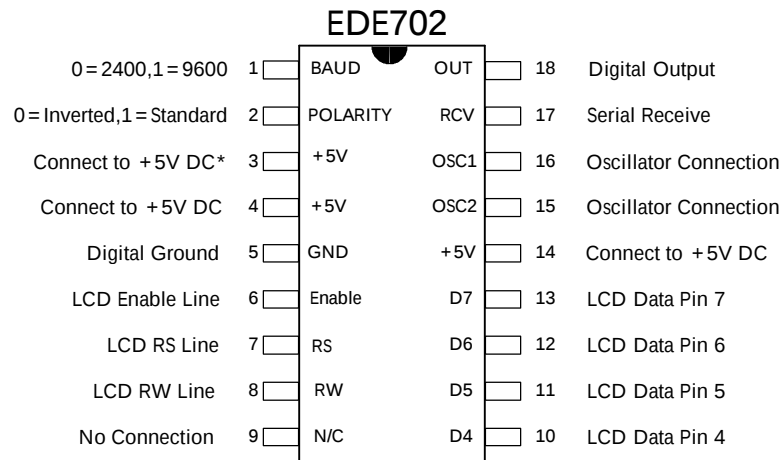


EDE702 Serial LCD Interface IC



The EDE702 Serial LCD Interface IC has been designed to provide a cost-effective LCD control solution for a wide variety of embedded designs. Offering the most frequently used features of the popular EDE700 IC (plus an added digital output line & lower crystal frequency), the EDE702 provides a tremendous price/ performance ratio. It allows nearly any text-based LCD module to be controlled via a simple one-wire data link, freeing an additional 6 to 10 I/O lines on your microcontroller/ microprocessor system - which frequently allows a smaller, less costly microcontroller to be utilized in your design.

The EDE702 allows full LCD control, including the creation of custom characters. Also, in addition to complete screen control, the EDE702 provides a convenient serial-controlled digital output pin for lighting an indicator LED, driving a sounder, etc. With a 2400 or 9600 Baud rate and selectable serial data polarity, the EDE702 can easily communicate with any device capable of sending asynchronous serial data. Connection to most microcontrollers, stamps, or microprocessors can be made using a single data wire without any type of voltage level conversion. Connection to a PC requires only a 33K Ω resistor.

Some of the special features of the EDE702 are as follows:

- *RS232 and TTL-level compatible*
- *Single-chip design allows for easy system integration*
- *Compatible with most 1x8 to 2x40 character HD44780 controlled LCDs*
- *Useable with LCDs having either 1x14 or 2x7 connector configuration*
- *Allows direct control of all LCD module functions*
- *Offers serial-controlled digital output line*
- *Selectable data polarity eliminates necessity of RS-232 voltage converter*
- *2400/9600 Baud data rates*
- *Available in 18 pin DIP or SOIC packages*
- *Cost-effective in OEM applications*

PIN DEFINITIONS

LCD Connection Pins

LCD Enable Line (Pin 6):	LCD Enable line; pin 6 on LCD screen module
LCD RS Line (Pin 7):	LCD Register Select line; pin 4 on LCD screen module
LCD RW Line (Pin 8):	LCD Read/Write line; pin 5 on LCD screen module
D4 (Pin 10):	LCD Data 4 line; pin 11 on LCD screen module
D5 (Pin 11):	LCD Data 5 line; pin 12 on LCD screen module
D6 (Pin 12):	LCD Data 6 line; pin 13 on LCD screen module
D7 (Pin 13):	LCD Data 7 line; pin 14 on LCD screen module

Control & Data Pins

BAUD (Pin 1):	Baud Rate Selection; 0 = 2400, 1 = 9600 Baud
Polarity (Pin 2):	Serial Data Polarity Control; 0 = Inverted, 1 = Standard
RCV (Pin 17):	Serial Data Input
OUT (Pin 18):	Digital Output (Need not be connected)

