NEW DBX SYSTEM — PLL FOR CB

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build this
2650 COMPUTER
on one board

experiment with
FUNCTION GENERATOR
new Exar IC

for your phone :
BUILD TELESWITCH
and turn things on

IC data sheet :
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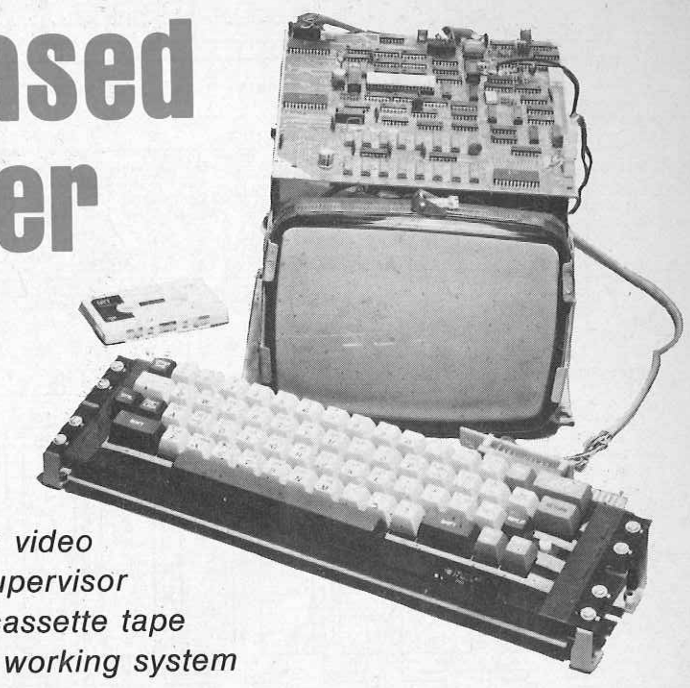
GERNSBACK PUBLICATION

Build 2650-Based Microcomputer System



Part I. Built on a single printed-circuit board, this 2650 microcomputer contains a video and cassette tape interface and resident supervisor program. Add a keyboard, video monitor, cassette tape recorder and power supply for a complete working system

JEFF ROLOFF

AN EASY-TO-USE COMPUTER SYSTEM MUST have essentially four major sections. There is, of course, the actual processing section that usually (at least for small users) contains a microprocessor IC. There must also be input and output sections so that the processor can communicate with the outside world. The last section that is essential for a computer's operation is the memory. This is used to store programs and data, and it can be either a memory that needs to be accessed very quickly when running a program or a memory used to store information for long periods of time, such as cassette tape.

The 2650 computer project presented here has all of the above circuits mounted on a single printed-circuit board. In addition, there is a versatile supervisor program that allows you to easily create your own programs. The heart of the unit is the Signetics 2650 microprocessor. Basically, it is a simple to use microprocessor with a powerful instruction set. The input device can be any ASCII-encoded keyboard, which simply hooks to an input port of the computer. The output device is a high quality 80-character by 16-line video display generator which is fully controlled by the processor. There are also parallel input and output ports (one each) to allow you to communicate with any other peripheral device, such as a line printer or a floppy disc. The

SPECIFICATIONS

DISPLAY GENERATOR

Display Format: 16 lines of 80 characters. User programmable character generator selected by setting bit 6 of the stored data to logic-1 level. Bit 7 available for any special user application.

Method of Accessing: The processor writes correct RAM location to place a character on the screen.

Output: Composite video, 1 volt P-P nominal, 75 ohms, 7.1 Mhz.

Cursor: Written by processor just like any other character. Supervisor uses a square dot centered in character field.

Screen Blanking: During horizontal or vertical retrace, between character lines and whenever the processor is accessing the display memory.

Display Addressing: Starts (upper left hand corner) at address H1000, and ends at H14FF. As addresses are incremented, the display position moves downward.

Additional User RAM: A total of 768 bytes starting at address H1500. Actually a part of the display memory, but this is transparent to the user.

PROCESSOR

Type: Signetics 2650 microprocessor.

Buffering: All processor signals buffered for TTL fan-out of 10.

