SENTRAN

TechNote

Innovative Measurement Solutions

# ACCURACY vs. RESOLUTION

*The term "accuracy" is frequently used in place of, or interchangeably with, the term "resolution". In fact, these two terms represent distinct performance characteristics. Resolution can often be more important than absolute accuracy, while resolution is in no way indicative of the accuracy of a sensor, transducer, load cell, weigh module, or related measurement system.*

**SO WHAT IS ACCURACY?**

The term accuracy can be stated as: "The conformance of a measurement relative to a standard or true value, often expressed as a percentage." For practical purposes, one can say it is, "An error tolerance limit that defines the average deviation between the actual output versus the theoretical output." In real world applications, the influence factors of nonlinearity, hysteresis, repeatability and temperature effects will not occur with absolute predictability, and they are not necessarily additive. Therefore, accuracy should be calculated based on the RMS value of the potential errors, a defined temperature range, as a percent of Full Scale Output (FSO), and in consideration of other mechanical and/or electrical influences.

**INFLUENCE FACTORS DEFINED**

The influence factors of nonlinearity, hysteresis, repeatability and temperature effects must be considered in determining the overall accuracy statement. The definition of these parameters is:

- Nonlinearity: The maximum deviation of the output curve from a theoretical straight line, which is drawn between the no load output and the output at rated capacity. Nonlinearity is expressed as a percentage of FSO and is measured during increasing loads only.
- Hysteresis: The maximum deviation of the output curve relative to the nonlinearity output curve at the same load, and measured in the same load cycle. Hysteresis is expressed as a percentage of FSO and is measured during decreasing loads only.
- Repeatability: The maximum difference between repeated output measurements made at identical loading point(s) under identical loading and environmental conditions.
- Temperature Effect On Zero Balance (TCZ): The change in zero balance due to a change in the sensor, transducer or load cell element temperature. This effect is expressed as a percentage of FSO per unit of temperature, e.g. "0.0015%/°F".
- Temperature Effect On Output (TCO): The change in output due to a change in the sensor, transducer or load cell element temperature. This effect is expressed as a percentage of FSO per unit of temperature, e.g. "0.0008%/°F".

Any precision measurement must be accompanied by the necessary facilities to address influence factors that can affect the accuracy, including: mechanical constraints and interference; load introduction anomalies; creep; thermal radiation; instrumentation power, signal conditioning or display variability; improper installation, setup or calibration, to name some. Generally speaking the sensor, transducer, load cell, or weigh module (hereafter simply referred to as a "transducer") can produce results that meet or exceed specifications. Unfortunately, these influence factors and others will affect the high performance capabilities of the measurement system. Reasonable care in managing these unwanted affects by employing the many techniques and accessories available to optimize mechanical and electrical performance will yield optimum results.

**SO WHAT IS RESOLUTION?**

The term resolution can be stated as: "The smallest incremental change in mechanical input that produces a detectable change in the output signal." Resolution is often characterized as a percent of Full Scale Output, e.g. 0.01% FSO. It is also be expressed as a ratio, e.g. 1:10,000, which is stated as

"one part in ten thousand divisions, or increments/counts/graduations". Both expressions define the same degree of resolution.

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## IDENTIFYING POTENTIAL INFLUENCE FACTORS

The factors that can influence the resolution of a measurement system include both mechanical and electrical phenomenon. The variability of one system to the next makes it impractical to attempt to define every possible consideration, so we will focus on the more common concerns for the sake of illustrating the issue.

The influences mentioned here are inter-related in some instances:

- Transducer sensitivity
- Bridge excitation voltage
- Instrumentation sensitivity and A/D resolution
- Vibration
- RFI/EMI
- Deadload/Liveload ratio
- Proper setup/calibration of the measurement system
- Incorporating “dummy” load cells in a weighing system
- Intrinsic safety barriers
- Long cable runs

Next, let’s take a look at how we can perform an accurate and reliable computation to select the optimum transducer capacity for any given application.

## SIGNAL SENSITIVITY

The industry standard for specifying the output signal strength of a strain gage-based transducer is expressed as a milli-volts per volt (mV/V) sensitivity at rated capacity. This sensitivity is often referred to as the Full Scale Output (FSO). The most common FSO ratings are 2 mV/V or 3 mV/V, nominally. Therefore, a transducer with a sensitivity of 3 mV/V will produce an output signal of 3 mV with 1 Volt of bridge excitation when loaded to rated capacity. Similarly, the same device will produce an output signal of 30 mV with 10 Volts of bridge excitation when loaded to rated capacity.

## THE INSTRUMENTATION FACTOR

The signal sensitivity of the transducer’s companion instrumentation can play a significant role in achieving the desired resolution for a given application. Typical instrumentation signal sensitivity for these devices is in the range of .01 to 1 micro-volt (µV) per graduation (Graduation, increment, count and sometimes division, are terms used interchangeably to define the smallest incremental change in mechanical input that produces a detectable change in the output signal.) Do not be misled by the stated A/D resolution of digital instrumentation. The signal sensitivity and the A/D resolution are not the same! Signal sensitivity is often only a fraction of the A/D resolution. Be certain to verify the signal sensitivity specification of the instrument being used meets the requirements of the application.

## OPTIMUM RESOLUTION

As we have stated, the goal is to select the lowest capacity sensor, transducer or load cell that also possesses the necessary safe working load and overload capacity ratings for the application under all conditions. This relationship will dictate the maximum resolution available from the transducer.

**The following steps describe a convenient method for determining the maximum ratio of micro-volts per display graduation. In preparation, you will require the following information about your system:**

- Signal sensitivity (FSO)
- Bridge excitation voltage
- System total rated capacity
- System liveload range (Defined as the total system capacity, less deadload/preload)

**STEP 1** Multiply the signal sensitivity at rated capacity by the excitation voltage to determine the millivolt output of the system at rated capacity.

Example: 3mV/V x 10V = 30mV output

**STEP 2** Determine how much signal will be generated by the system liveload. To do this, subtract the system deadload/preload from the total system capacity.

Example:
1000 lbs (System capacity)
less 250 lbs (System deadload/preload)
750 lbs (System liveload maximum)

750 lbs/1000 lbs = 75% of total system capacity (liveload percentage)

**STEP 3** Multiply the resulting liveload percentage result from Step 2 by the millivolt output from Step 1 to determine the millivolt output generated by the liveload.

Example:
30mV
X 75 %
22.5 mV total liveload output

**STEP 4** Multiply the mV result of Step 3 by 1,000 to determine the micro-volt equivalent value.

Example:
22.5mV
X 1,000
22,500 µV

**STEP 5** Divide the result of Step 4 by the total number of display graduations required to determine the µV/graduation ratio.

Example: 22,500 µV/10,000 Grads = 2.25 µV/Display Graduation

**OR…** Divide the result of Step 4 by the useable signal sensitivity (in this example, 0.5 µV) to determine the maximum µV/graduation ratio.

Example: 22,500 µV/0.5 µV = 45,000 Display Graduations

Proper selection of system components can make a critical difference in the safe and satisfactory performance of a measurement system. If any doubt exists concerning system component(s), or the accurate determination of the maximum ratio of micro-volt's per display graduation, please contact SENTRAN's Customer Solutions Group at solutions@sentranllc.com or 909-605-1544 for friendly, expert assistance.