EE6471: TABLE OF EQUATIONS AND CONSTANTS

Constants: $\varepsilon_0 = 8.85 \cdot 10^{-12}$ As/Vm $\mu_0 = 4\pi \cdot 10^{-7}$ Vs/Am $k = 1.38 \cdot 10^{-23}$ J/K
$e = -1.60 \cdot 10^{-19}$ C

1.	$Z_c = \frac{1}{j \cdot \omega \cdot C} = X_c \cdot e^{-j\frac{\pi}{2}}$ $\quad i_c = C \cdot \frac{dv_c}{dt}$	Complex impedance of a capacitor. Current through a capacitor.
2.	$Z_L = j \cdot \omega \cdot L = X_L \cdot e^{j\frac{\pi}{2}}$ $\quad v_L = L \cdot \frac{di_L}{dt}$	Complex impedance of an inductor. Voltage across an inductor.
3.	$T(j \cdot \omega) = \frac{1}{1 + \left(\frac{2d}{2\pi \cdot f_n}\right) j \cdot \omega + \left(\frac{j \cdot \omega}{2\pi \cdot f_n}\right)^2}$	Second order transfer function in normal form.
4.	$T(j \cdot \omega) = \frac{1}{1 + j \cdot \omega \cdot RC + (j \cdot \omega)^2 LC}$ $Z_0 = \sqrt{\frac{L}{C}}$ $\quad d = \frac{R}{2 \cdot Z_0}$ $\quad Q = \frac{1}{2d}$	RLC low-pass filter. Transfer function. Characteristic impedance. Damping ratio.
5.	$f_n = \frac{1}{2\pi \cdot \sqrt{LC}}$ $\quad f_r = f_n \sqrt{1 - d^2}$ for $d < 1$	RLC low-pass filter. Resonant frequency of undamped and damped system.
6.	$\delta = d \cdot \omega_n = \frac{R}{2L}$ $\quad V_{overshoot} = V_{step} \cdot e^{\frac{-\pi}{\sqrt{\frac{1}{d^2} - 1}}}$	RLC low-pass filter. Decay constant. Estimation of overshoot.
7.	$Tr_{composite} = \sqrt{\sum_{i=1}^{n} Tr_i^{\,2}}$ $\quad f_{3dB} = \frac{K}{Tr_{10\%-90\%}}$	Composite rise time of a linear system. Knee frequency of a signal. K≈0.35 for common pulse shapes.
8.	$T_r = RC \cdot \left(\ln\left(\frac{100\%}{10\%}\right) - \ln\left(\frac{100\%}{90\%}\right)\right) \approx 2.2RC$ $T_r \approx 3.4\tau = 3.4\sqrt{LC}$	Rise time (10%-90%) of an RC low-pass filter, and a critically damped RLC low-pass filter.
9.	$f(t) = \frac{A}{2} + \sum_{n=1,3,5\ldots}^{\infty} \frac{2A}{\pi} \cdot \frac{1}{n} \left[\sin(2\pi \cdot f_0 \cdot n \cdot t)\right]$	Fourier series of a square wave signal with a duty cycle of 50%.
10.	$Crosstalk = \frac{R \cdot i_{mutual}}{\Delta Va} = \frac{R \cdot C_{mutual}}{Tr}$	Capacitive crosstalk
11.	$Crosstalk = \frac{L_{mutual}}{R \cdot Tr}$	Inductive crosstalk

