SDGroup Technical Note – share the knowledge

Replacement Temperature and Humidity Probe for Miller-Nelson Research Model HCS-401 Flow-Temperature-Humidity Control System

by

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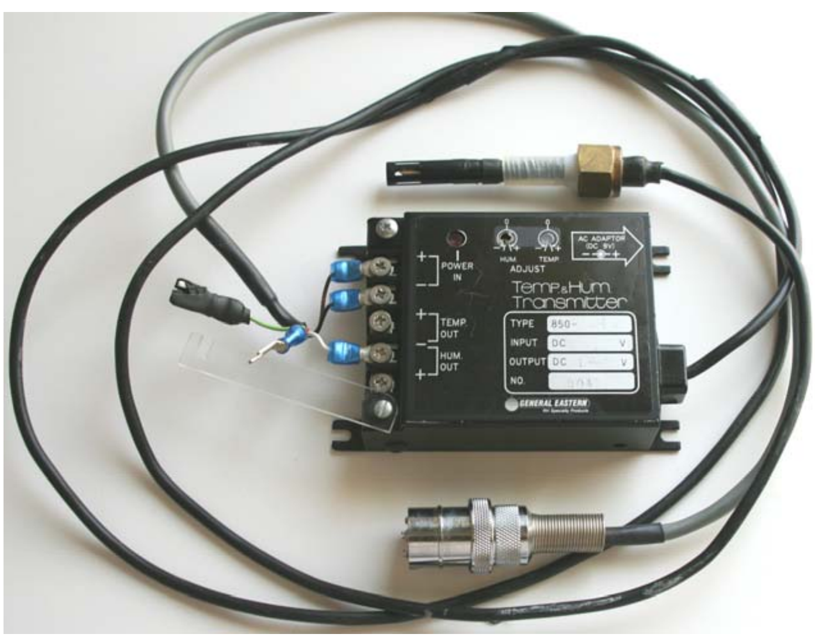
Summary. This technical note describes the design and installation of a low-cost do-it-yourself replacement probe for the Miller-Nelson Research HCS-401 Flow-Temperature-Humidity control system.

Attempts to repair the probe.

We did not have an original probe. A non-functioning replacement probe came with one of our three pre-owned, incomplete systems obtained at auction



That replacement temperature and humidity probe is shown above. The sensors are mounted in a (blue) plastic tee fitting in the output conditioned air stream. In our case, a cable from the sensors is attached to a General Eastern transmitter (type 850-242, input 12 volt DC, output 1-5 volt) and then on to a five-pin connector at the rear of the system. A backup transmitter without sensors was purchased on eBay. After some fiddling, the "repair" approach was abandoned. We simply did not have enough information, enough time, and could not easily obtain new sensors.

Official Spare Parts. Assay Technology (Reference 1) sells a complete replacement probe with sensors for about US$ 1,000. Unfortunately, our repair budget was limited.

Design a modern replacement probe.

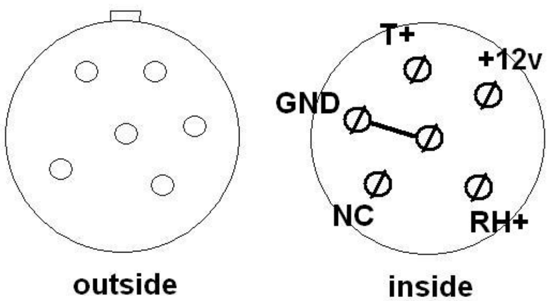
Since excellent solid state sensors are now readily available at low cost, we decided to build a new probe. The design choices and installation of a suitable probe is described in the remainder of this Technical Note.

First consideration, what signals must the sensors provide to the system?

The operation manual (Reference 2) states that the sensors provide a relative humidity signal of 0 to 5 volt, and temperature signal of 0 to 2.5 volt. Recall that the replacement temperature and humidity transmitter states that it provides 1 to 5 volts. So what does the system actually expect? This serves to remind us - don't always believe what is written, because things sometimes change and documentation rarely updates by itself!

