Harsh Environment Acquisition Terminal

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- HT electronics need
- High level overview of H.E.A.T
  - Description and block level diagram
- Core Devices
  - Key features
- Channel Content
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- Summary
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The Need for HT Electronics

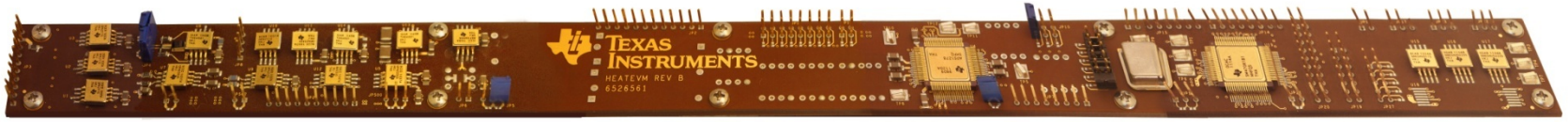
- Temperature requirements have been increasing within industrial, avionics, military and oil exploration markets for the past 20 years.

- In the energy exploration sector, the need to find new oil and natural gas resources has driven the industry to drill deeper and deeper. Wells of 15,000ft to 20,000ft (4.5 – 6.1km) are increasing common with some natural gas wells researching beyond 30,000ft, 9.4km.
  - With nominal Earth temperature gradients of 25 °C and 30 °C per kilometer, these deep well can reach very high temperatures.

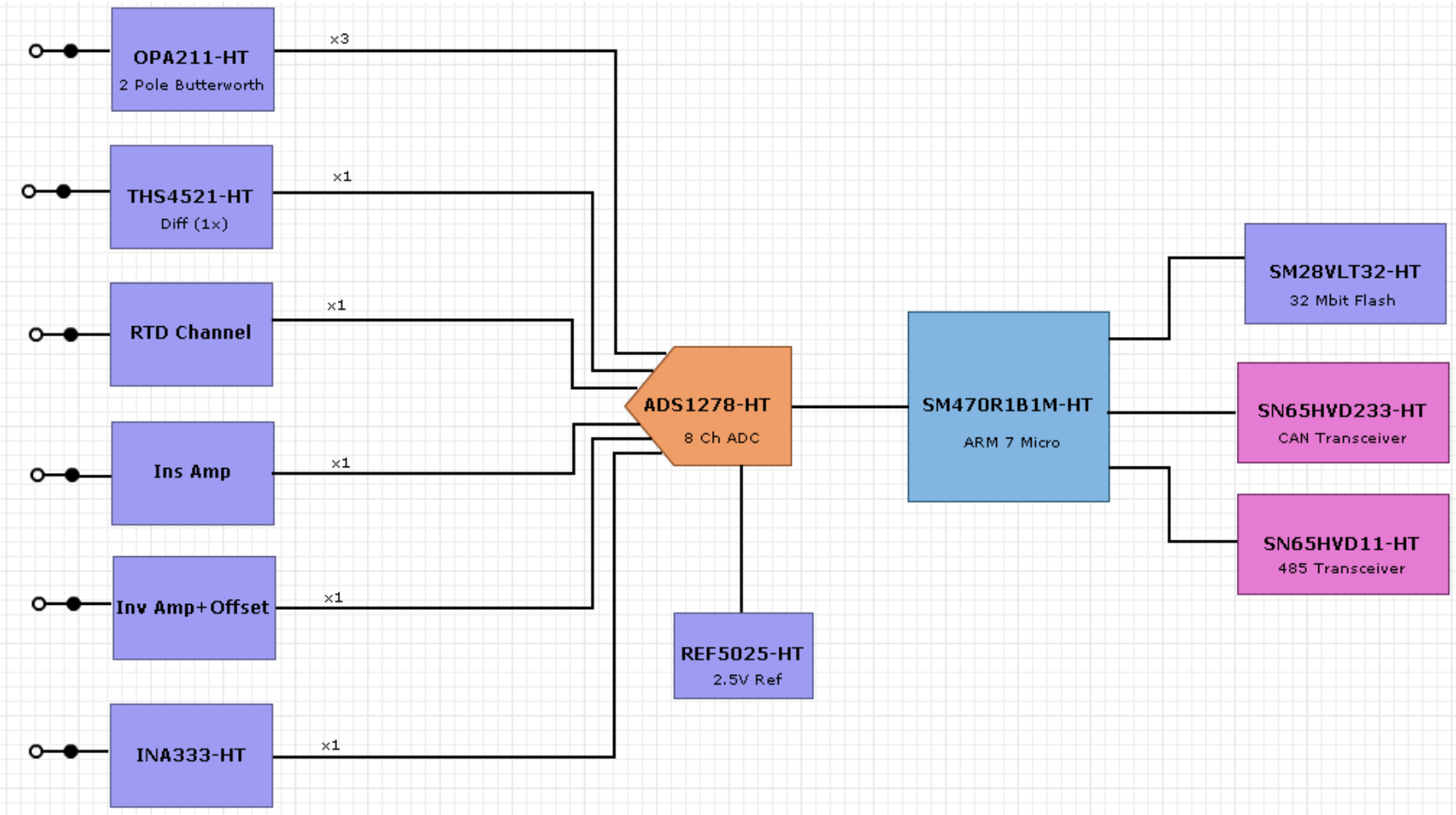
- Today, the military standard of 125°C is simply not HOT enough. Several semiconductor companies, like Texas Instruments, are reaching out to the industry with new products manufactured to meet >175°C temperature requirements.

