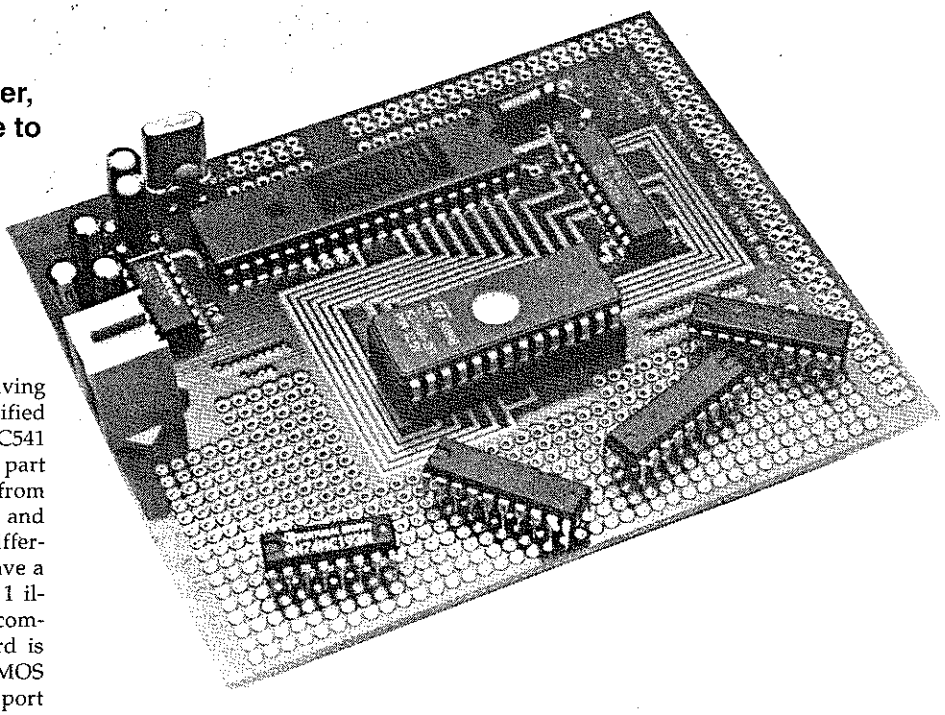
8051 SINGLE BOARD COMPUTER

This article describes an inexpensive single board computer based on the popular 8051 microcontroller, plus a bit of assembly code to get things going.



By Steve Sokolowski

NORMALLY, a number of ICs having features in common can be classified as a 'family'. Devices such as the 87C541 and the 80C525 can be considered as part of the 8051 family of microcontrollers from Intel. Although internal ROM/RAM and the added presence of EPROM are different between individual chips, they have a number of common features. Figure 1 illustrates the main blocks of the 8051 computer family. Our development board is based on the easily obtainable HMOS 8051, of which the basic architecture, port functions, programming, and many other features are discussed in great detail in our *8051/8032 Assembler Course*, of which part 7 appears elsewhere in this issue.

Circuit description

The circuit diagram of the 8051 SBC, Fig. 2, shows that very few components are required to build a versatile development system around the Intel controller. In fact, the circuit is probably the absolute minimum that you will need to start programming the device.

The 8051 clock oscillator is run at 11.0592 MHz to enable the serial interface of the controller to transmit and receive at any of the standard baud rates between 300 and 9600 bits s^{-1}.

The address latch enable (ALE) signal is used to separate the data bus signals from the multiplexed data/address bus signals on the AD0-AD7 pins of the 8051. The latch used is a Type 74LS373 octal D-type flip flop with 3-state output buffers. When the output enable (OE) pin is low, the latched data appears at the outputs. When OE is high, the outputs are in the high-impedance 'off' state. The enabling pulses are supplied by the 8051's ALE output. These pulses effectively enable the 74LS373 to strip the low-order address bus from the eight AD lines by turning on the latches' eight 3-state buffer outputs at the correct instant, thus allowing only the addressing information to be fed to the memory.

The external access enable (EA) input of the 8051 (pin 31) is made permanently low here to enable the controller to fetch program code from the external program memory locations in the address range between 0000H and 0FFFH. Here, the program code is stored in an EPROM, IC3.

