

Question #1

Ideal Cuk Converter

Conditions

$$V_g = 30[\text{V}]$$

$$R_{load} = 5[\Omega]$$

$$freq = 200[\text{kHz}]$$

$$L_1 = 50[\mu\text{H}]$$

$$C_1 = 330[\mu\text{F}]$$

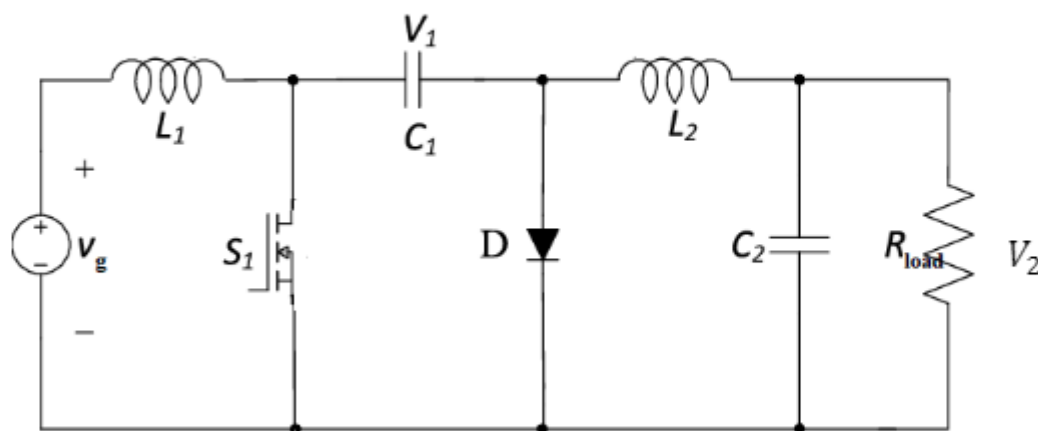
$$L_2 = 220[\mu\text{H}]$$

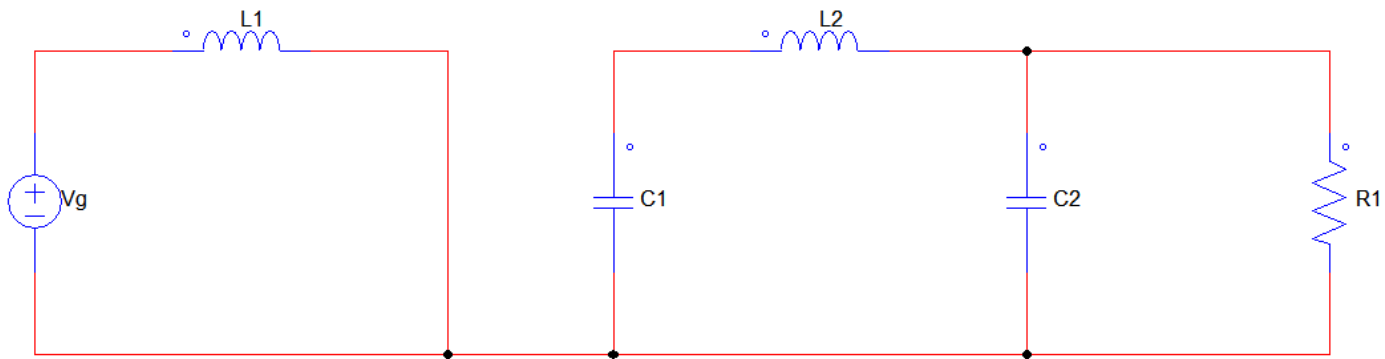
$$C_2 = 180[\mu\text{F}]$$

Problems

아래 회로와 왼쪽의 조건을 고려하여 문제를 푸시오

- 1) 입출력 관계식 V_2/V_g
- 2) $Duty = 0.3$ 일 때 인덕터 L_1 의 리플 전류 Δi_1 , 인덕터 L_2 의 리플 전류 Δi_2 , 커패시터 C_1 의 리플 전압 Δv_1 과 출력전압 V 계산
- 3) 2)의 결과를 PSIM simulation 결과와 비교



