Power Electronics Circuits

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ECE 482
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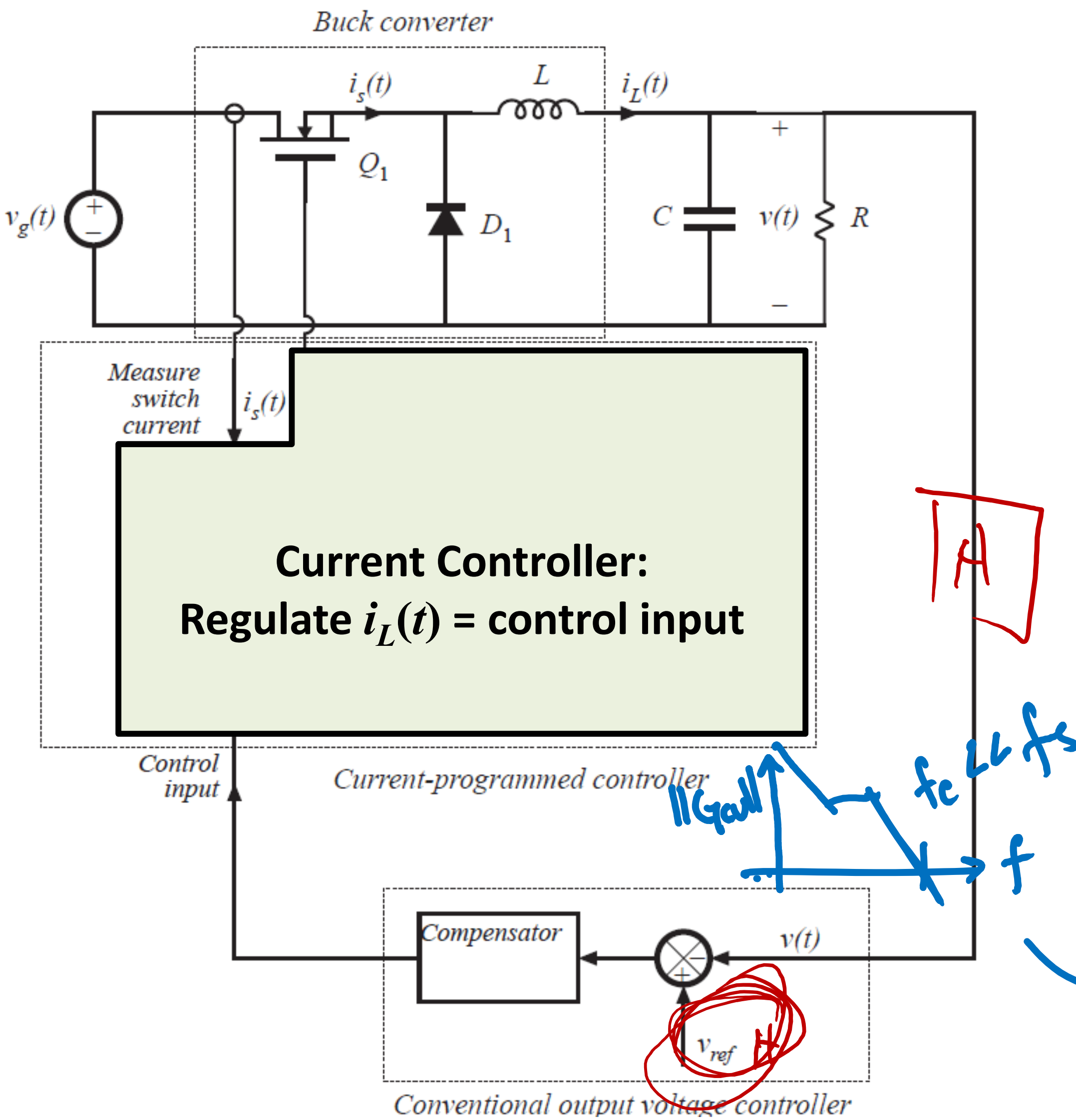
THE UNIVERSITY OF
TENNESSEE
KNOXVILLE

Current Control



Two control loops:

(1) Fast (inner) current loop control

– Not Averaged

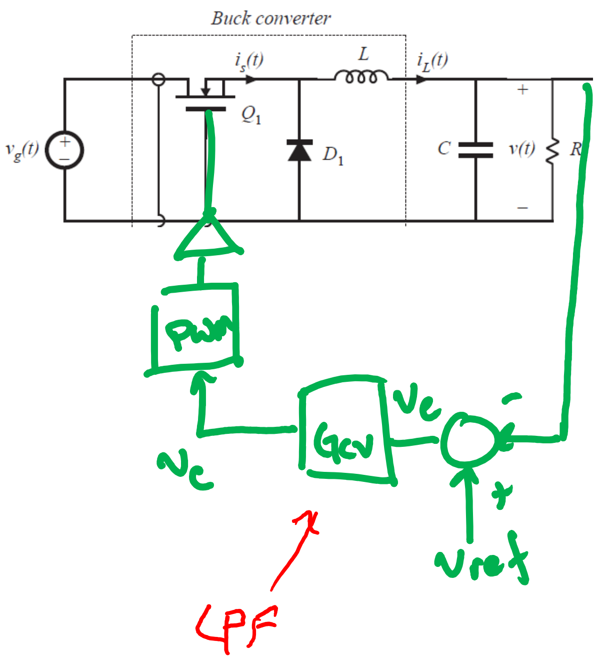
(2) Slow (outer) voltage loop control

– Averaged

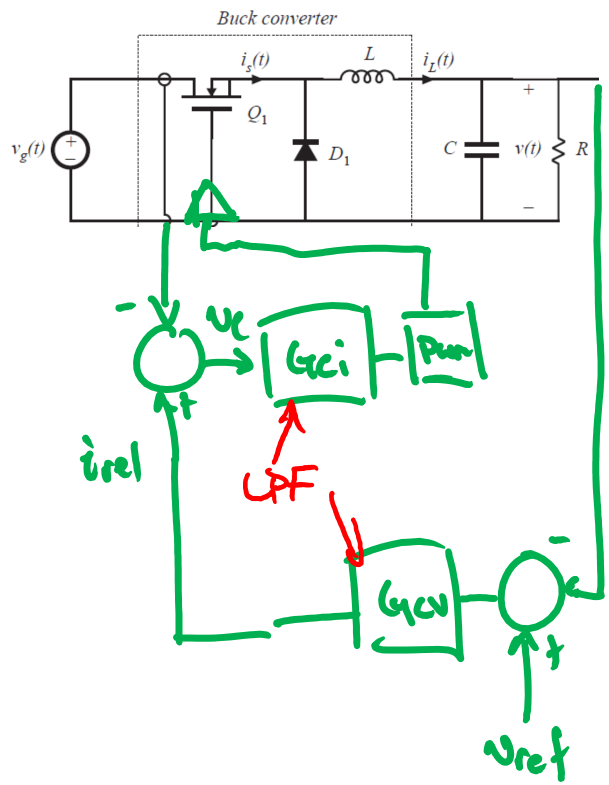
→ Effective low-pass filter averaged models can be used when $f_c \ll f_s$

