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Commodore 64

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This article is about the computer. For the Nerdcore group named after it, see Commodore 64 (band).

The **Commodore 64**, commonly called **C64**, **C=64** (after the graphic logo on the case) or occasionally **CBM 64** (for **C**ommodore **B**usiness **M**achines), or **VIC-64**,[5] is an 8-bit home computer introduced in January 1982 by Commodore International.

Volume production started in the spring of 1982, with machines being released on to the market in August at a price of US$ 595.[6][7] Preceded by the Commodore VIC-20 and Commodore PET, the C64 took its name from its 64 kilobytes (65,536 bytes) of RAM, and had favorable sound and graphical specifications when compared to contemporary systems such as the Apple II, at a price that was well below the circa US$ 1200 demanded by Apple.

During the C64's lifetime, sales totalled between 12.5 and 17 million units, making it the best-selling single personal computer model of all time.[3][4] For a substantial period (1983–1986), the C64

Commodore 64

Type	Home computer
Release date	August 1982[1][2]
Introductory price	US$ 595 (1982)
Discontinued	April 1994
Units sold	12.5[3] - 17[4] million
Operating system	Commodore KERNAL/ Commodore BASIC 2.0 GEOS (optionally)
CPU	MOS Technology 6510

dominated the market with between 30% and 40% share and 2 million units sold per year,[8] outselling the IBM PC compatibles, Apple Inc. computers, and Atari 8-bit family computers. Sam Tramiel, a later Atari president and the son of Commodore's founder, said in a 1989 interview "When I was at Commodore we were building 400,000 C64s a month for a couple of years."[9]

Part of its success was because it was sold in retail stores instead of electronics stores. Commodore produced many of its parts in-house to control supplies and cost. It is sometimes compared to the Ford Model T automobile for its role in bringing a new technology to middle-class households via creative mass-production.[10]

Approximately 10,000 commercial software titles were made for the Commodore 64 including development tools, office productivity applications, and games.[11] C64 emulators allow anyone with a modern computer, or a compatible video game console, to run these programs today. The C64 is also credited with popularizing the computer demoscene and is still used today by some computer hobbyists.[12]

	@ 1.023 MHz (NTSC version) @ 0.985 MHz (PAL version)
Memory	64 kB RAM + 20 kB ROM
Graphics	VIC-II (320 × 200, 16 colors, sprites, raster interrupt)
Sound	SID 6581 (3× Osc, 4× wave, filter, ADSR, ring)
Connectivity	2× CIA 6526 joystick, Power, ROM cartridge, RF, A/V, IEEE-488 floppy-printer, digital tape, GPIO/RS-232
Predecessor	Commodore VIC-20
Successor	Commodore 128

Contents [hide]

History

[edit]

In January 1981, MOS Technology, Inc., Commodore's

In January 1981, MOS Technology, Inc., Commodore's integrated circuit design subsidiary, initiated a project to design the graphic and audio chips for a next generation video game console. Design work for the chips, named MOS Technology VIC-II (graphics) and MOS Technology SID (audio), was completed in November 1981.[6]

The Commodore 64 startup screen

Commodore then began a game console project that would use the new chips—called the *Ultimax* or alternatively the *Commodore MAX Machine*, engineered by Yash Terakura from Commodore Japan. This project was eventually cancelled after just a few machines were manufactured for the Japanese market.

At the same time, Robert "Bob" Russell (system programmer and architect on the VIC-20) and Robert "Bob" Yannes (engineer of the SID) were critical of the current product line-up at Commodore, which was a continuation of the Commodore PET line aimed at business users. With the support of Al Charpentier (engineer of the VIC-II) and Charles Winterble (manager of MOS Technology), they proposed to Commodore CEO Jack Tramiel a true low-cost sequel to the VIC-20. Tramiel dictated that the machine should have 64 kB of random-access memory (RAM). Although 64 kB of dynamic random access memory (DRAM) cost over US$100 at the time, he knew that DRAM prices were falling, and would drop to an acceptable level before full production was reached. In November, Tramiel set a deadline for the first weekend of January, to coincide with the 1982 Consumer Electronics Show (CES).[6]

The product was code named the VIC-40 as the successor to the popular VIC-20. The team that constructed it consisted of Bob Russell, Bob Yannes and David A. Ziembicki. The design, prototypes and some sample software was finished in time for the show, after the team had worked tirelessly over both Thanksgiving and Christmas weekends.

The machine incorporated Commodore BASIC 2.0 in ROM. BASIC also served as the user interface shell and was available immediately on startup at the READY. prompt.

When the product was to be presented, the VIC-40 product was renamed C64 to fit the then-current Commodore business products lineup which contained the *P128* and the *B256*, both named by a letter and

their respective total memory size (in KBytes).

The C64 made an impressive debut at the January 1982 Winter Consumer Electronics Show, as recalled by Production Engineer David A. Ziembicki: "All we saw at our booth were Atari people with their mouths dropping open, saying, 'How can you do that for $595?'" The answer, as it turned out, was vertical integration; thanks to Commodore's ownership of MOS Technology's semiconductor fabrication facilities, each C64 had an estimated production cost of only US$135.

