

# Harsh Environment Acquisition Terminal (H.E.A.T.) System EVM User's Guide

## User's Guide



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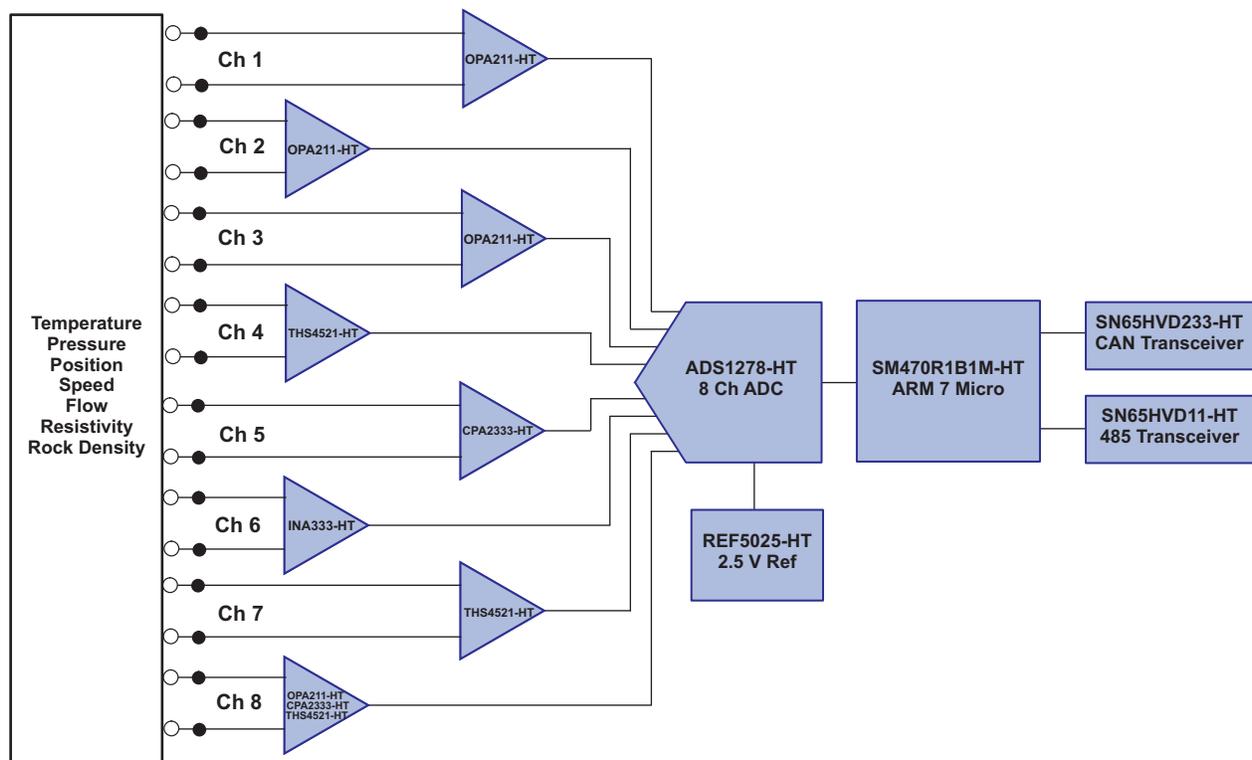
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This document outlines the basic steps and functions that are required to ensure proper operation of the harsh environment acquisition terminal (H.E.A.T.) system evaluation module (EVM) kit. The HEATEVM is a high-temperature development platform that provides a complete signal-acquisition system for operating temperature environments of 200°C. All of the high-temperature semiconductor devices are qualified and characterized from –55°C to 210°C operation for 1000 hour operating life, thus eliminating the need for expensive up-screening components or using commercial products that have a temperature range beyond the data sheet specifications.

## Overview

The HEATEVM platform contains a signal chain consisting of an eight-channel analog input which conditions, digitizes, and processes all of these signals. The EVM has six channels dedicated for temperature, pressure, and accelerometers and two are general-purpose channels (that is, fully differential and single-ended).

Figure 1-1 shows the HEATEVM block diagram. The analog inputs channels comprise six channels dedicated for temperature, pressure, and accelerometers. The OPA211-HT enables accelerometer inputs and all three axis inputs have a buffer amplifier with two poles in a 20-Hz Butterworth filter. Temperature sensing is performed with the THS4521-HT and OPA2333-HT devices. For pressure sensing, a high-impedance bridge instrumentation amplifier is used from the THS4521-HT and OPA2333-HT devices. This circuit realizes a high gain and is ideal for measuring pressure in harsh-environment applications such as down-hole drilling. HEATEVM also has dedicated INA333-HT inputs for pressure transducer coupling.



