Exercise E601-M02.DFT

Process Measurement Instrumentation Terms, Abbreviations And Designations

Objective

’ Using a DAC Process Trainer (DAC Models #601, #602 and/or #603), the DAC Process Trainer Use Guide and Reference Schematics & Drawings, and a Process Control Instrumentation Technology text (or an equivalent), identify the various concepts, terminology, abbreviations and standard industrial designations used in the maintenance of process measurement instrumentation.

Performance Standard

’ Identify all the *italicized* terms with 100% accuracy.
’ Define the term "Measurement" with 100% accuracy.
’ State the importance of specifying the units of measurement.
’ List the fundamental units of measurement in the MKS, CGS, and English Engineering systems.
’ Draw and label a block diagram of a Basic Measurement Channel with 100% accuracy.
’ Contrast accurately the terms direct and inferred measurement.
’ Discriminate clearly between the terms range and span and between the terms elevated zero and suppressed zero.
’ Define with 100% accuracy the following commonly encountered static characteristics of a process measurement channel:

- Accuracy
- Resolution
- Sensitivity
- Deadband
- Hysteresis
- Linearity
- Conformity

’ Given a diagram, explain the following characteristics of an instrument channel with 100% accuracy:

- Dead Time
- Time Constant

Foundation Competencies

- Knowledge of the DAC Process Trainer Use Guide terminology and process system construction (Exercise E601 or E602 or E603-M01).

Required Background Reading

- Process Control Instrumentation Technology, 6th Ed. by Curtis D. Johnson, pgs. 1-46. (DAC, #584-MAN)
- Measurement and Control Basics, 2nd Ed. by T.A. Hughes, pgs. 1-30. (DAC, #582-MAN)
- The Condensed Handbook of Measurement and Control, by N.E. Battikha, pgs. 1-19. (DAC, #581-HBK)

Tools Required

- Pencil and paper.

Components Required

- A DAC Process Trainer (Model #601, #602 and/or #603).

Introductory Discussion

The industrial plants of today utilize the *measurement* of many *parameters* in order to operate in the most efficient, effective, and reliable way possible. Conditions are constantly monitored to provide a safe and comfortable atmosphere for the workers in the plant and to limit emissions of hazardous materials from the plant that could impact the environment. The *instrumentation* industry has become a very diversified field; well trained and quality *instrument technicians* are needed to operate, calibrate, and maintain the equipment used to measure these parameters. To perform these tasks technicians must understand the meaning of measurement and be familiar with the *units of measurement*. They must also be familiar with the basic concepts and physical principles involved in detecting these parameters and the terminology used to express the parameter's characteristics and calibration of the measuring instruments. Any number of methods and/or sensors can be used to measure each parameter in a process.

In this exercise you will have the opportunity to investigate the basic terminology associated with the more commonly used measurement methods, concepts, and the principles involved, along with the fundamentals of measurement and the terms used to describe the set up, calibration and operation of measurement devices.

Given the many process applications used throughout industry, it is important that you know how to describe the instruments and how they function, so you can evaluate their operation and repair them when necessary.

Performance Steps

Step 1. Identify the most fundamental dimensions of measurement.

’ Describe what is meant by the term ‘Measurement’.

g A measurement is simply an exact comparison of a physical quantity to some definite standard or measure of dimension called a unit.

’ Describe the importance of specifying the units of any and all measurements.

g Whenever a physical quantity is described, the units of the standard to which the quantity was compared must be specified. A number alone is insufficient to describe a physical quantity.

g When a number is used to describe a physical quantity, it is important to include, and even emphasize, the specific unit used in the measurement, for the same physical quantity may be measured using a variety of different units. For example, length may be measured in inches, feet, yards, miles, centimeters, meters, kilometers, etc.

’ List the three (3) most fundamental units of measurement.

g All physical quantities can be expressed in terms of three fundamental units: (1) *length*, (2) *mass*, and (3) *time*.

