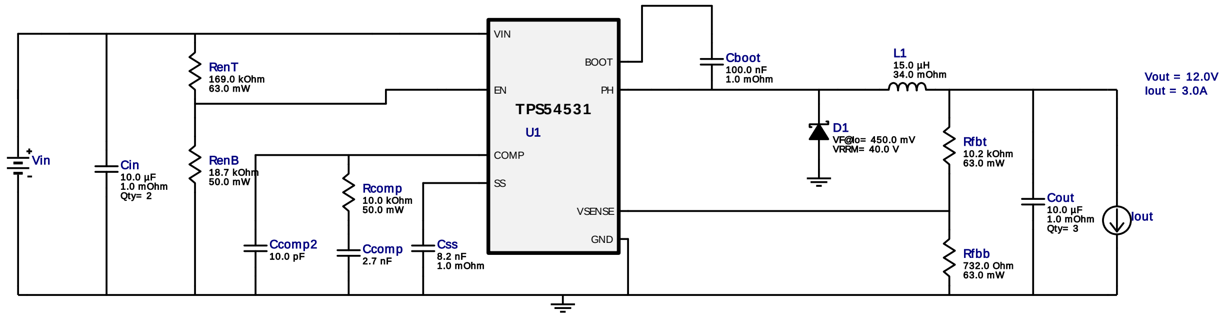
VinMin = 14.0V
VinMax = 28.0V
Vout = 12.0V
Iout = 3.0A

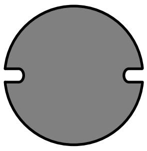
Device = TPS54531DDAR
Topology = Buck
Created = 2020-03-25 17:48:22.856
BOM Cost = $2.59
BOM Count = 17
Total Pd = 2.29W

WEBENCH ® Design Report

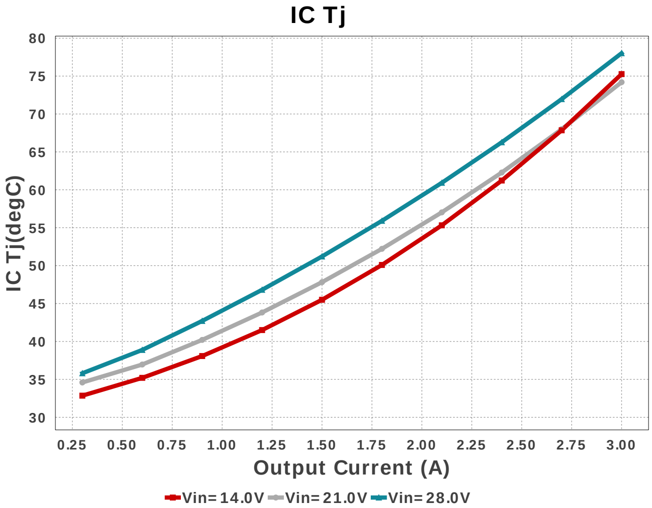
Design : 4 TPS54531DDAR
TPS54531DDAR 14V-28V to 12.00V @ 3A