Memory: 1K bytes of PROM which contains supervisor program. 768 bytes of RAM unused by display is available for user programs. PROM is on-board expandable to 4K bytes.

Control Lines: Pause and stop-clock lines allow single stepping of programs. Disable-lines for address data, and control buses to allow DMA (*Direct Memory Access*) or dual processor operation.

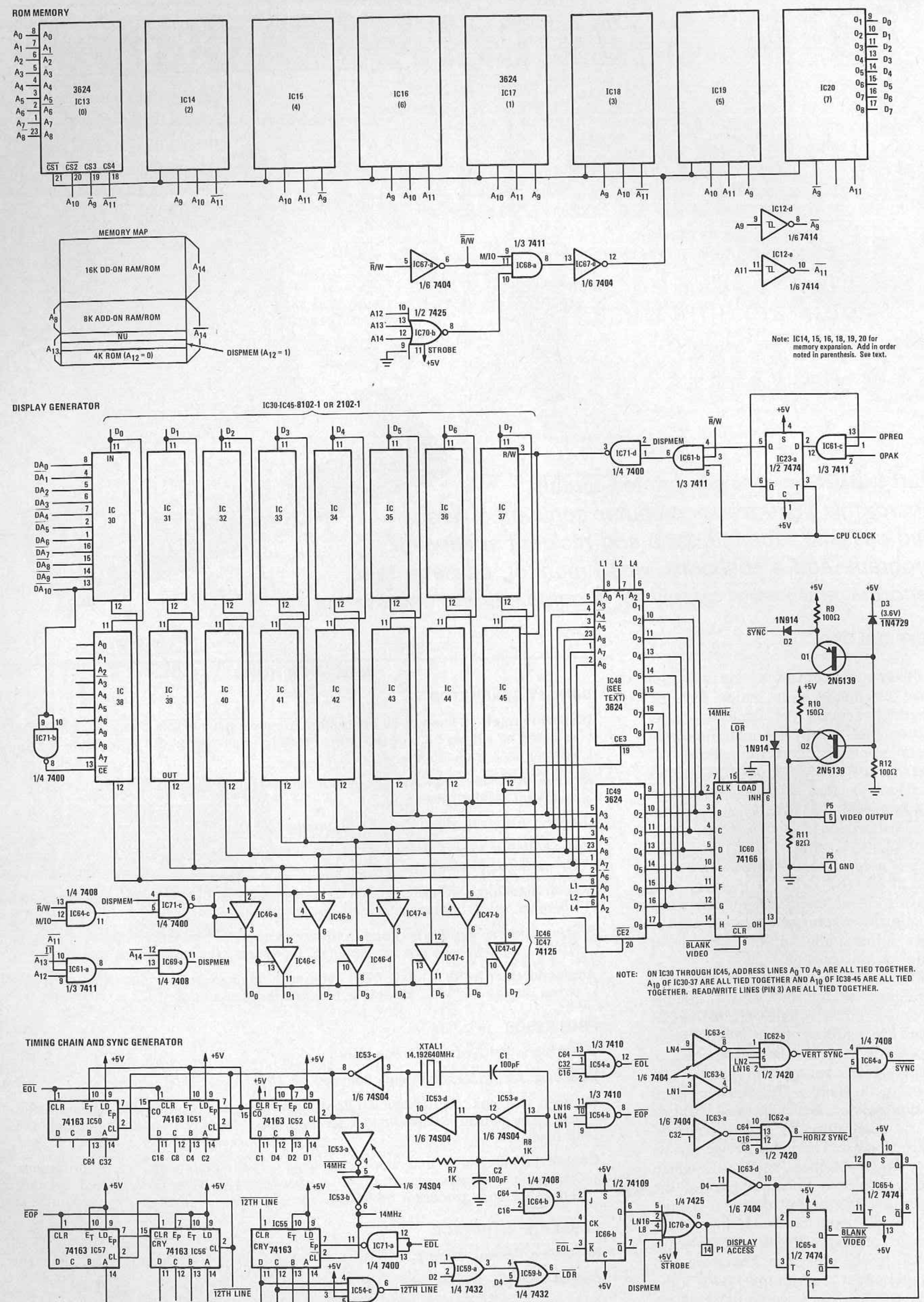
CASSETTE INTERFACE

Recording Format: 300 baud, 1200/2400-Hz Kansas City Standard.

