS was included in the ROMs, this was instead loaded from disk using the BOOT or BOOT 1 command, or the F9 key. The majority of disks shipped with SAMDOS, the system's first DOS, on them so that they could be directly booted. An improved replacement, MasterDOS, was also developed offering faster disk access, more files and support for the Real Time Clock for filestamps amongst many other improvements.

The BASIC was very advanced and included code for sprite drawing and basic vector shapes such as lines and circles. The screen co-ordinate system for these was variable and could be arbitrarily scaled and centred. A provision for "recording" sequences of graphics commands so that they could later be repeated without the speed penalty of a BASIC interpreter in between, very similar to the display lists of OpenGL, was provided.

Video memory problems

Internal RAM was shared between the video circuitry and the CPU, with CPU accesses incurring a speed penalty (the *memory contention delay*) as it waited for ASIC accesses to finish. As a result, the SAM Coupé's CPU ran only around 14% faster than the ZX Spectrum CPU, yet was required to do much more work in SAM's appealing high-resolution modes to produce a similar movement on the display. A Mode 3 or Mode 4 screen uses four times as much RAM as a ZX Spectrum, so four times the work had to be done in the same time.

A small compensation was the straightforward arrangement of colour pixels in this memory, instead of the ZX Spectrum's oddly-laid-out display and attributes memory. Low-level graphics software operations could be much simpler than their Spectrum equivalents and therefore somewhat faster to execute.

The penalty of memory contention delay applied to all memory accesses to RAM, and not just to memory associated with the video circuitry (as in the case of the ZX Spectrum). Hardware sprites and scrolling would have greatly improved the performance of games, unfortunately there was insufficient wafer space on the VLSI ASIC to include such circuitry.

While the main 256×192 area of the screen was being drawn, the processor could only access memory in 1 out of every 8 t-states. During the border area this was 1 out of every 4 t-states, which had no effect on the many instructions whose timings were a multiple of 4. In modes 3 and 4 the display could be disabled completely, eliminating these memory contention delays for a full 6 MHz running speed. Code running in ROM was unaffected by the contention, though any RAM accesses they performed would still be affected.

Disk drives


The original MGT SAM Coupé box — all original MGT material pictured a single disk drive inserted into the right hand side even though the machine required single drive users to use the left hand bay.

The SAM used Citizen 3.5 inch slimline drives which slotted in below the keyboard to provide front-facing slots. Like IDE hard disks, these enclosures contained not just the drives but also the drive controllers, a WD1772-02, with the effect that the SAM could use both drives simultaneously.

Due to a flaw in the Coupé's design, resetting the machine while a disk was left in a drive would be liable to cause data corruption on that disk. With the appropriate technical expertise, this fault was easily corrected.

The double density disks used a format of 2 sides, 80 tracks per side and 10 sectors per track, with 512 bytes per sector. This gave a total capacity of 800 KB, though the standard directory occupied 20 KB leaving 780 KB free for user files. Files were stored in the same structure as MGT's original +D interface, but with additional codes used for SAM Coupé file types. The firmware of the disk controllers was compatible with that for IBM PC, and programs were available to read FAT formatted disks.

Expansion ports

A large array of expansion ports were provided, including:


Rear of the **SAM Coupé**. From left to right: break button, MIDI IN/OUT ports, joystick port, mouse port, reset button, Euroconnector expansion port, cassette jack, stereo sound output/lightpen input, power button, SCART socket, power/RF socket

- Two internal drive bays.
- Slightly non-standard SCART connector offering composite video and digital and linear RGB.
- 64-pin Euroconnector for general purpose hardware expansions.
- Mouse socket (proprietary format, although a converter for Atari ST style mice was later available).
- Lightpen / Lightgun via 5-pin DIN.
- MIDI IN/OUT ports (and THROUGH, via a software switch).
- Network using the MIDI port (up to 16 machines could be interconnected).
- Atari-style 9-pin joystick port (dual capability with a splitter cable).
- 3.5 mm mono Cassette jack.
- Stereo sound output through 5-pin DIN.

