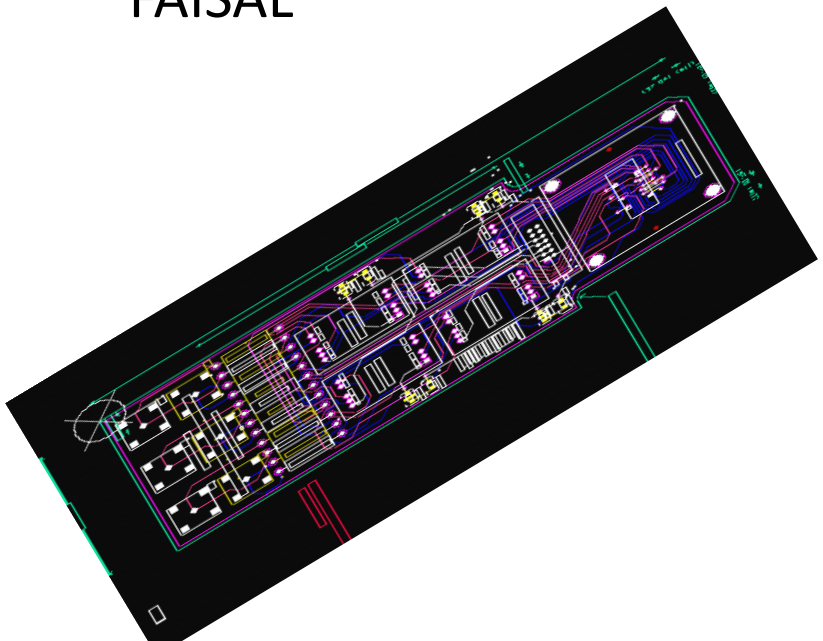
MEASUREMENT SYSTEM ANALYSIS DEMO
-L15 INTEGRATED LOADBOARD PROJECT

FAISAL



OVERALL OBJECTIVE OF MSA STUDY

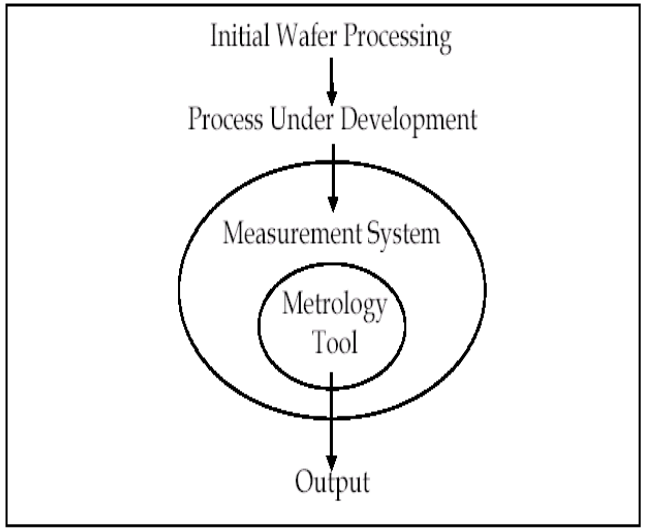
-The objective of this study to perform MSA on automated dc fet tester metrology tool to quantify the source of variation since a new component(Loadboard) from supplier BIM technologies has been added to metrology tool which might affect the performance.

-No intentional hardware or software changes were performed during the evaluation.

- Also ventured into other data collection areas:

The MSA was done based on the following steps:

1. Stability
2. Accuracy (Bias)
3. Linearity
4. Precision(Repeatabiity and Reproducibility)



GENERAL N PROCESS SPECIFIC INFORMATION

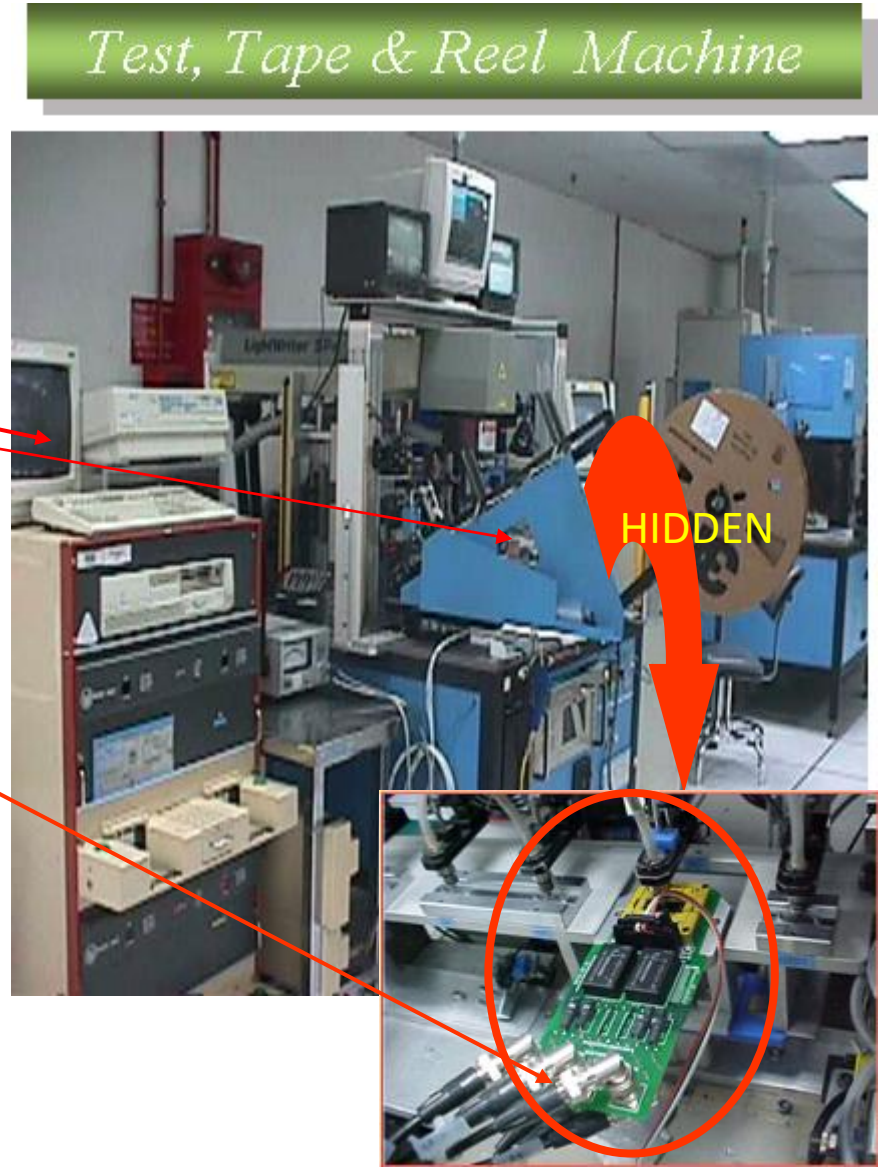
The Metrology tool used under study consist of :-

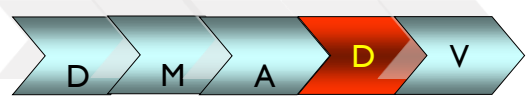
Measurement Equipment :

a) FET tester to measure the dc parametric
b) ISMECA test handler to load parts into loadboard ,laser marking and sorting into tubes or tape n reel.
c) LOADBOARD as an interface between FET test and device under test.

Measurement :VDSP,BVGSS,VGS

Process Spec : 1) VDSP = 0 – 800mV
: 2) BVGSS = 4 - 7V
: 3) VGS = 3 – 5 V





1. Stability
2. Accuracy (Bias)
3. Linearity
4. Precision

1)STABILITY-MSA

1) STABILITY THEORY

Gage stability examines how stable the measurements made from metrology tools ie is measurement varies a lot time to time, between part to part or within part when the same part is measured over time with repeated measurements for each time.

2) SAMPLING PLAN/PROCEDURE-STABILITY

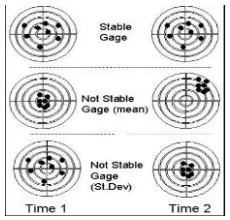
- Manufacturing technician will load the same part for three times in auto handler per day for total of 6 days (Day 1 to Day 6).
- The three repeated measurements were made per day with current loadboard(BIM) will be recorded.
- DC parametric data(Vds on) will be recorded.

