

Commodore 64



Photo 1: The Commodore 64 and 1541 disk drive. Inset shows rear view of the 64. From left to right, the cartridge slot for game or program cartridges; channel selector and TV output connector; the direct audio and video connector; serial port for disk drives or a printer; cassette interface; and the user port for peripherals such as the VICmodem.

by Stan Wszola

At first glance it's possible to mistake the Commodore 64 for its predecessor—externally the 64 looks like a tan VIC-20. But the similarities stop with the case design and keyboard layout (see photo 1). The 64 is a completely different machine. It has features, such as sprite graphics and high-quality sound, not to be found on the VIC-20. A full-featured and versatile machine, the 64 retails for \$595. At that price it promises to be one of the hottest contenders in the under-\$1000 personal computer market.

The Commodore 64 is based on MOS Technology's 6510 8-bit microprocessor, which uses the same instruction set as the 6502 (the heart of the VIC-20), but which includes eight additional input/output (I/O) lines used in the 64 for memory management; they control bank switching between the internal ROM, an external ROM cartridge, or an I/O device, which allows any of these to appear to occupy a certain portion of the processor's address space. This bank switching gives the 64 a total of 84K bytes of memory: 20K bytes of read-

only memory (ROM) and 64K bytes of random-access read/write memory (RAM). BASIC programs can access 39K bytes of RAM; machine-language programs (figure 1) can access 52K bytes of RAM.

The 64 can be expanded in a variety of ways. At the back of the case is a slot for program or game cartridges (see photo 1 inset). On the right side are two ports for joysticks or game paddles and a socket to plug in the outboard power supply. The 64 has a built-in RF (radio-frequency) modulator so you can use your TV as a video

monitor. All you have to do is make a simple connection to the antenna terminals; a switch on the computer lets you view the output on channel 3 or 4.

The 64 has connections for audio input and output and a connection that provides a composite video signal and direct audio for driving a video monitor. Also, the 64 contains a serial port for connecting a disk drive or printer, a cassette-recorder interface, and a user port for peripherals such as the VICmodem. It would be nice, however, if the 64 had real RS-232C and parallel printer ports so you could use someone else's peripherals. Even to load a cassette tape you must buy Commodore's cassette recorder.

The 6567 Video Interface Chip (also referred to as the VIC-II chip) controls graphics. It gives the Commodore 64 a 40-column by 25-line text display with 16 text colors and its own set of graphics characters. The chip can produce a 320- by 200-dot high-resolution display with up to 255 combinations of foreground and background colors and support up to eight sprites (movable object blocks) on the screen at one time.

The Commodore 64 has the 6581 Sound Interface Device (SID) chip, which produces music and sound effects covering a nine-octave range and generates three voices simultaneously. You can control all aspects of the sound generation via POKE instructions in BASIC. The volume, waveform, attack, decay, sustain, release, duration, and note selection are all under software control.

Such an inventory of standard features is impressive at \$595 (some discount houses advertise it for as little as \$399). As an added benefit, the 64 can run some PET software. And the optional Z80 CP/M cartridge gives you access to a potentially large base of well-established software that includes word-processing, electronic-spreadsheet, and communications programs.

First Touch

Having worked with the original PET 2001 back in 1978 and experienced the limitations of its keyboard,

At a Glance

Name: Commodore 64

Manufacturer
Commodore Business Machines Inc.
Computer Systems Division
The Meadows
487 Devon Park Rd.
Wayne, PA 19087
(215) 687-9750

Price
\$595

Dimensions
16 by 8 by 3 inches

Processor
6510 (a 6502-compatible processor with 8 additional I/O lines)

Memory
20K bytes of ROM
64K bytes of RAM

Data Storage
VIC-1530 Datassette audio-cassette recorder; VIC-1541 single-sided single-density floppy-disk drive

Languages
Commodore BASIC V2.0
Optional Z80 CP/M cartridge available

Documentation
Commodore 64 User's Guide, 167 pages
Optional Programmer's Reference Guide, 487 pages

Audience
Any computer buyer who wants an introductory machine with BASIC, color graphics, and sound

I found it a pleasure to sit down at the Commodore 64. Its full-size 66-key keyboard includes four special-function user-programmable keys. The graphics characters and special functions that are accessible from the keyboard are displayed on the sides of the keys.

