APPLICATION NOTE

Measurement System Analysis (MSA)

PATHWAVE

Why MSA

Measurement System Analysis (MSA) ensures consistent quality of the manufacturing process and ensuring accuracy of the test measurement readings collected. A manufacturing process setup in this manner, will prevent debug time, rework labor, scrap, lost capacity, degradation of DUT due to unnecessary retest, missing planned shipments etc.

In this era of big data, industries are using data in more ways than ever. Analytics of 'accurate' data in near real time is vital to produce quality products quickly. To generate 'accurate' data, the measurement system must be stable and produce reliable data repeatedly. If there are errors in measurement system, we could be making incorrect decisions or producing non-conforming parts. A thoughtfully planned and executed Measurement System Analysis (MSA) can help build a solid foundation for any data-based decision-making process. MSA will help prevent such problems and assure accuracy and relevance of the test data collected.

Consistent quality of manufacturing process

Overview of MSA

Gage R&R Study Details

This document further describes what is MSA, and it's importance in the Manufacturing environment to evaluate the accuracy, stability and precision of the test equipments and process.

What is Measurement System Analysis (MSA)

MSA is an experimental and mathematical method of determining the amount of variation that exists within a measurement process. Variation in the measurement process can directly contribute to our overall process variability. The figure below shows the minimal variance that is desired in the process such that all our measurements are tightly grouped towards the expectations with good consistency. The figure also shows how variations can result in measurement errors.

KEYSIGHT TECHNOLOGIES

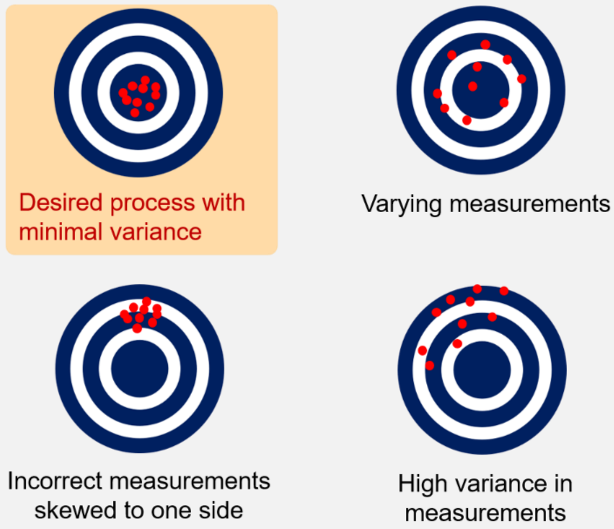

Figure 1: Importance of Measurement System Analysis

Measurement System Error

A measurement system error arises due to lack of Accuracy and Precision of the measurement system. Constant check on the Accuracy and Precision of the measurement system is important to minimize process error and increase consistency.

- Accuracy – Refers to how close is the measurement system performing to reading the correct value. It is the measure of the amount of difference between the average measurement value against desired value. The following can affect accuracy.
  a. Bias – Refers to how good is the system calibration to ensure that the measurements are not skewed erroneously to either higher or lower than the expected measurement reading.
  b. Variance – Refers to how close are the population of measurement readings compared to each other.
- Precision – Refers to the consistency of the recurrence of the same readings using the same method. The following 2 aspects are the key to precision.
  a. Repeatability – Refers to variations obtained when one person (operator) repeatedly measures the same part with the same measurement system.
  b. Reproducibility - Refers to variations seen when ‘different’ operators measure the same part using the same measurement system.

