

Advanced Simulation Techniques Using PSpice

Part 5: DC to DC Converters



STRATEGIC TECHNOLOGY GROUP

Experts in Power Electronics, Motor Drives
and Digital Control of Power

StrategicTechGroup.com

This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.

Advanced Simulation Techniques

Table of Contents

- Cycle by Cycle and Small Signal Simulation of
 - Buck Converter
 - Boost Converter
 - Buck-Boost Converter
 - Cuk Converter
 - + Eight Demonstrations



STRATEGIC TECHNOLOGY GROUP

Experts in Power Electronics, Motor Drives

and Digital Control of Power

StrategicTechGroup.com

This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.

Advanced Simulation Techniques

Buck Converter

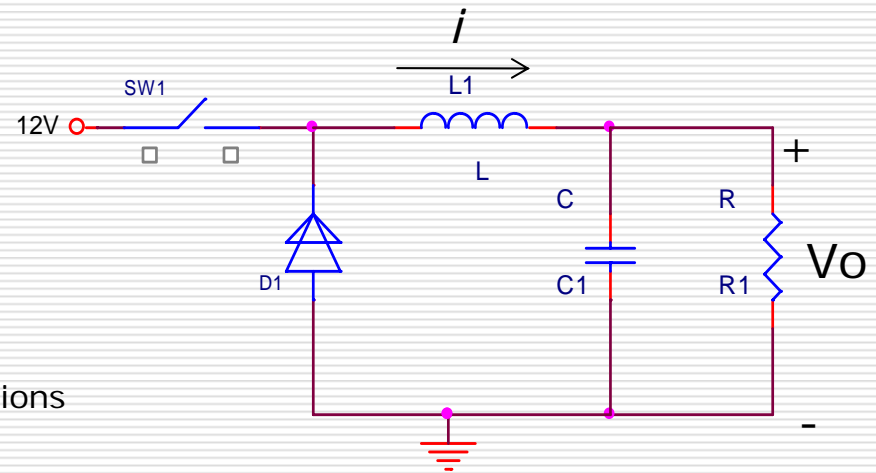
$$\frac{di}{dt} = \frac{dV_{in} - V_o}{L}$$

$$\frac{dV}{dt} = \frac{i}{C} - \frac{V_o}{RC}$$

$$\frac{di}{dt} = -\frac{1}{L}V_o + \frac{dV_{in}}{L}$$

$$\frac{dV}{dt} = \frac{1}{C}i - \frac{1}{RC}V_o$$

State Equations



Advanced Simulation Techniques

Buck Converter

On-Time Event

$$I_{peak} = I_{valley} + \frac{V_{in} - V_{out}}{L} t_{on}$$

Off-Time Event

$$I_{Valley} = I_{peak} - \frac{V_{out}}{L} t_{off}$$



Advanced Simulation Techniques

Buck CCM

$$(D(V_{in} - V_{out})T_{sw} - V_{out}(1 - D)T_{sw})\frac{1}{T_{sw}} = 0$$

$$V_{out} = DV_{in}$$

$$M = \frac{V_{out}}{V_{in}} = D$$



Advanced Simulation Techniques

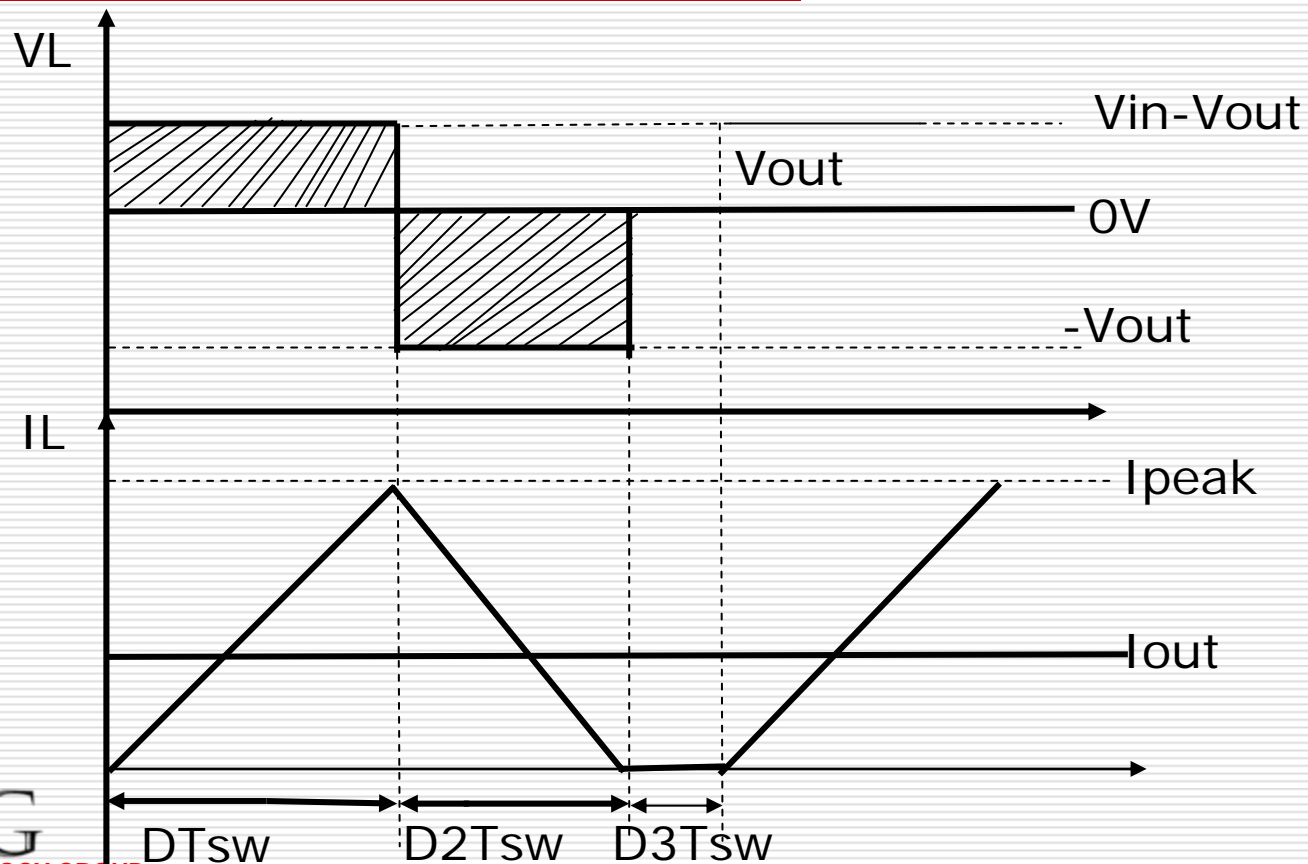
Buck CCM

- Salient Points
 - As $D < 1$, $M < 1$
 - M is Independent of The Load Current
 - By Varying the Duty Cycle D , V_{out} is Controllable



Advanced Simulation Techniques

Buck DCM



Advanced Simulation Techniques

Buck DCM

$$(V_{in} - V_{out}) DT_{sw} - V_{out} D_2 T_{sw} = 0$$

$$\frac{DT_{sw} I_{peak}}{2 T_{sw}} + \frac{D_2 T_{sw} I_{peak}}{2 T_{sw}} = I_{out}$$

$$D_2 = \frac{2 I_{out} - DI_{peak}}{I_{peak}}$$

$$I_{peak} = \frac{V_{out}}{L} D_2 T_{sw}$$

$$D_2 = \frac{2 I_{out} - DD_2 \frac{V_{out} T_{sw}}{L}}{V_{out}} \frac{L}{D_2 T_{sw}}$$



Advanced Simulation Techniques

Buck DCM

$$V_{out} = \frac{V_{in}}{1 + \frac{2V_{out}L}{D^2 T_{sw} V_{in} R}}$$

$$M = \frac{2}{1 + \sqrt{1 + \frac{8\tau_L}{D^2}}}$$

Where

$$\tau_L = \frac{L}{RT_{sw}}$$



Advanced Simulation Techniques

Buck DCM

- Salient Points:
 - M is now Dependent on the Load Current
 - For a given Duty Cycle, M is larger for a DCM than for a CCM Operation



Advanced Simulation Techniques

Buck Transition Point DCM-CCM

$$S_{on} = \frac{V_{in} - V_{out}}{L}$$

$$S_{off} = -\frac{V_{out}}{L}$$

$$I_{peak} = \frac{(V_{in} - V_{out}) DT_{sw}}{L}$$

$$\frac{(V_{in} - V_{out}) DT_{sw}}{2L} = \frac{V_{out}}{R} = \frac{DV_{in}}{R}$$

$$R_{critical} = 2 F_{sw} L \frac{V_{in}}{V_{in} - V_{out}}$$

$$L_{critical} = R \frac{(V_{in} - V_{out})}{2 F_{sw} V_{in}}$$



Advanced Simulation Techniques

Small Signal Modeling



STRATEGIC TECHNOLOGY GROUP

Experts in Power Electronics, Motor Drives
and Digital Control of Power

StrategicTechGroup.com

This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.

Advanced Simulation Techniques

Buck Converter

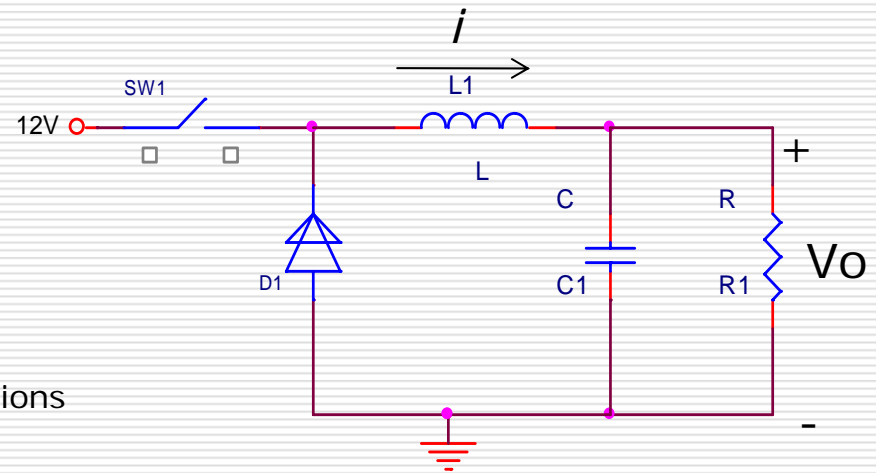
$$\frac{di}{dt} = \frac{dV_{in} - V_o}{L}$$

$$\frac{dV}{dt} = \frac{i}{C} - \frac{V_o}{RC}$$

$$\frac{di}{dt} = -\frac{1}{L}V_o + \frac{dV_{in}}{L}$$

$$\frac{dV}{dt} = \frac{1}{C}i - \frac{1}{RC}V_o$$

State Equations



Advanced Simulation Techniques

AC Perturbation

$$i = I_{dc} + \hat{i}$$

$$V_o = V_{dc} + \hat{v}$$

$$d = D + \hat{d}$$

$$\hat{i} = -\frac{V_o}{L} + \frac{DV_m}{L} + \frac{\hat{d} V_{in}}{L}$$

$$V \hat{o} = \frac{\hat{i}}{C} - \frac{V \hat{o}}{RC}$$



Advanced Simulation Techniques

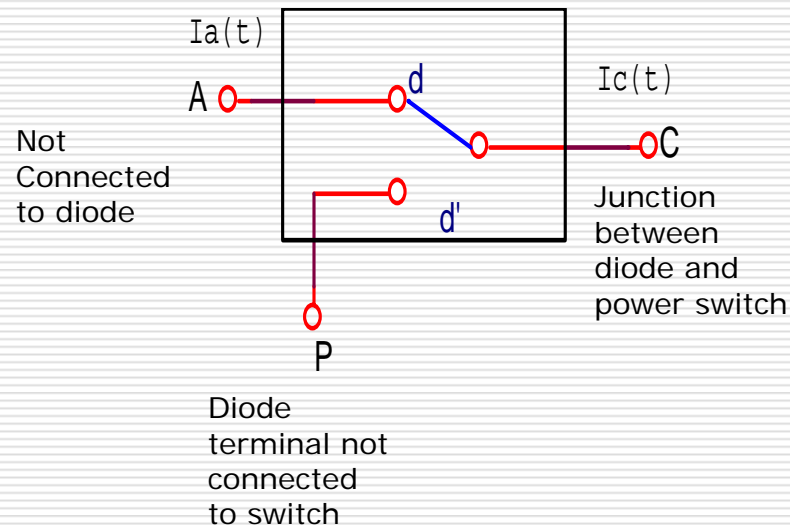
SSA Disadvantages

- Complicated Equations
- Change of Circuit requires Re-analysis
- Not really Practical for Practicing Engineers



Advanced Simulation Techniques

Pulse Width Switch Model



- Simpler than SSA
- Doesn't change with circuit or component modifications
- Identify PWM switch variables
- Average them
- Perturb them



Advanced Simulation Techniques

Small Signal Modeling

	Averaged Model	Switching Model
Bode Plot	✓	X
Control Loop Compensation	✓	X
Behavioral Model	✓	X
Simulation Time	Less	More
Time Duration	Large(in secs)	Small(in ms)
File Size	Small	Large
Parasites	X	✓
Switching Losses	X	✓



STRATEGIC TECHNOLOGY GROUP

Experts in Power Electronics, Motor Drives

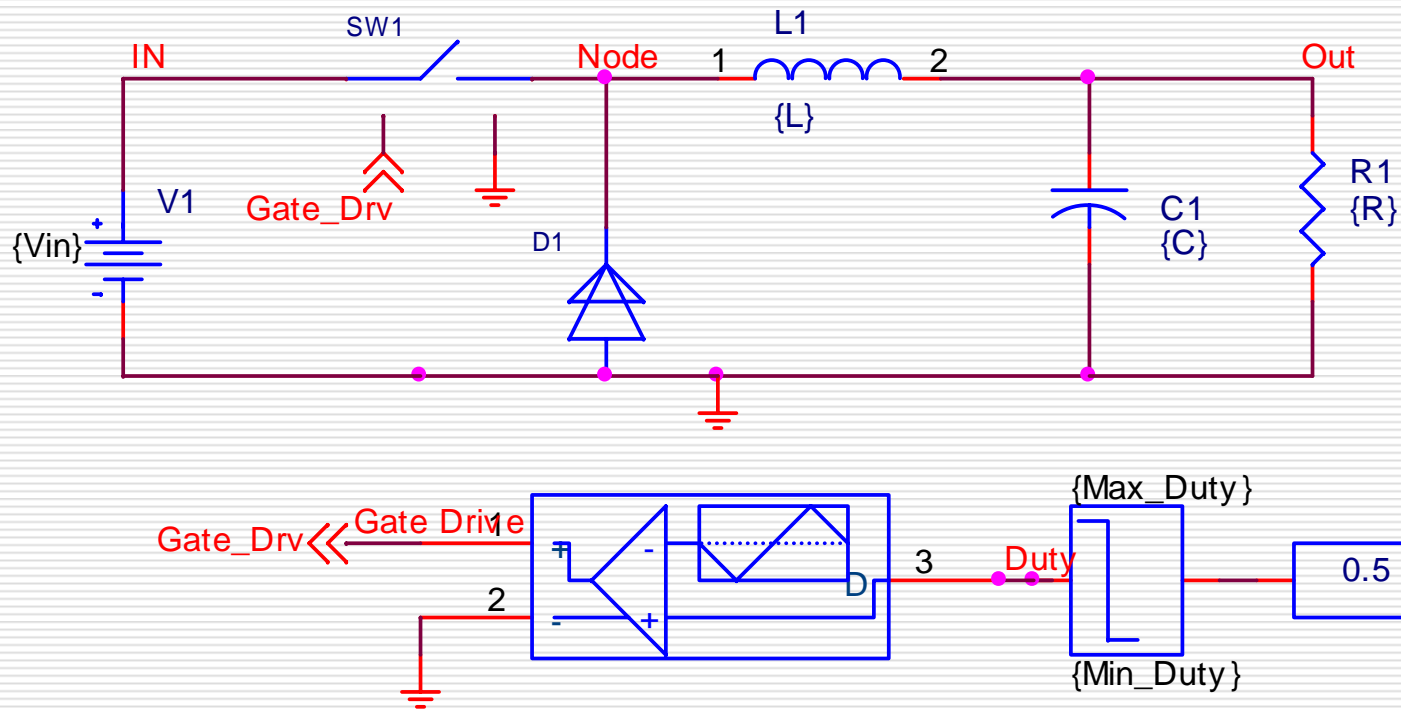
and Digital Control of Power

StrategicTechGroup.com

This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.

Advanced Simulation Techniques

Buck Converter Simulation – Cycle by Cycle



STRATEGIC TECHNOLOGY GROUP

Experts in Power Electronics, Motor Drives

and Digital Control of Power

StrategicTechGroup.com

This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.

