MAXIM
MAX147 Evaluation System/Evaluation Kit

Evaluates: MAX146/MAX147

General Description

The MAX147 evaluation system (EV system) is a complete, low-cost, 8-channel data-acquisition system consisting of a MAX147 evaluation kit (EV kit) and a Maxim 68HC16 or 80C32 microcontroller (µC) module. IBM PC-compatible software provides a handy user interface to exercise the MAX147's features. Source code is provided.

Order the EV system for comprehensive evaluation of the MAX147 using a personal computer. Order the EV kit if the 68HC16 or 80C32 µC module was purchased previously with another Maxim EV system, or for custom use in other µC-based systems.

The MAX147 EV kit evaluates both the MAX147 and the MAX146. To evaluate the MAX146, order a free sample of the MAX146BCPP along with the MAX147 EV kit.

Component List

DESIGNATION	QTY	DESCRIPTION
C1, C7–C14	9	0.01µF ceramic capacitors
C2, C4, C6, C15, C17–C20	8	0.1µF ceramic capacitors
C3	1	4.7µF tantalum capacitor
C5	1	10µF tantalum capacitor
C16	1	0.047µF ceramic capacitor
J1	1	2x20 right-angle socket
J18	1	10-pin header
JU1, JU2, JU5	3	2-pin jumpers
R1–R8	8	1kΩ, 5% resistors
R9	1	10kΩ, 5%, 10-pin SIP resistor pack
R10–R13	0	Open
R14	1	220kΩ, 5% resistor
R15	1	180kΩ, 5% resistor
R16	1	100kΩ trim pot
R17, R21	2	1MΩ, 5% resistors
R18	1	100Ω, 5% resistor
U1	1	Maxim MAX147BCPP
U2	1	Maxim MAX872CPA
U3	1	Maxim MAX393CPE
U4	1	Maxim MAX666CPA
U5	1	Maxim MAX495CPA
U6	1	74HCT04
U7	1	Maxim MAX494CPD
None	1	PC board
None	1	Software disk, MAX147 Evaluation Kit

Features

♦ **Proven PC Board Layout**

♦ **Complete Evaluation System**

♦ **Convenient Test Points Provided On-Board**

♦ **Data-Logging Software**

♦ **Source Code Provided**

♦ **Fully Assembled and Tested**

Ordering Information

PART	TEMP. RANGE	BOARD TYPE
MAX147EVKIT-DIP	0°C to +70°C	Through-Hole
MAX147EVC16-DIP	0°C to +70°C	Through-Hole
MAX147EVC32-DIP	0°C to +70°C	Through-Hole

MAX147EVC16 System Component List

QTY	DESCRIPTION
1	MAX147 Evaluation Kit (MAX147EVKIT-DIP)
1	68HC16 µC Module (68HC16MODULE-DIP)

MAX147EVC32 System Component List

QTY	DESCRIPTION
1	MAX147 Evaluation Kit (MAX147EVKIT-DIP)
1	80C32 µC Module (80C32MODULE-DIP)

MAX147 Stand-Alone EV Kit

The MAX147 EV kit provides a proven PC board layout to facilitate evaluation of the MAX147. It must be interfaced to appropriate timing signals for proper operation. Refer to the MAX147 data sheet for timing requirements.

The MAX147 EV kit operates with either a 3V supply or a 5V supply. The EV kit's own 3V regulator is powered by a user-supplied 5V source. Trim pot R16 sets the actual 3V voltage. R16 is adjustable from approximately 2.3V to 3.6V.

If a 3V power supply is already in use, disable the on-board 3V regulator by unplugging the MAX666 from its socket. Then connect the 3V supply to the VDD input pad.

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For small orders, phone 408-737-7600 ext. 3468.

3V-Only Systems

For 3V systems, unplug the MAX666 regulator and connect your 3V power supply to the VDD input pad. Connect the 3V and 5V input pads to each other to power the MAX393. (The MAX393 can be powered with 3V or 5V. See *Detailed Description of Hardware* section.) For development flexibility, the EV kit uses a MAX393 to route the EXTCOM signal to COM or to the CH0 input. Obtain the 3V DOUT and SSTRB signals from the header J18, not from the 40-pin connector (3V-only systems do not require the 74HCT04 level translator).

Systems Using 5V Logic

For 5V-logic systems, the 74HCT04 translates the MAX147's 3V outputs to 5V levels. The MAX147's input may be driven directly by 5V logic levels (obtain the 5V DOUT and SSTRB signals from the 40-pin connector). For 5V-only applications, refer to the MAX186/MAX188 analog-to-digital converters.

MAX147 EV System

The MAX147 EV system operates from a user-supplied 9V to 20V DC power supply, from which it generates a 5V supply for the µC board. A 3V regulator supplies power to the MAX147. 3V to 5V level translators are provided to interface the MAX147 with the µC board.

Quick Start

1) Copy the files from the distribution disk to your hard disk or to blank floppy disks. Make sure that the MAX147 EV kit software is in its own directory. The necessary files are in the root directory of the distribution disk, and the source code is in the SOURCE subdirectory. The SOURCE subdirectory is not required to operate the EV system.

2) Carefully connect the boards by aligning the MAX147 EV kit's 40-pin header with the µC module's 40-pin connector. Gently press them together, so that they are flush against one another.

3) Connect a 9V to 15V DC power source to the µC module at the terminal block. This is located next to the on/off switch, in the upper-right corner of the µC module. Observe the polarity marked on the board.

4) Connect a cable from the computer's serial port to the µC module. For a 9-pin serial port, use a straight-through, 9-pin female-to-male cable. If the only available serial port uses a 25-pin connector, a standard 25-pin to 9-pin adapter is required. The EV kit software checks the modem status lines (CTS, DSR, DCD) to confirm that the correct port is selected.

5) Start the MAX147 software on the IBM PC by setting the current directory to match the directory containing the Maxim programs, then type the program name *MAX147*. Do not turn off or disconnect the µC module while the program is running; if you do, you will have to restart the program.

6) The program asks which µC module is in use and to which port it is connected (the default µC is the 68HC16). For the 80C32 µC module, press µC to select the 80C32. Press the space bar until the correct PC serial port is highlighted, and press ENTER. The MAX147 program is now in terminal-emulation mode.

7) Turn on the µC module's power. The module displays its log-on banner and tests its RAM.

8) Download and run the RAM resident program on the µC module by pressing ALT+L (i.e., hold down the ALT key as you strike the L key). The program prompts you for the file name. Press the ENTER key to download and run the file.

9) Press ALT+C to switch to the control panel screen after the RAM resident program is successfully downloaded.

10) Apply input signals to the CH0–CH7 inputs at the top edge of the MAX147 EV kit board. Observe the readout on the screen. Table 3 lists the commands available from the control panel screen.

11) Before turning off power to the MAX147 EV kit, exit the program by pressing ALT+X.

Evaluating the MAX146

To evaluate the MAX146, turn off power to the EV kit, remove the MAX147 IC, and replace it with a MAX146BCPP. Disable the external reference by removing jumpers JU2 and JU5. Type *MAX147 146* to start the software.

Detailed Description of Software

Shutdown Power Cycling (MAX147)

From the control panel, use the up/down arrow keys to select the power cycling mode. Power cycling puts the MAX147 in powerdown (FULLPD) mode between readings. The MAX147 is always fully powered during conversions.

Shutdown Power Cycling (MAX146)

From the control panel, use the up/down arrow keys to select the power cycling mode. The MAX146 supports FULLPD mode as well as FASTPD mode, where the

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internal 1.2V bandgap reference remains active. The MAX146 is always fully powered during conversions.

Low-Speed Data Logging

The RS-232 serial link limits the data-logging sample rate to no more than 10sps (samples per second). The data-logging command is used to write data to a user-specified file in plain comma-spaced-value text format. From the control panel screen, press L. If a log file is not already open, the software asks for a file name. Only one log file is allowed per session. Once a log file is open, press L to toggle data logging on or off.

With data logging enabled, "Logging" flashes on the screen. One complete line of data is written after all enabled channels are sampled.

The first line of the log file contains the column headings. Each subsequent line of the log file contains all eight channels, separated by commas. The values are written as raw decimal output codes or as scaled voltages, depending on which setting the control panel is currently displaying. Use the C and V commands to select the display format (Table 3). F3, the log data marker command, can be used to sequentially tag different sections of the log file to indicate a change in setup or input conditions. Pressing F3 writes an extra entry at the end of the current line of the data log, to indicate a change in setup or input conditions.

High-Speed Data Sampling

The S command samples rates over 10 samples per second (sps). Data is collected from only one of the eight channels at a rate from 100sps to 91ksps. First, select the channel by pressing one of the number keys 0–7. Next, press F to specify the name of the file into which the samples should be written. If the file already exists, the screen displays "*** file already exists ***". To begin collecting data, press B. After the samples are collected, the data is automatically uploaded to the host and stored in the sample file.

Controlling the Sampling Rate

The rate for high-speed sampling, data logging, and the oscilloscope demo mode (Table 3, key O) is controlled by the D (delay between samples) command.

When used with the sample or oscilloscope demo commands, specify the approximate delay in microseconds or milliseconds by typing D, then the number, then "µsec" or "msec". Always verify timing by using an oscilloscope, since this delay is not linear due to code overhead. The fast sampling screen and oscilloscope demo mode use delays from 100µs to 1000µs. The 68HC16 software supports delays between 68µs and 1000ms. The 80C32 software supports delays between 450µs and 70ms.

When used with the slower data-logging command, specify the delay in seconds. The delay is between enabled channels, and one line of data is logged after all enabled channels have been polled.

COM Voltage

COM is connected to ground (default) or to a user-supplied analog common voltage applied to the EXTCOM input pad. Press F6 to select the desired COM connection.

The EV kit software can measure a user-applied COM voltage. When F4 is pressed from the control panel screen (Table 3), the software connects the EXTCOM input pad to input channel 0. Next, the software connects COM to ground. The channel 0 voltage is measured in single-ended unipolar mode. The measurement is performed several times and averaged. After measuring the external COM pad voltage, the switches are restored to their previous configuration.

Operating with QSPI, 24 Bits per Transfer

The EV kit software program KIT147.S19 loaded into the 68HC16 module uses a 24-bits-per-transfer mode, which operates at 59ksps throughput. Refer to the timing diagrams in the *Clock Modes* section of the MAX147 data sheet.

Table 1. Recommended QSPI Setup Parameters for 24 Bits per Transfer (used in KIT147.S19)

PARAMETER	VALUE
SPBR	5 (1.68MHz)
CPOL	0 (clock is idle low)
CPHA	0 (data is stable on clock rising edge)
BITS	16 (when enabled)
DTL	4 (7.6µs delay used in internal clock mode)
TR0	0000 0000 1xxx xxyy (configure and start conversion)
TR1	0000 0000 0000 0000 (read data)
CR0	External clock: 1000 xxx0 (hold CS low). Internal clock: 1010 xxx0 (hold CS low; DT delay after transfer).
CR1	0100 xxx0 (16-bit enable)
RR1	Received data, left justified, with one leading zero bit

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Operating with QSPI, 16 Bits per Transfer

The program KIT14716.S19 demonstrates the 16-bits-per-transfer interface scheme, which operates at 91ksps throughput. In this demonstration, $\overline{CS}$ is held low and the QSPI operates continuously in the background. Refer to the timing diagrams in the *Clock Modes* section of the MAX147 data sheet. To use this program, follow the instructions in *Quick Start*, but in step 8, download KIT14716.S19 instead of KIT147.S19. After loading, press ALT+C to switch to the control panel.

Changing the Reference Voltage

The MAX147 EV kit software assumes a 2.5V reference voltage, unless otherwise specified. When using a reference value other than 2.5V, specify the value when starting the program. For example, if VREF is driven by a 2.048V reference, start the MAX147 software by typing:

MAX147 VREF 2.048

Or, on the MAX146, if REFADJ is driven by a 1.2V reference, start the MAX147 software by typing:

MAX147 146 REFADJ 1.2

The external reference's temperature coefficient must be 20ppm/°C or less to achieve accuracy to within four LSBs over the 0°C to +70°C temperature range. For 12-bit accuracy over the 0°C to +70°C range, the reference's temperature coefficient must be 4ppm/°C or less.