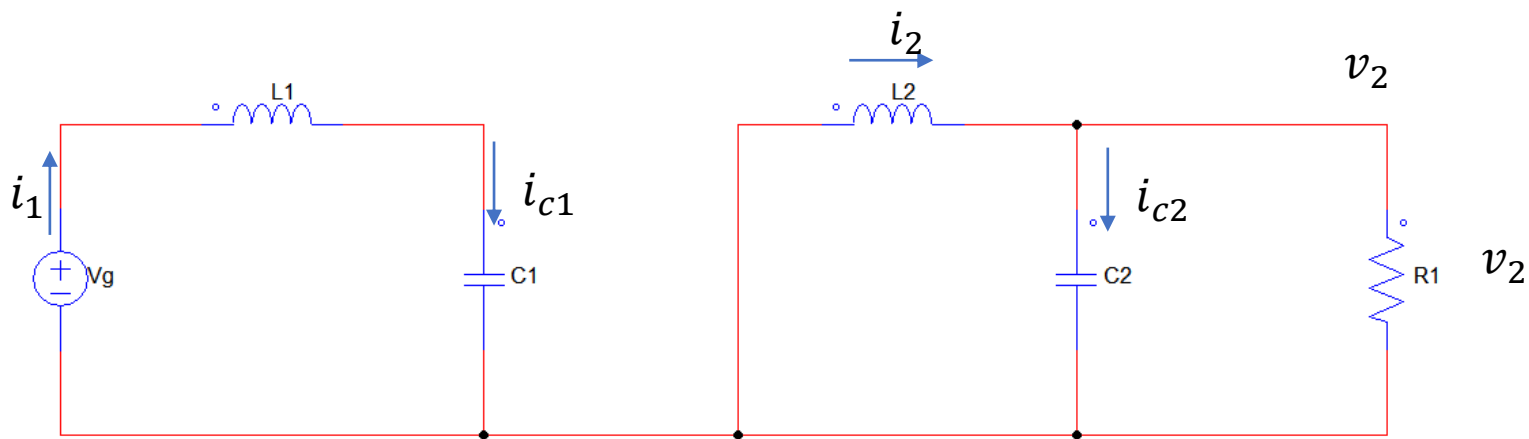


$$V_{L_1} = V_g$$

$$V_{L_2} = -v_1 - v_2 = -V_1 - V_2$$

$$i_{c_1} = i_2 = I_2$$

$$i_{c_2} = i_2 - \frac{V_2}{R} = I_2 - \frac{V_2}{R}$$

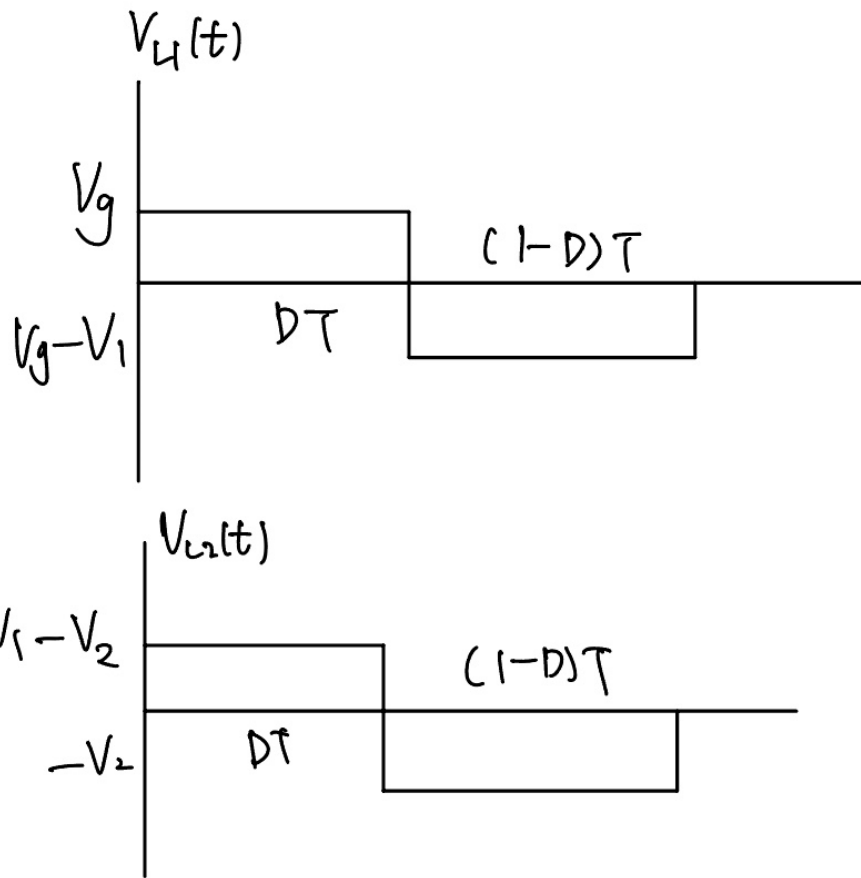


$$V_{L_1} = V_g - v_1 = V_g - V_1$$

$$V_{L_2} = -v_2 = -V_2$$

$$i_{c_1} = i_1 = I_1$$

$$i_{c_2} = i_2 - \frac{v_2}{R} = I_2 - \frac{V_2}{R}$$



$$V_g D + (1 - D)(V_g - V_1) = 0$$

$$DV_g + V_g - DV_g - V_1 + DV_1 = 0$$

$$V_g - V_1(1 - D) = 0$$

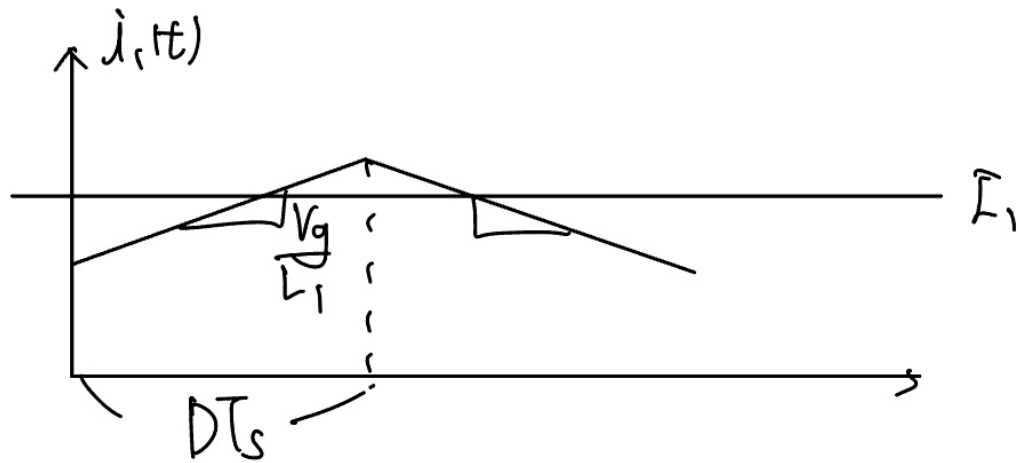
$$V_g = D'V_1$$

$$(-V_1 - V_2)D - (1 - D)V_2 = 0$$

$$-DV_1 - DV_2 - V_2 + DV_2 = 0$$

$$V_2 = -DV_1$$

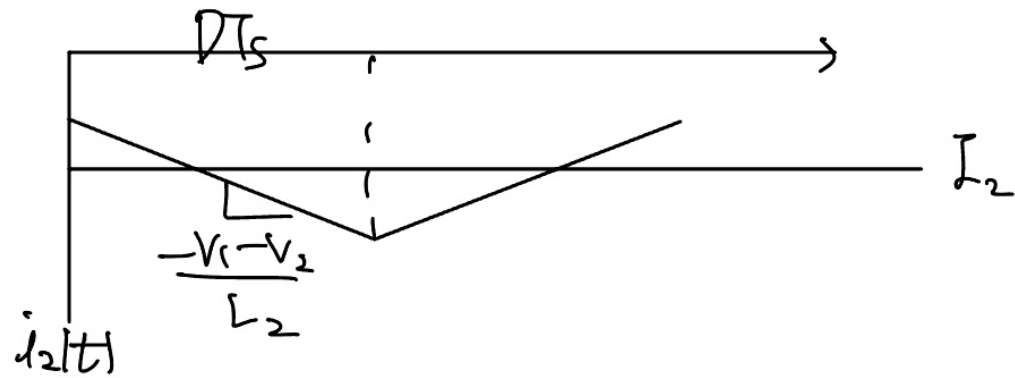
$$\frac{V_2}{V_g} = -\frac{D}{D'} = -\frac{D}{1 - D}$$



$$V_{L1}(t) = L_1 \frac{di_1(t)}{dt} = V_g$$

$$\frac{di_1(t)}{dt} = \frac{V_g}{L_1}$$

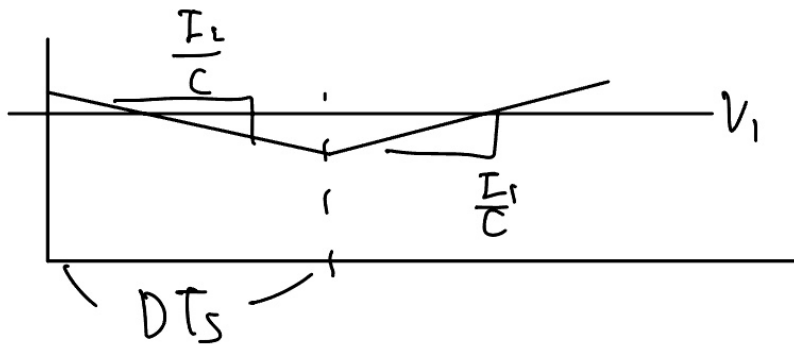
$$\Delta i_1 = \frac{V_g D T_s}{2 L_1} = \mathbf{0.45[A]}$$



$$\Delta i_2 = \frac{(V_1 + V_2) D T_s}{2 L_2} = \frac{V_g D T_s}{2 L_2} = \mathbf{0.1[A]}$$

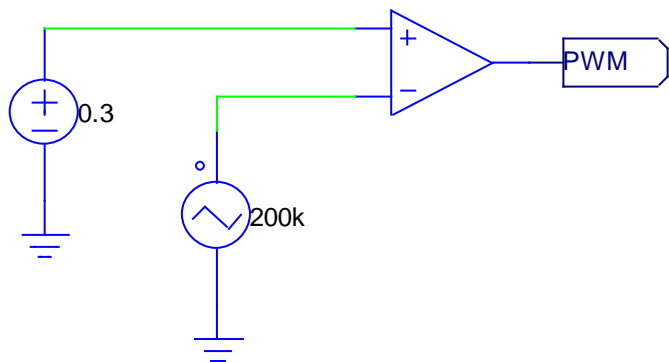
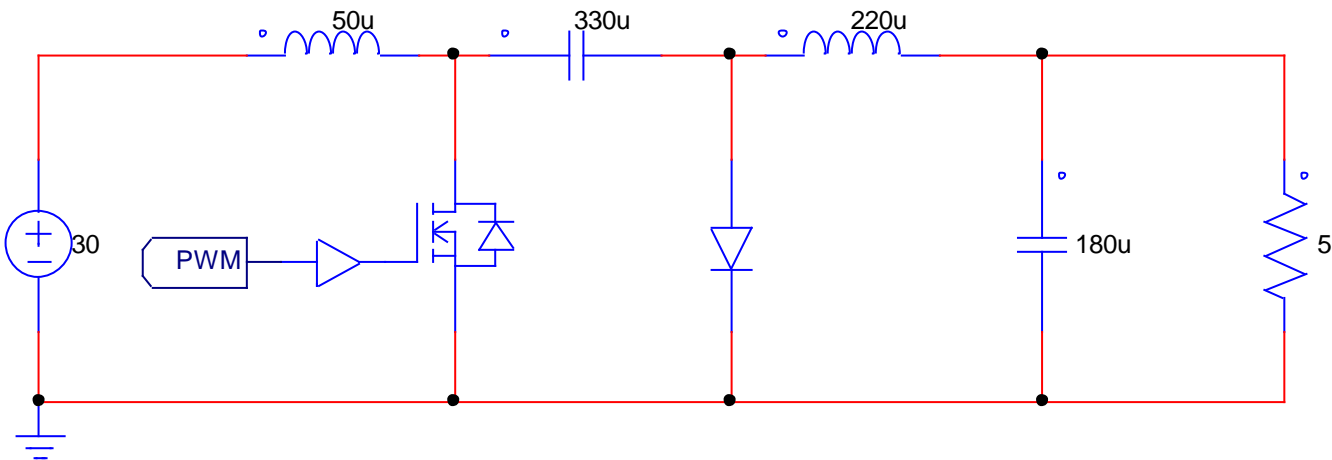
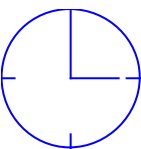
$$i_{c1}(t) = C \frac{dv_{c1}(t)}{dt}, \quad \frac{dV_{c1}(t)}{dt} = \frac{i_{c1}(t)}{C} = \frac{I_2}{C}$$

$$i_{c1}(t) = C \frac{dv_1(t)}{dt}, \quad \frac{dV_{c1}(t)}{dt} = \frac{i_{c1}(t)}{C} = \frac{I_1}{C}$$



$$\Delta v_1(t) = \frac{I_2}{2C} D T_s, \quad I_2 = \frac{V_2}{R}, \quad V_2 = \frac{D}{(1-D)} V_g = \mathbf{12.857[V]}$$

$$\Delta V_1(t) = \frac{V_g D^2 T_s}{2 D' R C_1} = \mathbf{5.84 \times 10^{-3}[V]}$$



Simulation Control

PSIM | SPICE | SimCoder | Color

Solver Type

☒ Fixed-step ☐ Variable-step (dual) [Help](#)

