National *Semiconductor*

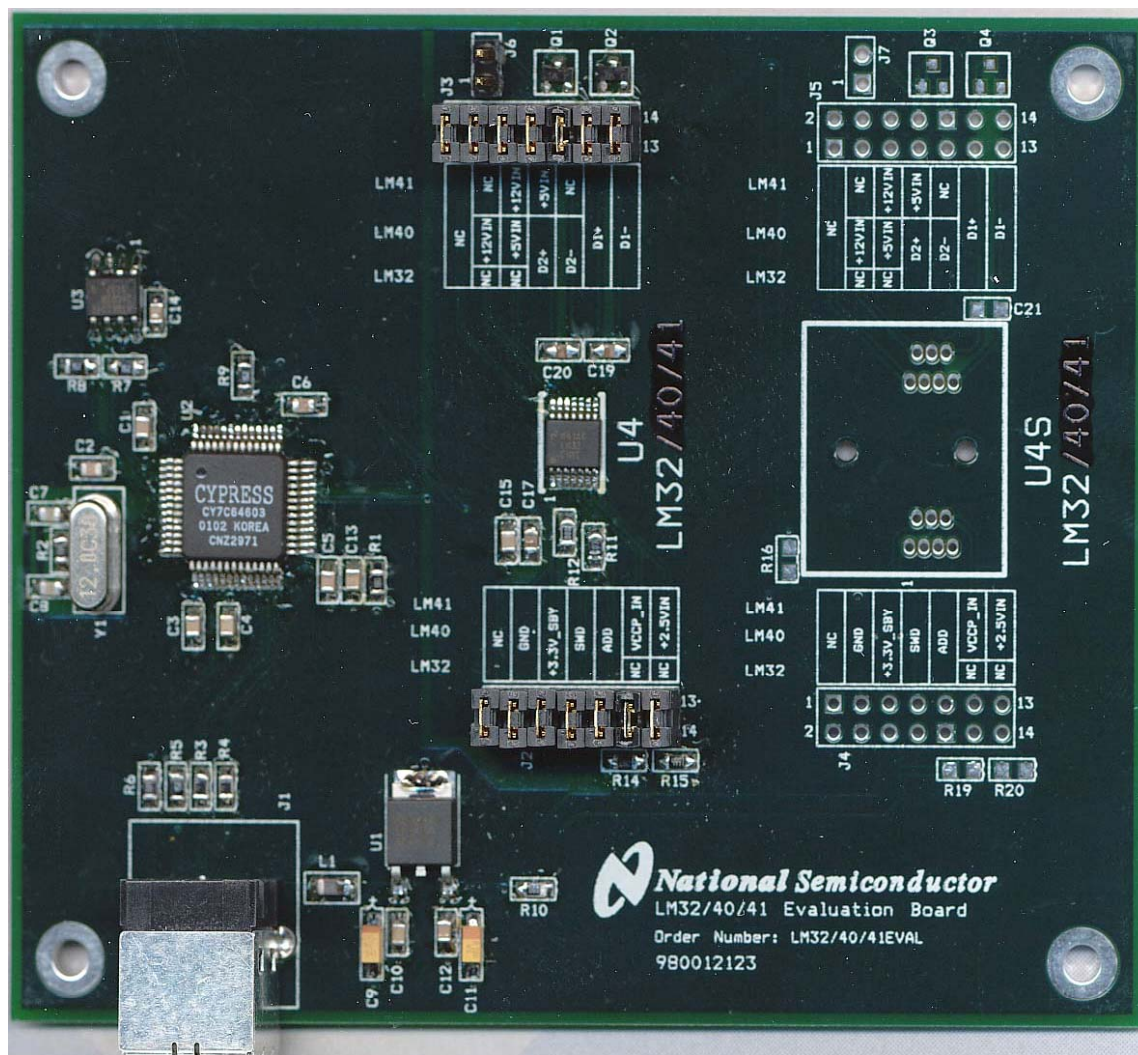# LM32, LM40, LM41 Evaluation Board User's Guide

LM32, LM40, LM41 Evaluation Board User's Guide
Table of Contents

LM32, LM40, LM41 Evaluation Board User's Guide

References

1. Datasheet for the device on the evaluation board:
   a. "LM32 Dual Thermal Diode Temperature Sensor With SensorPath™ Bus" or
   b. "LM40 Hardware Monitor with Dual Thermal Diodes and SensorPath™ Bus" or
   c. "LM41 Hardware Monitor with Thermal Diode Inputs and SensorPath™ Bus"

The latest copy of the LM32, LM40, LM41 datasheets can be obtained by going to the National Semiconductor website www.national.com, by searching on "LM32", "LM40", or "LM41", and then downloading the appropriate datasheet file.

2. SensorEval, Version 1.04b or later, Evaluation Board CD containing:
   a. The SensorEval.exe executable program used to run the LM32, LM40, or LM41 Evaluation Boards.
   b. A softcopy of this User's Guide
   c. A readme.txt file with useful information about the program.
   d. A softcopy of the SensorEval Software manual.

1.0 Introduction

The LM32/LM40/LM41 Evaluation Board is used together with the National Semiconductor SensorEval software (provided in the kit), and with a USB cable (not provided in the kit), and with an external personal computer (PC). Power to the LM32/LM40/LM41 Evaluation Board is provide by the +5VDC line of the USB connection. No external power supply or signal sources are required for operation of the LM32/LM40/LM41 evaluation board.

Before connecting the PC to the LM32/LM40/LM41 evaluation board through the USB cable, the PC is first turned on and allowed to go through its boot-up procedure. The user installs and initiates the SensorEval software. See Section 4.0 for software installation details.

After the SensorEval software is running, the user can connect the USB cable first to the computer and then to the LM32/LM40/LM41 Evaluation Board.

The PC should be able to recognize the board and the user simply runs the SensorEval software and selects the LM32/LM40/LM41 Eval Board radio button. The software allows the user to select which of the LM32, LM40, or LM41 devices is used.

The block diagram below describes the LM32/LM40/LM41 Evaluation Board itself. The USB input provides the +5.0 VDC power to the board, which is regulated down to 3.3 VDC to power the IC's. The EEPROM is programmed at the factory with a unique ID code for this particular board. When the USB cable is plugged in, the PC interrogates the USB devices and can identify this device as the LM32/LM40/LM41 Evaluation Board.

The microcontroller on the board provides the single wire signal (SWD), provides the address (ADD) select signal, and relays the information from the LM32, LM40, or LM41 to the PC via the USB lines.

The pins available to the user for probing vary according to device type. The output pinouts for each of the LM32, LM40, or LM41 are shown in the Connections sections and the Electrical Schematic.

1.1 Block Diagram
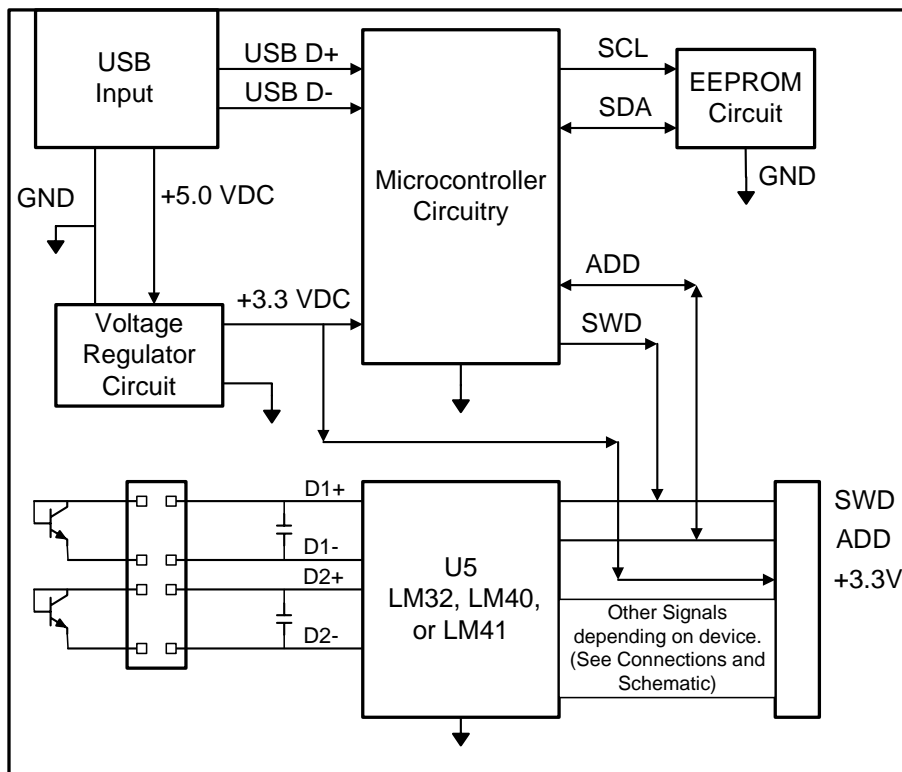
2.0 Quick Start

1. Install the CD into the CD drive of the computer and install the SensorEval software (see Section 4.0).

2. Hookup the USB cable between the PC or notebook computer and the LM32/LM40/LM41 Evaluation Board as shown in Quick Start Diagram below.

