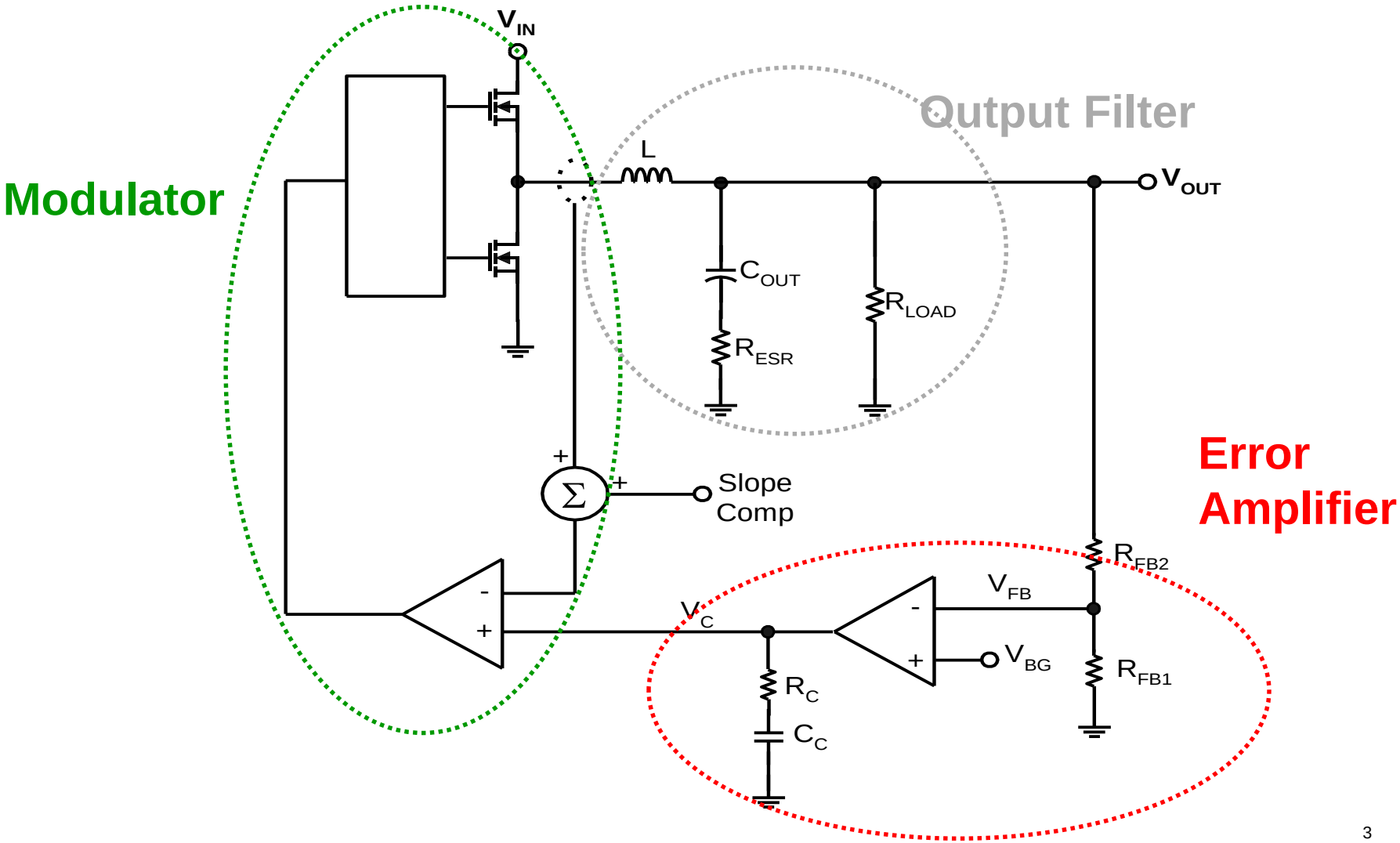
Buck Regulator Architectures

