UNITS – coul is electric charge, current is time rate of charge, volts are change of joules in terms of charge, 1 J = 1nm, 1J/C

Power rate of change of energy in time, P = VI, P = I^2R, p = v^2 / r power is positive when consumed and negative when supplied, all power absorbed – all power supplied = 0 (Tellegen's theorem), V = IR, voltage across resistive element = resistance times current flowing through resistive element.

CIRCUIT LAWS – Series and parallel resistors, everything is like them except inductors which are opposite. Voltage division is total voltage times resistance/impedance part over whole = part voltage, current division is total current times "total"(in parallel) resistance/impedance over part = part current. KCL all currents entering into node sum to zero, KVL all voltages around a circuit sum to zero.

CIRCUIT ANALYSIS METHODS A – nodal – identify and mark down every node, sum up all voltages entering into each node, and if enough info is known you can rref solve for the voltages. Must include all currents no matter what combination of nodes

Mesh – identify and mark down every loop, go around every loop summing up the voltages around the loop and rref solve for currents. Must include all voltage sources no matter what combination of loops.

Super Node/Super Mesh - ********* super nodes there is either a dependent of independent source in between two nodes, this relationship is evaluated and nodal analysis is performed as normal but the equation is factored back in at the end. Super meshes can be formed when two meshes share an independent or dependent source between them and the outer loop is evaluated. Current sources for meshes, and voltage sources for nodal

CIRCUIT ANALYSIS METHODS B – Superposition -

Only consider one source (open currents, short voltages), evaluate what is being solved for at that point, and now evaluate for all the other sources, at the end, add these values up to find the result

Source transforms – Source transforms, current source with impedance/resistance in parallel multiply the two together to get a voltage source with the impedance in series, voltage source with an impedance/resistance in series, divide out voltage source by impedance/resistance value to get current to then be placed in parallel with resistance/impedance.

Thevenin and Norton - (NOT ON TEST DIRECTLY), max power transfer on load, load equals Thevenin, pmax = Vth^2 / (4Rth) = Vth^2 / (4Rl)

INDUCTANCE AND CAPACITANCE – Inductor – v = Ldi/dt, p = Lidv/dt (watts), W = (½)(Li^2) (joules), inductors are added in the same way as resistors

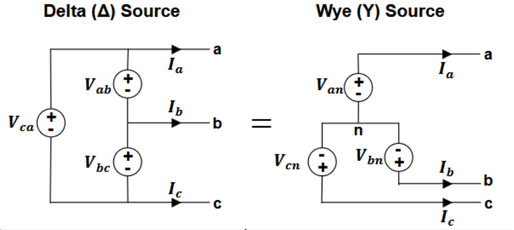
Capacitor – i = Cdv/dt, p = Cvdv/dt (watts), w = (1/2)(Cv^2) (joules), capacitors are added in an opposite way.

AC CIRCUIT ANALYSIS – Phasor transform – resistors stay as resistors, but inductors are now jwL and capacitors are (1/jwC), V = ZI, Z = R + jX (resistance reactance), impedances are treated in the same way as resistors.

PROCEDURE – 1. transform to phasor form for all sources and convert elements into impedances for all circuit elements. 2. Draw out the frequency domain. 3. Find frequency domain quantity which is being solved for. 4. Convert back to time domain

POLYPHASE – line impedance and load impedance, think y-y, Vl = sqrt3 Vp, phase Vab = phase (Van+30degrees) you can just add and subtract back and forth. Zy = 1/3 Zdelta, Il = sqrt3 Idelta

Delta (Δ) Source **Wye (Y) Source**



Delta (Δ) Source	Wye (Y) Source
$V_{ab} = V_L\angle 0°$	$V_{an} = \frac{V_L}{\sqrt{3}}\angle(-30°) = V_p\angle(-30°)$
$V_{bc} = V_L\angle(-120°)$	$V_{bn} = \frac{V_L}{\sqrt{3}}\angle(-150°) = V_p\angle(-150°)$
$V_{ca} = V_L\angle(+120°)$	$V_{cn} = \frac{V_L}{\sqrt{3}}\angle(-270°) = V_p\angle(+90°)$

