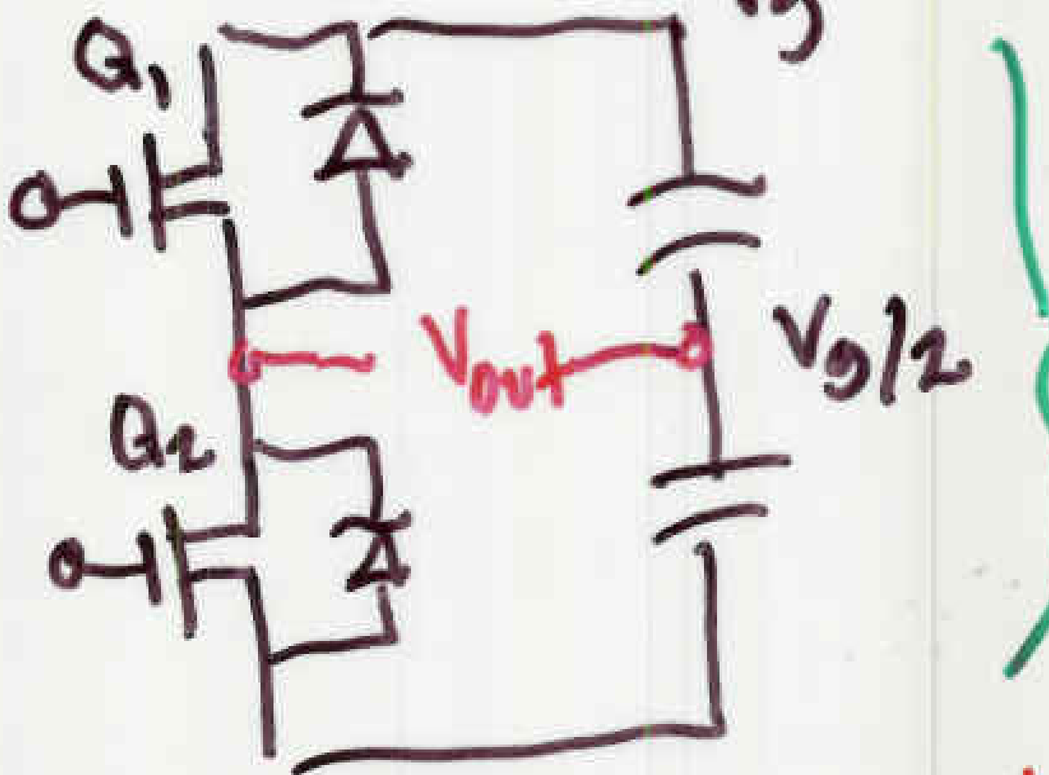
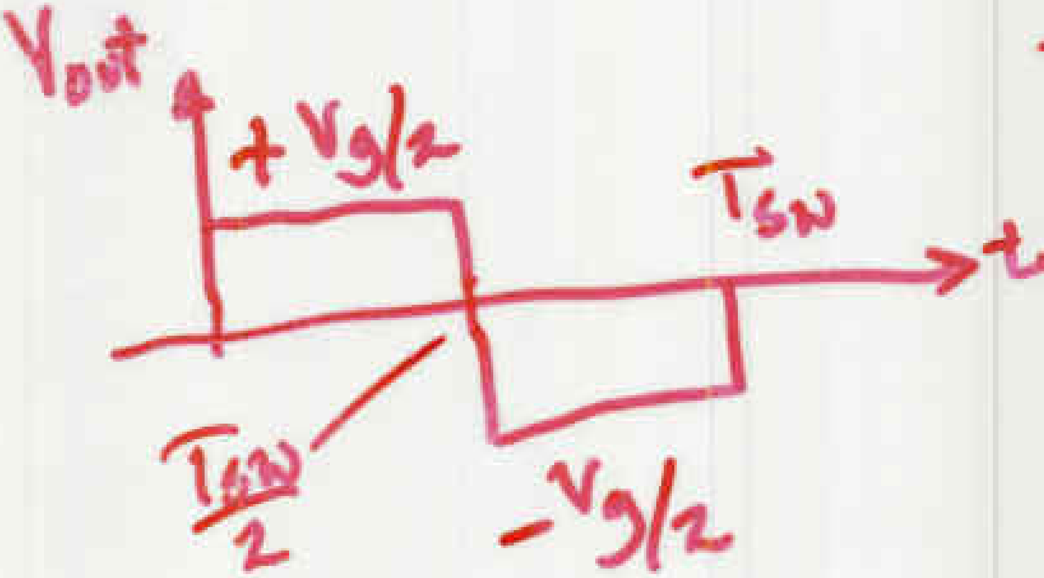


