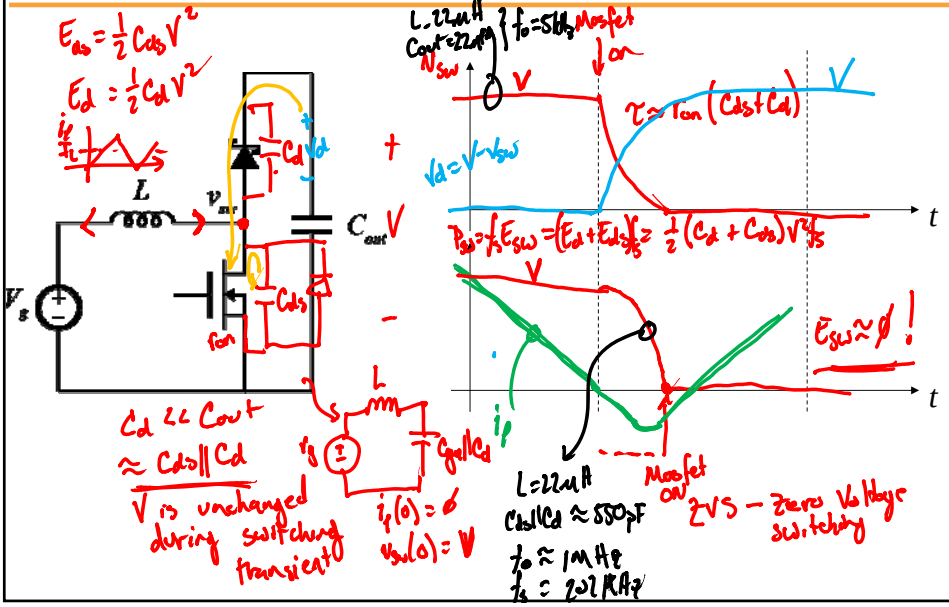
High Frequency Power Electronics

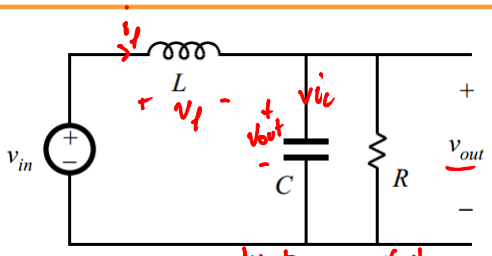
Prof. Daniel Costinett

ECE 581 Lecture 3
August 25, 2014

Device Capacitances



Resonant Circuits



$$\begin{cases} v_l = L\dfrac{di_l}{dt} \\ i_c = C\dfrac{dv_c}{dt} \end{cases}$$

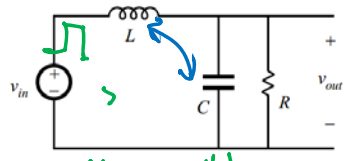
$$i_c = C\frac{dv_{out}}{dt} = i_l - \frac{v_{out}}{R} \rightarrow i_l = C\frac{dv_{out}}{dt} + \frac{v_{out}}{R}$$

$$v_l = L\frac{di_l}{dt} = v_{in} - v_{out}$$

$$v_{in} - v_{out} = L\frac{d}{dt}\left(C\frac{dv_{out}}{dt} + \frac{v_{out}}{R}\right)$$

$$= LC\frac{d^2v_{out}}{dt^2} + \frac{L}{R}\frac{dv_{out}}{dt}$$

Resonant Circuit Analysis



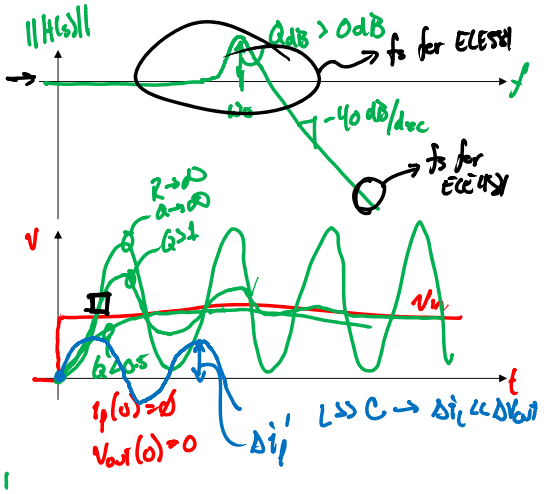
$$Z_{out}(s) = sL + R\|\frac{1}{sC}$$

$$H(s) = \frac{V_{out}(s)}{V_{in}(s)} = \frac{R\|\frac{1}{sC}}{sL + R\|\frac{1}{sC}}$$

