



## MAX187 Evaluation System/Evaluation Kit

### General Description

The MAX187 evaluation system (EV system) consists of a MAX187 evaluation kit (EV kit) board plus a Maxim 68HC16 microcontroller ( $\mu$ C) module. Both boards come fully assembled and tested, and software is provided. The unit connects to an IBM-compatible personal computer.

The EV system can function as a data acquisition system, collecting samples from the MAX187, storing them in memory, and displaying the conversion results on the host computer. Conversions may be self-timed or synchronized to an external timebase. Waveforms can be digitized and displayed graphically versus time.

The EV system can also evaluate the MAX187's shutdown feature, and has provisions for monitoring the supply current in the various modes of operation (internal reference, external reference, or power-down).

Order the EV system (MAX187EVC16-DIP) for comprehensive evaluation of the MAX187 or MAX189. Order the stand-alone EV kit (MAX187EV KIT-DIP) for custom use or if the 68HC16 module (68HC16MODULE-DIP) has already been purchased with another Maxim EV system. The MAX187 EV kit can also be used to perform limited evaluation on a stand-alone basis (see the MAX187 EV Kit Quick Start section). The EV system requires an external DC power source (such as a 12V DC wall transformer) and an IBM-compatible computer with a serial port and a 5 1/4" disk drive. To evaluate the MAX189, order the MAX187EVC16-DIP plus a free sample of the MAX189BCPA.

### Features

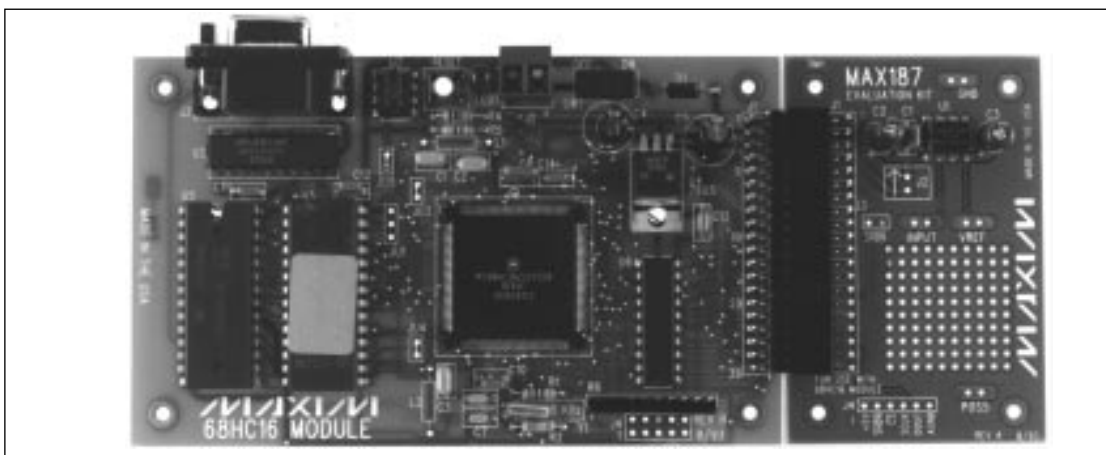
- ♦ Evaluates MAX187 and MAX189
- ♦ Complete Evaluation System Includes EV Kit and 68HC16  $\mu$ C Module
- ♦ 12-Bit Resolution ADC
- ♦ QSPI Serial Interface
- ♦ 0V to 4.096V Input Range
- ♦ Internal Reference Voltage (MAX187)
- ♦ Low-Supply-Current Shutdown Mode
- ♦ Complete Source Code Provided
- ♦ Proven PC Board Layout
- ♦ Convenient Test Points Provided on Board
- ♦ User Prototype Area
- ♦ Fully Assembled and Tested

Evaluates: MAX187

### Ordering Information

| PART             | TEMP. RANGE  | BOARD TYPE   |
|------------------|--------------|--------------|
| MAX187EVC16-DIP  | 0°C to +70°C | Through-Hole |
| MAX187EVKIT-DIP  | 0°C to +70°C | Through-Hole |
| 68HC16MODULE-DIP | 0°C to +70°C | Through-Hole |

### EV System



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# MAX187 Evaluation System/Evaluation Kit

## EV System Component List

| QTY | DESCRIPTION                              |
|-----|------------------------------------------|
| 1   | MAX187 evaluation kit (MAX187EVKIT-DIP)  |
| 1   | 68HC16 $\mu$ C module (68HC16MODULE-DIP) |

## MAX187 EV System Quick Start

This section applies only to the use of the MAX187 EV kit operating with Maxim's 68HC16 module.

- 1) Copy the files from the distribution disk to your hard drive or to blank floppy disks. Store the MAX187 EV kit software in its own directory to prevent conflicts with other Maxim EV kit files. The necessary files are in the root directory of the distribution disk, and ancillary files are located in the SOURCE and TMS320 subdirectories. These subdirectories are not required for EV kit operation, and are described in other sections of this manual.
- 2) Carefully connect the boards by aligning the 40-pin header of the MAX187 EV kit with the 40-pin connector of the 68HC16  $\mu$ C module and gently press them together. The two boards should be flush against one another.
- 3) Use a small flat-blade screwdriver to connect a 9V to 15V DC power source to the  $\mu$ C module. The terminal block is located next to the on/off switch, in the upper right corner of the module. Observe the polarity marked on the board.
- 4) Connect a cable from the computer's serial port to the  $\mu$ C module. If using a 9-pin serial port, use a straight-through 9-pin female-to-male cable. If the serial port uses a 25-pin connector, a standard 25-pin to 9-pin adapter will be required.
- 5) Start up the MAX187 software on the IBM PC by setting the current directory to match the directory containing the Maxim programs, and then type the program name "MAX187".
- 6) The program allows the user to select which serial port is connected to the  $\mu$ C module. Press the space bar until the correct port is highlighted, then press ENTER.
- 7) The MAX187 program will switch to terminal-emulation mode. At this point, apply power to the 68HC16 module. The LED should light, and within 5 seconds

## EV Kit Component List

| DESIGNATION | QTY | DESCRIPTION                         |
|-------------|-----|-------------------------------------|
| C1          | 1   | 0.1 $\mu$ F ceramic capacitor       |
| C2, C3      | 2   | 4.7 $\mu$ F electrolytic capacitors |
| J1          | 1   | Female 40-pin data connector        |
| J4          | 1   | 6-pin header                        |
| JU1         | 1   | 3-pin header                        |
| R1          | 1   | 10k $\Omega$ resistor               |
| U1          | 1   | Maxim MAX187ACPA                    |
| None        | 4   | Rubber feet                         |
| None        | 1   | 8-pin socket for U1                 |
| None        | 1   | MAX187 printed circuit board        |

the program will display a logon banner. The LED is a status indicator, not a power indicator; it will flash to indicate module readiness. Refer to the 68HC16 module self-check system.

- 8) To download and run the RAM resident code on the  $\mu$ C module, press ALT+L (i.e. hold down the ALT key and strike the L key). The program prompts for the file name. Press the ENTER key to download and run the file KIT187.S19 on the 68HC16 module.
- 9) The KIT187.S19 RAM resident program offers a menu of commands, listed in Table 1.

## Stand-Alone MAX187 EV Kit Quick Start

This section applies only to the use of the MAX187 EV kit without the  $\mu$ C module.

- 1) Connect a regulated 5V DC power supply to the terminals labeled POS5 and GND. The GND pad is ground, and the POS5 pad is the 5V input. The board draws less than 5mA of supply current.
- 2) To enable the MAX187's internal reference, connect the SHDN pin to 5V. To use an external reference, leave the SHDN pin open and provide a reference voltage at the VREF pad. To put the MAX187 in shutdown mode, connect the SHDN pin to ground.
- 3) Connect the interface signals to the  $\overline{CS}$ , SCK, and DOUT test points. Use the AGND test point as signal ground. See the MAX187 data sheet for timing information.
- 4) Apply the input voltage to the terminals labeled INPUT and GND.

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## Detailed Description of Software

### EPROM Resident Program

A small bootstrap program is stored in the EPROM located on the 68HC16 board. The EPROM resident program initializes the 68HC16, tests the static RAM, configures the chip-select logic, establishes serial communications with the host, and downloads a program into RAM. It starts operating on power-up or whenever the RESET button is pressed. After RESET, it tests the RAM and then waits to receive a character on its serial port before transmitting its identification banner.