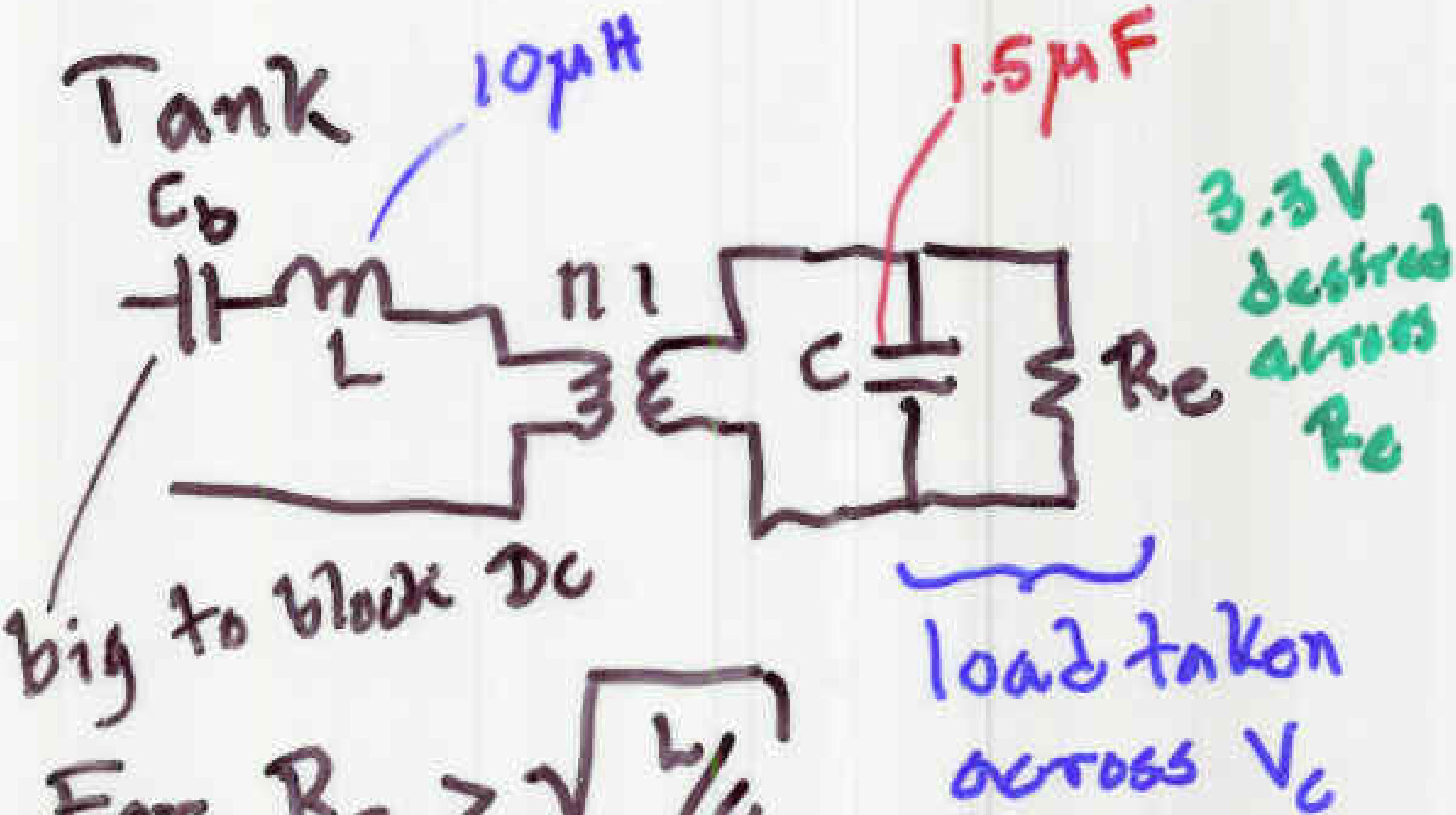


by symmetry only odd harmonics

Look @

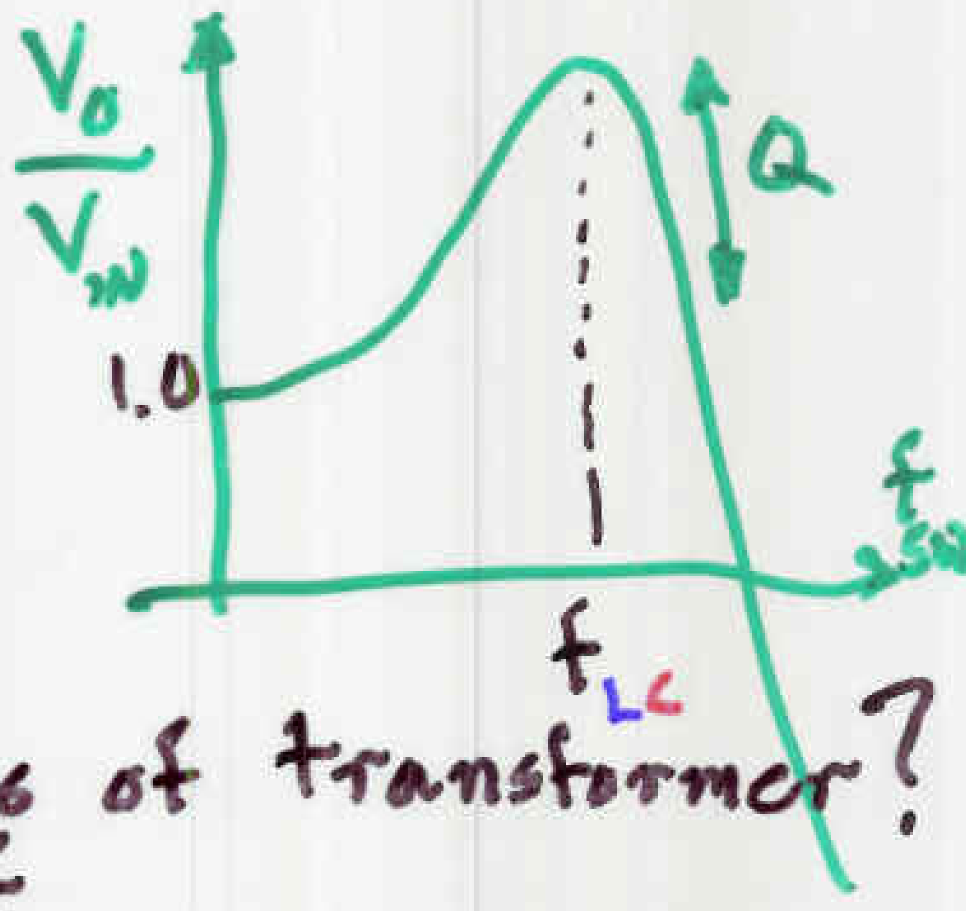
1. Input circuit model
2. Rectifier model
3. Tank model

Tank



For $R_e > \sqrt{L/C}$

expect $\frac{V_o}{V_{in}}$



Any effects of transformer?

