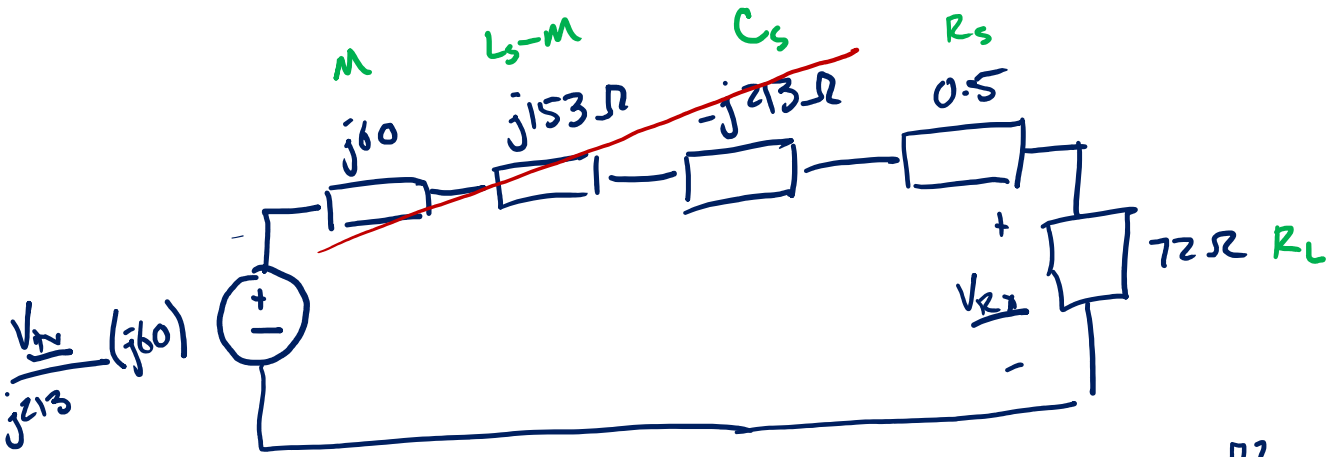


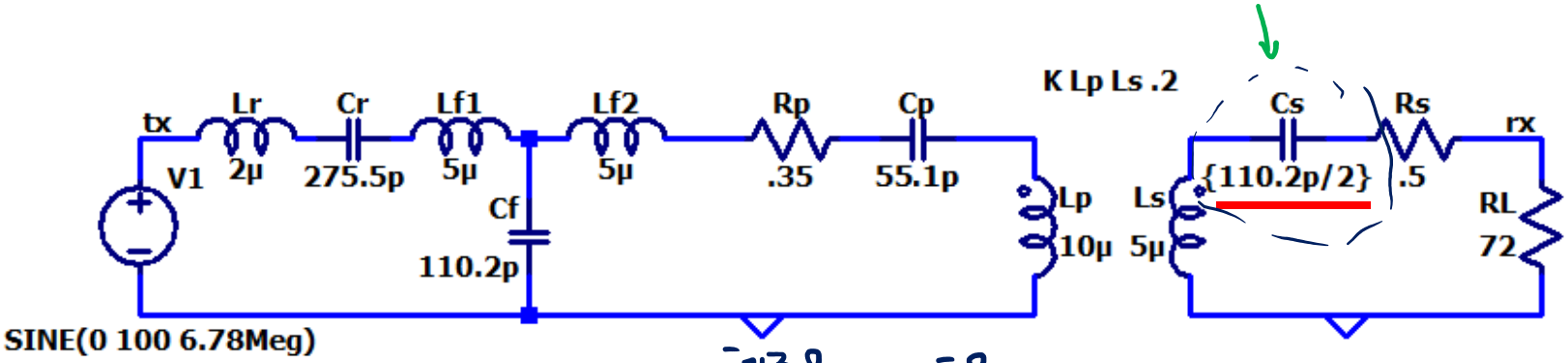
$$V_{RX} = \frac{V_{TX}}{\cancel{j}213}(\cancel{j}60)\,\frac{72}{72 + 0.5}$$

