



# Evaluation Board for Temperature Monitor with Series Resistance Cancellation

## EVAL-ADT7461\*

### FEATURES

**On-Chip and Remote Temperature Sensor**  
**0.25°C Resolution/1°C Accuracy on Remote Channel**  
**1°C Resolution/3°C Accuracy on Local Channel**  
**Series Resistance Cancellation Automatically Cancels**  
**1 kΩ(typ) of Parasitic Series Resistance on Remote Diode**  
**Extended, Switchable Temperature Measurement Range**  
**-64°C to +191°C or 0°C to +127°C**  
**Pin-Compatible with ADM1032**  
**2-Wire SMBus Serial Interface with SMBus Alert Support**  
**Programmable Over/Undertemperature Limits**  
**Offset Registers for System Calibration**  
**Up to 2 Overtemperature Fail-Safe THERM Outputs**  
**Small 8-Lead SOIC or MSOP Package**  
**170 μA Operating Current, 5.5 μA Standby Current**  
**3 V to 5.5 V Supply**

### APPLICATIONS

**Desktop Computers**  
**Notebook Computers**  
**Smart Batteries**  
**Burn-In Applications**  
**Telecom Equipment**  
**Instrumentation**  
**Embedded Systems**

### GENERAL DESCRIPTION

The ADT7461 evaluation board allows the ADT7461 temperature monitoring IC to be quickly and easily evaluated using a personal computer. Using the evaluation board and its accompanying software, the ADT7461 can be interfaced to any personal computer running Windows® 95 or Windows® 98, via the computer's parallel printer port.

The evaluation board allows the input and output functions of the ADT7461 to be exercised without the need for external components. The software allows control and monitoring of the ADT7461's internal registers. The series resistance cancellation feature of the ADT7461 can be investigated using two on-board variable resistors. A circuit description, as well as a schematic diagram and a bill of materials, is included in this document.

### THE ADT7461

The following is a brief description of the ADT7461. Further information can be found in the ADT7461 data sheet, which should be consulted in conjunction with this document.

\*Patents pending: 5,982,221, 6,097,239, 6,133,753, 6,169,442

### REV. B

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The ADT7461 is a dual-channel digital thermometer and undertemperature/overtemperature alarm, intended for use in personal computers and thermal management systems. It is pin-compatible and register-compatible with the ADM1032, and includes all features of the ADM1032. There are three additional features on the ADT7461: series resistance cancellation, where 1 kΩ (typical) of parasitic resistance in series with the temperature monitoring diode may be automatically cancelled; configurable  $\overline{\text{ALERT}}$  output; and an extended, switchable temperature measurement range. The ADT7461 can measure the temperature of a remote thermal diode accurate to  $\pm 1^\circ\text{C}$ . An on-board temperature sensor can measure the ambient temperature of the ADT7461 to  $\pm 3^\circ\text{C}$ . The measurement temperature range defaults to 0 to 127°C, which is compatible with ADM1032. However, it can be switched to a wider, -64°C to +191°C measurement range.

The ADT7461 communicates over a 2-wire serial interface compatible with system management bus (SMBus) standards. An  $\overline{\text{ALERT}}$  output signals when the on-chip or remote temperature is out of range, and can be used as an interrupt, or as an SMBus alert. The  $\overline{\text{THERM}}$  output is a comparator output that allows CPU clock throttling or on/off control of a cooling fan. The  $\overline{\text{ALERT}}$  output can be reconfigured as a second  $\overline{\text{THERM}}$  output if required.

### EVALUATION KIT CONTENTS

The evaluation kit contains the following items:

- Evaluation board data sheet
- ADT7461 evaluation board
- Centronics cable
- Evaluation software

### EVALUATION BOARD HARDWARE

The ADT7461 evaluation board contains the following main components which can be identified from the block diagram in Figure 1. The printed circuit board schematic and silk screen are shown in Figures 11 and 12.

- ADT7461 IC
- PNP sensor transistor
- LED indicators for power,  $\overline{\text{ALERT}}$ , and  $\overline{\text{THERM}}$
- Interface buffers
- Connector for parallel interface
- Test connector for connecting to CPU transistor
- Two variable resistors for adding series resistance

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# EVAL-ADT7461

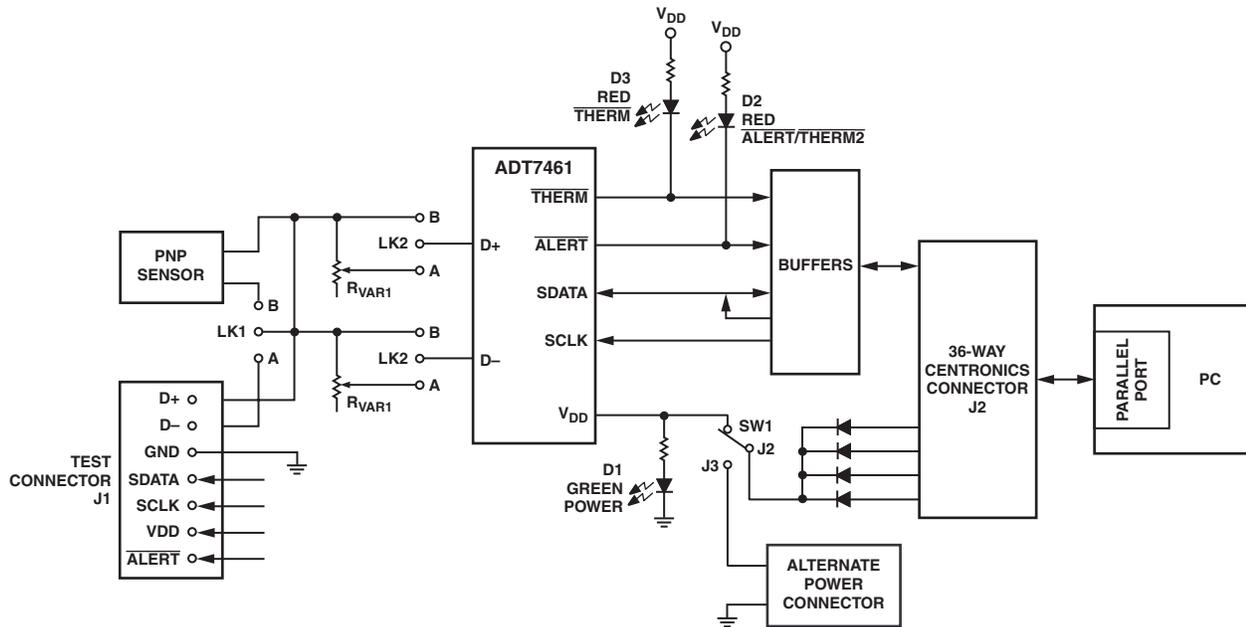


Figure 1. ADT7461 Evaluation Board Block Diagram

## CONNECTORS, SWITCHES, AND INDICATORS

The function of the various connectors, links, and indicators on the evaluation board are explained below.