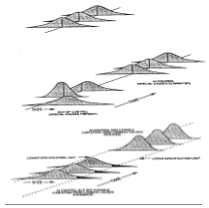
1)STABILITY-MSA

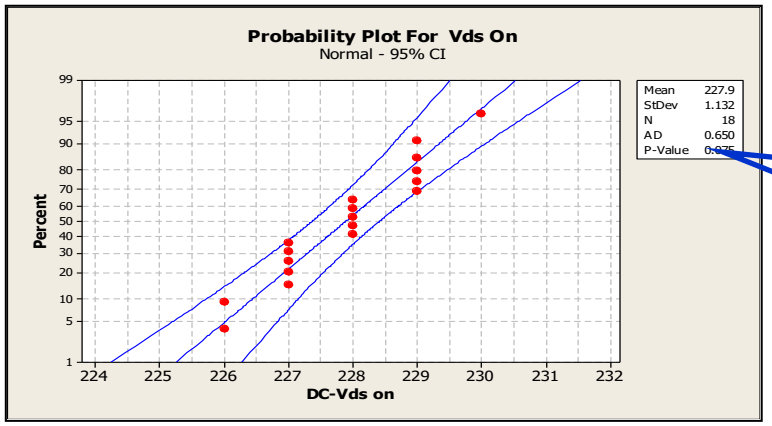
3) ANALYSIS METHOD/ASSUMPTIONS-MULTIVARI CHART

DC test data on the same part was collected for day 1 to day 6 and repeated 3 times.

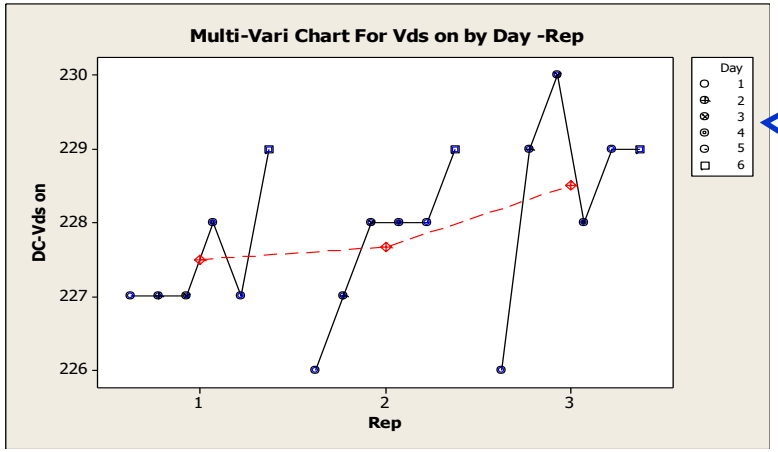
Day	Rep	DC-Vds on
1	1	227
1	2	226
1	3	226
2	1	227
2	2	227
2	3	229
3	1	227
3	2	228
3	3	230
4	1	228
4	2	228
4	3	228
5	1	227
5	2	228
5	3	229
6	1	229
6	2	229
6	3	229
MEAN		227.8888889







P-value > 0.05
The Vds on data is normally distributed



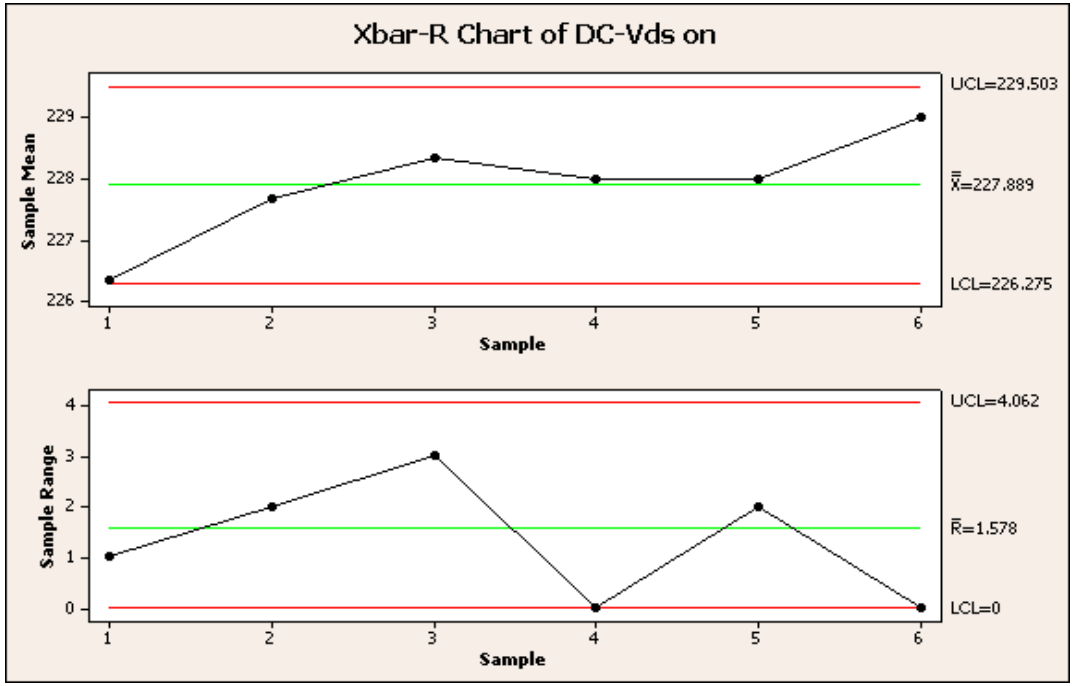
Multi-Vari chart shows there is no variation for Time to Time, between part to part and within part.
Thus , the Vds on data is STABLE

2) STABILITY-MSA

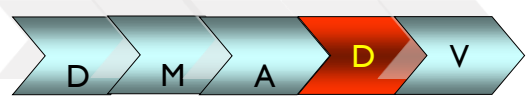
1. Stability
2. Accuracy (Bias)
3. Linearity
4. Precision

3) ANALYSIS METHOD/ASSUMPTIONS XBAR –R CHART

Day	Rep	DC-Vds on
1	1	227
1	2	226
1	3	226
2	1	227
2	2	227
2	3	229
3	1	227
3	2	228
3	3	230
4	1	228
4	2	228
4	3	228
5	1	227
5	2	228
5	3	229
6	1	229
6	2	229
6	3	229
MEAN		**227.8888889**



- No abnormally shown on Xbar-R chart which indicates that the measurement system is stable.



1. Stability
2. Accuracy (Bias)
3. Linearity
4. Precision

2) ACCURACY(BIAS) -MSA

1) BIAS THEORY

Gage bias examines the difference between the observed average measurement and a reference or master value. It answers the question, "How biased is my gage when compared to a master value?"

2) LINEARITY THEORY

Gage linearity tells you how accurate your measurements are through the expected range of the measurements. It answers the question, "Does my gage have the same accuracy for all sizes of objects being measured?"

3) SAMPLING PLAN /PROCEDURE-BIAS AND LINEARITY

-Firstly three golden parts were selected.
-Manufacturing tech. will load each of this golden part in automated dc test system and repeats for 5 times to make the 5 measurements for each golden parts.
-Measured data will be recorded and compared against actual data.

2) ACCURACY(BIAS) -MSA

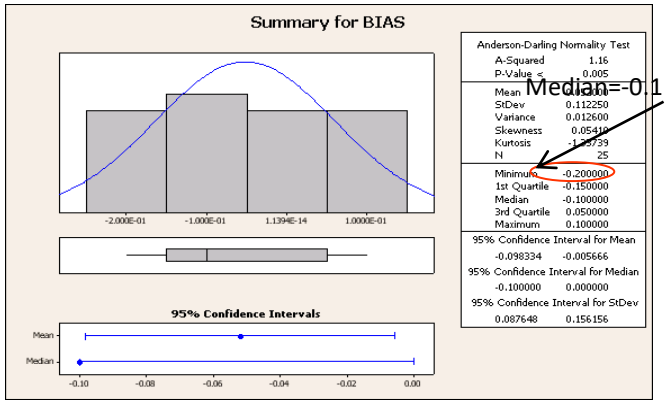
In order to test either the measurement system is "Bias" or not, one-sample T-test (two sided) is used.

1. Test for Independence

H_O: Data is order independent

H_A: Data is not order independent

Graphical summary



Runs Test: BIAS

```
Runs test for BIAS

Runs above and below K = -0.1

The observed number of runs = 13

The expected number of runs = 10.12

19 observations above K, 6 below

P-value = 0.101
```

PART	ACTUAL	REPEATABILITY	VDSON(mV)	BIAS
1	226	1	226.1	-0.10
1	226	2	226.2	-0.20
1	226	3	226	0.00
1	226	4	225.9	0.10
1	226	5	226.1	-0.10
1	226	6	226.1	-0.10
1	226	7	226	0.00
1	226	8	225.9	0.10
1	226	9	226.3	-0.30
1	226	10	226.2	-0.20
1	226	11	226.8	-0.80
1	226	12	225.4	0.60
1	226	13	226.4	-0.40
1	226	14	225.5	0.50
1	226	15	226.6	-0.60
1	226	16	226	0.00
1	226	17	225.7	0.30
1	226	18	226.2	-0.20
1	226	19	225.9	0.10
1	226	20	226.1	-0.10
1	226	21	226.2	-0.20
1	226	22	225.8	0.20
1	226	23	226.9	-0.90
1	226	24	225.9	0.10
1	226	25	226	0.00
MEAN			**226.088**	**-0.088**
MEDIAN			**226.1**	**-0.1**
STDEV			**0.3444**	**0.344**

