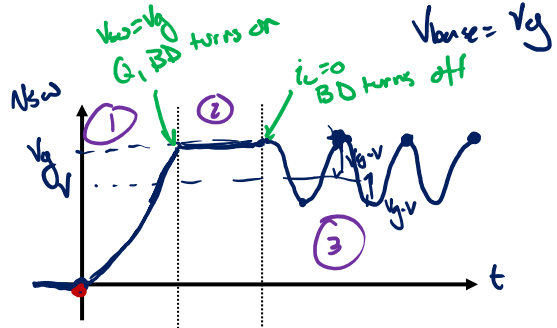
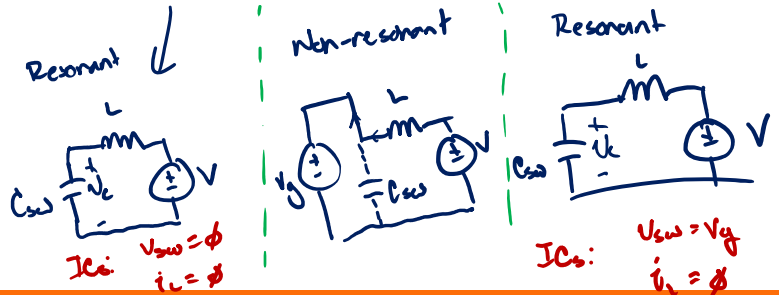
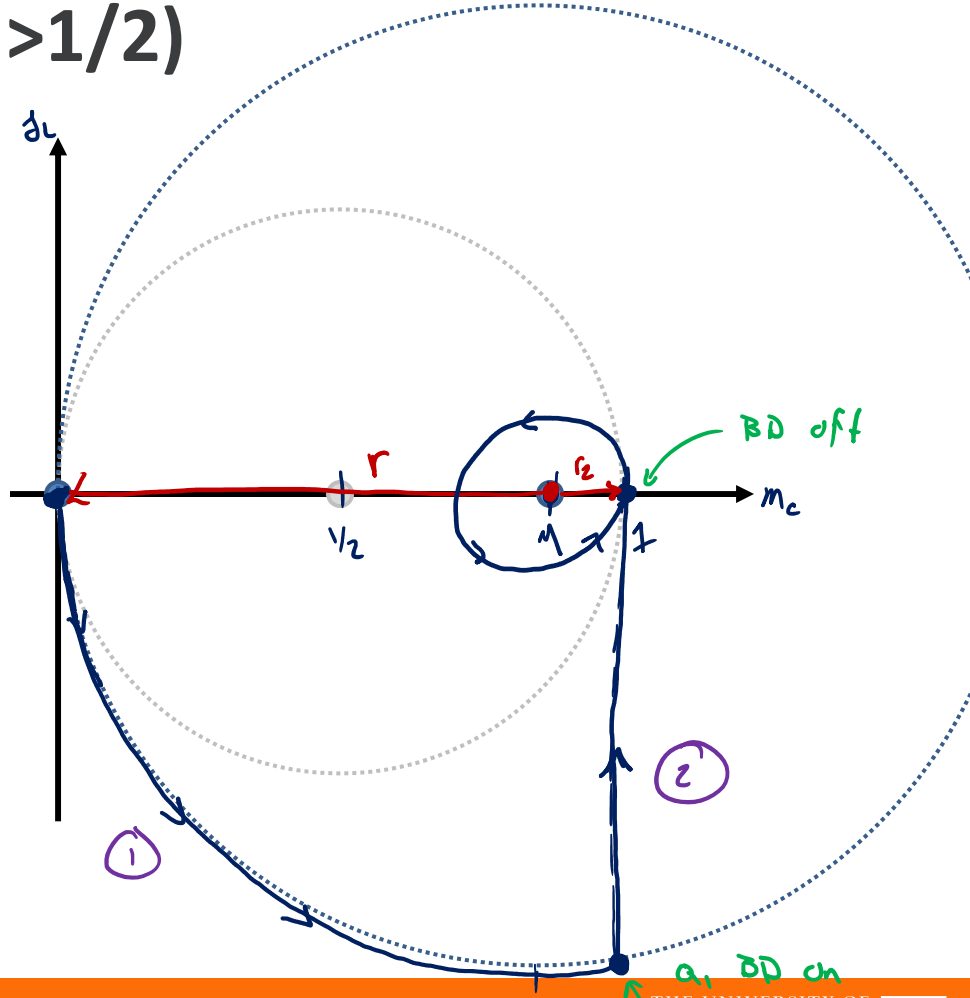
DCM Buck State Plane (M>1/2)