### Test Connector J1

This connector allows the user easy access to all the signals on the pins of the ADT7461. This connector is also used to connect an external remote thermal diode between the D+ and D- terminals of the ADT7461.

### Centronics Interface Cable J2

The evaluation board and the personal computer may be connected via the printer parallel port using the Centronics cable provided.

### Power Connector J3 and Switch SW1

Power can be supplied to the board either via the Centronics cable or via the power connector J3. If the switch is at J2, then power is supplied from the parallel port; if the switch is at J3, then power is supplied from the power connector.

### Remote Sensor Select LK1

The function of this jumper is to allow the user to choose between measuring temperature using the on-board remote sensor and an external one connected between the D+ and D- terminals of J1. When the middle pin is linked to B, the on-board sensor is used, and when the middle pin is linked to A, an off-board sensor is used.

Table I. ADT7461 Sensor Selection

LK1 Position	Sensor Selected
A	External Sensor
B	On-Board PNP Sensor

### D+ Series Variable Resistor Select LK2

The function of this jumper is to allow the user to include a variable resistor ( $R_{VAR1}$ ) in series with the D+ input on the ADT7461. The user can investigate the series resistance cancellation feature of the part by varying this resistor. When the middle pin is linked to A, the variable resistor is connected in series with the D+ input. When the middle pin is linked to B, the variable resistor is disconnected from the ADT7461.  $R_{VAR1}$  maximum = 2 k $\Omega$ .

Table II. D+  $R_{VAR1}$  Selection

LK2 Position	Selection
A	$R_{VAR1}$ connected in series with D+
B	$R_{VAR1}$ not connected

### D- Series Variable Resistor Select LK3

The function of this jumper is to allow the user to include a variable resistor ( $R_{VAR2}$ ) in series with the D- input on the ADT7461. The user can investigate the series resistance cancellation feature of the part by varying this resistor. When the middle pin is linked to A, the variable resistor is connected in series with the D- input. When the middle pin is linked to B, the variable resistor is disconnected from the ADT7461.  $R_{VAR2}$  maximum = 2 k $\Omega$ .

Table III. D-  $R_{VAR2}$  Selection

LK3 Position	Selection
A	$R_{VAR2}$ connected in series with D-
B	$R_{VAR2}$ not connected

**Power Indicator Green LED D1**

When lit, the LED D1 indicates that the ADT7461 evaluation board is powered.

**Therm Indicator Red LED D2**

When lit, the LED D2 indicates that the  $\overline{\text{THERM}}$  interrupt on the ADT7461 is active. The LED remains lit until the  $\overline{\text{THERM}}$  interrupt is cleared. For more information on the  $\overline{\text{THERM}}$  functionality, see the ADT7461 data sheet.

**ALERT/THERM2 Indicator Red LED D3**

The LED D3 lights up when an  $\overline{\text{ALERT/THERM2}}$  interrupt occurs on the ADT7461, and remains lit until the interrupt is cleared. For more information on the  $\overline{\text{ALERT/THERM2}}$  pin and the interrupt functions, see the ADT7461 data sheet.

**CONNECTING AN EXTERNAL REMOTE DIODE SENSOR TO THE EVALUATION BOARD**

The user may wish to use an external remote diode sensor with the ADT7461 evaluation board, instead of the on-board remote sensor. The user should connect the evaluation board to the external diode through a twisted pair cable. The connection to the board should be made through connector J1 at the D+ and D- pins. LK1 should be set to position A to connect in the external diode.

**MEASURING THE REMOTE DIODE TEMPERATURE**

While the ADT7461 has a measurement range of  $-64^{\circ}\text{C}$  to  $+191^{\circ}\text{C}$ , the maximum temperature it can measure is limited by the remote diode selection. Most temperature sensing diodes stop functioning correctly at about  $150^{\circ}\text{C}$ . More importantly, they lose their semiconductor characteristics at temperatures above  $150^{\circ}\text{C}$ , and approximate conductors instead. If this occurs, the diode will no longer give an accurate temperature measurement, and the diode short circuit interrupt on the ADT7461 will be triggered.

Even though the ADT7461 is capable of reading temperatures up to  $191^{\circ}\text{C}$ , most semiconductor diodes fail beyond  $150^{\circ}\text{C}$ , and will not give a correct temperature measurement. The user should note the maximum operating temperature of the remote temperature sensor. Any temperature measurement gained above this maximum temperature may be in error. A diode operating above its maximum temperature may, for example, give a temperature reading of  $75^{\circ}\text{C}$  instead of an accurate, real temperature reading of  $160^{\circ}\text{C}$ .

To prevent a potentially dangerous burnout situation, the user should program the ADT7461 temperature limits to ensure they are below the maximum operating temperature of the remote sensor. An interrupt should then be triggered in time for corrective action to be taken to cool the system, before the remote diode exceeds its maximum operating temperature.

The maximum operating temperature of the 2N3906 remote diode on the ADT7461 evaluation board is  $150^{\circ}\text{C}$ .

**EVALUATING THE ADT7461 SERIES RESISTANCE CANCELLATION FEATURE**

There are two variable resistors on the evaluation board for use in evaluating the series resistance cancellation feature. One variable resistor is located in series with the D+ input to the ADT7461, while the other is located in series with the D- input. In order to connect both these resistors into the circuit, the jumpers LK2 and LK3 must be set to position B.