2.1 Quick Start Diagram

Important! *NO EXTERNAL POWER SUPPLY OR SIGNAL INPUTS ARE REQUIRED!*

USB Cable

PC with
SensorEval
software
installed

National Semiconductor
LM32/40/41 Evaluation Board

J2

LM41
LM40
LM32

See
Connection
Diagrams

U4
LM32/40/41

LM41
LM40
LM32

J3

See
Connection
Diagrams

J6
Q1
Q2

For
Socket
(not used)
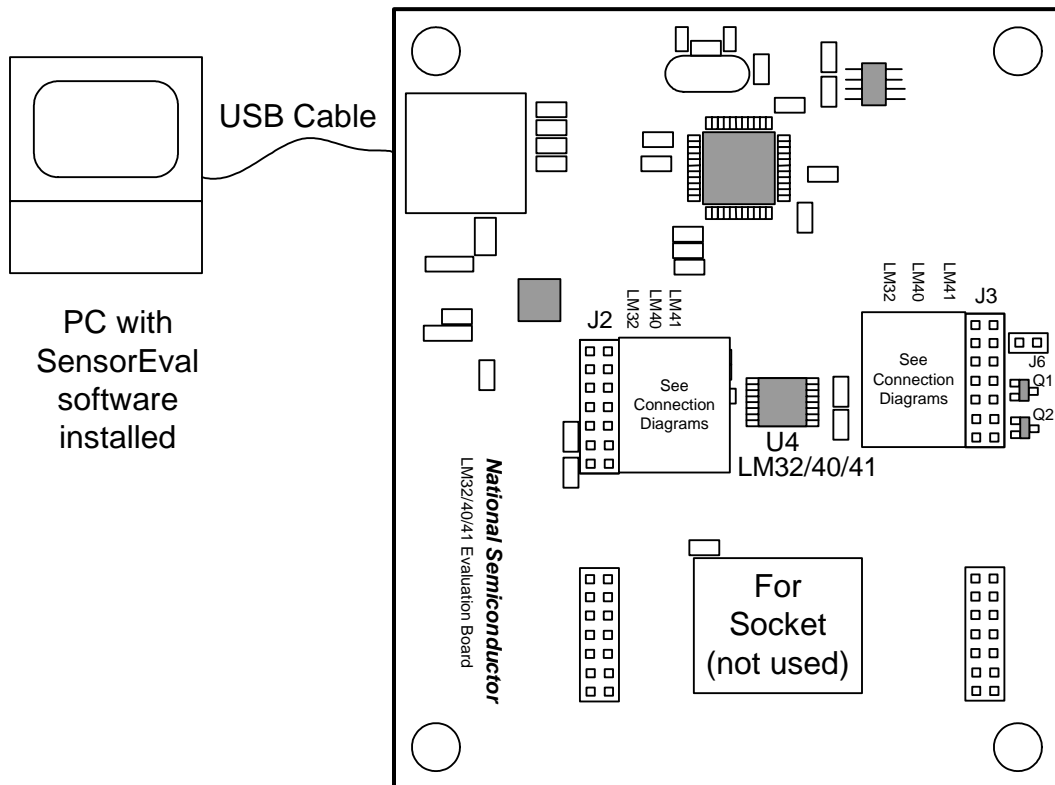
2.2 LM32 Quick Start

1. Run the SensorEval software by clicking the icon on the desktop.

2. The first screen will look like this:

> Select the LM32 Evaluation Board.
> Click OK.

3. The next screen will look like this:
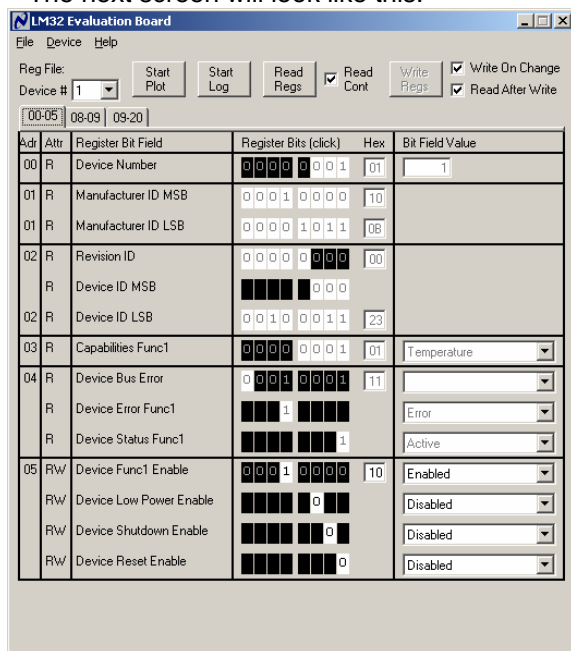
Select "Read Cont" box to read the temperature continuously. Notice that there are three tabs for the registers "00 through 05", "08 through 09", and "09 through 20". The first screen (above) displays the registers 00hex through 05hex.

For Register 05, "Device Func1 Enable", select ENABLED.

4. Click on the 09-20 Register Tab. The Screen should look like this:
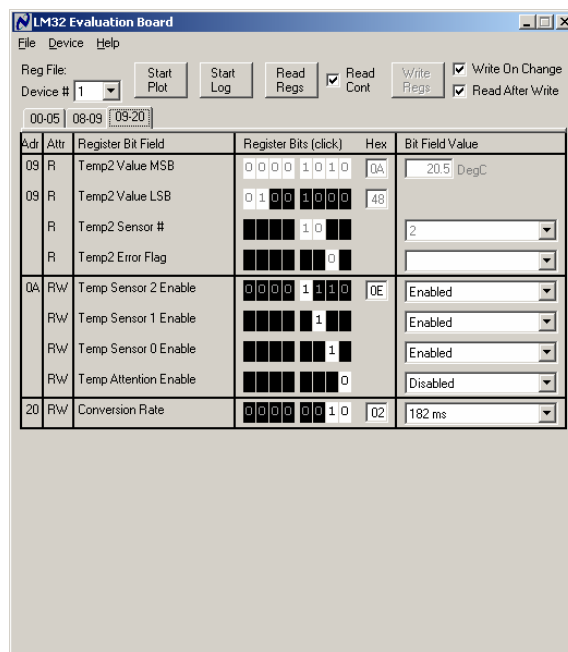
For Register 0A select Enable for Temp Sensor 0, 1 and 2.Note that Temp2 (Remote sensor [Q1 on the board] 2 is displayed in the box on the right and is updated as the temperature of the Q1 changes.

