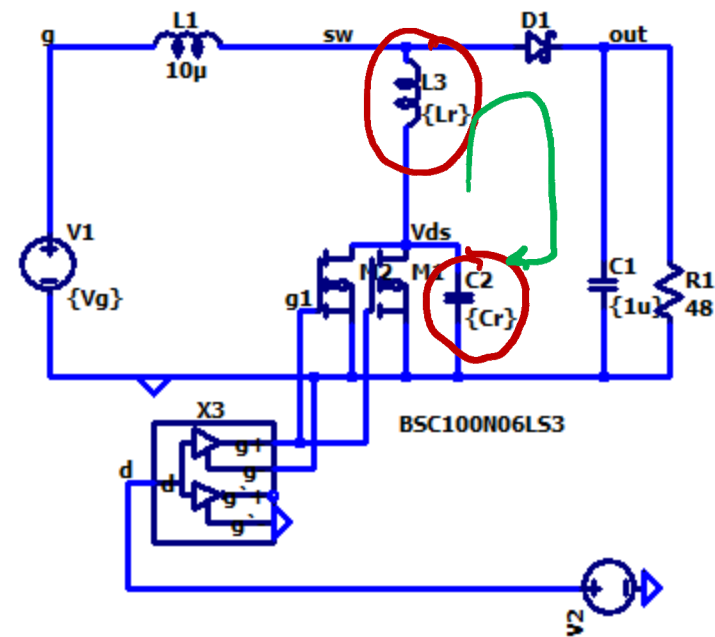


Resonant Operation

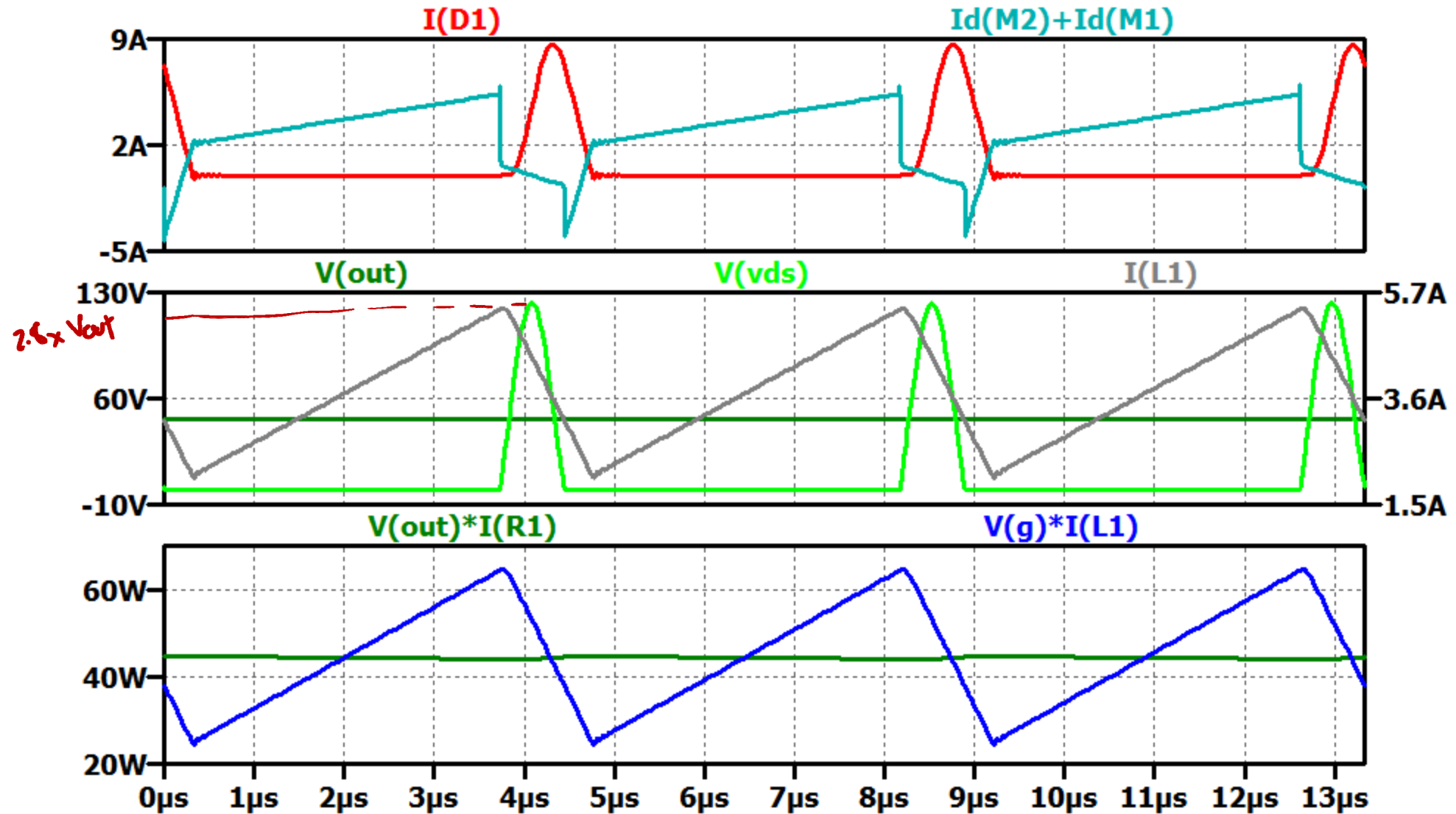
ZVS - Quasi - Resonant Boost Converter



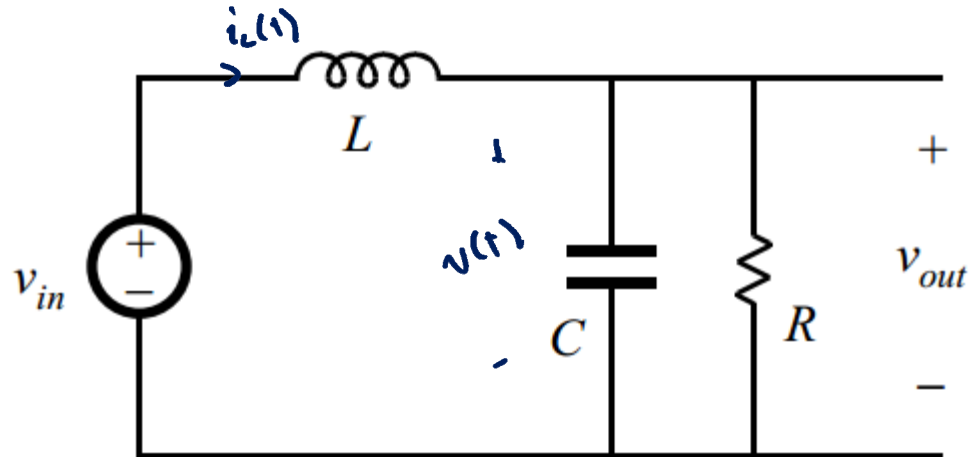
Switching	L	C_{out}	f_s	Diode	η (Sim)
Hard	22uH	22uF	202k	Si (FR)	93.9%
Hard	22uH	22uF	202k	Si Schottky	95.8%
Soft	4.65uH	22uF	202k	Si Schottky	98.4%
Soft	710nH	4.4uF	1 MHz	Si Schottky	98.2%
Soft	710nH	4.4uF	1 MHz	MOSFET	99.6%
Resonant	10uH + 2.4uH	1uF + 10nF	225 kHz	Si Schottky	98.6%
Resonant	10uH + 2.4uH	1uF + 10nF	225 kHz	MOSFET	99.96%

Not Real!

