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Bipolar vs. Unipolar Sensors

CONCEPTUAL REVIEW, SIGNAL DIAGRAMS, BASIC SETUP

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Contents

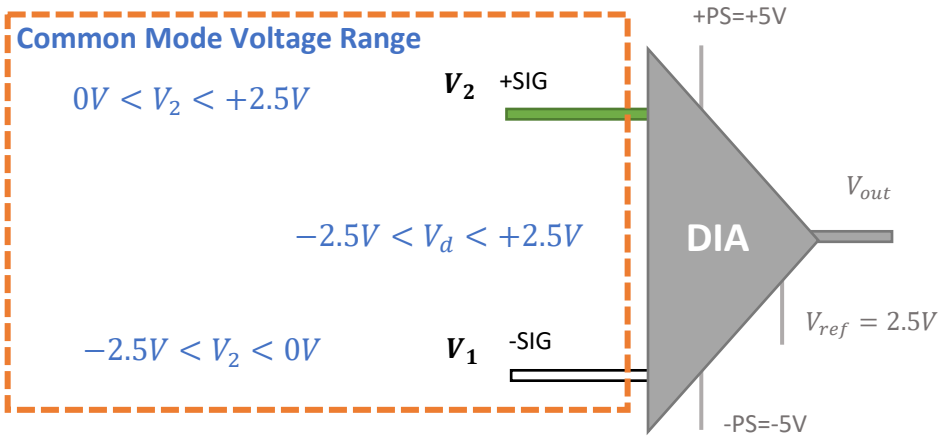
Introduction

While both Bipolar and Unipolar Sensors have generally wide use, Bipolar transducers are the most common. This article describes how their signal is interpreted in a DTS Data Acquisition System (DAS) to give the user a strong foundation.

Signal Range with Bipolar Sensors

For a bipolar sensor (which reads both negative and positive polarity), the total signal must be split in two, with half being used for the positive polarity and the other half being used for the negative polarity. Both the Positive and Negative Signal feed into the Differential Instrumentation Amplifier (DIA).

For now, we will be focusing on the Common Mode Range prior to any Reference Voltage or Gain is applied. The limits to the amplifier in this example are shown below. In theory, the lower half of our signal (-2.5V to 0.0V) is therefore available for the negative polarity, and the upper half of the signal (from 0.0V to +2.5V) is available for the positive polarity.



For safety, however, we never want to measure a signal that meets the limits of our Common Mode Range. Its best to give a **Safety Margin** of 0.1V in each direction. We will use -2.4V to 2.4V Common Mode Range, and our **Halfway Point (HP)** will fall on 0V (see diagram below). Since our sensor is bipolar, it should report 0V at its Halfway Point, or **0 EU**.

For a more comprehensive breakdown of DIA's, click here for the article: **Further Reading**

Signal Range with Bipolar Sensors (cont.)

OFFSET and ZEROING: No sensor is perfect, and a bipolar sensor may report a small non-zero voltage. We would need to remove this imperfection to proceed.

- **Offset:** **Remove**
- **Zero Type:** **Whatever suits the test at hand**

INITIAL EU: As explained above, a bipolar sensor has Zero EU at its Halfway Point, which keeps this simple for a bipolar sensor:

- **Initial EU:** **Zero**

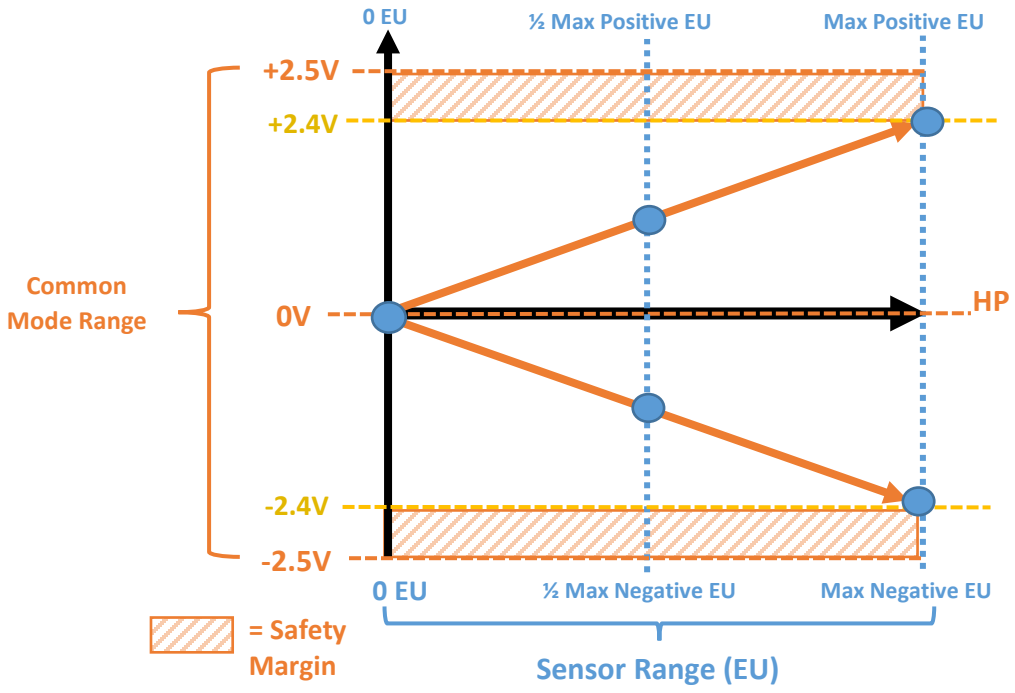
CALIBRATE: A bipolar sensor is calibrated simply by inputting the sensitivity value, based on the calibration sheet and your excitation voltage.

