

Meteorology 433

Thermometry

Spring 2022

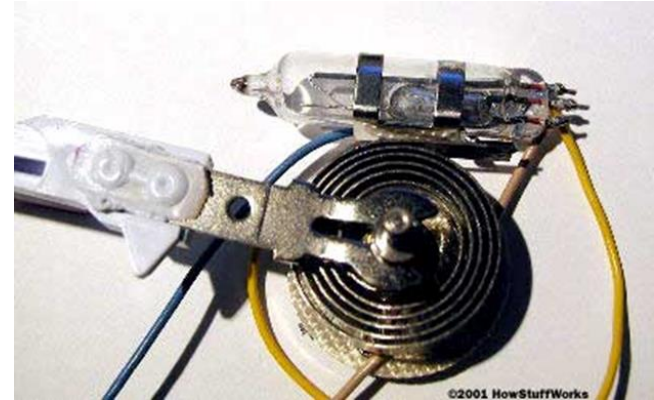
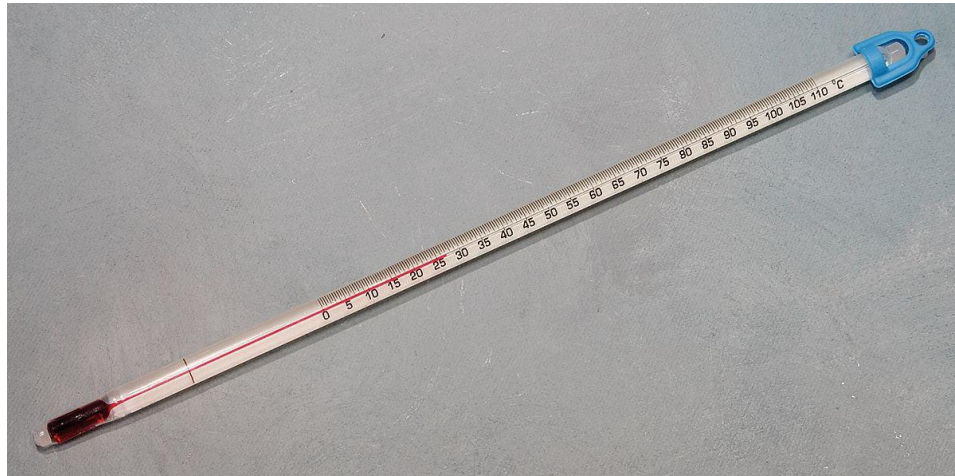
General

- Temperature impacts every day life.
- Errors of 2-3 °C are not uncommon in many networks.
 - Bank thermometers or Car thermometers.
- Errors of this magnitude are generally acceptable to the general public.
- Errors of just 1 °C have been shown to be the deciding factor between no storms initiated, and intense storms in mesoscale models (Crook, 1996)
- Errors as small as 0.2 °C can change prediction of a global climate model, depending on initial conditions (DeFelice, 1998).

Categories

- Temperature sensors are categorized according to the physical principle they use.
- Mechanical (thermo-expansion)
 - Direct indicating instruments
 - Mercury or Alcohol
 - Bi-metallics
- Electronic (thermo-electric)
 - Thermocouples.
 - Electrical resistance.
 - Thermistors.
 - LM35 or similar integrated circuit device.
 - Designed to work with data loggers.
- Sensing can be passive or remote.