Resonant Boost Converter



Resonant Circuits

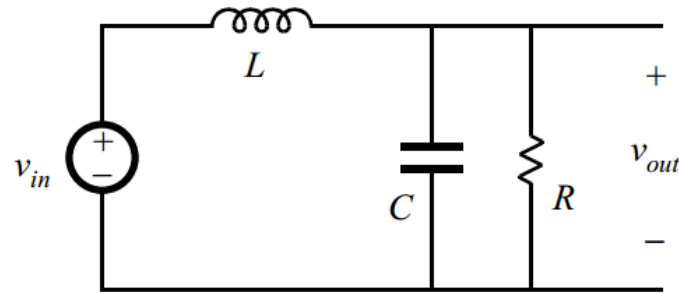


$$LC \frac{d^2 v_{out}}{dt^2} + \frac{L}{R} \frac{dv_{out}}{dt} + (v_{out} - v_{in}) = 0$$

{ Diff EAs
 Laplace
 numerical methods
 will develop new techniques

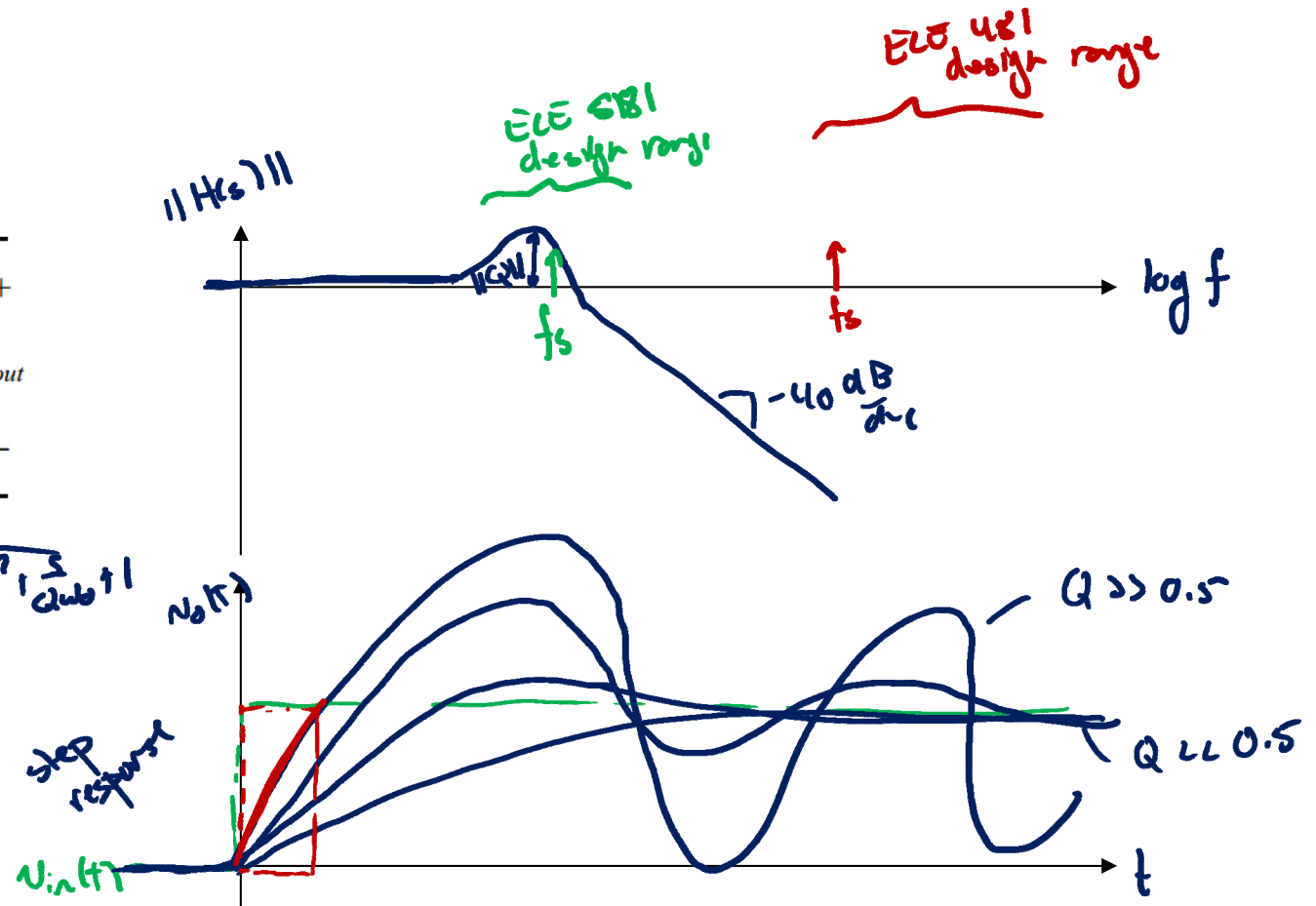
Small Ripple Approximation
 $v(t) \approx V$ $i_L(t) \approx I_L$
 ECE 481 :
 X Does not generally apply
 in ECE 581