Averaged vs CPM

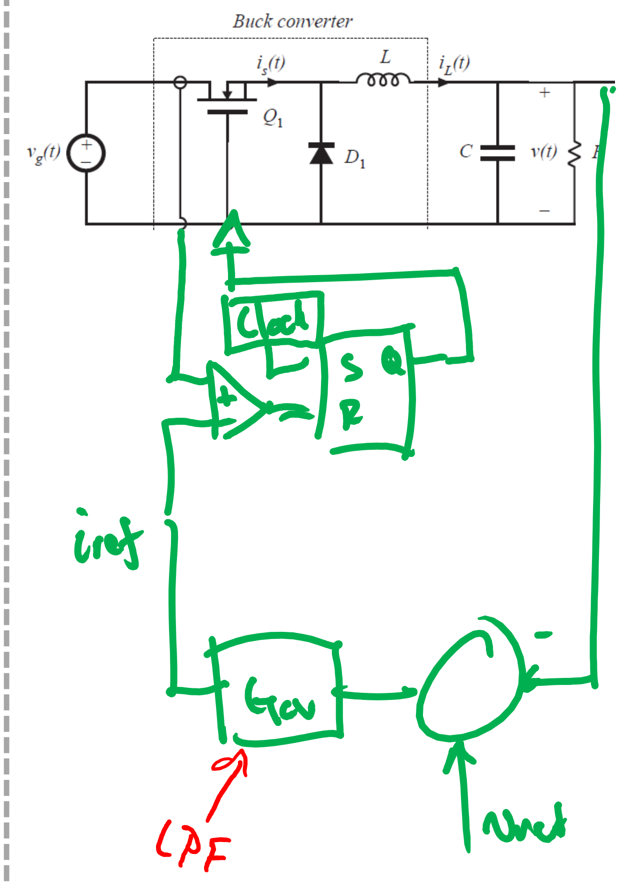
Voltage-Mode



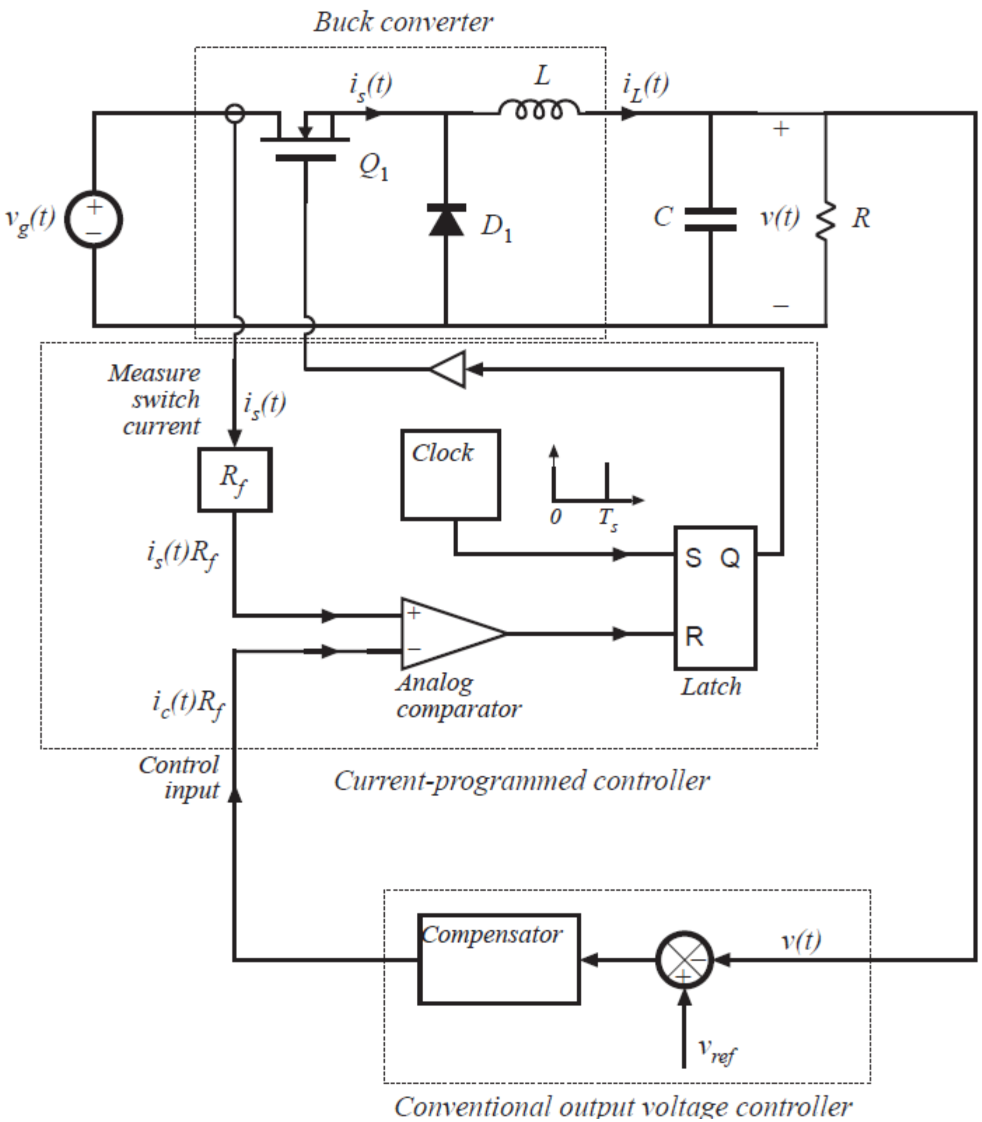
Averaged Current-Mode



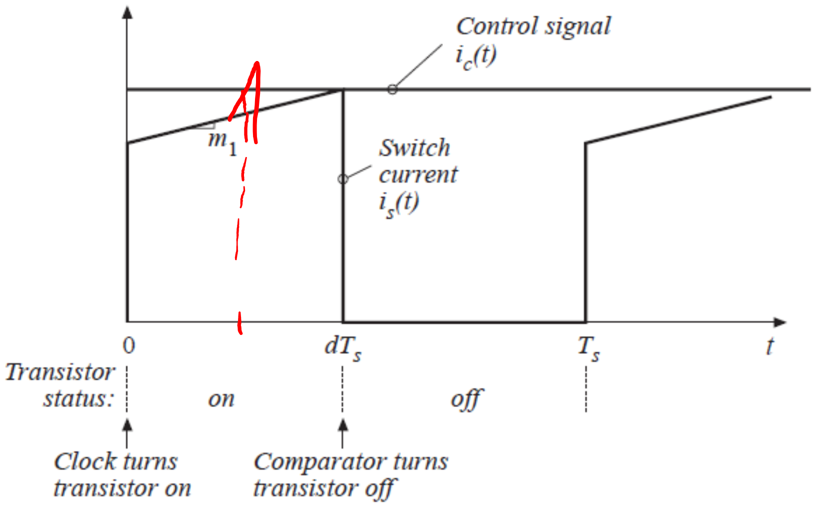
Current Programmed Mode