The MAX146 can use either its internal reference or an external reference. On the EV kit, the internal reference has been disabled by pulling REFADJ up to VDD (JU2) and driving VREF with a MAX872 2.5V reference (JU5).

Table 2. Recommended QSPI Setup Parameters for 16 Bits per Transfer (used in KIT14716.S19)

PARAMETER	VALUE
SPBR	5 (1.68MHz)
CPOL	0 (clock is idle low)
CPHA	0 (data is stable on clock rising edge)
BITS	16
DTL	4 (7.6µs delay used in internal clock mode)
TR0	0000 0001 xxxx xyy0 (configure and start conversion)
CR0	External clock: 1100 xxx0 (16-bit transfer). Internal clock: 1110 xxx0 (16-bit transfer with DT delay).
RR0	Received data, left justified

For lowest component count, enable the MAX146's internal reference by removing the shunts from JU2 and JU5. This enables the internal bandgap reference and the reference buffer, driving VREF internally to 2.5V. A 0.01µF ceramic bypass capacitor near REFADJ (C1 on the EV kit) provides noise filtering for the bandgap reference.

Detailed Description of Hardware

The MAX147 EV kit board includes a MAX666, configured as a 3V regulator. Trim pot R16 adjusts the VDD voltage between 2.3V and 3.6V.

The MAX872 is a micropower 2.5V reference.

The MAX494 and MAX495 are low-voltage, rail-to-rail op amps with 500kHz gain-bandwidth product. The MAX495 buffers the external COM input source. The MAX494 can be used to buffer some of the input signals.

The MAX393 analog switch allows the EV kit software to route the MAX147 COM pin to ground or to the external COM input. In addition, the external COM input can be routed to input channel 0. Typical systems connect COM directly to analog ground or the analog common voltage. The MAX393 can be powered by 3V, but if driven by 5V logic (as is the case with the EV system), it must be powered by 5V.

The 74HCT04 translates the DOUT and SSTRB signals from 3V to 5V logic levels for interfacing to the µC module. The MAX147's logic inputs can be driven directly from 5V logic levels.

Input-Signal Buffering

The analog-to-digital converter (ADC) inputs require a sufficiently low-impedance source for specified accuracy. An ADC can inject a small amount of charge at the start of the acquisition time, and the source signal must recover to within the desired accuracy before the acquisition time ends. If the source by itself cannot do this, use an op amp to buffer the input signal.

To buffer the CH4–CH7 input signals, unplug the 14-pin header from U7, and install the supplied MAX494 quad op amp in its place. Note the location of pin 1 toward the upper right corner of the board.

When using an input buffer, the buffer output cannot reach the power-supply rails. **If the MAX494 op-amp buffer is installed and the input to the buffer is grounded, the buffered output will not reach ground.** The MAX494 allows its output signal to go to within approximately 50mV of either supply.

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Table 3. MAX147 EV Kit Command Reference

KEY	FUNCTION
0, 1, 2, 3, 4, 5, 6, 7	Enables or disables the corresponding input channel 0, 1, 2, 3, 4, 5, 6, or 7. The EV kit software scans all enabled channels.
C	Displays the conversion results in decimal form.
D	Delay between samples. Delays longer than one second are handled by the IBM PC; otherwise, the µC module handles the delay. Timing is approximate and should be verified with an oscilloscope.
L	Enables or disables data logging. If the -L command-line option was not specified, the L command prompts for a log-file name.
O	Oscilloscope demo. Samples are collected and discarded as fast as possible. Observe waveforms and timing with an oscilloscope.
P	Power-up delay. Timing is approximate and should be verified with an oscilloscope. When using an external reference, power-up delay is not necessary and should be set to zero. Power-up delay is used regardless of which power-cycling mode is selected.
S	Samples one of the eight inputs at high speed. The sampling rate is controlled by the P and D delays. Due to program overhead, the O and S commands operate at different rates. Timing should be verified with an oscilloscope.
V	Displays the conversion results in volts.
F1	Chooses input scale (unipolar, bipolar, unipolar differential, bipolar differential) for all enabled channels. Disabled channels are unaffected.
F3	Writes a marker into the data-log file.
F4	Measures the value of a user-applied COM voltage.
F5	Changes the assumed value of VREF.
F6	Changes the assumed voltage at COM. Selecting G connects the COM pin to ground; selecting E connects the COM pin to the EXTCOM input pad.
F7	Internal clock mode
F8	External clock mode
⇕	Selects power-down mode.
ALT+T	Switches back to terminal mode.
ALT+X	Exits to DOS.

/VI/XI/VI

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Table 4. Command-Line Options when Starting MAX147 Software

COMMAND	FUNCTION
1	Defaults to COM1 PC serial port.
2	Defaults to COM2 PC serial port.
MONO	For use with monochrome or LCD display.
-L*filename*	Opens file *filename* for data logging and enables the data-logging commands.
VREF *vvv*	Specifies the actual measured voltage at the VREF pin (nominally 2.5V).
COM *vvv*	Specifies the voltage at the COM pin.
?	Lists command-line options.
146	Enables MAX146-specific program features (FASTPD power-down mode).

Table 5. Jumper Settings on MAX147 EV Kit

JUMPER	STATE	FUNCTION
JU1	Closed	Ties $\overline{\text{SHDN}}$ to pin 29 on the µC module.
	Open (default)	Forces $\overline{\text{SHDN}}$ to float.
JU2*	Closed (default)	Disable internal reference. VREF is an input.
	Open	Enable internal reference. VREF is a 2.5V output (**not** allowed with MAX147).
JU3	Closed (default trace)	Current-sense jumper. The MAX147 draws its +3V supply through this trace.
	Open	Do not operate kit with JU3 open.
JU4	Closed (default trace)	Switch U3 drives COM.
	Open	COM must be driven by an external source.
JU5*	Closed (default)	Drive VREF with external reference.
	Open	Use internal reference (**not** allowed with MAX147).

If JU2 is open, JU5 must also be open.

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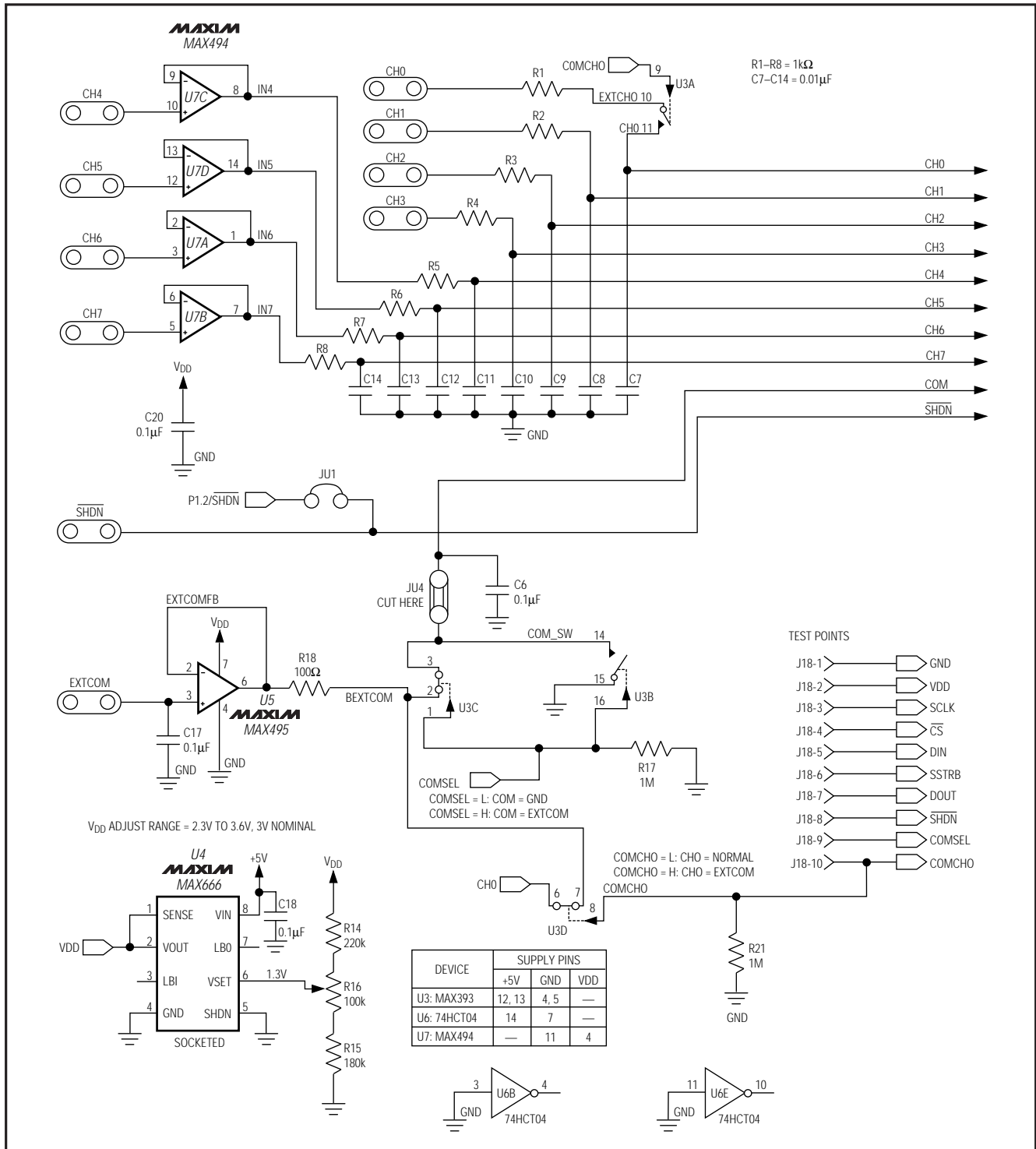
Figure 1. MAX147 EV Kit Schematic

DEVICE	SUPPLY PINS		
	+5V	GND	VDD
U3: MAX393	12, 13	4, 5	—
U6: 74HCT04	14	7	—
U7: MAX494	—	11	4

R1–R8 = 1kΩ
C7–C14 = 0.01µF

V_DD ADJUST RANGE = 2.3V TO 3.6V, 3V NOMINAL

COMSEL = L: COM = GND
COMSEL = H: COM = EXTCOM

COMCHO = L: CHO = NORMAL
COMCHO = H: CHO = EXTCOM

TEST POINTS

J18-1	GND
J18-2	VDD
J18-3	SCLK
J18-4	$\overline{CS}$
J18-5	DIN
J18-6	SSTRB
J18-7	DOUT
J18-8	$\overline{SHDN}$
J18-9	COMSEL
J18-10	COMCHO

