User Manual

Temperature -Pressure- RH Monitoring System

(For INO Detector)

TATA INSTITUTE OF FUNDAMENTAL RESEARCH

INO GROUP

Department of High Energy Physics

Author: Sampriti Bhattacharyya	Date: 14/7/2010
Reviewed by:	Date:
Approved by:	Date:

Scope

The procedure applies to the TPH (*T*emperature, *P*ressure, *H*umidity) monitoring system customized for the ICAL detector of the INO experiment built by the INO group during period February 2010 to July 2010 at Tata Institute of Fundamental Research, Mumbai. The manual includes details of set up, implementation, readout system and debugging procedure of the TPH unit.

Set Up

The set up of the circuit at present stage is represented by the block diagram below:

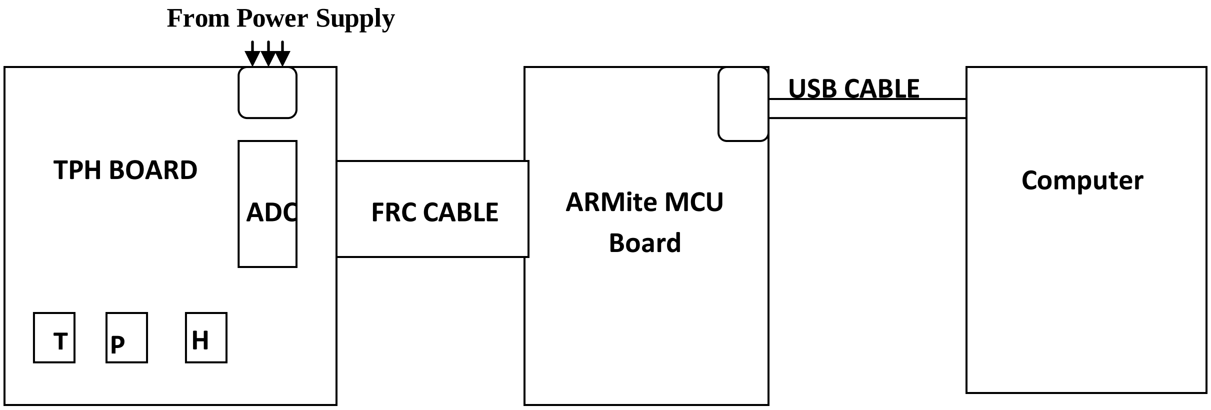


Fig 1

Our TPH board has a 14-pin, dual-row connector suitable for use with an FRC (*F*lat *R*ibbon *C*able). The present ARMmite MCU has a similar connector. Pin 1 of both connectors corresponds to each other. The two should be connected using a FRC cable. The length of the cable depends on application and disposition of the unit. The unit with effective alternate grounding minimizes effects of noise and attenuation.

The unit has three sensors. For temperature we use Omega F2020-100-1/3B RTD. For pressure and humidity we use a Bosch SMD085 device and HIH 4030 respectively. Depending on the need, a subset of these sensors can be mounted on the board.

For readout purpose the ARMmite MCU is connected to the computer which has the software called "MakeItC" required to communicate with our MCU. The C program to be loaded is called Read.c. The program displays the temperature, pressure and humidity on the terminal window.

The unit can be powered in two ways: 1) directly from the Power Supply; 2) from the MCU through the FRC cable. The latter requires a DC-DC converter NTA0509 to be mounted on the PCB. At present all PCBs have been provided with the space to mount the required converter, but we work only with the direct power supply. A three wire power connector and cable is used with this board. The leftmost pin of the power connector is positive, middle is ground and rightmost is negative supply. For a 2 channel power supply, the positive is set to 6 volts and negative to −8 volts. If possible, the current for the positive channel should be limited to 20mA and the negative to 10mA.

During initial set up, the board and the power supply should be connected first. The MCU is disconnected at this stage. The supply should be set up as mentioned, and turned on. A careful watch should be kept on the current. Any rise above 20mA (that is if the board goes into the current mode) the unit should be powered down immediately. Checks for errors as described on page 8.