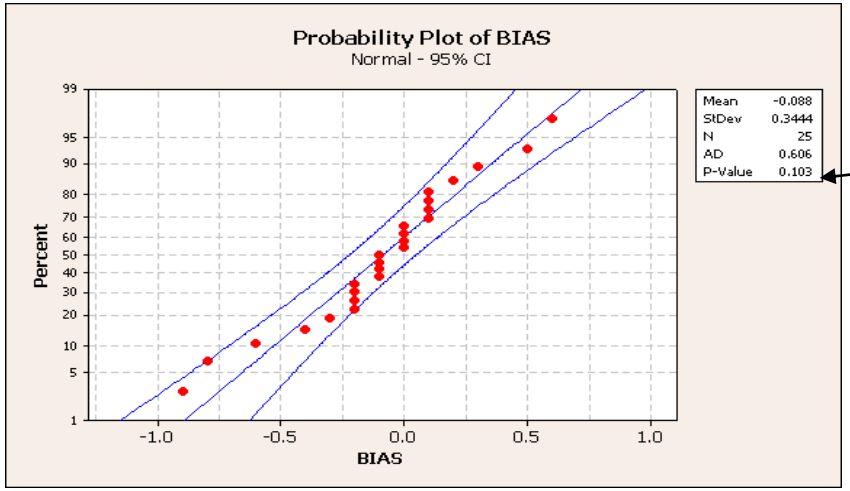
Conclusion: The observed number of runs, 13, is smaller than the expected number of runs, 10.12. The P-value for the test is 0.101, which is higher than α = 0.05. This result indicates that the data is independent in time order.

2) ACCURACY(BIAS) -MSA

2. Test for Normality

H_O: Sample data are normally distributed

H_A: Sample data are not normally distributed



The P-value for the normal probability test is 0.103, which is higher than α = 0.05. This result indicates that we fail to reject the null hypothesis (Ho) and accept the distribution as from a normal distribution.

3. Comparison statement

H_O: No Bias i.e. Mean (observed data) = 0

H_A: Bias i.e. Mean (observed data) ≠ 0

One-Sample T: BIAS

Test of mu = 0 vs not = 0

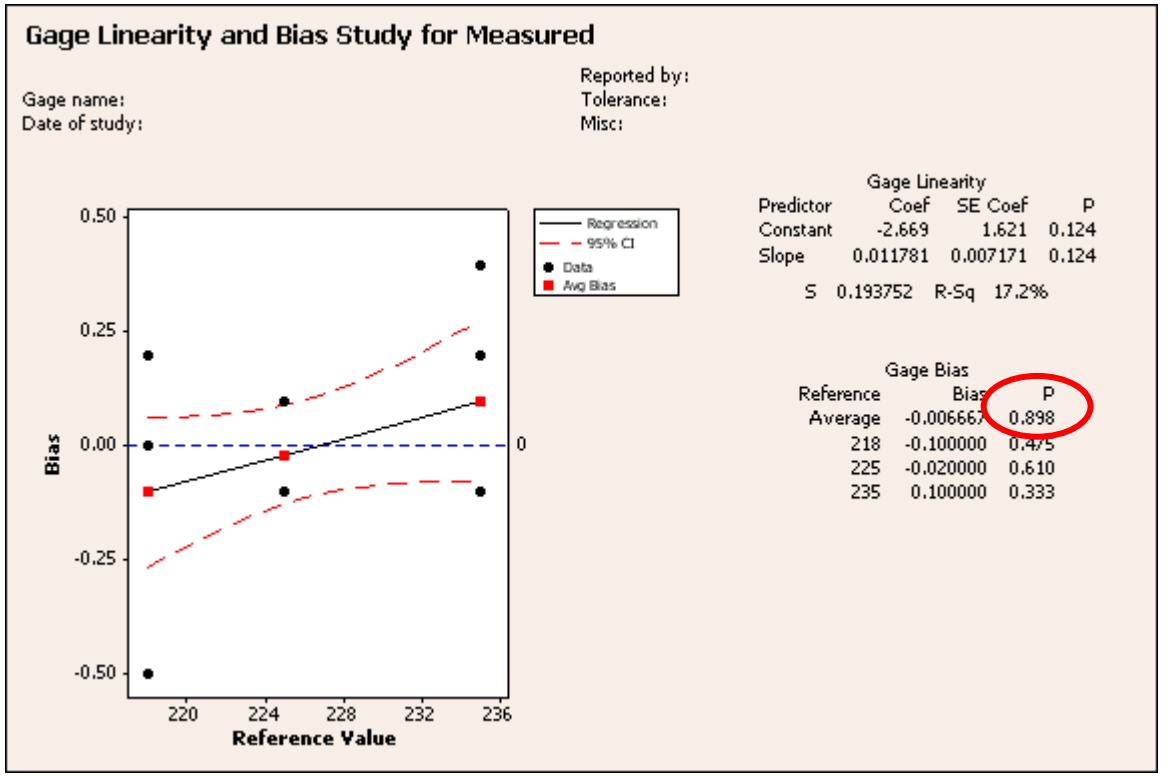
Variable	N	Mean	StDev	SE Mean	95% CI	T	P
BIAS	25	-0.088000	0.344384	0.068877	(-0.230155, 0.054155)	-1.28	0.214

The hypothesis result shows P value > 0.05, so fail to reject H_O. It can be interpreted as at the 95% confidence level, estimated that the gage has no significant bias from zero.

3)LINEARIT

4) ANALYSIS METHOD/ASSUMPTIONS

Part	Actual	Measured
1	218	217.9
1	218	217.5
1	218	218.2
1	218	218
1	218	217.9
2	225	224.9
2	225	225.1
2	225	224.9
2	225	224.9
2	225	225.1
3	235	234.9
3	235	235.2
3	235	234.9
3	235	235.1
3	235	235.4

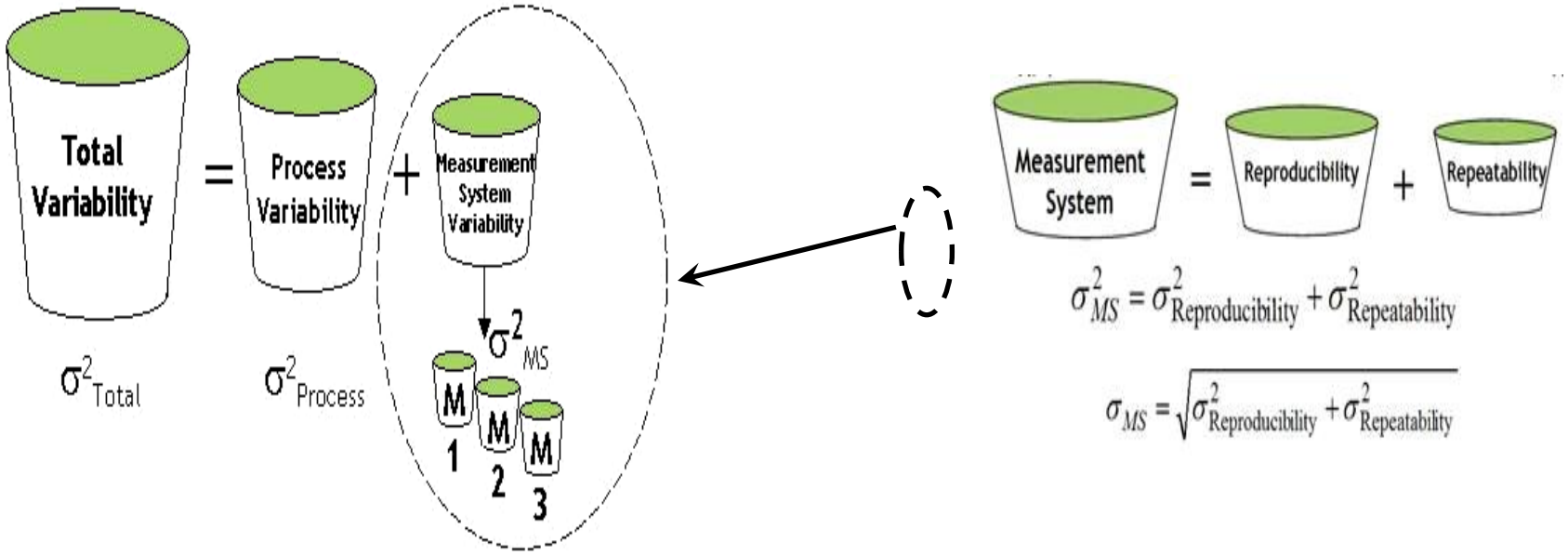


** The actual value computed based on industry standard curve traced parts

The hypothesis result shown that all p>0.05. It can be interpreted as at the 95% confidence level, estimated that the gage is performing well in the operating range of 217mV to 235mV.