Time Step ☐ Time Step Ratio ☐ Smaller Time Step

Total Time ☐ Free Run

Print Time

Print Step

Load Flag ☐

Save Flag ☐

Engine Default Values

R_switch_on

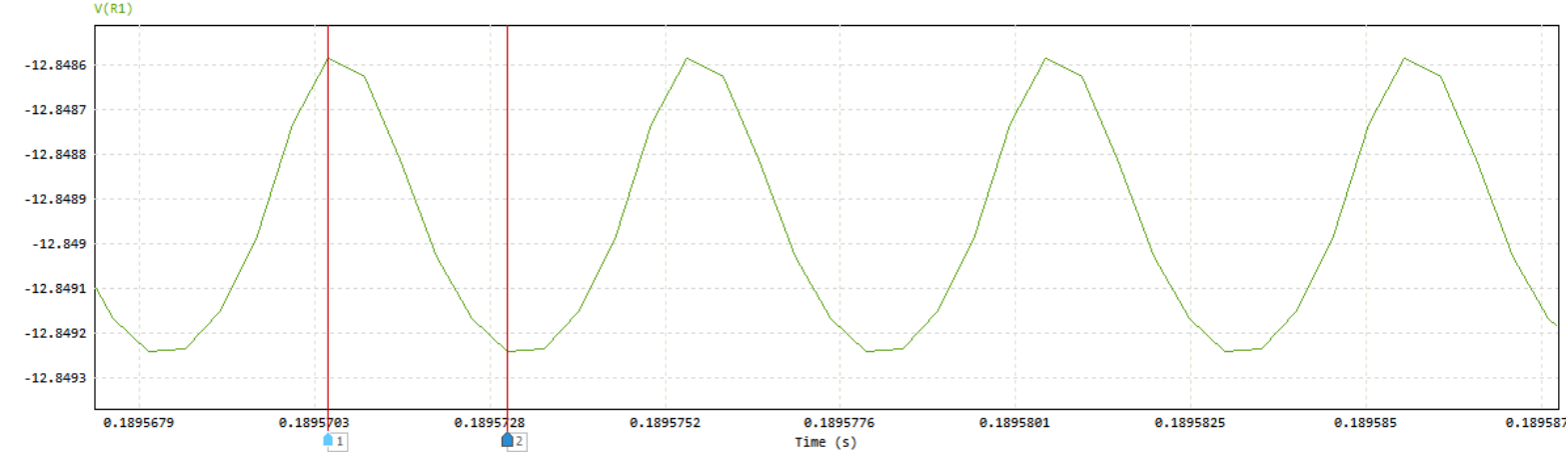
R_switch_off

Triangular : VTRI1

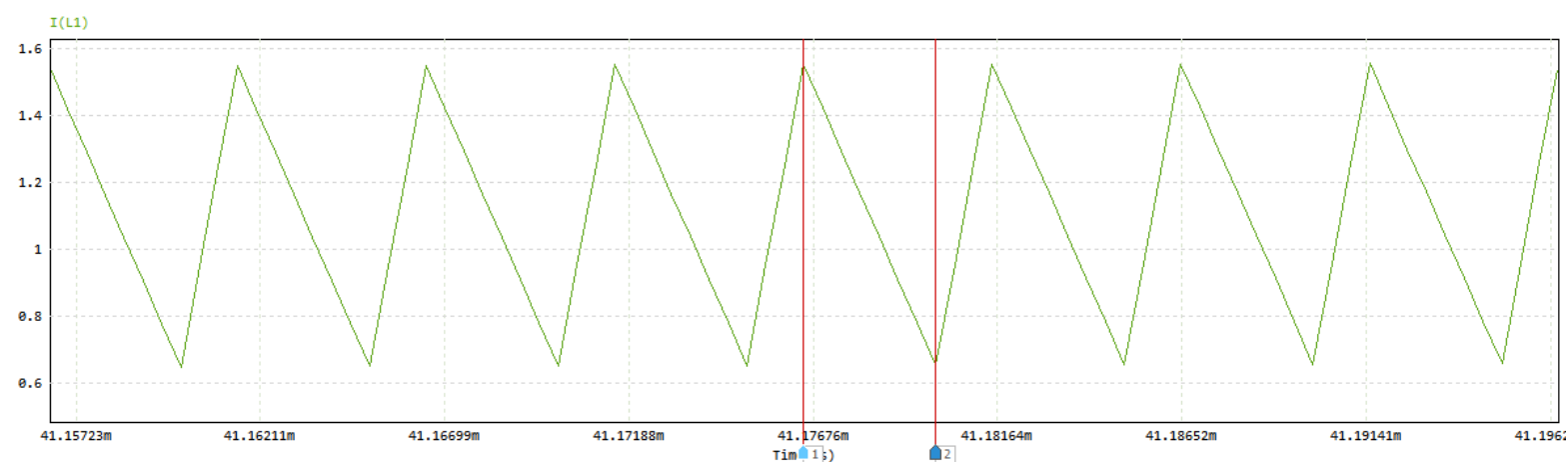
Parameters | Color

Triangular-wave voltage source [Help](#)

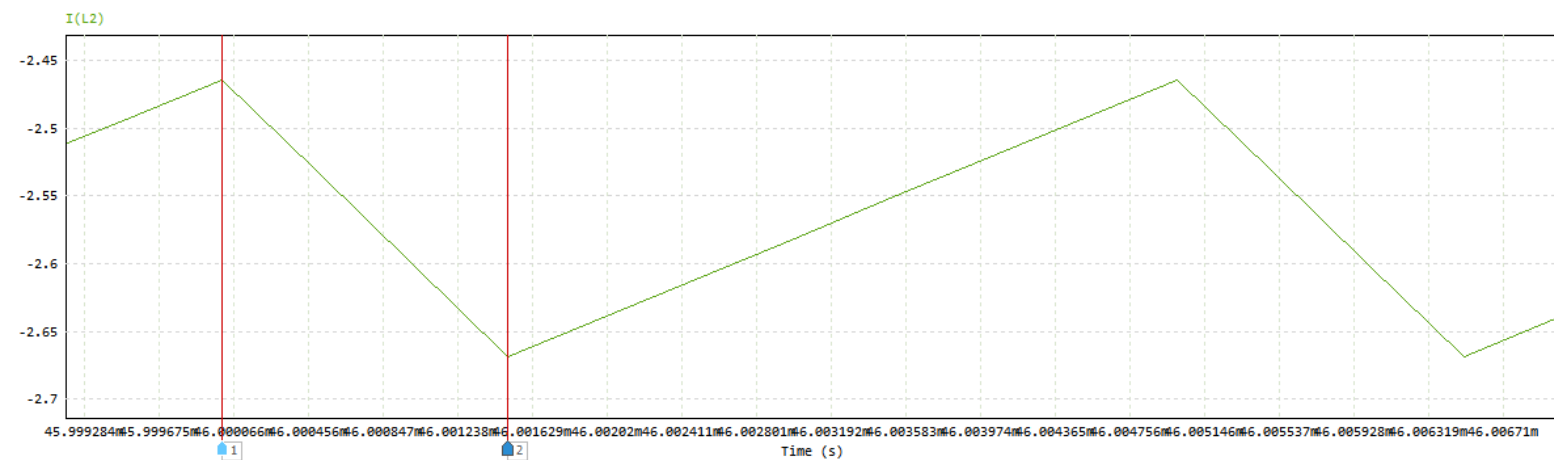
		Display
Name	<input type="text" value="VTRI1"/>	<input type="checkbox"/> <input type="text" value="V"/>
V_peak_to_peak	<input type="text" value="1"/>	<input type="checkbox"/> <input type="text" value="V"/>
Frequency	<input type="text" value="200k"/>	<input checked="" type="checkbox"/> <input type="text" value="Hz"/>
Duty Cycle	<input type="text" value="1"/>	<input type="checkbox"/> <input type="text" value="V"/>
DC Offset	<input type="text" value="0"/>	<input type="checkbox"/> <input type="text" value="V"/>
Tstart	<input type="text" value="0"/>	<input type="checkbox"/> <input type="text" value="s"/>
Phase Delay	<input type="text" value="0"/>	<input type="checkbox"/> <input type="text" value="s"/>



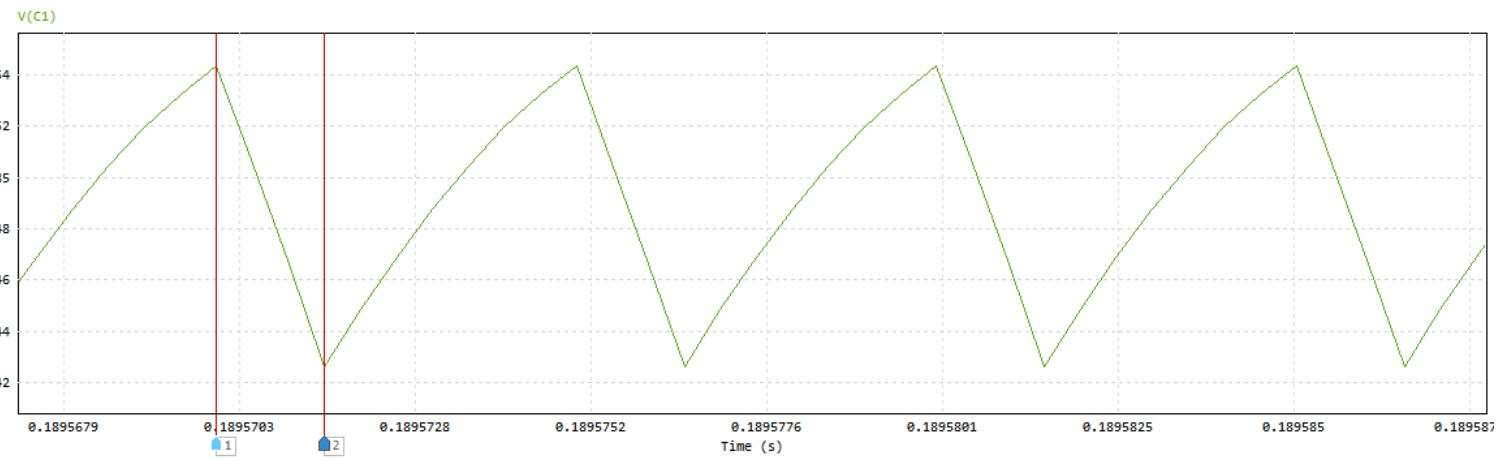
Measure					
		X1	X2	Δ	Average
Time		1.89570e-01	1.89573e-01	2.50000e-06	
V(R1)		-1.28486e+01	-1.28492e+01	-6.55808e-04	-1.28489e+01