Assuming the circuit passes the initial test, the power is turned off. The MCU is then connected to the TPH board. The MCU is powered via the USB cable from the PC. The power is then turned on (a watch must be kept for any abnormalities). The program is then loaded (MakeItC→File→Choose main→Read.c / Tools→Build and Run/ C program is now running/ Tools→ Terminal). A detail of readout procedure is attached with this manual.

TPH Board

A picture of the TPH board is given as below. The main units are marked in red.

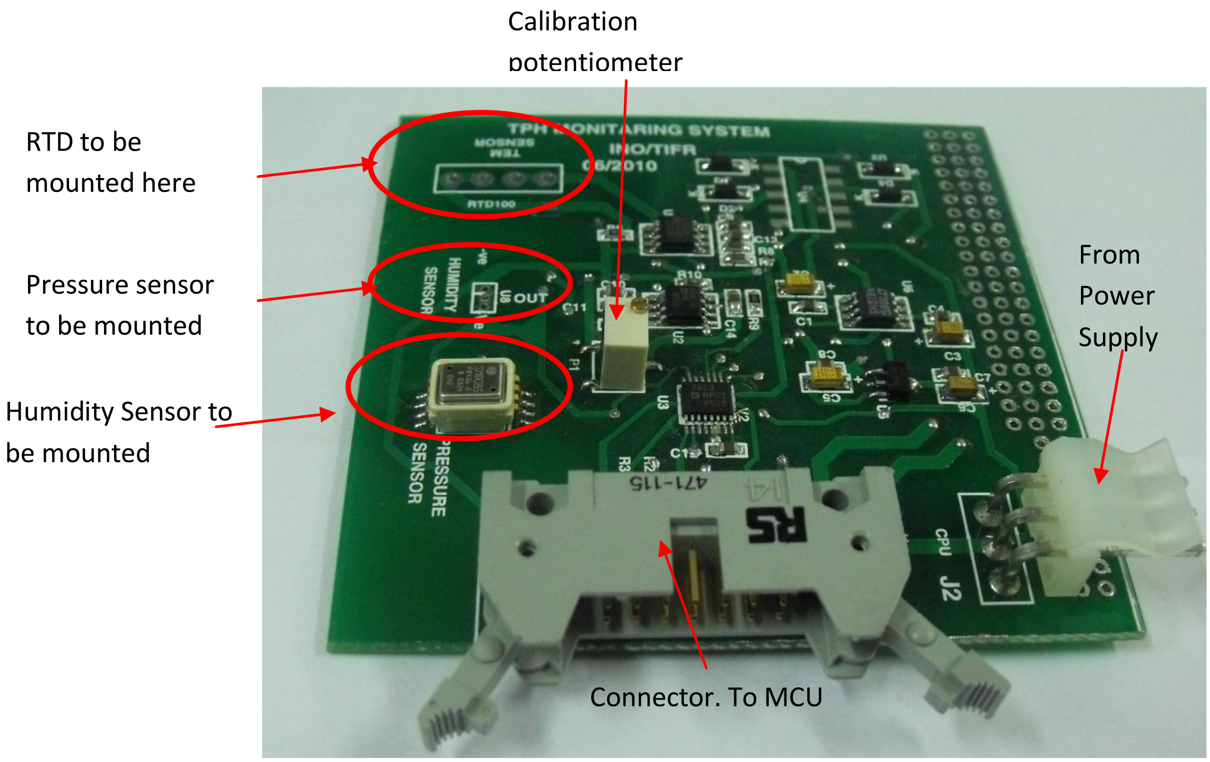


Fig 2

The board is 3x3 inches in size. The maximum current drawn by the board is <20mA and maximum power consumed is <200mW.

Sensor details

There are three sensors used in this board. The details of each one are as below.

