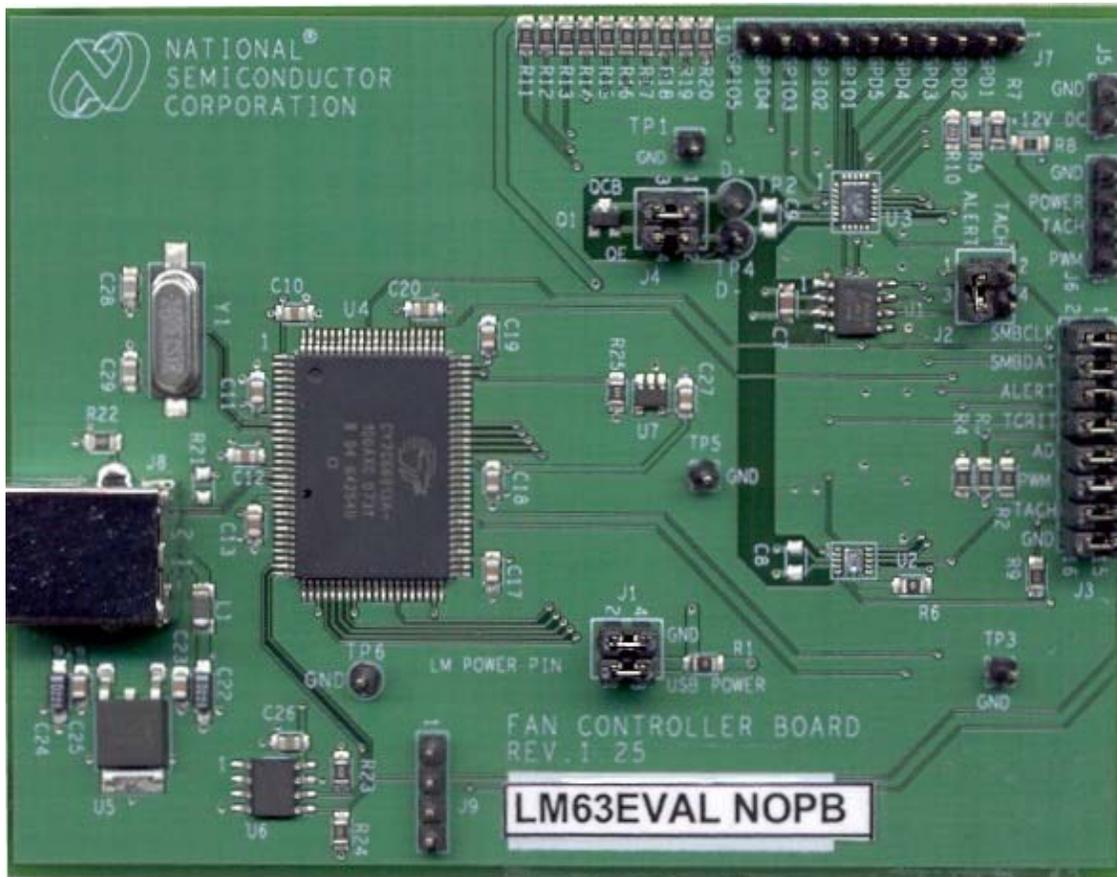


**Fan Controller Evaluation Board User's Guide for  
LM63EVAL/NOPB, LM64EVAL/NOPB, and LM96163EB/NOPB boards**



## Fan Controller Evaluation Board User's Guide

### Table of Contents

Table of Contents	2
References	3
1.0 Introduction	4
1.1 Block Diagram	4,5
2.0 Quick Start	6
2.1 LM63EVAL/NOPB Only	7
2.2 LM96163EVAL/NOPB Only	11
2.3 LM64EVAL/NOPB Only	16
3.0 Functional Description	17
3.1 Fan Controller Connection Table	17
4.0 Software Installation and Operation	18
5.0 Electrical and Mechanical Specifications	19
5.1 Electrical Specifications	19
5.2 Electrical Schematic	19-21
5.3 Evaluation Board Layout	22
5.4 Bill of Materials	23
5.5 Mechanical Specifications	24

## Fan Controller Evaluation Board User's Guide

### References

1. LM63  $\pm 1^{\circ}\text{C}/\pm 3^{\circ}\text{C}$  Accurate Remote Diode Digital Temperature Sensor with Integrated Fan Control datasheet
2. LM64  $\pm 1^{\circ}\text{C}$  Remote Diode Temperature Sensor with PWM Fan Control and 5 GPIO's datasheet
3. LM96163 Remote Diode Digital Temperature Sensor with Integrated Fan Control and TruTherm<sup>®</sup> BJT Transistor Beta Compensation Technology datasheet

The latest copy of the datasheets can be obtained by going to the National Semiconductor website [www.national.com](http://www.national.com), by searching on the part number, and then downloading the datasheet .pdf file.

4. SensorEval Version 1.1.0n or later Evaluation Board CD containing:
  - a. The SensorEval.exe executable program used to run the LM63EVAL/NOPB or LM64EVAL/NOPB or LM96163EB/NOPB 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

This User's Guide for the Fan Controller Evaluation Board is used with the 3 variations: LM63EVAL/NOPB, LM64EVAL/NOPB, and LM96163EB/NOPB boards. The board is used together with the National Semiconductor SensorEval software (provided in the kit), and with a USB cable (not provided in the kit), with an external personal computer (PC) running Microsoft Windows © 2000 or XP, an external 4-terminal DC brushless fan, and an external power supply capable of providing the correct voltage (+5VDC or +12VDC) and the correct current for the fan. Power to the Fan Controller Evaluation Board is provided by the +5VDC line of the USB connection.

The User should read through this User's Guide completely before proceeding to use the fan controller evaluation board.

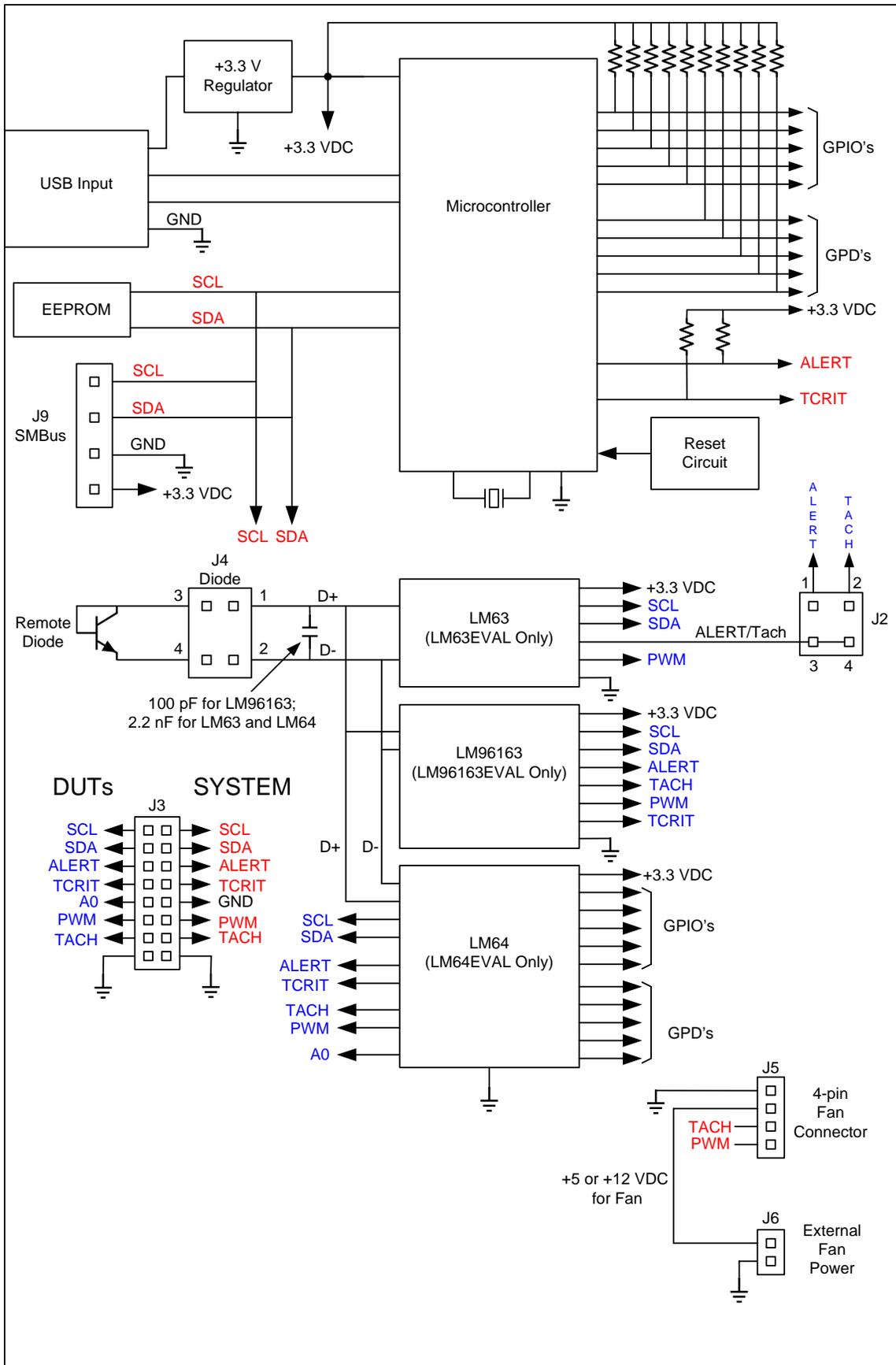
### 1.1 Block Diagram

See next page for the Block Diagram.