’ Describe what is meant by these three (3) fundamental units of measurement.

- g “Length” -- is the distance from one point to another.
- g “Mass” -- is the quantity of matter present.
- g “Time” -- is the period during which an event occurs.

’ Describe why these three (3) units of measurement are called ‘Fundamental’ units.

- g Length, mass, and time are called fundamental units because units of most other quantities are reducible to these three.
- g For example, area is the product of two lengths; it has units of length times length, or length squared. In the English system, the units of area are square feet, written ft^2, or square inches, written in^2.
- g Similarly, volume is the product of three lengths; it has units of length cubed. In the English system, the units of volume are cubic feet, written ft^3, or cubic inches, written in^3.
- g Other physical quantities are also combinations of the three fundamental units. Velocity is the time rate of change of distance or length per unit time, thus, it has units of length divided by time. In the English system, the units of velocity are feet per second, written ft/sec, or miles per hour, written mi/hr or mph.
- g Indeed, it can be shown that other, more complicated physical quantities, such as horsepower, watts, and British Thermal Units (BTUs), are all combinations of the three fundamental units of length, mass, and time.

Step 2. Identify the basic systems of fundamental units of measurement used throughout the process industry.

’ List the three (3) most widely used systems of measurement units.

- g The three most widely used systems of measurement units are:

1. The meter-kilogram-second (MKS) system

2. The centimeter-gram-second (CGS) system

3. The English system

’ Describe the fundamental units of length, mass, and time in each of these systems.

g Table 1 lists the fundamental units of length, mass, and time in each of these three systems.

Table 1. Fundamental Measurement Units

Unit	MKS	CGS	English
Length	meter (m)	centimeter (cm)	foot (ft)
Mass	kilogram (kg)	gram (g)	pound (lb)
Time	second (sec)	second (sec)	second (sec)

’ Describe when and where each system is normally used.

g The existence of different sets of fundamentals units contributes to a considerable amount of confusion in many calculations. Therefore, several years ago the United States attempted to adopt the more logical Metric System (i.e. the MKS and CGS), but it has not been accepted and applied universally.

g The MKS system, with some application of the CGS system, is employed for physics calculations. Many international manufacturers use this system exclusively; some will provide both the Metric and the English units, with the English in parentheses (...).

g The English system, however, is still often employed in engineering calculations.

g Therefore, in the process instrumentation industry it is necessary to have some degree of understanding of all three systems of units.

' Describe the advantages of using the Metric System.

g The Metric System is much simpler to use than the English system because it is a decimal system in which prefixes are used to denote powers of 10.

g The older, English system requires the use of conversion factors that must be memorized and are not necessarily categorized logically, as powers of 10 are. For example, 1 mile is 5,280 feet and 1 inch is 1/12 of a foot. Table 2 lists some of the more common units in the English system.

Table 2. Common Units in the English System

12 inches (in)	=	1 foot (ft)
1 yard (yd)	=	3 feet (ft)
1 mile (mi)	=	5,280 feet (ft)
16 ounces (oz)	=	1 pound (lb)
1 ton	=	2,000 pound (lb)
1 minute (min)	=	60 seconds (sec)
1 hour (hr)	=	3,600 seconds (sec)
1 U.S. gallon (gal)	=	0.1337 cubic foot (cu. ft)

g The use of the metric system is more logically arranged. The name of the unit will also represent an order of magnitude, via the prefix. One can tell at a glance the approximate size of a measurement. The metric system prefixes are listed in Table 3.

Table 3. Metric System Prefixes

Prefix	Decimally	Power of 10
micro-	1/1,000,000	10^{-6}
milli-	1/1,000	10^{-3}
centi-	1/100	10^{-2}
deci-	1/10	10^{-1}
deka-	10	10^{1}
hekto-	100	10^{2}

Prefix	Decimally	Power of 10
kilo-	1,000	10^3
mega-	1,000,000	10^6

’ Describe how to convert from the English System to the Metric System, and back to the English System. This may often be required on the job.

g Tables 4, 5 and 6 illustrate the relationships of the more common units of the three widely used unit systems.