Uniquely the SAM's RF modulator was built into the power supply unit and connected via a joint power/TV socket. This made signal interference from the ACDC converter common and it was a popular but entirely unofficial modification to remove the modulator and keep it as a separate unit.

Due to a flaw in the design, when two joysticks were used at the same time (through the approved splitter) they would interfere with each other.

Up to four devices could be connected to the Coupé's Euroconnector port, through the use of the **SAMBUS**, which also provided a built-in clock. When using more power-hungry peripherals, the SAMBUS required an additional power supply.

Kaleidoscope

The Kaleidoscope, announced by SAMCo shortly before bankruptcy, extended the machine's total colour palette to 32768 colours in such a way as to allow forwards and backwards compatibility by applications. Although complete, very few were produced and the design ceased with SAMCo.

ZX Spectrum compatibility

Emulation of the ZX Spectrum was limited to the 48K and was achieved by loading a copy of the ZX Spectrum ROM and switching to display mode 1, which mimicked the ZX Spectrum display mode and approximated that machines processor speed. The ROM was not supplied with the machine and had to be obtained from a real ZX Spectrum.

The *Messenger*

The 128K model's memory map was incompatible with the Coupé's memory model and the machine featured an entirely different sound generator. It was possible to convert games by hacking the 128K code.

Because the Coupé didn't run at exactly the same speed as the Spectrum even in emulation mode, many anti-piracy tape loaders would not work on the Coupé hardware. This led to the development by MGT of a special hardware interface called the *Messenger* which could capture the state of a connected ZX Spectrum to SAM Coupé disk for playback later without the Spectrum connected. The Messenger plugged into the Coupé's network port, and the Spectrum's expansion slot. Due to faulty break (NMI) buttons (needed to activate the Messenger software), a break-button card was also provided, which plugged into the Coupé's expansion slot.

Commercial fortunes

Three different companies have owned the rights to the SAM Coupé. It is believed that about 12,000 SAM Coupé and SAM Élite machines were sold in total.[665]

Miles Gordon Technology, plc.

MGT, Miles Gordon Technology, plc., which originally produced add-ons for the ZX Spectrum, launched the SAM Coupé (very) late in 1989, missing the Christmas sales. They ended up with a vast number of machines in stock. The 16-bit and PC markets were on the rise and it helped little that MGT in the beginning of 1990 had to ship a new ROM to about 8,000 existing customers to fix bugs, notably a DOS booting bug. MGT went into receivership in June 1990.

SAM Computers Ltd.

Immediately after the collapse of MGT, the founders of the company, Alan Miles and Bruce Gordon, bought back the company's assets and formed SAM Computers Ltd. The price of the SAM with floppy disk drive was brought down to under £200 and new games and hardware were released. SAMCo survived until 15 July 1992.

West Coast Computers

Stock from SAM Computers Ltd. were bought by West Coast Computers in November 1992. They revamped the SAM Coupé into SAM Élite. The only changes made were that 512 KB became standard and an external printer connector was added. The slim-line floppy drives from Citizen, which had withdrawn them from the European market in 1990, were replaced with standard 3.5 inch drives. Little is known about the company. For a long period the only point of contact was Format Publications, run by Bob Brenchley, which faded out of existence sometime around 1998.

SAM the robot

Devised by Mel Croucher and put in pen by Robin Evans as a mascot for the machine, SAM the robot appeared in the user manual and on most of the advertising literature for the machine, and later made an appearance as the main character in the game *SAM Strikes Out!*.

Notable software


SAM, a friendly robot

The SAM Coupé was particularly notable for the wide array of disk based magazines that originated for it, include FRED and the official SAMCo Newsdisk. It also became notorious for the overwhelming number of puzzle games for the system, something that Spectrum magazine Your Sinclair jokingly referred to on numerous occasions.