I have no trouble touch-typing on the Commodore 64. The layout differs only slightly from that of the Selectric. Fast typists will appreciate the type-ahead buffer that holds 10 keystrokes. Only the cursor, spacebar, and Insert/Delete keys repeat automatically when held down. A minor annoyance is that there are only two keys for cursor control. To move the cursor right or down, you simply press the appropriate keys but to move the cursor left or up you must press the Shift key in addition to the appropriate key. This is an awkward arrangement for those used to four separate cursor-control keys. In the graphics/text mode, pressing the shift key and any alphabetic key will give you the graphics character shown on the right side of the key. By pressing the Commodore key and an alphabetic key, you'll get the graphics character shown on the left side of the key. PET owners have long used this arrangement to produce graphics from within BASIC programs.

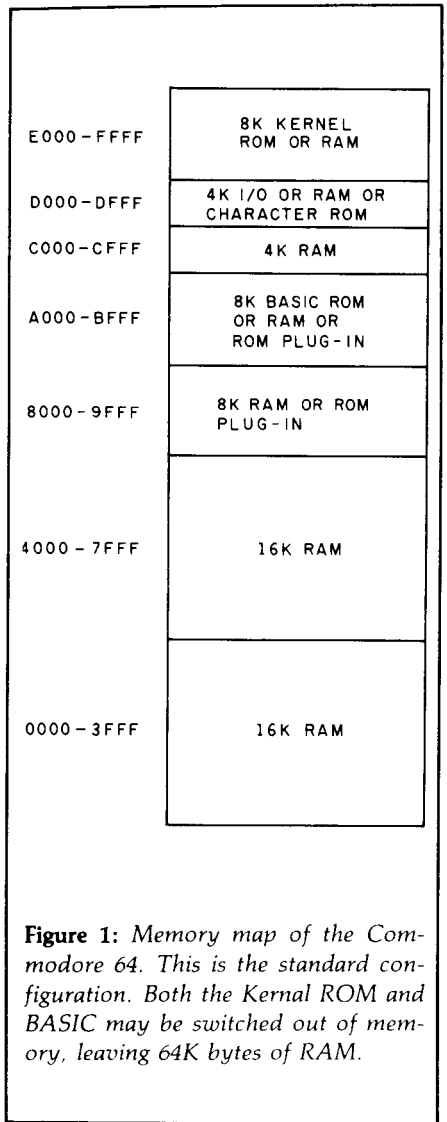


Figure 1: Memory map of the Commodore 64. This is the standard configuration. Both the Kernal ROM and BASIC may be switched out of memory, leaving 64K bytes of RAM.

Memory Management

The 64 uses the 6510's eight additional I/O lines as a memory-mapped control port. The eight lines are treated as one memory location and reside at address 0001; address 0000 is a control register that determines the direction of data flow on the lines. By sending a 0 to the least significant bit (called bit 0) of address 0001, you can replace the BASIC ROM with RAM, a process known as bank switching. Sending a 0 to bit 1 of address 0001 eliminates the Kernal ROM that contains the 64's operating system.

Bank switching explains how the 64 can run CP/M. By using bank switching to replace the ROMs with RAM, the system is left with an uncluttered 64K bytes of memory into which you can load CP/M. Of course, this also gives you the opportunity to design your own operating system.

Graphics

The Commodore 64 provides a variety of graphics modes. You use the POKE command to enter values into the 47 control registers of the VIC-II chip to set the various graphics modes. Although using POKE commands makes for awkward programming, it allows for fast-action graphics in BASIC.

The VIC-II chip is designed to access 16K bytes of memory, which means that, for example, it can be programmed to access the character-generator ROM or any 16K-byte bank in memory. By using POKE and PEEK instructions to enter values into port A of the 6526 Complex Interface Adapter Chip #2, you can control which bank of memory the VIC-II chip uses. This setup frees the 6510 microprocessor from the time-consuming work of controlling all the graphics and gives programmers a flexible tool to use in developing creative graphics.