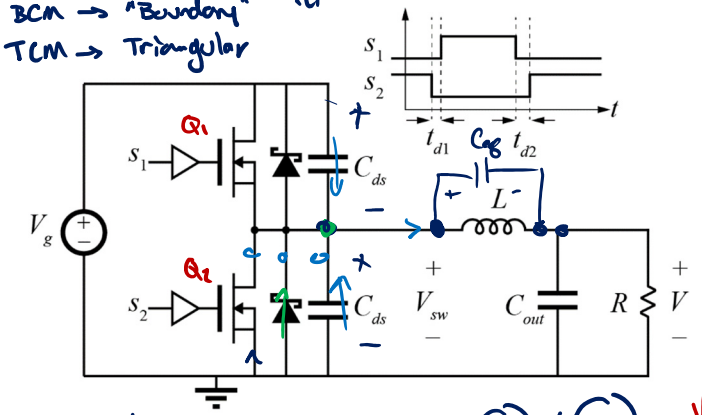
Synchronous Buck Converter

ZVS-QSW Buck Converter

CRM → Critical conduction mode

BCM → "Boundary"

TCM → Triangular



↓ During dead times (2) & (4)

$V_{base} = V_g$

DC solution

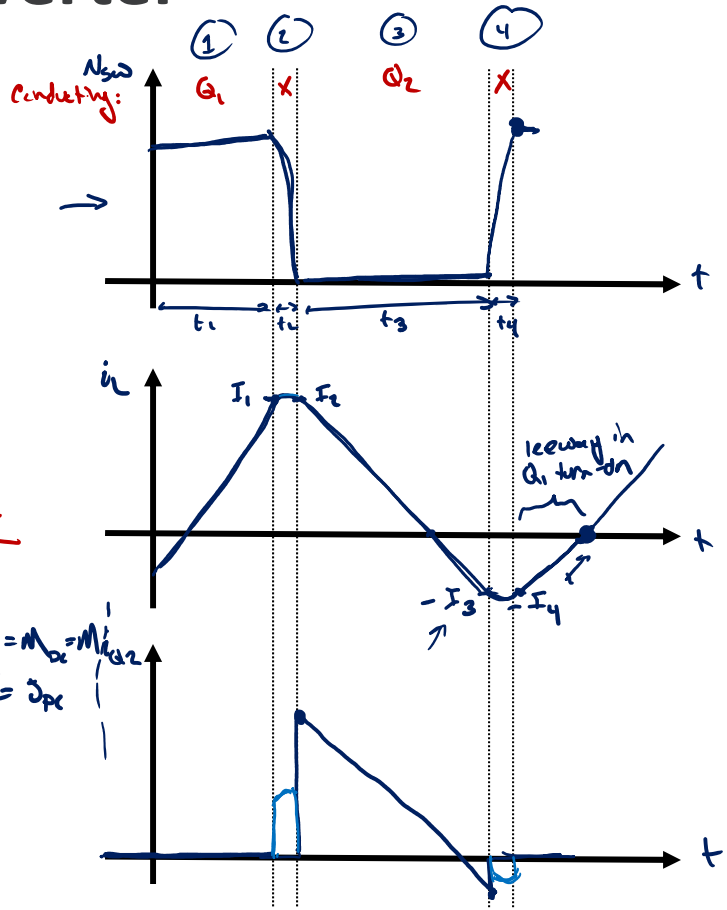
$v_{sw} = V$

$i_L = 0$

→ $m_{sw} = \frac{V}{V_g} = M_{DC} = M_{CCM}$

$j_L = \emptyset = j_{DC}$

ICs: vary by interval



Sync-Buck State Plane

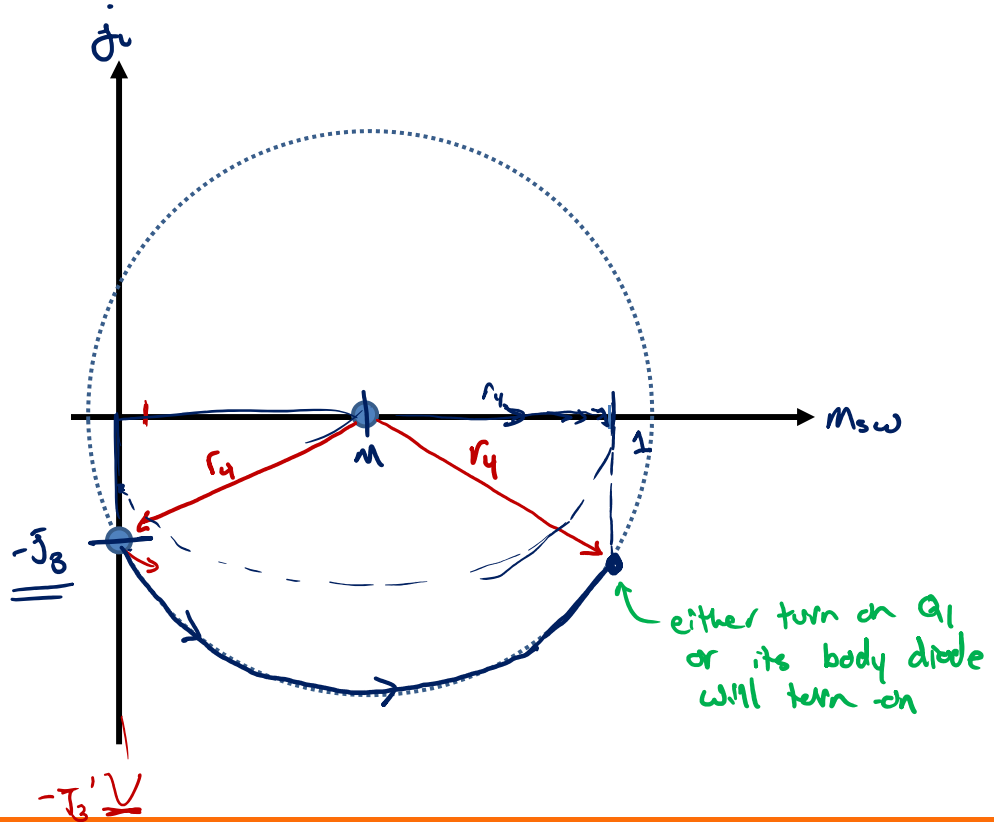
During 4

$V_{base} = V_g \qquad I_{base} = \frac{V_g}{R_o}$

DC: $(M, 0)$

FC: $i_L = -I_3$, $v_{sw} = 0$

$(0, -J_3)$



Sync-Buck ZVS Condition

During t_1

To get zvs turn-on of Q_1, we need

$$M + r_4 \geq 1 \qquad r_4 = \sqrt{J_3^2 + M^2}$$

$$\rightarrow \boxed{M + \sqrt{M^2 + J_3^2} \geq 1}$$

Denormalize:

$$\frac{V}{V_g} + \sqrt{\left(\frac{V}{V_g}\right)^2 + \left(\frac{I_3}{V_g} R_0\right)^2} \geq 1 \qquad R_0 = \sqrt{\frac{L}{C_{sw}}}$$

$$V^2 + I_3^2 \frac{L}{C_{sw}} \geq (V_g - V)^2$$

$$\rightarrow \boxed{\frac{1}{2} I_3^2 L \geq \frac{1}{2} C_{sw} (V_g - V)^2 - \frac{1}{2} C_{sw} V^2}$$

- $\frac{1}{2} I_3^2 L$: Initial energy in L
- $\frac{1}{2} C_{sw} (V_g - V)^2$: Add'l energy required
- $\frac{1}{2} C_{sw} V^2$: DC source Bias contributed energy

Sync-Buck State Plane (Ring out)

If we never turn Q_1 on after (4)