Output Voltage: 100 mV P-P.

Misc. Size: $8^1/_2$-inch square printed-circuit board.

Power Consumption: 3 amps at 5 volts.



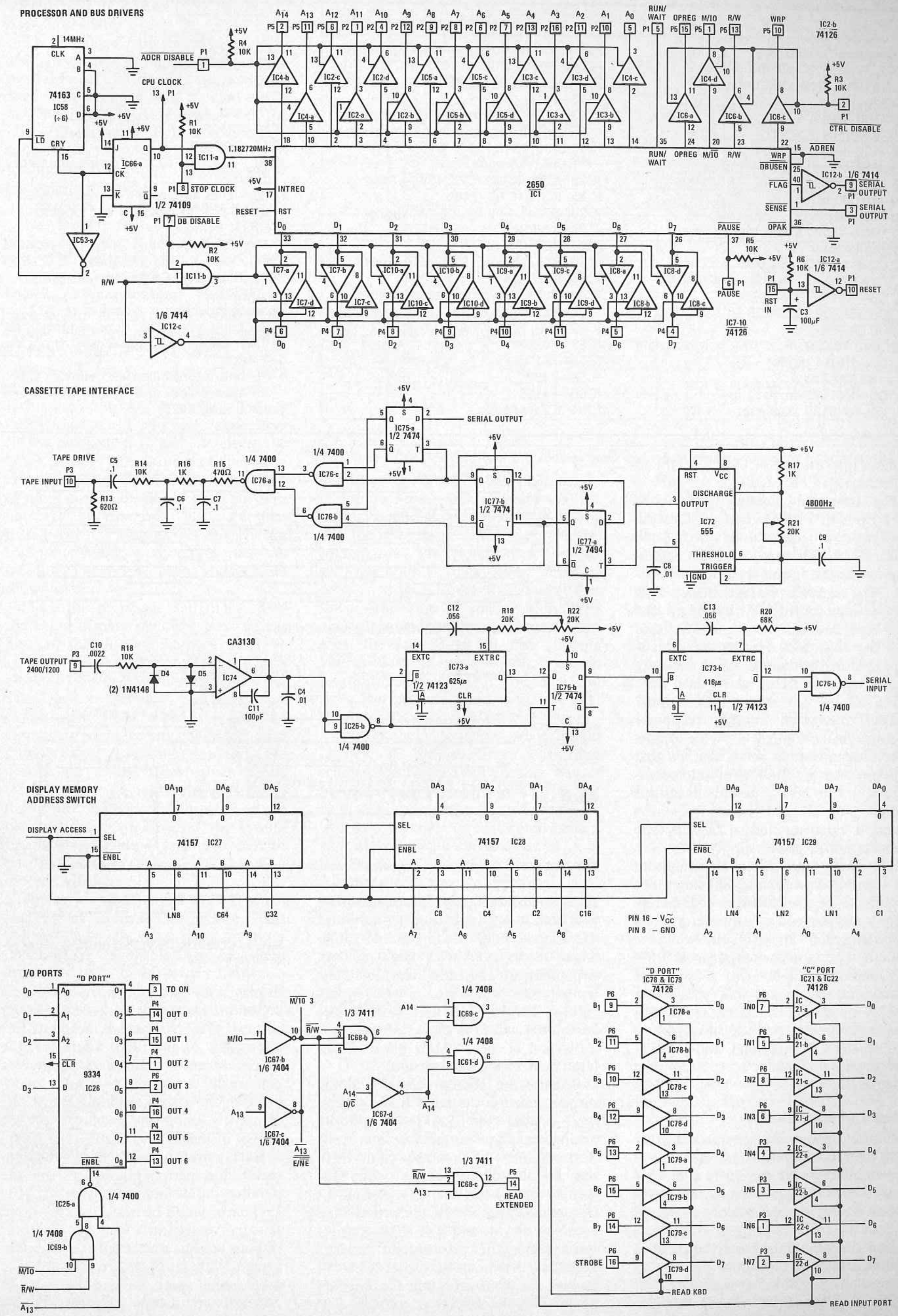


FIG. 1—COMPLETE SCHEMATIC of 2650-based microcomputer. All circuitry, including cassette-tape interface and video display generator, mount on single PC-board. Connection to peripheral devices is made via six IC sockets.