**Figure 1-1. HEATEVM Block Diagram**

The platform is suited for interfacing with external sensors. The user is expected to interface these sensors by means of user generated cabling. The HEATEVM is pre-loaded with basic firmware layer for the ARM7 microcontroller and source-code is provided in this user's guide. The data acquired by the system can be extracted by the HEATEVM graphical user interface (GUI) software. The GUI performs auto scrolling of data, provides a temperature display, illustrates actual minimum and maximum values, and provides data logging capability for all eight channels. This GUI software is optional, and the user can program their own firmware into the ARM7 microcontroller by means of the JTAG port on the HEATEVM. The optional software runs on a PC terminal and proper serial interfacing is required. The optional software is available to download through:

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<http://focus.ti.com/docs/toolsw/folders/print/heatevm.html>

The HEATEVM kit includes one EVM board. All power supply requirements and sequencing need to be provided externally and are outlined in the [Section 3.1](#) section. Refer to the HEATEVM schematic, Gerber, and BOM files for component use and their locations and references from this user's guide. The schematics, Gerbers, and BOM files are available at:

<http://focus.ti.com/docs/toolsw/folders/print/heatevm.html>

## System Design Guidelines

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### 2.1 PCB Details

The PCB in the HEATEVM is built from P95 polyimide material and has very good mechanical stability up to temperatures in excess of 210°C.

#### 2.1.1 PCB Materials

The dielectric constant of the polyimide varies between 3.74 and 3.95. With a base layer PCB thickness of 0.093 inches, the eight-layer HEATEVM has a reasonable amount of stiffness to reduce strain on solder joints. For prolonged 210°C elevated testing periods, the polyimide PCB needs to be kept dry and best results are obtained when testing is conducted inside a dry pressure chamber. In general, this is the case with many harsh environment high temperature drilling and logging tools.

The surface copper traces and pads are protected with a nickel-gold finish. The nickel isolates the gold from the copper, while the gold provides for good solder bonding. This type of system prevents the tin found in most solders from forming intermetallic bronze with the copper traces. For short-term exposure at elevated temperatures or temperatures below 98°C, the nickel-gold finish may not be required; however, this added margin safeguards against the intermetallic bronze formations.

#### 2.1.2 Layout Guidelines and Recommendations

Power and ground planes are suggested for optimizing the performance of the ADS1278. Decoupling capacitors should be physically placed as close as possible to the power pins of the ADS1278 and the SN470R1B1M-HT ARM7 microcontroller to minimize capacitance and gain optimized performance. The location of these decoupling capacitors becomes even more critical in high temperature operations since, in addition to the higher costs, larger valued capacitors become the life limiting component in many high-temperature systems. Most capacitor types have falling capacitance values and increasing IR values as the ambient temperature increases which present trade offs when working with capacitors at elevated temperatures. The HEATEVM uses a nominal number of capacitors and value of capacitance.

To reduce temperature effects, 200°C EIA rated capacitors have been used. The COG dielectric has a flat temperature coefficient over temperature and are also referred to as negative-positive-zero (NPO), referring to its value change over temperature. These COG/NPO capacitors are used as decoupling capacitors while 200°C rated tantalum capacitors are used to reduce power supply ripple to the circuit board. To reduce ripple on the voltage reference, a 1- $\mu$ F stacked capacitor was used to maintain fast transient response to reduce noise.

### 2.2 Derating of Integrated Circuits and Passive Components

When designing high-temperature circuits, engineers normally derate the electronic components from the manufacturer's specifications. This is particularly true for the voltage rating of capacitors and the power rating of resistors. As more manufacturers produce electronic components rated for operation at elevated temperatures and engineers gain experience working with these components, the act of derating will become less important.

In any case, the overall rating of an electronic circuit will always be less than the rating of the weakest component in the circuit. Virtually every high temperature application is also a high reliability application. For example, in high reliability applications using all electronic components rated to 200°C and 1000 operating hours, an overall derating of the electronic circuit could be as high as 50°C.

Despite the advancement of computer generated life prediction models, most manufacturers of high temperature control systems require hard numbers in performing accelerated life testing such as highly accelerated life tests (HALT) to find weak links in the design and/or manufacturing process. By starting with manufacturer qualified high temperature electronic components, the design engineer will enjoy a higher percentage of successful HALT testing of new products. Perhaps just as important, is knowing that the high temperature electronic component manufacture will continue to support a high temperature rating through design cycles which within the electronic industry are normally much shorter than the high temperature, high reliability product being designed. For example, an aircraft engine control system can be in production for extended product life-cycles between 20 to 30 years while an electronic component may see a new design cycle every 6 to 10 years.

For high-temperature operation, resistors are chosen for their temperature drift and hydrogen sensitivity. The HEATEVM uses low temperature drift, thin film resistors with a temperature drift of 30 ppm/°C.

