

THE QUARTER-MEG ATARI 800XL

BY CLAU BUCHHOLZ

*Upgrade your 8-bit microprocessor to 256K bytes
and add a RAM disk*

IT'S GETTING HARDER to find a microcomputer with less than 64K bytes of RAM (random-access read/write memory). A couple of years ago, the cost per bit of the 64K-bit RAM fell below its predecessor, the 16K-bit dynamic RAM, and the 64K-byte address space supplied by eight of the 64K-bit chips is ideal for the most common 8-bit microprocessors. Now, however, the cost per bit of the 256K-bit dynamic RAM is the lowest, and it is already common in powerful 16- and 32-bit microcomputer systems.

Since eight of these chips provide one-quarter of a megabyte and since they are so similar to their ancestors, it is tempting to upgrade an inexpensive 64K-byte micro to 256K bytes. Obviously, you can't fit 256K bytes of memory into the 64K-byte address space of a 6502 or Z80 all at once, but you can break it up into manageable chunks, called banks, and allow the processor to see one bank at a time. This method of interfacing RAM, called bank selection, requires some new hardware and software support.

This article describes the upgrade and presents a RAM-disk controller for the Atari 800XL. However, you can apply the basic idea to any micro that

uses 64K-bit RAMs—the Apple IIe, the Commodore 64, the MSX machines, and others.

THE ATARI 800XL

The 800XL is a modern version of the popular Atari 800. [Editor's note: See Jon Edwards's "Atari 800XL" system review, March BYTE, page 267.] Introduced in 1979, the 800 was the first machine to use VLSI (very-large-scale integration) technology to bring advanced graphics and sound capabilities into the low-price market. It was also the first to include a full operating system in ROM (read-only memory) to support the versatile hardware. RAM consisted of up to three 16K-byte modules, each constructed around eight 16K-bit dynamic RAM chips.

In the 800, the 6502 processor shares the system with a programmable video DMA (direct memory access) controller, which halts the 6502 for one cycle of the 1.8-MHz clock when it needs to access a byte of screen memory. The 800XL incorporates the same VLSI hardware with newer, higher-density RAM and ROM. One 16K-byte ROM holds the entire operating system, and another 8K-byte ROM contains the BASIC lan-

guage. The RAM consists of eight 64K-bit dynamic RAM chips. Under BASIC, 40K bytes of RAM are usable. The ROMs, which occupy high memory space, can be disabled to gain access to the remaining RAM. The new design is smaller, cheaper, less power-hungry, and more attractive. The Atari is unquestionably a very fine machine.

THE DYNAMIC RAM

The industry-standard dynamic RAM chip is itself an example of superb design. It is small, dense, adequately fast, and cheap. In the last decade, its memory capacity has doubled eight times without the chip outgrowing its 16-pin IC (integrated circuit) package. Each chip inputs or outputs one bit at a time, so each bit has a unique address.

For the 256K-bit chip, the address requires 18 bits. The chip has nine address inputs, each of which does

(continued)

Claus Buchholz (201C East Edgewood, Lansing, MI 48910) is a programmer for Meridian Instruments. He has a B.S. in astrophysics and computer science from Michigan State University. He uses an Atari 800 with a homebrew 192K-byte RAM and an ATR-8000.

double duty. During the first part of a memory access, half of the address bits are presented to the chip. This half is called the *row address*. Later in the access cycle, the chip receives the other half of the address, called the *column address*. The storage cells in the chip lie in a matrix, and the cell being addressed lies at the intersection of the row and column specified. To complete the access cycle, the chip reads or writes the selected bit.

The 800XL uses 64K-bit RAM chips, which have eight address inputs for an 8-bit row address and an 8-bit column address. This is fine for the 16-bit addresses the 6502 supplies. There are eight chips, and each contributes one bit to each byte of RAM.

