



# UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2018

Module Number: EE5208

Module Name: Electronic Circuit Design

[Three Hours]

[Answer all questions, each question carries 12.5 marks]

Q1 a) Explain the difference between passive circuit elements and active circuit elements.

[1.0 Mark]

b) A part of a power supply circuit is shown in Figure Q1 b). The specifications of the circuit are,

$$\begin{aligned}R &= 1 \text{ k}\Omega \pm 5\% \\V_{in} &= 30 \text{ V} \pm 5\% \\V_o &= 12 \text{ V} \pm 5\%\end{aligned}$$

The maximum load current should be kept to 5 mA while the minimum to 0 mA. The tolerance values of R1 and R2 are  $\pm 5\%$ .

The rated power and the rated voltage of the zener diode are 0.12 W and 12 V respectively at no load condition.

Stating any assumptions you make, determine suitable values for R<sub>1</sub> and R<sub>2</sub> from E12 series.

[8.0 Marks]

c) A Zener diode regulator circuit is shown in Figure Q1 c). Zener voltage  $V_Z = 12 \text{ V}$  and the tolerance of R<sub>s</sub> is  $\pm 5\%$ .

Determine the value range of R<sub>s</sub> for the parameters given in Table Q1 c) to ensure that the Zener diode remains in the breakdown region.

Hint: You can formulate the two worst case scenarios based on the condition,

$$I_{Z \min} \leq I_Z \leq I_{Z \max}$$

Table Q1 c)

Parameter	Minimum	Maximum
V <sub>in</sub>	20 V	25 V
I <sub>Z</sub>	5 mA	100 mA
I <sub>L</sub>	0 mA	20 mA

[3.5 Marks]

- Q2 a) A PCB (Printed Circuit Board) provides both a physical structure for mounting and holding electronic components and the electrical interconnection between components.
- State three advantages of PCBs.
  - Classify PCBs according to their use in applications.
  - Classify PCBs according to layers of wiring.
  - Discuss the pros and cons of having several layers of wiring in a PCB.
  - List the basic PCB design steps.

[6.5 Marks]

- b) i) Sketch how high speed, medium speed and low speed components are placed on a PCB.
- Explain why, critical/ high speed components need to be placed very close together on a PCB?
  - Explain why, the acute angle bends in conductors should be avoided when deciding PCB layout.

[3.0 Marks]

- c) Copper is liable to tarnish due to oxidation if exposed to atmosphere for a long time. "Coating" can prevent this.
- State three major coating techniques.
  - Briefly explain "Electroplating".
  - State three problems that can arise due to plating.

[3.0 Marks]

- Q3 a) i) State 2 differences between a Depletion type NMOSFET (N-channel Metal Oxide Semiconductor Field Effect Transistor) and an Enhancement type NMOSFET.
- Sketch the structure of an Enhancement type NMOSFET showing the DC biasing for normal operation in common source configuration (Clearly indicate the terminals, depletion region and the channel of conduction).

[2.5 Marks]

- b) i) Reproduce the Enhancement type NMOSFET transfer characteristics.
- Prove that the Transconductance ( $g_m$ ) for an Enhancement type NMOSFET is given by,

$$g_m = \beta (V_{GS} - V_T) \text{ Siemens}$$

Hint: Use the transfer characteristic curve produced in Q3 b) i.

[2.0 Marks]

- c) The Enhancement type NMOSFET in the circuit shown in Figure Q3 c) has the following parameters.

$$V_T = 2 \text{ V}, \beta = 0.6 \times 10^{-3} \text{ A/V}^2 \text{ and } r_d = 100 \text{ k}\Omega$$

- Verify that the MOSFET is operating as an amplifier.
- Determine the value of Transconductance ( $g_m$ ) of the MOSFET.
- Determine the input resistance of the MOSFET.
- Draw the small signal ac equivalent circuit.
- Determine the overall voltage gain.

[8.0 Marks]

- Q4 a) i) Sketch a practical low pass filter gain response curve and its phase response curve.  
 ii) Compare the Butterworth and the Chebyshev filter design techniques. [2.5 Marks]
- b) i) Give the first order low pass active filter circuit for the non-inverting case and derive the transfer function.  
 ii) Give the second order low pass active filter circuit for the non-inverting case using Sallen-Key topology. [3.0 Marks]

- c) Design a practical fifth order unity-gain Butterworth low pass filter with cutoff frequency  $f_c = 100$  kHz using Sallen-Key topology.

