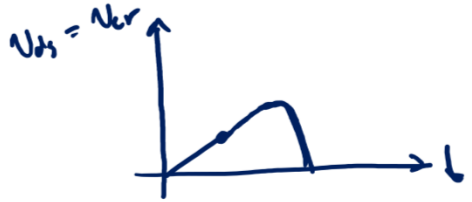
Complete Solution

$$M = 1 - \frac{F}{2\pi}\left(\frac{\theta}{2} + \beta + J_2 + J_L\right)$$

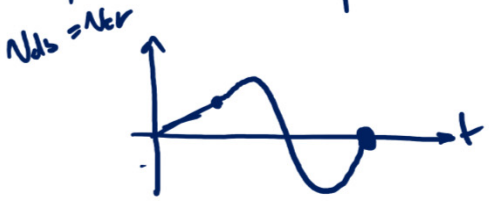
$$M = 1 - \frac{F}{2\pi}\left(\frac{1}{2J_L} + \pi + \sin^{-1}\left(\frac{1}{J_L}\right) + \sqrt{J_L^2 - 1} \quad \tau J_L\right)$$

In book, this is $M = 1 - F \cdot P_{1/2}\left(\frac{1}{J_L}\right)$

The ZVS-QR waveforms we analyzed are for a "half-wave" implementation



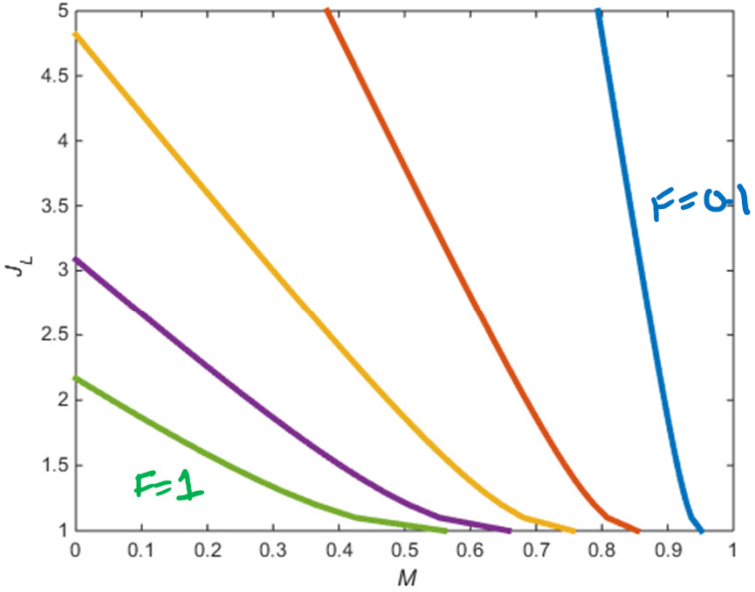
the full-wave implementation:



MOSFET must be voltage bidirectional

e.g.