A Quick Start section explains about the hardware setup, and there is a software section to get the SensorEval software up and running.

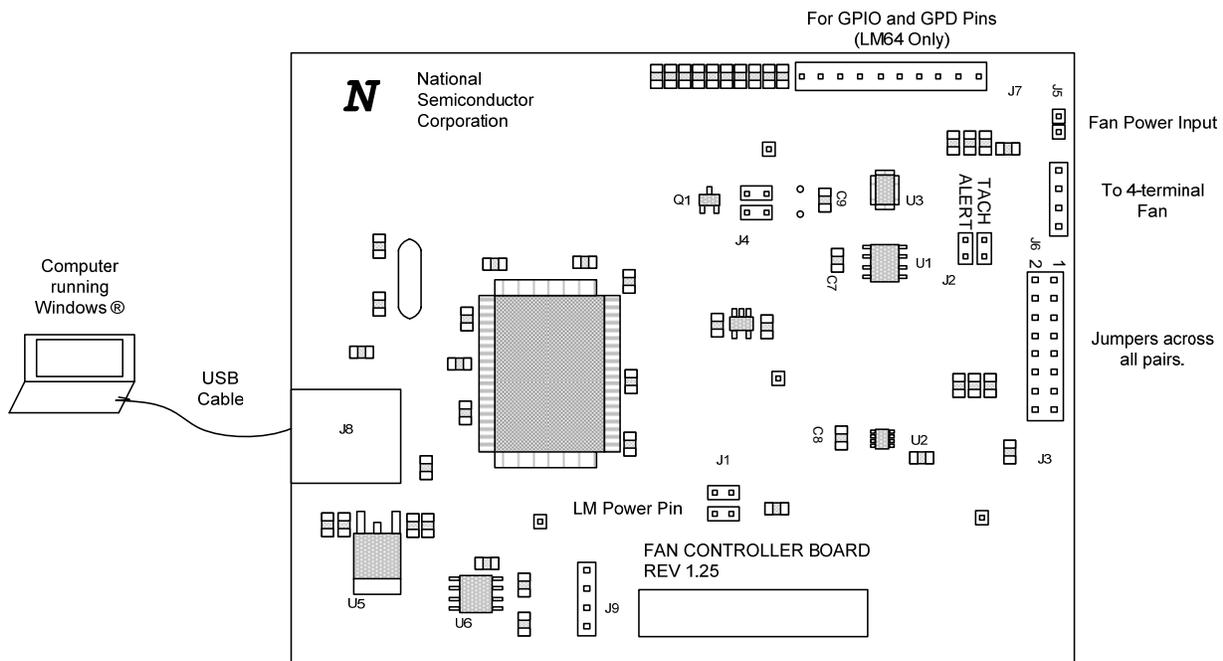
The block diagram below describes the Fan Controller Evaluation Board itself from a functional perspective. The EEPROM is programmed at the factory with a unique PID code for this particular board. When the USB cable is plugged in, the PC interrogates the USB devices and can identify this device as the specific variation of Fan Controller Evaluation Board.

The microcontroller on the board provides the SMBDAT, SMBCLK, and SMBALERT signals and relays the information from the temp sensor device to the PC via the USB lines.



## 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. Make sure that the jumpers are set for the correct initial setup for the particular board you have (See Section 3.1). This is important to make sure that the Device Under Test (DUT) is connected correctly.
3. Refer to Figure 2.1 Quick Start Diagram to see the test setup and connections.
4. Connect the fan's connector to the 4-terminal fan connector J6. Make sure that the fan's pinout is the same as for the board (refer to Section 3.1 connections for J6 connector).
5. Set the external fan supply to the proper voltage, turn it off, then connect it to the pins for the Fan Power Input carefully observing the correct polarity.



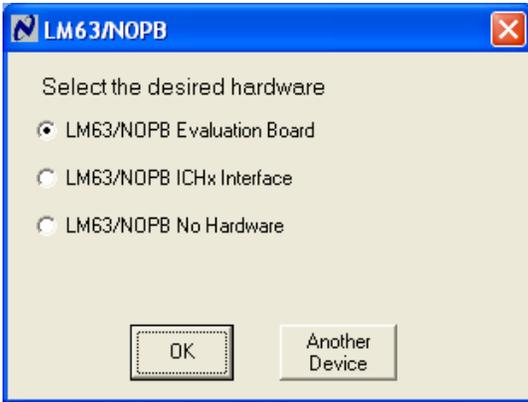
**Figure 2.1 Quick Start Diagram**

6. Hookup the USB cable between the PC or notebook computer as shown in the Quick Start Diagram.
7. Run the SensorEval software clicking the icon on the desktop. If the user has any trouble with running the SensorEval software please refer to the SensorEval Software User's Guide (pdf format) in the SensorEval CD. Make sure that you select the correct device file for the "LM63NOPB" or "LM96163NOPB" or "LM64NOPB" as required. In the following sections the screens for the 3 types of boards for the fan controller software are explained on the following pages.

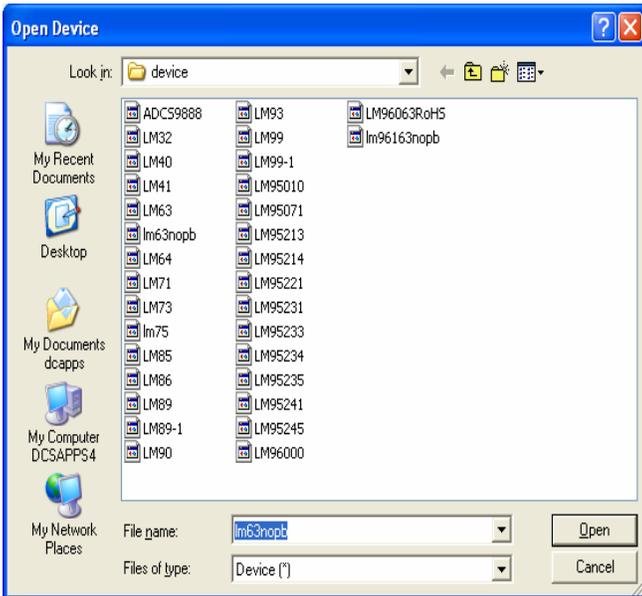
## 2.1 LM63EVAL /NOPB Board Only

For the LM63EVAL NOPB board make sure that the jumpers on the board are connected correctly according to Section 3.1 Fan Controller Evaluation Board Connection Table

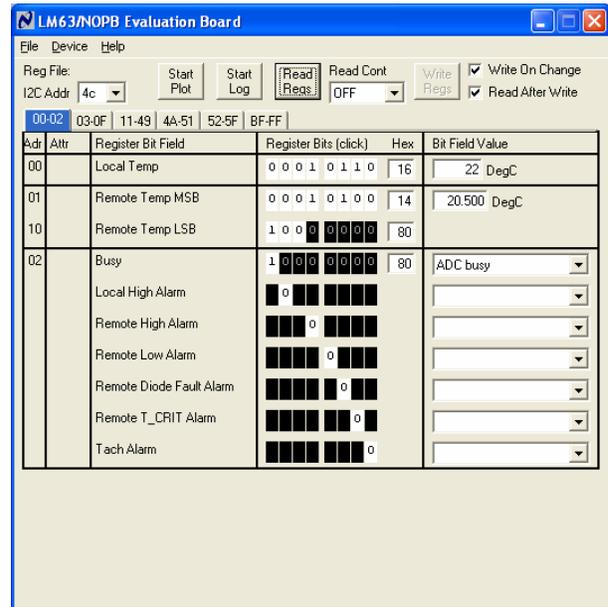
The first screen will look like this:



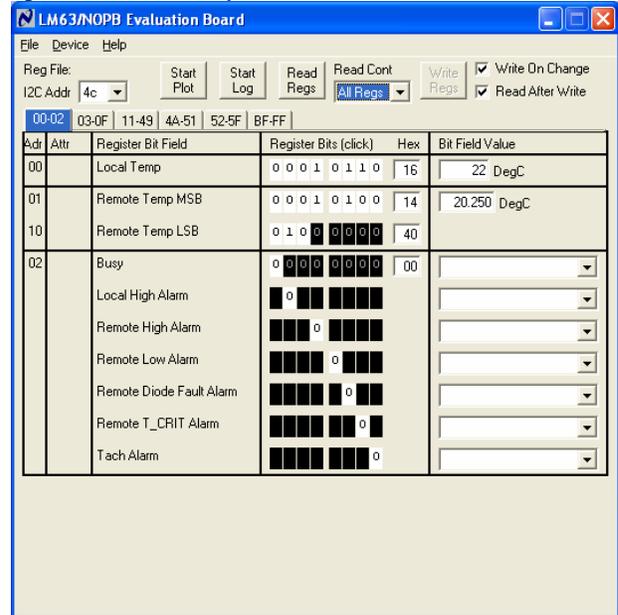
If this window is for another device's board the following window will show up. In this case simply select "Another Device" button and the "LM63 NOPB" device ID, as shown below.



The next screen shows the initial "tab" for Registers 00-02 in functional order.