Advanced Simulation Techniques

Buck Parameters

*Buck Converter Parameters

```
.PARAM Vin = 12
.PARAM L = 100u
.PARAM C = 10u
.PARAM R = 10
.PARAM Max_Duty = 0.99
.PARAM Min_Duty = 0.01
*** Gate Drive Voltage
.PARAM GATE_DRIVE_V = 5
****
```

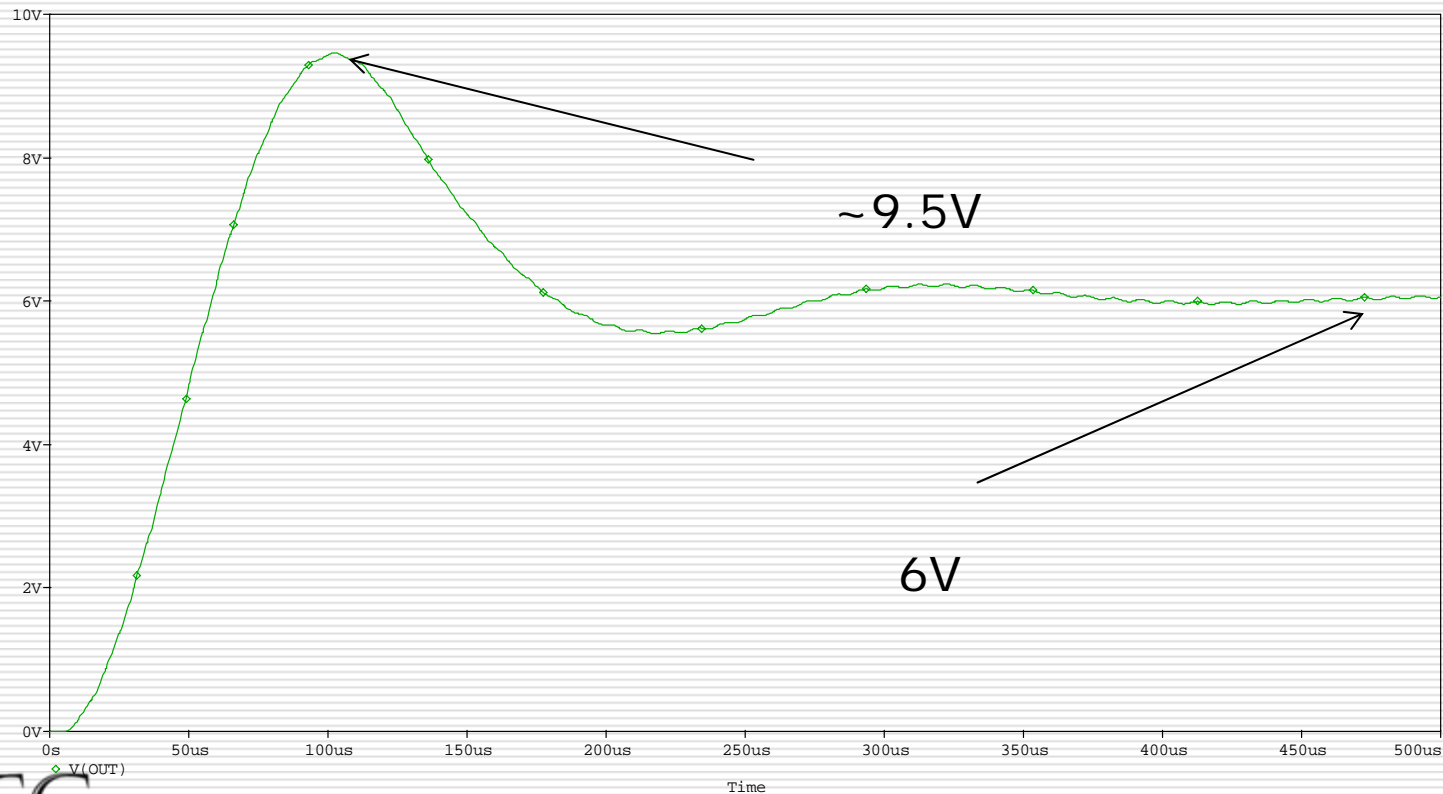
*Type 1 Amplifier Parameters

```
.PARAM C_COMP = 16nF
.PARAM R_COMP = 10k
**Triangular PWM Parameters
.PARAM Hi = {GATE_DRIVE_V}
.PARAM Lo = 0
.PARAM PWM_FREQ = 100k
.PARAM GAIN = 500
```



Advanced Simulation Techniques

Buck Converter Simulation – Cycle by Cycle



STRATEGIC TECHNOLOGY GROUP

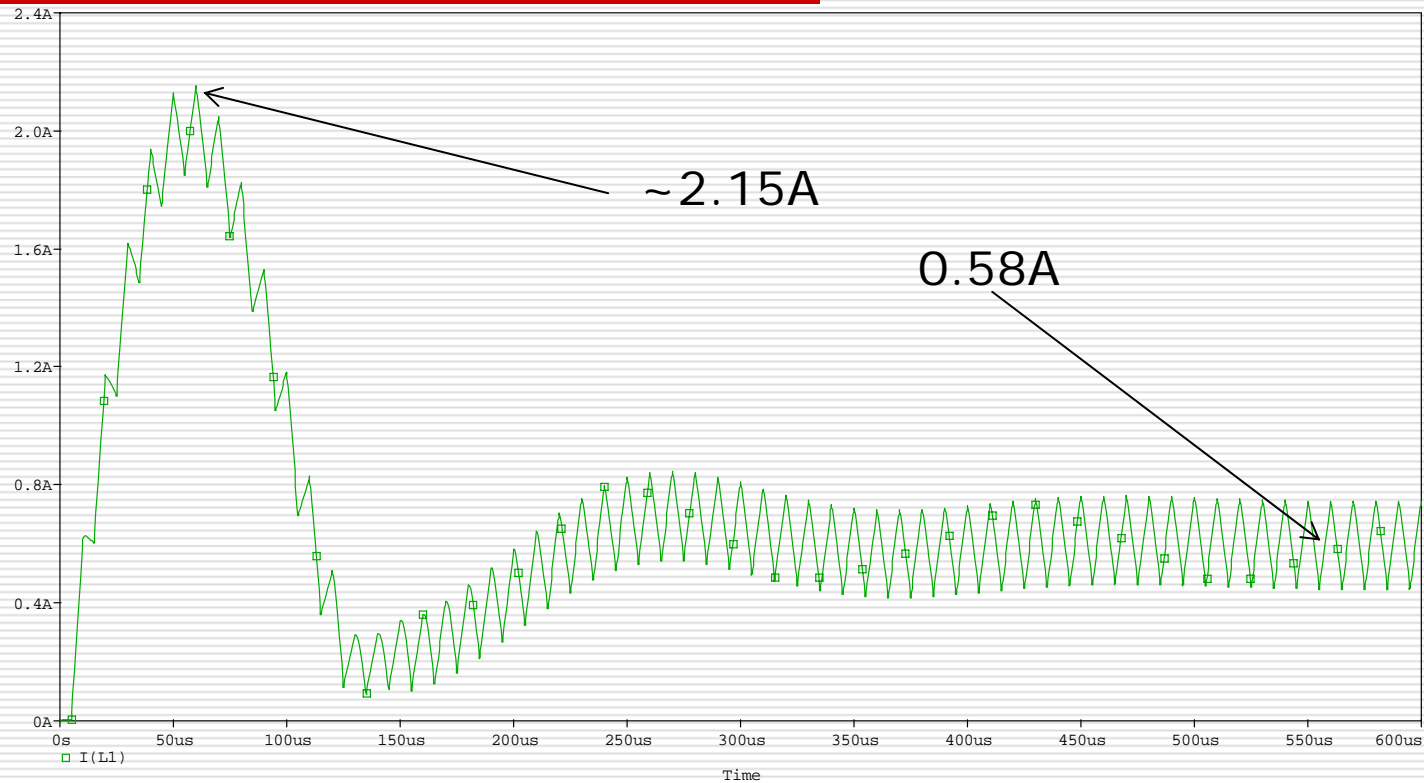
Experts in Power Electronics, Motor Drives
and Digital Control of Power

StrategicTechGroup.com

This document contains confidential and privileged information. Any unauthorized review, use,
disclosure, or distribution is prohibited.

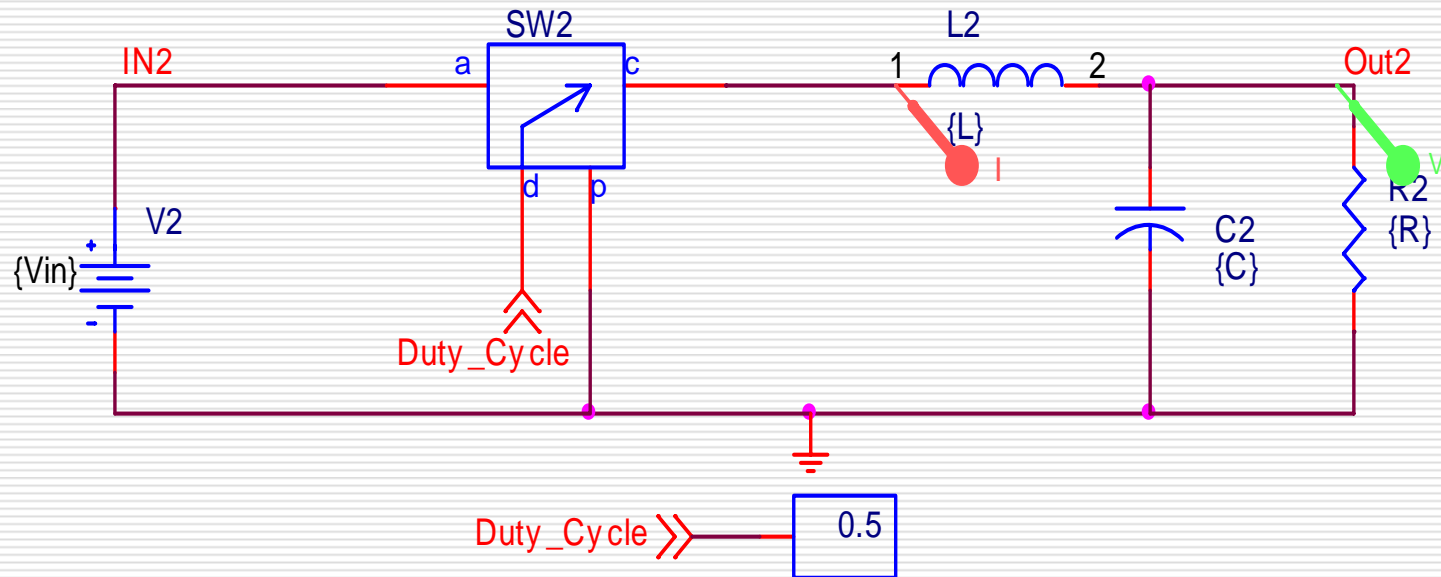
Advanced Simulation Techniques

Buck Converter Simulation – Cycle by Cycle



Advanced Simulation Techniques

Buck Converter Simulation – Average Switch



STRATEGIC TECHNOLOGY GROUP

Experts in Power Electronics, Motor Drives

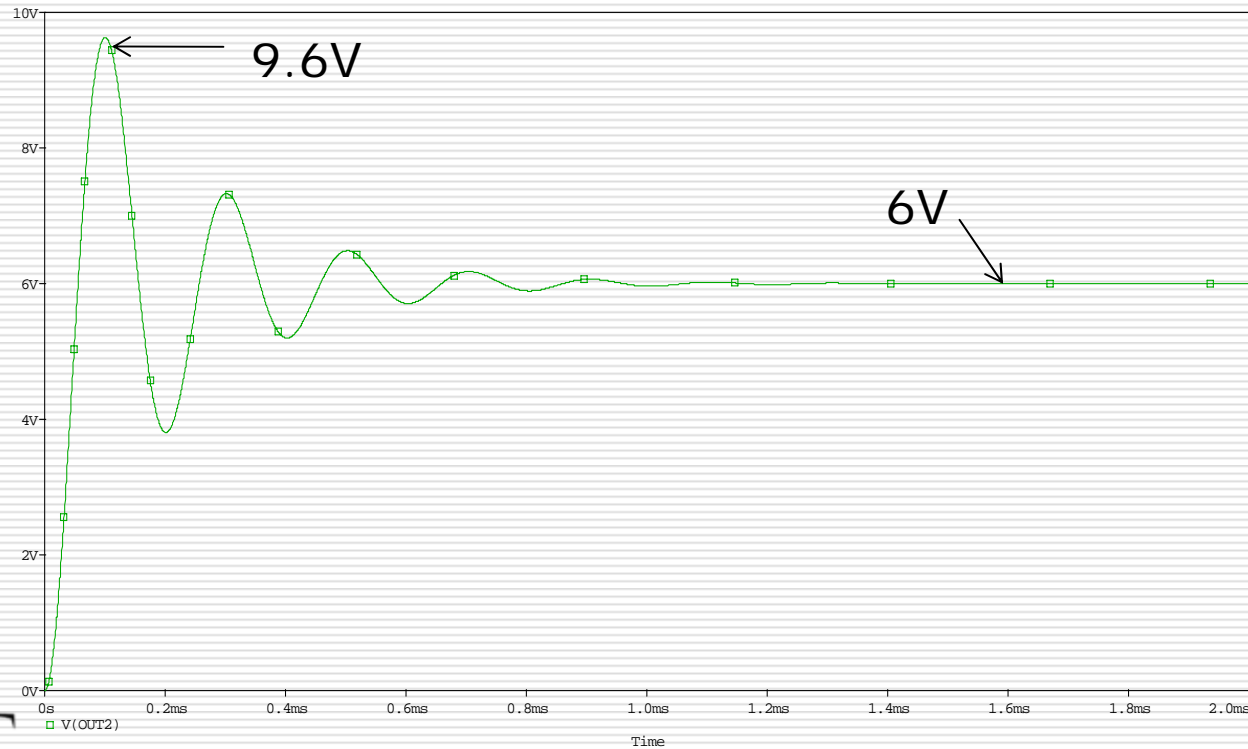
and Digital Control of Power

StrategicTechGroup.com

This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.

Advanced Simulation Techniques

Buck Converter Simulation – Average Switch



STRATEGIC TECHNOLOGY GROUP

Experts in Power Electronics, Motor Drives

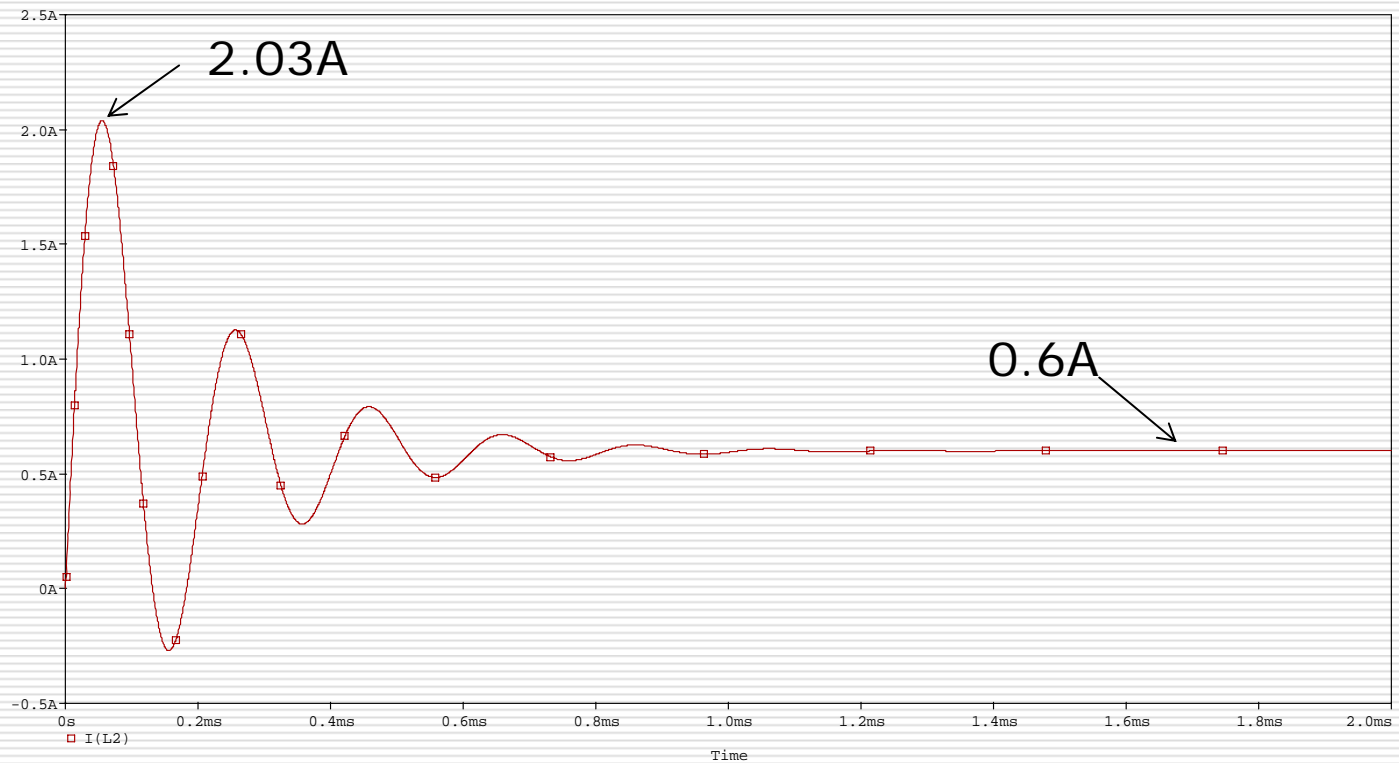
and Digital Control of Power

StrategicTechGroup.com

This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.