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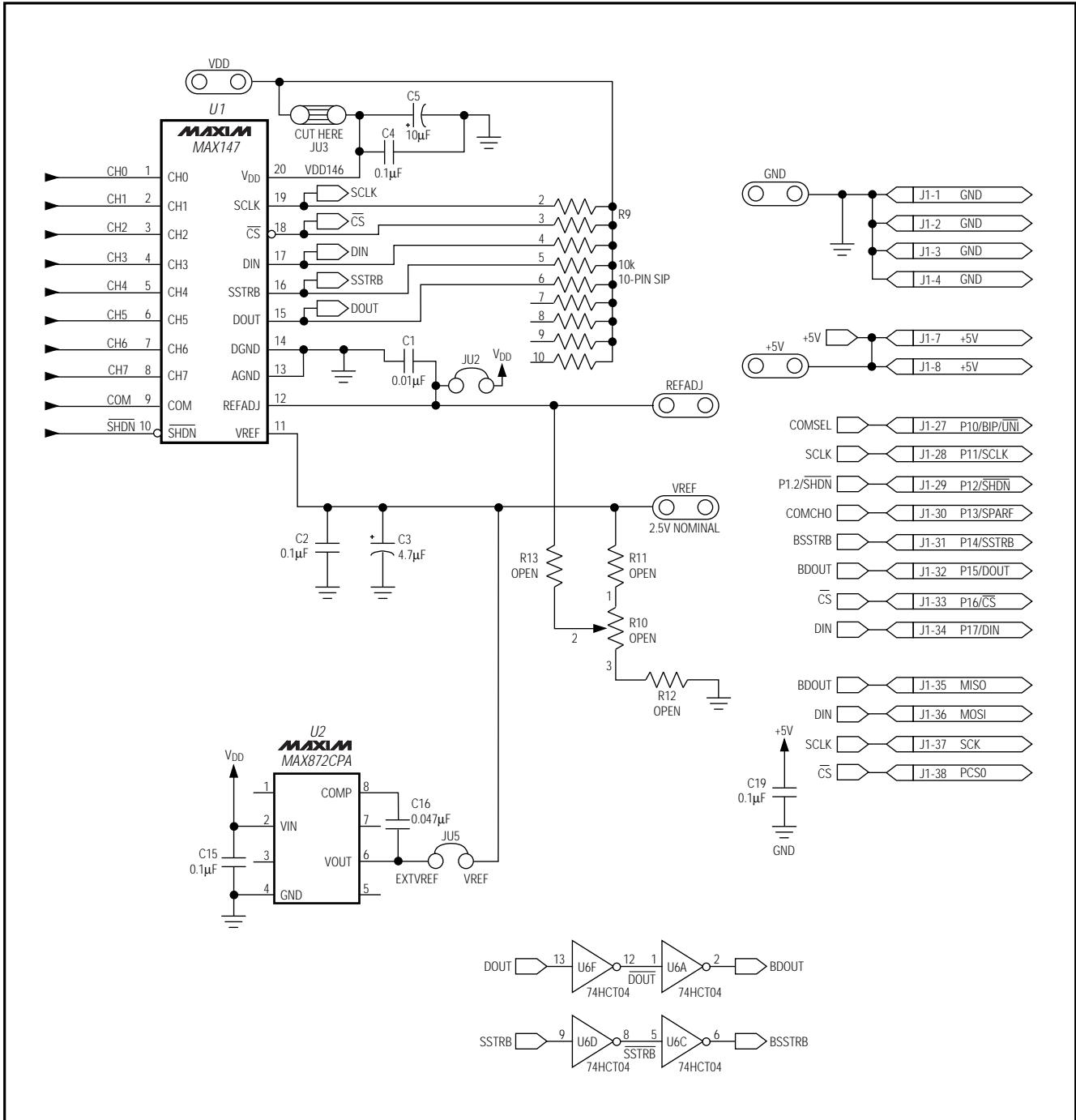
Figure 1. MAX147 EV Kit Schematic (continued)

MAX147 Evaluation System/Evaluation Kit
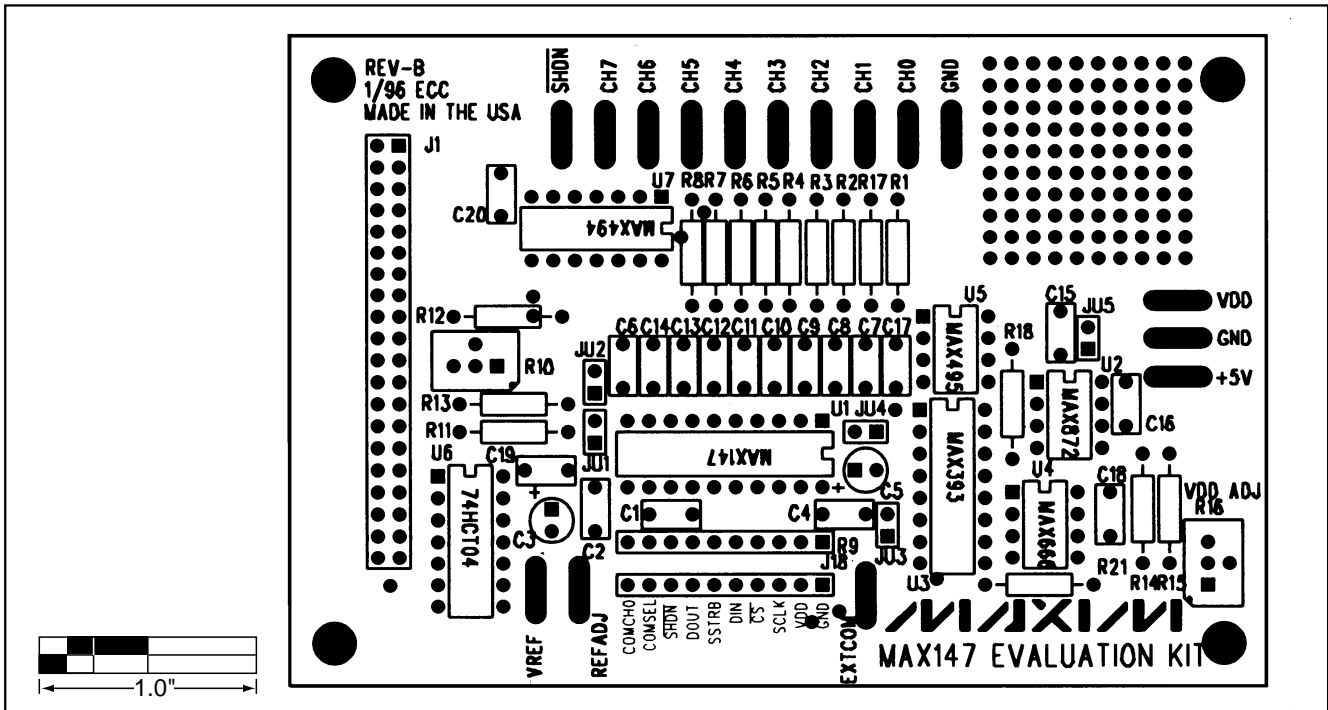
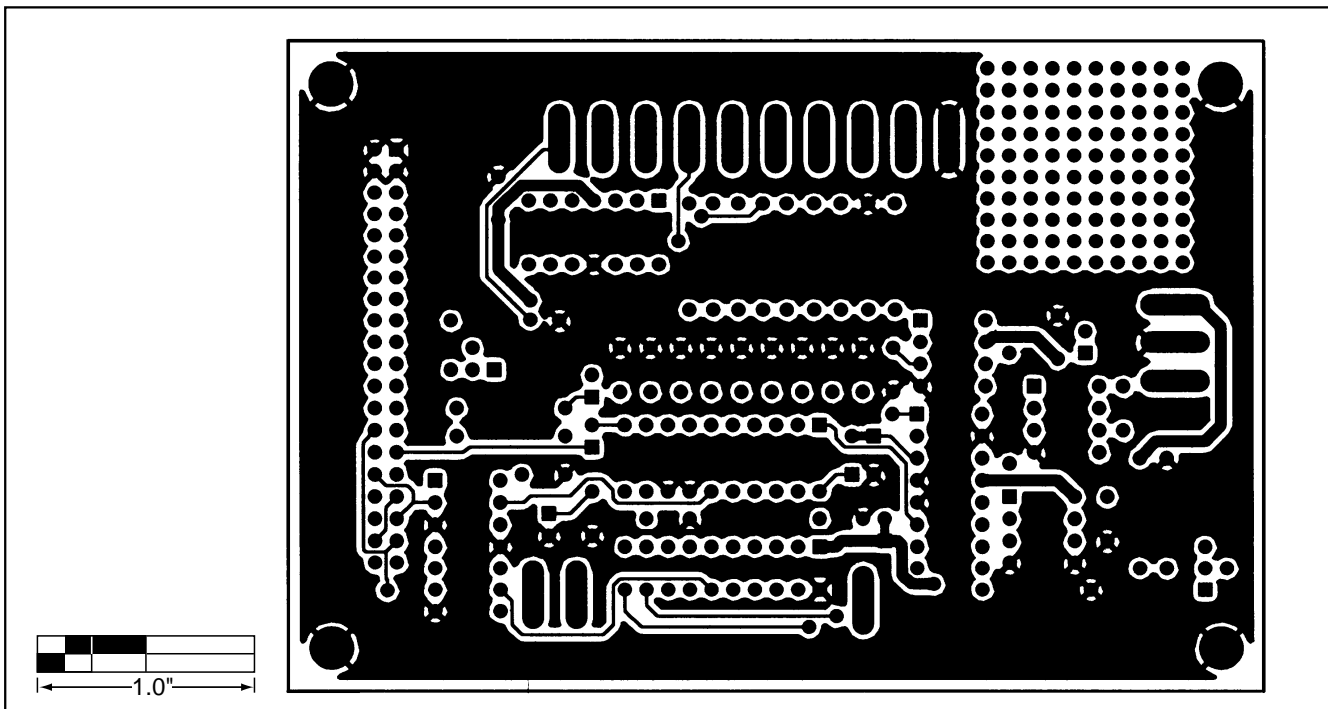Figure 2. MAX147EV Kit Component Placement Guide—Component Side

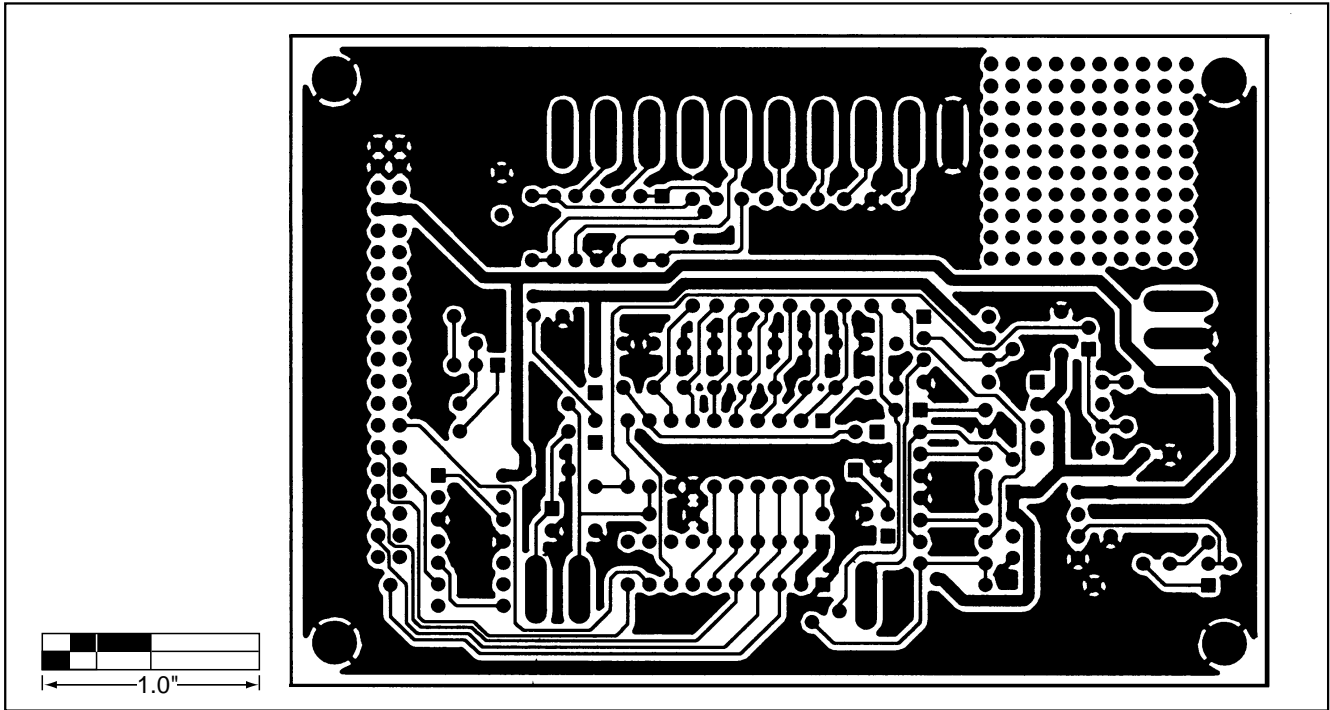Figure 3. MAX147EV Kit PC Board Layout—Component Side