These expected voltage levels can be measured directly. With the system cover removed, disconnect the sensors and transmitter. Use a multi-meter to verify that the 5-pin connector agrees with your system wiring. Then use a lab power supply (for example, 0-18 volt, shown below)

to send a variable voltage to the system, through the rear connector, shown below, and observe the temperature and humidity readings on the digital display. ***Be careful what you touch and where you connect***. ***Your model may be wired differently!***

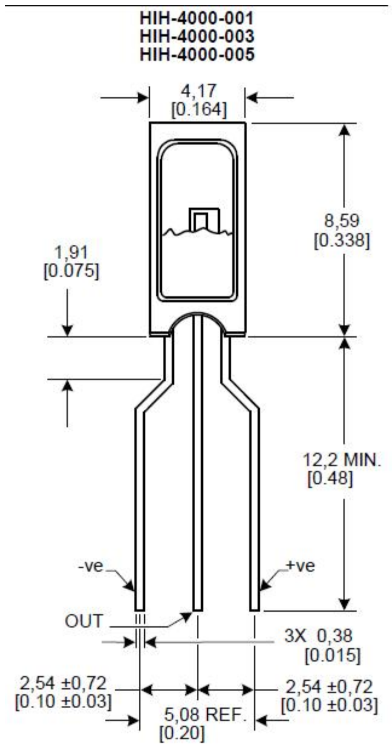


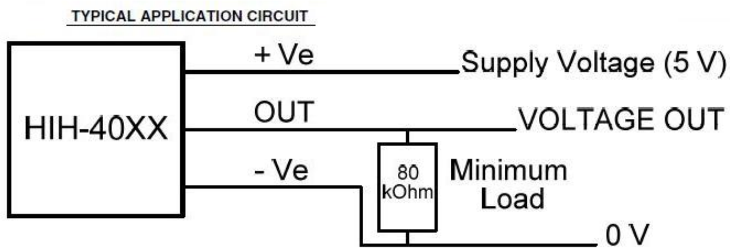
Temperature. A variable voltage input between T+ and ground should change the temperature readout. On our system, 0 volts gives a negative temperature, 0.9 volts gives 0C, and 8.9 volts gives 100C (but the system never gets that high). A plot of the values is kind of linear, but provides a reasonable first attempt. So the system expects 0.9 - 8.9 volts from the sensor to give 0-100C readings.

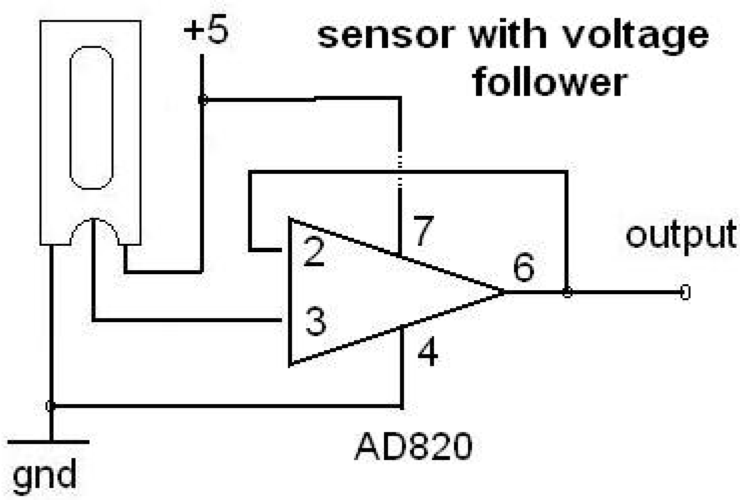
Humidity. A variable voltage input between RH+ and ground will change the humidity readout. On our system, 0 volts gives a negative value, 0.9 volts gives 0% RH and 4.9 volts gives 100% RH. A plot of the values is linear. So the system expects 0.9 – 4.9 volts from the sensor to give 0-100% RH.