The 256K-bit RAM is practically identical to the 64K-bit RAM except that it has one extra pin, #1 on the chip, to accommodate the two additional address bits it needs. Pin #1 on the 64K-bit chip has no function. The functions of all the other pins on both chips are identical. Therefore, our upgrade involves unplugging the eight 64K-bit RAMs and placing eight 256K-bit chips in their place. We must also add some circuitry to provide two extra address bits for pin #1.

The storage cells in dynamic RAM chips are actually microscopic capacitors, storing an amount of electric charge that represents a 0 or 1 bit. Since capacitors leak charge, they must be periodically recharged or refreshed. The chip refreshes one or two entire rows when accessed. Every row must be accessed frequently to keep the stored data accurate, but

normal operation of RAM can't guarantee that. The computer system must therefore provide special access cycles called *refresh cycles*, dummy read cycles in which refresh addresses are used as row addresses.

The 16K- and 64K-bit RAMs require 7-bit refresh addresses. The computer must provide all 128 possible refresh addresses every few thousandths of a second to keep the RAM refreshed. In the Atari, the video controller, which provides refresh cycles in addition to its screen-memory accesses, automatically provides 7 bits for the refresh address. The Atari, in fact, spends 8 percent of its time refreshing RAM.

One snag in designing the 256K-byte upgrade is that standard 256K-bit RAMs require an 8-bit refresh address. Older versions of the Atari video-controller chip provide only 7 bits of refresh address; newer versions provide all 8 bits. Therefore, I have designed two versions of the upgrade's interface circuit. The more complex one must add another bit to the Atari's refresh address. (See table 1 for a list of components.)

BANK SELECTION

To fit 256K bytes into the 6502's 64K-byte memory space, you must divide it into banks. The upgrade uses eight 32K-byte banks, numbered 0 through 7 and selected by setting 3 bits in the Atari's memory-control register. Any one bank can appear in the lower half of the 6502's memory space. At power-up, bank #7 appears in the lower 32K bytes of RAM, bank #6 ap-

pears in the top 32K bytes, and the Atari acts as a normal 64K-byte machine. To access bytes in the other 192K, a program must select one of banks #0 through #5, which would then appear in place of bank #7. After accessing the bytes, the program could then switch bank #7 back in, restoring the normal configuration.

I used eight 32K-byte banks instead of four 64K-byte banks for three reasons. If a program in RAM were to replace the entire 64K bytes of RAM with another bank, it would cause itself to disappear, crashing the system. Moreover, the top 32K bytes of the address space is already cluttered with hardware addresses and ROMs that can be switched in and out. Finally, the screen RAM is usually in the top 32K; switching it out would cause glitches to appear on the screen.

Even with eight 32K-byte banks, we must be cautious. The operating system keeps important data in the lower part of RAM, and it expects the data to be there. Worse, interrupts frequently invoke routines that keep data in low RAM. Programs must therefore follow a strict rule: Keep bank #7 enabled as much as possible. If you select another bank, you must first disable all interrupts and not call the operating system until bank #7 is restored. One further consideration involves the 6502's stack, which is in low memory. The program should not use the stack when bank #7 is not selected, unless it takes great care to keep the stack valid.

INTERFACING THE RAM

Figure 1 is a schematic diagram of the interface circuit for the 256K-byte RAM. It must be assembled on a small circuit board and installed inside the computer because the computer's expansion slot doesn't carry the signals we need. The circuit consists of two chips and replaces one of the chips on the motherboard. It also requires four jumper wires to various points on the motherboard.