Winning the market war   [edit]

The C64 faced a wide range of competing home computers at its introduction in August 1982.[2] With a lower price and more flexible hardware, it quickly outsold many of its competitors. In the United States the greatest competitors were the Atari 8-bit 400 and 800, and the Apple II. The Atari 400 and 800 had been designed to accommodate previously stringent FCC emissions requirements and so were expensive to manufacture. The latest revision in the aging Apple II line, the Apple IIe, had higher resolution graphics modes than the C64.[13][14] Upgrade capability for the Apple II was granted by internal expansion slots, while the C64 had only a single external ROM cartridge port for bus expansion. However, the Apple used its expansion slots for interfacing to common peripherals like disk drives, printers and modems; the C64 had a variety of ports integrated into its motherboard which were used for these purposes, usually leaving the cartridge port free.

Game cartridges for Radar Rat Race and International Soccer

All four machines had similar standard memory configurations in the years 1982/83: 48K for the Apple II+[15] (upgraded within months of C64's release to 64K with the Apple IIe) and 48K for the Atari 800.[16] At upwards of US$1200,[17] the Apple II was more than twice as expensive, while the Atari 800 cost US$899. One key to the C64's success was Commodore's aggressive marketing tactics, and they were quick to exploit the relative price/performance divisions between its competitors with a series of television commercials after the C64's launch in late 1982.[18]

Commodore sold the C64 not only through its network of authorized dealers, but also through department stores, discount stores, toy stores and college bookstores. The C64 had a built-in [RF modulator](#) and thus could be plugged into a television set. This allowed it (like its predecessor, the VIC-20) to compete directly against video game consoles such as the [Atari 2600](#). Like the Apple IIe, the C64 could also output baseband [composite video](#) and thus could be plugged into a specialized monitor for a sharper picture. Unlike the IIe, the C64's baseband NTSC output capability included separate luminance/chroma signal output equivalent to (and electrically compatible with) [S-Video](#), for connection to the [Commodore 1702](#) monitor.

Aggressive pricing of the C64 is considered to be a major catalyst in the [North American video game crash of 1983](#). In January 1983, Commodore offered a US$100 [rebate](#) in the United States on the purchase of a C64 to anyone trading in another video game console or computer.[*citation needed*] To take advantage of this rebate, some mail-order dealers and retailers offered a [Timex Sinclair 1000](#) for as little as US$10 with purchase of a C64, so the consumer could send the TS1000 to Commodore, collect the rebate, and pocket the difference; [Timex Corporation](#) departed the computer market within a year. Commodore's tactics soon led to a [price war](#) with the major [home computer](#) manufacturers. The success of the VIC-20 and C64 contributed significantly to the exit of [Texas Instruments](#) and other smaller competitors from the field. The price war with Texas Instruments was seen as a personal battle for Commodore president [Jack Tramiel](#); TI's subsequent demise in the home computer industry in October 1983 was seen as revenge for TI's tactics in the [electronic calculator](#) market in the mid-1970s, when Commodore was almost bankrupted by TI.[19] In parts of the US in the late 1980s, new C64s could be purchased in retail chains for a little more than US$100.

In 1984, Commodore released the [Commodore Plus/4](#). It had a higher-color display, a newer implementation of [Commodore BASIC](#) (V3.5), and built-in software in what was positioned as an inexpensive business oriented system. However, it was incompatible with the C64, and [Amstrad](#) and other PC and [CP/M](#) clones rendered the limited business software and lack of compactness of the multiple-lead Plus/4 system of marginal value. The Plus/4 lacked hardware [sprite](#) capability and lacked a [SID chip](#), thus under-performing in two of the areas that had made the C64 successful.

In [Europe](#), the primary competitors to the C64 were the British-built [Sinclair ZX Spectrum](#), [BBC Micro](#)

computer and the [Amstrad CPC](#) 464. In the UK, the Spectrum had been released a few months ahead of the C64, and was selling for less than half the price. The Spectrum quickly became the market leader and Commodore had an uphill struggle against the Spectrum. The C64 debuted at £399 in early 1983, while the Spectrum cost £175. The C64 would later rival the Spectrum in popularity in the latter half of the 1980s, eventually outselling the Spectrum after 1985.

Despite a few attempts by Commodore to discontinue the C64 in favor of other, higher priced machines, constant demand made its discontinuation a hard task. By 1988, Commodore was selling 1.5 million C64s worldwide.[20] Although demand for the C64 dropped off in the US by 1990, it continued to be popular in the UK and other European countries. In the end, economics, not obsolescence, sealed the C64's fate. In March 1994, at [CeBIT](#) in [Hanover](#), Germany, Commodore announced that the C64 would be finally discontinued in 1995.[21] Commodore stated that the C64's [disk drive](#) was more expensive to manufacture than the C64 itself.[21] Although Commodore had planned to discontinue the C64 by 1995, the company filed for bankruptcy a month later, in April 1994.

The C64 family   [[edit](#)]

1982: Commodore released the [Commodore MAX Machine](#) in Japan. It is called the Ultimax in the US, and VC-10 in Germany. The MAX was intended to be a game console with limited computing capability, and was based on a very cut-down version of the hardware family later used in the C64. The MAX was discontinued months after its introduction, because of poor sales in Japan.

