UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: December 2016

Module Number: ME 4311 **Module Name: Analog and Digital Electronics**

[Three Hours]

[Answer **all questions**, each question carries **twelve** marks]

All assumptions must be stated clearly. Sketches and diagrams are to be provided where required. Symbols stated herein denote standard parameters.

Q1. a) When a Voltmeter is used to measure a standard value of 12 volts, the following readings are obtained: 12.2V, 12.3V, 12V, 12.4V, 12V, 12.2V, 12.3V, 12V, 12.1V, 12V. Calculate the,

i) Absolute accuracy,
ii) Relative accuracy,
iii) Bias of the readings.

[4.0 Marks]

b) Figure Q1(b) shows some important characteristics of a prospective measuring instrument.

i) State these characteristics.
ii) Briefly explain their importance.
iii) Compare a, b and c, d images of Figure Q1(b) respectively.

[5.0 Marks]

c) State the main categories of measurement error and discuss each with examples.

[3.0 Marks]

Q2. a) Operational Amplifiers (Op-Amps) are "DC" amplifiers with very large gain, high input impedance, and low output resistance. They are constructed as a "difference" amplifier, i.e. the output signal is proportional to the difference between the two input signals. Figure Q2(a-i) and Figure Q2(a-ii) are typical forms of an Op-Amp being used in an analog circuit.

i) Briefly explain the importance of negative feedback when an Op-Amp is used as a part of a circuit?
ii) Prove that the output current is proportional to input voltage in the Op-Amp shown in Figure Q2(a-i).
iii) Identify the behavior of the Op Amp model in Figure Q2(a-i)
iv) In order to avoid some undesirable effects, the Op-Amp circuit in Figure Q2(a-i) is modified as the Op-Amp in Figure Q2(a-ii). Comment on the undesirable effects and show that the load current is independent of the load in the modified circuit.

[5.0 Marks]

Q2. is continued to Page 2

b) Figure Q2(b) presents three circuit configurations (X, Y and Z) of different applications of Op-Amps. Identify each of them.

[2.0 Marks]

c) Consider the amplifier circuit shown in Figure Q2(c). The input voltage is $V_i = 0.5\cos(\omega t)$. Assume a unity-gain bandwidth of 10^6 Hz, short circuit current $I_{SC} = 100$ mA, Slew Rate $S_0 = 1$ V/µs and the Op-Amp is powered by a ±15 V supply.

i) What is the amplifier gain in dB?

ii) For what range of frequencies does this amplifier behave as a linear amplifier?

[5.0 Marks]

Q3. a) Active filters can be used for many applications. One area in which these filters can be used is on the output of digital to analogue converters where they are able to remove the high frequency alias components. Figure Q3(a-i) shows a waveform of a noisy signal which is needed to be filtered out under different frequency components. The noisy sinusoidal signal is sent through different sets of filters and the filtered signal components are observed as A, B, C, D shown in Figure Q3(a-ii). All waveforms are recorded in the time domain.

i) Briefly explain the difference between active filters and passive filters in Analog Electronics.

ii) Identify, High Pass, Low Pass, Band Pass and Band Reject Filtered waveforms shown in Figure Q3(a-ii).

[5.0 Marks]

b) A 2nd order Band Pass Filter circuit is shown in Figure Q3(b).

i) Show that the voltage transfer function can be expressed as a combination of a high pass filter and a low pass filter, transfer functions.

ii) Convert the above voltage transfer function to the general form of a 2nd order band pass filter; $H(j\omega) = \dfrac{K}{1 + jQ\left(\dfrac{\omega}{\omega_0} - \dfrac{\omega_0}{\omega}\right)}$ and obtain expressions for K, Q and ω_0.

iii) Design an active wide-band filter with lower cutoff frequency $f_l = 20\ Hz$, upper cutoff frequency $f_u = 1\ kHz$, a gain of 4 and an input impedance larger than $5\ k\Omega$. Check the impact of the bandwidth of the Op-Amp and validate the design.

