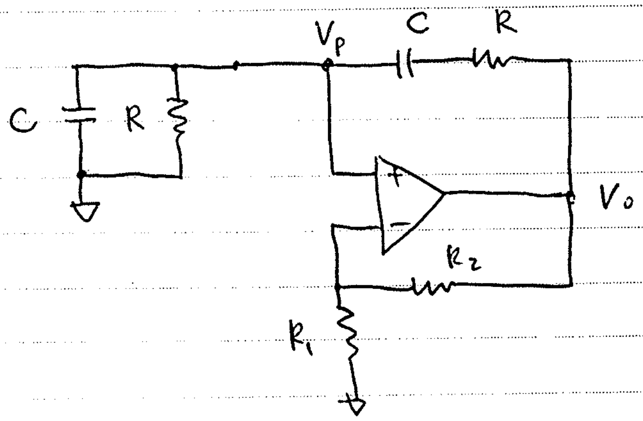
Chapter 10 Signal Generators

10.1 Sine Wave Generator

* Basic Wien-Bridge Oscillator



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

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

$$T(jf) = A\,B(jf)$$

at $f = f_o$, $\quad T(jf_o) = \dfrac{1 + \frac{R_2}{R_1}}{3}$

(i) $T(jf_o) < 1$ or $A < 3$ $\Rightarrow$ stable

(ii) $T(jf_o) > 1$ or $A > 3$ $\Rightarrow$ unstable (saturation)

(iii) $T(jf_o) = 1$ or $A = 3$ $\Rightarrow$ neutral stability (oscillation)

$$\Downarrow$$

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

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* Automatic Amplitude Control.

{ Fig 10.3 (p457)
{ Fig 10.5 (p458)

< C : polycarbonate cap.
< R : thin-film resistor.

With trimmer, THD ~ 0.01%

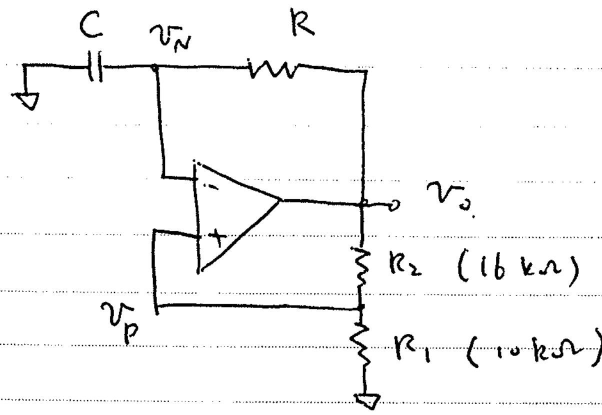
Op amp. selection ; $\begin{cases} SR > 2\pi V_{om} f_0 \\ GBP \geq 43 f_0 \end{cases}$

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

10.2 Multivibrator

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

* Basic Free-Running Multivibrator



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

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

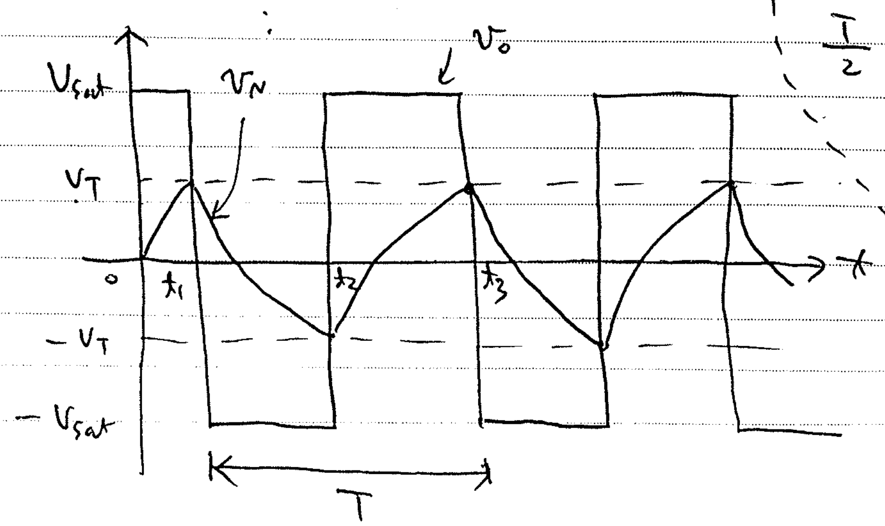
(ii) $t = t_1$ when $v_N(t_1) = V_T = \dfrac{R_1}{R_1+R_2} V_{sat}$

$$v_o = -V_{sat}.$$

$$v_N(t) = -V_{sat}\left(1 - e^{-t/\tau}\right)$$ ← 수정하자. (∵ 초기치 ≠ 0)

