# MACHAKOS UNIVERSITY

**University Examination 2018/2019**

**SCHOOL OF ENGINEERING AND TECHNOLOGY**

**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**THIRD YEAR SECOND SEMESTER EXAMINATION FOR**

**BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)**

**EMM 300: ENGINEERING ELECTRONICS**

**DATE: 16/5/2019** **TIME: 8.30-10.30 AM**

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**INSTRUCTIONS**

**Answer Question ONE and any other TWO Questions.**

**QUESTION ONE (30 MARKS)**

a) i Design a four-resistor bias network for an *npn* transistor to give $I_C$ = 10 μA and $V_{CE}$ = 6 V if $V_{CC}$ = 18 V and $\beta_F$ = 75.

ii. Replace your exact values with the nearest values from the resistor table in Appendix and find the resulting Q-point. (10 marks)

b) Derive the relationship between base current amplification factor β and emitter current amplification factor α. (6 marks)

i. State the two types of complement for a number system whose radix = r.

ii. Find the 2's complement of the decimal number 1/16.

ii. Determine the nine's complement of the decimal number 25.638?[7 marks]

c) For the network of Fig.Q1 (c)

i. Determine $I_{CQ}$ and $V_{CEQ}$;

ii. Find $V_B$, $V_C$, $V_E$ and $V_{BC}$.

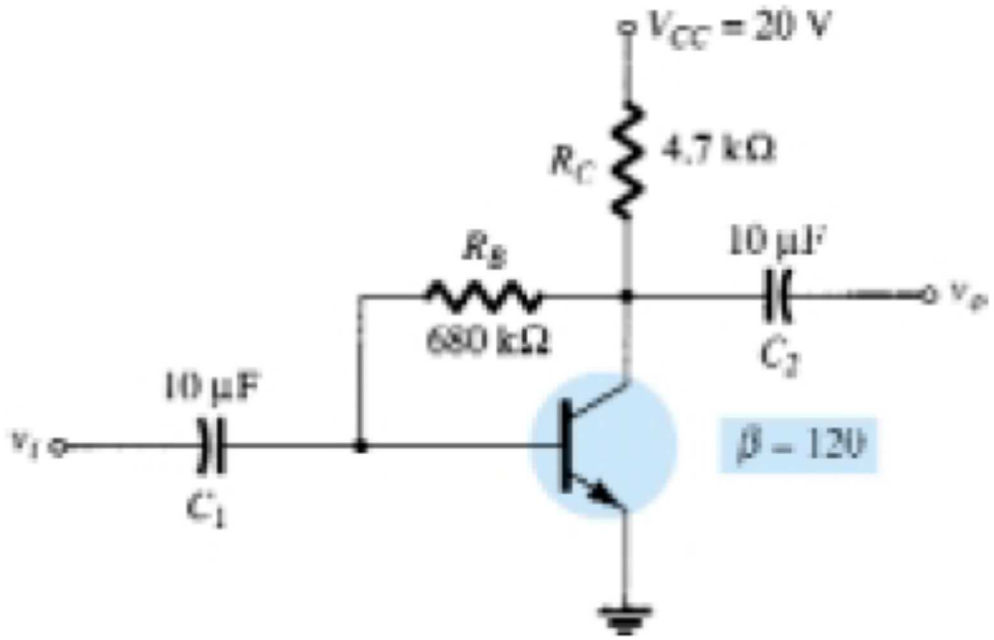



Fig.Q1 (c) (7 marks)

**QUESTION TWO (20 MARKS)**

a) Determine the dc bias voltage $V_{CE}$ and the current $I_C$ for the voltage-divider configuration of Fig.Q2 (a).