The circuit plugs into the socket at position U27 on the motherboard. This gives it access to six important

(continued)

Table 1: The components you'll need to upgrade the Atari 800XL.

| Quantity | Part Number | Description |
|--|-------------|---|
| 8 | 41256 | 256K-bit dynamic RAM (200 ns or faster) |
| 1 | — | 33-ohm, ¼-watt resistor |
| (following part for circuit in figure 1 only) | | |
| 1 | 74LS153 | Dual 4-to-1 multiplexer |
| (following parts for circuit in figure 2 only) | | |
| 1 | 74LS151 | 8-to-1 multiplexer |
| 1 | 74LS393 | Dual 4-bit counter |
| 1 | 74LS00 | Quad NAND gate |

CopyWrite

BACKS UP IBM PC SOFTWARE

Hundreds of the most popular copy-protected programs are copied readily. CopyWrite needs no complicated parameters. It needs an IBM Personal Computer, or an XT or an AT, 128k bytes of memory, and one diskette drive. CopyWrite will run faster with more memory or another drive.

CopyWrite is revised monthly to keep up with the latest in copy-protection. You may get a new edition at any time for a \$15 trade in fee.

CopyWrite makes back up copies to protect you against accidental loss of your software. It is not for producing copies for sale or trade, or for any other use that deprives the author of payment for his work.

To order CopyWrite, send a check for \$50 U.S., or call us with your credit card. We will ship the software within a day.



Quaid Software Limited

45 Charles Street East
Third Floor
Toronto, Ontario M4Y 1S2
(416) 961-8243

Ask about ZeroDisk to run copy-protected software from a hard disk without floppies.

signals, including power and ground. The chip that was at U27 becomes IC1 in the circuit. As U27, this chip was one of the two responsible for selecting which 8 of the 16 address bits were passed to the 64K-bit RAMs at one time.

IC2 performs the bank selection by modifying one of the eight original address inputs to the RAMs and adding a ninth. The bank-selection circuitry needs three jumpers from the motherboard to carry 3 bits from the Atari's memory-control register. A fourth jumper carries the ninth address input to the RAMs.

Figure 2 shows the four-chip interface circuit necessary for machines containing the older version of the video controller. IC3, an 8-bit binary counter that counts the refresh cycles, supplies the eighth bit of the refresh address for the 256K-bit chips. The

refresh signal it uses comes through a jumper wire from the motherboard. Parts of IC1, IC2, and IC4 perform the bank selection in this circuit.

PERFORMING THE UPGRADE

To disassemble the 800XL, remove the six screws on the underside and separate the top and bottom portions of the plastic case. Be careful of the flexible keyboard cable. Pull it straight up out of its socket on the motherboard. To detach the motherboard from the case bottom, remove three screws—one on the right side, one in the right rear corner, and one in the left rear. Gently pull the board free.

Next, remove the small nuts and bolts around the metal shielding that encases the motherboard. On the left side of the exposed motherboard, locate the row of eight 16-pin RAM chips. Just to their right is U27. Behind

