8/15/2015

Model 100

HIGH TEMPERATURE AIR FLOW MONITOR OPERATING/TEST MANUAL

Wind Probe LLC
8 STANDISH CIRCLE, ANDOVER MA 01810

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1 Specifications

Model 100
High Temp Air Flow Monitor

Wind Probe LLC is introducing a high temperature air flow monitor instrument for large and small size ovens. This instrument combines the latest advances in materials, process control, and microprocessor technology and hardware and software design. The model 100 is small light weight and suitable for harsh environments seen in high temperature curing ovens. The software permits selecting data rates and running averaging in both temperature and air flow. The software is easily updated and reference tables can be uploaded using the RS-232 communications interface. One of the most exciting markets includes air flow monitoring at 200 Degrees C in Carbon Composite Honeycomb ovens.

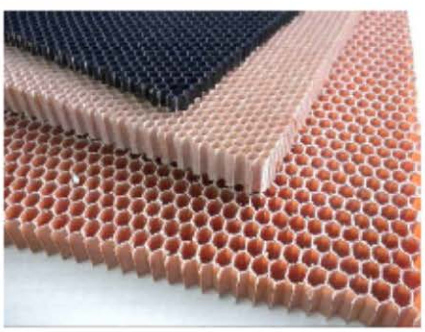
Wind Probe Corp

Applications

- Epoxy Curing Ovens
- Building Furnaces
- Manufacturing Process Control
- Conveyor Process control
- Engine Exhaust Manifolds
- Air Exhaust Systems

Features

- Measures Air Speed
- Solid State
- No Moving Parts
- Long Life
- Intrinsically Safe Certificate
- Traceable To National Standards



Honeycomb Material without the Resins

Boeing 787 Dreamliner 50% Carbon Composites

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www.wind-probe.com
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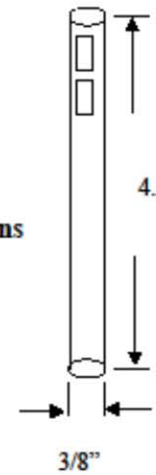
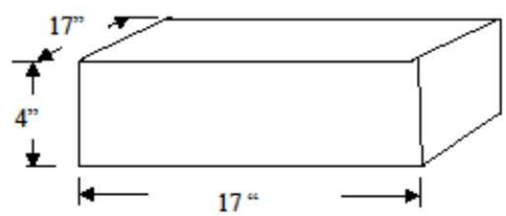
Model 100 High Temp Air Flow Monitor Typical Properties	
Air Speed	
Range	0 to 5 mph
Accuracy	+/- 5 %
Resolution	.1 mph (8.8 ft./min.)
Measurement	
Units of measure	Mph, ft/min.
Communication	
Mode	RS-232
Baud Rate	9600
Environment Probe	
Oper. Temperature	-10 to +200 Deg.C
Storage Temp.	-40 to +200 Deg. C
Environment Chassis	
Oper. Temperature.	0 to 50 Deg. C
Standards	
FM Global	Certified
Power Requirements	
External Supply	115 VAC +/- 10 %
Max. Current	1.5 Amp
Mechanical Probe	
Nominal Dimensions	3/8 inches Dia. X 6.0 inches long
Mechanical Electronic	
Control Box	17” x 17” x 4”
Weight	12 lbs.
Mechanical Cable	
Length	8 to 16 feet

Preliminary Product Information

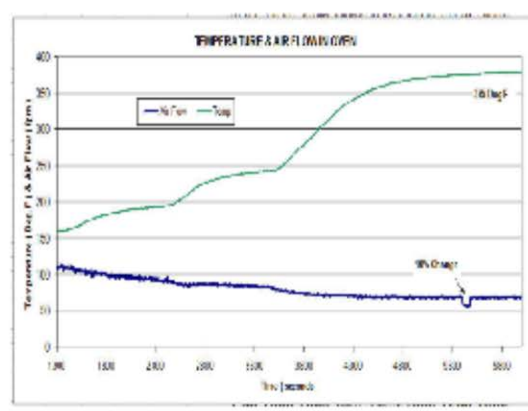
Probe Dimensions



Electronics Box Dimensions



Model 100 Open Chassis View



Oven Air Flow & Temp. In Oven Profile

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2 Model 100 Instrument

Figure 1. Hardware Setup Configuration

Figure 1 provides a good look at the components comprising the Model 100 High Temp Air Flow instrument. As can be seen the instrument consists of a control board, probe, output connectors and a power supply. The power supply plugs into a standard 115 VAC power outlet and provides 12 volts DC to the control board. On the control board there are four connectors all different to ensure no wrong placements. The DB-9 receptacle connects the control board to the Probe with either an eight or 16 foot cable. The output connectors provides the Speed, Temperature and RS-232 digital interface signals. The Speed output goes from 0 to 5 volts for 0 -5 mph and the Temperature output goes from 0 to 5 volts for 0 – 200 degrees C. The RS-232 output permits serial communications with a standard PC computer. Both monitoring Probe and board parameters as well as making commands to the control board are accomplished with this interface. A list of commands describing how to use this interface is included in another section of this manual.

3 Hardware Setup Configuration

The hardware set up can take on many forms from a simply volt meter monitoring the analog output signals to a Measurement Computing Corp. acquisition system permitting simultaneous monitoring of eight individual speed and temperature signals from eight separate instruments, see Figure 2.

