National Semiconductor

LM75 I²C Digital Temperature Sensor Demo Board Hardware and Software Guide

1.0.0 System Overview

The LM75 I²C Digital Temperature Sensor Demo package includes software and hardware evaluation tools for the LM75 Digital Temperature Sensor. The LM75 is a temperature sensor, Delta-Sigma analog-to-digital converter, and digital over-temperature detector with I²C interface. The parallel printer port of a PC is used to simulate the I²C bus interface required to drive the LM75. The software provided can query the LM75 at any time to read temperature and display it in two modes, Thermometer and Strip Chart. An open-drain Overtemperature Shutdown (O.S.) output on the LM75 becomes active when the temperature exceeds a programmable limit. This pin can operate in either "Comparator" or "Interrupt" mode. The state of this pin is sensed through the parallel printer port.

The software can program both the temperature alarm threshold (Tos) and the temperature at which the alarm condition goes away (THyst). In addition, the software can read back the contents of the LM75's Tos and THyst registers. Selection of I²C address is determined by the state of three pins (A0, A1, A2) on the LM75.

2.0.0 Installing the Hardware and Software

The LM75 Demo board is connected to the computer through a parallel printer port. The board derives all the necessary power through the port. External power supplies are not necessary. The board can be plugged in directly to the back of a computer or connected through a DB25 male-to-female straight-through cable. Before actually connecting the LM75 Demo Board to the PC you should first install the software and run it.

The LM75 Demo Software requires Windows 3.1or later. Running SETUP.EXE found on the supplied floppy diskette will install the software on your hard drive in a location you designate.

Before executing the software the parallel printer port address that the Demo Board will be connected to needs to be determined. MSD (Microsoft Diagnostic) utility can be used to determine this address. Start up a DOS shell and run MSD. The parallel printer port assignment can be found under LPT Ports. Note the address of the printer port that you are planning to connect the Demo Board to. Start up the LM75Demo software. Select the parallel printer port address under the LPT Assignment Menu. If your address is not displayed in the menu, use the Custom option to assign any hexadecimal address between 100 and FFF (Hexadecimal). Extreme caution should be used when using this option. If set incorrectly, your system may need to be rebooted.

Next use the I²C Address Menu to select the I²C address as set on the Demo Board. The Demo Board's I²C address can be set using jumpers that connect Address Bits A0-A2 to ground. A grounded Address Bit is a "0"; if a jumper is not installed, the bit is a "1". When the board was shipped to you, all three address jumpers were installed. Therefore selecting Address 1001 000 under the I²C Address Menu and configures the software to communicate with the LM75 Demo Board as shipped. If you change the Demo Board's address by removing any jumpers, be sure to select the corresponding address from the I²C Address Menu.

Now you are ready to turn on the board. Click the command button labeled "Off" found in left hand corner of the screen. You should get a message indicating that "LM75 registers are set to default power up state. All systems go!".

3.0.0 Software Description

3.1.0 Menus

3.1.1 File Menu

Exit - This command exits the LM75Demo software. The Demo Board is powered down. A dialog box will appear to indicate this. The board should now be disconnected from the port. After clicking "OK" in the dialog box the parallel printer port is reinitialized.

3.1.2 Temp Display Menu

This menu allows you to select how the temperature data retrieved from the LM75 will be displayed.

Thermometer - Choosing this option displays a thermometer in the bottom portion of the "LM75 I²C Digital Temperature Sensor Demo Software" window. The reading of the thermometer is updated when the Temperature Register of the LM75 is read. This occurs when the "Read" or "Loop" command buttons in the "Temperature Register" box are clicked. The two arrows point to the setting of the THyst and Tos Registers of the LM75. The red arrow with the match represents the Tos Register, while the blue arrow with the snowflake represents the THyst Register.

Strip Chart - Selecting this option will display a Strip Chart graph on the bottom portion of the "LM75 I²C Digital Temperature Sensor Demo Software" window. The chart is updated when the Temperature Register of the LM75 is read. This occurs when the "Read" or "Loop" command buttons in the "Temperature Register" box are clicked. The chart is also updated when the THyst and Tos Registers of the LM75 are read or written to.