Measure					
		X1	X2	Δ	Average
Time		4.11765e-02	4.11800e-02	3.50000e-06	
I(L1)		1.55261e+00	6.54376e-01	-8.98230e-01	1.10355e+00



Measure					
		X1	X2	Δ	Average
Time		4.60000e-02	4.60015e-02	1.50000e-06	
I(L2)		-2.46441e+00	-2.66893e+00	-2.04520e-01	-2.56667e+00



Measure					
		X1	X2	Δ	Average
	Time	1.89570e-01	1.89571e-01	1.50000e-06	
V(C1)		4.28544e+01	4.28426e+01	-1.17237e-02	4.28486e+01

Question #2

Practical Cuk Converter

Problems

Cuk 컨버터(Question #1)의 소자 데이터시트를 참고하여 Practical Cuk converter 시뮬레이션 진행

(데이터시트에 없는 소자는 이상적인 값을 사용하고 인덕터의 경우 L 과 $R_L(DCR_{max})$ 값만 사용)

※ on-off controller(multi-level) 를 사용할 때 gate voltage high= 18[V], gate voltage low = 0[V], gate resistance= 3[Ω]로 설정

L_1 : 50[μH]: LPA1020-500KL

<https://pdf1.alldatasheet.com/datasheet-pdf/view/161246/BOURNS/LPA1226-500KL.html>

L_2 : 220[μH]: 2100LL – 221 – RC

<https://pdf1.alldatasheet.com/datasheet-pdf/view/512878/BOURNS/2100LL-221-RC.html>

MOSFET: IRF540N

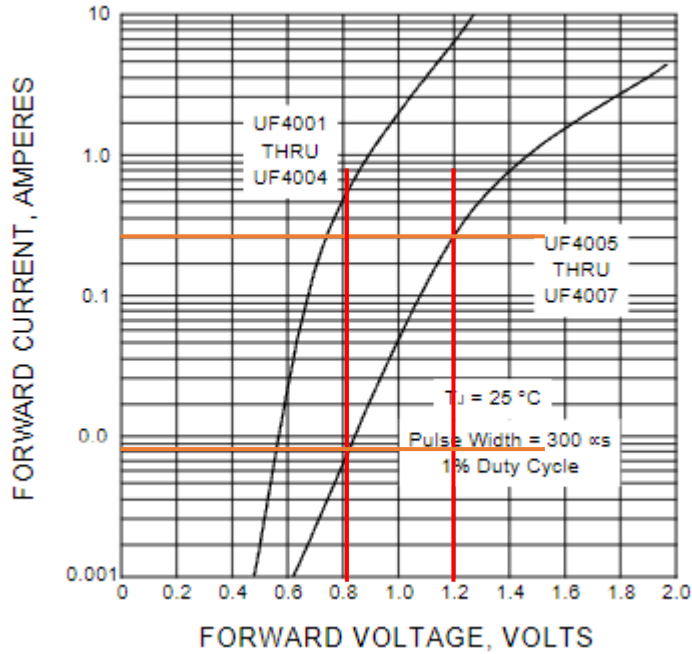
<https://pdf1.alldatasheet.com/datasheet-pdf/view/67486/INTERSIL/IRF540N.html>

Diode: UF4007

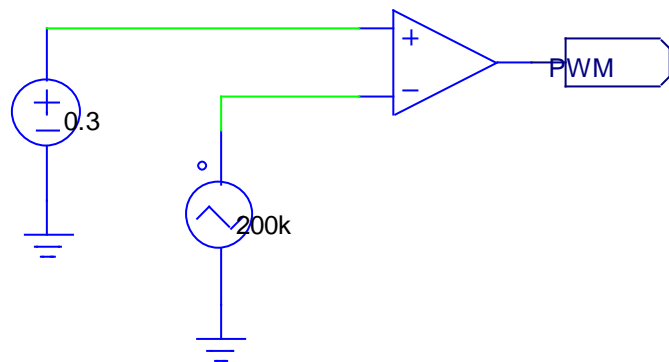
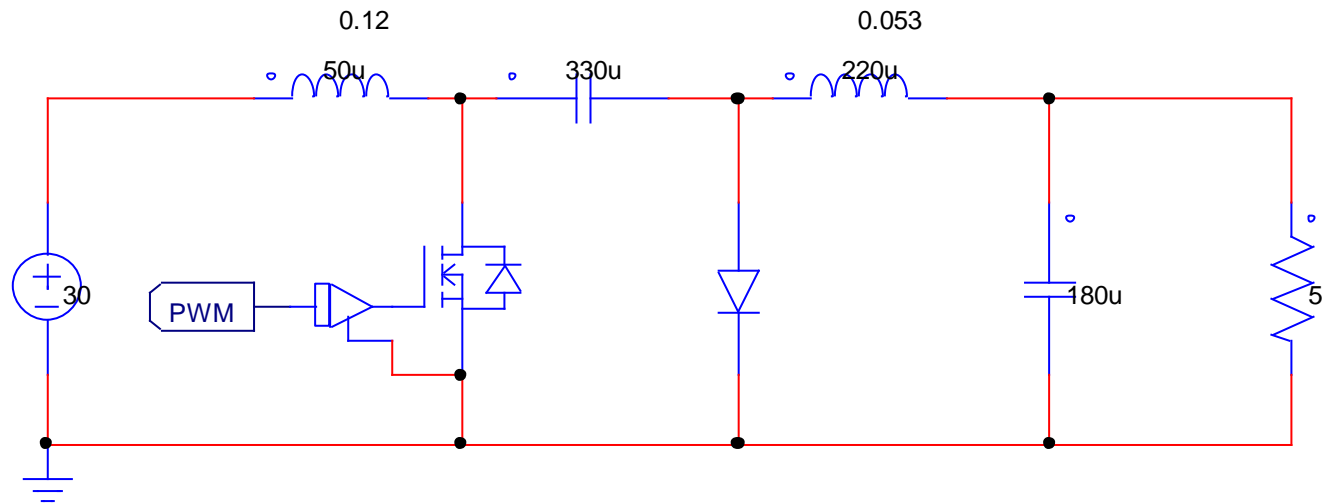
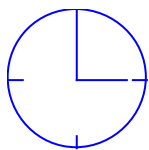
<https://pdf1.alldatasheet.com/datasheet-pdf/view/394824/EIC/UF4007.html>

Vbreakdown(drain-source)_MIN	100[V]
On Resistance_TYP.	0.033[Ω]
Threshold Voltage Vgs(th)_MAX.	4[V]
Transconductance_TYP.	8.25
Capacitance Cgs_TYP.	1120[pF]
Capacitance Cgd_TYP.	100[pF]
Capacitance Cds_TYP.	195[pF]
Diode Forward Voltage_MAX @Isd =17[A]	1{V}
Diode Resistance	1[mΩ]
Parasitic Inductance Ls	0
Internal Gate Resistance	5[Ω]

Forward Voltage @ $I_F = 1[A]$	17[V]
Resistance @ $T_j = 25C$	1.37[Ω]
Parasitic Inductance	20[nH]
Parallel Capacitance	0
Forward Current_MAX_avg	1[A]
Peak Reverse Current @ $T_a = 25C$	10[A]
Current Slope	200e6
Reverse Recovery Time_MAX	75[ns]



$$R = \frac{1.2 - 0.8}{0.3 - 0.007} = 1.37[\Omega]$$



Simulation Control

PSIM | SPICE | SimCoder | Color

Solver Type: ☒ Fixed-step ☐ Variable-step (dual) [Help](#)

Time Step: ☐ Time Step Ratio: ☐ Smaller Time Step:

Total Time: ☐ Free Run

Print Time:

Print Step:

Load Flag:

Save Flag:

Engine Default Values

R_switch_on:

R_switch_off:

MOSFET : Q1

Parameters | Color | Simulation Models

MOSFET (3-state) (Level 2) [Help](#)