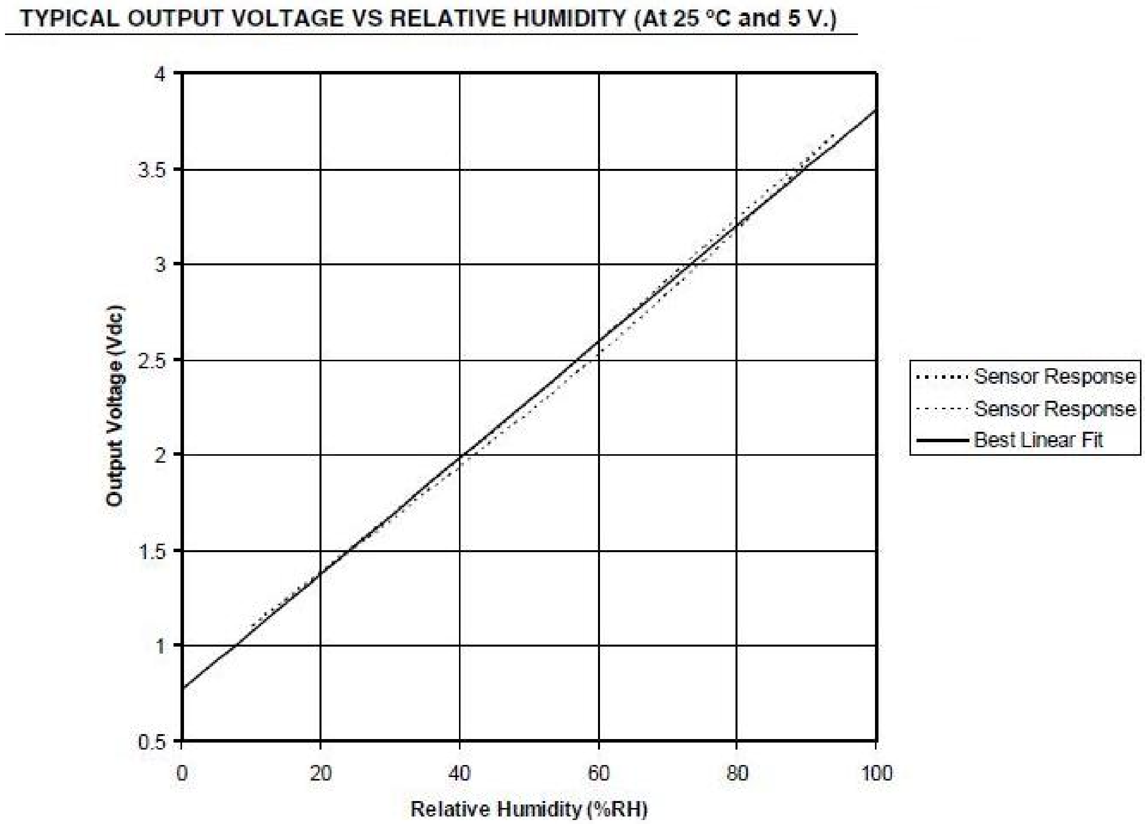
Second consideration, what sensors should be selected?

A. Humidity sensor. Consider the Honeywell HIH4000-002 or 003 (typical cost, $13 to $24 from Jameco Electronics).


HIH-4000-001
HIH-4000-003
HIH-4000-005
4,17
[0.164]
8,59
[0.338]
1,91
[0.075]
12,2 MIN.
[0.48]
-ve
+ve
OUT
3X 0,38
[0.015]
2,54 ±0,72
[0.10 ±0.03]
5,08 REF.
[0.20]
2,54 ±0,72
[0.10 ±0.03]