Clock/ Power Pins

OSC1, OSC2 (Pin 16, Pin 15):	4 MHz Resonator or Crystal Connection
+5V Power (Pin 14, Pin 4):	Connect to +5V DC
Ground (Pin 5):	Connect to 0 VDC (GND)
+5V or GND (Pin 3):	* To maintain compatibility with EDE700 pinout, pin may be connected to either +5V or GND

PC CONNECTION

The EDE702 can be used with most HD44780-based text LCD's. The two most common types of connectors on these modules are the 1x14 and 2x7 pin arrangements (there may be two additional pins if the LCD is the backlit type). The pin numbers should be identified on the LCD module. Refer to Figure One for connection of the LCD module to the EDE702. Notice that not all of the LCD module's pins need to be connected because the EDE702 uses a 4-bit transfer mode.

Figure One also illustrates the hookup used for connection to a PC. A RS-232 voltage-level converter IC such as the MAX232 is not required; internal clamp diodes on the EDE702 convert the incoming RS-232 level voltages into TTL-level signals. Also, notice that the POLARITY input on the EDE702 is tied low; this causes the EDE702 to interpret the inverted RS-232 signals correctly (a voltage-converter IC such as the MAX232, inside the PC, inverts the signal for transmission).

*** IMPORTANT NOTE:** The 33KW resistor must be used when connecting to a PC in this fashion; omitting it will cause excessive current to flow, possibly damaging both the PC serial port and the EDE702 IC.

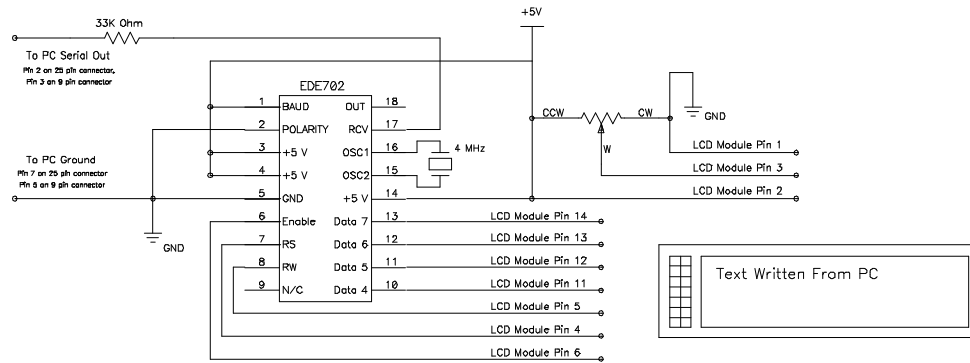


Figure One: Connection of EDE702 to a PC using only a 33K Ω Resistor

A 4 MHz resonator is used to clock the EDE702. Alternately, you may choose to use a 4 MHz crystal (parallel-cut) or a 4 MHz TTL oscillator. If you choose the latter, connect the oscillator output to only OSC1 (Pin 16), leaving OSC2 (Pin 15) unconnected. The LCD contrast is set by a 10-20K Ω potentiometer. If the LCD screen will be used in a relatively temperature-constant environment with a fixed viewing angle, you may choose to replace this potentiometer with two suitably-valued resistors connected in series. The contrast pin would then be connected between the two resistors (use a potentiometer to first determine the appropriate resistance values for your particular LCD).

The above schematic can be easily tested using the following QBASIC code; both the PC-executable and text versions are available on E-Lab's web site:

```
REM Open communication channel to COM1 at 9600 Baud
OPEN "com1:9600,n,8,1,cd0,cs0,ds0,op0,rs" FOR OUTPUT AS #1

REM Clear Display
GOSUB 999
OUT &H3F8, &HFE
GOSUB 999
OUT &H3F8, &H1
REM Pause for LCD screen clear command to complete on LCD module
FOR delay=1 to 5000: NEXT delay

REM Write first row of text to LCD screen
GOSUB 999
PRINT #1, "EDE702 Test Screen";

REM Jump to second row on 2 line LCD
GOSUB 999
OUT &H3F8, &HFE
GOSUB 999
OUT &H3F8, &HC0

REM Write second row of text to LCD screen
GOSUB 999
PRINT #1, "Time is: "; TIME$;

END

REM Hold until Transmit Buffer is empty
999 IF (INP(&H3FD) AND &H40) = 0 THEN GOTO 999
RETURN
```