Varying the resistors adds resistance in series with the remote diode. The normal consequence of increased series resistance is to add an offset to the temperature being measured. However, the ADT7461 automatically cancels out the effect of the series resistance, so the temperature of the remote diode should not change with increased series resistance. For more information on series resistance cancellation, see the ADT7461 datasheet.

If the user has both variable resistors connected in to the evaluation circuit, then the total resistance being cancelled by the ADT7461 is the sum of both resistances. If only one of the variable resistors is connected in, then the total resistance being cancelled is the value of that resistance only. The maximum resistance of both  $R_{\text{VAR1}}$  and  $R_{\text{VAR2}}$  is  $2\text{ k}\Omega$ , giving a total available resistance of  $4\text{ k}\Omega$ .

The user should see that the temperature measurement given by the ADT7461 remains constant while the variable resistances are changed. As the total series resistance value is increased above a certain value ( $1\text{ k}\Omega$  typ), a jump in the temperature measurement will occur, signifying that the series resistance cancellation has reached its threshold and is no longer cancelling resistance.

# EVAL-ADT7461

## ADT7461 EVALUATION SOFTWARE

Software allows the ADT7461's functions to be controlled from the PC via an easy to use interface operating under a Windows environment. The contents of the device's internal registers can easily be read or altered through a user-friendly graphics interface, while the Control Center window allows the graphing of the temperature readings.

### Installing the Software

To install the software, insert the CD-ROM with the program software into CD-ROM drive. The CD-ROM should auto-run and start installing the software. If this does not happen, click the Start icon, then click the Run icon and type D:setup.exe as

the file name. If the CD-ROM drive is not drive "D" then type "X" instead of "D", where "X" is the drive letter. To finish installing the software follow the on-screen instructions.

### Using the Software

When using the software, first ensure the evaluation board is connected to the parallel printer port.

To start the software, select Start-Programs-Analog Devices-ADT7461 Eval Software.

When the program is started, the search wizard will start. Click Next to go to the next screen.



Figure 2. Evaluation Software Search Wizard



Figure 3. ADT7461 Search Wizard: Choose Interface

Choose the interface over which you wish to communicate with the ADT7461 and click Next to continue. The software will then search for the ADT7461. It will display the results of that search on the screen shown in Figure 4.

Choose the ADT7461 you want to communicate with (there will always be only one option since the ADT7461 is available with only one possible SMBus address). Click Finish to start the software. If the software cannot find any ADT7461, click Back and check the connections to the board as well as the power supply switch SW1 to see if it is in the correct position.

The following is the main program tab that appears when the software is started.

There are three main sections to the evaluation software, which can be accessed easily from the tabs at the top of the evaluation window. The Read/Write section gives the user easy access to the ADT7461 registers. The Control Center window lets the user graph the temperature outputs of the ADT7461, check for interrupts, and set up log files. The CRC section allows the user to investigate the CRC functions of the ADT7461.