$$M = 1 - F \cdot P\left(\frac{1}{J_L}\right)$$



MOSFET Voltage Stresses

Peak voltage on transistor $m_{ds,pk} = m_{cr,pk} = 1 + r_2 = 1 + J_L$

together with ZVS condition $J_L \geq 1$

If we get ZVS, $V_{ds,pk} \geq 2 \cdot V_g$ → only ZVS @ full load

if e.g. we want for 80% of load range

at full load $J_L = 5$

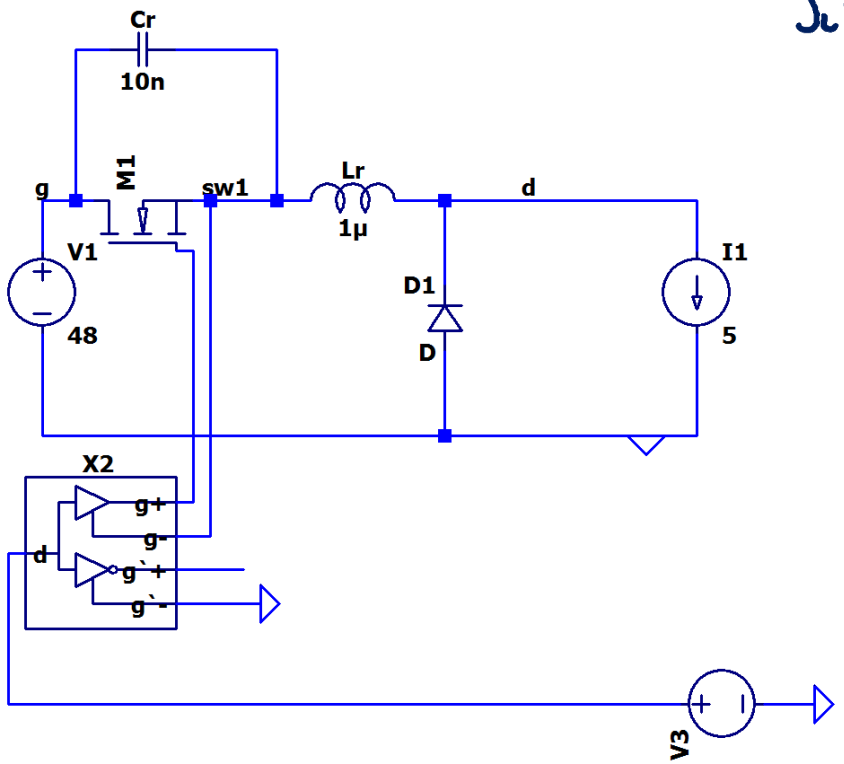
$$m_{ds,pk} = 1 + 5 = 6$$

$$V_{ds,pk} = 6 \cdot V_g$$

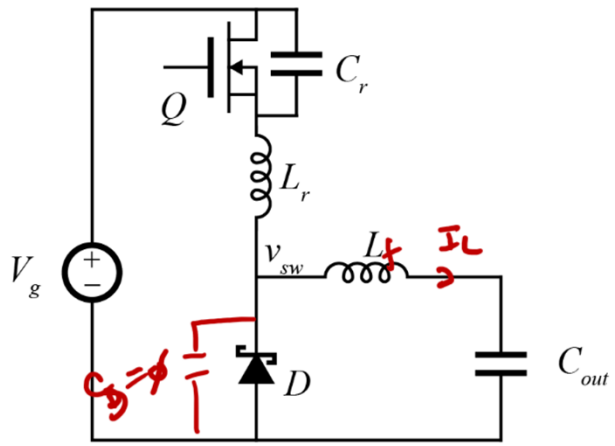
Test Circuit

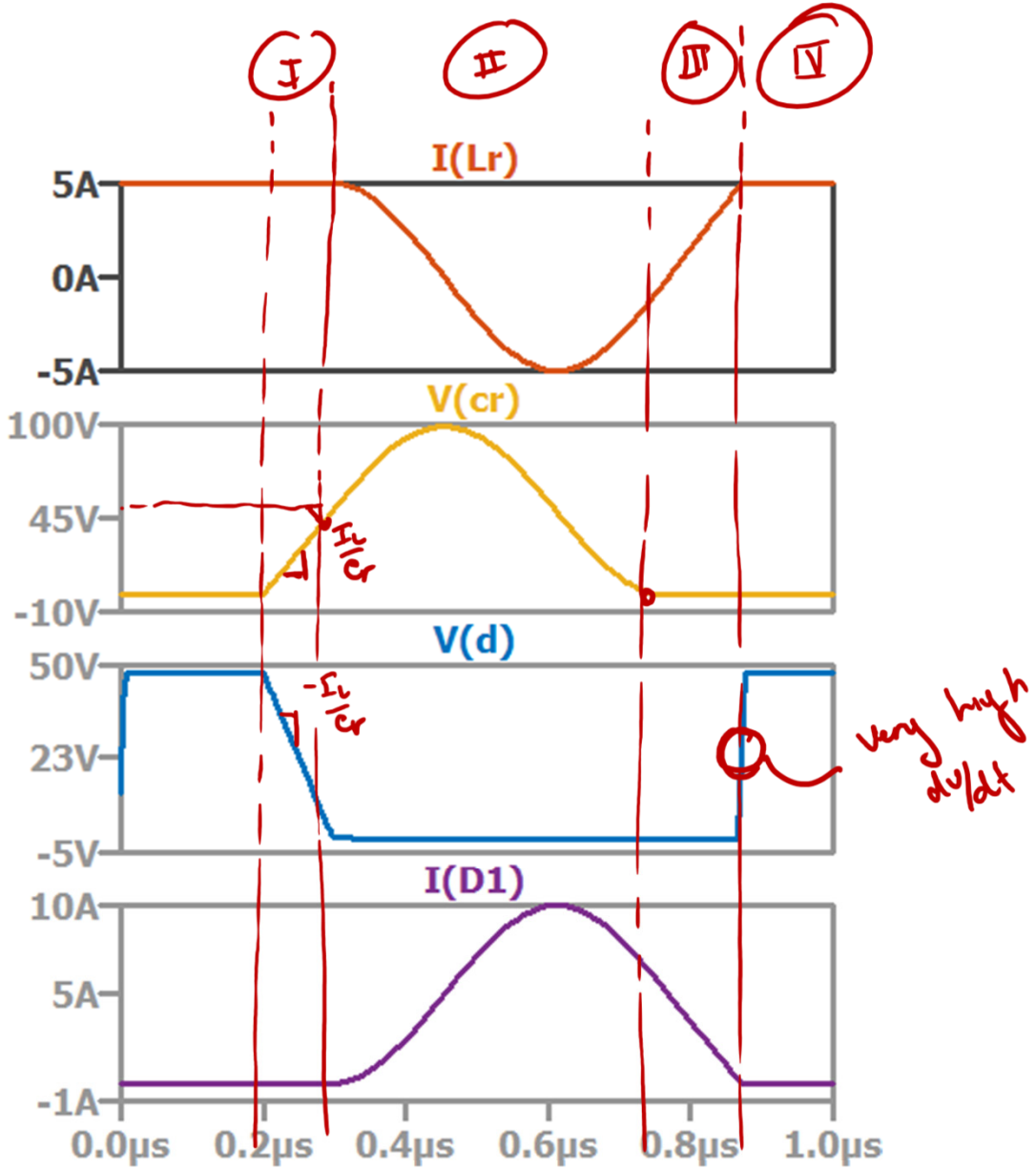
