Closed-Form Solution

$$J = \frac{F}{\pi} 2 M_1 \qquad \frac{\pi}{F} = \alpha + \beta$$

$$M_1 = \frac{2 \tan\frac{\alpha}{2} \tan\frac{\beta}{2}}{1 - \tan\frac{\alpha}{2} \tan\frac{\beta}{2}}$$

$$\alpha = \frac{\pi}{F} - \beta$$

$$J = \frac{F}{\pi} 4 \frac{\tan\frac{\alpha}{2} \tan\frac{\beta}{2}}{1 - \tan\frac{\alpha}{2} \tan\frac{\beta}{2}}$$

$$J = \frac{F}{\pi} 4 \frac{\tan\left(\frac{\pi}{2F} - \frac{\beta}{2}\right) \tan\left(\frac{\beta}{2}\right)}{1 - \tan\left(\frac{\pi}{2F} - \frac{\beta}{2}\right) \tan\frac{\beta}{2}}$$

$$J = f(F, \beta)$$

control

$$\begin{cases} \alpha = 2 \tan^{-1}\left(\frac{M_1}{J_1}\right) \\ \beta = 2 \tan^{-1}\left(\frac{J_1}{2 + M_1}\right) \end{cases}$$

$$M_1 = \tan\left(\frac{\alpha}{2}\right) J_1$$

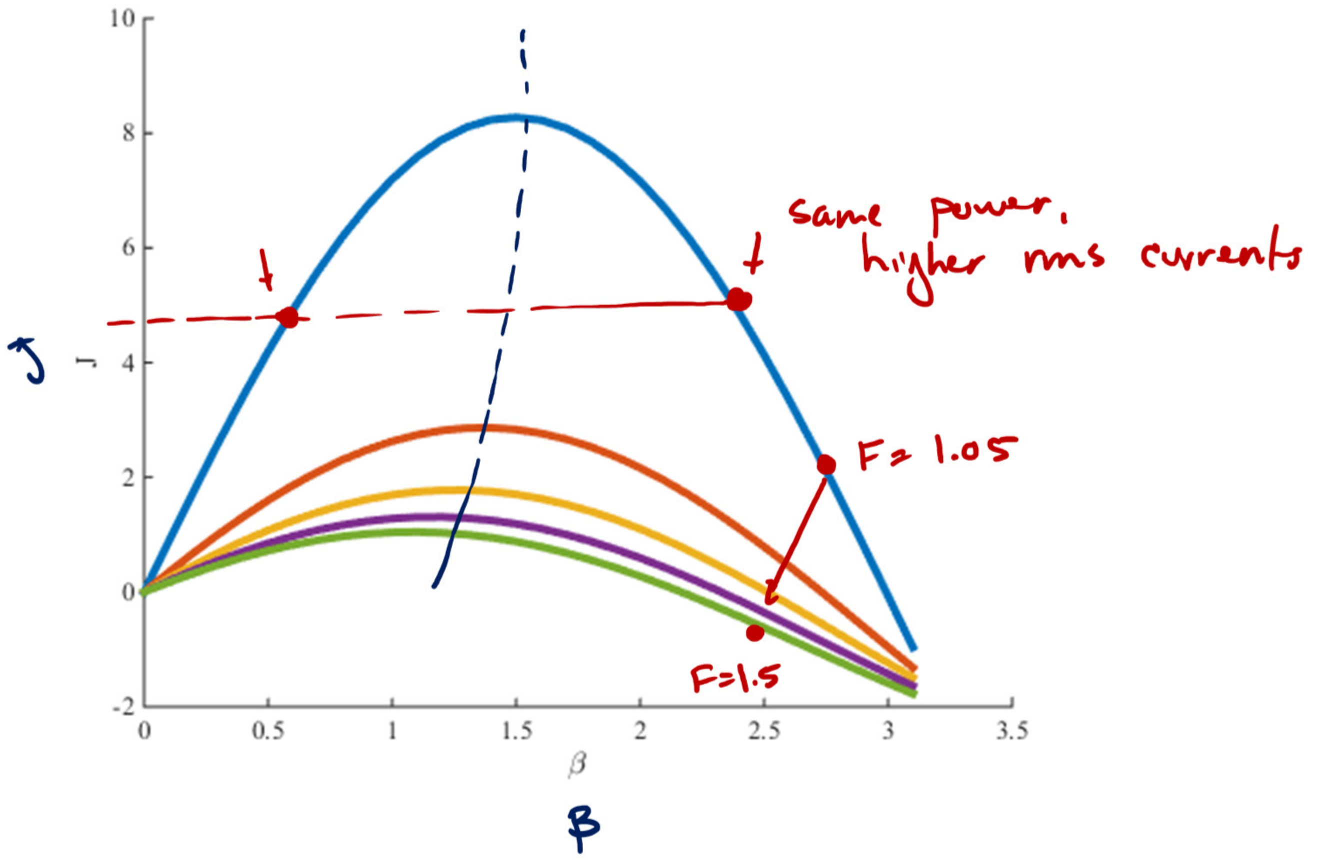
$$J_1 = \tan\left(\frac{\beta}{2}\right)\left(2 + \tan\frac{\alpha}{2} J_1\right)$$

$$J_1 = \frac{2 \tan\frac{\beta}{2}}{1 - \tan\frac{\beta}{2} \tan\frac{\alpha}{2}}$$