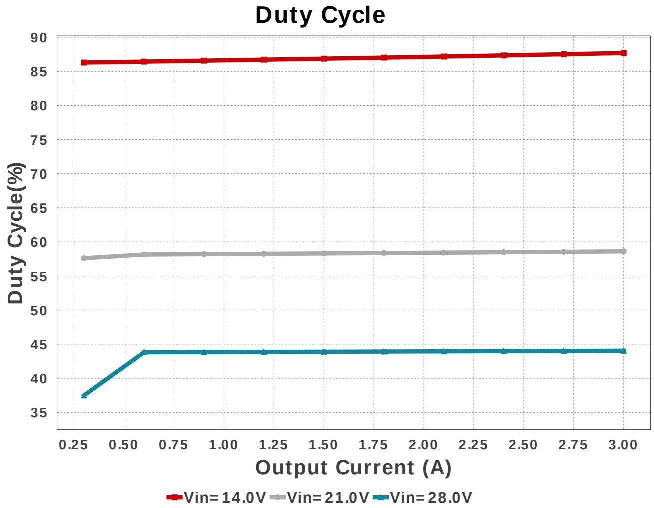


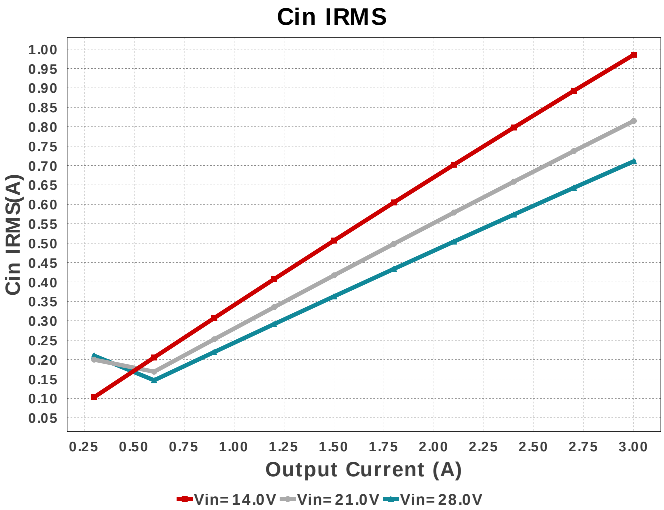
Electrical BOM

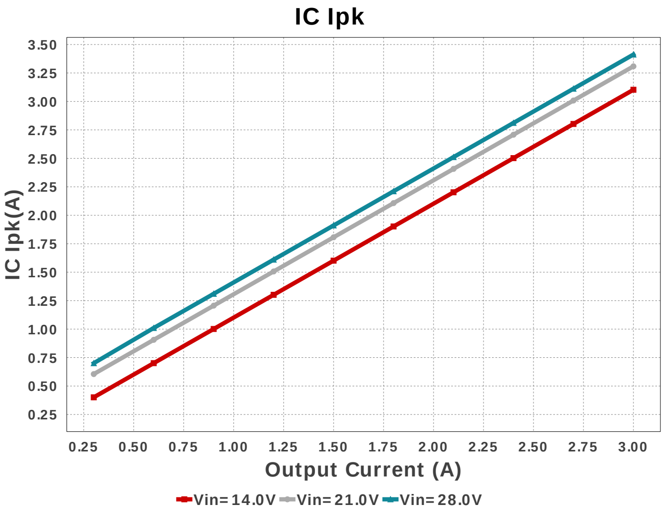
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM155R71A104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ccomp	TDK	C2012C0G1H272J060AA Series= C0G/NP0	Cap= 2.7 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.03	0805 7 mm^2
Ccomp2	Samsung Electro-Mechanics	CL21C100JBANNNC Series= C0G/NP0	Cap= 10.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Cin	TDK	C3225X7R1H106M250AC Series= X7R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 5.0 A	2	$0.28	1210 15 mm^2
Cout	TDK	C3225X7R1H106M250AC Series= X7R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 5.0 A	3	$0.28	1210 15 mm^2
Css	MuRata	GRM033R71A822KA01D Series= X7R	Cap= 8.2 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0201 2 mm^2
D1	Diodes Inc.	B340LA-13-F	VF@Io= 450.0 mV VRRM= 40.0 V	1	$0.13	SMA 37 mm^2
L1	Bourns	SDR1307-150ML	L= 15.0 µH 34.0 mOhm	1	$0.42	 SDR1307 226 mm^2
Rcomp	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
RenB	Yageo	RC0201FR-0718K7L Series= ?	Res= 18.7 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2

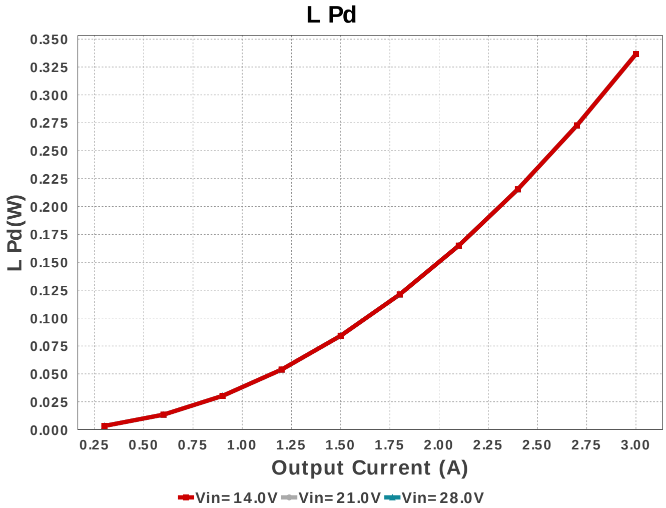
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
RenT	Vishay-Dale	CRCW0402169KFKED Series= CRCW..e3	Res= 169.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb	Vishay-Dale	CRCW0402732RFKED Series= CRCW..e3	Res= 732.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt	Vishay-Dale	CRCW040210K2FKED Series= CRCW..e3	Res= 10.2 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
U1	Texas Instruments	TPS54531DDAR	Switcher	1	$0.53	DDA0008E 55 mm^2

