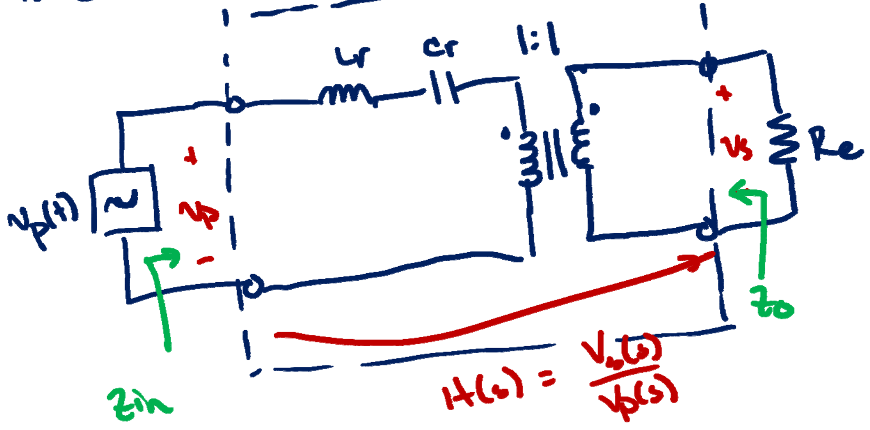
Construction of Tank Transfer Function

Take SRC tank as an example



$$Z_{in} = sL_r + \frac{1}{sC_r} + R_e$$

$$Z_o = sL_r + \frac{1}{sC_r}$$

$$H(s) = \frac{R_e}{Z_{in}} = \frac{sC_rR_e}{s^2L_rC_r + sR_eC_r + 1}$$

In standard form

$$H(s) = \frac{s/Q_e\omega_0}{\left(\frac{s}{\omega_0}\right)^2 + \frac{s}{Q_e\omega_0} + 1}$$

Q_e = "loaded Quality factor"

$$Q_e = \frac{R_0}{R_e}$$

$$\omega_0 = \frac{1}{\sqrt{L_rC_r}}, \quad R_0 = \sqrt{\frac{L_r}{C_r}}$$

$$M = \left\| H(s) \right\|_{s=j\omega_s} = \frac{1}{\sqrt{1 + Q_e^2\left(\frac{1}{F} - F\right)^2}}$$