Temperature:

Sensor Name: Omega f2020-100-1/3B

Type: RTD

Temperature Range: 0C – 200C

Accuracy: 0.1C

Resistance (in ohms): $100 + .39\times T - 5.775\cdot 10^{-5} \times T^{2}$

Cost per unit: $2.25 in a pack of 100

Manual: http://www.omega.com/prodinfo/oem_rtd/RTD_OEM.pdf

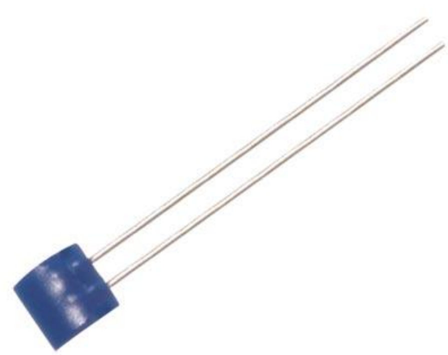


Fig. 3

Pressure

Sensor Name: Bosch SMD085

Type: Strain gauge Sensor

Pressure Range: 60 to 115KPascal

Accuracy: 10%

P in KPa = $(V_{out} - .003) / .03945$

Cost per unit: $6.67 in a pack of 100

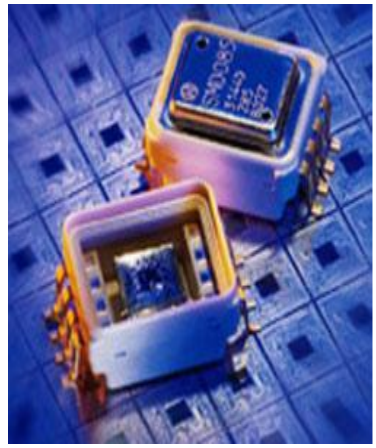


Fig 4

Manual: http://www.bosch-sensortec.com/content/language1/downloads/SMD085_V1_1105.pdf

Humidity

Sensor Name: HIH4030

Type: Capacitive Sensor

Humidity Range: 0 – 100%

Accuracy: ±3.5%

Cost per unit: $10 in a pack of 100.

Fig 5

Manual: http://sensing.honeywell.com/index.cfm/ci_id/142958/la_id/1/document/1/re_id/0

Readout

The readout part consists of two basic units. The ADC chip which is mounted on the TPH board itself and the microcontroller unit which further communicates with a computer and displays the temperature, pressure and humidity readings.

ADC

Name: AD7923, Analog Devices

Type: Low Power, SAR

Number of Channels: 4

Accuracy: 12 bits

Cost per unit: $3 each (when purchased in volumes of ~1000)

Required Supply: +5V main power
+2.5V reference with a precision of 1%. Derived from +5V on this board.

Manual: http://www.analog.com/static/imported-files/data_sheets/AD7923.pdf

Microcontroller

Name: ARMmite board, manufactured by Coridium.

Processor: LPC 2103

Frequency: 60 MHz

Power: USB (5V) or 5 – 12 V DC

Price: $49

Programming Language: C/Basic

Supporting software: http://www.coridiumcorp.com/Support.php

Manual: http://www.coridiumcorp.com/cHELP/index.htm

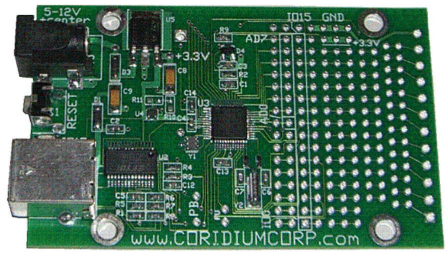


Fig 6

Key components

The other main electronics components used for the board are as follows.

AD8629: Auto-zero Operational amplifier. Used as a precision current source for the RTD.

AD8230: Auto-zero Instrumentation amplifier, Transfers voltage drop across RTD to the ADC.

LT1461: ~0.1% precision +5V reference, used as a 5V regulator. Precision is important for the ADC.