(a) on f

(b) on Q

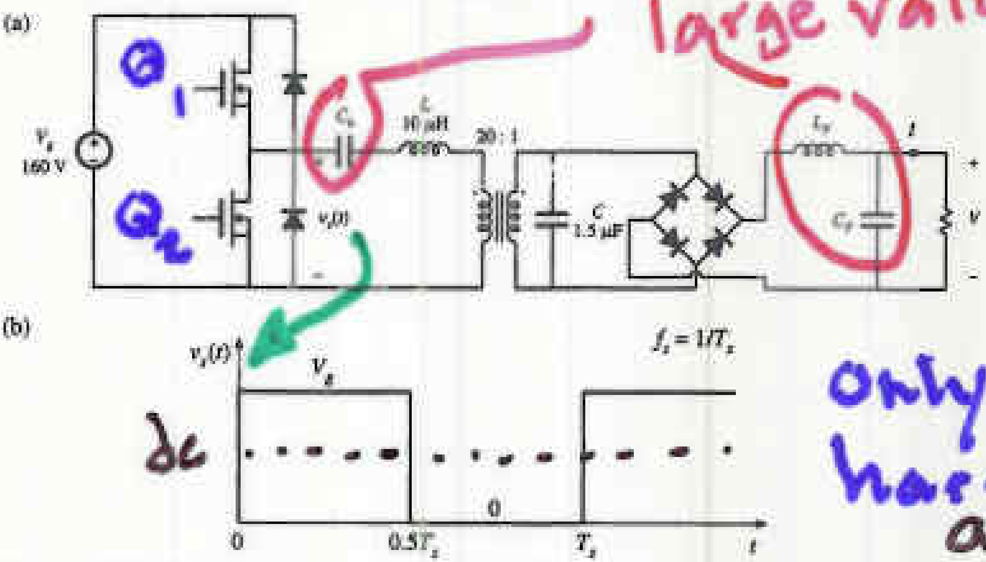
Prob 19.1 HW set #C

1. *Analysis of a half-bridge dc–dc parallel resonant converter, operated above resonance.* In Fig. 1, the elements C_b, L_F, and C_F are large in value, and have negligible switching ripple. You may assume that all elements are ideal. You may use the sinusoidal approximation as appropriate.

large values

(a)

(b)



only "odd" harmonics and dc load

Fig. 1 Half-bridge parallel resonant converter of Problem 1.: (a) schematic, (b) switch voltage waveform.

(a) Construct an equivalent circuit for this converter, similar to Fig. 19.22, which models the fundamental components of the tank waveforms and the dc components of the converter input current and output voltage. Clearly label the values and/or give expressions for all elements in your model, as appropriate.

At rated (maximum) load, this converter produces $I = 20$ A at $V = 3.3$ V.

(b) What is the converter switching frequency f_s at rated load?

(c) What is the magnitude of the peak transistor current at rated load?

At minimum load, the converter produces $I = 2$ A at $V = 3.3$ V.

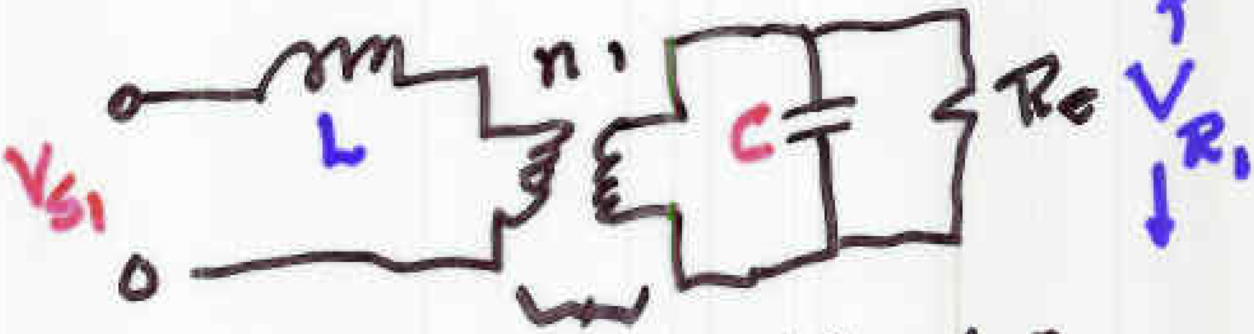
(d) What is the converter switching frequency f_s at minimum load?

(e) What is the magnitude of the peak transistor current at minimum load? Compare with your answer from part (c)—what happens to the conduction loss and efficiency at minimum load?

