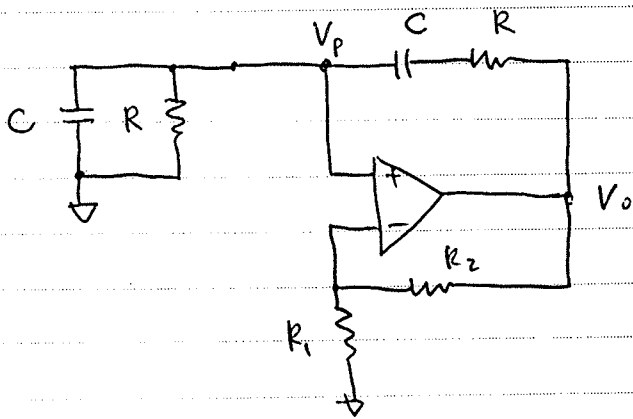


Chapter 10 Signal Generators

10.1 Sine Wave Generator

* Basic Wien-Bridge Oscillator



$$A = \frac{V_o}{V_p} = 1 + \frac{R_2}{R_1}$$

$$B(jf) = \frac{V_p}{V_o} = \frac{1}{3 + j(f/f_0 - f_0/f)}, \quad f_0 = \frac{1}{2\pi RC}$$

$$T(jf) = AB(jf)$$

$$\text{at } f = f_0, \quad T(jf_0) = \frac{1 + \frac{R_2}{R_1}}{3}$$

$$(i) \quad T(jf_0) < 1 \quad \text{or} \quad A < 3 \Rightarrow \text{stable}$$

$$(ii) \quad T(jf_0) > 1 \quad \text{or} \quad A > 3 \Rightarrow \text{unstable (saturation)}$$

$$(iii) \quad T(jf_0) = 1 \quad \text{or} \quad A = 3 \Rightarrow \text{neutral stability (oscillation)}$$

$$\Downarrow$$

$$\frac{R_2}{R_1} = 2$$

* Automatic Amplitude Control.

{ Fig 10.3 (p 457)

{ Fig 10.5 (p 458)

< C : polycarbonate cap.

< R : thin-film resistor.

With trimmer, THD $\sim 0.01\%$

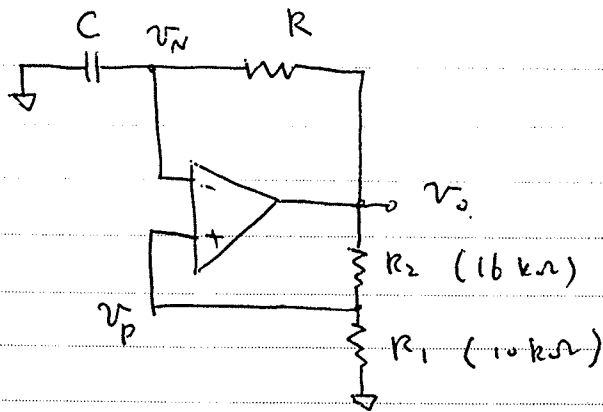
Op amp. selection ; { SR $> 2\pi V_{om} f_0$
 { GBP $\geq 43 f_0$

low freq. generation : { FET-input op amp.
 { C = $1\mu\text{F}$, R = $15.9\text{k}\Omega \Rightarrow 0.01\text{Hz}$

10.2 Multivibrator

{ bistable multivibrator (flip-flop)
 { monostable " \rightarrow (free-running)
 { astable " \rightarrow (one-shot)

* Basic Free-Running Multivibrator



(i) $t = 0$, assume $v_o = +V_{sat}$.