MC79L05: Negative 5 volts regulator used by the AD8230 chip.

NTA0509: This is a DC-DC converter to be mounted in case we want to use the +5 V from the microcontroller to power the circuit.

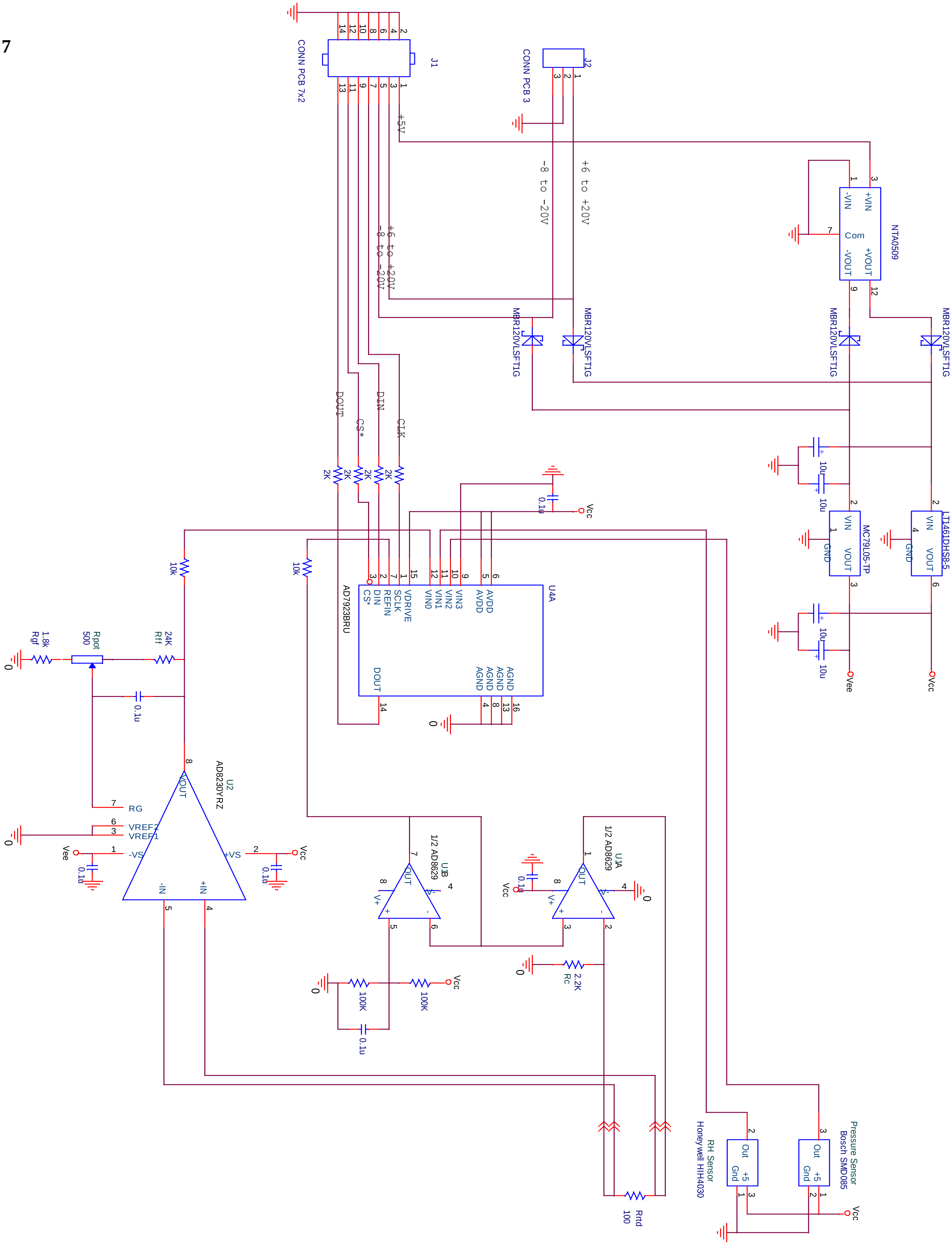
High Precision 13-turn pot: Required for circuit calibration of temperature readout.