When you first turn on the Commodore 64 it's in a graphics/text mode showing a 40-column by 25-line screen composed of two 256-character sets. Each character in the sets is made from an 8 by 8 matrix; the sets contain uppercase and lowercase letters, punctuation marks, graphics, and other special symbols and include

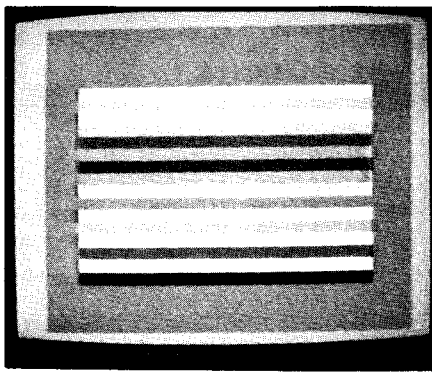


Photo 2: Sample screen display showing the 16 colors available.

normal and reverse-video characters. The 40 by 25 display format was chosen because most Commodore 64s will be used with home television sets that have a limited bandwidth for graphics. (An 80-column by 24-line adapter, the Video Pak 80, is available from the Data 20 Corp., Suite B10, 23011 Moulton Parkway, Laguna Hills, CA 92653.)

The screen initially displays dark blue characters on a light blue background. By pressing one of the number keys and either the Control or Commodore key, you can change the display characters to any of 16 different colors (photo 2). The background and border colors can also be changed by using POKE commands. For example, POKE 53280,*x* and POKE 53281,*y* (where *x* and *y* are the color numbers) alter the border and background screen colors, respectively. Screen colors may be restored to the default values by pressing the Run/Stop and Restore keys simultaneously.

In standard character mode, each of the 1000 character positions on the standard screen has a corresponding byte in memory. This is known as a memory-mapped display. By using POKE commands, you can enter an 8-bit number into any of the character locations in memory; the Commodore 64's character-generating ROM will make the correct pattern of dots appear at the corresponding screen location.

You can create a custom character set by instructing the system to use a section of RAM in place of the character-generating ROM. Then, by turning dots on or off in the 8 by 8

matrix that represents a character image (actually an 8-byte block in memory) you can design your own character set for foreign languages and technical or scientific applications.

The 64's memory-mapped display lets you use bit-mapped graphics. In this mode, each dot on the screen may also be represented by a bit in memory. Because each character is composed of an 8-byte block, the bit-mapping of the screen's 1000 blocks must contain 8000 bytes of memory, or 640,000 bits. Each of these bits can be turned on or off under program control.

The Commodore 64's high-resolution bit-mapped screen measures 320 dots horizontally by 200 dots vertically and gives you a choice of two colors for each 8- by 8-dot character block. A multicolor bit-mapped mode allows a choice of eight different colors for each block, but the resolution is reduced to 160 by 200 dots.

Sprites

Sprites, which are also referred to as movable object blocks, are similar to the player/missile graphics used on the Atari 400/800 computers. A sprite is a user-definable character composed of 24 horizontal by 21 vertical dots (photo 3). Sprites, which are generated and controlled by the VIC-II chip, can be sculpted into any shape, given any of 16 colors, combined with any other graphics mode, and made to move about the screen. As such they are ideal for use in arcade-type games. Independent of normal graphics, they can be used from within a BASIC program. Each sprite has its own 63-byte location in memory and its own position and color registers.

You can activate a sprite by entering a 1 for the appropriate bit in the sprite register of the VIC-II chip. You then program its shape, enter a value for its color, and set its position on the screen. You define each movement by providing a new set of Cartesian coordinates for its position.

You can enlarge a sprite to twice its original dimensions, but its resolution drops when it is expanded to the max-

Text continued on page 239

Line 20 sets a high attack rate and a low decay rate. (The number is broken into 8 bits: the high-order bits set the attack, while the low-order bits set the decay.) That value, 64, is entered into location 54277. Line 30 enters the sustain/release rate, which lets you prolong the note. Again, as in line 20, the two values are represented by one number. The number 128 produces a long sustain and a short release.

