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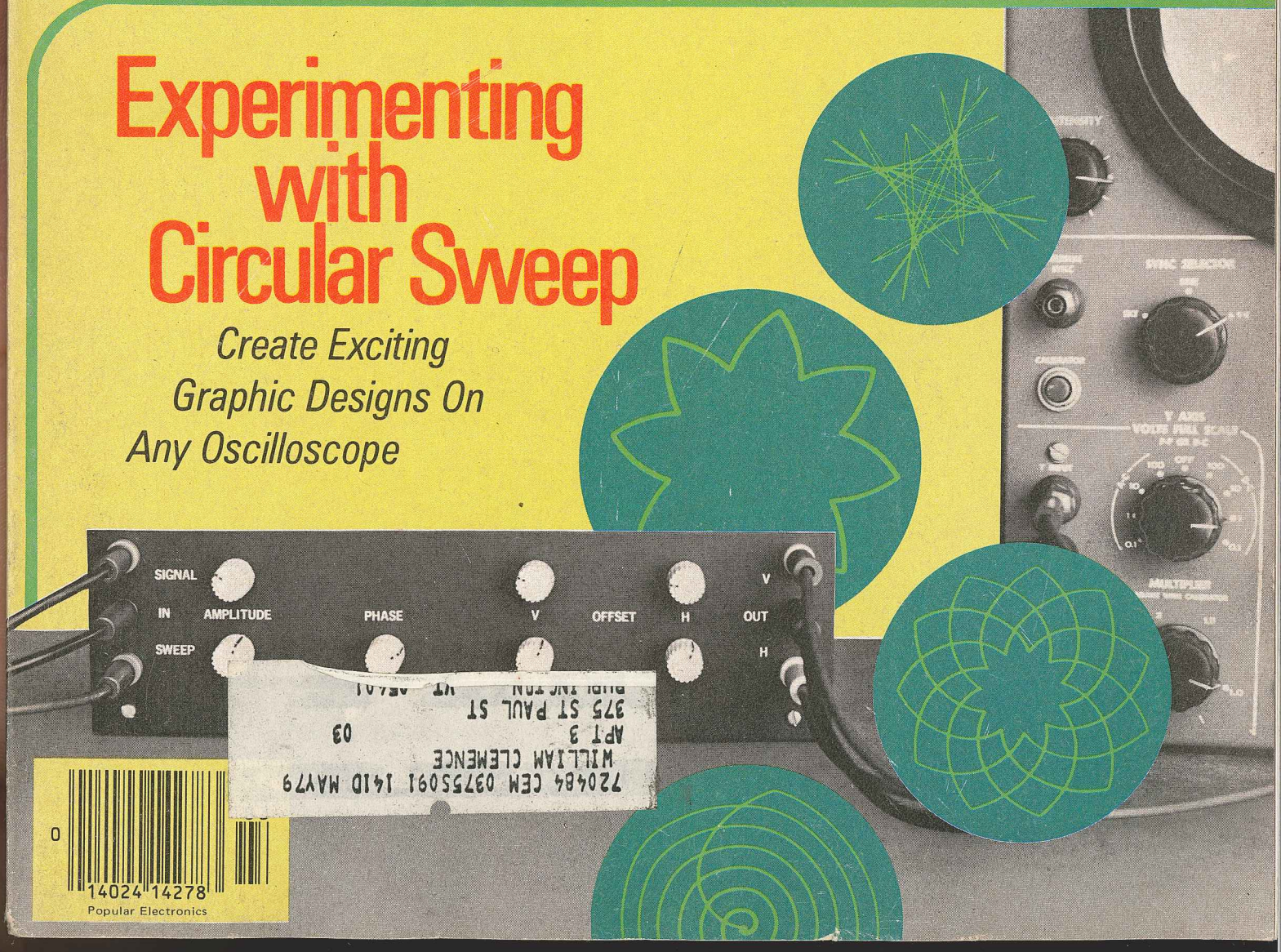