V_{out} fixed @ 3.3 V

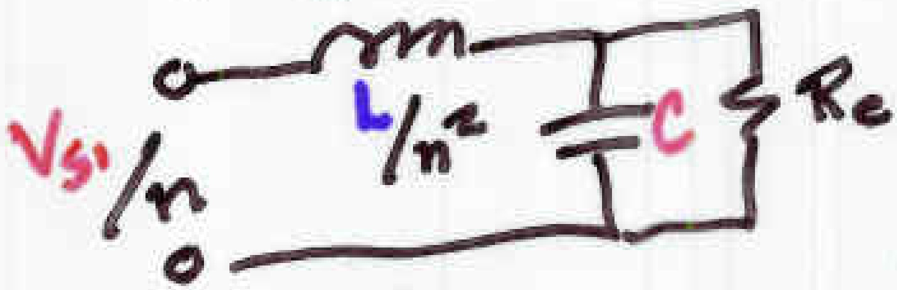
$2 \le I_{out} \le 20$ A

as V_g or I vary requires f to change to keep $V_o \approx 3.3$ V



makes $\omega_{LC} \propto n$

$\Longrightarrow$



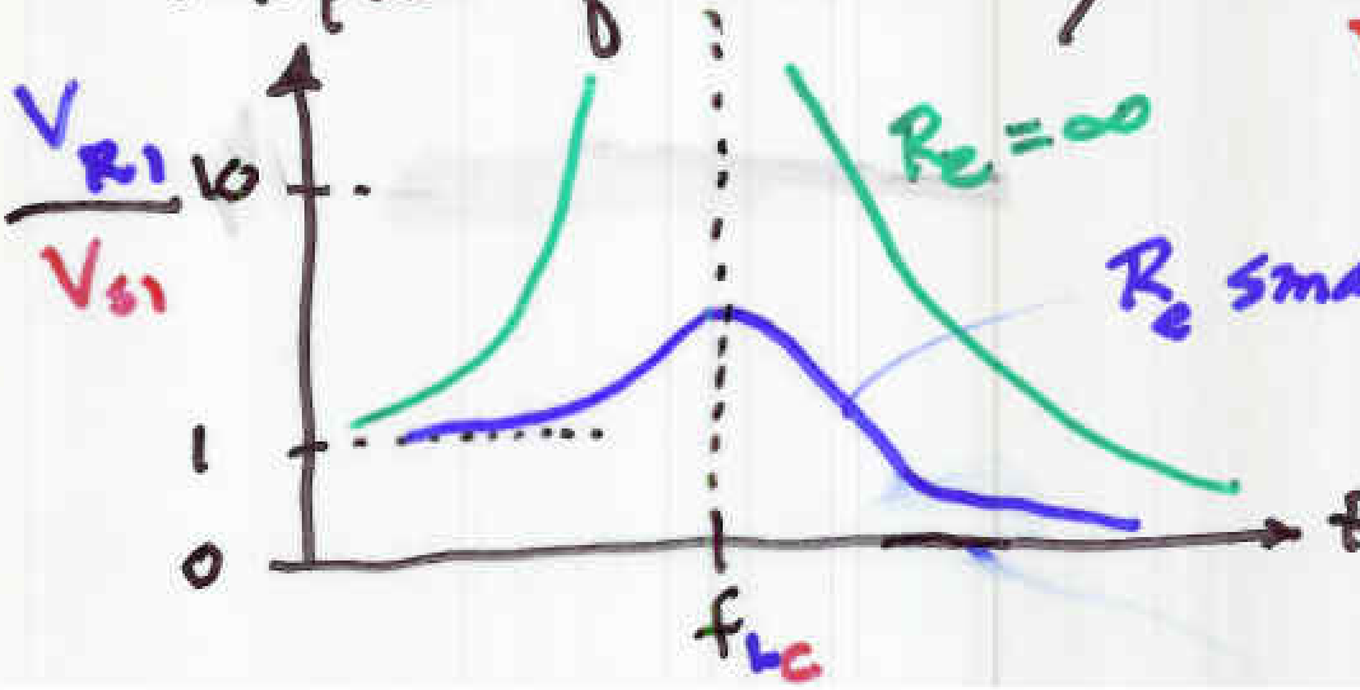
familiar?