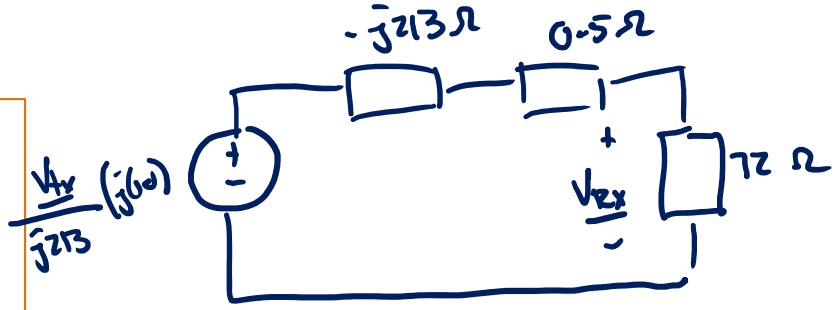
$$V_{RX} = 28 \angle -90^\circ$$

Numerical Example 2

$Z_{Cs} = \frac{1}{j\omega C_s} = -j426$

$(-j213\,\Omega + -j213\,\Omega)$





MATLAB Result:

mag =

9.06

phase =

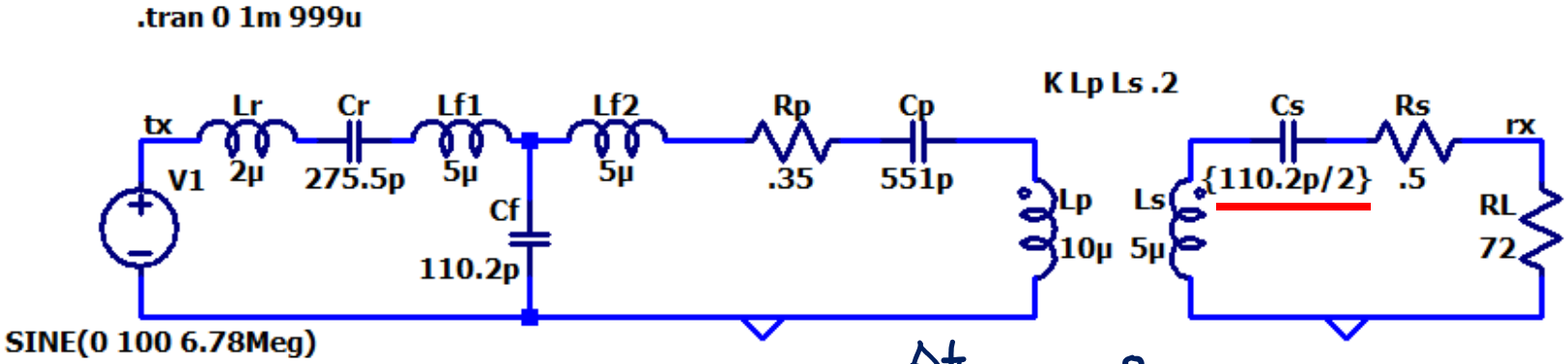
-18.7973

$$V_{Rx} = V_{tx}\,\frac{60}{213}\,\frac{72}{72 + 0.5 - j213}$$