$$v_N(t) = V_{sat} (1 - e^{-t/\tau}), \quad \tau = RC$$

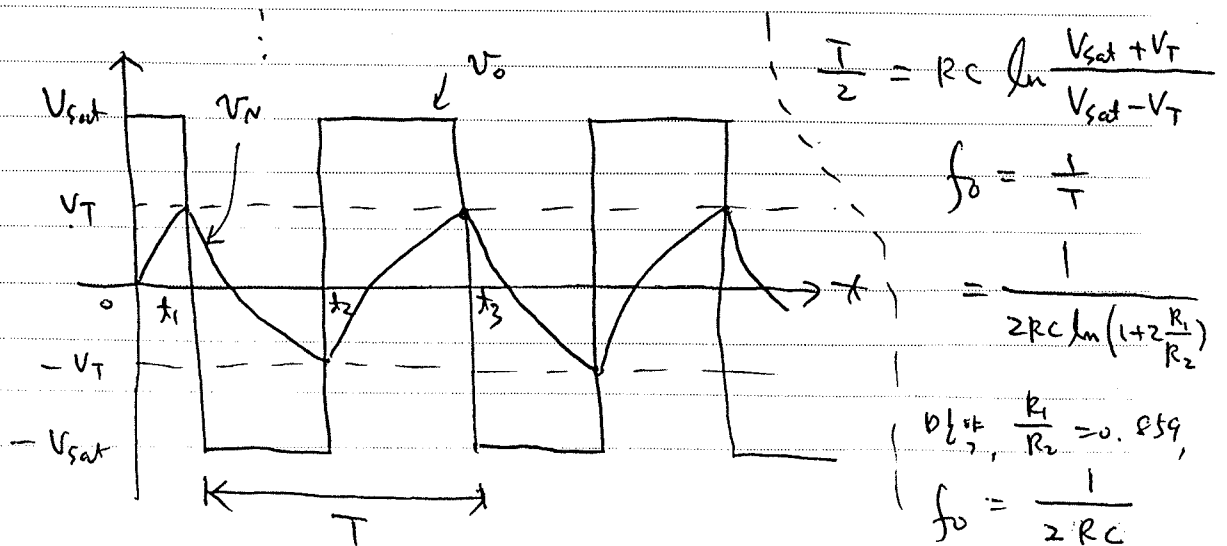
(ii) $t = t_1$, when $v_N(t_1) = V_T = \frac{R_1}{R_1 + R_2} V_{sat}$

$$v_o = -V_{sat}$$

$$v_N(t) = -V_{sat} (1 - e^{-t/\tau}) \quad (\because \tau_1 \neq \tau_2)$$

(iii) $t = t_2$ when $v_N(t_2) = -V_T = \frac{-R_1}{R_1 + R_2} V_{sat}$

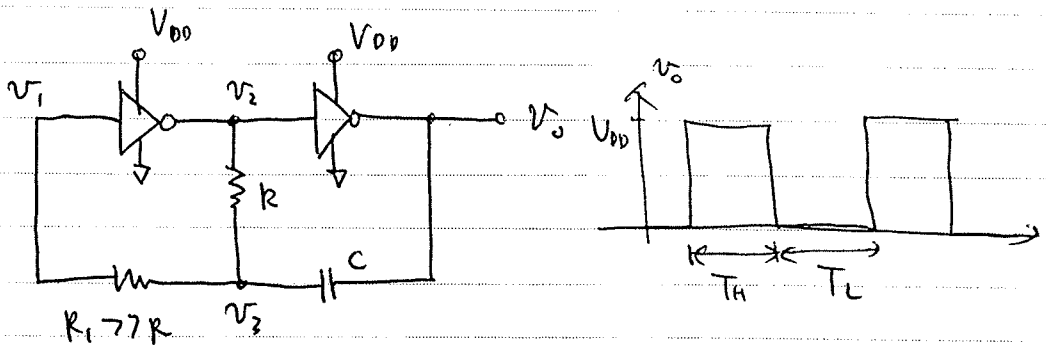
$$v_o = +V_{sat}$$



Single-supply free running multivibrator : Fig 10.9
(p 463)

$$f_0 = \frac{1}{RC \ln \left(\frac{V_{TH}}{V_{TL}} \times \frac{V_{CC} - V_{TL}}{V_{CC} - V_{TH}} \right)}$$