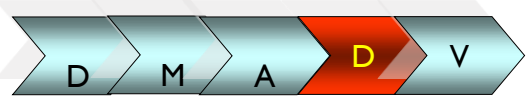
4) PRECISION-MSA

1. Stability
2. Accuracy (Bias)
3. Linearity
4. Precision



$$\sigma^2_{MS} = \sigma^2_{\text{Reproducibility}} + \sigma^2_{\text{Repeatability}}$$

$$\sigma_{MS} = \sqrt{\sigma^2_{\text{Reproducibility}} + \sigma^2_{\text{Repeatability}}}$$



1. Stability
2. Accuracy (Bias)
3. Linearity
4. Precision

4) PRECISION-MSA

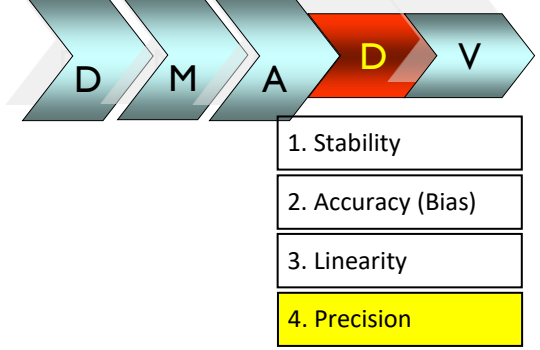
STEP 1: OVERVIEW OF PROCEDURE/SAMPLING PLAN

-For GRnR study, firstly manufacturing tech. will load 9 parts into dc test handler in serialized form to do the measurements using the new load board from vendor BIM. Repeat loading 2X and data will be recorded for the total of 27 measurements per time period.

Due to automation,operator is not a factor here.Instead the data were collected over three time periods (three different days).

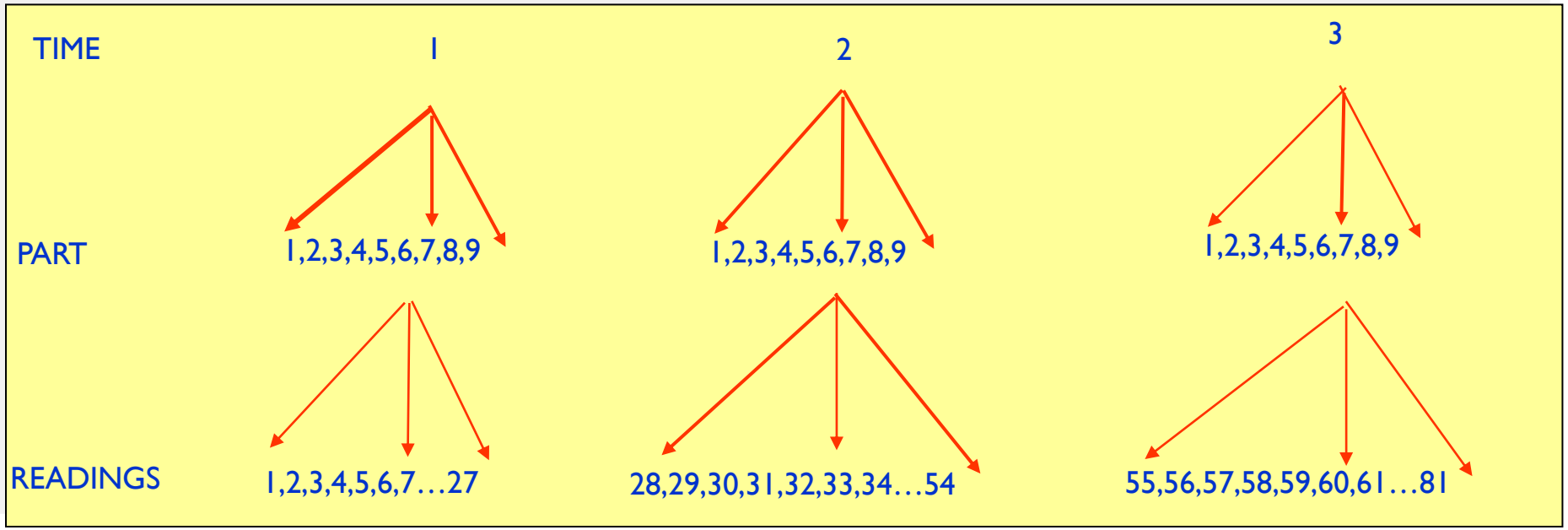
Factors	Type	Levels
1) TIME	Qualitative	3 levels
2) PART	Qualitative	9 levels per time
3) READINGS	Qualitative	3 levels per part

4) PRECISION-MSA



STEP 1: OVERVIEW OF PROCEDURE/SAMPLING PLAN

-The corresponding tree diagram for this study is as shown in BELOW

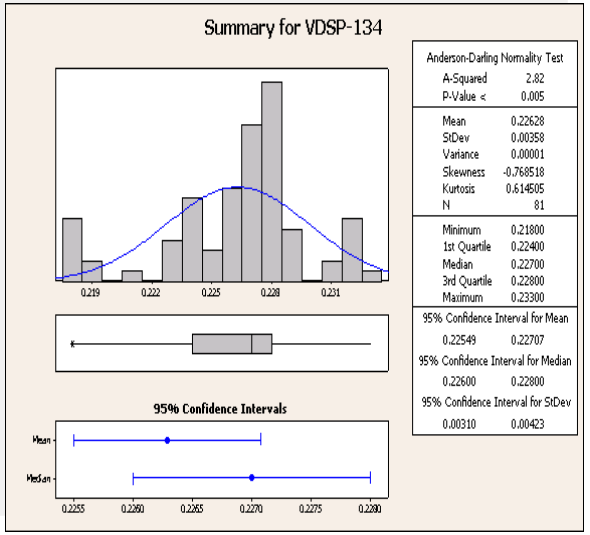


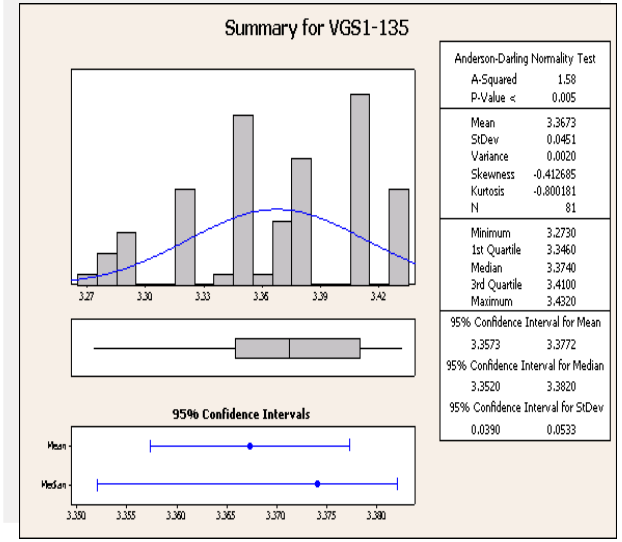
1. Stability
2. Accuracy (Bias)
3. Linearity
4. Precision

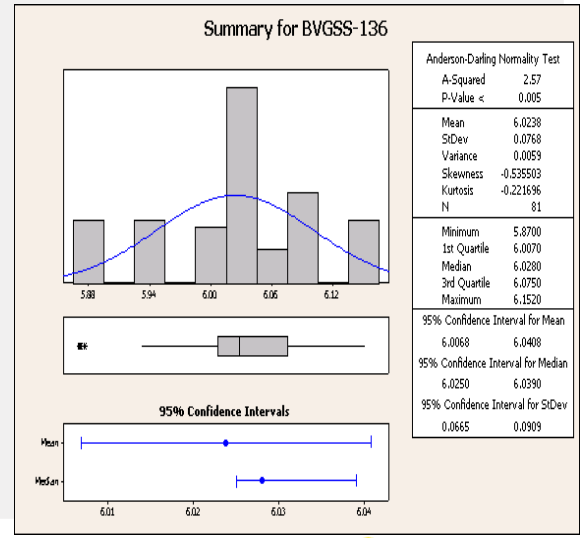
4) PRECISION-MSA

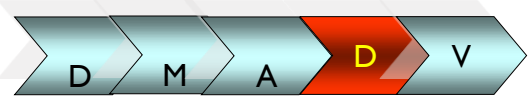
STEP2: OUTLIERS / ODD DATA POINTS

-There were no unusual measurements observed in the data.The tool continued to perform over the period of the evaluation with no unexpected hardware or software changes being required.An overall summary of the data in terms of its distributional properties is shown below.









1. Stability
2. Accuracy (Bias)
3. Linearity
4. Precision

4) PRECISION-MSA

STEP 3 : ANALYSIS METHOD/ASSUMPTIONS

Analysis Method

- Analysis of variance method were used to analyze the data and estimate the sources of variability using MINITAB 14.
- Since we are interested in time variability and part variability, time and parts are random factors while the lowest level which Readings is nested within all above factors(Error term).
-The model used to fit the data was a two factor cross model as shown below:-

Observed Y = Time + Parts + Time*Parts + Error

-The repeatability of the measurement system is observed from the error term in the model.
-The reproducibility of the measurement system is obtained from both the Time and Time to Part interactions variance components.
-The resulting multivariate chart and accompanying variance component estimates text report are shown in next slides.This is a two factor crossed model.