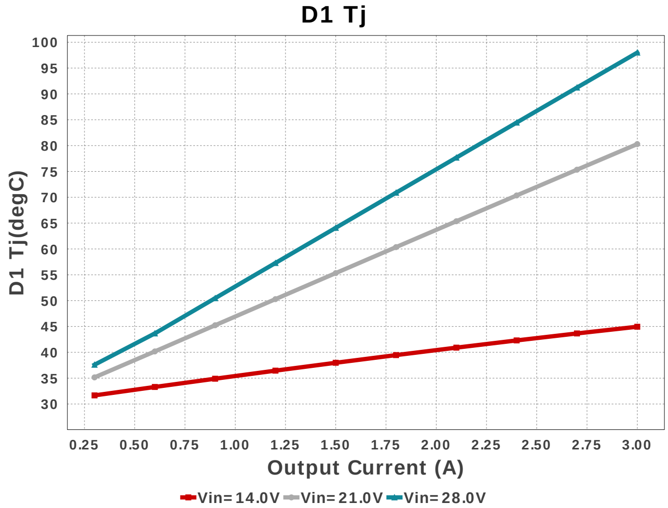


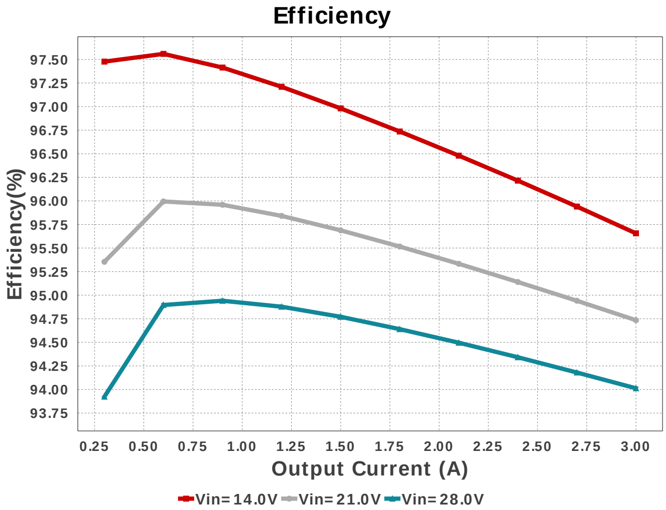


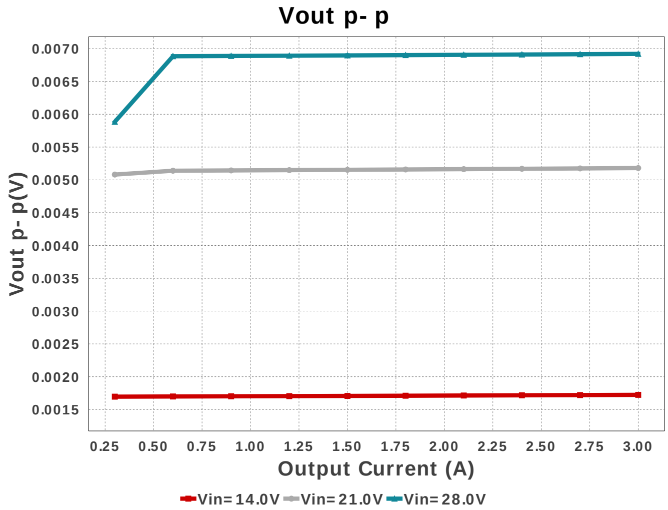


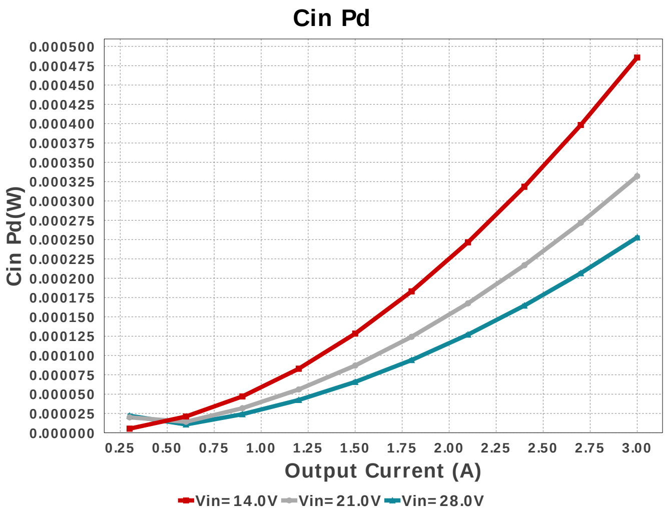


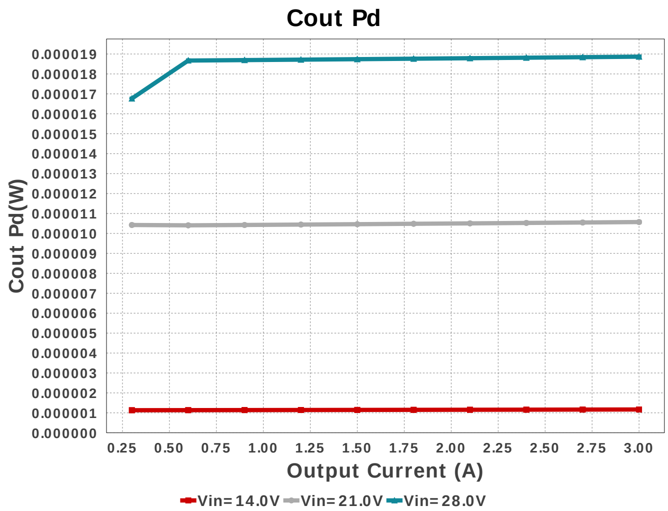

L Pd
L Pd(W)
0.350
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V

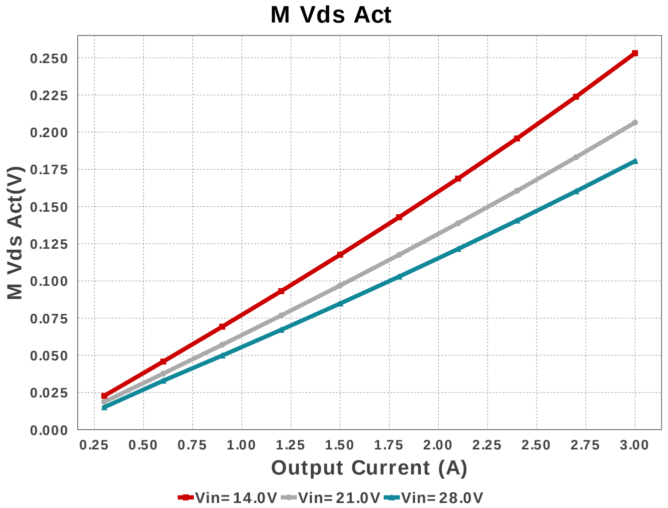

D1 Tj
D1 Tj(degC)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V

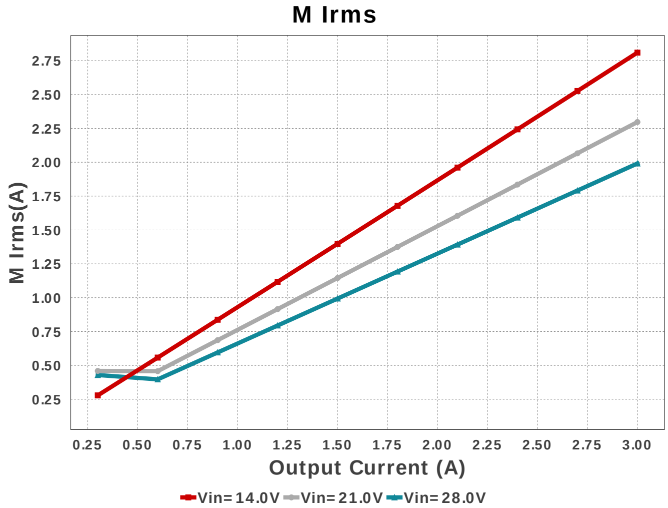

Efficiency
Efficiency(%)
97.50
97.25
97.00
96.75
96.50
96.25
96.00
95.75
95.50
95.25
95.00
94.75
94.50
94.25
94.00
93.75
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V

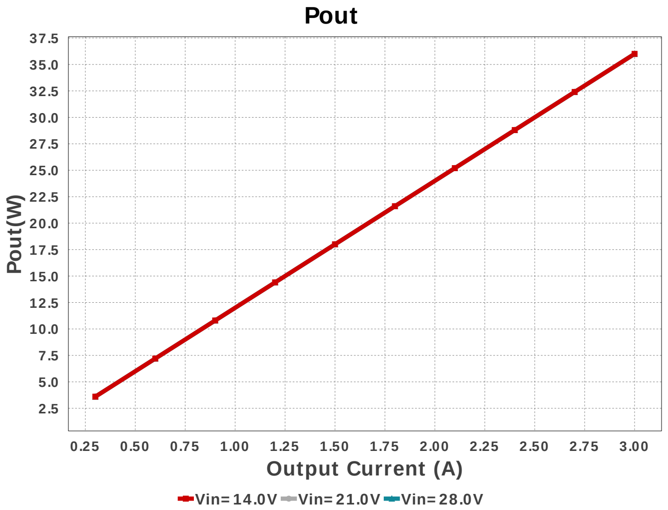

Vout p- p
Vout p- p(V)
0.0070
0.0065
0.0060
0.0055
0.0050
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V

