*E*lectrical
*E*ngineering
*T*echnology

Parallel Resonant Circuits and Simulation

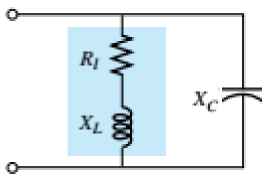
Spring 2019 (2185)

Parallel Resonant Circuits and Simulation

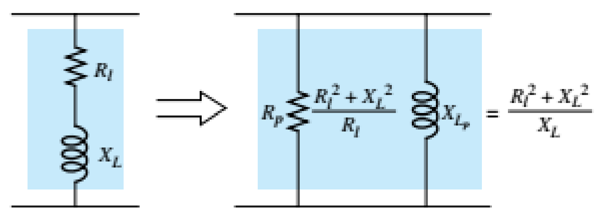
- Parallel Resonance (Summary)
  - General circuit
  - Simplified circuit (Q>=10)
  - Impedance and voltage over frequency (frequency response)
  - Selectivity change with varying R_L
  - Summary equations from the text
- Parallel Resonance ICP
  - Calculations using the Q>=10 equivalent circuit
  - $\mathbf{Z}_{TP}$ calculation (exact)
  - $\mathbf{I}_T$ calculation (exact)
  - $\mathbf{V}_C$ calculation (exact)
  - Simulation results/clarifications

Parallel Resonance - Summary

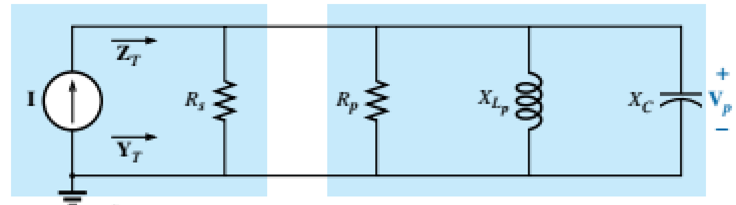
General Parallel R-L-C Circuit



Converted to parallel equivalent



General circuit



Simplified (Q>=10)

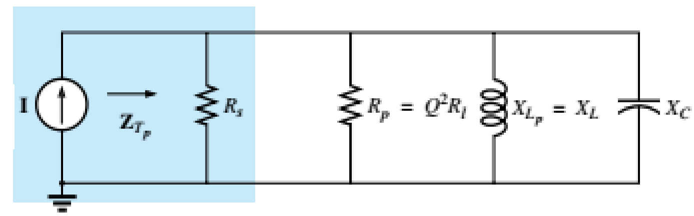
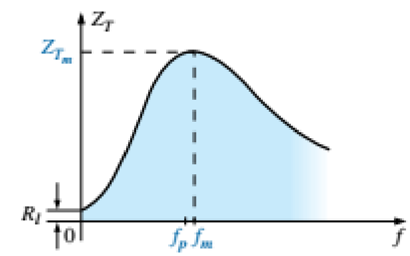
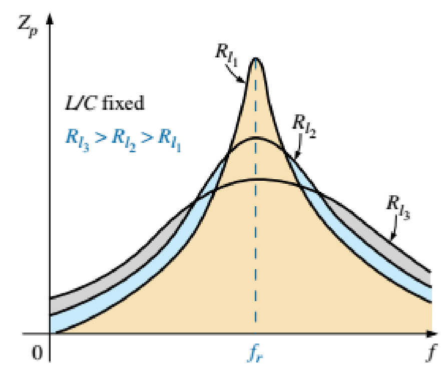


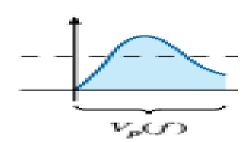
TABLE 21.2

Parallel resonant circuit ($f_s = 1/(2\pi\sqrt{LC})$).