What is H.E.A.T?

- Platform to minimize development time and accelerate industry wide adoption of HT qualified components.
  - Signal conditioning, acquisition and processing on board.
  - ADS1278-HT (A/D) and SM470R1B1M-HT (ARM7) as core devices
  - Basic firmware, user terminal (PC) software, BOM, design database all publicly available.
- Support for 200hrs of 200C testing.
  - Polyimide pcb + ht passives
- Six channels preconditioned for temperature, pressure and accelerometers.
- Two general purpose channels
  - one fully differential and one single ended.
- Approx dimensions
  - 15.6” x 1.1”



Simplified Block Diagram



Core Devices

- SM470R1B1M-HT
  - ARM7 architecture, 60 MHz system clk, 16/32-Bit RISC
  - On Chip 1MB flash
  - Flexible I/O options

- ADS1278-HT
  - Up to128KSPS, Sigma Delta Architecture
  - High Resolution (24 bits), 17 bits enob @ 210C.
  - Simultaneous Sampling Capabilities, 8 Ch.

Featured Analog Inputs

- OPA211-HT, accelerometer inputs
  - All three axis inputs have a buffer amplifier with two poles in a Butterworth filter at 20Hz using the OPA211-HT
  - For demonstration purposes of the above signal path we created a low temp sensor board and cabling.
- Temperature Sensing
  - based on the THS4521-HT and OPA2333-HT
  - If the on board RTD is not in place, there is a connection for a four wire external RTD
- Pressure Sensing
  - A high impedance bridge amplifier using the THS4521-HT and the OPA2333-HT to create an instrumentation amplifier.
  - This circuit is a high gain (251X) circuit for measuring downhole pressure
  - Alternatively, we are proving dedicated input with INA333-HT to be used for pressure transducer coupling.

General Purpose Analog Inputs

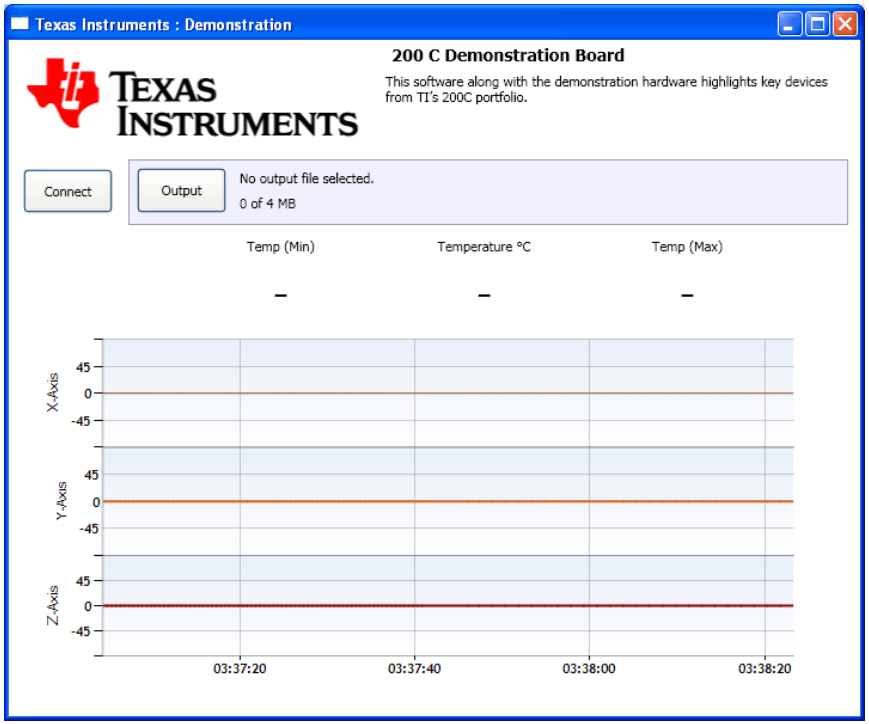
- To use the remaining two A/D inputs the following were added
  - Inverting amplifier with DC offset for proper A/D dynamic range (the user can exercise full dynamic range of A/D)
    - OPA211 + buffered Vref (REF5025-HT)
  - One standard (1x) differential inputs using THS4521-HT.