Figure 4. MAX147EV Kit PC Board Layout—Solder Side

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Listing 1a. Using the 68HC16 to Read the MAX147

```
QSPI Setup for 16 bits per transfer   (KIT14716)

InitADC:
        LDAA    #(BipUniPin)!(ShdnPin) ; initially high GPT pins
        STAA    GPTPDR
        LDAA    #(BipUniPin)            ; GPT output pins
        STAA    PDDR
        LDAA    #(CSto147)              ; initially high QSM pins
        STAA    QPDR
        LDAA    #(CSto147)!(SCKto147)!(DinTo147)!(DoutFrom147)      ; QSPI pins
        STAA    QPAR
        LDAA    #(CSto147)!(SCKto147)!(DinTo147)      ; QSPI output pins
        STAA    QDDR
        LDAA    #(CRBITSE)!(CRCONT)    ; 16 bit transfer, hold CS low between transfers
        STAA    CR0
        LDD     #%100001110            ; initial control word, with one following zero
        STD     TR0

        CLR     SPCR3          ; disable halt mode interrupt
        LDD     #$8005         ; Master, BITS=16, CPOL=0, CPHA=0, SPBR=5 (1.68 MHz)
        STD     SPCR0
        LDD     #$0204         ; DTL=4 (7.6 usec)
        STD     SPCR1
        LDD     #$6000         ; NEWQP=0, ENDQP=0, Wrap to NEWQP, no interrupt
        STD     SPCR2

        BSETW   SPCR1,#$8000   ; start the QSPI
        BCLR    SPSR,#$80      ; clear SPIF bit

ReadADC:
        LDD     RR0
        RTS
```

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Listing 1b. Using the 80C32 to Read the MAX147

```
80C32 Interface to MAX147

Read:   clr     CS                  ; assert chip select

If a power-up delay is used...
                mov     a,control_byte
                orl     a,#003h          ; Power On, External Clock Mode
                mov     SPIout,a
                call    SPI00Transfer  ; start dummy conversion
                setb    CS
                (execute power-up delay)
                clr     CS                  ; interrupt dummy conversion

        mov     SPIout,control_byte
        call    SPI00Transfer   ; send the start command

If internal clock mode is being used, wait until SSTRB is set
L1:     jnb     SSTRB, L1       ; loop while SSTRB is low

        mov     SPIout,#0
        call    SPI00Transfer   ; get the first 8 bits
        mov     data_high,SPIin
        mov     SPIout,#0
        call    SPI00Transfer   ; get the next 8 bits
        mov     data_low,SPIin
        setb    CS              ; negate chip select
        clr     c               ; shift data left
        mov     a,data_low
        rlc     a
        mov     data_low,a
        mov     a,data_high
        rlc     a
        mov     data_high,a
        ret

SPI00Transfer:                  ; simulate SPI with CPOL=0, CPHA=0
        setb    DOUT            ; use DOUT as an input
        clr     SCK             ; start with clock low
        mov     r2,#8           ; get 8 bits
loop:   mov     c,SPIout.7      ; write bit on DIN output
        mov     DIN,c
        setb    SCK             ; CLOCK RISING EDGE
        mov     c,DOUT          ; read bit on DOUT input
        mov     SPIin.7,c
        clr     SCK             ; CLOCK FALLING EDGE
        mov     a,SPIout        ; shift left
        rl      a
        mov     SPIout,a
        mov     a,SPIin         ; shift left
        rl      a
        mov     SPIin,a
        djnz    r2,loop         ; repeat 8 times
        ret
```

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68HC16 Module

_____*68HC16 Module Component List*

DESIGNATION	QTY	DESCRIPTION
C1, C2, C3	3	1µF ceramic capacitors
C4, C5	2	22µF, 25V radial-lead electrolytic capacitors
C6, C7	2	22pF capacitors
C8	1	0.01µF capacitor
C9	0	Reference designator, not used
C10–C14	5	0.1µF capacitors
D1	1	1N4001 diode
J1	1	40-pin right-angle male connector
J2	1	2-circuit terminal block
J3	1	Right-angle printed circuit board mount, DB9 female socket
J4	0	Open
JU1	0	Open
JU2	0	Reference designator, not used
JU3	0	Open
JU4	0	Open
JU5	0	Open
L1	0	Open
L2	0	Open
LED1	1	Light-emitting diode
R1	1	10MΩ, 5% resistor

DESIGNATION	QTY	DESCRIPTION
R2	1	330kΩ, 5% resistor
R3, R4	2	10kΩ, 5% resistors
R5	1	470Ω, 5% resistor
R6	1	10kΩ SIP resistor
SW1	1	Slide switch
SW2	1	Momentary pushbutton switch
U1	1	68HC16 µC MC68HC16Z1CFC16 (132-pin plastic quad flat pack)
U2	1	Maxim MAX233CPP
U3	1	27C256 EPROM containing monitor program
U4	1	7805 regulator, TO-220 size
U5	1	62256 (32K x 8) static RAM
U6	1	74HCT245 bidirectional buffer
U7	1	Maxim MAX707CPA
Y1	1	32.768kHz watch crystal
None	4	Rubber feet
None	1	28-pin socket for U3
None	1	20-pin socket for U6
None	1	3" x 5" printed circuit board
None	1	Heatsink for U4, thermalloy # 6078

68HC16 Module _____*General Description*

The 68HC16 module is an assembled and tested printed-circuit board intended for use with Maxim's high-speed serial-interface evaluation kits (EV kits). The module uses an inexpensive 8-bit implementation of Motorola's MC68HC16Z1 microcontroller (µC) to collect data samples at high speed using the QSPI™ interface. It requires an IBM-compatible personal computer and an external DC power supply, typically 12V DC or as specified in EV kit manual.

Maxim's 68HC16 module is provided to allow customers to evaluate selected Maxim products. It is not intended to be used as a microprocessor development platform, and such use is not supported by Maxim.

68HC16 Module _____*Detailed Description*

Power Input Connector J2

The 68HC16 module draws its power from a user-supplied power source connected to terminal block J2. Be sure to note the positive and negative markings on the board. A three-terminal 5V regulator allows input voltages between 8V and an absolute maximum of 20V. The 68HC16 module typically requires 200mA of input current.

68HC16 Microcontroller

U1 is Motorola's 68HC16Z1 µC. Contact Motorola for µC information, development, and support. Maxim EV kits use the high-speed queued serial peripheral interface (QSPI) and the internal chip-select generation.

A MAX707 on the module monitors the 5V logic supply, generates the power-on reset, and produces a reset pulse whenever the reset button is pressed.

QSPI is a trademark of Motorola Corp.

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The 68HC16 uses a phase-locked loop (PLL) to set its bus speed. Crystal Y1 is a 32.768kHz frequency reference. The internal oscillator runs 256 times faster than the external crystal. When the 68HC16 is reset, it waits for the PLL to lock before it executes any software. After the PLL locks onto the reference frequency, the software doubles the clock speed by writing to the clock synthesizer control register, selecting a bus speed of 16.78MHz.

U5, the user RAM area, is a 32kbyte CMOS static RAM.

The 74HCT245 octal buffer lets the 68HC16 module access an 8-bit port on the 40-pin interface connector. This memory-mapped port consists of separate read and write strobes, four chip selects, four address LSBs, and eight data bits.

Serial Communications

J3 is an RS-232 serial port, designed to be compatible with the IBM PC 9-pin serial port. Use a straight-through DB9 male-to-female cable to connect J3 to this port. If the only available serial port has a 25-pin connector, you may use a standard 25-pin to 9-pin adapter. Table 1 shows the pinout of J3.

The MAX233 is an RS-232 interface voltage level shifter with two transmitters and two receivers. It includes a built-in charge pump with internal capacitors that generates the output voltages necessary to drive RS-232 lines.

40-Pin Data Connector J1

The 20 x 2 pin header connects the 68HC16 module to a Maxim EV kit. Table 2 lists the function of each pin. Note that 68HC16 object code is not compatible with 68HC11 object code. Use the 68HC16 module only with those modules that are designed to support it, and only download code that is targeted for the 68HC16 module. Downloading incorrect object code into the 68HC16 module will have unpredictable results.

Address Ranges

The 68HC16 µC generates various enable signals for different address ranges. The ROM and RAM enable signals are fed directly to the respective chips. Several additional signals (J1.11–J1.14) are available on the data connector to be used by Maxim EV kits. Table 3 outlines the address ranges for each of the elements found on the 68HC16 module, and Table 4 is a truth table that describes the logic for each of the 68HC16's chip-select outputs. Because the addresses are not completely decoded, the boot ROM and user RAM have shadows.

Table 1. Serial Communications Port J3

PIN	NAME	FUNCTION
1	DCD	Handshake; hard-wired to DTR and DSR
2	RXD	RS-232-compatible data output from 68HC16 module
3	TXD	RS-232-compatible data input to 68HC16 module
4	DTR	Handshake; hard-wired to DCD and DSR
5	GND	Signal ground connection
6	DSR	Handshake; hard-wired to DCD and DTR
7	RTS	Handshake; hard-wired to CTS
8	CTS	Handshake; hard-wired to RTS
9	None	Unused

Table 2. 40-Pin Data-Connector Signals

PIN	NAME	FUNCTION
1–4	GND	Ground
5, 6	VPREREG	Unregulated input voltage
7, 8	VCC	+5V from on-board regulator
9	$\overline{RD}$	Read strobe
10	$\overline{WR}$	Write strobe
11	$\overline{7E000}$	Chip select for 7E000–7E7FF
12	$\overline{7E800}$	Chip select for 7E800–7EFFF
13	$\overline{7F000}$	Chip select for 7F000–7F7FF
14	$\overline{7F800}$	Chip select for 7F800–7FFFF
15	A00	Address bit 0 (LSB)
16	A01	Address bit 1
17	A02	Address bit 2
18	A03	Address bit 3
19	EXTD0	Buffered data bus 0 (LSB)
20–26	EXTD1–7	Buffered data bus bits 1–7
27	IC1	General I/O port bit 0 (LSB)
28	IC2	General I/O port bit 1
29	IC3	General I/O port bit 2
30	OC1	General I/O port bit 3
31	OC2	General I/O port bit 4
32	OC3	General I/O port bit 5
33	OC4	General I/O port bit 6
34	IC4	General I/O port bit 7
35	MISO	QSPI master-in, slave-out
36	MOSI	QSPI master-out, slave-in
37	SCK	QSPI serial clock
38	PCS0/SS	QSPI chip-select output
39	CLKOUT	System clock output
40	PWMA	Pulse-width-modulator output

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Table 3. 68HC16 Module Memory Map (all address values are in 20-bit hex)

PIN	FUNCTION
00000–07FFF	Boot ROM (U3, strobed by CSBOOT)
08000–0FFFF	Shadow of boot ROM
10000–17FFF	User RAM (U5, strobed by CS0 and CS2)
18000–1FFFF	Shadow of user RAM
20000–203FF	Internal standby RAM; 1kbyte
20400–7DFFF	Unused
7E000–7E7FF	External chip select (J1 pin 11) (CS7)
7E800–7EFFF	External chip select (J1 pin 12) (CS8)
7F000–7F7FF	External chip select (J1 pin 13) (CS9)
7F800–7FFFF	External chip select (J1 pin 14) (CS10)
80000–F7FFF	Not accessed by the 68HC16
F8000–FF6FF	Unused
FF700–FF73F	68HC16's built-in ADC (not used)
FF740–FF8FF	Unused
FF900–FF93F	General-purpose timer module (GPT)
FF940–FF9FF	Unused
FFA00–FFA7F	System integration module (SIM)
FFA80–FFAFF	Unused
FFB00–FFB07	Internal standby RAM (SRAM) control registers
FFB08–FFBFF	Unused
FFC00–FFDFF	Queued serial module (QSM)
FFE00–FFFFF	Unused

Boot ROM

The boot ROM, U3, is configured as an 8-bit memory device. Resistor R4 pulls data bit 0 low during system reset, forcing the µC to fetch instructions using only the upper eight data bits. The boot ROM checks the system and waits for commands from the host. Refer to the EV kit manual for specific start-up procedures.

Software

All software is supplied on a disk with the EV kit. Instructions for operating the software are included in the EV kit manual. Refer to the EV kit manual for more information.