Tank Input Impedance

SRC example

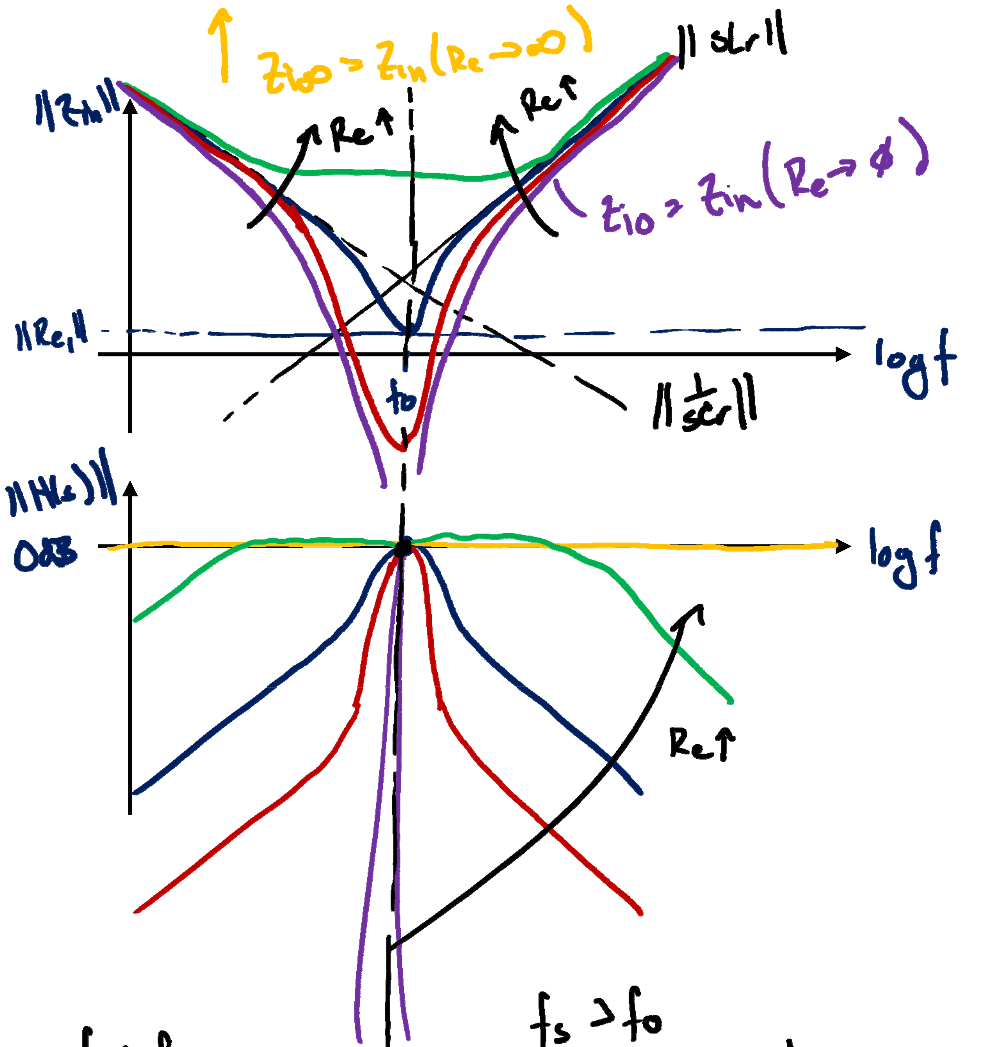
$Z_{in} = sL_r + \frac{1}{sC_r} + R_e$

$H(s) = \frac{R_e}{Z_{in}}$

SRC @ f_0 →

as $R_e \to \emptyset$, $Z_{in} \to \emptyset$

meaning circuit cannot tolerate a short-circuit



$f_s < f_0$ ←

Z_{in} is Capacitive / Resistive

ZVS unlikely, ZCS turn-off possible

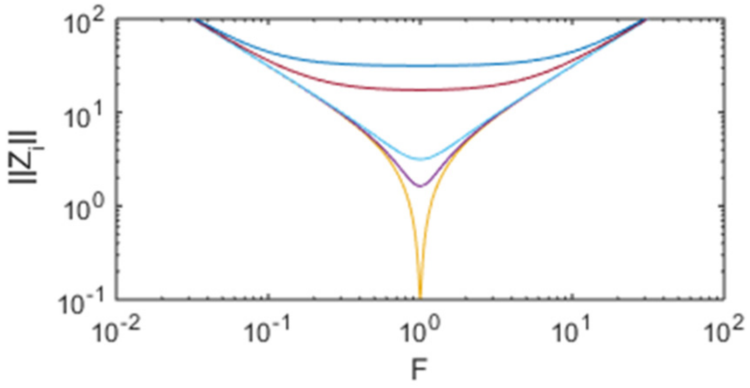
$f_s > f_0$

Z_{in} is inductive / Resistive

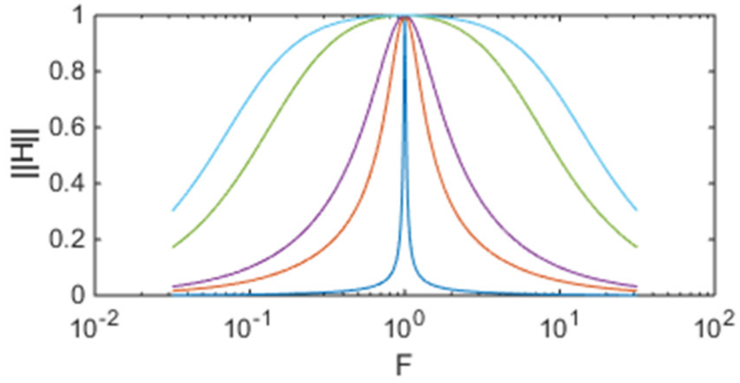