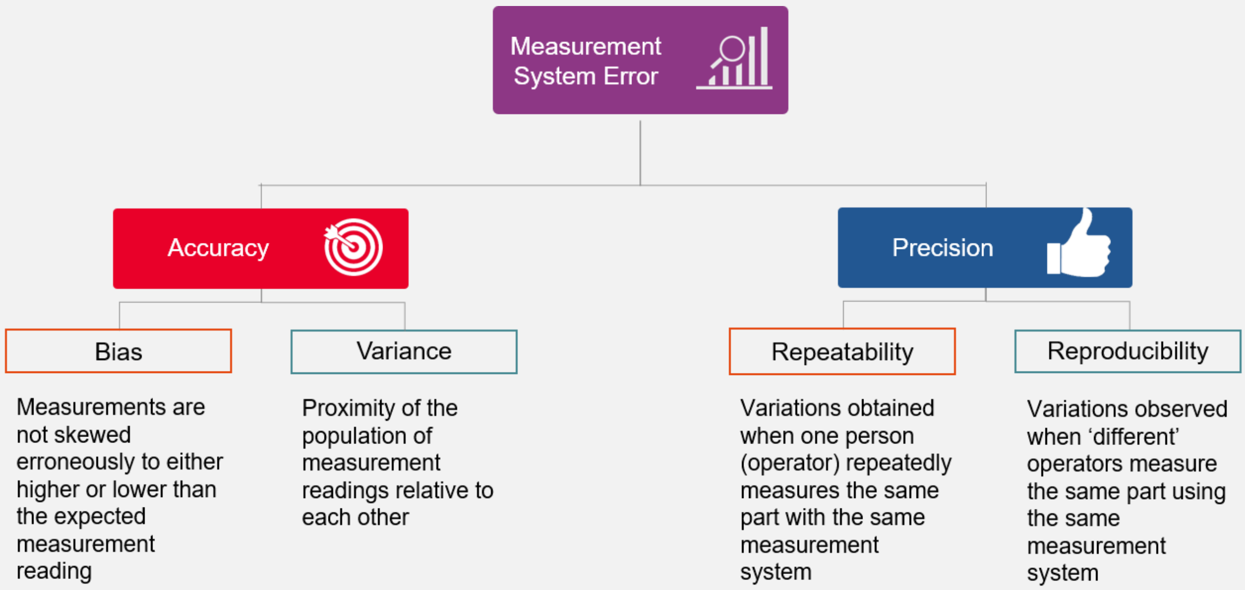

Figure 2: Measurement System Error

Sources of Variation in a Measurement System

There are several sources in a manufacturing process that result in variations in a measurement system resulting into measurement system error. These sources include the following:

- Process – test method and specification
- Personnel – the operators, their skill level, training, etc.
- Tools / Equipment – gages, fixtures, test equipment used and their associated calibration systems
- Parts that are measured – the part or material samples measured, the sampling plan, etc.
- Environmental factors – temperature, humidity, etc.

All these sources of variation should be factored during Measurement System Analysis. Evaluation of a measurement system should include the use of specific quality tools to find the likely source of variation.

Gage Repeatability and Reproducibility (Gage R&R)

Gage R & R is a method that measures the variance caused by - the measurement system, or by the operators taking the measurements. It estimates how much is the total process variation caused by the measurement system. Total process variation consists of:

1. Part to Part Variation (components/devices to be measured)
2. Measurement System Variation (instrument measuring the part)

The sum of these two values is the total variation in a measurement system. If the variation of repeatability and reproducibility exceeds the quality threshold (difference of variation on the upper end to the lower end) accepted by the Quality Assurance team, then improvements must be made to the measurement system, to reduce variation.

The results of Gage R&R are inferred by R chart and X-bar chart.

The R chart display the consistency of the operator measuring the part. R chart is a measure of operator repeatability.