- In addition, REF5025-HT, buffered references and other basic analog using OPA211-HT, OPA2333-HT are present in the board.

Firmware, interfaces and memory to uP

- Two HVD233-HT
  - CAN transciever (transmitter/receiver)
- One HVD11-HT
  - RS485 transciever (transmitter/receiver)
- In the HEAT design, a serial (SPI) interface links the ARM7 to the A/D
  - Basic firmware layer for A/D SPI and data relay.

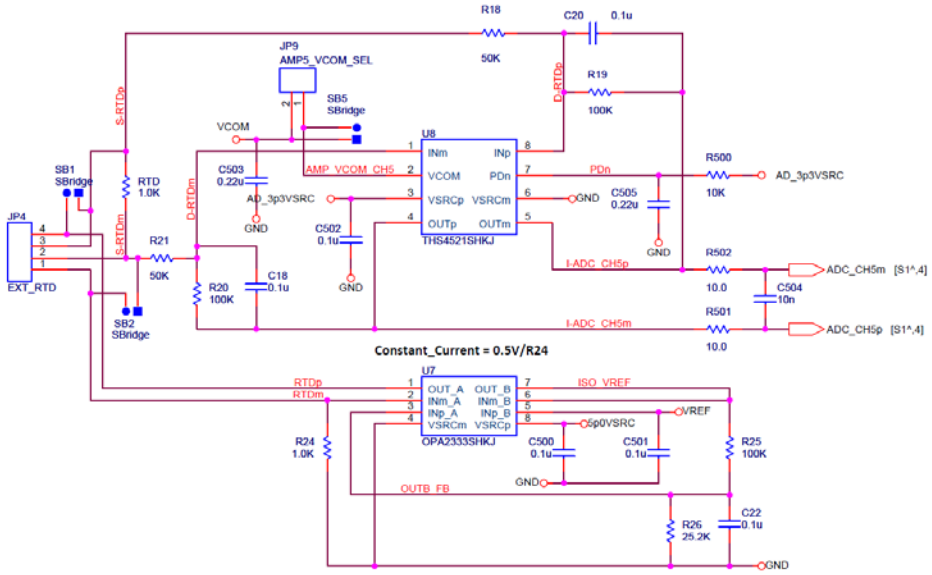
Graphical User Interface

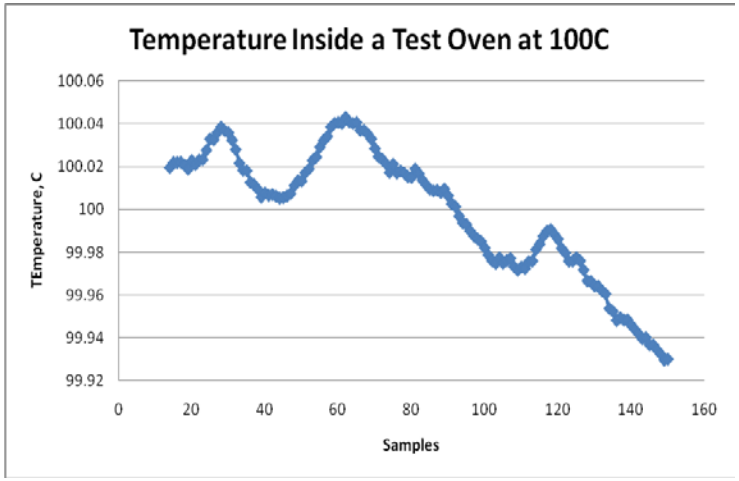


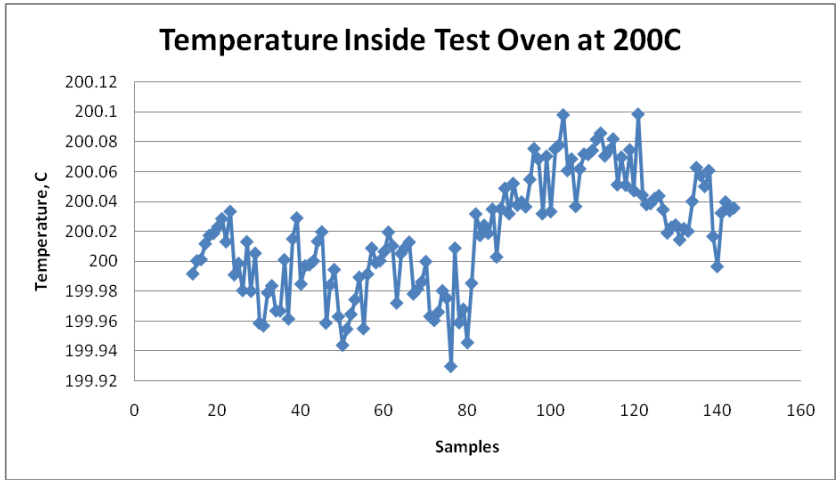
- Optional software layer for a PC terminal
- Simple Connection via serial
- Auto scrolling of data
- Temperature Display
  - Actual, Min and Max
- Data logging capability (save file) for all 8 Ch.

Temperature Sensing

- The measurement of temperature and pressure are clearly the two most measured parameters of any well.
- An RTD (Resistive Temperature Device) is commonly used in the drilling industry because it provides a linear response over a wide temperature range.
- The chosen circuit uses a constant current across a 1000 Ω RTD. The voltage across the RTD changes with temperature as the resistance changes. The 'basic' RTD relation to temperature is 1 kΩ @ 25C with a 3.85 Ω/°C slope.