### RAM Resident Program

KIT187.S19 and MIN187.S19 are 68HC16 RAM-resident programs that are transferred from disk to the static RAM on the 68HC16 module. They are used transparently by the example programs. The example programs that do not require the full command set of KIT187 download the MIN187 program, which is smaller and implements only the read and collect commands. Because the MIN187 occupies less user RAM, more sample data can be collected (MIN187 can collect approximately 400 more samples than KIT187 before it must upload the samples to the host.) When the KIT187 program is running, it offers the commands listed in Table 1. The MIN187 program commands are listed in Table 2.

**Table 1. Commands Available when  
KIT187.S19 is Running**

| KEY   | FUNCTION                                                                                                    |
|-------|-------------------------------------------------------------------------------------------------------------|
| Space | Read the MAX187 and print result in decimal.                                                                |
| V     | Repeatedly read the MAX187 and print result in decimal.                                                     |
| R     | Read the MAX187 and print result in hexadecimal.                                                            |
| O     | Oscilloscope test; observe system timing by operating the MAX187 at high speed without processing the data. |
| S     | Set the state of the SHDN pin.                                                                              |
| L     | Display low-power menu.                                                                                     |
| D     | Set power-up delay and sleep time (low-power menu only).                                                    |
| T     | Test the accuracy using the current power-up delay and sleep time settings (low-power menu only).           |
| M     | Return to main menu (low-power menu only).                                                                  |
| ?     | List the available commands.                                                                                |

### Personal Computer Program

MAX187.EXE, which runs on an IBM-compatible computer, is a terminal program that establishes communication with the 68HC16 module and allows the user to download and run a Maxim-provided RAM resident program. The serial communication baud rate is initiated at 1200 baud to ensure proper operation with slower systems.

The MAX187.EXE program provides several commands that are associated with the host computer. These functions are listed in Table 3.

The MAX187.EXE program can store the text of a terminal session in a log file. To begin recording the terminal session, press ALT+O [the letter O]. The program will ask for a file name. Press ENTER to accept the default file name, or type in a different name. If there is already a file with that name, the old file will be erased. To close the file, press ALT+C. The log file will contain the complete text of the terminal session from the time when the file is opened until the file is closed.

### Graphing Program

The program SAMPL187.BAS samples the MAX187 and draws a graph of voltage over time. Preset sample rates range from 2.5ksps to 10ksps. The time base is approximate and there is no triggering mechanism, so this program is only suitable for observing the waveforms of an external frequency generator.

**Table 2. Commands Available after  
MIN187 has been Downloaded**

| KEY | FUNCTION                                                                                                                                                                                                                                                                                             |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ?   | Print RAM resident program version and list of commands available.                                                                                                                                                                                                                                   |
| r   | Read the MAX187 and display the value as a 2-byte hexadecimal number.                                                                                                                                                                                                                                |
| c   | Collect and upload a number of data samples to the host PC. Samples can be collected at full speed, or collected with a fixed delay, or collected in accordance with an external clock. Approximately 16,000 samples may be collected and they can be displayed in either decimal or in hexadecimal. |
| ESC | Exit the evaluation software.                                                                                                                                                                                                                                                                        |

Evaluates: MAX187

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**Table 3. Commands Available in MAX187.EXE Terminal Program**

| KEY   | FUNCTION                              |
|-------|---------------------------------------|
| ALT+L | Load and run resident code on 68HC16. |
| ALT+X | Exit to DOS.                          |
| ALT+P | Change port (COM1, COM2).             |
| ALT+R | Send RESET command to 68HC16.         |
| ALT+O | Open a log file.                      |
| ALT+C | Close the log file.                   |
| ALT+B | Display baud rate menu.               |
| ALT+1 | 1200 baud                             |
| ALT+4 | 4800 baud                             |
| ALT+9 | 9600 baud                             |
| ALT+2 | 19200 baud                            |

**Table 4. Compiled Program Dependencies**

| PROGRAM    | PROGRAM SECTION          | SOURCE FILES             |
|------------|--------------------------|--------------------------|
| SIMPLE.EXE | main program             | simple.c                 |
|            | 68HC16 command interface | sercmd.c, sercmd.h       |
|            | MAX187 EV kit commands   | max187.c, max187.h       |
| MAX187.EXE | main program             | shell.cpp, global.h      |
|            | custom controls          | meters.cpp, meters.hpp   |
|            | terminal + downloader    | download.cpp, download.h |
|            | 68HC16 command interface | sercmd.c, sercmd.h       |
|            | MAX187 EV kit commands   | max187.c, max187.h       |

### DOS Development Platform

For applications that require custom software, the MAX187 EV kit includes a set of programs that can be used as a development platform to extend the functionality of the basic kit. Source code is in the SOURCE subdirectory of the MAX187 EV kit disk. Advanced C or C++ programmers should see Table 4 for the makefile dependencies.

The simplest program that accesses the MAX187 EV kit is SIMPLE.EXE, which loads the small RAM resident program into the 68HC16 module and then performs continuous conversions, until the user presses a key.

To run the SIMPLE.EXE program, enter the command SIMPLE from the DOS prompt. The program will ask which serial port is connected to the  $\mu$ C module. Press the '1' number key to select COM1, or press the '2' number key to select COM2. To terminate the program, press the ESC key.

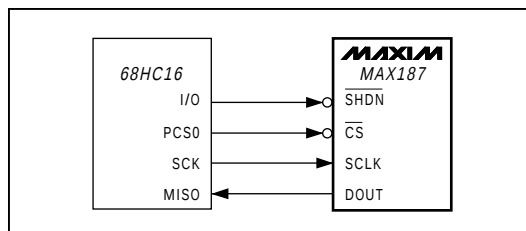


Figure 1. QSPI Interface Schematic

### Programming Languages Used

The IBM PC programs were compiled under Borland C++ version 3.1. The EPROM and RAM resident 68HC16 programs were assembled using the Motorola 68HC macro assembler version 4.1, which comes with Motorola's 68HC16Z1EVb evaluation board. Contact the Motorola Microprocessor and Memory Technologies Group at (512) 891-2628.

The BASIC programs are written in Microsoft QuickBasic 1.0, which comes with MS-DOS 5.0 and later versions.

### Using the QSPI to Read the MAX187

The 68HC16 module uses its queued serial peripheral interface (QSPI) in master mode to read the MAX187 between conversions. Figure 1 shows the schematic of the QSPI interface connections. The MAX187 EV kit software uses the following algorithm (provided on disk in the SOURCE subdirectory, file MIN187.ASM):

- 1) Initialize QSPI parameters as follows:  
Master Mode  
SPBR = 2 (4.192MHz serial clock)  
CPOL = 0, CPHA = 1  
BITS = 13 bits per transfer  
DTL = 1 (1.9 $\mu$ s delay after transfer)  
(DSCKL is not used)  
Control RAM entry must enable BITS and DTL;  
 $\overline{CS}$  = 0 when active.
- 2) Assert  $\overline{CS}$  low.
- 3) Wait 8.5 $\mu$ s (maximum conversion time for the MAX187) or until MISO goes high. (Since DSCKL is only 7 bits, the maximum delay-before-clock available for a 16.78MHz 68HC16 is  $128/16.78\text{MHz} = 7.628\mu\text{s}$ . Thus, the QSPI's DSCKL parameter cannot be used unless the system clock frequency is reduced.)
- 4) Start QSPI transfer.
- 5) Wait until QSPI transfer is complete.