Table 4. Common Unit Conversions for LENGTH

UNIT	CM	M	KM	IN	FT
1 centimeter	1	100^{-2}	10^{-5}	0.3937	3.281×10^{-2}
1 meter	100	1	10^{-3}	39.37	3.281
1 kilometer	10^5	1000	1	3.937×10^4	3281
1 inch	2.540	2.54×10^{-2}	2.54×10^{-5}	1	8.333×10^{-2}
1 foot	30.48	0.3048	3.048×10^{-4}	12	1

Table 5. Common Unit Conversions for MASS

UNIT	GM	KG	OZ	LB
1 gram	1	0.001	3.527×10^{-2}	2.205×10^{-3}
1 kilogram	1000	1	35.27	2.205
1 ounce	28.35	2.835×10^{-2}	1	6.25×10^{-2}
1 pound	453.6	0.4536	16	1

Table 6. Common Unit Conversions for TIME

UNIT	DAY	HR	MIN	SEC
1 day	1	24	1440	8.64×10^{-4}
1 hour	4.167×10^{-2}	1	60	3600
1 minute	6.944×10^{4}	1.667×10^{-2}	1	60
1 second	1.157×10^{-5}	2.778×10^{-4}	1.667×10^{-2}	1

Step 3. Identify the five (5) basic elements or blocks in a standard instrument channel.

’ List the basic elements that make up a typical process measurement instrument channel.

g The components used to build a basic instrument channel are:

1. *Detector*
2. *Transducer*
3. *Amplifier*
4. *Transmitter*
5. *Indicator*

’ Describe the function of each block.

g Detector - senses the parameter being monitored and converts the magnitude of the parameter to a mechanical or electrical signal.

g Transducer - converts the output signal of the detector to a signal that can be used easily. (Often the detector and transducer are accomplished in the same device.)

g Amplifier - increases the process signal to a usable magnitude. (In many cases, signal conditioning also occurs in the amplifier section.)

g Transmitter - transmits data from one instrument component to another when the components are physically separated.

g Indicator - displays the process variable signal being measured.

g A specific instrument channel may involve these basic components in any number and any combination. They need not appear in the order listed above and not all of the components described may be required in each application.

’ Describe the operation and its affect on the process it is measuring.

g To sense the process parameter, the detector receives energy from the process and produces an output that is dependent on the measured quantity.

g It is important to realize that the sensing element always extracts some energy from the process; the measured quantity is always disturbed by the act of measurement. However, a good instrument is designed to minimize this disturbance.

Step 4. Describe the difference between a measurement that is a *‘direct’ measurement* versus an *‘indirect’* measurement.

’ List the two most general categories of measurement.

g The basic nature of measurement can be divided into two general categories:

1) those measurements made directly, and
2) those that are inferred.

’ Describe and give some examples of a direct measurement.

g A direct measurement involves the sensing of the actual parameter you are attempting to measure without relying upon another aspect of the process. For example, if a tank was filled to some level with water, one way to measure that tank level would be to use a dip-stick. Another way would be to look at a gauge-glass on the side of the tank and measure the level in the glass with a ruler. These methods are examples of direct measurement.

’ Describe and give some examples of an indirect measurement.

g Many parameters are not measured directly. The parameter of interest is affecting a characteristic or property of a sensors operational material and that is actually measured. The change in this material’s properties or operating characteristics is what is actually being sensed. For example, if a tank was filled to some level with water, an indirect way to measure that tank level would be to use a pressure sensing device mounted near the bottom of the tank and have it sense the weight or pressure exerted by the water above it in the tank.