5. Click on the 08-09 Register Tab. The screen should look like this:
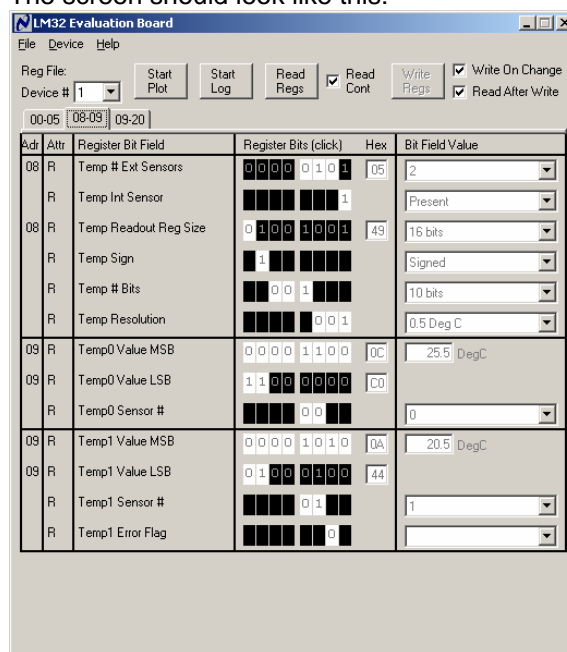
Notice the Local (on chip) sensor (Temp 0) and Remote 1 (Q2) sensor readings.

6. If the user clicks on the Start Plot button a graph box will appear and will graph the temperature. An example is shown below.
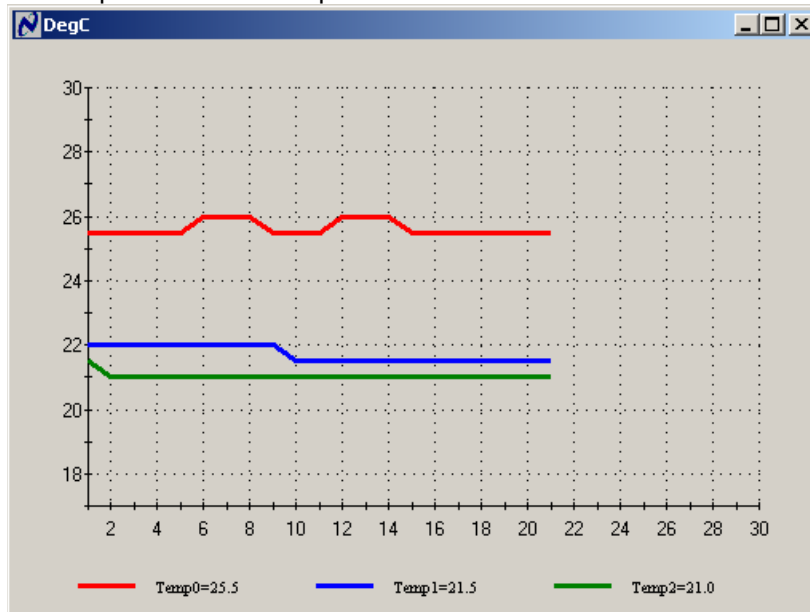
7. If the user clicks on the Start Log button a screen will appear that looks like this:
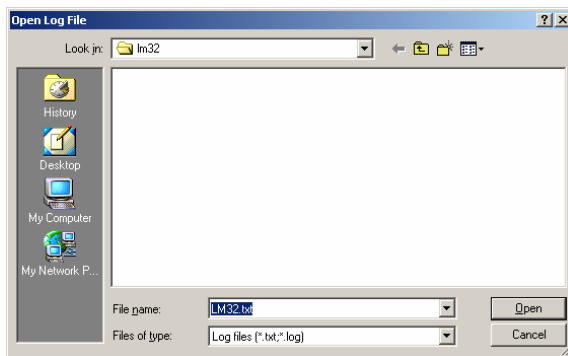
The user may then select whatever directory and file name of their choice and click on "Open". Data will be stored in the file for each date/time and temperature.

2.3 LM40 Quick Start

1. Run the SensorEval software by clicking the icon on the desktop.
2. The first screen will look like this:

Select the LM40 Evaluation Board.
Click OK.
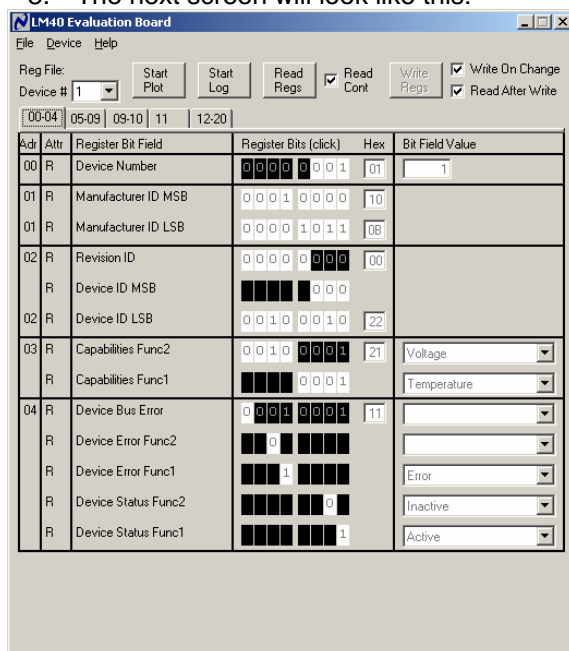
3. The next screen will look like this:

Select "Read Cont" box to read the temperature continuously.

Notice that there are four tabs for the registers "00 through 04", "05 through 09", and "09 through 10", "11", and "12-20". The first screen (above) displays the registers 00hex through 04hex.

4. Click on the 05-09 Register Tab. The Screen should look like this:
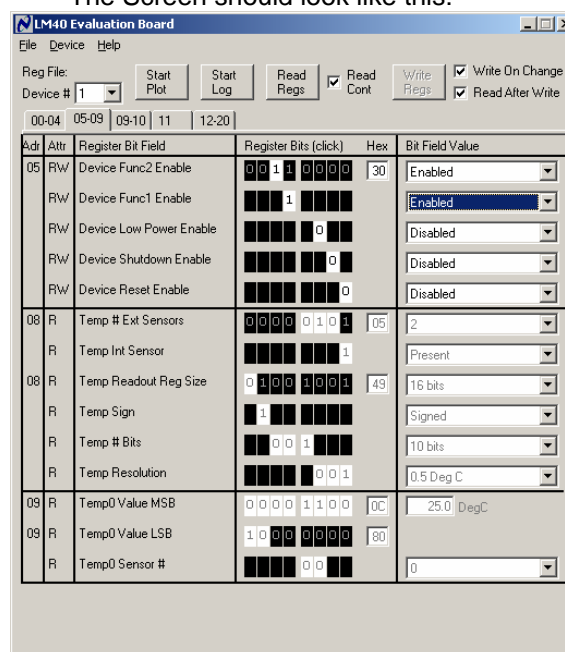
For Register 05 select Enable for "Device Func2 Enable" and "Device Func1 Enable".

5. Click on the 09-10 Register Tab. The screen should look like this:
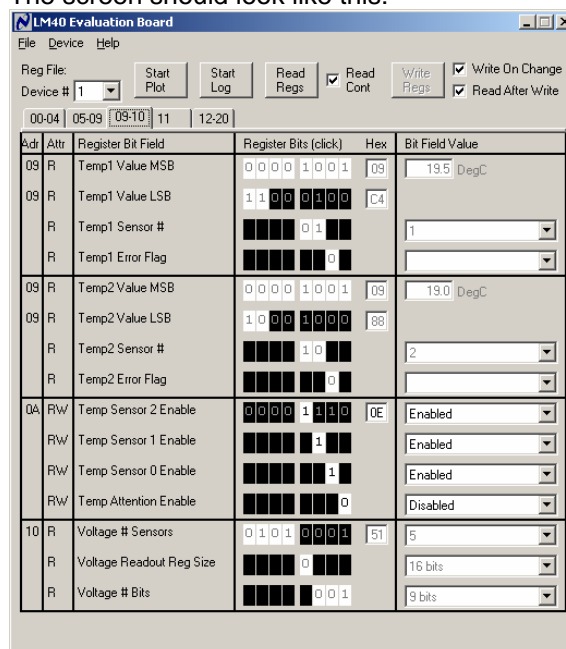
Select Enabled for Register 0A Temp Sensor (0,1,2) Enable. The temperature readings for Temp0 (Local) Temp 1 (Q2) and Temp2 (Q1) will be displayed in Register 09 screens.