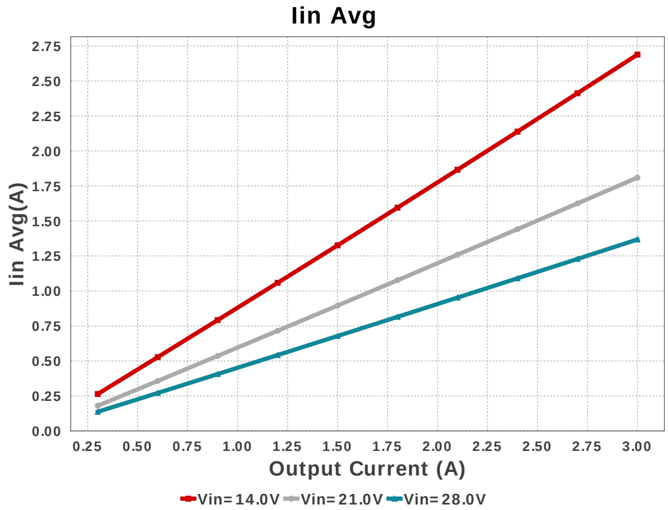

Cin Pd
Cin Pd(W)
0.000500
0.000475
0.000450
0.000425
0.000400
0.000375
0.000350
0.000325
0.000300
0.000275
0.000250
0.000225
0.000200
0.000175
0.000150
0.000125
0.000100
0.000075
0.000050
0.000025
0.000000
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V

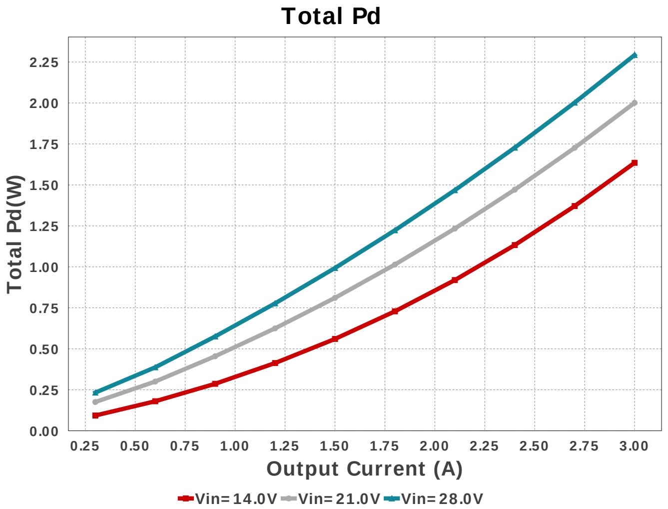

Cout Pd
Cout Pd(W)
0.000019
0.000018
0.000017
0.000016
0.000015
0.000014
0.000013
0.000012
0.000011
0.000010
0.000009
0.000008
0.000007
0.000006
0.000005
0.000004
0.000003
0.000002
0.000001
0.000000
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V