# MAX187 Evaluation System/Evaluation Kit

## Listing 1. Using the QSPI to Read the MAX187

```
* Compiled under Motorola 68HC macro assembler version 4.1
* Complete source code is in file KIT187.ASM in SOURCE sub-directory

* Pin assignment for MAX187 EVKIT
*
ShdnMask EQU 8      ; /SHDN/= OC1      = pin 30 (P1.3 on 80C32 module)
Dout187  EQU 1      ; DOUT  = MISO     = pin 35 (N/A on 80C32)
Sclk187  EQU 4      ; SCLK  = SCK      = pin 37 (N/A on 80C32)
Cs187    EQU 8      ; /CS/   = PCS0/\SS\ = pin 38 (N/A on 80C32)

* QSPI initialization parameters
*
CPOL EQU 0
CPHA EQU 1
SPBR EQU $2 ; QSPI baud rate = (16.78MHz/(2*SPBR)) = 4.195 MHz
BITS EQU $D ; 13 bits per transfer; enabled by CRBITSE field
DSCKL EQU $0 ; delay before SCK -- not used
DTL EQU $1 ; delay after transfer = (DTL*32/16.78MHz) = 1.9 usec
NEWQP EQU $0 ; pointer to first valid queue entry
ENDQP EQU $0 ; pointer to last valid queue entry

* Initialize the GPT module as an I/O port
*
BSET GPTPDR,#ShdnMask ; take \SHDN\ high to turn MAX187 ON
BSET PDDR,#ShdnMask ; make sure \SHDN\ is an output

* Initialize the QSPI module
*
LDAA #Cs187
STAA QPDR ; pins that are high by default

LDAA #Sclk187!Dout187!Cs187
STAA QPAR ; pins that are assigned to the QSPI

LDAA #Cs187!Sclk187
STAA QDDR ; pins that are outputs

LDAA #$60 ; enable BIT and DTL
STAA CR0 ; control ram entry

CLR SPCR3
LDD #B502 ; BITS=13,SPBR=2,MASTER,CPOL=0,CPHA=1
STD SPCR0
LDD #0001 ; DTL=1,DSCK=0
STD SPCR1
LDD #0000 ; NEWQP=0,ENDQP=0
STD SPCR2

...

*****
* ReadMAX187:
* Use the QSPI to read the value of the MAX187.
*
* On Entry:
* QSPI parameters must be initialized
*
* On Exit:
* D = 12 bit value, right justified
*
ReadMAX187:
BCLR QPDR,#Cs187 ; take \CS\ low
Wait1: BRCLR QPDR,#Dout187,Wait1 ; wait for start bit

BSETW SPCR1,#QSPIDisable ; start the QSPI transfer

WaitForQSPI: ; poll the QSPI until it is finished
BRCLR SPSR,#SPSRSPIF,WaitForQSPI

BSET QPDR,#Cs187 ; take \CS\ high
LDD RRO ; get result from receive ram
ANDD #0FFF ; mask off start bit
RTS
```

Evaluates: MAX187

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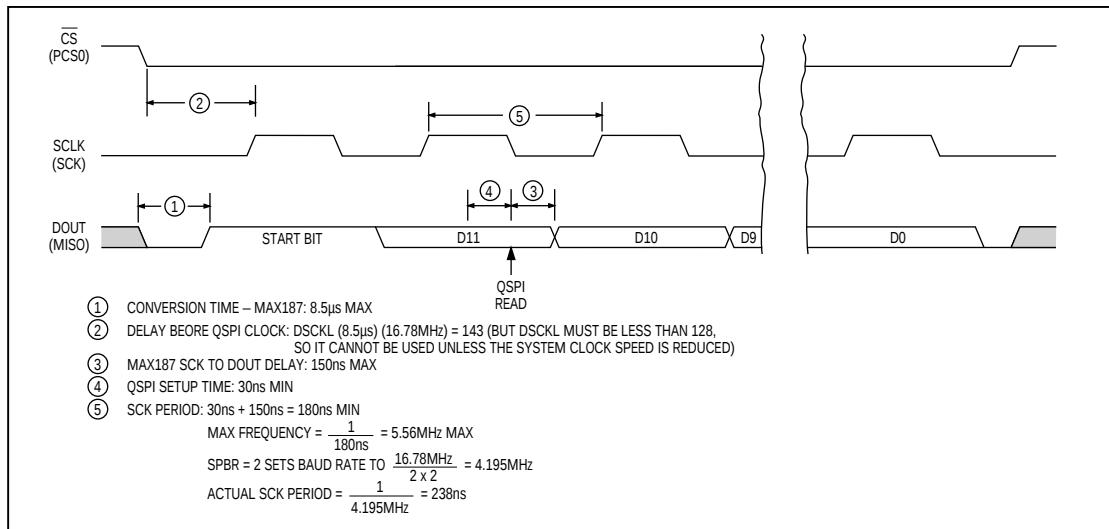


Figure 2. MAX187 to QSPI Interface Timing (CPOL = 0, CHPA = 1)

- 6) Set  $\overline{\text{CS}}$  high.
- 7) Extract the 12 significant bits from the read queue. The data is right-justified.

Figure 2 is the timing diagram for the QSPI interface. Listing 1 is an assembly-code listing that shows how to use the QSPI to read the MAX187.

### Using Bit-Pushing to Read the MAX187

The QSPI is not required by the MAX187. The MAX187 may be read by any equivalent bit-pushing algorithm. The following algorithm reads the MAX187 by setting and clearing I/O bits, and is functionally equivalent to the QSPI.

- 1) Assert SCK low.
- 2) Assert  $\overline{\text{CS}}$  low.
- 3) Clear a 16-bit register that will be used to store the reading.
- 4) Wait until DOUT becomes high.
- 5) Set SCK high.
- 6) Assert SCK low.
- 7) Repeat 12 times:
  - 7.1) Set SCK high.
  - 7.2) Rotate the 16-bit reading register left one bit (i.e. multiply by two).

- 7.3) Read DOUT into least significant bit of reading register.
- 7.4) Clear SCK low.

- 8) Set  $\overline{\text{CS}}$  high.
- 9) Extract the 12 significant bits from the 16-bit result register. The data is right-justified.

### Evaluating the MAX189

The MAX187 EV kit supports both the MAX187 and MAX189 ICs. The only difference between the two devices is that the MAX189 requires an external reference. Refer to the MAX187/MAX189 data sheet for the MAX189 reference requirements.

### Detailed Description of Hardware

#### MAX187 ADC

The central component of the evaluation board is the MAX187 analog-to-digital converter (ADC). Capacitor C1 is close to pin 1, C3 is close to pin 4, and analog ground is star grounded at pin 5. DC offset error may be improved by adding a 0.1μF capacitor between INPUT and AGND.

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Evaluates: MAX187

**Table 5. Data-Interface Connections for 68HC16**

| PIN No. | 68HC16 SIGNAL | MAX187 SIGNAL | FUNCTION                              |
|---------|---------------|---------------|---------------------------------------|
| 1-4     | GND           | AGND          | Ground                                |
| 7-8     | +5V           | +5V           | +5V Supply to MAX187 Evaluation Board |
| 30      | OC1           | SHDN          | Shutdown Pin                          |
| 35      | MISO          | DOUT          | Serial Data Output from MAX187        |
| 37      | SCK           | SCLK          | Serial Clock from 68HC16              |
| 38      | PSC0          | CS            | Chip Select from 68HC16               |

All other pins are reserved.

## Measuring Supply Current

To measure the amount of supply current drawn by the MAX187, use the following procedure:

- 1) Turn off the power to the EV system.
- 2) Carefully cut the trace at J2.
- 3) Install a 2-pin header at J2.
- 4) Connect a current meter in series with J2.

The direction of current flow is marked with an arrow. Do not connect or disconnect the current meter while the power is on.

After observing supply current in operating and in shutdown modes, the board may be restored by installing a shunt at J2.

## Data-Connector Interface

The 68HC16 and MAX187 communicate through the QSPI port on the 40-pin data connector. Table 5 lists the function of each bit when interfaced to the 68HC16 module. Figure 1b shows the QSPI interface schematic diagram.

**Table 6. 68HC11/SPI Interface Connections**

| SPI SIGNAL   | MAX187 SIGNAL | FUNCTION                                               |
|--------------|---------------|--------------------------------------------------------|
| SPARE I/O    | SHDN          | Shutdown Pin                                           |
| SPARE OUTPUT | CS            | Chip Select from 68HC11                                |
| MISO         | DOUT          | Serial Data Output from MAX187                         |
| SCK          | SCLK          | Serial Clock from 68HC11                               |
| SS           | —             | Slave Select Input to 68HC11; must be pulled up to 5V. |

## SPI Interface

A 68HC11 can use its SPI™ (serial peripheral interface) to read a MAX187. Table 6 lists the interface connections required by the SPI serial interface. Figure 2 is a schematic diagram of the SPI interface. Listing 2 shows how to use the SPI to read the MAX187. The algorithm is as follows:

- 1) Initialize SPI parameters:
  - Master Mode
  - SPR = 00 (1MHz serial clock)
  - CPOL = 0, CPHA = 0
- 2) Assert CS low.
- 3) Wait until MISO goes high.
- 4) Begin SPI transfer.
- 5) Wait until SPI transfer is complete.
- 6) Save the first 8 bits in temporary storage. This first SPI byte contains the start bit followed by MAX187 data bits 11-5.
- 7) Continue the SPI transfer.
- 8) Wait until SPI transfer is complete.
- 9) Negate CS high.
- 10) Extract the 12 significant bits from the 16 bits that the SPI read. The second SPI byte contains MAX187 data bits 4-0 followed by three zero bits.