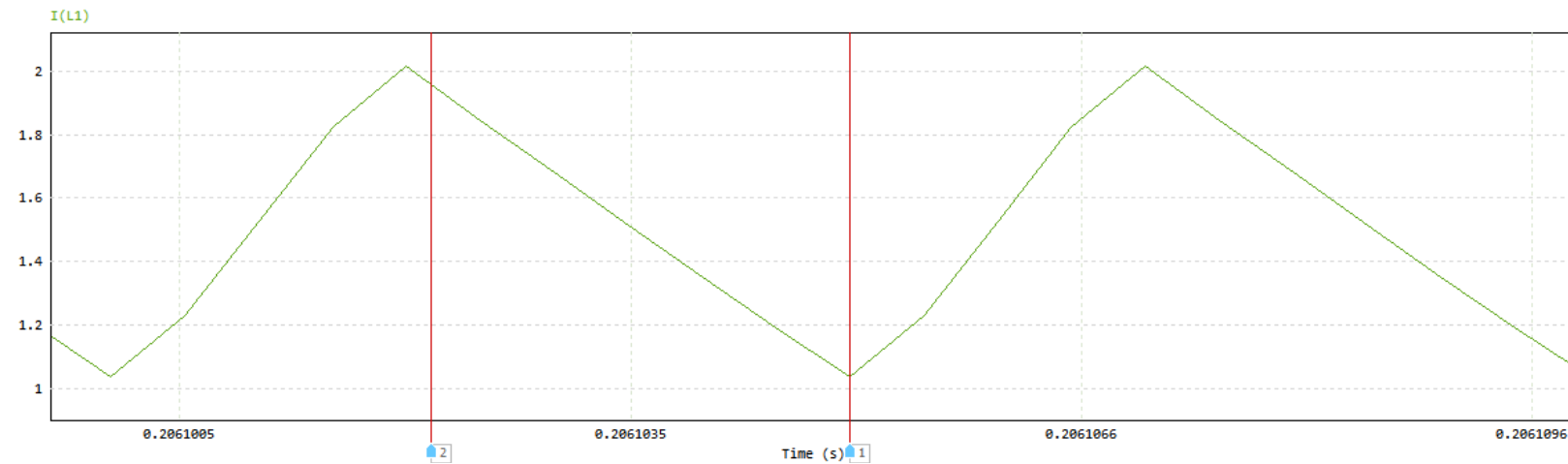
		Display
Name	Q1	<input type="checkbox"/>
Model Level	Level 2	<input type="checkbox"/>
Vbreakdown (drain-source)	100	<input type="checkbox"/>
On Resistance	0.033	<input type="checkbox"/>
Threshold Voltage VGS(th)	4	<input type="checkbox"/>
Internal Gate Resistance	5	<input type="checkbox"/>
Transconductance	8.25	<input type="checkbox"/>
Capacitance Cgs	1120p	<input type="checkbox"/>
Capacitance Cgd	100p	<input type="checkbox"/>
Capacitance Cds	195p	<input type="checkbox"/>
Diode Forward Voltage	1	<input type="checkbox"/>
Diode Resistance	1m	<input type="checkbox"/>
Parasitic Inductance Ls	0	<input type="checkbox"/>
Current Flag	0	<input type="checkbox"/>
Voltage Flag	0	<input type="checkbox"/>

Triangular : VTRI1

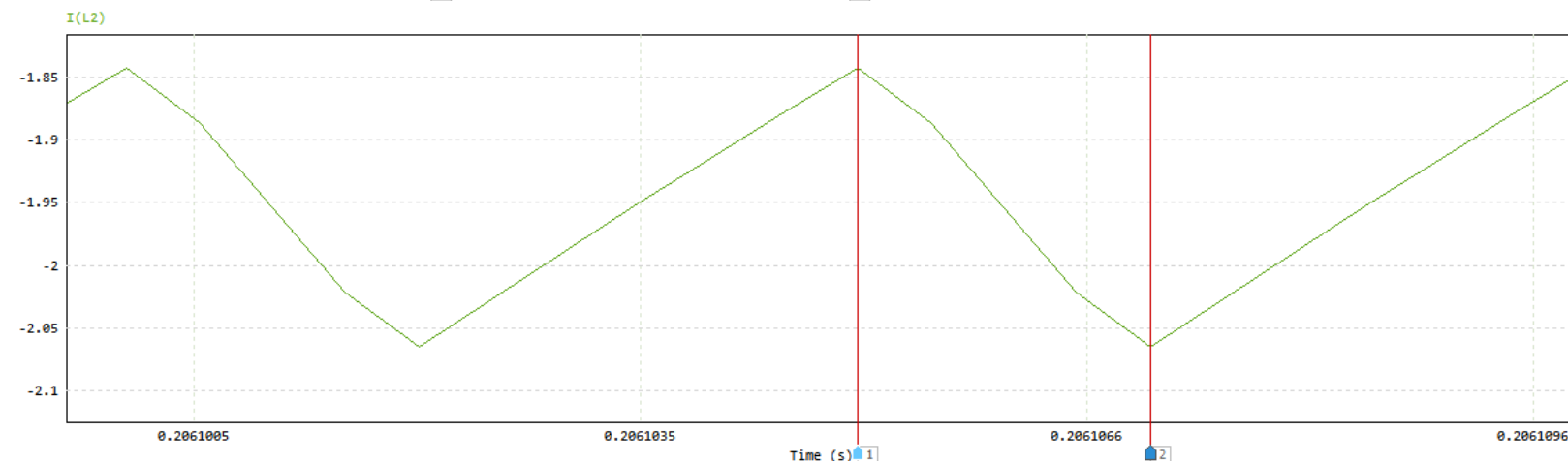
Parameters | Color

Triangular-wave voltage source [Help](#)

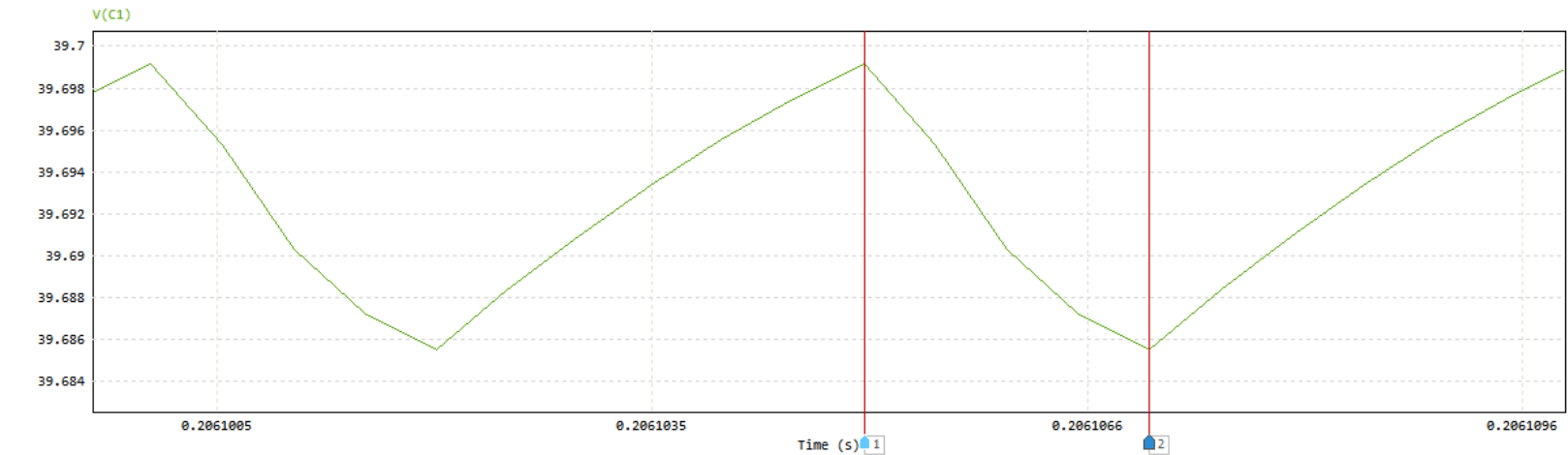
		Display
Name	VTRI1	<input type="checkbox"/>
V_peak_to_peak	1	<input type="checkbox"/>
Frequency	200k	<input checked="" type="checkbox"/>
Duty Cycle	1	<input type="checkbox"/>
DC Offset	0	<input type="checkbox"/>
Tstart	0	<input type="checkbox"/>
Phase Delay	0	<input type="checkbox"/>



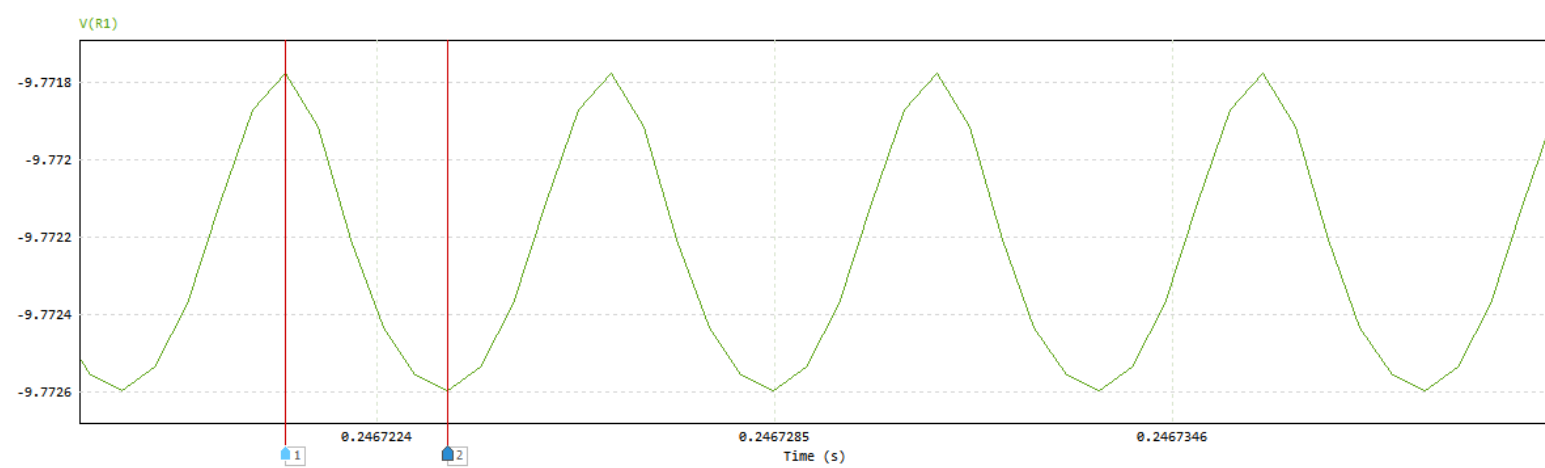
Measure					
⋮		X1	X2	Δ	Average
	Time	2.06105e-01	2.06102e-01	-2.82949e-06	
	I(L1)	1.03813e+00	1.95810e+00	9.19975e-01	1.51907e+00