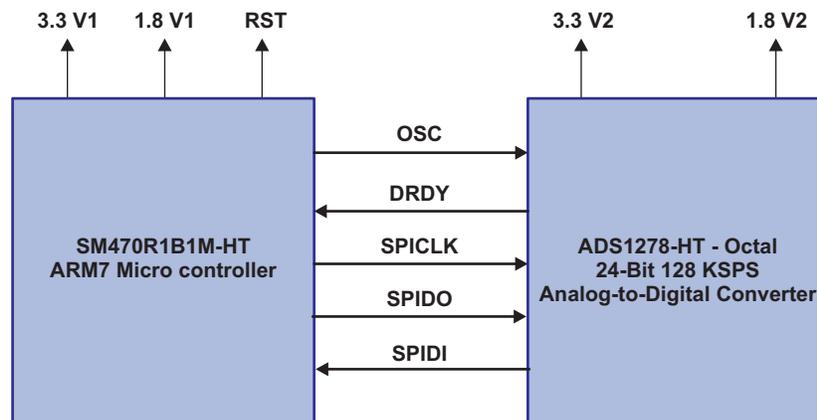
## Hardware Setup

The HEATEVM, for default operation, should be configured as shown in [Table 3-1](#).

**Table 3-1. HEATEVM Jumper Configuration for Default Operation**

JUMPER	DEFAULT STATUS	FUNCTION
JP4	Pins 1-2 and pins 3-4, closed	Enabling RTD on board
JP5	Pins 1-2, closed	Connect voltage reference from REF5025-HT to the rest of the board
JP10	Pins 1-2 (bridge is soldered)	Setting FORMAT[2:0] in ADS1278-HT to [001]
JP13	Closed	Setting CLKDIV in ADS1278-HT to 0
JP16	All closed	Connecting SPI signals from SM470R1B1M-HT to ADS1278-HT

The HEATEVM system is controlled by the SM470R1B1M-HT ARM7 microcontroller in conjunction with ADS1278-HT Octal 24-Bit 128KSPS analog-to-digital converter (ADC).



**Figure 3-1. HEATEVM ARM7 / ADC Communications**

The communications between the SM470R1B1M-HT ARM7 microcontroller and the ADS1278-HT Octal 24-Bit 128KSPS analog-to-digital converter is established using SPI. The ARM7 microcontroller reads the ADS1278-HT data stream using the SPI1 interface on the ARM7. The data ready line (ADSync, Pin 39 of the ADS1278-HT) signals the ARM7 that data is ready for reading on its pin 1 (which is defined as a general I/O pin in software). The three SPI1CLK, SPI1DO, SPI1DI signals from the ARM7 SPI1 are used. The software setup for the SPI1 interface is polarity 1 and phase 0 and the ADS1278-HT data changes on the negative SPI1CLK.

The ADS1278-HT, requires an external clock for operation. In the default case, the ARM7 generates an ADCLK signal from its ECLK, pin 80. ECLK is software programmable and in the source-code included in this manual, ECLK is set to 1.25MHz.

There is no software setup between the ARM7 and the ADS1278-HT as the setup options on the ADS1278-HT set up are defined by the user's choice of format and mode options with the channel enable pins.

The HEATEVM is shipped with preset format pin options on the ADS1278-HT as Format [001] which are set by soldered jumpers on JP10 and establishes a Time-Division Multiplexed bit stream. With this format, the position of each 24 bit ADC reading is fixed in time such that disabling any channel results in a 000000H reading for that channel and all the ADS1278-HT readings are serial out on pin DOUT1. If the user desires to change the format from this default setting, high-temperature solder should be used.

Each of the eight ADS1278-HT channels are enabled by default. To change the default channel enables, solder jumpers at JP12. Each jumper pair is tied to each PWDN channel enable (pins 45 to 52).

The ADS1278 has 4 mode options which can be set by the user by jumpers on JP11. The default setting is Mode[11] for low speed.

The power supply rails have been separated since the power-up sequence differs between the ADC and ARM7 devices.

### 3.1 Power-Up Requirements / Sequence

The HEATEVM has split power inputs supporting the ARM7 and the ADS1278-HT. Both the ARM7 and the ADS1278-HT have 3.3-V IO and 1.8-V core voltages. Splitting the supply inputs allows for differing power-up sequences for each chip. All voltages reference a common ground. The GND is tied to a ground plane located on layer 2 of the PCB.

All the power for the HEATEVM and the reset signal for the ARM7 (PORRSTN, pin 68 of the ARM7) are on JP2.

Pin 1 on JP2 has a square pad.

- JP2 – Pin 1: 3.3 V (This is the VIO for the ADS1278-HT.)
- JP2 – Pin 2: GND
- JP2 – Pin 3: 1.8 V (This is the ADS1278-HT core voltage.)
- JP2 – Pin 4: GND
- JP2 – Pin 5: 3.3 V (This is the VIO for the ARM7.)
- JP2 – Pin 6: GND
- JP2 – Pin 7: PORRSTN (reset signal of the ARM7)
- JP2 – Pin 8: 1.8 V (This is the ARM7 core voltage.)
- JP2 – Pin 9: GND
- JP2 – Pin 10: NC
- JP2 – Pin 11: 5 V (analog voltage)
- JP2 – Pin 12: GND

The SM470R1B1M-HT (document [SPNS155](#)), requires that the 3.3-V IO voltage is greater than 1.1 V before the 1.8-V core voltage is greater than 0.6 V. Specific timing requirements for the PORRSTN input are also outlined in [SPNS155](#). For detailed information on the power-up sequence of the ADS1278-HT, see [SBAS447](#). In general, core voltage should reach a nominal 1 V before the IO voltage reaches 1 V. The analog voltage must be last, with a nominal 3 V triggering an internal reset to the chip.