Commodore MAX Machine

1983 saw Commodore attempt to compete with the [Apple II](#)'s hold on the US education market with the [Educator 64](#),[22] essentially a C64 and "greenscale" monochrome monitor in a PET case. Schools preferred the all-in-one metal construction of the PET over the standard C64's separate components, which could be easily damaged, vandalized or stolen.

In 1984, Commodore released the [SX-64](#), a portable version of

In 1984, Commodore released the SX-64, a portable version of the C64. The SX-64 has the distinction of being the first *full-color portable computer*. While earlier computers using this form factor only incorporated monochrome "green screen" displays, the base SX-64 unit featured a 5 in (130 mm) color cathode ray tube (CRT) and an integrated 1541 floppy disk drive. The SX-64 did not have a cassette connector.

Commodore, specifically two designers; Fred Bowen and Bil Herd, were determined to avoid the problems of the Plus/4. They intended that the eventual successors to the C64—the Commodore 128 and 128D computers (1985)—were to be good as, and fully compatible with the original. The successors had many improvements (such as a structured BASIC with graphics and sound commands, 80-column display ability, and full CP/M

Commodore SX-64

compatibility). The decision to make the Commodore 128 plug compatible with the C64 was made quietly by Bowen and Herd, software and hardware designers respectively, without the knowledge or approval by the management in the post Jack Tramiel era. The designers were careful not to reveal their decision until the project was too far along to be challenged or changed and still make the impending Consumer Electronics Show (CES) show in Las Vegas. Upon learning that the C128 was designed to be compatible with the C64, Commodore's marketing department independently announced that the C128 would be 100% compatible with the C64, thereby raising the bar for C64 support.[23][*citation needed*]

In 1986, Commodore released the Commodore 64C (C64C)

In 1986, Commodore released the Commodore 64C (C64C) computer, which was functionally identical to the original. The exterior design was remodeled in the sleeker style of the [Commodore 128](#) and other contemporary design trends. The modifications to the C64 line were more than skin deep in the C64C with new versions of the SID, VIC and I/O chips being deployed—with the core voltage reduced from 12 V to 9 V. In the [United States](#), the C64C was often bundled with the third-party [GEOS graphical user interface](#) (GUI) based operating system. The [Commodore 1541](#) disk drive received a matching face-lift resulting in the 1541c. Later a smaller, sleeker 1541-II model was introduced along with the 800 kB 3.5-inch [microfloppy 1581](#).

Commodore 64C with [1541-II](#) floppy disk drive and 1084S monitor displaying television-compatible [S-video](#)

Commodore 64 Games System "C64GS"

In 1990, the C64 was rereleased in the form of a game console, called the [C64 Games System](#) (C64GS). A simple modification to the C64C's motherboard was made to orient the cartridge connector to a vertical position. This allowed cartridges to be inserted from above. A modified ROM replaced the BASIC interpreter with a boot screen to inform the user to insert a cartridge. It was designed to rival the Nintendo Entertainment System and the Sega Master System but it suffered from very low sales compared to its rivals and it was another commercial failure for Commodore, and it was never released outside of Europe.

In 1990, an advanced successor to the C64, the [Commodore 65](#) (also known as the "C64DX"), was prototyped, but the project was canceled by Commodore's chairman [Irving Gould](#) in 1991. The C65's specifications were very good for an 8-bit computer. For example, it could display 256 colors on screen, while [OCS](#) based Amigas could only display 64 in [HalfBrite](#) mode (32 colors and half-bright transformations); the [HAM](#) mode on the Amiga allowed all 4096 colors of the 12 bit color system, but it was awkward to use and had restrictions on color combinations between adjacent pixels. Although no specific reason was given for the C65's cancellation, it would have competed in the marketplace with Commodore's lower end Amigas and the [Commodore CDTV](#).

C64 clones [edit]

In the middle of 2004, after an absence from the marketplace of more than 10 years, PC manufacturer Tulip Computers BV (owners of the Commodore brand since 1997) announced the C64 Direct-to-TV (C64DTV), a joystick-based TV game based on the C64 with 30 games built into ROM. Designed by Jeri Ellsworth, a self-taught computer designer who had earlier designed the modern C-One C64 implementation, the C64DTV was similar in concept to other mini-consoles based on the Atari 2600 and Intellivision which had gained modest success earlier in the decade. The product was advertised on QVC in the United States for the 2004 holiday season. Some users have installed 1541 floppy disk drives, hard drives, second joysticks and keyboards to these units, which give the DTV devices nearly all of the capabilities of a full Commodore 64. The DTV hardware is also used in the mini-console/game *Hummer*, sold at RadioShack mid-2005.

C64 enthusiasts still develop new hardware, including Ethernet cards,[24] specially adapted hard disks and flash card interfaces (sd2iec).[25]

Brand re-use [edit]

> *Main article: Commodore 64x*

PC clones branded as C64x sold by Commodore USA, LLC, a company licensing the Commodore trademark,[26][27] began shipping in June 2011.[28][29] The C64x has a case resembling the original C64 computer, but it is based on x86 architecture and is not compatible with the Commodore 64 on either hardware or software level.

Virtual Console [edit]

Several Commodore 64 games were released on the Nintendo Wii's Virtual Console service in Europe and North America only.

Software [edit]

> *Main article: Commodore 64 software*

In 1982, the C64's graphics and sound capabilities were rivaled only by the Atari 8-bit family, and appeared

exceptional when compared with the widely publicised Atari VCS and Apple II.