The serial interface is formed by the well-known MAX232 RS232 level converter, which is connected directly to the serial input and output pins of the 8051. The MAX232 has on-board positive and negative step-up voltage converters that obviate a symmetrical supply. The IC gen-

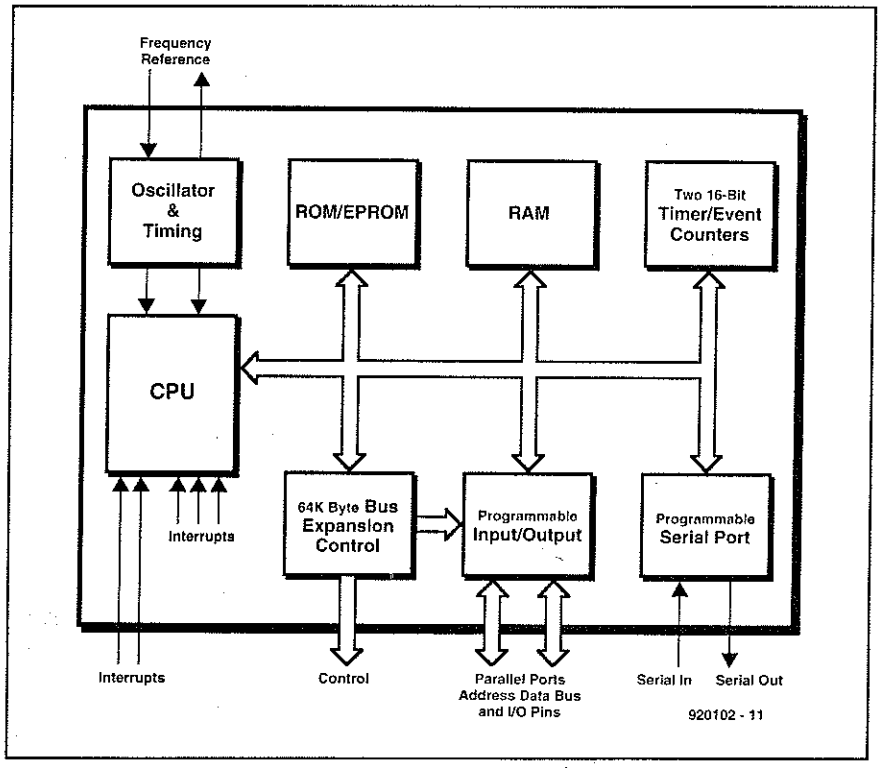


Fig. 1. 8051 family microcontroller architecture.