An example of a power sequence is shown in [Figure 3-2](#), [Figure 3-3](#), and [Figure 3-4](#). In summary, the 1.8-V analog supply must be powered up before the 1.8-V digital supply. The analog and digital 3.3-V supplies can be powered up at the same time. The PORRSTN signal must go high after all the power supplies are stable. For power down, the PORRSTN signal must go low before all the power supplies go low.

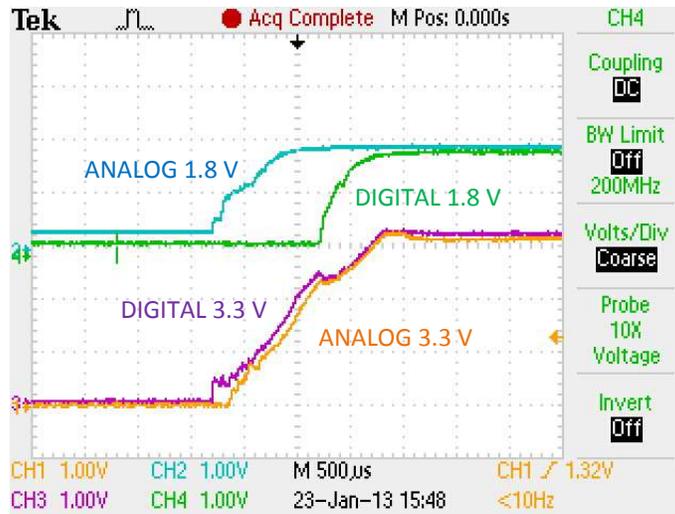


Figure 3-2. Analog and Digital Supplies Power-Up Sequence Example

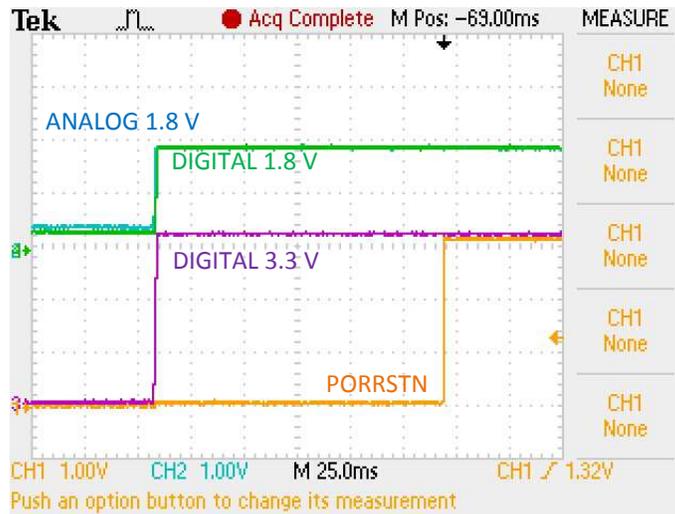
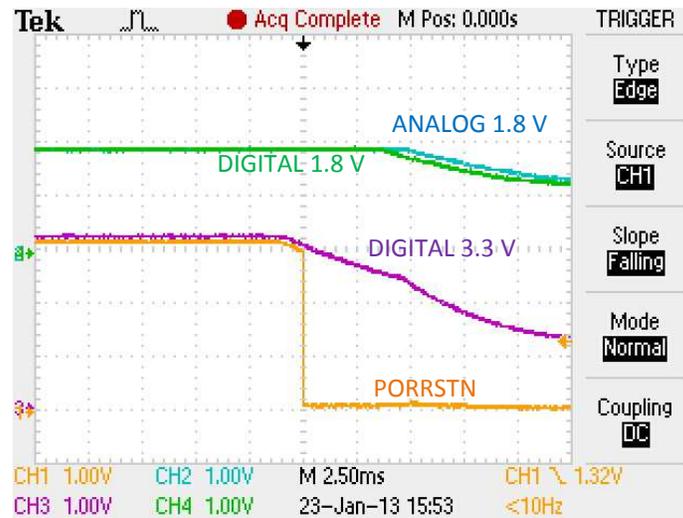


Figure 3-3. PORRST Signal Power-Up Sequence Example



**Figure 3-4. Power Down Sequence Example**

### 3.2 ADS1278-HT Connection Options

The ADS1278-HT has a several pin assigned options. To provide the user with maximum flexibility, the following jumper blocks connected to the following pin assignment pins of the ADS1278-HT. In all cases, a jumper installed results in a 'low' setting.

- JP10 pins set the AD format options
- JP11 pins set the AD mode options
- JP12 pins enable the AD channels

For running the demonstration board at 200°C, some jumpers are hardwired. The user can change these setting by removing or adding a solders jumper. These jumpers are of the same board layout as the other jumper blocks, as such all the hardwired jumpers can be replaced with jumper blocks if so desired.

