SENTRAN

INNOVATIVE MEASUREMENT SOLUTIONS

# TECHNICAL BULLETIN
## PERFORMANCE

# ACCURACY OR RESOLUTION?

### THE DIFFERENCES

***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, let's 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 do not occur with absolute predictability, and they are not necessarily additive. <u>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.</u>

### INFLUENCE FACTORS DEFINED

The influence factors of nonlinearity, hysteresis, repeatability and temperature effects should be considered in determining the 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 for increasing loads only.
- Hysteresis: The maximum deviation of the output curve relative to the nonlinearity curve at the same load, and measured in the same "load cycle". Hysteresis is expressed as a percentage of FSO and is measured for decreasing loads only.
- Repeatability: The maximum difference between output measurements for a repeated loading point(s) under identical loading and environmental conditions.
- Temperature Effect On Zero Balance (TCZ): The change in zero balance due to 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 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 technique must be accompanied by facilities to accommodate influence factors that can effect accuracy, including: mechanical constraints/interference; load introduction anomolies; creep; instrumentation power, signal conditioning or display variability; improper installation, setup or calibration. Generally speaking, the sensor, transducer, load cell, or weigh module can produce results that meet or exceed specifications. Unfortunately, these influence factors and others will effect the high performance capabilities of the measurement system. However, reasonable care in managing these unwanted effects, employing the many techniques and accessories available to optimize mechanical and electrical performance, can yield predictable and exceptionally *accurate* 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 defined as a percentage of Full Scale Output, e.g. 0.01% FSO. It is also defined as a ratio, e.g. 1:10,000, which is expressed as "one part in ten thousand divisions, or increments/counts/graduations". Both expressions define the same degree of resolution.

### IDENTIFYING POTENTIAL INFLUENCE FACTORS

The factors that can influence the resolution of a measurement system include both mechanical and electrical phenomonom. 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 in this article.

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

- Sensor, transducer, load cell 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 weigh 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 sensor, transducer, load cell or weigh module capacity for any given application.

Continued...



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### SIGNAL SENSITIVITY

The industry standard for specifying the output signal strength of a sensor, transducer, load cell or weigh module, is expressed as a millivolt 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 sensor, transducer, load cell or weigh module 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 sensor, transducer or load cell's companion instrumentation can play a significant role in achieving the desired resolution for a given application. Typical instrumentation signal sensitivity 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.) 1 micro-volt (µV) is 1/1,000,000 volts (.000001 V).
Do not be mislead by the stated A/D resolution of digital instrumentation. Signal sensitivity and the A/D converter 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 meets the requirements of the application under actual operating conditions. If the sensor , transducer or load cell's output signal is below the functional sensitivity threshold of the companion digital instrumentation, the system will not function properly.

### OPTIMUM RESOLUTION

As we have stated, the goal is to select the lowest capacity load cell that possesses the necessary safe overload capacity for the application. This will dictate the maximum signal available to determine the maximum system resolution, and ultimately the digital display resolution.

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

- Sensor, transducer, load cell rated sensitivity
- Bridge excitation voltage
- Sensor, transducer, load cell system rated capacity
- System liveload (System capacity, less deadload/preload)

STEP 1 Multiply the rated sensitivity 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)

$$\frac{750 \text{ lbs}}{1000 \text{ lbs}} = 75\%$$

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 microvolt 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 to determine the µV/graduation ratio.

Example: $$\frac{22{,}500\ \mu V}{10{,}000 \text{ Grads}} = 2.25\ \mu V/$$

OR… Divide the result of Step 4 by the useable signal sensitivity to determine the signal µV/graduation ratio.

Example: $$\frac{22{,}500\ \mu V}{0.5\ \mu V} = 45{,}000 \text{ Grads}$$

The 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 accurate determination of the maximum ratio of microvolts-per-display graduation, please contact SENTRAN's Applications Engineering Group for friendly, expert assistance.



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