48-to-16V converter
$f_s = 1$ MHz

$J_L = \frac{5A}{48V\sqrt{\frac{1m}{10n}}} \approx 1$ → operating @ ZVS boundary

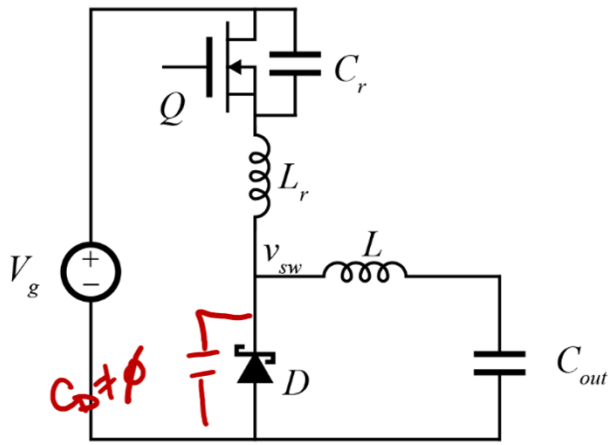


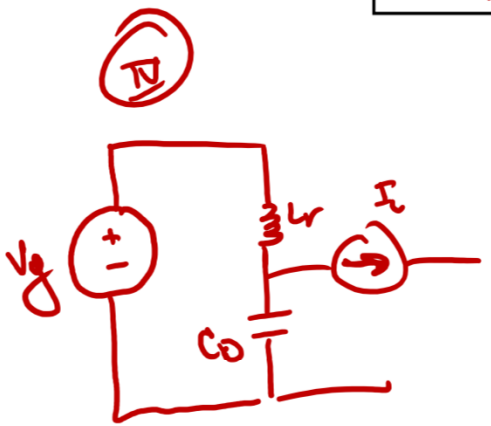
Simulation Results

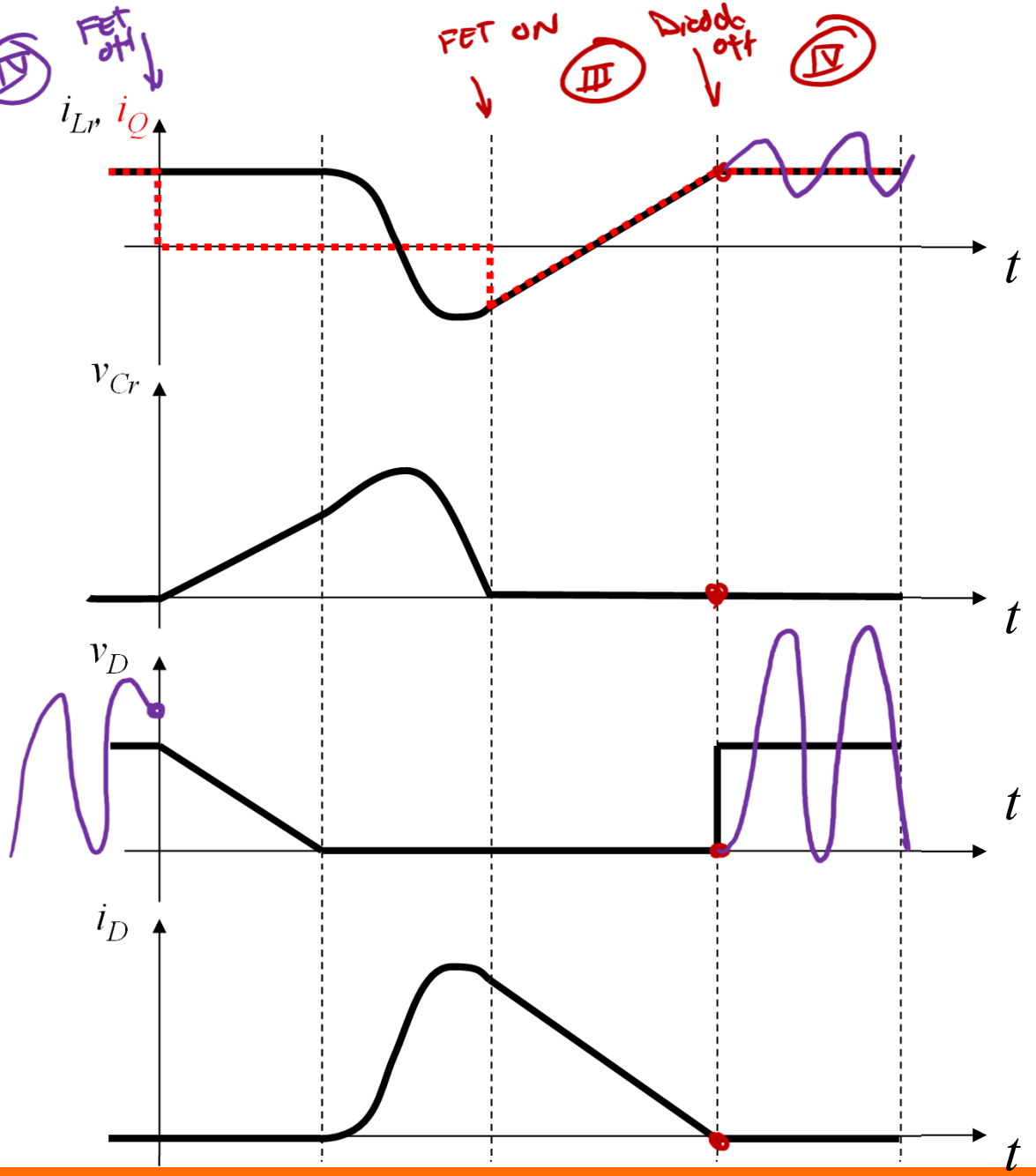