Several famous video games were ported to the SAM, notably *Manic Miner*, *Prince of Persia*, and *Lemmings*. An unofficial but arcade perfect port of *Defender* surfaced late in the machine's lifespan.

Flash!

Flash!, an art package, was the only full application bundled with every SAM Coupé and as a result is probably the program best known to SAM owners. Written by Bo Jangeborg, author of the earlier ZX Spectrum program *The Artist* and *The Artist II*, it offered pixel editing in all four graphics modes, conversion of graphics from one mode to another and some basic animation functions.

Only full screen images were supported and the program's main flaw was an inability to view the entirety of an image while working on it. A copy adapted for use with a mouse was bundled with the official mouse addon.

Software houses

Before the machine was released, US Gold claimed that "if, as with Strider, we've already produced a game across all common formats, all we have to do is simply take the code from the Speccy version and the graphics from the ST and sort of mix them together. This should take one bloke around two weeks at most".

Despite this, supporting the machine proved difficult and only a small number of software houses stepped forward, most SAM specific.

Enigma Variations

An early supporter of the SAM, Enigma published SAM versions of *Defenders of the Earth*, *Escape From the Planet of the Robot Monsters*, *Five on a Treasure Island* (based on Enid Blyton's Famous Five), *Klax*, *Pipe Mania* and SAM originals *SAM Strikes Out* (a *Jet Set Willy* influenced platformer), *Futureball* (a *Speedball* influenced futuristic sporting title) and *Sphera*.


Screenshot of *Sphera*, a mode 2 vertically scrolling shooter.

Revelation

The software arm of SAMCo, founded in 1992 due to the lack of support from mainstream publishing houses, was notable for publishing most of the SAM's best titles. SAM original titles included *Astroball*, *Batz 'n' Balls*, *Legend of Eshan*, *Sophistry* and *Wop Gamma*. Revelation also published *Hexagonia*, which is similar to *Atomix*.

SAM ports included *Elite* (nothing more than the ZX Spectrum 48K version repackaged onto floppy disk), *Prince of Persia*, *Manic Miner*, *Lemmings* and *Splat!*.

A later incarnation of Revelation was set up in conjunction with West Coast Computers, with titles distributed by Format Publications.

FRED Publishing

Spun off from the disk based magazine, FRED Publishing was relatively late to the scene, but supported the machine long after any of the other publishing houses. The jewel in its crown was the SAM conversion of *Lemmings* (and *Oh No! More Lemmings*), but they also published a number of SAM original titles such as *Boing*, *The Bulgulators*, *Dyzonium*, *Football League Manager*, *Impatience/Triltex*, *Momentum*, *Parallax*, *Waterworks* and *Witching Hour*.

Phoenix Software

This label released titles such as *Manic Miner* and *Dyadic*. They also distributed titles for other authors, such as MasterBasic and MasterDos. The same team was also involved with the *SAM Prime* magazine.

Quazar

A relatively late comer to the SAM scene, founded in 1995. Launching with a new soundcard for the SAM and continued producing a disk magazine to support it but later spanned over into games including *Stratosphere* and the *Money Bags* trilogy. Still actively producing software, hardware and a regular magazine for the SAM Coupe.

The Community

People

As a result of the low sales volume and high proliferation of disk based magazines, a number of individuals became well known amongst the SAM community. These include:

- Graham Burtenshaw — author of *SAM Paint* and *Momentum*. Also founder and editor of *Enceladus* magazine.
- Simon Cooke — One of the most prolific coders for the SAM.
- František Fuka — programmer and musician.
- David Gommeren — author of the SAM games *Tetris* and *Bats 'n Balls* and some demos.
- Colin Jordan — author of '"Five On a Treasure Island", "Splat" & the "SAM Adventure System (SAS)"'. Also worked at SAMCo.
- Balor Knight — author of *Astroball* and *Dyzonium*.
- Colin MacDonald — original editor of *FRED!* and man behind FRED Publishing.
- Simon Owen — author of *SimCoupe*, the SAM Coupé emulator.
- Colin Piggot — runs Quazar and has produced a vast amount of software and hardware for the SAM.
- Chris Pile — author of *Pro-Dos* (a CP/M implementation for SAM) and the port of *Defender*.
- Nick Roberts — programmer, writer of the SAM column in CRASH!.
- Allan Skillman — author of *XCoupe*, the prelude to *SimCoupe*.
- Brent Stevens — organiser of the SAM Coupé Public Domain Software Association. Also wrote SAM games and hardware reviews, and did related photography in Sinclair User magazine under the alias of Steve Brentwood.
- Ron Stirling — creator of *Review* disk magazine and *MegaDisk* compilation of games for SAMCo.
- Christopher J. White — coder of SAM ports of *Prince of Persia* and *Lemmings*.
- Dave Whitmore - Sysop of *Dalmation BBS* in the mid-nineties, a dial-up Bulletin Board System aimed at the SAM community. Also Technical Editor of the *SAM Coupe Adventure Club*.

Publications

The SAM Coupe had a number of publications created for it, mostly "fanzines" by Community members. Some of the more noted are listed below:

- Based On An Idea — paper-based magazine. Published by Simon Cooke and Martin Rookyard.
- Blitz — disk based magazine from the creators of SAM Newsdisk, SAM Prime and ZAT. Published by Persona.
- Enceladus — disk-based magazine published (and programmed) by Graham Burtenshaw.
- FRED — disk-based magazine published by Colin MacDonald.
- Format — paper-based magazine published by Robert Brenchley. (ISSN)0963-8598 [15]
- SAM Adventure Club — disk based magazine. Published by the SAM Coupe Adventure Club.
- SAM Newsdisk — official disk-based magazine published by SAM Computers Ltd by members of the "ZAT" and "SAM Quartet" teams.
- SAM Prime — disk (later paper) based magazine published by former SAM Newsdisk team members after SAMCo's demise.
- SAM Revival — paper-based magazine, with cover CD/disk. Currently the only remaining magazine under publication.
- SAM Supplement - disk based magazine published by Dave Tonks.
- ZAT — paper-based magazine for ZX Spectrum and SAM Coupé.

Emulation

As the SAM Coupe has been out of production for some time and is now relatively difficult to obtain, emulation has become more important. *Sim Coupe* is an emulator which is currently written and maintained by Simon Owen, and is based on the project *XCoupe* by Allan Skillman. The emulator has been ported to a number of platforms, including Microsoft Windows, Mac OS X, Linux and other Unixes, AmigaOS 4, Pocket PC, QNX, GP2X and PlayStation Portable. Assistance in the development of the emulator was provided by Simon Cooke, David Zambonini, Andrew Collier, Ian Collier and others. The Coupé is also emulated by the MESS.

External links

- World of SAM — the premier source for all things Coupé
- Quazar - Supporting the SAM with new Hardware, Software, Magazines, and Repairs
- SAM Coupé FTP archive at NVG
- SAM Coupe Scrapbook
- VELESOFT — hardware for SAM Coupé
- SAM Coupe Pro-Dos (CP/M 2.2) Resource Site
- SimCoupe - A SAM Coupé Emulator
- SAM Coupé overview at Planet Sinclair
- Dan's Coupe Pages, including FRED Magazine catalogue
- Spectrum Advanced Machine Website
- Edwin Blink's SAM Coupé webpage
- Simon Cooke's SAM Coupé Info Base

Timex Sinclair 1000

Timex Sinclair 1000	
Release date	July, 1982
Discontinued	1983
Operating system	Sinclair BASIC
CPU	Zilog Z80A @ 3.25 MHz
Memory	2 KB

The **Timex Sinclair 1000 (TS1000)** was the first computer produced by Timex Sinclair, a joint-venture between Timex Corporation and Sinclair Research. It was launched in July 1982.