PARTS LIST

All resistors 1/4 watt, 5%.
R1-R6, R14, R18—10,000 ohms
R7, R8, R16, R17—1000 ohms
R9—330 ohms
R10—150 ohms
R11—82 ohms
R12—100 ohms
R13—620 ohms
R15—470 ohms
R19—20,000 ohms
R20—68,000 ohms
R21, R22—20,000-ohm trimmer potentiometer
C1, C2, C11—100 pF, disc
C3, C14—100 μF, 16 volt, electrolytic
C4, C8—0.01 μF, disc
C5, C6, C7, C9, C15-C29—0.1 μF, disc
C10—0.0022 μF
C12, C13—0.056 μF, ±10% polyester film
D1, D2—1N914 diode
D3—1N4729 Zener
D4, D5—1N4148 diode
Q1, Q2—2N5139 transistor
IC1—2650 microprocessor (Signetics)
IC2-IC10, IC21, IC22, IC78, IC79—74126
IC11, IC64, IC69—7408
IC12—7414
IC13, IC17—3624, pre-programmed PROM containing supervisor program
IC14-IC16, IC18-IC20, IC48—3624, PROM (see text)
IC23, IC24, IC65, IC75, IC77—7474
IC25, IC71, IC76—7400
IC26—9344, 4-bit by 2-bit multiplier (Fairchild)
IC27-IC29—74157
IC30-IC45—2102-1, RAM (Signetics)
IC46, IC47—74125
IC49—3624, pre-programmed PROM character generator, upper case
IC50-IC52, IC55-IC58—74163
IC53—74S04
IC54—7410
IC59—7432
IC60—74166
IC61, IC68—7411
IC62—7420
IC63, IC67—7404
IC66—74109
IC70—7425
IC72—555, timer
IC73—74123
IC74—CA3130
XTAL1—14.192640 MHz series-resonant crystal
MISC.—One 40-pin DIP socket for IC1, six 16-pin DIP sockets and printed-circuit board.

The following parts may be ordered from: Central Data Company, P.O. Box 2484, Station A, Champaign, IL 61820.
IC49—3624, pre-programmed PROM character generator, upper case, $27.
IC13, IC17—3624, pre-programmed PROM containing supervisor program, $27 each.
PC board, predrilled and etched, $30.
An assembled and tested microcomputer board, $325.

number of ports can be easily expanded to 256.

The on-board memory consists of 1024 bytes of PROM used to store the supervisor program along with 2048 bytes of RAM used for the video-display generator and for program storage. The external storage device is a cassette-tape recorder. An on-board cassette-tape interface IC is provided that uses the 1200/2400 Hz, 300-baud standard to store the data. When the cassette interface is not being used, data lines are available for serial I/O (*I*nput/*O*utput) data transfer. The computer operates off of a single +5-volt supply. When it comes right down to it, *all* that you need to get rolling in microcomputers is the board described in this article, plus an ASCII-encoded keyboard, a video monitor, a cassette-tape recorder and a power supply.

Something more should be said about the supervisor program at this time since it pulls all of the hardware together to form a simple to use computer system. The program allows you to have cassette-tape input or output to or from any memory block (in a standard format, in any length that you want), display or change memory, set a software breakpoint (stop) address, inspect and set the CPU registers, and jump to any memory location to execute your program.

Theory of operation

Figure 1 shows the schematic for the 2650 microcomputer system. Because of the architecture of the 2650 microprocessor, the Processor and Bus Drive circuit is very simple. All of the output lines of the 2650 are buffered by tri-state buffers, and the data bus is buffered in both directions, with only one set of buffers being enabled at a time.