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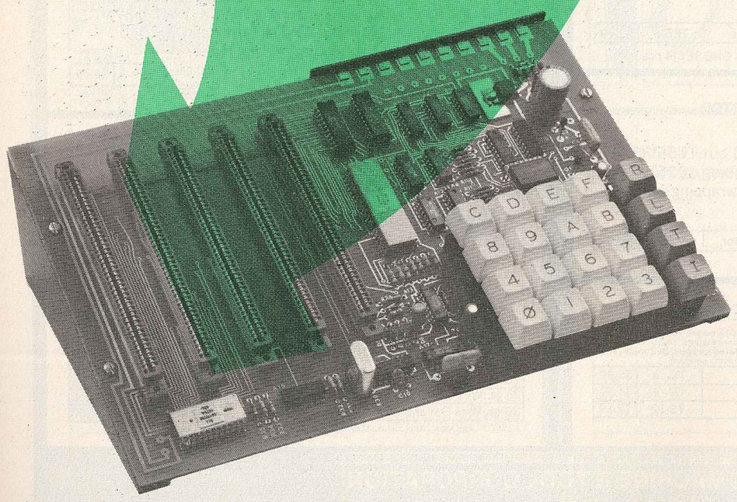
BY MARTIN MEYER

Expanding THE ELF II

- Write/Read From Cassette
- Display/Change Memory Contents
- Execute From Any Location
- Search For Any Byte
- 8-Bit Parallel I/O
- 20 mA/RS-232 I/O
- N-Line Decoding



LAST month, POPULAR ELECTRONICS described some hardware and software methods of upgrading a basic Elf microcomputer, based on the 1802 MPU. Here are plans to go beyond this, boosting an Elf from a microcomputer trainer to virtually a personal computer. Though based on an Elf II model (see "Build a Personal Microcomputer for $100" in PE's ELECTRONIC EXPERIMENTER'S HANDBOOK, 1978 Edition) from Netronics R&D, which includes a hex keypad, a bus structure and a pc board, the enhancements can be easily applied to any basic Elf.

The upgraded Elf II lends itself to especially easy expansion because of its bus structure. Since all of the 1802 signals, plus the power (+5 volts), ground, and 3.58 MHz from the clock oscillator are located on the bus, all that has to be done is to build an expansion circuit on a pc board having suitable dual-43-pin edge pads. Then a mating connector is mounted on the main Elf II pc board and the new board is plugged in.

All of the circuits shown in this article can be built on a single pc board. If desired, the newly created signals can be connected to the bus by using any of the odd-numbered bus lines. (Other than lines 1 and 3, none of the Elf II odd-numbered bus lines is currently used.) It is advisable to keep a record identifying each signal on the newly used lines.

The expansion system described here introduces a new monitor, located in ROM, that allows:

- Writing and reading from a cassette recorder.
- Displaying the address and contents of any memory location from 0000 to FFFF.
- Changing the contents of any memory location displaying both the address and the changed data.
- Execution of a program at any location.
- Scan entire memory for a specific byte.

Besides the hardware to implement the monitor, this article also describes the construction of an 8-bit parallel I/O port, interface for 20-mA/RS-232 peripherals, and the decoding of the three 1802 "N" lines to fully utilize all "6n" (I/O) instructions.

Monitor. The monitor program (overleaf) is stored in ROM *IC2* in the circuit shown in Fig. 1. The address of *IC2* corresponds to the hex address F0 00 where the most significant four bits of the high-order address are all high. The