SRC Control Trajectory

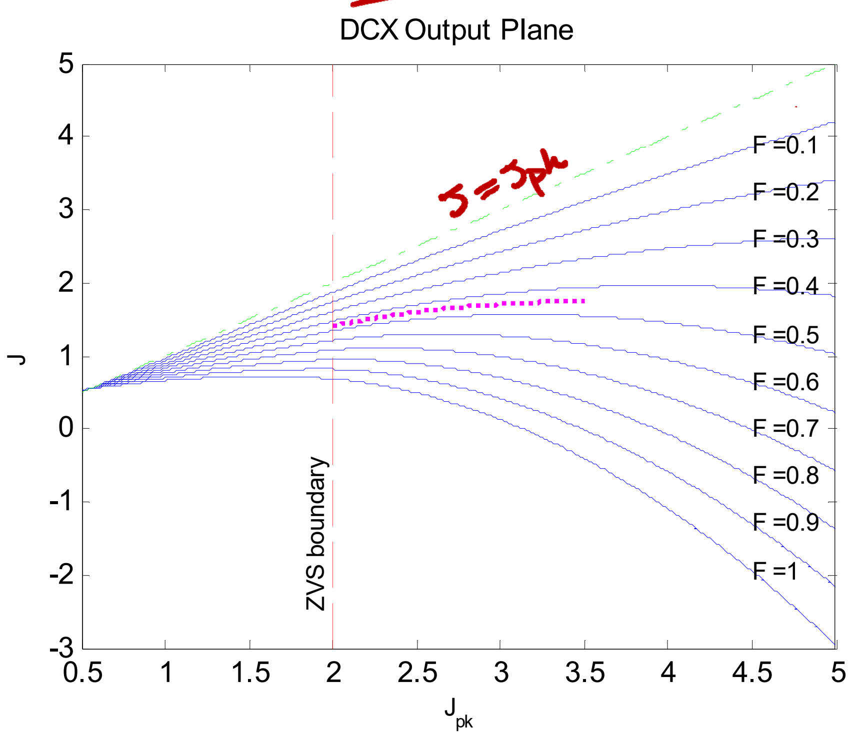
$F = \frac{f_s}{f_0} \geq 1$ for this SRC mode operation