Directions: The capacitance values for the filters are shown in Table Q4 c). Design each partial filter and draw it as a combination by specifying the available capacitor values and the resistor values. Make necessary assumptions if required. Refer to Table Q4 c1) and Table Q4 c2) to find the resistor and capacitor values respectively.

Table Q4 c)

Type	$a_i$	$b_i$	Capacitance
Filter 1	$a_1 = 1.0000$	$b_1 = 0.0000$	15 nF
Filter 2	$a_2 = 1.6180$	$b_2 = 1.0000$	680 pF
Filter 3	$a_3 = 0.6180$	$b_3 = 1.0000$	120 pF

[7.0 Marks]

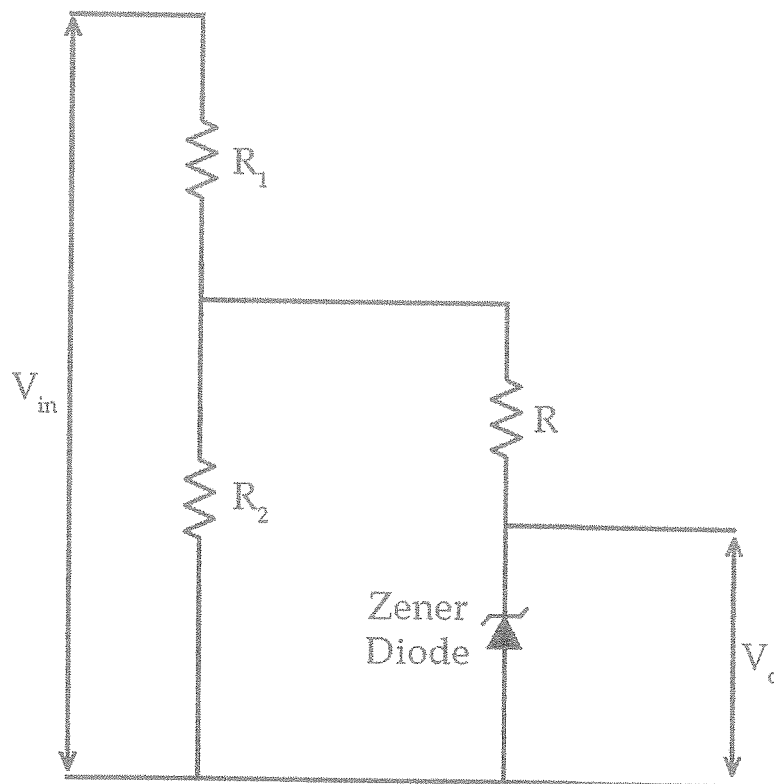


Figure Q1 b)

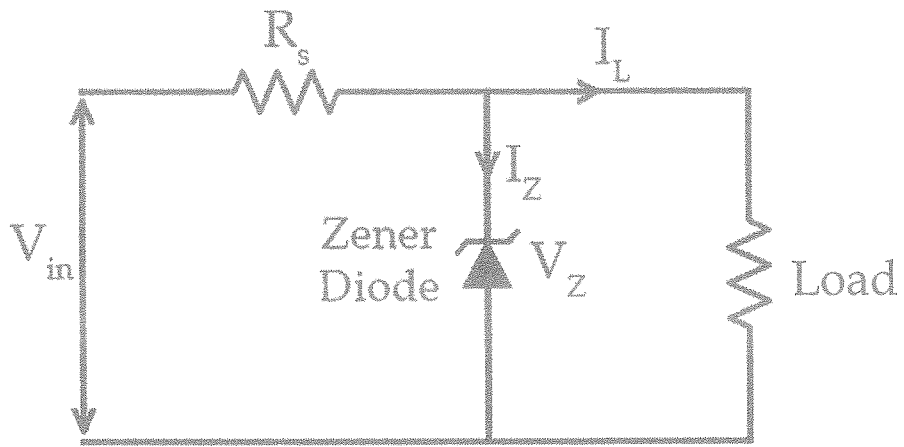


Figure Q1 c)