- **Calibrate Using:** **Sensitivity**

SENSITIVITY: The sensitivity is therefore the critical part of the sensor calibration, as at this point, we already know our Initial EU should be zero. The Calibration Sheet (or "cal sheet") will give us this final piece.

- **Sensitivity:** **Use Calibration Sheet Data**

Figure 1: Common Mode Range of a Bipolar Sensor

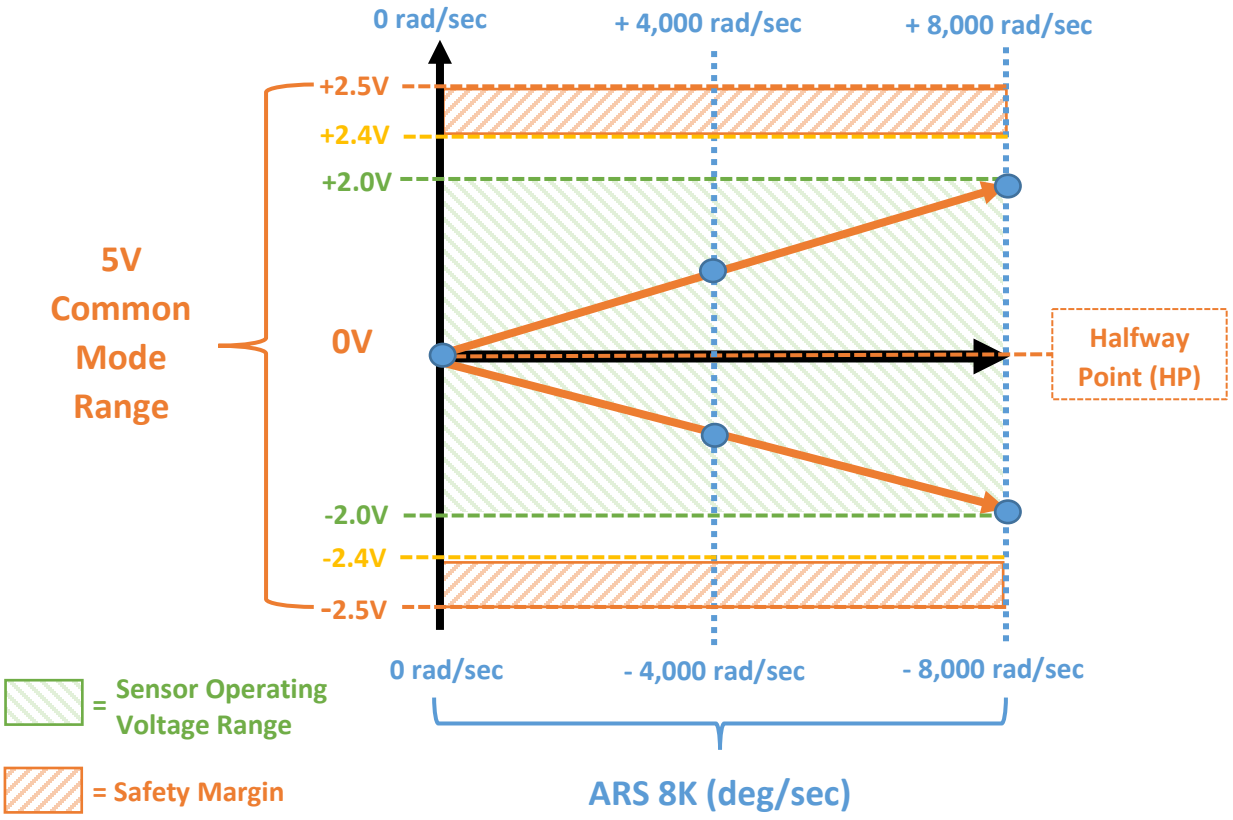


Bipolar Sensor Example – ARS 8K

Let's take an ARS with an 8,000 rad/sec range and use it with 5V Common Mode Range. Since a typical ARS of this type will read 8,000 rad/sec in the positive direction, and 8,000 rad/sec in the negative direction (this makes it bipolar), we want to use our whole 5V signal range across that entire output.