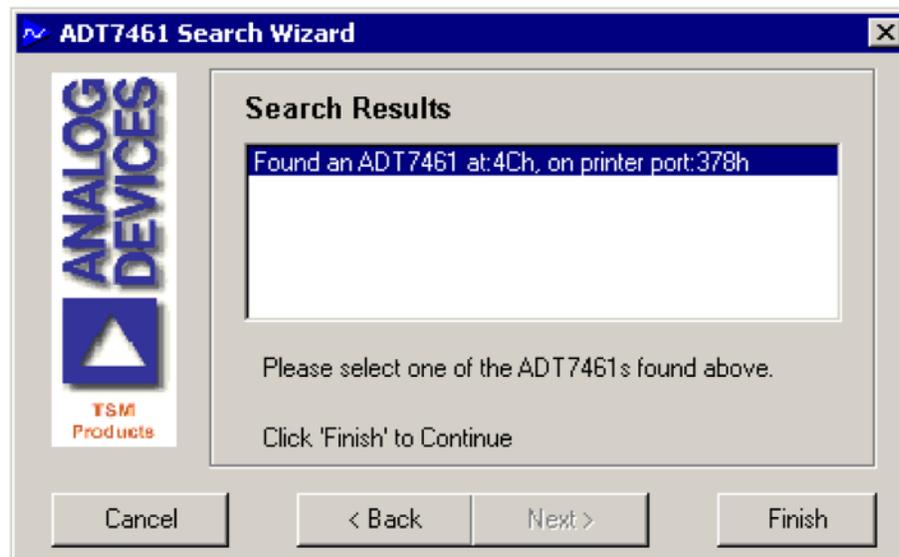


Figure 4. ADT7461 Search Wizard Results

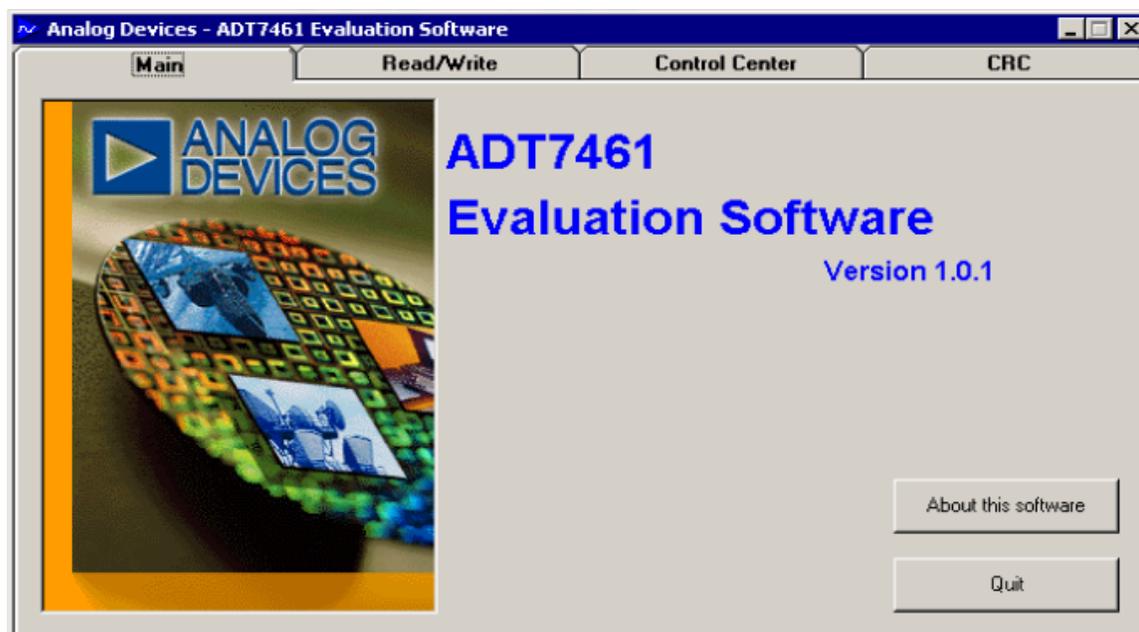


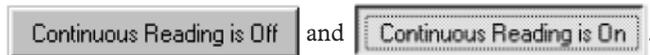
Figure 5. ADT7461 Evaluation Software Main Program Tab

# EVAL-ADT7461

## READ/WRITE

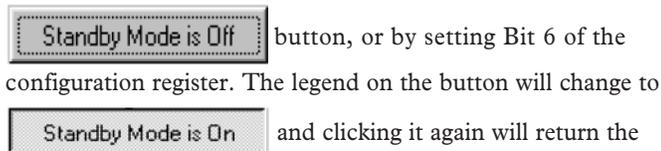
This tab displays information about the ADT7461's internal registers and allows their contents to be read and/or altered. Each register has a button associated with it. Clicking a button will display the contents of the selected register in the register contents box and the name of each register bit. The register contents are also displayed in hexadecimal and decimal.

Clicking a register button causes its contents to be read once if continuous reading is off. If continuous reading is on, the register will be updated continuously. Click the button to toggle between

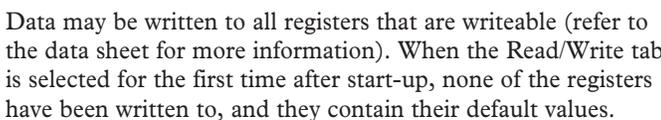


The type of register selected, its hexadecimal address, its current value in hexadecimal and decimal, and the previous value written to the register are also displayed.

The ADT7461 may be put into standby mode by clicking the



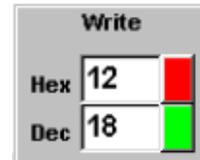
button, or by setting Bit 6 of the configuration register. The legend on the button will change to



and clicking it again will return the ADT7461 to normal operating mode. Data may be written to all registers that are writeable (refer to the data sheet for more information). When the Read/Write tab is selected for the first time after start-up, none of the registers have been written to, and they contain their default values.

Registers may be written to in two ways. Clicking a bit in the Read/Write display will toggle its value between 0 and 1. This is useful where a function is controlled by setting or clearing individual bits in a register, i.e., turning standby mode on or off by setting or clearing the operating mode bit in the Configuration Register.

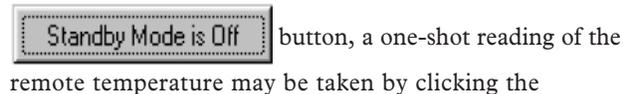
The entire contents of a register may be changed by typing a Hex or decimal value in the text boxes of the Write display. The button will change from green to red and the new value can be written to the register by clicking the button.



This is useful where a register contains a numeric value such as a temperature limit.

## ONE-SHOT OPERATION

When the ADT7461 is put into standby mode by setting Bit 6 of the configuration register or clicking the



button, a one-shot reading of the remote temperature may be taken by clicking the



button. The temperature found will then be displayed.

