Electronics Cheat Sheet

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Revision 2

Miscellaneous

Time Constants

For capacitors $V_C = V_s\left[1 - e^{-\frac{t}{RC}}\right]$

$V_R = V_s e^{-\frac{t}{RC}}$

And for inductors $V_R = V_s\left[1 - e^{-\frac{tR}{L}}\right]$

$V_L = V_s e^{-\frac{tR}{L}}$

Thévenin

Solve circuit for voltage across port ($V_A - V_B$), solve for equivalent resistance by replacing batteries with wires and current sources with opens and trace a current path from A to B. Put the voltage source in **series** with the equivalent resistor.

Norton

Short the port and find the current through the port short. Find resistance using the same method as Thévenin. Put the current source in **parallel** (across the port) with the equivalent resistor.

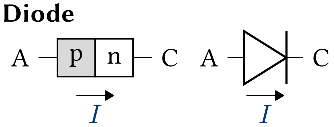
Differentials

$V_R = IR = R\frac{dQ}{dt}$

$V_L = L\frac{dI}{dt} = L\frac{d^2Q}{dt^2}$

$V_C = \frac{Q}{C}$

Diode



SCR

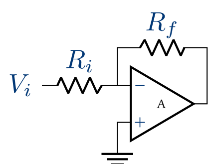
SCRs act like normal diodes when off and do not conduct when reverse biased. When forward biased the device has two states, one where there is a very high resistance and therefore little current and another where there is very little reistance in which the SCR acts like a conventional diode. An SCR is switched from the above "off" state to an "on" state by applying a gate voltage $V_G > V_{trig}$ and only drops back to the off state when $V_G < V_{trig}$ **and** the current drops below some known holding current (very small)

Triac

The triac is kind of like an SCR for both parts of an AC wave. It is triggered with $|V_G| > V_{trig}$ and stays on until the voltage drops and $I_{through} < |V_{hold}|$

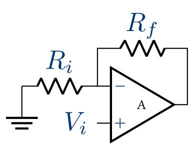
Op-Amps

Inverting Amplifier



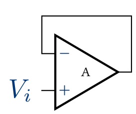
$V_o = -\frac{R_f}{R_i}V_i$

Non-Inverting Amplifier



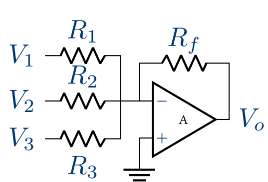
$V_o = \left(1 + \frac{R_f}{R_i}\right)V_i$

Voltage Follower



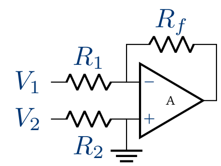
$V_o = V_i$

(Inverting) Adder



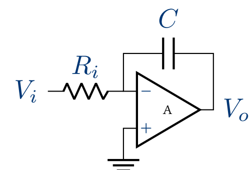
$V_o = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)$

Subtractor



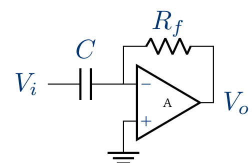
$V_o = \frac{R_f}{R_i}(V_2 - V_1)$

Integrator



$V_o = -\frac{1}{R_iC}\int_0^t V_i\,dt + V_o(t=0)$

Differentiator



$V_o = -RC\frac{dV_i}{dt}$

Transistors

$\beta = \frac{I_C}{I_B} \implies I_C = \beta I_B \implies I_E = (\beta + 1)I_B$

V	NPN	PNP
$E < B < C$	$Active$	$Reverse$
$E < B > C$	$Saturation$	$Cutoff$
$E > B < C$	$Cutoff$	$Saturation$
$E > B > C$	$Reverse$	$Active$

Logic

$\cdot \implies AND$

$+ \implies OR$

$\oplus \implies XOR$ (either !both)

$A + (AB) = A,\ A(A+B) = A$

$\overline{(A+A)} = \overline{(AA)} = \overline{A}$

$\overline{(A+B)} = \overline{A}\cdot\overline{B}$

$\overline{(AB)} = \overline{A} + \overline{B}$

Binary

$1011_2 = 1\cdot 2^3 + 0\cdot 2^2 + 1\cdot 2^1 + 1\cdot 2^0$ (note: leading digit read first), decimals are just done with negative powers of 2

$11_{10} \to x_2$ is done by repeatedly dividing by 2 and taking note of the remainders, then reading them backwards

$11/2 = 5R1 \to 5/2 = 2R1 \to 2/2 = 1R0 \to 1/2 = 0R1 \implies 1011$

$0.34_{10} \to x_2$ here you multiply by two repeatedly, taking note of when you roll over to $1.n$, then reading the result forwards. If the number you are trying to convert when expressed as a fraction does not have a denominator of 2^n then the number cannot fully be represented, so stop at some point.

$0.34\cdot 2 = 0 + 0.68 \to 0.68\cdot 2 = 1 + 0.36 \to 0.36\cdot 2 = 0 + 0.72 \to 0.72\cdot 2 = 1 + 0.44 \implies 0.34_{10} \approx 0.0101$

Complex Numbers and AC circuits

$a + bj$ can be represented as $\sqrt{a^2+b^2}e^{j\arctan\frac{b}{a}}$

Given two signals their phase difference is $\arctan\left[\frac{\Im\left[\frac{\widetilde{V}_2}{\widetilde{V}_1}\right]}{\Re\left[\frac{\widetilde{V}_2}{\widetilde{V}_1}\right]}\right]$

$\widetilde{Z}_R = R$, $\widetilde{Z}_C = \frac{1}{j\omega C}$, $\widetilde{Z}_L = j\omega L$

$\langle P\rangle = \frac{1}{2}\Re\left[\widetilde{V}^*(t)\widetilde{I}(t)\right] = \frac{1}{2}\Re\left[\widetilde{V}(t)\widetilde{I}^*(t)\right] = \frac{1}{2}\widetilde{I}^*(t)\widetilde{I}(t)\Re\left[\widetilde{Z}\right] = \frac{1}{2}\frac{\widetilde{V}^*(t)\widetilde{V}(t)}{\Re\left[\widetilde{Z}\right]}$

Impedance adds like resistance

Power gain in dB is $10\log_{10}\left|\frac{P_{out}}{P_{in}}\right|$ and in voltage $20\log_{10}\left|\frac{V_{out}}{V_{in}}\right|$

Cutoff is when $\left|\frac{V_{out}}{V_{in}}\right| = \frac{1}{\sqrt{2}}$

Transducers

Thermocouples operate with "hot" (measured) and "cold" (reference) junctions. The measured voltage of a thermocouple is given by $V_{meas} = V_{hot} - V_{cold}$