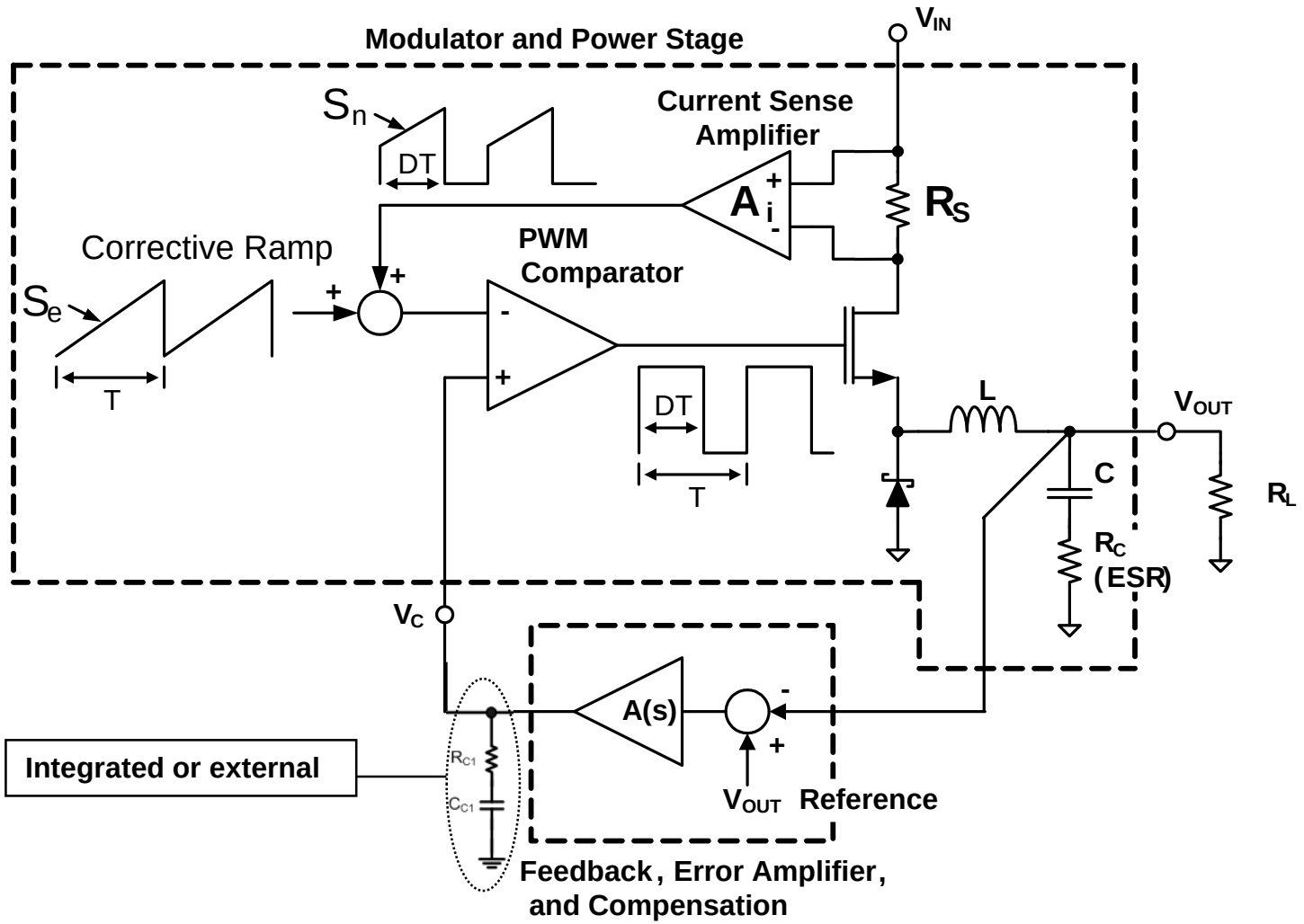
4.5 Current/Emulated Current Mode Buck Regulators