3.1.3 LPT Assignment Menu

Before powering up the board it is necessary to set the LPT port address that the board is going to be plugged into. The

three most common addresses are show below and are displayed in the "LPT Assignment" menu:

378 (HEX)

278 (HEX)

3BC (HEX)

MSD (Microsoft Diagnostic) utility can be used to determine this address. Start up a DOS shell and run MSD. The parallel printer port assignment can be found under LPT Ports. Note the address of the printer port that you are planning to connect the Demo Board to. Selecting an address by trial and error basis is an option if the LM75 will be the only device attached to any LPT port of the computer.

Custom - If the parallel printer port address is not one of the ones displayed in the menu then this option can be used to set the address to any hexadecimal value greater than 100 and less than FFF. Extreme caution should be used when using this option because if set incorrectly it may be necessary to reboot the computer. It is not recommended that this address be arbitrarily set because many strange things can happen, such as rebooting DOS or maybe writing to a drive. Please use this option with extreme care!

3.1.4 I^2C Address Menu

The address selected in this menu should match the address set on the Demo Board. According to I^2C bus specifications, the LM75 has a 7-bit slave address. The four most significant bits of the slave address are hard wired inside the LM75 and are "1001". The three least significant bits of the address are assigned to pins A2-A0, and are set by connecting these pins to ground for a low, (0); or to +VS for a high, (1). Jumpers A0-A2 found on the LM75 Demo Board select the state of the three least significant bits of the I^2C address. When a jumper is installed that bit is set to zero. When the jumper is removed that bit is set to one.

3.1.5 Help Menu

Contents - Selecting this option will display this file using WinHelp.

About - Selecting this option will display the initial opening screen.

3.2.0 LM75 Operation

The LM75 temperature sensor incorporates a band-gap type temperature sensor and 9-bit Delta-Sigma ADC (Analog-to-Digital Converter). The temperature data output of the LM75 is available at all times via the I^2C bus. The function of this interface is fully explained in the LM75 data sheet (See Sections 1.2 I^2C Bus Interface and 4.0 Internal Register Structure). If temperature data is read while a conversion is in progress, the conversion will be stopped and restarted after the read. A digital comparator is also incorporated that compares a series of readings, the number of which is user-selectable, to user-programmable set point and hysteresis values. The comparator trips the O.S. output line, which is programmable for mode and polarity.

In Comparator mode the O.S. output behaves like a thermostat. The output becomes active when temperature exceeds the Tos limit, and leaves the active state when the temperature drops below the THyst limit. In this mode the O.S. output can be used to turn a cooling fan on, initiate an emergency system shutdown, or reduce system clock speed.

In Interrupt mode exceeding Tos also makes O.S. active but O.S. will remain active indefinitely until reset by reading any register via the I^2C interface. Once O.S. has been activated by crossing Tos, then reset, it can be activated again only by Temperature going below THyst. Again, it will remain active indefinitely until being reset by a read. Placing the LM75 in shutdown mode also resets the O.S. Output.

3.2.1 LM75 Pin Description:

Label	Pin #	Function	Typical Connection
SDA	1	I^2C Serial Bi-Directional Data line	From controller
SCL	2	I^2C Clock Input	From controller
O.S.	3	Overtemperature Shutdown Open Collector Output	Pull Up Resistor, Controller interrupt line
GND	4	Power Supply Ground	Ground
$+V_S$	8	Positive Supply Voltage Input	DC voltage from 3 to 5.5 volts
A0-A2	7,6,5	User-Set I^2C Address Inputs	Ground (Low, "0") or $+V_S$ (High, "1")

3.2.2 LM75 Default Setting

LM75 always powers up in a known state. LM75 power up default conditions are:

1. Comparator mode
2. Tos set to 80 °C
3. THyst set to 75 °C
4. O.S. active low
5. Pointer set to "00"; Temperature Register

With these operating conditions, the LM75 can act as a stand-alone thermostat with the above temperature settings. Connection to an I^2C bus is not required.

3.3.0 LM75 Registers

3.3.1 Temperature Data Format

Temperature data can be read from the Temperature, Tos Set Point, and THyst Set Point registers, and written to the Tos Set Point, and THyst Set Point registers. Temperature data is represented by a 9-bit, two's complement word with an LSB (Least Significant Bit) equal to 0.5 °C:

Temperature	Digital Output	
	Binary	Hex
+125°C	0 1111 1010	0FAh
+25°C	0 0011 0010	032h
+0.5°C	0 0000 0001	001h

0°C	0 0000 0000	000h
-0.5°C	1 1111 1111	1FFh
-25°C	1 1100 1110	1CEh
-55°C	1 1001 0010	192h

The Tos, THyst and Temperature registers are 16 bits long. The data format is show below:

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
MSB	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	LSB	X	X	X	X	X	X	X

Note that the 7 LSBs (D0-D6) are not always set to zero.