The TS1000 was a slightly modified Sinclair ZX81 with an NTSC RF modulator instead of a UK PAL (Units sold in Portugal have a PAL RF modulator) device and the onboard RAM doubled to 2 kB. The TS1000's casing had slightly more internal shielding but remained the same as Sinclair's, including the membrane keyboard. It had black and white graphics, and no sound. It was followed by an improved version, the **Timex Sinclair 1500**.

Like the Sinclair ZX81, the TS1000 used a form of BASIC as its primary interface and programming language. To make the membrane keyboard less cumbersome for program entry, the TS1000 used a shortcut system of one-letter "keywords" for most commands (i.e. pressing "P" while the cursor was in "keyword mode" would generate the keyword "PRINT"). Some keywords required a short sequence of keystrokes (e.g. SHIFT-ENTER S would generate the keyword "LPRINT"). The TS1000 clued the user in on what to expect by changing the cursor to reflect the current input mode.

The TS1000 sold for $99.95 in the US when it debuted, making it the cheapest home computer to date at the time of its launch (its advertising angle was "the first computer under $100".) This pricing initiated a price war with Commodore International, who quickly reduced the price of its VIC-20 to match and later announced a trade-in program offering $100 for any competing computer toward the purchase of a Commodore 64. Since the TS1000 was selling for $49 by this time, many customers bought them for the sole purpose of trading it in to Commodore.

The black and white display showed 32 columns and 24 lines (22 of which were normally accessible for display and 2 reserved for data entry and error messages). The limited graphics were based on geometric shapes contained within the operating system's non-ASCII character set. The only form of long-term storage was to plug into a home tape cassette recorder. The 16K memory expansion sold for $49.95. A shortage of the memory expansions coupled with a lack of software which ran within 2K meant that the system had little use for anything other than an introduction to programming. Home computer magazines of the era such as Compute! showed enthusiasts how to interface the computer with various kinds of equipment, providing the opportunity of learning about early speech synthesis technology through a Speak & Spell, robotics control through the memory port, and scrolling text displays for advertising.

Over time, the TS1000 spawned a cottage industry of third-party add-ons designed to help remedy its limitations. Full-size keyboards, speech synthesizers, sound generators, disk drives, and memory expansions (up to 64K) were a few of the options available. Languages like Forth and Pascal as well as BASIC compilers, and assemblers augmented the TS1000's programming possibilities. Microcomputing magazine published an article in April 1983 decrying the membrane keyboard ("The designers of the Timex-Sinclair 1000 ... reduced this important programming tool to a fraction of the required size") and describing how to wire up external full-size keyboards.

Timex Sinclair 1500

Timex Sinclair 1500

The **TS1500** was a slightly-upgraded development of the TS1000. Because of the big problem built around TS1000 in the US (keyboard and RAM Pack mainly), Timex Sinclair (TMX Portugal) designed TS1500 and offered it to Timex Corporation to solve the problems (RAM pack connection) and use the TS2000 (ZXSpectrum) silver case that were never used because they launched TS2068. It replaced the earlier machine's ZX81-like case with a ZX Spectrum-like case (in Silver), the same ZX Spectrum rubber keyboard, a custom ULA (it does not have the Ferranti ULA) and increased the onboard RAM to 16 KB.

The TS 1500 used a standard television for its display, "broadcasting" on either channel 2 or 3. It defaulted to TV channel 2, but if the "3" was pressed on the keyboard within a few seconds of turning the computer on, it changed to channel 3 instead.

Although the TS 1500 came with 16K internal RAM, an external 16K RAM pack could be added for a total 32K RAM. A few keyboard commands (POKEs) were required for the system to recognize the additional memory space (the Ram pack is multiplexed to the start of the RAM).

In spite of this, it was not a commercial success because it was launched too late when the ZX 81/TS1000's successors, the ZX Spectrum/TS2068, were already available and the home computer market in general was dominated by . It was sold in the USA and Portugal.

