Microprocessor makes alphanumeric display smart

Bipolar processor controls up to 10 multisegment displays of 32 ASCII characters; user can generate own symbols as well

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Friendly displays—alphanumeric readouts that talk the user's language—have grown more popular in point-of-sale, instrumentation, and other interactive applications. But the ability to communicate translates into higher overhead for the terminal's main processor. One way to reserve the processor's power for the computational tasks it was designed for is to add microprocessor control to the alphanumeric display.

A demonstration unit built by Monsanto exploits the speed of the 8X300 bipolar microprocessor[1,2] to drive and control a 32-character readout consisting of four multisegment eight-digit MAN2815 light-emitting-diode displays.[3] This unit exercises all possible permutations of the display, whether it be hooked up to peripheral equipment for on-line display or used as a learning tool to develop different programs for the display. The design process was documented and indicates several important tradeoffs—notably the decision between a metal-oxide-semiconductor processor and a bipolar one.

The type of display selected is important from the standpoint of cost and power requirements. The fundamental choice is between a dot-matrix and a multisegment format.

A five-by-seven-dot matrix display, such as Monsanto's MAN2A, offers greater font variety than does a multisegment display like the MAN2815. However, where segmented representations or approximations of curved symbols prove adequate, multisegment units can significantly reduce per digit cost, system power and heat-sinking requirements, and circuit complexity. For example, a segmented design might require addressing and driving 15 LEDS per character versus 35 for a dot matrix. The cost savings that may be realized in moderate- to high-volume applications encourage the use of multisegment displays where possible.

Display considerations

Basic criteria to consider when selecting a multisegmented, multidigit alphanumeric display include total range format of the characters, the relationship between character height and intended viewing distance, and the character spacing needed for the number of characters to be used. Another concern is readability at various viewing angles. If more than eight characters are needed, can one display unit be stacked easily with another, and if so will they maintain uniform separation between character sets? Finally, operation of the display at uniform, acceptable light-intensity levels should reflect minimum

EXAMPLES OF ASCII-TO-15 SEGMENT DECODING

Character	Figure eight portion of digit		Star portion of digit	
	Hex address [lower] (ASCII)	Coding/hex # HGFEDCBA/hex	Hex address [upper]	Coding/hex # ONMLKJI/hex
Space	(020) 000	00000000 = 00	04B	00000000 = 00
Dollar	(024) 004	11101101 = ED	04F	00000011 = 03
Zero	(030) 010	01111111 = 3F	05B	00011000 = 18
One	(031) 011	00000110 = 06	05C	00010000 = 08
Eight	(049) 019	11111111 = FF	063	00000000 = 00
Asterisk	(02A) 00A	11000000 = C0	055	00111111 = 3F
Plus	(02B) 00B	11000000 = C0	056	00000001 = 03
Period	(02E) 00E	00000000 = 00	059	01000000 = 40
Eight	(039) 019	11111111 = FF	063	00000000 = 00
Question mark	(03F) 01F	10000011 = 83	06A	01000010 = 42
B	(042) 022	01001111 = 4F	06D	00000011 = 03
Display test	(- - -) 044	11111111 = FF	08F	01111111 = 7F

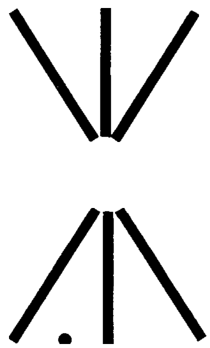
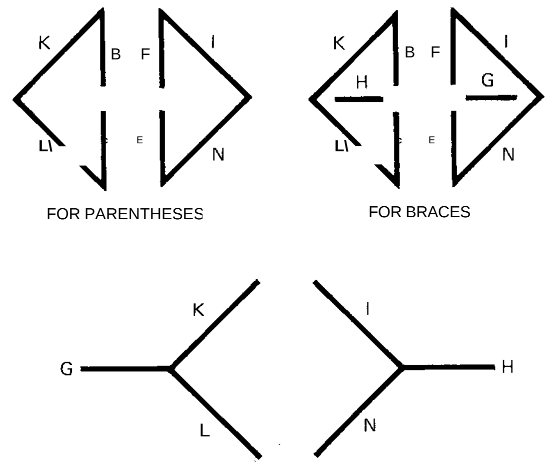


FIGURE8PORTION STAR PORTION



1. Segment decoding. The 15 segments for a character are partitioned into an 8-segment figure eight, labeled A through H, and a 7-segment star labeled I through 0. Two NE591 addressable peripheral drivers source current to the two portions.