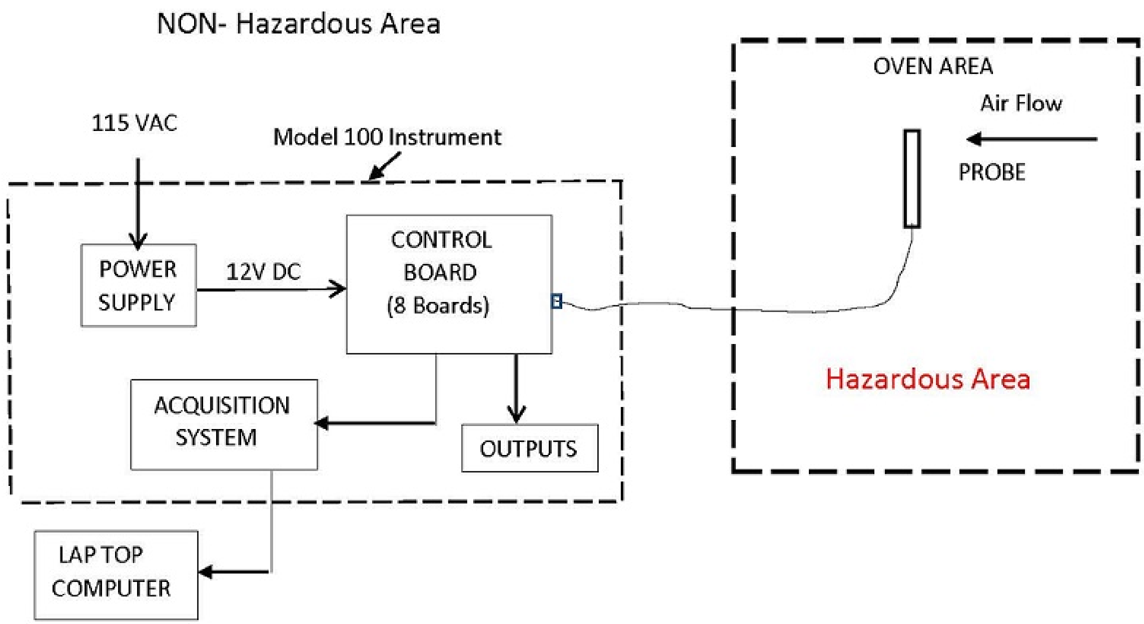

Figure 2. Hardware Setup and Configuration

Note, the Model 100 High Temp Air Flow sensor instrument must be installed in a protective cabinet.

Figure 2 illustrates the critical safety zones required using the High Temp Air Flow monitor instrument. The control board incorporates a safety barrier needed to insure intrinsically safe operation with the Probe in an Oven. All control boards are tested to meet the maximum allowable current to insure the Rws sensor never rises above 390 degrees C.

The control board can be connected to a PC computer via the output RS-232 connector or through an acquisition system similar to the Measurement Computing Corp. USB-201. Using the digital interface method allows both setting and monitoring parameters internal to the Control board. The digital interface also permits down loading new processor code and calibration data.

The analog outputs for temperature and Speed can be displayed and stored simultaneously from eight instruments using the MCC acquisition system.

4 Block Diagram

Figure 3 represents a simplified block diagram of Wind Probe’s High Temp Air Flow instrument. Only the important items are depicted in this drawing. Rws is the air flow monitor element and RTD is the ambient temperature compensating element. Both are located in the Probe assembly 16 feet from the control board.

A control loop keeps the bridge balanced by adjusting the bridge voltage (Vbr). The left side of the bridge is a voltage divider formed by 1.5 ohm 1 watt resistor and the wind sensor (Rws) which is a high positive temp coefficient Ni resistor. The right side of the bridge is a voltage divider formed by a resistor and an RTD (high positive temp coefficient resistor). The wind sensor is operated at high current so that it gets very hot(40 degrees C above ambient). The RTD is operated at very low current (no self-heating), so that it is at the ambient temperature. The control loop adjusts the bridge voltage (Vbr) to balance the bridge. As Vbr is increased the resistance of the wind sensor increases and vice versa.

The current that this control loop operates at is limited such that the sensor never reaches a temperature of 390 Degrees C. This is accomplished by triple redundancy circuitry which uses the 3 Linear Technology LT3092. This current limit is set at about 150 mA. The +12V supply voltage is also limited by three redundant voltage regulators.

The Processor collects data and outputs linear speed and temperature through look up tables linearizing the speed and calculating the actual temperature of the ambient air. Both analog outputs and an RS-232 communications lines are available.