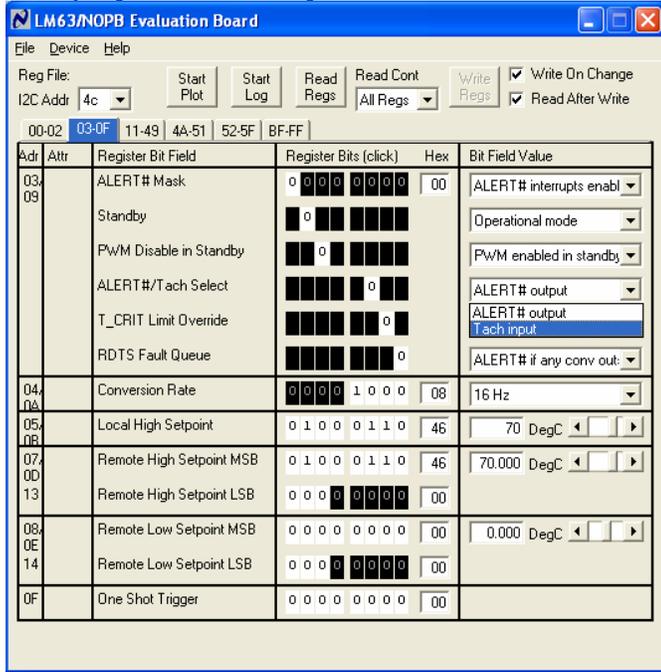


The screen shows what the first initial reading is from the first data conversion. The next step is usually for the user to select the pull-down box labeled "Read Cont" ALL REGS to continuously read all registers so that the Local and Remote temperatures are updated continuously. See below.



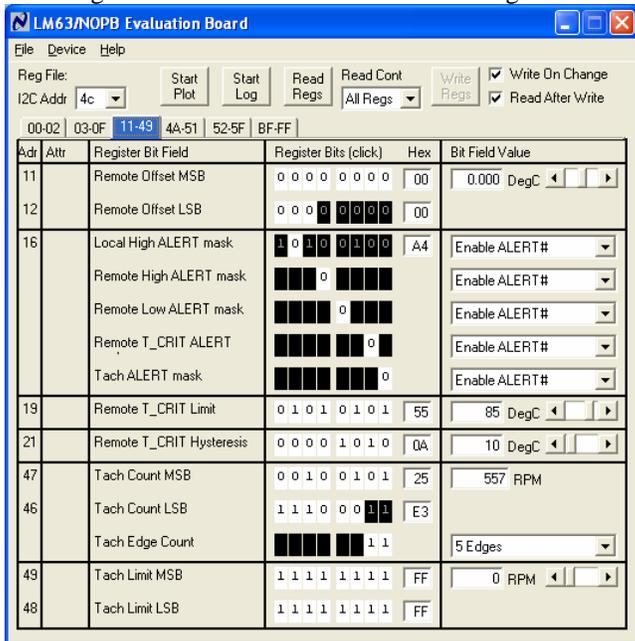
In Register 02 hex the bits will change to 1 if the specific alarm condition is met and the box to the right will also show the word "alarm". Whenever the alarm condition is cleared the bit will return to 0 and the box will be blank. See the LM63 datasheet for further details.

Selecting the 03-0F Tab will show this screen. Notice that the ALERT#/Tach Select is showing the option to either select the ALERT# function for the ALERT#/Tach pin or the Tach function for the ALERT#/Tach pin. Make sure that if ALERT# is desired that the jumper for J2 is in the ALERT position. Likewise, if Tach (tachometer) is desired then the jumper for J2 should be in the TACH position. See Section 3.1. The following windows will assume that the Tach input has been selected and the J2 jumper is in the Tach position.



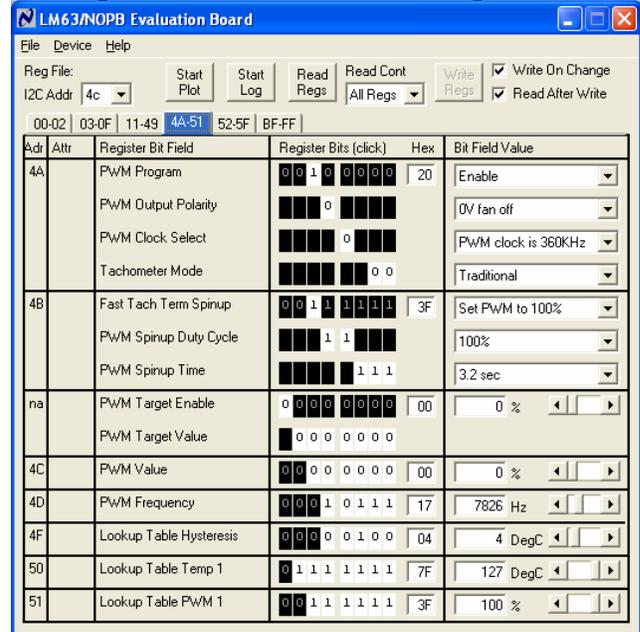
The user can experiment with the register functions for these registers as explained in the LM63 datasheet.

Selecting the 11-49 tab will reveal the following screen.



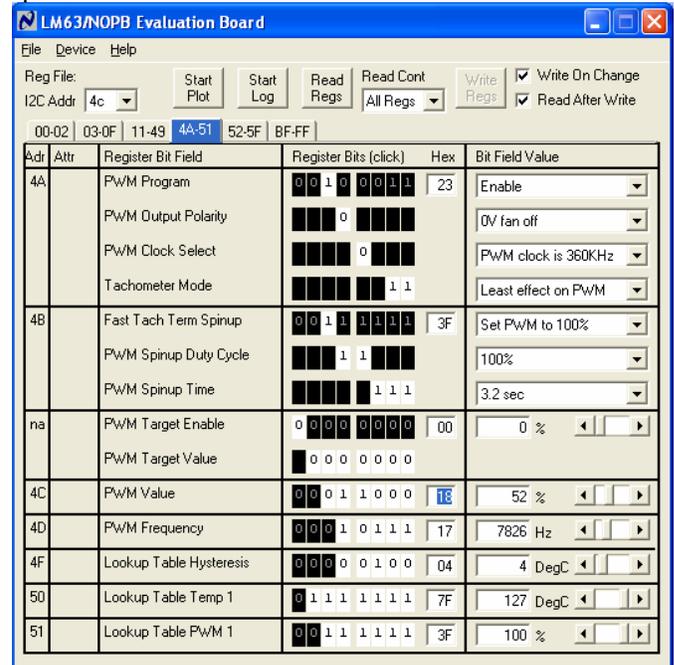
Notice that the tach count will show the RPM of the fan based on the Tach pulses coming from the 4-terminal fan. Again, the user can experiment with the different limit, mask, and offset registers.

Selecting the 4A-51 tab shows the following screen.

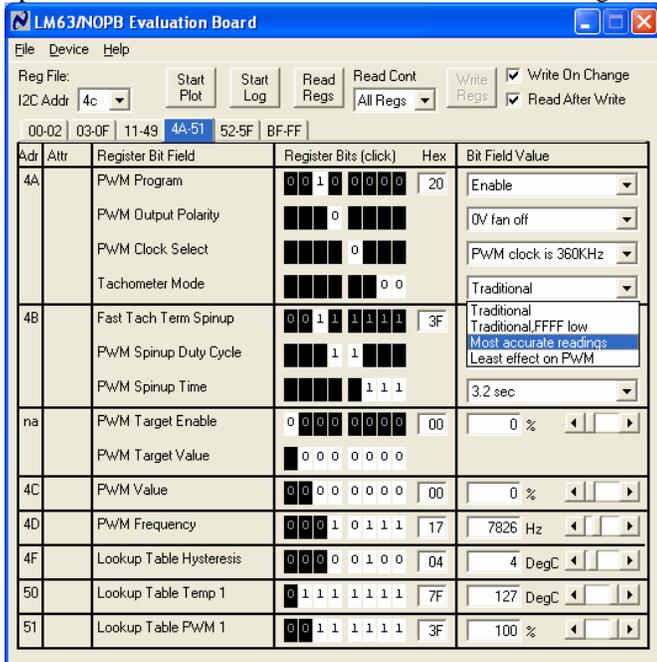


This is for experimenting with the PWM, Tach and fan speed settings according to the PWM Value and PWM frequency. Consult the LM63 datasheet and the fan manufacturer's datasheet for the fan. Changing bits in 4C register will have the most dramatic change in fan speed.

The following screen shows selected bits for essentially 52% fan speed.

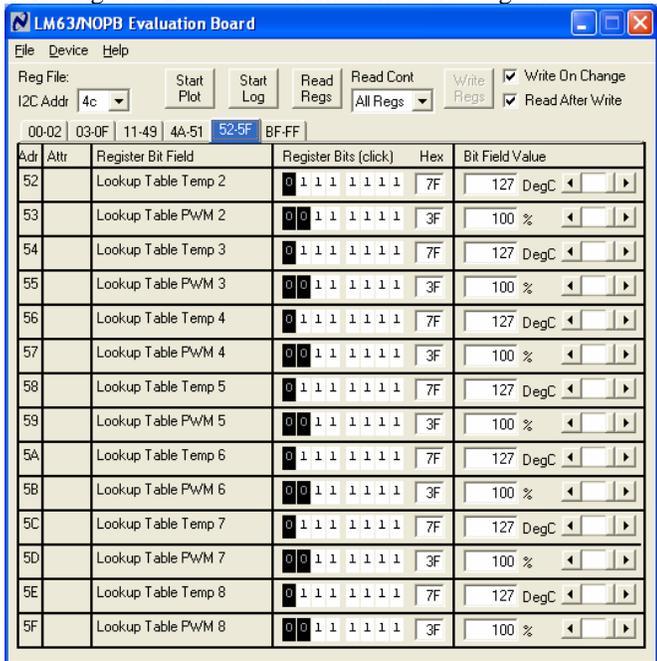


Another selection that can be made with the 4A-51 tab screen is to select the accuracy of the tach measurements. Refer to the LM63 datasheet for the details. The screen below shows the options and the selection of the “Most Accurate” readings.