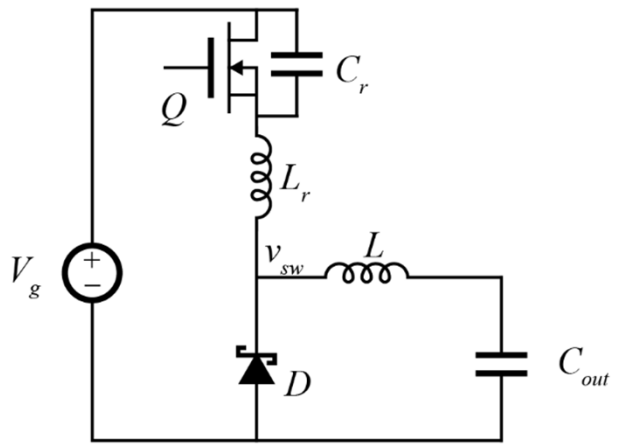
Diode Capacitance



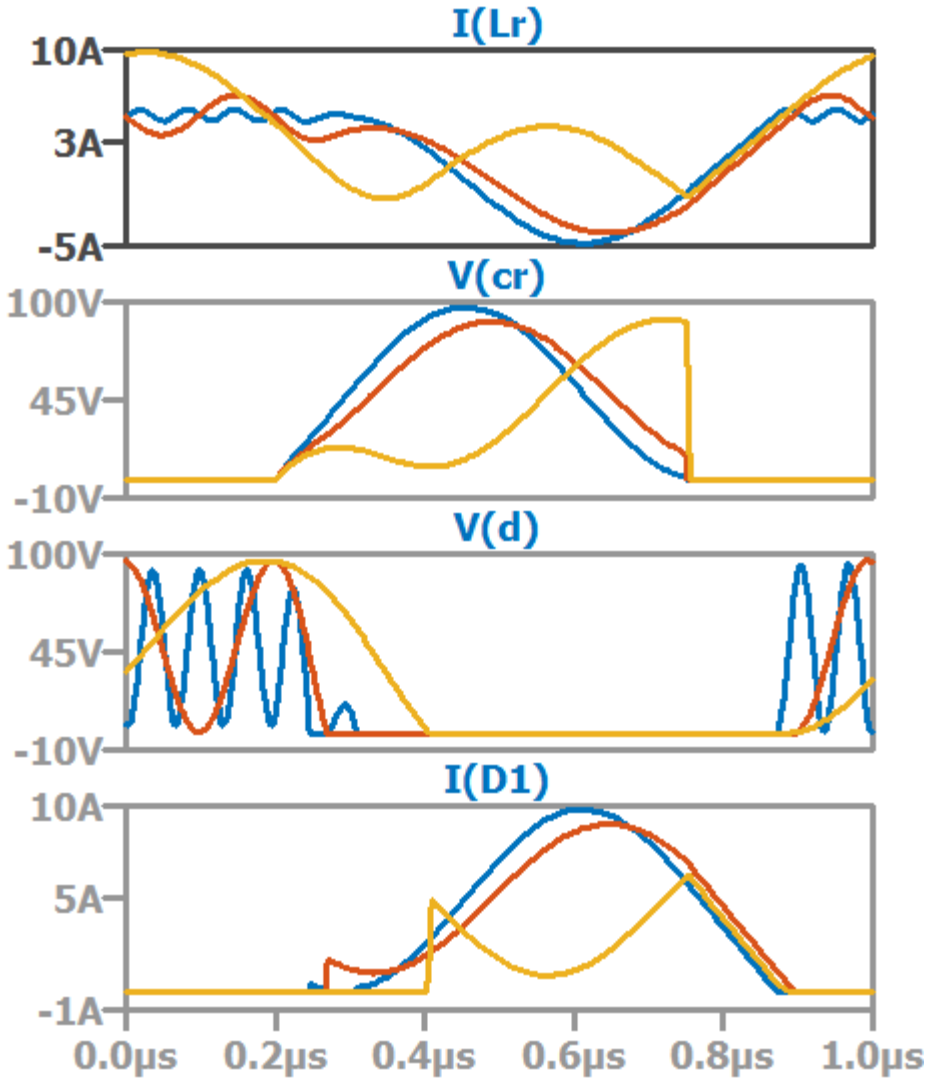




Simulation Results: Diode Capacitance

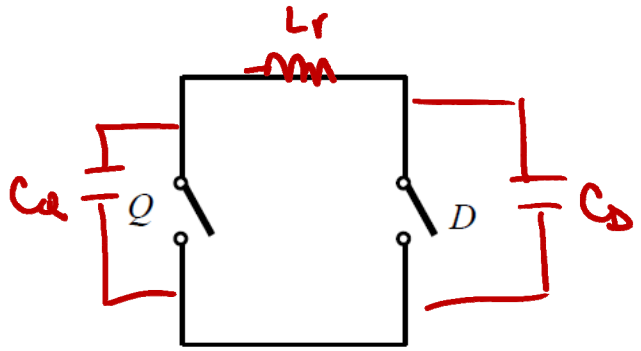


C_D = 100pF
1nF
10nF

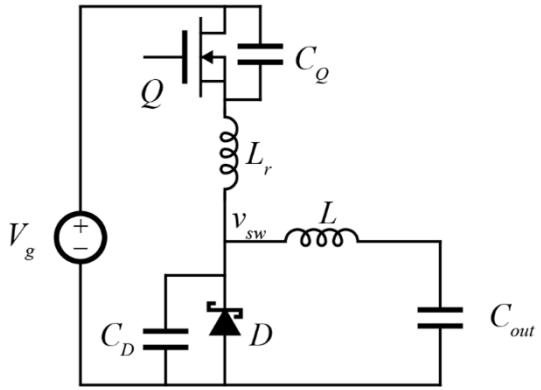