↳ gives possibility of ZVS

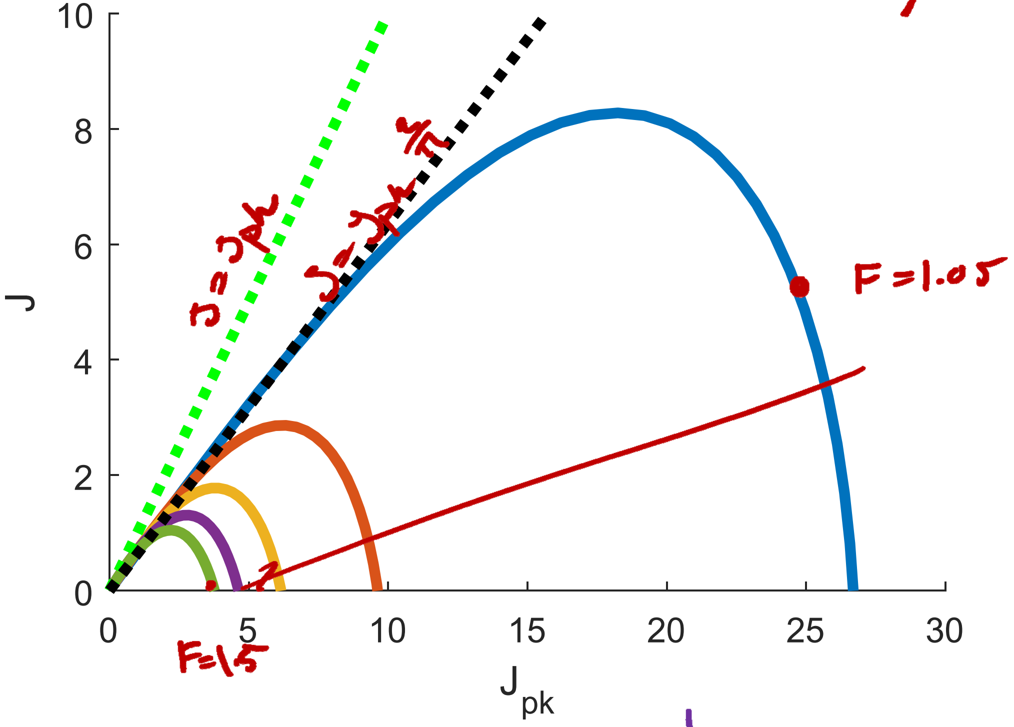


SRC Current Stress

DAB



SRC

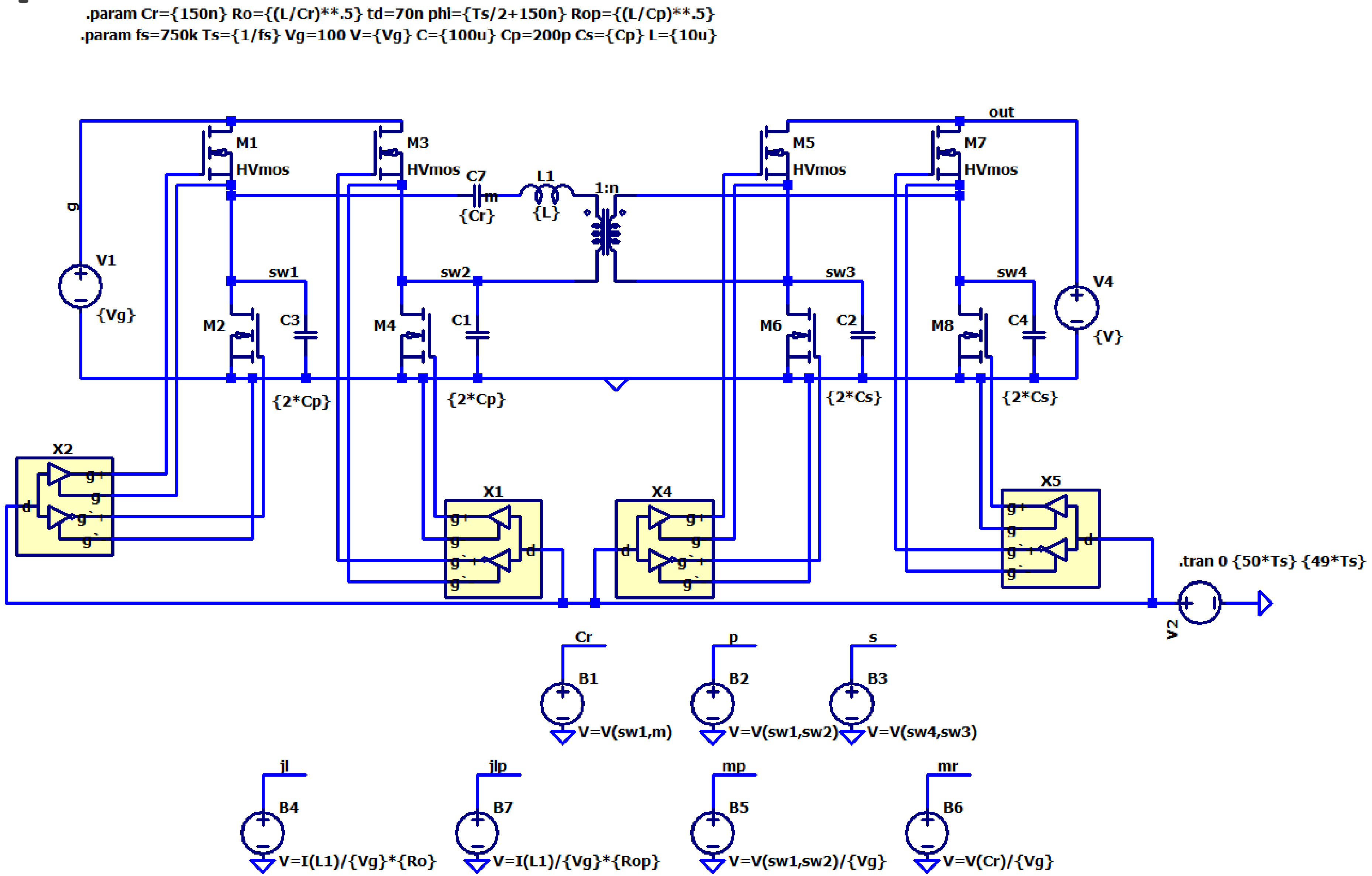


$\omega_0 = \frac{1}{\sqrt{L_\ell C_p}}$

$\omega_0 = \frac{1}{\sqrt{L_\ell C_r}}$

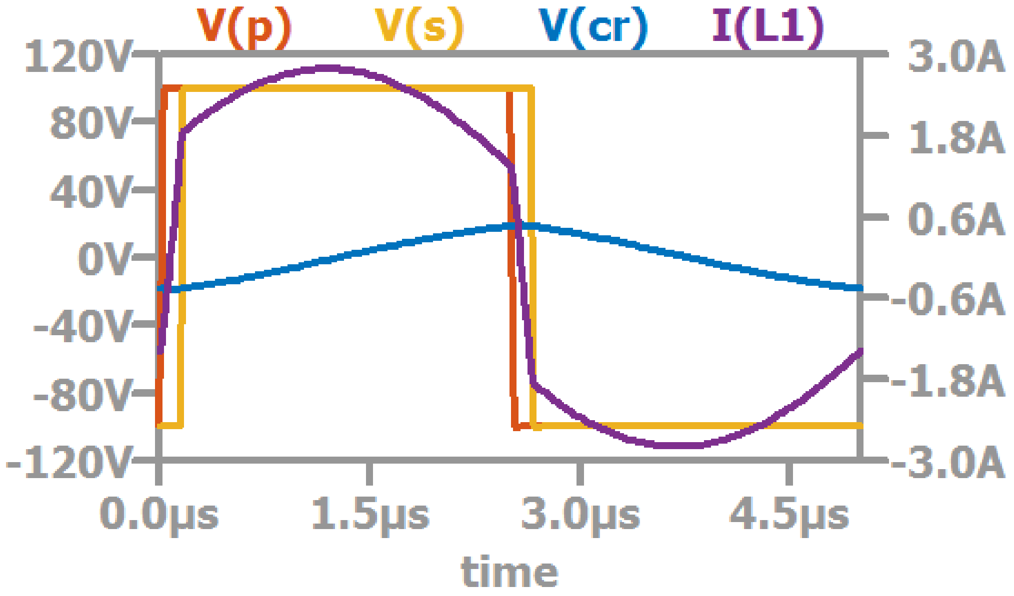
C_p & C_s neglected

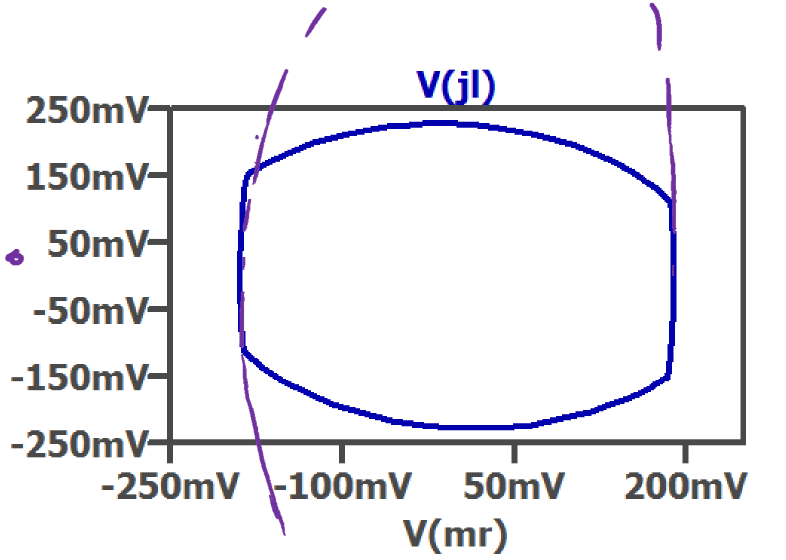
Example Simulation

