State Plane Algorithm

Manipulate the circuit (during a subinterval) into 1-L, 1-C ac-equivalent w/ (possibly) DC bias sources

- May require some approximation

(1) Normalize waveforms & time

$$\begin{cases} m_x(t) = \dfrac{v_x(t)}{V_{base}} \\ j_x(t) = \dfrac{i_x(t)}{I_{base}} \\ \theta_x = \omega_0 t_x \end{cases}$$

V_{base} = anything you choose

$I_{base} = \dfrac{V_{base}}{R_0}$

(2) Plot the (m_c, j_L) trajectory on the state plane

- Will form a circle with
  - center at (M_{DC}, J_{DC}) → the DC solution
  - initial point at (M_0, J_0) → the initial condition
  - Direction (cw or ccw) from I.C. on first derivative of m_c & j_L

(3) Solve parameters of interest (using Geometry & trig)

(4) Denormalize $(m, j, \theta) \rightarrow (v, i, t)$

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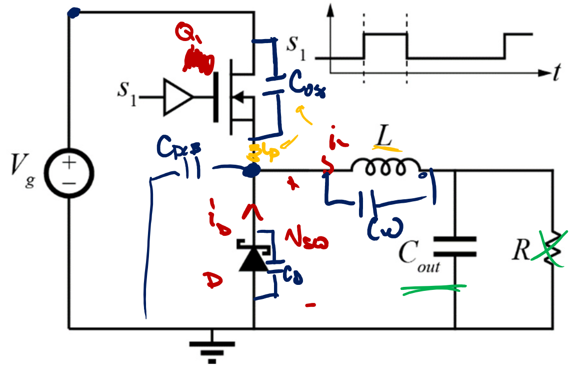
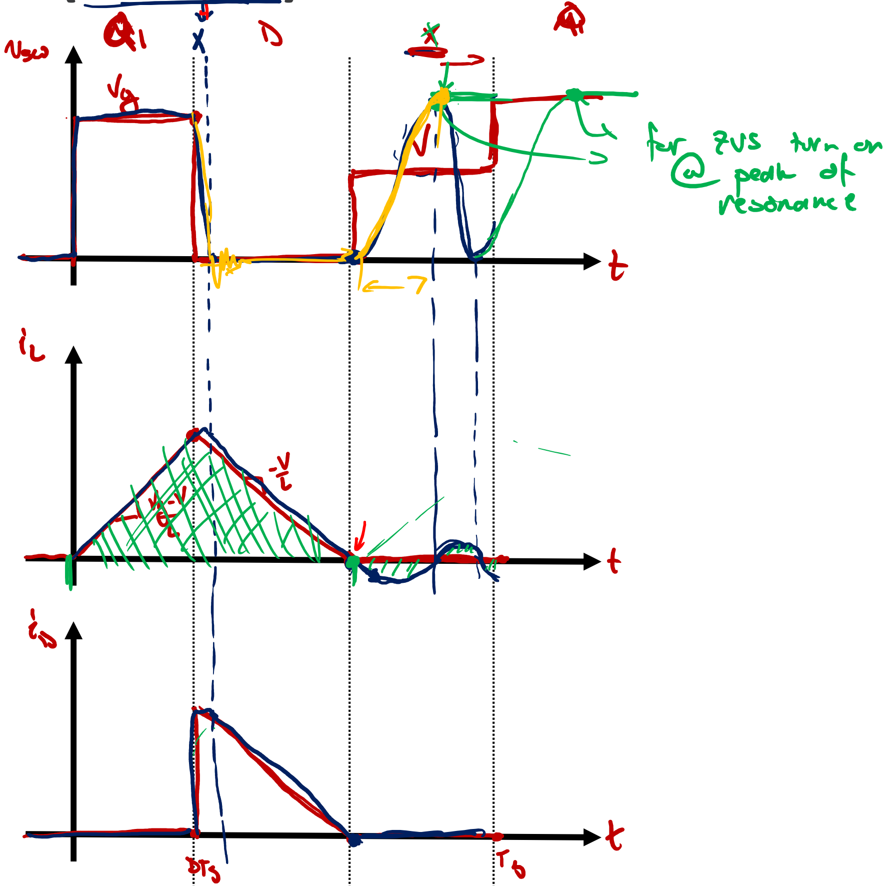
DCM Buck Converter Example ($M=1/2$) $= \frac{V}{V_g}$