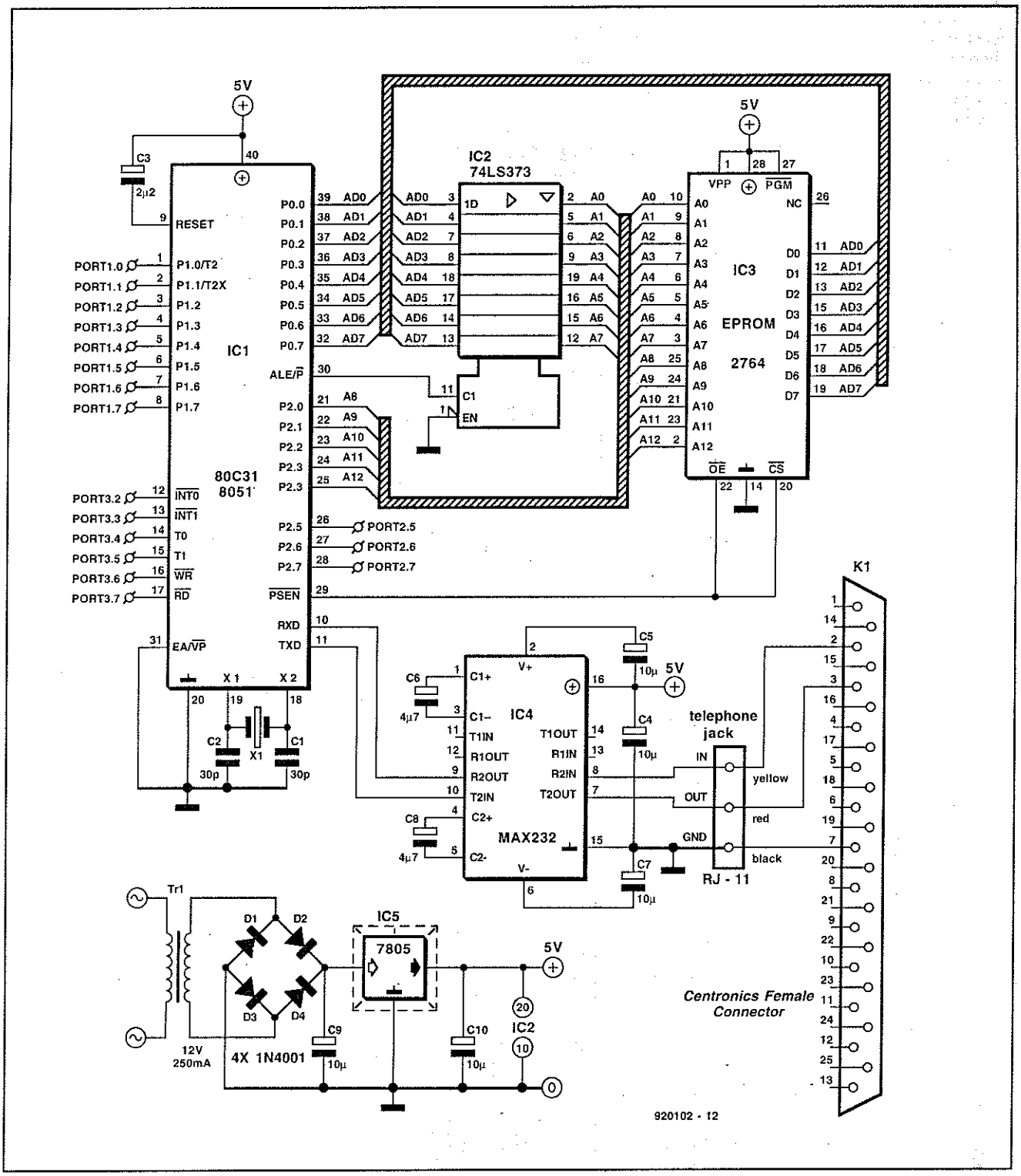


Fig. 2. Circuit diagram of the 8051 single-board computer, its power supply, and the serial interface connection to the PC.

erates internal supply voltages that result in a swing of 20 V (±10 V) on the RS232 output line.

A short length of inexpensive telephone cord is used to connect the 8051 board to the RS232 port on the PC. At the board side of the cable is a 4-way miniature latching telephone cord plug, while a standard D25 sub-D connector (female) is used at the computer side (for pinning details refer to the circuit diagram).

The power supply of the SBC is a classic one designed around the 7805. The mains transformer could be a small mains adaptor with a.c. output. Such and adaptor will in many cases be cheaper (and in all cases, safer to use!) than a discrete transformer. The current demand on the adaptor will be between 250 mA and 500 mA, depending on the circuit fitted in the extension area on the SBC board. In any case, the 7805 will run fairly hot, so it must be fitted with a heat-sink.

Building the SBC

If you are interested in building the present 8051 development system, you have two options: (1) produce the PCB yourself (using the artwork given in Fig. 3) and purchasing the components from your local stockist, or (2) purchase a complete kit from Suncoast Technologies.

The following few paragraphs are intended for those of you who wish to assemble the 8051 SBC on a home brewed printed circuit board, which will probably not be plated through, contrary to the one supplied by Suncoast Technologies. Since a fair number of PCB through connections is required, it is best to use Molex clip-type connectors for the IC sockets. These clips can be placed in the holes provided for the IC pins, and soldered at both sides of the board before they are removed from their metal carrier. The resulting pin strips then form an IC socket. To reduce cost, you may want to use Molex connector strips for the EPROM socket only, and solder the 8051, the 74LS373 and the MAX232 direct on to the board, making sure that all pins are soldered at both sides of the board.