Resonant Circuit Analysis



$$H(s) = \frac{V_{out}(s)}{V_{in}(s)} = \frac{1}{s^2 LC + s \frac{L}{R} + 1} = \frac{1}{\left(\frac{s}{\omega_0}\right)^2 + \frac{s}{Q} + 1}$$

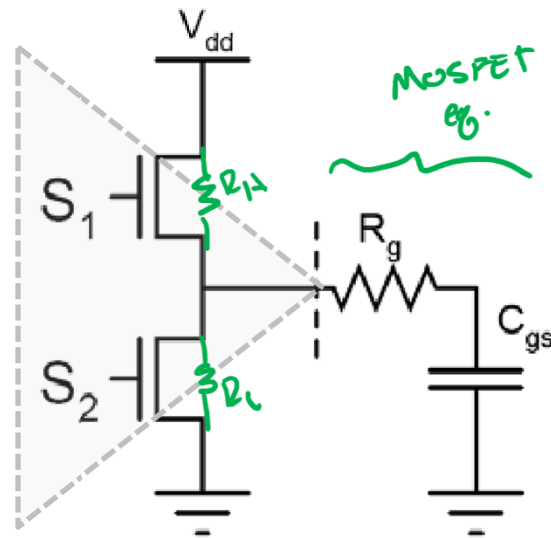
$$Q = \frac{R}{\omega_0 L} \quad R_0 = \sqrt{\frac{L}{C}} \quad \omega_0 = \frac{1}{\sqrt{LC}}$$



Soft Switching

- Advantages
 - Reduced switching loss
 - Possible operation at higher switching frequency
 - Lower EMI
- Disadvantages
 - Increased current and/or voltage stresses due to circulating current
 - Higher peak and rms current values
 - Complexity of analysis and modeling