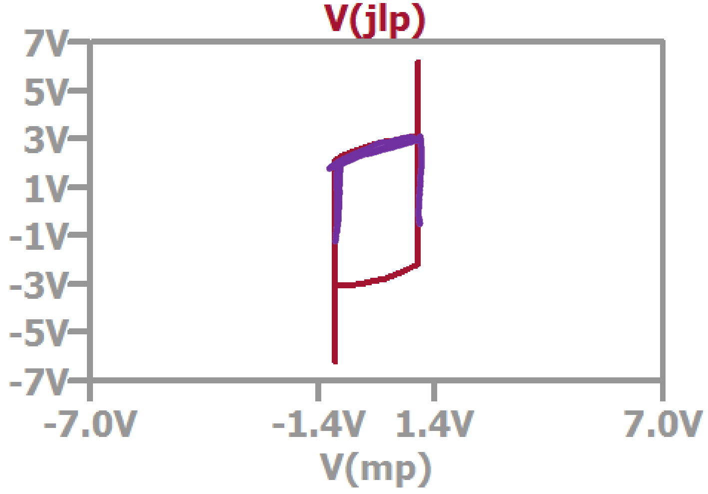


SRC Simulation

I_{out} = 2A
f_s = 200kHz
f_o = 130kHz
V_g = 100V
V_{out} = 100V

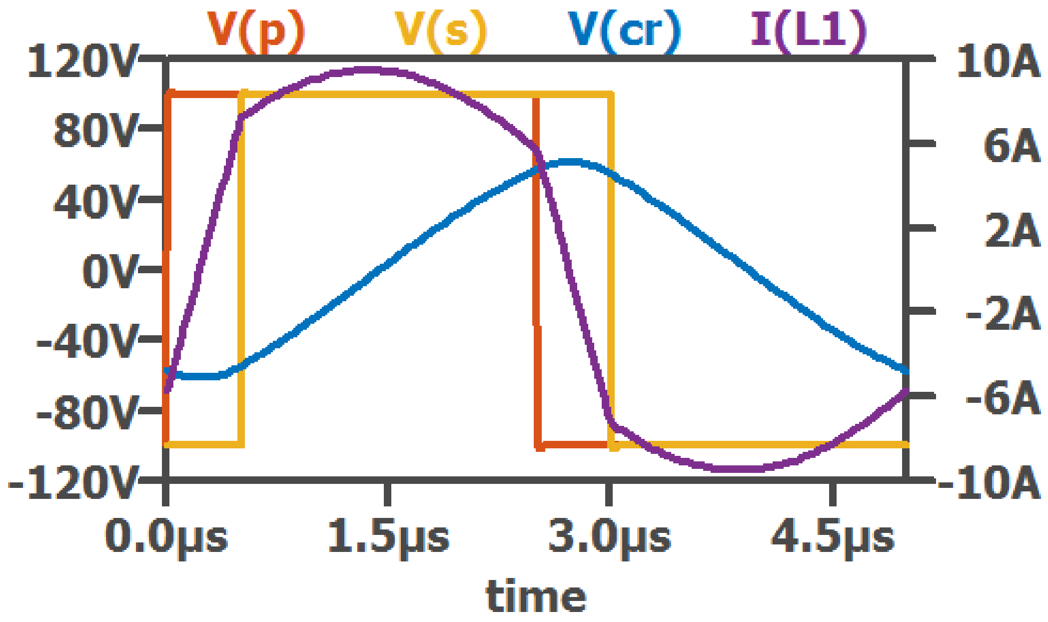


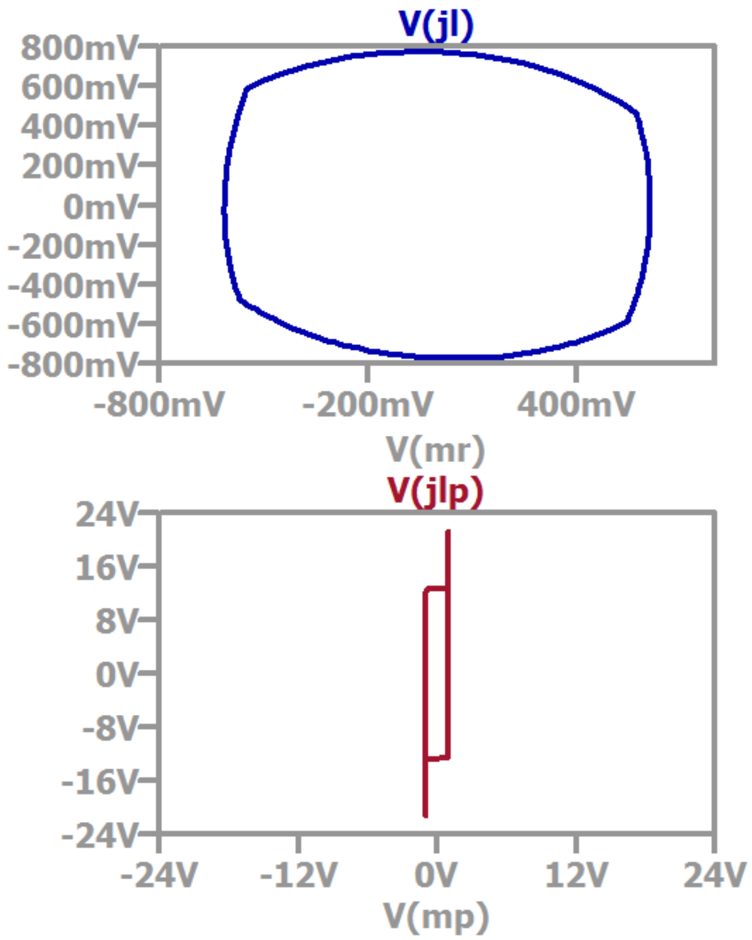




SRC Simulation

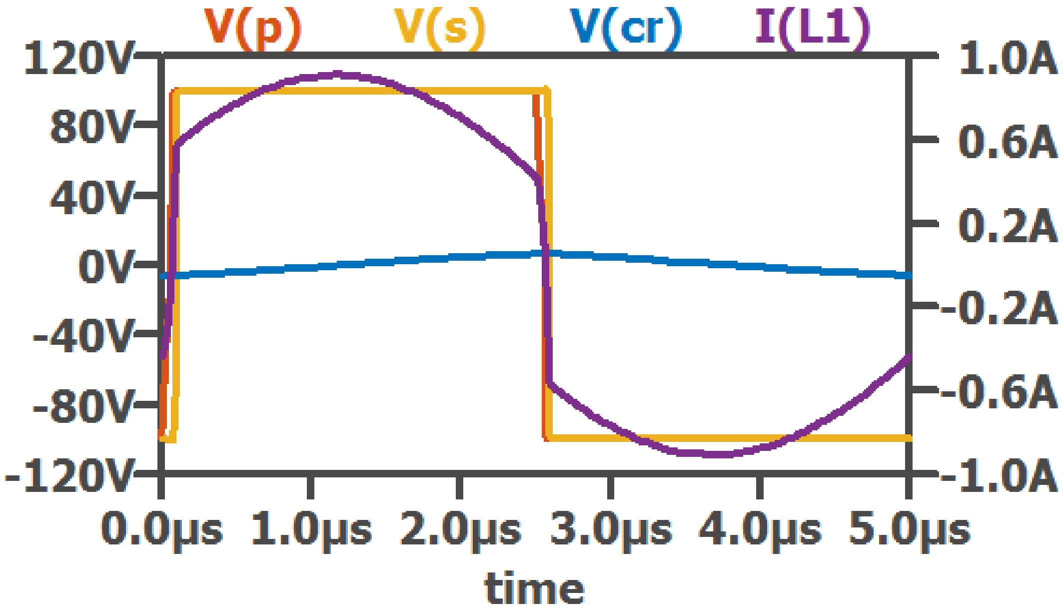
I_{out} = 6.5A
f_s = 200kHz
f_o = 130kHz
V_g = 100V
V_{out} = 100V

