Measurements

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ELEN4006:Measurements and Systems Lab 1
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PART I

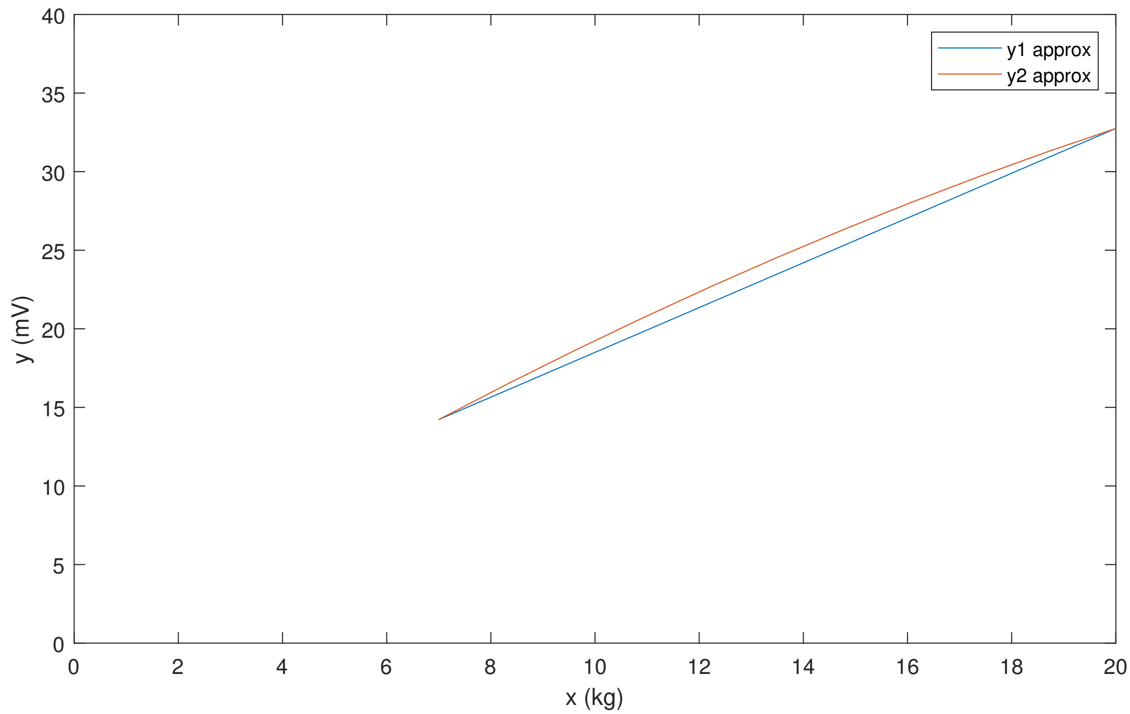


Fig. 1. Data graph.

Characteristics of measurement system or their relevance to a measurement system

1) Linearity: is measure of how the size of the part affects the bias of a measurement system. It is the difference in the observed bias values through the expected range of measurement.

2) 0-bias: is the original drift of the output when there is zero input on a sensor at standard temperature.

3) 0-bias drift: is the drift produced to the original O-bias when the temperature is changed from standard temperature.

4) Sensitivity: This is the change in output for unit change in input, measures the rate of change at STP.

5) Sensitivity drift: This is the change in output for unit change in input at non STP standars.

The results to the mentioned characteristics of measurement system can be found in the Appendix PartI.