CPM Voltage Loop



The peak transistor current replaces the duty cycle as the converter control input.



CPM Transfer Functions

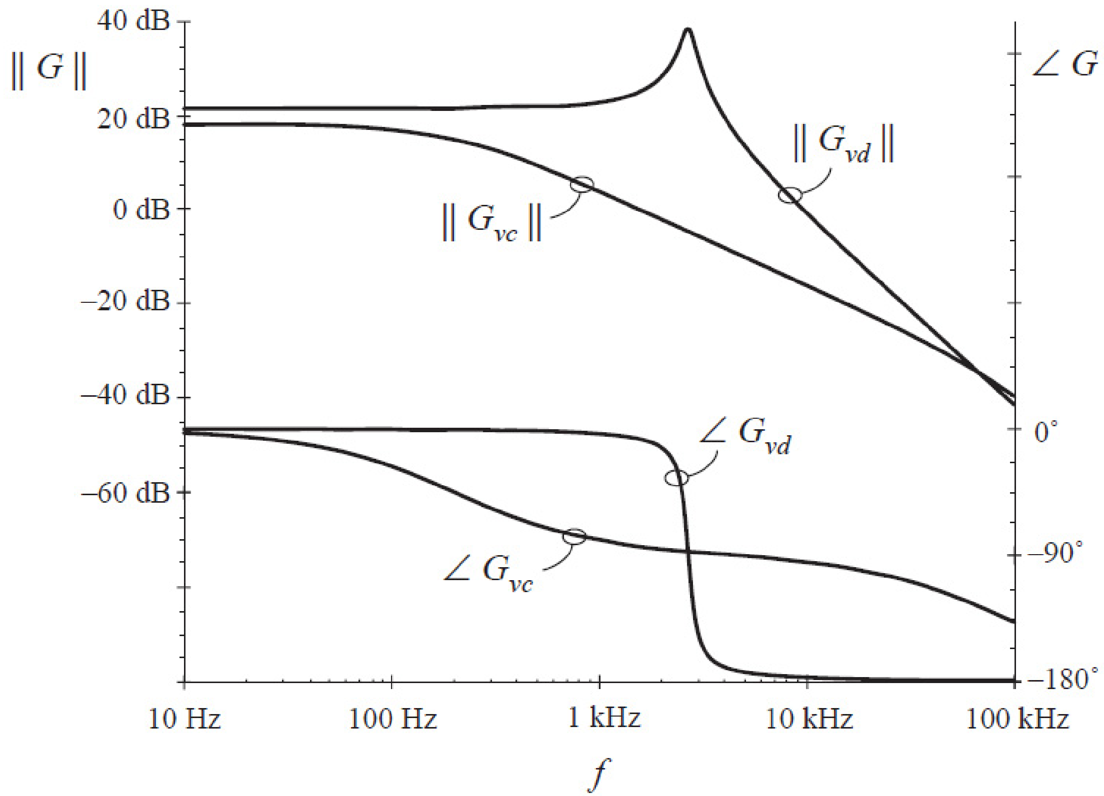
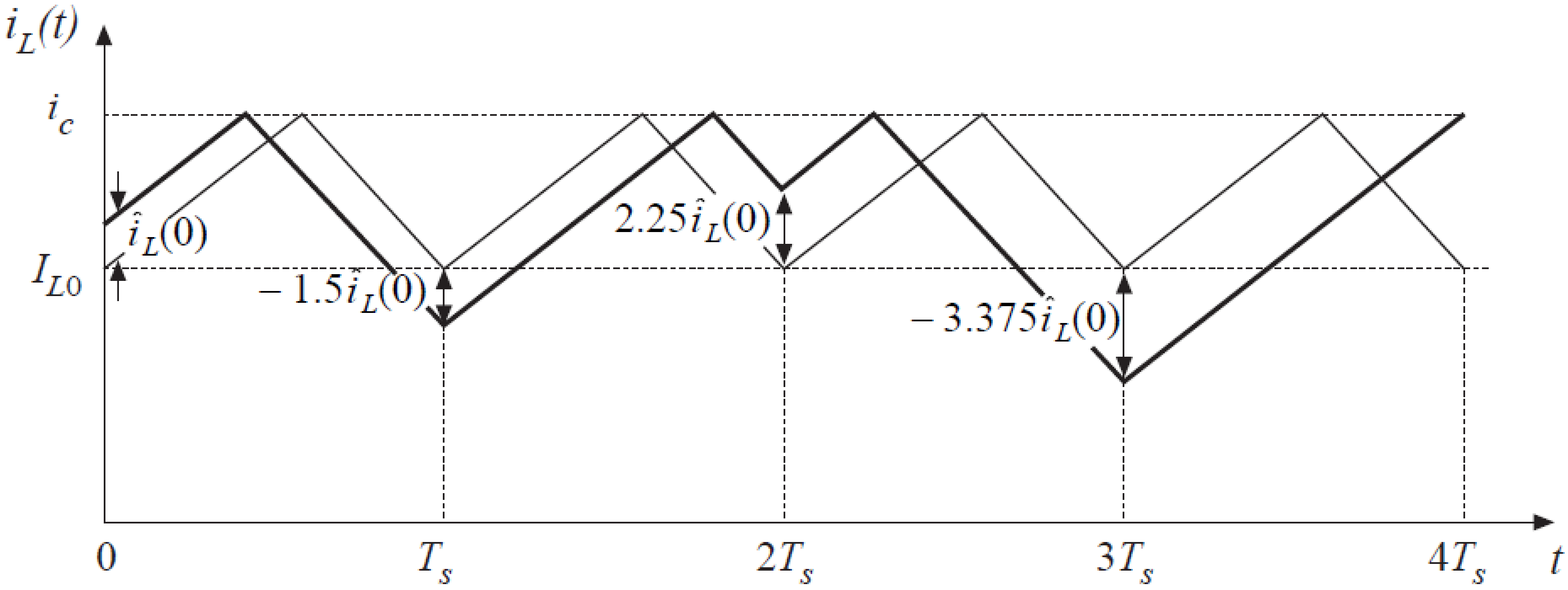