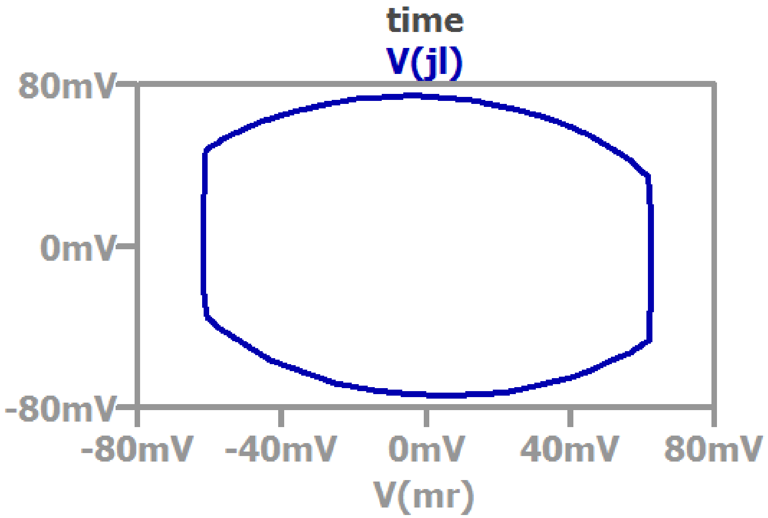


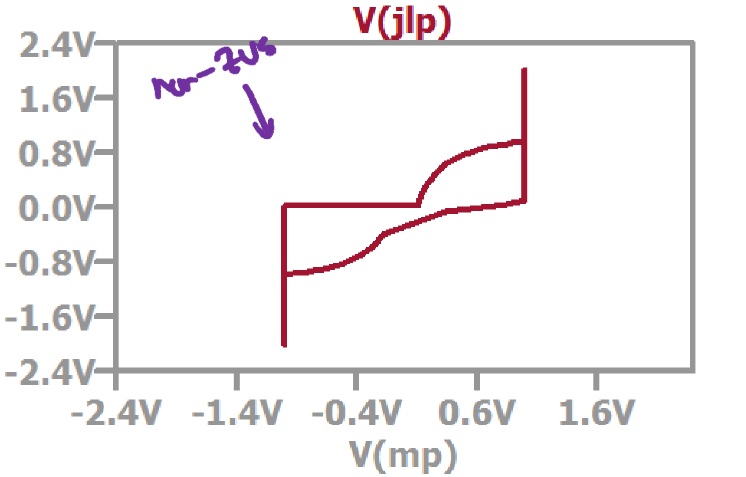


SRC Simulation

I_{out} = 500mA
f_s = 200kHz
f_o = 130kHz
V_g = 100V
V_{out} = 100V



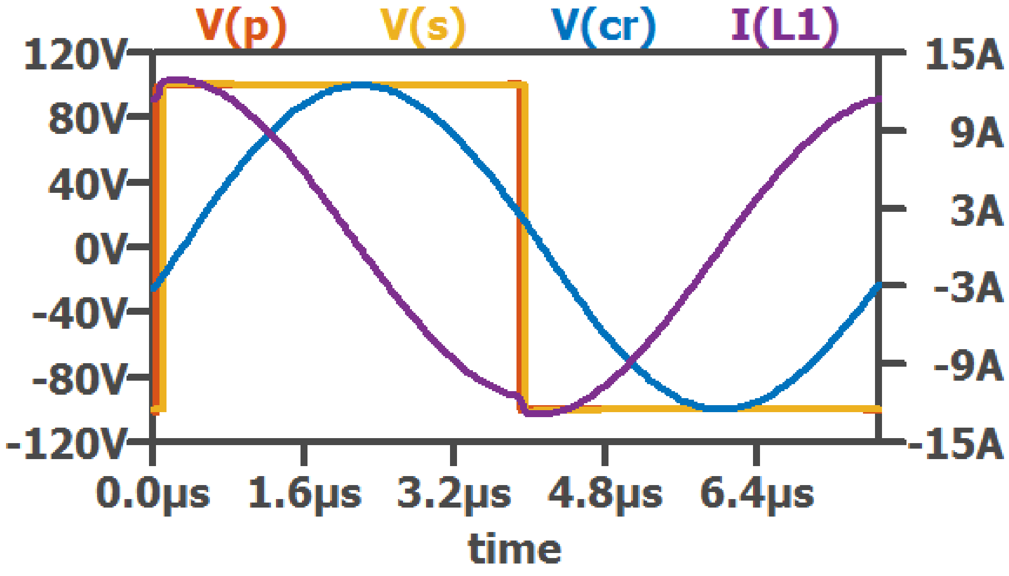


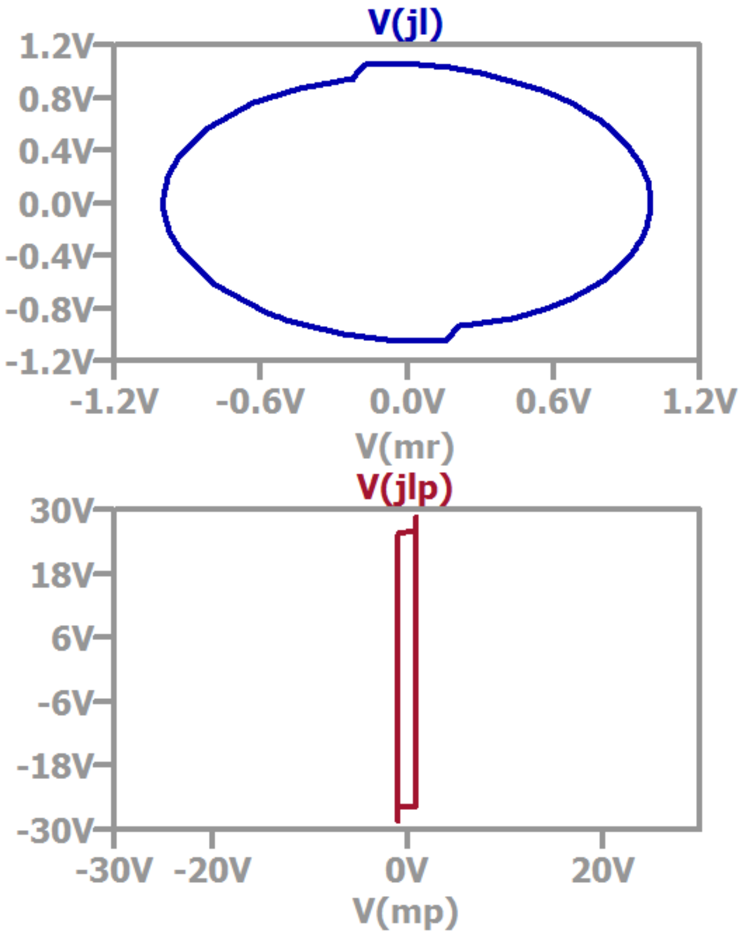


SRC Simulation