	Any Q_l	$Q_l \geq 10$	$Q_l \geq 10, R_s \gg Q_l^2R_l$
f_p	$f_s\sqrt{1 - \frac{R_l^2C}{L}}$	f_s	f_s
f_m	$f_s\sqrt{1 - \frac{1}{4}\left[\frac{R_l^2C}{L}\right]}$	f_s	f_s
Z_{T_p}	$R_s \\| R_p = R_s \\| \left(\frac{R_l^2 + X_L^2}{R_l}\right)$	$R_s \\| Q_l^2R_l$	$Q_l^2R_l$
Z_{T_m}	$R_s \\| \mathbf{Z}_{R\text{-}L} \\| \mathbf{Z}_C$	$R_s \\| Q_l^2R_l$	$Q_l^2R_l$
Q_p	$\frac{Z_{T_p}}{X_{L_p}} = \frac{Z_{T_p}}{X_C}$	$\frac{Z_{T_p}}{X_L} = \frac{Z_{T_p}}{X_C}$	Q_l
BW	$\frac{f_p}{Q_p}$ or $\frac{f_m}{Q_p}$	$\frac{f_p}{Q_p} = \frac{f_s}{Q_p}$	$\frac{f_p}{Q_l} = \frac{f_s}{Q_l}$
I_L, I_C	Network analysis	$I_L = I_C = Q_lI_T$	$I_L = I_C = Q_lI_T$







Parallel Resonance – In Class Example

18. For the network in Fig. 21.59:

a. Find the resonant frequencies f_s, f_p, and f_m. What do the results suggest about the Q_p of the network?

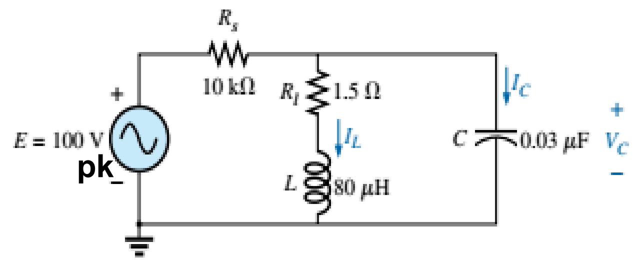
b. Find the values of X_L and X_C at resonance (f_p). How do they compare?

c. Find the impedance Z_{T_p} at resonance (f_p).

d. Calculate Q_p and the BW.

e. Find the magnitude of currents I_L and I_C at resonance (f_p).

f. Calculate the voltage V_C at resonance (f_p).



(a) f_s, f_p, f_m

$$f_s = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{(2\pi)\sqrt{(80\mu H)(0.03\mu F)}} = \boxed{102.7kHz}$$

$$f_p = f_s\sqrt{1 - \frac{R_l^2 C}{L}} = (102.7kHz)\sqrt{1 - \frac{(1.5)^2(0.03\mu F)}{80\mu H}}$$

$$= (102.7kHz)(0.9995)$$

$$= \boxed{102.7kHz}$$

$$f_m = f_s\sqrt{1 - \frac{1}{4}\left(\frac{R_l^2 C}{L}\right)}$$

$$= (102.7kHz)(0.9999)$$

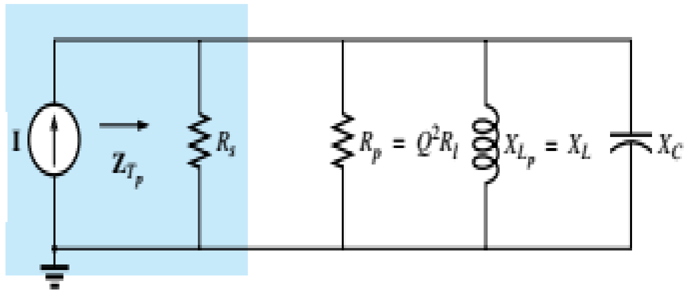
$$\boxed{f_m = 102.7kHz}$$

$f_s \sim f_p \sim f_m \Rightarrow$ HIGH Q ($Q > 10$)

Therefore, we are using the Q>= 10 circuit and equations

Parallel Resonance – In Class Example

Simplified Circuit
(Q>=10)