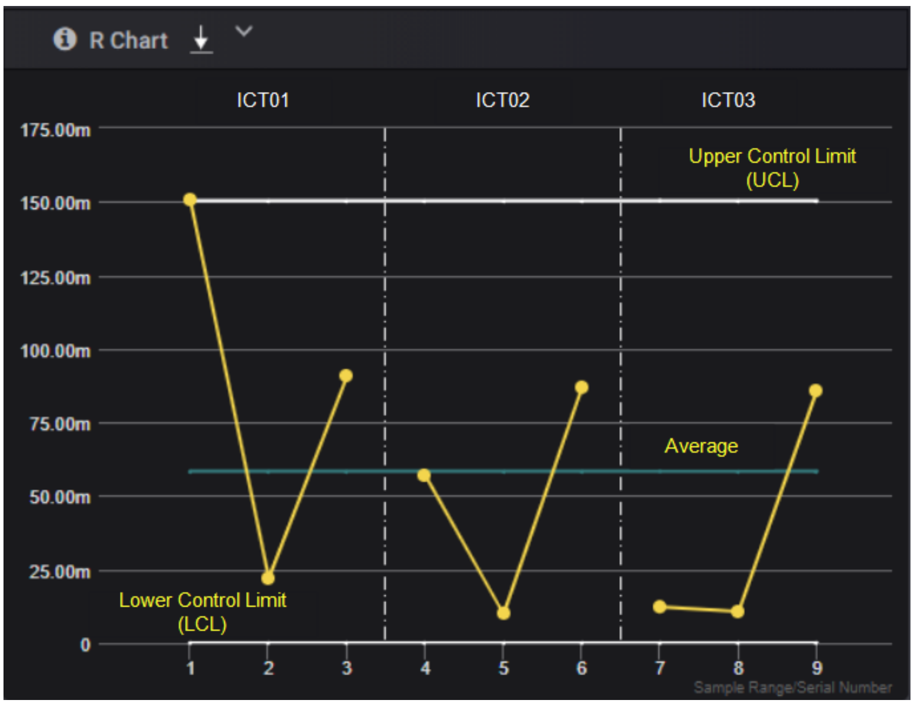

Figure 3: R Chart Example

In the example depicted in Figure 3, we see that the consistency of ICT02 is better than ICT01 and ICT03, as the 3 measurements from this operator are closer to average.

The X-bar chart displays part-to-part variation against the repeatability of the operator.

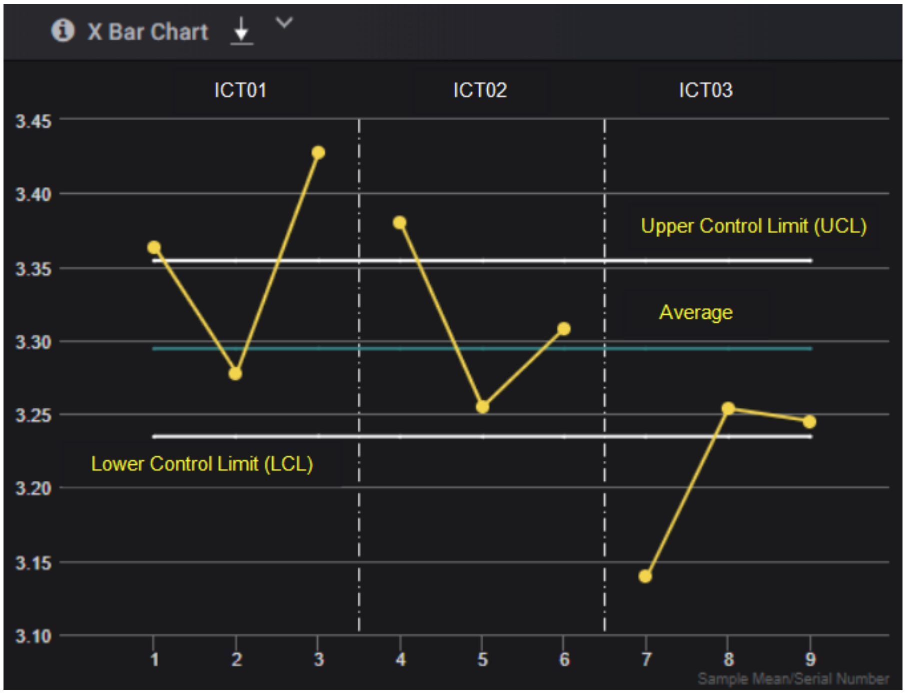

Figure 4: X Bar Chart Example

In the example depicted in Figure 4, we see that for ICT02, the part-to-part variations are minimal (in the band of upper and lower control limits).

With ICT02 having better repeatability score from the example depicted in Figure 3, and Figure is better than ICT01 and ICT03, as the 3 measurements from this operator are closer to average.

The X-bar chart displays part-to-part variation against the repeatability estimate determined from the R chart.

As part of MSA, following metrics are computed.

- %Study Variation – Shows how much is the variation caused by the measurement system as against the total variation due to other sources.
- % Tolerance – Compares if the %Study Variation falls in the set tolerance band. %Tolerance shows how much is the variability in the set band from the center.
  %Study Variation together with %Tolerance indicate if the measurement system variability is acceptable for a consistent process.
- % Contribution - This shows the contribution of measurement error due to part to part variation over the total variation (other variation sources).
  Typically, the measurement error is more prone to part to part variation as compared to other variations for a consistent measurement system.
- Number of distinct categories – A value which estimates how many separate groups of parts the system can distinguish. For example, if the value is 1, the system cannot distinguish between 2 different parts to distinguish which has a higher value compared to the other. If the value is 2, the system can distinguish the part measurements into 2 categories as to which group is measuring higher value and which group of parts are measuring lower value. So, higher this number of this value, better is the system to distinguish the parts.