Advanced Simulation Techniques

Buck Converter Simulation – Average Switch



Advanced Simulation Techniques

Buck Converter: Demonstration

Demonstration #16: Buck Converter



Advanced Simulation Techniques

Boost Converter

On-Time Event

$$I_{peak} = I_{valley} + \frac{V_{in}}{L} t_{on}$$

Off-Time Event

$$I_{valley} = I_{peak} - \frac{V_{out} - V_{in}}{L} t_{off}$$



Advanced Simulation Techniques

Boost CCM

$$(DV_{in}T_{sw} - (V_{out} - V_{in})D'T_{sw})\frac{1}{T_{sw}} = 0$$

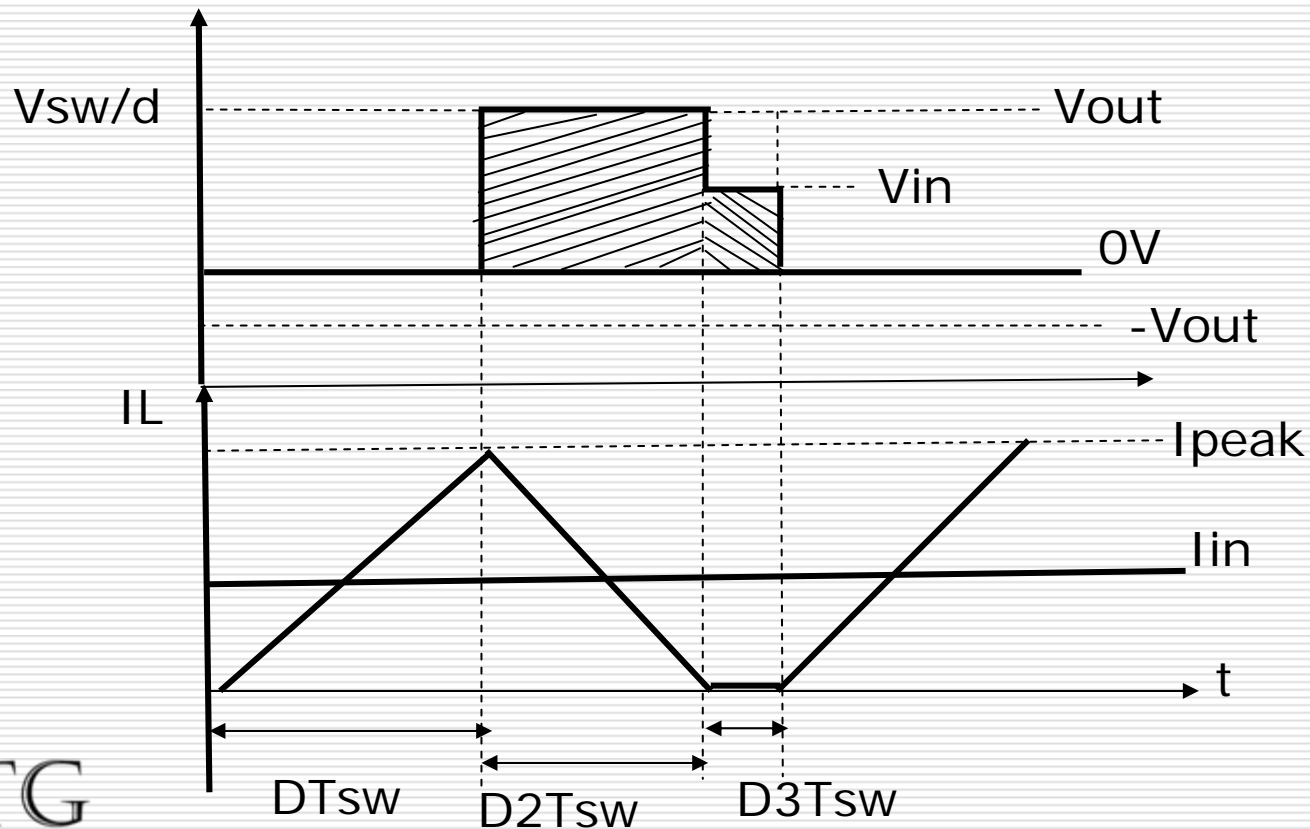
$$M = \frac{V_{out}}{V_{in}} = \frac{1}{D'} \quad \text{Where } D' = 1 - D$$

$$= \frac{1}{1 - D}$$



Advanced Simulation Techniques

Boost DCM



Advanced Simulation Techniques

Boost DCM

$$\langle V_L \rangle T_{sw} = \langle V_{in} \rangle T_{sw} - \langle V_{sw/D} \rangle T_{sw} = 0$$

$$\langle V_{sw/D} \rangle T_{sw} = D_2 V_{out} + D_3 V_{in}$$

$$\langle V_{in} \rangle T_{sw} = D_2 V_{out} + (1 - D - D_2) V_{in}$$

$$\frac{V_{out}}{V_{in}} = \frac{D}{1 - D - D_2} + 1$$

$$\frac{V_{in}}{V_{out}} I_{in} = \frac{D_2}{1 - D - D_2} I_{out}$$



Advanced Simulation Techniques

Boost DCM

$$\langle I_L \rangle T_{sw} = \frac{DI_{peak}}{2} + \frac{D_2 I_{peak}}{2} = \frac{V_{out}}{V_{in}} \frac{V_{out}}{R}$$

$$D_2 = \frac{2V_{out}^2}{V_{in} R I_{peak}} - D$$

$$I_{peak} = \frac{V_{out} - v_{in}}{L} D_2 T_{sw}$$

$$D_2 = \frac{2V_{out}^2 L}{V_{in} R (V_{out} - V_{in}) D_2 T_{sw}} - D$$

$$M = \frac{1}{2} \left(1 + \sqrt{1 + \frac{2T_{sw} R D^2}{L}} \right)$$



Advanced Simulation Techniques

Boost DCM

$$M = \frac{1 + \sqrt{1 + \frac{2D^2}{\tau_L}}}{2}$$

Where

$$\tau_L = \frac{L}{RT_{sw}}$$



Advanced Simulation Techniques

Boost DCM

- Salient Points:
 - M is Dependent on the Load Current
 - A Certain Linearity exists between M and D, as on a buck in CCM
 - For a given Duty Cycle, M can be Larger For DCM than For CCM



Advanced Simulation Techniques

Boost Transition Point DCM-CCM

$$S_{on} = \frac{V_{in}}{L}$$

$$S_{off} = - \frac{V_{out} - V_{in}}{L}$$

$$I_{peak} = \frac{V_{in} DT_{sw}}{L}$$

$$\langle I_L \rangle T_{sw} = \frac{V_{in} DT_{sw}}{2L}$$



Advanced Simulation Techniques

Boost Transition Point DCM-CCM

$$\langle I_L \rangle T_{sw} = \frac{V_{out}^2}{R V_{in}}$$

Since $\frac{V_{out}}{V_{in}} = \frac{1}{1-D}$

$$\frac{DT_{sw}}{2L} = \frac{1}{R(1-D)} \frac{1}{(1-D)}$$

$$R_{critical} = \frac{2F_{sw}L}{D(1-D)^2}$$

$$L_{critical} = \frac{RD(1-D)^2}{2F_{sw}}$$



Advanced Simulation Techniques

Boost Transition Point DCM-CCM

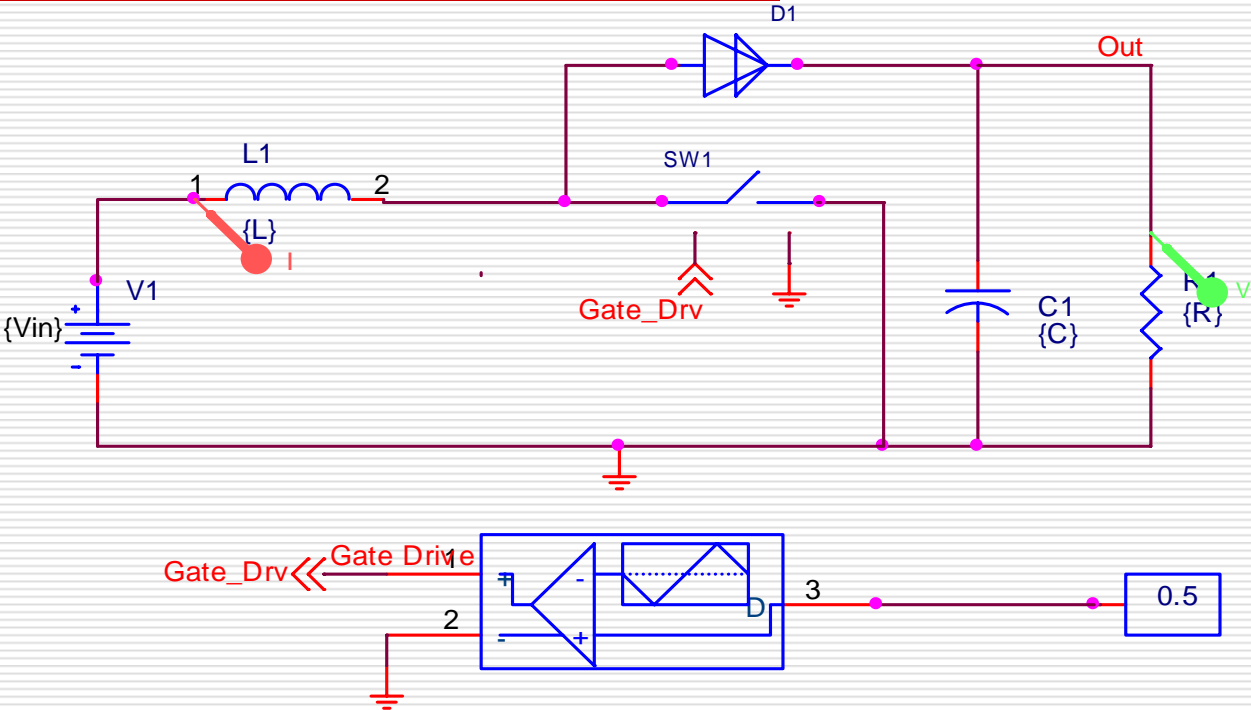
$$R_{critical} = \frac{2F_{sw}LV_{out}^2}{\left(1 - \frac{V_{in}}{V_{out}}\right)V_{in}}$$

$$L_{critical} = \frac{\left(1 - \frac{V_{in}}{V_{out}}\right)}{2F_{sw}V_{out}^2}V_{in}^2R$$



Advanced Simulation Techniques

Boost Converter Simulation – Cycle by Cycle



Advanced Simulation Techniques

Boost Parameters

*Boost Converter Parameters

```
.PARAM Vin = 20  
.PARAM L = 1m  
.PARAM C = 30u  
.PARAM R = 20  
.PARAM Max_Duty = 0.99  
.PARAM Min_Duty = 0.01  
*** Gate Drive Voltage  
.PARAM GATE_DRIVE_V = 5  
****
```

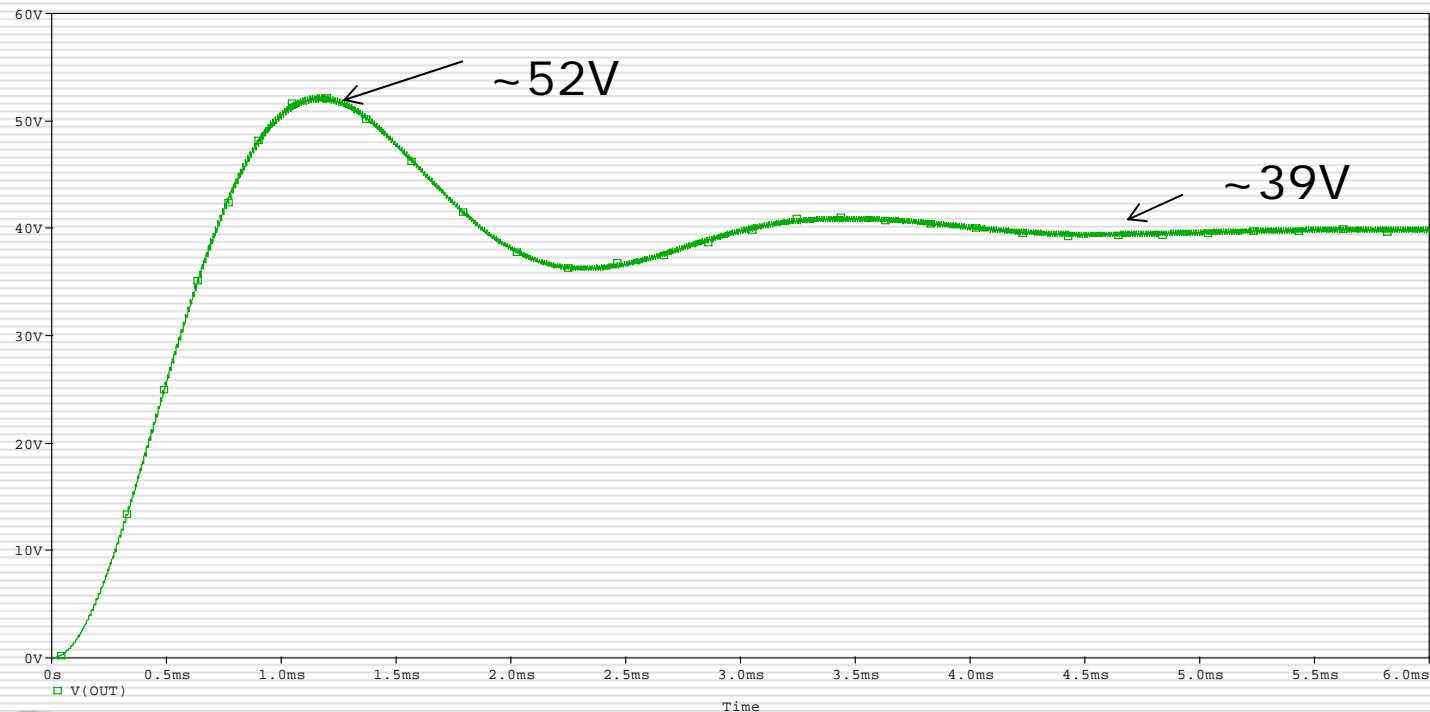
*Type 1 Amplifier Parameters

```
.PARAM C_COMP = 16nF  
.PARAM R_COMP = 10k  
**Triangular PWM Parameters  
.PARAM Hi = {GATE_DRIVE_V}  
.PARAM Lo = 0  
.PARAM PWM_FREQ = 100k  
.PARAM GAIN = 500
```