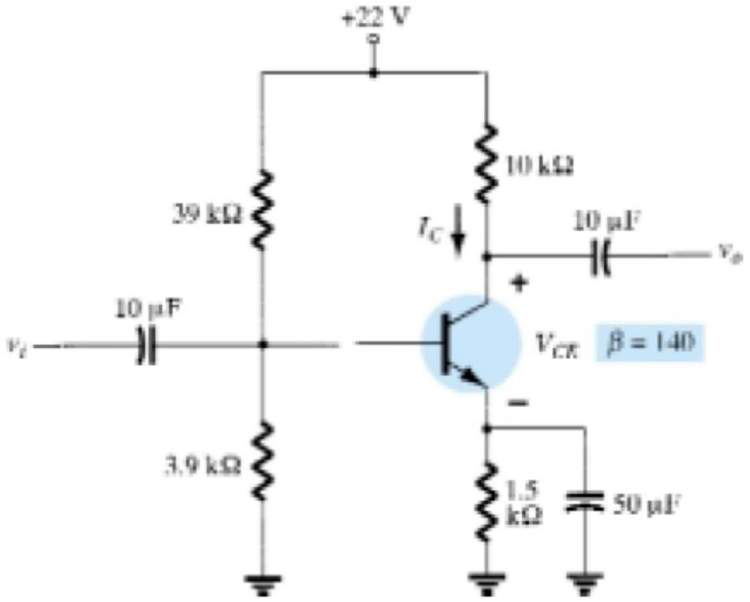



Fig.Q2 (a). (8 marks)

b) The parameters of the zener diode for the voltage regulator of the circuit of Fig. Q2 (b) are $V_Z = 4.7$ V at test current $I_{ZT} = 53$ mA, $R_Z = 8\ \Omega$, and $R_{ZK} = 500\ \Omega$ at $I_{ZK} = 1$ mA. The supply voltage $v_S = V_S = 12 \pm 2$ V, and $R_s = 220\ \Omega$.

i. Find the nominal value of the output voltage $v_O$ under no-load condition $R_L = \infty$;

ii. Find the maximum and minimum value of the output voltage for a load resistance $R_L = 470\ \Omega$;

iii. Find the nominal value of the output voltage $v_O$ for a load resistance $R_L = 100\ \Omega$;

iv. Find the minimum value of $R_L$ for which the zener diode operates in the breakdown region.

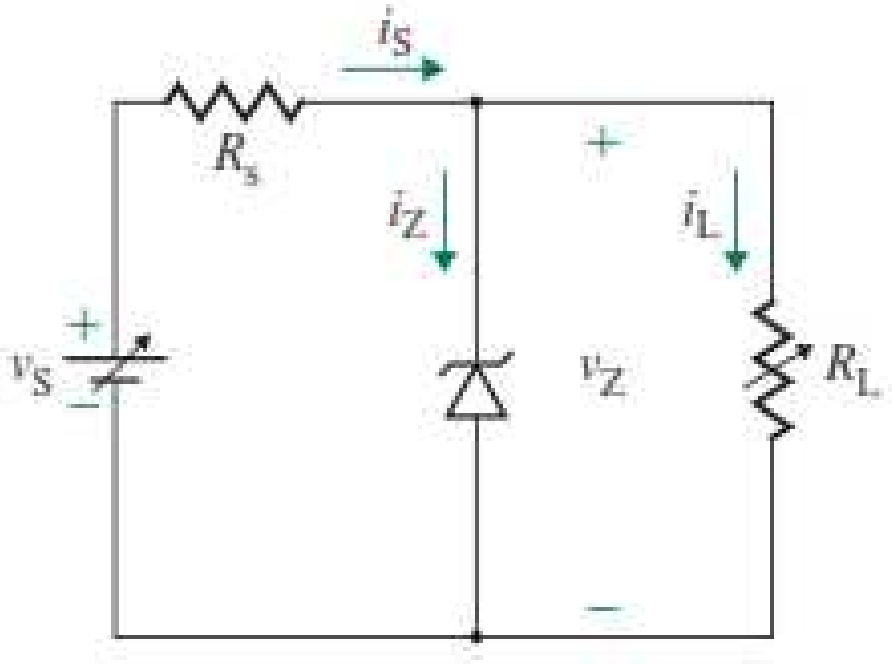
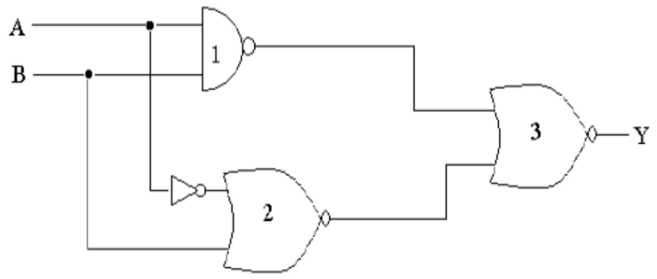



Fig.Q2 (b) (12 marks)

**QUESTION THREE (20 MARKS)**

a) Find the Boolean expression for the logic circuit in FigQ3 (a).




