

Series Resonant Tank

$$Z_{i\phi} = Z_{in} \Big|_{R_e \rightarrow \text{short}}$$

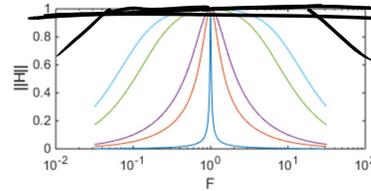
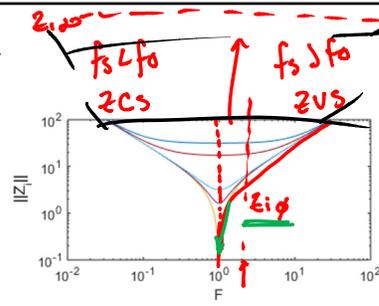
$$Z_{i\infty} = Z_{in} \Big|_{R_e \rightarrow \text{open}}$$

As R_e goes from zero to ∞
 Z_i increases

→ Good!

→ Conduction losses decrease
 at low P_{out}

→ If operating near $F=1$
 short circuit current can be very large

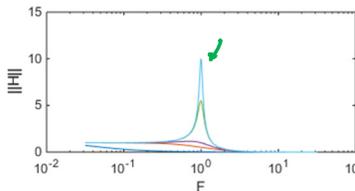
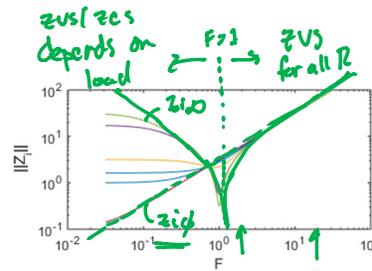


PRC Tank

→ ZVS possible for all R
 if $F > 1$

→ But, conduction losses @
 light load don't decrease

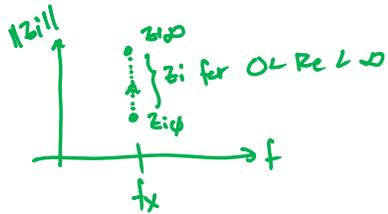
→ short circuit current limited
 by L → Z_{i0} has a
 non-zero value



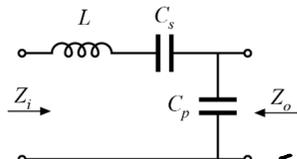
Circulating Current

- Textbook Theorem 1 in Section 19.4.7

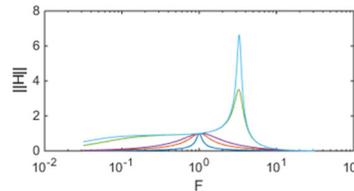
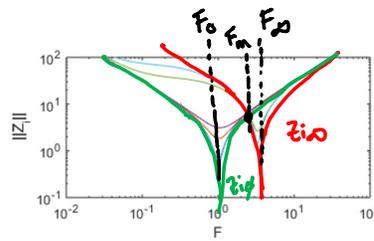
→ if a tank is purely reactive $\|Z_{i||}$ is a monotonic function of Re



LCC



Cond loss decreases @ light load | Cond losses worse @ light load



LLC

Z_i L_s C L_p Z_o
 F_x F_m F_o
 ZCS | ZVS/ZCS depends on R | ZVS

conduction losses ↑ @ light load conduction losses decrease @ light load

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Tank Summary (1/2)

Series

ZCS ZVS

→ ZVS for $f_o > f_o$
→ $i_{in} < i_o$ (good!)

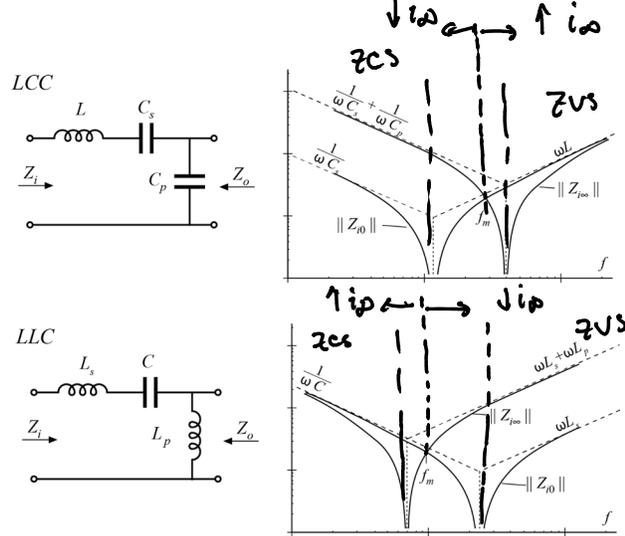
Parallel

ZVS/ZCS ZVS

- $i_{in} > i_o$ for $f_o > f_o$ (ZVS)