I_{out} = 1.2A
f_s = 130kHz
f_o = 130kHz
V_g = 100V
V_{out} = 100V

F=1

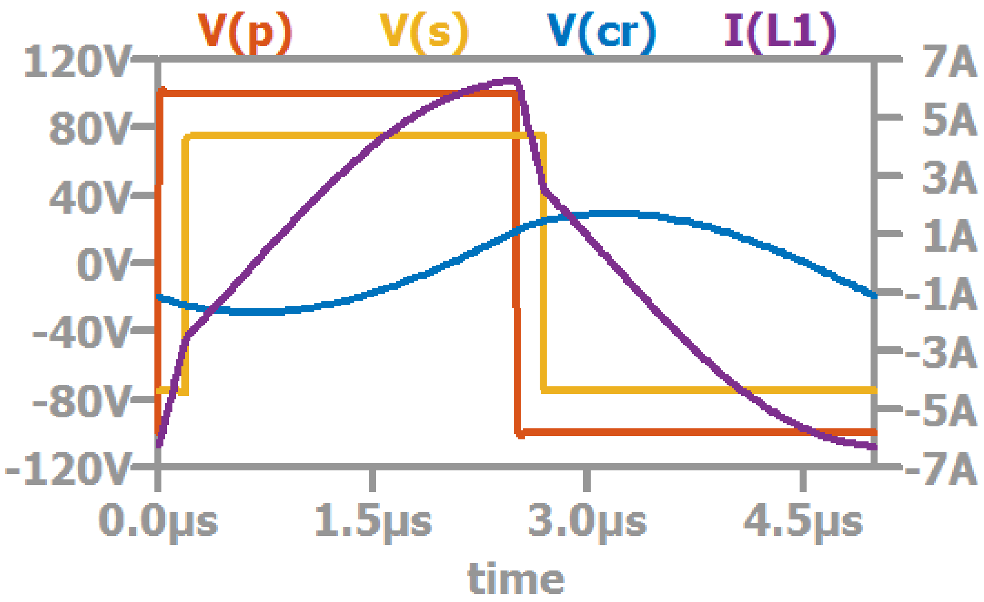


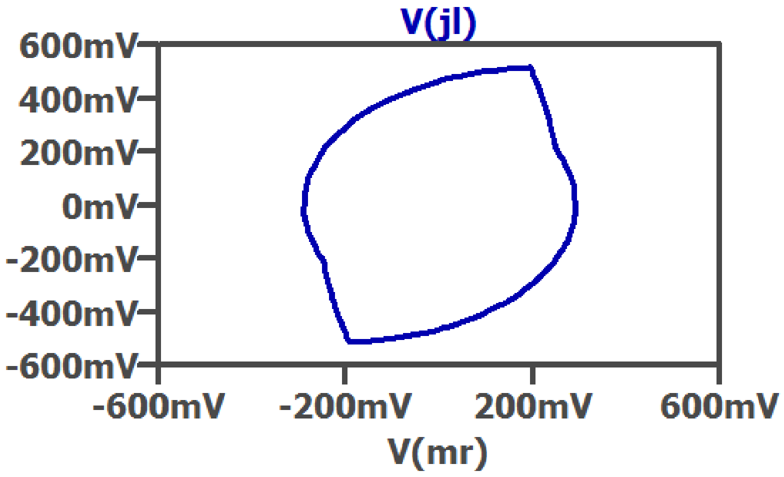


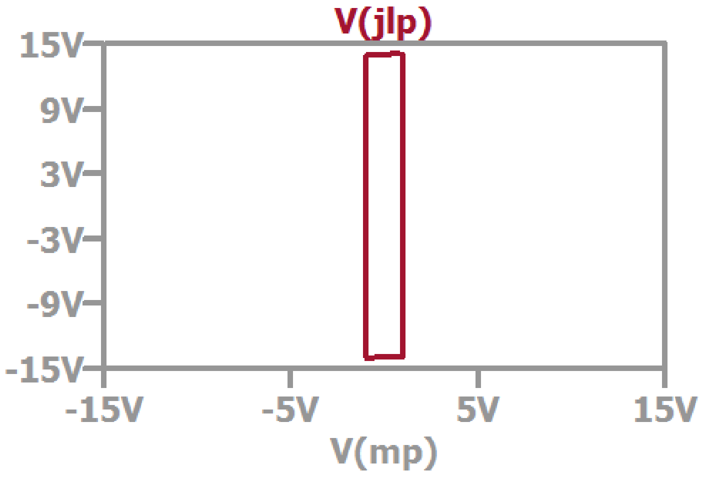
SRC Simulation

all cases
n=1

I_{out} = 3A
f_s = 200kHz
f_o = 130kHz