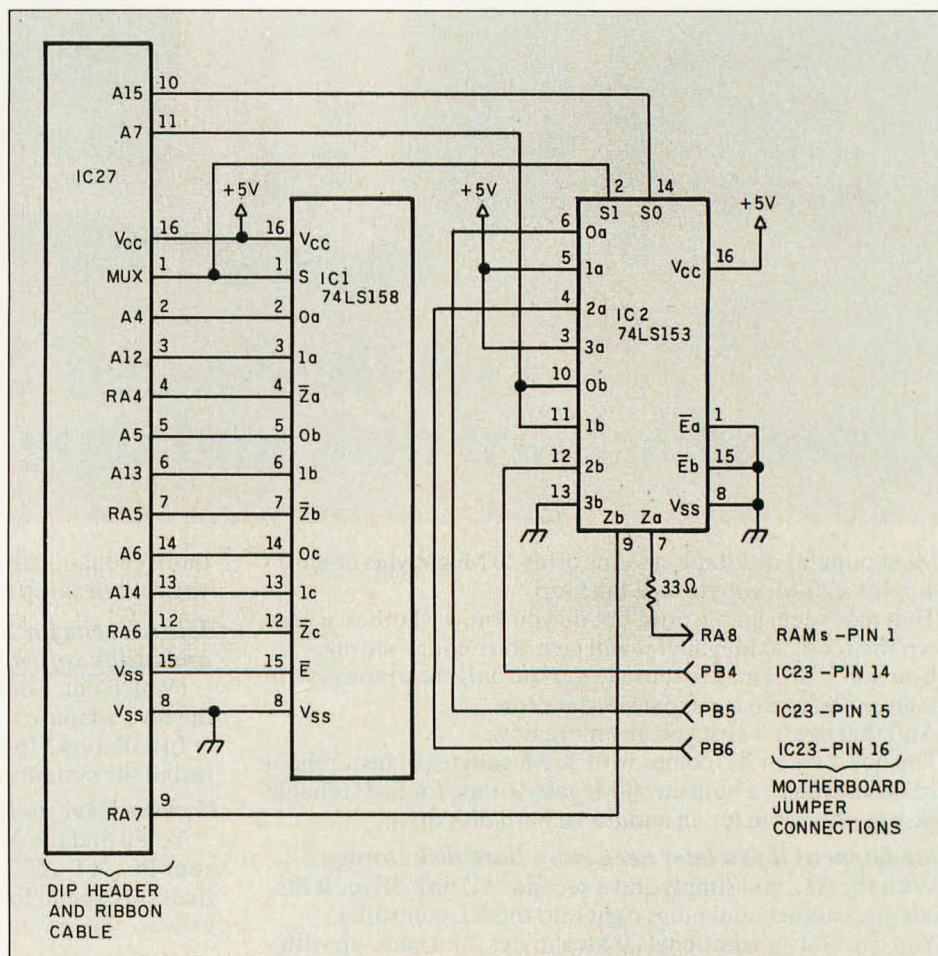


Figure 1: The schematic diagram of the interface circuit for the 256K-byte RAM. Use this circuit if the part number on the video controller is CO21697.

U27 is a 3-inch square area that fits inside the shielding. The circuit goes there because the shielding is highest toward the rear.

Replace the 64K-bit RAMs with the 256K-bit RAM chips. The new RAMs are very easily destroyed by static discharges, so extreme care is necessary in their handling. Lay aluminum foil on the work surface and keep the motherboard, RAM chips, tools, and your hands in contact with the foil at all times. This keeps everything at the same potential, decreasing the possibility of damage.

On the motherboard, locate the video controller, the 40-pin chip at U7. If the part number stamped on it reads "CO21697," you can use the simpler circuit shown in figure 1. If the number reads "CO12296," you must use the larger circuit.

Assemble the appropriate circuit on a 2- by 3-inch circuit board (Radio Shack's #276-150 is ideal). Use very low-profile sockets or no sockets at all because the shielding severely limits the height. If you do not use sockets, be careful not to apply heat to the IC pins for too long. Keep the wiring on the chip side of the board to conserve space. The wiring must be soldered because there is no room for wire-wrap posts.

The board plugs into the socket at U27 via a 16-pin DIP header and short ribbon cable. Finally, install the jumper wires. Find a resistor marked R32 immediately behind the row of RAM chips and remove it. A trace from one of the holes runs to pin 1 of the RAMs. Solder the first jumper to that hole. The next three jumpers run to a parallel port that the Atari uses to control ROM switching. We need pins 14 through 16, which are normally unused and not connected to any traces. Locate U23 and carefully pry the 40-pin chip from its socket. Bend up pins 14, 15, and 16 so that they point straight out. Re-insert the chip. Cut three adjacent pin positions from an IC socket and solder the three jumpers to them. Use this custom socket to connect the jumpers to the three protruding pins.

(continued)

FREE high tech catalog

| | |
|--|--|
|  <p>Most accurate Clock</p> |  <p>IBM-compatible computers, peripherals, software</p> |
|  <p>Computerized weather station</p> |  <p>Ham radio gear of every type</p> |
|  <p>Low-cost audio spectrum analyzer</p> |  <p>Microprocessor trainer and courses</p> |
|  <p>HERO® robots and robotics training</p> |  <p>Professional test instruments</p> |

A trustworthy guide to what's new in electronics and computers.