$$\omega_{LC} = \frac{n}{\sqrt{LC}}$$

$$Q_e = \frac{R_e}{Z_0} = \frac{R_e}{\sqrt{\frac{L/n^2}{C}}} = \frac{n R_e}{\sqrt{L/C}}$$

$$Q = f(n)$$

Expect qualatatively two $\frac{V_{R1}}{V_{S1}}$



Analytically $\frac{V_{R1}}{V_{S1}} =$

$$\frac{R_e \| \frac{1}{sC}}{\frac{sL}{n^2} + R_e \| \frac{1}{sC}} = \frac{Z_{load}}{Z_{in}}$$

$$\frac{R_e/sC}{R_e + \frac{1}{sC}} = \frac{R_e}{R_e C s + 1} = R_e \| \frac{1}{sC}$$

$$\frac{R_e}{(R_e C s + 1)\frac{sL}{n^2} + R_e}$$

from $\frac{Z_{load}}{Z_{in}}$ $\frac{1}{R_e C s + 1}$

$$\left[s^2 \frac{LC}{n^2} + s \frac{L}{R_e n^2} + 1 \right]^{-1} \frac{1}{n} = \frac{V_{R1}}{V_{S1}}$$

$\frac{1}{n}$ from $\frac{V_{S1}}{n}$

$$\frac{1}{n} \frac{1}{\frac{s^2}{w_R^2} + \frac{s}{Q w_r} + 1} = \frac{V_{R1}}{V_{S1}}$$