FigQ3 (a) (6 marks)

b) A single-phase rectifier can be employed as a battery charger, as shown in Fig. Q3 (b). The battery capacity is 100 Wh, and the battery voltage is E = 12 V. The average charging current should be $I_{o(av)}$ = 5 A. The primary AC input voltage is $V_p$ = 120 V (rms), 60 Hz, and the transformer has has a turns ratio of n = 2:1.

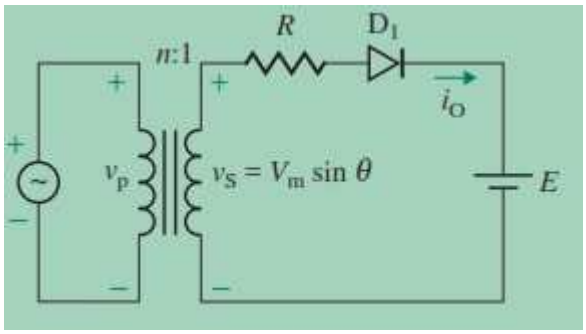



Fig.Q3 (b).

Calculate

i. the angle δ over which the diode conducts;

ii. The current limiting resistance R;

iii. The power rating $P_R$ of the resistance R;

iv. The charging time h in hours;

v. the rectifier efficiency $\eta_R$;

vi. The peak inverse voltage PIV of the diode. (14 marks)

**QUESTION FOUR (20 MARKS)**

a) Consider the ac equivalent circuit of the Hartley oscillator in Fig.Q4 (a)

i. Derive the expression for the frequency of oscillation;

ii. Determine the condition for sustained oscillations.

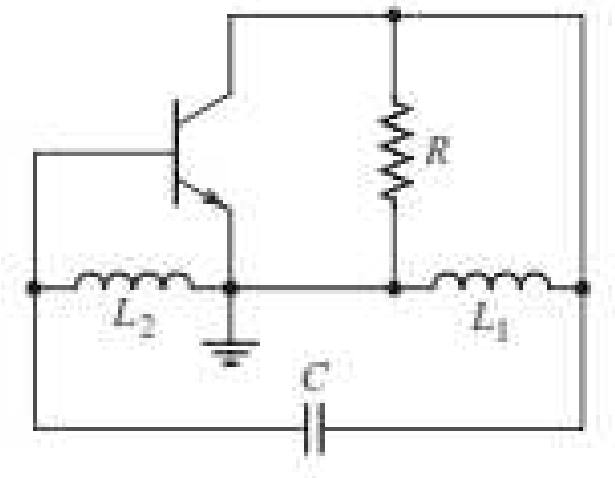



Fig.Q4 (a) (14 marks)

b) Draw a block diagram of a BCD-to-7 segment decoder indicating the output given that the input is 0101. (6 marks)

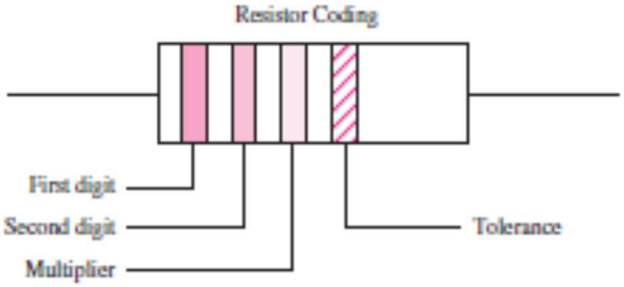
**QUESTION FIVE (20 MARKS)**

a) i Define synchronous counters.

ii Design a **MODULO-5** synchronous counter using **JK** flip-flops. (13 marks)

b) Explain how a shift register can be used as a ring counter giving the wave forms at the output of the flip-flops. (7 marks)

## Appendix




**Resistor Color Code**

| COLOR | DIGIT | MULTIPLIER | TOLERANCE, % |
|---|---|---|---|
| Silver | ··· | 0.01 | 10 |
| Gold | ··· | 0.1 | 5 |
| Black | 0 | 1 | |
| Brown | 1 | 10 | |
| Red | 2 | $10^2$ | |
| Orange | 3 | $10^3$ | |
| Yellow | 4 | $10^4$ | |
| Green | 5 | $10^5$ | |
| Blue | 6 | $10^6$ | |
| Violet | 7 | $10^7$ | |
| Gray | 8 | $10^8$ | |
| White | 9 | $10^9$ | |

*Standard resistor values:* All values available with a 5 percent tolerance. Bold values are available with 10 percent tolerance.