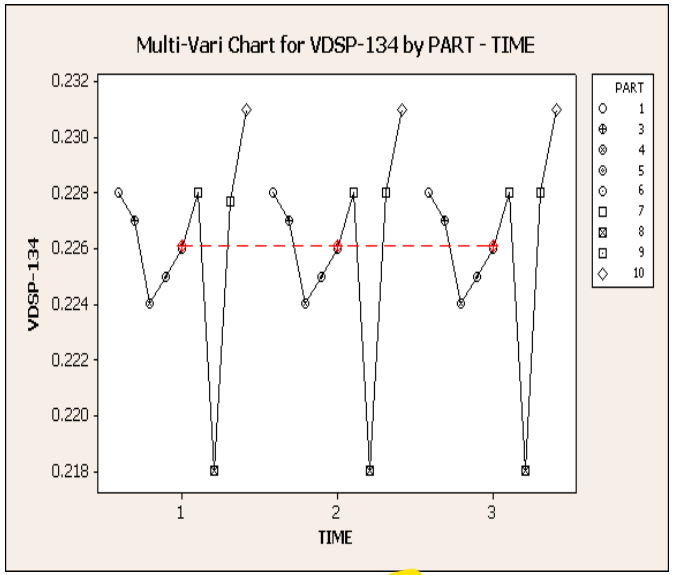
1. Stability
2. Accuracy (Bias)
3. Linearity
4. Precision

4) PRECISION-MSA

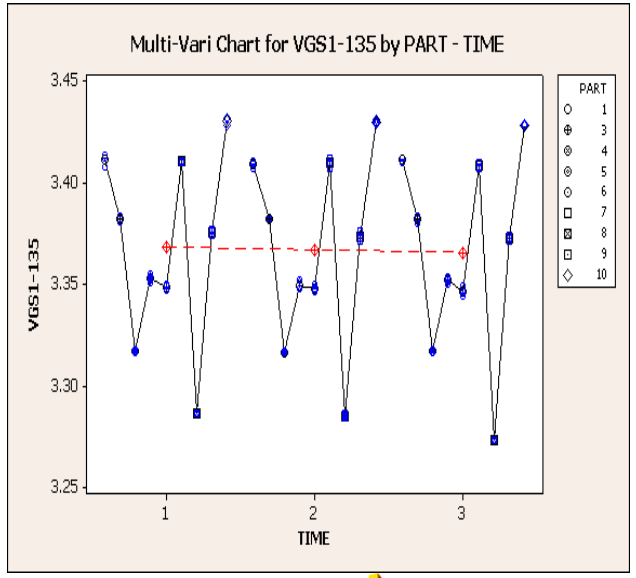
STEP 3 : ANALYSIS METHOD/ASSUMPTIONS

The above analysis assumes the following:
1. The repeatability estimate is the same for all parts measured.
2. The reproducibility estimate is the same for all parts measured.

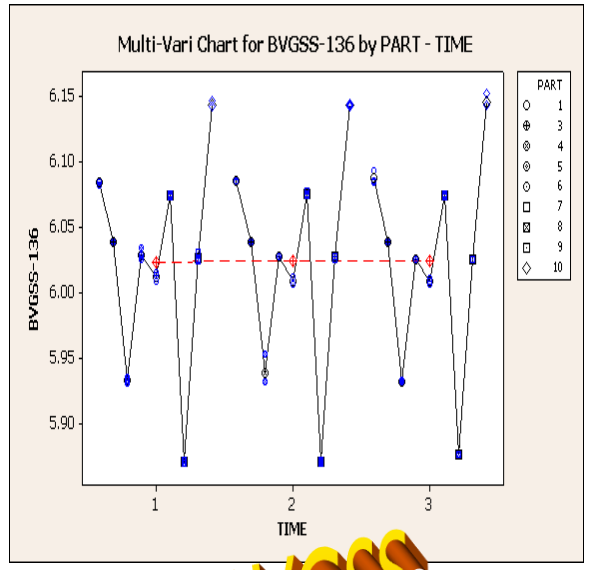
STEP 4 : ANALYSIS RESULTS AND ASSOCIATED GRAPHICS-MULTIVARI CHART



VDSP



VGS1



BVGSS

4) PRECISION-MSA

STEP 5 : ANOVA ANALYSIS AND VARIANCE COMPONENTS ESTIMATES- VDSP,VGS1 AND BVGSS

VARIANCE COMPONENT WERE ZERO

ANOVA: VDSP-134 versus TIME, PART

```
Factor  Type    Levels  Values
TIME    random       3  1, 2, 3
PART    random       9  1,  3,  4,  5,  6,  7,  8,
9, 10

Analysis of Variance for VDSP-134
Source     DF          SS          MS   F  P
TIME        2  0.000000025  0.000000012  **
PART        8  0.000958321  0.000119790  **
TIME*PART  16  0.000000198  0.000000012  **
Error      54  0.000000667  0.000000012
Total      80  0.000959210
** Denominator of F-test is zero.
S = 0.000111111   R-Sq = 99.93%   R-Sq(adj) =  99.90%

                                Expected Mean Square
                  Variance  Error  for Each Term (using
   Source      component   term  unrestricted model)
1  TIME          0.00000      3  (4) + 3 (3) + 27 (1)
2  PART          0.00001      3  (4) + 3 (3) + 9 (2)
3  TIME*PART    -0.00000      4  (4) + 3 (3)
4  Error         0.00000         (4)
```

ANOVA: VGS1-135 versus TIME, PART

```
Factor  Type    Levels  Values
TIME    random       3  1, 2, 3
PART    random       9  1,  3,  4,  5,
9, 10

Analysis of Variance for VGS1-135
Source     DF          SS          MS
TIME        2  0.0000542  0.0000271
PART        8  0.1620987  0.0202623  33
ME*PART    16  0.0000971  0.0000061
Error      54  0.0002160  0.00000
Total      80  0.1624660
S = 0.002   R-Sq = 99.87%    Sq(adj) =

                Expected Mean Square
                Variance  Erro
   Source      component   term
1  TIME          0.00000      3  (4) + 3
2  PART          0.00225      3  (4) + 3
3  TIME*PART     0.00000      4  (4) + 3
4  Error         0.00000         (4)
```

ANOVA: BVGSS-136 versus TIME, PART

```
Factor  Type    Levels  Values
TIME    random       3  1, 2, 3
PART    random       9  1,  3,  4,  5,  6,  7,  8,
  9, 10

Analysis of Variance for BVGSS-136
Source     DF        SS        MS        F      P
TIME        2  0.000004  0.000002     0.18  0.839
PART        8  0.471453  0.058932  5187.85  0.000
TIME*PART  16  0.000182  0.000011     1.04  0.428
Error      54  0.000587  0.000011
Total      80  0.472227
S = 0.00329796   R-Sq = 99.88%   R-Sq(adj) = 99.82%

                Expected Mean Square
                Variance  Error  for Each Term (using
   Source      component   term  unrestricted model)
1  TIME         -0.00000      3  (4) + 3 (3) + 27 (1)
2  PART          0.00655      3  (4) + 3 (3) + 9 (2)
3  TIME*PART     0.00000      4  (4) + 3 (3)
4  Error         0.00001         (4)
```

VDSP

VGS1

BVGSS

4) PRECISION-MSA

STEP 5 : ANOVA ANALYSIS-RESPONSES MULTIPLIED BY 1000

Worksheet 1 ***

→	C2	C3	C4	C5	C6	C7	C8	C9
	TRIAL	PART	VGS1-135	VGS1*1000-135	BVGSS-136	BVGSS*1000-136	VDSP-134	VDSP*1000-134
1	1	1	3.414	3414	6.082	6082	0.228	228
2	1	3	3.382	3382	6.039	6039	0.227	227
3	1	4	3.318	3318	5.935	5935	0.224	224
4	1	5	3.353	3353	6.034	6034	0.225	225
5	1	6	3.350	3350	6.013	6013	0.226	226
6	1	7	3.411	3411	6.074	6074	0.228	228
7	1	8	3.286	3286	5.872	5872	0.218	218
8	1	9	3.377	3377	6.025	6025	0.228	228
9	1	10	3.432	3432	6.142	6142	0.231	231
10	2	1	3.408	3408	6.086	6086	0.229	229
11	2	3	3.381	3381	6.039	6039	0.227	227
12	2	4	3.316	3316	5.933	5933	0.224	224
13	2	5	3.351	3351	6.029	6029	0.225	225
14	2	6	3.349	3349	6.009	6009	0.227	227
15	2	7	3.410	3410	6.075	6075	0.228	228
16	2	8	3.286	3286	5.872	5872	0.218	218
17	2	9	3.374	3374	6.031	6031	0.227	227
18	2	10	3.428	3428	6.147	6147	0.233	233
19	3	1	3.412	3412	6.084	6084	0.228	228
20	3	3	3.384	3384	6.038	6038	0.226	226