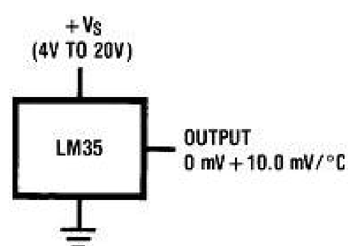

TYPICAL APPLICATION CIRCUIT
HIH-40XX
+ Ve
Supply Voltage (5 V)
OUT
VOLTAGE OUT
- Ve
80
kOhm
Minimum
Load
0 V


+5
sensor with voltage
follower
7
2
6
output
3
4
AD820
gnd



This humidity sensor is very linear, and naturally provides a 0.7 volt to 3.7 volt for 0-100% RH. Because the sensor is easily overloaded, the output signal must go through a hi-impedance voltage follower, or in our case an amplifier, such as the FET input AD820 described later. We need a gain of about 1.3x to expand from 0.7-3.7 volt range up to 0.9-4.9 volt range. No offset is needed. This sensor is powered by +5 volts.

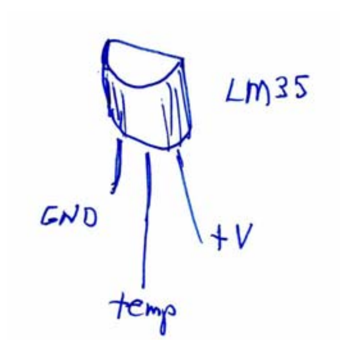
B. Temperature Sensor. Consider the LM35, precision Centigrade temperature sensor (typical cost, $1.59 from Jameco Electronics).



Basic Centigrade Temperature Sensor
(+2°C to +150°C)

TO-92
Plastic Package

BOTTOM VIEW
LM35CZ

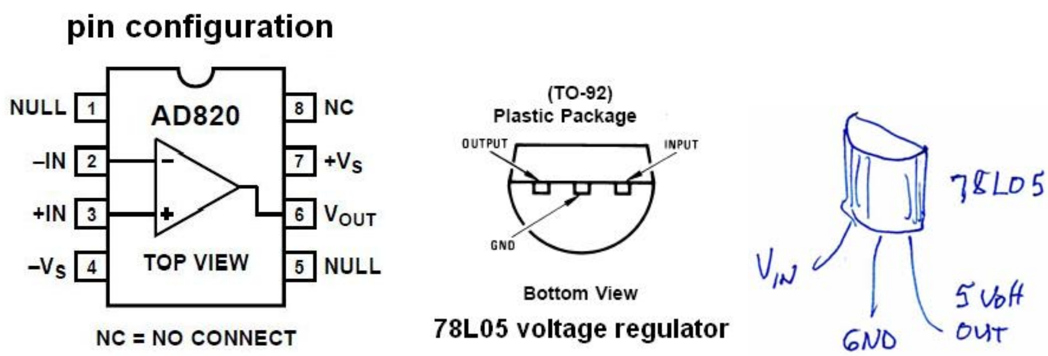


This temperature sensor provides 10 millivolt per degree Centigrade. That is, at 0C degrees it provides 0 volts, at 25C it provides 0.25 volt, and at 100C it provides 1.0 volts.