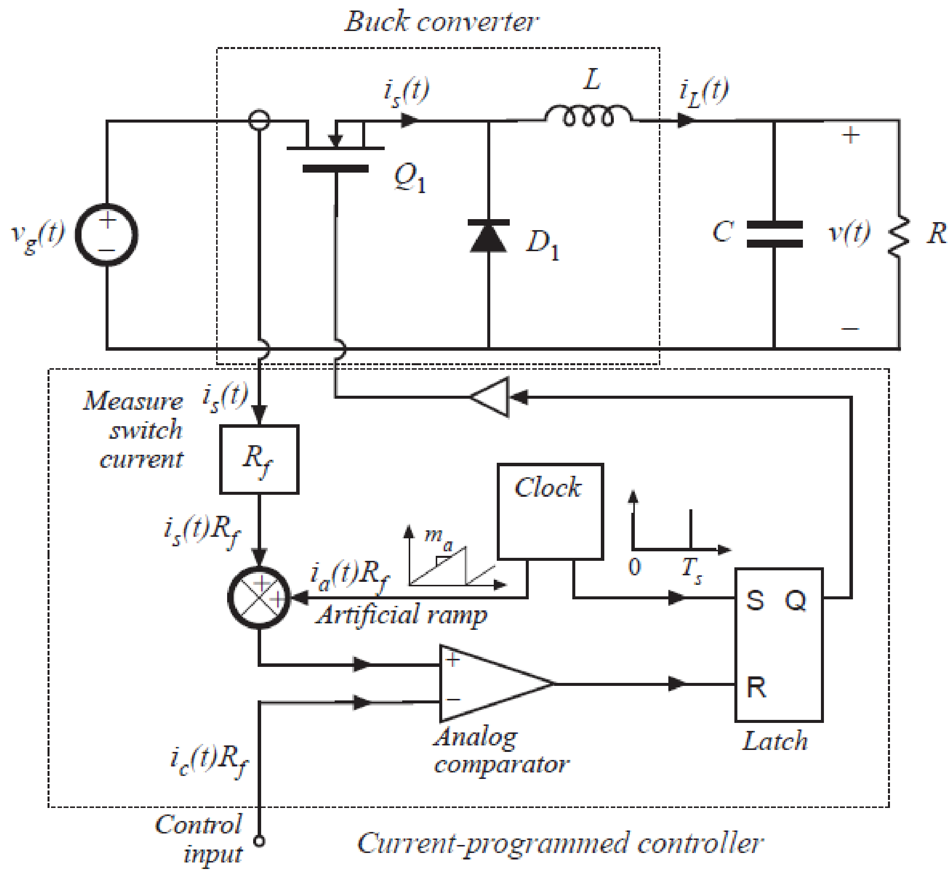
Fig. 12.28 Comparison of CPM control with duty-cycle control, for the control-to-output frequency response of the buck converter example.