_____68HC16 Module Self Check

To test the 68HC16 module's integrity, connect the power supply to the power terminals (J2). Do not connect anything to J1 or J3. Slide the power switch SW1 to the "ON" position. The LED will light up, and will flash within 5 seconds.

If the LED flashes with a 50%-on/50%-off duty cycle, then it passed its self check. Note that this test does not exercise the RS-232 port or the EV kit 40-pin interface, but it does confirm that the power supply, microprocessor, ROM, and RAM passed the self test.

If the LED flashes with a 10%-on/90%-off duty cycle, then it failed its self check. Most likely, the RAM chip (U5) is bad.

If the LED remains on and does not flash, then the problem is either U3 (the EPROM), U1 (the microprocessor), U4 (the regulator), the MAX707 reset generator, or the power supply. Use a voltmeter to verify that the power supplies are good. Check the power-supply input and the +5V output from the regulator. Use an oscilloscope to see if the 32.768kHz reference oscillator is running.

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68HC16 Module *(side margin, vertical)*

Table 4. 68HC16 Chip-Select Outputs Truth Table

ADDRESS RANGE	CSBOOT	CS0	CS1	CS2	CS5	CS6	CS7	CS8	CS9	CS10
0xxxx read	L	H	H	H	H	H	H	H	H	H
1xxxx read	H	H	H	L	H	H	H	H	H	H
1xxxx write	H	L	H	H	H	H	H	H	H	H
7E0xx read	H	H	L	H	H	L	L	H	H	H
7E0xx write	H	H	H	H	L	L	L	H	H	H
7E8xx read	H	H	L	H	H	L	H	L	H	H
7E8xx write	H	H	H	H	L	L	H	L	H	H
7F0xx read	H	H	L	H	H	L	H	H	L	H
7F0xx write	H	H	H	H	L	L	H	H	L	H
7F8xx read	H	H	L	H	H	L	H	H	H	L
7F8xx write	H	H	H	H	L	L	H	H	H	L
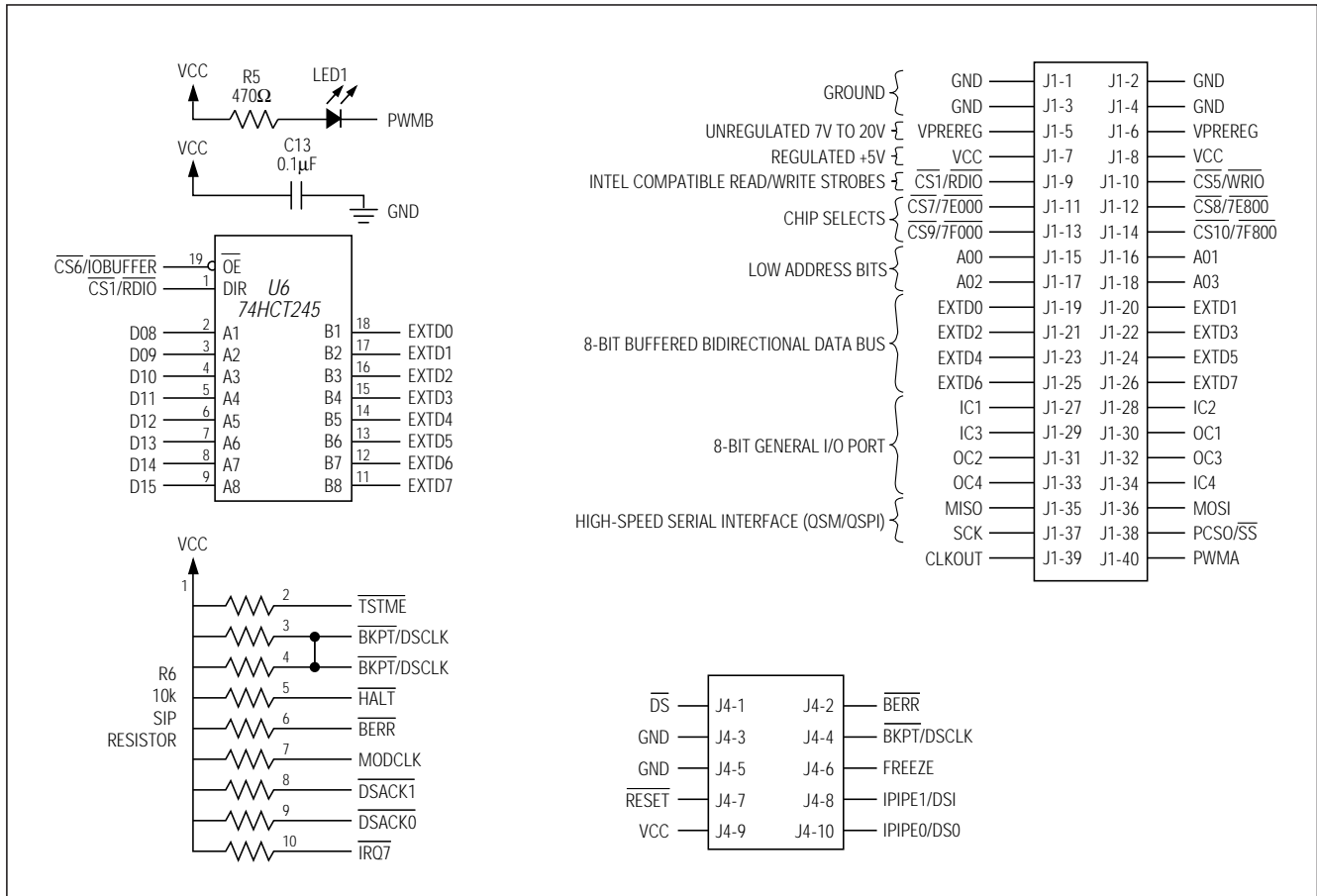
Figure 1. 68HC16 Module Schematic
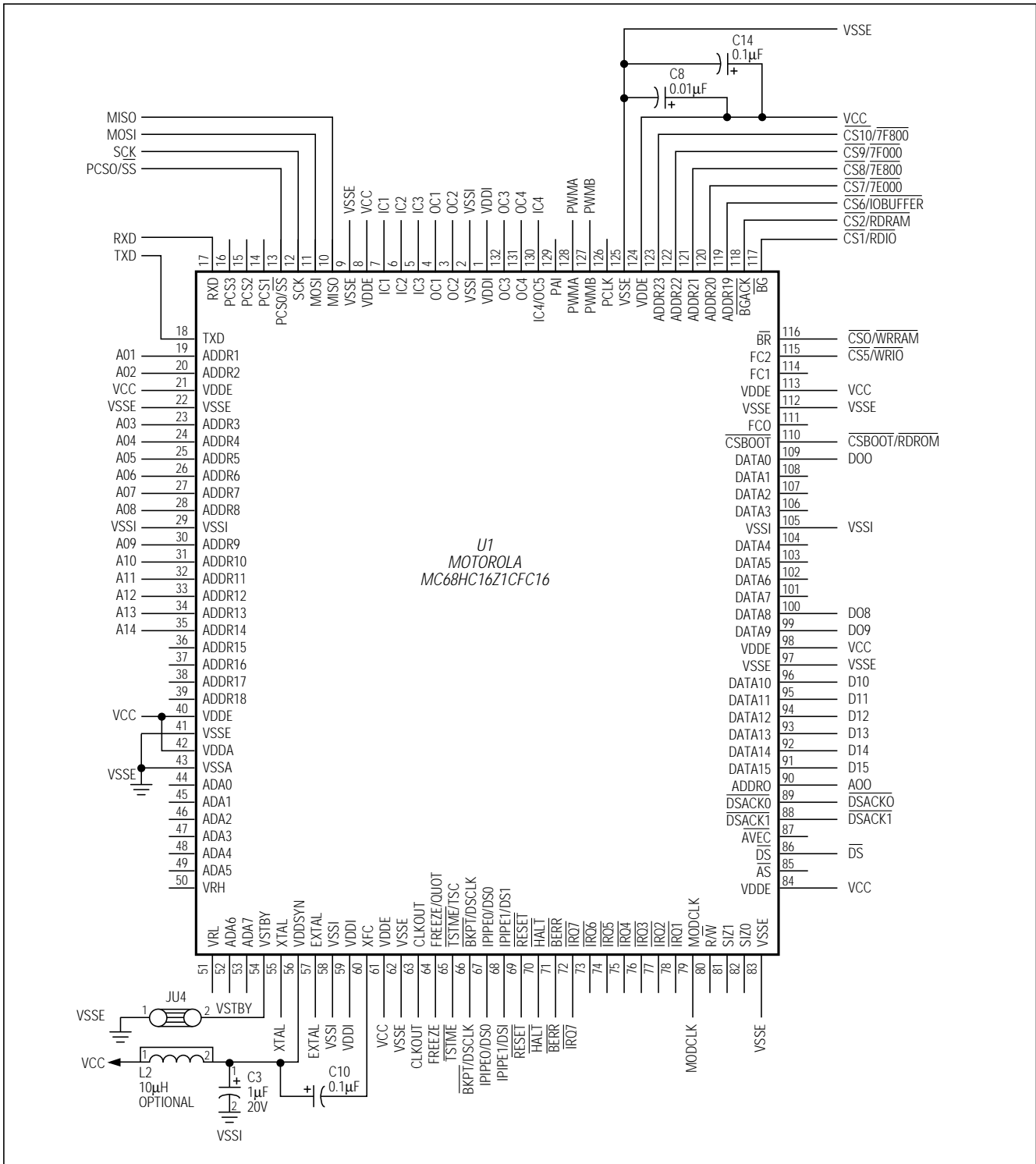
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Figure 1. 68HC16 Module Schematic (continued)

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Figure 1. 68HC16 Module Schematic (continued)