- JP13 is jumper to set CLKDIV to 'low' input.
- JP16 are jumpers to interface the ADS1278 to SM470R1B1M (ARM7). The ADS1278 is connecting to the ARM7 as a SPI device.

### 3.3 Voltage Reference

The REF5025-HT is supplied as the on board voltage reference. The REF5025-HT has a nominal voltage of 2.5 V. The on board voltage reference can be replaced by placing a jumper between pins 2 and 3 of JP5 and applying a new external voltage to JP6 with pin 1 as the positive voltage and pin 2 as GND.

### 3.4 SM470R1B1M-HT Connection Options

The TI ARM7 is in circuit programmable using either the 20-pin JP20 or the 14-pin JP19. Because the demonstration board can be heated to 200°C, a standard gold plated pin header is used in both cases. The user must check the pin orientation against the circuit layout. Looking at the circuit board, with the ARM7 chip toward the user's left hand, pin 1 on JP20 and JP19 is on the top left side of each pin header. A 1.8-V oscillator is strongly recommended to drive the SM470R1B1M-HT as indicated in the data sheet.

### 3.5 ADS1278-HT Analog Inputs

The ADS1278-HT has eight differential inputs to its eight parallel 24-bit analog to digital converters. The HEATEVM provides input to all eight channels using the analog circuits described below.

### 3.5.1 Channels 1, 2, and 3: Inclination Circuits

Measuring inclination (or tilt) is a common measurement in the harsh-environment down-hole drilling industry. For example, most drilling tools measure 3-axis inclination to determine what the orientation of the drill bit is. The first 3 channels of the ADS1278-HT are examples of a filtered buffer/amplifier for use in measuring the 3-axis inclination signals.

The HEATEVM inclination signals are filtered in an active two pole Butterworth filter using the using the OPA211-HT. Low Pass filters of 20 Hz to reduce 60-Hz noise picked up by the cable running between the HEATEVM (inside an oven) and the inclination sensor board located outside of the oven.

When the cable is not connected, a precision resistor network provided a fixed DC voltage to the three inclination inputs on the HEATEVM. This allows operation without the inclination circuit.

An RTD circuit can be added to the HEATEVM to provide a differential signal to the THS4521-HT and will need to use the REF5025-HT to bias the circuit. The OPA211-HT can be used to buffer the REF5025-HT to the circuit. The REF5025-HT will also provide the reference voltage to the ADS1278-HT.

Figure 3-5 shows the block diagram of the inclination circuits.

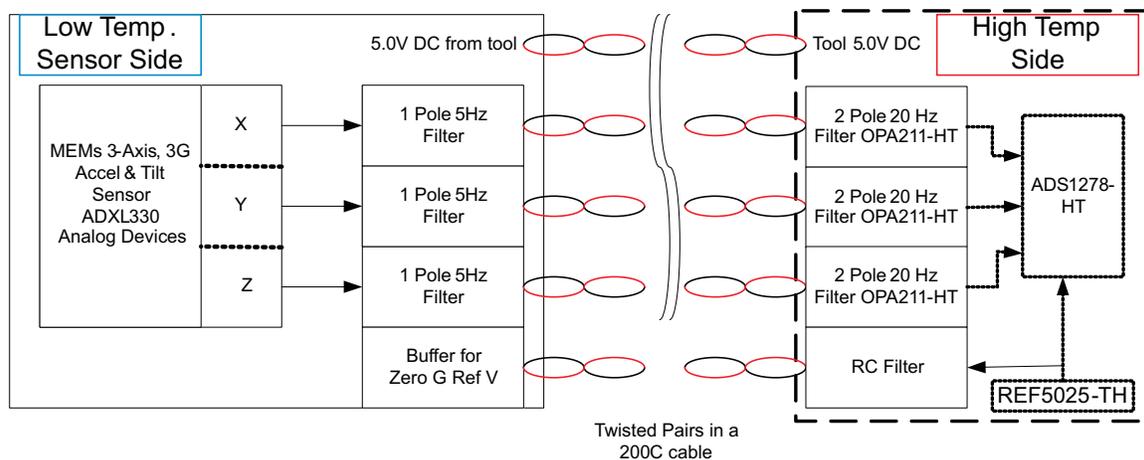


Figure 3-5. Inclination Block Diagram

### 3.5.2 Channel 4: Simple Amplifier Using the OPA211-HT

A simple amplifier circuit using the OPA211-HT with a fixed gain of  $-10$ . The user can supply an input signal to pin 7 of JP26. The amplifier has a 1.25-V reference at the +in pin. TP8 is a test point for monitoring the amplifiers output.

### 3.5.3 Channel 5: RTD

Channel 5 of the ADS1278-HT is setup to measure board temperature using an onboard 1000- $\Omega$  RTD located at JP4. An external RTD can be used by removing the onboard RTD and the two jumpers on JP4 and replacing them with the standard 4-wire RTD.