Limitations: Gate Drive

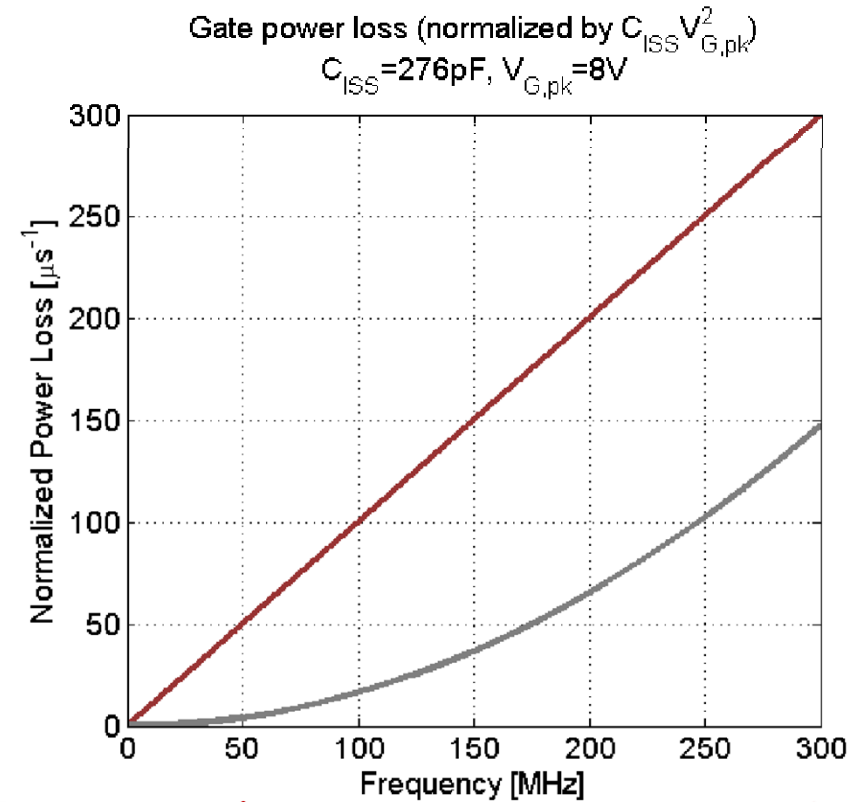


$$E_{g,on} = \left(\frac{1}{2} C_{gs} V_{DD}^2 \right)$$

$$E_{g,off} = \frac{1}{2} C_{gs} V_{DD}^2$$

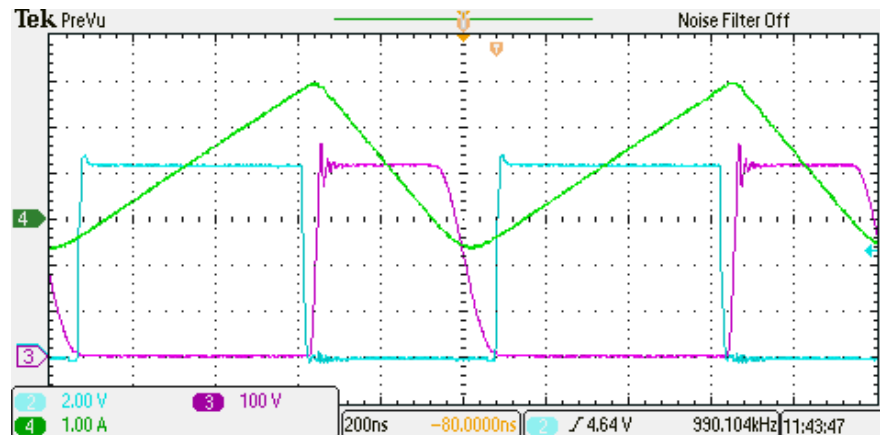
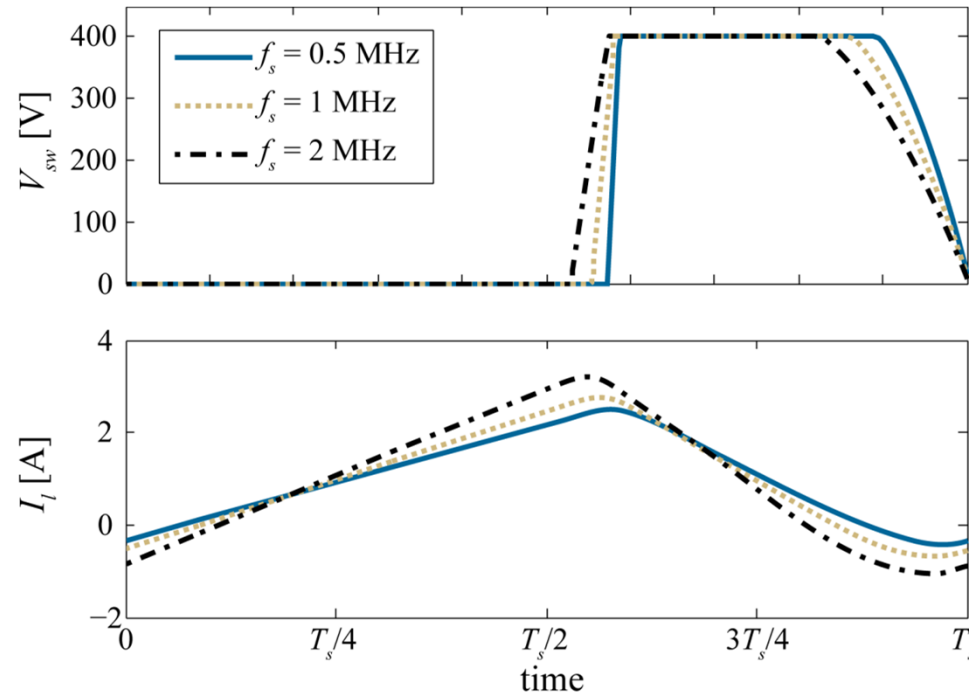
$$E_g = C_{gs} V_{DD}^2$$