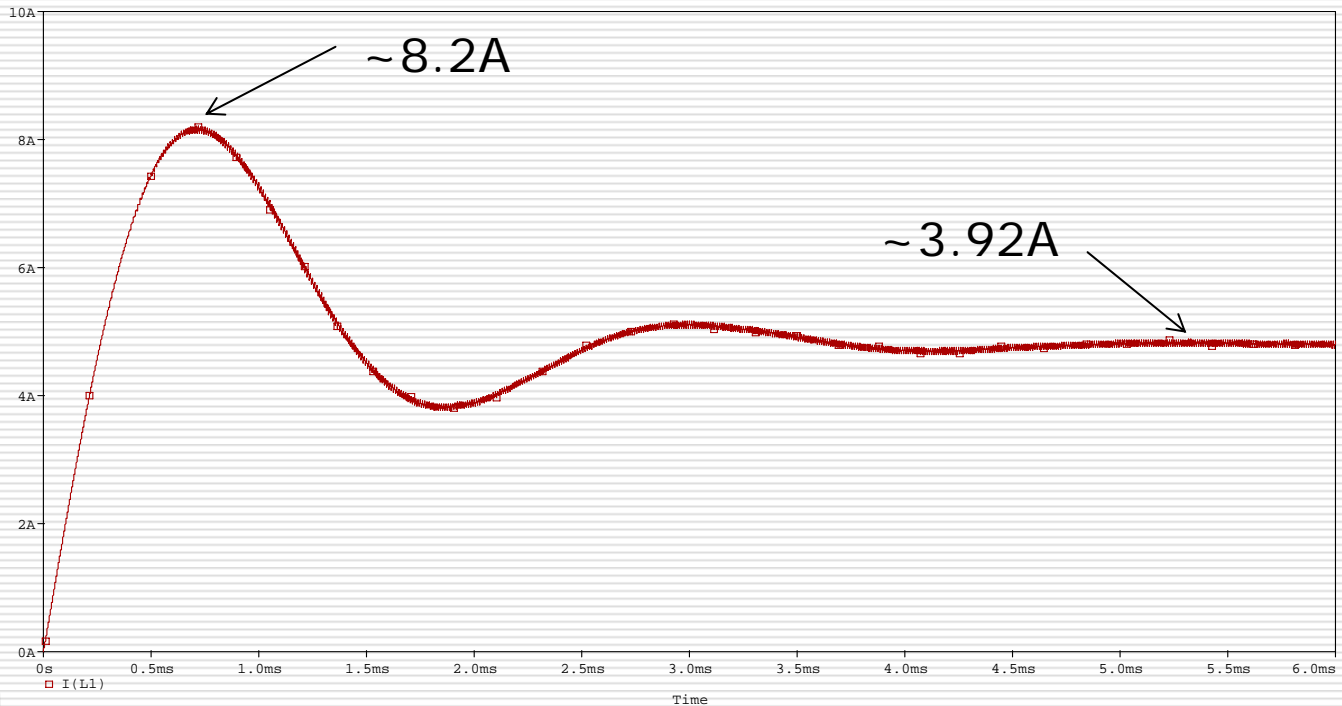
Advanced Simulation Techniques

Boost Converter Simulation – Cycle by Cycle



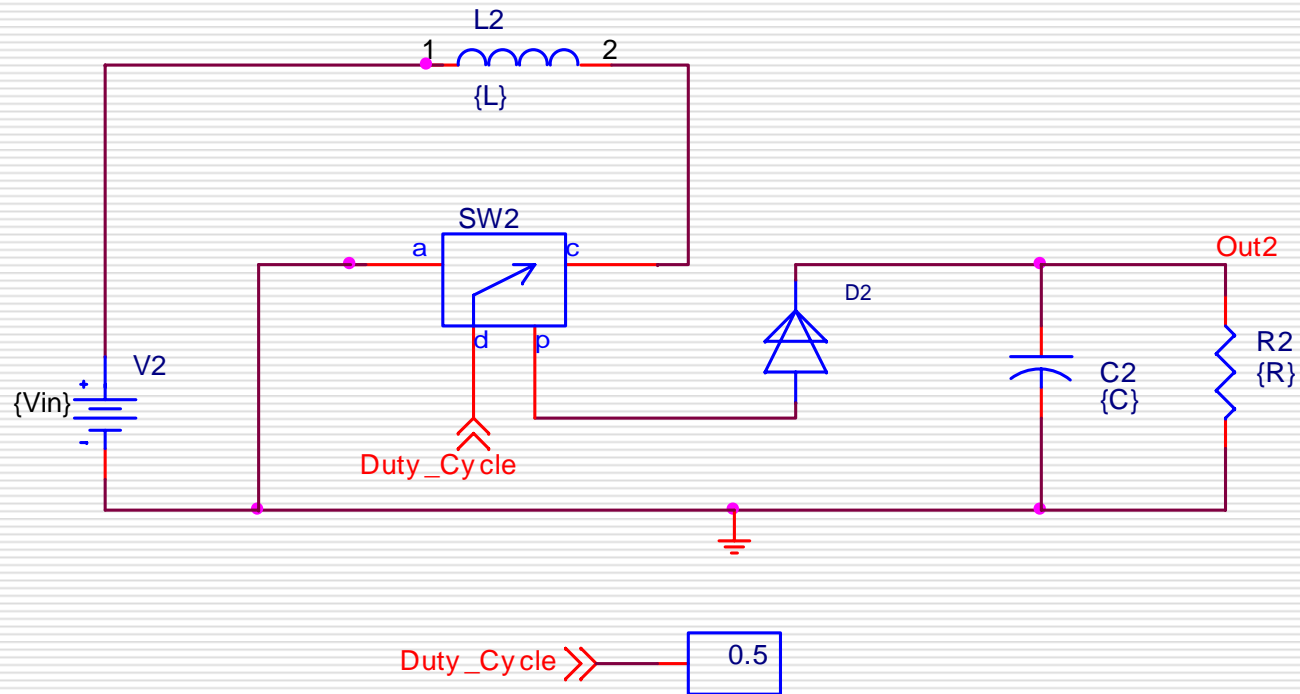
Advanced Simulation Techniques

Boost Converter Simulation – Cycle by Cycle



Advanced Simulation Techniques

Boost Converter Simulation – Average Switch



STRATEGIC TECHNOLOGY GROUP

Experts in Power Electronics, Motor Drives

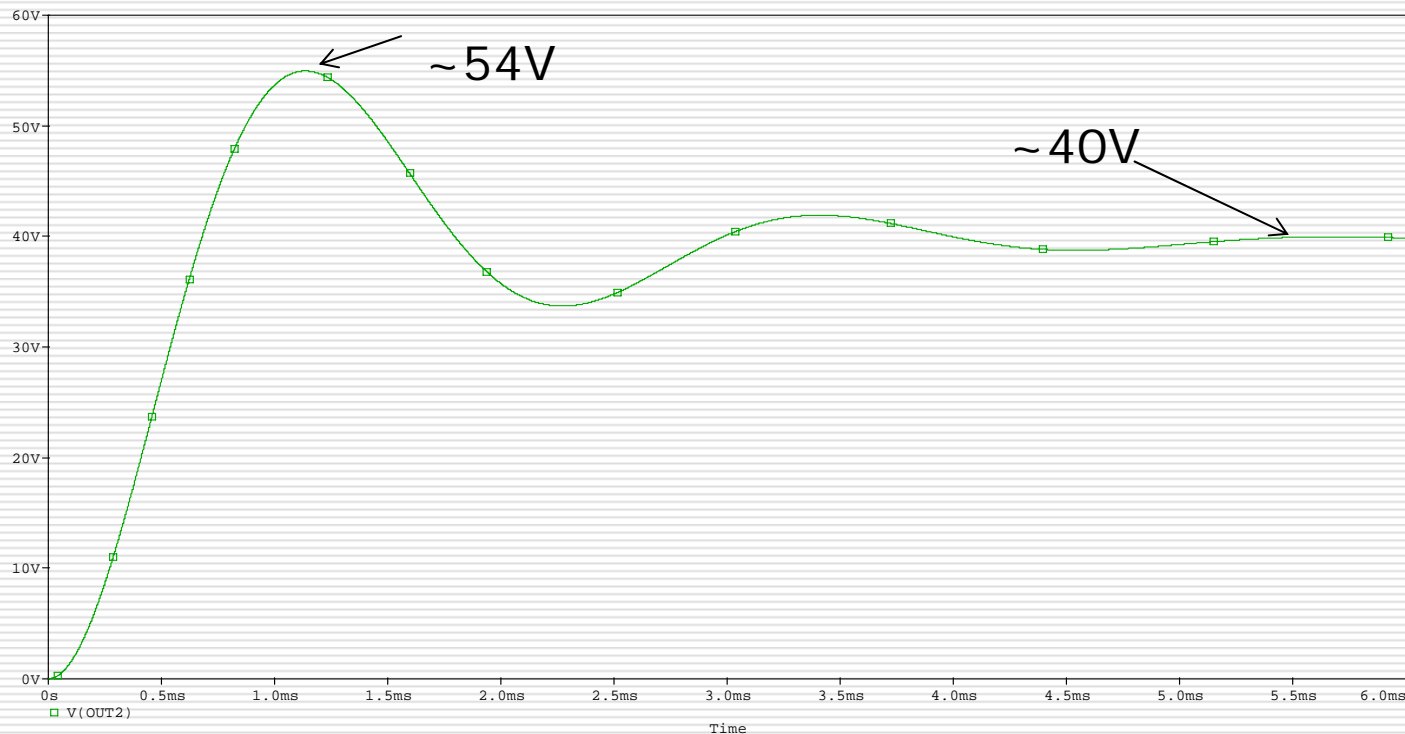
and Digital Control of Power

StrategicTechGroup.com

This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.

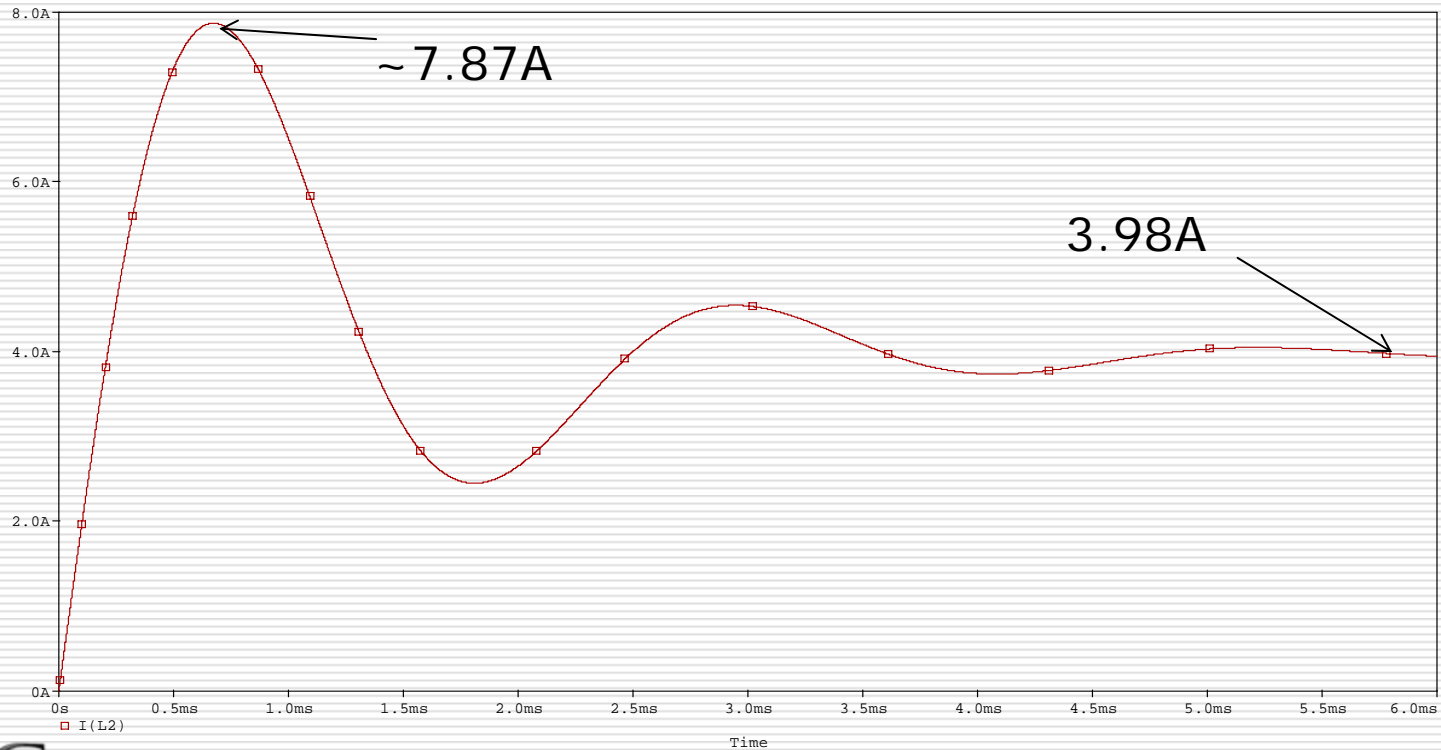
Advanced Simulation Techniques

Boost Converter Simulation – Average Switch



Advanced Simulation Techniques

Boost Converter Simulation – Average Switch



STRATEGIC TECHNOLOGY GROUP

Experts in Power Electronics, Motor Drives

and Digital Control of Power

StrategicTechGroup.com

This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.

Advanced Simulation Techniques

Boost Converter: Demonstration

Demonstration#17 : Boost Converter



Advanced Simulation Techniques

Buck-Boost Converter

On-Time Event

$$I_{peak} = I_{valley} + \frac{V_{in}}{L} t_{on}$$

Off-Time Event

$$I_{valley} = I_{peak} - \frac{V_{in}}{L} t_{on}$$



Advanced Simulation Techniques

Buck-Boost CCM

$$V_{in} D - V_{out} D' = 0$$

$$\frac{V_{out}}{V_{in}} = \frac{D}{1-D} = M$$



Advanced Simulation Techniques

Buck-Boost DCM

$$\langle V_L \rangle_{T_{sw}} = \left\langle V_{sw} / D \right\rangle_{T_{sw}} = 0$$

$$0 = DV_{in} - D_2 V_{out}$$

$$\langle I_D \rangle_{T_{sw}} = \frac{I_{peak} D_2 T_{sw}}{2} \frac{1}{T_{sw}} = I_{out}$$

Since

$$I_{out} = \frac{V_{out}}{R}$$

$$D_2 = \frac{2V_{out}}{RI_{peak}}$$



Advanced Simulation Techniques

Buck-Boost DCM

$$I_{peak} = DT_{sw} \frac{V_{in}}{L}$$

$$D_2 = \frac{2V_{out}}{R} \frac{L}{DV_{in}T_{sw}} = \frac{2V_{out}\tau_L}{DV_{in}}$$

where

$$\tau_L = \frac{L}{RT_{sw}}$$

$$\frac{2V_{out}\tau_L}{DV_{in}} V_{out} = DV_{in}$$



Advanced Simulation Techniques

Buck-Boost DCM

$$D^2 V_{in}^2 = 2V_{out}^2 \tau_L$$

$$M = -D \sqrt{\frac{1}{2\tau_L}}$$



Advanced Simulation Techniques

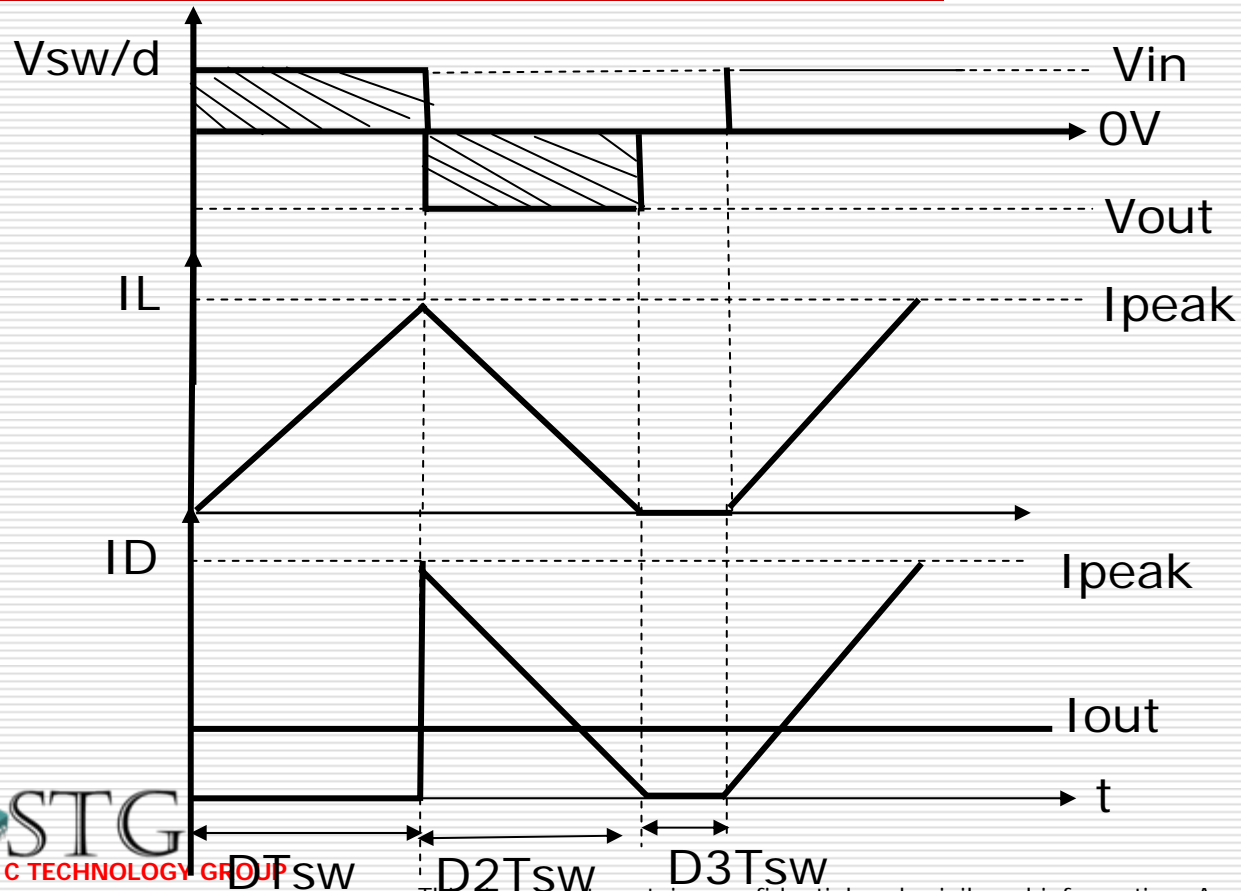
Buck-Boost DCM

- Salient Points:
 - M is Dependent on the Load Current
 - Linearity Exists Between M And D, as on a Buck in CCM.
 - For a given Duty Cycle, M Can be Larger for DCM than CCM