Figure 2 shows the timing relationships for the 2650 microprocessor. Note that both OPREQ (operation request) and the address lines become stable somewhere in an interval of about 600 ns, depending on the individual 2650, the temperature and the power supply voltage. The 1.18 Mhz TTL clock for the 2650 is derived from the output which is a division of the 14-MHz master oscillator used in the display unit.

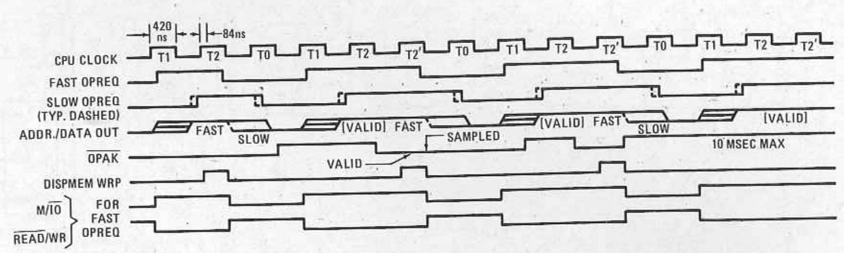


FIG. 2—2650 MICROPROCESSOR timing relationships.

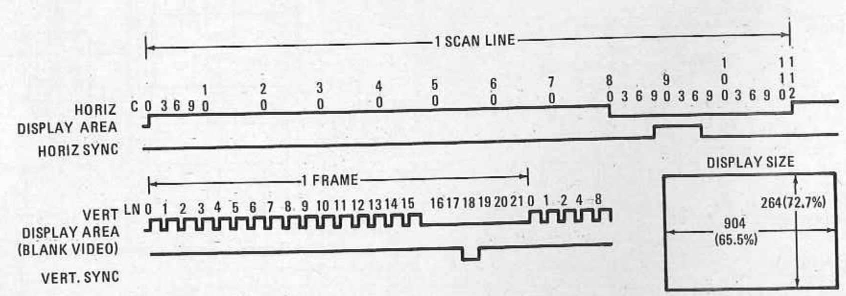


FIG. 3—TIMING DIAGRAM of horizontal, vertical and sync signals supplied to video monitor.

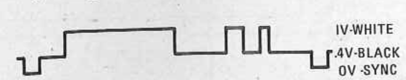


FIG. 4—COMPOSITE VIDEO SIGNAL supplied to video monitor.

Because the microprocessor and the display unit use the same RAM (unless you expand the RAM), a priority arrangement for the memory had to be devised. Since the processor could be in the middle of an access when the display needs the memory again, the display checks to see if the processor is accessing RAM, and if it is, the display waits. After the processor is finished accessing the memory, the processor is locked out from accessing the memory again until the display is through. The display releases the memory to the processor whenever it is doing inter-line or vertical blanking, which accounts for about 53% of the time. Therefore, the processor runs at about half-speed when continually accessing the display memory, which is very seldom. When the display is using the memory, pin 36 (OPAK) of the 2650 is high.

Data is transferred between the processor and peripheral devices via the parallel input and output ports. The keyboard should be hooked to the input port by connecting it to the correct pins of plug P6. The data from the keyboard is read by the READ DATA command. The other input port is read by a READ CONTROL command. The bit settable output port is accessed by the WRITE DATA instruction.

The Timing Chain and Sync Generator circuit divides the 14 Mhz clock in several stages to form the various signals needed to interface with a video monitor. Derived from these divisions of the master clock are the signals HORIZONTAL SYNC, VERTICAL SYNC, and BLANK VIDEO (composite blanking). Figure 3 shows the relation between the vertical and horizontal timing and the sync pulses.