Capacitors C4 and C8 are electrolytic types and require proper placement on the board. Mis-insertion of these polarity sensitive components can spell disaster for the part, so take care while fitting them.

The RJ-11 telephone jack was designed in such a way that it can be inserted on the board in only one way. Carefully line up the four 'pig-tail' terminals with their corresponding holes. When lined up, carefully press the jack on to the board until its mounting clips protrude on the opposite side of the board. Solder the four contacts at the solder side of the board. Finally, fit the crystal and the two ceramic capacitors.

Note that the SBC has a large prototyping area. To help eleminate the need for extra wiring of the voltage buses, the board also contains a common ground and positive supply bus etched in. It is this area where the required interfacing components for future projects can be mounted. The power supply may also be hand wired in this section.

Inspect the completed board for solder

COMPONENTS LIST

Capacitors:		
2	33pF 16V disc ceramic	C1;C2
1	2µF2 16V radial	C3
3	10µF 16V radial	C4;C5;C7
2	4µF7 16V radial	C6;C8
1	470µF 35V radial	C9
1	100µF 16V radial	C10
Semiconductors:		
4	1N4001	D1-D4
1	8051 or 8031	IC1
1	74LS373	IC2
1	2764 EPROM	IC3
1	MAX232	IC4
1	7805	IC5
Miscellaneous:		
1	12V a.c. mains adaptor	Tr1
1	11.0592MHz quartz crystal	XTAL
1	25-pin female sub-D connector with hood	P1
1	4-conductor telephone line cord with clip (approx. 6 ft.)	
1	RJ-11 PCB mount telephone jack	
1	TO-220 heat-sink	
28	Molex connector pin or	
1	28-pin IC socket (see text)	
1	Printed circuit board (Suncoast Technologies)	

