19EEE111: Numerical Questions

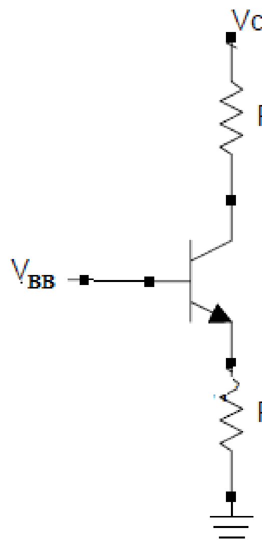
Zener Diode

1. A 5.0V stabilised power supply is required to be produced from a 12V DC power supply input source. The maximum power rating P_Z of the zener diode is 2W. Using the zener regulator circuit above calculate:
    a. The maximum current flowing through the zener diode.
    b. The minimum value of the series resistor, R_S
    c. The load current IL if a load resistor of 1kΩ is connected across the zener diode.
    d. The zener current IZ at full load.

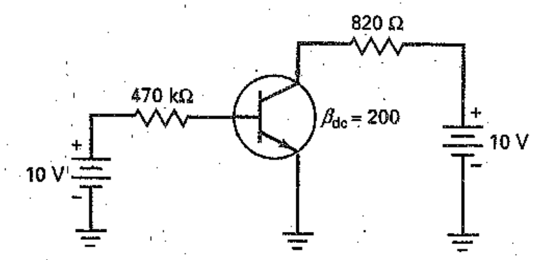
Transistor

2. In the NPN transistor, 108 holes/µs move from the base to the emitter region while 1010 electrons/µs move from the emitter to the base region. An ammeter reads the base current as i_B= 16µA. Determine the emitter current i_E and the collector current i_C.
3. Given that
    a. Given $\alpha = 0.987$, determine the corresponding value of β.
    b. Given β=120, determine the corresponding value of α.
    c. Given β= 180 and IC = 2.0 mA, find I_E and I_B.

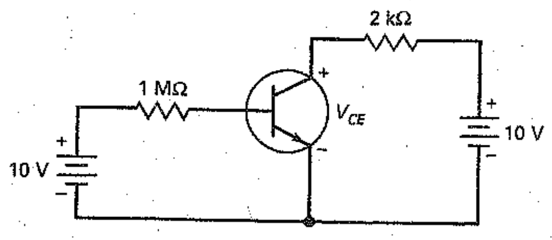
4. A bipolar NPN transistor has a DC current gain, (Beta) value of 200. Calculate the base current Ib required to switch a resistive load of 4mA.
5. An NPN Transistor has a DC base bias voltage, Vb of 10v and an input base resistor, R_b of 100kΩ. What will be the value of the base current into the transistor?
6. What is the collector voltage in the given Figure? Also find the emitter voltage. Find the Q point. Given VBB = 2.5 V; VCC = 20 V, RE = 1.8 kOhm, RC = 10 kOhm.



7. If the 470 kΩ resistor has a tolerance of ±5% then what is the maximum base current?



8. Transistor shown in the figure has β= 300 find, I_B

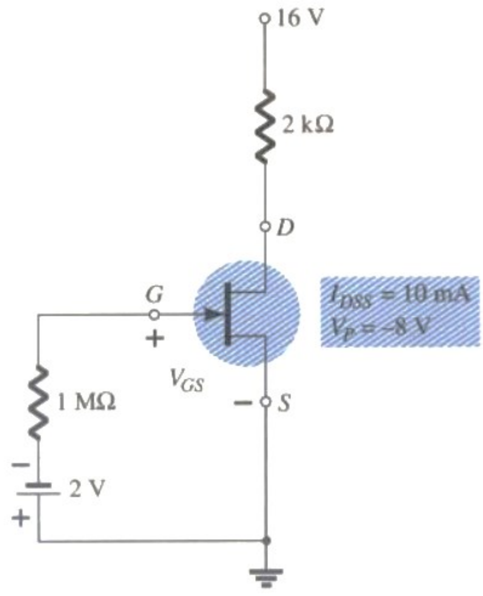


Transistor as a Switch

9. Using the transistor values of: β = 200, Ic = 4mA and Ib = 20uA, find the value of the Base resistor (Rb) required to switch the load fully "ON" when the input terminal voltage exceeds 2.5v.
10. Using the transistor values of : β = 200,, find the minimum Base current required to turn the transistor "fully-ON" (saturated) for a load that requires 200mA of current when the input voltage is increased to 5.0V. Also calculate the new value of Rb.