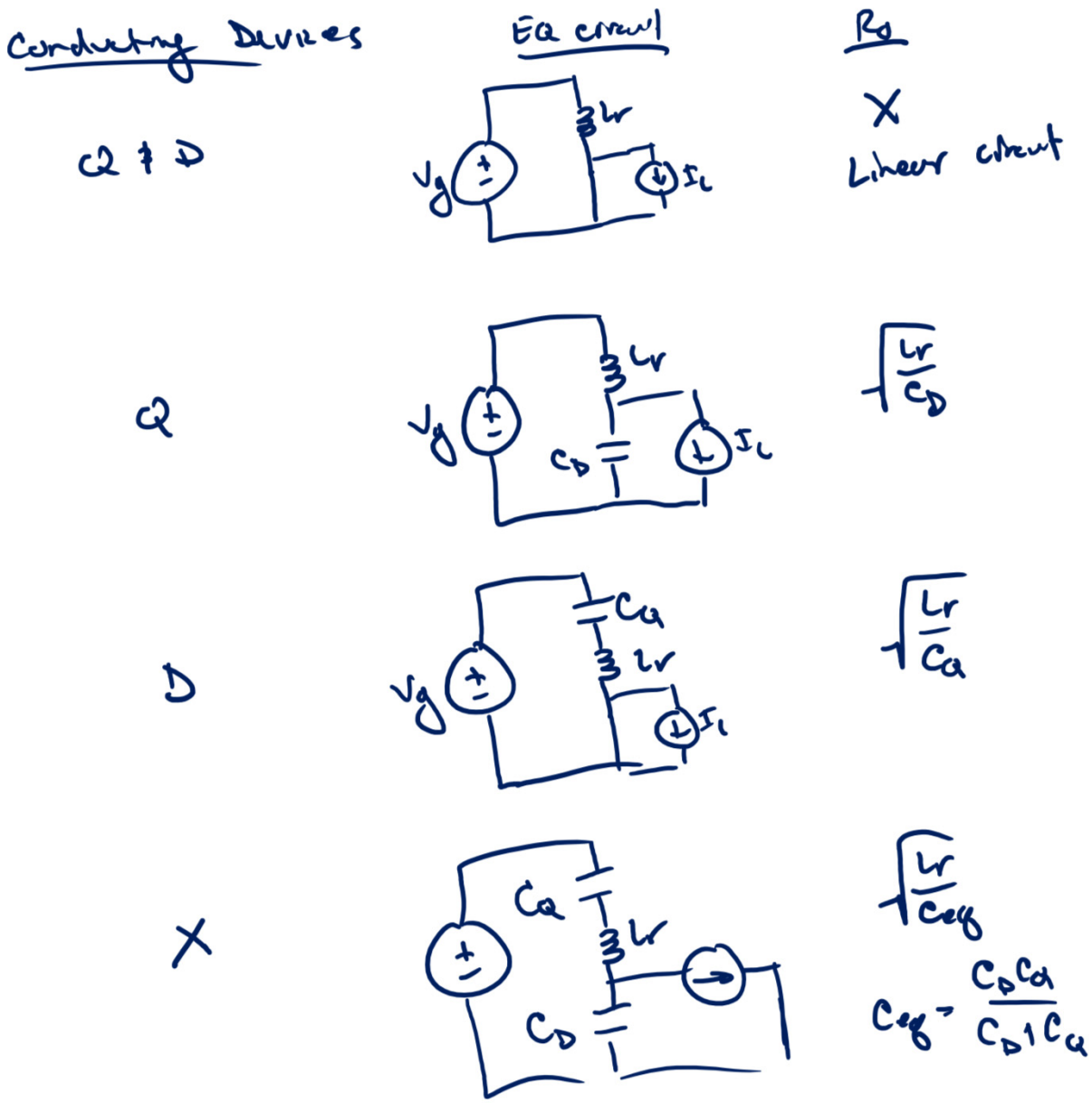
Wishlist: Multi-Resonant

ZVS-MR switch Network



ZVS-MR Buck





W. A. Tabisz and F. C. Lee, "Zero-voltage-switching multi-resonant technique-a novel approach to improve performance of high frequency quasi-resonant