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## MAX187 Evaluation System/Evaluation Kit

Listing 2. Using the SPI to Read the MAX187

```

* Compiled under Motorola Freeware assembler ASxx.EXE Ver 1.03.
*
* Code fragment to show how to read the MAX187 with the SPI.

* Pin assignment:
* PA6 = OC2 = output   /CS/ active low chip select to MAX187
* PD2 = MISO = input   DOUT data output from MAX187
* PD4 = SCK = output   SCLK clock input to MAX187
*
PINOC2 EQU %01000000
PINMISO EQU %00000100
PINMOSI EQU %00000100
PINSCK EQU %00010000
PINSS EQU %00100000

Dout187 EQU PINMISO ; DOUT = MISO
Sclk187 EQU PINSCK  ; SCLK = SCK
Cs187   EQU PINOC2  ; /CS/ = OC2

* Initialize the SPI
LDX #base                      ; 68HC11 register base
BSET DDRD,X PINSCK+PINMOSI     ; SPI output pins
BCLR DDRD,X PINSS+PINMISO      ; SPI input pins

temp_value DS 2 ; reserve 2 bytes of RAM for ReadMAX187 subroutine

*****
* Use the SPI to read the value of the MAX187.
*
* On Entry:
*   X contains 68HC11 register base address
*
* On Exit:
*   D = 12 bit right-justified value read from MAX187
*
* SPI Parameters:
*   Master mode
*   CPOL = 0, CPHA = 0
*   1 MHz baud rate
*
* Uses temp_value

ReadMAX187:
LDAA #$50                      ; No interrupt, Enable SPI, Master Mode
STAA Spcr                      ; CPOL=0, CPHA=0, SPR=00=1 MHz
BCLR PortA,X Cs187             ; take /CS\ low
Wait1:                          ; wait until MISO goes high
BRCLR PortD,X PINMISO Wait1
LDAA #%11101010
STAA Spdr                      ; dummy write to begin SPI transfer
Wait2:                          ; wait until SPI finishes
BRCLR Spdr,X Spdr_SPIF Wait2
LDAA Spdr                      ; get first 8 bits
STAA temp_value
LDAA #%11101010
STAA Spdr                      ; dummy write to continue SPI transfer
Wait3:                          ; wait until SPI finishes
BRCLR Spdr,X Spdr_SPIF Wait3
LDAA Spdr                      ; get next 8 bits
STAA temp_value+1
BSET PortA,X Cs187             ; take /CS\ high
LDD temp_value                 ; get result
ROR                             ; locate the actual data field
ROR
ROR
ROR
ROR
ROR
ROR
ANDAA #$0F                     ; mask off non-data bits
RTS

```

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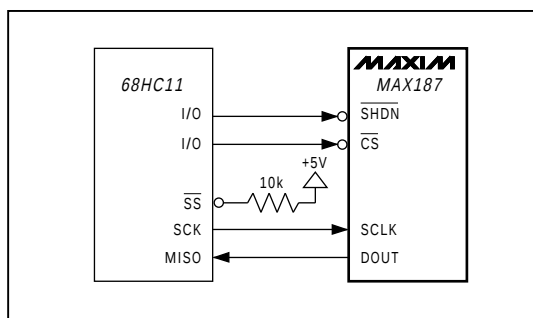


Figure 3. SPI Interface Schematic

### TMS320 Interface

The TMS320 subdirectory of the program disk contains a demonstration program that interfaces the MAX187 to Texas Instruments' TMS320C3X Evaluation Module (EVM), as shown in Figure 3. This demonstration requires the additional software included with the TMS320C3X EVM board, and is provided for the convenience of programmers who are already familiar with Texas Instruments' TMS320 family of digital signal processors. To connect the MAX187 EV kit to the

TMS320C3X EVM, install a 2 x 5 pin ribbon-cable header in the prototype area and wire it in accordance with Table 7. The SHDN pin should be tied to 5V for normal operation.

The demo software configures the TMS320C30 so that FSR1 and DR1 are inputs, and CLKR1 and XF1 are outputs. The software uses the XF1 output to start a conversion. The XF1 pulse drives the MAX187 chip-select input. The CLKR1 output provides the serial clock to the MAX187. Data output from the MAX187 is received on the DR1 input. The FSR1 frame-start signal is also tied to the data output, so the start bit from the MAX187 marks the beginning of the serial frame.

To read the MAX187, the software drives the XF1 output low, then waits 8.5μs (the maximum conversion time). It then enables the serial receive clock. The MAX187 sends its start bit, followed by the serial data. The demo software polls the serial receiver until a complete frame has been received. Since only 12 of the 16 bits received are significant, the demo software right-justifies the significant bits and removes the start bit, then writes the 12-bit word to the TMS320C3XEVM's host data port.

For the complete ribbon-cable pinout, consult the TMS320C3X Evaluation Module Technical Reference that came with your TMS320C3X EVM.

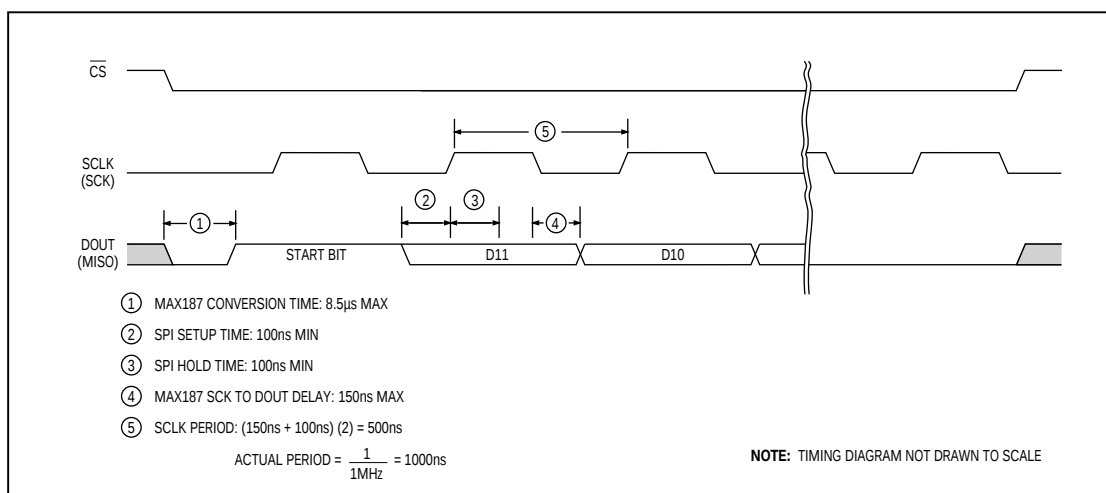


Figure 4. MAX187 to SPI Interface Timing (CPOL = 0, CPHA = 0)

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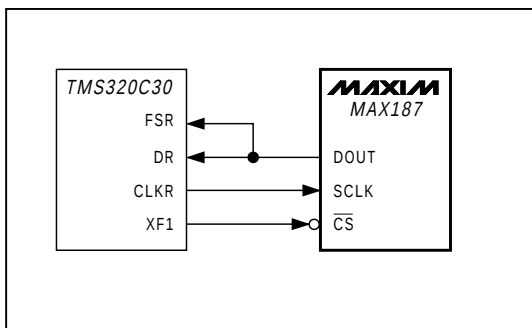


Figure 5. TMS320 Interface Schematic

Table 7. TMS320C3X EVM Interface Connections

| TMS320C30 SIGNAL | TMS320C3X EVM CONNECTOR PIN No. | MAX187 SIGNAL   | FUNCTION                         |
|------------------|---------------------------------|-----------------|----------------------------------|
| GND              | 1                               | AGND            | Signal Ground                    |
| DR               | 4                               | DOUT            | Data Received from MAX187        |
| XF1              | 8                               | $\overline{CS}$ | Active-Low Chip Select to MAX187 |
| FSR              | 2                               | DOUT            | Frame-Start Input to TMS320      |
| CLKR             | 9                               | SCLK            | Serial Clock to MAX187           |
| GND              | 10                              | AGND            | Signal Ground                    |

Note: TMS320 FSR and DR both connected to MAX187 DOUT.