Advanced Simulation Techniques

Buck-Boost DCM



Advanced Simulation Techniques

Buck-Boost Transition DCM-CCM

$$S_{on} = \frac{V_{in}}{L}$$

$$I_{peak} = \frac{V_{in} DT_{sw}}{L}$$

$$\langle I_{in} \rangle T_{sw} = \frac{I_{peak} D}{2}$$

$$\langle I_{in} \rangle T_{sw} = \frac{V_{in} D^2 T_{sw}}{2L}$$



Advanced Simulation Techniques

Buck-Boost Transition DCM-CCM

Assuming a 100% Efficiency

$$V_{in} \langle I_{in} \rangle T_{sw} = V_{out} I_{out} \rightarrow \frac{V_{in}^2 D^2 T_{sw}}{2L} = \frac{V_{out}}{R}$$

$$V_{in}^2 D^2 T_{sw} R = 2L V_{out}^2$$

Since

$$\frac{V_{out}}{V_{in}} = \frac{D}{1-D}$$

$$R_{critical} = \frac{2LF_{sw}}{(1-D)^2}$$



Advanced Simulation Techniques

Buck-Boost Transition DCM-CCM

$$R_{critical} = 2LF_{sw} \left(\frac{V_{in} + V_{out}}{V_{in}} \right)^2$$

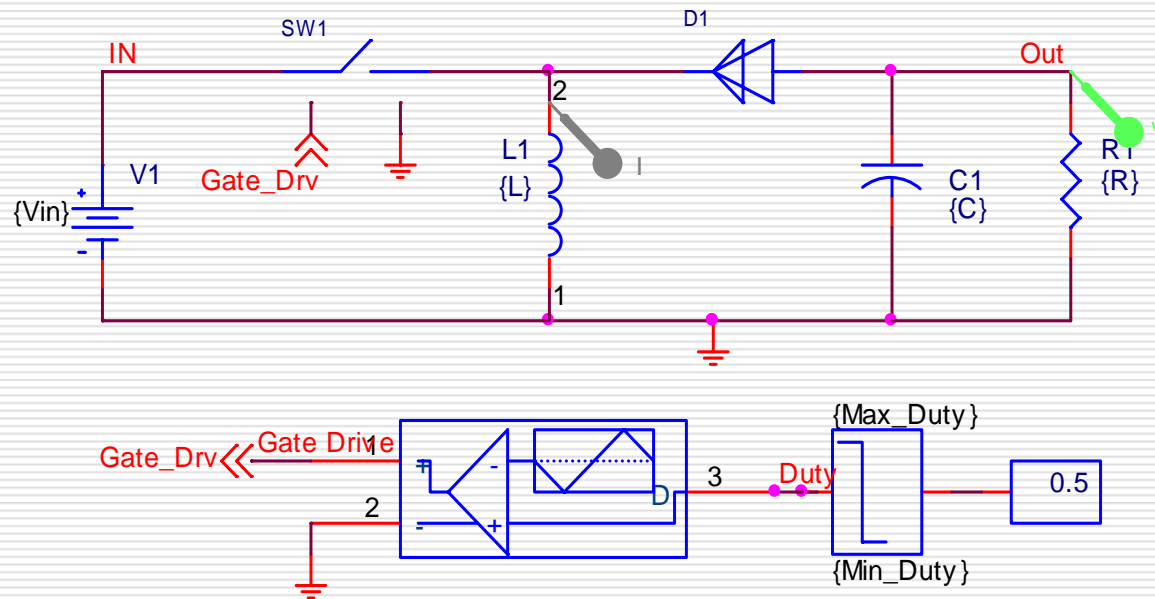
$$L_{critical} = \frac{R}{2F_{sw}} \left(\frac{V_{in}}{V_{in} + V_{out}} \right)$$

$$L_{critical} = \frac{(1 - D)^2 R}{2F_{sw}}$$



Advanced Simulation Techniques

Buck-Boost Converter Simulation – Cycle by Cycle



STRATEGIC TECHNOLOGY GROUP

Experts in Power Electronics, Motor Drives

and Digital Control of Power

StrategicTechGroup.com

This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.

Advanced Simulation Techniques

Buck Boost Parameters

*Buck Converter Parameters

```
.PARAM Vin = 40  
.PARAM L = 2m  
.PARAM C = 20u  
.PARAM R = 20  
.PARAM Max_Duty = 0.99  
.PARAM Min_Duty = 0.01  
*** Gate Drive Voltage  
.PARAM GATE_DRIVE_V = 5  
****
```

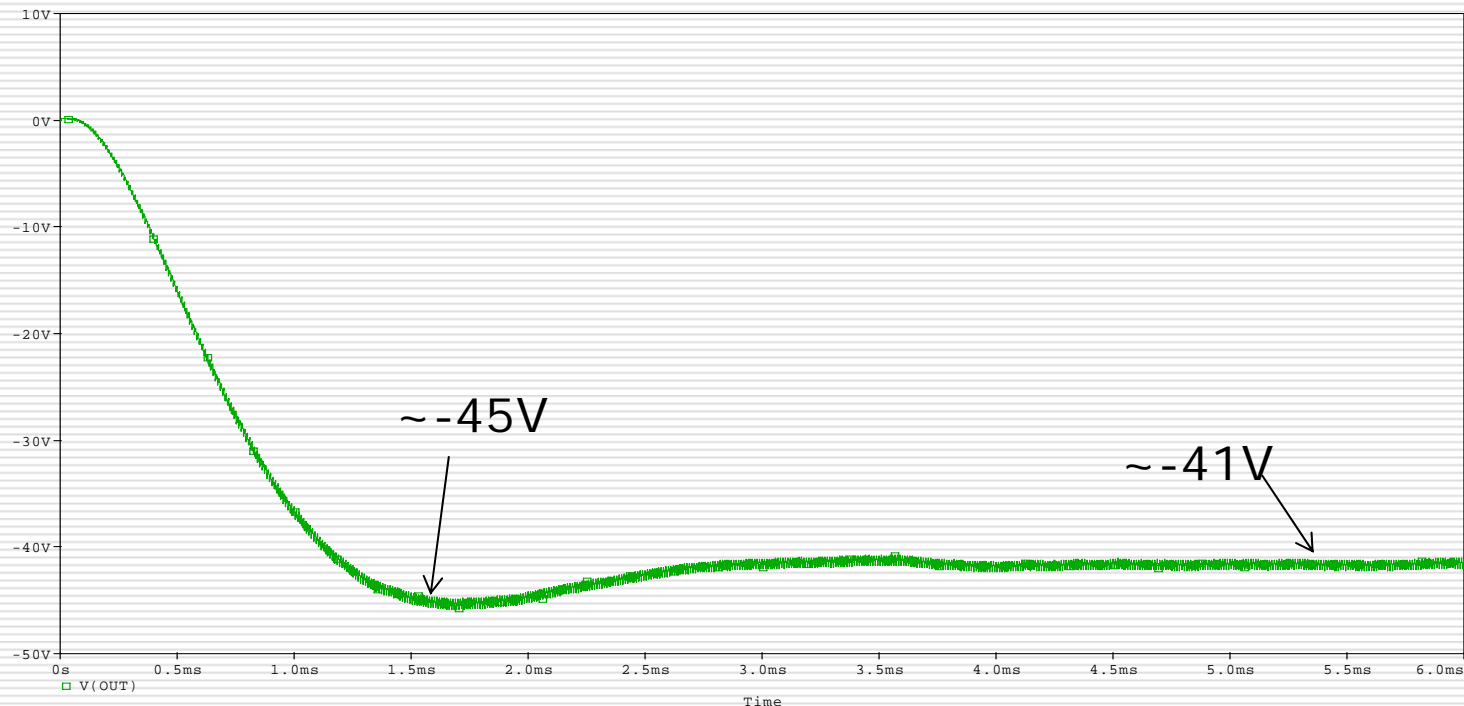
*Type 1 Amplifier Parameters

```
.PARAM C_COMP = 16nF  
.PARAM R_COMP = 10k  
**Triangular PWM Parameters  
.PARAM Hi = {GATE_DRIVE_V}  
.PARAM Lo = 0  
.PARAM PWM_FREQ = 100k  
.PARAM GAIN = 500
```