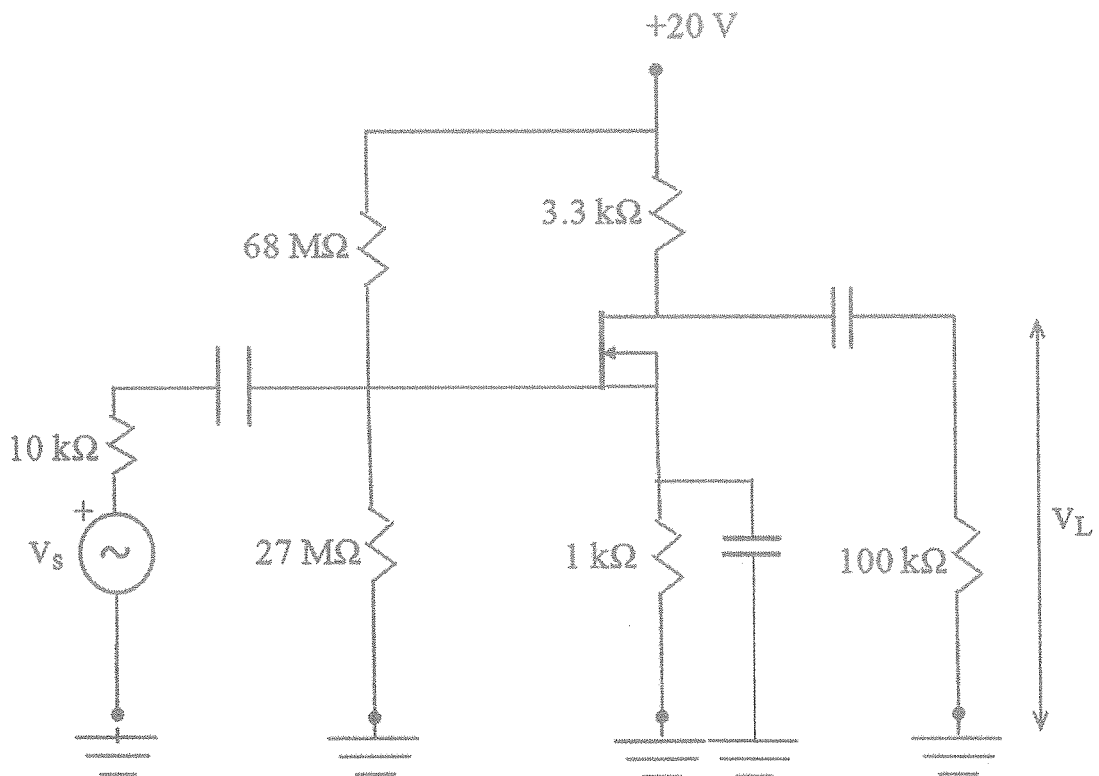


Figure Q3 c)

Table Q4 c<sub>1</sub>): E96 Resistor Series

100	102	105	107	110	113	115	118	121	124	127	130
133	137	140	143	147	150	154	158	162	165	169	174
178	182	187	191	196	200	205	210	215	221	226	232
237	243	249	255	261	267	274	280	287	294	301	309
316	324	332	340	348	357	365	374	383	392	402	412
422	432	442	453	464	475	487	499	511	523	536	549
562	576	590	604	619	634	649	665	681	698	715	732
750	768	787	806	825	845	866	887	909	931	953	976

Table Q4 c<sub>2</sub>): Capacitor Letter Codes

Picofarad (pF)	Nanofarad (nF)	Microfarad ( $\mu$ F)	Code	Picofarad (pF)	Nanofarad (nF)	Microfarad ( $\mu$ F)	Code
10	0.01	0.00001	100	4700	4.7	0.0047	472
15	0.015	0.000015	150	5000	5.0	0.005	502
22	0.022	0.000022	220	5600	5.6	0.0056	562
33	0.033	0.000033	330	6800	6.8	0.0068	682
47	0.047	0.000047	470	10000	10	0.01	103
100	0.1	0.0001	101	15000	15	0.015	153
120	0.12	0.00012	121	22000	22	0.022	223
130	0.13	0.00013	131	33000	33	0.033	333
150	0.15	0.00015	151	47000	47	0.047	473
180	0.18	0.00018	181	68000	68	0.068	683
220	0.22	0.00022	221	100000	100	0.1	104
330	0.33	0.00033	331	150000	150	0.15	154
470	0.47	0.00047	471	200000	200	0.2	254
560	0.56	0.00056	561	220000	220	0.22	224
680	0.68	0.00068	681	330000	330	0.33	334
750	0.75	0.00075	751	470000	470	0.47	474
820	0.82	0.00082	821	680000	680	0.68	684
1000	1.0	0.001	102	1000000	1000	1.0	105
1500	1.5	0.0015	152	1500000	1500	1.5	155
2000	2.0	0.002	202	2000000	2000	2.0	205
2200	2.2	0.0022	222	2200000	2200	2.2	225
3300	3.3	0.0033	332	3300000	3300	3.3	335