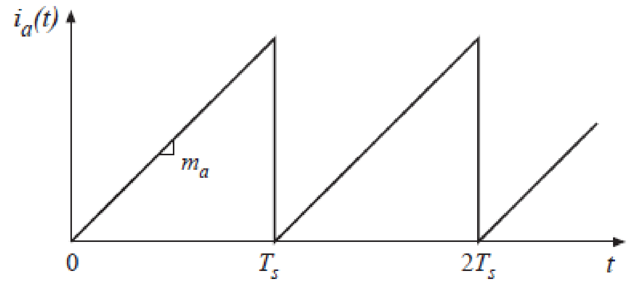
Example: Unstable operation for D=0.6

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



Stabilization Through Artificial Ramp





Now, transistor switches off when

$$i_a(dT_s) + i_L(dT_s) = i_c$$

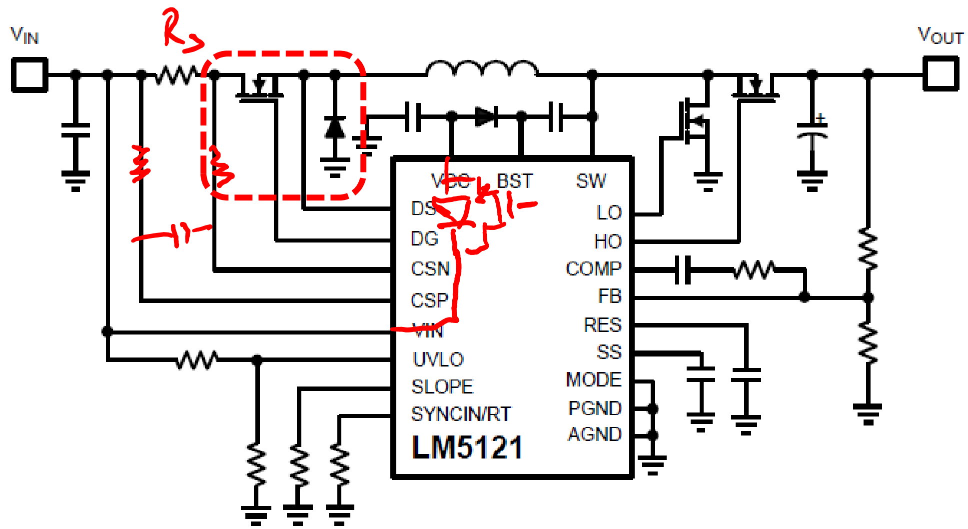
or,

$$i_L(dT_s) = i_c - i_a(dT_s)$$

if $i_a \gg i_L$ → PWM control

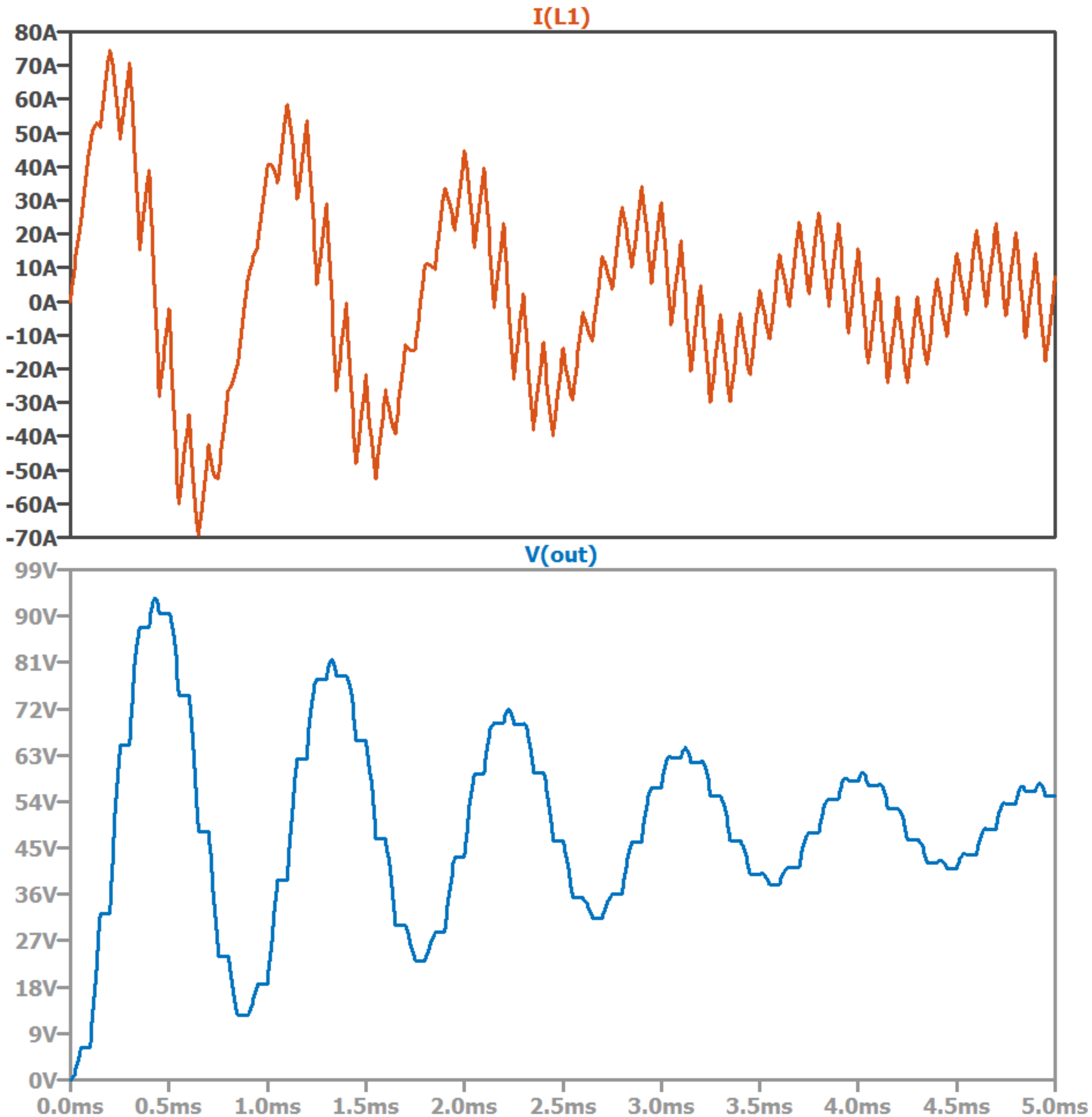
if $i_a \ll i_c$ → CPM

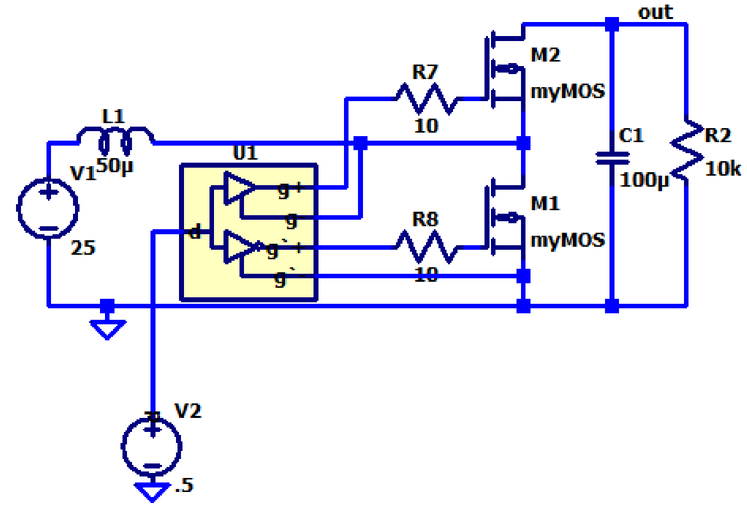
Application to Experiment 4



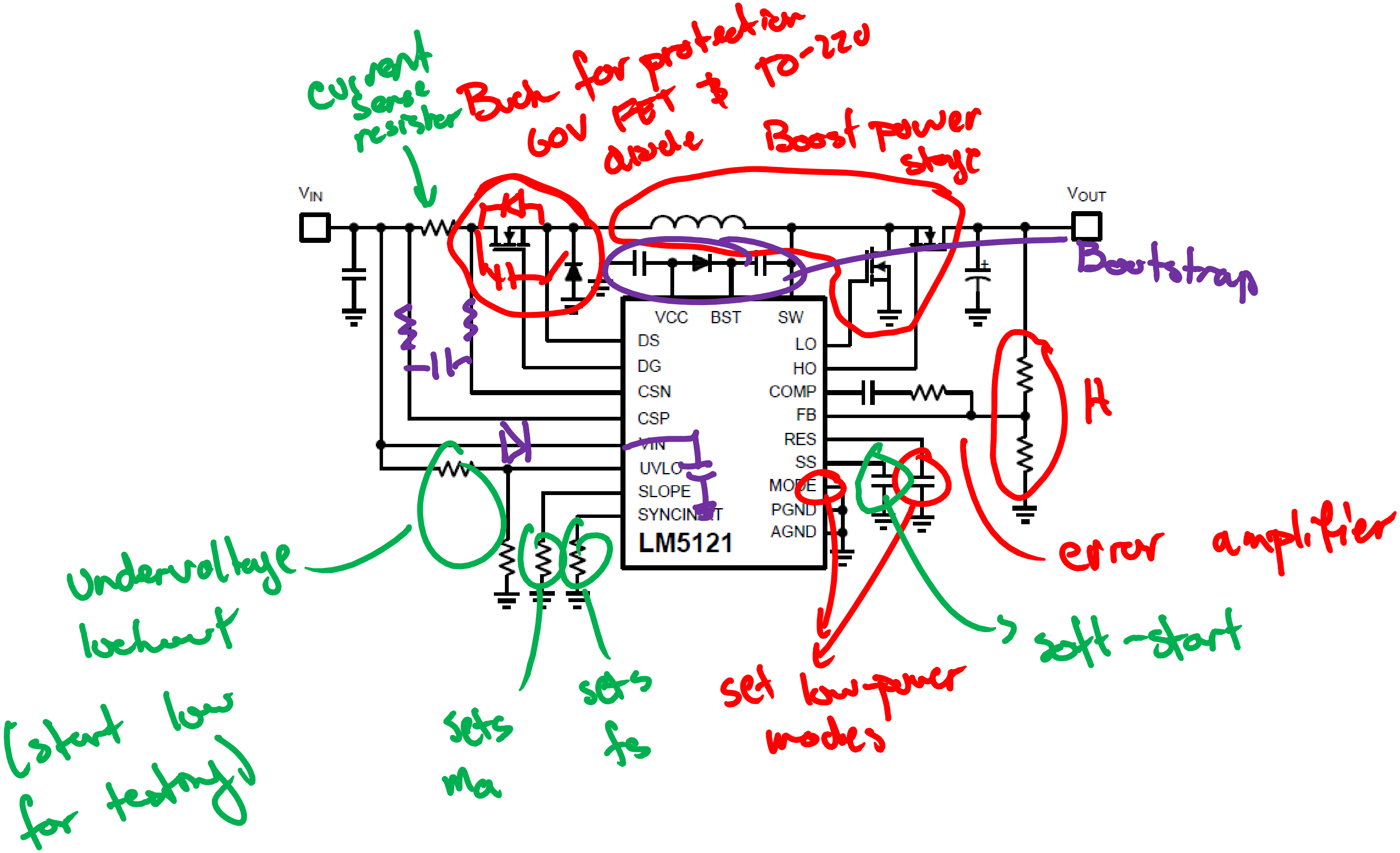
- Complex switching controller
- **Read** the datasheet first
  - Input Buck
  - Current sense filter
  - Vg/Vcc diodes
  - Forced PWM mode