Other than these, we also use high precision resistors, capacitors and diodes as follows:

Precision (1%), low temperature coefficient metal film resistors of 2.5KΩ, 10KΩ, 2KΩ, 100KΩ, 24KΩ.
Capacitors of 0.1μF and 10μF
Schottky diodes. These units are easily available and replaceable.

A circuit diagram of out TPH monitoring board has been given in the next page (Fig 7).

Fig 7



CONN PCB 7x2
J1
CONN PCB 3
J2
+5V
+6 to +20V
-8 to -20V
DOUT
CS*
DIN
CLK
NTA0509
+VIN
-VIN
Com
+VOUT
-VOUT
MBR120VLSFT1G
MC79L05-TP
LT1461DHS8-5
VIN
VOUT
GND
Vee
Vcc
U4A
AD7923BRU
AVDD
VIN3
VIN2
VIN1
VIN0
VDRIVE
SCLK
REFIN
DIN
CS*
DOUT
AGND
U2
AD8230YRZ
VOUT
RG
VREF2
VREF1
-VS
+VS
-IN
+IN
Rpot
500
Rgf
1.8k
Rff
24K
U1B
1/2 AD8629
U1A
1/2 AD8629
OUT
V+
V-
Rc
2.2K
100K
Rrtd
100
RH Sensor
Honeywell HIH4030
Pressure Sensor
Bosch SMD085
Out
+5
Gnd
10k
2K
0.1u
10u

Temperature Calibration

In the TPH board, the voltage output of the SMD085 and HIH4030 are fed directly into our ADC. However, the RTD requires a current source and an instrumentation amplifier to convert resistance to the voltage that is then fed into our ADC. The temperature is supposed to be read to a high precision ~.1C. This can be ensured by a systematic calibration of the board. The procedure is described as below:

The system is first powered up. The program is run, and the TCL window (in debugging mode) should display the corresponding values of temperature, pressure and RH. The RTD should be dismounted and replaced with a 100ohms high precision resistor good to 0.1% manufactured by Vishay. The temperature on the TCL window should read 0. This is because, the RTD f2020 has a value of R0=100 at 0C. So, replacing the RTD with a precise 100ohm should display 0C on the terminal window.

If it is not 0C, use a tuner to adjust the potentiometer (as marked on the picture) and keep reading the TCL window, till the temperature goes to 0C. Wait till the 0C becomes stable. Replace back the RTD. The board is now calibrated for temperature readout.

Powering the circuit

The circuit can be powered in two ways.

1) Directly from the power supply: The board is provided with a three pin power connector which can be connected to the power supply. The power supply can be set to ± 8V or +6V and −8 V, and current to 15mA. Pin 2 and 3 of the FRC cable connector can also be used to draw in power from a supply board.

2) From the microcontroller board: Pin 1 of the FRC connector on TPH board draws power when available from MCU. In this case the DC-DC converter chips must be mounted on the board. There is a +5 voltage output even in our ARMmite Express MCU board. A jumper from it can be given into the corresponding pin.

Debugging and Common Errors

During initial testing we often encounter problems with our system. At present 12 PCBs have been manufactured, and only one complete unit has been put to proper implementation with all the sensors mounted. Some of the common problems and their solutions are given below:

MCU isn't compiling:

Go to options and check on the serial port. The most common mistake is that the wrong serial port is chosen and so the computer is in fact not communicating with the MCU at all! Also check the connection of the USB cable between the MCU and the computer. During compilation, the LED on the MCU blinks to orange. After successful compilation, a pop up message appears "Your C program is now running".

Bugs:

If you are working on a newly downloaded version of "MakeItC" it might be possible that it has a bug. Sometimes such bugs might prevent a long file name (more than 8 letters. I faced this problem with a new version). Either change the file name to a shorter one or contact the Coridium technical support at http://www.coridiumcorp.com/Support.php.They are amazingly fast at responding!