For many years the illustrated Heathkit Catalog has been a guide to new and exciting kit products for people like you to build. To enjoy and learn from them, while saving money in the process. What sets the Heathkit Catalog apart is its range of high quality products and accurate information to help make your buying decisions easy. If you've never tried kit-building, you have an absorbing new experience in store as you create products you'll take pride in.

Send for free catalog If coupon is missing, write Heath Company, Dept. 334-332 Benton Harbor, Michigan 49022



Heathkit
Heath Company

Mail to: Heath Company, Dept. 334-332
Benton Harbor, Michigan 49022

Please send me my **FREE HEATHKIT CATALOG.**

Name _____

Address _____

City _____ State _____ Zip _____

Heathkit products are also displayed, sold and serviced at 64 Heathkit Electronic Centers nationwide. Consult telephone directory white pages for location. Operated by Veritechnology Electronics Corporation, a wholly-owned subsidiary of Zenith Electronics Corporation. CL-778D

Cover the connector with electrical tape because the shielding is very low at this point.

If you are using the circuit of figure 2, you must install a fifth jumper. Locate a trace on the motherboard from pin 8 of the video controller, U7. Find a hole along the trace and solder the jumper there. Finally, insert a thin

piece of stiff cardboard or plastic under the small circuit board to avoid shorting the circuit. Refasten the shielding to the motherboard. If it doesn't fit over the circuit, carefully pound a dent out of the shielding with a hammer. Reassemble the computer. If all has gone well, the computer should power up normally and per-

form exactly as before, as long as the 3 bits in the memory-control register are left alone. The computer is ready to try some software that makes use of the large RAM space.

THE RAM-DISK SOFTWARE

Bank-selectable RAM is useless without software to control it. The software must obey strict rules as outlined above to work properly. The software must also be tailored to fit the application.

For example, you could store many graphics screens in the RAM and use page flipping to display them in quick succession for animation. Alternatively, the RAM could act as a print spooler. A word processor could print an entire document quickly into the RAM and go on to other jobs while the RAM emptied its contents slowly to a printer.

A more universal application is the RAM disk, a RAM-based disk-drive simulator. To DOS (disk operating system) and to the user's programs, the RAM disk appears to be just another disk drive, except that it is very fast. Application programs could then use standard DOS commands to access the large RAM space. The 192K bytes of available RAM hold more data than two Atari 810 drives or one double-density drive. I have written an assembly-language program that modifies the Atari's operating system to treat the RAM as either a single-density or double-density disk drive. The program is available for downloading as ATARIRAM.ASM on BYTEnet Listings, (617) 861-9774. It works with Atari DOS 2.0, OS/A+ (versions through 2.xx) and compatible DOSes. Assemble the source code with any assembler that accepts the syntax of the Atari Assembler/Editor. Assembly produces an object file that performs several tasks as it loads. First, it copies the operating system from ROM into the underlying RAM. Next, the RAM-disk routines load into the RAM-based operating system, overwriting the international character set, a little-used feature of the 800XL. Finally, it

(continued)

A new name for us, even better values for you.

We've combined Silicon Valley Liquidators and Supply Line to increase our buying power — we pay less so you pay less.

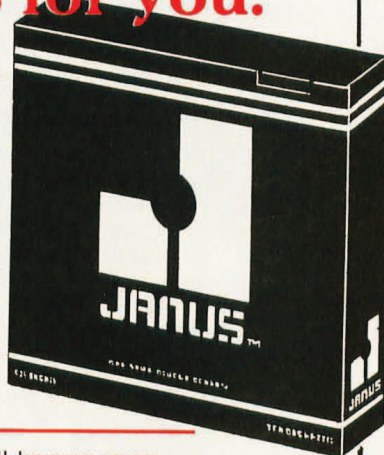
JANUS™ Diskettes

One of the most respected names in the business, Janus disk is a SUPER VALUE!!