CONNECTION TO OTHER HOST SYSTEMS

Of course most applications of the EDE702 will not involve connection to a PC. The EDE702 can be utilized with a variety of controllers such as the BASIC Stamp™, nearly any microcontroller, or a microprocessor system. The type of connection used (direct wire or RS-232 voltage level conversion IC's) is determined by the communications level voltage of the host system. For

instance, the PC serial port transmits using voltages ranging from -15 to +15 VDC. The schematic in Figure One relies on the EDE702's internal input-clamping diodes to reduce the signal's voltage to TTL-levels. The 33K Ω resistor is necessary to limit the current through these diodes. Because the voltage driver inside the PC contains a level inverter, the EDE702 is used in "Inverted Mode" (Pin 2 Low). This causes the EDE702 to transmit and receive using a polarity-inverted serial data stream.

If your EDE702 circuit does use a voltage-converter IC such as the MAX232, you will not need this 33K Ω series resistor. Also, since the MAX232 Level Shifter IC contains an inverter, the EDE702 should, when used with any level converter IC such as this, be operated in "Standard Mode" (Pin 2 High).

Connection to a microcontroller requires no voltage level conversion or current-limiting resistor; simply connect the microcontroller's serial output to the EDE702's Serial Data Input (Pin 17). The serial data is transmitted using TTL-compatible voltage levels. Depending upon the length of the data line, you may need to pull up this line using a 4.7K Ω resistor, as shown in Figure Two. Figure Two illustrates the connection of a BASIC Stamp[™] I to the EDE702. Notice that only one I/O pin is required to display text on the LCD screen. For this example, the EDE702 is set to 2400 Baud (Pin 1 Low), Standard Polarity (Pin 2 High).

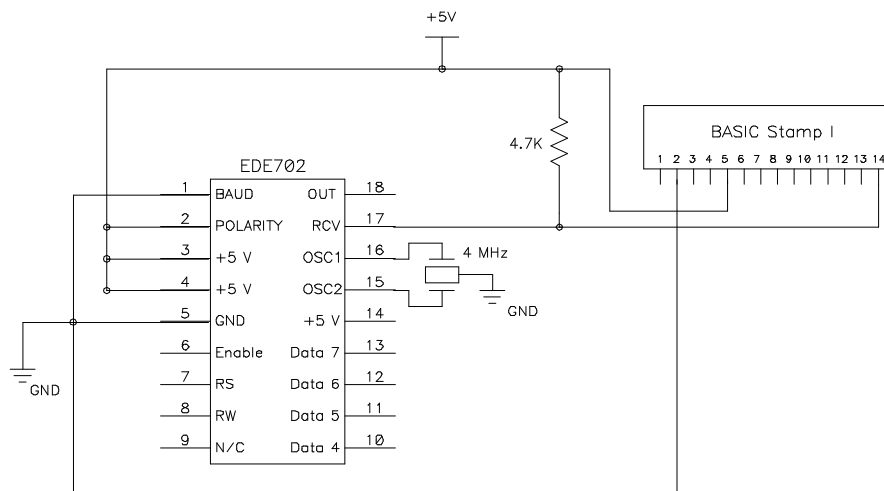


Figure Two: Connection of EDE702 to BASIC Stamp[™] I

The following software, written for the BASIC Stamp[™] I, outputs text on both lines of a two-line LCD. Notice that a "Pause 10" instruction is added after each write to the LCD's internal control registers to allow time for the LCD to execute the instruction.

```
REM Delay while LCD powers up.
PAUSE 500

REM Clear display and home cursor
SEROUT 7,T2400,($FE)
SEROUT 7,T2400,($01)
PAUSE 10

SEROUT 7,T2400,("Hello World...")

REM Move to start of second row
SEROUT 7,T2400,($FE)
SEROUT 7,T2400,($C0)
PAUSE 10

SEROUT 7,T2400,("This text should be on the second row!")
```

