

# Understanding Common Measurement Terms



## Abstract

This technical brief will explain four commonly used measurement terms and how they relate to cathodic protection:

- Resolution
- Range
- Sensitivity
- Accuracy

Measurement terms are typically included in specifications for digital volt meters, data loggers and other remote monitoring or survey instruments you use in your cathodic protection program. In this paper, we describe four of the most commonly used terms and how they can impact the measurements you rely on to make critical maintenance and mitigation decisions.

## Resolution

Resolution is the smallest digitized measurement increment that a device can represent. It's often described as x parts of y. Resolution can also be described in terms of bits, with each bit acting as a power of two. This means that a device with 3-bit resolution can represent 8 voltage levels (or 1 part out of 8) while a device with 16-bit resolution can represent 65,535 voltage levels (or 1 part out of 65,535). An example you might see in a data sheet for a remote monitor is 1 mV resolution on a 10-volt range. This implies 1 part out of 10,000.

For cathodic protection measurements, resolution is only critical if the smallest increment that can be represented would trigger a decision if visible.

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For example, a pipe-to-soil reading of 0.833 versus a reading of 0.912 volts is actionable but a reading of 0.833 volts versus a reading of 0.8334 volts is not.

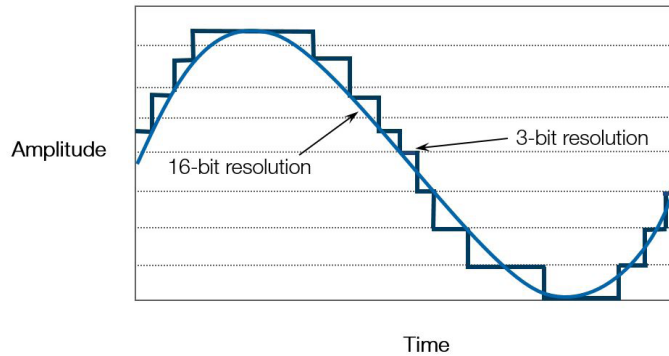


Figure 1: 16-bit resolution is more precise than 3-bit resolution

## Range

Range describes the highest and lowest measurement that a device can take. It is often expressed as  $\pm x$ , where  $x$  is the unit of measure. For example, a range of  $\pm 200$  mV means that the highest measurement that can be taken by the device is 200 mV and the lowest is  $-200$  mV.

It's important to ensure that your instruments have a sufficient range for the measurements you'll be taking with them. For example, an AC coupon monitor with a range of  $\pm 200$  mA that's being used to measure current on a  $10 \text{ cm}^2$  coupon is able to measure current densities of up to  $200 \text{ A/m}^2$ . If you expect lower current density than that, a range of  $\pm 200$  mA will be sufficient. Note that instruments can have multiple ranges. For example, most digital volt meters have multiple voltage ranges with autoranging so that they can provide the best resolution for a broader range of input signals.

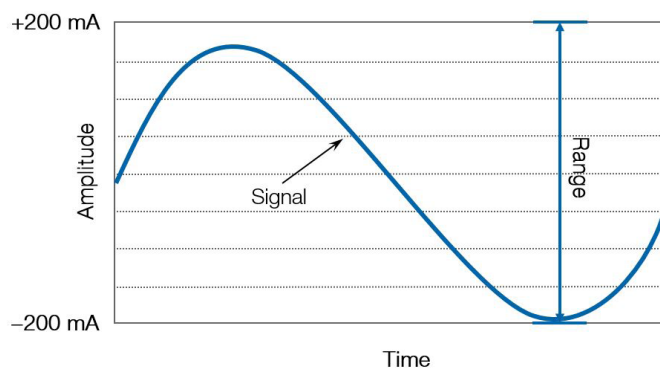
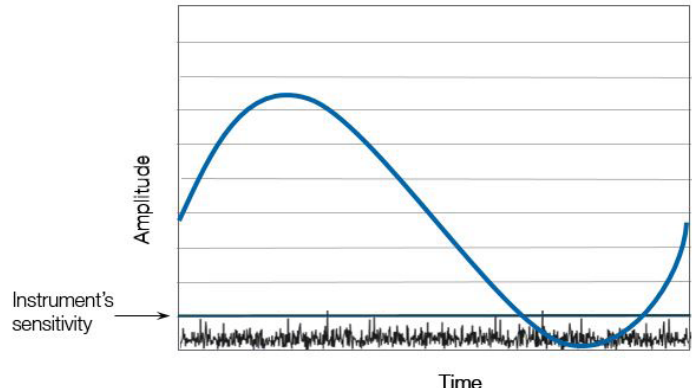