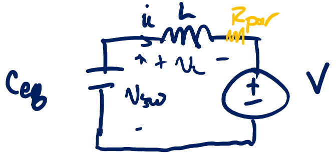


$V_{base} = V_g$

$I_{base} = \frac{V_g}{R_0}$



when both Q_1 & D are off:



$C_{eq} = C_{oss} \| C_D \| C_W \| C_{PCB}$

Initial Condition: $i_L = \emptyset \rightarrow j_L = \emptyset$

$v_{sw} = \emptyset \rightarrow m_{sw} = \emptyset$

DC solution: $i_L = \emptyset \rightarrow J_L = \emptyset$

$v_{sw} = V \rightarrow M_{sw} = \frac{V}{V_g} = M$

DCM Buck State Plane

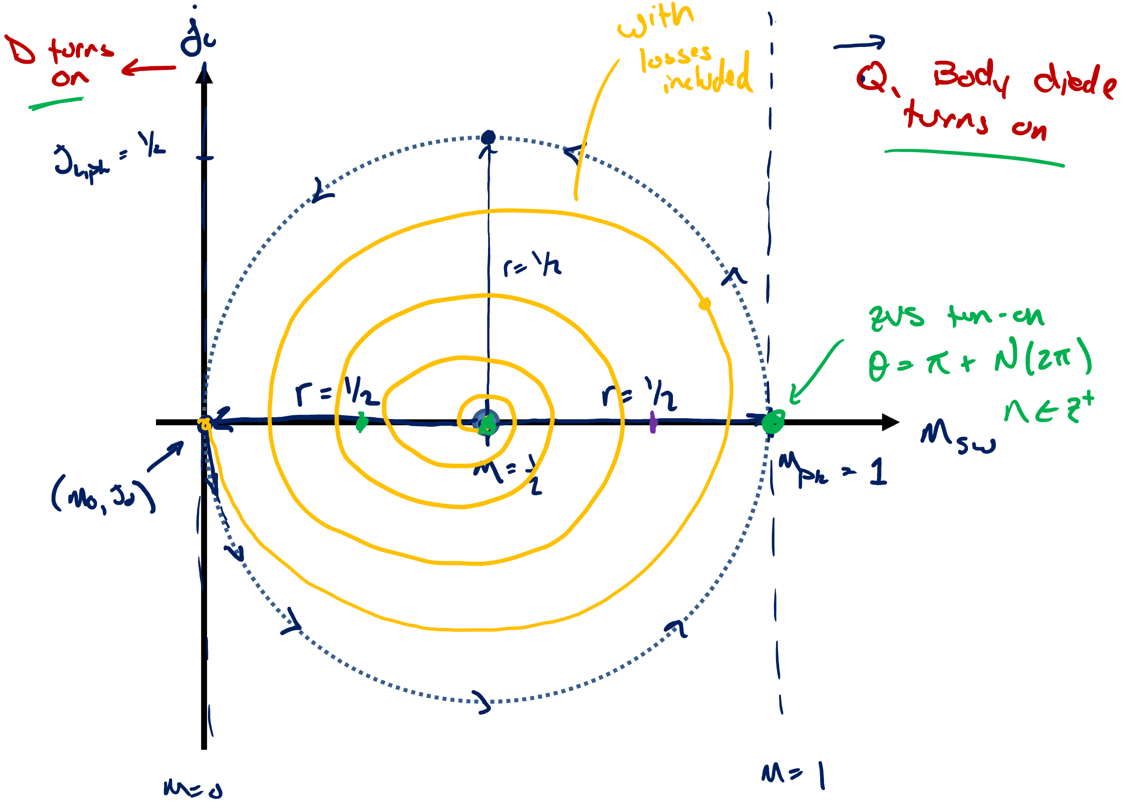
$V_{base} = V_g$ $\quad$ $I_{base} = V_g/R_o$