| OHMS | | | | | | | | MEGOHMS | |
|---|---|---|---|---|---|---|---|---|---|
| **1.0** | **5.6** | **33** | **180** | **1000** | **5600** | **33000** | **180000** | **1.0** | **5.6** |
| 1.1 | 6.2 | 36 | 200 | 1100 | 6200 | 36000 | 200000 | 1.1 | 6.2 |
| **1.2** | **6.8** | **39** | **220** | **1200** | **6800** | **39000** | **220000** | **1.2** | **6.8** |
| 1.3 | 7.5 | 43 | 240 | 1300 | 7500 | 43000 | 240000 | 1.3 | 7.5 |
| **1.5** | **8.2** | **47** | **270** | **1500** | **8200** | **47000** | **270000** | **1.5** | **8.2** |
| 1.6 | 9.1 | 51 | 300 | 1600 | 9100 | 51000 | 300000 | 1.6 | 9.1 |
| **1.8** | **10** | **56** | **330** | **1800** | **10000** | **56000** | **330000** | **1.8** | **10** |
| 2.0 | 11 | 62 | 360 | 2000 | 11000 | 62000 | 360000 | 2.0 | 11 |
| **2.2** | **12** | **68** | **390** | **2200** | **12000** | **68000** | **390000** | **2.2** | **12** |
| 2.4 | 13 | 75 | 430 | 2400 | 13000 | 75000 | 430000 | 2.4 | 13 |
| **2.7** | **15** | **82** | **470** | **2700** | **15000** | **82000** | **470000** | **2.7** | **15** |
| 3.0 | 16 | 91 | 510 | 3000 | 16000 | 91000 | 510000 | 3.0 | 16 |
| **3.3** | **18** | **100** | **560** | **3300** | **18000** | **100000** | **560000** | **3.3** | **18** |
| 3.6 | 20 | 110 | 620 | 3600 | 20000 | 110000 | 620000 | 3.6 | 20 |
| **3.9** | **22** | **120** | **680** | **3900** | **22000** | **120000** | **680000** | **3.9** | **22** |
| 4.3 | 24 | 130 | 750 | 4300 | 24000 | 130000 | 750000 | 4.3 | |
| **4.7** | **27** | **150** | **820** | **4700** | **27000** | **150000** | **820000** | **4.7** | |
| 5.1 | 30 | 160 | 910 | 5100 | 30000 | 160000 | 910000 | 5.1 | |