12.	$E_R = \frac{1}{2} C \cdot (V_{end} - V_{start})^2 = \frac{1}{2} C \cdot \Delta V^2$	Heat energy per cycle in charge and discharge resistor each
13.	$P_{internal} = P_{static} + C_{PD} \cdot Vcc^2 \cdot f_{cycle}$	Internal power dissipation of an integrated circuit
14.	$P_{driver_{dyn}} = C_{load} \cdot Vcc^2 \cdot f_{cycle}$	Dynamic driver power dissipation of an integrated circuit
15.	$T_J = T_{amb} + P_{diss} \cdot (Rth_{JC} + Rth_{CAmb})$	Junction temperature of an IC
16.	$L_{rect} \approx 400 \frac{nH}{meter} \cdot \left(x \cdot \ln\left(\frac{2y}{d}\right) + y \cdot \ln\left(\frac{2x}{d}\right)\right)$	Self inductance of a rectangular loop. Dimensions of rectangle x*y. Wire diameter d.
17.	$L_{circ} \approx 614 \frac{nH}{meter} \cdot x \cdot \left(\ln\left(\frac{8x}{d}\right) - 2\right)$	Self inductance of a circular loop. Circle diameter x. Wire diameter d.
18.	$L_{mutual} \approx 200 \frac{nH}{meter} \cdot \frac{A_1 \cdot A_2}{d^3}$	Mutual inductance between two loops.
19.	$L_{mutual} \approx L_{individual} \cdot \frac{1}{1 + \left(d/h\right)^2}$	Mutual inductance between two transmission lines.
20.	$C_{rwire\ pul} \approx 55.6 \, pF/meter \cdot \left(\ln\left(\frac{4h}{d}\right)\right)^{-1}$ $L_{rwire\ pul} \approx 200 \frac{nH}{meter} \cdot \ln\left(\frac{4h}{d}\right)$	Capacitance and inductance of a suspended round wire above a ground plane
21.	$l_r = Tr \cdot v_p$	Effective length of rising edge
22.	$Z_0 = \sqrt{\frac{R + pL}{G + pC}}$	Characteristic impedance of a transmission line.
23.	$A = \sqrt{(G + pC)(R + pL)}$	Propagation constant of a transmission line
24.	$H_x(p) = e^{-A \cdot x}$	Voltage transfer function of an infinite transmission line
25.	$T_{p\ pul} = \sqrt{LC}$	Propagation delay of an LC transmission line
26.	$T_d \approx 0.4 x^2 RC$ $\quad T_r \approx x^2 RC$	Estimation of time delay and rise time for an RC transmission line.
27.	$A = \sqrt{pC(R + pL)} \xrightarrow{p << \frac{R}{L}} A \approx \sqrt{pRC}$	Estimation of the propagation constant for an RLC transmission line in the RC

		region (p<<R/L)
28.	$A = p\sqrt{LC}\sqrt{1+\frac{R}{pL}} \xrightarrow{Taylor} A \approx p\sqrt{LC}\left(1+\frac{R}{2pL}\right)$	Estimation of the propagation constant for an RLC transmission line in the LC region (p>>R/L)
29.	$TL_{IA}(p) = \frac{Z_0(p)}{Z_S(p)+Z_0(p)}$	Transmission line input acceptance function.
30.	$TL_{RS}(p) = \frac{Z_S(p)-Z_0(p)}{Z_S(p)+Z_0(p)}$ $TL_{RL}(p) = \frac{Z_L(p)-Z_0(p)}{Z_L(p)+Z_0(p)}$	Transmission line source-end and load-end reflection function.
31.	$S_\infty(p) = \frac{TL_{IA}(p)\cdot H_x(p)\cdot(1+TL_{RL}(p))}{1-TL_{RL}(p)\cdot TL_{RS}(p)\cdot H_x(p)^2}$	Voltage transfer function for a finite-length transmission line
32.	$\delta = \sqrt{\frac{\rho}{\pi\cdot f\cdot\mu}}$	Skin depth
33.	$f_s = \frac{\rho}{\pi\mu r^2}$	Skin effect frequency
34.	$R_{hf\ pul} = \frac{1}{2r}\sqrt{\frac{f\mu\rho}{\pi}}$	High frequency resistance of a round conductor due to skin effect
35.	$R_{pul} \approx \sqrt{R_{dc\ pul}{}^2 + R_{hf\ pul}{}^2}$	Effective resistance of a conductor per unit length
36.	$Z_0 \approx \frac{87\Omega}{\sqrt{\varepsilon_r+1.41}}\ln\left(\frac{5.98h}{0.8w+d}\right)$	Characteristic impedance of a microstrip transmission line
37.	$T_{p\ pul} \approx 3.35\frac{ns}{meter}\sqrt{0.475\varepsilon_r+0.67}$	Propagation delay (per unit length) of a microstrip transmission line
38.	$Z_0 \approx \frac{60\Omega}{\sqrt{\varepsilon_r}}\ln\left(\frac{1.9b}{0.8w+d}\right)$	Characteristic impedance of a stripline transmission line
39.	$T_{p\ pul} \approx 3.35\frac{ns}{meter}\sqrt{\varepsilon_r}$	Propagation delay (per unit length) of a stripline transmission line
40.	$R = R_{sheet}\frac{L}{W}$	Resistance of a uniform slab