Bugs

There are two little-known software differences between the TS1000 and TS1500.

On the TS1000 and ZX81, the command:

```
LPRINT 0.00001
```

results in the Timex printer outputting 0.0XYZ1. This well-known fault is corrected on the TS1500.

The TS1000 runs the following loop correctly, but the TS1500 does not; making one fewer iteration than it should.

```
10 FOR I = 0 TO 1 STEP .2520 PRINT I30 NEXT I
```

Peripherals

As explained in the "users guide" for the TS 1000 when connected to a B/W TV a clock could be produced without a cartridge. Timex Computer Corporation produced a cartridge interface for the TS1000, the Timex Sinclair 1510 Command Cartridge Player. Only four cartridge titles were ever released:

- 07-9001 Supermath
- 07-9002 States and Capitals
- 07-9003 Chess
- 07-9004 Flight Simulator

The TS1510 can be used with a TS1000 and a 16K RAMPack.

External links

- 1982: Timex Sinclair Computer
- Timex Sinclair 1000
- Timex Sinclair / ZX81 Museum
- Suitcase version of Timex Sinclair 1500
- Timex Computer World-Timex Sinclair 1500
- Timex Computer World-Timex Sinclair 1510
- Timex Computer World - Pictures of Timex Sinclair 1500
- Timex Computer World - Pictures of Timex Sinclair 1510
- Timex Sinclair 1000 Fan Page
- Historycorner.de - German Site for the Timex Sinclair 1000

Timex Sinclair 2048

- *This article is about the Timex Sinclair 2048 (TS 2048). For the similarly named but different ZX Spectrum-variant sold in Portugal and Poland, see Timex Computer 2048 (TC 2048).*

The "Timex Sinclair 2048" was to be an improved version of the Sinclair ZX Spectrum computer. Never released by Timex Corporation because of TS1500 failure. According to an early Timex Sinclair 2000 computer flyer, it should be a cut-down TS2068 with 16 KB of RAM and advertised as a 40 KB memory machine (24 KB ROM + 16 KB RAM).

It seems that Timex Corporation USA used the 2048 model number before. It was the intended model number for what finally got named TS2068. In an interview with Lou Galie, Senior Vice President of Technology at Timex, he tells what he claims to be the real story. Danny Ross, Timex Computer Corporation president was giving a speech. Lou points: "When Danny announced what was supposed to be the 2048, he mis-spoke and called it the 2068. When I called him on it, he laughed and said 'Rename it. 2068 is better than 2048'".

External links

- Timex Computer World - Timex Sinclair 2048
- "American cousins" article, interview with Lou Galie

External links

- Timex Computer World - Timex Sinclair 2048

Timex Sinclair 2068

Timex Sinclair 2068

Release date	November 1983
Discontinued	1989
Operating system	Sinclair BASIC
CPU	Zilog Z80A @ 3.5 MHz
Memory	48 KB

The **Timex Sinclair 2068** (**TS2068**), released in November 1983, was Timex Sinclair's fourth and last home computer for the United States market. It was also marketed in Portugal and Poland, as the **Timex Computer 2068**.

A variant of the machine was later sold in Poland under the name **Unipolbrit Komputer 2086**.[666]

Technical specifications

TS 2068 with open ROM cartridge port and a cartridge

The TS2068 was based on the ZX Spectrum and followed Timex's ZX81-based TS1000 and TS1500, and the Spectrum-based TS2048.

Like the TS2048 was announced as a 40K memory machine (16K RAM + 24K ROM), so the 2068 was announced as a 72K machine (48K RAM + 24K ROM).