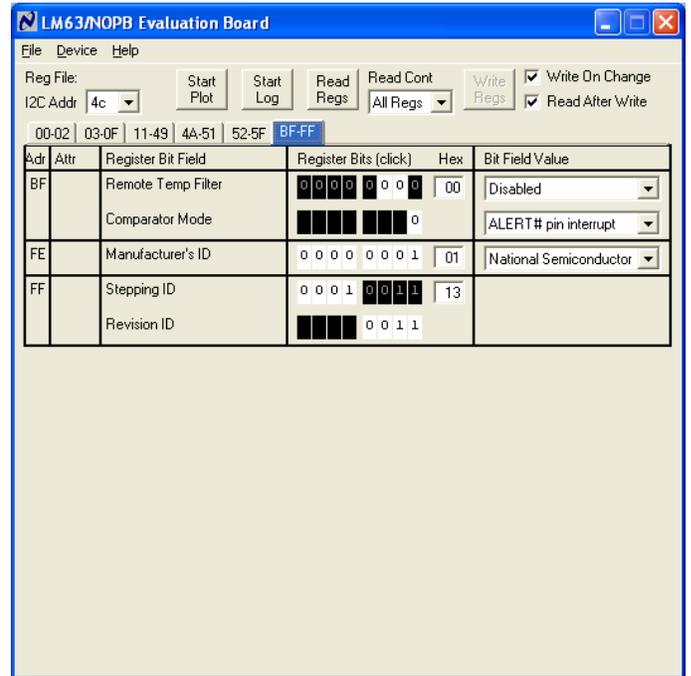
Notice Lookup Table Temperature and PWM for the first step. See LM63 Datasheet for details.

Selecting the 52-5F tab will show the following screen.

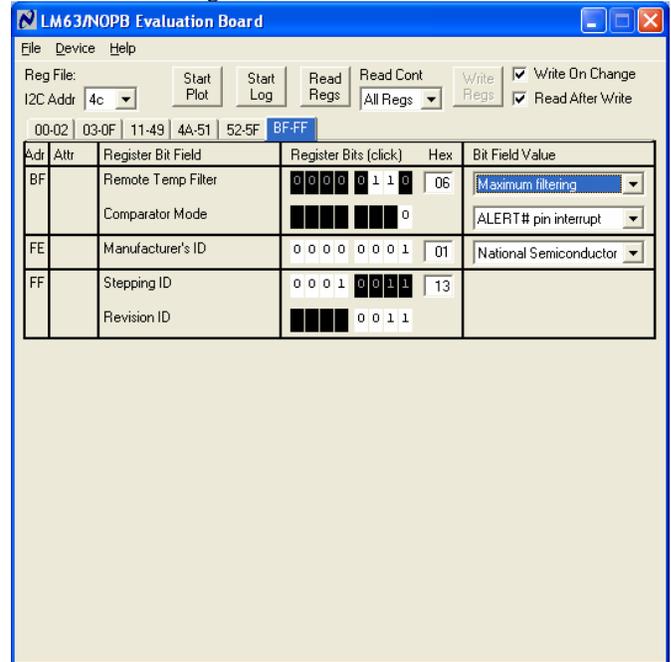


This is for selecting the various Lookup Table Temperature and PWM settings. The first Lookup Table settings are shown on the previous tab.

When the last tab, BF-FF, is selected the screen looks like this:

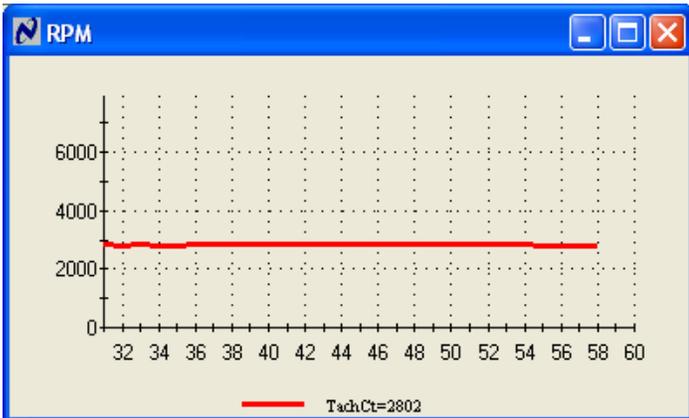
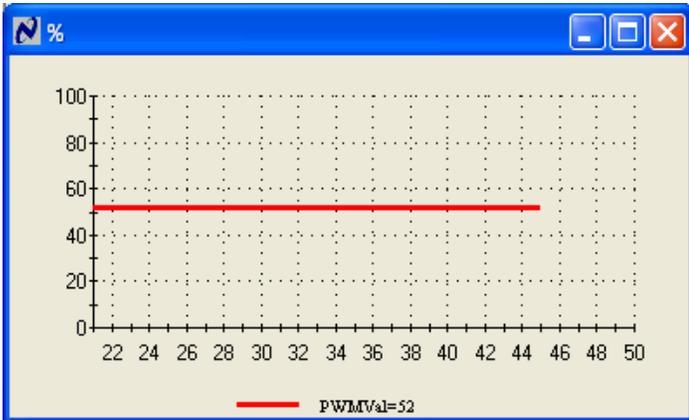
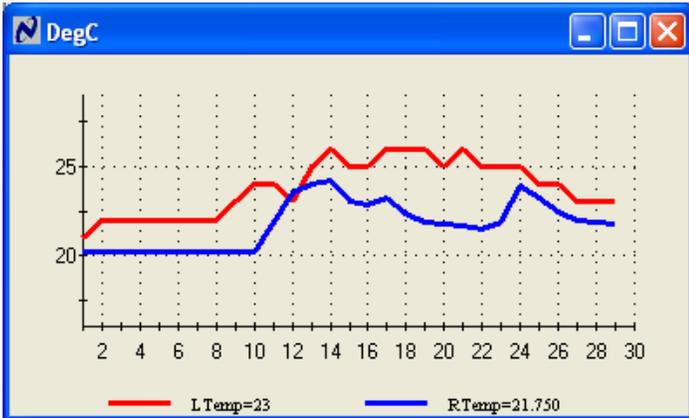


In the next screen the Remote Temp Filtering box shows the Maximum Filtering selected.

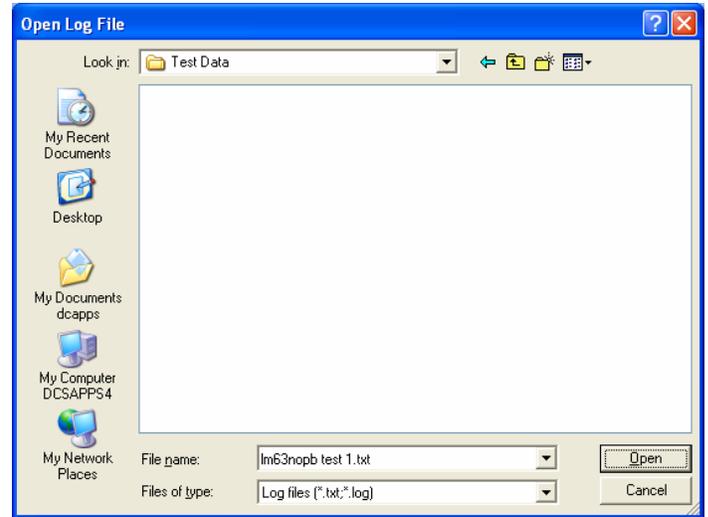


Lastly, for this tab, for the ALERT# pin selection (note the Register 03/09 and ALERT jumpered for J2) the user may choose either the Comparator or the Interrupt Mode.

If the user wants to plot temperature, RPM and PWM% the “Start Plot” button at the top can be selected. The three plots, shown below, will be displayed. Plotting is stopped by pressing the STOP button.

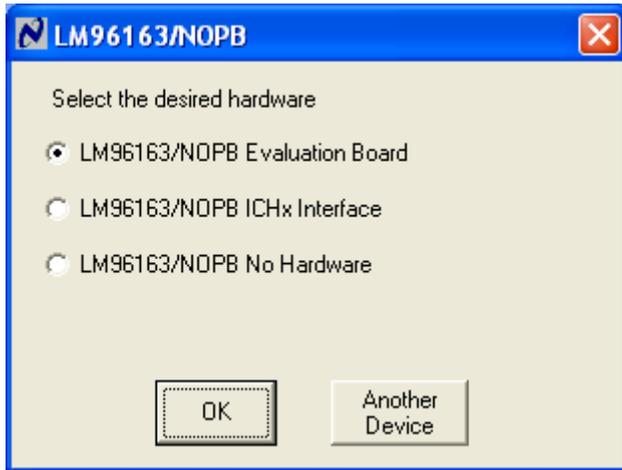


If the user wants to log the data then the Log Data Button is selected. The following screen pops-up asking for a filename and directory as to where to store the logged data test file. The Directory shown is the “Im63nspb” but it’s the user’s preference. The filename shown is “Im63nspb test1.txt” but the user can create whatever filename is desired.