The C64 is often credited with starting the computer subculture known as the demoscene (see Commodore 64 demos). It is still being actively used in the demoscene,[30] especially for music (its sound chip even being used in special sound cards for PCs, and the Elektron SidStation synthesizer). Unfortunately, the differences between PAL and NTSC C64s caused compatibility problems between US/Canadian C64s and those from most other countries. The vast majority of demos run only on PAL machines.

Even though other computers quickly caught up with it, the C64 remained a strong competitor to the later video game consoles Nintendo Entertainment System and Sega Master System, thanks in part to its by-then established software base, especially outside of North America, where it comprehensively outsold the NES.[*citation needed*]

BASIC [edit]

> *Main article: Commodore BASIC*

As was common for home computers of the early 1980s, the C64 incorporated a ROM based version of the BASIC programming language. There was no *operating system* as such. The KERNAL was accessed via BASIC commands. The disk drive had its own microprocessor (like in the Atari 800). This meant that no memory space had to be dedicated to run the drive, as remained the case with earlier systems such as the Apple II.

Commodore BASIC 2.0 was used instead of the more advanced BASIC 4.0 from the PET series, since its users were not expected to need the disk-oriented enhancements of BASIC 4.0. "The choice of BASIC 2.0 instead of 4.0 was made with some soul-searching, not just at random. The typical user of a C64 is not expected to need the direct disk commands as much as other extensions and the amount of memory to be committed to

The Simons' BASIC start-up screen. Note the altered background and text colors (vs the ordinary C64 blue tones), and the 8 kB reduction of available BASIC program memory due to the address space used by the cartridge.

BASIC were to be limited. We chose to leave expansion space for color and sound extensions instead of the disk features. As a result, you will have to handle the disk in the more cumbersome manner of the 'old days'."[31]

The version of BASIC was limited and did not include specific commands for sound or graphics manipulation, instead required users to use the "POKE" commands to access the graphics and sound chip registers directly. To provide extended commands, including graphics and sound, Commodore produced two different cartridge-based extension to BASIC 2.0 — Simons' BASIC and Super Expander 64.

Other languages available for the C64 included Pascal, Logo, Forth, and FORTRAN. Compiled versions of BASIC such as Petspeed 2 (from Commodore) and Turbo Lightning (Ocean Software) were also available. While the first generation of C64 software may have used one of these or even the standard BASIC, after 1983 most professionally produced programs were written in assembly language, using a machine code monitor or an assembler. This maximised speed and minimised memory use.

Alternative operating systems [edit]

Many third party operating systems have been developed for the C64. As well as the original GEOS, two third-party GEOS-compatible systems have been written: Wheels and GEOS megapatch. Both of these require hardware upgrades to the original C64. Several other operating systems are or have been available, including WiNGS OS, the Unix-like LUnix, operated from a command-line, and the embedded systems OS Contiki, with full GUI. Other less well known OSes include ACE, Asterix, DOS/65 and GeckOS.

GEOS for the Commodore 64
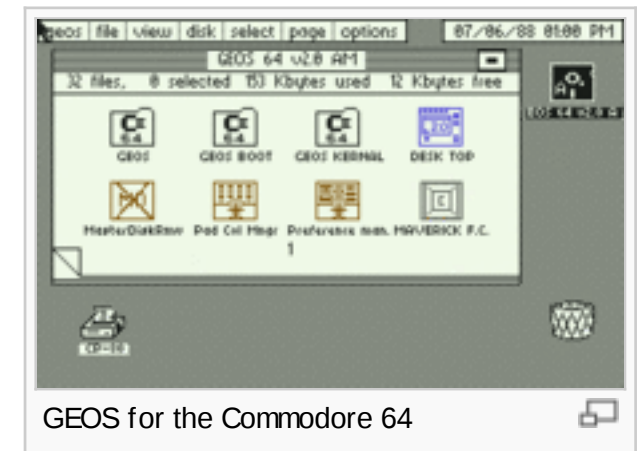
A version of CP/M was released, but this required the addition of an external Z80 processor to the expansion bus, so is not considered a true C64 OS. Furthermore, the Z80 processor was underclocked to be compatible with the C64's memory bus, so performance was poor compared to other CP/M implementations. C64 CP/M and C128 CP/M both suffered a lack of software: although most commercial CP/M software could run on these systems, software media was incompatible between platforms. The low usage of CP/M on Commodores meant that software houses saw no need to

invest in mastering versions for the Commodore disk format.

Networking software [edit]

During the 1980s, the Commodore 64 was used to run many bulletin board systems using software packages such as Bizarre 64, Blue Board, C-Net, Color 64, CMBBS, DMBBS and The Deadlock BBS Construction Set, often with sysop-made modifications. These boards sometimes were used to distribute cracked software.

There were also major commercial online services, such as Compunet (UK), CompuServe (US - later bought by America Online), The Source (US) and Minitel (France) among many others. These services usually required custom software which was often bundled with a modem and included free online time as they were billed by the minute.

Quantum Link (or Q-Link) was a US and Canadian online service for Commodore 64 and 128 personal computers that operated from November 5, 1985 to November 1, 1994. It was operated by Quantum Computer Services of Vienna, Virginia, which in October 1991 changed its name to America Online, and continues to operate its AOL service for the IBM PC compatible and Apple Macintosh today. Q-Link was a modified version of the PlayNET system, which Control Video Corporation (CVC, later renamed Quantum Computer Services) licensed.