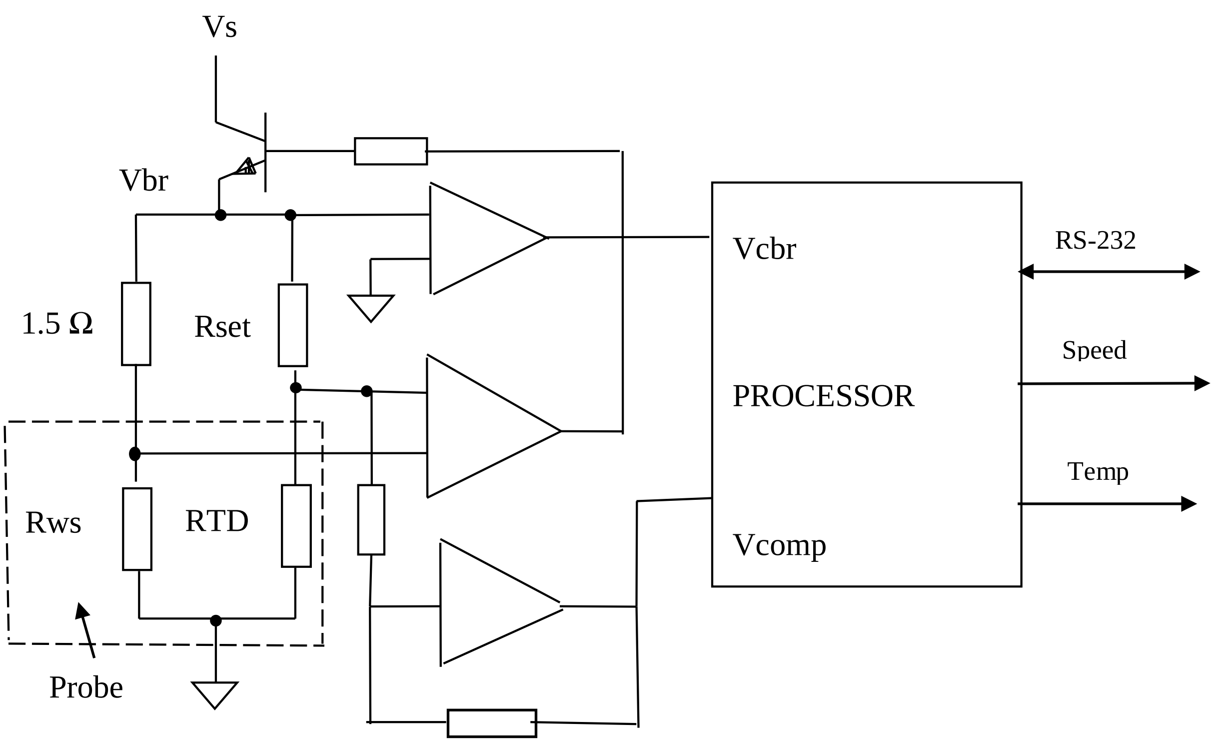

Figure 3. High Temperature Air Flow Instrument Block Diagram

5 Current Limit Test Circuit

Figure 4 shows the current limiting and over voltage protection circuits. For our curing oven application, alcohol has the lowest auto-ignition temperature of 399 degrees C. To determine the required current limit for safe operation of our wind sensor during a worst case condition, which is defined by an oven temperature of 200 degrees C, no air flow and the wind sensor control loop failed in a way that causes full available current to be applied to the wind sensor. To insure that the wind sensor element never goes above 390 degrees C, the current needs to be limited by a triple redundant current limiter circuit as shown. To determine the appropriate current limit, we measure the resistance of the wind sensor (Rws) first over a temperature range of 20 to 400 degrees C and next over a range of applied currents while in a 200 degrees C oven. With the knowledge of this Rws versus temperature behavior, we can measure the wind sensor resistance to determine its temperature. By combining both characterizations, we can determine the wind sensor current value (Iws) that causes a wind sensor temperature of 390 degrees C. The current limit testing is performed by simulating a fault at the output with Jumper4. By using jumpers as shown in Table 1, one current limiter at a time can be tested. This is accomplished by measuring the voltage across the 1 ohm resistor in the non-shorted current limit circuit. This voltage is the current flowing in that circuit.

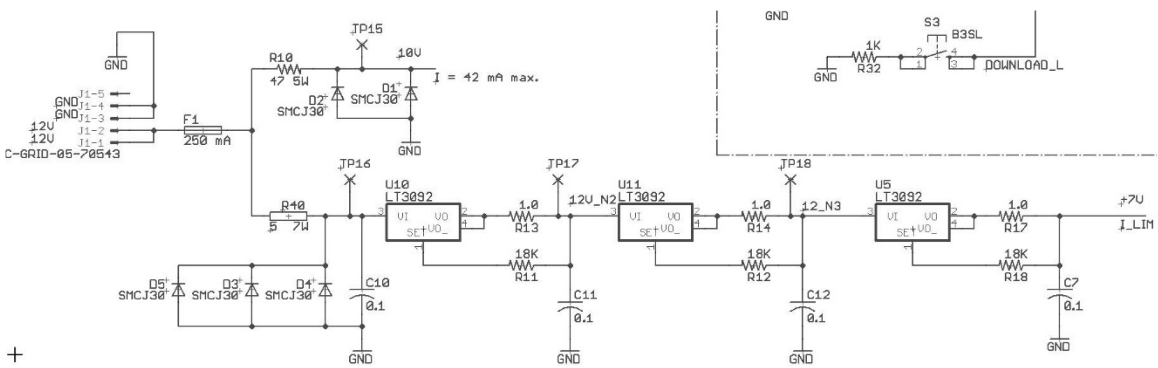

Figure 4. Current Limit Test Circuit

Output Shorted With	U11 Current Lim	U10 Current Lim	U5 Current Lim
Jumper 1 & 2 Shorted			.177
Jumper 1 & 3 Shorted	.179		
Jumper 2 & 3 Shorted		.180	
No Jumper In Place	.177		

Table 1. Current Limt Jumper Settings

By knowing the auto ignition temperatures of all the gases present in the oven and using the lowest value to determine the maximum allowable temperature the sensor can reach insures a safe operating environment. For example, Alcohol and Iso Propanol both have auto ignition temperatures of 399 °C therefore, if we chose 390 °C we are sure to stay in the safe operating area.

Using calibrated Ohm meter and temperature readout devices three Sensor's Rws resistance versus temperature from 25 °C to 400 °C are recorded. These sensor elements must be wound from the same spool of Ni205 wire. The ohm meter should be calibrated to +/- 1% and the temperature readout to +/- 1°C.