CURRENT MODE

Current-Mode Buck Regulator



Current-Mode Buck-Regulator Architecture



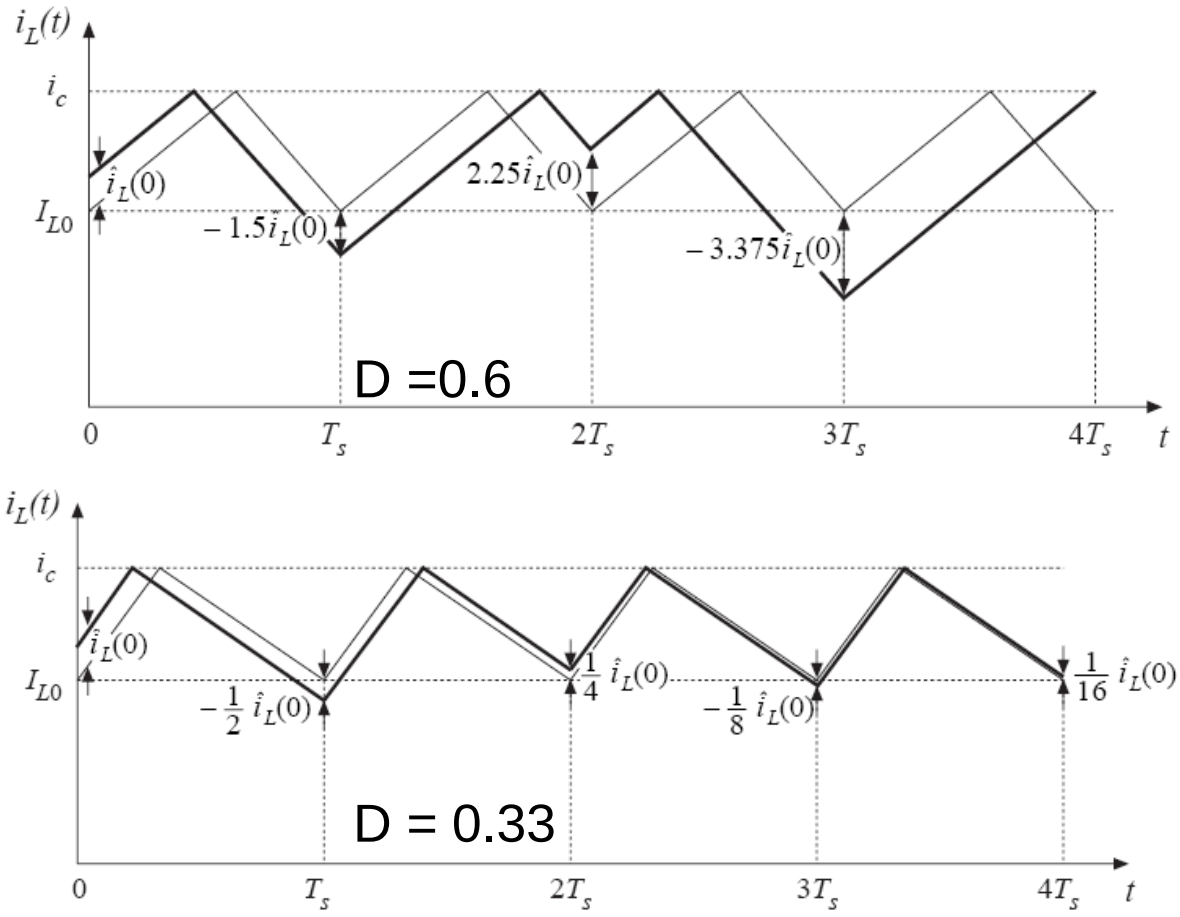
Advantages and Disadvantages

- Advantages
  - Power plant gain offers a single-pole roll-off
  - Line rejection
  - Cycle-by-cycle current limiting protection
  - Current sharing