Quantative

⑤

Chosen values

Element values

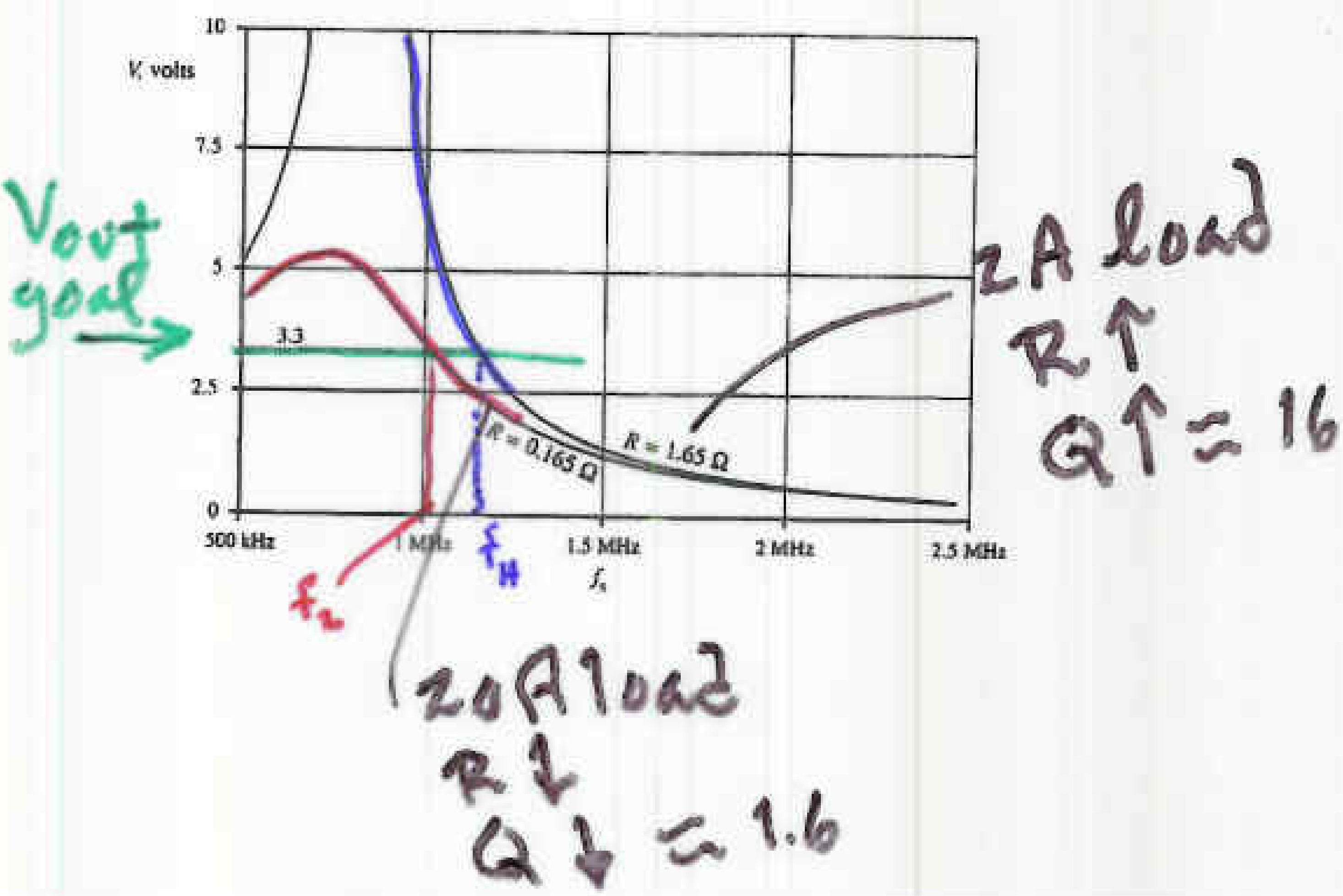
L	10 μH
C	1.5 μF
n	20
V_g	160 V
V	3.3 V

Operating points

at I =	20 A	2 A
R =	0.165 Ω	1.65 Ω
R_e =	0.204 Ω	2.036 Ω
f_0 =	821,873 Hz	821,873 Hz
Q_e =	1.58	15.77
f_s	1,031,696 Hz	1,156,025 Hz