ZVS possible, ZCS unlikely

as $R_e \uparrow$, $Z_{in} \uparrow$ → P_{cond} will be smaller @ light load

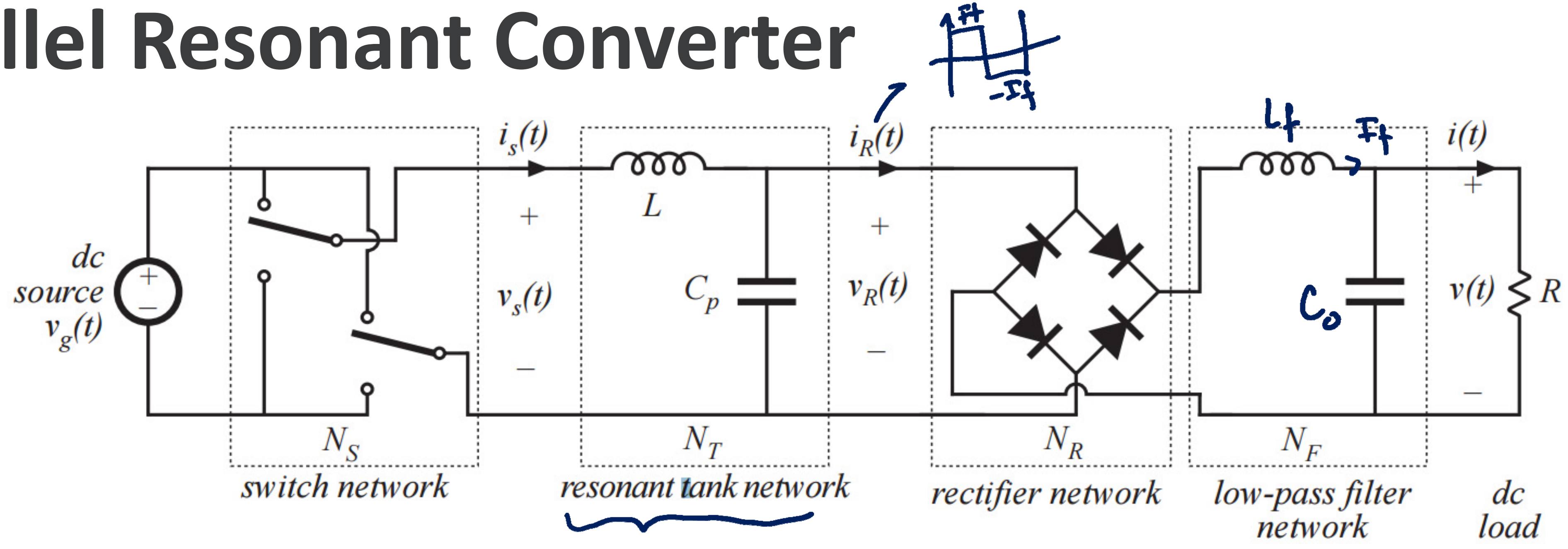
Series Resonant Tank



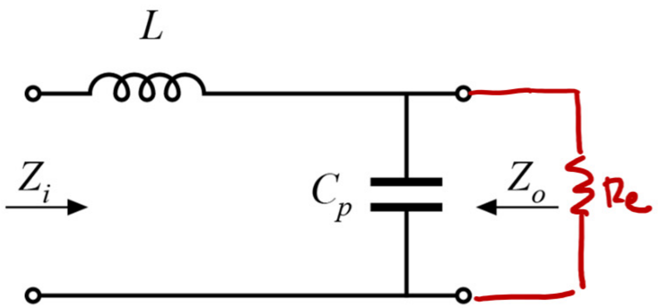
not log scale



Parallel Resonant Converter

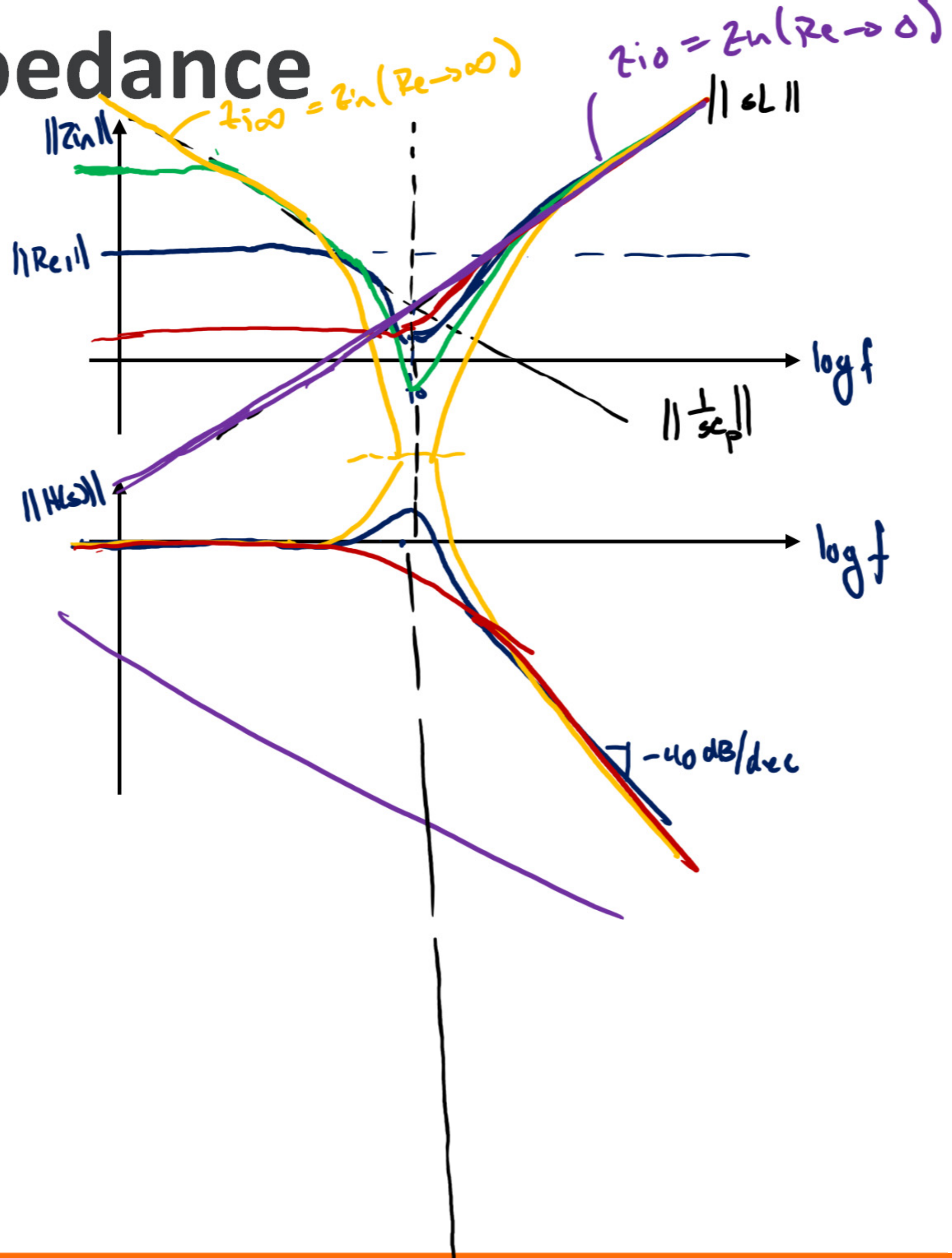


PRC Tank Input Impedance



$$Z_{in} = sL + R_e \,||\, \frac{1}{sC_p}$$

$$H(s) = \frac{R_e \,||\, \frac{1}{sC_p}}{Z_{in}}$$



PRC Tank

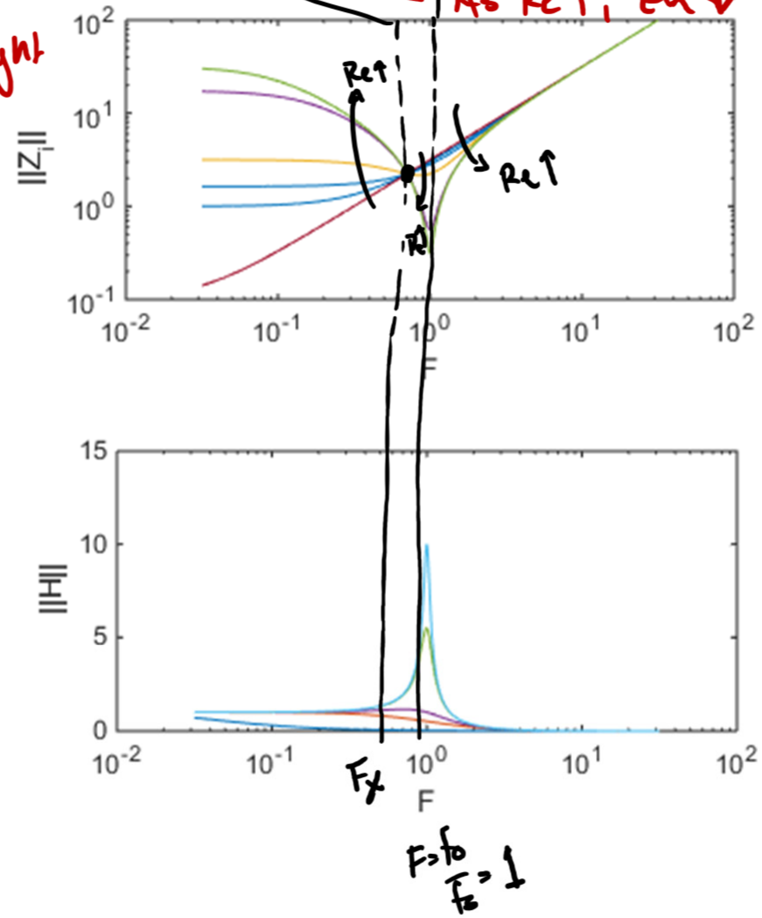
I: Z_{in} → Inductive for small R_e, capacitive for large R_e

II: Z_{in} → L for large R_e, C for small R_e

III: Z_{in} → inductive/Resistive, ZVS possible

As R_e ↑, Z_{in} ↑
light P_{cond} @ light load

" ← As R_e ↑, Z_{in} ↓ → largest P_{cond} @ light load



Textbook (2nd Edition)
theorem 1 in 19.4.2
(See 22.4 in 3rd Edition)

if tank is a purely reactive $\|Z_i(j\omega)\|$ is a purely monotonic function of R_e @ any ω_s

Only need to look @ Z_{i0} & $Z_{i\infty}$