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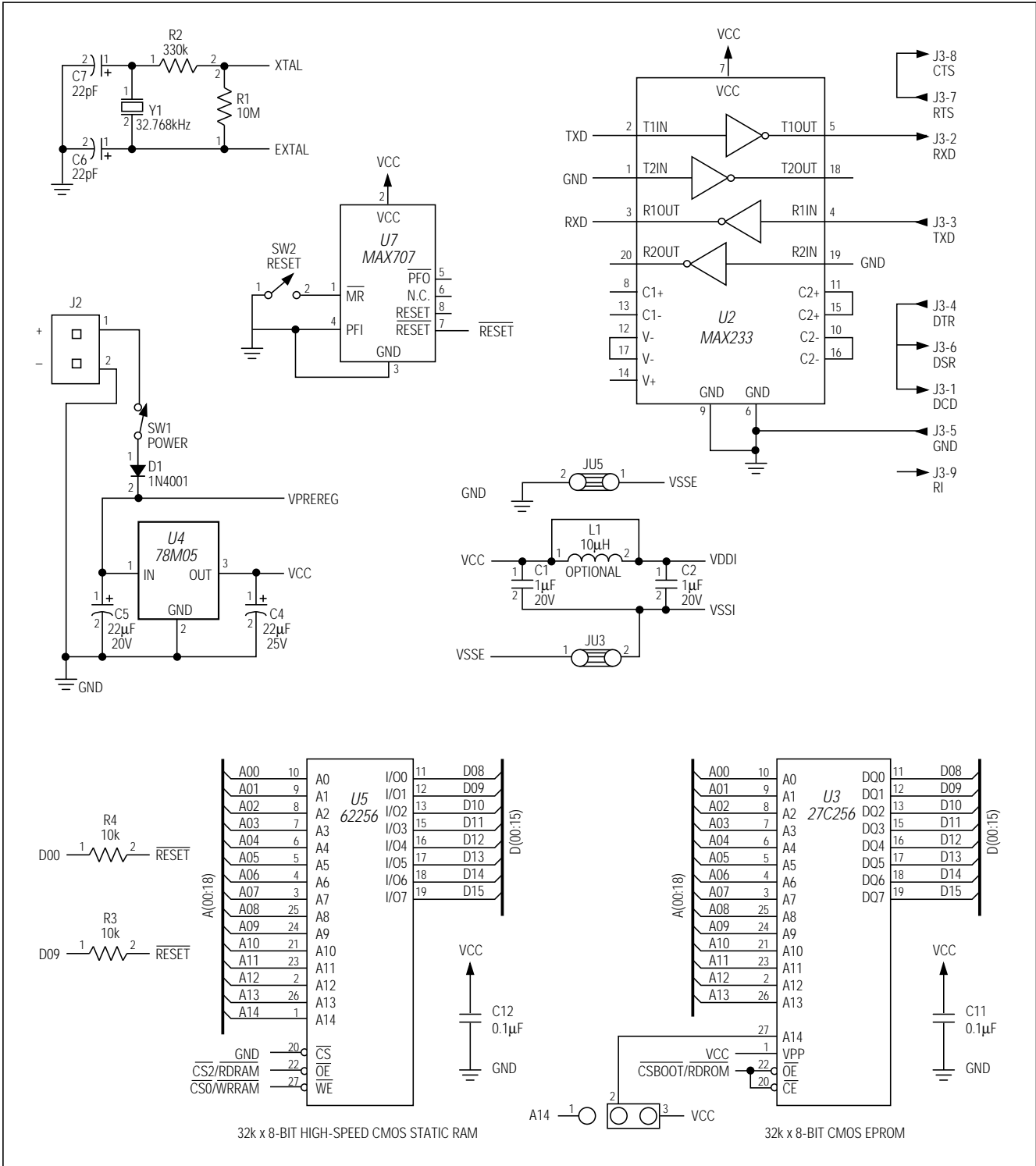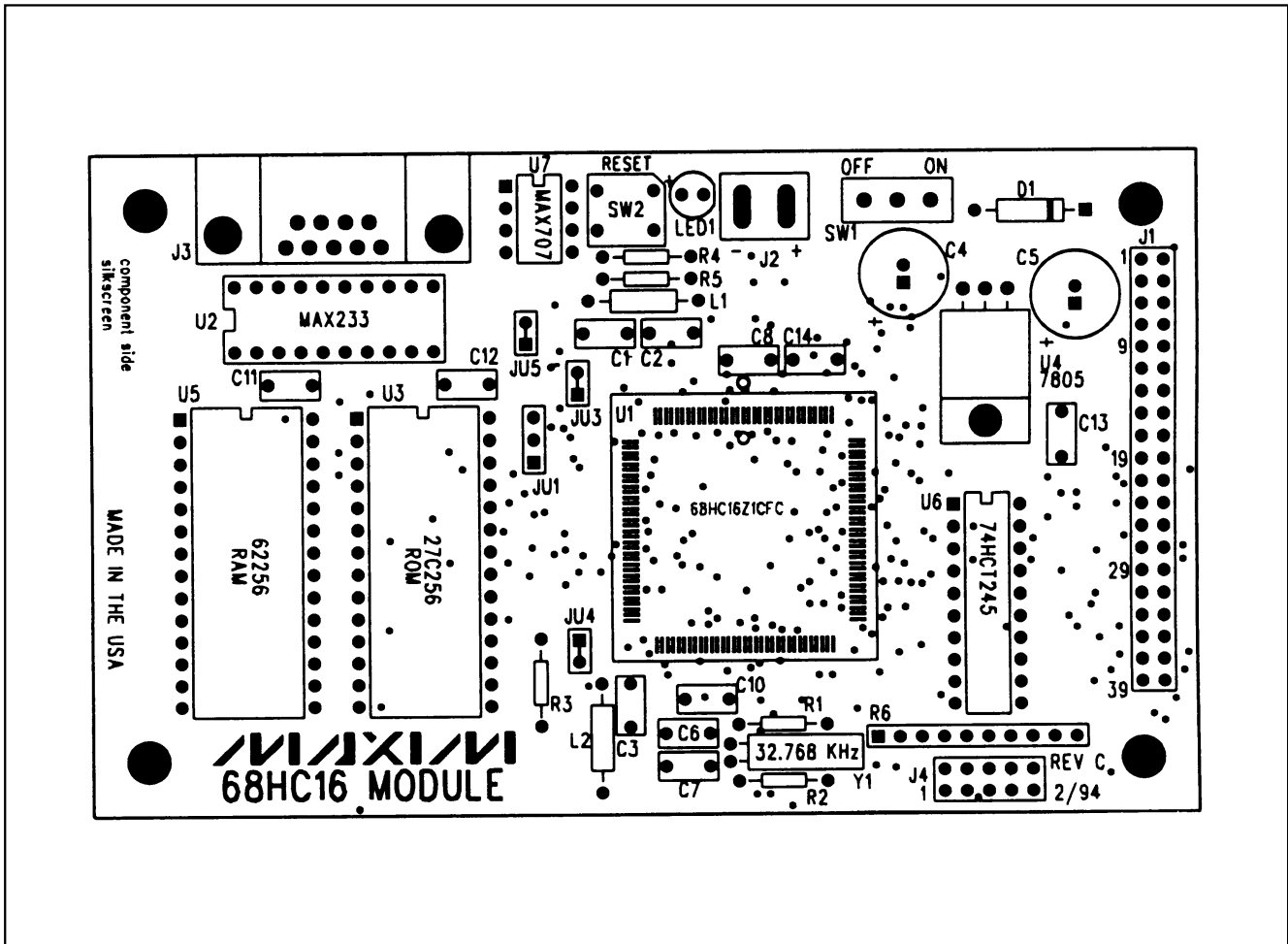
Figure 2. 68HC16 Module Component Placement Guide

68HC16 Module
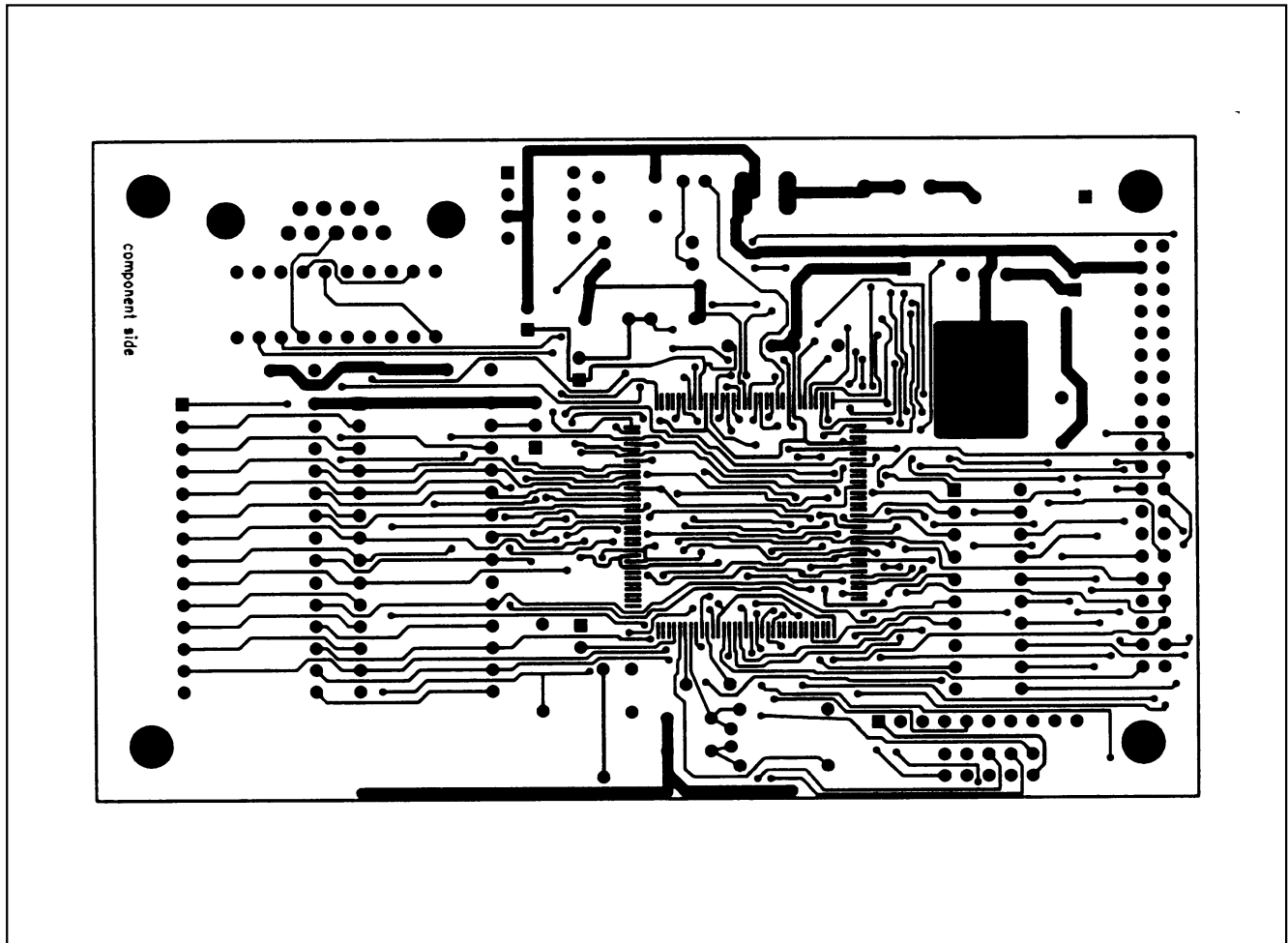
Figure 3. 68HC16 Module PC Board Layout—Component Side

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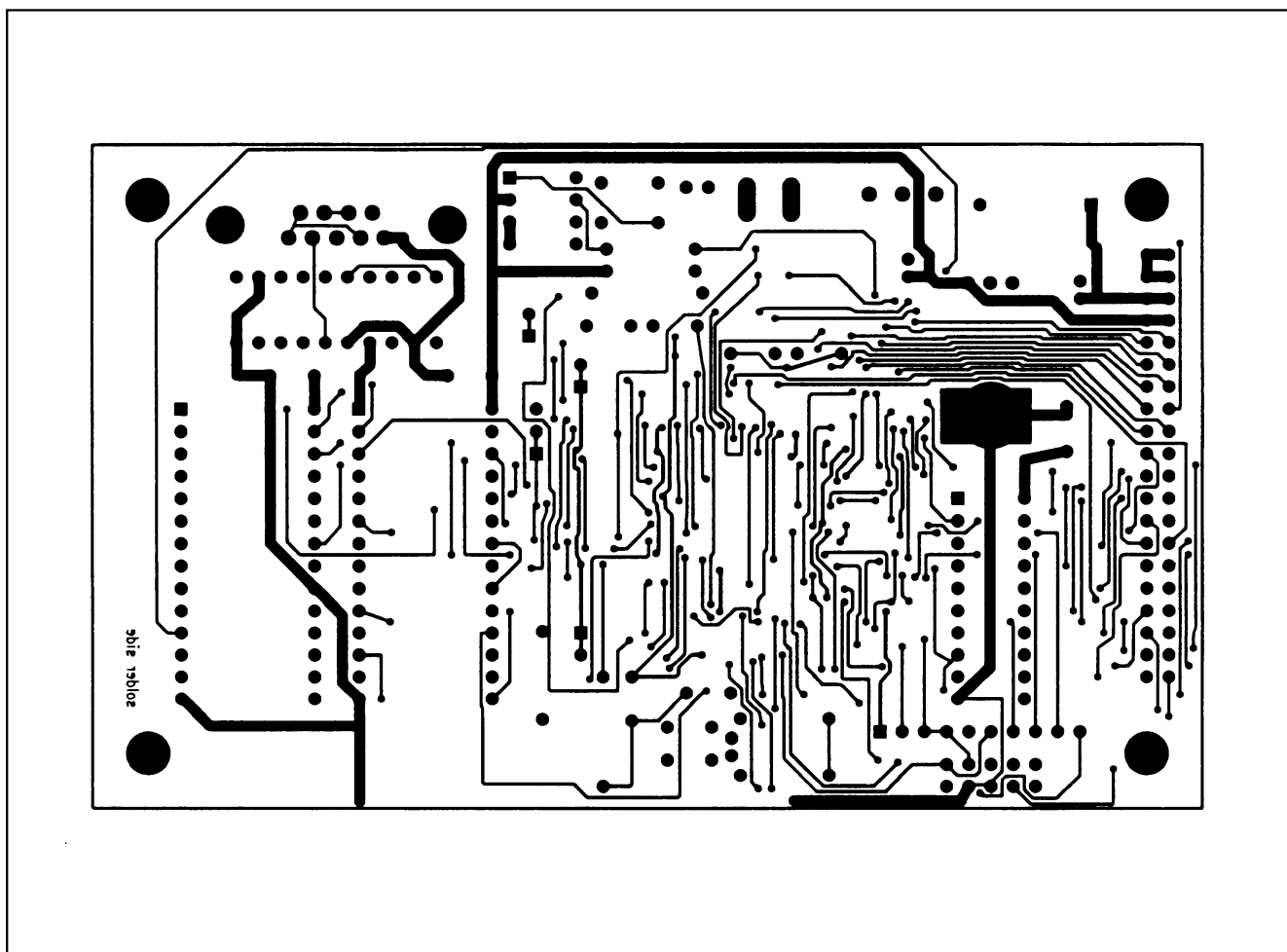
Figure 4. 68HC16 Module PC Board Layout—Solder Side