$V_{tx} = 100\angle -90^\circ$

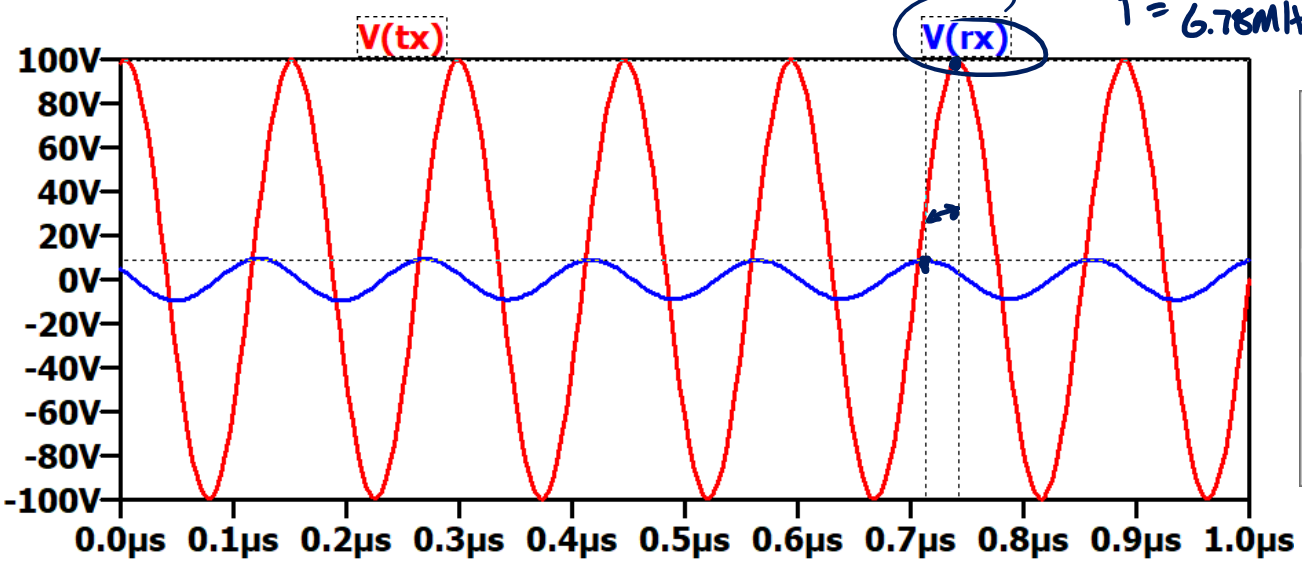
$$V_{Rx} = 9\angle -18^\circ$$

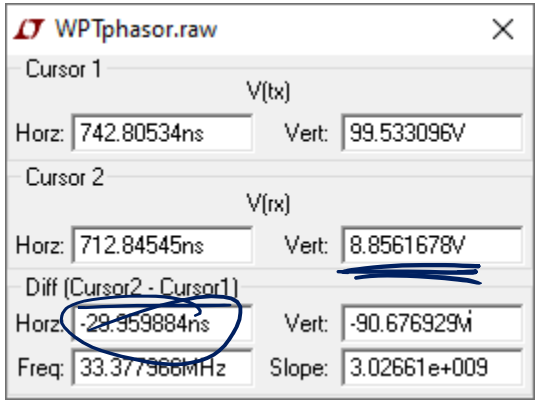
Circuit Simulation 2



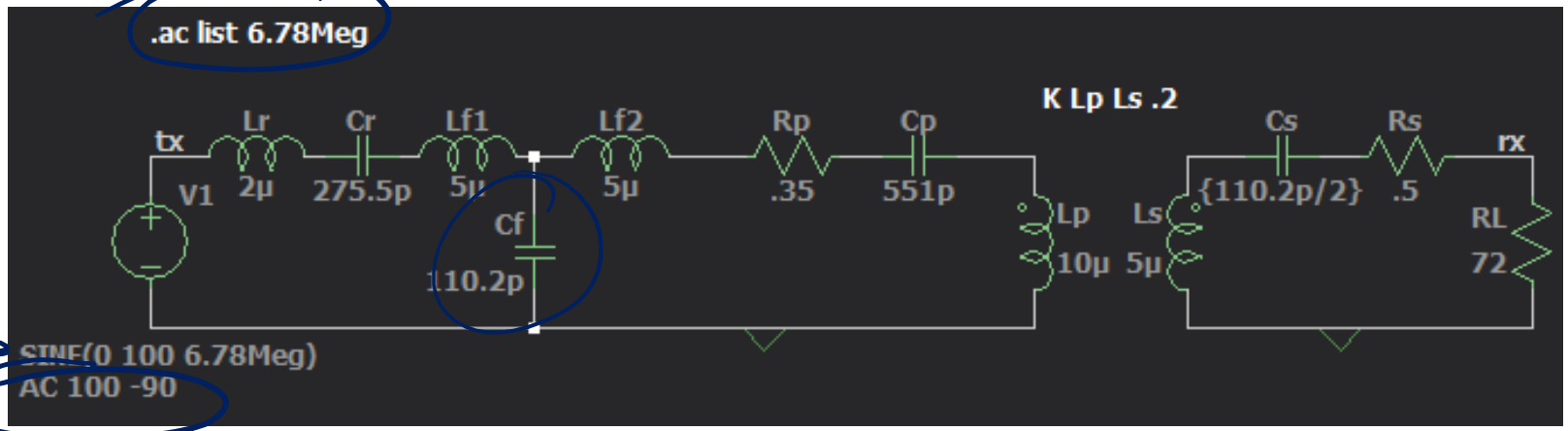
$$\varphi_{tx} - \varphi_{rx} = \frac{\Delta t}{T} \cdot 360^\circ$$