Line 40 sets the waveform of the note in one of four shapes: sawtooth, triangle, pulse, and white noise. Sawtooth waves contain a lot of harmonics and are good for simulating horns or string instruments. Triangle waves produce flute-like sounds. Pulse waves can simulate many different sounds depending on the pulse width. A square wave will produce a woodwind sound similar to a clarinet. A very narrow pulse will produce a sound similar to an oboe or bassoon. White noise is used for producing untuned sounds such as percussion instruments. Line 40 uses a triangle waveform.

Line 50 performs two functions: the two memory locations 54273 and 54272 determine the voice to be used, while the values 17 and 37 determine the note to be played (in this case a quarter note). Finally, line 70 clears all previously used memory locations in preparation for playing another note.

The Commodore 64 has a few more musical tricks up its sleeve: the harmonic content of a note can be altered by filtering. The SID chip has three different filters: high-pass, low-pass, and bandpass. As you might expect, the high-pass filter allows only frequencies above a certain value to get through, the low-pass filter allows only frequencies below a certain value to get through, and the bandpass filter lets through only frequencies of a specified range. As mentioned previously, generating and altering sound is done with POKE commands. The filters give you another method of shaping the sound.

The Commodore 64 has an audio input line. You can take an audio signal from an electric guitar, for ex-

ample, and process it through the 64. There the signal can be filtered or combined with one or more voices to create a unique sound. In effect, the 64 is both a synthesizer and processor. Using POKE commands is somewhat distracting but the 64's version of BASIC does not have any commands for controlling sound directly from within a BASIC program.

BASIC

It's a pity Commodore saddled such a fine computer with its inadequate Commodore BASIC 2.0. An 8K-byte interpreted BASIC, it is a subset of the standard Microsoft BASIC and uses its own commands for file handling and I/O. Most BASIC instructions can be abbreviated to just two letters. A program written using this abbreviated technique displays BASIC commands as a letter and graphics symbol. A Commodore 64 program may be difficult to understand unless you've memorized all the abbreviations. Program lines are limited to 80 characters. Only the first two letters in a variable name are used. Obviously, Commodore feels that most home users will be running prepackaged software—there is no provision for using graphics (or sound as mentioned above) from within a BASIC program except by means of POKE commands.

The one bright point in programming the Commodore 64 is its very powerful screen editor. Once you have written a BASIC program, you can move your cursor through the program and make corrections by typing over the previously entered characters. A modified line can be inserted into a program by simply positioning the cursor on that line and pressing the Enter key. You can use the Insert/Delete key to add or remove characters from a line.

In addition, the editor has a unique "quote mode." If the cursor is positioned to the right of an odd number of quote marks in a program line, you can enter cursor control and color control codes within strings. When the text within the string is printed on the screen, the cursor and color con-

control codes automatically perform their tasks. This gives you another way to control screen displays.

Because the Commodore 64's version of BASIC makes extensive use of graphics and reverse-letter characters, you might have a problem when you want to print a program. Most printers can't handle Commodore graphics. Only the VIC-1525 Graphic Printer is designed explicitly for use with the Commodore 64. (If you are interested in connecting other printers to the Commodore 64, see "The Enhanced VIC-20, Part 3: Interfacing an MX-80 Printer," by Joel Swank, April 1983 BYTE, page 260.)

Data Storage

The Commodore 64 uses the VIC-1530 Datassette cassette recorder for data storage. The Datassette is adequate for someone who wants to load an occasional game or use a cas-

Having the DOS In ROM simplifies disk operations and saves computer memory and space on the disk.

sette-based word-processing program. But for users who don't like the limitations of cassette storage, Commodore offers the VIC-1541 disk drive, a smart peripheral with its own 6502 microprocessor (to control I/O), 2K bytes of RAM, and a disk operating system (DOS) in 16K bytes of ROM. The drive uses standard 5¼-inch single-density single-sided floppy disks for a storage capacity of 170K bytes per formatted disk.

Having the DOS in ROM simplifies disk operations and saves both the computer's memory and space on the disk. This means that every disk contains data only and that you never have to worry about accidentally destroying the DOS. Of course, you'll have to use Commodore's DOS unless you change the ROM.