[7.0 Marks]

Q4. a) A storage element in a digital circuit can maintain a binary state indefinitely (as long as power is delivered to the circuit), until directed by an input signal to switch states. These storage elements are identified as flip flops and latches. They are widely used in both Synchronous and Asynchronous sequential logic circuits.

i) Differentiate Synchronous Logic circuits from Asynchronous Logic circuits.

Q4. is continued to Page 3

ii) Distinguish Flip-Flops from Latches.

[2.0 Marks]

b) A sequential circuit has two *JK* flip-flops *A* and *B*, two inputs x and y, and one output z .The flip-flop input equations and circuit output equation are

$J_A = Bx + B'y'$ $K_A = B'xy'$

$J_B = A'x$ $K_B = A + xy'$

$z = Ax'y' + Bx'y'$

i) Draw the logic diagram of the circuit.
ii) Tabulate the state table and derive the state equations for A and B.
iii) Create PLC Ladder logic diagrams for the state equations.
iv) *JK* flip-flops are less frequently used in industrial applications compared to *D* flip-flops. Briefly explain the reason(s).

[6.0 Marks]

c) Table Q4(c-i) presents a state table which is to be implemented using D flip-flops. Table Q4(c-ii) presents three possible binary state assignments.

i) Apply state reduction principles to obtain a reduced state table.
ii) Assign Gray code values [Table Q4(c-ii)] to the states and build a reduced state diagram.
iii) Design the corresponding sequential circuit using D Flip-Flops.
iv) What are the advantages of 'One-Hot' binary state assignment in sequential circuit design?

[4.0 Marks]

Q5. a) Figure Q5(a-i) shows three Data Acquisition (DAQ) boards which are available in the Mechatronics Laboratory, DMME, University of Ruhuna. The devices are used to acquire electrical signals measured through industrial sensors.

i) Comment on the nature of the electrical signals which the DAQ boards are capable of acquiring?
ii) What are the communication protocols used in these devices?
iii) Briefly explain the procedure to acquire signals through these hardware units.
iv) Figure Q5(a-ii) shows the pin-out of NI-USB 6343 DAQ board. Identify the number of analog inputs and analog outputs which can be directly interfaced with analog devices.
v) Briefly explain the technical benefits of NI-USB 6343 over NI-USB 6211.
vi) The available Yokogawa MW100 DAQ unit at DMME is not capable of displaying signals in real time graphical view. Propose two methods to configure it for real time graphical signal processing.
vii) What are the advantages and disadvantages of using these DAQ hardware in research/industry environment?

[6.0 Marks]

Q5. is continued to Page 4

b) Two temperature sensors, one proximity sensor and one sonar sensor are occupied in an automated conveyer line to detect respective physical parameters. Temperature sensors produce a 0-5V signal. The proximity sensor produces a digital signal and the sonar sensor produces a 4-20 mA current signal. Based on the readings of sensors, a control algorithm is developed and implemented in NI-Labview to send signals to operate two actuators thereby fulfilling control objectives. The first actuator is operated by sending a current signal and the second actuator is operated by sending a digital signal. NI-USB 6211 is used as the signal processing unit for reading and writing signals. With the help of pin-out diagram in Figure Q5(b), build a schematic wiring diagram to show hardware and software interfacing of the sensors, actuators, NI-Labview and DAQ board.

[6.0 Marks]