Online gaming [edit]

Main article: History of massively multiplayer online games

The original interactive game on the micro was M.U.D, the *Multi User Dungeon*, a text based adventure-RPG program based on the original adventure game written by William Crowther for the DEC PDP-9. Written for British Telecom on Compunet, the game was expanded to Compuserve in US. This text based adventure game allowed real time conversations and combats (in text) via the large commercial BBS.

Don Daglow and the Stormfront Studios game design team began working with AOL on original online games in 1987, in both text-based and graphical formats. At the time AOL was a Commodore 64 only online service, known as Quantum Computer Services, with just a few thousand subscribers, and was called Quantum Link. Online graphics in the late 1980s were severely restricted by the need to support

modem data transfer rates as slow as 300 [bits per second](#) (bit/s). During the early 1990s, commercial use of the Internet was limited by [NSFNET](#) acceptable use policies. Consequently, early online games like [Legends of Future Past](#), [Neverwinter Nights](#), [GemStone III](#), [Dragon's Gate](#), and [Federation](#) relied heavily on proprietary services such as [CompuServe](#), [America Online](#), and [GEnie](#) for distribution.

The first graphical character-based interactive environment was *[Club Caribe](#)*. First released as *[Habitat](#)* in 1988, *Club Caribe* was introduced by [LucasArts](#) for [Q-Link](#) customers on their Commodore 64 computers. Users could interact with one another, chat and exchange items. Although very basic, its use of online avatars (already well-established off-line by [Ultima](#) and other games) and combination of chat and graphics was revolutionary.

Hardware [[edit](#)]

This article **may contain too much repetition or redundant language**. Please help [improve it](#) by merging similar text or removing repeated statements. *(April 2010)*

CPU and memory [[edit](#)]

> *Main article: [MOS Technology 6510](#)*

The C64 uses an [8-bit MOS Technology 6510 microprocessor](#). This is a close derivative of the [6502](#) with an added 6-bit internal I/O port that in the C64 is used for two purposes: to bank-switch the machine's [read-only memory](#) (ROM) in and out of the processor's address space, and to operate the [datasette](#) tape recorder.

The C64 has 64 kB of [RAM](#), of which 38 kB are available to built-in [Commodore BASIC](#) 2.0 on startup.

There is 20 kB of ROM, made up of the BASIC interpreter, the kernel, and the character ROM. As the processor could only address 64 kB at a time, the [ROM](#) was mapped into memory and only 38,911 bytes of RAM were available at startup.

If a program did not use the BASIC interpreter, RAM could be mapped over the ROM locations. However, this meant the character ROM would not be available, and the RAM in its place was instead used for the

character glyphs. Normally, this RAM was uninitialised, which would then result in nothing but random patterns appearing on the screen. This was solved by copying the character ROM into RAM. This had two benefits - the standard typeface could be rewritten, and character codes could be rewritten as picture elements.

Most C64 games were written in this way, using low resolution, which required much less processor time and saved memory. Furthermore, picture elements could be reused, saving even more precious memory. The same technique was used in systems like the NES.

Graphics   [edit]

Main article: MOS Technology VIC-II

The graphics chip, VIC-II, features 16 colors, eight hardware sprites per scanline (enabling up to 112 sprites per PAL screen), scrolling capabilities, and two bitmap graphics modes. The standard text mode features 40 columns, like most Commodore PET models; the built in character encoding is not standard ASCII but PETSCII, an extended form of ASCII-1963.

Most screen shots show borders around the screen, which is a feature of the VIC-II chip. By utilising interrupts to reset various hardware registers on precise timings it was possible to place graphics within the borders and thus utilise the full screen.[32]

There were two low-resolution and two bitmapped modes. Multicolor bitmapped mode had an addressable screen of 160 × 200 pixels, with a maximum of four colors per 4 × 8 character block. High-resolution bitmapped mode had an addressable screen of 320 × 200 pixels, with a maximum of two colors per 8 × 8 character block.

Multicolor low-resolution had a screen of 160 × 200 pixels, 40 × 25 addressable with four colors per 8 × 8 character block.

High resolution "low resolution" had a screen of 320 × 200 pixels, 40 × 25 addressable with two colors per 8 × 8 character block.

Most video games used Multicolor low-resolution.

This allowed only block-by-block character animation due to the limited addressable space.

This was not an issue however, as the video chip automated [sprites](#) and vertical and horizontal scrolling pixel-by-pixel, and worked smoothly and quickly regardless of the video mode.

Some animation (for instance, bullets) used character animation when sprites were not available.