The DOS commands are extensions of the same commands used with the Datassette recorder. For example, to load a disk program called SAMPLE, you would type the command

```
LOAD "SAMPLE",8
```

The 8 at the end of the command is the device number of the disk drive. This number is hard-wired into the disk drive, but it can be changed temporarily by a software command.

You must load a directory of the disk into the Commodore 64 as if it were a BASIC program. You use the command

```
LOAD "$",8
```

Then type LIST to see the directory display. The disk-drive manual lists some utility programs that will produce a directory with a little more ease. Or you can use the WEDGE program, included with the 1541 disk drive, that will allow you to use shorthand commands to load and save files, see a directory, etc. However, this is still an awkward way to access a disk when compared to commands used with disk operating systems such as TRSDOS or CP/M.

Files

The 64 supports sequential, random, and relative disk files. Sequential files are recorded serially on the disk as if they were being saved on a cassette tape. Random-access files are treated as one (or more) 256-byte blocks of data, with each block saved in a single disk sector. Relative files are organized into records that can be read or replaced within a file. They make use of what Commodore calls "side sectors," actually a series of indexes that act as pointers to the particular sectors associated with the file. Using this method, one file fills an entire disk.

The disk drive uses the 64's serial port. Because data is sent to the disk one bit at a time, disk operation is very slow. I found it to be even slower than the Atari 810 drive. Also, Commodore's method of writing 256-byte blocks of data to the internal

RAM and then finally writing the data to disk slows down disk operation. Up to five drives may be chained together and used simultaneously. Disks created on the 1540 drive and the older CBM 4040 can be read by the 1541 drive.

Documentation

The *User's Guide*, which is heavy on programming, is a good introduction to the 64's features. It has all the essential information required for working with BASIC, graphics, and sound. But it doesn't contain enough information about working with peripherals or connecting the computer to an audio system or video monitor.

The optional *Programmer's Reference Guide*, a 487-page informative book, is essential for anyone serious about programming the 64. It covers the same material as does the *User's Guide*, but in greater depth and detail. Many sample programs are listed and discussed that help to explain the operation of the Commodore 64's special features. One sec-

tion gives the specifications for each LSI (large-scale integration) chip used in the computer; it also includes a schematic of the Commodore 64, but it's not complete enough to use as a repair guide.

My only complaint about the *Reference Guide* is the lack of information on using disk drives for data

A great many PET BASIC 2.0 programs can be easily transferred to the 64, and emulator programs give you even more software.

storage. Apparently Commodore believes that the manual included with the 1541 is sufficient (it's not), and that if you don't own a drive, you don't need the information. Another not-so-surprising omission is the lack of information on using CP/M with the Commodore 64. It was merely mentioned in several

pages. I expect more complete documentation to be included with the plug-in Z80 cartridge.

Software

The availability of software can make or break a computer. In this respect, Commodore 64 owners are fortunate. A great many PET BASIC 2.0 programs can be easily transferred to the 64. And Commodore offers the PET Emulator program that lets you load a substantial portion of PET programs into the 64. It converts memory addresses used with the PET to those used with the 64.

You can get also an Apple II emulator, a combination of software and hardware available from Home Computer Services, 2028 West Camelback Rd., Phoenix, AZ 85015. The company says the emulator allows you to load and run Apple II programs with your Commodore 64. I'll reserve judgment until I have a chance to work with the product.

The Commodore software catalog for the 64 has a listing for an Easydisk

64, a collection of utility programs and editors for sound and graphics, and Easygraphics 64, a utility program that extends BASIC by giving you several simple commands to control sound and graphics without the use of POKE commands. These programs were not available in April but should be by the time you read this.

Although the 64 is essentially a home computer, Commodore is offering several business-oriented software packages for it. Designated as

part of the "Easy" group, they include Easycalc 64, an electronic spreadsheet program; Easyfile 64 for database management; Easyplot 64 for business graphics; and Easyschedule 64, a time-scheduling program.

Considering the sophistication of the 64's graphics, the one package I most want to try is Logo. As described by Commodore, its version of Logo will be similar to Terrapin Logo for the Apple II, except that it will take full advantage of sprite graphics

and color. Logo on the Commodore 64 should be a natural for schools. (The August 1982 BYTE was devoted to the Logo language.)