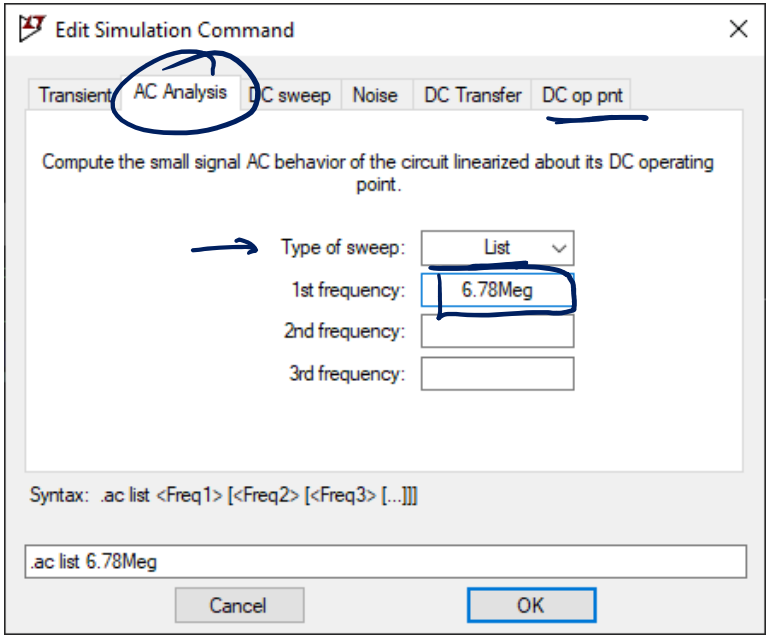
$$T = \frac{1}{6.78\text{MHz}}$$

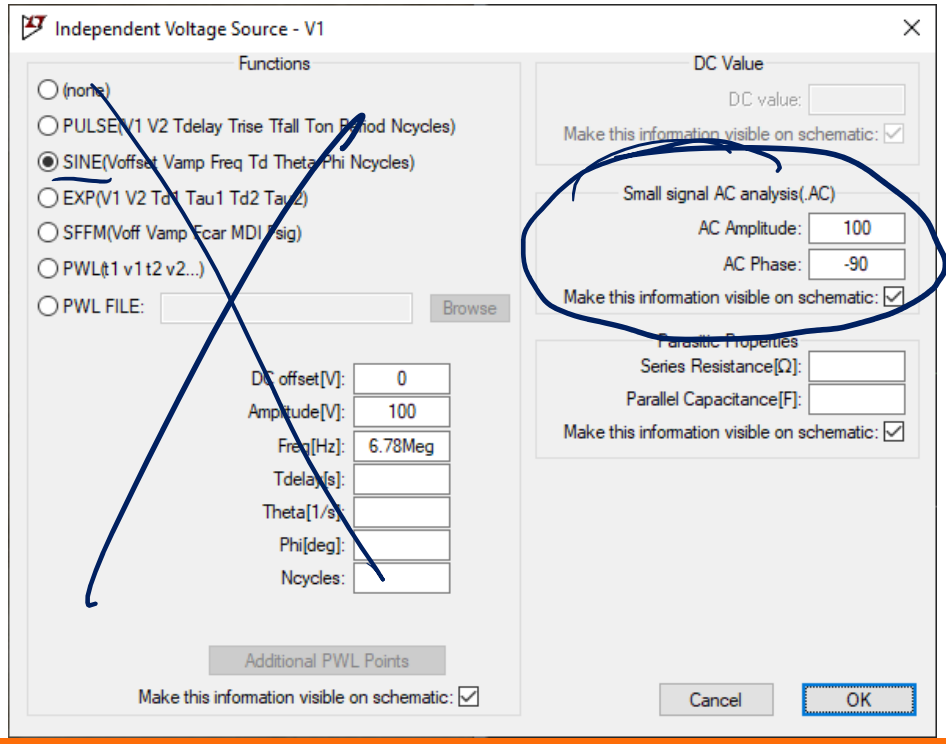




AC Analysis


.ac list 6.78Meg
K Lp Ls .2
tx
Lr
Cr
Lf1
Lf2
Rp
Cp
Cs
Rs
rx
V1
2µ
275.5p
5µ
5µ
.35
551p
Cf
110.2p
Lp
10µ
Ls
5µ
{110.2p/2}
.5
RL
72
SINE(0 100 6.78Meg)
AC 100 -90