$$P_g = E_g / t_s$$

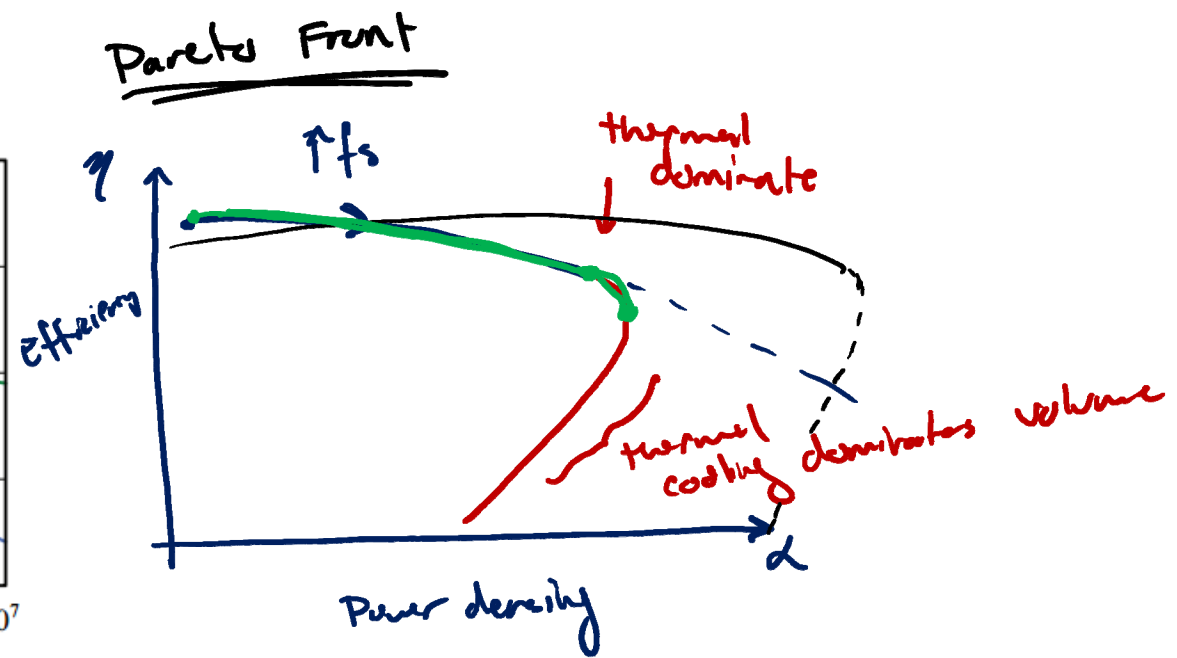
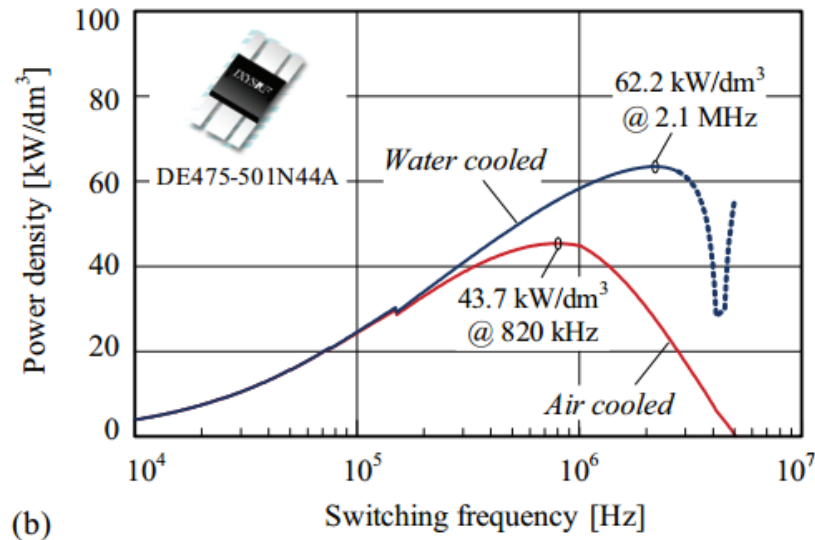
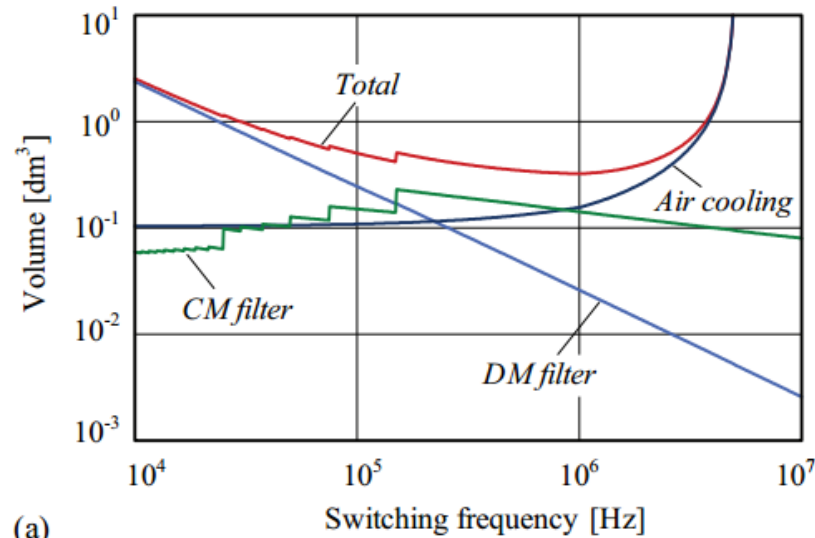