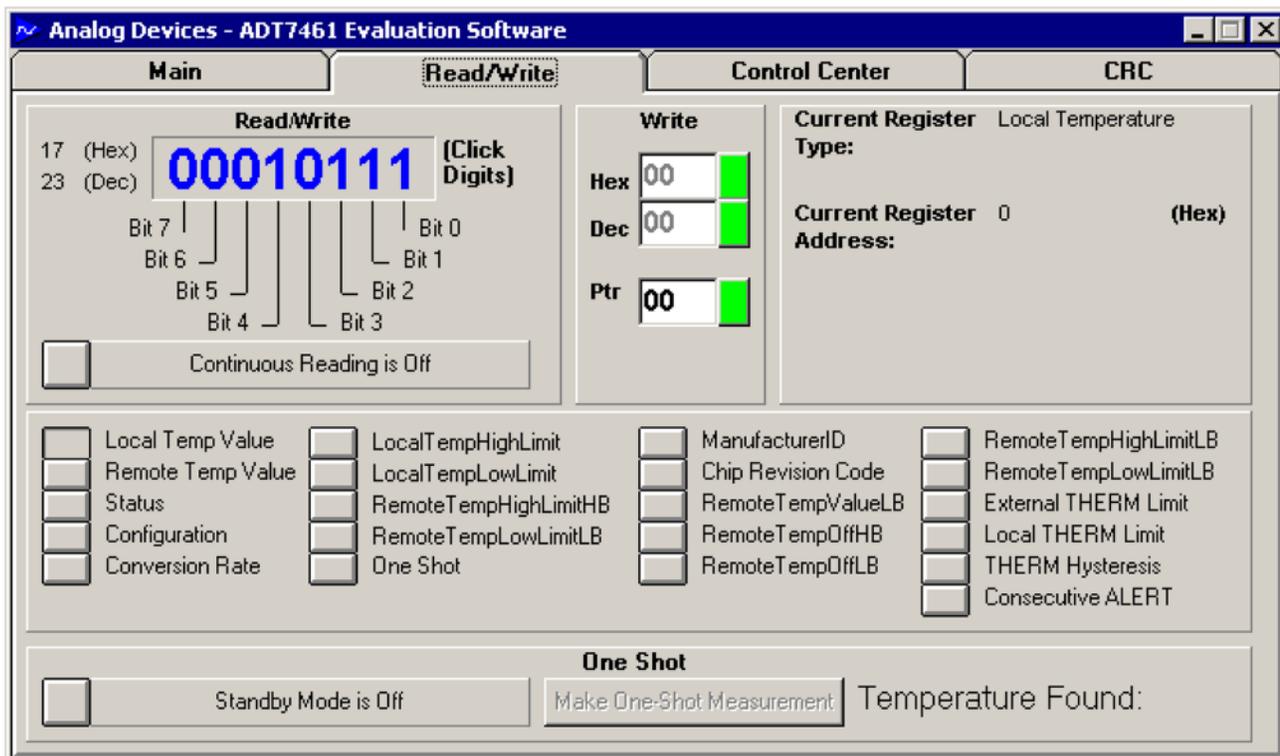


Figure 6. ADT7461 Evaluation Software Read/Write Tab

**CONTROL CENTER**

The Control Center tab allows readings to be displayed graphically on bar graphs or line graphs.

**Bar Graphs**

At the bottom of the Control Center tab are bar graphs for the local and remote sensors. These can be toggled on and off by clicking the “Bargraphs are Off” button. The legend will change to “Bargraphs are On” and clicking again will turn off the bar graphs. The high and low temperature limits can be changed by moving the pointer arrows below the bar graphs.

**ADC Sampling Rate**

The ADC sampling rate can be changed by rotating the control knob next to the bar graphs.

**Line Graphs**

Line graphs of temperature against time can be plotted by clicking the “Graphing Stopped” button. The legend will change to “Graphing Now” and clicking again will stop the graph.

While the graph is displayed on the screen, it is possible to zoom in or out by moving the arrows on the temperature and time axes. Moving the lower arrow up the temperature axis increases the minimum temperature shown on the axis, while moving the upper arrow down decreases the maximum temperature displayed, thus zooming in on a narrower temperature range. Similarly, moving the left arrow to the right on the time axis and/or the right arrow to the left displays a narrower band of time on this axis.

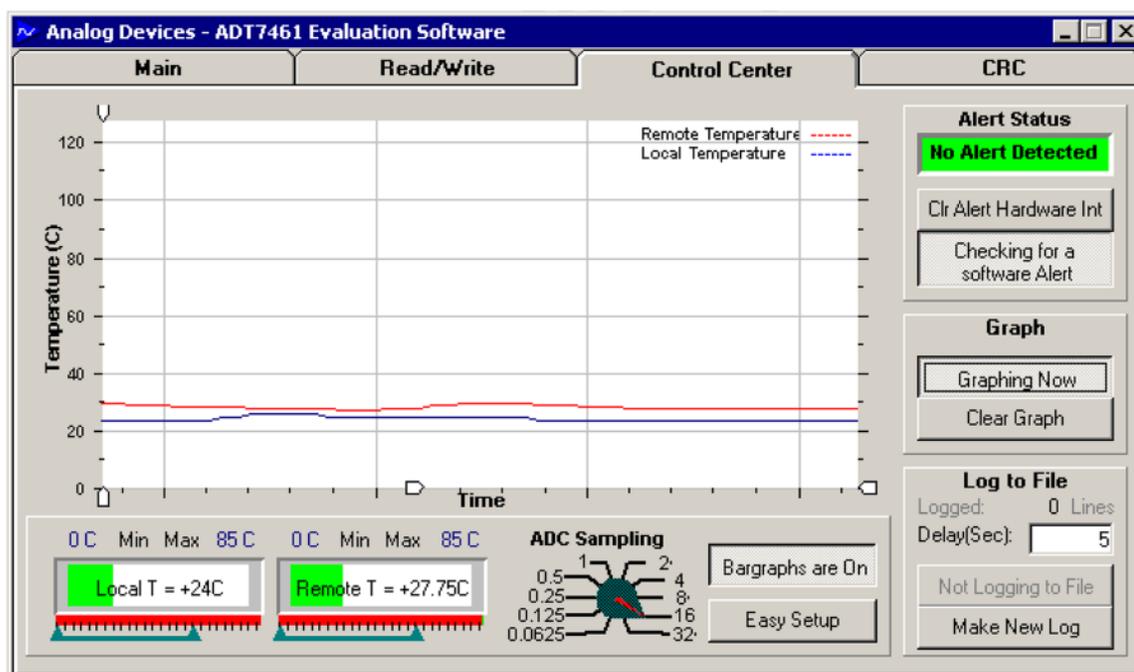


Figure 7. ADT7461 Evaluation Software Control Center Tab

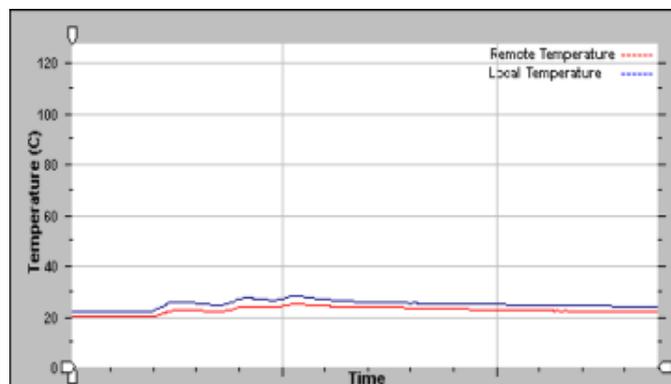


Figure 8. Example Line Graph

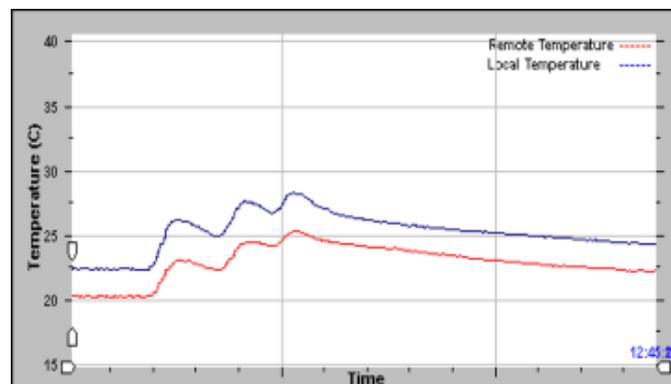


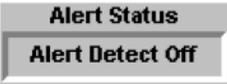
Figure 9. Zoom in on Figure 8

# EVAL-ADT7461

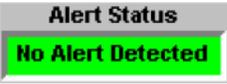
The graph can be cleared by clicking the  button.