- Disadvantages
  - Noise
  - Minimum ON-time
  - Sense resistor

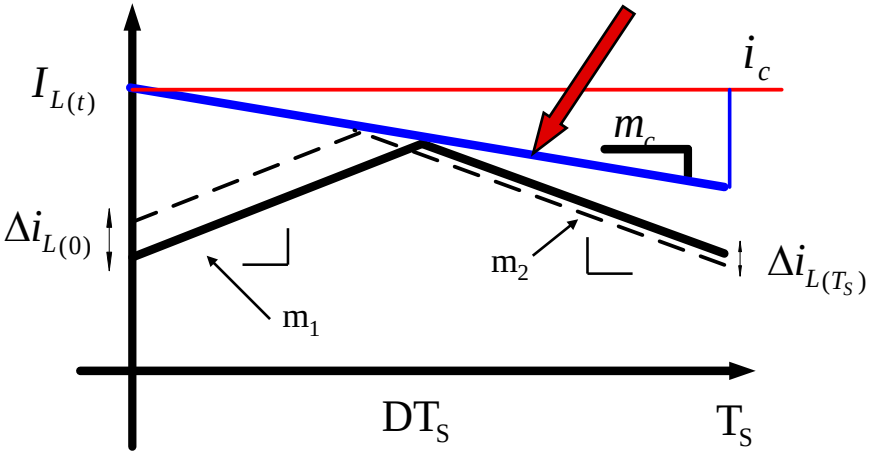
CMC Sub-Harmonic Oscillation

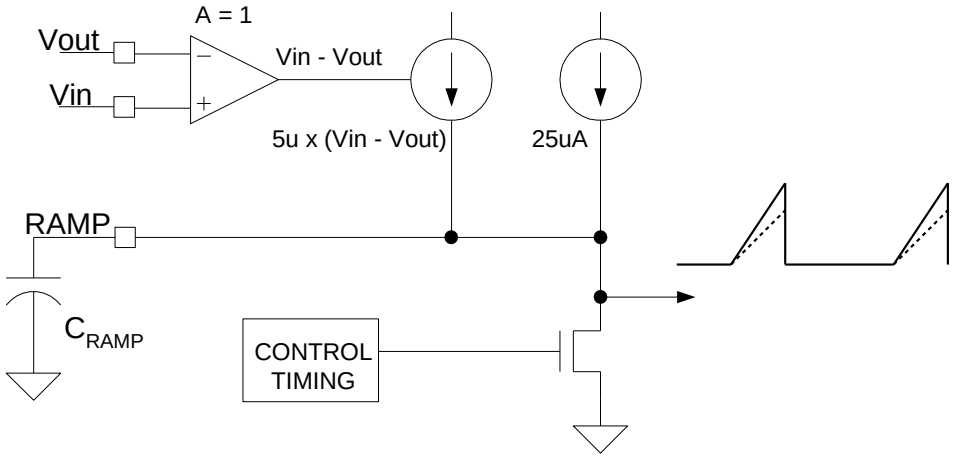
- Current mode controlled power converters operating at duty cycles >50% are prone to sub-harmonic oscillation
- Disturbances in peak rising current (Δ I) increase at the end of the cycle