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___80C32 Module Component List

DESIGNATION	QTY	DESCRIPTION
C1, C2	2	15pF ceramic capacitors
C4, C5, C6, C7, C8, C9, C10, C11, C12	9	0.1µF, 50V ceramic capacitors
C3, C13, C14	3	22µF, 16V radial electrolytic capacitors
D1	1	1N4001 diode
J1	1	40-pin right-angle male connector
J2	1	DB9 right-angle socket
R1	1	620Ω resistor
RS1	1	10kΩ 10-pin, 9-resistor SIP
SW1	1	Power switch
SW2	1	Reset switch
IC1	1	80C32
IC2	1	MAX233CPP
IC3	1	27C64
IC4	1	74HCT573
IC5	1	74HCT139
IC6	1	74HCT08
IC7	1	74HCT245
IC8	1	62256
IC9	1	78M05
IC10	1	MAX707CPA
Y1	1	11.059MHz crystal
None	1	2-pin power connector
None	1	28-pin 600-mil socket for IC3 (the EPROM)
None	4	Rubber feet
None	1	3.00" x 5.50" PC board

_____80C32 Module

80C32 Module General Description

The Maxim 80C32 microcontroller (µC) module is intended for use with this and other Maxim evaluation kits (EV kits). It contains the 80C32 µC, RS-232 interface, 8kbytes of EPROM, 32kbytes of static RAM, and address decoding logic. A 40-pin connector mates with a connector found on Maxim EV kits designed to interface with the 80C32 module.

The module is connected to an IBM-compatible personal computer over a serial communications port. Software provided with each EV kit runs on the computer and controls the unit consisting of the 80C32 module and EV kit. The program uses a routine stored in the 27C64 EPROM to download special 80C32 code for each kit. The downloaded code controls the EV kit and, together with the program running on the personal computer, displays the output data.

The board operates from a single 8V to 22V supply. Both the pre-regulated and regulated +5V levels are available to the EV kit through the 40-pin connector.

80C32 Module Power Supply

The Maxim 80C32 module requires an input of 8V to 22V for normal operation. An on-board 78M05 power regulator supplies the 5V required for the logic on the module, and any 5V requirements for the EV kit attached to the 40-pin connector. The pre-regulated voltage is also available on the data connector. The source must be capable of supplying 100mA for the module and meeting the load requirements of the EV kit.

Microprocessor Supervisor

A MAX707 on the module monitors the 5V logic supply, generates the power-on reset, and produces a reset pulse whenever the reset button is pressed. A watchdog function was not included because they frequently interfere while debugging programs, and debugging is a prime function of this board.

80C32 Microcontroller

The 80C32 is a member of the popular Intel 8051 family of µCs. It is a low-power CMOS version that requires external ROM for program storage, 256 bytes of internal RAM, and four 8-bit I/O ports. Three of the ports are required by the system for serial communications and memory control. The fourth port (P1) is available through the data connector.

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The 80C32 communicates with the PC over a serial RS-232 link. A MAX233 acts as a level shifter between the ±15V RS-232 signals and the TTL levels of the 80C32. The MAX233 also generates the output voltages necessary to drive RS-232 lines.

Port 0 (pins 32–39) of the 80C32 multiplexes the lower eight bits of memory address and the eight bits of read/write data. The lower eight bits of address data are latched during each I/O cycle by the 74HCT573 octal latch. The latch is controlled by the address latch enable (ALE) signal of the 80C32. Port 2 (pins 21–28) of the 80C32 supplies the upper eight bits of address information.

The port 3 pins (10–17) provide several unrelated functions. Pins 10 and 11 are used as the receive data (RxD) and transmit data (TxD) pins of the RS-232 link. Pins 16 and 17 act as the write (WR) and read (RD) control signals for the data I/O cycles. Four other pins are configured as interrupt and timer controls, but are not used on this board.

Memory

The board has a 27C64 EPROM containing code for initializing the 80C32 and downloading additional program code to the 62256 RAM. After a reset, the EPROM resident code initializes the 80C32, determines the address range of the RAM, sets the RS-232 baud rate to 1200, and waits for communications from the PC. Receiving any character will prompt the program to send an initial banner that includes the program name, revision level, and boundaries of the on-board RAM.

The 62256 CMOS (32kbyte) static RAM is used to hold program code for the various Maxim EV kits that use the 80C32 module as the controller. Programs are transferred from disk to the RAM using software running on a personal computer, such as MAXLOAD or other programs provided with Maxim EV kits. Programs written to execute from this RAM start at 4000 (HEX) and are typically less than 4kbytes long. The remaining RAM is available for data storage.

Address Ranges

Logic on the module board generates various enable signals for different address ranges. The ROM and RAM enable signals are fed directly to the respective chips. Several additional signals (CS0–CS3) are available on the data connector to be used by Maxim EV kits. Table 1 outlines the address range for each of the elements found on the 80C32 module.

Table 1. Address Ranges in Hexadecimal

ADDRESS RANGE (HEX)			ENABLE SIGNAL
0000	➜	3FFF	ROM
4000	➜	BFFF	RAM
C000	➜	CFFF	CS0
D000	➜	DFFF	CS1
E000	➜	EFFF	CS2
F000	➜	FFFF	CS3

Data I/O Connector

A 40-pin connector mounted on the edge of the printed circuit board provides connection between the µC module and other Maxim EV kits. Both power and digital signals are transferred via the connector. To join the module board with an EV kit, carefully align and insert the pins on the connector with the mating 40-pin female connector of the kit. The pin functions are listed in Table 2.

Table 2. I/O Connector Pin Functions

PIN	FUNCTION	DESCRIPTION
1–4	Ground	
5, 6	Pre-regulator input	
7, 8	Regulated +5V	
9	RD	Read strobe
10	WR	Write strobe
11	CS0	Address C000-CFFF
12	CS1	Address D000-DFFF
13	CS2	Address E000-EFFF
14	CS3	Address F000-FFFF
15–18	ADDR0-ADDR3	Lowest 4 bits of address
19–26	DB0–DB7	8-bit data bus
27–34	P1.0–P1.7	8 bits of port 1
35–40	Reserved	

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Software Architecture

Software for EV kits using the Maxim 80C32 module is divided into three elements: the interface program running on an IBM-compatible PC, a module program located in EPROM, and a program supplied on disk that is transferred to the RAM located on the module.

EPROM Resident Program

The EPROM resident program initializes the 80C32, establishes communications over the RS-232 link, verifies the static RAM, and downloads other programs. Its operation starts on power-up and whenever the reset button is pressed. After reset, the program waits indefinitely to receive a character over the RS-232 port. When the first character is received, a logon banner identifying the module and firmware revision is transmitted.

Immediately following transmission of the logon banner, the program runs a checker routine for the on-board 256kbit static RAM. The RAM is filled with several patterns and then read to verify that each pattern has been retained. A pass or fail indication is displayed on the personal computer after each pass. EV kit software requires proper operation of the RAM. Do not attempt to use the board if any of the RAM checks fail.

Two other programs for the EV kits are provided on a floppy disk shipped with each kit. One program acts as the user interface and transmits commands to the 80C32 module. The other is an 80C32 application program that executes from the RAM located on the module. The procedure for loading the programs varies with each kit, so follow the instructions provided.
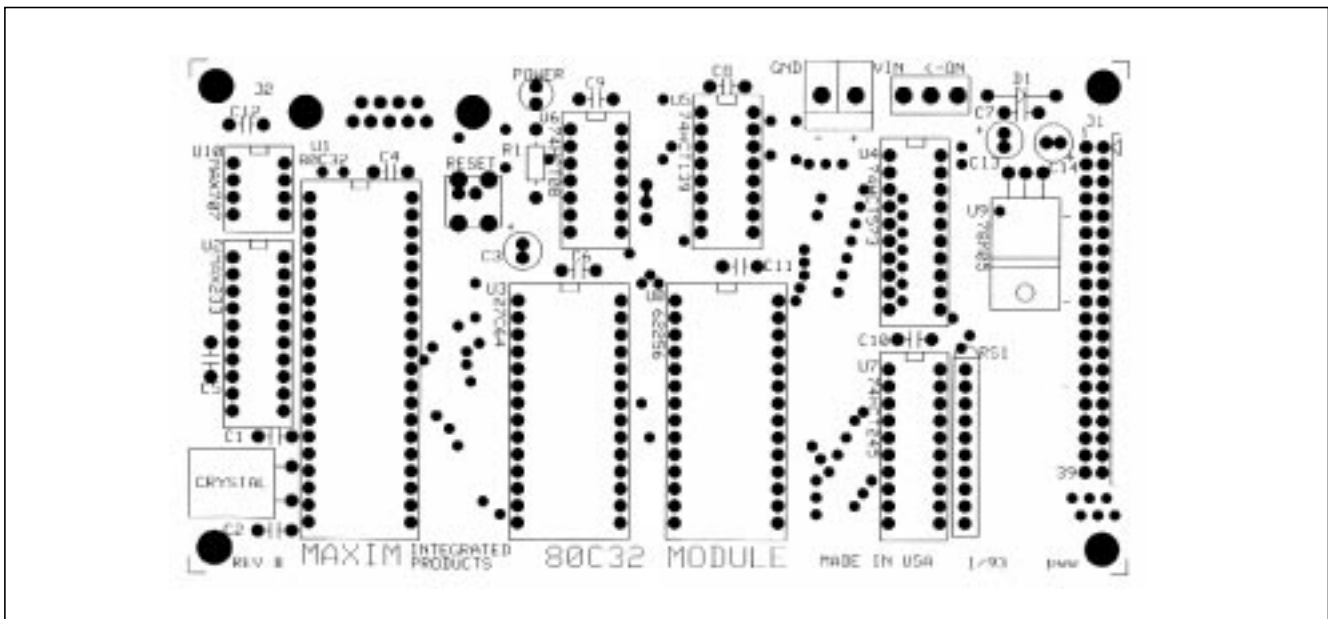