2. Curved symbols. In multisegmented displays, restricted font vari-ety is overcome by creating approximations for curved symbols. Here, designations for parentheses, brackets, and braces are assembled using segments from both the figure eight and star.

power dissipation and total system cost.

The demonstration unit was designed to exercise fully all of the MAN2815 display's specifications. For the first-time user, a sequence of standard messages illustrate the basic ASCII character set. A keyboard enables real-time field trials and font assessment of the MAN2815 display. This permits the user to create any of 2^{15} possible characters simply by performing a straightforward sequence of key depressions. One keystroke allows the user to observe intensity changes due to a doubling of the time-averaged forward current for any message selected or created. In addition, a display interface permits the display module to be addressed as a peripheral device on a microprocessor input bus.

Defining desired functions

Before selecting the microprocessor, system requirements must be determined from the desired functions. For the demonstration unit, the display had to be refreshed at a flicker-free 200-hertz rate for 32 characters or 480 separate channels (32 characters by 15 segments per character). The microprocessor would have to scan a full-size ASCII keyboard, determine if a key had been depressed, and if so, decode which one. Then, from the decoded information, it would perform a conversion from a lookup table stored in a programmable read-only memory. Finally, it had to supply the key's font to the display, or execute a command in response to a command key. In addition, the microprocessor had to possess enough additional processing power (in the form of idle time) to accommodate additional MAN2815 displays or interface with other equipment or devices.

In comparing component counts, processing execution times, and lines of instruction code for a system implemented with a general-purpose 8-bit MOS microprocessor like the 8080, on the one hand, and one using a Schottky-bipolar fixed-instruction-set microprocessor like the Signetics 8X300, on the other, the only significant difference is in processing speed. An MOS processor typically has a 1-microsecond instruction cycle time, while the 8X300 can execute instructions in 250 nanoseconds.

