9. APPENDICES

9.1 Analysis of biasing points, D-C stabilization of low level discriminator using tunnel diode monostable circuit. (See Fig. 4.2)

9.1.1 Biasing point of tunnel diode.

Maximum available voltage across the tunnel diode 1N 3712 is calculated from a voltage divider R 4 and R 5

$$V = \frac{1}{180} \times 12{,}000 = 67 \text{ mv.}$$

This biasing point can be adjusted by varying a 100 ohm potentiometer connected across the R 5 resistor.

9.1.2 Analysis of the steady state of Schmitt trigger.

let $I_E = 5$ ma. $V_E = 0.05$ volts.

$$R_E = \frac{0.05}{5 \times 10^{-3}} = 10 \text{ ohm.}$$

Neglecting V_{CE} (sat) of Q2 then the collector resistance is given by

$$R_{C2} = \frac{12}{5} = 2.4 \text{ K}\Omega$$

For Q1 and Q2 transistor 2 N 3640, Si PNP type are chosen. The values of β of these transistor are equal to 30 then

$$I_{B(sat)} = \frac{5}{30} = 0.17 \text{ ma}$$

To be sure that Q2 will saturate let V_{BE} be 0.8 V. To find the value of R_1, R_2 and R_{e1}. The biasing circuit is redrawn in Fig. 9.1.1 and it is reasonable to let R_2 equal to 2.7 K then

$$I_2 = \frac{0.85}{2.7K} = 0.31 \text{ ma.}$$

$$R_{c1} + R_1 = \frac{12 - 0.85}{0.31+0.17} = \frac{11.15}{0.48} = 24.7\ K\Omega$$

Choose $R_1 = 22\ K$ and $R_{c1} = 2.2\ K$

For Q_1 to be cut off let $V_{B1} = 0.6$ volt.
(base to ground voltage)

let I_1 in Fig. 4.2 be 1 ma.

then $R_3 = \frac{12 - 0.6}{1 \times 10^{-3}} = 11.4\ K\Omega$

$$R_L = \frac{0.6}{1 \times 10^{-3}} = 600\ \Omega$$

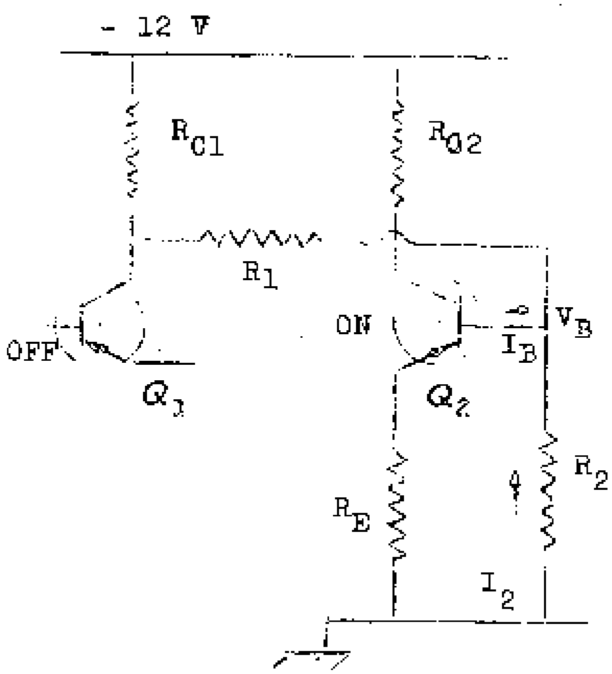

Fig. 9.1.1

9.2 Analysis of biasing point, D - C stabilization of Low Level discriminator using tunnel diode bistable circuit. (See Fig. 5.2)

9.2.1 Stabilization of power supply by using Zener diode 1N961A

Positive polarity power supply = 12 volts.

Stabilized voltage required = 9 volts at 15 ma.

$$R_1 = \frac{12 - 9}{15\ ma} = \frac{3,000}{15} = 200$$

Using 180 Ω, V = 10 volts (due to discrepancy in zenor diode)

Negative polarity power supply = 12 volts.

stabilized voltage required = 9 volts at 30 ma.

$$R_2 = \frac{12 - 9}{30} = 100$$

9.2.2 Biasing point of tunnel diode.

Tunnel diode TD is biased by a constant current source (Transistor Q 7), the bias current can be adjusted by a 1,000 ohm helicoidel potentiometer.

let $I_1 = 0.5$ ma $I_2 = 0.2$ ma

Voltage across R_3 should be 1 volt.

$$R_3 = \frac{1}{0.5} = 2\ K$$

Voltage across R_4 should be 4 volts and Q 6 should slightly conduct.

$$R_4 = \frac{4}{0.2} = 20\ K$$

Both transistors are temperature compensated through transistors Q 8 and Q 9 connected in diode operation.

9.2.3 Analysis of the steady state of difference amplifier.

For Q 1 to be cut off and Q 2 to conduct and with $\beta = 40$ we assume

$$V_{E1} = 0, \quad V = 10 \text{ mv}, \quad I_E = 10 \text{ ma}$$

$$R_E = \frac{10}{10} = 1 \text{ K} \quad \text{using } 1.2 \text{ K}$$

we obtain $I_E = \frac{10}{1.2} = 8.3$ ma

$$I_{B2} = \frac{8.3}{40} = 0.2 \text{ ma}$$

From data sheet $V_{B2} = 0.2$ V

To assure good stability we assume

$$I = 20\, I_{B2} = 20 \times 0.2 = 4 \text{ ma}$$

$$R_a = \frac{0.2}{4} = 50\ \Omega$$

and $R_6 = \frac{9 - 0.2}{0.2 + 4} = \frac{8.8}{4.2} = 2.1$ K

For the second difference amplifier which composes of Q 3 and Q 4 and with $\beta = 30$