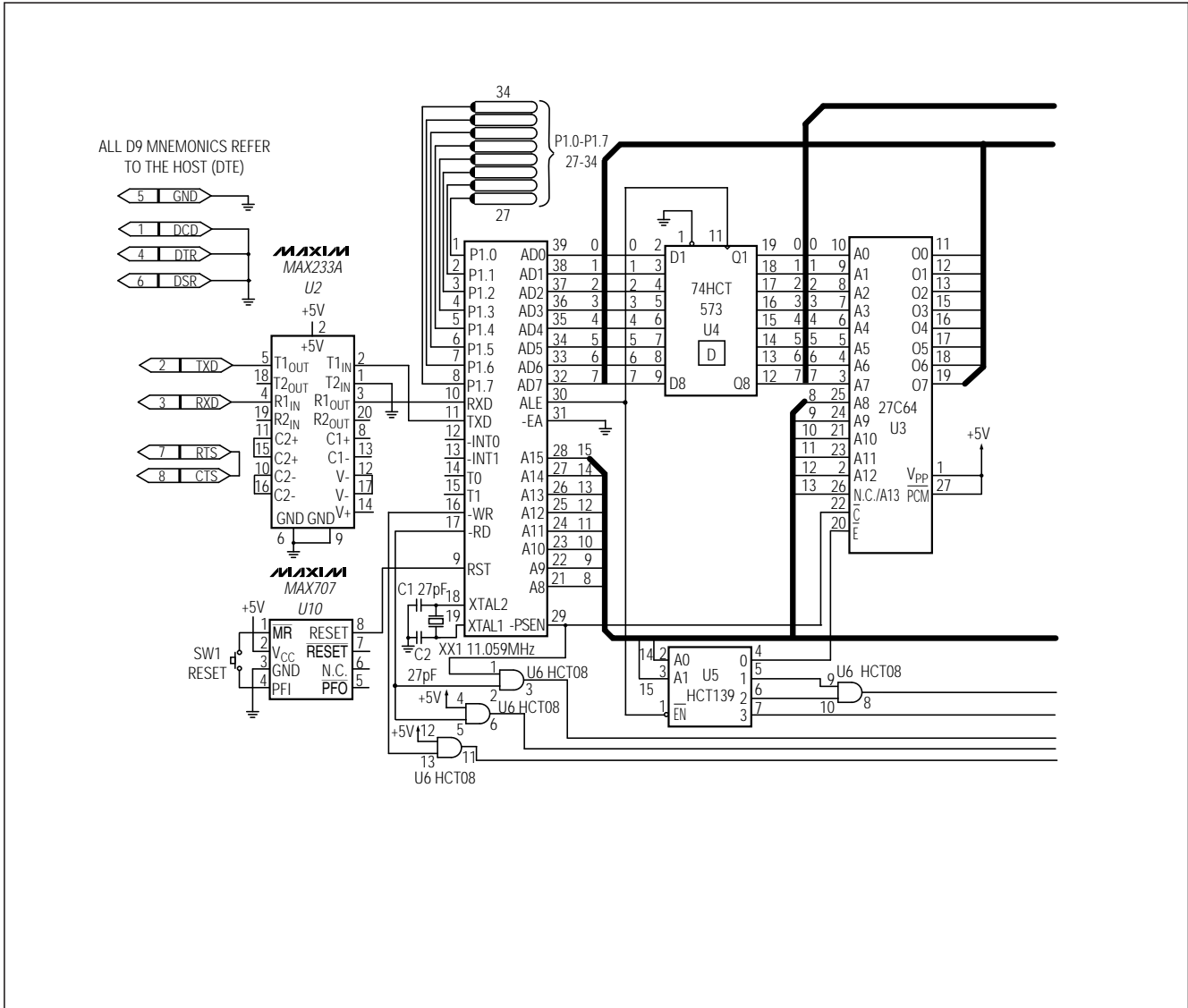*Figure 1. 80C32 Module Component Placement Guide (x1)*

80C32 Module
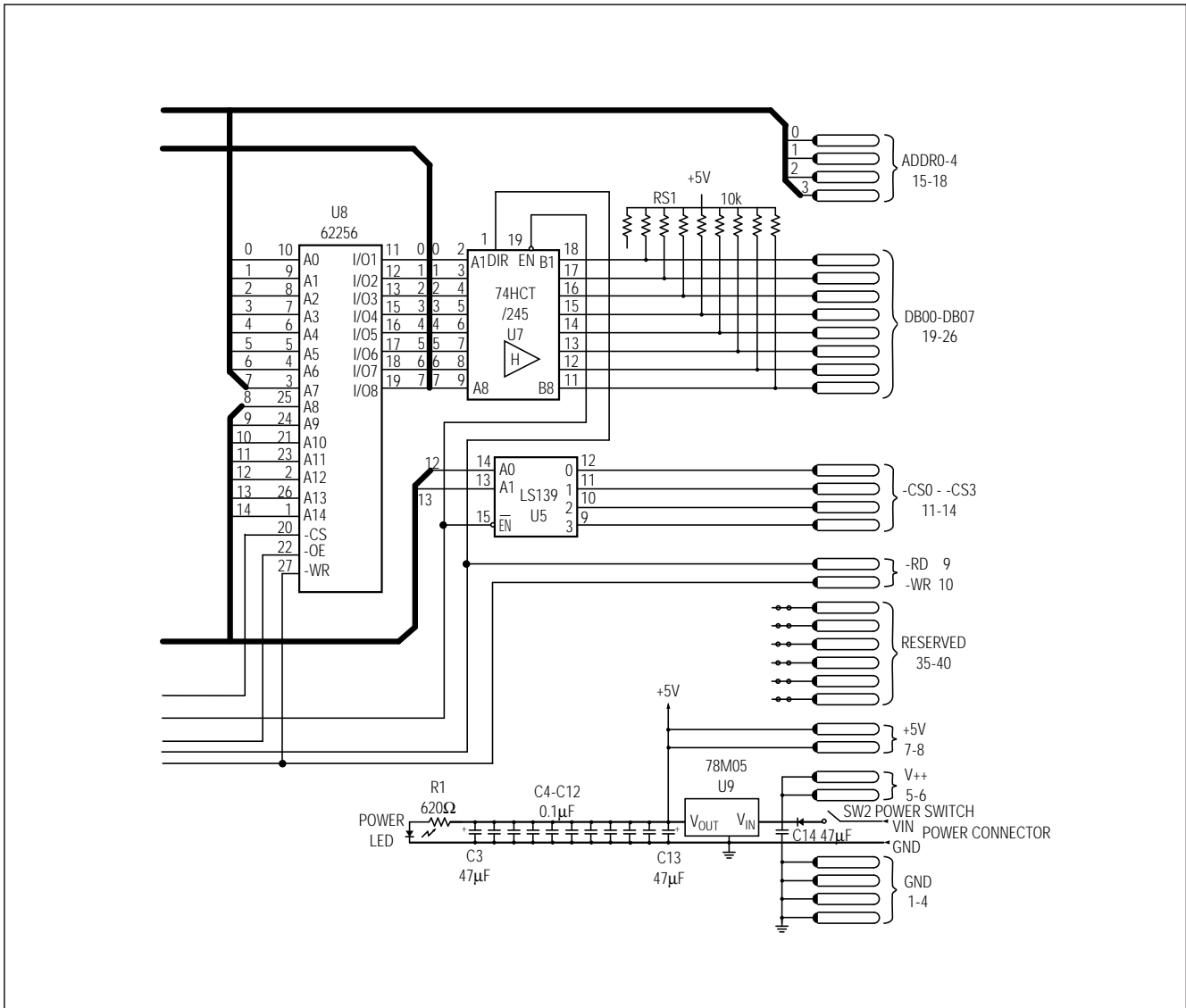

Figure 2. 80C32 Module Schematic

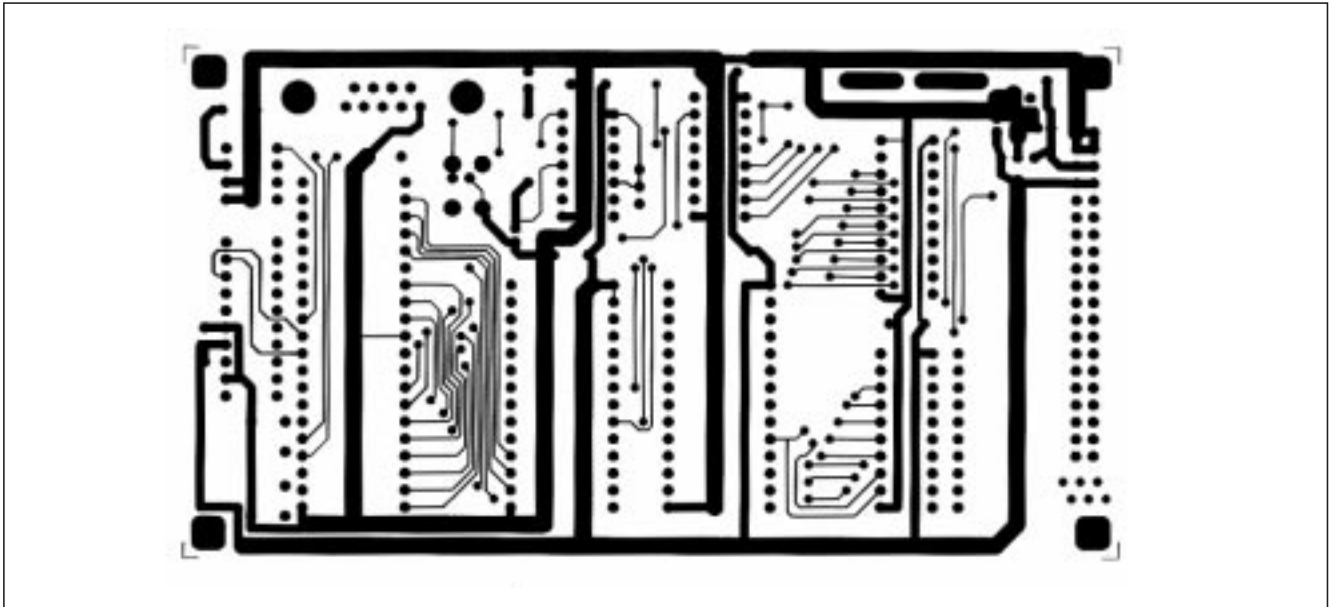Figure 2. 80C32 Module Schematic (continued)

80C32 Module

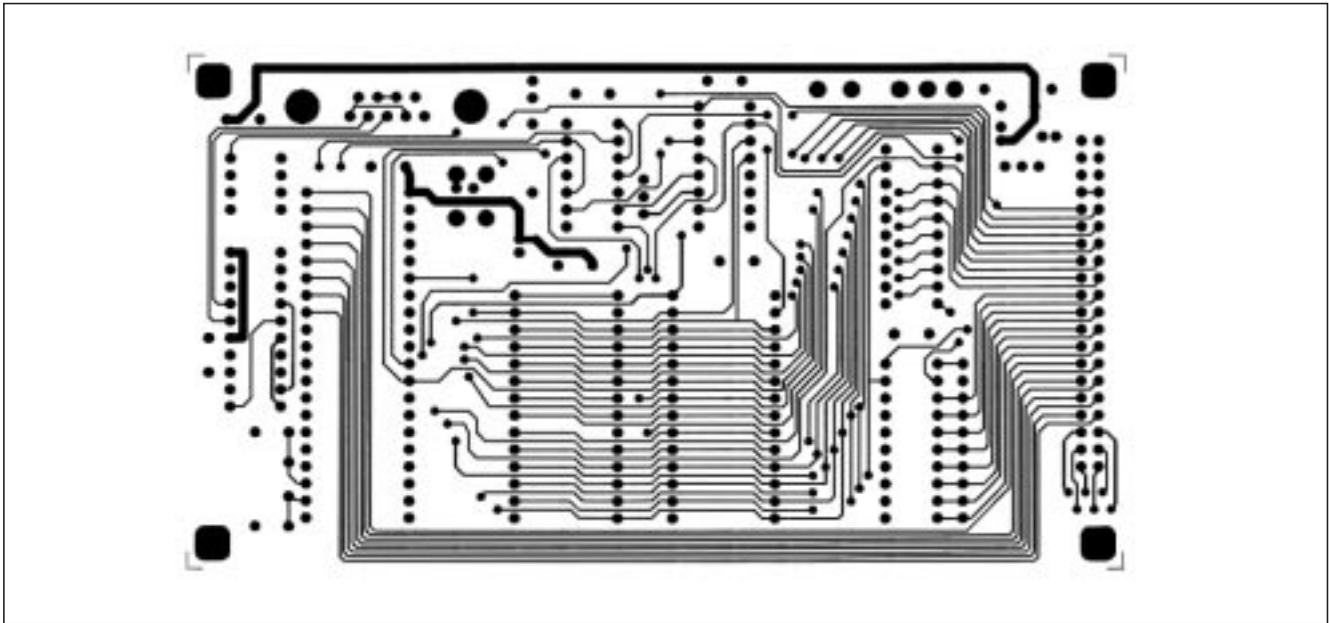Figure 3. 80C32 Module Component-Side Layout (x1)

Figure 4. 80C32 Module Solder-Side Layout (x1)

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