← for $V_0 = 3.3$

← $R_e \cong \frac{\pi^2}{8} R$



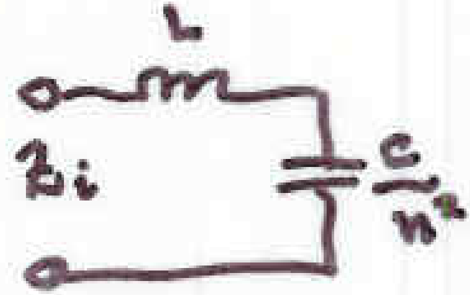
Largest $i_{IN} = i_Q$ when

$R_L = \infty$

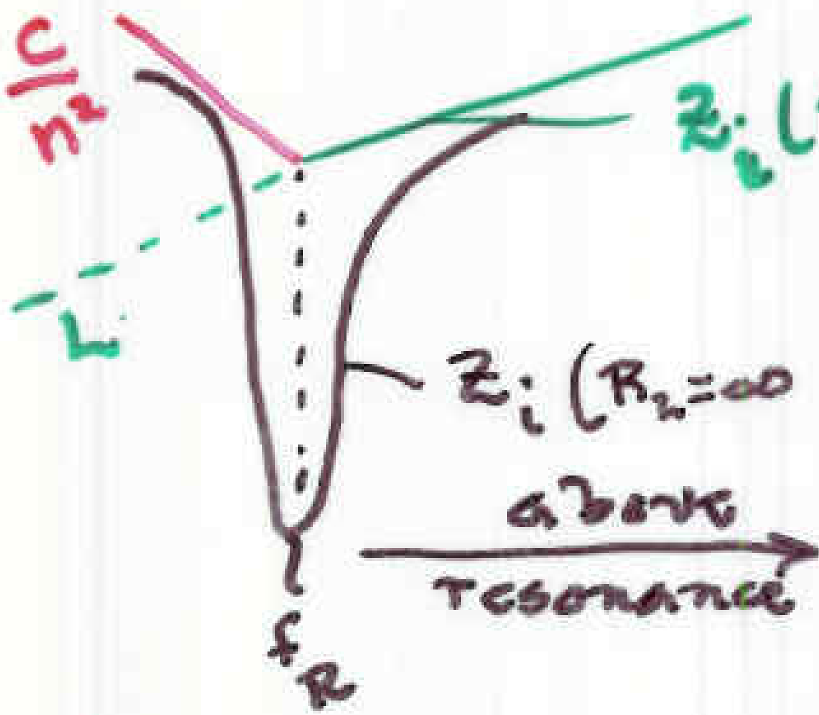
$R_L = 0$

$R_L = 0$

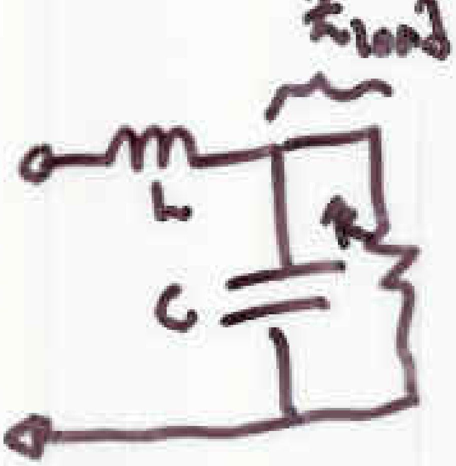
$R_L = \infty$

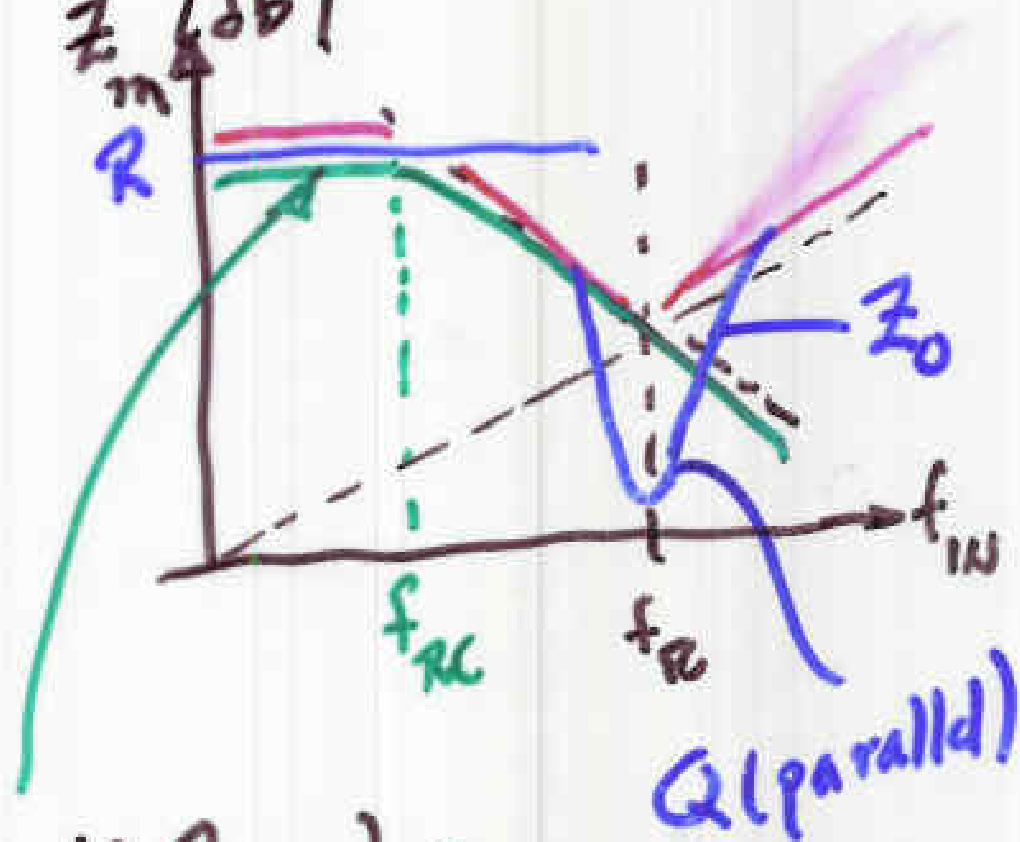


Series resonance



$i_{IN} = i_Q$ largest for $R_L = \infty$





$$\frac{V_{out}}{V_{IN}} = \frac{\overbrace{\frac{1}{\omega C} \parallel R}^{Z_{load}}}{\underbrace{\omega L + \frac{1}{\omega C} \parallel R}_{Z_{IN}}}$$