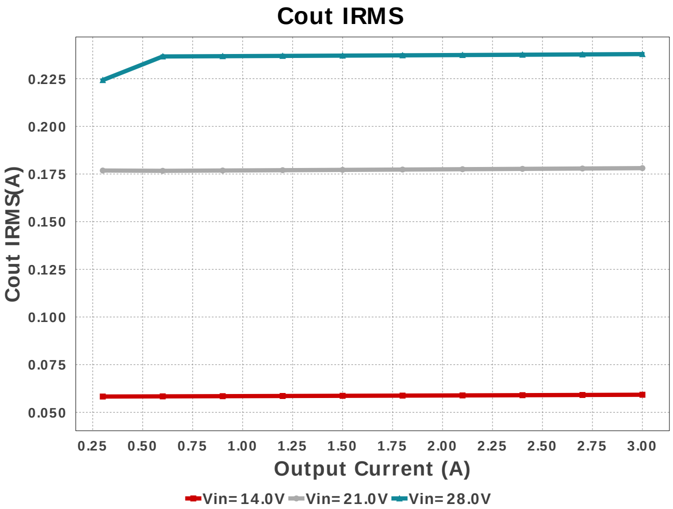

M Vds Act
M Vds Act(V)
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V

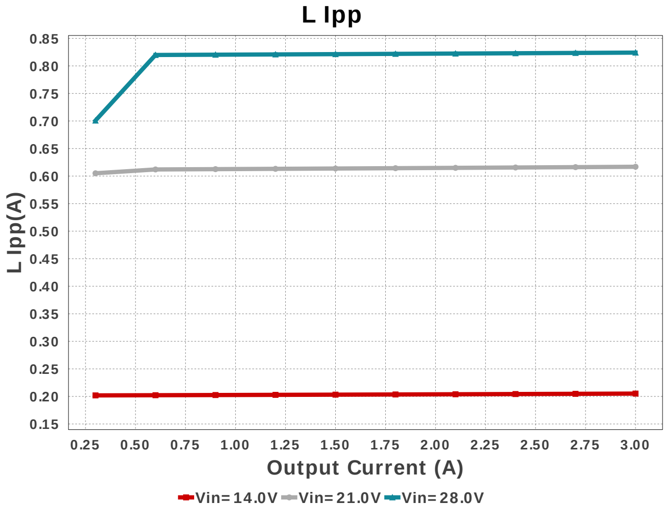

M Irms
M Irms(A)
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V

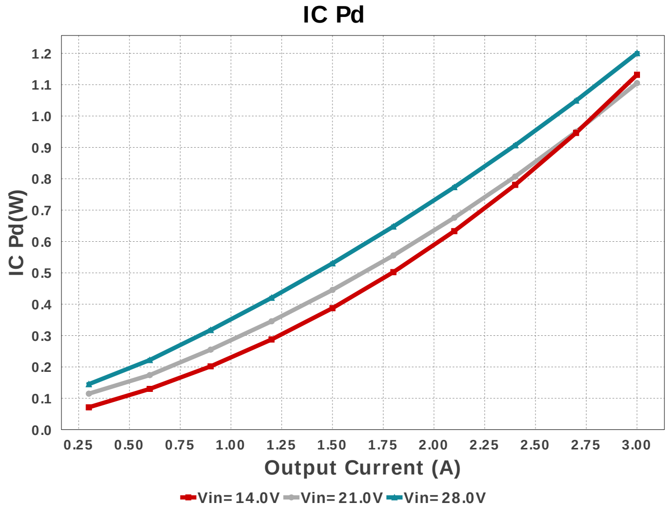

Pout
Pout(W)
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V

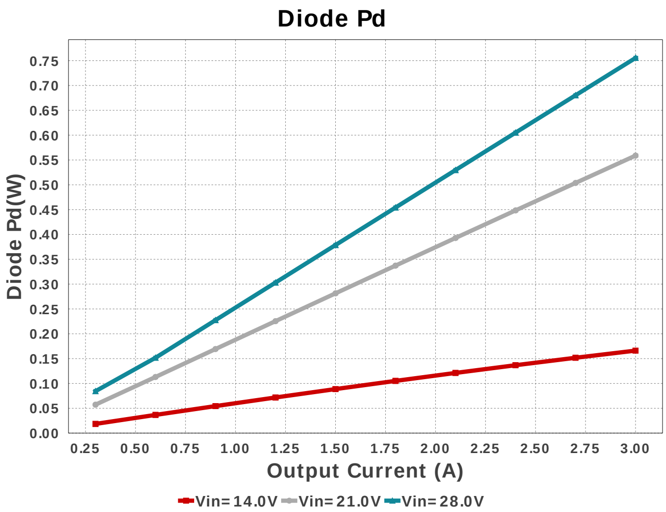

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V

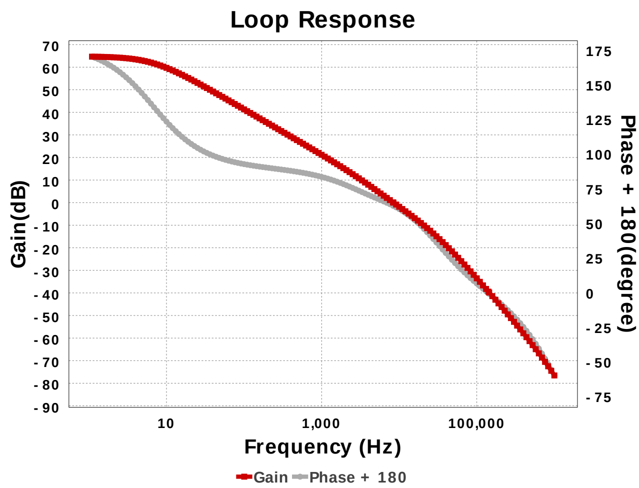

Total Pd
Total Pd(W)
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V


Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V









Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	710.911 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	252.7 µW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	237.911 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	18.867 µW	Capacitor	Output capacitor power dissipation
5.	D1 Tj	97.991 degC	Diode	D1 junction temperature
6.	Diode Pd	755.45 mW	Diode	Diode power dissipation
7.	IC Ipk	3.412 A	IC	Peak switch current in IC
8.	IC Pd	1.2 W	IC	IC power dissipation
9.	IC Tj	78.016 degC	IC	IC junction temperature
10.	ICThetaJA	40.0 degC/W	IC	IC junction-to-ambient thermal resistance
11.	Iin Avg	1.368 A	IC	Average input current
12.	L Ipp	824.15 mA	Inductor	Peak-to-peak inductor ripple current
13.	L Pd	336.6 mW	Inductor	Inductor power dissipation
14.	M Irms	1.991 A	Mosfet	MOSFET RMS ripple current
15.	M Vds Act	180.533 mV	Mosfet	Voltage drop across the MosFET
16.	Cin Pd	252.7 µW	Power	Input capacitor power dissipation
17.	Cout Pd	18.867 µW	Power	Output capacitor power dissipation
18.	Diode Pd	755.45 mW	Power	Diode power dissipation
19.	IC Pd	1.2 W	Power	IC power dissipation
20.	L Pd	336.6 mW	Power	Inductor power dissipation
21.	Total Pd	2.293 W	Power	Total Power Dissipation
22.	BOM Count	17	System Information	Total Design BOM count
23.	Cross Freq	8.428 kHz	System Information	Bode plot crossover frequency
24.	Duty Cycle	44.04 %	System Information	Duty cycle
25.	Efficiency	94.013 %	System Information	Steady state efficiency
26.	FootPrint	424.0 mm^2	System Information	Total Foot Print Area of BOM components

#	Name	Value	Category	Description
27.	Frequency	570.0 kHz	System Information	Switching frequency
28.	Gain Marg	-39.422 dB	System Information	Bode Plot Gain Margin
29.	Iout	3.0 A	System Information	Iout operating point
30.	Low Freq Gain	64.657 dB	System Information	Gain at 1Hz
31.	Mode	CCM	System Information	Conduction Mode
32.	Phase Marg	63.031 deg	System Information	Bode Plot Phase Margin
33.	Pout	36.0 W	System Information	Total output power
34.	Total BOM	$2.59	System Information	Total BOM Cost
35.	Vin	28.0 V	System Information	Vin operating point
36.	Vout	12.0 V	System Information	Operational Output Voltage
37.	Vout Actual	11.948 V	System Information	Vout Actual calculated based on selected voltage divider resistors
38.	Vout Tolerance	5.451 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
39.	Vout p-p	6.92 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	3.0	Maximum Output Current
SoftStart	3.0 ms	Soft Start Time (ms)
VinMax	28.0	Maximum input voltage
VinMin	14.0	Minimum input voltage
Vout	12.0	Output Voltage
base_pn	TPS54531	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature

WEBENCH® Assembly

Component Testing

Some published data on components in datasheets such as Capacitor ESR and Inductor DC resistance is based on conservative values that will guarantee that the components always exceed the specification. For design purposes it is usually better to work with typical values. Since this data is not always available it is a good practice to measure the Capacitance and ESR values of Cin and Cout, and the inductance and DC resistance of L1 before assembly of the board. Any large discrepancies in values should be electrically simulated in WEBENCH to check for instabilities and thermally simulated in WebTHERM to make sure critical temperatures are not exceeded.