Figures 5 and 6 illustrate data taken and with one ohm meter instrumentation approach respectively

Time	Omega Temp.	Breadbd Pt Temp.	Meter Pt Temp.	Yellow Rws	White Rws	Blue Rws
11:05	406.2	396	401	22.8	22.4	24.7
11:12	399.4	389	396	22.6	22.3	24.4
11:17	388.3	379	386	22.2	21.9	24.1
11:36	376.7	368	375	21.7	21.3	23.4
11:56	356.7	350	356	20.4	20.0	22.0
12:43	326.4	322	327	18.3	18.0	19.7
1:07	302.2	298	304	16.9	16.7	18.3
1:42	276.1	273	279	15.6	15.2	16.8
2:05	269	267	272	15.2	15.0	16.3
2:35	251.9	250	254	14.4	14.1	15.4
2:53	225.7	225	229	13.2	13.0	14.3
3:25	200.8	200	205	12.1	11.9	13.1
4:31	176.1	175	182	11.2	10.9	12.0
5:18	151.9	151	158	10.3	10.1	11.1
6:23	125.9	124	131	9.4	9.3	10.2
7:01	102	103.8	105	8.6	8.5	9.4
9:44	78.7	76	79	7.8	7.7	8.5
11:22	53.3	50	55	7.1	7	7.8
6:27	24.8	20	25	6.3	6.3	7.0

Breadbd Pt Temp.	Yellow Rws_Y	White Rws_W
396	22.8	22.4
389	22.6	22.3
379	22.2	21.9
368	21.7	21.3
350	20.4	20.0
322	18.3	18.0
298	16.9	16.7
273	15.6	15.2
267	15.2	15.0
250	14.4	14.1
225	13.2	13.0
200	12.1	11.9
175	11.2	10.9
151	10.3	10.1
124	9.4	9.3
103.8	8.6	8.5
76	7.8	7.7
50	7.1	7
20	6.3	6.3