The TS2068 was a more sophisticated device, significantly changed from its UK ancestor. Arguably one of the first Sinclair clones to significantly improve on the original design, it added a number of new features:

- an AY-3-8912 sound chip, as later used by Sinclair in the *ZX Spectrum+ 128K* (but mapped to different I/O ports and thus incompatible)
- twin joystick ports
- a slightly better "chiclet keyboard" with plastic keycaps
- a cartridge port to the right of the keyboard for ROM-based software
- an improved ULA offering additional screen modes:
  - The standard Sinclair 256×192 mode with a colour resolution of 32×24
  - An "extended colour mode", 256×192 pixels with colour resolution of 32×192
  - A monochrome 512×192 mode

Sinclair BASIC was extended with new keywords (STICK, SOUND, ON ERR, FREE, DELETE, RESET) to address the new hardware and the machine offered bank-switched memory, allowing ROM cartridges to be mapped in.

However, these changes made the machine incompatible with most Spectrum machine-code software, which is to say virtually all commercial titles; less than 10% would run successfully. In an attempt to remedy this, many TS users built a cartridge with a Spectrum ROM for emulation. The emulation was sufficiently accurate that it was able to run the majority of software produced for the Spectrum. Later, Timex of Portugal produced a Spectrum emulator cartridge that would auto-boot. This cartridge did not fit in a TS2068 as it was higher than TC2068 cartridges. The TC2068 casing was changed to accommodate this.

Although Timex Computer Corporation folded in February 1984, the independent Portuguese division continued to sell the machine in Portugal as the Timex Computer 2068, and Poland until 1989, as the Unipolbrit Komputer 2086. (Although the Portuguese-made TC-2068 was also sold in Poland, only the UK2086 was actually made there). Timex of Portugal sold 2 versions of TC2068: the Silver TC2068 version came with a ZX Spectrum emulator cartridge and a black TC2068 version sold with TimeWord word processing cartridge plus the Timex RS232 Interface to use TimeWord with a RS232 printer. Strangely the black version came with a silver keyboard template with TimeWord commands to be used with the program. It can be removed because it is not glued to the black keyboard template.[667]

Although the TS2068's main improvements over the original Spectrum were in areas that had come in for widespread criticism (graphics, sound, keyboard, instant load software cartridges and—to a lesser extent—the lack of joystick ports), it was not used as the basis for the Spectrum's successors. The ZX Spectrum+ (1984) changed the keyboard only, and even the ZX Spectrum+ 128K (announced in May 1985, but not released in the UK until February 1986) retained the original machine's graphical capabilities. However, unlike the UK models, the TS2068 was not burdened by the requirement of compatibility with previous models.

Differences between TS2068, TC2068 and UK2086

As Timex Corporation made the TS2068 even hardware incompatible with ZX Spectrum, Timex of Portugal made some changes in the TC2068:

- Replaced the bus buffers with resistors like ZX Spectrum
- Changed the I/O connector to be ZX Spectrum compatible (not requiring the Zebra Twister board).
- Changed the cartridge slot top casing to accept bigger cartridges (ZX Spectrum emulator and Timeword cartridges will not fit in the TS2068 cartridge slot)
- Instead of 15V, it uses 9V.

UniPolbrit also made some changes to the TC2068 for their Komputer 2086:

- Modified ROM
- Replaced a joystick port with a parallel printer interface

Software List

Timex Computer Corp published 7 cartridges and 41 cassettes to kick-start the launch of the TS2068 (some titles released on cartridge and tape). The software was varied, ranging utilities and personal accounting programs, educational titles and games. All software have a "part number" and are grouped with all software of the same kind. 4 cartridges and 23 tapes planned were never released and from the known list, 10 titles are missing. Timex of Portugal released some more cartridges (ZX Spectrum emulator was sold with TC2068), software in tapes and software on FDD disks. Tasword for Timex FDD was sold by Timex of Portugal.