Soldering Component to Board

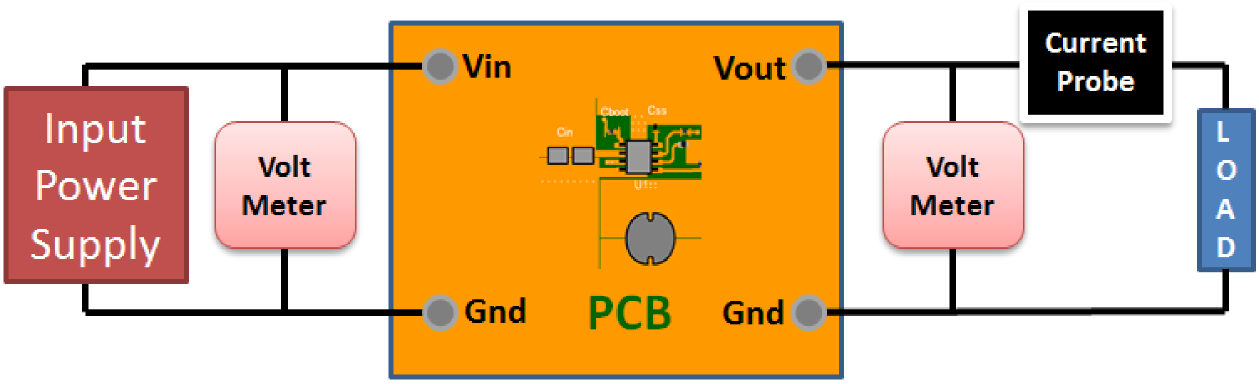
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. To solder the tab town to the board place the iron down on the board while resting against the tab, heating both surfaces simultaneously. Apply light pressure to the top of the plastic case until the solder flows around the part and the part is flush with the PCB. If the solder is not flowing around the board you may need a higher wattage iron (generally 25W to 30W is enough).

Initial Startup of Circuit

It is best to initially power up the board by setting the input supply voltage to the lowest operating input voltage 14.0V and set the input supply's current limit to zero. With the input supply off connect up the input supply to Vin and GND. Connect a digital volt meter and a load if needed to set the minimum Iout of the design from Vout and GND. Turn on the input supply and slowly turn up the current limit on the input supply. If the voltage starts to rise on the input supply continue increasing the input supply current limit while watching the output voltage. If the current increases on the input supply, but the voltage remains near zero, then there may be a short or a component misplaced on the board. Power down the board and visually inspect for solder bridges and recheck the diode and capacitor polarities. Once the power supply circuit is operational then more extensive testing may include full load testing, transient load and line tests to compare with simulation results.

Load Testing

The setup is the same as the initial startup, except that an additional digital voltmeter is connected between Vin and GND, a load is connected between Vout and GND and a current meter is connected in series between Vout and the load. The load must be able to handle at least rated output power + 50% (7.5 watts for this design). Ideally the load is supplied in the form of a variable load test unit. It can also be done in the form of suitably large power resistors. When using an oscilloscope to measure waveforms on the prototype board, the ground leads of the oscilloscope probes should be as short as possible and the area of the loop formed by the ground lead should be kept to a minimum. This will help reduce ground lead inductance and eliminate EMI noise that is not actually present in the circuit.