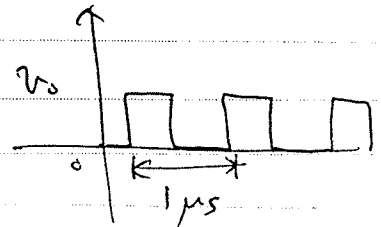
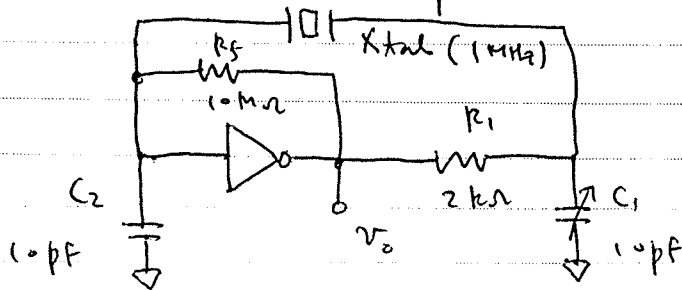
* Free-Running Multivibrator using CMOS Gates



$$f_0 = \frac{1}{RC \ln \left(\frac{V_{DD} + V_T}{V_T} \times \frac{2V_{DD} - V_T}{V_{DD} - V_T} \right)}$$

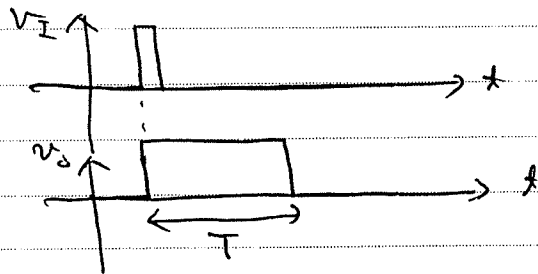
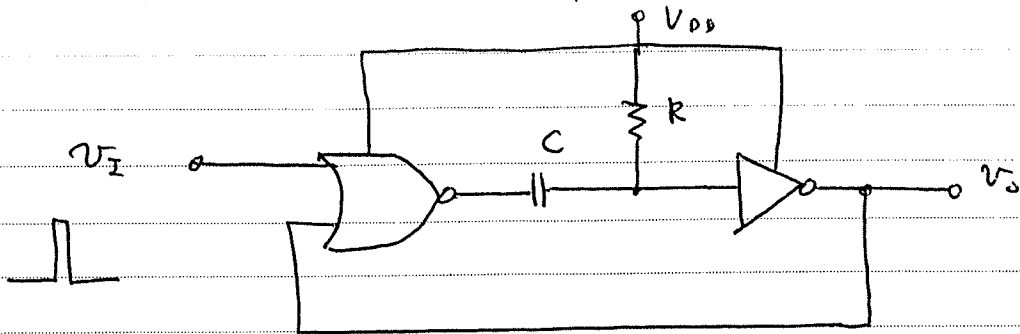
$$V_T \approx \frac{V_{DD}}{2}$$

* CMOS Crystal Oscillator



Stability: 1 ppm/°C

* Monostable Multivibrator



$$T = RC \ln \frac{V_{DD}}{V_{DD} - V_T}, \quad V_T = \frac{V_{DD}}{2}$$

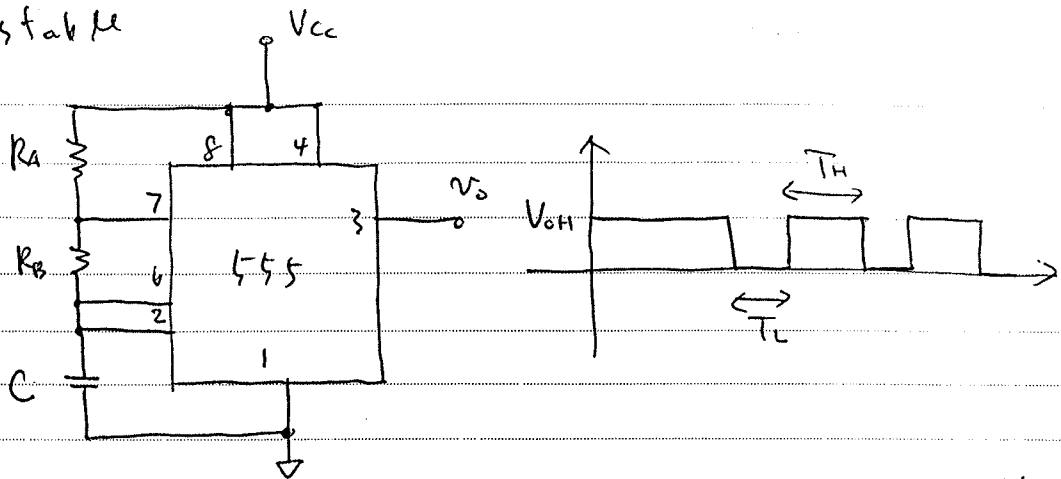
$$= RC \ln 2 = 0.69 RC$$

10.3 Monolithic Timers

* 555 Timer

(Fig 10.15
 Fig 10.16
 Fig 10.17

* Astable



$$T = T_L + T_H = R_B C \ln 2 + (R_A + R_B) C \ln \frac{V_{CC} - \frac{V_{TH}}{2}}{V_{CC} - V_{TH}}$$