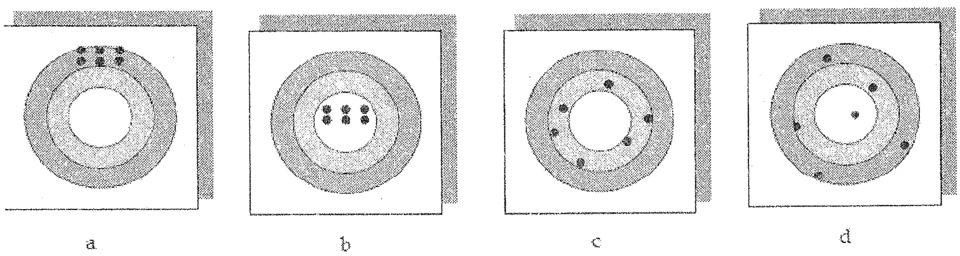


Figure Q1(b): Characteristics of a Measuring Instrument

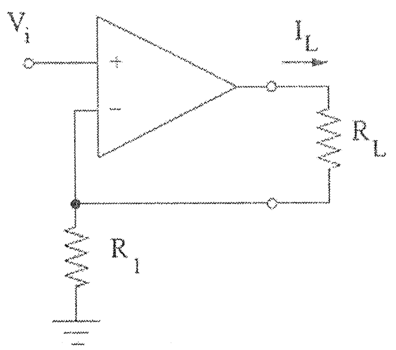


Figure Q2(a-i): Op-Amp Circuit

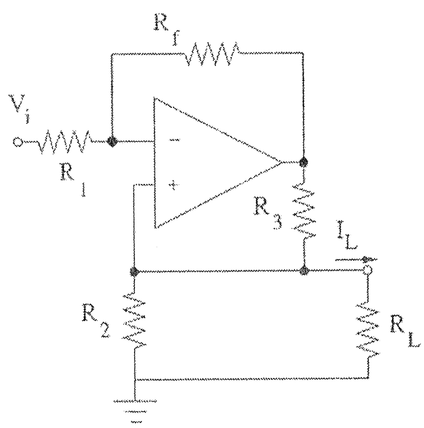


Figure Q2(a-ii): Modified Op-Amp Circuit

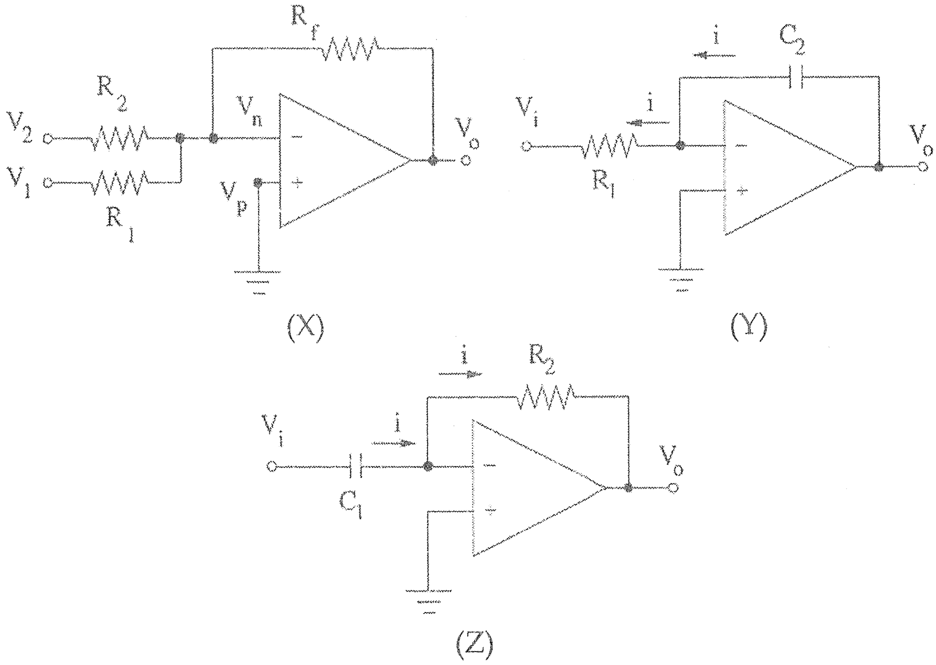


Figure Q2(b): The Circuit Configurations for Three Applications of Op-Amps

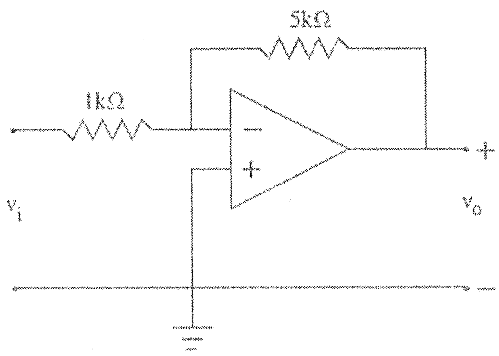


Figure Q2(c): Amplifier Circuit