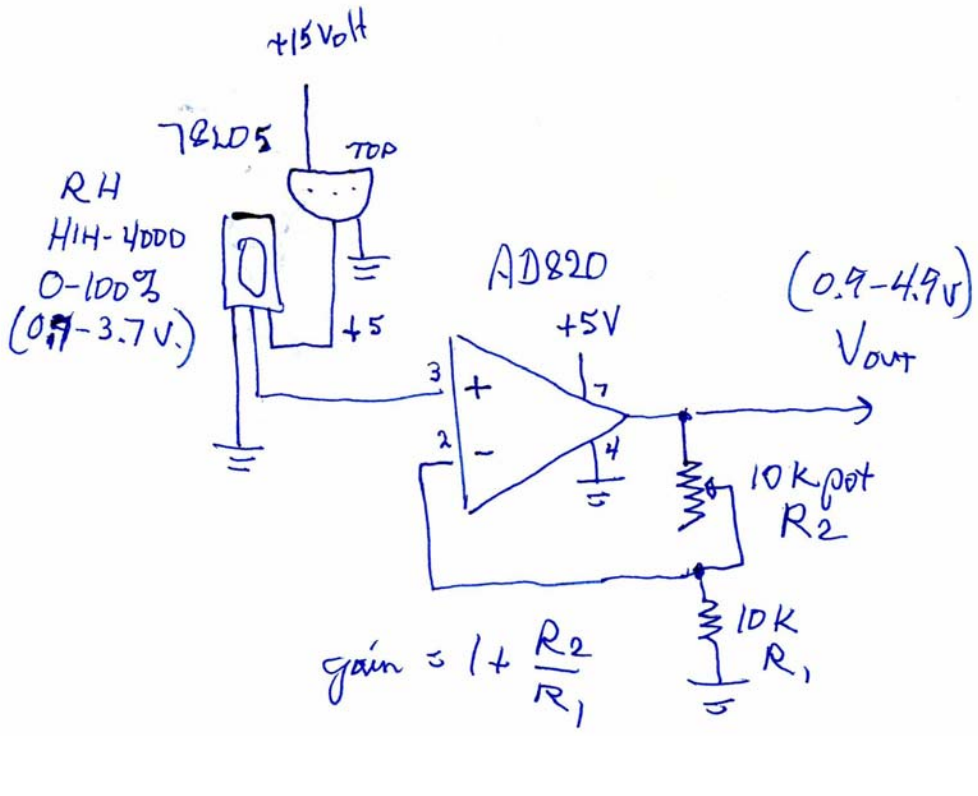
In order to match the sensor with our system we need amplification (approximately 8x gain) and offset (approximately +0.9 volts).

Third consideration, what is a suitable circuit design?

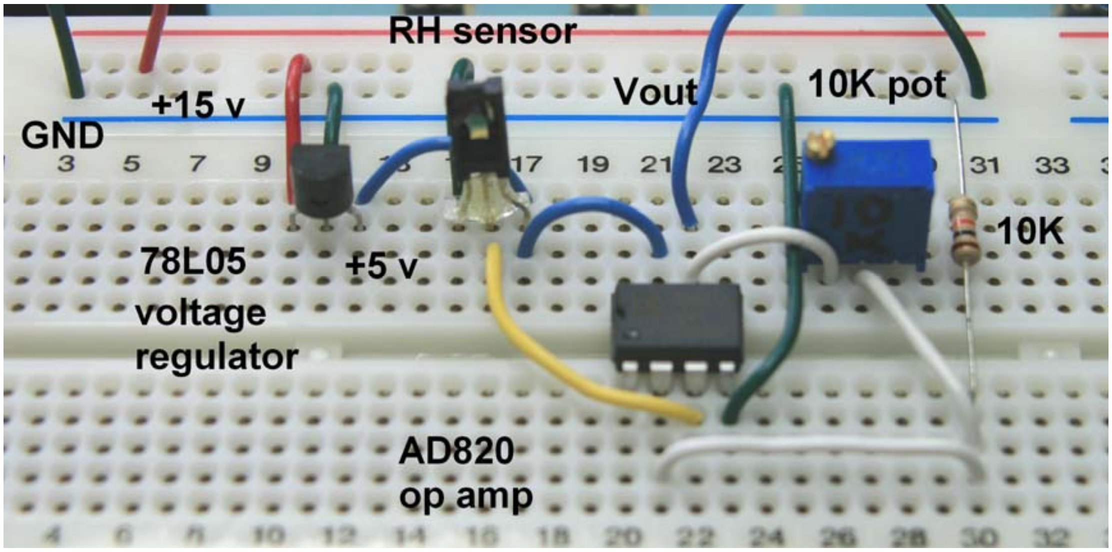
Starting from the discussion above, provide 5 volt, low current power for the humidity sensor with a 78L05 voltage regulator and appropriate amplification with the AD820 general purpose operational amplifier having very high impedance FET input and low drift.