Mechanical Sensors



Thermocouple

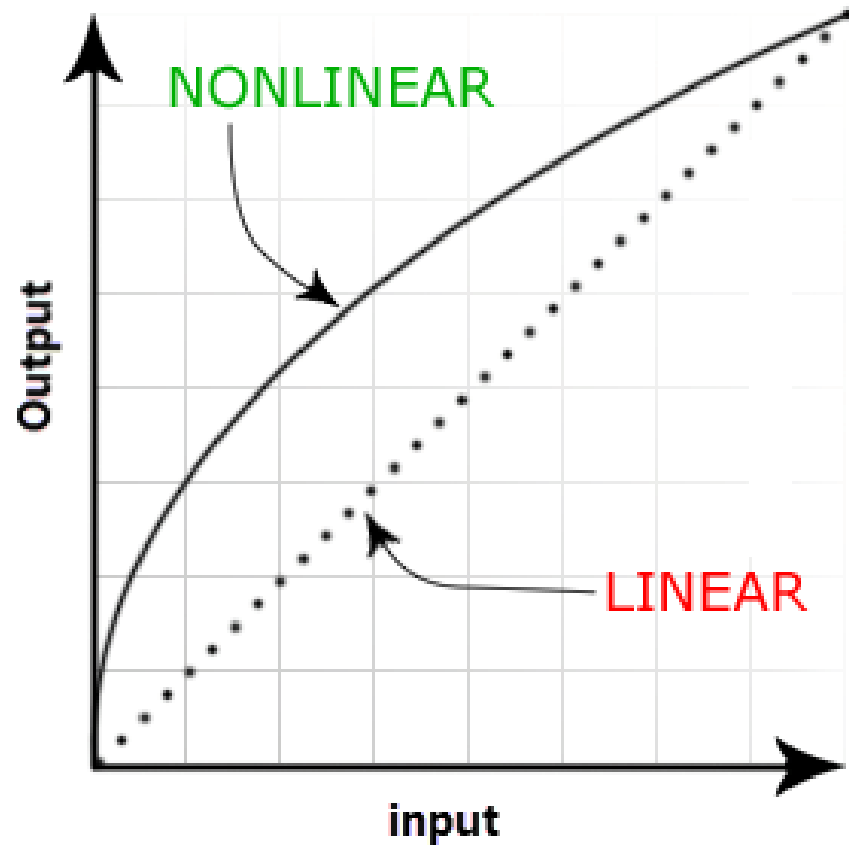
- Junction of two dissimilar metals
- Seebeck effect: when the temperature of the two junctions of two dissimilar metals are at different temperatures, a voltage develops between them.
 - Thomas (1821)
- By measuring the voltage difference between the two junctions, the difference in temperature between the junctions can be calculated.
- Alternately, if the temperature of one junction is known and the voltage difference is measured, then the temperature of the second junction can be calculated.
- Want more details? See five “laws of thermocouple behavior” starting on page 67.

Advantages/disadvantages

- Advantages
 - Rugged
 - Reliable
 - Inexpensive
- Disadvantages
 - Very low voltage output ($\sim 40 \mu\text{V} / ^\circ\text{C}$) – amplifier needed.
 - Slight non-linearity
 - Need to be calibrated
- Thermopile: a number of thermocouple connected in series.
 - All junctions are exposed to the same temperature
 - Voltages add up allowing for a large voltage.

What is a linear sensor?

What can you say about the static sensitivity of these sensors?



Electrical Resistance Sensors

- Resistance varies as a function of temperature.
- Conductive sensors \equiv Resistance Temperature Detectors
 - RTD's
- Thermistors

RTD's

- Platinum is most common
 - Stable, Resists corrosion, High melting point
 - Simple resistance-temperature relationship
- $R_T = R_0 (1 + aT + bT^2)$
 - Sufficient accuracy from -50 °C to 50 °C.
 - R_0 = resistance at 0 °C.
 - Coefficients a and b depend on purity of platinum.
- What if b is small?
- Resistance is converted to a voltage.