converters," *Power Electronics Specialists Conference, 1988.*

Operating Modes

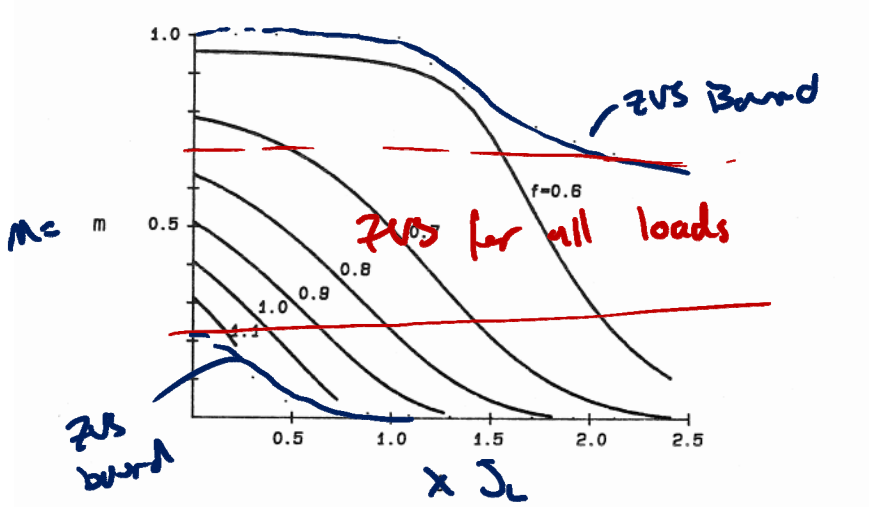
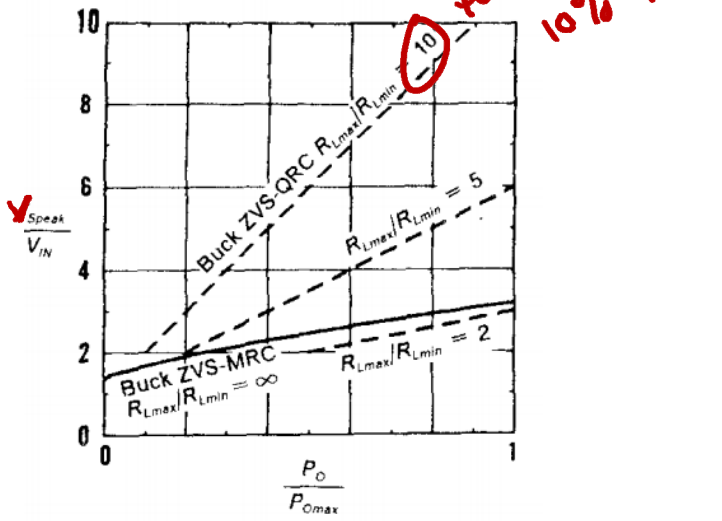


Figure 10.7: Load-to-output DC characteristics of a ZV-MR converter operating in modes $(I, II)_1$.