6. For Voltage Monitoring input functions select the "12-20" Register Tab. The screen should look like this:
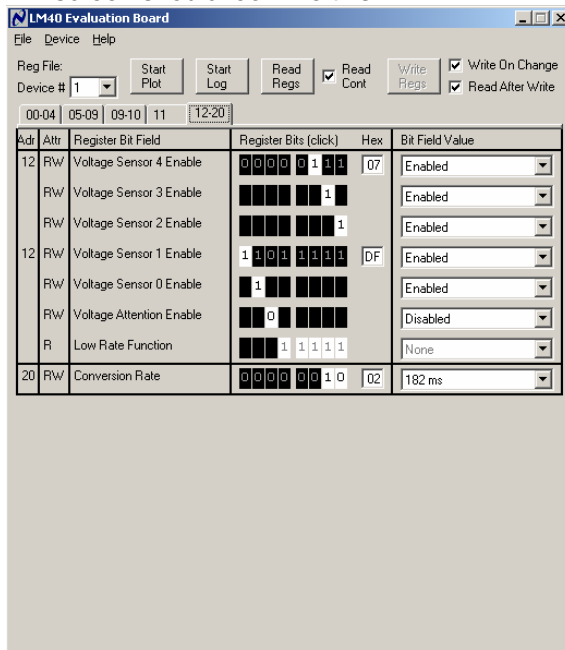
In Register 12, Enable Voltage Sensor (0-4).

7. Click on the Register 11 tab. The screen should look like this:
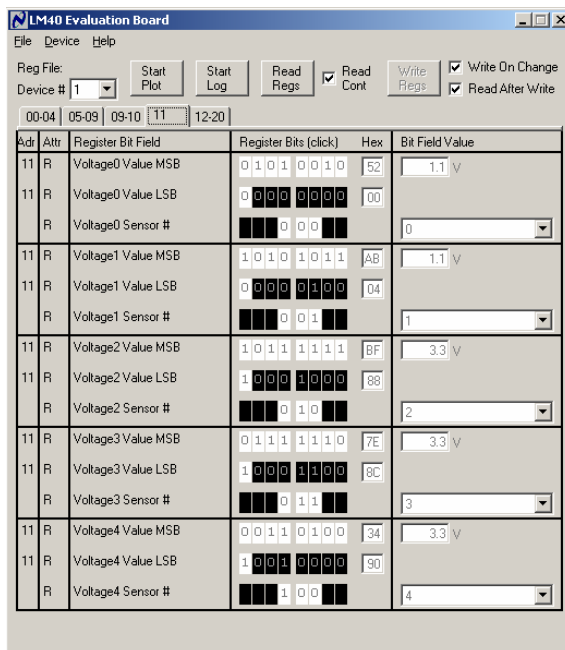
The voltages that are present at the voltage inputs of the LM40 will be displayed in Register 11.

8. If the user clicks on the Start Plot button a graph box will appear and will graph the temperature. A temperature example is shown below.
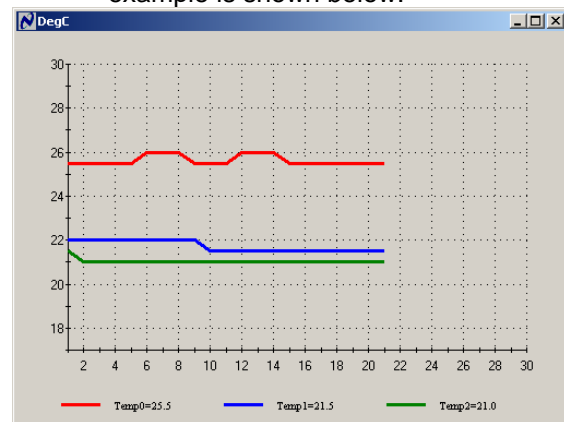
A Voltage Input Monitoring plot is shown below.
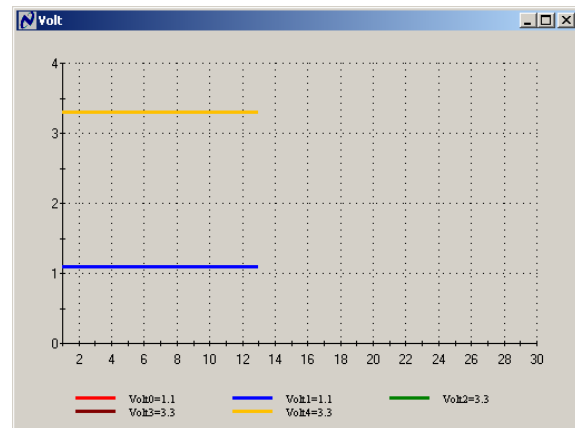
9. If the user clicks on the Start Log button a screen will appear that looks like this:
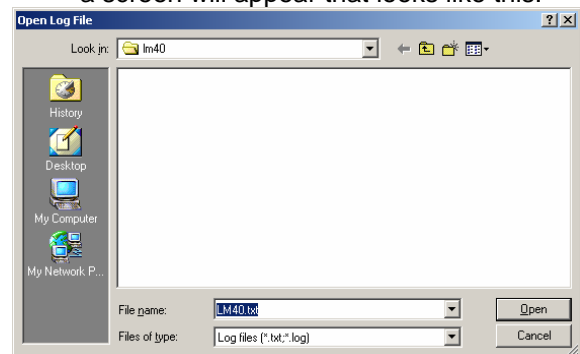
The user may then select whatever directory and file name of their choice and click on "Open". Data will be stored in the file for each date/time and temperature.

2.4 LM41 Quick Start

1. Run the SensorEval software by clicking the icon on the desktop.

2. The first screen will look like this:

LM41

Select the desired hardware

- ⦿ LM41 Evaluation Board
- ○ LM41 No Hardware

[OK]   [Another Device]

Select the LM41 Evaluation Board.
Click OK.

3. The next screen will look like this:

LM41 Evaluation Board

File Device Help

Reg File:
Device # 1   [Start Plot] [Start Log] [Read Regs] ☑ Read Cont [Write Regs] ☑ Write On Change ☑ Read After Write

00-04 | 05-09 | 09-11 | 11-12 | 20

| Adr	Attr	Register Bit Field	Register Bits (click)	Hex	Bit Field Value
00	R	Device Number	0 0 0 0 0 0 0 1	01	1
01	R	Manufacturer ID MSB	0 0 0 1 0 0 0 0	10	
01	R	Manufacturer ID LSB	0 0 0 0 1 0 1 1	0B	
02	R	Revision ID	0 0 0 0 0 0 0 0	00	
	R	Device ID MSB	... 0 0 0		
02	R	Device ID LSB	0 0 1 0 0 1 0 0	24	
03	R	Capabilities Func2	0 0 1 0 0 0 0 1	21	Voltage
	R	Capabilities Func1	... 0 0 0 1		Temperature
04	R	Device Bus Error	0 0 0 0 0 0 0 0	00	
	R	Device Error Func2	... 0 ...		
	R	Device Error Func1	... 0 ...		
	R	Device Status Func2	... 0		Inactive
	R	Device Status Func1	... 0		Inactive

Select "Read Cont" box to read the temperature continuously.

Notice that there are four tabs for the registers "00 through 04", "05 through 09", and "09 through 10", "11-12", and "20". The first screen (above) displays the registers 00hex through 04hex.

4. Click on the 05-09 Register Tab. The Screen should look like this:

LM41 Evaluation Board

File Device Help

Reg File:
Device # 1   [Start Plot] [Start Log] [Read Regs] ☑ Read Cont [Write Regs] ☑ Write On Change ☑ Read After Write

00-04 | 05-09 | 09-11 | 11-12 | 20

| Adr	Attr	Register Bit Field	Register Bits (click)	Hex	Bit Field Value
05	RW	Device Func2 Enable	0 0 1 1 0 0 0 0	30	Enabled
	RW	Device Func1 Enable	... 1 ...		Enabled
	RW	Device Low Power Enable	... 0 ...		Disabled
	RW	Device Shutdown Enable	... 0 ...		Disabled
	RW	Device Reset Enable	... 0		Disabled
08	R	Temp # Ext Sensors	0 0 0 0 0 0 1 1	03	1
	R	Temp Int Sensor	... 1		Present
08	R	Temp Readout Reg Size	0 1 0 0 1 0 0 1	49	16 bits
	R	Temp Sign	1 ...		Signed
	R	Temp # Bits	0 0 1 ...		10 bits
	R	Temp Resolution	... 0 0 1		0.5 Deg C
09	R	Temp0 Value MSB	0 0 0 0 1 1 0 0	0C	24.5 DegC
09	R	Temp0 Value LSB	0 1 0 0 0 0 0 0	40	
	R	Temp0 Sensor #	... 0 ...		0

For Register 05 select Enable for "Device Func2 Enable" and "Device Func1 Enable".