PART II

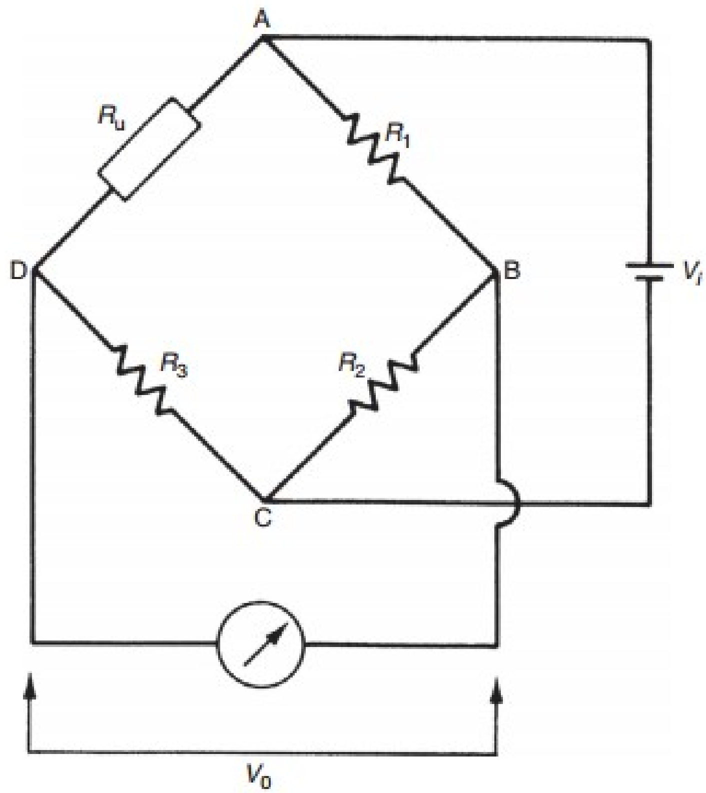


Fig. 2. Circuit.

From the circuit given, Equation 1 was derived. Tolerances were added and subtracted from the given resistors. 10 measurements were taken with the strain gauge with values varying from 1k to 10k Ohms (using 1k Ohms intervals). The calculations where performed using Matlab and the results can be viewed in the published PDF at the end of the report.

$$V_o = \left(\frac{R_3}{R_3 + R_u} - \frac{R_2}{R_2 + R_1} \right) * V_i \tag{1}$$

Non-linearity, hysteresis and resolution effects in many modern sensors and transducers are so small that it is difcult and not worthwhile to exactly quantify each individual effect. The error bands are the limits of the off-set that the resistors can take which are acceptable.

PART III

TABLE I
DATA ON BREAKDOWN HISTORY

Times before breakdown [days]	Time to repair [days]
21.4	0.4
18.5	0.7
36.7	2.0
19.8	0.1
22.3	0.6
27.9	3.5
24.1	0.5
30.2	0.2
25	1.3
8.6	0.8

Calculate the availability of a sensor based on the following data that has been collected of breakdowns of the sensor. The Availability, A(t), of the sensor is given as the probability that the sensor is in an operable state at any time of repair since repair takes time. Availability is affected by the rate of occurrence of failures plus maintenance time. Availability is calculated using Equation 2.

$$\begin{aligned} Availability A(t) &= \frac{MTBF}{MTBF + MTTR} \\ &= \frac{23.45}{23.45 + 1.0100} \\ &= 0.9587 \end{aligned} \tag{2}$$

Where :MTTR is the Mean Time To Repair, defined as the total amount of time spent performing all forms of maintenance repairs divided by the total number of those repairs.And MTBF is the Mean Time Between Failures, which is a basic measure of reliability for repairable items. It can be described as the time passed before a component, assembly, or system fails, under the condition of a constant failure rate.

Availability is important in measurements because it indicates the probability that the sensor is in an operable state at any time of repair. This is important

Table of Contents


```
clc;
%APPENDIX
%ELEN4006A – Measurements Systems Lab 1
%
```