$$T_L = R_B C \ln 2$$

$$T_H = (R_A + R_B) C \ln \frac{V_{CC} - \frac{V_{TH}}{2}}{V_{CC} - V_{TH}}$$

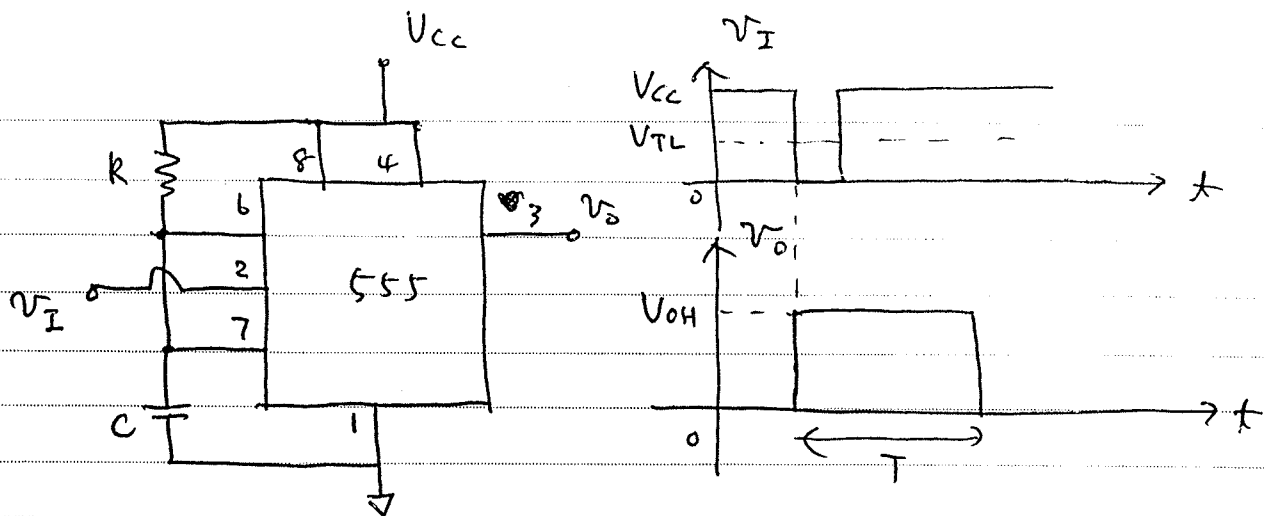
$$V_{TH} = \frac{2}{3} V_{CC}, \quad V_{TL} = \frac{1}{3} V_{CC}$$

$$\left. \begin{aligned} f_o &= \frac{1}{T} = \frac{1.44}{(R_A + 2R_B) C} \\ D(\%) &= 100 \times \frac{R_A + R_B}{R_A + 2R_B} \end{aligned} \right\}$$

* Monostable

$$T = R C \ln \frac{V_{CC}}{V_{CC} - V_{TH}} = R C \ln 3$$

$$\cong 1.10 R C$$



10.4 Triangular Wave Generator

Fig 10.19 (p 475)

Fig 10.20 (p 477)

* VCO (Voltage-Controlled Oscillator)

Fig 10.21 (p 477)

10.5 Sawtooth Wave Generator

Fig 10.24 (p 480)

10.6 Monolithic Waveform Generator

ICL 8038 (Fig 10.26)

XR 2206 (Fig 10.31)

10.7 V-F and F-V converters

$$VFC : f_o = k v_I, \text{ Fig 10.33 (AD 537)}$$

Fig 10.35 (VFC32)
↳ B.B

$$FVC : v_o = k f_I, \text{ Fig 10.36}$$