Chapter 14
Blocking Oscillators

1. For the monostable blocking oscillator in Fig. 14.1(a), following are the parameters:
   \( V_{CC} = 15 \text{ V}, R = 0.5 \text{ k}\Omega, L = 3 \text{ mH}, h_{FE} = 20 \) and \( n = 1 \). (a) Calculate and plot the base current and collector current waveforms and calculate the pulse width, (b) If due to temperature variation \( h_{FE} \) increases to 30, then calculate the pulse width.

**Solution:**
(a) We have
\[
i_B = \frac{nV_{CC}}{R} = \frac{1 \times 15}{0.5 \times 10^{-3}} = 30 \text{ mA}
\]
\[
i_C = \frac{n^2V_{CC}}{R} + \frac{V_{CC}}{L}t = \frac{(1)^2 \times 15}{0.5 \times 10^{-3}} + \frac{15}{3 \times 10^{-3}}t = 30 \times 10^{-3} + 5 \times 10^{3}t
\]
\[
\therefore \quad t_p \approx \frac{nL}{R}h_{FE} = \frac{1 \times 3 \times 10^{-3}}{0.5 \times 10^{3}} \times 20 = 120 \mu\text{s}.
\]
i_C at \( t = t_p \) is
\[
i_C = 30 \times 10^{-3} + 5 \times 10^{3} \times 0.120 \times 10^{-3} = 630 \text{ mA}.
\]
(b) Pulse width when \( h_{FE} = 30 \)
\[
t_p \approx \frac{nL}{R}h_{FE} = \frac{1 \times 3 \times 10^{-3}}{0.5 \times 10^{3}} \times 30 = 180 \mu\text{s}.
\]
The waveforms for condition (a) are plotted in Fig. 2.1.

![Waveforms for condition (a)](image)

2. For the blocking oscillator with emitter timing shown in Fig.14p.2 it is given that \( n = 1, n_1 = 1, L = 3 \text{ mH}, R = 0.5 \text{ k}\Omega, h_{FE} = 20 \) and \( V_{CC} = 15 \text{ V} \). Calculate (a) the amplitude of the trigger; (b) the value of \( R_L \) that allows pulse formation; (c) pulse width with \( h_{FE} = 20 \) and also calculate \( t_p \) using the approximate relation; and (d) the base, collector and emitter currents and (e) plot the current waveforms.
Solution:

(a) Amplitude of the trigger pulse is

\[ V = \frac{V_{CC}}{n+1} = \frac{15}{1+1} = 7.5 \text{ V}. \]

(b) The value of \( R_L \) that allows pulse formation is given by the relation:

\[ R_L > \frac{n^2 R}{n} \]

\[ \frac{n^2 R}{n} = \frac{1 \times 0.5 \times 10^3}{1} = 500 \Omega \]

As \( R_L \) should be greater than 500 \( \Omega \), choose, \( R_L = 1000 \Omega \).

(c) The pulse width is calculated using the relation

\[ t_p = \frac{nL}{R} \left[ h_{FE} - n \right] - \frac{n^2 L}{R_L} = \frac{1 \times 3 \times 10^{-3}}{0.5 \times 10^3} \left[ \frac{20-1}{1+20} \right] - \frac{1 \times 3 \times 10^{-3}}{1 \times 10^3} = 5.42 - 3 = 2.42 \mu s \]

The pulse width using the approximate relation is given by:

\[ t_p = \frac{nL}{R} - \frac{n^2 L}{R_L} = \frac{1 \times 3 \times 10^{-3}}{0.5 \times 10^3} - \frac{1 \times 3 \times 10^{-3}}{1 \times 10^3} = 6 - 3 = 3 \mu s. \]

(d) The base current is given by the relation:

\[ i_B(t = t_p) = \frac{V_{CC}}{(n+1)^2} \left\{ \frac{n}{R} - \frac{n_1^2}{R_L} - \frac{t}{L} \right\} = \frac{15}{(1+1)^2} \left\{ \frac{1}{0.5 \times 10^3} - \frac{1}{1 \times 10^3} - \frac{2.42 \times 10^{-6}}{3 \times 10^{-3}} \right\} = 0.72 \]

\[ i_B(t = 0) = 3.75 \text{ mA}. \]