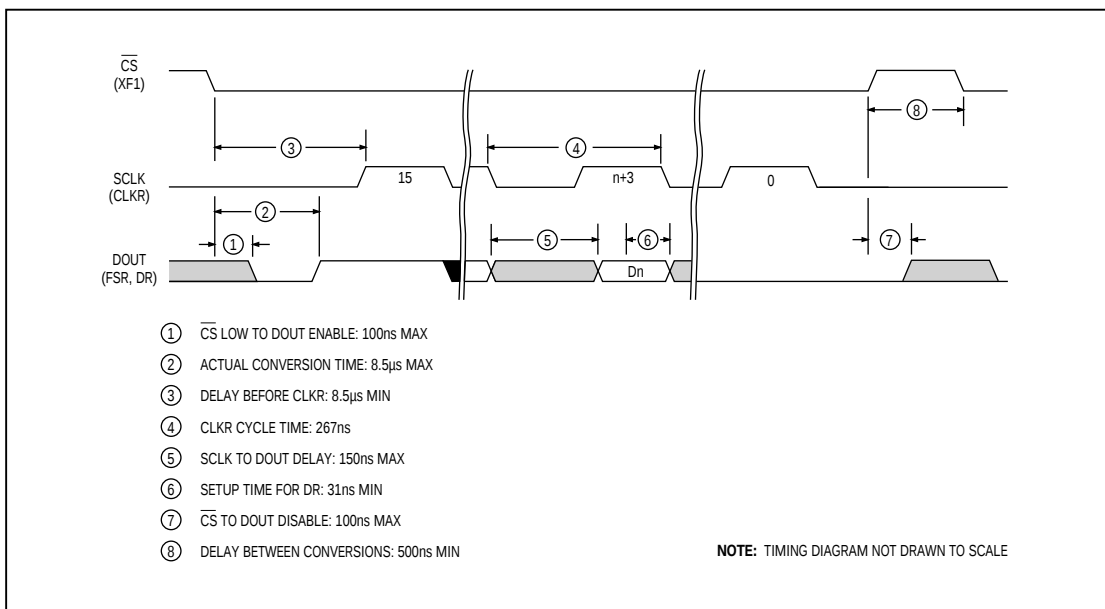


Figure 6. MAX187 to TMS320 Interface Timing

# MAX187 Evaluation System/Evaluation Kit

**Listing 3. Using the TMS320C3X EVM to Read the MAX187**

```
; Compiled under TMS320C3X/4x COFF Assembler version 4.50

        .data
STCK     .word 0809F00H ; initial stack pointer
CTRL     .word 0808000H ; peripheral interface base address
HOST_DATA .word 0804000H ; host data port address
IOF_AMASK .set 0000EH ; clear all XF1 bits in IOF register
IOF_SET_XF1 .set 00060H ; make XF1 pin an output; value = 1
IOF_RESET_XF1 .set 00020H ; make XF1 pin an output; value = 0
SerGlob1 .word 08100280H
SerPrtX1 .word 00H ; assign CLKX,DX,FSX pins as general inputs
SerPrtR1 .word 0111H ; assign CLKR,DR,FSR to serial port
SerTim1 .word 03C0H
SerTim1Val .word 010000H

        .text
init
LDI 0,ST ; initialize status register
LDI 0,DP ; point data page pointer into rom
LDI @STCK,SP ; initialize stack pointer
LDI IOF,R1 ; start with XF1 high
AND IOF_AMASK,R1
OR IOF_SET_XF1,R1
LDI R1,IOF
LDI @CTRL,AR0 ; peripheral interface address
LDI @HOST_DATA,AR1 ; host interface address
LDI @SerTim1Val,R0
STI R0,*+AR0(86) ; serial ch1 timer period
LDI @SerGlob1,R0
STI R0,*+AR0(80) ; serial global register
LDI @SerPrtX1,R0
STI R0,*+AR0(82) ; serial transmit control register
LDI @SerPrtR1,R0
STI R0,*+AR0(83) ; serial receive control register
LDI @SerTim1,R0
STI R0,*+AR0(84) ; serial ch1 timer register

next_sample:
LDI IOF,R1 ; assert chip select
AND IOF_AMASK,R1
OR IOF_RESET_XF1,R1
LDI R1,IOF
LDI 61,R0 ; delay for 10 usec (30 MHz system clock)
wait_for_conversion:
SUBI 1,R0 ; 5 cycles = 166.6 nsec per delay iteration
BNZ wait_for_conversion
LDI 03C0H,R1
STI R1,*+AR0(84) ; turn on the serial receive clock

loop
LDI *+AR0(80),R2 ; read global control register
AND 01H,R2 ; test the receiver ready bit
BZ loop ; loop until data is received
LDI 0300H,R1
STI R1,*+AR0(84) ; turn off the serial receive clock
LDI IOF,R1 ; negate chip select
AND IOF_AMASK,R1
OR IOF_SET_XF1,R1
LDI R1,IOF
LDI *+AR0(92),R3 ; copy received data into R3
ROR R3 ; strip off the leading one
ROR R3
ROR R3
AND 0FFh,R3
SendToHost
STI R3,*+AR1(0) ; send R3 to host
LDI 9,R0 ; delay for 1.5 usec (30 MHz system clock)
wait_for_tracking:
SUBI 1,R0
BNZ wait_for_tracking
BR @next_sample ; this program runs forever
.end
```