Measure					
⋮		X1	X2	Δ	Average
	Time	2.06105e-01	2.06107e-01	2.00000e-06	
	I(L2)	-1.84256e+00	-2.06484e+00	-2.22277e-01	-1.95375e+00



Measure					
⋮		X1	X2	Δ	Average
	Time	1.89570e-01	1.89571e-01	1.50000e-06	
	V(C1)	4.28544e+01	4.28426e+01	-1.17237e-02	4.28486e+01



Measure				
	X1	X2	Δ	Average
Time	2.46721e-01	2.46723e-01	2.50000e-06	
V(R1)	-9.77178e+00	-9.77260e+00	-8.21353e-04	-9.77226e+00

Question #3

Ideal Buck-Boost Converter

Conditions

$$V_g = 30[V]$$

$$R_{load} = 10[\Omega]$$

$$freq = 200[kHz]$$

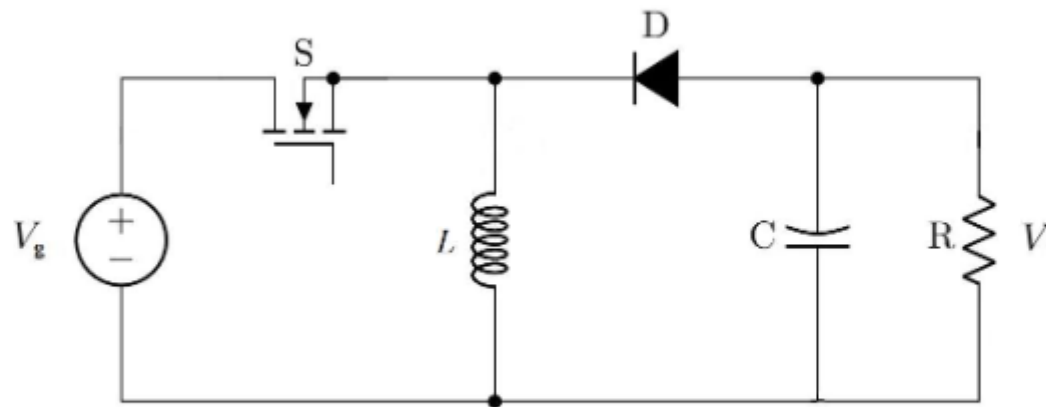
$$L = 150[\mu H]$$

$$C = 330[\mu F]$$

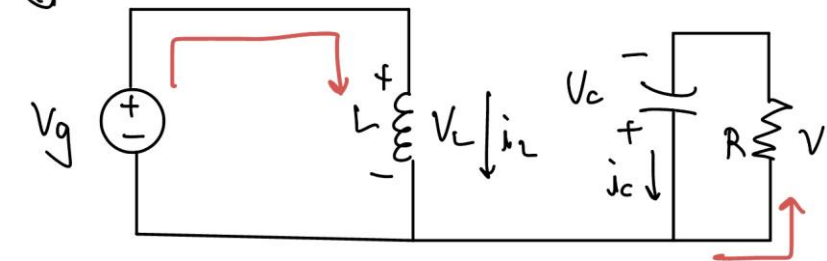
Problems

아래 회로와 왼쪽의 조건을 고려하여 문제를 푸시오

- 1) 입출력 관계식 V/V_g
- 2) $Duty = 0.6$ 일 때 인덕터 리플 전류 Δi , 출력 리플 전압 Δv , 출력전압 V 계산
- 3) 2)의 결과를 PSIM simulation 결과와 비교

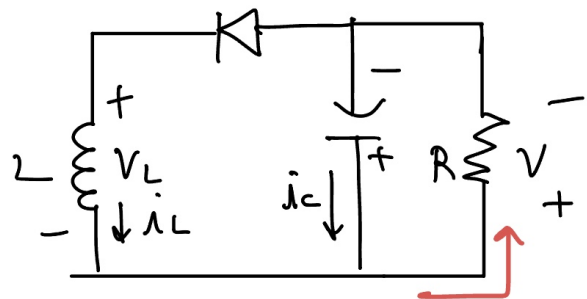


①

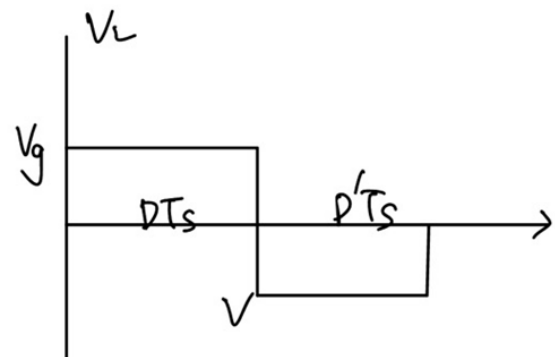


$$V = V_c$$

$$V_L = V_g$$



$$V_L = V$$

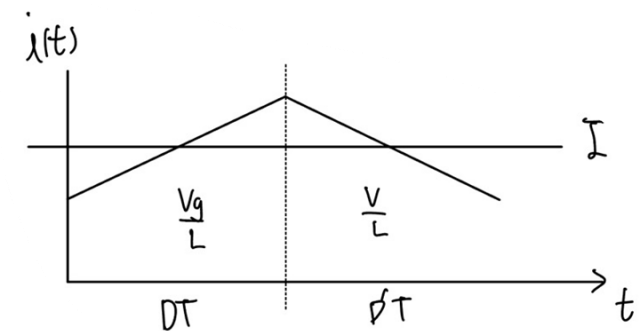


$$DV_g + D'V = 0$$

$$\frac{V_g}{V} = -\frac{D}{D'}$$

$$V = -\frac{D}{1-D} V_g = -45[V]$$

$$\frac{dV}{dt} = \frac{i}{C}, \quad i = \frac{V}{R}$$

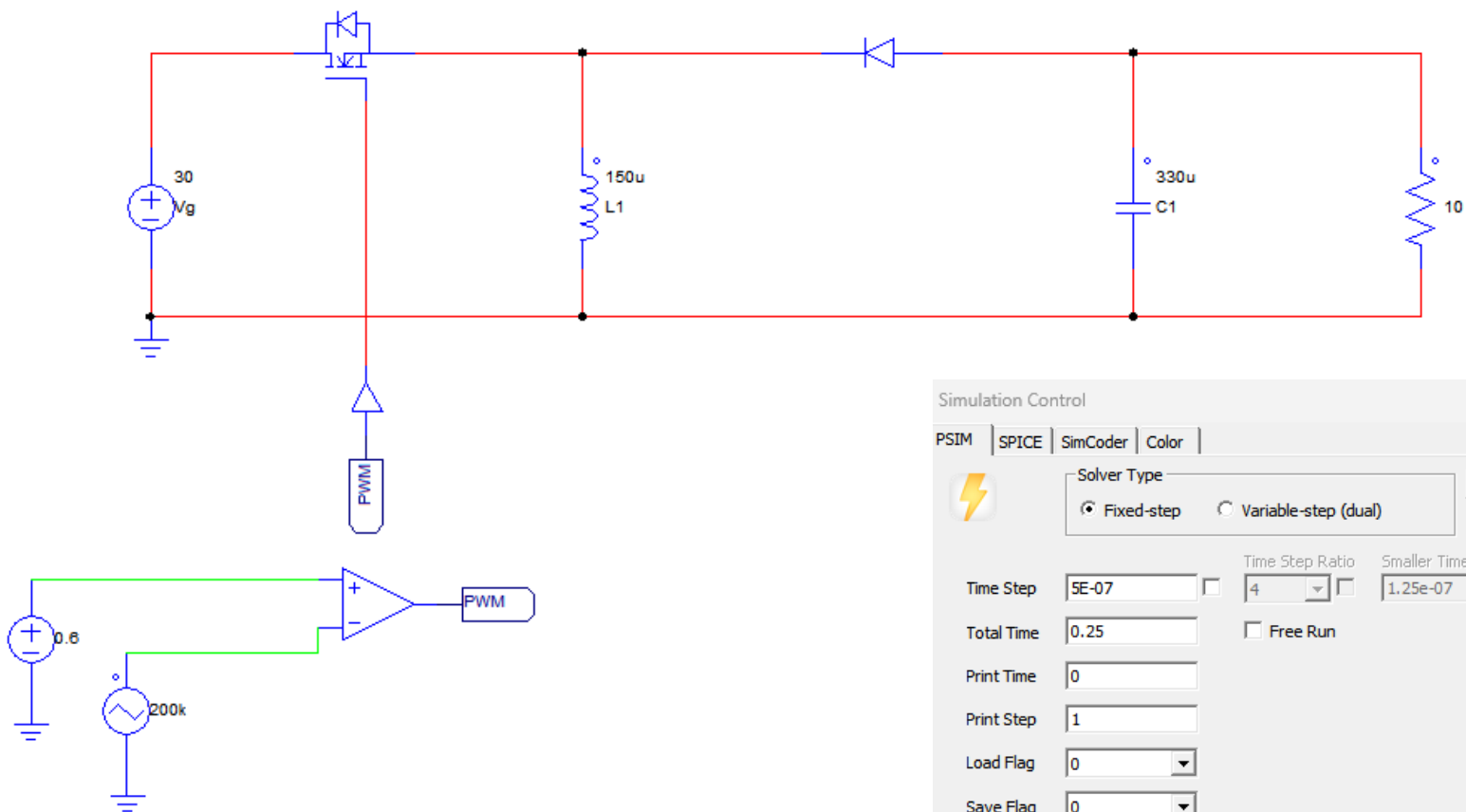
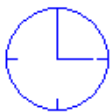


$$V_L = L \frac{di}{dt}$$

$$\frac{di}{dt} = \frac{V_L}{L} = \frac{V_g}{L}, \quad \Delta i = \frac{V_g D T_s}{2L} = 0.3[A]$$

$$\frac{dV}{dt} = \frac{V}{RC}$$

$$\Delta V = \frac{D T_s V}{2RC} = -0.02045[V]$$



Simulation Control

PSIM | SPICE | SimCoder | Color

Solver Type

☒ Fixed-step ☐ Variable-step (dual)