The Display Memory circuit consists of sixteen 2102-1 RAM IC's and up to two 3624 PROM's. The 3624 PROM's are used for both the character generators and the supervisor program (as opposed to 1702's) so that the whole system could run off of a single supply. The use of PROM's for character generators also allows you to create your own characters, symbols or limited graphics. If bit 6 of the ASCII data is low, it selects one of the character generators (IC49), while if it is high it selects the other (IC48). The outputs of the character generators are fed into a parallel-to-serial converter where they are sent out at a 14 Mhz rate. They are then mixed with the sync pulses to form the composite video signal that is sent to the monitor. The video output voltages are shown in Fig. 4.

Since the processor and the display share the display memory, the address lines of the display memory must be switched between the processor address bus and the display timing generator. The Display Memory Address Switch circuit does this. When the Display Generator is not writing characters (and therefore not accessing memory), the DISPLAY ACCESS line is low, which selects the processor address bus to be gated to the RAM. When the display is not blanking the video, however, the Timing Chain and Sync Generator circuit selects the addresses for the RAM in an ordered fashion.

There is a special pattern by which the display accesses the RAM. This pattern allows all locations of memory not used by the display section (there are 768 of these bytes) to be confined to one memory block, not just several bytes here and there scattered throughout memory. A memory map for the display is shown in Fig. 5. When the address of the RAM is incremented, the character on the video display moves down one line. When it gets to the bottom line, the next character is on the top line, one character to the right of the present one. Therefore, when the display memory is filled, every memory location from address 1000 to 14FF is filled with data. If you wish to write characters across a line, you must increment the address by 16, thus moving you to the right one position. So from locations 1500 to 17FF you may put your own programs and data, just as if the video display wasn't there.

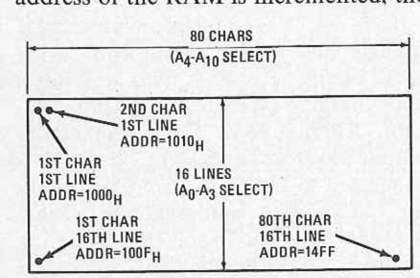


FIG. 5—RANDOM ACCESS MEMORY is simultaneously used for the video display and program storage.

PIN NO.	P1	P2	P3	P4	P5	P6
1	$\overline{\text{ADDR DISABLE}}$	A_{11}	IN6	OUT 2	M/IO	GND
2	$\overline{\text{CTRL DISABLE}}$	GND	IN7	+5V	A14	OUT 3
3	SERIAL INPUT	+5V	IN5	GND		TD-ON
4		A_{10}	IN4	D_7	GND	+5
5	RUN/WAIT (OUT)	A_0		D_6	VIDEO OUT	IN1
6	$\overline{\text{PAUSE}}$	A_6		D_0	A_{12}	IN3
7	$\overline{\text{DB DISABLE}}$	A_5		D_1	+5V	IN0
8	$\overline{\text{STOP CLOCK}}$	A_7	GND	D_2	+5V	IN2
9	SERIAL OUT	A_8	TAPE RECORDER EARPHONE	D_3	GND	B_1
10	$\overline{\text{RESET}}$ OUT (SQUARED)	A_1	TAPE RECORDER MICROPHONE	D_4	WRP	B_3
11	+5V	A_2		D_5	A_{13}	B_2
12	+5V	A_9		OUT 5		B_4
13	CPU CLK	A_4	GND	OUT 6	$\overline{R}$/W	B_5
14	DISPLAY ACCESS	+5		OUT 0	READ EXTENDED	B_7
15	$\overline{\text{RESET IN}}$	A_9		OUT 1	OPREQ	B_6
16		A_3		OUT 4	$\overline{A_{13}}$	STROBE

FIG. 6—PIN CONNECTIONS of DIP sockets used to connect microcomputer to external devices.

It may help to show what would happen if the memory addressing scheme was worked out another way. If the addresses were incremented as the characters were being printed on a line, then addresses 80 to 127 would be left unused, along with 207 to 254 and so on to form 16 groups of 48 characters each. All of these groups are separated by 80 characters, and programs cannot be written in them unless they are less than 49 bytes long! The addressing format can be ignored by someone programming the unit, for it is transparent to the programmer. It was thought that it would be appropriate, however, to bring it out here for a more hardware oriented person.