let $V_C = 3$ volts and $R_D = 2.2$ K

$$I_C = \frac{1.3}{2.2} = 6 \text{ ma}$$

$$I_{B4} = \frac{6}{30} = 0.2 \text{ ma}$$

Now $I_{C2} = I_E - I_{B2} = 8.3 - 0.2 = 8.1$ ma

also $I_4 = I_{C2} - I_{B4} = 8.1 - 0.2 = 7.9$ ma

then with $R_{C2} = 680$

$$V_{B4} = -9. + 680 \times 7.9 = -3.6 \text{ volts.}$$

and $R_{E2} = \frac{9 - 4.2}{6} = \frac{4.8}{6} = 800\ \Omega$

the value used for R_{E2} is adjusted to be 820 Ω . Owing to diode D 1 which is reverse biased no current flows through the emitter resistance and the 1.0 K resistor across base and emitter of transistor Q 5.

9.3 Analysis of biasing point, D - C stablization of low level discriminator using both tunnel diode monostable and bistable circuits (See Fig. 6.2)

9.3.1 Stabilization of power supply through the use of zener diode 1N 4742 A

Positive polarity voltage supply = 15 volts

stabilized voltage = 10 volts at 50 ma.

$$\therefore R_2 = \frac{15 - 10}{50 \times 10^{-3}} = 100\ \Omega$$

Negative polarity voltage supply = 15 volts

stabilized voltage = 12 volts at 50 mA

$$R_1 = \frac{15 - 12}{50 \times 10^{-3}} = 60\ \Omega \text{ using } 56\ \Omega$$

9.3.2 Biasing point of tunnel diode

Tunnel diode TD 1 is biased to work as monostable circuit at V_1 = 50 mV. by a divider R_{TD} and R_L

R_L is adjustable. The maximum value of R_L is chosen to be 2.5 K

$$R_{TD} = \frac{0.05 \times 2.5 \times 10^3}{12} = 10\ \Omega$$

Tunnel diode TD 2 is biased to work as bistable circuit at V_2 = 40 mA then D1 is on the verge of conduction.

let V_{E3} = 6 V I_2 = 1 mA

$R_{E3} = \frac{6}{1} = 6$ K using 6.8 K

$I_2 = \frac{6}{6.8} = 0.9$ mA

Choose $R_3 = 2.7$ K and $V_{B3} = -5.4$ V

$I_3 = \frac{5.4}{2.7} = 2$ mA

with $\beta = 20$

$$R_4 = \frac{12 - 5.4}{2 - \frac{0.9}{20}} = \frac{6.6}{1.95} = 3.4 \text{ K}$$

9.3.3 Analysis of steady state of difference amplifier

For Q 1 to be cut off and Q 2 to conduct and with $\beta = 30$ we assume

$V_{E1} = 0$; $I_E = 10$ mA

$R_{E1} = 1$ K

From data sheet $V_{B2} = 0.2$ volts

Choose $R_{C1} = 2.4$ K

$I_1 = \frac{10}{2.4} = 4.15$ mA , $I_B = \frac{10}{30} = 0.33$ mA

$$R_{C2} = \frac{12 - 0.2}{4.15+0.33} = \frac{11.8}{4.5} = 2.62 \text{ K}$$

let $I = 20$ mA and $V_C = -5$ volts

$$R_E = \frac{5 + 10}{20} = 750\ \Omega$$

Choose $R_C = 680\ \Omega$ for the second difference amplifer Q 3 and Q 4 and with $\beta = 20$

$I_{C2} = 10 - 0.33 = 9.67$ mA

$I_4 = 9.67 - \frac{10}{20} = 9.17$ mA

$V_{B4} = 12 - 9.17 \times 680 = 5.8$ volts.

$V_{E2} = 5.8 + 0.6 = 6.4$ volts.

$R_{E2} = \frac{12 - 6.4}{20 + 1.0} = \frac{5.6}{21} = 266\ \Omega$

9.4 Analysis of biasing point, D - C stabilization of the low level pulse height discriminator (See Fig.7.2)

Initially TD 1 and TD 2 are short circuited causing Q 1 and Q 4 to be cut off. In quiescent state Q 1, Q 2, Q 3, Q 4, Q 5 and Q 7 are cut off.

let $I_{E1} = 2$ mA (when Q 1 conducts)

$R_1 = \frac{6}{2} = 3\ K = R_2$

let $I_{E2} = 6$ mA (when Q 2 conducts)

$R_3 = \frac{6}{6} = 1\ K$

Q 1, Q 2, Q 4 are chosen to be 2 N 396 A (high gain transistors) to ensure fast switching action.

R_L is chosen to be 1.5 K to make voltage across Q 7 about 1 volts.

The output pulse width is about 3 μsec.

To ensure the anticoincident action the monostable circuit Q 5 and Q 6 should have the output pulse width greater than 3 μsec.

let T = the switching time of the monostable circuit

= 8 μsec.

$0.7\ R_B C = 8\ \mu$sec.

let $I_{C6} = 2$ ma

$R_{C2} = \frac{6}{2} = 3\ K$

choose $C = 470$ pF

$$R_B = \frac{8 \times 10^6}{0.7 \times 470 \times 10^{-12}} = 24.5 \text{ K}$$

Using R_{C2} = 2.7 K, the voltage at the collector of Q 6 in conducting state is about 0.2 volts. Q 5 is biased to be cut off by the voltage divider 2.2 K and 1.2 K

When Q 5 conducts the collector current should be approximately 1 mA.

$$R_{C1} = \frac{6}{1} = 6 \text{ K.}$$