’ Given the parameters to measure below and the listed sensors that could be used to measure the parameter, describe why you believe the measurement is or is not a ‘direct’ measurement.

g <u>Parameter</u> & <u>Detector</u>
Temperature & Resistance Temperature Detector (RTD)

This is an ‘indirect’ measurement because it is the ‘resistance’ of the metal detector that varies with temperature and it is that ‘resistance’ effect that is actually measured

g <u>Parameter</u> & <u>Detector</u>
Temperature & Thermocouple

This is an ‘indirect’ measurement because it is the voltage produced by two joined dissimilar metals that is proportional to a temperature differential that is being actually measured.

g <u>Parameter</u> & <u>Detector</u>
Temperature & Bimetallic Strip

This is an ‘indirect’ measurement because it is the expansion of the metal, when heated, that is actually being measured.

- g <u>Parameter</u> & <u>Detector</u>
  Temperature & Thermometer

  This is an 'indirect' measurement because it is the expansion of the liquid, when heated, that is actually being measured.

- g <u>Parameter</u> & <u>Detector</u>
  Pressure & Differential Pressure Cell

  This is a 'direct' measurement because the bellows in the cell will move or flex when the internal pressure is greater than the surrounding pressure. System pressure can be applied to the internal volume of the bellows with a fixed pressure (normally atmospheric) surrounding the bellows.

- g <u>Parameter</u> & <u>Detector</u>
  Pressure & Bourdon Tube

  This is a 'direct' measurement because the curved, oval bourdon tube will attempt to achieve a straight cylindrical shape when internal pressure is applied.

- g <u>Parameter</u> & <u>Detector</u>
  Level & Level Differential Pressure Cell

  This is a 'direct' measurement of pressure but an 'indirect' measurement of the level because the bellows in the cell will move or flex when the internal pressure is greater, not level.

- g <u>Parameter</u> & <u>Detector</u>
  Level & Float Detector

  This is a 'direct' measurement of level because the float material, less dense than the fluid being monitored, will float on the fluid's surface.

- g <u>Parameter</u> & <u>Detector</u>
  Flow & Flow Restrictor Combined with a Differential Pressure Cell

  This is an 'indirect' measurement because flow in the restricted line is actually proportional to the square root of the pressure drop across the flow restriction. The differential pressure cell is used to measure the pressure drop.

Step 5. Describe the difference between the terms *'Range'* and *'Span'* with respect to instrumentation.

’ Describe what is meant by the term ‘Range’.

g Range is the region between the limits within which a quantity is measured. These limits are expressed by stating the upper range value, which is the highest quantity that a device is adjusted to measure, and the lower range value, which is the lowest quantity that a device is adjusted to measure.

’ Describe what is meant by the term ‘Span’.

g Span is the algebraic difference between the upper and lower range values.

’ Demonstrate the difference between range and span.

g If a gauge is used to measure the pressure in a closed tank, the range of this gauge might be 100 psi to 180 psi. The span of this gauge is then 80 psi.

g The meanings are different but they are often used improperly to represent the same thing.

Step 6. Describe the difference between an *'Elevated Zero'* and a *'Suppressed Zero'* with respect to instrumentation.

’ Describe what is meant by the term ‘Elevated Zero’.

g Measured Variable is the term used to describe the quantity, property, or condition which is measured. Notice that in Step 5 above that the range of an instrument does not always start at the zero value of the measured variable (i.e. 100psi).

g An elevated-zero range is a range in which the zero value of the measured variable is greater than the lowest range value.

g If the range of the pressure gauge in Step 5 above were -30 psi to 50 psi, it would be an elevated-zero range because the 0 point is greater than the lowest range value of -30 psi.

’ Describe what is meant by the term ‘Suppressed Zero’.

g Suppressed zero range is a range in which the zero value of the measured variable is less than the lowest range value.

g In the example in Step 5 above, the 100 psi to 180 psi range is a suppressed-zero range because the 0 is less than the lowest range value of 100 psi.