- (1) V_{gs} rise/fall dictated by $\tau_H = (R_g + R_{th}) C_{gs}$ & $\tau_L = (R_g + R_{th}) C_{gs}$
- (2) P_g power from gate drive rises $\propto f_s$

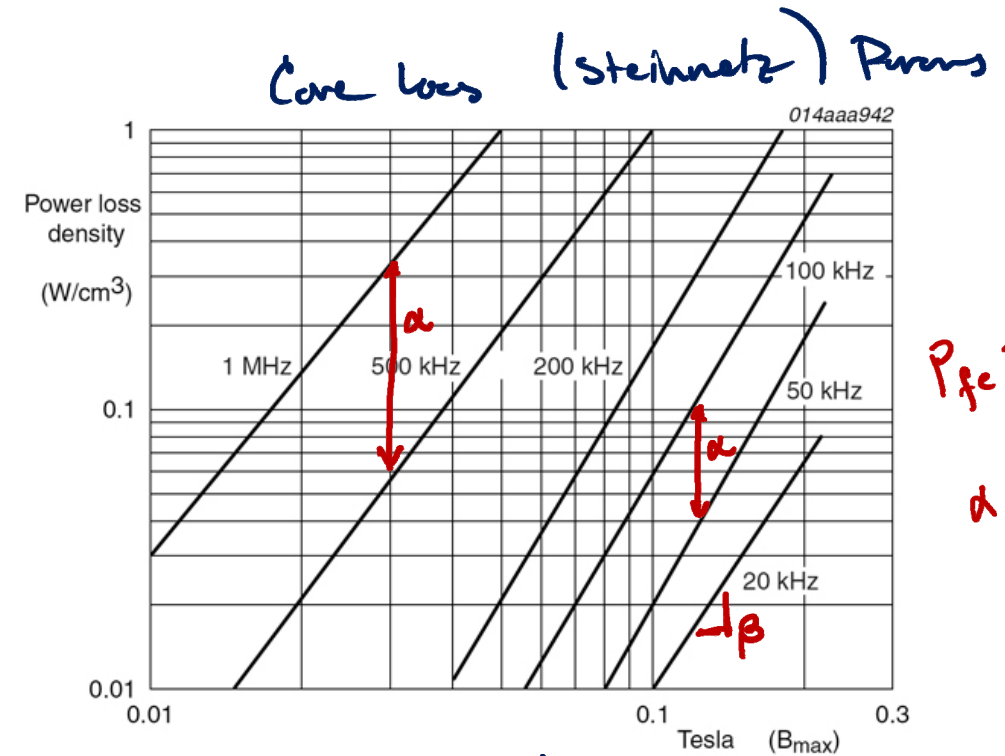
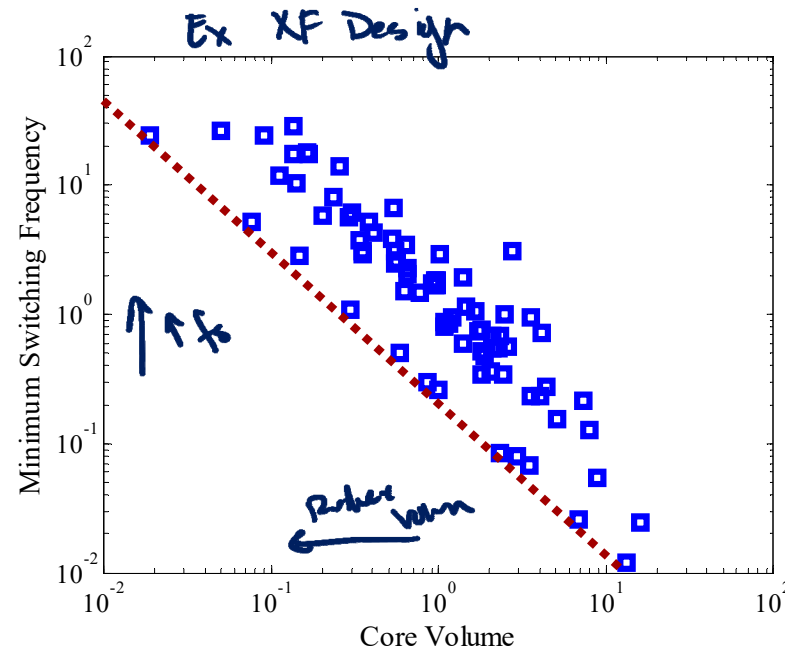
Limitations: t_d/T_s