In Well Logging systems, it is typical to detect relative temperature changes of  $0.001^{\circ}\text{C}$  so the 24-bit accuracy associated with the ADS1278-HT is necessary in order to facilitate this measurement.

The RTD has a nearly flat response of  $3.85\Omega/^{\circ}\text{C}$  starting with a nominal  $1000\ \Omega$  at  $0^{\circ}\text{C}$ . At  $20^{\circ}\text{C}$  room temperature, the RTD is about  $1077\ \Omega$  and about  $1385\ \Omega$  at  $100^{\circ}\text{C}$ . The use of  $3.85\ \Omega$  per degree will create about 1 to  $2^{\circ}\text{C}$  error at  $200^{\circ}\text{C}$ . Use of a typical second-degree polynomial curve fit will improve this measurement while also correcting for small circuit offsets. However, for demonstration purposes these small errors are negligible for a board mounted sensor and no system calibration unique to each board was performed.

The RTD measurement circuit uses the voltage reference (U6, REF5025-HT) to create a bias current for a 1000- $\Omega$  RTD. The reference voltage is 2.5 V. This voltage is buffered (U7, OPA2333 “B”) with a resistor divider network of R25 and R26. The resistor divider is used to reduce the reference voltage to 0.5 V. This voltage is used to create a DC bias to the positive input to +INA of U7.

The “A” amplifier of U7 (OPA2333-HT) has the 1000- $\Omega$  RTD in its feedback. This amplifier holds the voltage across R24 to the bias value of 0.5 V. This sets the current in the feedback RTD resistor to  $I_{RTD} = 0.5/R24$ . As R24 is a fixed, high precision resistor equal to 1000  $\Omega$ ,  $I_{RTD} = 0.005$  A and the voltage across the RTD at 0°C is 0.5 V. As the temperature increases, the voltage across the RTD increases at 0.0173 V/°C.

U8 (THS4521) is used to amplify the differential signal across the RTD. The gain of U8 is fixed by  $R19/R18 = R20/R21 = 2$ . At 0°C, the differential output is  $2 \times 0.5 = 1$  V. The output is then subject to change over temperature by about 0.0346 V/°C.

The differential amplifier, U8 (THS4521-HT) has its VOCM pin either as an open circuit or tied back to the ADS1278, VCOM pin using jumper block JP9. In the case of the RTD circuit, a zero temperature creates a differential voltage of 0.5 V, so an offset is accounted for in the display software

### 3.5.4 Channel 6: INA333-HT Instrumentation Amplifier

Channel 6 of the ADS1278-HT is setup as a differential channel and is a user illustrated circuit based on the INA333-HT and pins 6 and 5 of JP26. R42 is used to set the gain value of the INA333-HT. The gain is calculated by  $\text{Gain} = 1 + (100k/R42)$ , for  $R42 = 100 \Omega$  the gain is 1001. A simple RC filter is placed between the amplifier and the ADS1278. Test point TP10 is available to monitor the amplifiers output.

### 3.5.5 Channel 7: THS4521-HT Differential Amplifier

Channel 6 of the ADS1278-HT is setup as a differential channel and a differential amplifier circuit for user input signals based on the THS4521-HT. Full access to the THS4521 input pins are available at JP26, pins 1-4. The amplifier has a fix gain of 1 set by  $R47/R48$  and  $R51/R52$ . This amplifier is operating from the 3.3-V supply.

### 3.5.6 Channel 8: Discrete Differential Amplifier Circuit

Channel 8 of the ADS1278-HT is setup as a differential channel and is left for the users discretion. It can be used for simulating the measurement of a standard 4-wire bridge type pressure transducer. In this case, the pressure transducer cable would be connected to JP8. U10 (OPA211-HT) is used to bias the bridge circuit to 2.5 V. The bridge differential voltage is input is buffered by U11 (OPA2333-HT). The OPA2333-HT is precision amplifier well suited for this type of application. U14 (THS4521-HT) is used to amplify the buffered signals coming from U11. The gain of this circuit is about 501 set by the resistor pairs  $R54/R53$  and  $R56/R55$ . A small differential RC filter is in between the outputs of U14 and the ADS1278.

## Software Installation

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The software installation for the HEATEVM system is broken into two sections: *First Time Installation* and *Upgrading Existing Installation*.

### 4.1 First Time Installation

The software installation has several prerequisites that may or may not be already installed on your PC. If the software is already installed you can safely proceed to the next step.