Edit Simulation Command
Transient
AC Analysis
DC sweep
Noise
DC Transfer
DC op pnt
Compute the small signal AC behavior of the circuit linearized about its DC operating point.
Type of sweep: List
1st frequency: 6.78Meg
2nd frequency:
3rd frequency:
Syntax: .ac list <Freq1> [<Freq2> [<Freq3> [...]]]
.ac list 6.78Meg
Cancel
OK


Independent Voltage Source - V1
Functions
(none)
PULSE(V1 V2 Tdelay Trise Tfall Ton Period Ncycles)
SINE(Voffset Vamp Freq Td Theta Phi Ncycles)
EXP(V1 V2 Td1 Tau1 Td2 Tau2)
SFFM(Voff Vamp Fcar MDI fsig)
PWL(t1 v1 t2 v2...)
PWL FILE:
Browse
DC offset[V]: 0
Amplitude[V]: 100
Freq[Hz]: 6.78Meg
Tdelay[s]:
Theta[1/s]:
Phi[deg]:
Ncycles:
Additional PWL Points
Make this information visible on schematic:
DC Value
DC value:
Make this information visible on schematic:
Small signal AC analysis(.AC)
AC Amplitude: 100
AC Phase: -90
Make this information visible on schematic:
Parasitic Properties
Series Resistance[Ω]:
Parallel Capacitance[F]:
Make this information visible on schematic:
Cancel
OK

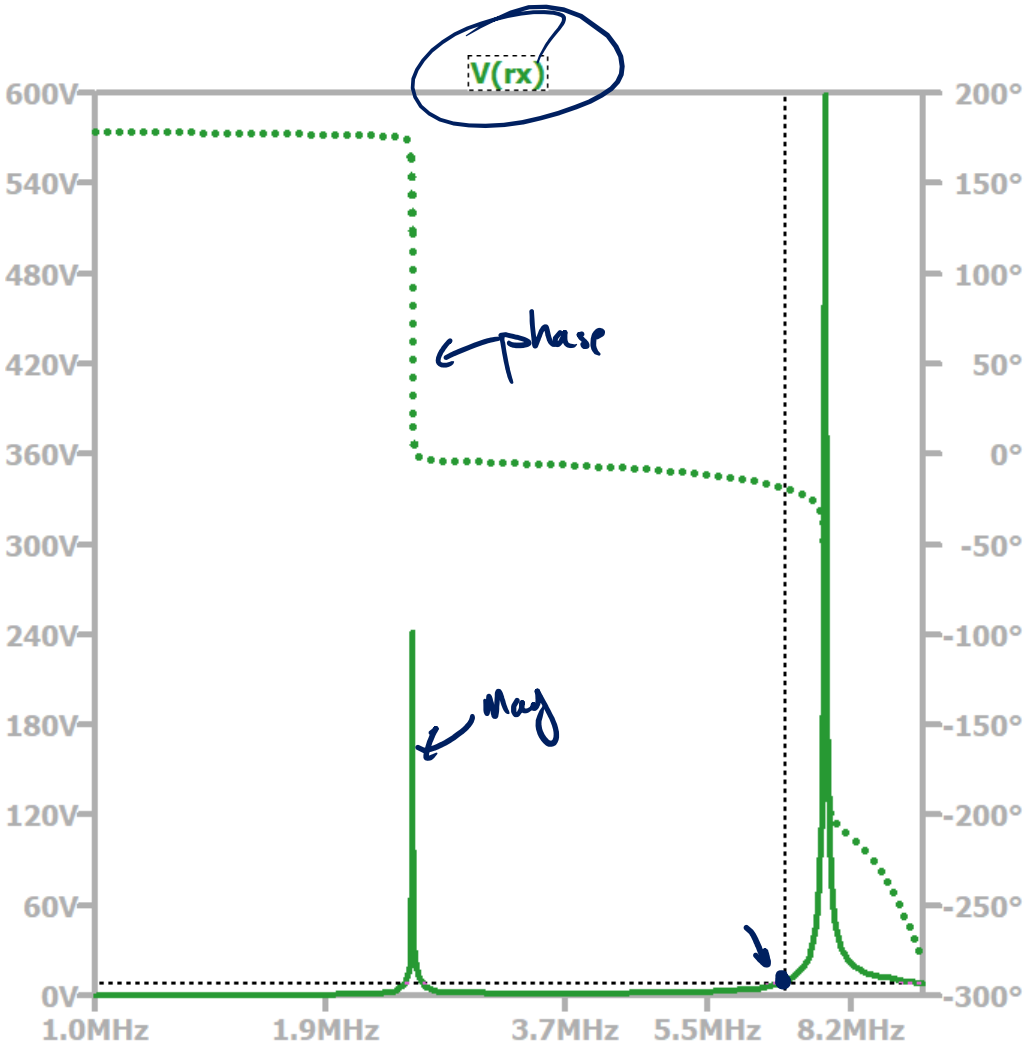
AC Simulation Results (Single Point)