The PROM memory consists of up to eight 3624 4K-bit PROM's that are selected as a function of the upper six address lines. The first two IC sockets (IC13 and IC17) on the PC board are usually filled with the supervisor program. It should be pointed out that other programs could be written that would allow the board to have a special purpose such as an intelligent terminal or a process controller. These programs could either replace the supervisor program or be added to the empty sockets.

The last circuit is the Cassette Interface, which connects to the serial input and output pins of the 2650 processor. The modulator consists of an oscillator and gating circuitry to allow either 1200 or 2400 Hz go to the tape recorder's microphone jack. The demodulator consists of a limiter (IC74) and two Monostable Multivibrators (IC73-a and IC73-b). The output of monostable IC73-a goes low if the input frequency is not fast enough to keep retriggering it (somewhere between 2400 and 1200 Hz). This output is latched by IC75-b, and the other monostable (IC73-b) takes care of bias and distortion problems. This output is sent to the serial input (sense) line of the 2650.

Installation

Connecting the circuit board to external devices is accomplished through the use of DIP plugs and sockets. Figure 6 shows the pin connections of these sockets.

Connection to your video monitor is made using plug 5, pins 4 and 5. Pin 4 is the ground, and pin 5 is the 1 volt P-P composite-video signal. Plug 6 is used to connect to your keyboard. The pin numbers that correspond to the ASCII data bits can be found in Fig. 6.

The strobe signal must be low going, and should ideally be active as long as the key is depressed. Note that the supervisor program will not accept a very short strobe pulse, since the software is used to detect the strobe. If your keyboard strobe is small (less than 1 ms), you can add the circuit shown in Fig. 7 to be sure that the program will catch every keypress.

Most keyboards have a strobe that lasts as long as a key is depressed, so it is then simply a matter of hooking up the

continued on page 90

of the output signal are typically 250 ns and 50 ns, respectively, when pin 11 is loaded by 10 pF.

Figure 8 shows a simple add-on buffer stage that can be used to provide a low-impedance variable-amplitude squarewave output signal. The circuit is a simple complementary emitter-follower that is driven directly from the pin-11 squarewave output of the IC. Short circuit output protection is provided by the 47-ohm resistors (R5 and R6) in series with the transistor emitters. The output level is fully variable from maximum to zero using LEVEL potentiometer R7. The output signal is referenced to zero volts (ground) and can be used to drive high- or low-impedance external loads.

continued next month

BUILD A COMPUTER
continued from page 35

wires to the correct pins of the DIP plug. If you have a keyboard with tri-state outputs, they can be always enabled. Then their outputs can be wired to the inputs of the on-board buffers as in a normal keyboard.

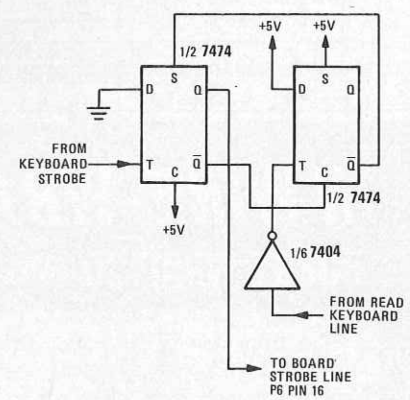


FIG. 7—DURATION OF STROBE pulse from keyboard is increased using this add-on circuit.

To hook up your cassette-tape unit, you use plug 3 of the board. Pin 10 is for the record jack and pin 9 is for the earphone jack. Pin 14 of plug 3 can be used to turn off and on the tape recorder (using the auxillary control line) by simply hooking up a relay and switching transistor to the circuit as shown in Fig. 8. You may need to adjust the volume and tone controls on the

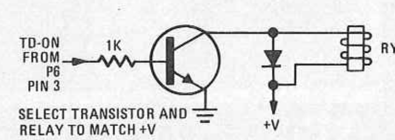


FIG. 8—AUTOMATIC CASSETTE TAPE operation is obtained by adding driver transistor and relay.

tape recorder in order to get perfect data storage (no errors on loading).

continued next month

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