## Alert Indication

When the Control Center tab is first selected, the Alert Status

Indicator  is off.

Alert detection is turned on by clicking the “Not Checking for Hardware Alert” button. The legend will change to “Checking

for Hardware Alert” and the  indicator will become active. It will change from green to red

 when the local or remote temperature goes outside limits, and the ALERT LED (D3) on the evaluation board will light.

The LED can be turned off by clicking the

 button, provided the temperature has gone back within limits, or the limits have been adjusted to be

outside the temperature reading. The Alert Status Indicator automatically changes back to green when the temperature is within limits. Alert detection can be turned off again by clicking the “Checking for Software Alert” button.

## Easy Setup

The line and bar graphs can be started with a single click of the  button. This starts the line and bar graphs, sets temperature limits of 0°C and 85°C, and turns on the Alert detection.

## Log to File

This function allows the user to record the values of the remote and local temperatures to an Excel file. The frequency at which values are stored to the file are determined by the delay(sec) window. To change this value, click the screen and type in the new value in seconds.

To start a new Log click the “Make New Log” button. The “Open” Box will appear. Type in a name for the file and click “Open.” The program will begin storing the values of both the remote and local temperatures to the file at the chosen intervals. The number of lines logged will be displayed on the Control Center window. To stop writing to the file click the “Not Logging to file” button.

To view this table open the document using Excel.

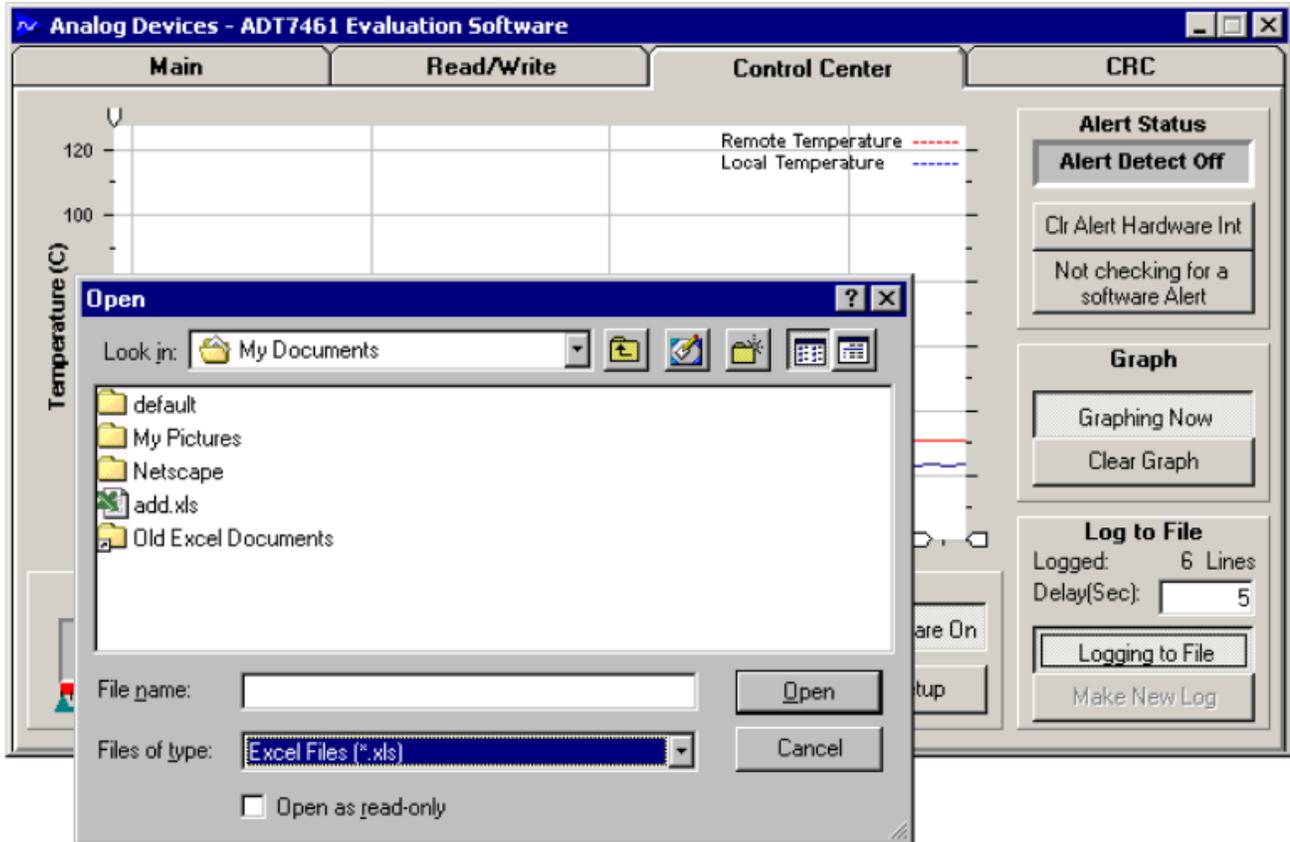


Figure 10. Opening a New Log File

**CRC TAB**

The ADT7461 supports packet error checking (PEC). Its use is optional. It is triggered by supplying the extra clock for the PEC byte. The function of the PEC byte is to allow the user to determine the accuracy with which to read the previous data. The PEC byte is calculated using CRC-8 (cyclic redundancy code).

The CRC tab allows the user to easily exercise the CRC capability of the ADT7461. When reading data it supplies the extra clock pulse and reads back the PEC byte. If the value of the PEC byte is as expected, it is displayed in green, next to the value read back from the register. If the PEC byte is different, then it is displayed in red. Click "Read All" button to read back from all the registers and their PEC bytes. Click "Write All" to write to all the registers the values in the white read/write boxes. To change the value to be written to the registers, change the value in the white read/write box next to the register address. To randomly write a value to each of the write registers, click "Random Fill."