V_g = 100V
V_{out} = 75V

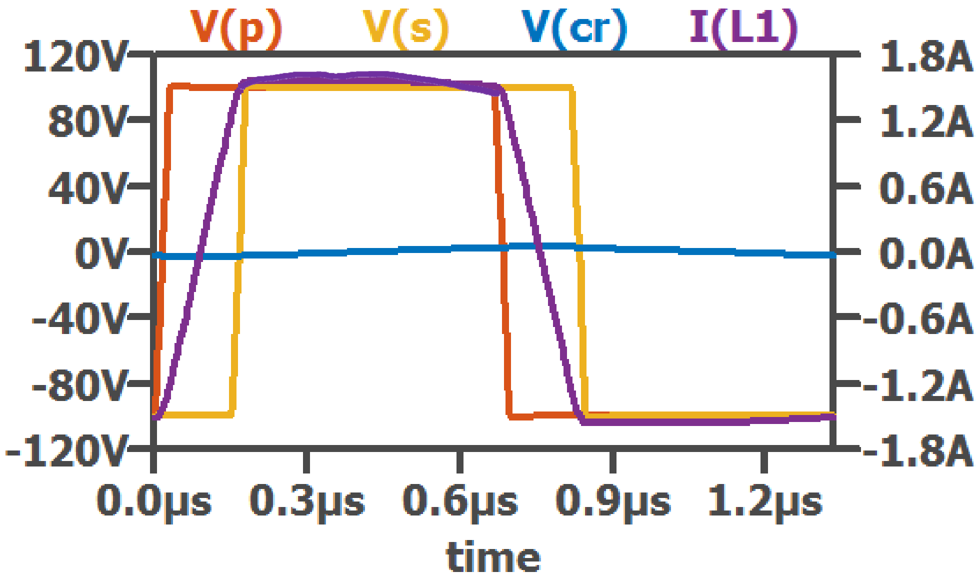


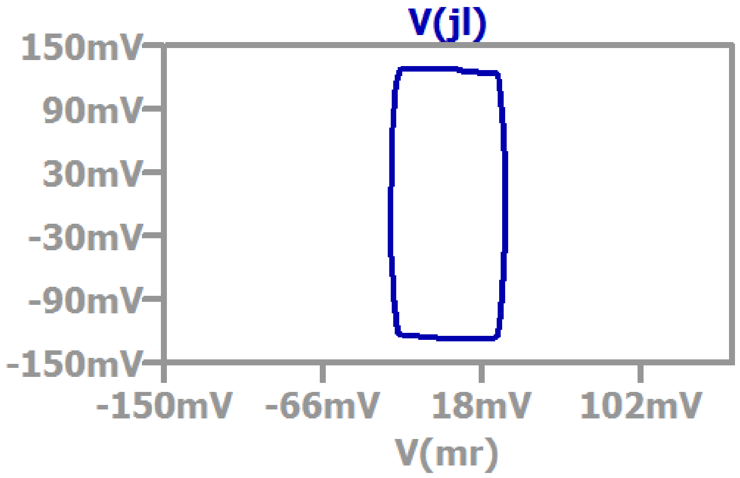


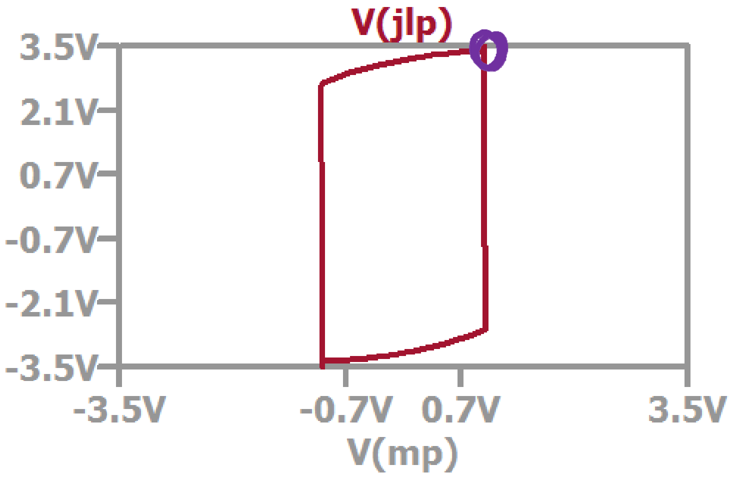


SRC Simulation

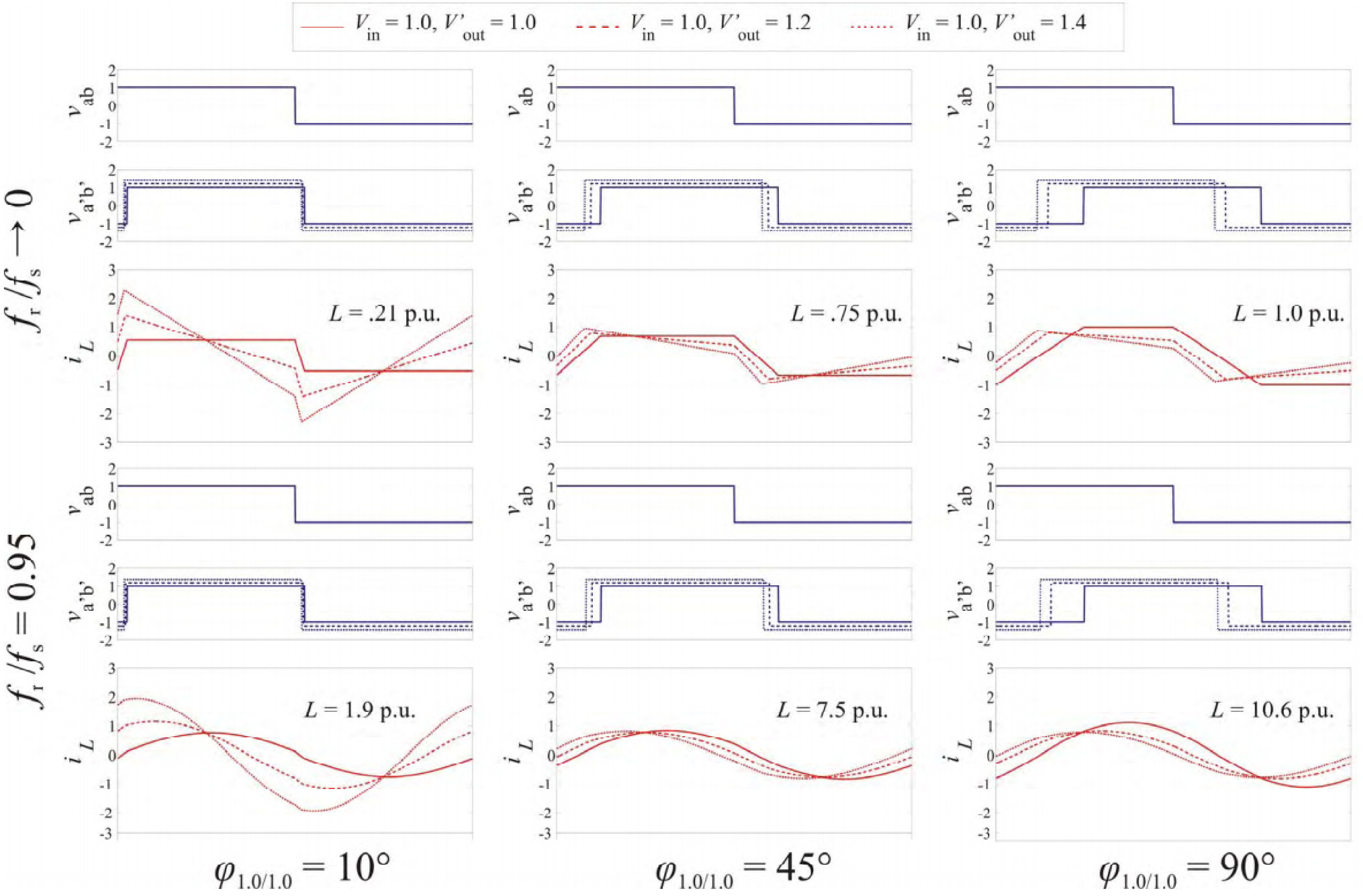
I_{out} = 1A
f_s = 750kHz
f_o = 130kHz
V_g = 100V
V_{out} = 100V



