



# MACHAKOS UNIVERSITY

University Examinations for 2021/2022

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC  
ENGINEERING

EEE 533: ELECTRONIC CIRCUITS AND SYSTEMS

DATE:

TIME:

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## INSTRUCTIONS

Answer question **ONE** and **ANY OTHER TWO** questions

### QUESTION ONE (COMPULSORY) (30 MARKS)

- a) i. With the aid of a circuit diagram describe the operation of a Widlar current source;  
(8 marks)
- ii. For Widlar current source assume that  $V_{CC} = 12\text{ V}$ ,  $R_1 = 15\text{ k}\Omega$  and  $V_{BE(ON)} = 0.7\text{ V}$  Find the value of  $R_2$  to be connected to produce a current  $I_{C2}$  of 10 mA.  
(6 marks)
- b) i. Draw the circuit diagram of a simple multiplier using an emitter coupled transistor pairs;  
(2 marks)
- ii. Show that the difference between the two output currents of the circuit in (b) i is

$$I_{EE} \tanh\left(\frac{V_1}{2V_T}\right)$$

(6 marks)

- c) The control line of a VCO senses a rectangular signal toggling between  $V_1$  and  $V_2$  at a period  $T_m$ . Plot the frequency, phase, and output waveform as a function of time. (8 marks)

### QUESTION TWO (20 MARKS)

- a) A typical energy band-gap voltage reference circuit is shown in Fig Q2 (a)

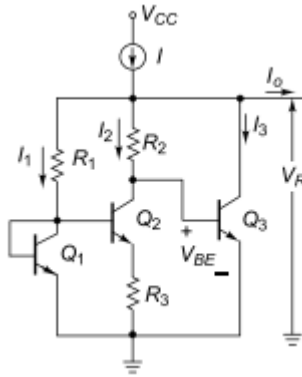


Fig Q2 (a)

- i) Describe how the circuit operates; (6 marks)
- ii) For the circuit in Fig Q2 (a), show that

$$V_R = V_{BE3} + \frac{R_2}{R_3} V_T \ln \frac{I_1}{I_2}$$

(6 marks)

- b) i. With the aid of a circuit diagram describe the operation of a current repeater;
- ii. For the repeater in (b) i, show that the output current is given by

$$I_C = I_{ref} \times \frac{\beta}{\beta + N + 1}$$

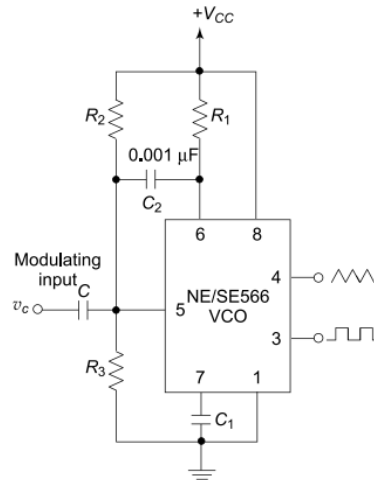
(8 marks)

### QUESTION THREE (20 MARKS)

- a) A PLL IC 565 connected for FM detection has  $R_1 = 8.3 \text{ kW}$ ,  $C_1 = 0.001 \text{ mF}$  and  $C_c = 0.02 \text{ mF}$ . The supply voltage is +12V. Determine the
- Free-running frequency;
  - Capture-range and
  - Lock-range.

(6 marks)

- b) Explain the following terms with respect to phase locked loops (PLLs) application:
- Frequency synthesis;
  - Skew reduction;
  - Jitter reduction.
- (6 marks)
- c) For the VCO circuit shown in Fig Q3 (c), assume  $R_2 = 1.5 \text{ k}\Omega$ ,  $R_1 = R_3 = 12 \text{ k}\Omega$ ,  $C_2 = 0.001 \text{ mF}$  and  $V_{CC} = 10 \text{ V}$ . Calculate the output frequency and the change in output frequency if modulating input  $v$  is varied from 7 V to 8 V.



**Fig Q3 (c)**

(8 marks)

#### QUESTION FOUR (20 MARKS)

- a) With the aid of a simplified block diagram describe the operation of a digital cellular telephone.
- (12 marks)
- b) For the R – 2R 4 -bit converter assume that feedback resistance  $R_f$  of the op-amp is variable, the resistance  $R = 10 \text{ k}\Omega$  and  $V_R = 10 \text{ V}$ . Determine the value of  $R_f$  that should be connected to achieve the following output conditions.
- The value of 1 LSB at the output is 0.5 V.
  - An analog output of 6V for a binary input of 1000.
  - The full-scale output voltage of 12 V.
  - The actual maximum output voltage of 10 V.
- (8 marks)

#### QUESTION FIVE (20 MARKS)

- a) With the aid of a block diagram describe the operation of a frequency synthesizer.
- (12 marks)
- b) i. Describe the THREE categories of equipment that fall within the IEEE 488 bus;
- ii. State any TWO specifications of the IEEE 488 bus.

(8 marks)