Sound   [[edit](#)]

> *Main article: [MOS Technology SID](#)*

The [SID](#) chip has three channels, each with its own [ADSR envelope](#) generator, [ring modulation](#) and filter capabilities. Bob Yannes developed the SID chip and later co-founded synthesizer company [Ensoniq](#). Yannes criticized other contemporary computer sound chips as "primitive, obviously… designed by people who knew nothing about music". Often the game music became a hit of its own among C64 users. Well-known composers and programmers of game music on the C64 are [Rob Hubbard](#), [David Whittaker](#), [Chris Hülsbeck](#), [Ben Daglish](#), [Martin Galway](#), David Dunn, and Kjell Nordbø among many others. Due to the chip's three channels, chords are played as [arpeggios](#), coining the C64's characteristic lively sound. It was also possible to continuously update the master volume with sampled data to enable the playback of 4-bit digitized audio. As of 2008, it became possible to play four channel 8-bit audio samples, 2 SID channels and still use filtering.[[*citation needed*](#)]

There are two versions of the SID chip, the 6581 and the 8580. The MOS Technology 6581 was used in the original "breadbox" C64s, the early versions of the C64C and the [Commodore 128](#). The 6581 was replaced with the MOS Technology 8580 in 1987. The 6581 sound quality is a little crisper, and many Commodore 64 fans prefer its sound. The main difference between the 6581 and the 8580 is the supply voltage. The 6581 uses a 12 volt supply - the 8580, a 9 volt supply. A modification can be made to use the 6581 in a C64C board (which uses the 9 volt chip).

The SID chip has a distinctive sound which has retained a following of devotees to such a degree, that a number of audio enthusiasts and companies have designed [SID-based products](#) as add-ons for the C64, [x86 PCs](#), and standalone or [MIDI](#) music devices such as the [Elektron SidStation](#). These devices use chips taken from excess stock, or removed from used computers.

In 2007, [Timbaland](#)'s extensive use of the [SidStation](#) led to the [2007 Timbaland plagiarism controversy](#) around his tracks "Block Party" and "[Do It](#)" (written for [Nelly Furtado](#)).

Hardware revisions [edit]

Cost reduction was the driving force behind the C64's motherboard revisions. Reducing manufacturing costs was vitally important to Commodore's survival during the price war and leaner years of the 16-bit era. The C64's original (NMOS based) motherboard would go through two major redesigns, (and numerous sub-revisions) exchanging positions of the VIC-II, SID and PLA chips. Initially, a large portion of the cost was eliminated by reducing the number of discrete components, such as diodes and resistors, which enabled the use of a smaller printed circuit board.

The case is made from ABS plastic which may become brown with time. This can be reversed by using the public domain chemical mix "Retr0bright".

ICs [edit]

The VIC-II was manufactured with 5 micrometer NMOS technology[6] and was clocked at either 17.73447 MHz (PAL) or 14.31818 MHz (NTSC). Internally, the clock was divided down to generate the dot clock (about 8 MHz) and the two-phase system clocks (about 1 MHz; the exact pixel and system clock speeds are slightly different between NTSC and PAL machines). At such high clock rates, the chip generated a lot of heat, forcing MOS Technology to use a ceramic DIL package (called a "CERDIP"). The ceramic package was more expensive, but it dissipated heat more effectively than plastic.

After a redesign in 1983, the VIC-II was
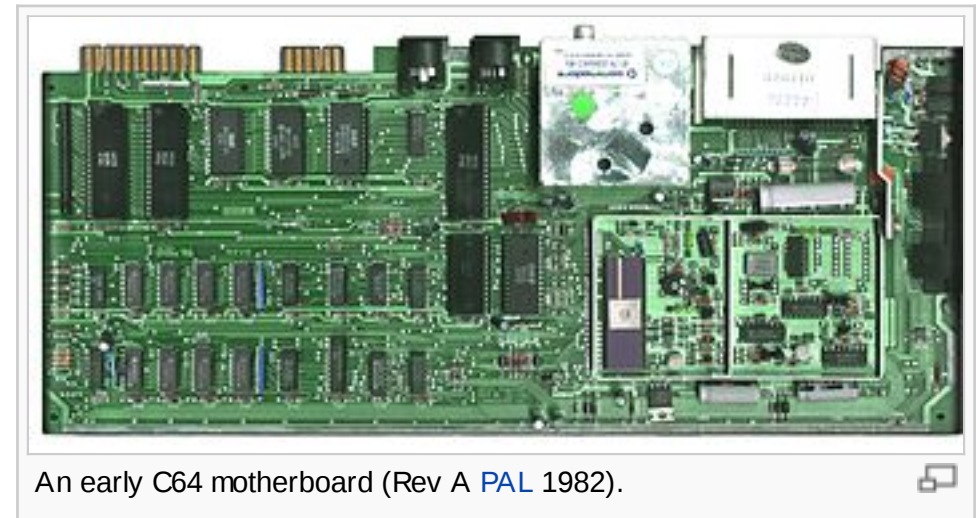
An early C64 motherboard (Rev A PAL 1982).
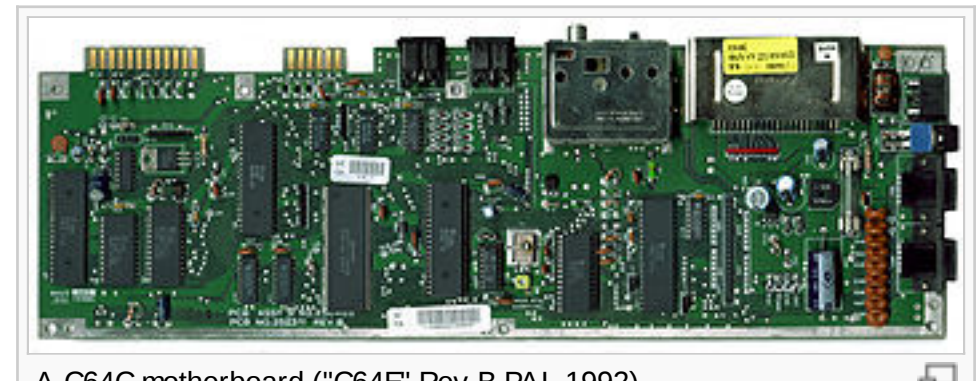
A C64C motherboard ("C64E" Rev B PAL 1992)