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Z_{T_m}	$R_s \parallel \mathbf{Z}_{R\text{-}L} \parallel \mathbf{Z}_C$	$R_s \parallel Q_l^2 R_l$	$Q_l^2 R_l$
Q_p	$\frac{Z_{T_p}}{X_{L_p}} = \frac{Z_{T_p}}{X_C}$	$\frac{Z_{T_p}}{X_L} = \frac{Z_{T_p}}{X_C}$	Q_l
BW	$\frac{f_p}{Q_p}$ or $\frac{f_m}{Q_p}$	$\frac{f_p}{Q_p} = \frac{f_s}{Q_p}$	$\frac{f_p}{Q_l} = \frac{f_s}{Q_l}$
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- **a.** Find the resonant frequencies f_s, f_p, and f_m. What do the results suggest about the Q_p of the network?
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- **d.** Calculate Q_p and the BW.
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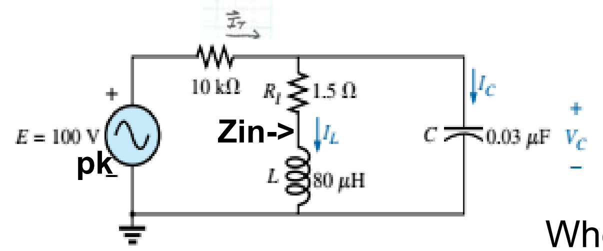
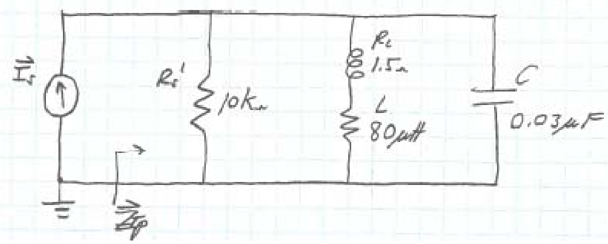


FIG. 21.59
Problem 18.

Where is **ZTP** in this circuit?

CONVERT $\vec{E}_s$, $\vec{R}_s$ TO A PRACTICAL CURRENT SOURCE:



RECALL: $f_p = 102.7\,kHz$

@ f_p: $X_L = X_C = 51.7\,\Omega$

$\vec{Z}_{TP}$ ($\vec{Z}_T$ @ f_p):

$$\vec{Z}_{TP} = R_s' \,//\, (R_L + jX_L) \,//\, -jX_C$$

$$= 10{,}000\,\Omega \,//\, (1.5 + j51.7)\,\Omega \,//\, -j51.7\,\Omega$$

$$\vec{Z}_{TP} = \boxed{1{,}513\,\Omega \angle -1.4^\circ}$$

At fp:
Zin = (-jXc) // (R+jXL)
= (-j51.7Ω) // (1.5 + j51.7) Ω
= 1,783Ω < -1.66º

IT = **E**/(**Zin** + Rs)
= 8.49mApk < 0.3º

Vc = (**IT**)(**Zin**)
= 15.1Vpk < -1.4º

Standard circuit analysis still works!

Very close to the value obtained using the Q>= 10 circuit approximation of 1507 Ohms