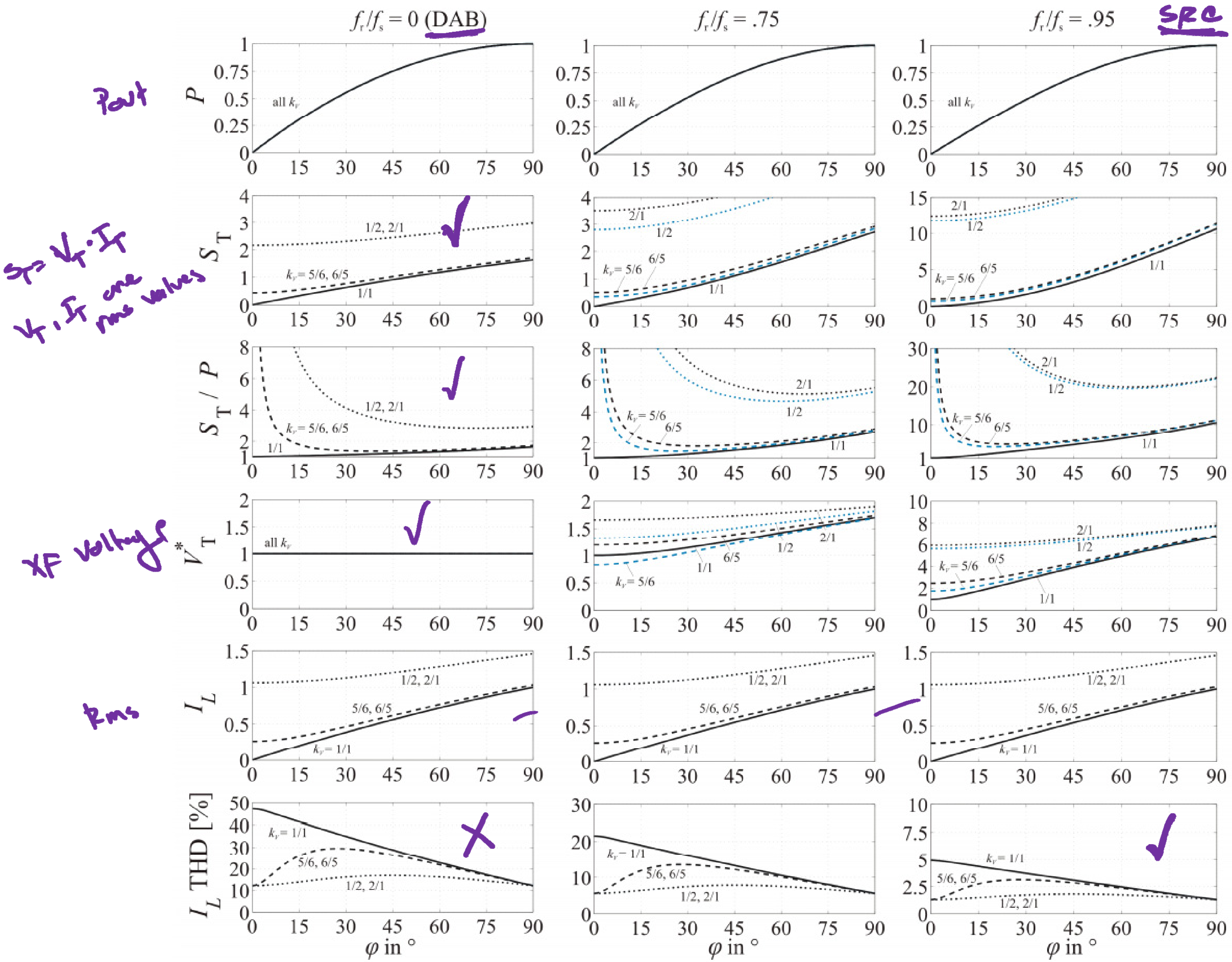




DAB vs SRC



R. Lenke, F. Mura and R. W. De Doncker, "Comparison of non-resonant and super-resonant dual-active ZVS-operated high-power DC-DC converters,"



R. Lenke, F. Mura and R. W. De Doncker, "Comparison of non-resonant and super-resonant dual-active ZVS-operated high-power DC-DC converters,"

DAB vs SRC: Conclusions

DAB

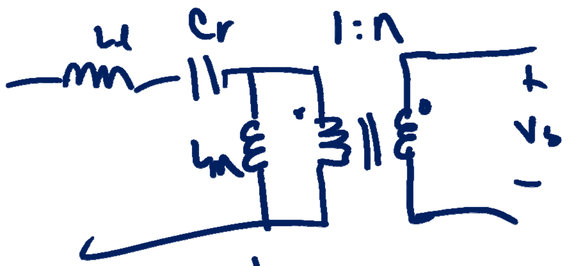
+ Smaller resonant tank
+ Smaller RMS currents
+ Wider Soft-switching range

SRC

+ Can be designed with larger XF inductance
+ Lower AC winding losses
+ Reduced device turn-off losses

modify

LLC tank → SRC with extended ZVS range



↳ let Lm reduce from → ∞

R. Lenke, F. Mura and R. W. De Doncker, "Comparison of non-resonant and super-resonant dual-active ZVS-operated high-power DC-DC converters,"