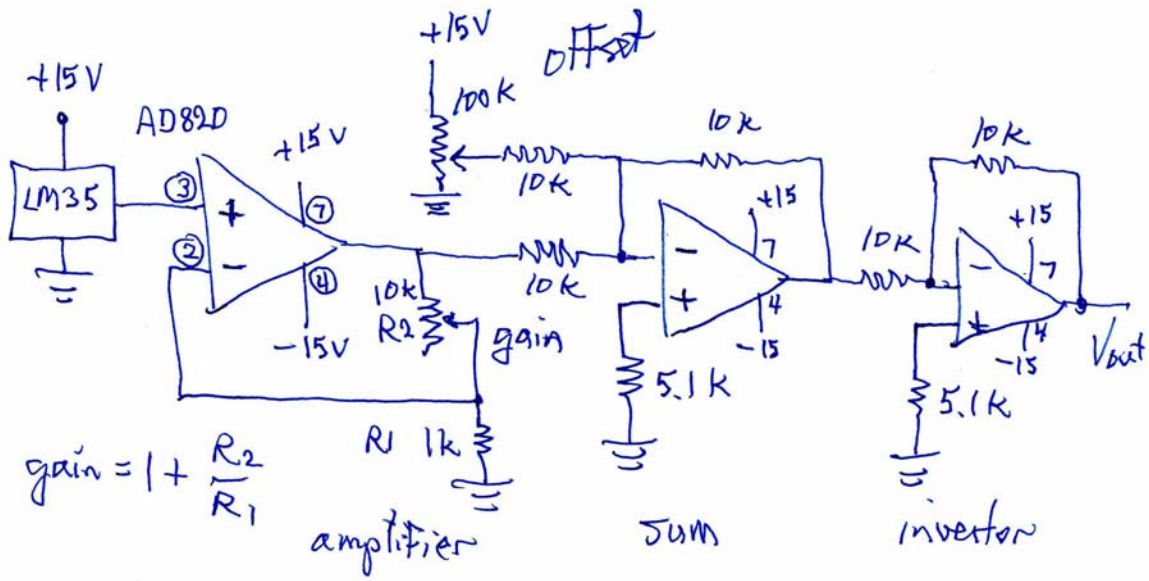
Humidity Circuit. A suitable circuit for relative humidity measurements is shown below. The required voltage follower is replaced by a low gain amplifier. Here the gain = 1 + R_2/ R_1 (Reference 3). The 10K variable resistor easily provides gain from about 1 to 2. We need a gain of about 1.35.



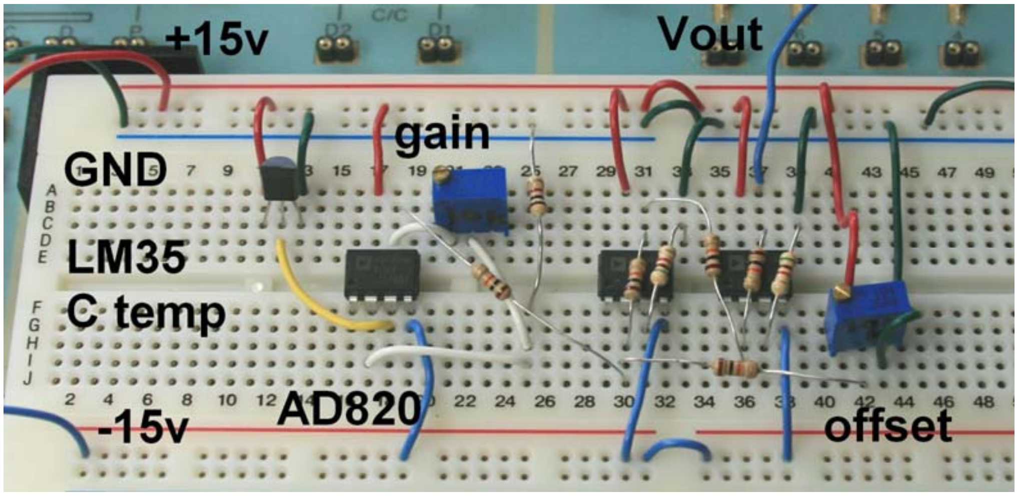
This circuit was tested on a breadboard shown below.