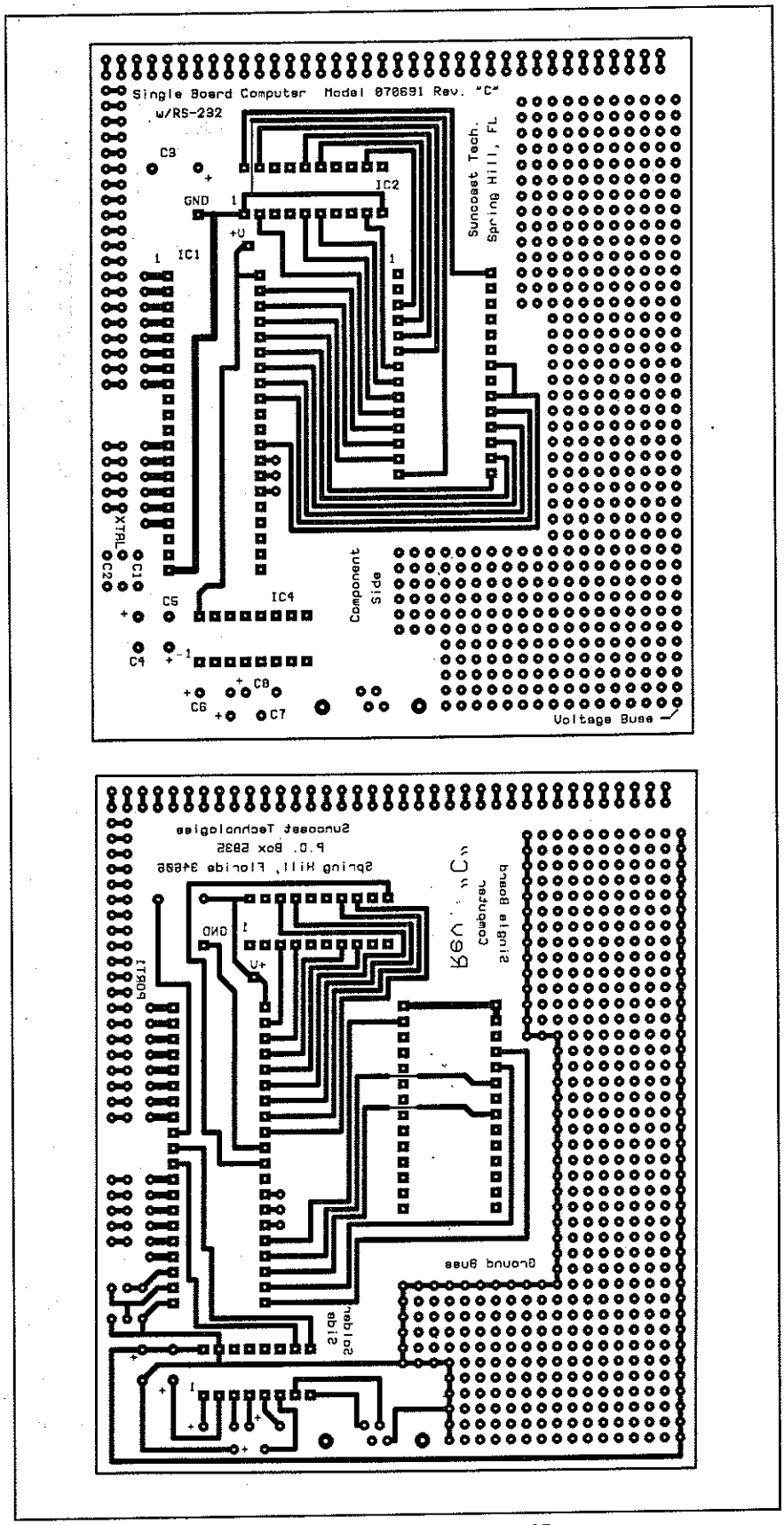


Fig. 3a. Component side and solder side track layout of the PCB.

splashes, dry joints and solder bridges. When all is to your satisfaction, the 5-volt power supply can be connected to the board.

Testing the SBC

Shown in Fig. 4 is a test program in assembly language. When programmed into a 2764 EPROM, TEST.ASM will determine if all address and data lines are wired correctly. It also checks the serial cable to the PC, and the wiring of the MAX232.

TEST.ASM uses the serial output feature (CHR_OUT) of the 8051 to print any character on the computer screen. It also allows keyboard input (CHR_IN) to be echoed to the screen. Both CHR_IN and CHR_OUT check out the operation of the MAX232 chip. If either feature does not work, double check the wiring of IC4 and that of the interface cable assembly (which also includes the RJ-11 telephone jack).

TEST.ASM was written to be assembled into machine code with the A51 assembler (version 1.4 or earlier), an inexpensive program that can be purchased from just about any shareware distributor. Once assembled, TEST.ASM is converted into a series of hexadecimal numbers (TEST.HEX). Although converted, TEST.HEX can not be loaded into an EPROM just like that. Further conversion is necessary, and for this HEXBIN.COM is proposed. HEXBIN.COM takes the hexadecimal format of TEST.HEX, and transforms it into a binary file (TEST.BIN), which is programmed into the 2764 EPROM.

```
;   8051 SBC Test Program
; by: Suncoast Technologies
;     Spring Hill, Florida
;
; Program set to 1200 Bauds
;
        .EQU    ESC,H'1B
        .ORG    H'0000
INIT:   MOV     A,#H'40
        MOV     SP,A
        CLR     A
        MOV     PSW,A
;
;  INITIALIZE SERIAL PORT
;
        MOV     SCON,#H'52
        MOV     TMOD,#H'20
        MOV     TH1,#H'E8
        SETB    TR1
;
;     PRINT GREETINGS
;
MENU:   LCALL   XSTRING
        .DB     "\n\r"
        .DB     "8051 Single Board "
        .DB     "Computer Test Program"
        .DB     "\r\n\n"
        .DB     ESC
LOOP_1: LCALL   XSTRING
        .DB     "Hit a key - I will echo "
        .DB     "the character \n\n\r"
        .DB     ESC
LOOP_2: LCALL   CHR_IN
        CJNE    A,#D'13,LOOP_2
        .DB     ESC
        LCALL   XSTRING
        .DB     "\n\r"
        .DB     ESC
        LJMP    LOOP_2
;
;     'PRINT'  PROGRAM
;
XSTRING: POP    DPH
        POP     DPL
SRT_1:  CLR     A
        MOVC    A,@A+DPTR
STR_2:  JNB     TI,*
        CLR     TI
        MOV     SBUF,A
        INC     DPTR
        CLR     A
        MOVC    A,@A+DPTR
        CJNE    A,#ESC,STR_2
        MOV     A,#1
        JMP     @A+DPTR
;
;       SERIAL  I/O
;
CHR_IN: JNB     RI,*
        CLR     RI
        MOV     A,SBUF
        ANL     A,#H'7F
        ACALL   CHR_OUT
        RET
;
CHR_OUT: JNB    TI,*
        CLR     TI
        MOV     SBUF,A
        RET
        .END
```