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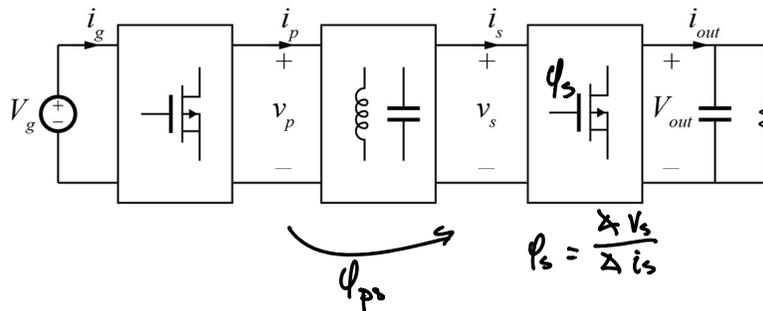
Tank Summary (2/2)



R. L. Steigerwald, "A comparison of half-bridge resonant converter topologies," in *IEEE Transactions on Power Electronics*, vol. 3, no. 2, pp. 174-182, Apr 1988.



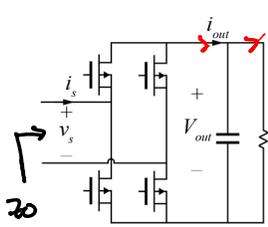
Synchronous Rectification



if $\phi_s \rightarrow \phi \rightarrow$ same analysis as diode rectifier



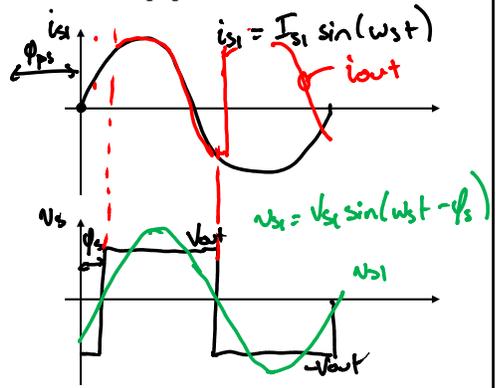
Synch Rectifier Sinusoidal Approximation



$$I_{out} = \frac{2}{\pi} I_{s1} \cos \phi_s$$

$$V_{out} = I_{out} R = R \frac{2}{\pi} I_{s1} \cos \phi_s$$

$$V_{s1} = \frac{4}{\pi} V_{out} = R \frac{8}{\pi^2} I_{s1} \cos \phi_s$$

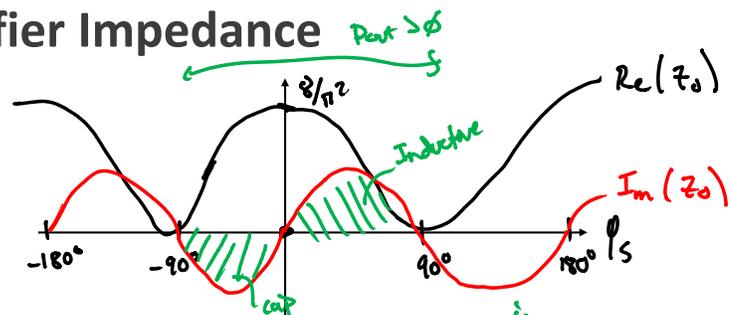


$$Z_o = \frac{V_{s1}}{i_{s1}} = \frac{R \frac{8}{\pi^2} I_{s1} \cos \phi_s \sin(\omega_s t - \phi_s)}{I_{s1} \sin(\omega_s t)}$$

→ Phasor $Z_o = R \frac{8}{\pi^2} \cos \phi_s \angle \phi_s$



Rectifier Impedance



$$Z_o = R \frac{8}{\pi^2} \cos \phi_s \angle \phi_s$$

$$= R \frac{8}{\pi^2} \cos \phi_s (\cos \phi_s + i \sin \phi_s)$$

$$= R \frac{8}{\pi^2} \cos^2 \phi_s + i \frac{R 8}{\pi^2} \cos \phi_s \sin \phi_s$$

$$= R \frac{8}{\pi^2} \frac{\cos(2\phi_s) + 1}{2} + i \frac{R 8}{\pi^2} \frac{\sin(2\phi_s)}{2}$$