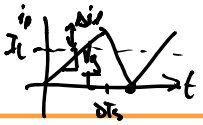
$$H(s) = \frac{1}{\frac{sL}{R\|\frac{1}{sC}} + 1}$$

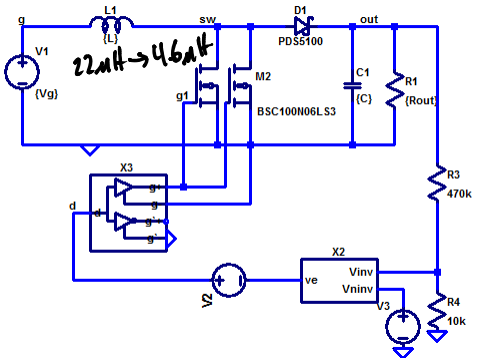
$$= \frac{1}{\frac{sL(sC)(R+\frac{1}{sC})}{R} + 1}$$

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



Soft Switching





$\Delta i_p \geq I_L \rightarrow$ DCM

$\Delta i_p = \frac{1}{2}\frac{V_g}{L} DT_s$

DCM boundary:

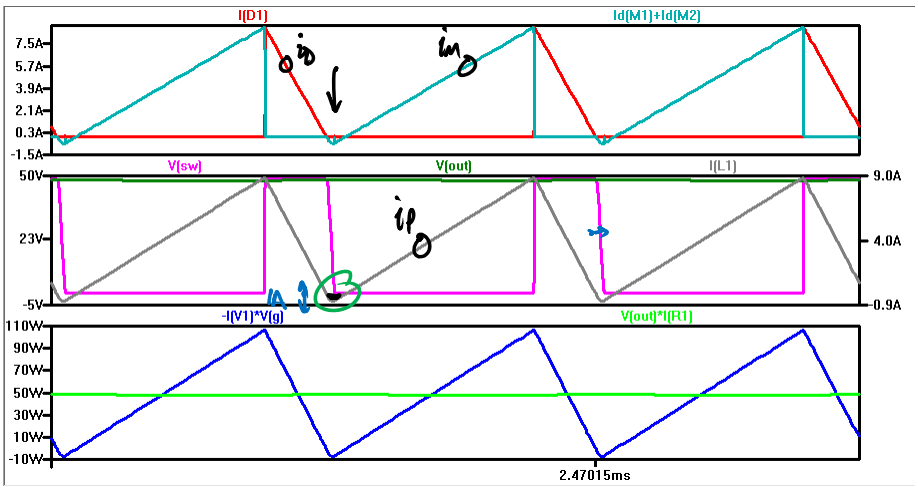
$L = \frac{1}{2}\frac{V_g}{I_L} DT_s = \frac{1}{2}\frac{(12V)}{(4A)}\frac{(0.75)}{(202kHz)}$