’ Demonstrate the difference between an ‘Elevated Zero’ and a ‘Suppressed Zero’ range.

g Using a pressure gauge as above, if it was set to measure a pressure range of 0 psi to 80 psi, then the range would not have to be adjusted at all. The zero point on the ‘Span’ is equal to the zero point of the ‘Range’ to be measured.

g If we wanted to use this gauge to measure the range -30 psi to +50 psi, then we would have to use the ‘Zero Adjust’ to ‘Elevate’ the instrument’s zero reference point 30 psi above its normal zero (atmospheric pressure) setting.

g If we wanted to use this same gauge to measure the 100 psi to 180 psi, then we would have to use the ‘Zero Adjust’ again but this time to lower or ‘Suppress’ the instrument’s zero reference point 100 psi below its normal zero (atmospheric pressure) setting.

g **Note:** In all of the examples above the ‘Span’ of the instrument always remained a constant 80 psi.

Step 7. Describe the most common static characteristics of process measurement systems encountered by instrumentation technicians.

’ Describe what is meant by the term *‘Accuracy’*.

g Accuracy is the degree to which the output of an instrument approaches an accepted standard or true value.

- As the definition states, the output of a device is compared or referenced to some value or standard to determine whether the instrument is performing as required. Therefore, when used as a performance specification for an instrument, 'accuracy' means 'reference' accuracy.

- *Reference accuracy* is a number or quantity that defines the limits that errors will not exceed when the device is used under referenced conditions.

’ Describe how to express 'Accuracy' properly.

- Reference accuracy can be expressed in a number of ways.

- It can be expressed in terms of the *measured variable* .

  For a temperature measuring device, the reference accuracy would be expressed simply as ±1°F (i.e. °F is the measured variable's units).

- Reference accuracy can be expressed in terms of *percent of span* .

  This can be explained by using the following example:

  A meter is used to indicate the water level in a tank between 50 inches and 150 inches. The reference accuracy of the indicator is ±1/2% of span. Therefore, the reference accuracy of the indicator is 1/2 inch of level.

- Reference accuracy can be expressed in *percent of the upper range value*.

  If the upper range value of a pressure gauge were 100 psi, and the reference accuracy were ± 0.1% of upper range value, the reference accuracy of the gauge would be 0.1 psi.

- Reference accuracy can be expressed in *percent of scale length*.

  For an indicating meter with a 6-inch scale length and a reference accuracy of ±1/2% of scale length, the reference accuracy would be 0.3 inches (or about 5/16 inch).

- g Finally, reference accuracy can be expressed in *percent of actual output reading*.

  If the 50-inch to 150-inch level indicator discussed above has a reference accuracy of ±1% of actual reading and the tank presently has 125 inches of water in it, the indicator should be reading 125 inches ±1.25 inches.

- g When stating the accuracy of an instrument, it is very important to express the quantity to which the accuracy is referenced. To say that a component is accurate to within 0.1% is meaningless. The percent specification must be related to some specific magnitude or reference value.

- ' Demonstrate the ability to express 'Accuracy' in each of the above ways.

- g Given the following example:

  A temperature-measuring instrument produces an output with a range of 180°F to 320°F, which is displayed on a meter with a scale length of 4 inches. Express the accuracy of this meter in the five ways just discussed, if the accuracy is 2% absolute..

  1. Expressed in terms of measured variable:
     Accuracy = ±2°F

  2. Expressed in terms of percent of span:
     Accuracy = ±2% of Span
     = (0.02 x 140°F)
     = ±2.8°F

  3. Expressed in terms of percent of upper-range value:
     Accuracy = ±2% of upper-range value
     = (0.02 x 320°F)
     = ±6.4°F

  4. Expressed in terms of percent of scale length:
     Accuracy = ±2% of scale length
     = (0.02 x 4 inches)
     = ±0.08 inches
     = approximately ±1/16 inch or ±2.8°F

5. Expressed in terms of percent of actual reading:

Accuracy = ±2% of actual reading (mid-range)
= (0.02 x 250°F)
= ±5°F

So, you see the importance of how accuracy is expressed.