Figure 2: Range must accommodate your expected measurements

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## Sensitivity

Sensitivity is about measurement detection. It is the smallest signal that a particular instrument can detect on its most sensitive range, which is largely dependent on its baseline noise level. It's not the same as resolution, which describes how finely the device can digitize a signal. For instance, a device might have a sensitivity of 10 microvolts on its most sensitive range, but the same instrument might have a resolution of only 10 mV on its most sensitive range.

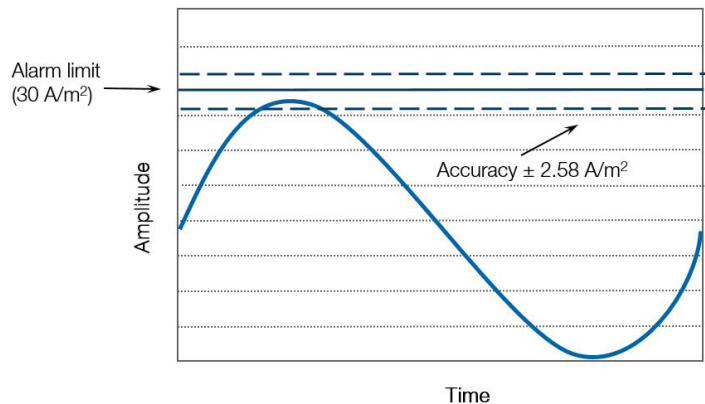


**Figure 3: An instruments sensitivity is largely limited by its baseline noise level**

For example, if you want to measure AC interference on a pipeline using an AC corrosion monitoring device, you need to make sure your instrument is sensitive enough to detect a signal well below your alarm levels. This will prevent false alarms or uncertainty about whether you have a problem or not. As such, if you have a 1 cm<sup>2</sup> coupon with an alarm level of 30 A/m<sup>2</sup>, you must have a sensitivity well below 3 mA. In this case, a sensitivity of 0.3 mA (10 times better than what you are trying to measure) would be advisable so that you don't confuse the measurement you're trying to take with instrument sensitivity issues such as noise, drift, etc.

## Accuracy

Accuracy is about measurement uncertainty relative to standards. For example, NIST, the National Institute of Standards and Technology, is responsible for measurement standards in the United States. Accuracy is often expressed as a percentage of a reading plus a percentage of range, and it illustrates the expected difference between the device's measurement and absolute traceable standards. The percentage of range term represents the offset error, while the percentage of reading term describes gain accuracy or inaccuracy, depending on the magnitude of the input signal.



**Figure 4: Ensure accuracy is sufficient to measure actual AC current density**

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For example, assume you want to take a 29 mA measurement on a monitoring unit's 200 mA range and that the device's accuracy specification is  $\pm (2 \% \text{ of reading} + 1 \% \text{ of range})$ . In this case, the expected error is going to be  $\pm 2.58 \text{ mA}$  ( $0.58 \text{ mA} + 2 \text{ mA}$ ). With the threshold for corrosion risk at  $30 \text{ A/m}^2$ , this instrument is probably not going to be accurate enough to effectively monitor the risk of AC corrosion. In this example, the percent of range is the limiting factor since it represents the majority of the error ( $\pm 2 \text{ A/m}^2$ ).

## Summary

We hope this paper has helped you better understand why selecting instruments with the right measurement resolution, range, sensitivity, and accuracy is critical to determining the most appropriate mitigation activities and maintaining safe operating conditions.

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