**ABOUT MENU**

The About Menu on the main menu tab gives information about the software and contains the copyright notice.

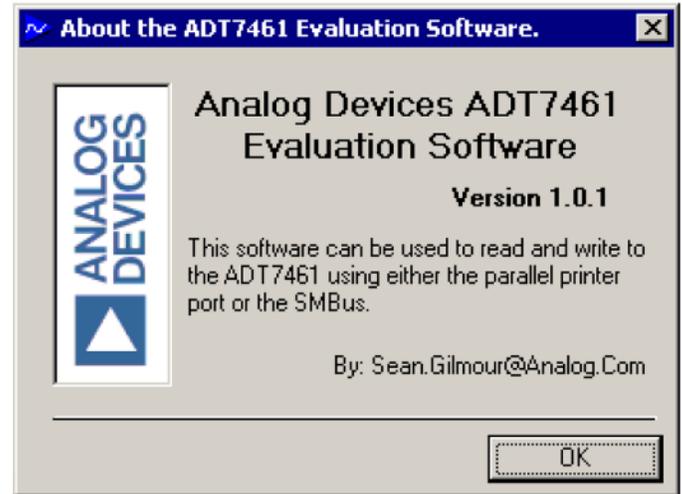


Figure 11. About Menu

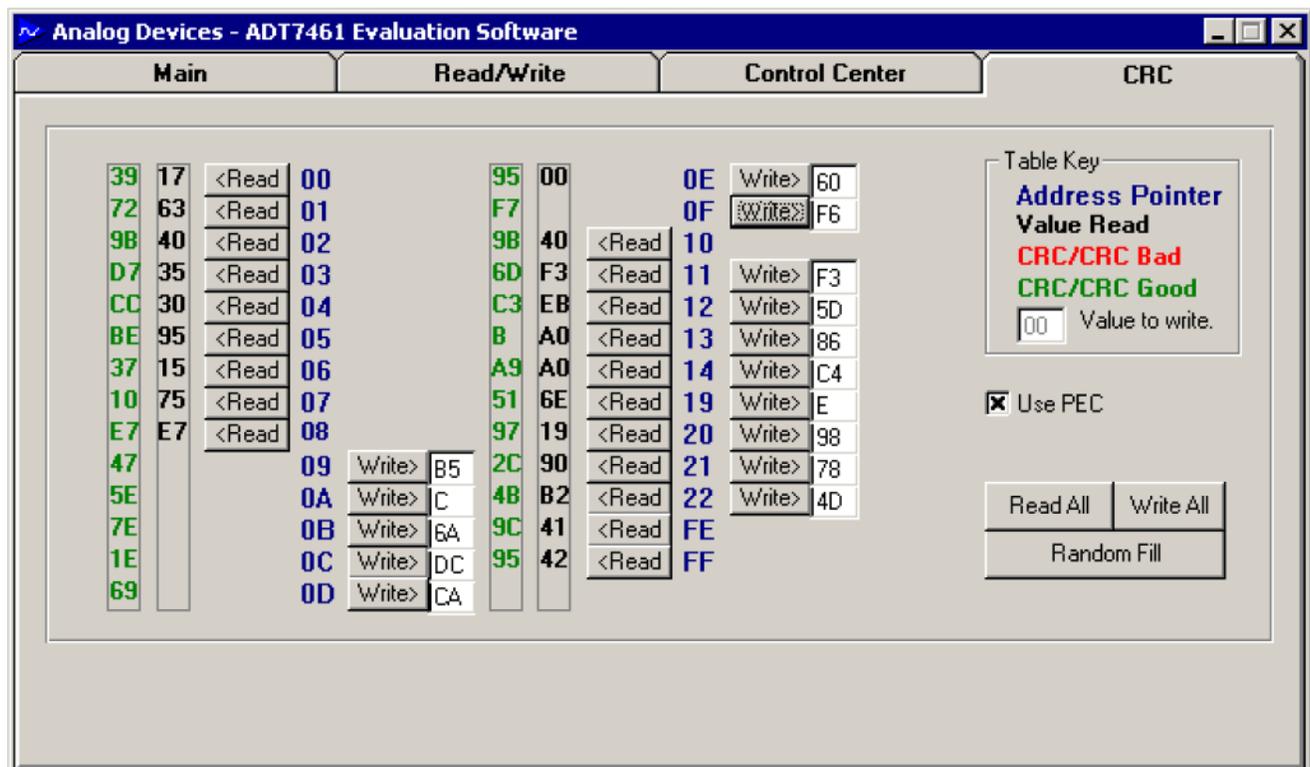


Figure 12. ADT7461 Evaluation Software CRC Tab

# EVAL-ADT7461

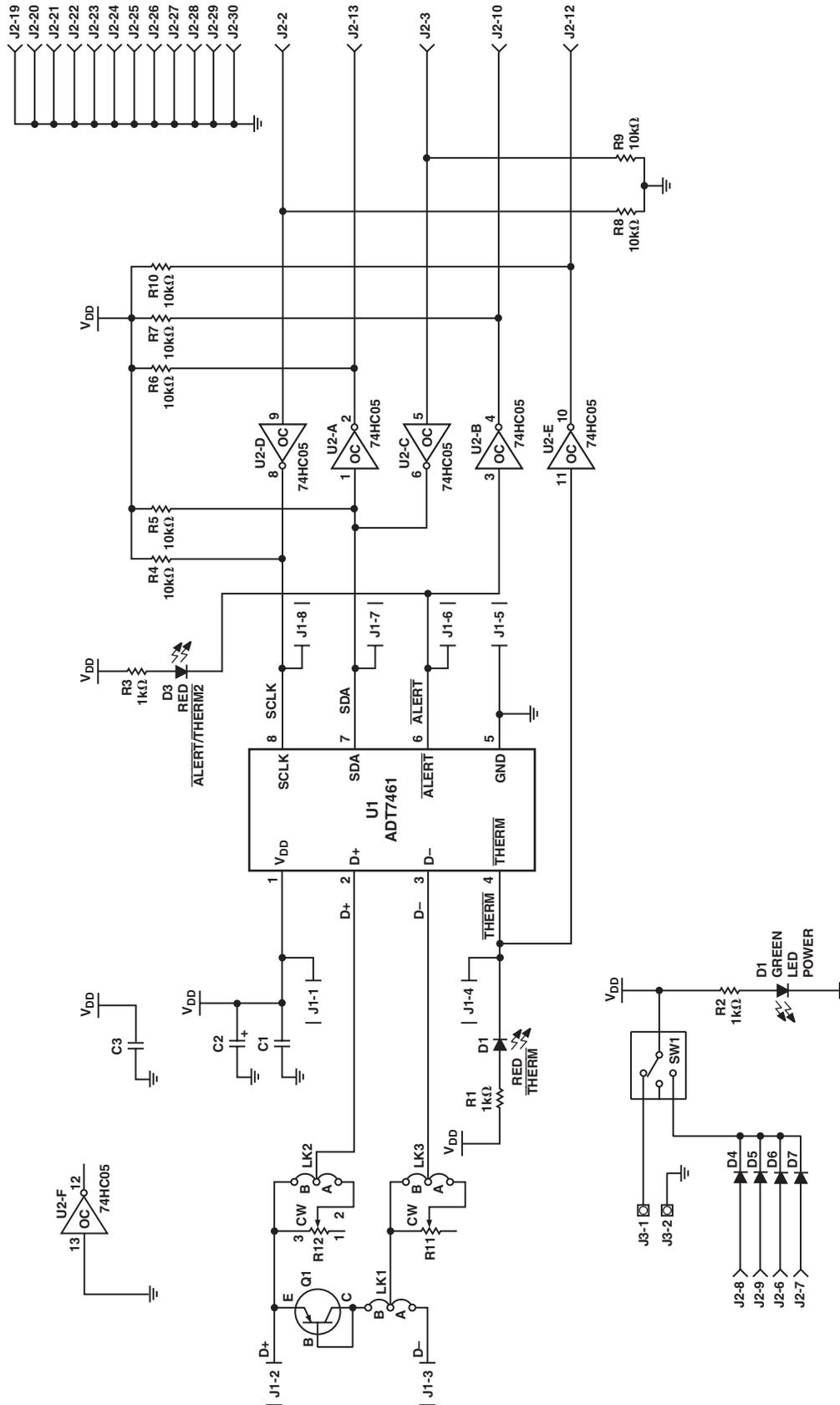


Figure 13. ADT7461 Evaluation Board Schematic

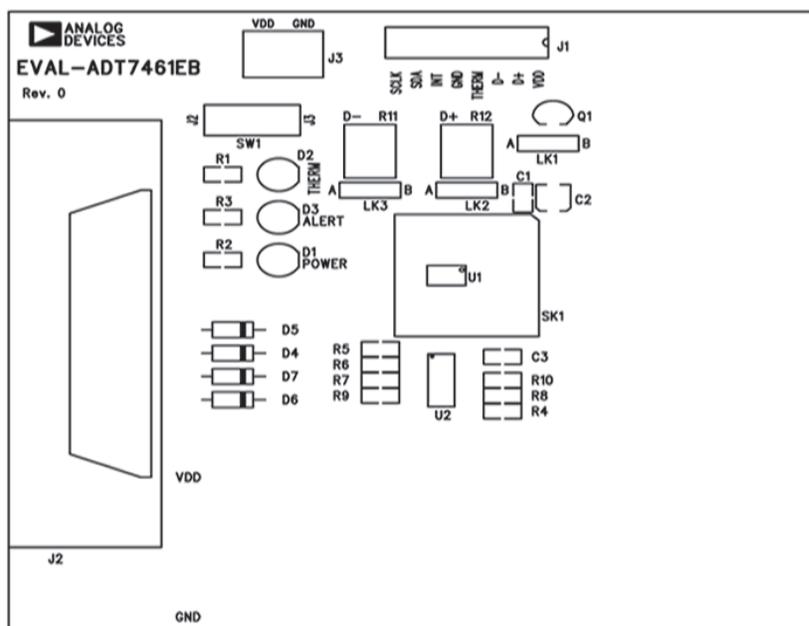


Figure 14. ADT7461 Evaluation Board Silkscreen

Table IV. Component List

Name	Type	Value	Description	Stock Code
C1,C3	CAP	0.1 μF	0.1 μF X7R Multilayer Ceramic	FEC 108-941
C2	CAP+	10 μF	10 μF 16 V Electrolytic (SMD B Size)	FEC 556-166
D1	LED		Green LED	FEC 657-141
D2, D3	LED		Red LED	FEC 657-130
D4, D5, D6, D7	SD103C		Schottky Diode	Digikey SD103CCT-ND
J1	HEAD8_SIDE_ENTRY		8-Way 90° Side Entry Single Row Header	FEC 512-369
J2	CENTRONICS		36-Pin Centronics Connector	FEC 147-753
J3	CON\POWER		2-Way Terminal Block	FEC 151-789
LK1, LK2, LK3	JUMPER2/SIP3		3-Pin Sil Header	FEC 312-228 +148-029
Q1	2N3906		PNP Bipolar Transistor	FEC 358-848
R1, R2, R3	RES	1 kΩ	1k Ohm ±5% Resistor (0805)	FEC 613-095
R4 to R10	RES	10 kΩ	10k Ohm ±5% Resistor (0805)	FEC 613-216
R11, R12	VRES	2 kΩ	VRES-T7-SERIES	
SW1	SW3/SPST/SIP		SPDT Slide Switch	FEC 733-647
U1	ADT7461		ADT7461AR	
U2	74AC05M		Harris Semi CD74AC05M	Radionics 833-096

# EVAL-ADT7461

## ORDERING GUIDE

<b>Model</b>	<b>Package Description</b>
EVAL-ADT7461EB	Evaluation Board

D04911-0-8/04(B)