$L = 5.5\mu H$

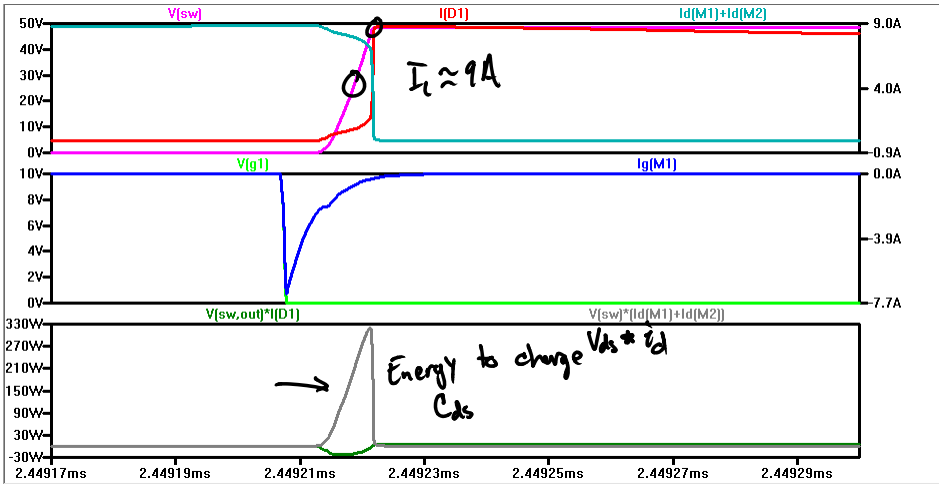
$\Delta i_p \approx 5A$

$L = 4.6mH$

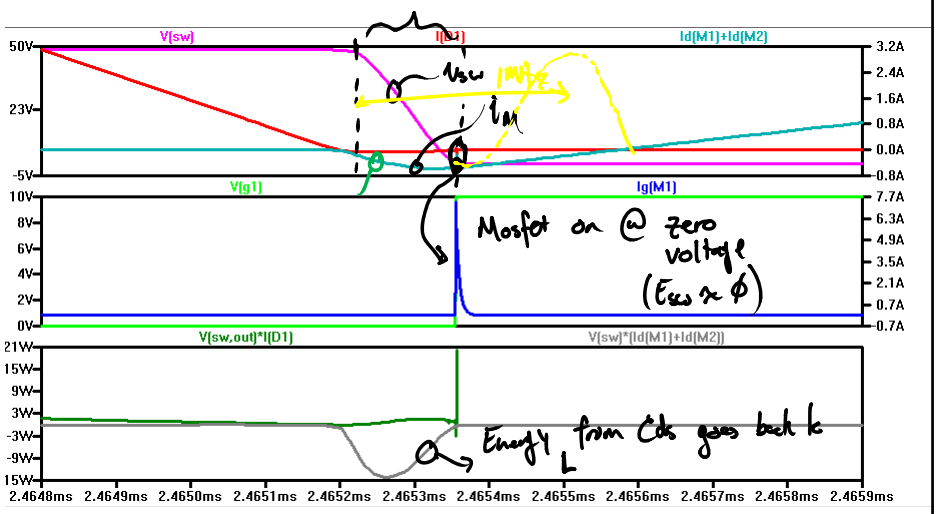
Soft Switching Simulation



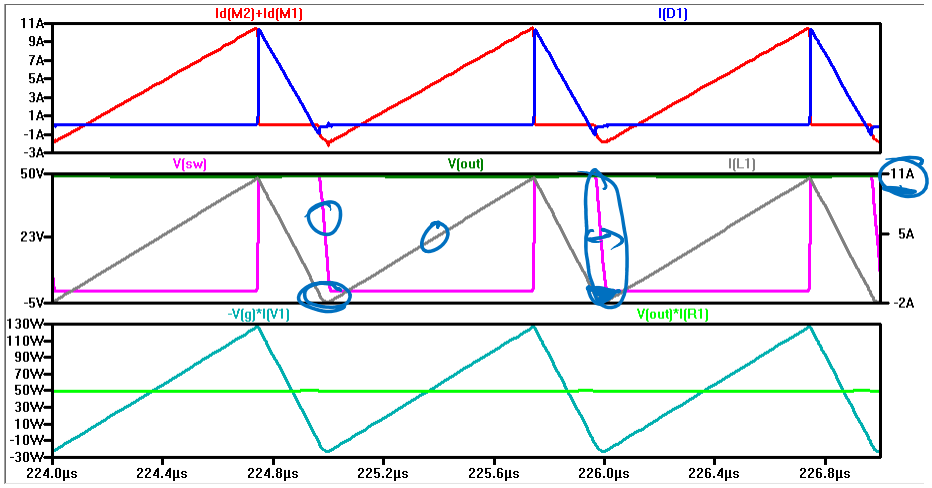
MOSFET Turn-Off



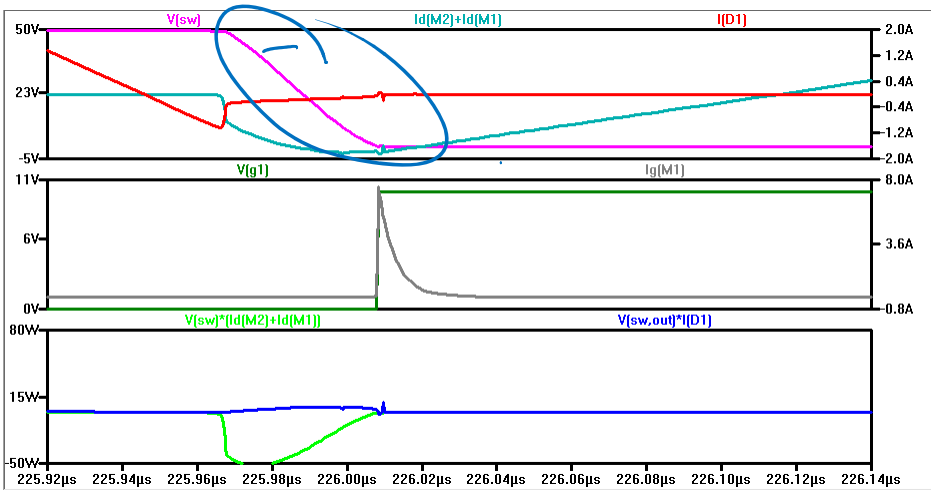
MOSFET Turn-On



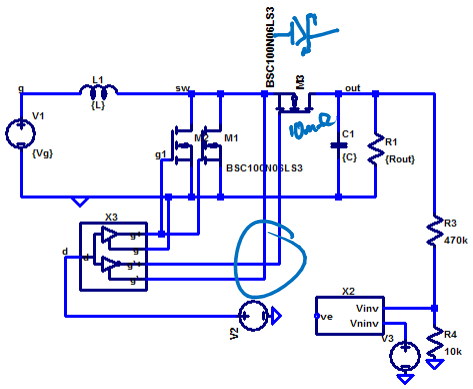
1 MHZ Operation



MOSFET Turn-On



Synchronous Operation



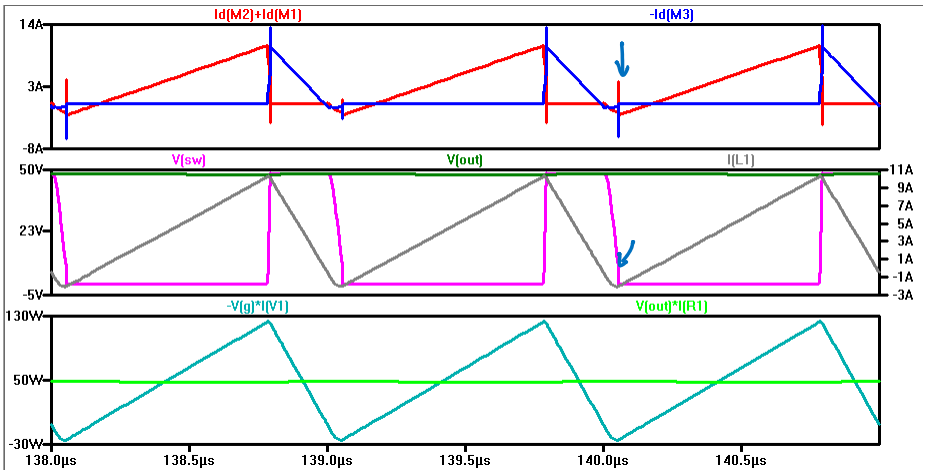
$i_{D,cond} \approx I_{out} V_D$