• **BOX** SS/DD **99¢**/DISK DS/DD **\$1⁰⁹**/DISK
(10 DISKS PER BOX)

• **BULK**
SS/DD **69¢** EA DS/DD **79¢** EA

CALL FOR QUOTES ON LARGER VOLUMES.



Verbatim

Check out our DYNAMITE PRICES

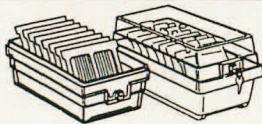
Probably the most well-known name in diskettes. We offer an alternative in buying them — OEM BULK packaging! Get the same top-quality, critically certified diskette that you get in the store.

• MD 525 SS/DD **89¢** EA (100 lot pricing) • MD 550 DS/DD **\$1⁰⁹** EA (100 lot pricing)

Sentinel

With specs that exceed all others, Sentinel is a premium disk at a bargain price.

• **BOX** - SS/DD **\$1⁰⁹**/DISK DS/DD **\$1¹⁹**/DISK (100 lot pricing)
CALL FOR QUOTES ON LARGER VOLUMES.
• **BULK** - SS/DD **79¢** EA DS/DD **89¢** EA
• **COLOR BULK** - SS/DD **95¢** EA DS/DD **\$1⁰⁹** EA



DISK STORAGE BOXES

holds 100 disks — only **\$12⁹⁵**
— ALSO —
10-disk boxes — low as **99¢** EA

PRINTER RIBBONS - for all makes and models — CALL!
PRINTWHEELS - Camwill by FABER CASTELL — CALL!
DISKETTE ENVELOPES - low as **5¢** ea. **DISKETTE MAILERS** - low as **32¢** ea.

P.O.'s accepted from recognized corporations, institutions and educational accounts. Please call for specific information before placing your order.

Order Today!



- Lifetime Guarantee
- 100 disk minimum order
- Orders shipped within 24 hrs of placement
- We accept A/E, VISA & MasterCard

800/437-0900 • 800/435-9700 in CA

patches the operating system to install the RAM-disk program and calls DOS's initialization routine to let DOS recognize the new drive.

The source code provides two op-

tions: the drive number and the density. The RAM disk can act as any drive numbered 1 to 8. If you have one real drive, you might want the RAM disk to be drive number 2.

Remember that your DOS must be set up to look for the drive number chosen. See the DOS manual for instructions concerning drive numbers.

Like the Atari 810 disk drive, a single-density RAM disk has 720 sectors of 128 bytes each, for a total of 90K bytes. Like all double-density disk drives for the Atari, a double-density RAM disk has 720 sectors of 256 bytes, for a total capacity of 180K bytes. Atari DOS checks each drive in a system for its density and compensates. All DOS functions except duplicate disk operate with double-density drives. You obviously cannot duplicate a double-density disk to a single-density disk and vice versa.

Boot in the RAM-disk object file after DOS by renaming the object file AUTORUN.SYS. Once the file has loaded, you must format the RAM disk before use. You can do this manually from DOS, use the BASIC XIO command, use a call to CIO in machine code, or rely on an application program.

RESET and warm starts won't harm the contents of the RAM disk. If you reboot without powering down (through a POKE 580,1 and RESET, or by jumping to \$E477 in machine code), you must reload the RAM-disk program to access the data, which will remain unharmed in the RAM disk. The RAM-disk program, therefore, does not automatically format the RAM disk upon loading.

The major disadvantage of the RAM-disk approach is that all data is lost when the computer is turned off. You should therefore be sure to save important data to a real disk before ending. However, the speed, convenience, and versatility of the RAM disk outweigh its drawbacks.