Terminal window isn't reading anything or reading garbage:

Case 1: I faced this problem quite a few times. The first step – check the supply to pin 15 of the ADC, that is the power pin. It should be +5Volts. A dry soldering might give rise to this problem. If so, press the chip a little bit if that removes the problem and then resolder.

Case 2: Sensors not properly mounted. Improper soldering of the sensors might also give rise to this problem. Check voltages at the pin 10, 11 and 12 of the ADC which are the input from the sensors.

Case 3: Check the soldering of the FRC connectors on the MCU and TPH board. Loose connections may interrupt data transfer.

Temperature is still a garbage value of 247C or so:

The RTD soldering is loose. This is a common problem. Instead of soldering try welding the RTD to the wire; might work better. Loose contact is the most common problem with the RTD.

RH sensor isn't working well

Unfortunately, presently we have a single RH sensor with which we are facing some problems. If the RH sensor reading seems to be off by too much, try calibrating against a standard. You can add the offset, or back calculate the voltage obtained from the DMM reading of the sensor output and tally that with the one read from the program. If there is any scale or offset error, try modifying the formula in the program by adding necessary error terms.

Debugging mode

The TCL window in normal mode would display 1 set of T-P-H reading in 1 minute. When the TCL window is started, it asks whether you want to debug or not. Entering a Y would let you work in a debugging mode where you display 1 reading every 2 seconds or so. This allows a quick check when you don't want to wait to see how the system is working. Especially during temperature calibration with the potentiometer, debugging mode is used. For circuit check up debugging mode is used, and for final implementation we should use the normal mode.

A Systematic Circuit Checking Procedure:

After the sensors are mounted on a new PCB, the following procedure ***must*** be carried before implementing the unit.

1) Check the resistances between the positive supply pin and ground (a few kilo ohms), negative and ground (high – several kilo ohms), and positive and negative supply (high) pin in the circuit off conditions.

2) Power the circuit. Set it to 6 volts for positive channel and 8 volts in negative channel. Set the current to 20mA for positive and 10mA for negative channel. Keep a watch on the current. If current is >20mA turn down the power and recheck the circuit as described in the following steps.

3) Cross check or identify the input power pins, to make sure you are have not swapped the positive and negative. Check output of pin 2 of LT1461 to three possible power inputs. To be more specific … since there is a diode in between, set the DMM to diode test, touch the negative (black) lead to pin 2 of the LT1461 and check with the positive (red) lead which power input pin it goes to. In our PCB, the leftmost one is positive, and rightmost one is negative and middle is ground. This should be verified.

4) Check from the output of the LT1461, which is pin 6 (V_{cc}), to the input power for all other chips, that is pin 8 of AD8629, pin2 of AD8230, pin 5,6 and 15 of AD 7923, pin 1 of SMD085 and pin 3 of HIH4030.

5) Check that V_{cc} does not connect any output. Like pin 1 and 7 of AD8629, pin 8 of AD8230, pin 1,7,2,3 and 14 of AD7923 , pin 2 of HIH 4030 and pin 3 of SMD085.

6) Check the −5V connection. From pin 2 of MC79L05 to pin 1 of AD8230. Also check that the −5V do not connect to any output.

7) Check the ground connections. It should be high at pin 1 and 7 of the AD 8629, pin 8 of the AD8230 pin 2 of the HIH4030, pin 3 of the SMD085, pin 14 of the 7923 and it should be LOW to pin 4 of the 8629, pins 4, 8, 13, and 16 of the 7923, pin 1 of the HIH4030 and pin 2 of the SMD085

8) Check the IO connections from MCU to the ADC.

9) All these steps make sure that the board will not be damaged. Power the circuit. And run the program. In case any problem persists while reading out, refer to the previous section (Debugging and Common Errors) for further help.