5. Click on the 09-11 Register Tab. The screen should look like this:

LM41 Evaluation Board

File Device Help

Reg File:
Device # 1   [Start Plot] [Start Log] [Read Regs] ☑ Read Cont [Write Regs] ☑ Write On Change ☑ Read After Write

00-04 | 05-09 | 09-11 | 11-12 | 20

Adr	Attr	Register Bit Field	Register Bits (click)	Hex	Bit Field Value
09	R	Temp1 Value MSB	0 0 0 0 1 0 0 1	09	18.0 DegC
09	R	Temp1 Value LSB	0 0 0 0 0 1 0 0	04	
	R	Temp1 Sensor #	... 1 ...		1
	R	Temp1 Error Flag	... 0 ...		
0A	RW	Temp Sensor 1 Enable	0 0 0 0 0 1 1 1	07	Enabled
	RW	Temp Sensor 0 Enable	... 1		Enabled
	RW	Temp Attention Enable	... 1		Enabled
10	R	Voltage # Sensors	0 1 0 1 0 0 0 1	51	5
	R	Voltage Readout Reg Size	... 0 ...		16 bits
	R	Voltage # Bits	... 0 0 1		9 bits
11	R	Voltage0 Value MSB	0 0 0 0 0 0 0 0	00	0.0 V
11	R	Voltage0 Value LSB	0 0 0 0 0 0 0 0	00	
	R	Voltage0 Sensor #	... 0 ...		0
11	R	Voltage1 Value MSB	0 0 0 0 0 0 0 0	00	0.0 V
11	R	Voltage1 Value LSB	0 0 0 0 0 0 0 0	00	
	R	Voltage1 Sensor #	... 0 0 ...		0

Select Enable for Register 0A Temp Sensor (0,1) Enable. The temperature readings for Temp0 (Local) and Temp1 (Q2) will be displayed in Register 09 screens.

6. For Voltage Monitoring input functions select the "11-12" Register Tab. The screen should look like this:

In Register 12, Enable Voltage Sensor (0-4) Enable and Voltage Attention Enable.

7. Click on the Register 11 tab. The screen should look like this:

The voltages that are present at the voltage inputs of the LM41 will be displayed in Register 11.
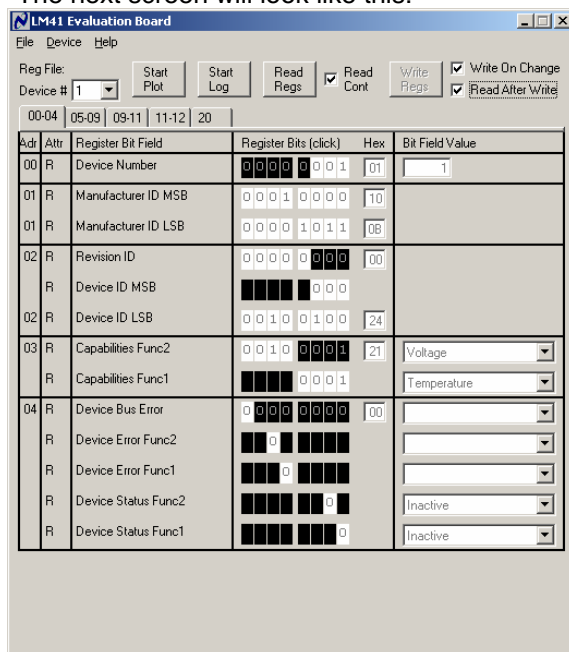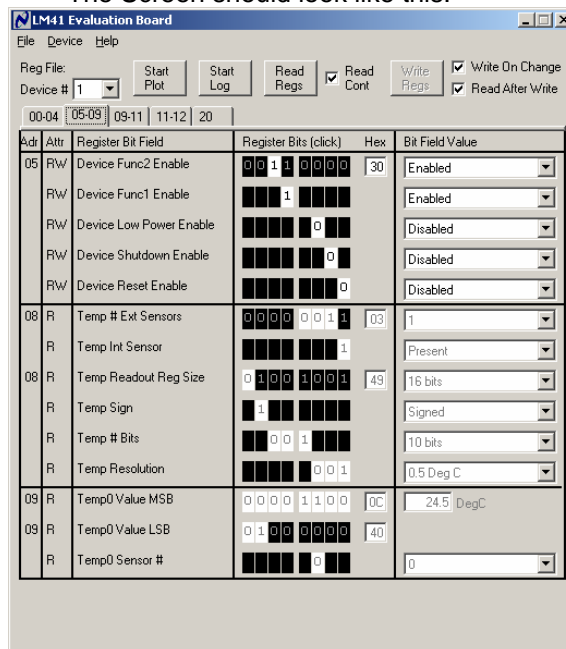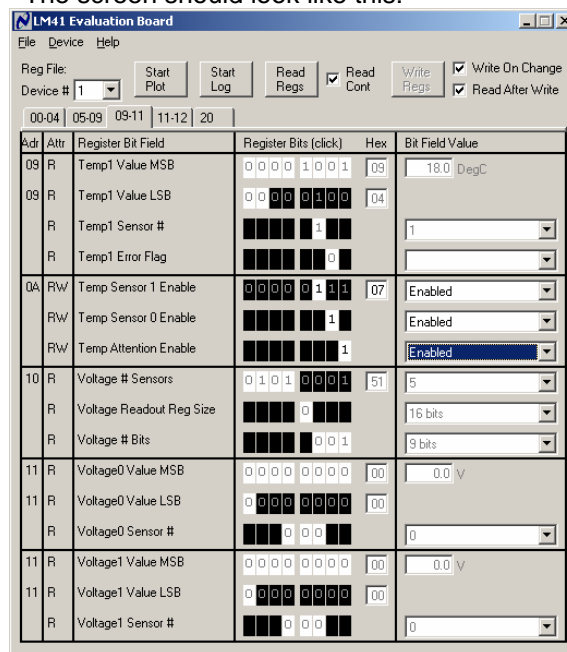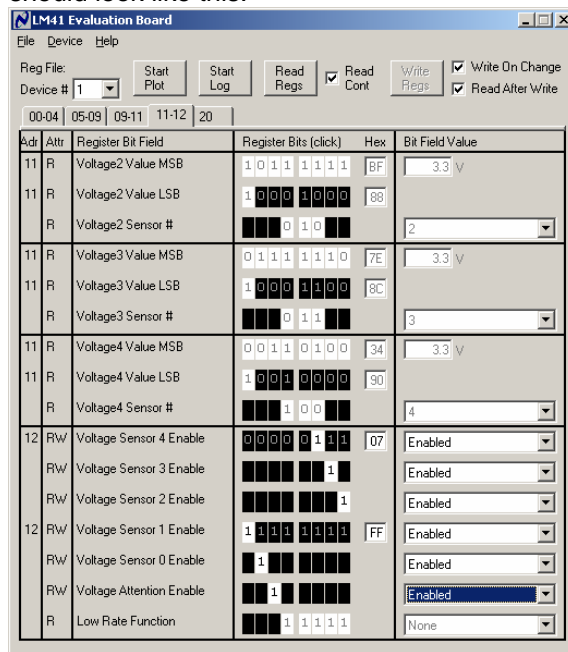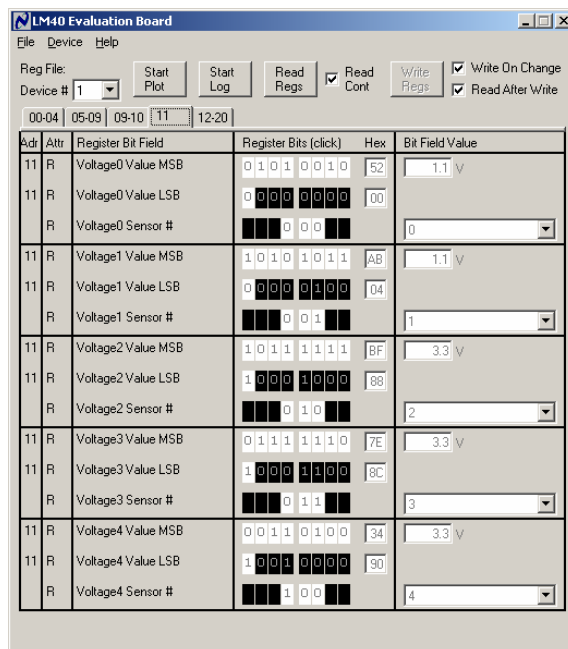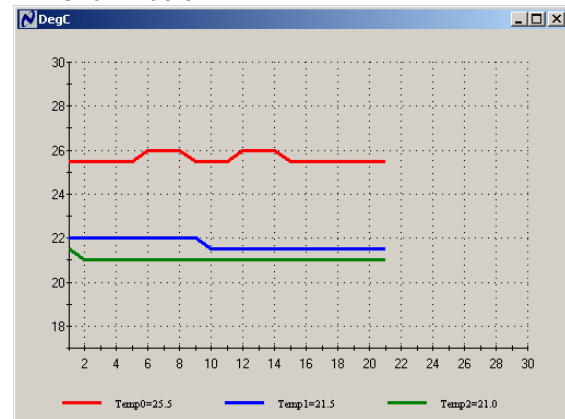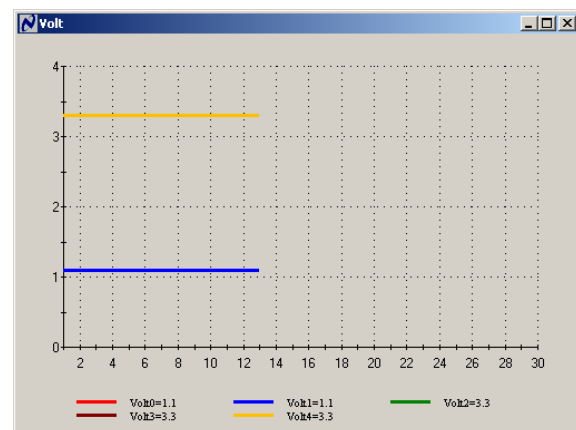
8. If the user clicks on the Start Plot button a graph box will appear and will graph the temperature. A temperature example is shown below.