The following section outlines the use and function of the EDE702 LCD controller. While this datasheet explains many of the specific LCD module features, your particular module may be slightly different. When in doubt, always refer to the datasheet for your particular LCD module. In addition, note that some one-line LCD modules do not have the entire row mapped contiguously in memory; you must move the cursor position to the start of the LCD memory's "second line" in order to write to the second half of the locations on these one-line displays.

USING THE EDE702 SERIAL LCD CONTROLLER

The EDE702 can be written to in much the same way as a terminal display device. It accepts standard ASCII characters and writes them to the display screen. In addition, the EDE702 will interpret several ASCII control commands and perform specific functions as directed by them. This section details the use of the various commands available on the EDE702.

Upon powerup, your host controller (the device writing to the EDE702) should be programmed to wait approximately 50 mS for the LCD to initialize. Following this, the display is ready to accept data for display. Before the first character is written, the EDE702 will home the cursor (the cursor will be invisible). Therefore, the first character written to the EDE702 will be displayed in the upper-left hand corner of a two row display, or in the left-most position of a one-row display. Subsequent character writes to the EDE702 will cause the cursor location to increment by one for each character written.

Most ASCII characters can be displayed on the LCD module using the EDE702 (see your LCD module datasheet for a complete listing). However, the EDE702 will intercept certain ASCII control characters and not display them on the screen, instead performing a specific command upon the LCD module. The following table shows the ASCII codes that will be intercepted by the EDE702:

Value	ASCII Command	Function Performed
\$0D	Carriage Return	Ignore this character and print nothing.
\$0A	Line Feed	Ignore this character and print nothing.
\$0C	Form Feed	Clear screen, home cursor.
\$08	Backspace	Perform destructive backspace (move cursor back one position and erase character in that position).
\$FE	EDE702 Control	Read next command and perform desired function (see Table Two).

Table One: ASCII Control Characters

Sending the Form Feed character to the EDE702 causes it to clear the screen and home the cursor. The Backspace command causes the cursor to be moved back by one space (on a given row), deleting the character that was in that position (commonly called a "destructive backspace").

Notice that the last command, \$FE, has special meaning to the EDE702. It is used to issue direct commands to the LCD module. The following table shows the direct commands that can be sent after sending the value \$FE (1111 1110 binary, 254 decimal) to the EDE702:

Binary Value Sent	Action Taken
0 0 0 0 0 0 0 1	Clear display and return cursor to home position.
0 0 0 0 0 0 1 X	Home Cursor.
0 0 0 0 0 1 I/D S	Sets cursor move direction & shifting. I/D = 1 for increment, S = 1 for shift.
0 0 0 0 1 D C B	Sets display on (D), cursor on (C), blink on (B). 1 = on, 0 = off.
0 0 0 1 S/C R/L X X	Moves cursor and shifts display without affecting DDRAM. S/L = 1: display shift; 0 = cursor movement. R/L = 1, shift right; 0 = left.
0 0 1 DL N F X X	Sets data length (DL), number of lines (N), and character font (F). DL = 1: 8 bit; 0 = 4 bit. N = 1: 2 lines; 0 = 1 line. F = 1: 5x10; 0 = 5x7 dots.
0 1 X X X X X X	Set CGRAM Address. Character data is sent after receiving this setting.
1 X X X X X X X	Set DDRAM Address. Data display address is set using this command. (Line one starts at \$00, line two starts at \$40 (Therefore the command \$C0 would move the cursor to the start of the second row).
1 1 1 1 1 1 0 0	Outputs a 'LOW' (GND) on the Digital Output pin.
1 1 1 1 1 1 0 1	Outputs a 'HIGH' (+5V) on the Digital Output pin.