Slope Compensation

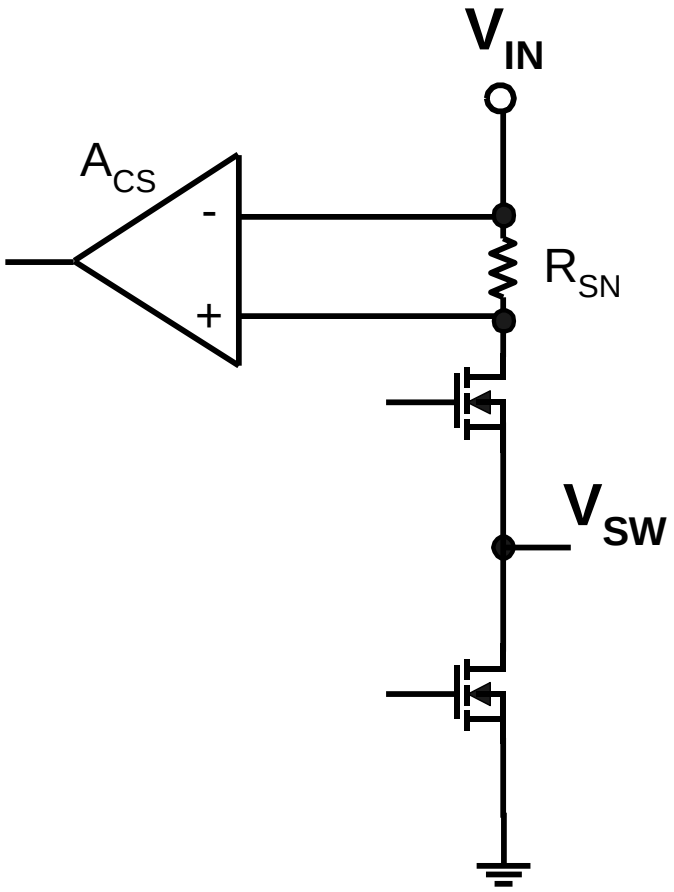
m_c = Internal Slope Comp





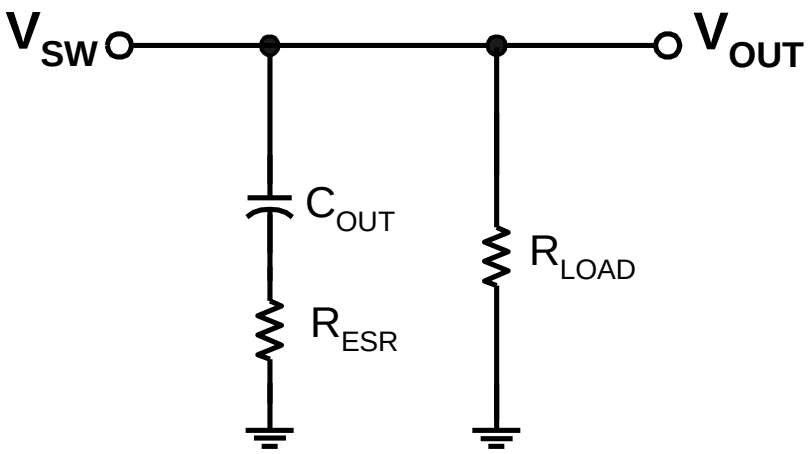
Stability criteria $1 > \dfrac{m_2 - m_C}{m_1 + m_C}$

Modulator Gain



The current sense element is usually a resistor or the $R_{DS\text{-}ON}$ of the FET.

Output Filter



$$\omega_{z1} = \frac{1}{C_{OUT} R_{ESR}}$$

$$\omega_{p1} = \frac{1}{C_{OUT} R_{LOAD}} + \frac{1}{f_s L C_{OUT}} \left(m_c D' - 0.5 \right)$$

Control-Loop Considerations
Rules of Thumb

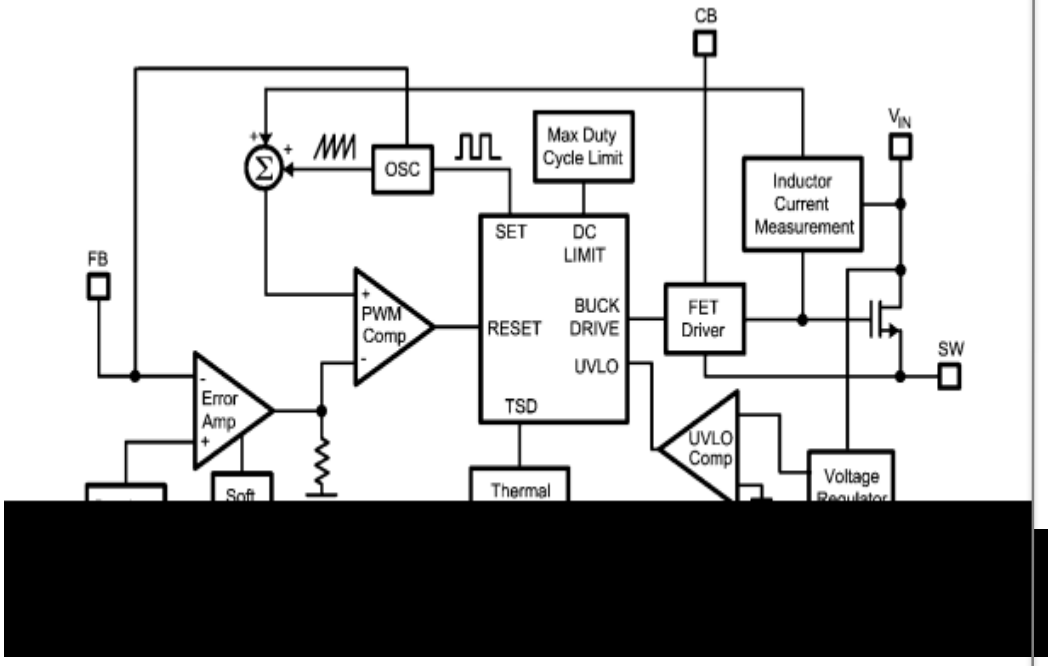
- Crossover frequency at 1/5th the switching frequency with a phase margin of 45˚
- Higher crossover frequency relates to faster transient response and an increased likelihood of instability
- Lower crossover frequency relates to slower transient response and an increased likelihood of stability