Prerequisites:

1. Microsoft® .NET Framework 3.5 sp1  
<http://www.microsoft.com/downloads/en/details.aspx?FamilyId=333325fd-ae52-4e35-b531-508d977d32a6>
2. Microsoft Charting  
This can be found in the in the 3rd Party folder of the program files: MSChart.exe  
OR  
Download from:  
<http://www.microsoft.com/downloads/en/details.aspx?FamilyId=130F7986-BF49-4FE5-9CA8-910AE6EA442C>

Installation:

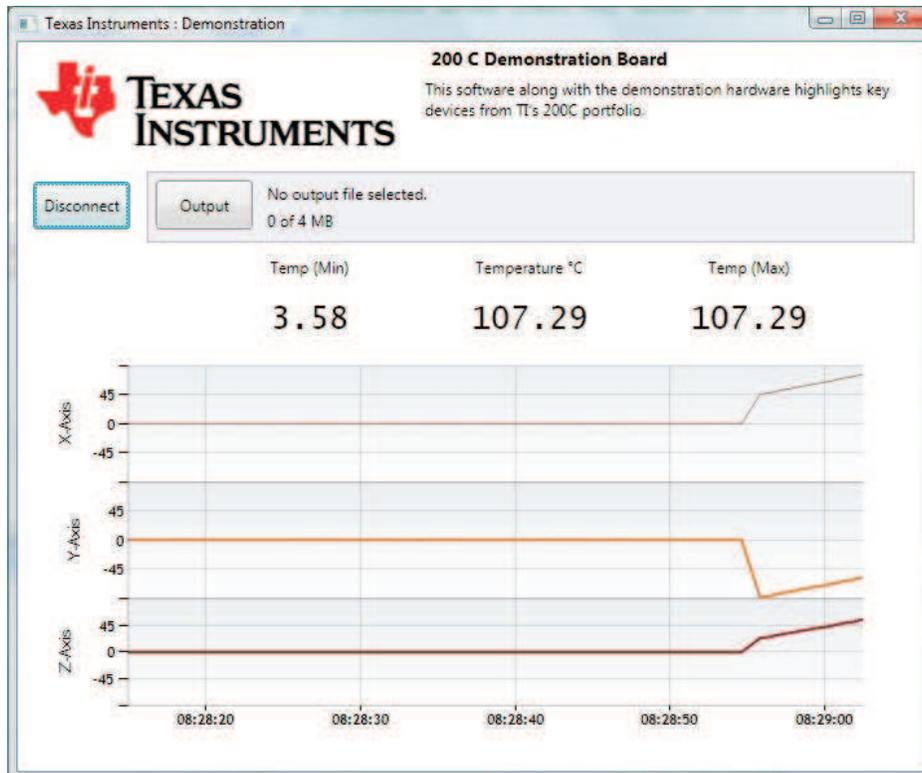
1. Install Microsoft .NET Framework 3.5 sp1 and follow instructions.
2. Install Microsoft Charting and follow instructions.
3. Copy the program folder onto the local computer. The software can run from the desktop or can be placed in Program Files along with other software.

### 4.2 Upgrading Existing Installation

When upgrading to a new version there is only one file that could be important to preserve between versions. It is located in the program folder and is the TIDemo.exe.config file. This file, as you'll read later, possibly contains calibration information regarding your actual hardware. Other files can be simply copied over or removed and replaced with the updated software version.

## Software Application Overview

The HEATEVM demonstration screen (Figure 5-1) illustrates what will be seen on the user terminal interface.



**Figure 5-1. HEATEVM Demonstration Screen**

### 5.1 Connect / Disconnect

The upper left most button is labeled “Connect” or “Disconnect” depending on whether or not you’re currently connected and receiving data from the electronics.

The HEATEVM uses serial port (COM) communication. This is frequently provided by USB to Serial connectors in recent computers. If the computer has only a single COM port installed the Connect button will automatically try to connect to that port. If there are more than one COM port available a window will pop up allowing you to choose which COM port is connected to the TI Demo hardware.

### 5.2 Output / Stop

This button is labeled “Output” or “Stop” depending on whether or not the real time data is being saved to a file. The output button allows the saving of the real time data into a file. By selecting the output file all data from that point begins to be saved. Data that was received prior to setting an output file is not retroactively saved.

### 5.3 Status Label

The file name label below and to the right of the Output button is a status label, here it shows “0 of 4 MB”. When saving data to an output file this counter will demonstrate how much raw binary data is being saved. This correlates to the future version of a memory demonstration where the 200 C memory will be 4 MB.

It will also report errors if it cannot successfully interpret the data frame being sent from the electronics or if the electronics themselves report an error.

1. Electronics error, if the analog to digital circuit is not responding to the processor it will flash in red:  
“!ADC communication failure”
2. Communications error, if the software is unable to interpret the data frame:  
“Cannot parse: [index, value]”

There are log files saved with non-critical exceptions but can be useful in identifying issues.

### 5.4 Temperature Data

Low, max, and current temperatures are displayed here. These are reported from a built-in RTD on the board. See calibration section on how to calibrate the values.

### 5.5 Axis Data (Line Charts)

The initial demonstration of the Demo Board is to have an accelerometer transmitting data from all three axes (X, Y, Z). These values are demonstrated here in degrees. See calibration section for how to calibrate the values.

### 5.6 Four Miscellaneous A/D Channels (Not Visible on GUI)

There are four additional channels in the eight channel A/D converter that are not displayed but are still recorded in the output file. These values do not have a calibration applied to them but the data is accessible through Excel® or other comma separated values (csv) software. See the section on the output file.