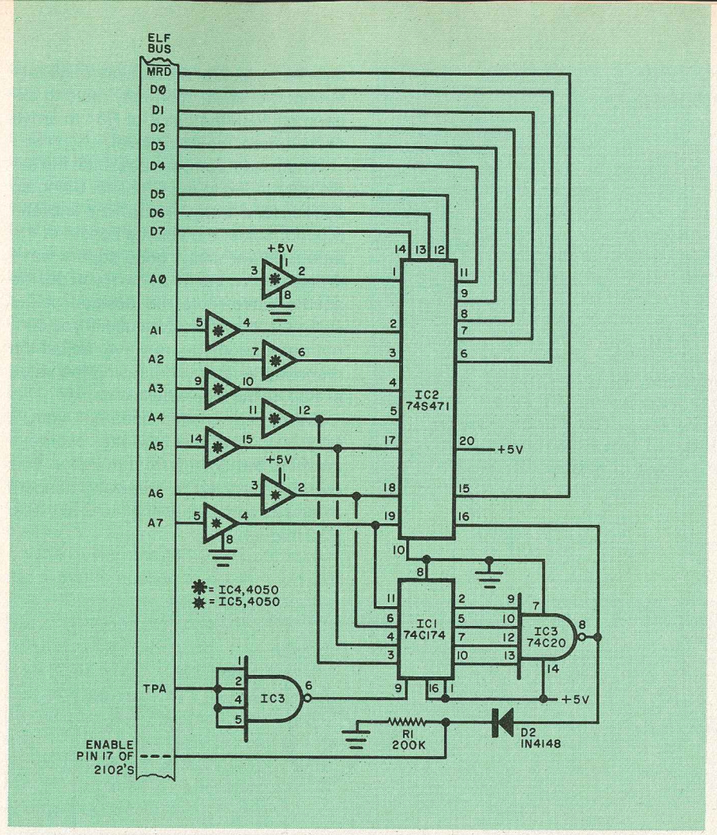


Fig. 1. The ROM (IC2) contains the monitor program and is addressed at F000 by IC1 and IC3.

four-bit latch in *IC1* decodes these four bits to drive 4-input NAND gate *IC3*. When the F000 address appears, the ROM is enabled via pin 16. The eight address lines from the bus are buffered by *IC4* and sections of *IC5*.

To use the monitor program, turn off the RUN, LOAD and M/P (memory protect) switches to reset the 1802. Place the LOAD switch in the on position and, using the keypad, enter C0 F0 00. Set the LOAD switch in the off position. When the RUN switch is on, the monitor will come into play. The next input will determine the monitor mode: 00 is execute, 01 is memory examine, 02 is memory change, 03 is cassette write, and 04 is cassette read.

To execute (run) a program from a memory location other than 0000, enter the monitor (C0 F0 00), then enter 00. Insert the two-byte address of the beginning location. When the INPUT switch is depressed, the program executes from the memory location specified.

To examine a memory location, enter the monitor and key in 01. Insert the two-byte address of the memory to be examined, then depress and release the INPUT switch. The byte stored at that memory location will be displayed. Depress and hold the INPUT switch down and the low-order address of the next byte will be displayed, followed by the memory byte when the INPUT switch is released.

To change data at a memory location, enter the monitor then enter 02. Insert the two-byte address of the memory to be changed and note that the Q LED comes on. Enter the new data. Then depress and release the INPUT switch. The new byte will then be displayed. Note that the low-order address of the next byte is displayed if you hold the INPUT switch down. If desired, that byte can also be changed.

For cassette write, enter the monitor, then enter 03. Key in the starting two-byte address of the memory to be recorded, then the ending two-byte address. Place the tape recorder in the record mode, allow several seconds for the leader to pass the heads, then depress the INPUT key. The Q LED will extinguish when the recording is complete.

To perform a cassette read, enter the monitor and then enter 04. Enter the starting two-byte address of the memory to be loaded. Then enter the ending two-byte address. Put the cassette recorder in the playback mode and depress the input switch. Allow 2.5 seconds for each 256 memory bytes recorded. The display will increment the low-order address of memory being entered. When the display stops incrementing at the last low-order address, the playback is complete. The final digits in the display will show the low-order address of the data being written (recorded).

If you are in the monitor program and select an illegal operating code (other than those spelled out above), an EE will be displayed on the readouts and the Q LED will come on.

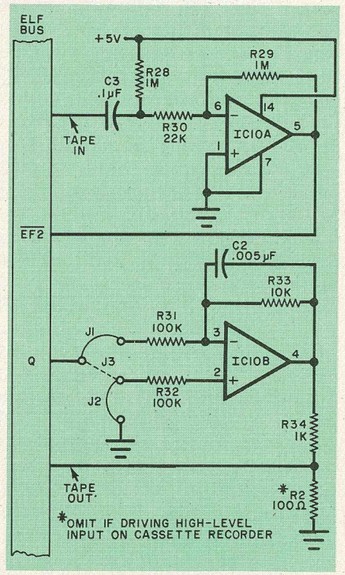


Fig. 2. Read and write circuits. Jumpers select signal polarity.