encased in a plastic Dual Inline Package, which reduced costs substantially, but it did not totally eliminate the heat problem.[6] Without a ceramic package, the VIC-II required the use of a heat sink. To avoid extra cost, the metal RF shielding doubled as the heat sink for the VIC, although not all units shipped with this type of shielding. Most C64s in Europe shipped with a cardboard RF shield, coated with a layer of metal foil. The effectiveness of the cardboard was highly questionable, and worse still it acted as an insulator, blocking airflow which trapped heat generated by the SID, VIC, and PLA chips.

The SID was manufactured using NMOS at 7 and in some areas 6 micrometers.[6] The prototype SID and some very early production models featured a ceramic Dual Inline Package, but unlike the VIC-II, these are extremely rare as the SID was encased in plastic when production started in early 1982.

Motherboard [edit]

In 1986, Commodore released the last revision to the classic C64 motherboard. It was otherwise identical to the 1984 design, except for the two 64 kilobit × 4 bit DRAM chips that replaced the original eight 64 kilobit × 1 bit ICs.

After the release of the C64C, MOS Technology began to reconfigure the C64's chipset to use HMOS production technology. The main benefit of using HMOS was that it required less voltage to drive the IC, which consequently generates less heat. This enhanced the overall reliability of the SID and VIC-II. The new chipset was renumbered to 85xx to reflect the change to HMOS.

In 1987, Commodore released C64Cs with a highly redesigned motherboard commonly known as a "short board". The new board used the new HMOS chipset, featuring a new 64-pin PLA chip. The new "SuperPLA", as it was dubbed, integrated many discrete components and transistor–transistor logic (TTL) chips. In the last revision of the C64C motherboard, the 2114 color RAM was integrated into the SuperPLA.

Power supply [edit]

The C64 used an external power supply, a conventional

The C64 used an external power supply, a conventional transformer with multiple tappings (as opposed to switch mode, the type now used on PC power supplies), encased in an epoxy resin gel which discouraged tampering but tended to increase the heat level during use.

Joystick ports, power switch, power inlet

This saved space within the computer's case and allowed international versions to be more easily manufactured. The 1541-II and 1581 disk drives, along with various third-party clones, also came with their own external power supply "bricks", as did most peripherals leading to a "spaghetti" of cables and the use of numerous double adapters by users. These power supplies were notorious for failing over time,[33] usually because of overheating.

Commodore later changed the design, omitting the gel. The follow-on model, the Commodore 128, used a larger, much improved power supply that included a fuse.

Specifications [edit]

Internal hardware [edit]

- Microprocessor CPU:
  - MOS Technology 6510/8500 (the 6510/8500 is a modified 6502 with an integrated 6-bit I/O port)
  - Clock speed: 0.985 MHz (PAL) or 1.023 MHz (NTSC)
- Video: MOS Technology VIC-II 6567/8562 (NTSC), 6569/8565 (PAL)
  - 16 colors
  - Text mode: 40×25 characters; 256 user-defined chars (8×8 pixels, or 4×8 in multicolor mode); 4-bit color RAM defines foreground color
  - Bitmap modes: 320×200 (2 unique colors in each 8×8 pixel block),[34] 160×200 (3 unique colors + 1 common color in each 4×8 block)[35]
  - 8 hardware sprites of 24×21 pixels (12×21 in multicolor mode)
  - Smooth scrolling, raster interrupts
- Sound: MOS Technology 6581/8580 SID

- 3-channel synthesizer with programmable ADSR envelope
- 8 octaves
- 4 waveforms per audio channel: triangle, sawtooth, variable pulse, noise
- Oscillator synchronization, ring modulation
- Programmable filter: high pass, low pass, band pass, notch filter
- Input/Output: Two 6526 Complex Interface Adapters
  - 16 bit parallel I/O
  - 8 bit serial I/O
  - 24-hours (AM/PM) Time of Day clock (TOD), with programmable alarm clock[36]
  - 16 bit interval timers
- RAM:
  - 64 kB, of which 38 kB (minus 1 byte) were available for BASIC programs
  - 512 bytes color RAM (memory allocated for screen color data storage) [37]
  - Expandable to 320 kB with Commodore 1764 256 kB RAM Expansion Unit (REU); although only 64 kB directly accessible; REU mostly intended for GEOS. REUs of 128 kB and 512 kB, originally designed for the C128, were also available, but required the user to buy a stronger power supply from some third party supplier; with the 1764 this was included. Creative Micro Designs also produced a 2 MB REU for the C64 and C128, called the 1750 XL. The technology actually supported up to 16 MB, but 2 MB was the biggest one officially made. Expansions of up to 16 MB were also possible via the CMD SuperCPU.
- ROM:
  - 20 kB (9 kB Commodore BASIC 2.0; 7 kB KERNAL; 4 kB character generator, providing two 2 kB character sets)