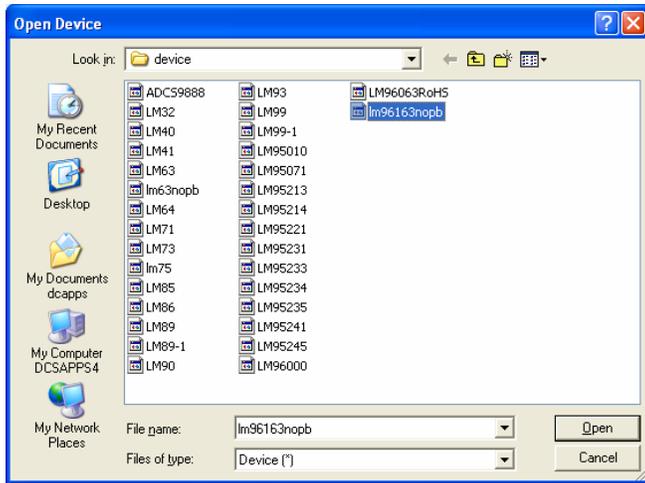


## 2.2 LM96163EVAL /NOPB Board Only

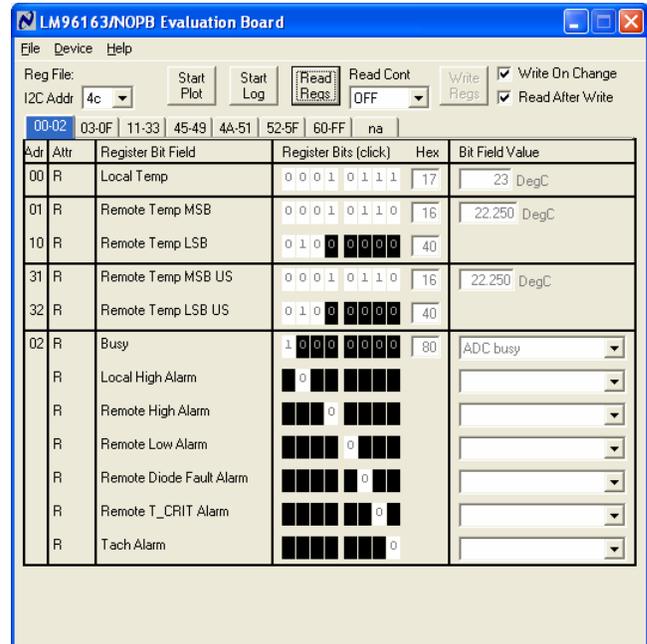
For the LM96163EVAL NOPB board the first screen will look like this:



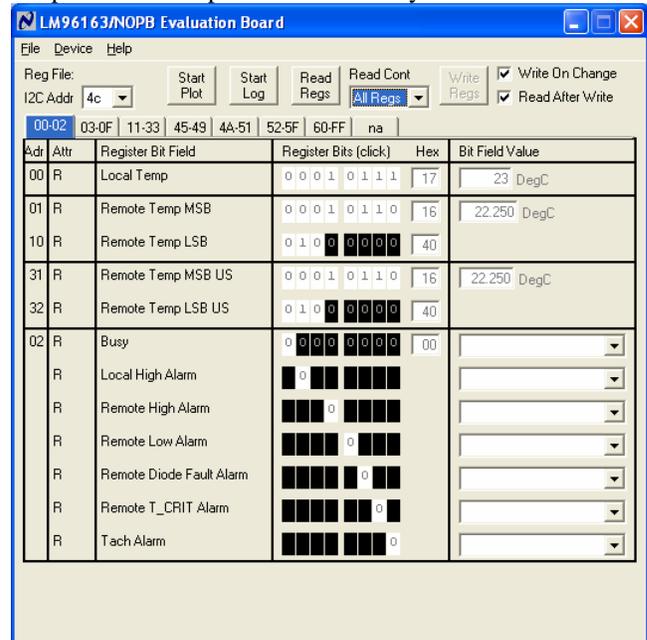
If this window is for another device's board the following window will show up. In this case simply select "Another Device" button and the "LM96163 NOPB" device ID, as shown below.



The next screen shows the initial "tab" for Registers 00-02 in functional order.



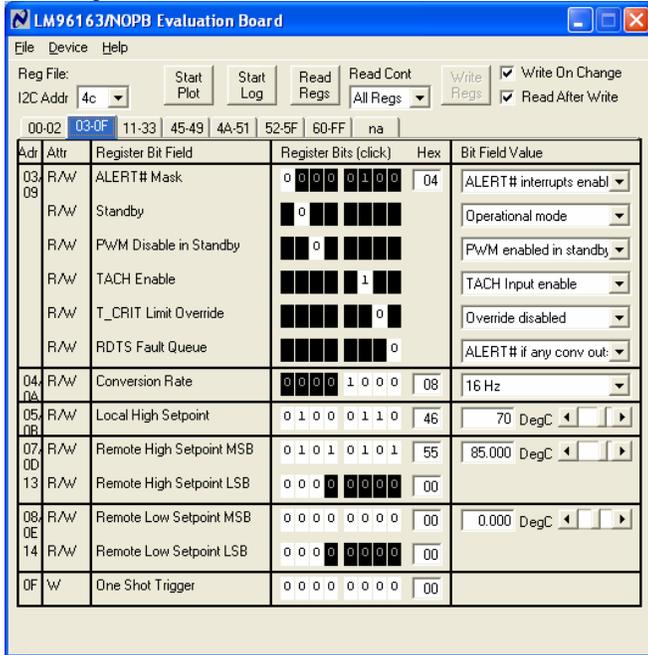
The next screen shows what the first initial reading is from the first data conversion. The next step is usually for the user to select the pull-down box labeled "Read Cont" ALL REGS to continuously read all registers so that the Local and Remote temperatures are updated continuously. See below.



NOTE: This screen shows the result of 2 conversions. On the initial conversion the Remote temp will show an erroneous reading because the Remote diode selects TruTherm on POR but the input is connected to the on-board MMBT3904 (see Register 30). Select TruTherm disable then do another conversion.

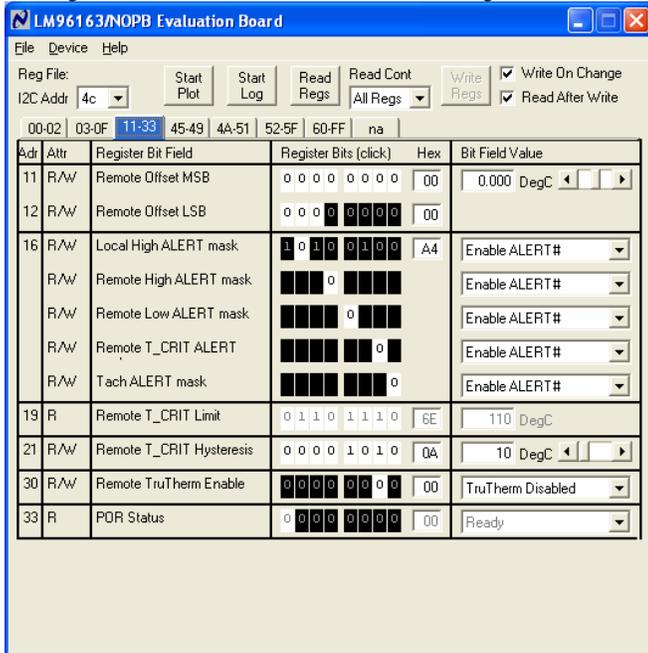
In Register 02 the bits will change to 1 if the specific alarm condition is met and the box to the right will also show the word "alarm". Whenever the alarm condition is cleared the bit will return to 0 and the box will be blank. See the LM96163 datasheet for further details.

Selecting the 03-0F Tab will show this screen.



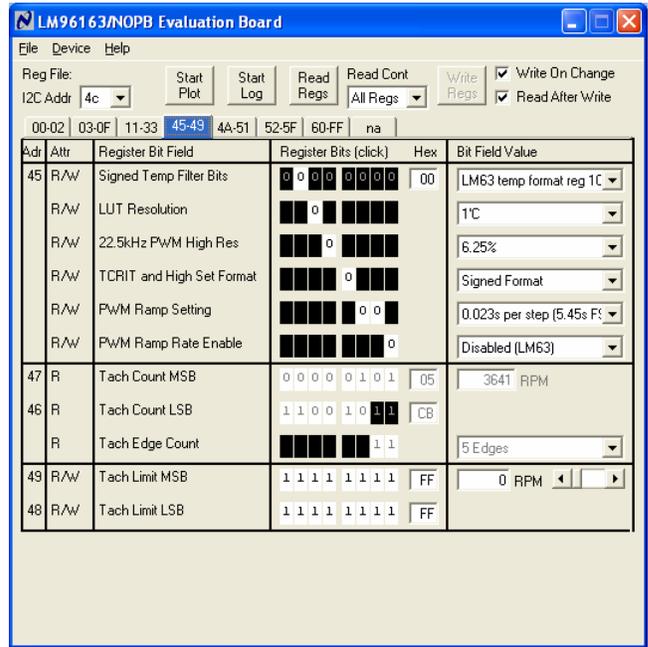
The user can experiment with the register functions for these registers as explained in the LM96163 datasheet.

Selecting the 11-33 tab will reveal the following screen.

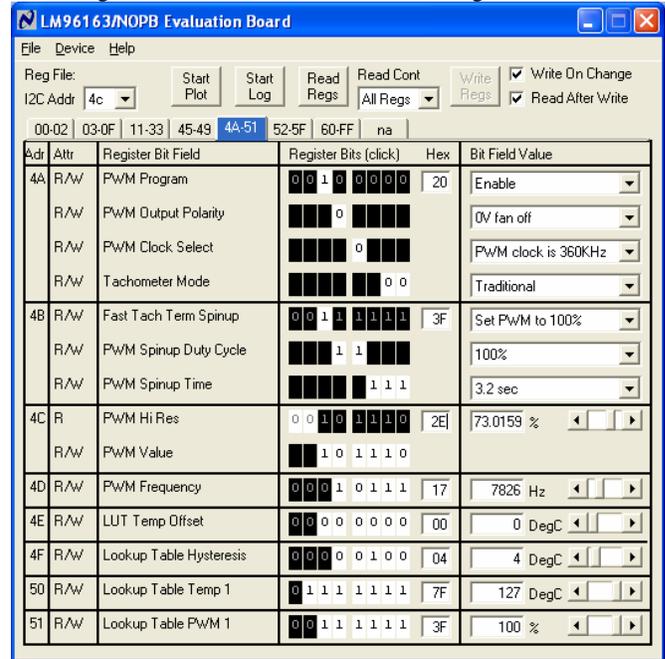


Again, the user can experiment with the different limit, mask, and offset registers.