3.3.2 Tos Register

Read Command Button - This command sends a "read Tos register" command to the LM75. The output from the LM75 is then displayed in the text box to the left of the command button. The two text boxes on the left side of the Tos register field display the actual binary data transmitted by the LM75. The temperature data format is 9-bit two's complement MSB first.

Write Command Button - This command sends a "write Tos register" command to the LM75. The data transmitted to the LM75 is displayed in the text box to the left of the command button. The two text boxes on the left side of the Tos register field display the actual binary data transmitted to the LM75. The temperature data format is 9-bit two's complement MSB first. The data in the text box can be modified to be greater than or equal to -40 °C and less than or equal to -125 °C in 0.5 degree increments. If any other increment is set the software will round off the value to the nearest half degree.

3.3.3 THyst Register

Read Command Button - This command sends a "read THyst register" command to the LM75. The output from the LM75 is then displayed in the text box to the left of the command button. The two text boxes on the left side of the THyst register field display the actual binary data transmitted by the LM75. The temperature data format is 9-bit two's complement MSB first.

Write Command Button - This command sends a "write THyst register" command to the LM75. The data transmitted to the LM75 is displayed in the text box to the left of the command button. The two text boxes on the left side of the THyst register field display the actual binary data transmitted to the LM75. The temperature data format is 9 bit two's complement MSB first. The data in the text box can be modified to be greater than or equal to -40 °C and less than or equal to +125°C in 0.5 degree increments. If any other increment is set the software will round off the value to the nearest half degree.

3.3.4 Temperature Register

The LM75 Temperature Register is a read only register. This register is updated when a temperature conversion is completed. A temperature conversion is stopped when a read command is sent and restarted after the data has been read by the host.

Read Command Button - This command sends a "read Temperature" register command to the LM75. The output from the LM75 is then displayed in the text box to the left of the command button. The two text boxes on the left side of the Temperature register field display the actual binary data transmitted by the LM75. The temperature data format is 9-bit two's complement MSB first.

Loop Command Button - This command button first disables all other command buttons. The command will continuously send Temperature register read commands to the LM75. The interval between each read can be set in 1-second increments in the dialog box that appears when the Loop command button is clicked. The accuracy of the intervals set will depend on the speed of the computer used. This dialog box also allows setting the total number of readings that are displayed when the Strip Chart option is selected and whether looping should continue after this total is reached. Switching between the Thermometer display and the Strip Chart display while looping is possible.

3.3.5 Configuration Register

The configuration register is an 8-bit register that has the following format:

D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	Fault Queue		O.S. Polarity	Cmp/Int	Shutdown

Pressing the "Update" command in the configuration register field enables a dialog box which allows the setting of the individual bits of this register. The individual bits can be modified by modifying the text boxes or clicking the radio buttons, etc. Clicking the "Write" command button in this dialog box sends the displayed data to the LM75 configuration register. Clicking the "Read" command button reads the LM75's configuration register and displays the data. Clicking the "OK" button disables the dialog box. Note that when the configuration register dialog box is enabled the data displayed will not necessarily reflect what is in the LM75's configuration register. The data displayed in the dialog box is valid only after clicking the "Read" command button.

3.4.0 OS Output Function

The OS output of the LM75 drives high intensity LED. The anode of the LED has a printer port pin dedicated to it for power. The OS output then is fed to another pin on the parallel printer port so that the software can sense when an alarm condition has occurred. The OS output functions in two modes: Interrupt and Comparator.

In the Interrupt mode the OS output is cleared when any register in the LM75 is read. Comparator mode requires that the temperature that the LM75 is sensing drops below the setting of the Hysteresis register before the OS output is cleared.

This output can be set to be active high or active low.

The function of this output is defined by the configuration register setting.

3.5.0 Pointer Command

The four data registers (Tos, THyst, Temperature and Configuration) are selected by the pointer register. This register is an 8-bit register. The 2 LSBs are used to select one of the four data registers. Please refer to the LM75 data sheet Section 4.0 Internal Register Structure for a detailed description of this register.