’ Describe what is meant by the term *‘Resolution’*.

g Resolution is defined as the smallest interval between two adjacent discrete details that can be distinguished one from the other or simply the degree to which equal values of a quantity such as temperature or pressure can be discriminated by observing a device.

g As an example, consider two pressure gauges, both of which are calibrated to indicate 0-100 psi. The scale on gauge No. 1 is marked in 0.5 psi increments. The scale on gauge No. 2 is marked in 5 psi increments. By the definition, gauge No. 1 has better resolution because smaller equal values of pressure can be recognized by the person reading the gauge.

’ Describe what is meant by the term *‘Sensitivity’*.

g The sensitivity of a device is the ratio of a change in output magnitude to the change of input that causes it, after steady-state has been reached.

g It is a ratio that describes how much the input variable must change to produce some change in output magnitude.

’ Describe what is meant by the term *‘Deadband’*.

g Deadband is the range through which the input of a device can be varied without causing observable response.

g Deadband is a result of friction or "play" between the elements of an instrument, which must be overcome before any force or motion is available to produce an output.

g The dead band of an instrument is determined by a simple test. The input to the device being tested should be slowly increased until a change in the output is observed. This value of the input should be recorded and then the input should be slowly decreased until a change in the output is again observed. The difference between these two values, the increment through which the input was varied, is the deadband.

g These steps should be performed several times to ensure the correct value for deadband is determined and should be performed at a number of points to ensure that the maximum deadband has been observed.

g The value determined for the dead band of an instrument is expressed in percent of span. For example, deadband is 0.5% of span.

g **Note**: It should be clear, that there is a difference between sensitivity and deadband. Sensitivity describes how much the input must change in one direction, increase or decrease, to produce some change in the output magnitude. Deadband describes the range through which the input can increase and decrease without producing a change in the output.

’ Describe what is meant by the term *‘Hysteresis’*.

g Hysteresis is the property of an element evidenced by the dependence of the output value of the device, for a given change of the input, upon the history of prior excursions of the input and the direction of the current excursion.

g This means simply that the output values obtained while increasing the input will be different from the output values obtained while decreasing the input. Hysteresis is based on inherent physical characteristics of the materials used to construct the instrument. Hysteresis can be mechanical or magnetic.

g When the magnetic input (magnetic intensity, H) is varied in the positive and negative directions and back to zero, the output (the magnetic flux, B) is not completely cancelled when zero input is again reached. Some amount of magnetic flux B is retained by the core material.

g When the mechanical input (stress, F [force being applied to an elastic sample]) is varied first in one direction than the other, the strain or sample deformation (S) is not completely relieved when zero input stress is re-achieved. Some amount of strain or deformation (S) remains.

g It is the material characteristic of retentivity and remanence that cause the effect known as hysteresis.

’ Describe what is meant by the term *‘Retentivity’*.

g Retentivity is the capacity for retaining magnetism or deformation after the action of the applied force has ceased.

’ Describe what is meant by the term *‘Remanence’*.

g Remanence is the magnetic induction or deformation remaining in a substance when the applied force has become zero.

’ Describe what is meant by the term *‘Linearity’*.

g The linearity of an instrument's output is the closeness to which the output curve of the device approaches a straight line. It is actually a measure of the nonlinearity of the output.

g The first step in determining linearity is to make a plot of the average output curve. This curve is determined by averaging the output values observed during two or more completed cycles of the input to the instrument.

g This method permits observation of linearity independent of the effects of deadband and hysteresis. It assumes that if no dead band or hysteresis error existed, the actual output curve would be a single line mid way between the upscale and downscale readings.

g The average output curve is then compared to a straight line drawn between the output values with upper and lower range value inputs. The maximum deviation of the average output curve from the line is the linearity of the instrument.

g The value of linearity determined is expressed in percent of span.