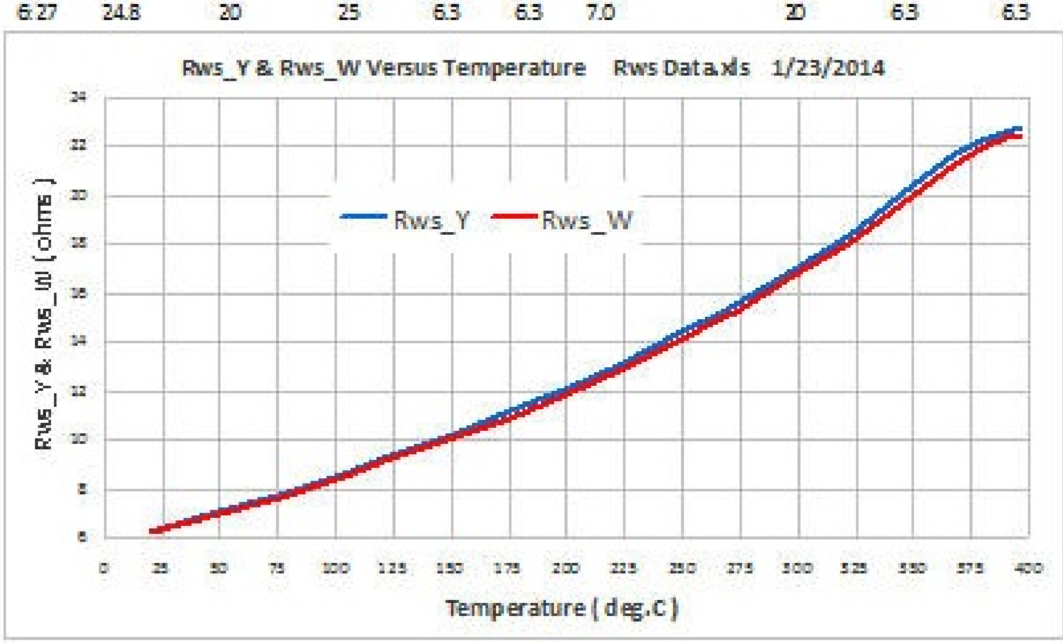

Figure 5. Rws and Temperature Data

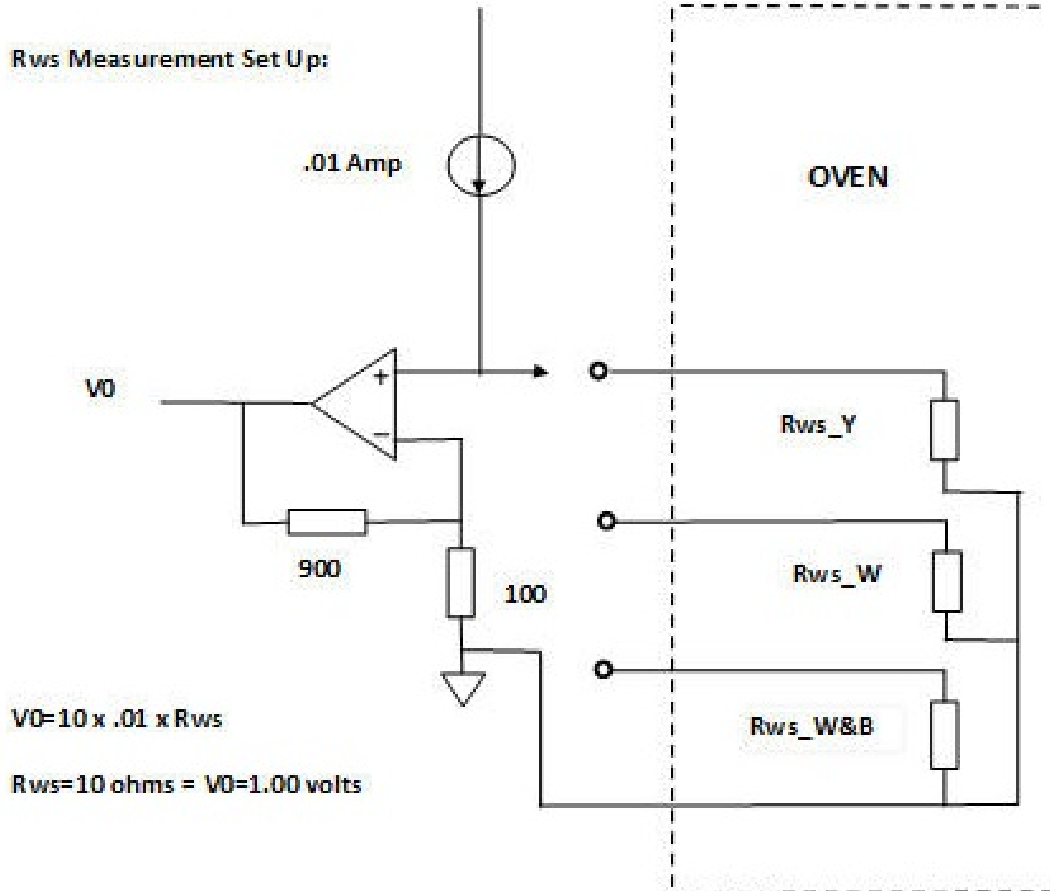

Figure 6. Rws Measurement Setup

With the oven temperature at 200 degrees C the data shown in Figure 7 was taken. Column D, Rws is calculated by dividing V2 by Iws as measured in the figure. Using the values in Column D and the Rws Data Curve,, it is possible to determine the actual temperature of Rws for a specific current throught it. For Rws to never rise above 390 degrees C, Imax must be less than 0.21 Amps.

Oven Temp=200 C

Vs	V2	Iws	D Rws	Temp Rws_Y (deg.C)
1.7	0.963	0.07	13.76	228
2.4	1.385	0.09	15.39	269
3.0	1.783	0.11	16.21	285
4.0	2.508	0.14	17.91	310
4.5	2.905	0.15	19.37	340
4.7	3.103	0.16	19.39	340
5.0	3.303	0.16	20.64	351
5.2	3.461	0.17	20.36	350
5.5	3.728	0.17	21.93	368
6.0	4.091	0.19	21.53	366
7.0	4.868	0.21	23.18	390
8.0	5.653	0.23	24.58	400

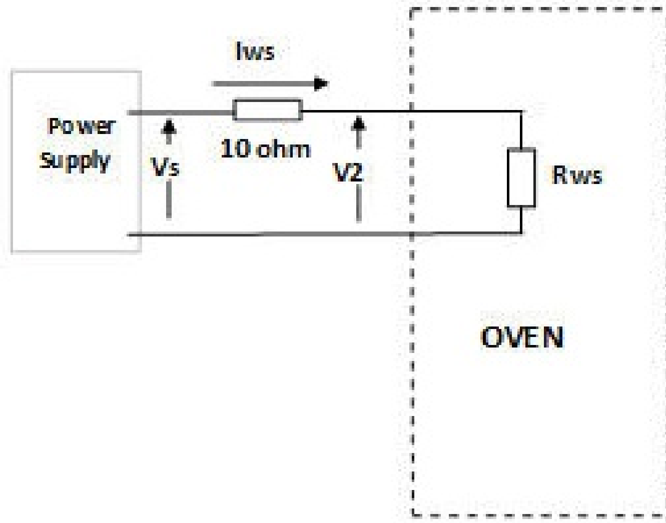

Figure 7. Current Limit Test Data

6 Example Calculation for Determining Imax for Q8

1. Choose the maximum allowable temperature for the Q8 probe, say 380 C.
2. With it's Given Rws @ 23 C equals 5.74 ohms use the "Tool for Rws vs Temp Curve" to find the value of Rws at 380 C, that would be 21.8 ohms. See Figure 8
3. Now using the plot Rws vs Iws @ 200 C curve for Q8 determine the Imax for Rws=21.8 ohms. That is 212 mA. See Figure 9.
4. Hence, as long as the current Iws < 212 mA the temperature of the element Q8 will be less than 380 C.