Junction Field Effect Transistor

11. For the JFET Circuit shown below Determine the following : Vgs, Id, Vds, Vd, Vg, Vs



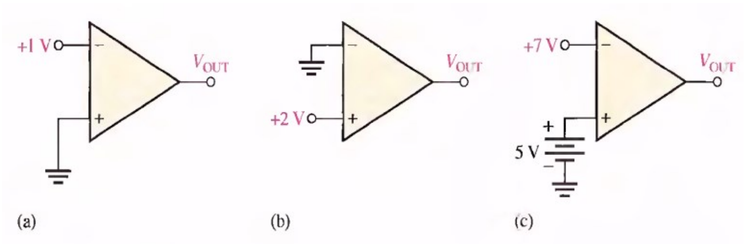
12. An n channel JFET has a drain current of 5 mA. OF I_{DSS} =10mA and V_{GS} (off)= - 6V. Find the value of
    a. V_{GS} (Gate to Source Voltage)
    b. Vp

Light Emitting Diode

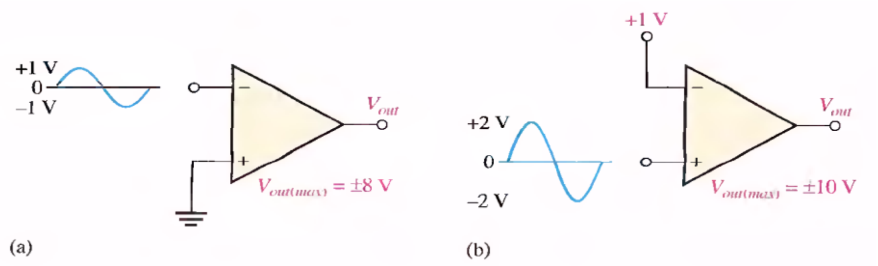
13. An amber coloured LED with a forward volt drop of 2 volts is to be connected to a 5.0v stabilised DC power supply. Using the circuit above calculate the value of the series resistor required to limit the forward current to less than 10mA. Also calculate the current flowing through the diode if a 100Ω series resistor is used instead of the calculated first.
    a. Series resistor required at 10mA.
    b. with a 100Ω series resistor.

Operational Amplifiers

14. Determine the output level (maximum positive or maximum negative) for each comparator in Figure.



15. Draw the output voltage waveform for each circuit in Figure with respect to the input. Show voltage levels.



Answer Key

Zener Diode

1. Using the zener regulator circuit above calculate:
   a. The maximum current flowing through the zener diode.
   b. The minimum value of the series resistor, R_S
   c. The load current IL if a load resistor of 1kΩ is connected across the zener diode.
   d. The zener current IZ at full load[1].

a). The maximum current flowing through the zener diode.

$$\text{Maximum Current} = \frac{\text{Watts}}{\text{Voltage}} = \frac{2w}{5v} = 400mA$$

b). The minimum value of the series resistor, R_S

$$R_S = \frac{V_S - V_Z}{I_Z} = \frac{12-5}{400mA} = 17.5\Omega$$

c). The load current I_L if a load resistor of $1k\Omega$ is connected across the zener diode.

$$I_L = \frac{V_Z}{R_L} = \frac{5v}{1000\Omega} = 5mA$$

d). The zener current I_Z at full load.

$$I_Z = I_S - I_L = 400mA - 5mA = 395mA$$

[1] Source : https://www.electronics-tutorials.ws/diode/diode_7.html

Transistor

2. Ans:

The emitter current is found as the net rate of flow of positive charge into the emitter region:

$$i_E = (1.602 \times 10^{-19}\ \text{C/hole})(10^{14}\ \text{holes/s}) - (-1.602 \times 10^{-19}\ \text{C/electron})(10^{16}\ \text{electrons/s})$$
$$= 1.602 \times 10^{-5} + 1.602 \times 10^{-3} = 1.618\,\text{mA}$$

Further, by KCL,

$$i_C = i_E - i_B = 1.618 \times 10^{-3} - 16 \times 10^{-6} = 1.602\,\text{mA}$$

3. Given that

(a) $\beta = \dfrac{\alpha}{1-\alpha} = \dfrac{0.987}{1-0.987} = \dfrac{0.987}{0.013} = \mathbf{75.92}$

(b) $\alpha = \dfrac{\beta}{\beta+1} = \dfrac{120}{120+1} = \dfrac{120}{121} = \mathbf{0.992}$

(c) $I_B = \dfrac{I_C}{\beta} = \dfrac{2\text{ mA}}{180} = \mathbf{11.11\ \mu A}$

$I_E = I_C + I_B = 2\text{ mA} + 11.11\ \mu\text{A}$
$= \mathbf{2.011\ mA}$

4. Calculate the base current Ib required to switch a resistive load of 4mA[2].

$$I_B = \frac{I_C}{\beta} = \frac{4\times10^{-3}}{200} = 20\mu A$$

Therefore, β = 200, Ic = 4mA and Ib = 20μA.