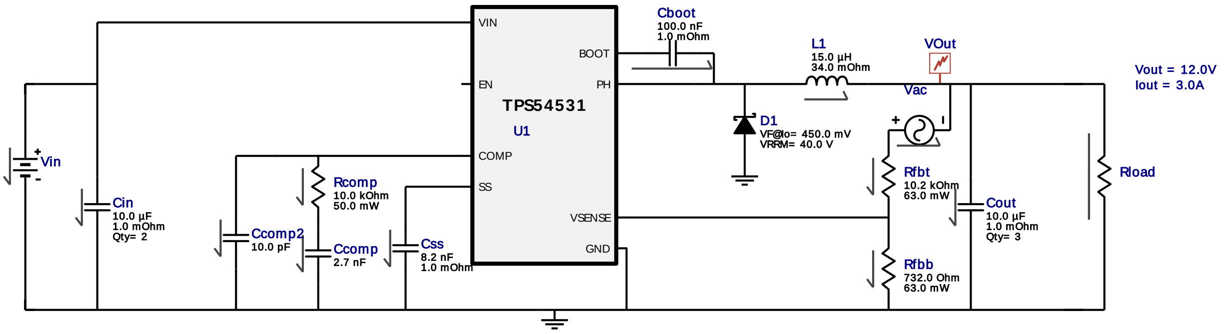


WEBENCH® Electrical Simulation Report

Design Id = 4

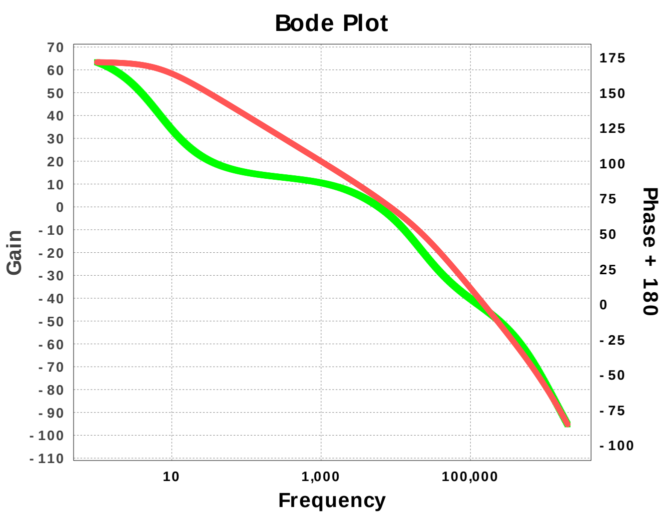
sim_id = 17

Simulation Type = Bode Plot



Simulation Parameters

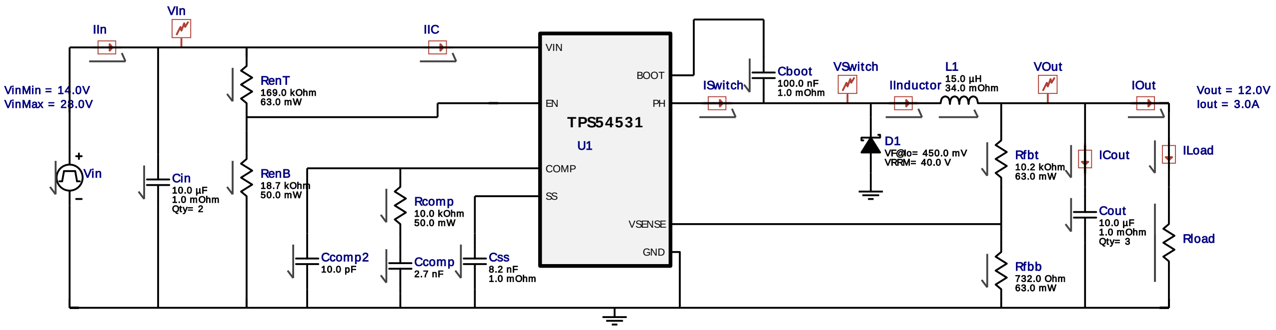
#	Name	Parameter Name	Description	Values
1.	Cout	IC	Initial Condition	no values
2.	Cinj	C	Injection Capacitance	10000000 F
3.	Linj	L	Injection Inductance	10000000 H
4.	Vinj	AC	AC Input	1
5.	Rload	R	Load Resistance	4.0 Ohm



Design Id = 4

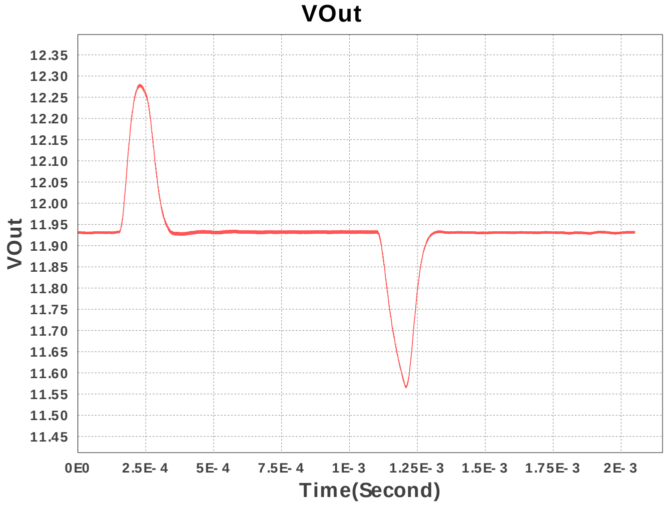
sim_id = 18

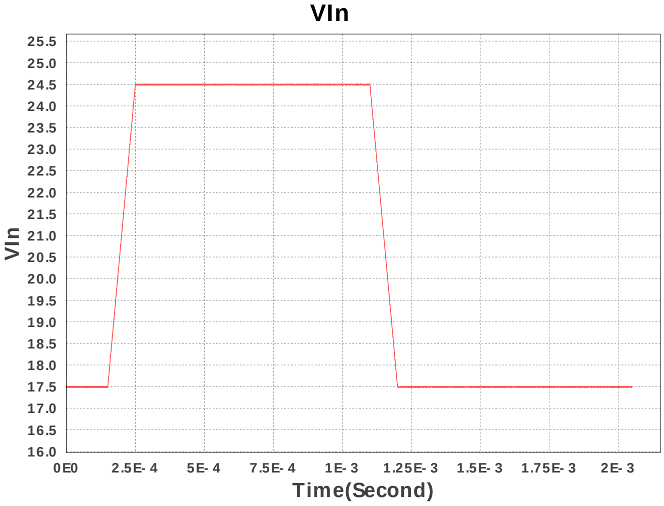
Simulation Type = Input Transient



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Css	IC	Initial Voltage	1 V
2.	Cboot	IC	Initial Voltage	21.0 V
3.	L1	IC	Initial Current	3.0 A
4.	Rload	R	Load Resistance	4.0 Ohm