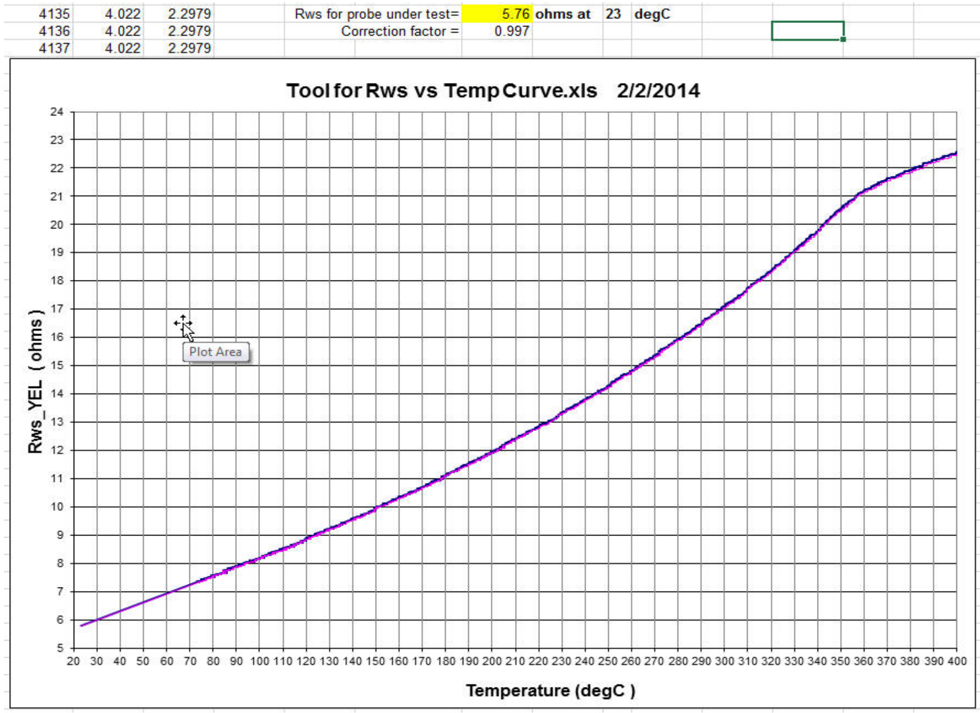

Figure 8. Tool for Rws Vs Temperature

Rws vs Iws Curve @ 200C.xls

Oven Pt _BD	Oven Pt Om	Vs	Q8 V2	Q8 Irws	Q8 Rws	Q14 V2	Q14 Irws	Q14 Rws	Q15 V2	Q15 Irws	Q15 Rws	Q24 V2	Q24 Irws	Q24 Rws	Vs set
201	202.7	3.035	1.773	0.126	14.0	1.813	0.122	14.8	1.806	0.123	14.7	1.805	0.123	14.7	3
200	201.3	4.09	2.557	0.153	16.7	2.6	0.149	17.4	2.58	0.151	17.1	2.594	0.150	17.3	4
201	202.7	4.532	2.908	0.162	17.9	2.967	0.157	19.0	2.943	0.159	18.5	2.938	0.159	18.4	4.5
200	201.6	5.057	3.315	0.174	19.0	3.373	0.168	20.0	3.347	0.171	19.6	3.361	0.170	19.8	5
202	202.7	6.039	4.065	0.197	20.6	4.136	0.190	21.7	4.107	0.193	21.3	4.114	0.193	21.4	6
201	202.5	7.04	4.841	0.220	22.0	4.91	0.213	23.1	4.88	0.216	22.6	4.894	0.215	22.8	7
202	203.5	8.076	5.652	0.242	23.3	5.723	0.235	24.3	5.696	0.238	23.9	5.701	0.238	24.0	8

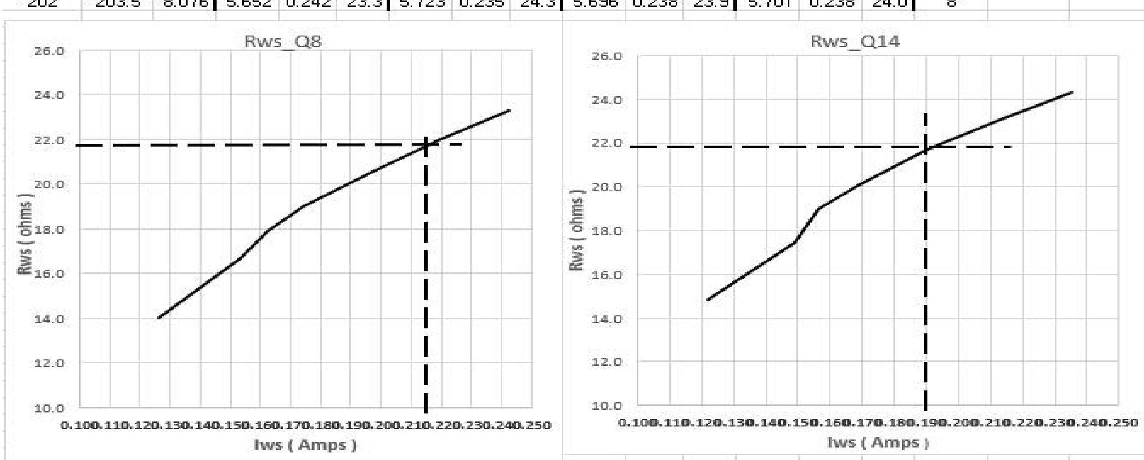

Figure 9. Rws Vs. Iws

7 Trouble Shooting and Maintenance

The trouble shooting and maintenance is controlled by software communications using a terminal program such as Hyper Terminal and the RS-232 interface. Commands are entered via the terminal as capital letters. A help screen is displayed by using the H command. The help screen is shown in Figure 10 which displays all the commands built into the software of the control processor.