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

$$v_o = +V_{sat}$$



$$\frac{T}{2} = RC \ln \frac{V_{sat}+V_T}{V_{sat}-V_T}$$

$$f_0 = \frac{1}{T}$$

$$= \frac{1}{2RC \ln\left(1 + 2\frac{R_1}{R_2}\right)}$$

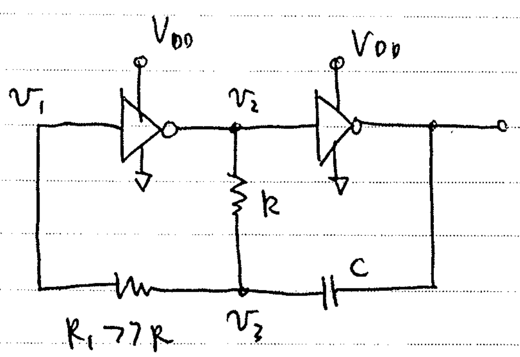
만약, $\dfrac{R_1}{R_2} = 0.859$,

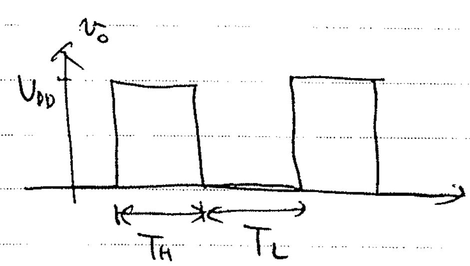
$$f_0 = \frac{1}{2RC}$$

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

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

* Free-Running Multivibrator using CMOS Gates

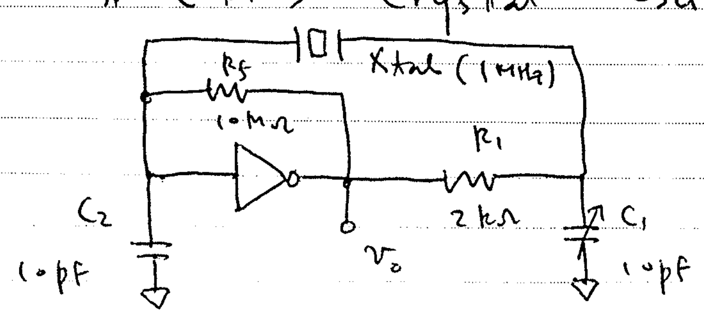


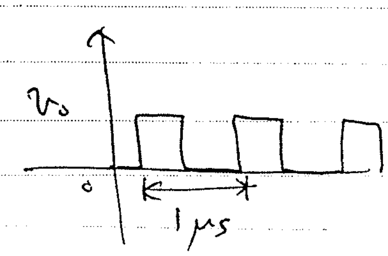


$$f_o = \frac{1}{RC\ln\left(\frac{V_{DD}+V_T}{V_T}\times\frac{2V_{DD}-V_T}{V_{DD}-V_T}\right)}$$