Different types of performing Gage R&R Study

Type of parts measured, determine the design of Gage R&R study.

If successive testing of a part alters or damages the value of the part then, it is a destructive test. For example, measuring the tensile strength of steel tube after heat treatment is destructive as the tensile strength is altered for each iteration of heat process.

If successive testing does not alter or damage the value of the part, then it is a non-destructive test. For example, measuring the length of a table side. Repetitive measurements do not alter the length of table side.

Based on type of part under test, Gage R&R study design can be chosen between the following 2 methods.

1. Nested – Each person or operator measures the same device that are homogenous multiple times. But the samples are unique for each operator and as the parts may vary upon multiple measurements. Hence, a careful choice of batch of samples are chosen that ensure homogeneity.
2. Crossed – is a method of Gage R&R study where by, multiple operators take repeated measurements of the same device. Repeatability and reproducibility of this approach is possible for non-destructive parts.

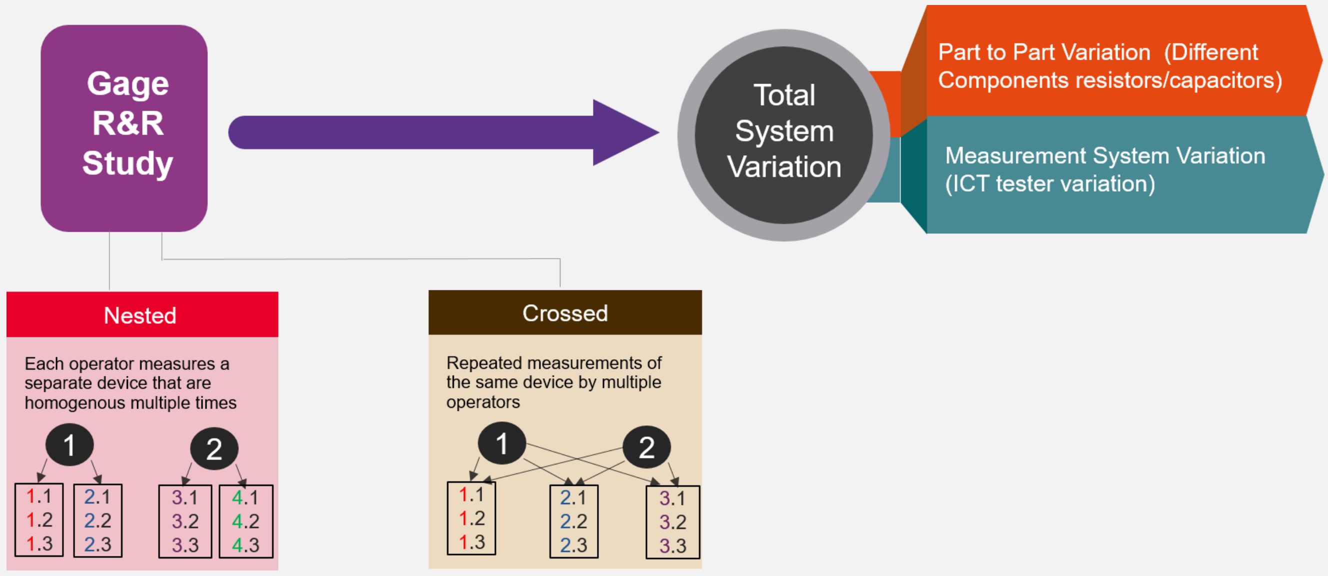

Figure 5: Gage R&R Study

How to Perform Measurement System Analysis (MSA)

MSA is a collection of experiments and analysis performed to evaluate a measurement system's capability, performance, and the amount of uncertainty about the values measured. We should review the measurement data being collected, the methods and tools used to collect and record the data. The goal is to quantify the effectiveness of the measurement system, analyze the variation in the data and determine its source. We need to evaluate the quality of the data being collected with regards to location and width variation. Data collected should be evaluated for bias, stability, and linearity.