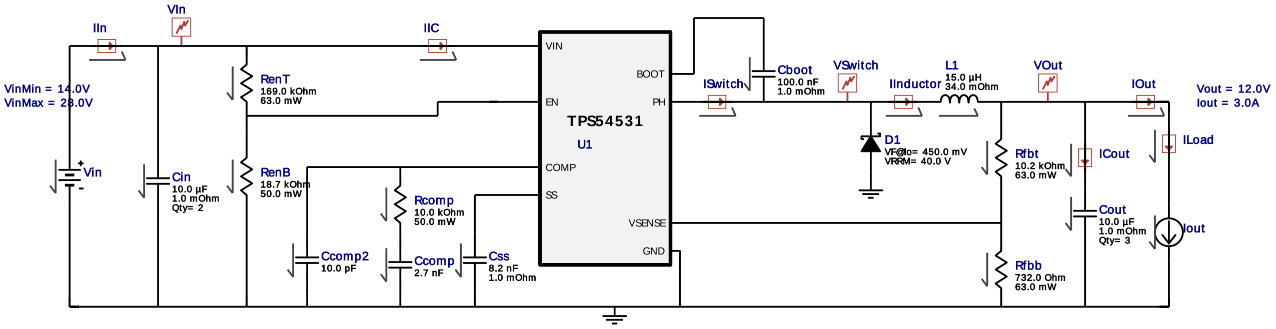




Design Id = 4

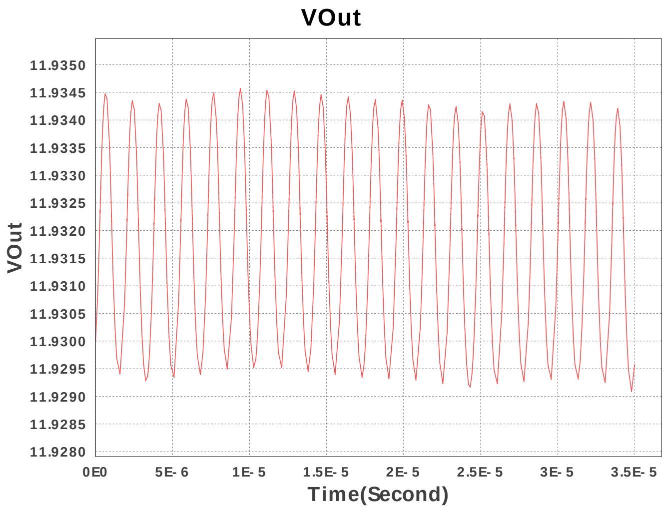
sim_id = 19

Simulation Type = Steady State



Simulation Parameters

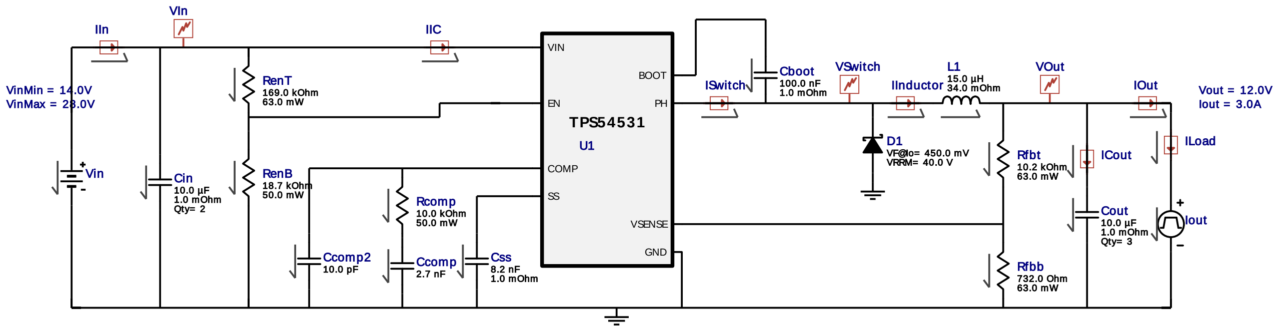
#	Name	Parameter Name	Description	Values
1.	Css	IC	Initial Voltage	1 V
2.	Cboot	IC	Initial Voltage	21.0 V
3.	L1	IC	Initial Current	3.0 A
4.	Iout	I	Load Current	3.0 A



Design Id = 4

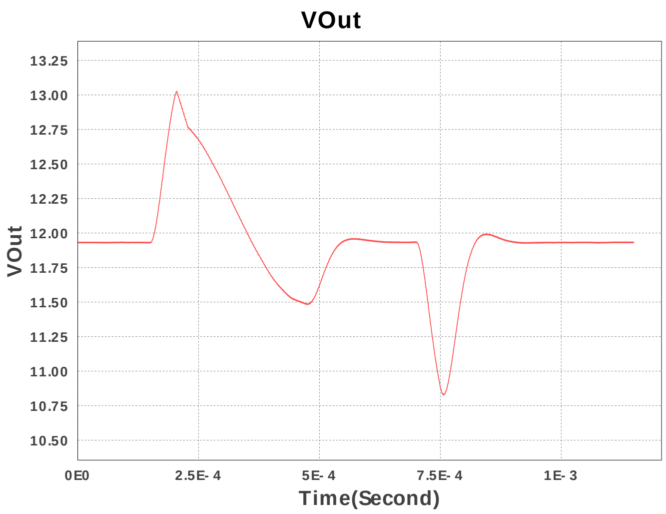
sim_id = 20

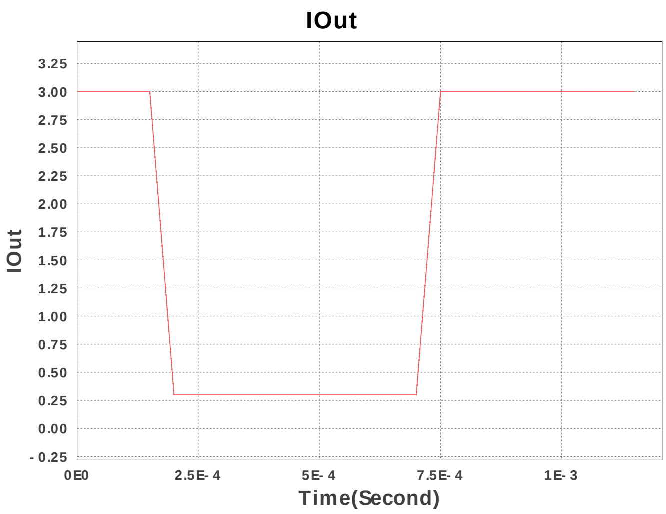
Simulation Type = Load Transient



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Css	IC	Initial Voltage	1 V
2.	Cboot	IC	Initial Voltage	21.0 V
3.	L1	IC	Initial Current	3.0 A
4.	Iout	signal_type	Signal Type	PULSE
		I1	Initial Load Current	3.0 A
		I2	Minimum Load Current	0.3 A
		Td	Initial Time Delay	150u s
		Tf	Fall Time	50u s
		Tr	Rise Time	50u s
		Pw	Pulse Width	500u s





Design Assistance

1. Master key : 4E4581885D4BEE2E[v1]

2. **TPS54531** Product Folder : http://www.ti.com/product/TPS54531 : contains the data sheet and other resources.

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