Collector current \( i_C \) is given by:

\[ i_C(t = t_p) = \frac{V_{CC}}{(n+1)^2} \left[ \frac{t}{L} + \frac{n_1^2}{R_L} + \frac{n_2^2}{R} \right] = 3.75 \left[ \frac{2.42 \times 10^{-6}}{3 \times 10^{-3}} + \frac{1}{1 \times 10^3} + \frac{1}{0.5 \times 10^3} \right] \]

\[ i_C = 14.2 \text{ mA}. \]

\[ i_C(t = 0) = 11.25 \text{ mA}. \]

The emitter current \( i_E \) is given as

\[ i_E = \frac{nV}{R} = \frac{7.5}{0.5 \times 10^3} = 15 \text{ mA}. \]

(e) The current waveforms are shown in Fig. 2.1.
3. For the diode-controlled astable blocking oscillator shown in Fig. 14p.3, \( L = 3 \) mH, \( C = 100 \) pF, \( V_{CC} = 15 \) V, \( R = 500 \) \( \Omega \), \( V_r = 4.4 \) V, \( n = 1 \) and \( V_{BB} = 0.7 \) V, \( R_L = \infty \).

(a) Calculate the amplitude of the trigger pulse; (b) time period of the oscillations and the frequency and (c) the duty cycle.

\[ V = \frac{V_{CC}}{n+1} = \frac{15}{1+1} = 7.5 \text{ V}. \]
(b) When $R_L=\infty$, $t_p = \frac{nL}{R} = \frac{1 \times 3 \times 10^{-3}}{0.5 \times 10^3} = 6 \mu s$

$$t_a = 1.57\sqrt{\frac{L}{C}} = 1.57\sqrt{3 \times 10^{-3} \times 100 \times 10^{-12}} = 0.86 \mu s$$

$$t_f = \frac{n}{(n+1)} \times \frac{V_{CC}}{V_j} \times \frac{L}{R} = \frac{1}{(1+1)} \times \frac{15 \times 3 \times 10^{-3}}{4.4 \times 0.5 \times 10^3} = 10.23 \mu s$$

$$T = t_p + t_a + t_f = 6 + 0.86 + 10.23 = 17.09 \mu s.$$  

$$f = \frac{1}{T} = \frac{1000 \times 10^3}{17.09} = 58.51 \text{ kHz}.$$  

(c) Duty cycle = \( \frac{t_p}{T} = \frac{6}{17.09} \times 100 = 35.11 \text{ per cent.} \)

4. For the $RC$-controlled astable blocking oscillator shown in Fig. 14p.4, following are the parameters: $V_{CC} = 20 \text{ V}$, $n = n_1 = 1$, $V_{BB} = 3 \text{ V}$, $R = 100 \ \Omega$, $R_1 = 1000 \ \Omega$, $R_L = 1000 \ \Omega$, $C_1 = 0.01 \ \mu \text{F}$, $L = 2 \ \text{mH}$. (a) Calculate the amplitude of the trigger; (b) $t_p$, the pulse duration; (c) $V_1$, the maximum voltage to which $C_1$ charges; (d) $t_f$, the discharge period of $C$; (e) $T$, the time period of the astable multivibrator and its frequency of oscillations and finally (f) the duty cycle.

**Solution:**

(a) We have

$$V = \frac{V_{CC} - V_{BB}}{(n+1)} = \frac{20 - 3}{(1+1)} = 8.5 \text{ V}.$$  

(b) \[ t_p = \frac{nL}{R} = \frac{1 \times 2 \times 10^{-3}}{0.1 \times 10^3} = 20 \ \mu s. \]

(c) \[ (n + 1)V_1 = nV_{CC} + V - n(V_{CC} - V_{BB})e^{-t_p/RC_1} \]

\[ (1+1)V_1 = 1 \times 20 + 3 - 1(20 - 3)e^{-20 \times 10^{-6}/0.1 \times 10^3} \]

Fig. 14p.4 $RC$-controlled astable blocking oscillator
\[ 2V_1 = 23 - 17 \times 0 \]
\[ 2V_1 = 23 \]
\[ V_1 = 11.5 \text{ V}. \]

(d) \( t_f \) is given as
\[ t_f = RC \ln \frac{V_i}{V_{bb} - V_r} = 1 \times 10^3 \times 0.01 \times 10^{-6} \ln \frac{11.5}{3 - 0.5} = 15.2 \mu s. \]

(e) \( T = t_p + t_f = 20 + 15.2 = 35.2 \mu s. \)
\[ f = \frac{1}{T} = \frac{1}{35.2 \times 10^{-6}} = 28.4 \text{ kHz}. \]

(f) Duty cycle = \[ \frac{t_p}{T} = \frac{20}{35.2} \times 100 = 56.8 \text{ per cent.} \]