## Output File

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The output file contains time data, 4 calibrated channels, and 4 non-calibrated channels in a comma separated file. The 4 calibrated correspond to the 4 displayed data in the software: temperature, x-axis, y-axis, and z-axis.

```
# TI 200C Demonstration Output File
# Below is a CSV file of the data seen while running the demonstration
# Recording started: 4/19/2011 8:55:02 AM
Time          Temp (F)  X Axis  Y Axis  Z Axis  AD4      AD6      AD7      AD8
55:02.70     185.97  -79.27  -34.21  78.29  -8388608 -8388608 -8388608 -8388608
55:02.90     189.55  -78.2   -33.14  79.36  -8388608 -8388608 -8388608 -8388608
55:03.20     193.12  -77.13  -32.06  80.44  -8388608 -8388608 -8388608 -8388608
```

The other four channels can be raw data as well if the calibration is changed to pass through the value rather than modifying it. See [Chapter 7](#) section.

The four non-calibrated channels cannot be calibrated via the demonstration software.

## Calibration

Calibration applies coefficients and functions to obtain an accurate representation of a sensor's measurement. To do this to the analog to digital converter the coefficients can be entered into a text file prior to running the software.

Within the program's folders there is a file "TIDemo.exe.config". Open this file with a text editor such as Notepad and you'll see something similar to below.

```
<?xml version="1.0" encoding="utf-8" ?>
<configuration>
  <appSettings>
    <!-- To fake serial data for GUI testing make the value="Fake" below -->
    <add key="COMPort" value="Fake" />

    <!-- To allow the chart axis to show all possible values (24bit int) rather than
    the axis +/-90 degrees set value="True" below. -->
    <add key="FullRange" value="False" />

    <!-- Temp Coefficients Match Cal Function y(x) = a*x+b -->
    <add key="TempCoeff1" value="0.0000357632473028550992430112654229" />
    <add key="TempCoeff2" value="0" />

    <!-- Axis Coefficients Match Cal Function y(x) = a*x+b -->
    <add key="AxisCoeff1" value="0.0000107288360595703125" />
    <add key="AxisCoeff2" value="0" />

  </appSettings>
</configuration>
```

The TempCoeff1 and TempCoeff2 correspond to the a and b variables of the point slope function  $y(x) = a x x + b$  respectively. When the AD counts (x) are evaluated the result is the RTD's temperature.

The AxisCoeff1 and AxisCoeff2 do the same thing for the axes calibration into degrees.

By changing Coeff1 value to 1 and Coeff2 value to 0 for both Temp and Axis the resulting output will be the raw AD data just like the other 4 channels which have no calibrations applied.

If this is done, or any calibration applied that would result in a range greater than 90, the "FullRange" value can be set to "True" so that the data can still be visible in the line charts.

Changes to this file are only interpreted at the application start. So if a change has been made here the software must be closed and reopened to recognize it.

## ***Establishing Tool Communication Via Terminal***

The tool data can be seen and interpreted directly without using the demonstration software.

Close all software that might be using the same port the electronics are connected to. Start your terminal program with the following settings:

**Table A-1. Configuration**

Connect using:	Installed COM Port tool is attached to
Bits per second:	576000
Data bits:	8
Parity:	None
Stop bits:	1
Flow control:	None

If the electronics are currently logging information its output should appear almost immediately.

### **A.1 Interpreting Data Frames**

Data frames are visible while communicating with the tool in a terminal.

Terminal output example:

9E58BE, BD8D85, 800071, BD07F2, C9D0CE, 7FFDE9, 80005C, 80006C

The frame is a series of numeric values in hexadecimal format separated by commas. The values represent A/D counts. Converting these A/D counts into sensor data requires calibration as described above. Accessing the data in this manner removes any limitations on interpretation.

Terminal error output example:

!Error message here

Any data frame that starts with an exclamation point is an error frame and the cause of the error is contained in the text following it.

**Table A-2. Data Frame Example Breakdown**

<b>9E58BE, BD8D85, 800071, BD07F2, C9D0CE, 7FFDE9, 80005C, 80006C</b>	
9E58BE	24-bit channel (x-axis)
BD8D85	24-bit channel (x-axis)
800071	24-bit channel (x-axis)
BD07F2	24-bit channel (spare)
C9D0CE	24-bit channel (temperature)
7FFDE9	24-bit channel (spare)
80005C	24-bit channel (spare)
80006C	24-bit channel (spare)

## *Hexadecimal*

---



---



---

Hexadecimal is the number format output by the electronics. For quick reference hexadecimal (base 16) is counted as follows with decimal (base 10).

**Decimal (Base 10)**

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	...	24	25	26	27
0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	10	11	12	13	14	...	18	19	1A	1B

**Hexadecimal (Base 16)**

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## Revision D History

Changes from C Revision (October 2012) to D Revision	Page
• Added jumper configuration for default operation.....	9
• Added power sequence example for the board.....	10

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NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

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- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

### 3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210

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