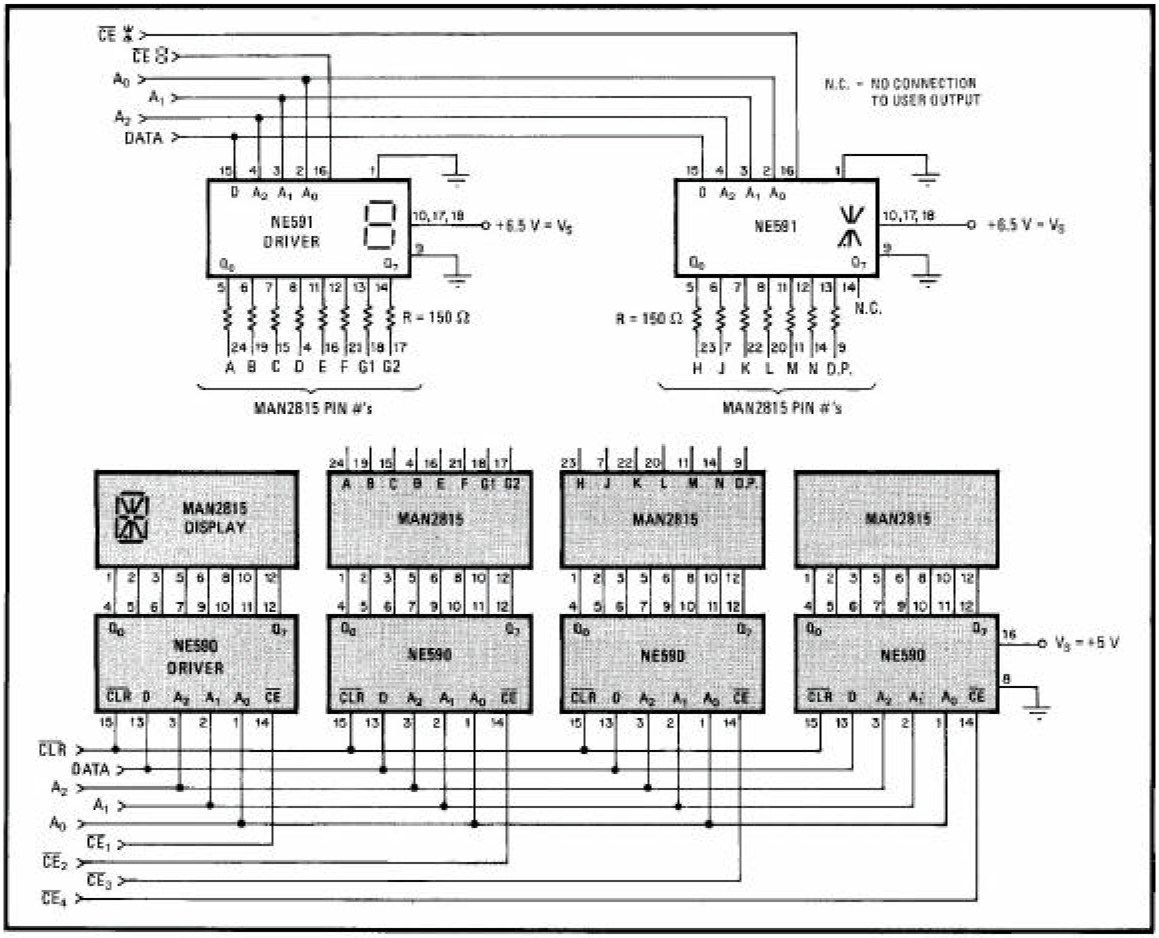
Processor time use

For a display where the microprocessor is dedicated solely to display refresh and keyboard scanning operations, or where not very sophisticated editing is needed, any of the popular MOS microprocessors, such as the 8080, 6800, 2650, 6502, F8, or SC/MPII is highly suitable. For this system design, however, the bipolar device was chosen because its higher speed allows it to perform more on-chip operations.

With a 32-character display and a 200-Hz display refresh rate, each character position is scanned every 5 milliseconds/32 = 156.25 ?s. Using the 8X300, the system requires only 13.5 ?s to fetch the next character from line buffer and the 15-segment font data (3.5 ?s), output the data and select the character position (5 *?s),* and read and decode the keyboard strobe and character (5 *?s).* When the keyboard executive is involved, an additional 3 us are used.

Therefore, worst-case time usage is 16.5 ?s out of every 156.25 ?s, or 10.56% of the available processing time. This leaves nearly 90% of available idle time compared to 20% for an MOS processor, so the basic system can service up to 10 32-character display groups. Alternatively, other measurements and/or calculations could be made with inputs from peripheral devices tied into the system.

The 8X300-based system also uses fewer parts than would an MOS-based system, because an MOS microprocessor requires external components to interface memory, buffer, and logic ICs. The availability of an 8X300 evaluation board kit, which has a wire-wrap area for interfacing memory and other diagnostics and control



3. Display module. Four MAN2815 15-segment light-emitting diode displays form the heart of the 32-character display-interface module. The 150-ohm resistors provide short-duration protection for the displays should latch-up problems develop.

capability, reduced development time from the design to the final product.

Decoding the ASCII characters into 15 segments is achieved by partitioning the 15 segments into an 8-segment figure eight and a seven-segment star as indicated in Fig. 1. Figure 2 shows segmented approximations for curved symbols. The hexadecimal code equivalents for each portion of the overall font for each ASCII character are then generated as shown in the table.

Font generation

As for font generation, a fixed-address displacement between the two font portions associated with any ASCII character was chosen to permit sequential, or interlaced, call-up of any addressed character during all display-character–related software routines. This was readily achieved since only 3.5 μs were required to call up any character. Furthermore, a single 82S115 8-bit programmable read-only memory conducts this interlacing activity under software control. The software becomes translated into a fixed program (firmware), that resides in the control program (four 512-by-8-bit 82S115 PROMS).