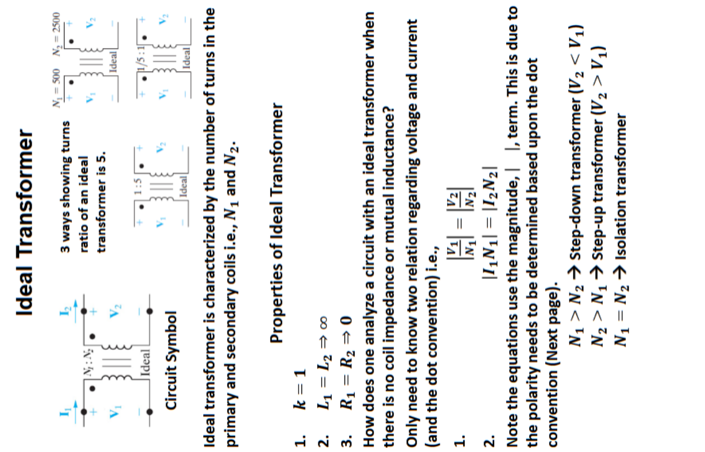
For Y, $V_L = \sqrt{3}V_p\angle(\emptyset + 30°)$ $\boxed{Z_y = \frac{1}{3}Z_\Delta}$ $\boxed{I_L = \sqrt{3}I_\Delta}$,

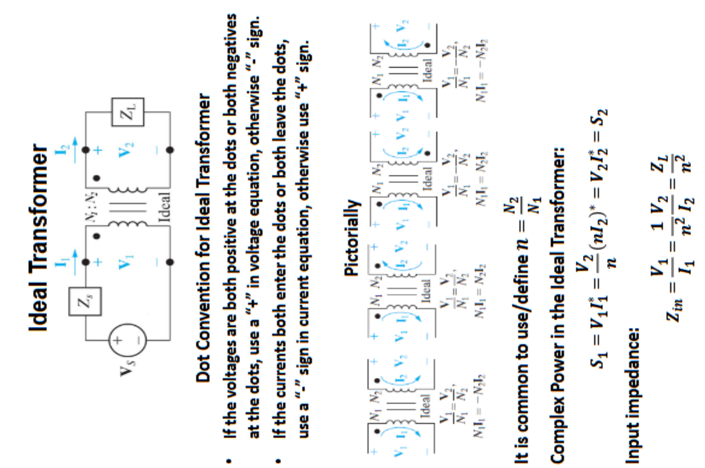
how is rms dealt with by polyphase11

with y-y, each phase is 120 degrees out of phase with one another and are all in relation to a neutral line

IDEAL TRANSFORMER – KVL is the preferred method to analyze transformers

V1/N1 = V2/N2, V2 = V1n, n =N2/N1, in the one dot and out of the other instant power must always balance. Polarity (+) = dot





LAPLACE TRANSFORM –

Properties of the Laplace Transform

Property	f(t)	F(s)
Linearity	$a_1f_1(t) + a_2f_2(t)$	$a_1F_1(s) + a_2F_2(s)$
Scaling	$f(at)$	$\frac{1}{a}F\left(\frac{s}{a}\right)$
Time Shift	$f(t-a)u(t-a)$	$e^{-as}F(s)$
Frequency Shift	$e^{-at}f(t)$	$F(s+a)$

Some Common Laplace Transform Pairs*

f(t)	F(s)
$\delta(t)$	1
$u(t)$	$\frac{1}{s}$
e^{-at}	$\frac{1}{s+a}$

Denominator can be factored into a combination of the 4 following factors: D(s)

Partial Fraction Expansion Factors

Root type	F(s)	f(t)
Distinct Real	$\frac{K}{s+a}$	$Ke^{-at}u(t)$
Repeated Real	$\frac{K}{(s+a)^2}$	$Kte^{-at}u(t)$

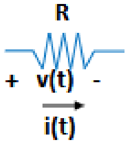
Example

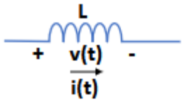
$$\therefore F(s) = \frac{s+6}{s(s+3)(s+1)^2} = \frac{2}{s} + \frac{-\frac{1}{4}}{(s+3)} + \frac{-\frac{5}{2}}{(s+1)^2} + \frac{-\frac{7}{4}}{(s+1)}$$

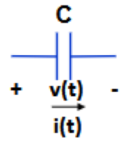
Inverse Laplace Transform each term:

$$\therefore f(t) = (2 - 0.25e^{-3t} - 2.5te^{-t} - 1.75e^{-t})u(t)$$

Time Domain







$v(t) = i(t)R$

$v(t) = L\frac{di(t)}{dt}$

$i(t) = \frac{1}{L}\int_{0^-}^{t} v(\tau)d\tau + I_0$

$v(t) = \frac{1}{C}\int_{0^-}^{t} i(\tau)d\tau + V_0$

$i(t) = C\frac{dv(t)}{dt}$

PASSIVE FILTERS – (most likely LP or HP),

LP – low pass series RL vs RC, inductor first, resistor first

Transfer Function for Low Pass Filters

$$H(s) = \frac{\omega_c}{s + \omega_c}$$

ω_c, Cutoff frequency

$$\omega_c = \frac{R}{L} \qquad \omega_c = \frac{1}{RC}$$

HP – transfer function for high pass filters resistor first, capacitor first

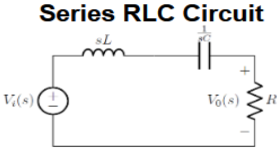
Transfer Function for High Pass Filters

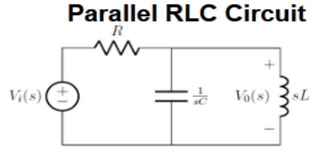
$$H(s) = \frac{s}{s + \omega_c}$$

Same cutoff frequencies

Passive Filters
Bandpass Filters: Summary

Series RLC Circuit | **Parallel RLC Circuit**





$$H(s) = \frac{\left(\frac{R}{L}\right)s}{s^2+\left(\frac{R}{L}\right)s+\left(\frac{1}{LC}\right)} \qquad H(s) = \frac{\left(\frac{1}{RC}\right)s}{s^2+\left(\frac{1}{RC}\right)s+\left(\frac{1}{LC}\right)}$$

Transfer Function for Bandpass Filters

$$H(s) = \frac{\beta s}{s^2+\beta s+\omega_0^2}$$

ω_0, Center Frequency

$$\omega_0 = \sqrt{\omega_{c1}\omega_{c2}} = \sqrt{\frac{1}{LC}} \qquad \omega_0 = \sqrt{\omega_{c1}\omega_{c2}} = \sqrt{\frac{1}{LC}}$$

β, Bandwidth

$$\beta = \omega_{c2} - \omega_{c1} = \frac{R}{L} \qquad \beta = \omega_{c2} - \omega_{c1} = \frac{1}{RC}$$

Q, Quality Factor

$$Q = \frac{\omega_0}{\beta} = \sqrt{\frac{L}{R^2C}} \qquad Q = \frac{\omega_0}{\beta} = \sqrt{\frac{R^2C}{L}}$$

ω_{c1}, ω_{c2}, Cutoff Frequencies

$$\omega_{c1} = -\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}} \qquad \omega_{c1} = -\frac{1}{2RC} + \sqrt{\left(\frac{1}{2RC}\right)^2 + \frac{1}{LC}}$$

$$\omega_{c2} = \frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}} \qquad \omega_{c2} = \frac{1}{2RC} + \sqrt{\left(\frac{1}{2RC}\right)^2 + \frac{1}{LC}}$$

BP –

ω_{c1}, ω_{c2}, Cutoff Frequencies, Equivalent Expressions

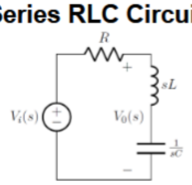
$$\omega_{c1} = -\frac{\beta}{2} + \sqrt{\left(\frac{\beta}{2}\right)^2 + \omega_0^2} \qquad \omega_{c1} = \omega_0\left[-\frac{1}{2Q} + \sqrt{1 + \left(\frac{1}{2Q}\right)^2}\right]$$

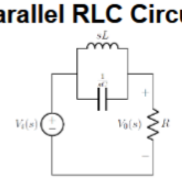
$$\omega_{c2} = \frac{\beta}{2} + \sqrt{\left(\frac{\beta}{2}\right)^2 + \omega_0^2} \qquad \omega_{c2} = \omega_0\left[\frac{1}{2Q} + \sqrt{1 + \left(\frac{1}{2Q}\right)^2}\right]$$

BR -

Passive Filters
Bandreject Filters: Summary

Series RLC Circuit | **Parallel RLC Circuit**





$$H(s) = \frac{s^2+\left(\frac{1}{LC}\right)}{s^2+\left(\frac{R}{L}\right)s+\left(\frac{1}{LC}\right)} \qquad H(s) = \frac{s^2+\left(\frac{1}{LC}\right)}{s^2+\left(\frac{1}{RC}\right)s+\left(\frac{1}{LC}\right)}$$

Transfer Function for Band Reject Filters

$$H(s) = \frac{s^2+\omega_0^2}{s^2+\beta s+\omega_0^2}$$

The rest is the same

POLYPHASE
IDEAL TRANSFORMER
LAPLACE TRANSFORM
Probably PASSIVE FILTERS/LOOK AT FILTER DESIGN, probably not BP or BR, most likely HP or LP because inductors aren't on test