Limitations: Thermal



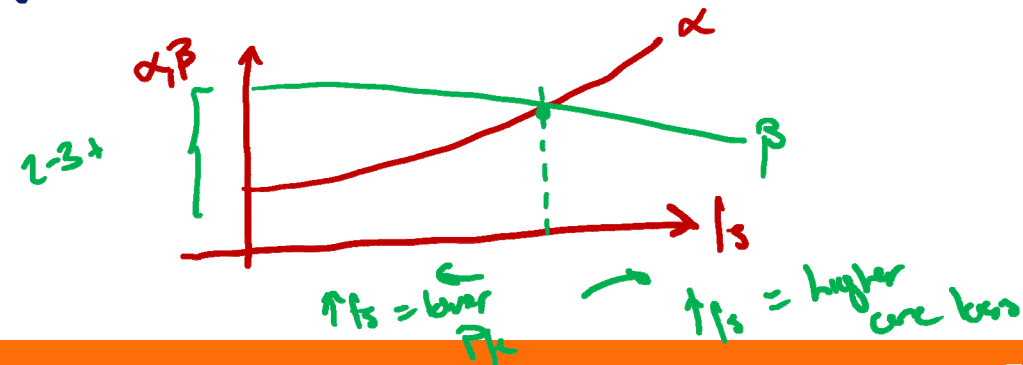
Limitations: Magnetics Design



$$P_{fe} = k_{fe} f_s^\alpha B_{max}^\beta$$

$$\alpha, \beta = f(f_s)$$

Core loss, Skin Effect, Proximity, Fringe, etc. worse @ HF



Limitations: Circuit Modeling