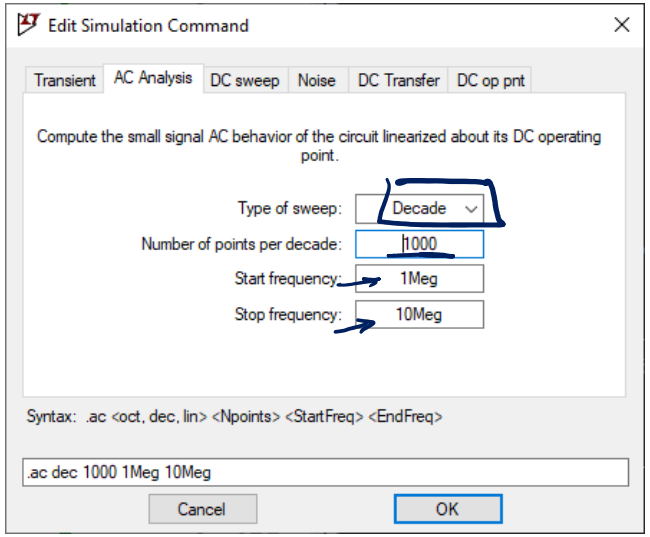
* C:\Users\dcostine\Dropbox\Courses\UTK Courses\ECE 202\In Class Examples\WPTExample-Phasors\WPT...

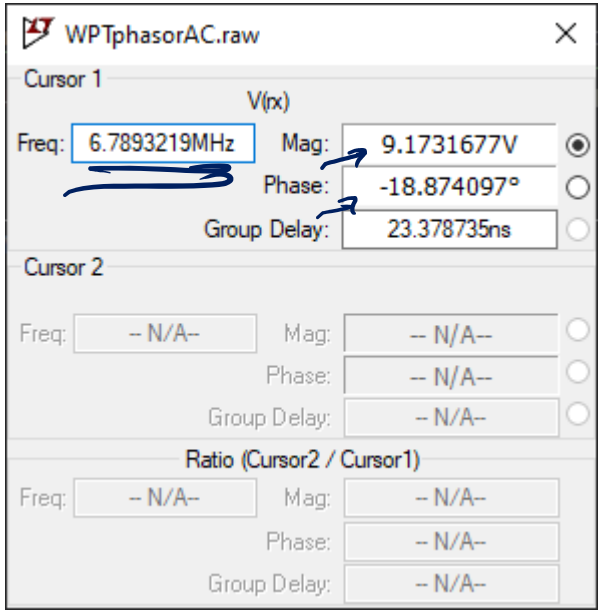
```
        --- AC Analysis ---

frequency:      6.78e+006      Hz
V(tx):          mag:        100 phase:        -90°          voltage
V(n001):        mag:    174.844 phase:   -90.3419°          voltage
V(n002):        mag:    99.9949 phase:   -90.0005°          voltage
V(n003):        mag:    287.109 phase:   -90.5205°          voltage
V(n004):        mag:     187.14 phase:    -90.798°          voltage
V(n006):        mag:    207.132 phase:   -90.6756°          voltage
V(n007):        mag:    54.3051 phase:    -99.138°          voltage
V(n005):        mag:    187.137 phase:   -90.7477°          voltage
V(n008):        mag:    9.11047 phase:   -18.7958°          voltage
V(rx):          mag:    9.04764 phase:   -18.7958°          voltage
I(Cs):          mag:   0.125662 phase:   -18.7958°          device_current
I(Cp):          mag:   0.469369 phase:    179.999°          device_current
I(Cf):          mag:    1.34784 phase:     179.48°          device_current
I(Cr):          mag:   0.878499 phase:    179.202°          device_current
I(Ls):          mag:   0.125662 phase:   -18.7958°          device_current
I(Lp):          mag:   0.469369 phase: -0.000865793°        device_current
I(Lf2):         mag:   0.469369 phase:    179.999°          device_current
I(Lf1):         mag:   0.878499 phase:  -0.798129°          device_current
I(Lr):          mag:   0.878499 phase:  -0.798129°          device_current
I(Rp):          mag:   0.469369 phase: -0.000865793°        device_current
I(Rl):          mag:   0.125662 phase:    161.204°          device_current
I(Rs):          mag:   0.125662 phase:    161.204°          device_current
I(V1):          mag:   0.878499 phase:    179.202°          device_current
```