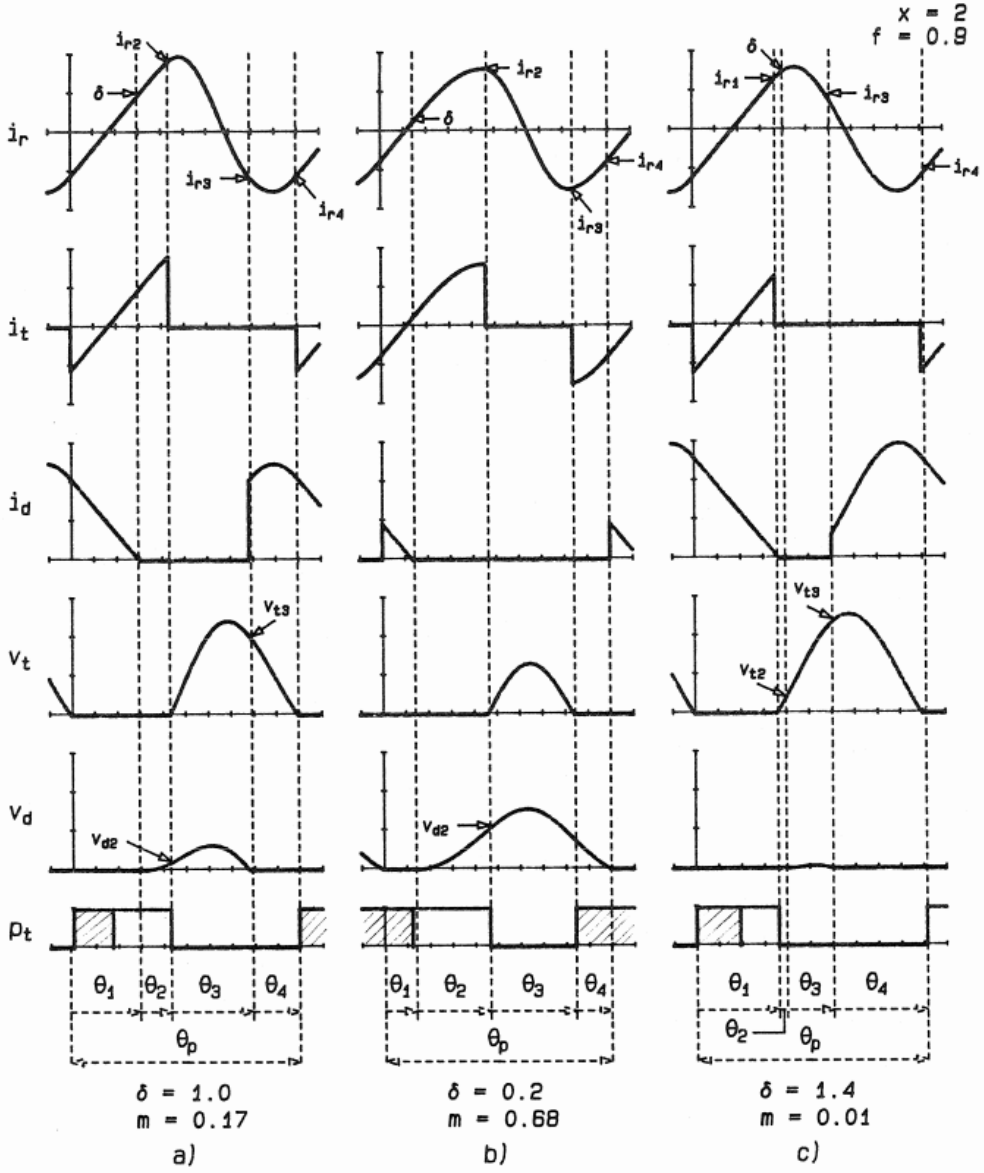


Figure 10.2: Typical waveforms for a ZV-MR converter operating in modes I_1 (a), II_1 (b) or III_1 (c).