**PRECISION (±1%) RESISTORS**

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10.0 | 19.1 | 36.5 | 69.8 | 133 | 255 | 487 | 931 | 1.78K | 3.40K | 6.49K | 12.4K | 23.7K | 45.3K | 84.5K | 158K | 294K | 549K |
| 10.2 | 19.6 | 37.4 | 71.5 | 137 | 261 | 499 | 953 | 1.82K | 3.48K | 6.65K | 12.7K | 24.3K | 46.4K | 86.6K | 162K | 301K | 562K |
| 10.5 | 20.0 | 38.3 | 73.2 | 140 | 267 | 511 | 976 | 1.87K | 3.57K | 6.81K | 13.0K | 24.9K | 47.5K | 88.7K | 165K | 309K | 576K |
| 10.7 | 20.5 | 39.2 | 75.0 | 143 | 274 | 523 | 1.00K | 1.91K | 3.65K | 6.98K | 13.3K | 25.5K | 48.7K | 90.9K | 169K | 316K | 590K |
| 11.0 | 21.0 | 40.2 | 76.8 | 147 | 280 | 536 | 1.02K | 1.96K | 3.74K | 7.15K | 13.7K | 26.1K | 49.9K | 93.1K | 174K | 324K | 604K |
| 11.3 | 21.5 | 41.2 | 78.7 | 150 | 287 | 549 | 1.05K | 2.00K | 3.83K | 7.32K | 14.0K | 26.7K | 51.1K | 95.3K | 178K | 332K | 619K |
| 11.5 | 22.1 | 42.2 | 80.6 | 154 | 294 | 562 | 1.07K | 2.05K | 3.92K | 7.50K | 14.3K | 27.4K | 52.3K | 97.6K | 182K | 340K | 634K |
| 11.8 | 22.6 | 43.2 | 82.5 | 158 | 301 | 576 | 1.10K | 2.10K | 4.02K | 7.68K | 14.7K | 28.0K | 53.6K | 100K | 187K | 348K | 649K |
| 12.1 | 23.2 | 44.2 | 84.5 | 162 | 309 | 590 | 1.13K | 2.15K | 4.12K | 7.87K | 15.0K | 28.7K | 54.9K | 102K | 191K | 357K | 665K |
| 12.4 | 23.7 | 45.3 | 86.6 | 165 | 316 | 604 | 1.15K | 2.21K | 4.22K | 8.06K | 15.4K | 29.4K | 56.2K | 105K | 196K | 365K | 681K |
| 12.7 | 24.3 | 46.4 | 88.7 | 169 | 324 | 619 | 1.18K | 2.26K | 4.32K | 8.25K | 15.8K | 30.1K | 57.6K | 107K | 200K | 374K | 698K |
| 13.0 | 24.9 | 47.5 | 90.9 | 174 | 332 | 634 | 1.21K | 2.32K | 4.42K | 8.45K | 16.2K | 30.9K | 59.0K | 110K | 205K | 383K | 715K |
| 13.3 | 25.5 | 48.7 | 93.1 | 178 | 340 | 649 | 1.24K | 2.37K | 4.53K | 8.66K | 16.5K | 31.6K | 60.4K | 113K | 210K | 392K | 732K |
| 13.7 | 26.1 | 49.9 | 95.3 | 182 | 348 | 665 | 1.27K | 2.43K | 4.64K | 8.87K | 16.9K | 32.4K | 61.9K | 115K | 215K | 402K | 750K |
| 14.0 | 26.7 | 51.1 | 97.6 | 187 | 357 | 681 | 1.30K | 2.49K | 4.75K | 9.09K | 17.4K | 33.2K | 63.4K | 118K | 221K | 412K | 768K |
| 14.3 | 27.4 | 52.3 | 100 | 191 | 365 | 698 | 1.33K | 2.55K | 4.87K | 9.31K | 17.8K | 34.0K | 64.9K | 121K | 226K | 422K | 787K |
| 14.7 | 28.0 | 53.6 | 102 | 196 | 374 | 715 | 1.37K | 2.61K | 4.99K | 9.53K | 18.2K | 34.8K | 66.5K | 124K | 232K | 432K | 806K |
| 15.0 | 28.8 | 54.9 | 105 | 200 | 383 | 732 | 1.40K | 2.67K | 5.11K | 9.76K | 18.7K | 35.7K | 68.1K | 127K | 237K | 442K | 825K |
| 15.4 | 29.4 | 56.2 | 107 | 205 | 392 | 750 | 1.43K | 2.74K | 5.23K | 10.0K | 19.1K | 36.5K | 69.8K | 130K | 243K | 453K | 845K |
| 15.8 | 30.1 | 57.6 | 110 | 210 | 402 | 768 | 1.47K | 2.80K | 5.36K | 10.2K | 19.6K | 37.4K | 71.5K | 133K | 249K | 464K | 866K |
| 16.2 | 30.9 | 59.0 | 113 | 215 | 412 | 787 | 1.50K | 2.87K | 5.49K | 10.5K | 20.0K | 38.3K | 73.2K | 137K | 255K | 475K | 887K |
| 16.5 | 31.6 | 60.4 | 115 | 221 | 422 | 806 | 1.54K | 2.94K | 5.62K | 10.7K | 20.5K | 39.2K | 75.0K | 140K | 261K | 487K | 909K |
| 16.9 | 32.4 | 61.9 | 118 | 226 | 432 | 825 | 1.58K | 3.01K | 5.76K | 11.0K | 21.0K | 40.2K | 76.8K | 143K | 267K | 499K | 931K |
| 17.4 | 33.2 | 63.4 | 121 | 232 | 443 | 845 | 1.62K | 3.09K | 5.90K | 11.3K | 21.5K | 41.2K | 78.7K | 147K | 274K | 511K | 953K |
| 17.8 | 34.0 | 64.9 | 124 | 237 | 453 | 866 | 1.65K | 3.16K | 6.04K | 11.5K | 22.1K | 42.2K | 80.6K | 150K | 280K | 523K | 976K |
| 18.2 | 34.8 | 66.5 | 127 | 243 | 464 | 887 | 1.69K | 3.24K | 6.19K | 11.8K | 22.6K | 43.2K | 82.5K | 154K | 287K | 536K | 1.00M |
| 18.7 | 35.7 | 68.1 | 130 | 249 | 475 | 909 | 1.74K | 3.32K | 6.34K | 12.1K | 23.2K | 44.2K | | | | | |