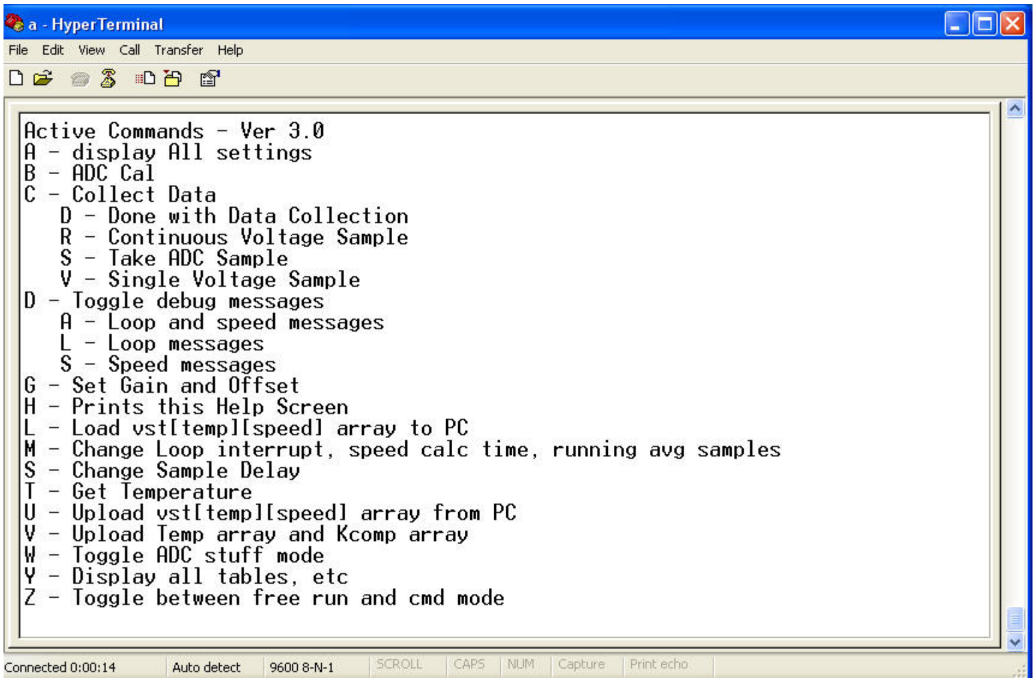

Figure 10. Help Menu

Figure 11 through Figure 13 are some of the diagnostic screens available to examine the health of the instrument’s working condition.

Figure 11is displayed when a DA command is typed in at the terminal. The processor will continue to spurt out this data until a repeat command DA is entered. This stops the scrolling process and it is then possible to read the last screen outputted. The Vbr, Vcbr, Vcomp and temperature values state the condition of voltages present in the hardware.

Figure 12 is displayed when the A command is entered. By scrolling up a short distance all software gain and offset values are displayed. These are used during the calibration process. Of significance are the following parameters; Vbr Gain, Vcp Gain, Speed Gain, Vbr Offset and Vcp Offset. Additionally, the VLST table is displayed above the Vtemp Table. The VLST table linearizes the nonlinear speed data acquired during calibration.

Figure 13 is displayed when the A command is entered, but no scrolling is done. This displays the Kcomp Table which calculates the ambient temperature from the temperature compensating Ni RTD sensor.