5. What will be the value of the base current into the transistor[3].

$$I_B = \frac{V_B - V_{BE}}{R_B} = \frac{10-0.7}{100k\Omega} = 93\mu A$$

6. Find the Q point. Given VBB = 2.5 V; VCC = 20 V, RE = 1.8 kOhm, RC = 10 kOhm.

[2] Source : https://www.electronics-tutorials.ws/transistor/tran_2.html
[3] Source : https://www.electronics-tutorials.ws/transistor/tran_2.html

$V_{BE} = 0.7$ V

$V_E = V_{BB} – V_{BE} = 2.5 – 0.7 = 1.8$ V

$I_E = V_E/R_E=1$ mA

$I_C = I_E = 1$ mA [Assumption $I_B=0$]

$V_C = V_{CC}-I_CR_C = 20 – (1x10^{-3})(10x10^3) = 10$ V

The Q point is (10 V, 1 mA).

7. what is the maximum base current?

Soln: $I_B= \dfrac{V_{BB}-V_{BE}}{R_B}$

I_B increases as R_B decreases So, I_B max= (10-0.7)/ (470-5%)
=9.3/(446.5K)
= 0.208 μA

8. Transistor shown in the figure has β= 300 find, I_B

Soln:

$$I_B = \frac{V_{BB} - V_{BE}}{R_B}$$

$= (10-0.7)/ (1X10^6)$

$= 9.3\ \mu A$

$\beta = I_C/I_B$

So, $I_C = 2.79mA$

$V_{CE} = V_{CC} - I_C R_C$

So, $V_{CE} = 4.42$ V

$$P_D = V_{CE} I_C$$

So, $P_D = 12.3mW$

Transistor as a switch

9. find the value of the Base resistor (Rb) required to switch the load fully "ON" when the input terminal voltage exceeds 2.5v.[4]

$$R_B = \frac{V_{in} - V_{BE}}{I_B} = \frac{2.5v - 0.7v}{20x10^{-6}} = 90k\Omega$$

10. Also calculate the new value of Rb. [5]

Transistor Base current:

$$I_B = \frac{I_C}{\beta} = \frac{200mA}{200} = 1mA$$

Transistor Base resistance:

$$R_B = \frac{V_{in} - V_{BE}}{I_B} = \frac{5.0v - 0.7v}{1\times10^{-3}} = 4.3k\Omega$$

[4] Source : https://www.electronics-tutorials.ws/transistor/tran_4.html

[5] Source: https://www.electronics-tutorials.ws/transistor/tran_4.html

Junction Field Effect Transistor

11. For the JFET Circuit[6]

(a) $V_{GS_Q} = -V_{GG} = \mathbf{-2\ V}$

(b) $I_{D_Q} = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2 = 10\text{ mA}\left(1 - \frac{-2\text{ V}}{-8\text{ V}}\right)^2$

$= 10\text{ mA}(1 - 0.25)^2 = 10\text{ mA}(0.75)^2 = 10\text{ mA}(0.5625)$

$= \mathbf{5.625\ mA}$

(c) $V_{DS} = V_{DD} - I_D R_D = 16\text{ V} - (5.625\text{ mA})(2\text{ k}\Omega)$

$= 16\text{ V} - 11.25\text{ V} = \mathbf{4.75\ V}$

(d) $V_D = V_{DS} = \mathbf{4.75\ V}$

(e) $V_G = V_{GS} = \mathbf{-2\ V}$

(f) $V_S = \mathbf{0\ V}$

12. A n-channel JFET

Numerical 01

A n-channel JFET has a drain current of 5mA. If I_{DSS} = 10mA and $V_{GS(off)}$ = −6V. Find value of a) V_{GS} (Gate to source voltage)
b) V_P

Soln: a) $I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_{GS(off)}}\right)^2$

$5mA = 10mA\left(1 + \frac{V_{GS}}{6}\right)^2$

$\frac{1}{2} = \left(1 + \frac{V_{GS}}{6}\right)^2$

ie $1 + \frac{V_{GS}}{6} = \frac{1}{\sqrt{2}} = 0.707$

ie $V_{GS} = -1.757\ V$

b) $V_P = |V_{GS(off)}| = 6\ V$

6 For more Details : https://home.kku.ac.th/rujchai/analog/FETBiasing.pdf

Light Emitting Diode

13. An amber coloured LED[7].

1). series resistor required at 10mA.

$$R_S = \frac{V_S - V_F}{I_F} = \frac{5v - 2v}{10mA} = \frac{3}{10x10^{-3}} = 300\Omega$$

2). with a 100Ω series resistor.

$$R_S = \frac{V_S - V_F}{I_F}$$

$$\therefore \; I_F = \frac{V_S - V_F}{R_S} = \frac{5-2}{100} = 30mA$$

[7] For more Details : https://www.electronics-tutorials.ws/diode/diode_8.html

Operational Amplifiers

14. Determine the output level

(a) Maximum negative
(b) Maximum positive
(c) Maximum negative

15. Draw the output voltage waveform