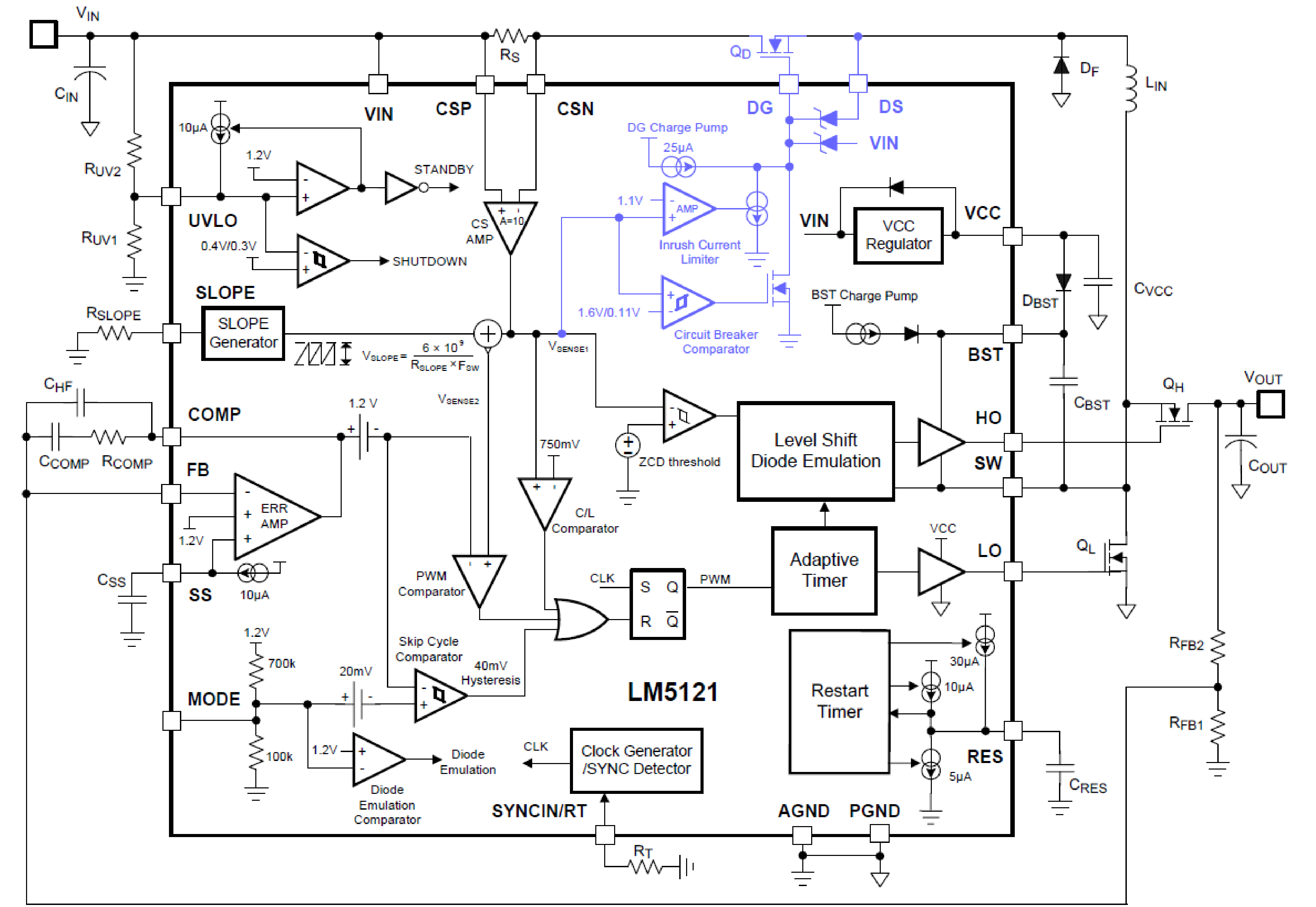
Startup: Switching





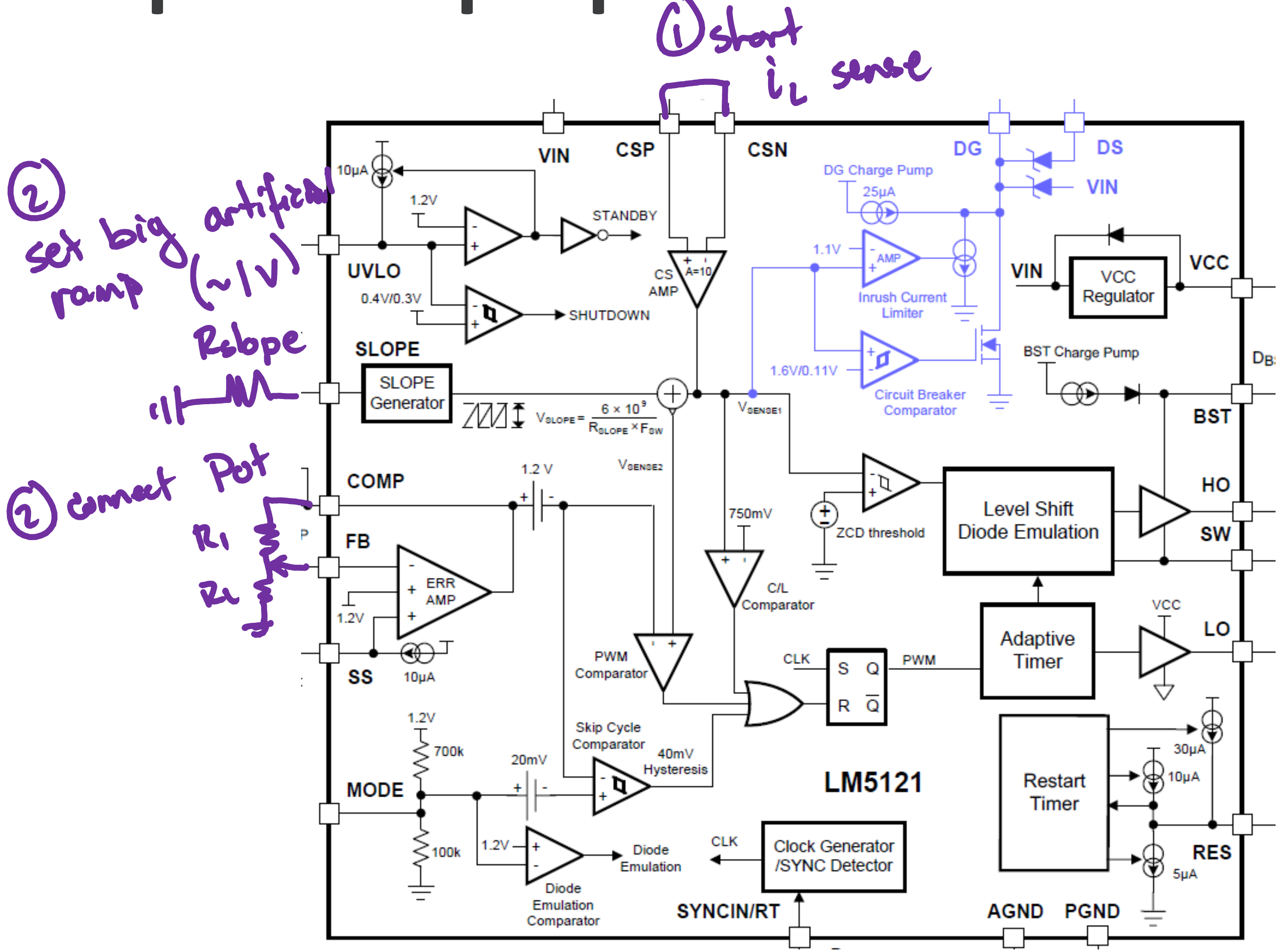
LM5121: Functionality



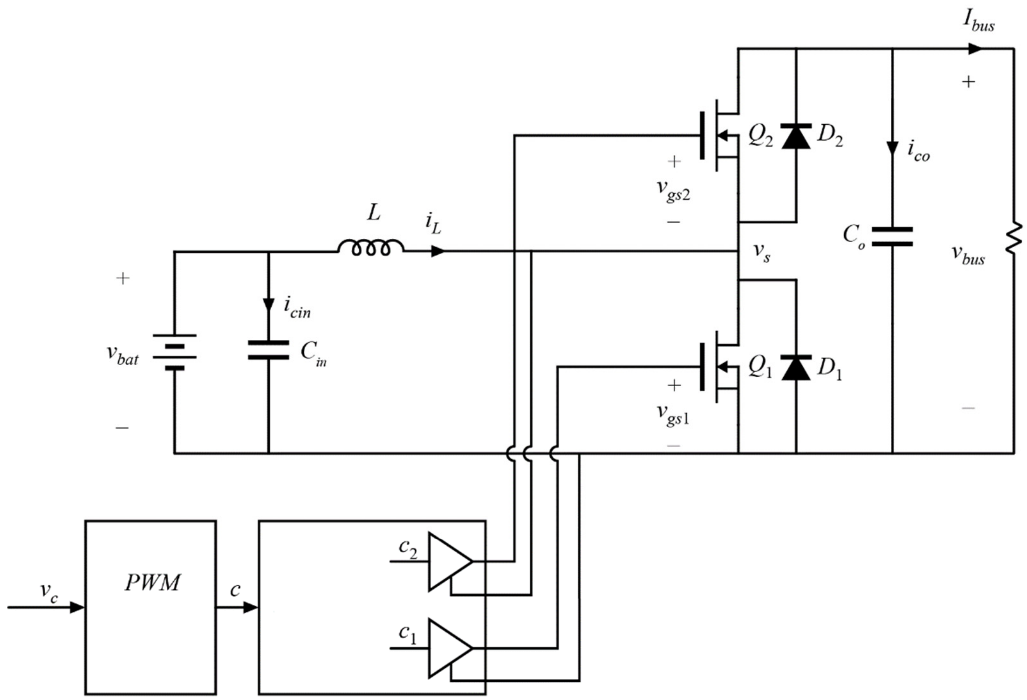


VIN
CIN
RUV2
RUV1
RSLOPE
CHF
CCOMP
RCOMP
CSS
RS
QD
DF
LIN
CVCC
DBST
CBST
QH
VOUT
COUT
QL
RFB2
RFB1
CRES
RT
VIN
CSP
CSN
DG
DS
10μA
1.2V
STANDBY
UVLO
0.4V/0.3V
SHUTDOWN
CS AMP
A=10
DG Charge Pump
25μA
1.1V
AMP
Inrush Current Limiter
1.6V/0.11V
Circuit Breaker Comparator
VCC Regulator
VCC
BST Charge Pump
BST
SLOPE
SLOPE Generator
$V_{SLOPE} = \frac{6 \times 10^9}{R_{SLOPE} \times F_{SW}}$
VSENSE1
VSENSE2
COMP
1.2 V
FB
ERR AMP
SS
750mV
ZCD threshold
Level Shift Diode Emulation
HO
SW
C/L Comparator
PWM Comparator
CLK
S
Q
R
PWM
Adaptive Timer
LO
MODE
700k
100k
20mV
Skip Cycle Comparator
40mV Hysteresis