A Voltage Input Monitoring plot is shown below.

9. If the user clicks on the Start Log button a screen will appear that looks like this:
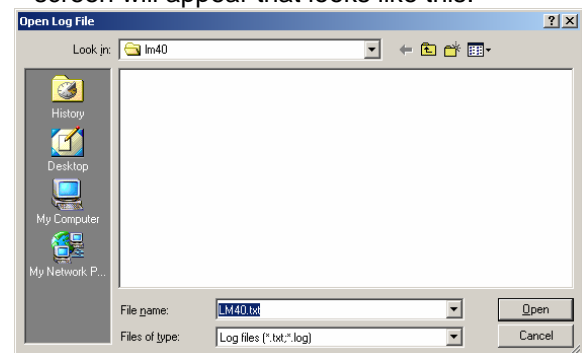
The user may then select whatever directory and file name of their choice and click on "Open". Data will be stored in the file for each date/time and temperature.

3.0 Functional Description

The LM32/LM40/LM41 Evaluation Board, along with the SensorEval Software, provides the system designer with a convenient way to learn about the operation of the LM32, LM40, or LM41 Temperature Sensor chip. The user simply has to install the SensorEval software on his PC, run it, connect the USB cable from the PC to the Evaluation Board, and the user can read temperatures. It's that simple! The user doesn't have to provide any power or external signals to the evaluation board.

Power to the LM32/LM40/LM41 Evaluation Board is taken from the USB 5-Volt line. This +5VDC is the input to the on-board LM2950 low dropout voltage regulator, which regulates the output voltage to +3.3 VDC. This output voltage powers the LM32, LM40, LM41, the on-board microcontroller, and the EEPROM chip where the board ID information is stored.

The microcontroller on the board provides the single wire signal (SWD), provides the Address (ADD) select signal, and relays the information from the LM32, LM40, or LM41 to the PC via the USB lines.

3.1 Evaluation Board Connection Tables

3.1.1 LM32 Evaluation Board Connections Only

Connector Label	Pin Number	Description
J1	N/A	USB Cable Input. Connect the USB cable to this jack after the SensorEval software has been loaded on the PC.
J2 Output header provides user with signals for test purposes only. Do not apply any external power or signals to any of the pins on these headers!	1,2	NC
	3,4	GND
	5,6	3.3_SBY This is the +3.3V voltage supplied by the on-board voltage regulator.
	7,8	SWD This is the Single wire interface signal created by the on-board microcontroller.
	9,10	ADD This is the address select signal created by the on-board microcontroller.
	11,12	NC
	13,14	NC
J3 Output header provides user with signals for test purposes only. Do not apply any external power or signals to any of the pins on these headers!	1,2	NC
	3,4	NC
	5,6	NC
	7,8	D2+ This is the anode of the second remote diode input.
	9,10	D2- This is the cathode of the second remote diode input.
	11,12	D1+ This is the anode of the first remote diode input.
	13,14	D1- This is the cathode of the first remote diode input.
J4, J5		These Headers are not used for evaluation board purposes. They are not stuffed or used.

3.1.2 LM40 Evaluation Board Connections Only

Connector Label	Pin Number	Description
J1	N/A	USB Cable Input. Connect the USB cable to this jack after the SensorEval software has been loaded on the PC.
J2 Output header provides user with signals for test purposes only. Do not apply any external power or signals to any of the pins on these headers!	1,2	NC On the evaluation board this is jumpered to ground.
	3,4	GND On the evaluation board this is jumpered to ground.
	5,6	3.3_SBY This is the +3.3V voltage supplied by the on-board voltage regulator.
	7,8	SWD This is the Single wire interface signal created by the on-board microcontroller.
	9,10	ADD This is the address select signal created by the on-board microcontroller.
	11,12	VCCP_IN This is the +1.2V voltage monitoring input to the LM40. On the evaluation board this input is jumpered to a +1.1V (typical) source.
	13,14	+2.5VIN This is the +2.5V voltage monitoring input to the LM40. On the evaluation board this input is jumpered to a +1.1V (typical) source.
J3 Output header provides user with signals for test purposes only. Do not apply any external power or signals to any of the pins on these headers!	1,2	NC On the evaluation board this is jumpered to ground.
	3,4	+12VIN This is the +12V voltage monitoring input to the LM40. On the evaluation board this is jumpered to +3.3V for test purposes.
	5,6	+5VIN This is the +5V voltage monitoring input to the LM40. On the evaluation board this is jumpered to +3.3V for test purposes.
	7,8	D2+ This is the anode of the second remote diode input to the LM40. A jumper connects to the base-collector (anode) of Q1, a MMBT3904 transistor.
	9,10	D2- This is the cathode of the second remote diode input to the LM40. A jumper connects to the emitter (cathode) of Q1, a MMBT3904 transistor.
	11,12	D1+ This is the anode of the second remote diode input to the LM40. A jumper connects to the base-collector (anode) of Q2, a MMBT3904 transistor.
	13,14	D1- This is the cathode of the second remote diode input to the LM40. A jumper connects to the emitter (cathode) of Q1, a MMBT3904 transistor.
J4, J5		These Headers are not used for evaluation board purposes. They are not stuffed or used.