Speaking of schools, Commodore has announced its version of PILOT, a language designed specifically for use in education. Commodore claims that its PILOT is based on a "common" version of the language. One hopes that this will allow many existing programs to be used with the 64.

Of course, the programs I have mentioned here represent just a small portion of the software available for the 64. A quick glance through BYTE and other magazines shows that software publishers recognize the significance of the machine.

Complaints

My biggest complaint is with Commodore's quality control. I had to return two computers before I got one that didn't have display problems. Evidently, the fault was in the video output or RF modulator circuitry. If I used a defective unit for more than 15 minutes, the display on the TV would begin to break up and distort. I know that early production models often have a few bugs, but it's discouraging to think of first-time computer users having to figure out what's wrong with their new system on top of learning how to use it.



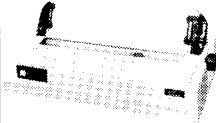
Conclusions

The Commodore 64 is a good introductory machine. It has something for almost every type of user. Its range of features make it equally suitable for me and my 5-year-old daughter to use. The color and graphics make games and educational software interesting enough to hold a child's attention, yet it has enough sophisticated features to allow me to do productive work such as word processing and home finances.

With the right price, plenty of available software, and numerous desirable features, the Commodore 64 is an impressive machine. ■

About the Author

Stan Wszola is a technical editor of BYTE.

		<h1>EXPOTEK</h1> <p>2723 W. Windrose Suite 3 Phoenix, Arizona 85029</p> <h2>1-800-528-8960</h2> <p>All Prices Subject To Change</p>		 	
COMPUTERS			PRINTERS		
ALTOS 5-15D - \$2120 5-5D - \$3985 580-10 - \$4695 586-10 - \$5698 580-14 - \$9395 8600-12 - \$8950			OKIDATA M92A - \$480 M93A - \$830 M82A - \$385 W/Tractor & Grap. - \$465 M84P - \$965 M84S - \$ CALL Pacemark 2350P - \$1999		
NORTHSTAR Advantage - \$2250 280A - \$1950 5m Byte - \$3350 15m Byte - \$4499			CITOH F10 40 cps - \$1170 F10 55cps - \$1580 1550P - \$659 1550CD - \$709 8510P - \$399 8510BCD - \$499		
TELEVIDIO 802 - \$2599 802H - \$4450 806 - \$4950 800A - \$1250 803 - \$1890 1603 - \$2695			DATASOUTH DS120 - \$595 DS180 - \$1175		
APPLE-LOOK-A-LIKE CALL			DIABLO 630RO \$1749 620 - \$895		
APPLE CARDS 16K RAM - \$78 Z80 CARD - \$235 Videx Card - \$227 Viewmax-80 - \$175 Microsoft Prem. Pk - \$475			NEC 8023 - \$425 7710 - \$2045 3510 - \$1375 3550 - \$1834		
SOFTWARE All Major Brands 25% off List \$ CALL			TRANSTAR 140 - \$1290 130P - \$715		
DISK DRIVE Microsci Apple Dr. - \$265 Rana Elite I - \$275 Rana Elite III - \$550 Rana 1000 - \$375			TERMINALS		
MODEMS HAYES - MICROMODEM - \$263 HAYES - SMARTMODEM - \$199 HAYES - 1200 Baud - \$530			ADDS A1 - \$485 Viewpoint A3 - \$485		
DISKETTES/BOXES Elephant - \$19 Scotch - \$25 Dysan - \$35			HAZELTINE 1500 - \$995 ESPRIT - \$498		
GUARANTEED LOW PRICES			TELEVIDEO 910 - \$569 925 - \$718 970 - \$1040 950 - \$899		
Customer Service 602-863-0759			ZENITH Z19 - \$670 Z89 - \$2129		
MONITORS Amdek 300 - \$135 Color I - \$295 Amdek Color II - \$625 Amber - \$149 BMC Green - \$85 USI Amber - \$149			COMPUTER IC'S COMPLETE LINE SPECIAL 4164 (150ns) \$6.50ea.		