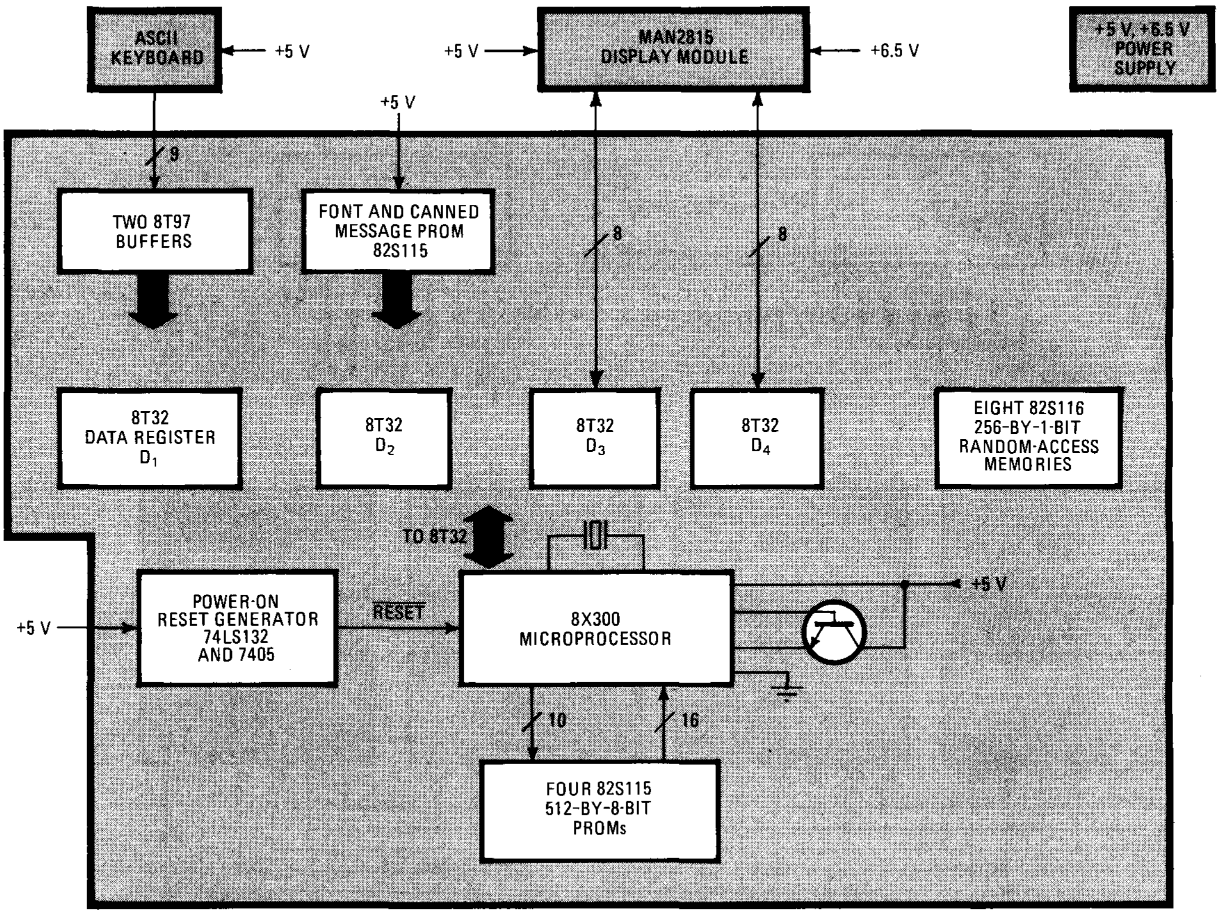
When this interlacing activity is coordinated with the microprocessor's activity by instructions in the control program (organized 1024 by 16 bits), the system generates the fonts associated with each alphanumeric key symbol.

Display module

Figure 3 illustrates the configuration chosen for the four MAN2815s that form the heart of the display-interface module. There are two NE591 addressable peripheral drivers, with two 150-ohm resistor networks that provide short-time protection for the displays should latch-up occur. The NE591s in the display module are used to source current to the figure eight and star portions of each character.

Four current-sinking NE590 drivers select which one of the 32 character positions is to be addressed at any instant during the overall multiplexing operation.