Frequency Sweep







Form of the solution

$$\sum_{i=0}^{N} b_i \frac{d^i}{dt^i} v_o(t) = \sum_{i=0}^{M} a_i \frac{d^i}{dt^i} v_i(t)$$

phasor transform

$$\sum_{i=0}^{N} b_i (j\omega)^i \underline{V_o} = \sum_{i=0}^{M} a_i (j\omega)^i \underline{V_i}$$

$$\boxed{\underline{V_o} = \underline{V_i} \frac{\sum_{i=0}^{M} a_i (j\omega)^i}{\sum_{i=0}^{N} b_i (j\omega)^i}}$$

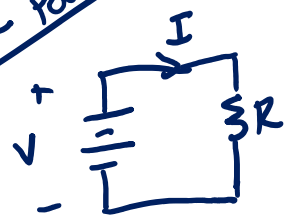
$H(j\omega)$

Chapter 11

AC CIRCUIT POWER ANALYSIS

Average Power

DC Power

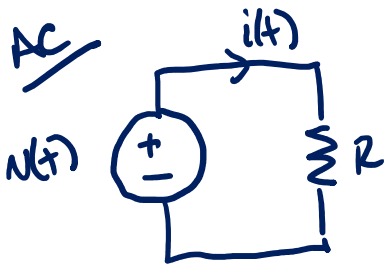


$P = V \cdot I$ → Generally true for any 2-terminal element

for resistors $V = IR$

$$P_R = \frac{V^2}{R} = \underline{I^2 R}$$

AC



$p(t) = \underline{v(t) \cdot i(t)}$ → Generally true for any 2-terminal element

for resistors $P_R(t) = \underline{\frac{v(t)^2}{R}} = \underline{i(t)^2 R}$

power calculation is <u>not</u> LTI

Average Power

Average power over some interval $[t_1, t_1 + T]$

capital P for average →

$$P = \frac{1}{T} \int_{t_1}^{t_1+T} p(t)\, dt$$

Average power over all time

$$P = \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} p(t)\, dt$$

for sinusoidal signals, Averge over <u>any</u> integer number of periods is equal to averge over all time $T = \frac{2\pi}{\omega} = \frac{1}{f}$

Power in a Resistor

Average power in a resistor with some periodic (e.g. sinusoidal) current

$$P_R = \frac{1}{T}\int_0^T P_R(t)\,dt = \frac{1}{T}\int_0^T i_R(t)^2 R\,dt$$

$$= R\,\underbrace{\frac{1}{T}\int_0^T i_R(t)^2\,dt}$$

$$P_R = R\left(\sqrt{\frac{1}{T}\int_0^T i_R(t)^2\,dt}\right)^2 \longleftrightarrow P_R = (I_{rms})^2 R$$

rms = "root mean square"

Define rms $\rightarrow$

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T v(t)^2\,dt}$$

$$X_{rms} = \sqrt{\frac{1}{T}\int_0^T x(t)^2\,dt}$$

Note: book calls this "effective" instead of rms

I_{eff}, V_{eff}. $\Longleftrightarrow$ V_{rms} I_{rms}