3.1.3 LM41 Evaluation Board Connections Only

Connector Label	Pin Number	Description
J1	N/A	USB Cable Input. Connect the USB cable to this jack after the SensorEval software has been loaded on the PC.
J2 Output header provides user with signals for test purposes only. Do not apply any external power or signals to any of the pins on these headers!	1,2	NC On the evaluation board this is jumpered to ground.
	3,4	GND On the evaluation board this is jumpered to ground.
	5,6	3.3_SBY This is the +3.3V voltage supplied by the on-board voltage regulator.
	7,8	SWD This is the Single wire interface signal created by the on-board microcontroller.
	9,10	ADD This is the address select signal created by the on-board microcontroller.
	11,12	VCCP_IN This is the +1.2V voltage monitoring input to the LM41. On the evaluation board this input is jumpered to a +1.1V (typical) source.
	13,14	+2.5VIN This is the +2.5V voltage monitoring input to the LM41. On the evaluation board this input is jumpered to a +1.1V (typical) source.
J3 Output header provides user with signals for test purposes only. Do not apply any external power or signals to any of the pins on these headers!	1,2	NC On the evaluation board this is jumpered to ground.
	3,4	NC On the evaluation board this is jumpered to +3.3V.
	5,6	+12VIN This is the +12V voltage monitoring input to the LM41. On the evaluation board this is jumpered to +3.3V for test purposes.
	7,8	+5VIN This is the +5V voltage monitoring input to the LM41. On the evaluation board this input is jumpered to +3.3V. Note: J6 must also have a jumper installed
	9,10	NC
	11,12	D1+ This is the anode of the second remote diode input to the LM41. A jumper connects to the base-collector (anode) of Q2, a MMBT3904 transistor.
	13,14	D1- This is the cathode of the second remote diode input to the LM41. A jumper connects to the emitter (cathode) of Q1, a MMBT3904 transistor.
J4, J5		These Headers are not used for evaluation board purposes. They are not stuffed or used.
J6	1,2	Jumper these pins so that the +3.3V can be connected to the +5VIN input to the LM41.

4.0 Software Installation and Operation

4.1 Installation

The CD provided in the LM32/LM40/LM41 Evaluation Board Kit contains the SensorEval software used to make the LM32, LM40, LM41 Evaluation Board operate with the user's PC. It is assumed that the user will be using a PC with a Pentium® III or higher processor and Microsoft Windows® XP/2000/98/ME operating system.

The software is installed as follows:

1. Insert the LM32/LM40/LM41 Evaluation Board CD into the CD drive of the PC. See details in the readme.txt file.
2. The software manual, provided on the CD, may be useful to the user during this process.
3. Follow all of the Installation instructions in the windows as the SensorEval software is installing.
4. The installation process will put an icon on the PC desktop so that the SensorEval program will run when the icon is double-clicked.
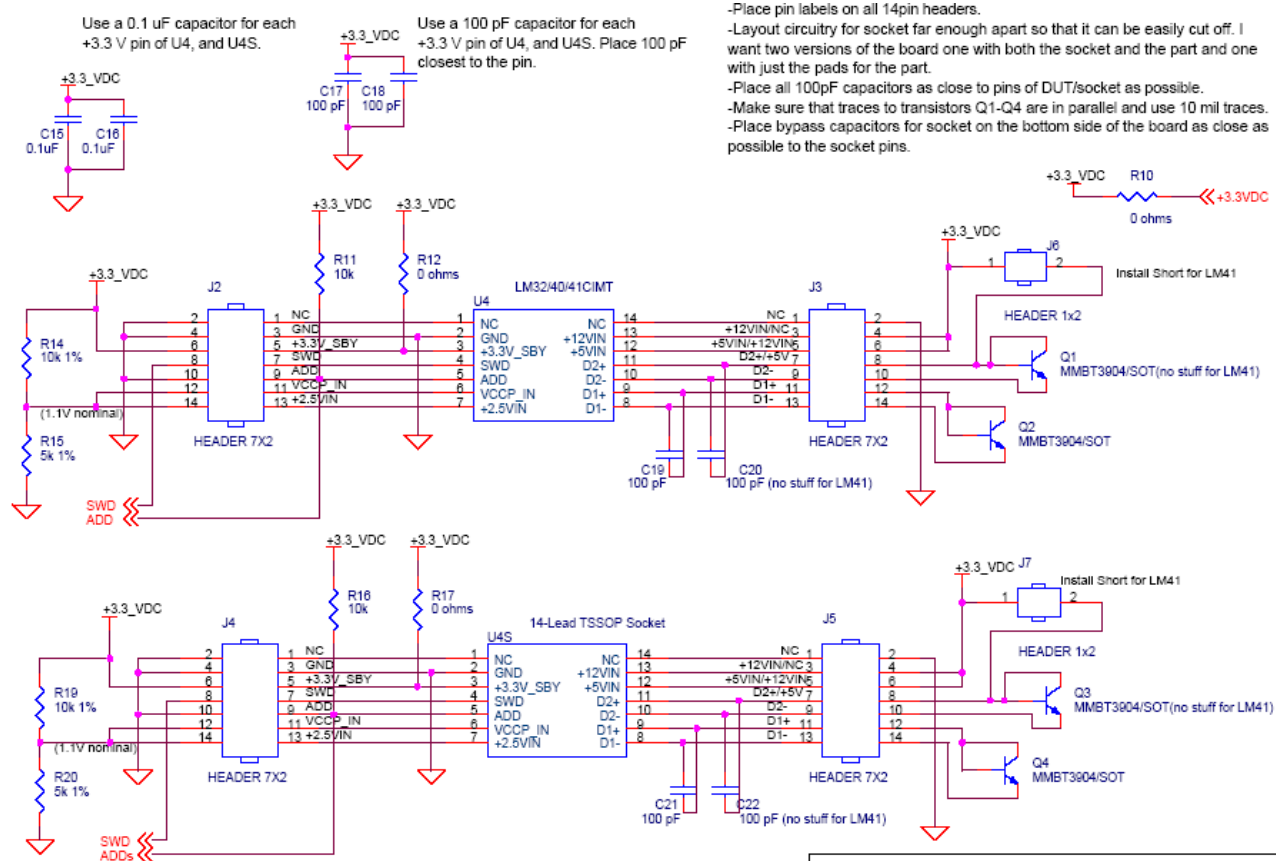
4.2 Operation

Follow the following procedure for operation the LM32/LM40/LM41 Evaluation Board using the SensorEval software:

1. Run the SensorEval program by either double-clicking on the icon on the desktop or by selecting Start, Run, and browse to find the SensorEval.exe file.
2. Plug in the USB cable on both the PC and the LM32/LM40/LM41 Evaluation Board.

Follow the register setup steps given in 2.0 Quick Start section of this User's Guide. Make sure that you are following the given procedure for the specific evaluation board you are working with.

Temperature and voltage monitoring can easily be done using external thermal diodes and/or external voltages applied to the pins that are jumpered on J2 and J3. Refer to the schematic, layout and electrical connection tables to be sure about the connections the user will make.

5.0 Electrical and Mechanical Specifications

5.1 Electrical Specifications

Power Requirements	
The Board uses the +5.0 VDC and GND lines from the USB connection. This +5.0 VDC voltage is regulated down to +3.3 VDC for board power. * NO EXTERNAL POWER SUPPLY INPUTS ARE REQUIRED *	+5.0 ± 0.1 V, 100 mA max.