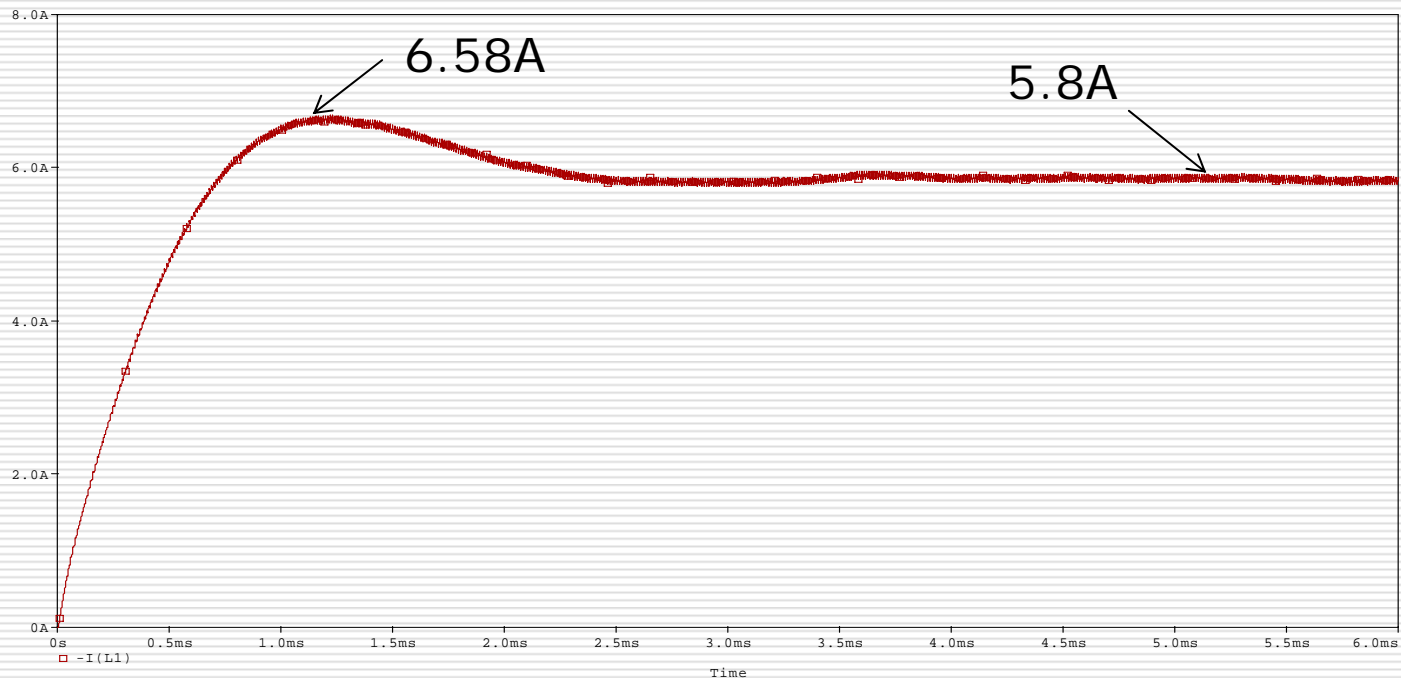
Advanced Simulation Techniques

Buck-Boost Converter Simulation – Cycle by Cycle



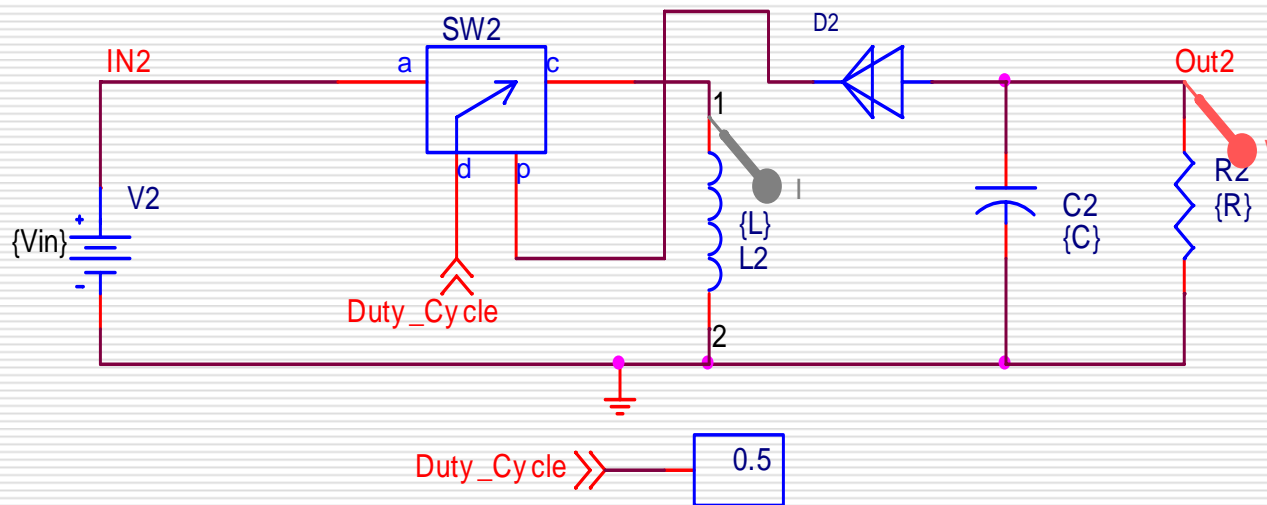
Advanced Simulation Techniques

Buck-Boost Converter Simulation – Cycle by Cycle



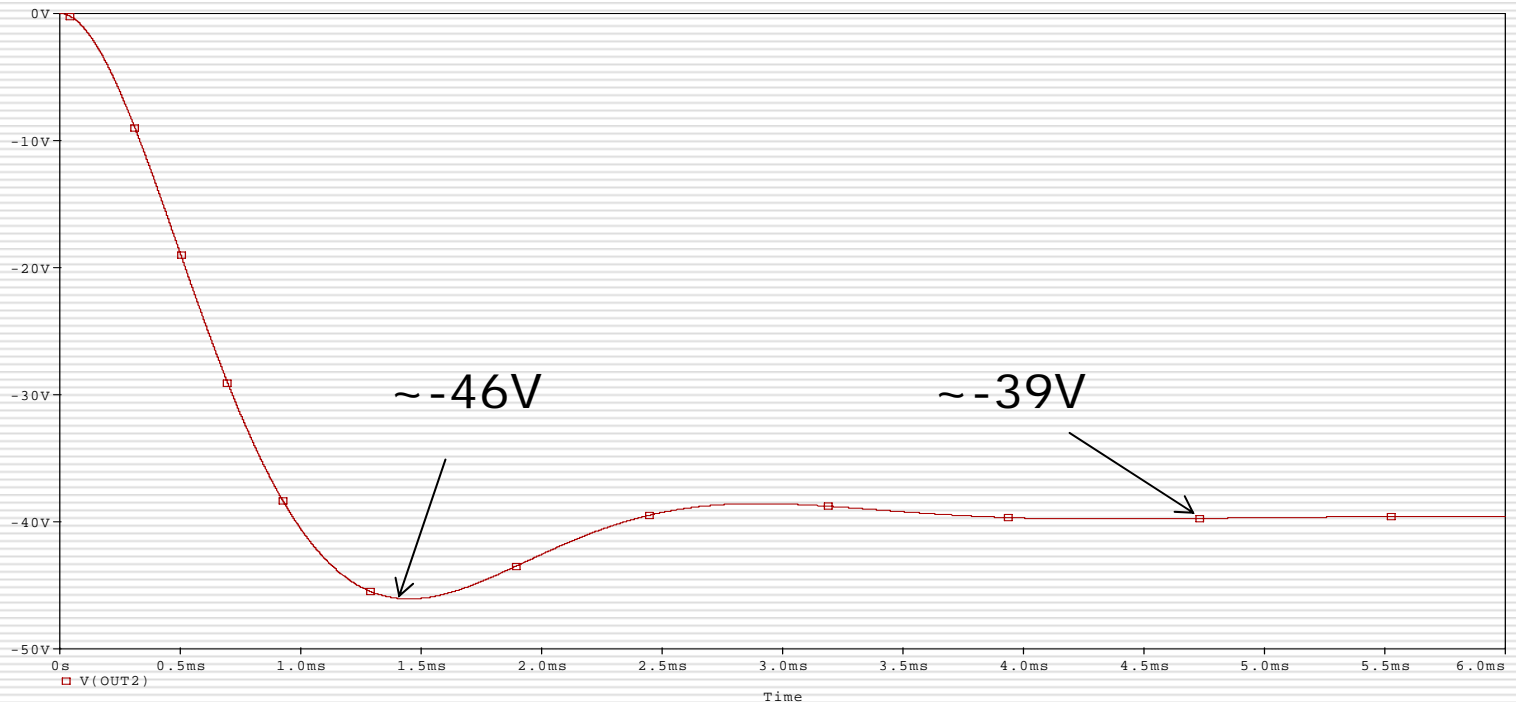
Advanced Simulation Techniques

Buck-Boost Converter Simulation – Average Switch



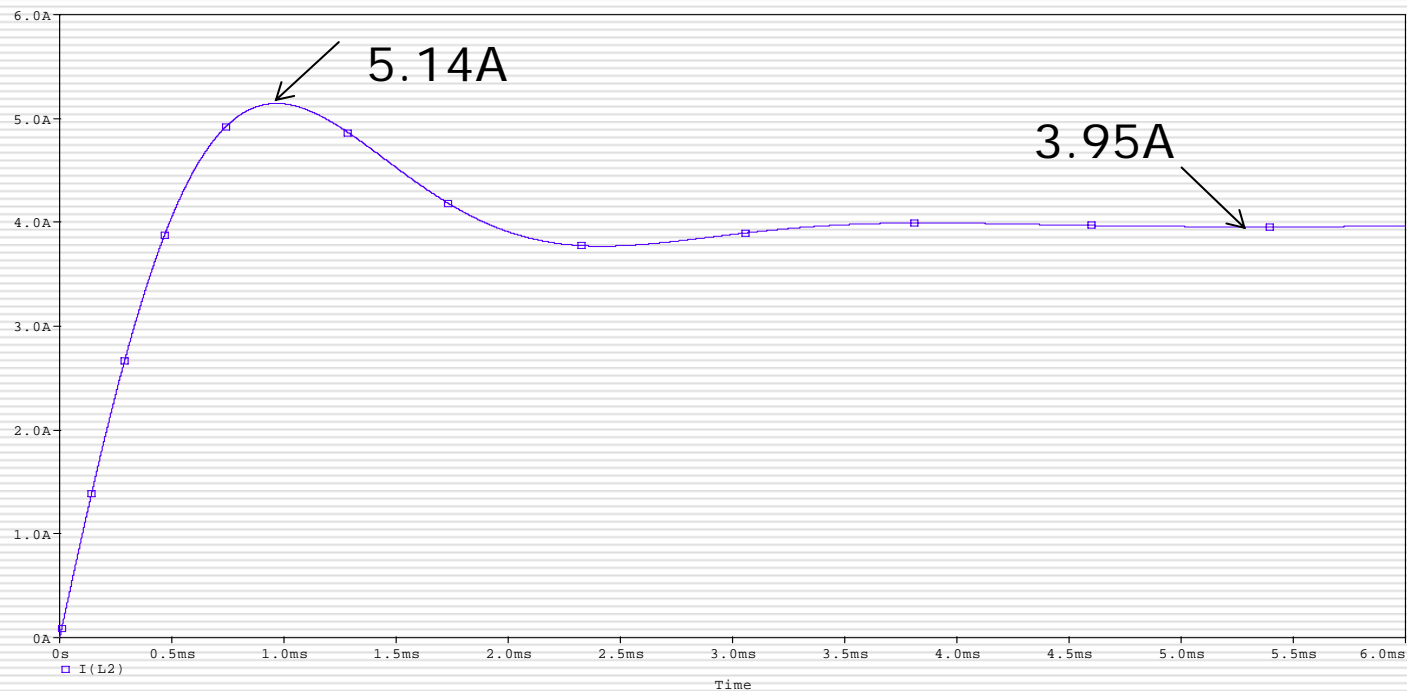
Advanced Simulation Techniques

Buck-Boost Converter Simulation – Average Switch



Advanced Simulation Techniques

Buck-Boost Converter Simulation – Average Switch



Advanced Simulation Techniques

Buck-Boost Converter: Demonstration

Demonstration #18: Buck-Boost Converter



STRATEGIC TECHNOLOGY GROUP

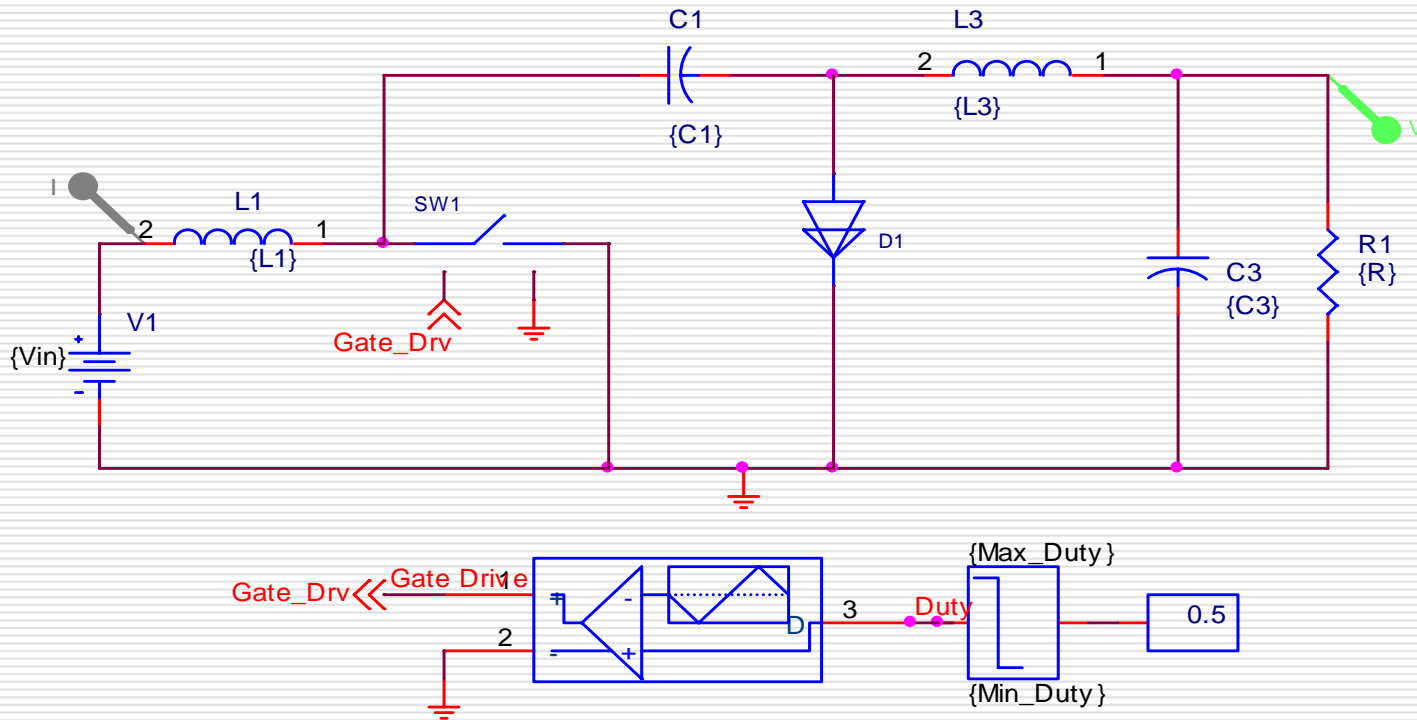
Experts in Power Electronics, Motor Drives
and Digital Control of Power

StrategicTechGroup.com

This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.

Advanced Simulation Techniques

Cuk Converter Simulation – Cycle by Cycle



STRATEGIC TECHNOLOGY GROUP

Experts in Power Electronics, Motor Drives

and Digital Control of Power

StrategicTechGroup.com

This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.

Advanced Simulation Techniques

Cuk Parameters

*Buck Converter Parameters

```
.PARAM Vin = 40  
.PARAM L1 = 5m  
.PARAM C1 = 5u  
.PARAM L3 = 5m  
.PARAM C3 = 2.5u  
.PARAM R = 20  
.PARAM Max_Duty = 0.99  
.PARAM Min_Duty = 0.01  
*** Gate Drive Voltage  
.PARAM GATE_DRIVE_V = 5  
****
```

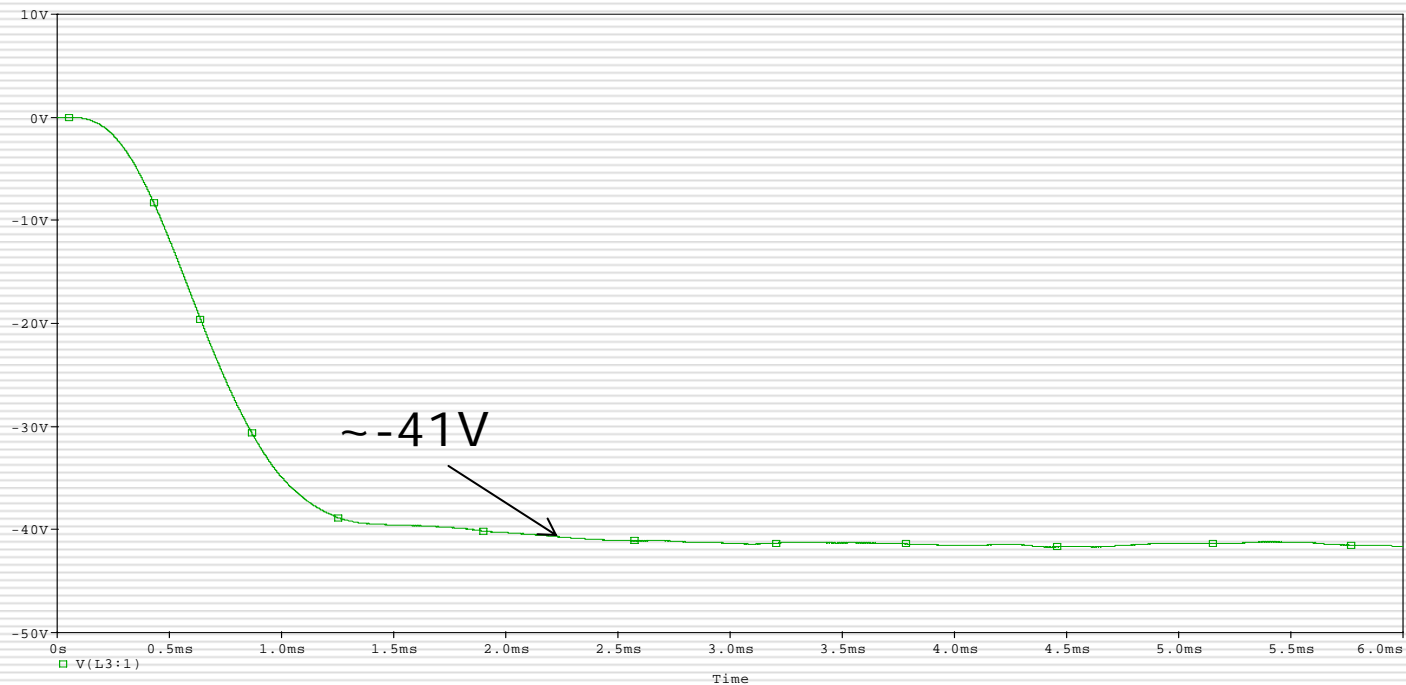
*Type 1 Amplifier Parameters

```
.PARAM C_COMP = 16nF  
.PARAM R_COMP = 10k  
**Triangular PWM Parameters  
.PARAM Hi = {GATE_DRIVE_V}  
.PARAM Lo = 0  
.PARAM PWM_FREQ = 100k  
.PARAM GAIN = 500
```



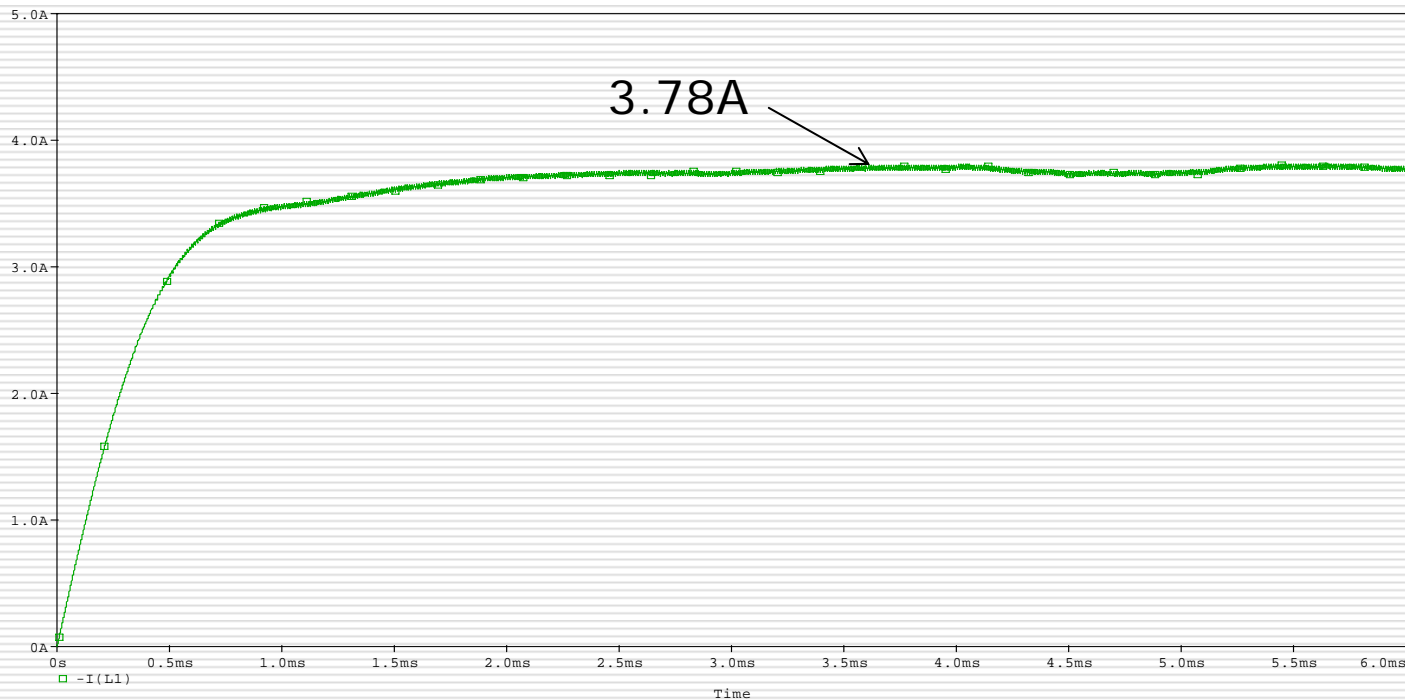
Advanced Simulation Techniques

Cuk Converter Simulation – Cycle by Cycle



Advanced Simulation Techniques

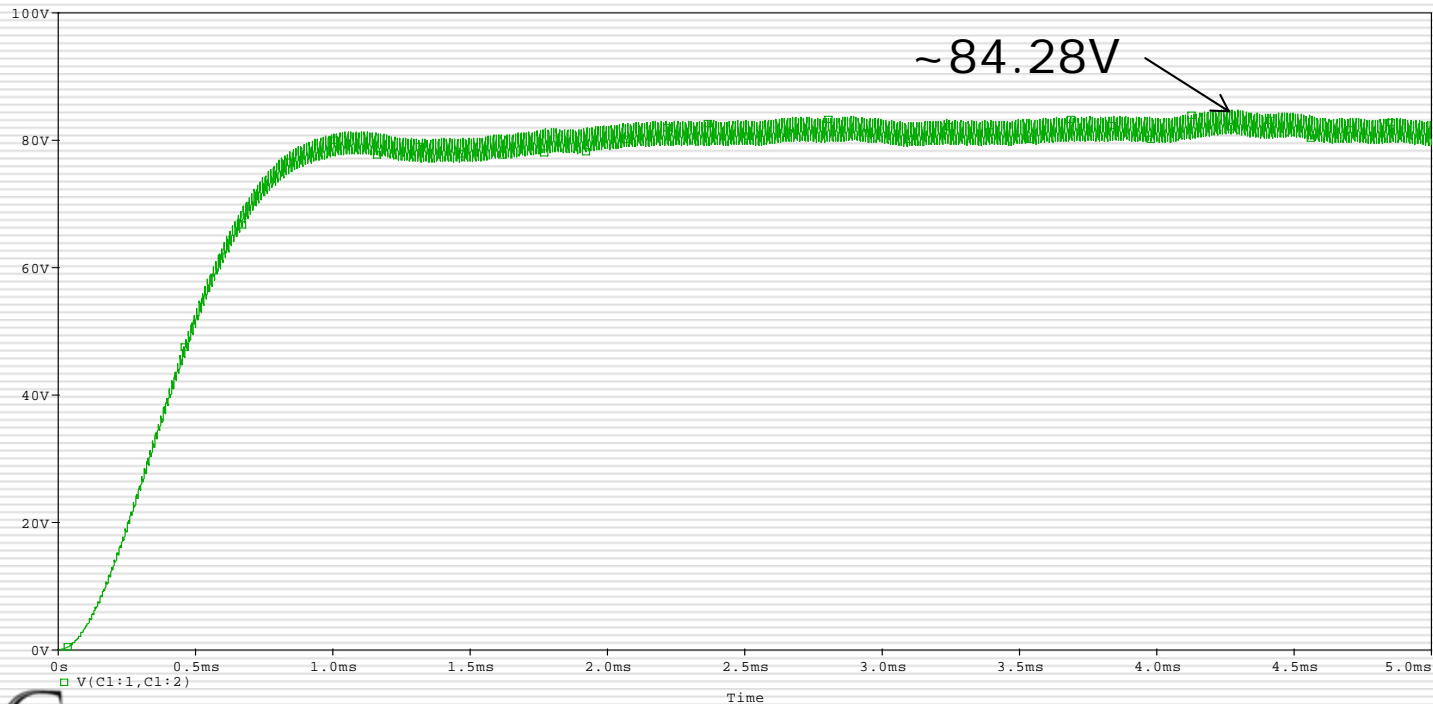
Cuk Converter Simulation – Cycle by Cycle



