THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND COMMUNICATIONS ENGINEERING

FIRST SEMESTER EXAMINATION – 2021

EE312 ELECTRICAL MEASUREMENT & INSTRUMENTATION

ELECTRICAL ENGINERING YEAR THREE (BEEC3 and BEEP3)

TIME ALLOWED: 3 HOURS

INFORMATIONS FOR STUDENTS

1. You have **TEN [10] MINUTES** to read through the paper. You must not begin writing during this time.
2. Answer **FIVE QUESTIONS (5Q x 20 Marks = 100 Marks)**. Attend to all the Examination Questions in any order.
3. All Answers must be written in the **ANSWER BOOK** supplied.
4. Make sure that you have a data sheet at the final page of the Exam Paper.
5. **COMPLETE THE DETAILS REQUIRED ON THE FRONT COVER OF YOUR ANSWERBOOK – DO THIS NOW.**
6. Only the drawing instruments and the calculators are permitted on your desk. Textbooks and notebooks are **NOT** permitted.
7. If you are found cheating in the Examination, the penalties specified by the University shall apply.
8. **TURN OFF** all **Mobile Phones** and place them on the floor under your seat before the start of Examination.

QUESTION ONE [20 Marks]

There are three sets to this question. SETA is 9 Marks, SETB is 6 Marks and SETC is 5 marks. Each set of questions has choice selection pool. Select the your choice answer from the pool corresponding to answer the question.

SETA (i to ix)

A: RS-232 Interface,
B: Electro-Pneumatic Positioner,
C: Analogue to Digital Converter,
D: Widespread Measuring System,
E: Single/Dual 4 – 20mA proportional (linearized) Signal,
F: RS485_2wire with MODBUS RTU in Slave Mode,
G: Electro-Hydraulic Positioner,
H: Computer Measuring System
I: DAQ Hardware,

(i) Which subsystem of instrumentation subsystem is partly described? When the input current signal varies from this balanced position, the moving coil moves upward (or downward), the jet pipe injects oil toward the lower (or upper) orifice. _____.

(ii) _____ is the standard continuous output signal from microcontroller outputs to drive Actuators and Positioners.

(iii) _____ can be bought separately and mounted on the pneumatic actuating valve as shown above.

(iv) There are many different implementations of an _____. These types are as listed; (1) Single and double slope Integration ADC, (2) Sigma-Delta Σ-Δ ADC, (3) Flash ADC, (4) Successive Approximation Register (SAR), (5) Microcontroller ADCs

(v)_____ consists of interconnection of more than one **(vi)** _____ using Ethernet technology. The measurement status can be observed at two or more computer terminal within the local area network.

(vii) _____ is a standard interface found in industrial microcontrollers that is utilised in automation and industrial measurement networks.

(viii) _____ is .the Electronic Industries Association (EIA) standard for the interchange of serial binary data between two devices.

(ix) The _____ is configured and controlled by DAQ software executing on the computer system.

SETB (x to xv)

Insert the following Terminologies (or phrases) into the blank spaces describing operating characteristics of transducers. Fill the blank gaps (x to xv) using corresponding alphabetical letters.

A: Resolution
B: Dynamic Range
C: Linearity
D: Accuracy
E: Repeatability
F: Sensitivity

The operation of an Electrical Transducer (Passive / Active) should meet the following basic parameters to be ideally used in electrical (electronic measurements).

(x) _____. The difference between the measured value and the true value of the variable. This value is experimental.

(xi) _____. The ratio of the change in output for a unit change in the transducer input. For instance, for a thermocouple this characteristic is measured in volts output per degree Celsius.

(xii) _____. The smallest change in the value of measurand that results in a detectable change at the transducer output.

(xiii) _____. How closely does output versus input curve of the transducer approach a straight line.

(xiv) _____. The operating range of a transducer should be wide to permit it use under wide range of measurement condition.

(xv) _____. Input or output relationship for a transducer should be predictable over a long period of time.

SETC (xvi to xx)

For Questions xvi to xx, write appropriate instrument into classification tree provided in Figure 1. Write the letter that represents the type of instrument.