Temperature Circuit. A suitable circuit for temperature measurement is shown below. The temperature sensor provides a linear 10mV per C degree over the full range, giving a voltage output from 0 to 1 volt (0-100C). But our system expects 0.9 to 8.9 volt. Three AD820 op amps powered by +15/-15 volts are required. The first op amp serves as a non-inverting amplifier and provides a gain of up to 11. We need approximately 8x. A second op amp serves as an inverting summing amplifier, with adjustable offset, here using a 10K or 100K pot. Since the signal at this point is the desired value but negative, a third op amp inverter stage provides a final positive value. Less expensive op amps, such as LM358, may be substituted – but decide only after testing your circuit.



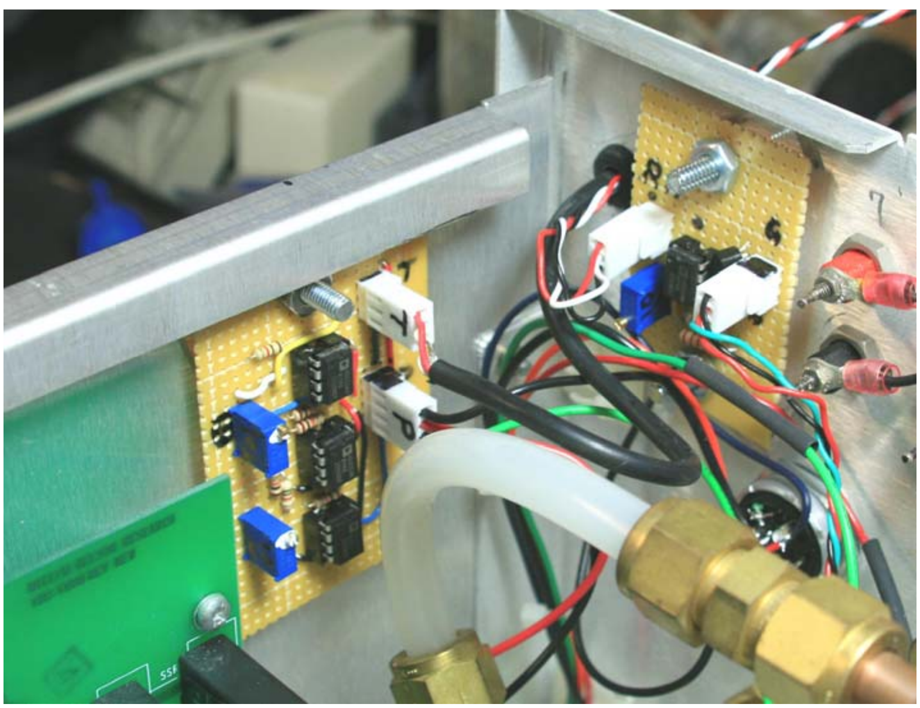
The circuit was tested on a breadboard shown below.