Evaluates: MAX187

## MAX187 Evaluation System/Evaluation Kit

Evaluates: MAX187

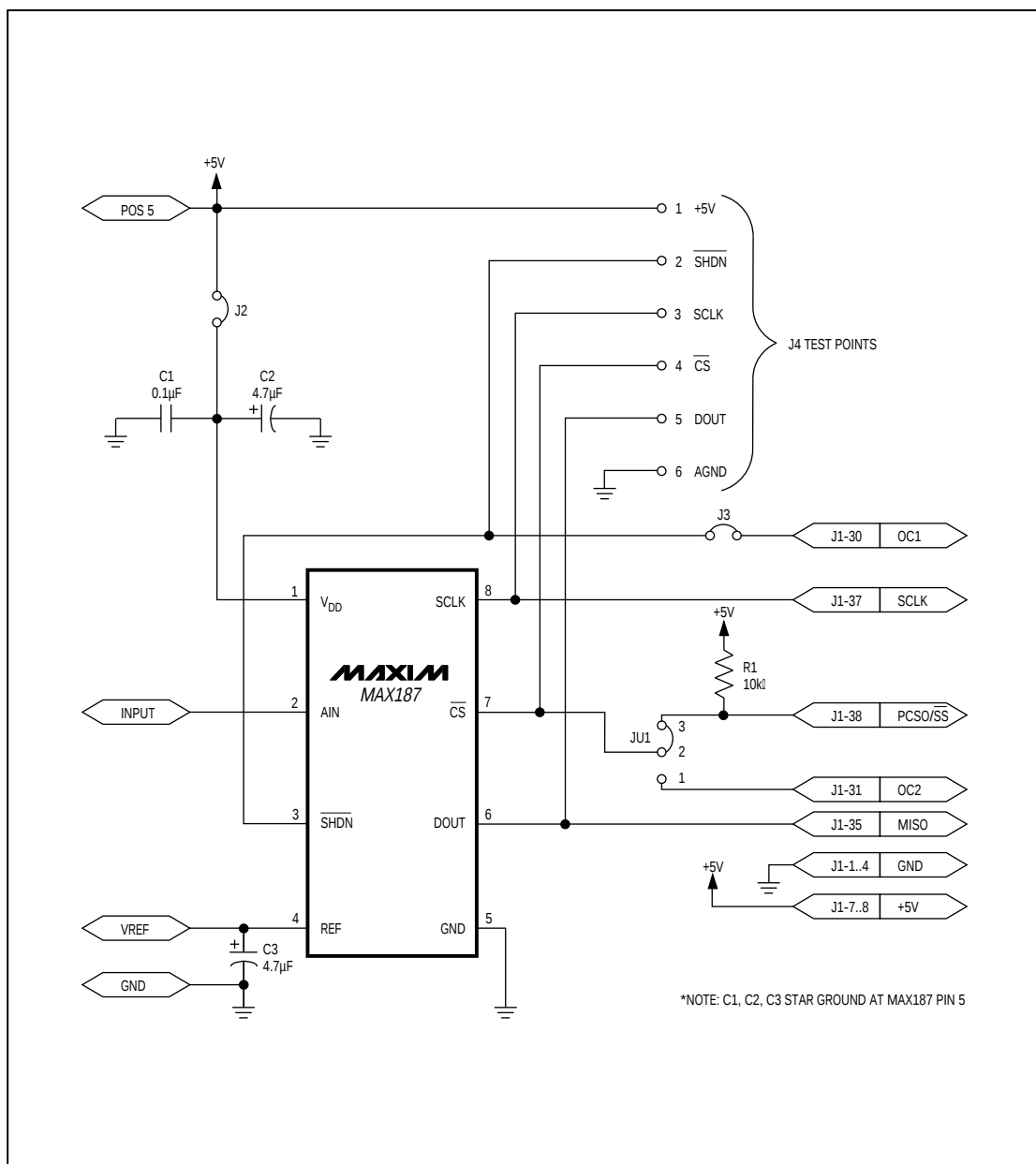


Figure 7. MAX186 EV Kit Component-Side Layout

MAX187 Evaluation System/Evaluation Kit

Evaluates: MAX187

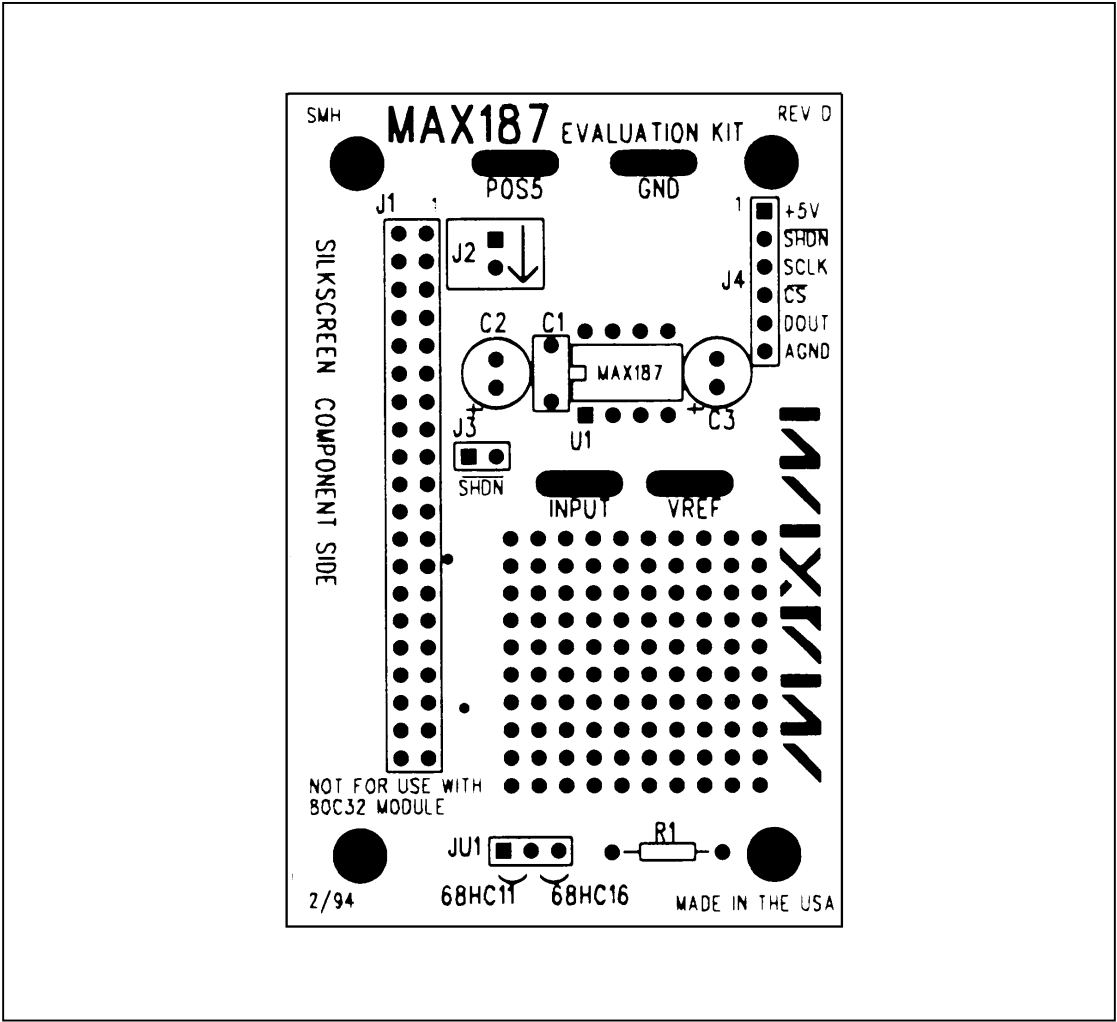


Figure 8. MAX187 EV Kit Component Placement Guide

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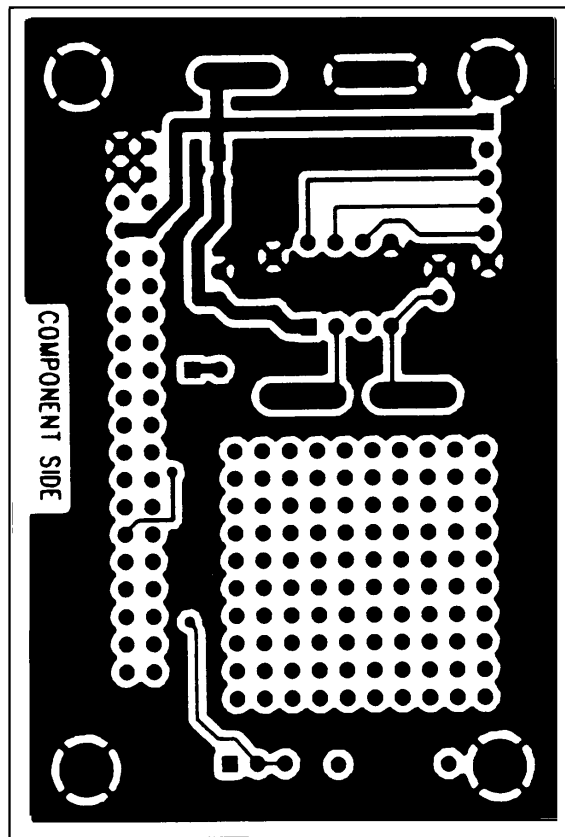


Figure 9. MAX187 EV Kit PC Board Layout—Component Side

## MAX187 Evaluation System/Evaluation Kit

Evaluates: MAX187

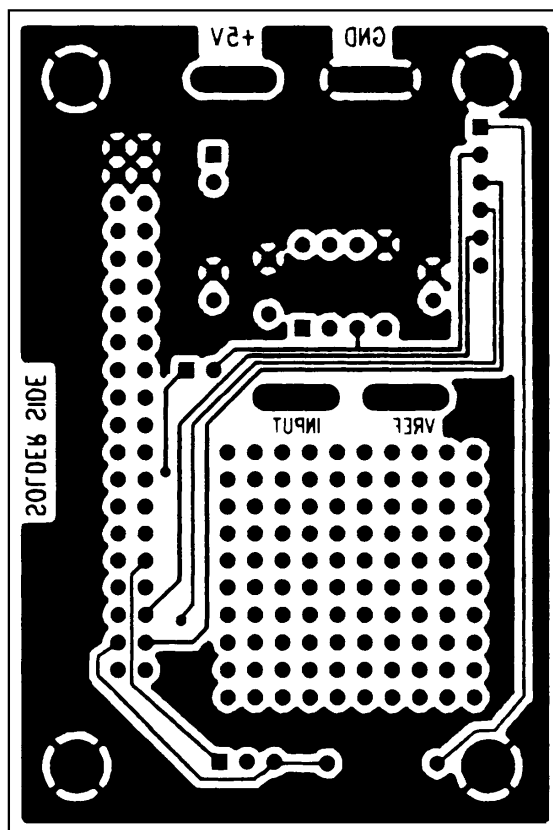


Figure 10. MAX187 EV Kit PC Board Layout—Solder Side

# MAX187 Evaluation System/Evaluation Kit

## 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   | Empty                                                      |
| JU1         | 0   | Empty                                                      |
| JU2         | 0   | Reference designator, not used                             |
| JU3         | 0   | Empty                                                      |
| JU4         | 0   | Empty                                                      |
| JU5         | 0   | Empty                                                      |
| L1          | 0   | Empty                                                      |
| L2          | 0   | Empty                                                      |
| LED1        | 1   | Light-emitting diode                                       |
| R1          | 1   | 10MΩ, 5% resistor                                          |

| DESIGNATION | QTY | DESCRIPTION                                                        |
|-------------|-----|--------------------------------------------------------------------|
| R2          | 1   | 330kΩ, 5% resistor                                                 |
| R3, R4      | 2   | 10kΩ, 5% resistor                                                  |
| R5          | 1   | 470Ω, 5% resistor                                                  |
| R6          | 1   | 10kΩ SIP resistor                                                  |
| SW1         | 1   | Slide switch                                                       |
| SW2         | 1   | Momentary pushbutton switch                                        |
| U1          | 1   | 68HC16 μC, part # 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 8 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 9 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  $\mu$ C 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 10 outlines the address ranges for each of the elements found on the 68HC16 module, and Table 11 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 8. 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 9. 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 |

## MAX187 Evaluation System/Evaluation Kit

**Table 10. 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  $\mu$ C 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.