Advanced Simulation Techniques

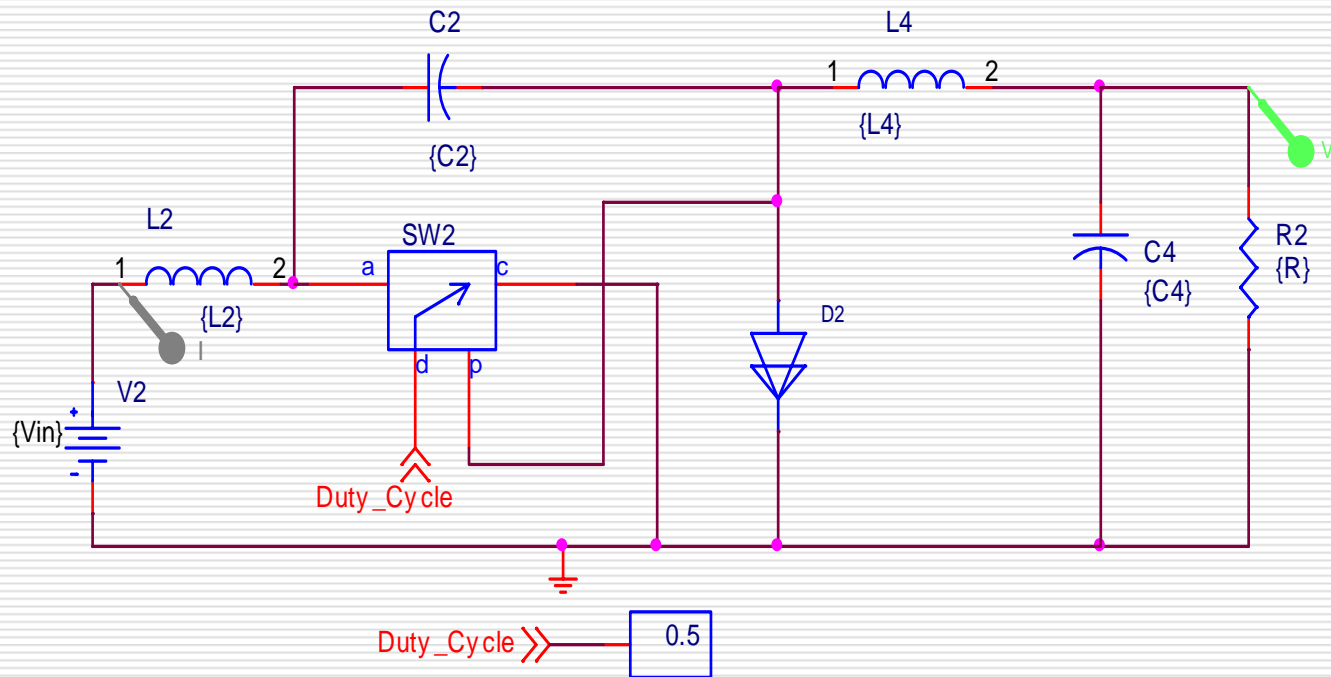
Cuk Converter Simulation – Cycle by Cycle

Voltage across capacitor C1



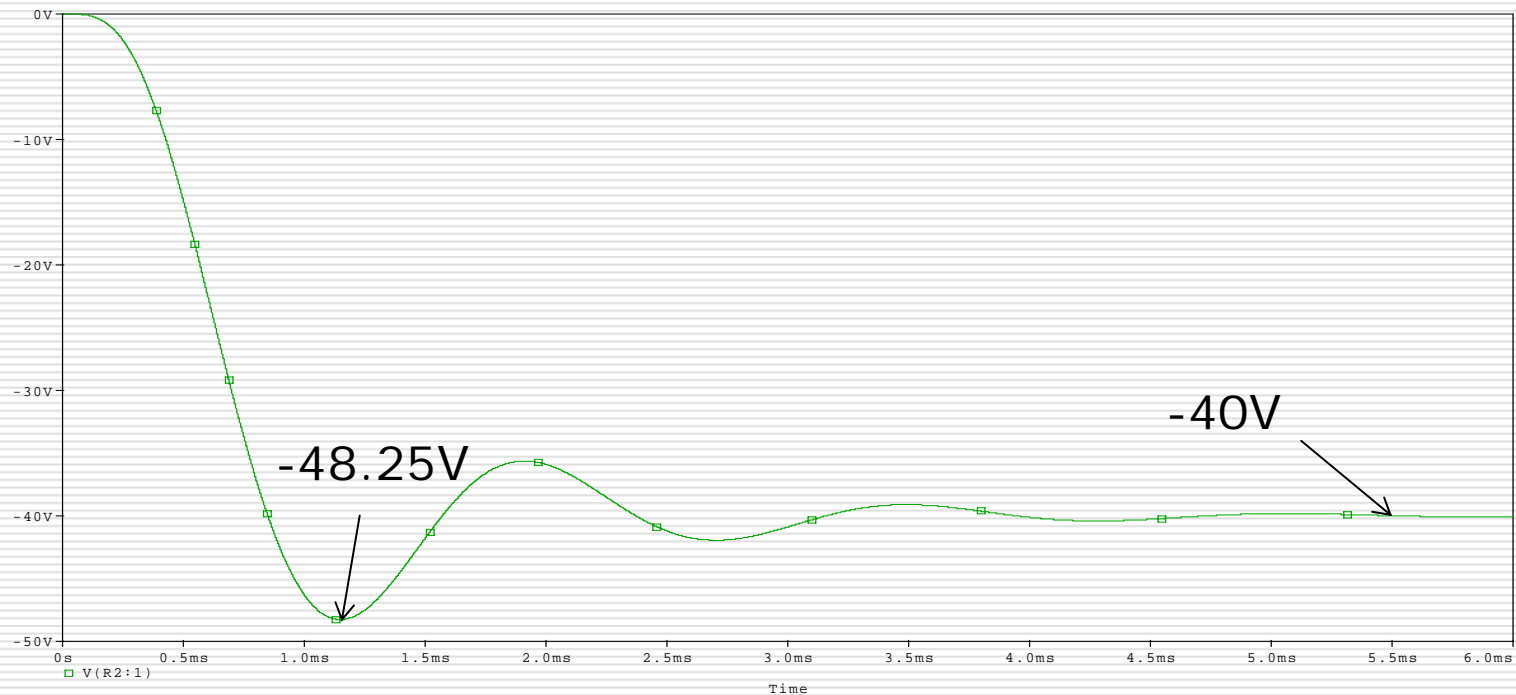
Advanced Simulation Techniques

Cuk Converter Simulation – Average Switch



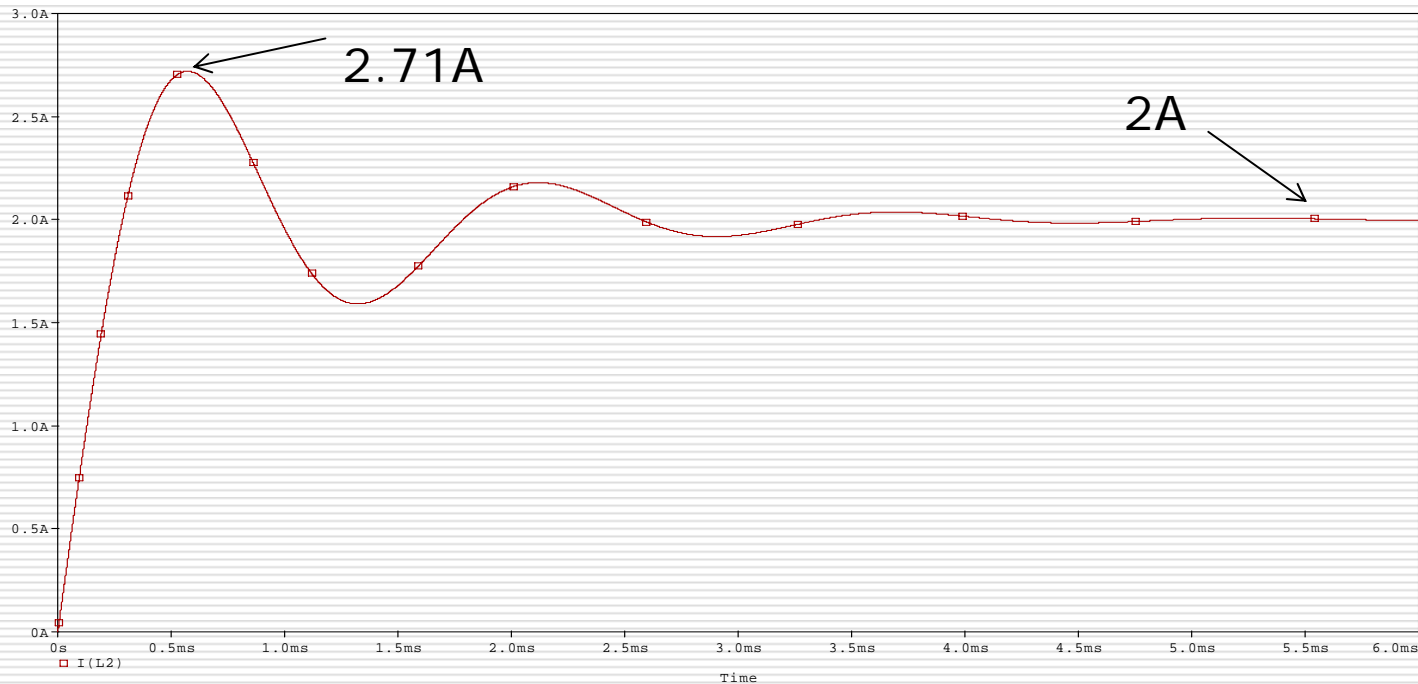
Advanced Simulation Techniques

Cuk Converter Simulation – Average Switch



Advanced Simulation Techniques

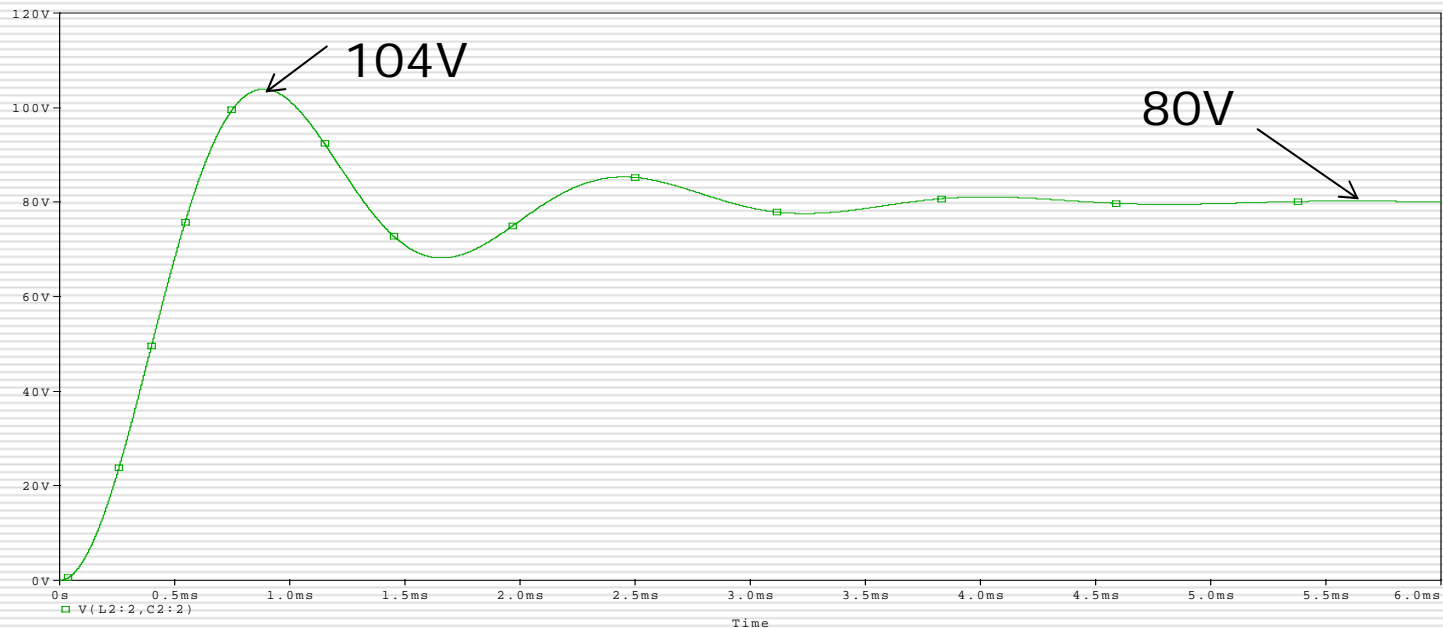
Cuk Converter Simulation – Average Switch



Advanced Simulation Techniques

Cuk Converter Simulation – Average Switch

Voltage across capacitor C2



STRATEGIC TECHNOLOGY GROUP

Experts in Power Electronics, Motor Drives

and Digital Control of Power

StrategicTechGroup.com

This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.

Advanced Simulation Techniques

Cuk Converter: Demonstration

Demonstration #19: Cuk Converter



STRATEGIC TECHNOLOGY GROUP

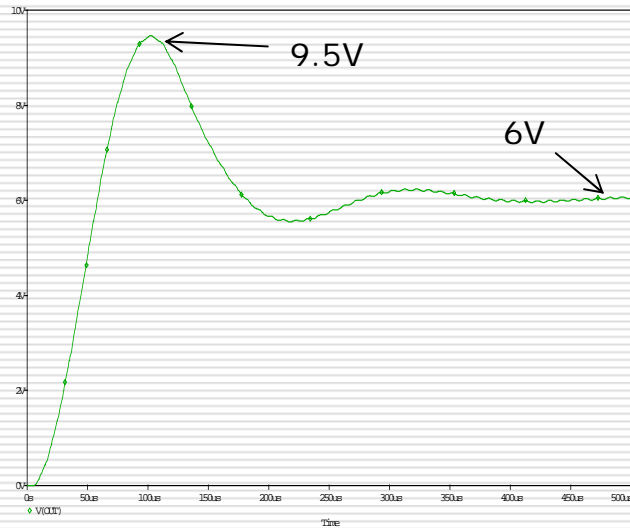
Experts in Power Electronics, Motor Drives
and Digital Control of Power

StrategicTechGroup.com

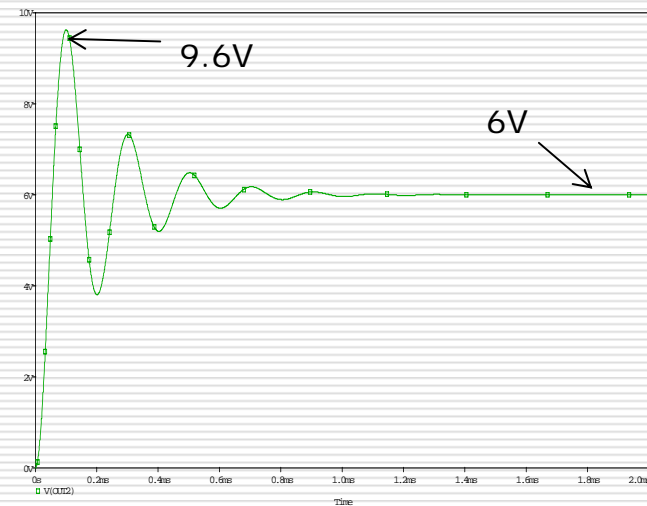
This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.