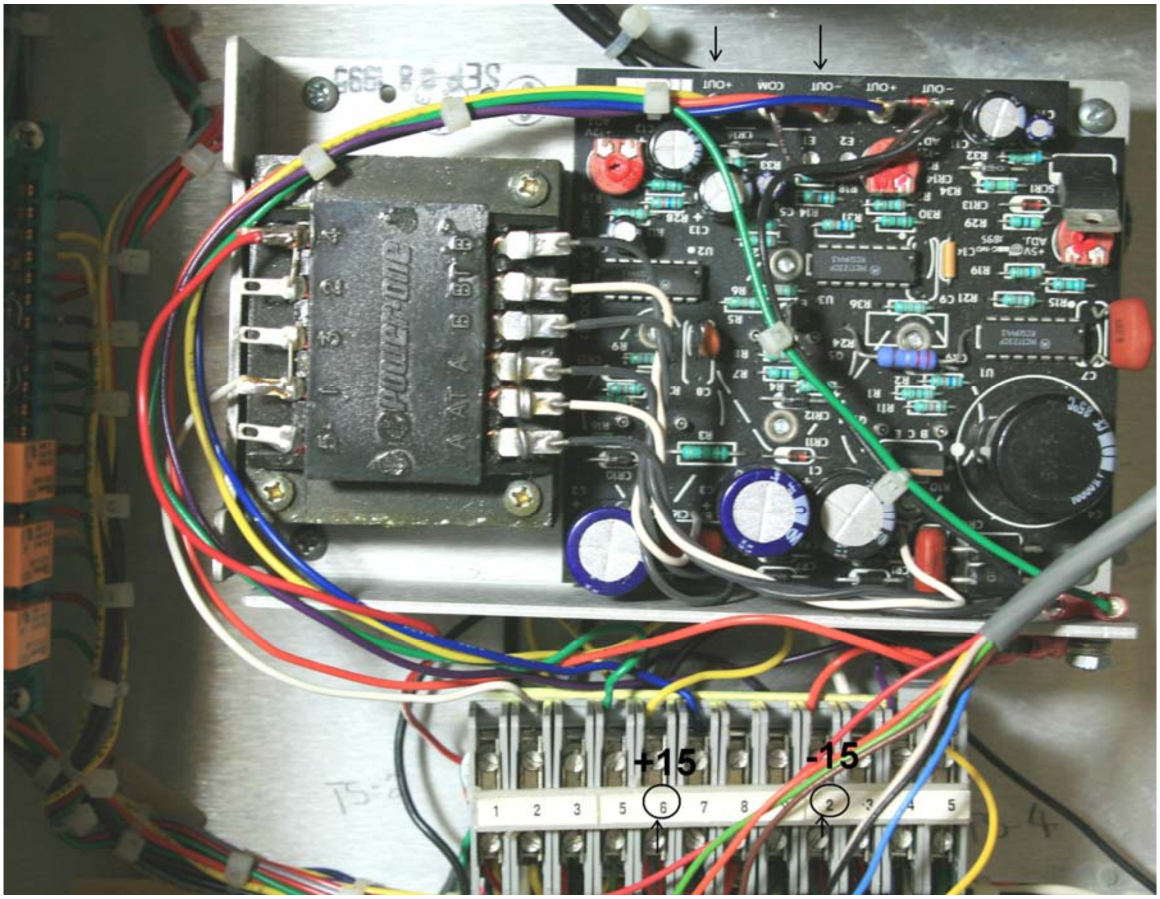


The two breadboard circuits can be combined onto perfboard for use in the system.

Installation. We mount the perfboard circuits on the rear and side wall and run wires to the sensors through a hole and grommet. Power is supplied from +15volt and -15 volt running from the main power supply and connection block. On our model these connection points are numbered at the main connection block as 6 (+15 volt) and 2 _15 volt).

The photo below shows the humidity perfboard at the right, grommet to its left and round 5-pin connector below. The temperature perfboard is at the left.





GOOD LUCK!

References:
1. Official replacement parts are available from Assay Technology, Livermore, California, www.assaytech.com
2. Operation Manual (PDF), www.assaytech.us/op_manual_hcs_401.pdf
3. nice discussion of voltage follower, summing and inverting op amps, pages 224-226, Paul Scherz, Practical Electronics for Inventors, McGraw Hill (2000)