Typical sensors that work with a 5V sensors operate around 2.0V for each polarity. The example ARS here gives us a +/- 2V **Sensor Operating/Nominal Voltage Range**, which falls well into the safety margin explained in the previous section.

Figure 2: Example: Bipolar Sensor (ARS 8K) and Excitation Range (5V)



Signal Range with Unipolar Sensors

For a sensor that is not bipolar, its output signal will typically begin at or near zero then approach its max reading. An example Thermocouple runs from 0°C to 1250°C. It does not have an evenly split negative and positive range.

OFFSET and ZEROING: As discussed in the previous section, a bipolar sensor's Halfway Point should report around 0V, and as no sensor is perfect, we would need to remove any non-zero offset voltage. However, a unipolar sensor reading temperature or pressure will have an initial reporting voltage that references our ambient temperature or pressure, so we do not want to remove this voltage from the readings.

- **Offset:** **Do Not Remove**
- **Zero Type:** **Absolute Zero**

Initial EU: The Halfway Point (HP) is still halfway through our signal, but as our unipolar sensors range is not centered at zero, we need to find that actual halfway value. By looking at actual midpoint of the reported range of our unipolar sensor (for example, 0°C to 1250°C), we can estimate that Initial EU (1250/2 which is 625°C). This number is also the starting point for our sensor calibration (see below). Any Lower Limit (negative range) is added afterwards to ensure we are properly centered.

- **Initial EU:** $\left(\frac{1}{2}\boldsymbol{Sensor\ Range}\right) + \boldsymbol{Lower\ Limit}$

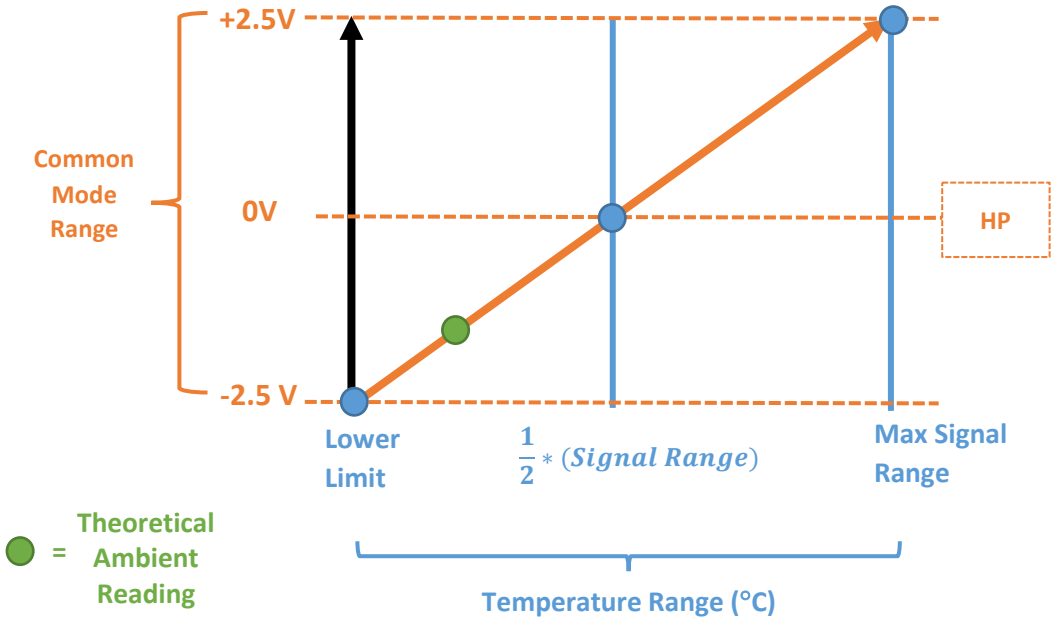
CALIBRATE: Since our unipolar sensor is likely reporting an ambient value, to calibrate the sensor by fine tuning that Initial EU. If we used that 625°C estimate, we could begin there then adjust it as needed to match a known ambient reading. A more robust method would be to also measure 0°C and 100°C using a calibrated thermometer or simulator, and adjust accordingly.

- **Calibrate Using:** **Initial EU**

SENSITIVITY: Here we'll still use the Sensitivity from the sensor's calibration sheet, relying on the Initial EU precise adjustments for the calibration.

- **Sensitivity:** **Use Calibration Sheet Data**

Figure 3: Differential Signal of a Unipolar Sensor within the Common Mode Range



The lower green circle could theoretically be room temperature, were this a thermocouple or other temperature detecting device. As we setup the unipolar sensor, we would want to ensure we take the above into account as we calibrate it for best use.

For using the above concepts with Thermocouples, click here for the article: Further Reading

Additional Reading: Measuring Temperature with DTS DAS

We have a full summary on measuring temperature with DTS Data Acquisition Systems, which describes the basics of each method and links to more comprehensive articles.

To see our summary on **Measuring Temperature with DTS DAS** and all related articles, click here: Further Reading

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