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Fig. 4. An assembly language program to test your new 8051 single board computer.

Once programmed, carefully insert the EPROM into its IC3 location on the board. With your PC running your favourite communication program (QMODEM, PC TALK, Procomm, etc.) at 1200 baud, take the mains adaptor and plug it in. Within an instant the SBC will display the following:

8051 Single Board Computer Test Program
Hit a key — I will echo the character

Now, just for fun, type "Hello there" on the PC keyboard, then press the ENTER or RETURN key. The keyboard input will be echoed and printed on the next line. When the 25th line is reached, all text is scrolled up by one line.

If you wish to start programming to 8051 single board computer, I suggest you obtain the collection of 'start up' programs contained on a floppy disk supplied by Suncoast Technologies. This 5¼-inch MSDOS floppy disk (3½-inch not available) contains the following conversion tools that can be run on any IBM PC or compatible running under DOS 2.11 or higher:

- simple communication program
- program editor
- A51 program assembler
- D51 program disassembler
- hex-to-binary conversion program
- 8051 test program in .ASM and .BIN

Final thoughts

TEST.ASM is not a very elaborate program, and was not meant to be. It is included here so that you can quickly and easily determine that your 8051 SBC is functioning. As the programming of the 8051 chip becomes easier, you will no doubt start to come up with your own state-of-the-art programs. ■

Price and ordering information relevant to the 8051 single board computer and the associated software is available from **Suncoast Technologies, P.O. Box 5835, Spring Hill, Florida FL 34606, U.S.A.**

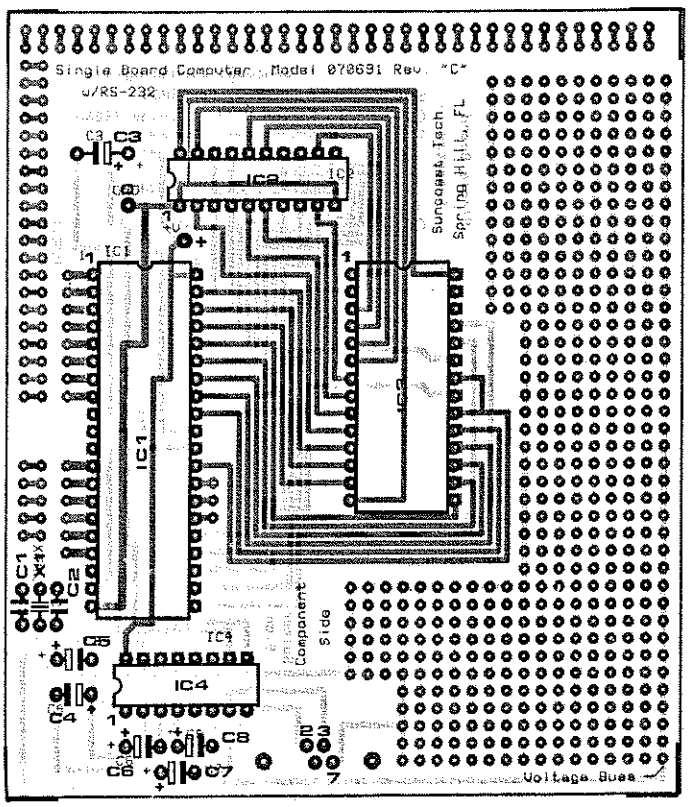

Fig. 3b. Component mounting plan.