4) PRECISION-MSA

D M A D V

1. Stability
2. Accuracy (Bias)
3. Linearity
4. Precision

STPE 5 : RECOMPUTE ANOVA ANALYSIS N VARIANCE COMPONENTS -BVGSS*1000,

STAT-ANOVA-BALANCED ANOVA

ANOVA: VDSP*1000-134_1 versus TIME, PART

```
Factor  Type    Levels  Values
TIME    random       3  1, 2, 3
PART    random       9  1,  3,  4,  5,  6,  7,
9, 10

Analysis of Variance for VDSP*1000-134_1

Source     DF       SS       MS        F      P
TIME        2    0.025    0.012     1.00  0.390
PART        8  958.321  119.790  9703.00  0.000
TIME*PART  16    0.198    0.012     1.00  0.471
Error      54    0.667    0.012
Total      80  959.210

S = 0.111111   R-Sq = 99.93%   R-Sq(adj) = 99.90%

                                    Expected Mean Squ
                 Variance  Error  for Each Term (us
   Source     component   term  unrestricted mode
1  TIME          0.0000      3  (4) + 3 (3) + 27
2  PART         13.3086      3  (4) + 3 (3) + 9 (
3  TIME*PART    -0.0000      4  (4) + 3 (3)
4  Error         0.0123         (4)
```

ANOVA: VGS1*1000-135 versus TIME, PART

```
Factor  Type    Levels  Values
TIME    random       3  1, 2, 3
PART    random       9  1,  3,  4,  5,  6,
 9, 10

Analysis of Variance for VGS1*1000-135

Source     DF       SS       MS        F
TIME        2     54.2     27.1     4.47
            8   162098.7  20262.3  3339.27
*PART      16     97.1      6.1     1.52
Error      54    216.0      4.0
Total      80   162466.0

   2   R-Sq = 99.87%   R-Sq(adj) = 99
ed Mean Square
                 Variance  Error  for ach Te
(using
   Source     component   term  unres
1  TIME            0.78      3  (4) + 3 (3
(1)
2  PART         2250.70      3  (4) + 3 (3)
3  TIME*PART       0.69      4  (4) + 3 (3)
4  Error           4.00         (4)
```

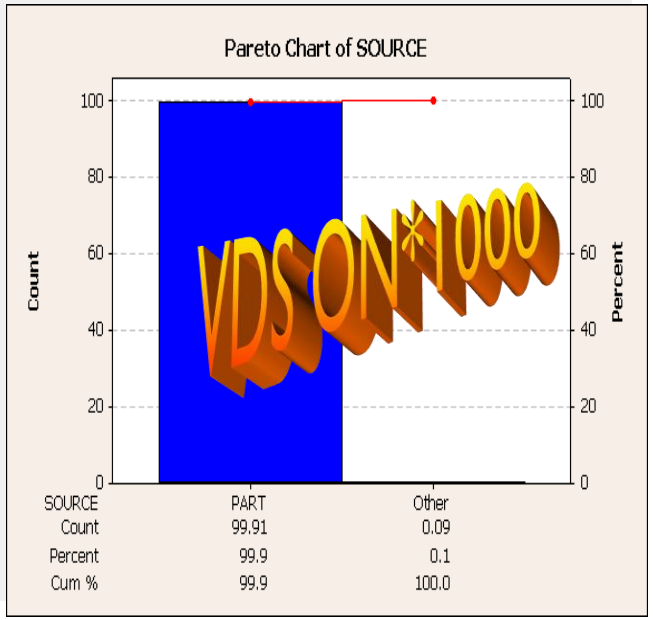
ANOVA: BVGSS*1000-136 versus TIME, PART

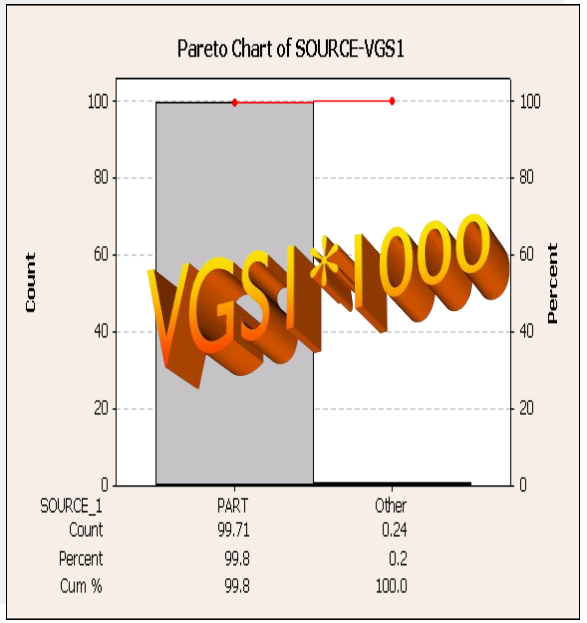
```
Factor  Type    Levels  Values
TIME    random       3  1, 2, 3
PART    random       9  1,  3,  4,  5,  6,  7,  8,
 9, 10

Analysis of Variance for BVGSS*1000-136

Source     DF      SS     MS        F      P
TIME        2       4      2     0.18  0.839
PART        8  471453  58932  5187.85  0.000
*PART      16     182     11     1.04  0.428
r          54     587     11
Total      80  472227

 = 3.29796   R-Sq = 99.88%   R-Sq(adj) = 99.82%
                 Expected Mean Square
                 Variance  Error  for Each Term (using
   Source     component   term  unrestricted model)
1  TIME           -0.35      3  (4) + 3 (3) + 27 (1)
2  PART         6546.70      3  (4) + 3 (3) + 9 (2)
3  TIME*PART       0.16      4  (4) + 3 (3)
4  Error          10.88         (4)
```

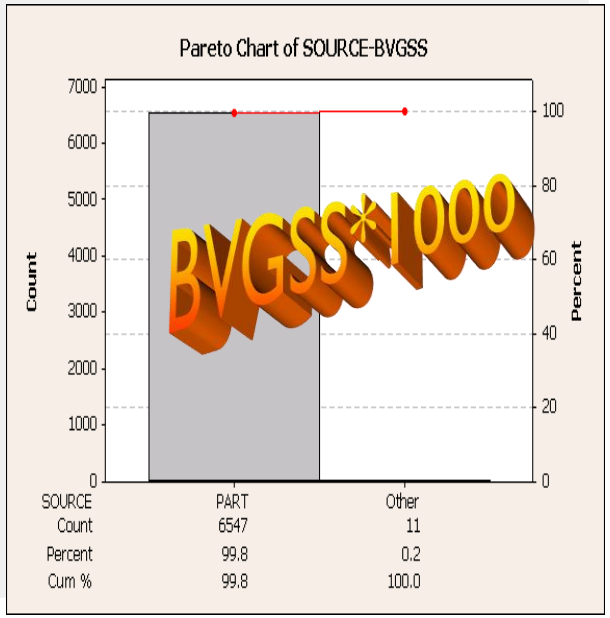
4) PRECISION-MSA

1. Stability
2. Accuracy (Bias)
3. Linearity
4. Precision

STEP 6: PARETO CHART FOR SOURCE-BVGSS,VGS1 AND VDS ON







Conclusion : Majority of variation in measurement system coming from part itself which is part of the process which is accountable for >99% of total variation.

4) PRECISION-MSA

STEP 7 : DERIVED METRICES-BVGSS*1000,VGS1*1000 AND VDSP*1000

D M A D V

VDSP

1. Stability
2. Accuracy (Bias)
3. Linearity
4. Precision

BVGSS

Worksheet 2 ***

	C1-T	C2	C3-T	C4
	SOURCE	VAR .COMP	% TOTA	TrueVarComp
1	TIME	0.00	0.00	0.000000000000
2	PART	6546.70	99.83	0.006546700000
3	TIME*PART	0.16	0.0024	0.000000160000
4	ERROR	10.88	0.1659	0.000010880000

Repeatability, σ^2_{RPT} = Error term = 0.000010880000

Repeatability, σ_{RPT} = 0.0032984

Reproducibility, σ^2_{RPD} = Time + Time* Part = 0 + 0.00000016

Reproducibility, σ_{RPD} = 0.0004

Measurement, $\sigma^2_{MS} = \sigma^2_{RPT} + \sigma^2_{RPD}$ = 0.000010880000+0.00

Measurement, σ_{MS} = 0.003322 (Precision)

Part Variability, σ^2_{PART} = 0.0065467

Total Variability, $\sigma^2_{TOTAL} = \sigma^2_{PART} + \sigma^2_{MS}$=0.00655774