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

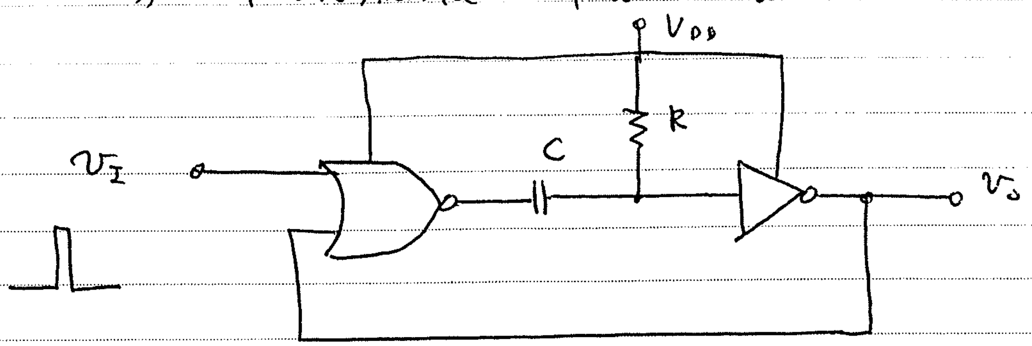
* CMOS Crystal Oscillator

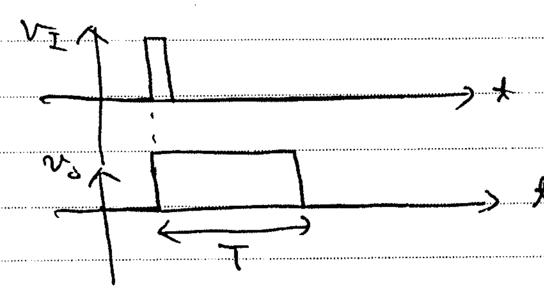




Stability : 1ppm/°C

* Monostable Multivibrator





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

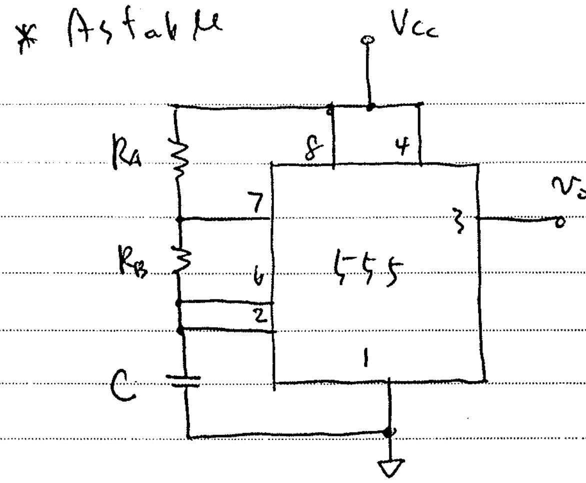
$$= RC \ln 2 = 0.69 RC .$$

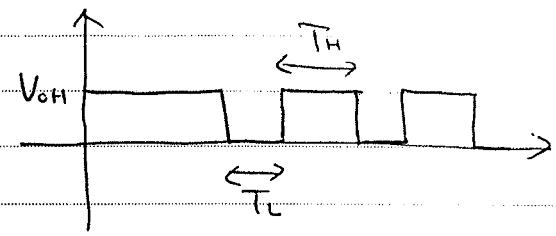
10.3 Monolithic Timer

* 555 Timer

Fig 10.15
Fig 10.16
Fig 10.17

* Astable





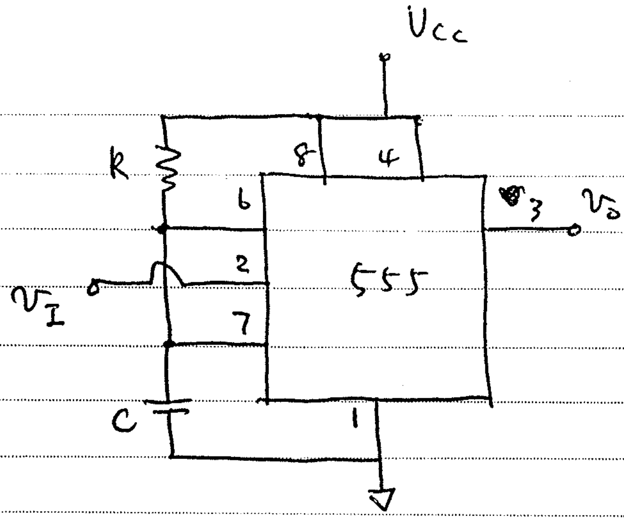
$$\begin{cases} T = T_L + T_H = R_B C \ln 2 + (R_A + R_B) C \ln \dfrac{V_{CC} - \frac{V_{TH}}{2}}{V_{CC} - V_{TH}} \\ T_L = R_B C \ln 2 \\ T_H = (R_A + R_B) C \ln \dfrac{V_{CC} - \frac{V_{TH}}{2}}{V_{CC} - V_{TH}} \\ V_{TH} = \frac{2}{3} V_{CC}, \quad V_{TL} = \frac{1}{3} V_{CC} \end{cases}$$

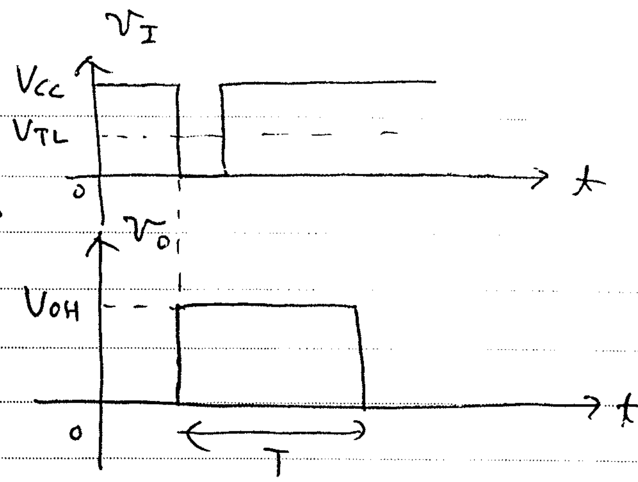
$$\begin{cases} f_o = \dfrac{1}{T} = \dfrac{1.44}{(R_A + 2R_B) C} \\ D(\%) = 100 \times \dfrac{R_A + R_B}{R_A + 2R_B} \end{cases}$$

* Monostable

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

$$\fallingdotseq 1.10\, RC$$





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 converter

VFC : $f_o = k v_I$, Fig 10.33 (AD 537)
Fig 10.35 (VFC 32)
↳ BB

FVC : $v_o = k f_I$, Fig 10.36