' Describe three (3) types of Linearity.

g As a performance specification, linearity should be referred to as:

(1) *independent linearity*,
(2) *terminal-based linearity*, or
(3) *zero-based linearity*.

If not specified, it is assumed that the simple expression, linearity, implies independent linearity.

g Independent linearity is the maximum deviation of the average curve from a straight line that is positioned to minimize the maximum deviation of the output curve from the line.

g Terminal-based linearity is the maximum deviation of the average output curve from a straight line that is positioned to coincide with the actual output curve at the upper and lower range values.

g Zero-based linearity is the maximum deviation of the average output curve from a straight line that is positioned to coincide with the average output curve at the lower-range value and to minimize the maximum deviation of the curve from the zero-based line.

' Describe what is meant by the term *'Conformity'*.

g The terms conformity and linearity are very close in meaning.

g Conformity applies to instruments designed to provide nonlinear output for a linear input; linearity describes the output of a linear device.

g The conformity of the output signal of an instrument is the closeness to which the output curve approximates a specified curve, such as a parabolic or logarithmic. It is also actually a measure of the non-conformity of the output.

g The first step in determining conformity is to plot the average output curve by the method described for linearity. Then this average output curve is compared to the specified curve. The value of conformity determined is expressed in percent of span.

g As a performance specification, conformity should be referred to as *'independent conformity'*, *'terminal-based conformity'*, and *'zero-based conformity'*. Again, the assumption is made that conformity implies independent conformity.

g Independent conformity is the maximum deviation of the average output curve from a specified characteristic curve that is positioned to minimize the maximum deviation of the output curve from the specified curve.

g Terminal-based conformity is the maximum deviation of the average output curve from a specified characteristic curve that is positioned to coincide with the actual output curve at the upper and lower range values.

g Zero-based conformity is the maximum deviation of the average output curve from a specified curve that is positioned to coincide with the average output curve at the lower range value and to minimize the maximum deviation of the average output curve from the specified curve.

Step 8. Describe the most common static calibration errors of process measurement systems encountered by instrumentation technicians.

' Describe what is meant by the term *'Calibration Error'*.

g There are two categories, although they usually are found to exist together:

'Zero error' consists of a linear shifting of the whole instrument range. This is usually corrected by the zero or null adjustment of the instrument.

'Angular error' consists of a shifting of the upper portion of the instrument range and is usually corrected by adjusting the

input-output ratio adjustment or 'Range' adjustment (gain adjustment in electronic circuits).

Step 9. Describe the most common dynamic characteristics of process measurement systems encountered by instrumentation technicians.

’ Describe what is meant by the term *'Dynamic Characteristics'*.

g *'Static characteristics'* provide a means of expressing how good the output of a measuring instrument is under steady-state conditions. Although important, they are not the only characteristics used to describe the output of the instrument.

g It is also important to know how quickly the output of the measuring instrument responds to changing conditions. This is known as the 'dynamic response'.

g The dynamic response is defined as the behavior of the output of an instrument as a function of its input, both with respect to time and expressed by means of dynamic characteristics.

g Dead time, rise time, settling time and time constant are dynamic characteristics and describe the response time of the instrument.

’ Describe what is meant by the term *'Dead Time'*.

g One method of determining the dynamic response of an instrument is to introduce a step change into its input. A plot of the device's output with respect to time will contain some amount of time where there is no response. This is called dead time, t_d (not to be confused with dead band). Then the output begins to change.

’ Describe what is meant by the term *'Rise Time'*.

g The time for the output of the instrument to change from some small percentage (usually 5 or 10%) of the difference between initial and final values to some larger percentage (usually 90 or 95%) is the rise time.

’ Describe what is meant by the term *‘Settling Time’*.

g The total time required for the output to enter and remain within a specified narrow band centered on the final steady-state value is the settling time.