USES

Assembly-language programmers, after studying the RAM-disk source code and heeding the rules above, can devise many practical uses for a quarter-megabyte of RAM. The large RAM space, joined with the Atari's versatile hardware and low price, provides a performance/price ratio that is unbeatable in today's market. ■

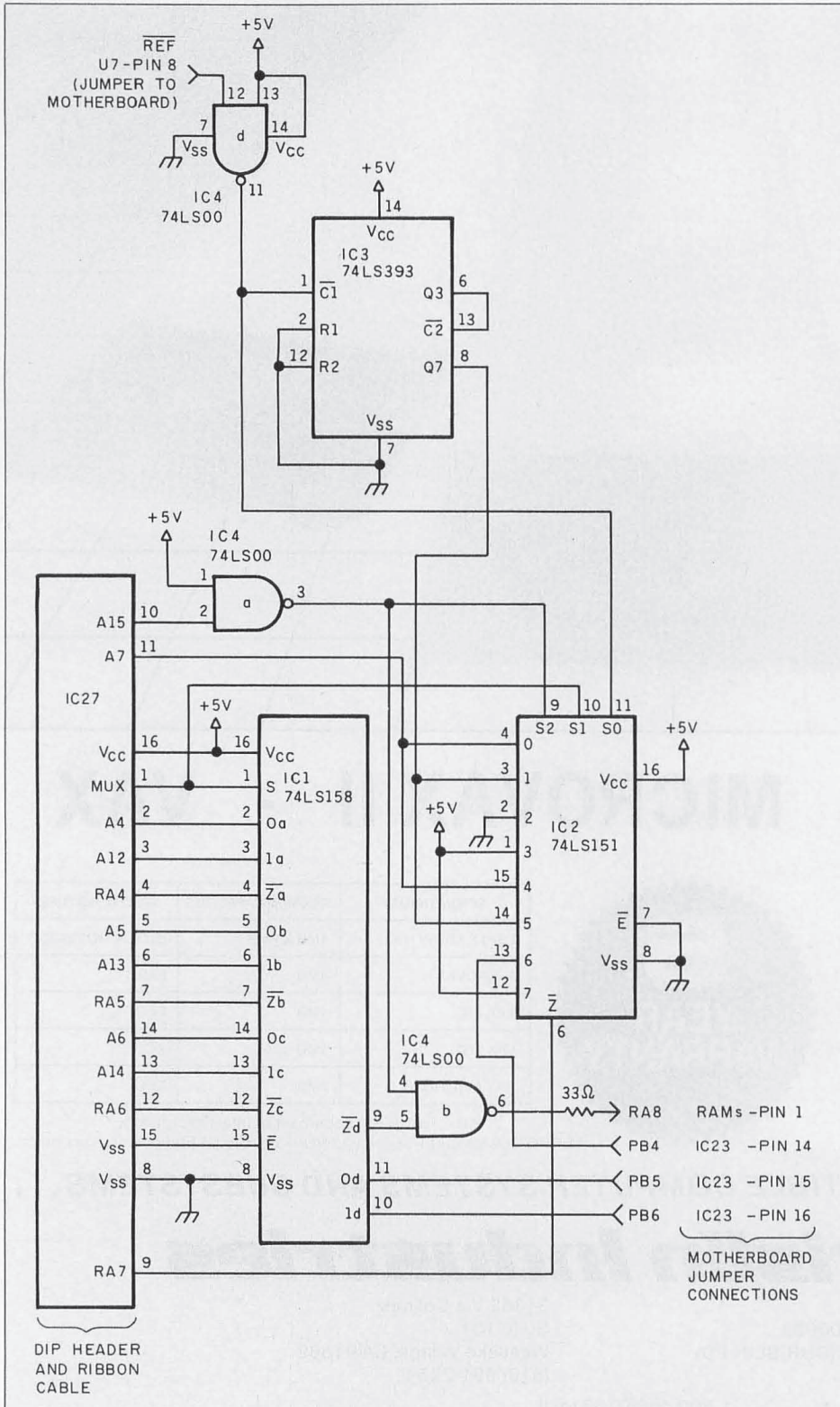


Figure 2: Use this circuit if the video controller part number reads CO12296.