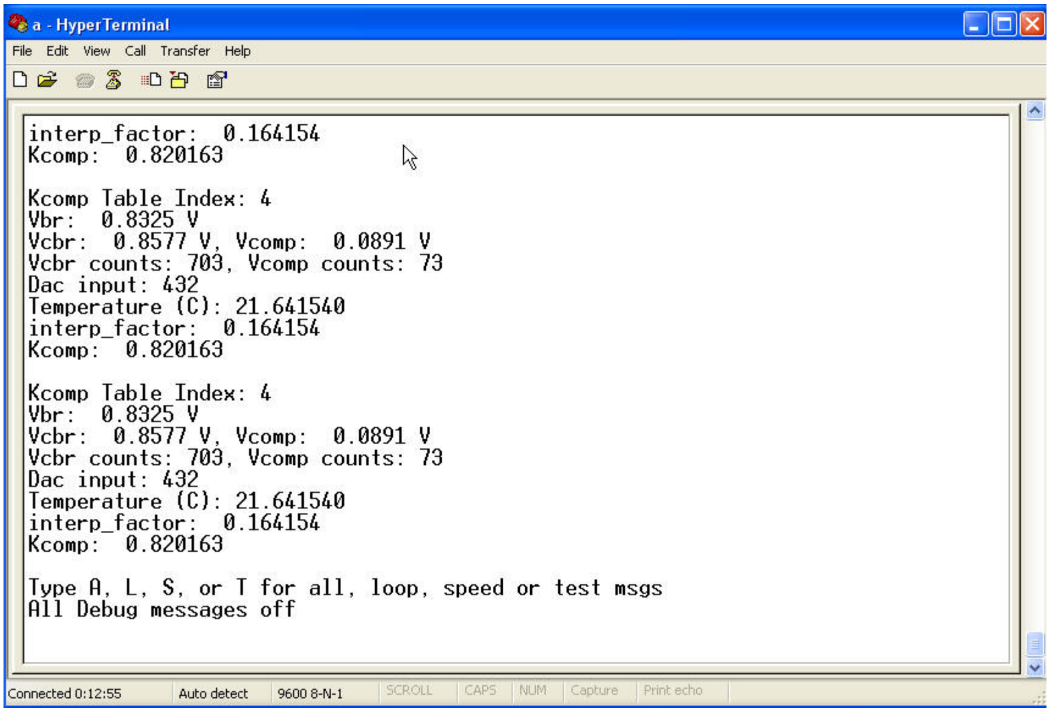

Figure 11. Debug Data Monitoring

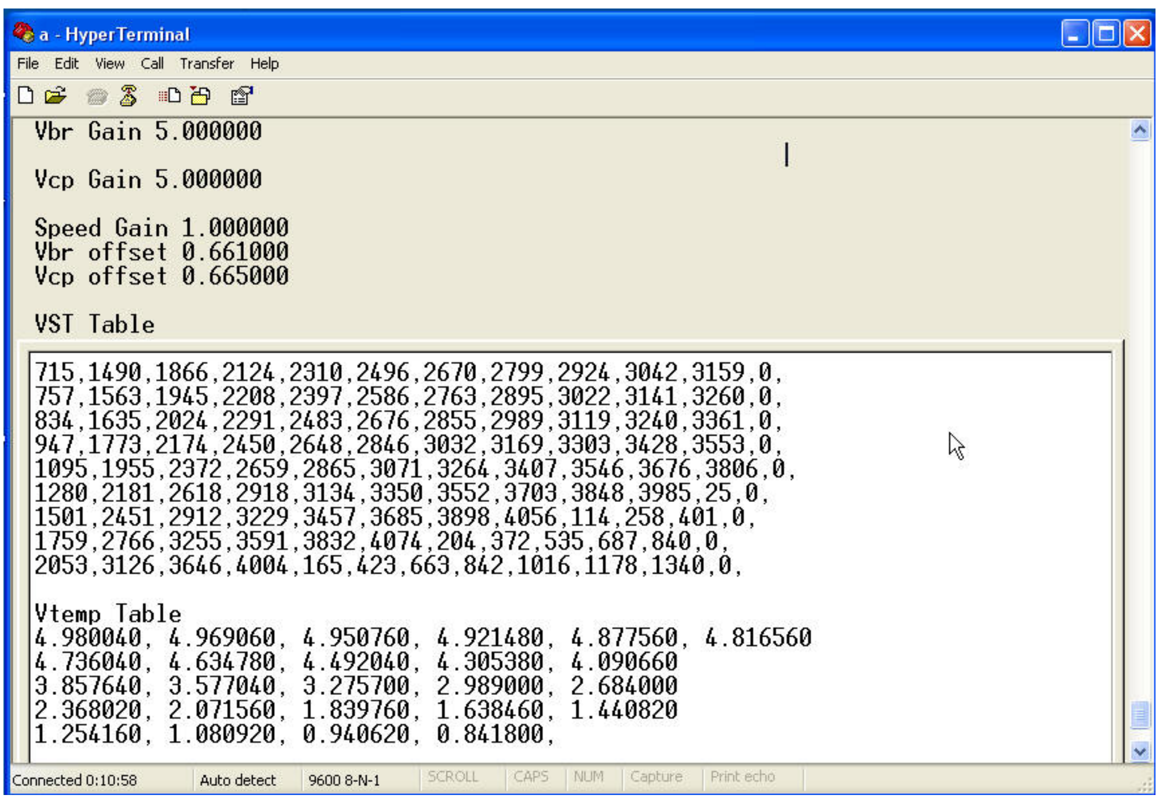

Figure 12. Gains and Offsets

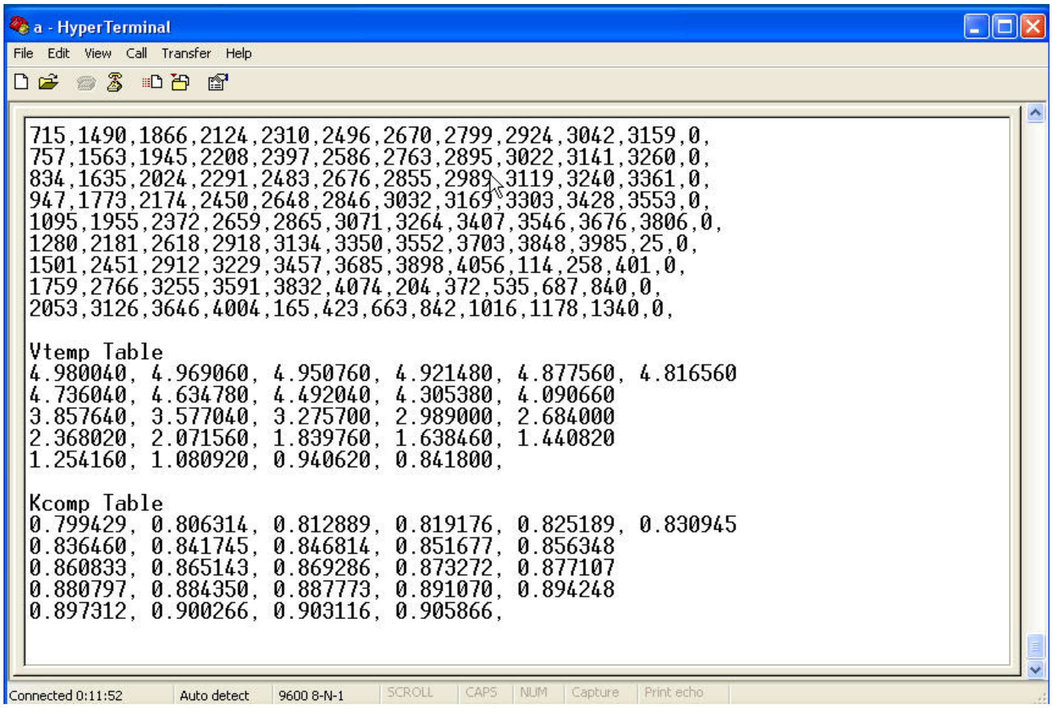

Figure 13. Kcomp Table