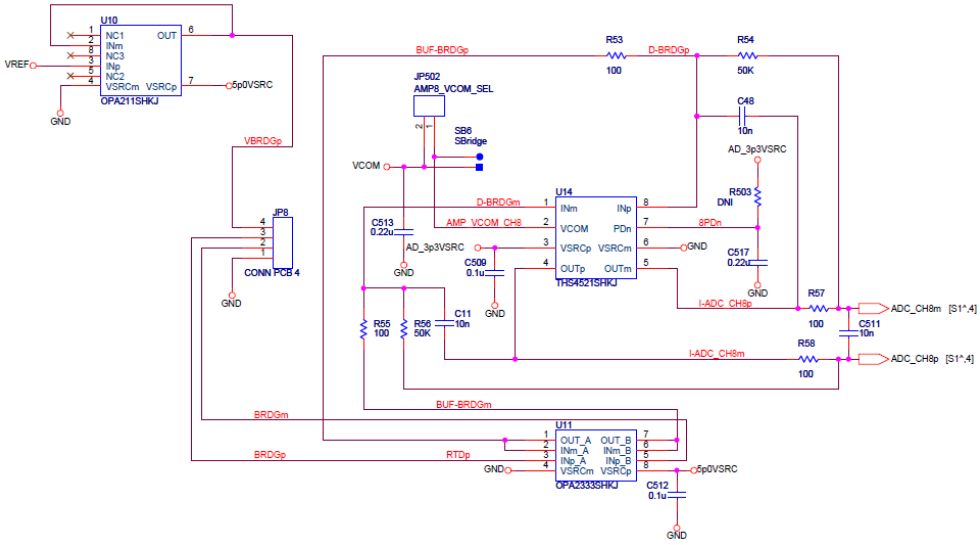


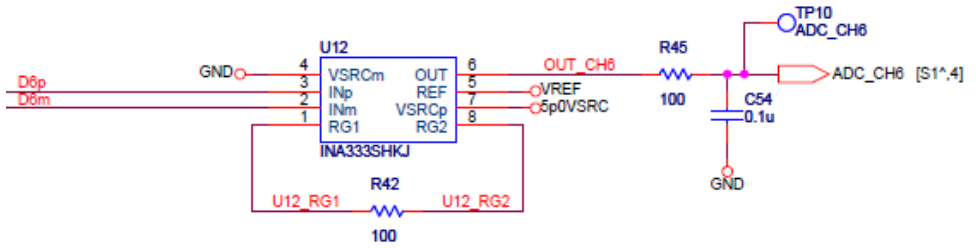




Pressure Sensing

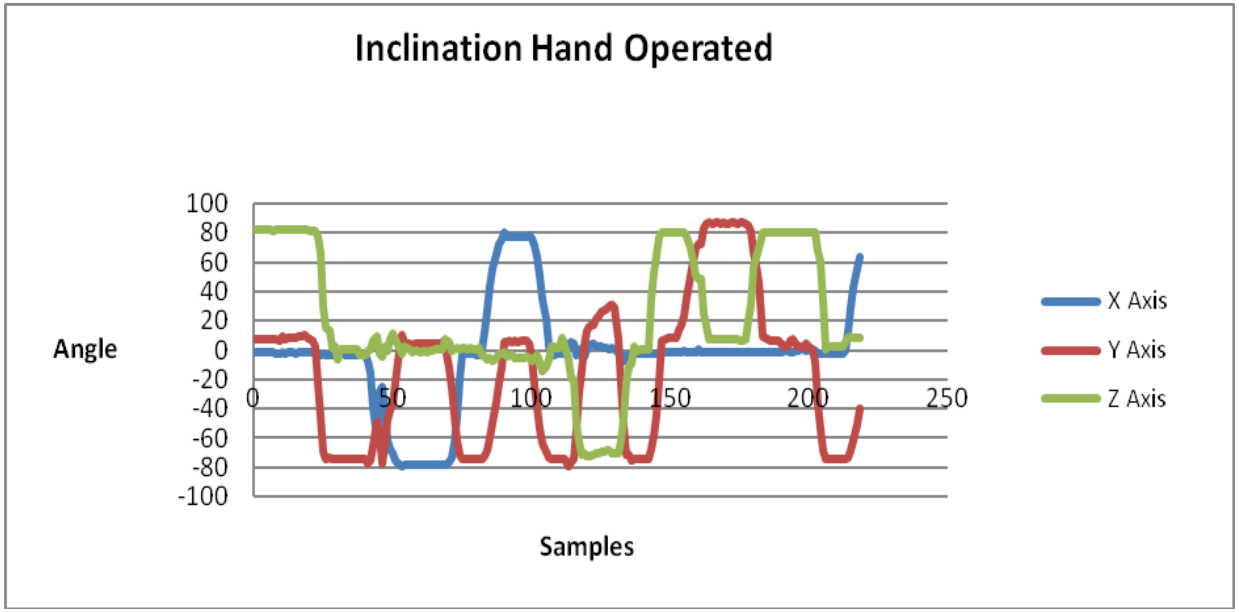
- The HEAT circuit has two pressure measurement type circuits on it, both with a gain of 251.
- Top right – A discrete implementation of an instrumentation amplifier. Essentially a buffered difference amplifier. THS4521-HT combined with a OPA211-HT and a OPA2333-HT.
- Bottom right -The second pressure transducer type circuit is one more commonly used by the well logging industry, an instrumentation amplifier with resistor set gain. The instrumentation amplifier is the INA333-HT. The gain is set by choice of R42.





Inclination Sensing

- All three axis (x,y,z) inputs have a buffer amplifier with two poles in a Butterworth filter at 20Hz using the OPA211-HT
- Using a three axis inclination sensor mounted on a handheld cube, the position of the cube can be traced. Because the ADS1278 samples all 8 inputs at the same time, the position calculation can be conducted without the need to adjust for phase differences created by a single ADC sampling one axis at a time.
- This parallel sampling is a significant advantage when measuring 3 axis seismic signals where amplitude and phase are critical to the interpretation of the data. The ADS1278 is ideal for this application.



General Analog

- Fully differential path leveraging THS4521-HT into the A/D.
  - Ideal to get an evaluation window into the A/D.
  - Good for general purpose sensor evaluation.

- Inverting amplifier
  - Added DC offset for dynamic input range correction into A/D
  - Added a small high frequency RC filter
  - OPA211 + buffered Vref (REF5025-HT)

Power

- Three main supply rails
  - Five volts (5V) for analog A/D core and conditioning circuits.
  - Three point three volts (3.3V) for interfaces (I/O).
  - One point eight (1.8V) for digital cores in both A/D and processor

- Separate 1.8V rail and 3.3V rail each for A/D and ARM7 to satisfy power sequencing requirements.