Table Two: \$FE Direct Control Codes

As an illustration of these direct control codes, the following code, written in QBASIC for clarity, will print two lines of text on the LCD and then scroll the entire display to the left 40 positions.

```

REM Open communication channel to COM1 at 9600 Baud
OPEN "com1:9600,n,8,1,cd0,cs0,ds0,op0,rs" FOR OUTPUT AS #1

REM Clear Display
GOSUB 999
OUT &H3F8, &HFE
GOSUB 999
OUT &H3F8, &H1
REM Pause for LCD screen clear command to complete on LCD module
FOR delay=1 to 5000: NEXT delay

GOSUB 999
PRINT #1, "Line One Text.";

REM Move to first location on row two
GOSUB 999
OUT &H3F8, &HFE
GOSUB 999
OUT &H3F8, &HC0

GOSUB 999
PRINT #1, "Line Two Text.";

REM Shift Entire Display Left
FOR shift = 1 TO 40
GOSUB 999
OUT &H3F8, &HFE
GOSUB 999
OUT &H3F8, &H18
REM Slow down shifting...
FOR delay=1 to 50000: NEXT delay
NEXT shift

END

REM Hold until transmit buffer is empty
999 IF (INP(&H3FD) AND &H40) = 0 THEN GOTO 999
RETURN

```

As illustrated in the bottom two rows of Table Two, the EDE702 contains a serial-controlled digital output pin. This pin's voltage level can be changed by sending the appropriate control characters to the EDE702. For instance, to make this pin high, send \$FE (to enter into Control Mode) and then send \$FD. To set it low, send \$FE followed by \$FC. Sending control signals to the Digital Output pin will not affect the LCD screen. Upon powerup, the Digital Output pin is set low by the EDE702.

A MICROCONTROLLER EXAMPLE

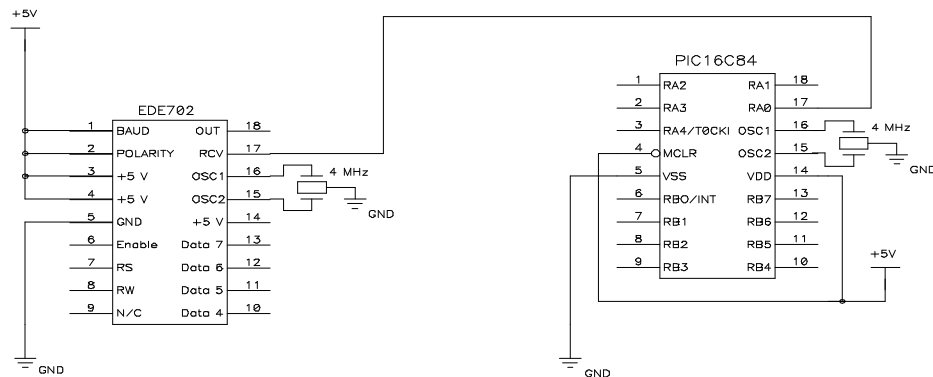


Figure Three: Connection of EDE702 to a Microcontroller

This code, written in C (PCM Compiler from Custom Computer Services, Inc.), illustrates the use of the EDE702 in conjunction with a microcontroller.

```
#include<16C84.H>
#use delay(clock=4000000)
#use rs232(baud=9600,rcv=pin_a1,xmit=pin_a0)

main() {

    delay_ms(50);                /* Wait while LCD powers up */

    printf("Writing to the LCD is very simple...");    /* Write text to first row */
}
```

The above C-language example is extremely simple and straightforward. Using the EDE702 with a system programmed in assembly language is simple as well - the manufacturer of your particular microcontroller has application notes illustrating how to transmit serial data with their microcontroller. If the selected microcontroller has an internal hardware UART, connecting to the EDE702 will simply consist of loading the appropriate registers to set the baud rate and other communications parameters. If your microcontroller does not have an internal hardware UART, you will be able to send serial data via a 'software UART' - a subroutine which rotates through the byte to be transmitted one bit at a time, thereby sending the data out a digital I/O pin. Again, your particular microcontroller manufacturer's application notes should offer examples of this. The EDE702 has been designed for embedded microcontroller interfacing and is useable with any microcontroller or other embedded system that is programmed in either C or assembly language, or any other system capable of sending serial data.

