CMPE 1400 Formula Sheet

$$I = \frac{Q}{t}$$

$$G = \frac{1}{R}$$

$$V = IR$$

$$P = \frac{W}{t}$$

$$P = IV = \frac{V^2}{R} = I^2 R$$

$$\eta = \frac{P_{useful}}{P_{total}} \times 100\%$$

$$V_{R_1} = V_s \left(\frac{R_1}{R_1 + R_2} \right)$$

$$I_{R_1} = I_T \left(\frac{R_2}{R_1 + R_2} \right)$$

$$a(t) = A_o + A\sin(\omega t + \theta)$$

$$\omega = 2\pi f$$

$$A_{RMS(\sin)} = \frac{|A_p|}{\sqrt{2}}$$

$$C = \frac{\Delta Q}{\Delta V}$$

$$I = C\frac{\Delta V}{\Delta t}$$

$$i_C = C\frac{dV}{dt}$$

$$W = \frac{1}{2}CV^2$$

$$\tau = RC$$

$$V_L = L\frac{\Delta I}{\Delta t}$$

$$v_L = L\frac{dI}{dt}$$

$$W = \frac{1}{2}LI^2$$

$$\tau = \frac{L}{R}$$

$$a(t) = a_{final} - \left(a_{final} - a_{initial}\right)e^{-\frac{t}{\tau}}$$

$$\Delta P_{db} = 10\log\left(\frac{P_2}{P_1}\right)$$

$$\Delta P_{db} = 20\log\left(\frac{V_2}{V_1}\right)$$

$$f_c = \frac{1}{2\pi RC}$$

$$X_C = \frac{-j}{2\pi fC}$$

$$f_c = \frac{1}{2\pi \, L/R}$$

$$X_L = j2\pi fL$$

$$f_o = \frac{1}{2\pi\sqrt{LC}}$$

$$Q = \frac{f_o}{BW} = \frac{|X_L|}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$\frac{V_s}{V_p} = \frac{n_s}{n_p}$$

$$\frac{I_s}{I_p} = \frac{n_p}{n_s}$$

$$\frac{R_s}{R_p} = \left(\frac{n_s}{n_p}\right)^2$$

$$e_{\max} = 2n^2$$

$$r'_D = \frac{\Delta V}{\Delta I}$$

$$V_{DC(HWR)} = \frac{V_p}{\pi}$$

$$V_{RMS(HWR)} = \frac{|V_p|}{2}$$

$$V_{DC(FWR)} = \frac{2V_p}{\pi}$$

$$V_{RMS(FWR)} = \frac{|V_p|}{\sqrt{2}}$$

$$V_{r(p-p)} = \frac{I_L T}{C}$$

$$V_{DC(fil)} = V_P - \frac{V_{r(p-p)}}{2}$$

$$V_{r(p-p)} \approx \frac{V_p T}{R_L C}$$

$$1.25 = V_{out}\frac{R_1}{R_1 + R_2}$$

$$RR = 20\log\left(\frac{V_{r(in)}}{V_{r(out)}}\right)$$

$$I_E = I_C + I_B$$

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

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

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

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

$$A_v = \frac{v_{out}}{v_{in}}$$

$$A_{vo} = \frac{v_{oc}}{v_{in}}$$

$$r_{in} = R_S \frac{v_{in}}{(v_s - v_{in})}$$

$$r_{out} = R_L \frac{(v_{oc} - v_o)}{v_o}$$

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_{GSoff}}\right)^2$$

$$A_v = A_{vo}\left(\frac{R_L}{r_{out} + R_L}\right)$$

For properly designed amplifiers only:

$$V_E = \frac{V_{CC}}{10}$$

$$V_{CE} = \frac{V_{CC}}{2}$$

$$R_{B2} = 10R_E$$

$$R_{E1} \ge \left|\frac{R_C}{2V_{CC}}\right|$$

$$A_{vo} \approx -\frac{R_C}{R_{E1}}$$

$$r_{in} \approx (\beta R_{E1}) \parallel R_{B1} \parallel R_{B2}$$

$$r_{out} = R_C$$

$$V_E = \frac{V_{CC}}{2}$$

$$R_{B2} = 10R_E$$

$$A_{vo} \approx +1$$

$$r_{in} \approx R_{B1} \parallel R_{B2}$$

$$r_{out} \approx \left|\frac{R_E}{20V_{CC}}\right|$$

$$A_{vCS} = \frac{v_{oCS}}{v_{iCS}}$$

$$A_{vDS} = \frac{v_{oDS}}{(v_{i2} - v_{i1})}$$

$$CMRR_{dB} = 20\log\left(\frac{A_{vDS}}{A_{vCS}}\right)$$

$$A_v = -\frac{R_f}{R_i}$$

$$A_v = \frac{R_f}{R_i} + 1$$

$$\beta = \frac{R_i}{R_f + R_i}$$

$$A_v = \frac{A_{vol}}{1 + A_{vol}\beta}$$

$$r_{in} = (1 + A_{vol}\beta) r_{id}$$

$$r_{out} = \frac{r_o}{1 + A_{vol}\beta}$$

$$A_v = 1 - \frac{A_{vol}}{1 + A_{vol}\beta}$$

$$r_{in} = R_i \parallel [(1 + A_{vol}\beta) r_{id}]$$

$$BW = \frac{GBP}{A_v}$$

$$BW_{circuit} = BW_{stage}\sqrt{2^{\frac{1}{n}} - 1}$$

$$f_{PBW} = \frac{SR}{2\pi V_p}$$

$$V_{out} = -R_f\left(\frac{V_{in1}}{R_{i1}} + \frac{V_{in2}}{R_{i2}} + \frac{V_{in3}}{R_{i3}} + \ldots\right)$$

$$V_{step} = \frac{V_{range}}{2^n - 1}$$

$$V_{step} = \frac{V_{ref}}{2^n}$$

$$V_{out}(t) = \frac{1}{R_i C}\int_0^t v_i(t)\,dt$$

$$v_{out} = R_f C \frac{dV_{in}}{dt}$$

$$f_c = \frac{1}{2\pi R_f C}$$

$$f_c = \frac{1}{2\pi R_i C}$$

$$A_v = 3 - 2\zeta$$

$$f_c = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$$

$$f_c = \frac{1}{2\pi RC}$$

$$v_o = \frac{R_f}{R_i}(V_{in+} - V_{in-})$$

$$A_v = \frac{2R}{R_G} + 1$$

$$v_o = A_v(V_{in+} - V_{in-}) + V_{off}$$

n	Normalized Butterworth Polynomial	Stage Gains
1	$s+1$	(x)
2	$s^2 + 1.414s + 1$	(1.586)
3	$(s+1)(s^2 + s + 1)$	(x)(2.000)
4	$(s^2 + 0.765s + 1)(s^2 + 1.848s + 1)$	(2.235)(1.152)
5	$(s+1)(s^2 + 0.618s + 1)(s^2 + 1.618s + 1)$	(x)(2.382)(1.382)
6	$(s^2 + 0.518s + 1)(s^2 + 1.414s + 1)(s^2 + 1.932s + 1)$	(2.482)(1.586)(1.068)

Typical Component Values

Typical Component Values		
5%	10%	20%
10	10	10
11		
12	12	
13		
15	15	15
16		
18	18	
20		
22	22	22
24		
27	27	
30		
33	33	33
36		
39	39	
43		
47	47	47
51		
56	56	
62		
68	68	68
75		
82	82	
91		

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