# MAX187 Evaluation System/Evaluation Kit

Evaluates: MAX187

Table 11. 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    |

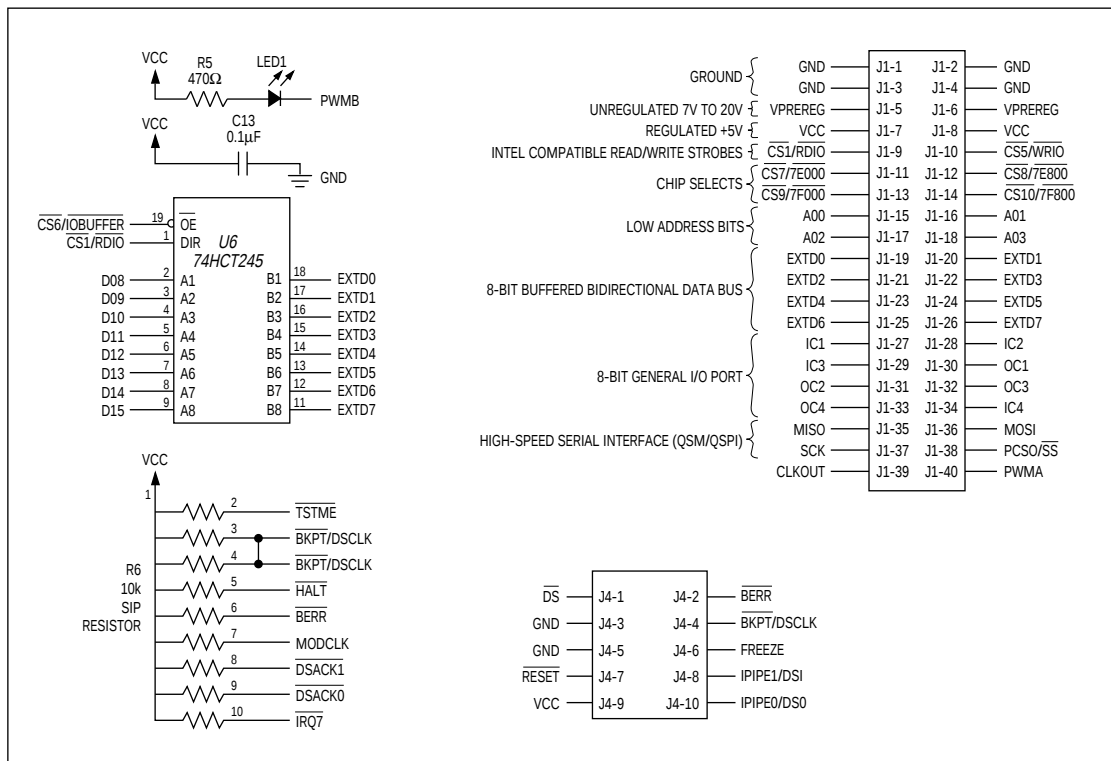


Figure 11. 68HC16 Module Schematic

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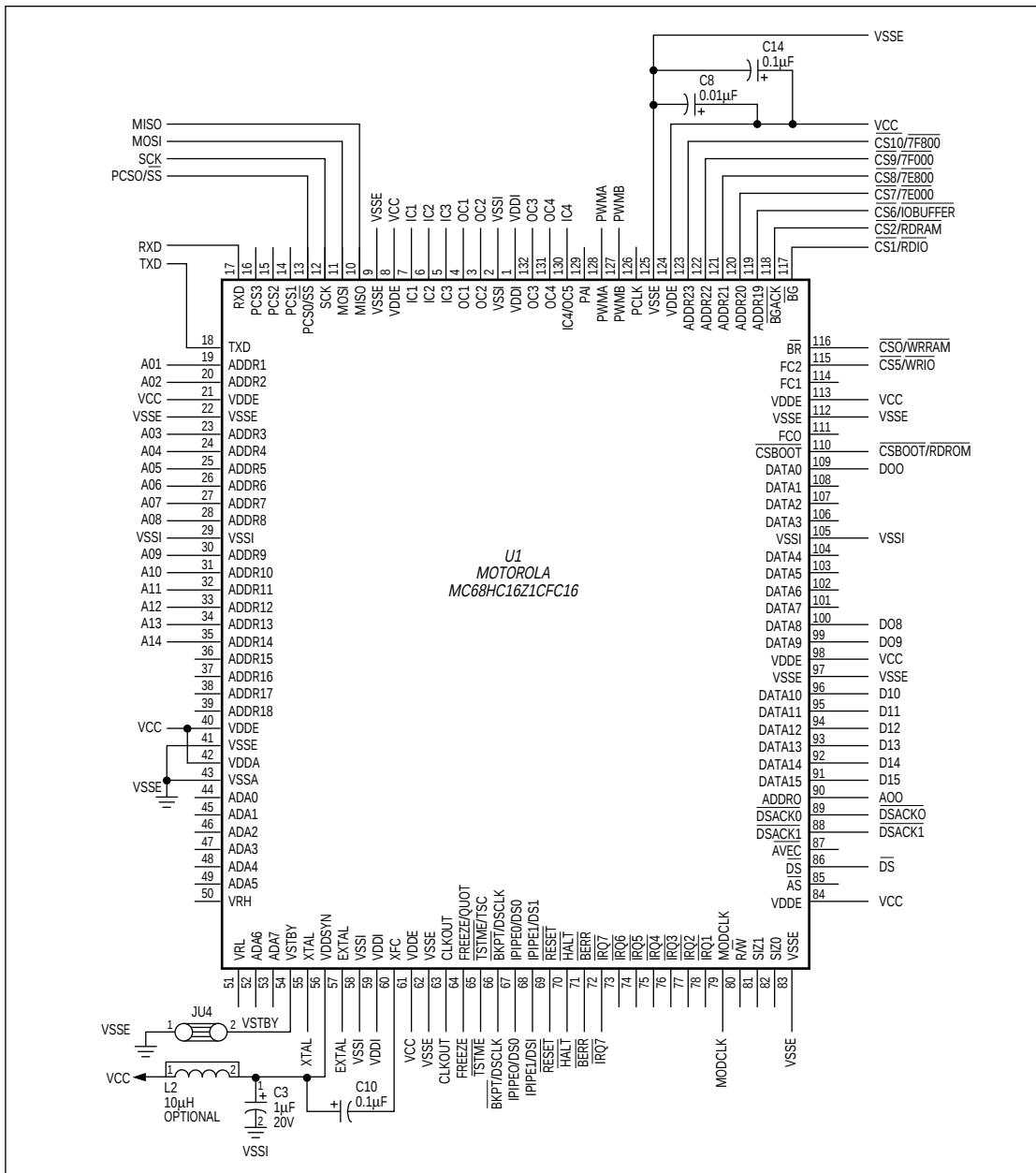


Figure 11. 68HC16 Module Schematic (continued)

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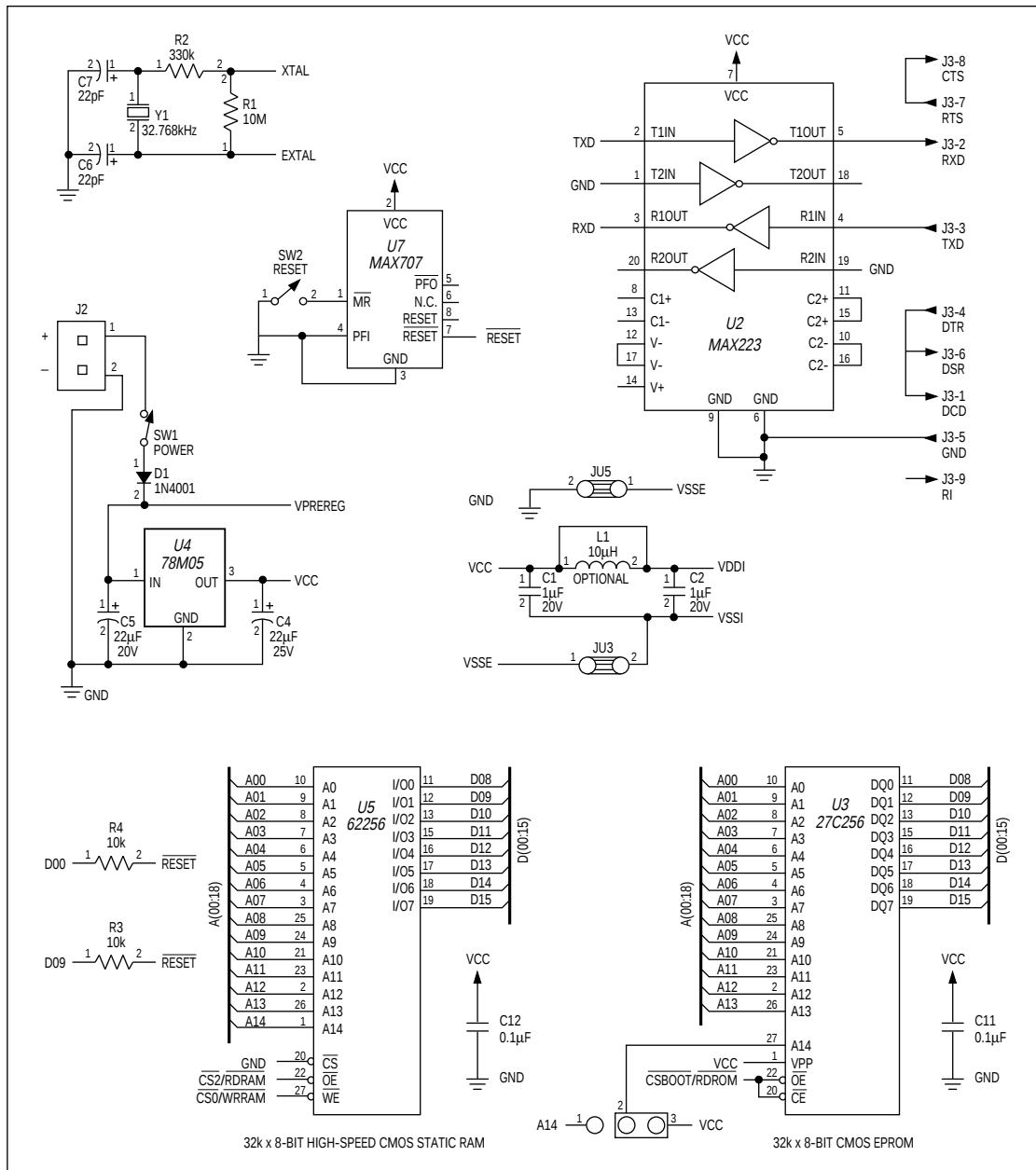