Total Variability, σ_{TOTAL} = 0.081

% R & R = $(\sigma_{MS}/\sigma_{TOTAL})*100$=(0.003322/0.081)*100= 4 %

% P/T = $(6*\sigma_{MS}/$ USL-LSL)=(6*0.003322/3)*100 = 0.66%

VGS1*1000

Worksheet 2 ***

	C7-T	C8	C9	C10
	SOURCE_1	VAR .COMP_1	%TOTAL_1	TrueVarComp_1
1	TIME	0.78	0.0346	0.0000007800
2	PART	2250.70	99.7130	0.0022507000
3	TIME*PART	0.69	0.0305	0.0000006900
4	Error	4.00	0.1777	0.0000040000

Repeatability, σ^2_{RPT} = Error term = 0.000004

Repeatability, σ_{RPT} = 0.002

Reproducibility, σ^2_{RPD} = Time + Time* Part = 0.00000078 + 0.00000069

Reproducibility, σ_{RPD} = 0.0012124

Measurement, $\sigma^2_{MS} = \sigma^2_{RPT} + \sigma^2_{RPD}$ = 0.000004+0.00 0147

Measurement, σ_{MS} = 0.002338 (Precision)

Part Variability, σ^2_{PART} = 0.00225070

Total Variability, $\sigma^2_{TOTAL} = \sigma^2_{PART} + \sigma^2_{MS}$= 0.00225070 + 0.00000547

Total Variability, σ_{TOTAL} = 0.0474991

% R & R= $(\sigma_{MS}/\sigma_{TOTAL})*100$=(0.002338/0.0474991)*100= 4.92%

% P/T = $(6*\sigma_{MS}/$ USL-LSL)*100=(6*0.002338/3)*100= 0.47%

Worksheet 2 ***

	C1-T	C2	C3	C4
	SOURCE	VAR.COMP	% T	
1	TIME	0.0000	0.0	
2	PART	13.3086	99.9	
3	TIME*PART	0.0000	0.00000	0.0000000000
4	Error	0.0123	0.09230	0.0000000123

Repeatability, σ^2_{RPT} = Error term = 0.0000000123

Repeatability, σ_{RPT} = 0.000111

Reproducibility, σ^2_{RPD} = Time + Time* Part =0+0

Reproducibility, σ_{RPD} = 0.0000

Measurement, $\sigma^2_{MS} = \sigma^2_{RPT} + \sigma^2_{RPD}$ = 0.0000000123+0

Measurement, σ_{MS} = 0.000111(Precision)

Part Variability, σ^2_{PART} = 0.0000133086

Total Variability, $\sigma^2_{TOTAL} = \sigma^2_{PART} + \sigma^2_{MS}$

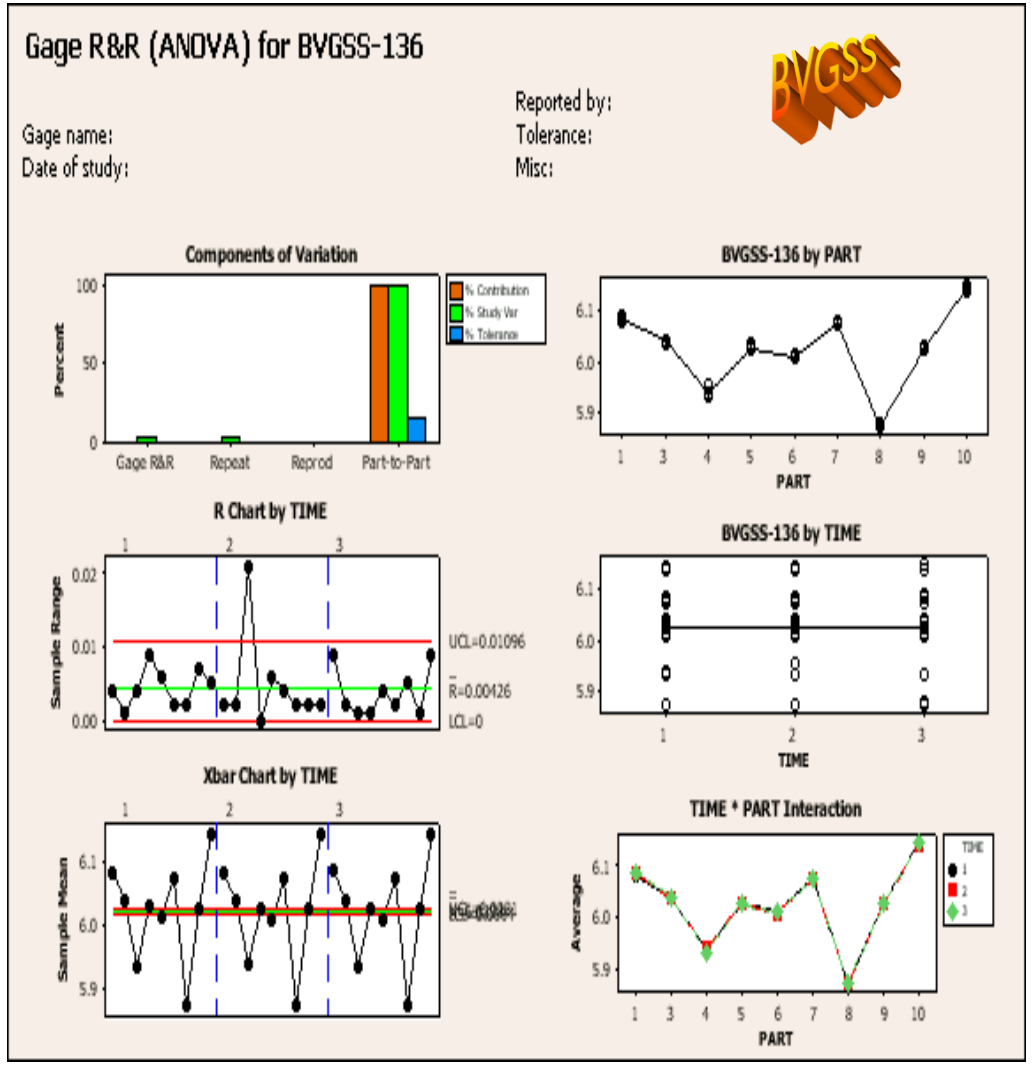
Total Variability, σ_{TOTAL} = 0.003649

% R & R = $(\sigma_{MS}/\sigma_{TOTAL})*100$=(0.00011/0.003649)*100=3%

% P/T = $(6*\sigma_{MS}/$ USL-LSL)*100= 6*0.00011/(0.8)*100 = 0.08%

<u>Conclusion</u>

The percentage variation for both %RR and %P/T is less than 10%.In this experiment we do not have process variation, σ process however the spec. limits are specified. This measurement process is deemed acceptable.From the GRR study total six sigma spread for Bvgss is 0.019V while for Vgs1 is 0.014V while for Vdson is 0.0006V which is rather low.



Two-Way ANOVA Table Without Interaction

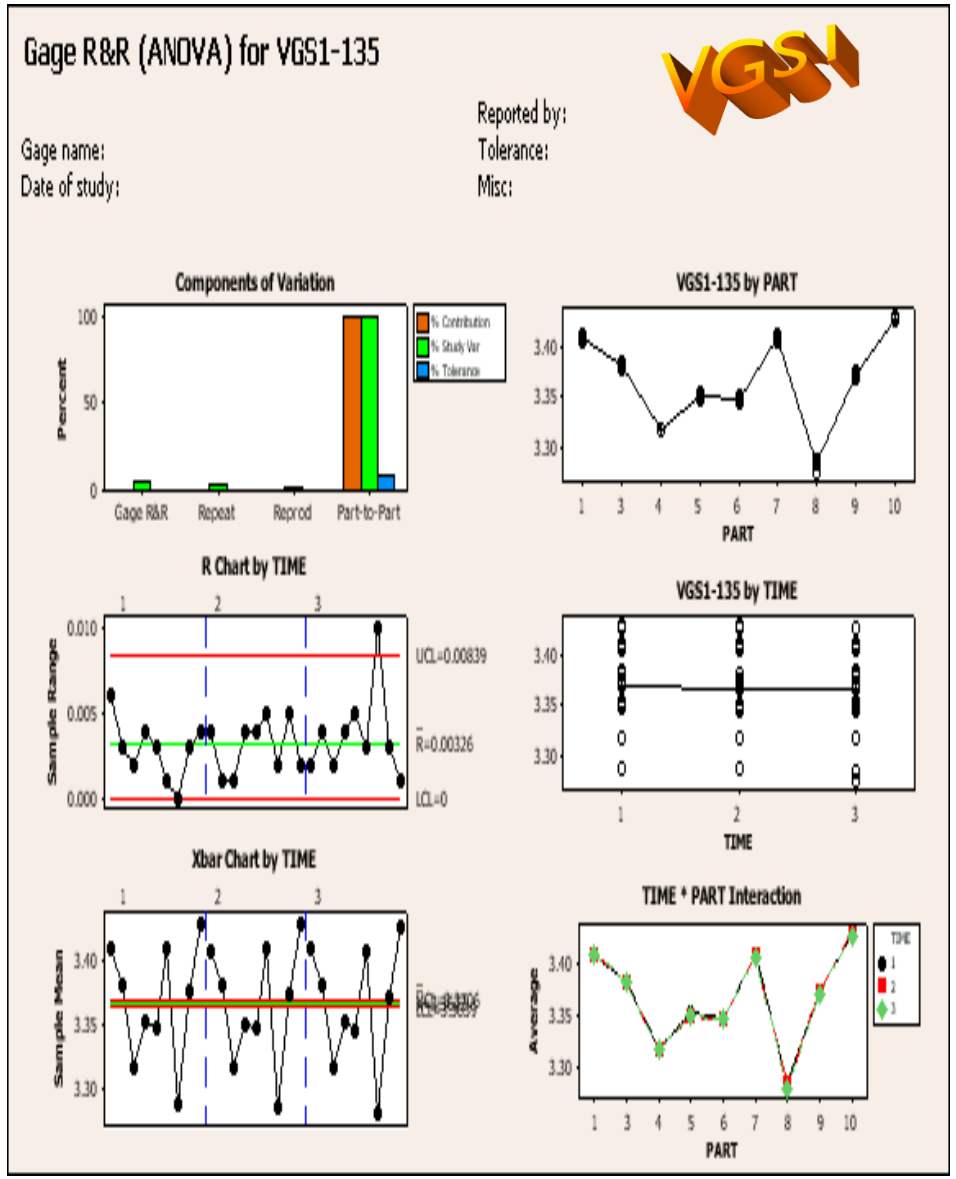
Source	DF	SS	MS	F	P
PART	8	0.471453	0.0589317	5363.79	0.000
TIME	2	0.000004	0.0000020	0.18	0.833
Repeatability	70	0.000769	0.0000110		
Total	80	0.472227			