Footnotes

1. Note that the "2086" in the name was not a corruption of "2068". The "86" derived from the year the computer was first made.[668]

External links

- Unofficial Timex Sinclair 2068 site
- Timex Computer World
- Timex Sinclair Showcase

Timex Computer 2048

- *This article is about the Timex Computer 2048 (TC 2048). For the similarly named but different ZX Spectrum-variant prototype intended for sale in North America, see Timex Sinclair 2048 (TS 2048).*

Timex Computer 2048	
Release date	1984
Discontinued	1989
Operating system	Sinclair BASIC
CPU	Zilog Z80A @ 3.5 MHz
Memory	48 KB

The **TC 2048** or **Timex Computer 2048** is a computer created by "Timex of Portugal, Lda", a branch of Timex Corporation.

It was highly compatible with the Sinclair ZX Spectrum computer, although differences in the ROM prevented 100% compatibility. Timex Portugal sold the TC 2048 in Portugal and Poland, where it was very successful. Also, a NTSC version was sold in Chile. This computer forms the basis of an improved Spectrum-compatible machine, the Spectrum SE.

Technical specifications

CPU

- Zilog Z80A @ 3.50 MHz

ROM

- 16 KB

RAM

- 48 KB

Display

- Improved ULA offering additional screen modes:
  - Text: 32×24 characters (8×8 pixels, rendered in graphics mode)
  - Graphics: 256×192 pixels, 15 colours (two simultaneous colours - "attributes" - per 8×8 pixels, causing attribute clash)
  - Extended Color: 256×192 pixels, 15 colors with colour resolution of 32×192 (two simultaneous colours - "attributes" - per 1×8 pixels)
  - Dual Screen: (two 256×192 pixels screens can be placed in memory)
  - A monochrome 512×192 mode

Sound

- Beeper (1 channel, 10 octaves and 10+ semitones via internal speaker)

[By separate purchase the Joystick/Sound Unit was available to enhance sound and provide a joystick port.]

I/O

- Z80 bus in/out
- Tape audio in/out for external cassette tape storage
- RF television out
- Kempston Joystick input

Storage

- External cassette tape recorder
- 1–8 external ZX Microdrives (using ZX Interface 1)
- Timex FDD (Floppy Disk Drive System Power Supply, Controller and Disk Drive in separate cases. 16K RAM, Timex Operating System (TOS))
- Timex FDD3000 (Enhanced version (all in one case) of the Timex FDD but upgraded to 64K RAM & TOS with two Hitachi 3" disk drives)

External links

- Timex Computer World

Komputer 2086

Komputer 2086

Unipolbrit Komputer 2086

Release date	1986
Media	Casette tapes, 3½-inch floppy disks, 5¼-inch floppy disks, ROM Catridges
Operating system	Sinclair BASIC with Timex Computer Corp. extension
CPU	Zilog Z80A @ 3.58 MHz
Memory	48 KiB
Input	Keyboard

The **Unipolbrit**[669] **Komputer 2086** was a Polish version of the home computer Timex Sinclair 2068, produced by a joint venture of the Polish Unimor and Timex Computer of Portugal. The machine wasn't 100% ZX Spectrum-compatible (like all other Timex Sinclair versions) and a "Spectrum Emulation" cartridge was available (usually bundled).

Technical specifications

External 3" drive.

CPU	Zilog Z80A @ 3.58 MHz
RAM	48 KiB (max.)
ROM	24 KiB
Keyboard	mechanic, 42 keys, five function keys, cursor keys
Display	TV set or video monitor, 8 colours; text: 32×24 lines; graphics: 256×192 or 512×192 pixels (monochrome).
Sound	PSG AY-3-8912, three channels
Ports	cartridge port, tape recorder ports, TV out, RGB video monitor out, joystick port, Centromix printer port.
Storage	tape recorder; external 5" 1/4 or 3" drives.

External links

- Komputer 2086 at HCM. Accessed on April 5, 2008.
- Timex Computer World UK2086 page

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669. **Unipolbrit** is a portmanteau word of **Uni**, from *Unimor* company of Gdansk (or *Uni*ted, as said by another sources), *pol*, from Poland and *brit* from British. The number *86* in *2086* isn't *2068* misspelled, but the two last digits of the year of the production start.