$M_{pk} = \frac{V}{V_g} = M = \frac{1}{2}$ $\quad$ $J_{pk} = \phi$

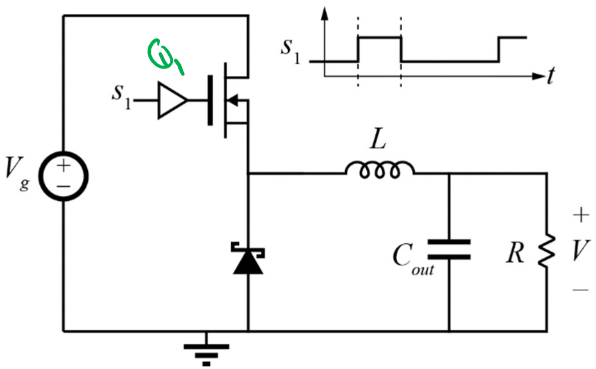
$M_o = \phi$ $\quad$ $J_o = \phi$

ICs on 1st derivative

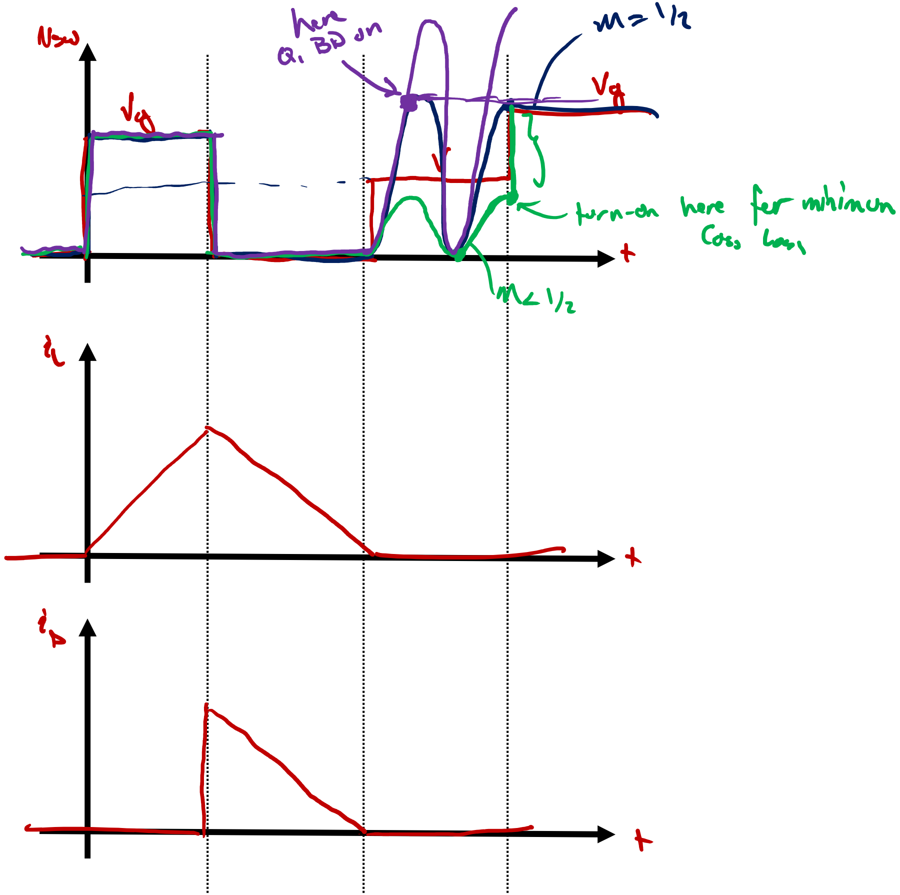
- M_{sw} is increasing
- j_L is decreasing



DCM Buck M≠1/2



Q_1
s_1
t
V_g
L
C_{out}
R
V



v_{sw}
V_g
here Q_1 BD on
$M=1/2$
turn-on here for minimum C_{oss} loss
$M<1/2$
i_L
i_D
t

DCM Buck State Plane (M<1/2)