Figure 11. 68HC16 Module Schematic (continued)

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Evaluates: MAX187

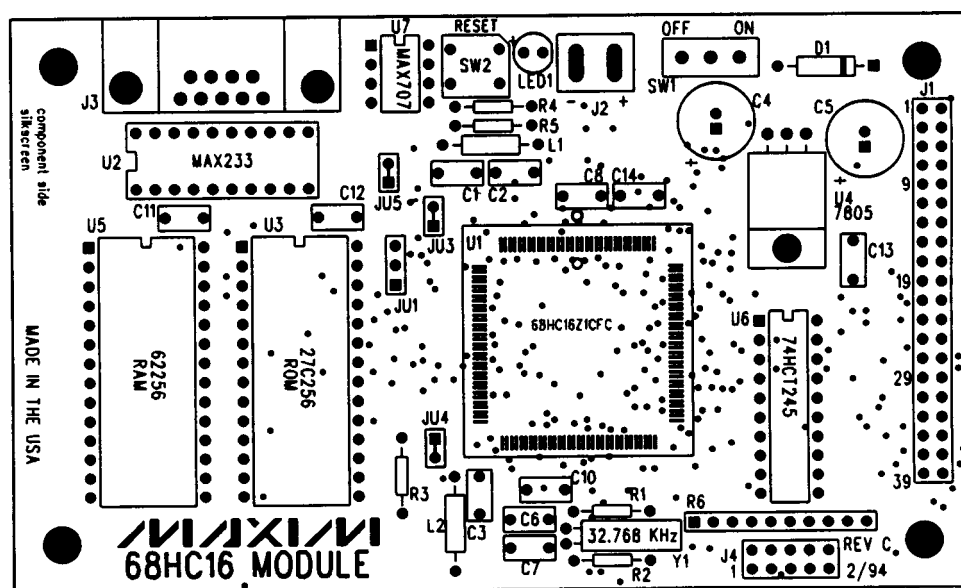


Figure 12. 68HC16 Module Component Placement Guide

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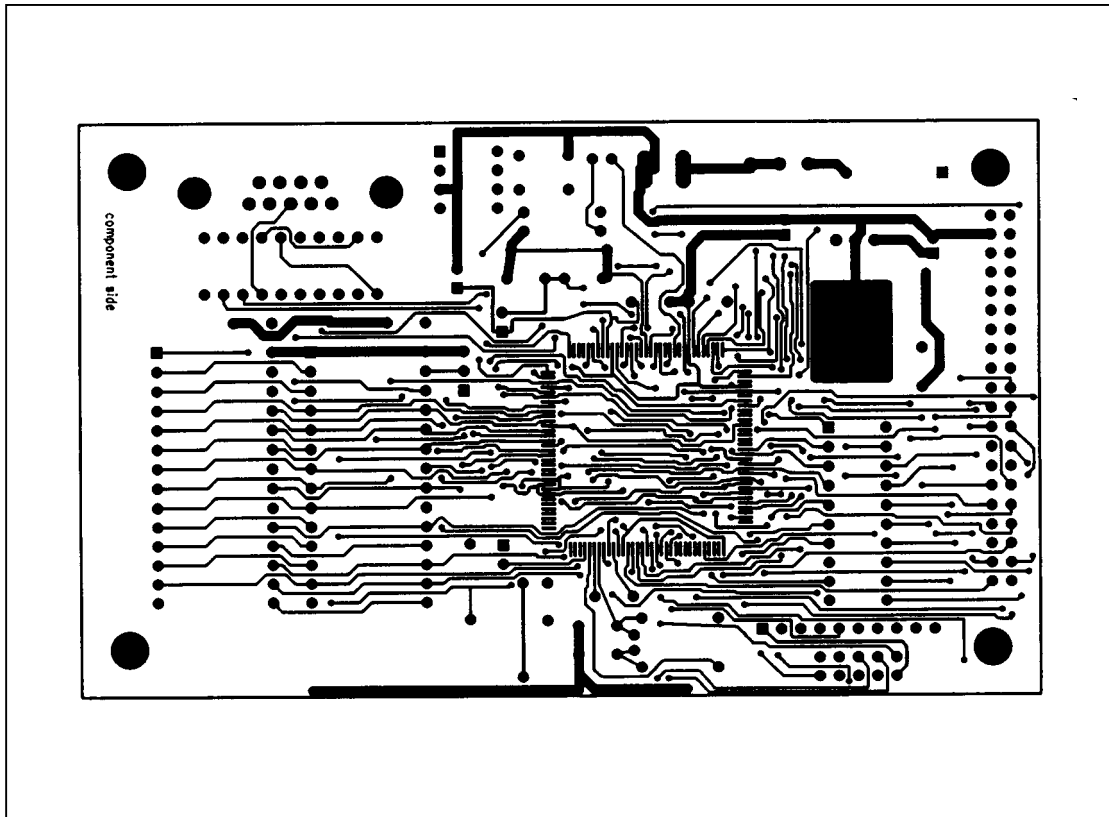


Figure 13. 68HC16 Module PC Board Layout—Component Side

## MAX187 Evaluation System/Evaluation Kit

Evaluates: MAX187

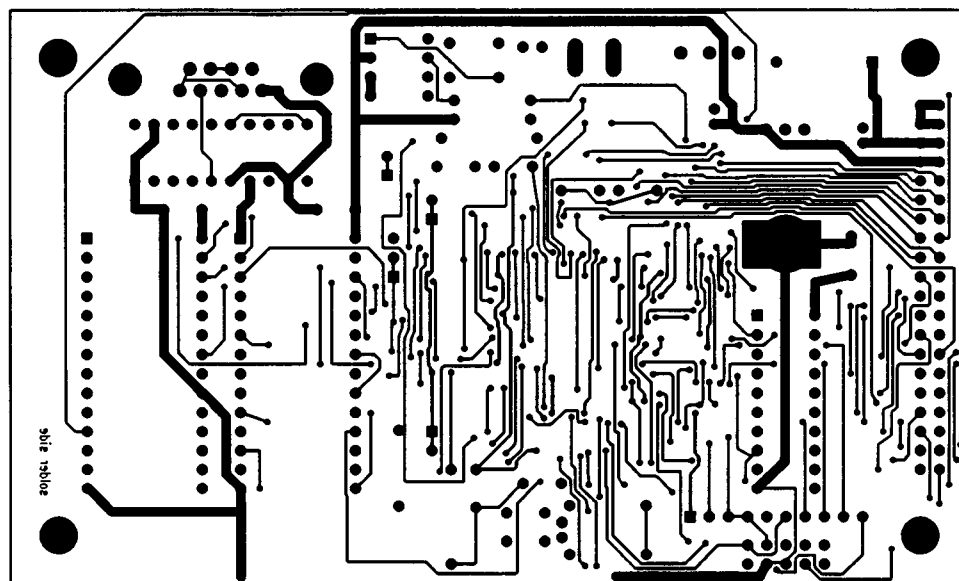


Figure 14. 68HC16 Module PC Board Layout—Solder Side

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