The tab 45-49 screen shows the registers for selecting PWM values and various resolution settings. It also shows the actual RPM for the Tach Count

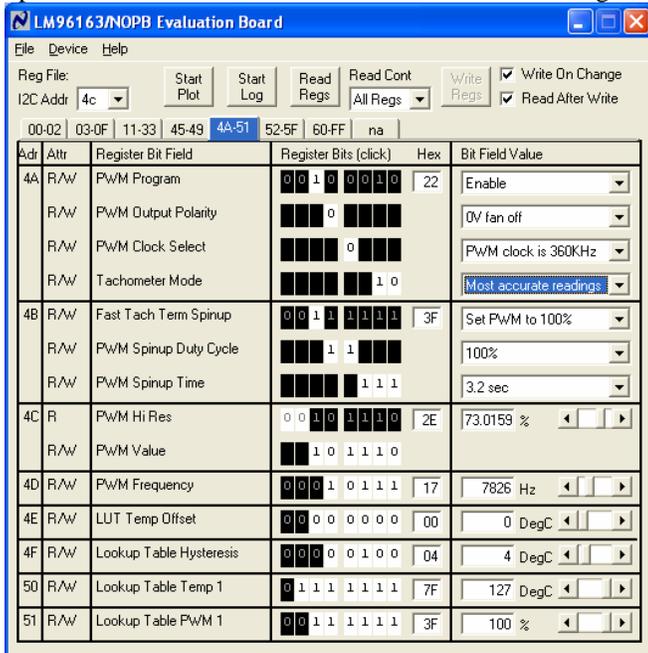


Selecting the 4A-51 tab shows the following screen.



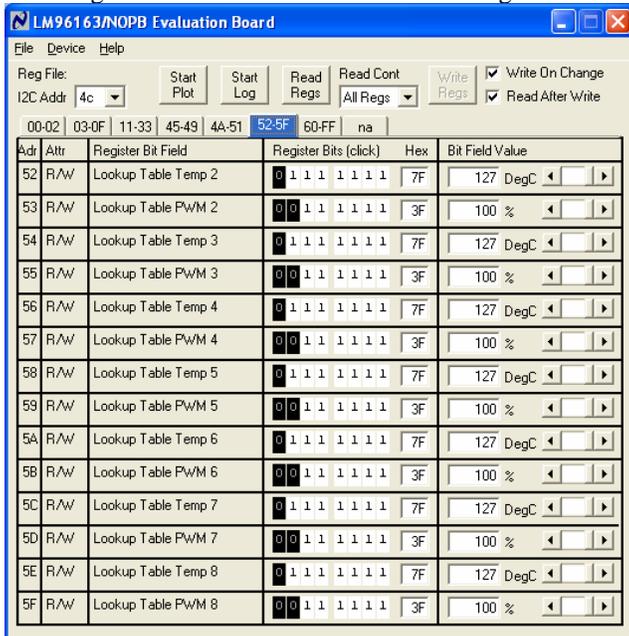
This is for experimenting with the PWM, Tach and fan speed settings according to the PWM Value and PWM frequency. Consult the LM96163 datasheet and the fan manufacturer's datasheet for the fan. Changing bits in 4C register will have the most dramatic change in fan speed. In this case the PWM value bits were set such that the PWM % was 73+ %.

Another selection that can be made with the 4A-51 tab screen is to select the accuracy of the tach measurements. Refer to the LM96163 datasheet for the details. The screen below shows the options and the selection of the “Most Accurate” readings.



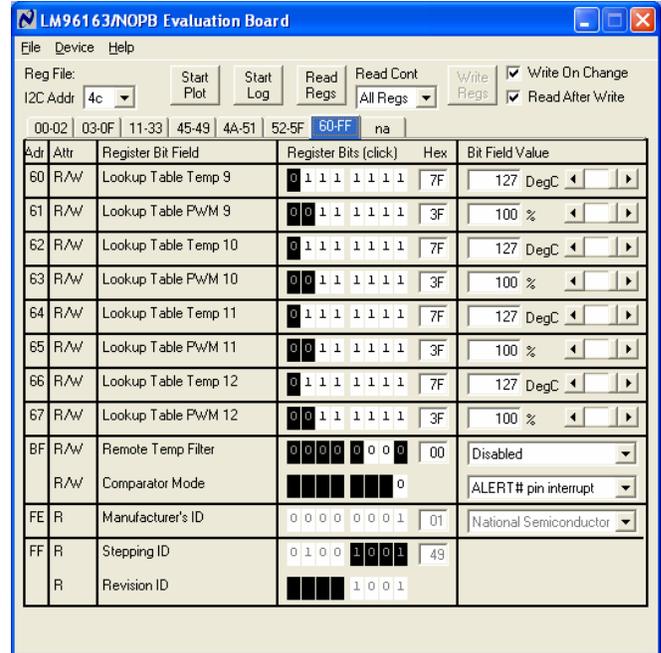
Notice Lookup Table Temperature and PWM for the first step. See LM96163 Datasheet for details.

Selecting the 52-5F tab will show the following screen.

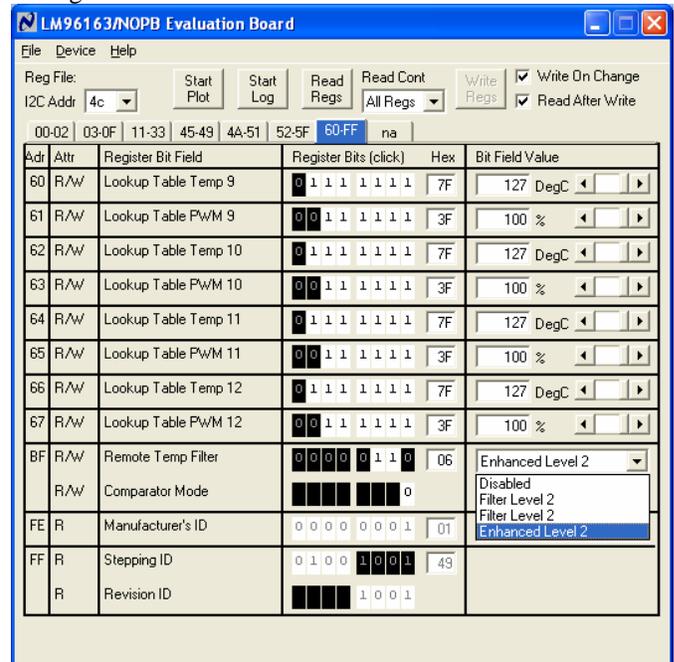


This is for selecting the various Lookup Table Temperature and PWM settings. The first Lookup Table settings are shown on the previous tab.

When the last tab, 60-FF, is selected the screen looks like this:



Register BF allows for the selection of different filtering settings. See the screen below.



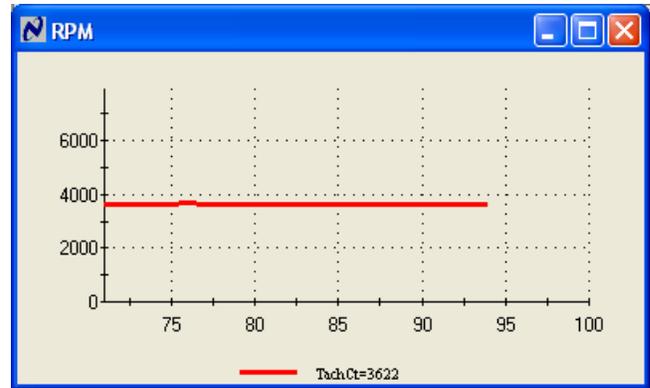
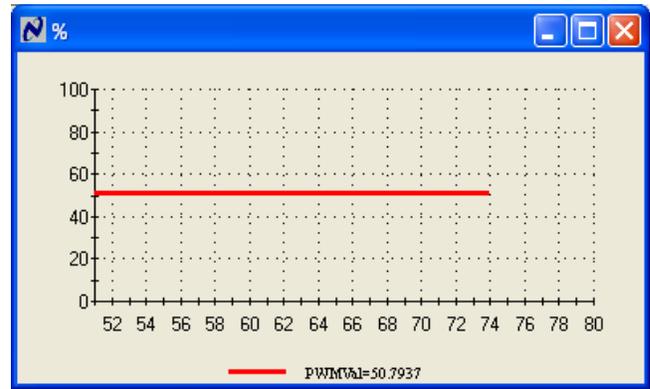
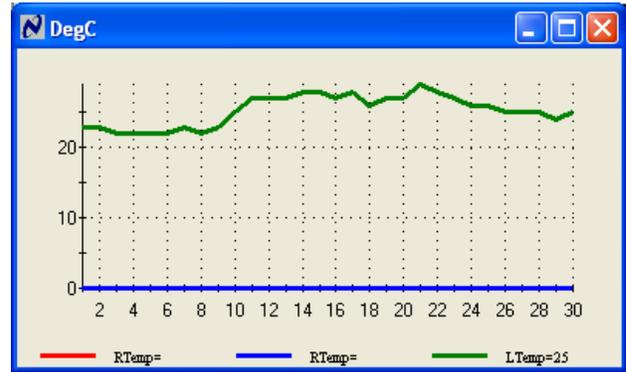
Register BF also allows for the ALERT# pin to function either in the Comparator Mode or the Interrupt Mode. See the screen below.