4.0.0 Hardware Description

Figure 1 shows the Demo Board schematic diagram. P1 is a DB25 connector that plugs into the parallel printer port connector of your computer. Description of the pinout is shown in the following table:

DB25 Pin Number	Function
1	No Connection
2	Supplies +5V to R1, R2, R3 and V+ of the LM75
3	Supplies +5V to R5
4	Supplies +5V to R6
5-7	No Connection
8	Drives SCL input of LM75. Provides clocking for I^2C interface.
9	Provides low data for SDA input
10	No Connection
11	Input to software for state of OS output
12	No Connection
13	Input to software for SDA state.
14-17	No Connection
18-25	Ground Connection

JP1 is an 8 pin header that is directly mapped to the LM75 pinout. JP2, JP3 and JP4 are used to control the state of Address Bits A2, A1 and A0. When a shorting bar is installed on the header the input is set to a logic low.

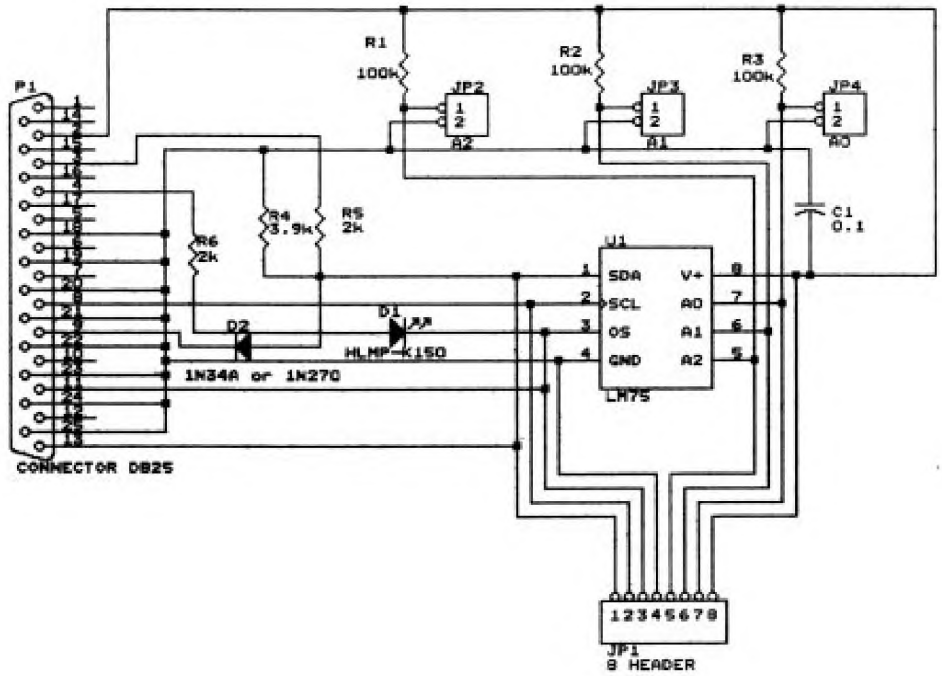

Figure 1. LM75 Demo Board Schematic

4.1.0 PC Board Layout

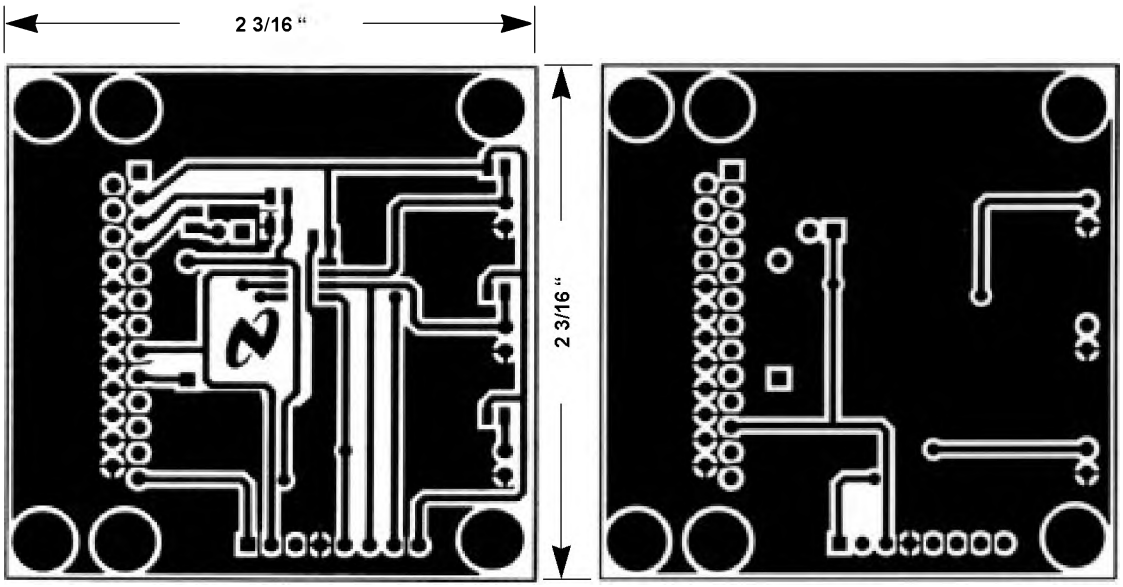

Figure 2a. Component Side of Demo Board

Figure 2b. Solder Side of Demo Board

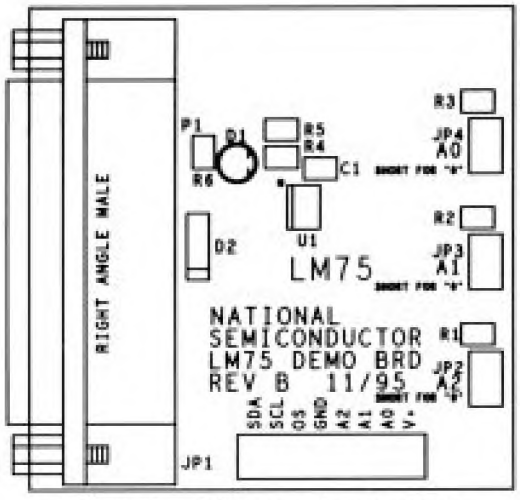

Figure 2c. Silk Screen of Demo Board

Figure 2. LM75 Demo Board printed circuit board layout.

4.2.0 LM75 Demo Board Bill Of Materials

Item	Quantity	Reference	Part
1	1	C1	0.1μF (0805 case SMT)
2	1	D1	1N34A or 1N270
3	1	D1	HLMP-K150
4	1	JP1	1x8 HEADER
5	1	JP2	A2 (1x2 pin Header with Short)
6	1	JP3	A1 (1x2 pin Header with Short)
7	1	JP4	A0 (1x2 pin Header with Short)
8	1	P1	CONNECTOR DB25 MALE/RightAngle PC Board Mount
9	3	R1,R2,R3	100k (0805 case SMT)
10	1	R4	3.9k (0805 case SMT)
11	2	R6,R5	2k (0805 case SMT)
12	1	U1	LM75

5.0.0 Using Multiple LM75 Demo Boards