Parallel Resonance – Simulation

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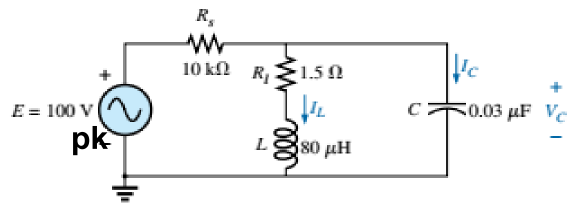
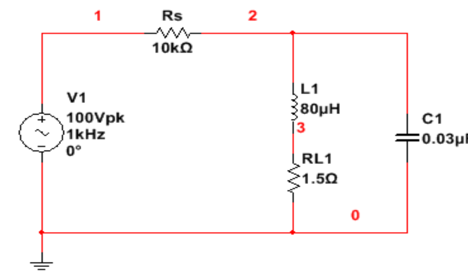
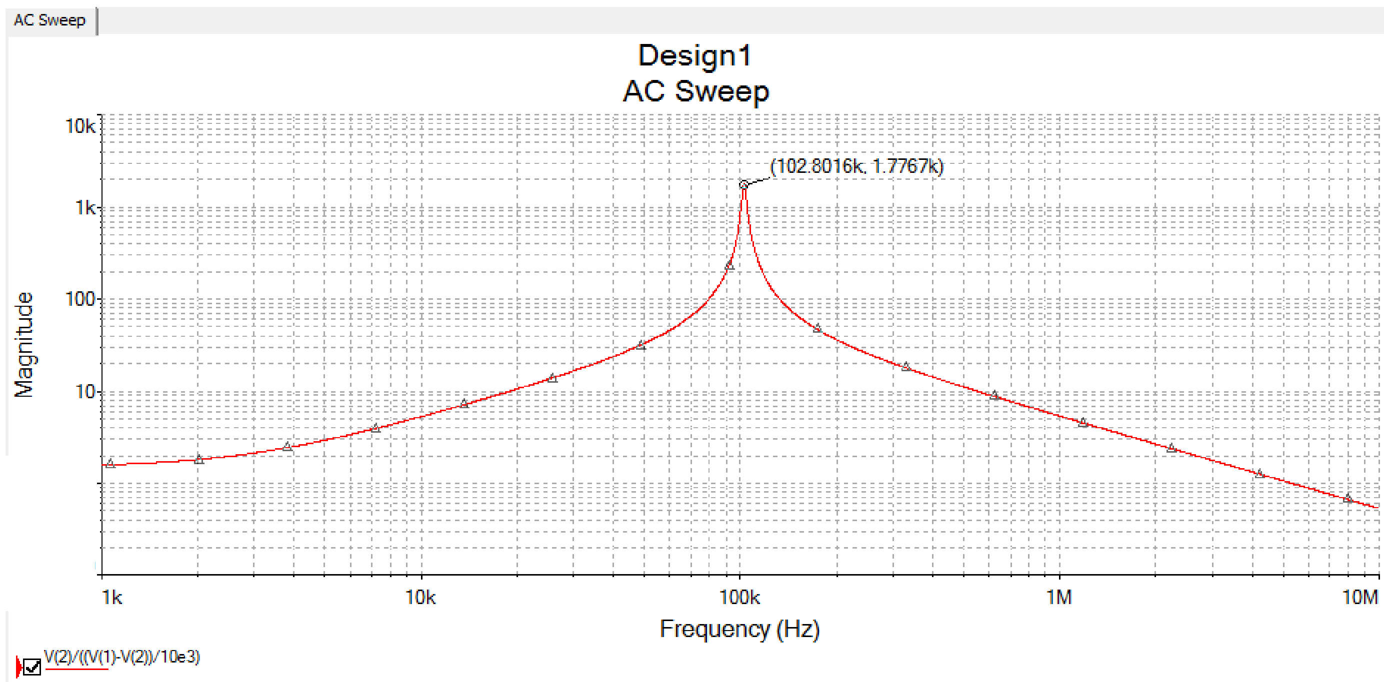


FIG. 21.59
Problem 18.



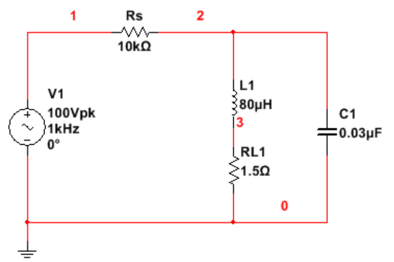
What is this the plot of?