Current Mode Line Transients
Performance Trade-offs

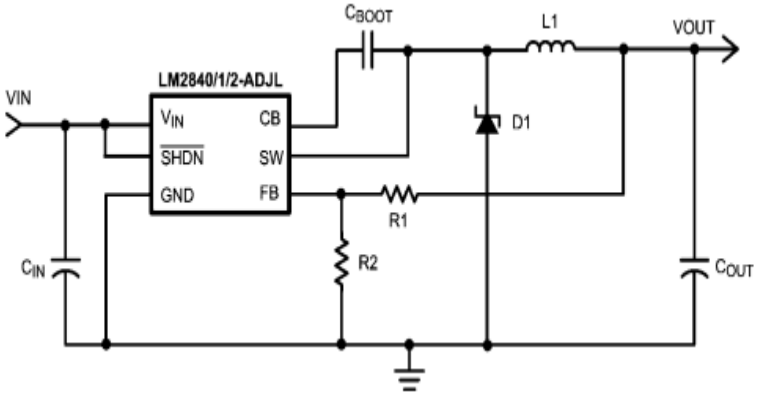
- Sudden changes in the line voltage are alleviated by use of a large input cap
- Inherently better response in current mode because of implicit line feed-forward
- Use of several caps in parallel reduces the ESR also improving performance
- High crossover frequency allows control loop to quickly accommodate perturbations in the system

Current Mode Control Example: LM284x

Internal Block Diagram



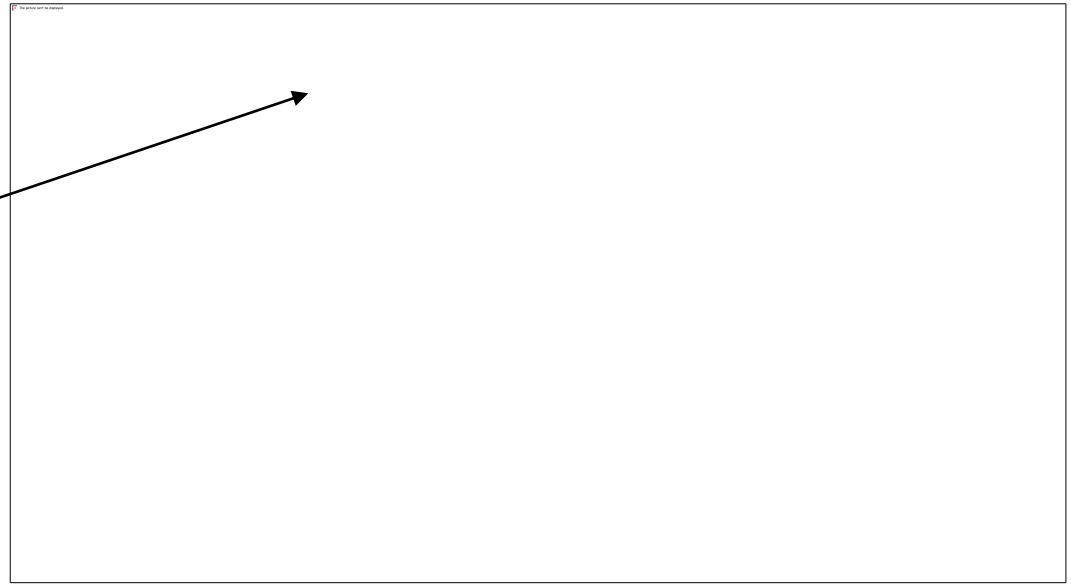
Typical Application Circuit



EMULATED CURRENT MODE (ECM) BUCK REGULATORS

Why Emulated Current Mode?