The addressing capability of the LM75 allows up to 8 devices to share the same serial I/O lines. However the capabilities of your output port may not be able to drive that many devices in parallel. Connector JP1 on the board allows you to connect several LM75 Demo Boards in parallel so long as their I^2C address settings do not match. The only lines that should be connected are V+, GND, SDA and SCA. The only drawback is that the OS outputs on the boards that are not connected directly to the parallel printer port will not function correctly. The LEDs will not light up and the software will not sense when an alarm has occurred. The board that is plugged in directly to the parallel printer port will be completely functional. Selection between the boards is a simple matter of just changing the I^2C address in the software. The register data of the new device being addressed is not displayed until the read buttons are clicked.

6.0.0 Typical Problems You May Encounter

Moisture or any conductive fluid on the board or its components will cause the board to operate improperly. Even condensation from your breath can cause havoc.

The loop time between temperature readings is longer than programmed. The computer being used cannot process the program steps quickly enough. Try a faster computer. This occurs only when the loop interval is set to 1 to 2 seconds.

7.0.0 Who to Call when you need HELP

Please call our Customer Response Center in Arlington, Texas. The phone numbers are: 1(800)272-9959 (voice) 1(800)432- 9672 (fax).

You can also leave a message at our Web site. We are at http://www.national.com. Also available on our Web site are data sheets for other temperature sensor products.