Power Electronics Circuits

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Current Control

Two control loops:
1. Fast (inner) current loop control
   - Not Averaged
2. Slow (outer) voltage loop control
   - Averaged

Current Controller:
Regulate $i_L(t) = \text{control input}$

Effective low-pass filter averaged models can be used when $f_c \ll f_s$
Averaged vs CPM

Voltage-Mode

Averaged Current-Mode

Current Programmed Mode
The peak transistor current replaces the duty cycle as the converter control input.
**Fig. 12.28** Comparison of CPM control with duty-cycle control, for the control-to-output frequency response of the buck converter example.
Example: Unstable operation for $D=0.6$

$$\alpha = -\frac{D}{D'} = \left(-\frac{0.6}{0.4}\right) = -1.5$$
Stabilization Through Artificial Ramp

Now, transistor switches off when

\[ i_a(dT_s) + i_L(dT_s) = i_c \]

or,

\[ i_L(dT_s) = i_c - i_a(dT_s) \]

if \( i_a \gg i_c \) \( \rightarrow \) PWM control
if \( i_a \ll i_c \) \( \rightarrow \) CPM
Application to Experiment 4

- Complex switching controller
- **Read** the datasheet first
  - Input Buck
  - Current sense filter
  - Vg/Vcc diodes
  - Forced PWM mode
Startup: Switching
LM5121: Functionality

- Current sense
- Buck for protection
- Low side FET
- Boost power stage
- Undervoltage lockout
- Soft start
- Set low power modes
- Set for testing
- Bootstrap
Open-Loop Operation

1. Short in sense

2. Set big artificial ramp (~1V)

- Correct P ot R i

LM5121
Setting the Electronic Load

Low-frequency model

1. Open loop:

\[ V = \frac{V_o}{n} \]
\[ P_{out} = \left(\frac{V_o}{n}\right)^2 \frac{1}{R} \]

2. Current Loop Only

\[ P_{out} = IV_o \]
\[ V \approx \frac{1}{I} dV_o \]
Large R = large voltage

3. Voltage & Current Loop

\[ V = V_{ref} \]
\[ P_{out} = \frac{V_{ref}^2}{R} \]

Be careful with how you set electronic load

Safest:
1. & 3. Current or resistance
2. Voltage
Make sure to include \( H \) & \( R_f \).