LM5121
Restart Timer
30μA
10μA
5μA
RES
Diode Emulation
Diode Emulation Comparator
Clock Generator /SYNC Detector
SYNCIN/RT
AGND
PGND

Open-Loop Operation

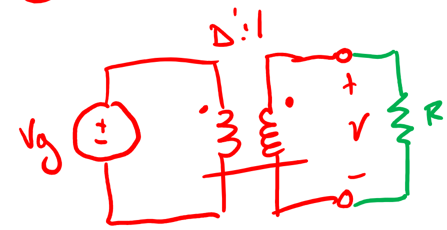


Setting the Electronic Load



Low-frequency model

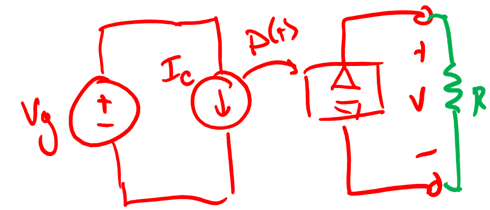
① Open Loop:



$V \approx \frac{V_g}{D'}$

$P_{out} = \left(\frac{V_g}{D'}\right)^2 \frac{1}{R}$

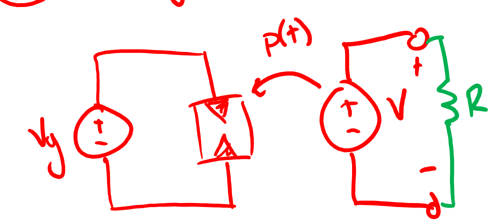
② Current Loop Only — Large R = large voltage!



$P_{out} = I_c V_g$

$V \approx \sqrt{I_c V_g R}$

③ Voltage & Current Loop



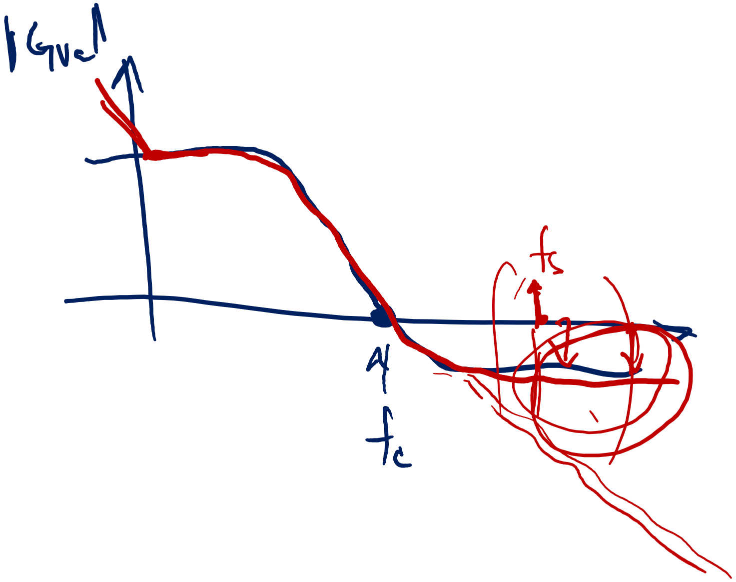
$V \approx V_{ref}$

$P_{out} = \frac{V_{ref}^2}{R}$

Be careful with how you set electronic load

Safest: ① & ③ current or resistance

② voltage



Make sure to include

H $ Rf