During an MSA activity, the amount of measurement uncertainty must be evaluated for each type of gage or measurement tool defined within the process control plans. Each tool should have the correct level of discrimination and resolution to obtain useful data. The process, the tools being used (gages, fixtures, instruments, etc.) and the operators are evaluated for proper definition, accuracy, precision, repeatability, and reproducibility.

To perform MSA, the manufacturing line must be setup with proper sample data to collect the readings for analysis. This involves time and effort to periodically setup the manufacturing line for MSA analysis. This is where PathWave Manufacturing Analytics brings in its power of automated MSA which is described in specific details in the App Note – MSA Implementation in PathWave Manufacturing Analytics.

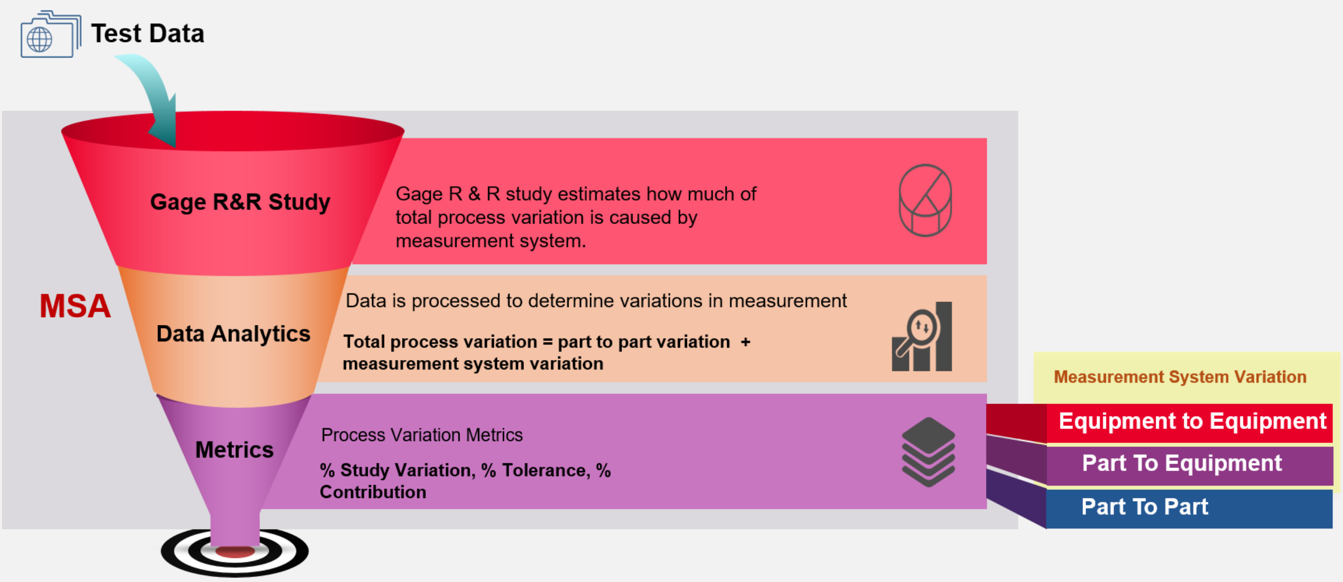

Figure 6: How to perform MSA

Conclusion

MSA is a measurement method to determine the variance of a measurement system. It is used to ensure that the measurement systems used in the manufacturing floor is consistent. Applying MSA allows the manufacturer to have confidence that the measurement systems are filtering out defects effectively and consistently, thus ensuring only good quality products are shipped to their customers.

The challenge is that MSA is tedious to implement with many cycles of tests to conduct, compilation and calculation of the measures.

Keysight's PathWave Manufacturing Analytics is a web-based application that has a Process Analysis module to automatically calculate and plot the required data for the MSA study. You can specify the products and equipment that you want to analyze. The application will automatically do its work to product the R and X-bar charts for your analysis. A lite version of the MSA can also be configured to run automatically with a minimum of 2 equipments, so that the manufacturing process can be continuously monitored to ensure that the measurement system variation is low.

Contact your Keysight representative to talk to you about learn how PathWave Manufacturing Analytics can work to help you to maintain consistency in your manufacturing?

Web Resources

Keysight PathWave Manufacturing Analytics: http://www.keysight.com/pathwaveanalytics

Keysight i3070 In-Circuit Test System: http://www.keysight.com/find/ict

MSA Implementation in PathWave Manufacturing Analytics, Sivakumar Vijayakumar