A: Indicating Instruments,
B: Absolute Instruments,
C: Recording Instruments,
D: Secondary Instruments
E: Integrating Instruments

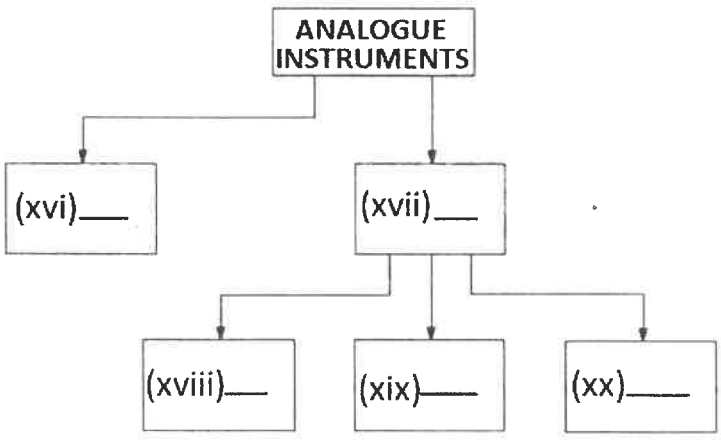


Figure 1 For QUESTION ONE SETC

QUESTION TWO [20 Marks]

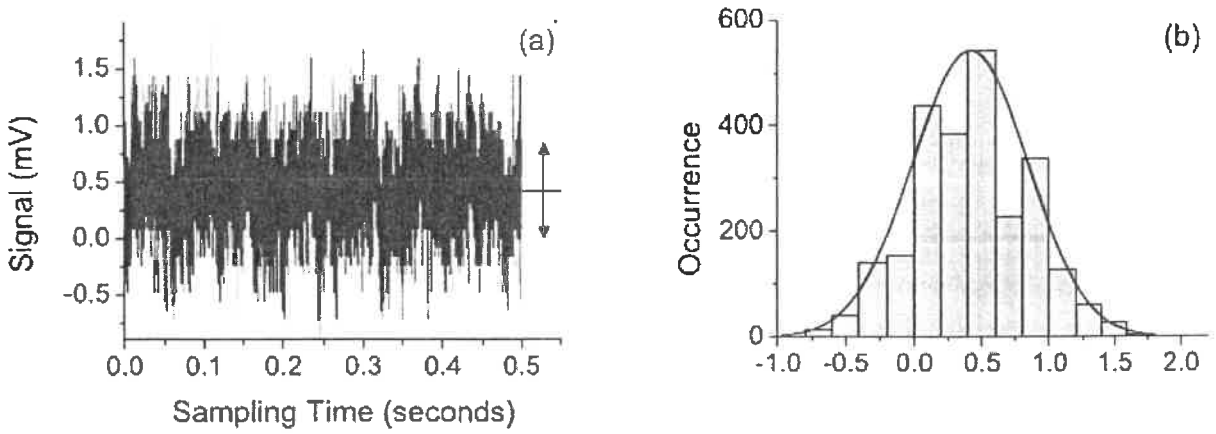


Figure 2 (a) Measurement (b) Distribution of measured data

Figure 2 (a) displays the voltage across a photodiode as a function of time sampled 2500 times. In Figure 2(a), the standard deviation σ is indicated by the arrow centred on the mean of the signal. In Figure 2(b), the histogram of the number of occurrences in (a) is indicated, together with a smooth curve. The curve is the Gaussian distribution which has the same mean and standard deviation as the data.

From above information,

A. Redraw envelope curve of Figure 2(b) and insert the labels to correspond Gaussian Probability Distribution Function.
B. Determine by inspection the value of standard mean.
C. Apply Gaussian PDF to evaluate the standard deviation (show calculations).
D. Calculate the standard deviation of the mean (error).
E. Calculate the probability of obtaining a measurement of 0.35 mV.
F. Calculate the probability of obtaining measurements within the range 0.35mV to 0.5mV
G. Report the result at the 95%confidence limit.

QUESTION THREE [20 Marks]

A. At a given frequency, w, a series R-L circuit can be exactly replaced by a parallel R-L circuit. Find expressions for Lp and Rp in terms of Ls, Rs and Qs = wLs/Rs.

B. A Wien bridge is shown in Figure 3. Find *fo* of the source and the value for Rx that will give null.

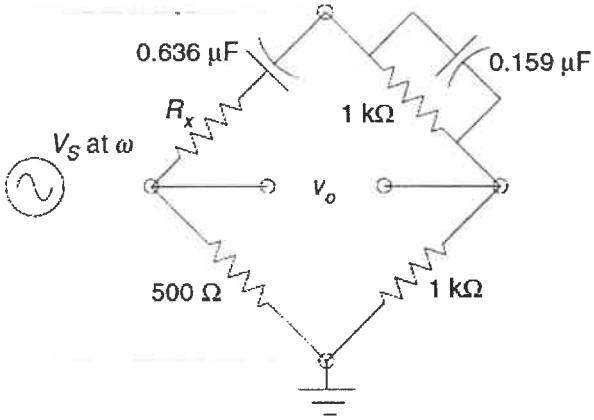


Figure 3 For QUESTION THREE(B)

QUESTION FOUR [20 Marks]

Instrument Amplifiers (IAs) are widely utilized and preferred over OP Amps in precision measurement. For (B), (C), & (D) refer to Figure 4.