Adr	Attr	Register Bit Field	Register Bits (click)	Hex	Bit Field Value
60	R/W	Lookup Table Temp 9	0 1 1 1 1 1 1 1 1 1	7F	127 DegC
61	R/W	Lookup Table PWM 9	0 0 1 1 1 1 1 1 1 1	3F	100 %
62	R/W	Lookup Table Temp 10	0 1 1 1 1 1 1 1 1 1	7F	127 DegC
63	R/W	Lookup Table PWM 10	0 0 1 1 1 1 1 1 1 1	3F	100 %
64	R/W	Lookup Table Temp 11	0 1 1 1 1 1 1 1 1 1	7F	127 DegC
65	R/W	Lookup Table PWM 11	0 0 1 1 1 1 1 1 1 1	3F	100 %
66	R/W	Lookup Table Temp 12	0 1 1 1 1 1 1 1 1 1	7F	127 DegC
67	R/W	Lookup Table PWM 12	0 0 1 1 1 1 1 1 1 1	3F	100 %
BF	R/W	Remote Temp Filter	0 0 0 0 0 0 1 1 0 0	06	Enhanced Level 2
	R/W	Comparator Mode	0 0 0 0 0 0 0 0 0 0	0	ALERT# pin interrupt
FE	R	Manufacturer's ID	0 0 0 0 0 0 0 0 0 1	01	ALERT# pin interrupt
					ALERT# pin comparator
FF	R	Stepping ID	0 1 0 0 0 1 0 0 1 1	49	
	R	Revision ID	0 0 0 0 1 0 0 0 1		

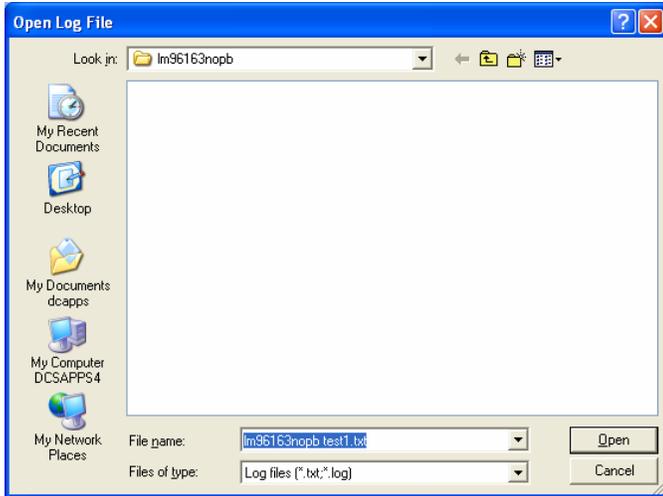
The next screen simply displays the status of the TCRIT# and ALERT# pins.

Adr	Attr	Register Bit Field	Register Bits (click)	Hex	Bit Field Value
na	R	Tcrit#	0 1 1 1 1 1 1 0 1 1	FD	Inactive
	R	Alert#	0 0 0 0 0 0 0 0 0 0	0	Active

If the user wants to plot temperature, RPM and PWM% the "Start Plot" button at the top can be selected. The three plots, shown below, will be displayed. Plotting is stopped by pressing the STOP button.



If the user wants to log the data then the Log Data Button is selected. The following screen pops-up asking for a filename and directory as to where to store the logged data test file. The Directory shown is the “lm96163nopb” but it’s the user’s preference. The filename shown is “lm96163nopb test1.txt” but the user can create whatever filename is desired.



### **2.3 LM64EVAL /NOPB Board Only**

[This section is reserved.]

### 3.0 Functional Description

The Fan Controller Evaluation Board, along with the SensorEval Software, provides the system designer with a convenient way to learn about the operation of the LM63 and LM96163 Temperature Sensor chips. 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 Fan Controller 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 LM63/LM96163, the on-board microcontroller, and the EEPROM chip, which stores the board ID information.

The microcontroller provides the SMBus signals SMBCLK, SMBALERT, and SMBDAT to the LM63/LM96163 chips. The Serial communications between the LM63/LM96163 and the PC USB data lines is controlled by the microcontroller. For all of the details of this communication protocol see the latest device datasheet, available at [www.national.com](http://www.national.com).

### 3.1 Fan Controller Evaluation Board Connection Table

Connector Label	Pin Number	Description
J1	1-3 3-4	Jumper Pins 1 and 3 together to provide power to the DUT. Jumper Pins 2 and 4 together.
J2 (LM63EVAL/NOPB boards only)	See Description	LM63EVAL/NOPB only: Select ALERT circuit by jumpering Pins 3 and 4 together (1 and 2 are open) or, Select TACH input circuit by jumpering Pins 2 and 4 (1 and 3 open). LM64EVAL/NOPB and LM96163EVAL/NOPB boards: do not connect jumpers.
J3 (all pairs are jumpered across for the typical configuration)	1-2	SMBCLK (SCL). Serial SMBus Clock signal from the microcontroller to the SMBCLK input of DUT.
	3-4	SMBDAT (SDA) is the bi-directional signal for communications between the DUT and the microcontroller.
	5-6	ALERT# is the ALERT signal generated by the DUT to the rest of the board.
	7-8	TCRIT is the TCRIT signal generated by the DUT to the rest of the board.
	9-10	LM64EVAL/NOPB only: connects the A0 address pin of the DUT to ground. Jumpering on other boards doesn't matter.
	11-12	This is the PWM Signal generated by the DUT to the fan.
	13-14	This is the TACH signal generated by the fan to the DUT.
	15-16	Ground connection from system to DUT.
J4	1-3 and 2-4	Jumper these pairs for connection to the MMBT3904 remote diode. Do not jumper them if an external remote diode is to be soldered to TP2 and TP4 of the board.
J5	1 2	Fan Power Supply voltage appropriate for Fan (+5V or 12V) Fan Power Supply Ground.
J6	1 2 3 4	Fan PWM Connection Fan Tach Input to board. Fan + Power Supply GND
J7	1 through 10	LM64EVAL/NOPB Only. GPD and GPIO test pins only.
J8	1 2 3 4	USB VBUS (+5VDC) input USB DMINUS USB DPLUS USB GND
J9	1 2 3 4	SMBCLK (SCL) Test Pin or external output SMBDAT (SDA) Test Pin or external output GND connection to board ground +3.3V Connection to board regulator +3.3VDC.

## 4.0 Software Installation and Operation

### 4.1 Installation

The CD provided in the Fan Controller Evaluation Board Kit contains the SensorEval software used to make the LM63/LM96163 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 a Microsoft Windows® XP/2000/98/ME operating system.

The software is installed as follows:

1. Insert the 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. 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 LM63/LM96163 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 Evaluation Board. The first screen will look like this:

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

Refer to the schematic, layout and connector diagrams for the connections to remote diodes for the temperature readings.

## 5.0 Electrical and Mechanical Specifications

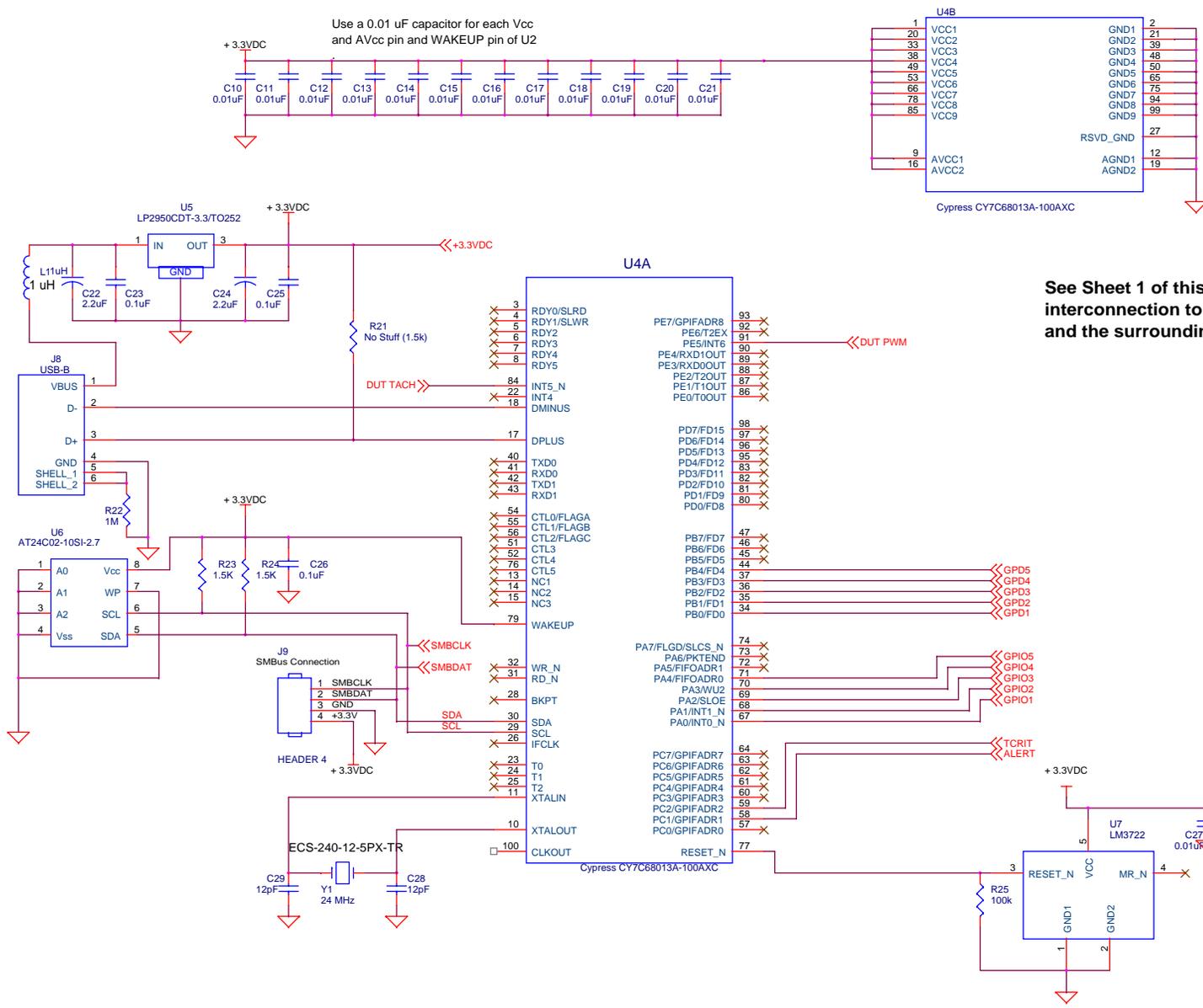
### 5.1 Electrical Specifications

Power Requirements	
The Board uses the +5.0 VDC and GND lines from the USB connection.	+5.0 ± 0.1 V, 100 mA max.
An external power supply is required for the Fan Power. If the 4-terminal fan is 5VDC or 12VDC then apply that voltage to the Fan Power input.	+5.0 ± 0.1 V or +12 ± 0.1 as required by the fan.