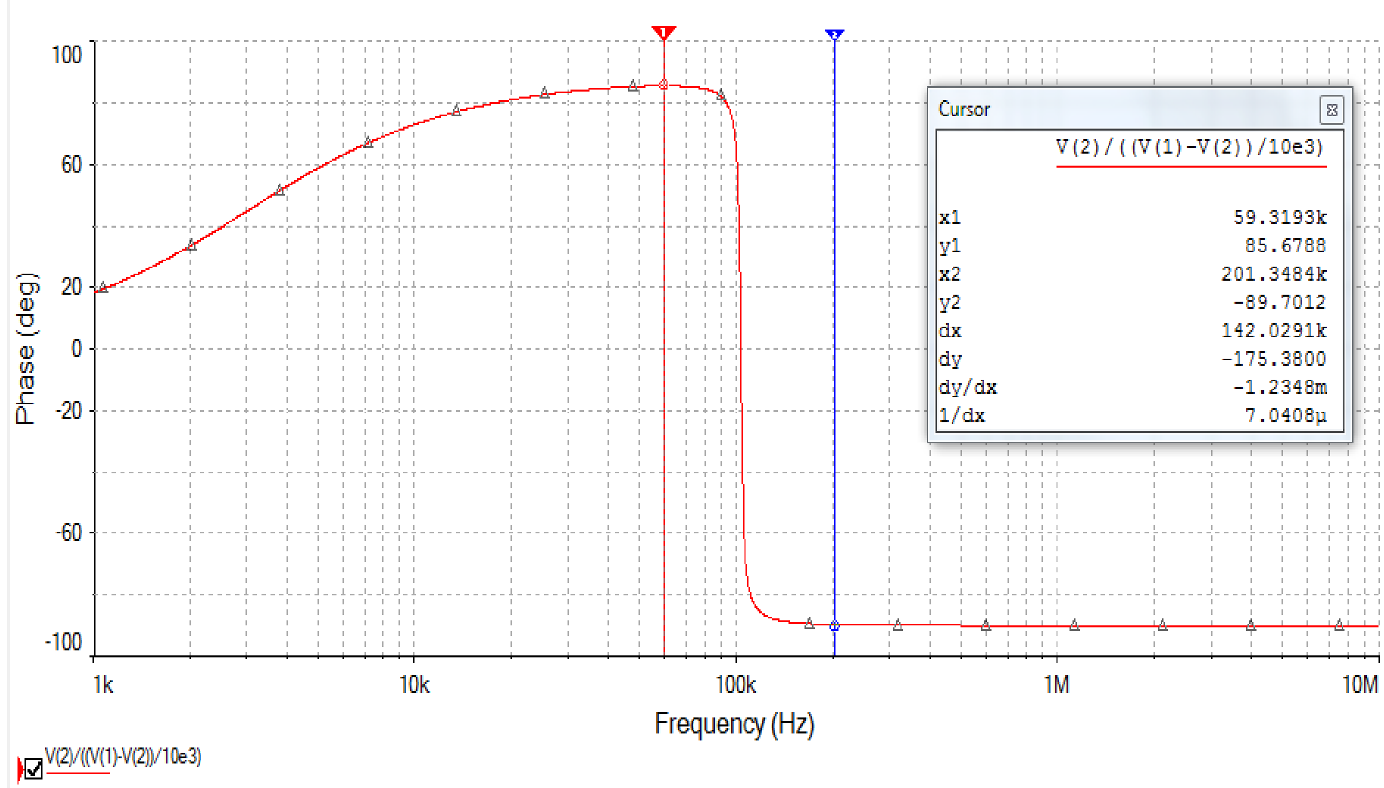


Interpret the plot

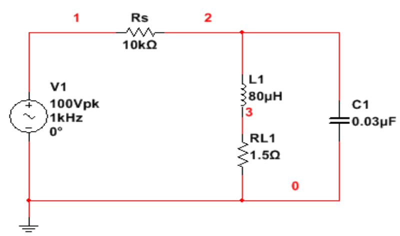
- What is fp?
- What is |ZTP|?