As shown in Fig. 3, the only connections involved are those for address lines A_1–A_2, six active-low chip-enable ($\overline{CE}$) lines, a clear line ($\overline{CLR}$), two data-input lines for turning on or off the Darlington power outputs within the 590/591 addressable peripheral drivers, 5- and 6.5-volt supply lines, and a supply-return line. Thus,



4. Demonstration unit. An 8X300 bipolar microprocessor, the brain of the demonstration alphanumeric display, uses only 10.56% of its available processing time to control the 32-character display. Expansion to 10 such displays is thus possible.

with a total of 15 signal lines that are readily configured for termination using conventional flat cable and connectors along with the 5-v, 6.5-v, and supply ground lines separately provided, an addressable peripheral display is made.

System operation

A simplified block diagram of the microprocessor-controlled alphanumeric display system is shown in Fig. 4. A 63-key keyboard with ASCII-encoded output was chosen for operational control. Seven-bit ASCII coding was used, together with strobe and E output lines. The E line allows designer-created non-ASCII codes, such as BREAK, CLEAR, HERE is, and the two blank keys, to appear on the same bus as the ASCII codes. The ASCII-encoded output from the keyboard becomes the raw data input to the four 8T32 bidirectional data registers, D_1-D_1, via the 8T97 buffer ICs. This data is converted by software into the appropriate character font or keyboard command.

Font/message data for the figure eight and star portions and for the unadjusted ASCII (hex-code) equivalents of the characters that comprise the eight canned messages is stored in an 82S115 font/message PROM.[4] The microprocessor does not differentiate between a keyboard input code or the font/message PROM's output code for a given ASCII character. Which of the two is presented for processing is determined by a control logic signal to pin 10 of D_3 (see Fig. 5).

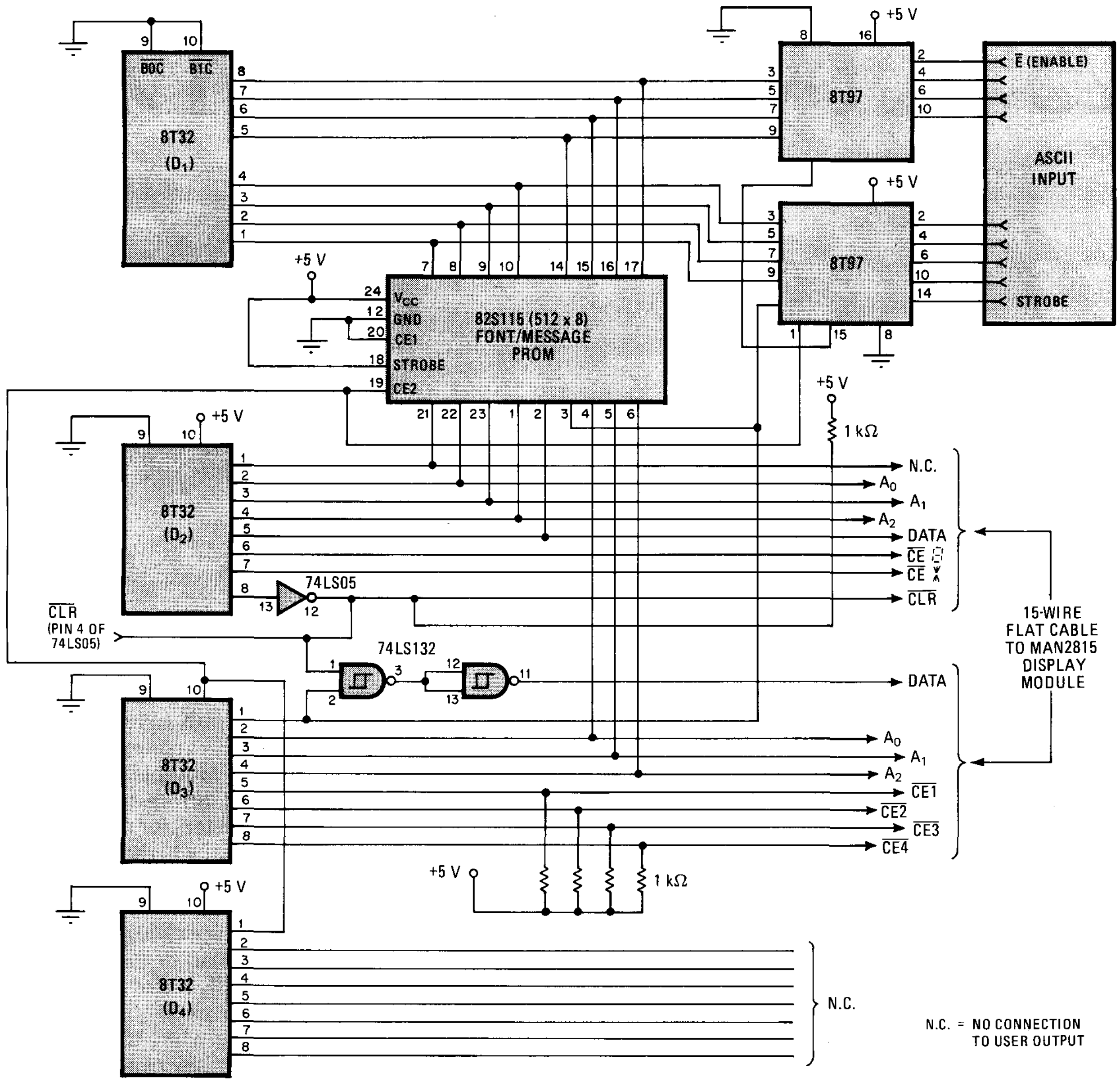
Additionally, this exclusive-OR arrangement assures that no conflict will arise even though the two outputs of the 8T97 and the font/message PROM are connected in parallel to the input/output port of D_1.