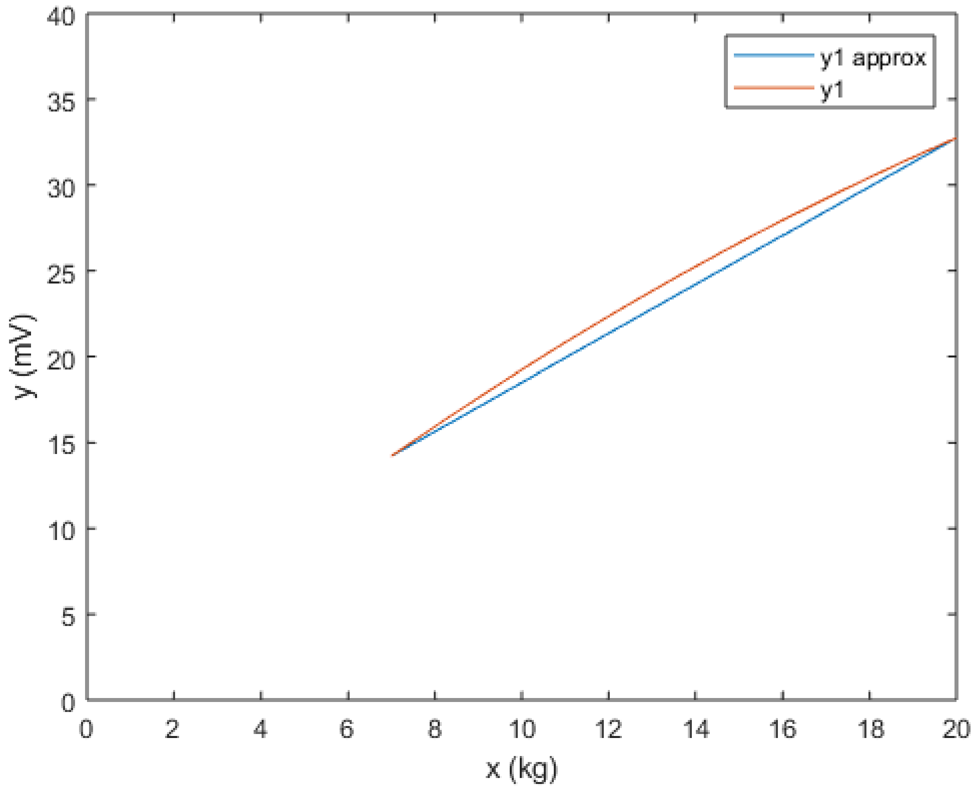
Part I

```
disp ("===================  PART I  ===================")

x = [7.0, 8.3 ,9.6 ,10.9 ,12.2 ,13.5 ,14.8 ,16.1 ,17.4 ,18.7 ,20.0];
% at 21 degrees Celcious
T1 = 21;
y1 =
 [14.225 ,16.458 ,18.606 ,20.670 ,22.649 ,24.544 ,26.354 ,28.080 ,29.721 ,31.278 ,
% at 40 degrees Celcious
T2 = 40;
y2 =
 [15.675 ,18.168 ,20.576 ,22.900 ,25.139 ,27.294 ,29.364 ,31.350 ,33.215 ,35.068 ,

%(i) linearity
disp("(i) linearity y = K*x + a ")

Ymax = max(y1);
Ymin = min(y1);
Xmin = min(x);
Xmax = max(x);

K = (Ymax - Ymin)/(Xmax - Xmin);
a = Ymin - K*Xmin;
K
a

R = corrcoef(x,y1);
disp("Correlation");
R(1,2)

Ymax = max(y2);
Ymin = min(y2);
K2 = (Ymax - Ymin)/(Xmax - Xmin);
a2 = Ymin - K2*Xmin;

Yideal_1 = K*x + a;
Yideal_2 = K2*x + a2;
```

```
figure
  plot(x,Yideal_1);
  hold on
  plot(x,y1);
 axis([0 20 0 40]);
legend('y1 approx','y1');
xlabel('x (kg)');
ylabel('y (mV)');

%-------------------------------------------
disp("--------------------------------------");
% (ii) Zero-bais = a
disp("(ii) Zero-bais = a");
disp("At 21 degrees zero bias (mV) =");
 a
%disp("At 40 degrees zero bias =");
% a2

%--------------------------------------------
disp("---------------------------------------");
% (iii) Zero-bias drift
disp("(iii) Zero-bias drift (mV/Degree Celcious)");


ZeroBiasDrift = (a2- a)/(T2-T1)

%-------------------------------------------
disp("---------------------------------------");
% (iv) Sensitivity
disp(" (iv) Sensitivity (mV/kg)");
Sensitivity = K;
Sensitivity

%-------------------------------------------
disp("----------------------------------------");
% (v) Sensitivity Drift
disp(" (v) Sensitivity Drift (mv/kg*Degree Celcious)");

Sensitivity_Drift = (K2- K)/(T2-T1)
%
```

```
===================  PART I  ===================
(i) linearity y = K*x + a

K =

    1.4250


a =

    4.2500

Correlation
```

```
ans =

    0.9980

--------------------------------------
(ii) Zero-bais = a
At 21 degrees zero bias (mV) =

a =

    4.2500

---------------------------------------
(iii) Zero-bias drift (mV/Degree Celcious)

ZeroBiasDrift =

    0.0026

---------------------------------------
 (iv) Sensitivity (mV/kg)

Sensitivity =

    1.4250

----------------------------------------
 (v) Sensitivity Drift (mv/kg*Degree Celcious)

Sensitivity_Drift =

    0.0105
```