$= (1A)(0.75V) \approx 0.75W$

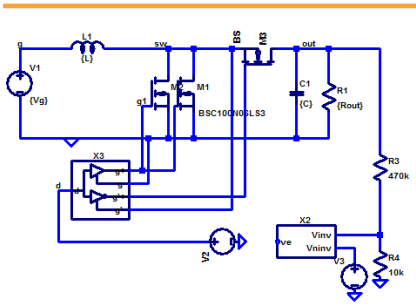
$i_{M,cond} = I_{M,rms}^2 r_{on}$

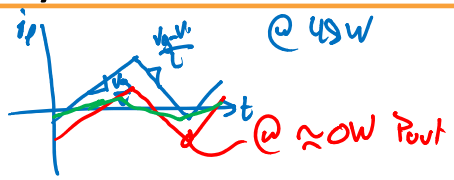
$\geq I_{out}^2 r_{on} \approx 10mW$

Synchronous Simulation



Summary Results





	L	C_{out}	f_s	Diode	η (Sim)
	22uH	22uF	202k	Si (FR)	93.9%
	22uH	22uF	202k	Si Schottky	96.9%
Soft Switched	4.65uH	22uF	202k	Si Schottky	98.5%
Soft Switched	710nH	4.4uF	1 MHz	Si Schottky	98.4%
Soft Switched	710nH	4.4uF	1 MHz	MOSFET	99.8%