

$$v_c = v_{fin} - (v_{fin} - v_{in})e^{\frac{-t}{RC}}$$

$$apa = \frac{v_{max} + v_{min}}{2}$$

$$Tilt_{\%} = \frac{v_{max} - v_{min}}{apa}$$

$$AWV = \frac{(+APA \times PW) + (-APA \times PS)}{Period}$$

$$Bandwidth = \# \text{ of Harmonics} \times \text{Fundamental}$$

- $\# \text{ of Harmonics} = \frac{Bandwidth}{Fundamental}$
- $Fundamental = \frac{Bandwidth}{\# \text{ of Harmonics}}$

$$F_{CH} = \frac{0.35}{t_r}$$

$$F_{CL} = \frac{\text{fractional tilt}}{2\pi(pw)}$$

$$\# \text{ of cycles?} = \frac{5\tau}{Period} (\text{cycles})(\text{Stabilization})$$

- $v_{max} = \frac{v_{gen+}}{1 + e^{\frac{-t}{RC}}}$
- $v_{min} = v_{gen+} - v_{max}$

$$\text{Integration, time} = \frac{1}{10} \tau$$

$$\text{Differentiation, time} = 10\tau$$

$$v_{inst} = V_{max} \sin(360Ft \pm \theta)$$

$$\text{Diode Static Resistance, } R_D = \frac{V_F}{I_F}$$

$$\text{Diode Dynamic Resistance, } r'd = \frac{26mv}{I_F}$$

$$t_{rr} \leq \frac{\text{time}_{rise/fall}}{10}$$

$$\text{time}_{rise/fall} \geq 10 \times t_{rr}$$

$$F_{CH} = \frac{0.35}{t_r}$$

$$F_{CL} = \sqrt{(F_{C1})^2 + (F_{C2})^2 + (F_{C3})^2 \dots}$$

$$C_{TotalIN} = C_{gen} + C_{stray} + C_{probe} + C_{millerIN} + C_{BG}$$

- $C_{millerIN} = CBC(1 + \Delta v_{CE})$
- $CBC \approx C_{obo}$
- $C_{BG} = C_{BE}(1 - \Delta v_{CC})$ 
  - $C_{BE} = \frac{1}{(2\pi)(r'e)(f_T)}$

$$C_{TotalOUT} = C_{MillerOUT} + C_{stray} + C_{probe}$$

- $C_{MillerOUT} = CBC(\frac{1+\Delta v_{CE}}{\Delta v_{CE}})$

$$FCH_{Total} = \frac{0.35}{\sqrt{(\frac{0.35}{FCH_{IN}})^2 + (\frac{0.35}{FCH_{MID}})^2 + (\frac{0.35}{FCH_{OUT}})^2}}$$

$$\frac{V_{out}}{V_{in}} = \frac{1}{\sqrt{1 + (\frac{f_1}{f})^2}}$$

$$V_{out}\% \text{ of } V_{in} = 100\% \times \frac{1}{\sqrt{1 + (\frac{f_1}{f})^2}}$$

$$\Delta v_{dB} = 20 \log \frac{1}{\sqrt{1 + (\frac{f_1}{f})^2}}$$

$$\theta = \cos^{-1} \frac{1}{\sqrt{1 + (\frac{f_1}{f})^2}}$$

$$V_{out}\% \text{ of } V_{in} = 100\% \times \frac{1}{\sqrt{1 + (\frac{f}{f_2})^2}}$$

$$\Delta v_{dB} = 20 \log \frac{1}{\sqrt{1 + (\frac{f}{f_2})^2}}$$

$$-\theta = \cos^{-1} \frac{1}{\sqrt{1 + (\frac{f}{f_2})^2}}$$

$$\beta = \frac{I_C}{I_B}$$

$$\alpha = \frac{I_C}{I_E}$$

$$\alpha = \frac{\beta}{\beta + 1}$$

*Emitter Peaking improvement factor* = 1.72658

*Shunt Peaking Optimal Flatness improvement factor* = 1.414

$$CMRR_{dB} = 20 \log\left(\frac{\Delta v_{cm}}{\Delta v_{diff}}\right)$$

$$OpAmp f_{ch} = \frac{FAB}{\Delta v} \text{ OR } \frac{Slew Rate}{2\pi V_p}$$

$$Z_{in \text{ Inverting Op Amp}} = (R_I + R_{miller}) // [Z_{in_{dev}} \left(1 + \Delta vol \left(\frac{R_I}{R_I + R_F}\right)\right)]$$

$$\bullet \quad R_{miller} = \frac{R_F}{1 + \Delta vol}$$

$$Z_{out \text{ Inverting Op Amp}} = \frac{Z_{out_{dev}}}{(1 + \Delta vol \left(\frac{R_I}{R_I + R_F}\right))}$$

$$Z_{in \text{ Non-Inverting Op Amp}} = Z_{in_{dev}} \left(1 + \Delta vol \left(\frac{R_I}{R_I + R_F}\right)\right)$$

$$Z_{out \text{ Non-Inverting Op Amp}} = \frac{Z_{out_{dev}}}{(1 + \Delta vol \left(\frac{R_I}{R_I + R_F}\right))}$$

*2nd Order Active Filtering:*

- Low-Pass
  - $R_1 = R_2 \text{ \& } C_2 = 2C_1 \text{ \& } f_c = \frac{1}{2\pi\sqrt{R_1 \times R_2 \times C_1 \times C_2}}$
- High-Pass
  - $C_1 = C_2 \text{ \& } R_1 = 2R_2 \text{ \& } f_c = \frac{1}{2\pi\sqrt{R_1 \times R_2 \times C_1 \times C_2}}$
- $Q = \frac{f_R}{BW}$

*Switching Transistors:*

- $t_{on} = t_d + t_r \text{ \& } t_{off} = t_s + t_f$
- $t_{on} = 0.1RC_C$
- $C_C = \frac{t_{on}}{0.1R}$
- $t_{re} = 2.3(R \times C_C)$
- $f_{max_{CC}} = \frac{1}{2t_{re}}$

*555 timers (two diode circuit):*

$$\bullet \quad PW = -[(LN \left[\frac{V_{CC}-2.1}{2V_{CC}-2.1}\right])] \times (RA \times C), \quad PS = -[(LN \left[\frac{V_{CC}-2.1}{2V_{CC}-2.1}\right])] \times (RB \times C)$$