Advanced Simulation Techniques

Comparison of Buck Output Voltage



Cycle by cycle

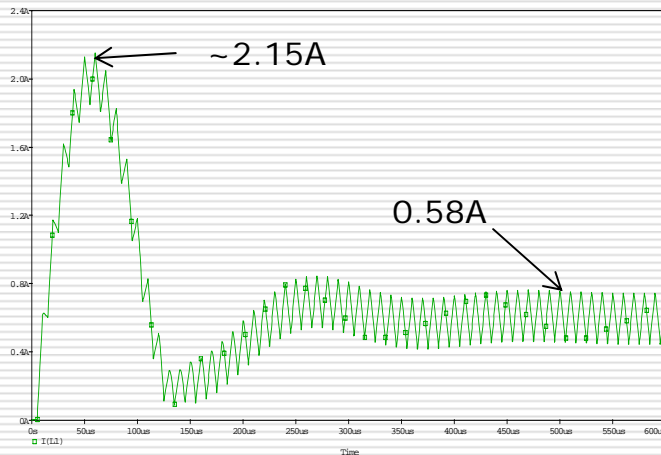


Average Switch

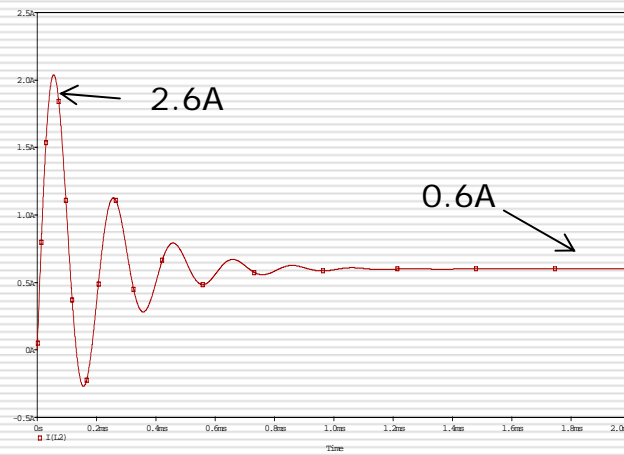


Advanced Simulation Techniques

Comparison of Buck Inductor Current



Cycle by cycle

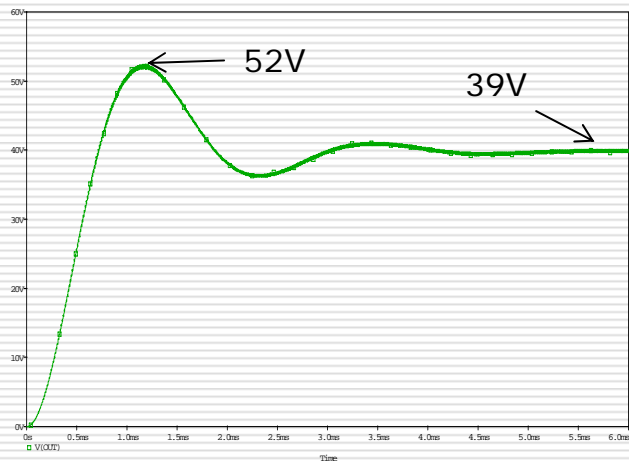


Average Switch

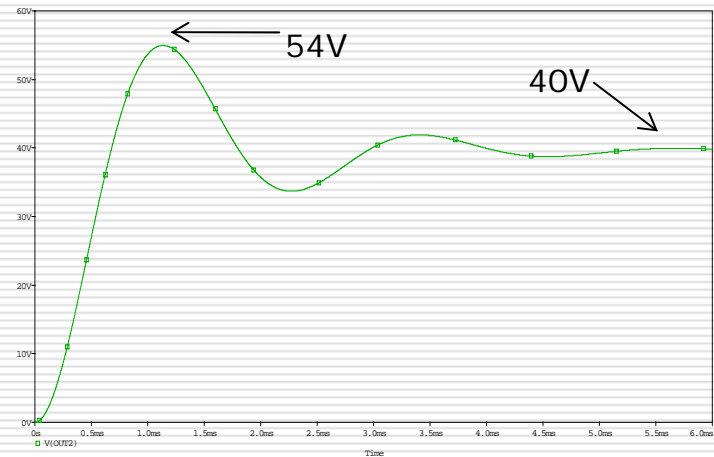


Advanced Simulation Techniques

Comparison of Boost Output Voltage



Cycle by cycle

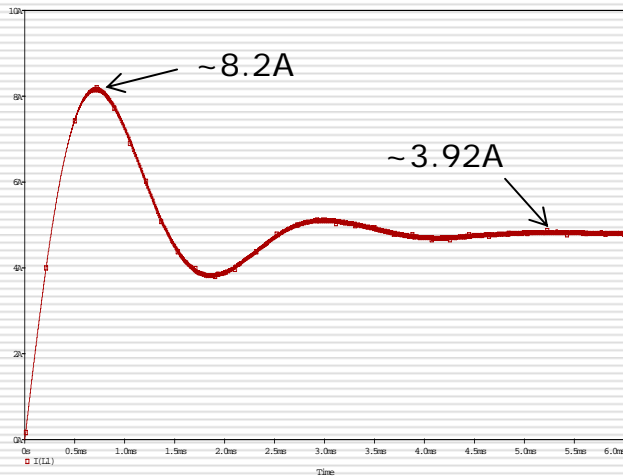


Average Switch

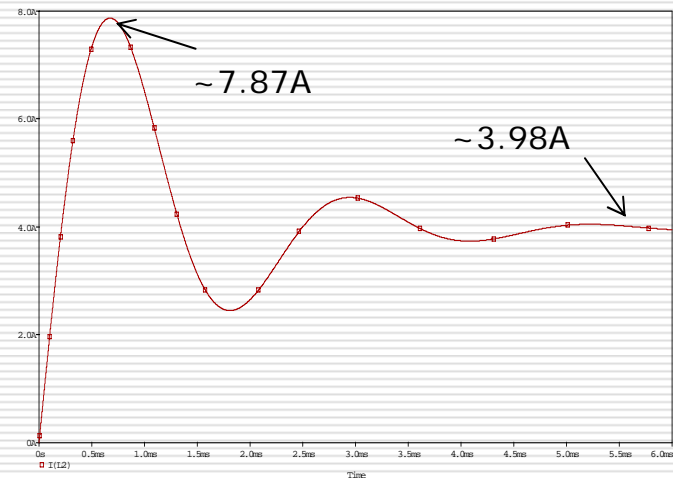


Advanced Simulation Techniques

Comparison of Boost Inductor Current



Cycle by cycle

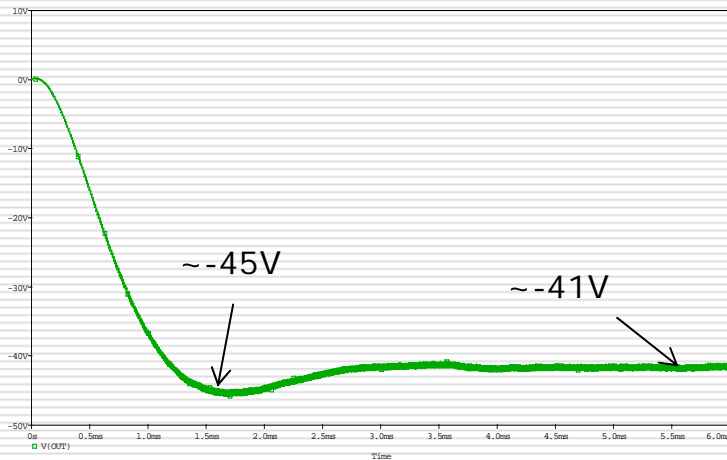


Average Switch

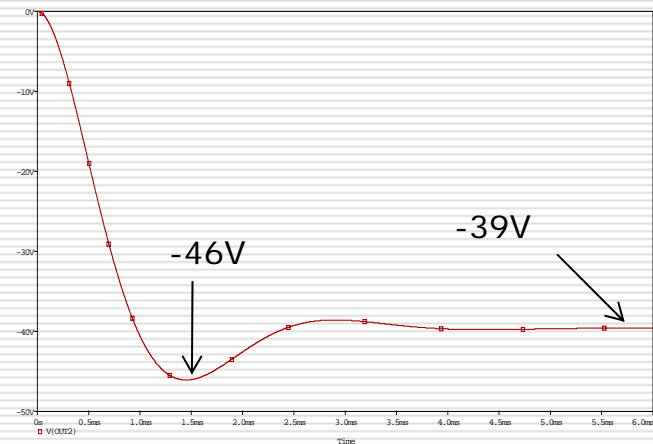


Advanced Simulation Techniques

Comparison of Buck-Boost Output Voltage



Cycle by cycle



Average Switch



STRATEGIC TECHNOLOGY GROUP

Experts in Power Electronics, Motor Drives

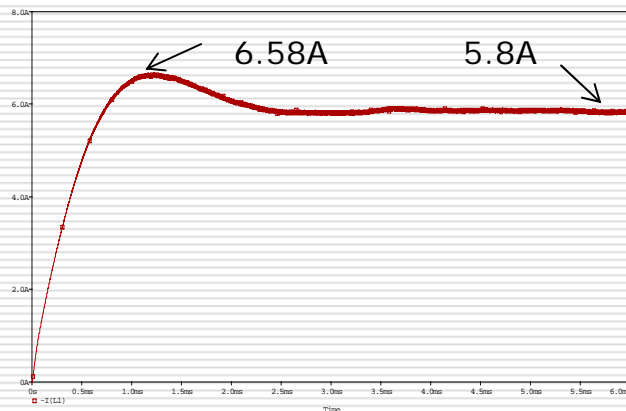
and Digital Control of Power

StrategicTechGroup.com

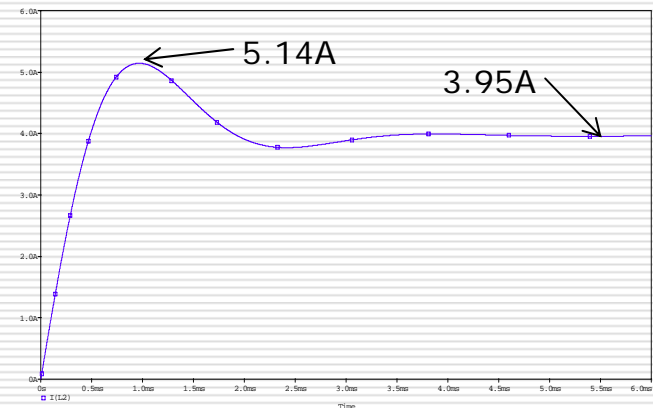
This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.

Advanced Simulation Techniques

Comparison of Buck-Boost Inductor Current



Cycle by cycle

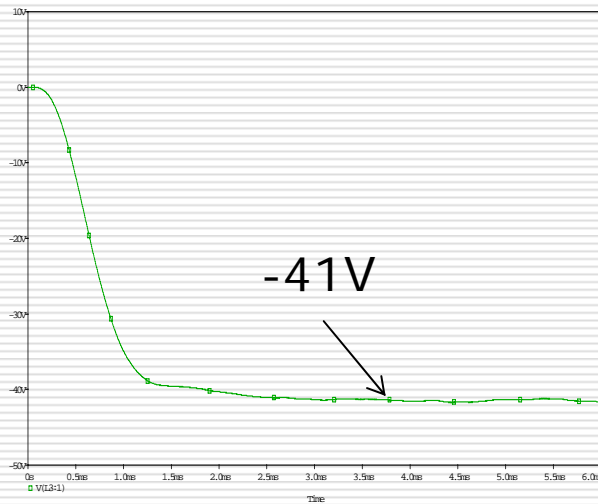


Average Switch

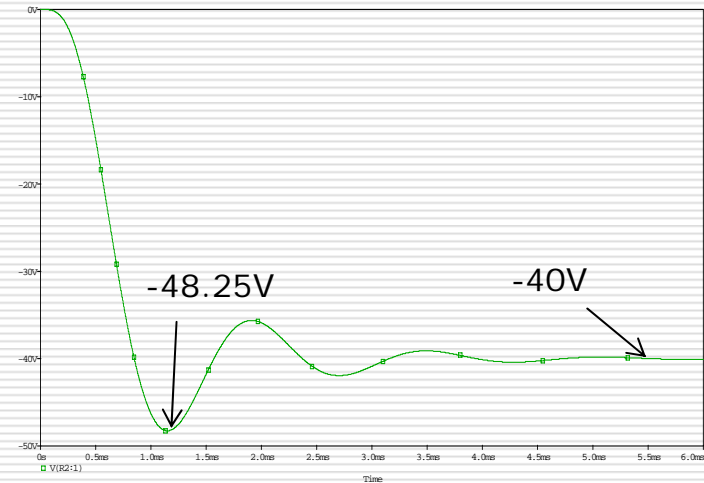


Advanced Simulation Techniques

Comparison of Cuk Output Voltage



Cycle by cycle

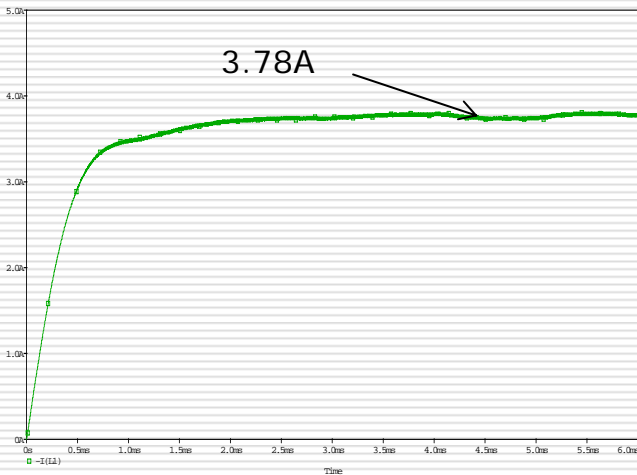


Average Switch

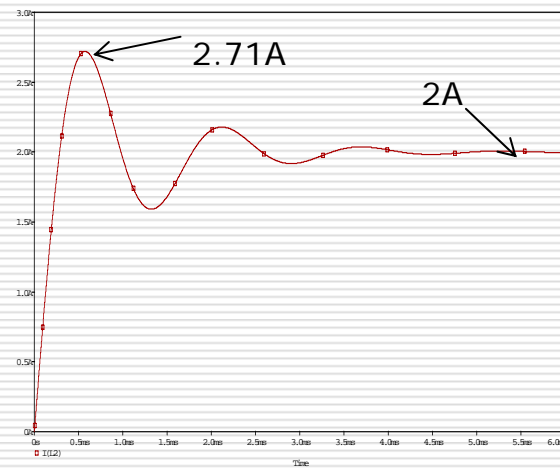


Advanced Simulation Techniques

Comparison of Cuk Inductor Current



Cycle by cycle



Average Switch



Advanced Simulation Techniques

Flyback Converter: Demonstration

Demonstration #20: Flyback Converter



STRATEGIC TECHNOLOGY GROUP

Experts in Power Electronics, Motor Drives
and Digital Control of Power

StrategicTechGroup.com

This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.

Advanced Simulation Techniques

Flyback in Parallel : Demonstration

Demonstration #21: Flyback in Parallel



STRATEGIC TECHNOLOGY GROUP

Experts in Power Electronics, Motor Drives
and Digital Control of Power

StrategicTechGroup.com

This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.

Advanced Simulation Techniques

Forward Converter: Demonstration

Demonstration #22: Forward Converter



Advanced Simulation Techniques

Forward Converter: Demonstration

Demonstration #23: Forward Converter in Parallel



STRATEGIC TECHNOLOGY GROUP

Experts in Power Electronics, Motor Drives

and Digital Control of Power

StrategicTechGroup.com

This document contains confidential and privileged information. Any unauthorized review, use, disclosure, or distribution is prohibited.