Figure Q3(a-i): Noisy Sinusoidal Signal

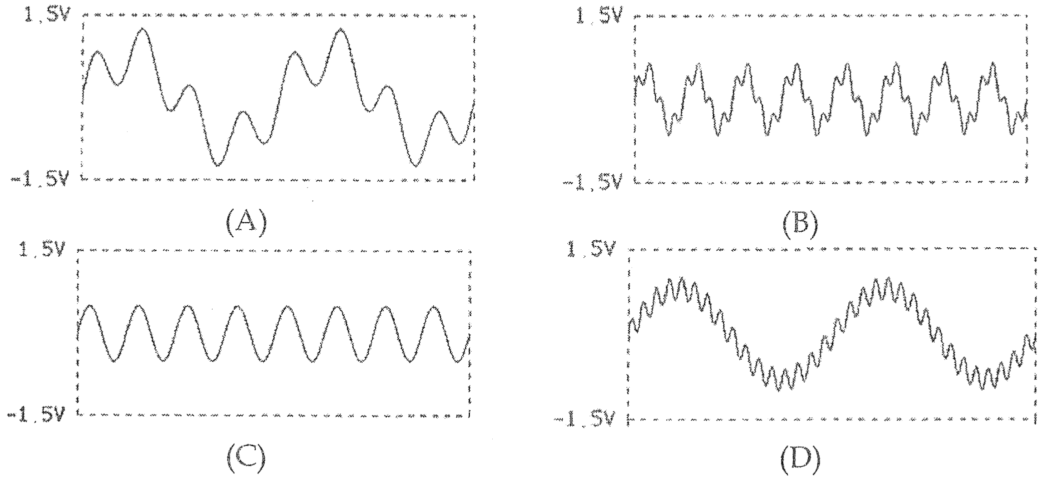


Figure Q3(a-ii): Filtered Sinusoidal Signal Components

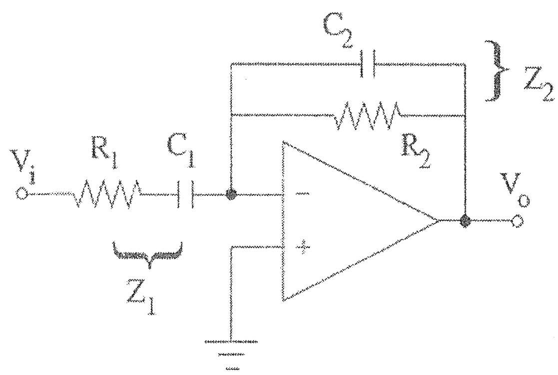


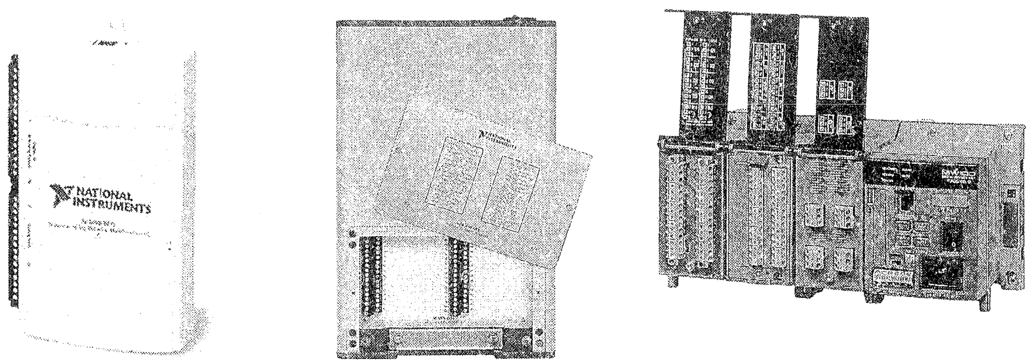
Figure Q3(b): 2nd Order Band Pass Filter

Table Q4(c-i): The State Table

Present State	Next State		Output	
	$x = 0$	$x = 1$	$x = 0$	$x = 1$
a	*a*	*b*	0	0
b	*c*	*d*	0	0
c	*a*	*d*	0	0
d	*e*	*f*	0	1
e	*a*	*f*	0	1
f	*g*	*f*	0	1
g	*a*	*f*	0	1