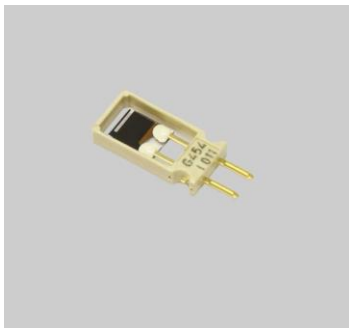
RTD



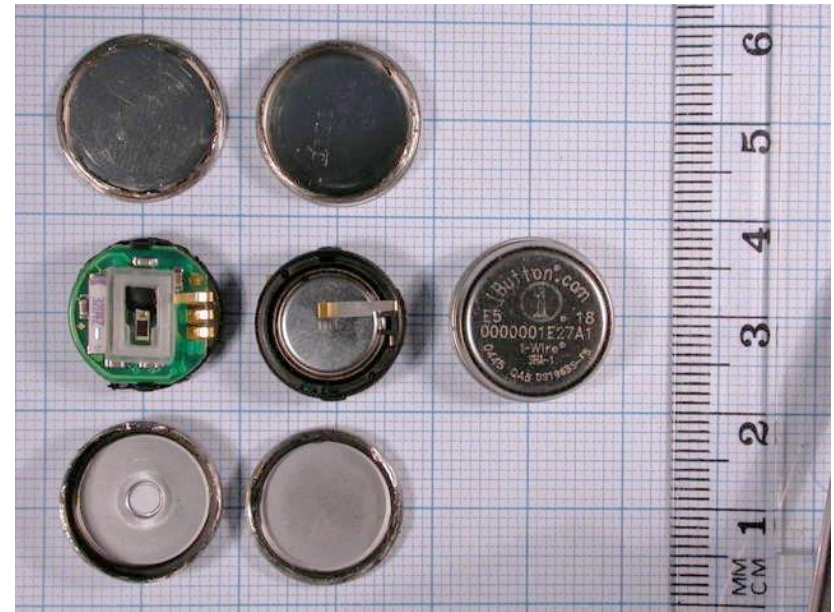
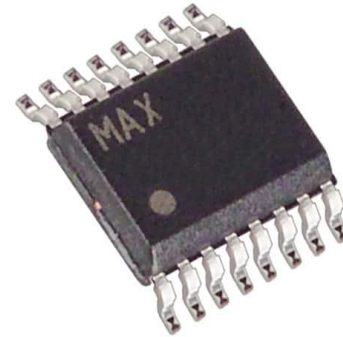
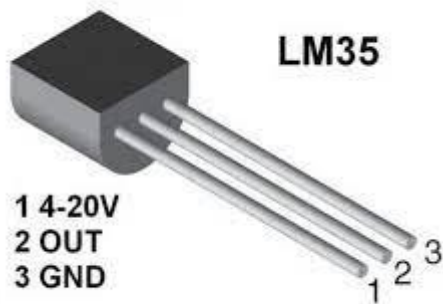
Thermistors

- Temperature sensitive semiconductors
 - Typically metallic oxides.
- Large and significantly non-linear temperature sensitivity.
- Transfer equation.
 - Most have decreasing sensitivity with increasing temperature.
- Despite their nonlinearity, thermistors are used in a wide variety of applications.
- High resistance (compared to RTD's)
 - Lead wires

Thermistors



Integrated Circuit Sensors



RTD Problem

- Self-heating.
- Measurement of resistance typically involves the passage of electrical current.
 - Heats RTD.

Exposure

- What processes or types of exposure errors is a temperature sensor (without a shelter) exposed to?
- Conduction
- Convection
- Radiation

Reducing Exposure

- Completely isolate the instrument from the atmosphere.
- Conduction: non-heat conductive mounting bracket.
- Convection: Shelter that isolates it from the air flow.
- Radiation: Highly reflective shelter.
- Sensor still needs to be in contact with what you are measuring, i.e., the atmosphere.

Gill Plate Aspiration

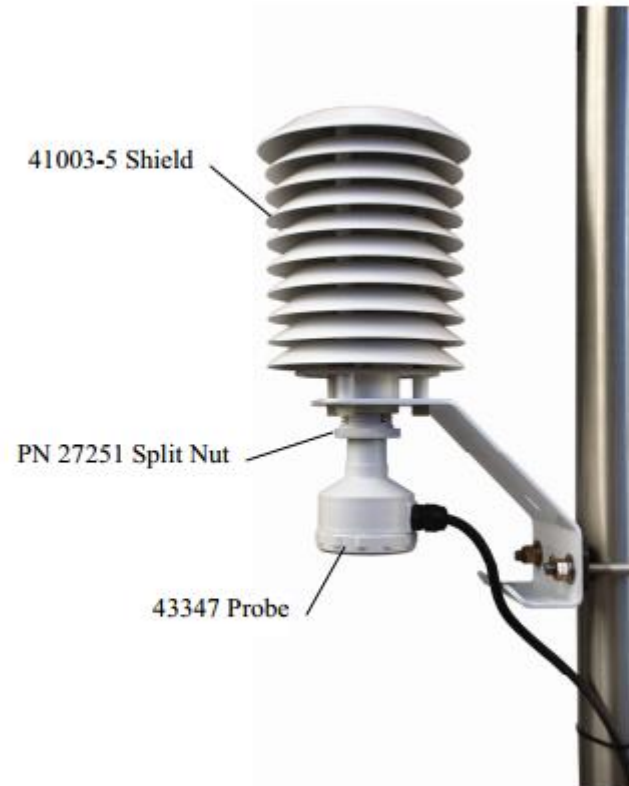


FIGURE 3-3. 41003-5 Radiation Shield Mounted to Tripod Mast

Compact Fan Aspiration



No win situation

- If snow is present (or other highly reflective ground surface), the exposure errors will increase.
- Exposure errors are always excluded from laboratory calibrations, so manufacturer performance specifications are not necessarily a good prediction of actual field performance.