### 5.2 Electrical Schematic

See next 2 pages for the schematic.





### 5.3 Evaluation Board Layout

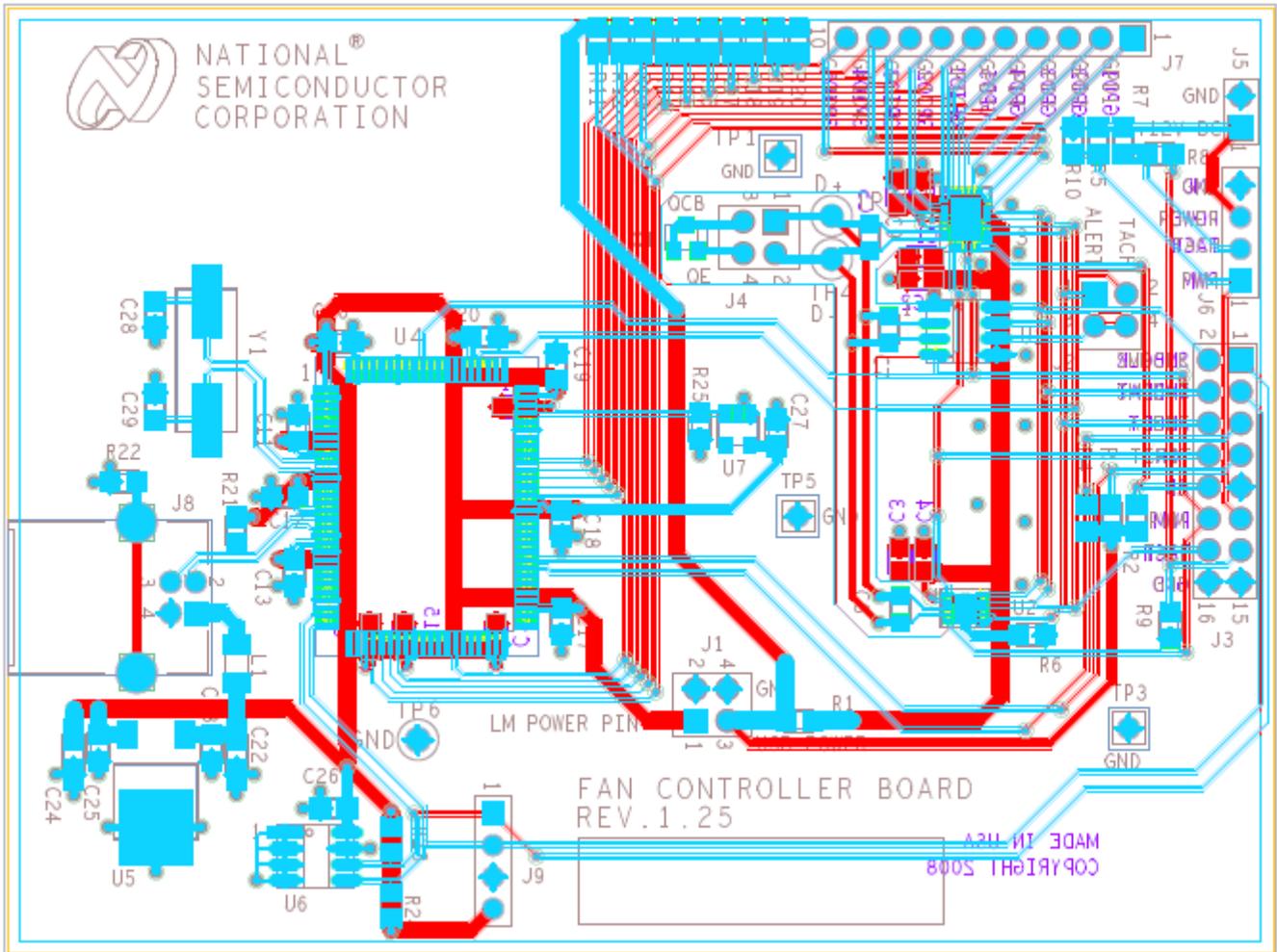


Figure 5.3 Layout diagram of the Fan Controller Evaluation Board

#### 5.4 Bill of Materials for Fan Controller Evaluation Board

Item	Quantity	Reference	Part
1	6	C1,C3,C5,C23,C25,C26	0.1uF
2	4	C2,C4,C6,C8	100 pF
3	1	C7	100 pF or 2.2nF
4	1	C9	2.2 nF
5	13	C10,C11,C12,C13,C14,C15, C16,C17,C18,C19,C20,C21, C27	0.01uF
6	2	C22,C24	2.2uF
7	2	C28,C29	12pF
8	1	J1	DUT Power
9	1	J2	LM63/96063 Alert/Tach Select
10	1	J3	HEADER 8X2
11	1	J4	HEADER 2X2
12	1	J5	HEADER 2
13	1	J6	4-Pin Fan Header
14	1	J7	HEADER 10
15	1	J8	USB-B
16	1	J9	HEADER 4
17	1	L1	1uH
18	1	Q1	MMBT3904/SOT
19	2	R1,R6	0 ohms
20	4	R2,R3,R4,R9	10 kohms
21	1	R5	6.3kohms
22	1	R7	1 kohms
23	1	R8	13 kohms
24	1	R10	5.1 kohms
25	10	R11,R12,R13,R14,R15,R16, R17,R18,R19,R20	10 k
26	1	R21	No Stuff
27	1	R22	1M
28	2	R23,R24	1.5K
29	1	R25	100k
30	4	TP1,TP3,TP5,TP6	GND
31	1	TP2	D+ DNS
32	1	TP4	D- DNS
33	1	U1	LM63/LM96063
34	1	U2	LM96163
35	1	U3	LM64
36	1	U4	Cypress CY7C68013A-100AXC
37	1	U5	LP2950CDT-3.3/TO252
38	1	U6	AT24C02-10SI-2.7
39	1	U7	LM3722
40	1	Y1	24 MHz

## 5.5 Mechanical Specifications

### 5.5.1 Operating Mechanical and Environmental Specifications

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

### 5.5.3 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](http://www.national.com).

**BY USING THIS PRODUCT, YOU ARE AGREEING TO BE BOUND BY THE TERMS AND CONDITIONS OF NATIONAL SEMICONDUCTOR'S END USER LICENSE AGREEMENT. DO NOT USE THIS PRODUCT UNTIL YOU HAVE READ AND AGREED TO THE TERMS AND CONDITIONS OF THAT AGREEMENT. IF YOU DO NOT AGREE WITH THEM, CONTACT THE VENDOR WITHIN TEN (10) DAYS OF RECEIPT FOR INSTRUCTIONS ON RETURN OF THE UNUSED PRODUCT FOR A REFUND OF THE PURCHASE PRICE PAID, IF ANY.**

The Fan Controller Evaluation Boards are intended for product evaluation purposes only and are not intended for resale to end consumers, are not authorized for such use and are not designed for compliance with European EMC Directive 89/336/EEC, or for compliance with any other electromagnetic compatibility requirements.

National Semiconductor Corporation does not assume any responsibility for use of any circuitry or software supplied or described. No circuit patent licenses are implied.

### **LIFE SUPPORT POLICY**

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

### **BANNED SUBSTANCE COMPLIANCE**

National Semiconductor certifies that the products and packing materials meet the provisions of the Customer Products Stewardship Specification (CSP-9-111C2) and the Banned Substances and Materials of Interest Specification (CSP-9-111S2) and contain no "Banned Substances" as defined in CSP-9-111S2.



**National Semiconductor Corporation**  
**Americas Customer Support Center**  
Tel: 1-800-272-9959  
Email: new.feedback@nsc.com

**National Semiconductor Europe Customer Support Center**  
Fax: +49 (0) 1 80-530 85 86  
Email: europe.support@nsc.com  
Deutsch Tel: +49 (0) 699508 6208  
English Tel: +49 (0) 870 24 0 2171  
Français Tel: +49 (0) 141 91 8790

**National Semiconductor Asia Pacific Customer Support Center**  
Email:  
ap.support@nsc.com

**National Semiconductor Japan Customer Support Center**  
Tel: 81-3-5639-7560  
Fax: 81-3-5639-7507  
Email:  
jpn.feedback@nsc.com

National does not assume any responsibility for any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.