Table Q4(c-ii): Three Possible Binary State Assignments

State	Assignment 1, Binary	Assignment 2, Gray Code	Assignment 3, One-Hot
a	000	000	00001
b	001	001	00010
c	010	011	00100
d	011	010	01000
e	100	110	10000



NI-USB 6211 NI-USB 6343 Yokogawa MW100

Figure Q5(a-i): Data Acquisition Boards

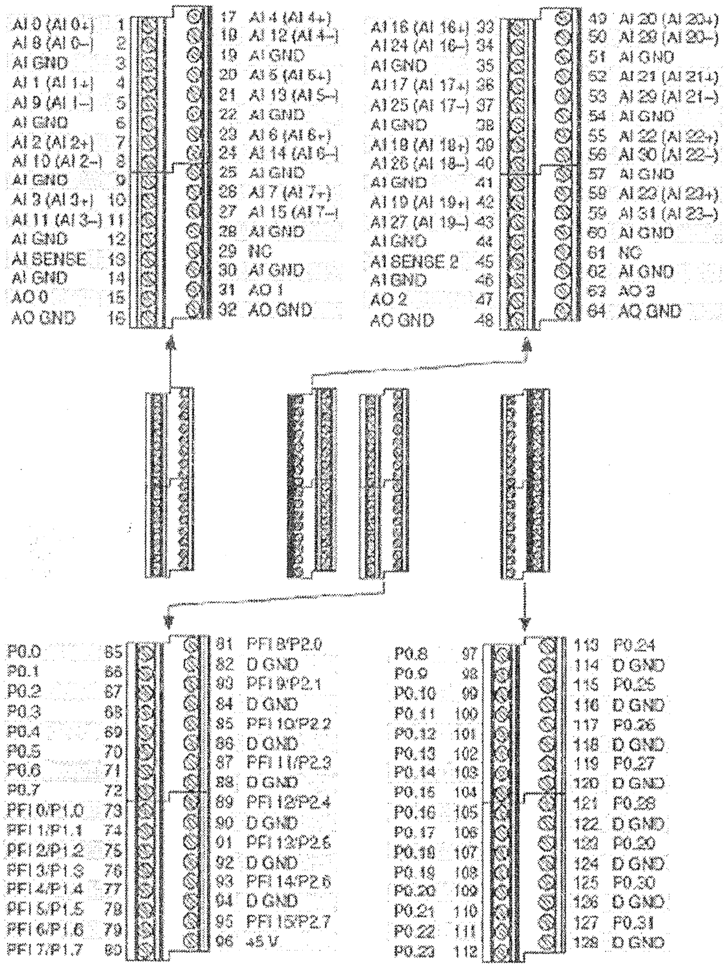


Figure Q5(a-ii): Pinout Diagram of NI-USB 6343

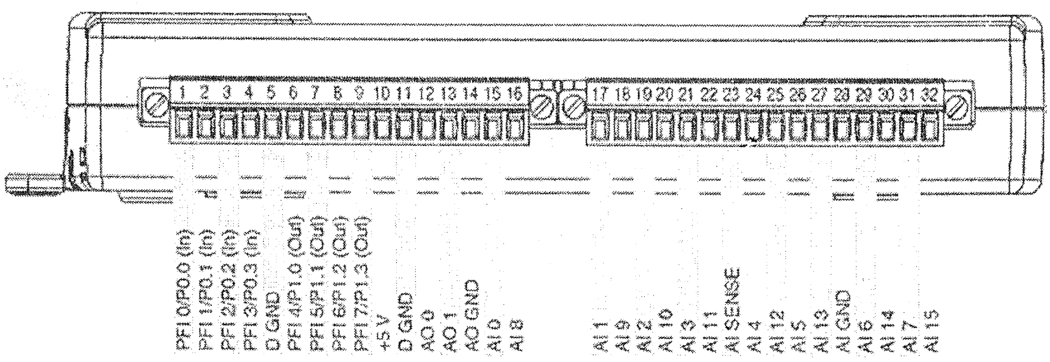


Figure Q5(b): Pinout Diagram of NI-USB 6211