5.2 Electrical Schematic

Page 1 of 2 Pages of the Schematic of the LM32/LM40/LM41 Evaluation Board

5.2 Electrical Schematic (continued)

Page 2 of 2 Pages of the Schematic of the LM32/LM40/LM41 Evaluation Board
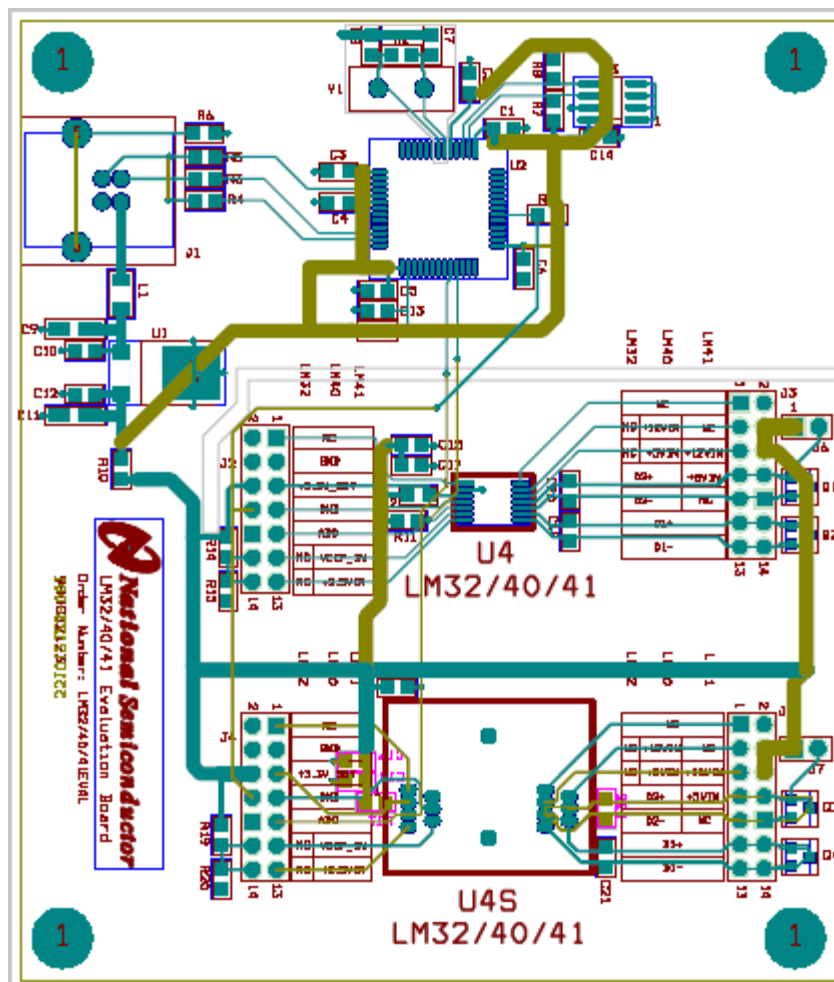
5.3 Evaluation Board Layout

Figure 5.3 Layout diagram of the LM32/LM40/LM41 Evaluation Board

**5.4 Bill of Materials for LM32/LM40/LM41 Evaluation Board**

Item	Quantity	Reference	Part
1	12	C1, C2, C3, C4, C5, C6, C10, C12, C13, C14, C15, C16	Capacitor, ceramic, SMT, 0.1 uF
2	2	C7, C8	Capacitor, ceramic, SMT, 33 pF
3	1	C9	Capacitor, electrolytic, SMT, 2.2 uF
4	1	C11	Capacitor, electrolytic, SMT, 10 uF
5	3	C17, C18, C19, C21	Capacitor, ceramic, SMT, 100 pF
	2	C20, C22	Capacitor, ceramic, SMT, 100 pF [Do Not Stuff for LM41]
	1	J1	Connector, USB-B
	2	J2, J3	Header, 7X2, 0.1 in centers
	2	J4, J5	Header, 7X2, 0.1 in centers [Do Not Stuff]
	1	J6	Header, 1X2, 0.1 in centers
	1	J7	Header, 1X2, 0.1 in centers [Do Not Stuff]
	15	Shunt	Shunt, 1x2 installed on the pins of J2 and J3, and [for LM41 Evaluation Board only] on J6
	1	L1	Filter, 1 uH, Stewart MI1206K900R-00
	1	Q2	Transistor, NPN, MMBT3904, SMT
	3	Q1, Q3, Q4	Transistor, NPN, MMBT3904, SMT [Do Not Stuff]
	1	R1	Resistor, SMT, 100 k, 0805
	2	R2, R6	Resistor, SMT, 1M, 0805
	2	R3, R4	Resistor, SMT, 22 Ohm, 0805
	4	R5, R7, R8, R9	Resistor, SMT, 1.5 k, 0805
	1	R10, R12	Resistor, SMT, 0 Ohm, 0805
	1	R17	Resistor, SMT, 0 Ohm, 0805 [Do Not Stuff]
	2	R11, R14	Resistor, SMT, 10k, 0805
	2	R15, R20	Resistor, SMT, 5k, 0805
	2	R16, R19	Resistor, SMT, 10k, 0805 [Do Not Stuff]
	1	U1	IC, Voltage Regulator, National LP2950CDT-3.3
	1	U2	IC, Microcontroller, Cypress CY7C64613-52NC
	1	U3	IC, EEPROM, Atmel AT24C02-10SI-2.7
	1	U4	LM32, LM40, or LM41CIMF Device Under Test (DUT)
	1	U4(for socket)	LM32, LM40, or LM41CIMF [Do Not Stuff] used with socket
	1	U4s	Socket, Loranger, 14-pin TSSOP-14 [Do Not Stuff]
	1	Y1	Crystal, 12 MHz, Pletronics 2S1200G140
	1	--	Circuit Board, Fabricated, LM32, LM40, LM41 Evaluation Board, Rev. 1

5.4 Mechanical Specifications

5.4.1 Operating Mechanical and Environmental Specifications

	Minimum	Typical	Maximum
Temperature	0°C	25°C	70°C

5.4.2 Evaluation Board Mechanical Dimensions
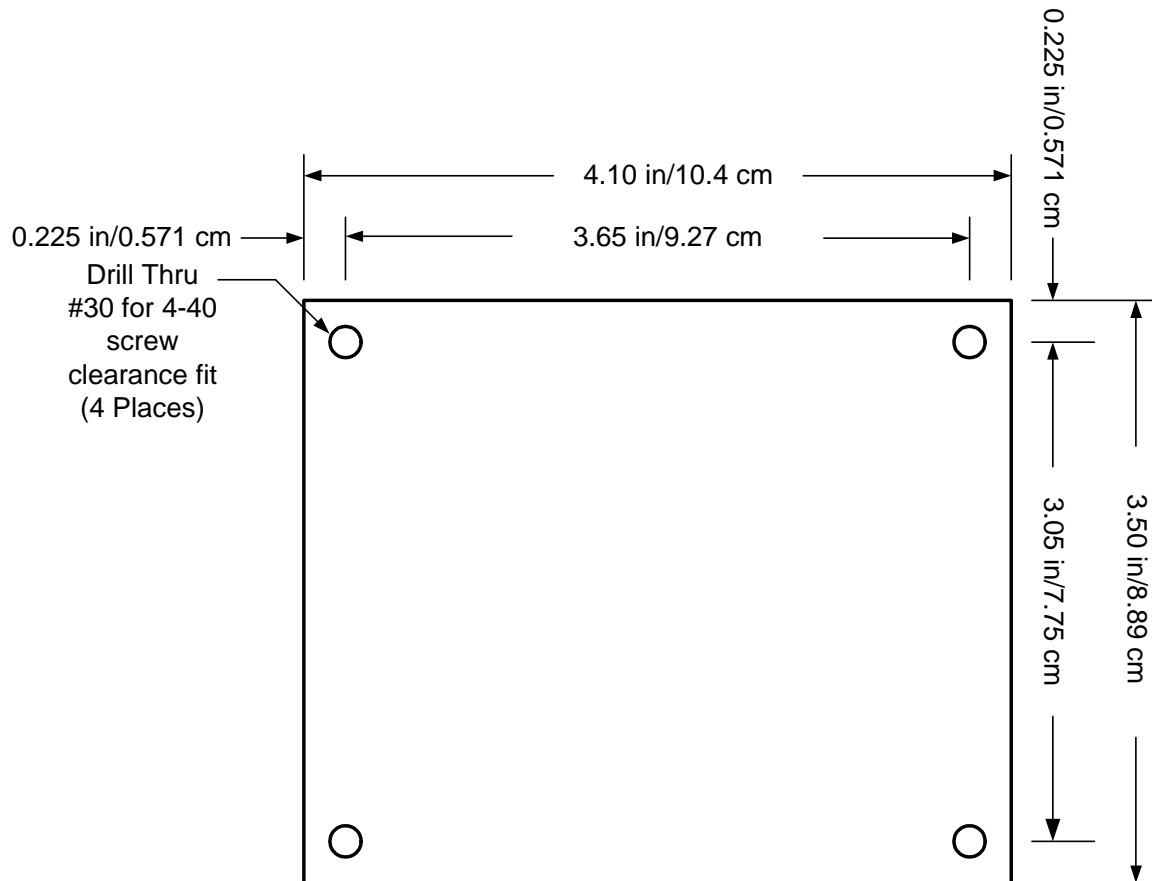
5.4.3 Electrostatic Discharge (ESD) Precautions

The user shall use ESD precautions as specified in National Semiconductor ESD control document (SC)CSI-3-038 available through www.national.com.

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