Time Step: 5E-07 Time Step Ratio: 4 Smaller Time Step: 1.25e-07

Total Time: 0.25 ☐ Free Run

Print Time: 0

Print Step: 1

Load Flag: 0

Save Flag: 0

Engine Default Values

R_switch_on: 1E-05

R_switch_off: 1E+007

Triangular : VTRI1

Parameters | Color

Triangular-wave voltage source

Name: VTRI1

V_peak_to_peak: 1

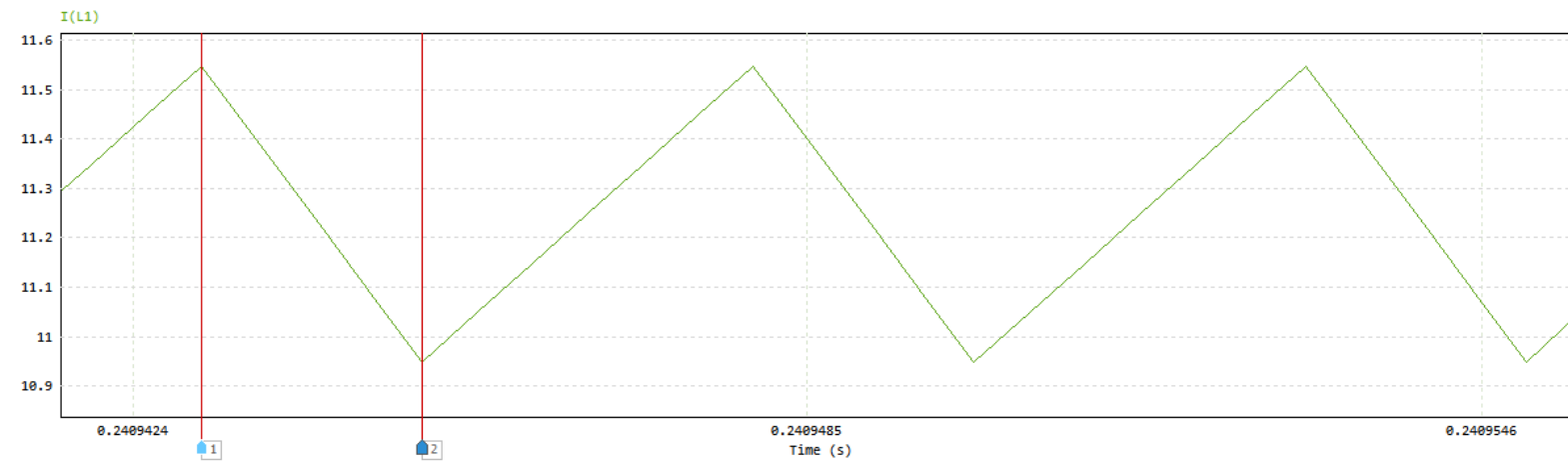
Frequency: 200k

Duty Cycle: 1

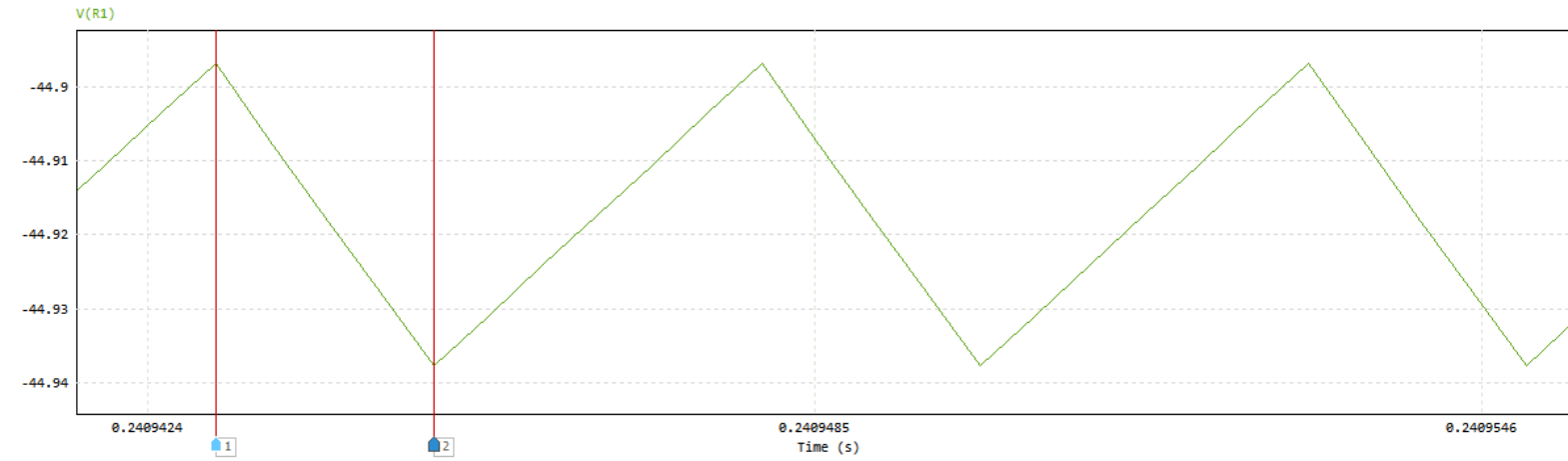
DC Offset: 0

Tstart: 0

Phase Delay: 0



Measure					
		X1	X2	Δ	Average
	Time	2.40943e-01	2.40945e-01	2.00000e-06	
	I(L1)	1.15475e+01	1.09486e+01	-5.98918e-01	1.12481e+01



Measure					
		X1	X2	Δ	Average
	Time	2.40943e-01	2.40945e-01	2.00000e-06	
	V(R1)	-4.48969e+01	-4.49377e+01	-4.08333e-02	-4.49175e+01

Question #4

Practical Buck-Boost Converter

Problems

Buck-Boost 컨버터(Question #3)의 소자 데이터시트를 참고하여 Practical Buck-Boost 컨버터 시뮬레이션
진행

(데이터시트에 없는 소자는 이상적인 값을 사용하고 인덕터의 경우 L 과 $R_L(DCR_{max})$ 값만 사용)

※ on-off controller(multi-level) 를 사용할 때 gate voltage high= 18[V], gate voltage low = 0[V], gate resistance= 3[Ω]로 설정

L_1 : 150[μH] 2100LL-150-RC

<https://pdf1.alldatasheet.com/datasheet-pdf/view/512876/BOURNS/2100LL-151-RC.html>

MOSFET: EPC2212

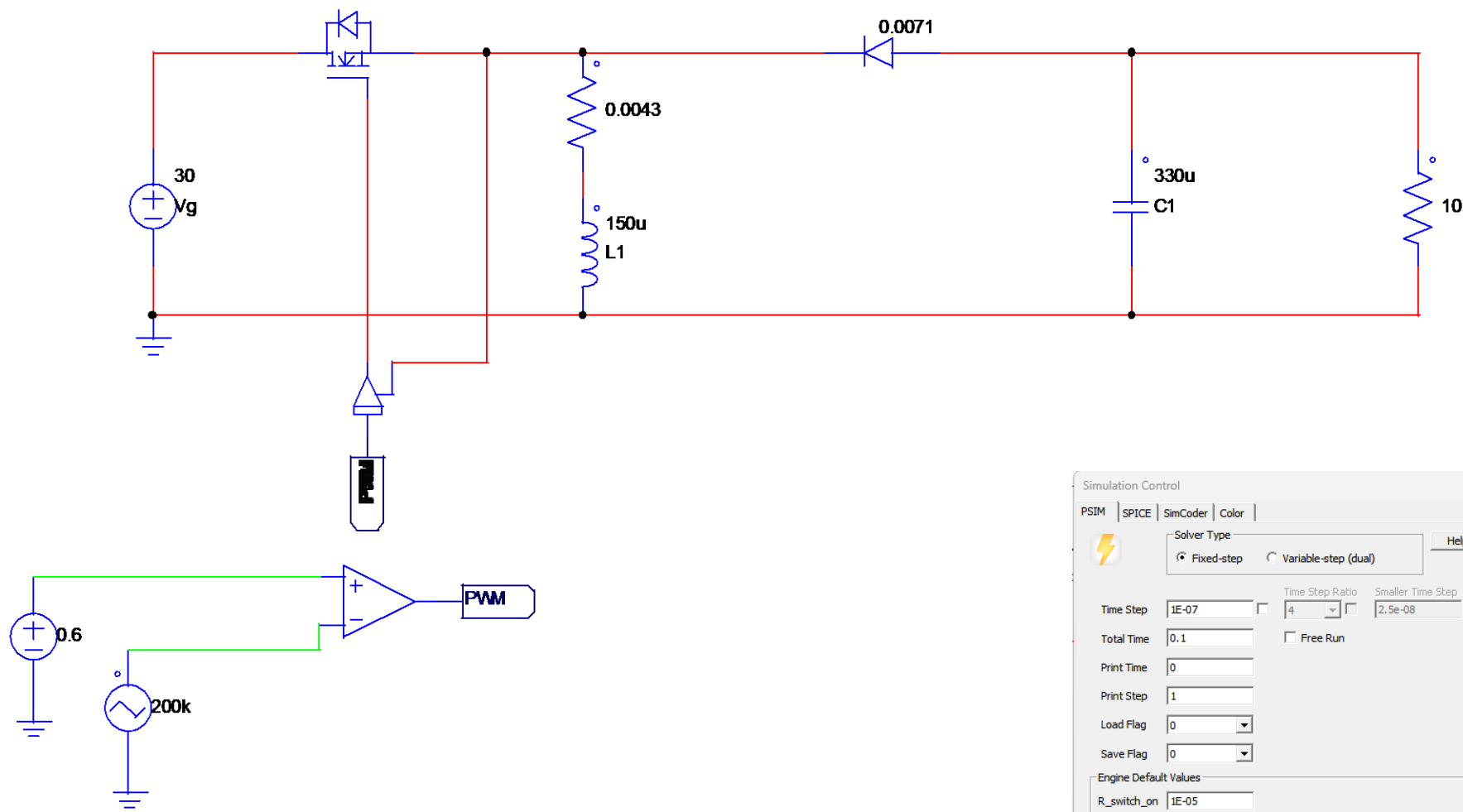
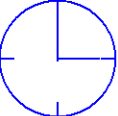
<https://pdf1.alldatasheet.com/datasheet-pdf/view/1317290/EPC-CO/EPC2212.html>