’ Describe what is meant by the term *‘Time Constant’*.

g One further characteristic used to describe the dynamic response of an instrument is the time constant, J, of the instrument.

g The time constant is the time required for the output of the instrument to undergo 63.2% of the total change following a step change at the input.

g The output of the instrument is considered to have reached the final steady-state value after five time constants.

Summary

Congratulations! You have just demonstrated your ability to describe and define many of the most common terms used in the area of process instrumentation technology.

It is important for the maintenance instrument technician to have an understanding of process instrumentation terminology used in this training program. Having acquired this familiarity, the maintenance instrument technician will be able to perform the training exercises more easily.

Optional Tasks

’ None.

Resources

Use Guide for the appropriate Model DAC Process Trainer.

Hughes, Thomas A., Measurement and Control Basics, 2nd Ed. Research Triangle Park, NC: Instrument Society of America, 1995.

Johnson, Curtis D., Process Control Instrumentation Technology, 6th Ed. Upper

Saddle River, NJ: Prentice-Hall, Inc., 2000.

Murrill, Paul W., Fundamentals of Process Control Theory, 3rd Ed. Research Triangle Park, NC: Instrument Society of America, 2000.

Review Questions

Name:_____________________________________ Date:___________

1. What does the term ‘Measurement’ mean?

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2. Draw and label a basic instrument measurement channel block diagram.

3. What is the difference between a ‘direct’ measurement and an ‘inferred’ or ‘indirect’ measurement?

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(4) What is the difference between the terms ‘Range’ and ‘Span’?

(5) What is the difference between an ‘Elevated Zero’ and a ‘Suppressed Zero’ range?

(6) What is meant by the term ‘Accuracy’?

(7) What is the difference between the terms ‘Dead Band’ and Dead Time’, with respect to instrumentation?

(8) What is the difference between the terms ‘Accuracy’ and ‘Linearity’?

(9) What are the 2 most common types of ‘Calibration Error’ and what adjustment is normally used to correct each type?

(10) What is meant by the term ‘Time Constant’?

Exercise E601-M02.DFT

Process Measurement Instrumentation Terms, Abbreviations And Designations Exercise Data Sheet

Name (s): ________________________ Date Completed: _________

____

Initials:

¥___¦ **Step 1.** Identified and defined the most fundamental dimensions of measurement:

¥___¦ Length

¥___¦ Mass

¥___¦ Time

¥___¦ **Step 2.** Identified and described the three basic systems of fundamental units of measurement used throughout industry:

¥___¦ The Meter-Kilogram-Second (MKS) System

¥___¦ The Centimeter-Gram-Second (CGS) System

¥___¦ The English (Foot-Pound-Second) System

¥___¦ **Step 3.** Identified and defined the five basic elements or blocks in a standard instrument channel:

¥___¦ Detector

¥___¦ Transducer

¥___¦ Amplifier

¥___¦ Transmitter

¥___¦ Indicator

¥___¦ **Step 4.** Described the difference between a ‘direct’ measurement and an ‘indirect’ measurement.

¥___¦ **Step 5.** Described the difference between ‘Range’ and ‘Span’

¥___¦ **Step 6.** Described the difference between an ‘Elevated Zero’ and a ‘Suppressed Zero’.

¥___¦ **Step 7.** Described and defined each of the following terms:

¥___¦ Accuracy
¥___¦ Resolution
¥___¦ Sensitivity
¥___¦ Deadband
¥___¦ Hysteresis
¥___¦ Retentivity
¥___¦ Remanence
¥___¦ Linearity
¥___¦ Conformity

¥___¦ **Step 8.** Described the difference between ‘Zero Calibration Error’ and ‘Angular Calibration Error’.

¥___¦ **Step 9.** Described and defined each of the following terms:

¥___¦ Dead Time
¥___¦ Rise Time
¥___¦ Settling Time
¥___¦ Time Constant