A. State the main reason why IAs are preferred over OP Amps in precision measurement.

B. Proof your answer in (A) with respect to bridge circuit given in Figure 4.

C. Proof analytically that the gain calculation of Instrumentation Amplifier is given by the equation,

$$Ad = \frac{V_O}{V_1 - V_2} = \frac{(2R_B + R_G)R_D}{R_G\,(R_C)}$$

D. Calculate the magnitude of amplifier gain if the resistors within the IA circuit are rated as follow, $RG = 500\ \Omega$, $Rb = 1500\ \Omega$, $RC = 100\ \Omega$, $Rd = 1000\ \Omega$

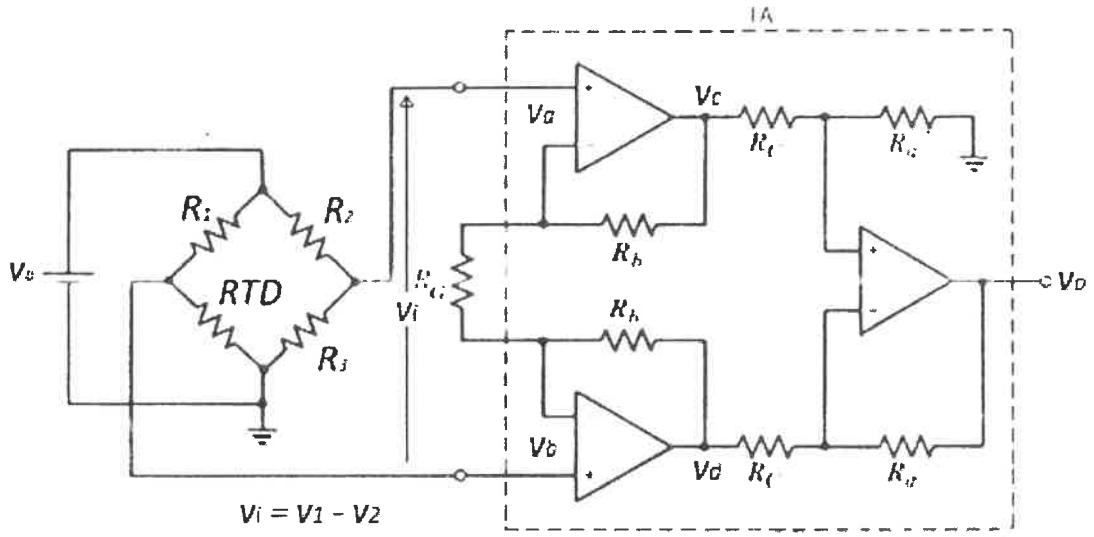
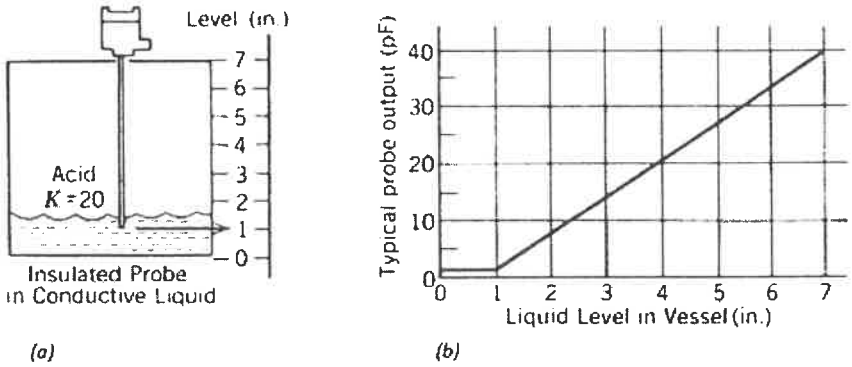


Figure 4 For QUESTION FOUR

QUESTION FIVE [20 Marks]

The pump in Figure 5(a) is turned on when the liquid level in the sump reaches 12 ft. When the liquid level is reduced to 3 ft the pump is turned off to prevent the liquid level from dropping below the level of the pump input pipe. An AC voltage of $v(t) = 0.012 \, Sin \, wt$ is supplied as shown in Figure 5(c).