Leading edge spike, conventional current mode control.

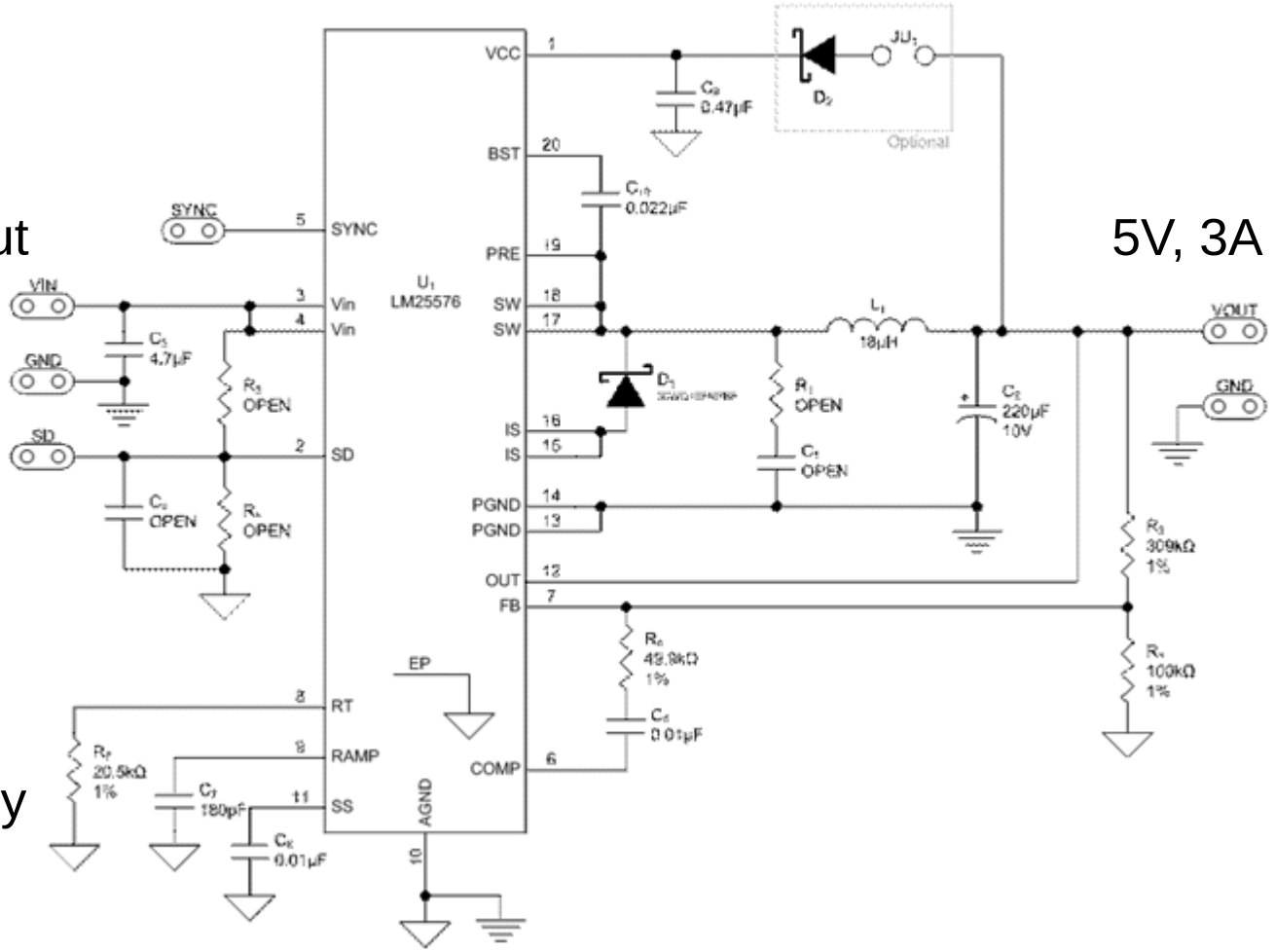


15W Supply With Emulated Current Mode Regulator

6-42V input

5V, 3A output

300 kHz Switching Frequency



Thank you!