Figure 5 indicates the specific configuration of 8T32, 8T97, and 82S115 devices, together with the associated input/output control lines as labeled, that interface to the MAN2815 display module shown in Fig. 3.

The basic functions of $\mathbf{D_1}$-$\mathbf{D_4}$ are numerous (see Fig. 3 again). $\mathbf{D_1}$ serves entirely as an input port. Either the keyboard or the font/message PROM is serviced by this device at any one time. During the power-on initialization the canned messages are stored in a random-access memory. This takes about 50 ?s per message.

$\mathbf{D_2}$ serves entirely as an output port. It addresses the font/message PROM for either a message or to pull a font, according to a PROM address. It also supplies the strobing and star and figure-eight data signals to the appropriate 591 driver.

D_3 can be either an input or an output port. Used as an output port, the four CE lines to the 590 drivers



5. I/O configuration. Circuitry needed to interface to the MAN2815 display module consists of font/message programmable read-only memory and bidirectional input/output-port integrated circuits that control the data traffic at the four ports.

determine which of 32 positions are to be lighted. Also, the three address lines (A_0, A_1, A_2) to each 590 deter - nine which of eight characters within a MAN2815 is being addressed. A data pin to the 590 determines whether the addressed segment is to be on or off. When D_3 acts as an input port, it monitors strobe signals from the keyboard, via the 8T97. D_4 strobes D_3 only to determine whether it is working with the keyboard input or the 82S115 PROMS, which store the program controls.

Only 773 instructions out of the 1,024 available in the control program store are used in this particular system, so expansion to include additional functions or processing is possible without adding PROM. The eight 82S116s are 256-by-1-bit random-access memories for temporary storage of various system parameters such as pointers, labels, and flags. These system parameters tell the microprocessor what state the system is in, where it is, or where to go once a given operation has been completed. The RAMS are also loaded with character-font data for both figure-eight and star portions from the font/message PROM immediately following power-on initialization. This need be done only once, unless the system is shut off. In addition, the canned messages and user-generated messages are stored here.

Finally, the 32-character display is being controlled within the design constraints put down initially in only 11% of the bipolar microprocessor's processing time, leaving plenty of room for expansion.

References

1. 8X300 Reference Manual, Signetics. October 1977. Sunnyvale, Calif.
2. *Electronics,* Sept. 1, 1977, pp. 91-96
3. Monsanto MAN2815 Spec Sheet, Palo Alto, Calif.
4. NE590/NE591 Specifications, Signetics, Sunnyvale, Calif.