CREATING CUSTOM SCREEN CHARACTERS

You may occasionally have need to display a character not included in the standard ASCII character set. Or, as is the case in this example, you may need to modify a certain character to make it more suitable for your application. In this instance, we choose to make a "\" because the backslash character on most LCD modules is an unusable, odd-looking character. For illustrative purposes, a BASIC Stamp™ (as was depicted in Figure Two) is used as the controlling host.

Because the Hex Codes \$00 through \$07 are seldom used, we will use these locations to store our custom characters. Each character is displayed as an 8 row by 5 column grid. Grid data is written to the CGRAM memory area of the LCD Module (see Table Two for details). Because each character contains eight bytes of data, and because the CGRAM area starts at \$40 (0100 0000 binary, again see Table Two), the CGRAM address for ASCII character \$00 is \$40, ASCII character \$01 is \$48, ASCII character \$02 is \$50, etc.

The 5x8 grid is arranged in CGRAM memory as shown below:

```

- - - X X X X X    ($1F, or 0001 1111 binary, would turn on all the pixels in this row)
- - - X X X X X
- - - X X X X X
- - - X X X X X
- - - X X X X X
- - - X X X X X
- - - X X X X X
- - - X X X X X
```

The "X" locations are turned on or off depending upon whether a 0 or a 1 is written to that particular location in memory. For instance, to turn all the pixels on in the top row of a character, we would write the value \$1F (0001 1111 binary) to the CGRAM. However, to prevent the EDE702 from intercepting certain ASCII values as commands and interpreting them as shown in Table One, we will perform a logical "or" operation on all pixel data that is sent to the CGRAM. The value that should be "or"ed with the pixel data is \$20. Therefore, instead of sending \$1F, we should send \$3F (0011 1111 binary). All pixel data in the following code has been logically "or"ed with \$20.

The following BASIC Stamp™ I code causes the ASCII character \$03 to be displayed as a "\" character on the LCD module:

```

REM Wait while LCD powers up
PAUSE 200

REM Set CGRAM address to character $3: $40 + $8 + $8 + $8 = $58
SEROUT 7,T2400,($FE)
SEROUT 7,T2400,($58)

REM Enter data for grid. Example: '---1 0000' on first row attained
REM by sending $10 (0001 0000 binary)
REM NOTE: To prevent the EDE702 from intercepting certain ASCII value
REM and interpreting them as commands, all grid values are "or"ed with $20
REM For example, $10 'or'ed (+) with $20 = $30
SEROUT 7,T2400,($30)
SEROUT 7,T2400,($30)
SEROUT 7,T2400,($28)
SEROUT 7,T2400,($24)
SEROUT 7,T2400,($22)
SEROUT 7,T2400,($21)
SEROUT 7,T2400,($21)
SEROUT 7,T2400,($20)

REM Move cursor back to start of DDRAM area
SEROUT 7,T2400,($FE)
SEROUT 7,T2400,($80)

REM Write newly-defined character
SEROUT 7,T2400,($03)
```

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ABSOLUTE MAXIMUM RATINGS

Oscillator frequency 4 MHz
Supply Voltage 6.25V
Ambient temperature under bias -55°C to +125°C
Max. current sunk by an output pin 25mA
Max. current sourced by an output pin 20mA

STANDARD OPERATING CONDITIONS

Supply voltage 3.0V to 5.5V
Operating temperature 0°C to +70°C

The EDE702 IC is implemented as firmware on a PIC16C54B microcontroller, manufactured by Microchip Technology, Inc. For a more comprehensive technical summary of this device, please refer to the PIC16C54B datasheet (accessible from the E-Lab web site).

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