Cassette Read/Write. This simple circuit (Fig. 2) uses the Q and EF2 lines on the Elf II bus. When executing the tape write function, the monitor produces a 10-second train of sync pulses followed by the serial output of data (plus parity) on the Q line from the memory boundaries selected. Resistors *R34* and *R2* form an attenuator that provides adequate record level for the tape recorder used. If your tape recorder has a microphone input, the typical value for *R34* would be about 1000 ohms. If your

MONITOR PROGRAM

00	90	A1	B3	B4	B5	B6	B7	F8	FF	A2	E2	21	81	B2	80	52
10	F3	3A	0B	F8	38	A3	F8	29	A4	F8	33	A5	D3	3F	1D	22
20	8A	52	64	37	23	6C	30	1C	D3	3F	29	37	2B	6C	64	22
30	30	28	D3	22	52	64	30	32	D4	F8	4D	F4	A6	02	FD	05
40	33	47	F8	EE	D5	7B	00	D4	BA	D4	AA	06	A3	53	58	5D
50	78	C8	F6	9A	B0	8A	A0	E0	D0	4A	D5	30	58	7B	D0	D5
60	5A	1A	30	5D	D3	7B	F8	1D	3B	6D	F8	07	1D	52	FF	01
70	33	6E	39	64	7A	02	30	6E	F8	8D	A1	D4	73	D4	8A	F5
80	AC	12	9A	75	FC	01	BC	D0	F8	65	A6	81	A3	F8	80	BD
90	FF	00	D6	9D	3A	90	8A	D5	7B	4A	BB	FC	00	F8	09	AB
A0	AD	D6	2B	8B	32	AB	9B	FE	BB	30	A1	8D	F6	D6	2C	9C
B0	3A	96	D6	D6	D6	D6	30	38	1D	D3	F8	0D	35	BC	35	B8
C0	FF	01	33	BE	3D	C4	30	B9	F8	CD	A1	30	7B	F8	BA	A7
D0	F8	F9	BD	D7	3B	D0	9D	3A	D3	D7	33	D9	F8	01	BD	AD
E0	D7	9D	7E	BD	3B	E0	D7	8D	F6	33	45	9D	5A	8A	D5	1A
F0	2C	9C	3A	D9	30	38	D4	4A	F3	3A	F7	2A	9A	D5	30	58

tape recorder has an auxiliary (high-level) input, omit *R2*. You may have to experiment with the value of *R34* to arrive at the correct recording level.

When reading from a cassette, the serial data is fed to the EF2 line. Using an oscilloscope between the EF2 line and ground, adjust the volume control of the tape recorder until a good square wave is obtained on the EF2 line. If you get the square wave, note the position of the volume control for future use. If you cannot get a good square wave, adjust the recording level by decreasing the value of *R34* (in the tape write circuit).

If the read function does not work, it may be due to the cassette recorder's inverting the polarity of the signal. This can be corrected by removing jumpers *J1* and *J2* and connecting the Q signal to *R32* through *J3*.

PARTS LIST

C1, C3—0.1-μF, 100-V Mylar capacitor
C2—0.005-μF Mylar capacitor
D1,D2—1N4148 diode
IC1—74C174 hex latch
IC2—74S471 256x8 PROM
IC3—74C20 dual 4-input NAND gate
IC4, IC5, IC9—4050 hex buffer
IC6—1853 N-line decoder
IC7, IC8—1852 8-bit I/0 port
IC10—LM3900 quad op amp
Q1, Q3—2N5232 transistor
Q2,Q4—2N5306 transistor
The following are ¼-W, 5% resistors unless otherwise noted:
R1—200,000 ohms
R2—100 ohms
R3, R11, R18—3900 ohms
R4—330 ohms
R5, R6, R10, R14—15,000 ohms
R7—300,000 ohms
R8, R9,R15,R16,R17,R34—1000 ohms
R12—47 to 250 ohms (value for 20 mA current loop)
R13—2200 ohms
R19 through R27, R30—22,000 ohms
R28,R29—1 megohm
R31,R32—100,000 ohms
R33—10,000 ohms
Misc.—Pc board with edge connectors to match Elf II bus, 86-pin connector, optional sockets for IC's, etc.
Note—The following are available from Netronics R&D Ltd., 333 Litchfield Rd., New Milford, CT 06776: complete set of parts including pc board, pre-programmed monitor PROM, less 86-pin connector for $39.95 plus $2 postage and handling; PROM IC2 available separately for $25 plus $1.50 postage and handling; 86-pin connectors for $5.70 each plus 30 cents postage and handling.