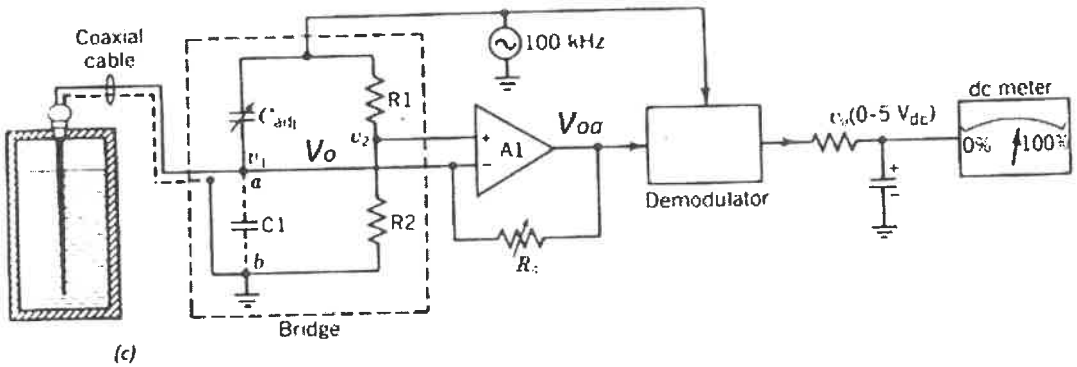


Figure 5 For QUESTION FIVE (A), (B), & (C)

A. Calculate the values in capacitance for high and low levels respectively. (Hind: Convert feet to inches).

B. Evaluate the values of output voltage (vo) at the bridge output for level at 75% full.

C. Determine the value of voltage voa equivalent to the 75% level of the conductive liquid if the gain of the OP Amp is 250.

D. Perform the Following Design Analysis if the measurement done at 75% level in Figure 6 is to be converted to digital pulse via a voltage to frequency converter (Figure 6). We desire the maximum frequency of 60 kHz out of the AD537 voltage-to-frequency converter to occur when the measurement of level is at its maximum (12 Feet). Find the 75% of full-scale value of *I* and the required value of capacitor when R5 = 150Ω and R6 = 390Ω.

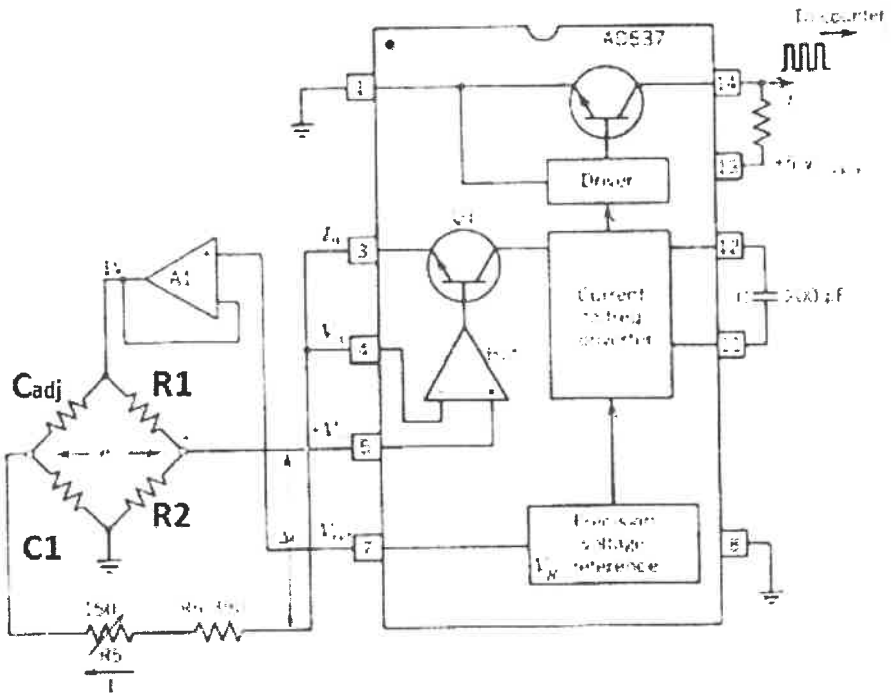


Figure 6 For QUESTION FIVE(D)

FINAL PAGE OF EXAMINATION QUESTIONS