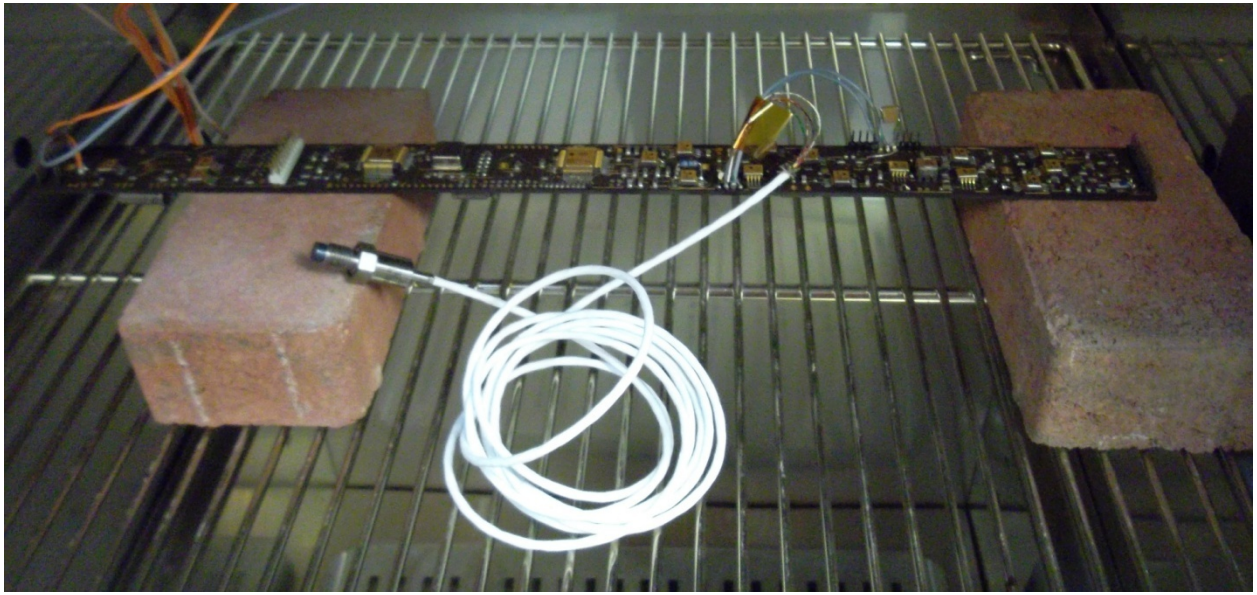
- Power rails and sequencing to the HEATEVM need to be provided externally.

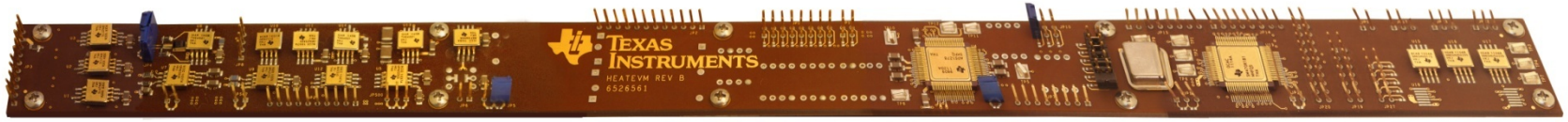
Additional Points

- Solder material type #240 (Sn95, Sb5) by Senju
- Onboard HT clocking running at 7.5 MHz
- Lifetime of 200 hrs driven by conservative de-rating of wet tantalums capacitors.
- There is no shock testing or long term qualification in place.
- All documentation, BOM, firmware source code and design database are available.

For Technical Information and BOM

http://www.ti.com/tool/heatevm





Closing Remarks and Summary

- The HEAT circuit board is built around the SM470R1B1M-HT (ARM7 core) microprocessor and the ADS1278-HT, A/D.
  - The ARM7 has a 32bit architecture, operating with a 60MHz internal core and 1MB flash.
  - The ADS1278 has 8, 24 bit analog to digital converters channels supporting simultaneous sampling.

- Pre-conditioned analog channels for a number of commonly used scenarios.

- Our main intend is to accelerate adoption of manufacturer qualified HT components.

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