Diode: RURG3020CC

<https://pdf1.alldatasheet.com/datasheet-pdf/view/54465/FAIRCHILD/RURG3020CC.html>

Vbreakdown(drain-source)_MIN	100[V]
On Resistance_TYP.	10[Ω]
Threshold Voltage Vgs(th)_MAX.	1[V]
Transconductance_TYP.	64
Capacitance Cgs_TYP.	336[pF]
Capacitance Cgd_TYP.	3[pF]
Capacitance Cds_TYP.	235[pF]
Diode Forward Voltage_MAX @Isd =17[A]	1{V]
Diode Resistance	1[mΩ]
Parasitic Inductance Ls	0
Internal Gate Resistance	0.4[Ω]

Forward Voltage @ $I_F = 1[A]$	1[V]
Resistance @ $T_j = 25C$	0.0071[Ω]
Parasitic Inductance	20[nH]
Parallel Capacitance	0
Forward Current_MAX_avg	40[A]
Peak Reverse Current @ $T_a = 25C$	2[A]
Current Slope	100e6
Reverse Recovery Time_MAX	35[ns]



MOSFET : Q1

Parameters | Color | Simulation Models | Help

MOSFET (3-state) (Level 2)

		Display
Name	Q1	<input type="checkbox"/>
Model Level	Level 2	<input type="checkbox"/>
Vbreakdown (drain-source)	100	<input type="checkbox"/>
On Resistance	10m	<input type="checkbox"/>
Threshold Voltage VGS(th)	1	<input type="checkbox"/>
Internal Gate Resistance	0.4	<input type="checkbox"/>
Transconductance	64	<input type="checkbox"/>
Capacitance Cgs	336p	<input type="checkbox"/>
Capacitance Cgd	3p	<input type="checkbox"/>
Capacitance Cds	235p	<input type="checkbox"/>
Diode Forward Voltage	1	<input type="checkbox"/>
Diode Resistance	1m	<input type="checkbox"/>
Parasitic Inductance Ls	0	<input type="checkbox"/>
Current Flag	0	<input type="checkbox"/>
Voltage Flag	0	<input type="checkbox"/>

Simulation Control

PSIM | SPICE | SimCoder | Color | Help

☒ Fixed-step ☐ Variable-step (dual)

Time Step: 1E-07 ☐ Time Step Ratio: 4 ☐ Smaller Time Step: 2.5e-08

Total Time: 0.1 ☐ Free Run

Print Time: 0

Print Step: 1

Load Flag: 0

Save Flag: 0

Engine Default Values

R_switch_on: 1E-05

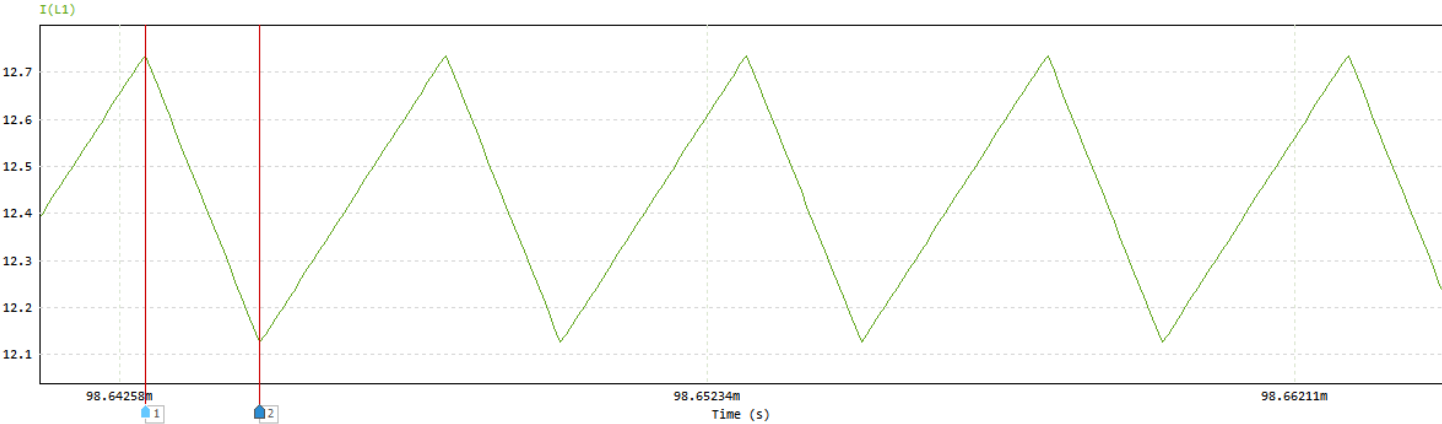
R_switch_off: 1E+007

Diode : D1

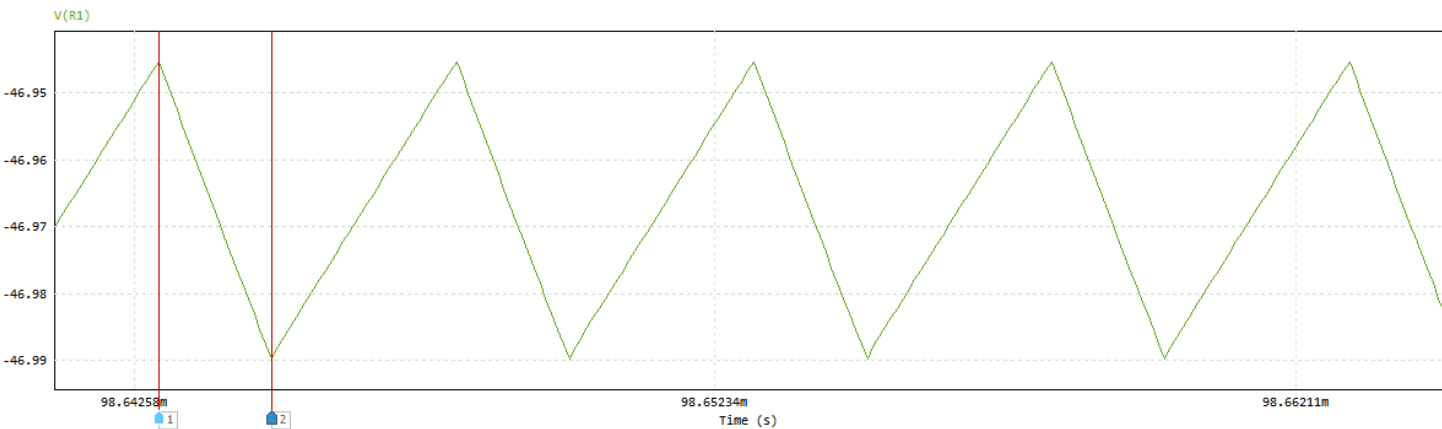
Parameters | Color | Simulation Models | Help

Diode with reverse recovery (Level 2)

		Display
Name	D1	<input type="checkbox"/>
Model Level	Level 2	<input type="checkbox"/>
Forward Voltage	1	<input type="checkbox"/>
Resistance	0.0071	<input checked="" type="checkbox"/>
Parasitic Inductance	20n	<input type="checkbox"/>
Parallel Capacitance	0	<input type="checkbox"/>
Forward Current	30	<input type="checkbox"/>
Peak Reverse Current	2	<input type="checkbox"/>
Current Slope	100e6	<input type="checkbox"/>
Reverse Recovery Time	35n	<input type="checkbox"/>
Initial Position	0	<input type="checkbox"/>
Current Flag	0	<input type="checkbox"/>
Voltage Flag	0	<input type="checkbox"/>



Measure					
		X1	X2	Δ	Average
	Time	9.86430e-02	9.86449e-02	1.90000e-06	
	I(L1)	1.27356e+01	1.21262e+01	-6.09414e-01	1.24309e+01



Measure					
		X1	X2	Δ	Average
	Time	9.86430e-02	9.86449e-02	1.90000e-06	
	V(R1)	-4.69453e+01	-4.69898e+01	-4.45313e-02	-4.69679e+01