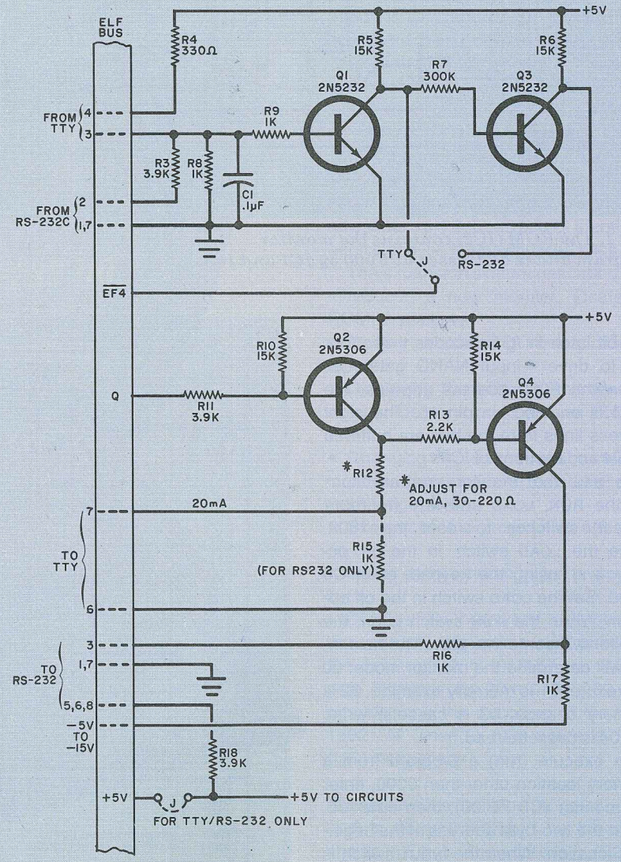


Fig. 3. Transistors Q1 and Q2 form the 20-mA current loop with Q3 and Q4 added to make up the RS-232 loop.

20-mA/RS-232 Interface. This circuit (Fig. 3) requires an external dc supply of −5 to −15 volts for the RS-232 section. To receive data from a 20-mA current-loop peripheral (such as a TTY), and if the peripheral requires an external current source, then connect the R4 line to the external device (on the TTY, this should be terminal 4). The current from the device (on the TTY, terminal 3) is fed to the *Q1* input circuit. The output of *Q1* is jumper-selected to drive the EF4 line on the bus.

To transmit data to the current-loop peripheral, the signal from the Q line drives constant current (20mA) source *Q2*. Resistor *R12* is adjusted to deliver a 20-mA current into the peripheral. Note that *R15* is not used in the current mode. On the TTY, the two terminals would be 6 and 7.

When using the RS-232 input mode, the signal is applied to *Q1* through *Q3*. The EF4 jumper is then set to the RS-232 position at the output of *Q3*.

To transmit data to the external RS-232 device, *R15* is inserted between *R12* and ground, and *Q4* is added to produce the correct output. Note that a negative voltage supply is required for RS-232 operation. A jumper, or switch, is optionally used to remove or turn power on to this circuit.