Part II

```
disp ("===================  PART II  ===================")

Ru = [1e3 2e3 3e3 4e3 5e3 6e3 7e3 8e3 9e3 10e3];
% -5 percent
R1 = 5700;
R2 = 7600;
R3 = 3800;
Vi = 9;

Vo = ((R3./(Ru+R3))-(R2./(R2+R1)))*Vi;

% +5 percent
R1_ = 6300;
R2_ = 8400;
R3_ = 4200;
Vi = 9;

Vo_ = ((R3_./(Ru+R3_))-(R2_./(R2_+R1_)))*Vi;



Vo_error_Band = Vo_-Vo
```

```
figure
plot(Ru, Vo);
hold on
plot(Ru, Vo_);
plot(Ru, Vo_error_Band);
xlabel('Ru');
ylabel('Vo');
legend('-5 percent','+ percent',' V-diff');
```

```
%
```

==================== PART II ====================

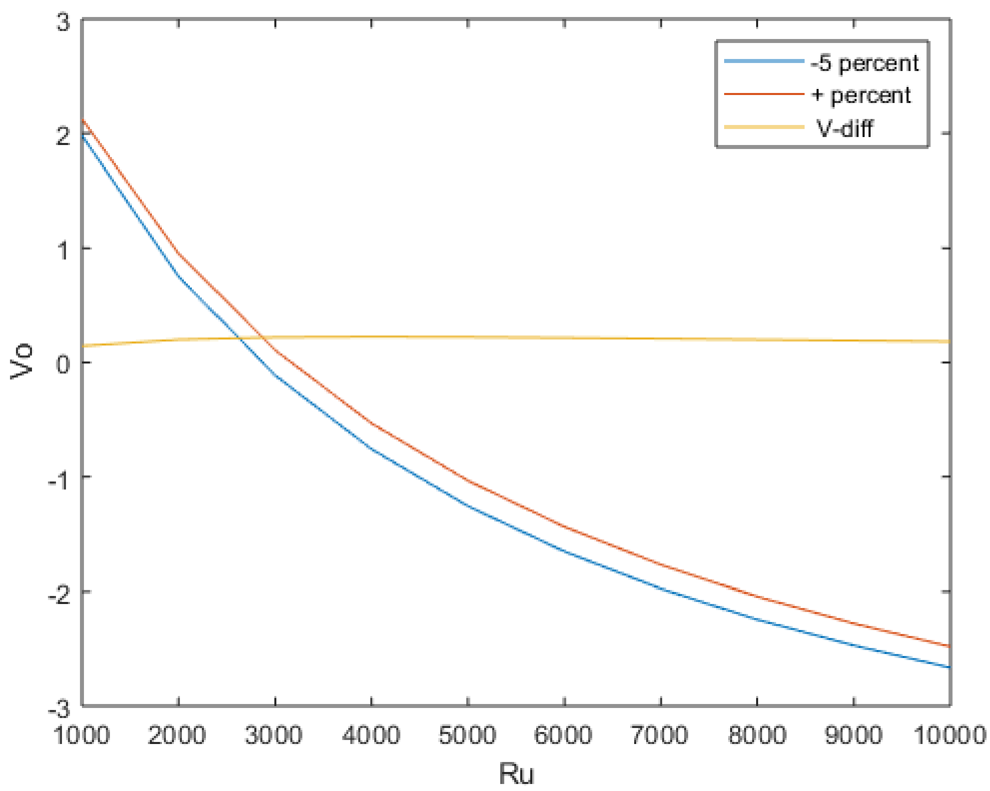
Vo_error_Band =

Columns 1 through 7

0.1442 0.2002 0.2206 0.2251 0.2223 0.2161 0.2083

Columns 8 through 10

0.2001 0.1918 0.1837



Part III

```
disp ("===================  PART III  ===================")

TimeBeforeBreakDown = [21.4,
 18.5 ,36.7 ,19.8 ,22.3 ,27.9 ,24.1 ,30.2 ,25 ,8.6];
TimeToRepair = [0.4 ,0.7 ,2.0 ,0.1 ,0.6 ,3.5 ,0.5 ,0.2 ,1.3 ,0.8];


disp ("MeanTimeBetweenFailures ");
MTBF = mean(TimeBeforeBreakDown)

disp ("MeanTimeToRepair");
MTTR = mean(TimeToRepair)

disp ("Availability A(t) = MTBF / (MTBF + MTTR)");
A_t = MTBF/(MTBF + MTTR)
```

```
===================  PART III  ===================
MeanTimeBetweenFailures

MTBF =

   23.4500

MeanTimeToRepair

MTTR =

    1.0100

Availability A(t) = MTBF / (MTBF + MTTR)

A_t =

    0.9587
```

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