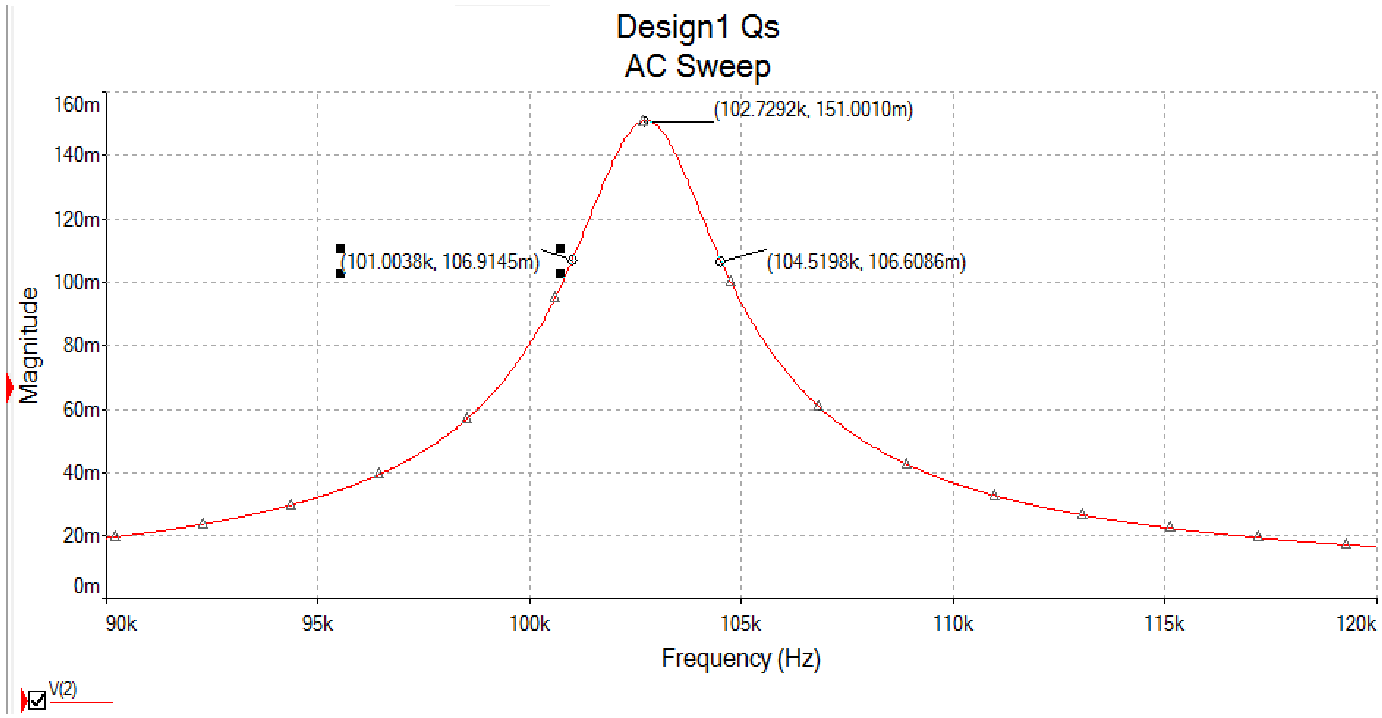
Parallel Resonance – In Class Example





Parallel Resonance – In Class Example

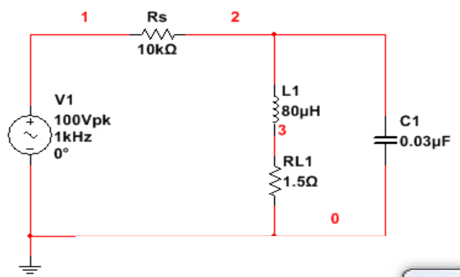


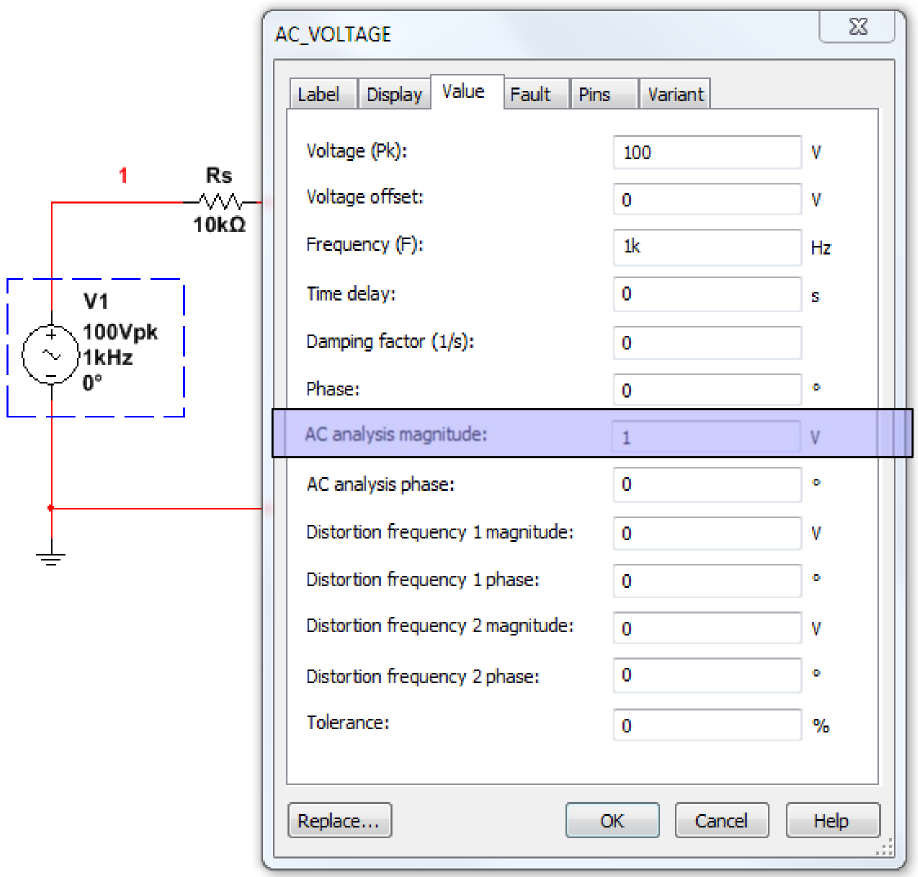


Plot of $V_2 = V_P$

- This should be 15.1V at fp
- Why isn't it?