I/O ports and power supply [edit]

- I/O ports:[38]
  - ROM cartridge expansion slot (44-pin slot for edge connector with 6510 CPU address/data bus lines and control signals,

as well as GND and voltage pins;[39] used for program modules and memory expansions, among others)

Commodore 64 ports (from left: Joy1, Joy2, Power, ROM cartridge, RF-adj, RF, A/V, 488, Tape, User)

- Integrated RF modulator antenna output via a RCA connector. The used channel could be adjusted from number 36 with the potentiometer to the left.
- 8-pin DIN connector containing composite video output, separate Y/C outputs and sound input/output. Beware that this is the 270° (horseshoe) version of the plug, not the 360° circular version. Also note that some early C64 units use a 5-pin DIN connector that carries composite video and luminance signals, but lacks a chroma signal.[40]
- Serial bus (serial version of IEEE-488, 6-pin DIN plug) for CBM printers and disk drives
- PET-type Commodore Datassette 300 baud tape interface (edge connector with digital cassette motor/read/write/key-sense signals, Ground and +5V DC lines. The cassette motor is controlled by a +5V DC signal from the 6502 CPU. The 9 V AC input is transformed into unregulated 6.36 V DC[41] which is used to actually power the cassette motor.[42]
- User port (edge connector with TTL-level signals, for modems and so on.; byte-parallel signals which can be used to drive third-party parallel printers, among other things, 17 logic signals, 7 Ground and voltage pins, including 9V AC)
- 2 × screwless DE9M game controller ports (compatible with Atari 2600 controllers), each supporting five digital inputs and two analog inputs. Available peripherals included digital joysticks, analog paddles, a light pen, the Commodore 1351 mouse, and graphics tablets such as the KoalaPad.
- Power supply:
  - 5V DC and 9V AC from an external "power brick", attached to a 7-pin female DIN-connector on the computer.[43]

The 9 volt AC is used to supply power via a charge pump to the SID sound generator chip, provide 6.8V via a rectifier to the cassette motor, a "0" pulse for every positive half wave to the time-of-day (TOD) input on the CIA chips, and 9 volts AC directly to the user-port. Thus, as a minimum, a 12 V square wave is required. But a 9 V sine wave is preferred.[44][45]

Peripherals

Commodore 1541 Floppy Drive, 1st model.

Commodore 1541C Floppy Drive, 2nd model.

Commodore 1541-II Floppy Drive, 3rd model.

Commodore 1530 Datasette

Commodore MPS-802 Dot-matrix Printer

Commodore VIC-Modem

[edit]

Commodore 1351 Mouse

Commodore 1702 video monitor

See also [edit]

- Commodore SX-64 – Portable version
- History of personal computers
- Commodore 64 peripherals
- List of Commodore 64 games
- Commodore 64 demos
- Commodore MAX Machine – the Commodore 64's predecessor
- Commodore 128 – the Commodore 64's descendant
- C-One – Programmable FPGA clone
- C64 Direct-to-TV – ASIC clone with 30 built in games
- IDE64 – P-ATA interface cartridge for the C64
- Commodore 64x is a x86-based recreation of C64, coupled with a software emulator

Computer Science portal

Footnotes [edit]

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27. **^** "Recreating the Legendary Commodore 64" .
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External links [edit]

- Commodore 64: 8-Bit Legend ⤢ 12 minute video compilation of Commodore 64 nostalgia and history
- C64 Preservation Project ⤢ Discusses preservation of classic software for the Commodore 64
- Commodore 64 ⤢ at the Open Directory Project
- Chronology of the Commodore 64 Computer ⤢
- The History of the Commodore 64 ⤢
- C64.com ⤢ The home of Commodore 64 software and interviews with many game producers
- Commodore 64 history, manuals, and photos ⤢
- Extensive collection of information on C64 programming ⤢
- A History of Gaming Platforms: The Commodore 64 ⤢ from October 2007
- Images of the C64 prototype ⤢ from 2003
- A Commodore 64 Web Server Using Contiki v2.3 ⤢
- Commodore 8-bit web links Project 70 sites and counting ⤢
- Commodore 64 Search Engine + Cloud ⤢
- "Commodore 64 still loved after all these years ⤢", *CNN*
- "The Commodore 64 at 25: thank you for the music ⤢", *The Guardian*
- Review of 5 different Commodore 64 models/motherboards ⤢, MOS6502.com ⤢
- Commodore Computer Club ⤢ Discusses hardware, software, repairs and the scene for the Commodore 64
- "How to use the Commodore 64 for chiptunes ⤢", *2D-X*

Wikimedia Commons has media related to: *Commodore 64*

- Variations on the Commodore 64 🔗 at the Wayback Machine (archived May 4, 2010)
- Commodore 64 turns 30: What do today's kids make of it? 🔗, *BBC*

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68000-based (16-bit / 32-bit)	Amiga 1000 · Amiga 500 · Amiga 2000 (Amiga 2500) · Amiga 1500 · Amiga CDTV · Amiga CD32 · Amiga 3000 · (Amiga 3000UX · Amiga 3000T) · Amiga 500 Plus · Amiga 600 · Amiga 1200 · Amiga 4000 · Amiga 4000T ·	

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