Gage R&R

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	0.0000110	0.17
Repeatability	0.0000110	0.17
Reproducibility	0.0000000	0.00
TIME	0.0000000	0.00
Part-To-Part	0.0065467	99.83
Total Variation	0.0065577	100.00

Source	StdDev (SD)	Study Var (6 * SD)	%Study Var (%SV)	%Tolerance (SV/Toler)
Total Gage R&R	0.0033147	0.019888	4.09	0.66
Repeatability	0.0033147	0.019888	4.09	0.66
Reproducibility	0.0000000	0.000000	0.00	0.00
TIME	0.0000000	0.000000	0.00	0.00
Part-To-Part	0.0809119	0.485472	99.92	16.18
Total Variation	0.0809798	0.485879	100.00	16.20

Conclusion: The gauge is suitable for maintaining Bvgss within specification limits since %PT <<< 10% which is 0.66%. The gauge also suitable for process improvement since % R+R is < 10% which is 4.09%.



Gage R&R Study - ANOVA Method

Two-Way ANOVA Table With Interaction

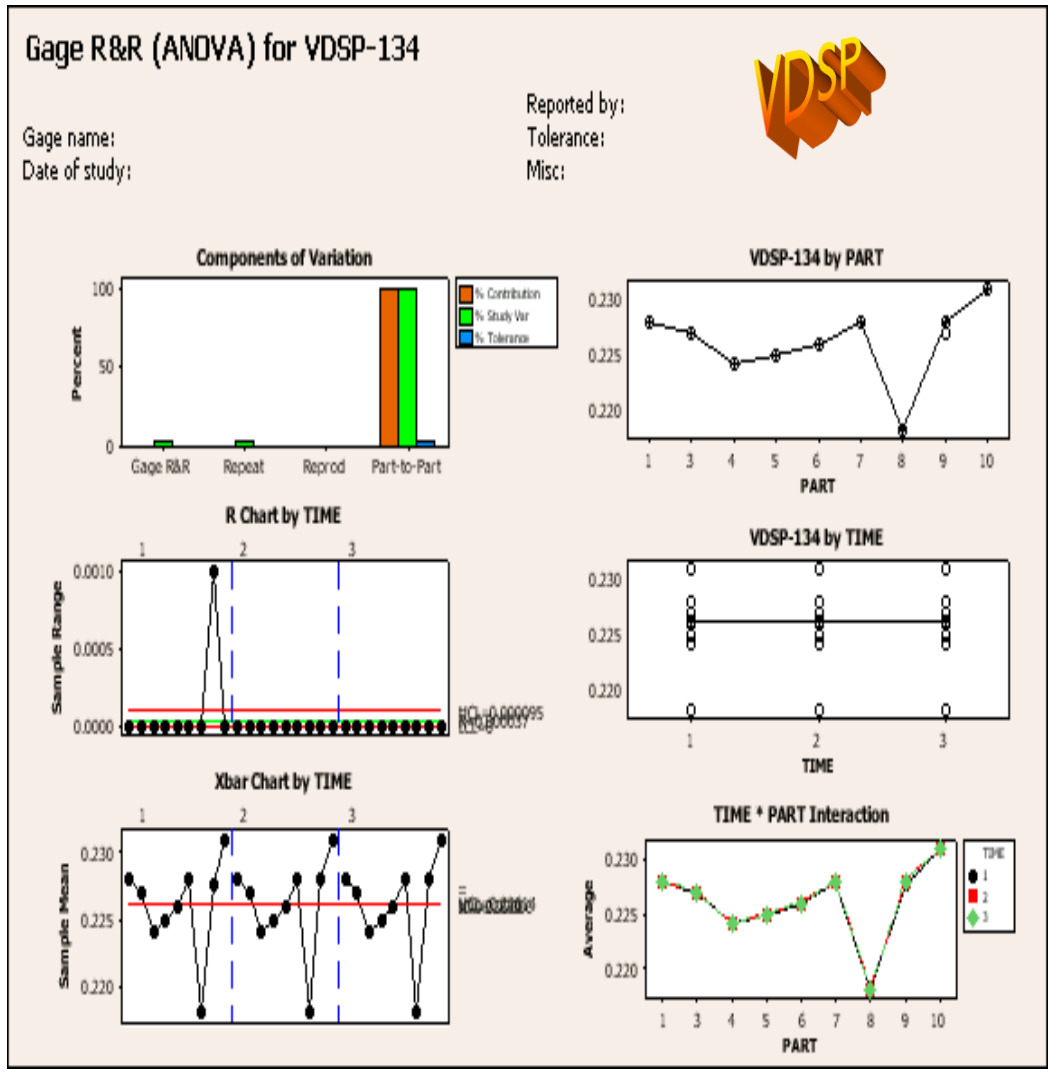
Source	DF	SS	MS	F	P
PART	8	0.162099	0.0202623	3339.27	0.000
TIME	2	0.000054	0.0000271	4.47	0.029
PART * TIME	16	0.000097	0.0000061	1.52	0.128
Repeatability	54	0.000216	0.0000040		
Total	80	0.162466			

Gage R&R

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	0.0000055	0.24
Repeatability	0.0000040	0.18
Reproducibility	0.0000015	0.07
TIME	0.0000008	0.03
TIME*PART	0.0000007	0.03
Part-To-Part	0.0022507	99.76
Total Variation	0.0022562	100.00

Source	StdDev (SD)	Study Var (6 * SD)	%Study Var (%SV)	%Tolerance (SV/Toler)
Total Gage R&R	0.0023386	0.014032	4.92	0.47
Repeatability	0.0020000	0.012000	4.21	0.40
Reproducibility	0.0012121	0.007272	2.55	0.24
TIME	0.0008831	0.005298	1.86	0.18
TIME*PART	0.0008302	0.004981	1.75	0.17
Part-To-Part	0.0474415	0.284649	99.88	9.49
Total Variation	0.0474991	0.284995	100.00	9.50

Conclusion: The gauge is suitable for maintaining Vgs1 within specification limits since %PT <<< 10% which is 0.47%. The gauge also suitable for process improvement since % R+R is < 10% which is 4.92%.



Two-Way ANOVA Table Without Interaction

Source	DF	SS	MS	F	P
PART	8	0.0009583	0.0001198	9703	0.000
TIME	2	0.0000000	0.0000000	1	0.373
Repeatability	70	0.0000009	0.0000000		
Total	80	0.0009592			

Gage R&R

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	0.0000000	0.09
Repeatability	0.0000000	0.09
Reproducibility	0.0000000	0.00
TIME	0.0000000	0.00
Part-To-Part	0.0000133	99.91
Total Variation	0.0000133	100.00

Source	StdDev (SD)	Study Var (6 * SD)	%Study Var (%SV)	%Tolerance (SV/Toler)
Total Gage R&R	0.0001111	0.0006667	3.04	0.08
Repeatability	0.0001111	0.0006667	3.04	0.08
Reproducibility	0.0000000	0.0000000	0.00	0.00
TIME	0.0000000	0.0000000	0.00	0.00
Part-To-Part	0.0036481	0.0218886	99.95	2.74
Total Variation	0.0036498	0.0218988	100.00	2.74

Number of Distinct Categories = 46

Conclusion: The gauge is suitable for maintaining Vdsp within specification limits since %PT <<< 10% which is 0.08%. The gauge also suitable for process improvement since % R+R is < 10% which is 3.04%.