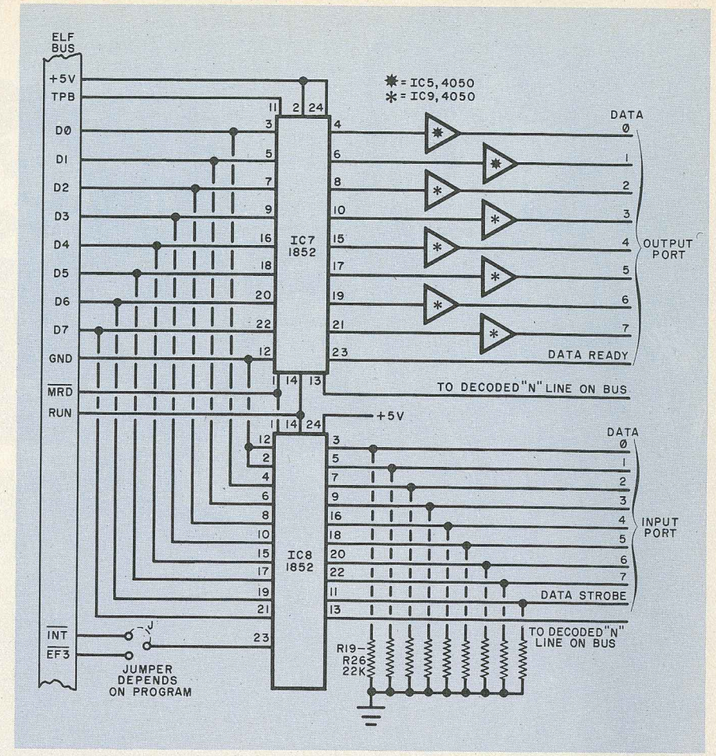


Fig. 5. Two IC's form 8-bit parallel input/output port. They use N-line from Fig. 4 determined by program.

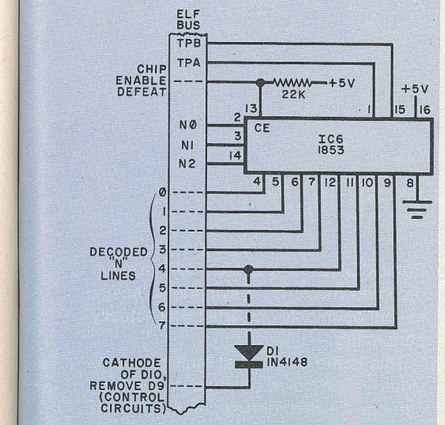


Fig. 4. The N-line decoder expands three lines from 1802 into eight.

N-Line Decoder. The three N-lines (N0, N1, N2) of the 1802 can be decoded into eight separate instructions that can be used to control eight I/O (input/output) ports using the circuit shown in Fig. 4. The decoded outputs can be connected to unused lines on the bus for easy connection to any future I/O control inputs. Control line 4 is connected to the cathode of *D10* in the Elf-II (*D3* in the original Elf) with *D9* (D4 on the original) removed. This will allow the 6C and 64 instructions in the original programs to be executed properly.

I/O Ports. If you have a need to interface the Elf II to an external peripheral that requires parallel data (ASCII keyboard, for example), use the circuit shown in Fig. 5. Output port *IC7* has its data output lines buffered by *IC9* and sections of *IC5*. Pin 13 (CS2) of this stage can be connected to any of the decoded N-lines. When pin 2 (mode control) is high, the 1852 is configured into an output port. Data is strobed into the output port when pins 11 and 1 are high. The three-state output drivers are enabled at all times when the 1852 is used as an output port. The service request signal at pin 23 is generated at the termination of the pin 1 and pin 13 signals and will be present (high) until the following negative high-to-low transition of the clock pulse at pin 11. The signal at pin 14 resets the port's register and service request flip-flop.

The input port is formed by *IC8* with pin 2 low. The data input lines are held low by resistors *R19* through *R25*. Pin 13 is tied to the desired decoded N-line.

Data is strobed into the port's 8-bit register by a high on the clock (pin 11) line. The negative high-to-low transition of the clock sets the service request (pin 23) flip-flop to latch the data into the register. The service-request output at pin 23 signals the 1802 that data is ready to be transferred to the bus and can be connected to either the EF3 or INT lines, depending on program requirements. The 8-bit parallel input port can service an ASCII keyboard with use of the proper software control. ◇