Parallel Resonance – In Class Example

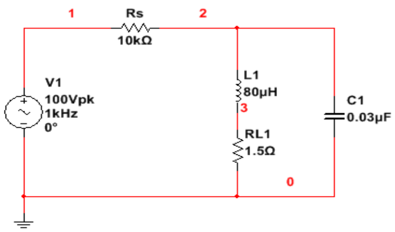




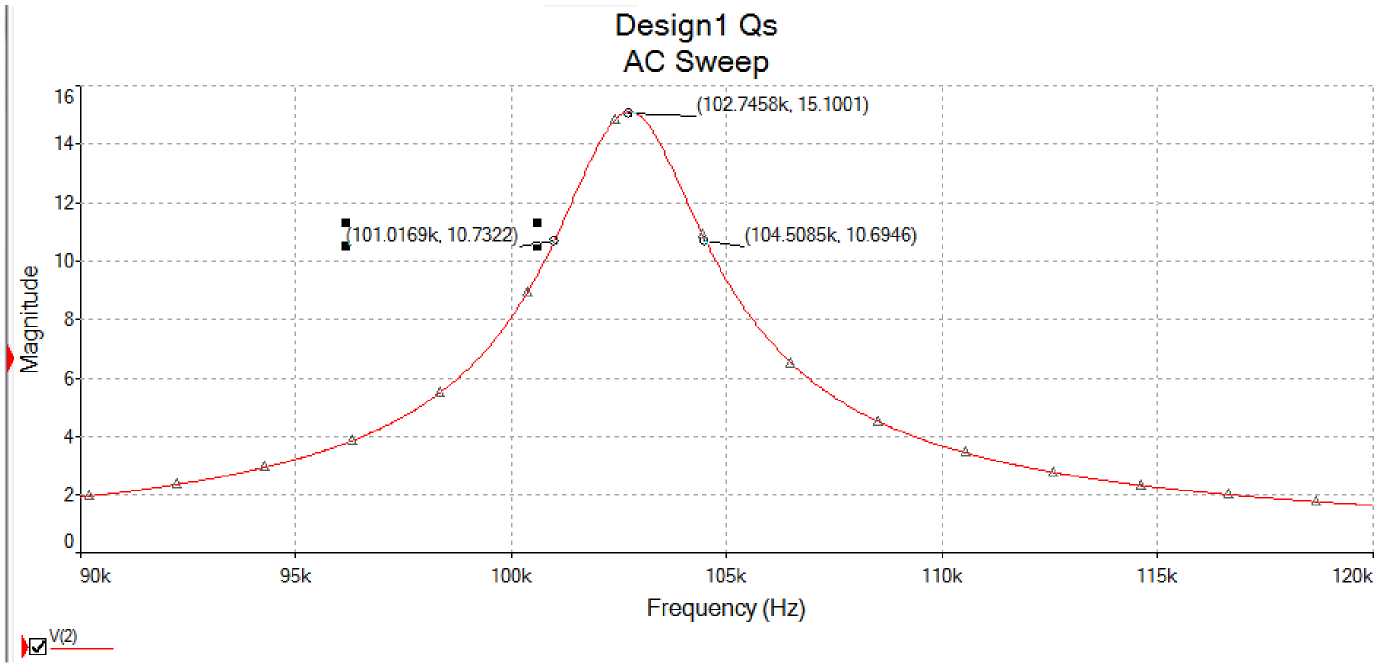
AC analysis magnitude is set to 1V by default

- We usually scale the result (i.e. 151mV * 100 = 15.1V)
- We can change the number and re-simulate

Parallel Resonance – In Class Example



AC analysis magnitude set to 100V



Interpret the plot

- What is Vp at fp?
- What is fp?
- What is the BW?
- What is Qp?