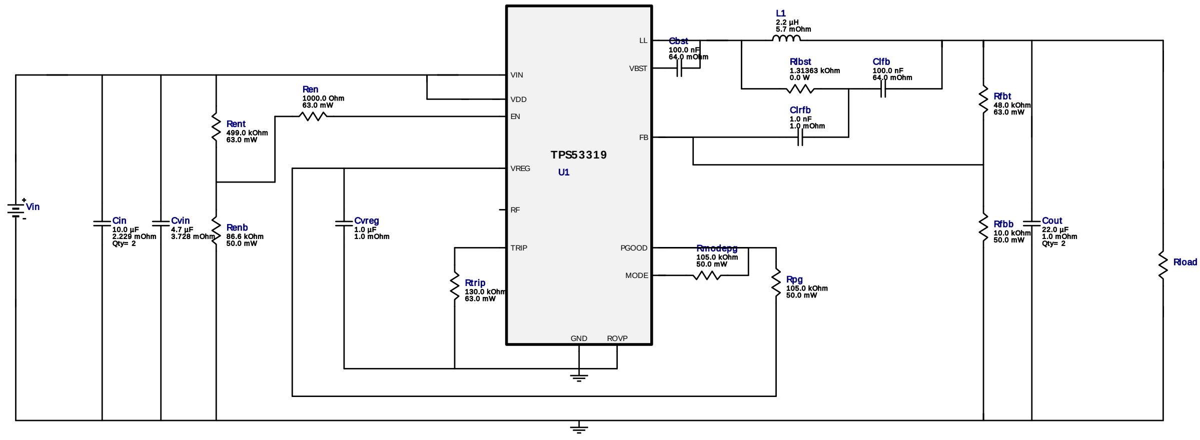
Texas Instruments

WEBENCH ® Design Report

VinMin = 11.0V
VinMax = 13.0V
Vout = 3.8V
Iout = 9.0A

Device = TPS53319DQPR
Topology = Buck
Created = 2020-09-24 03:23:45.675
BOM Cost = NA
BOM Count = 20
Total Pd = 1.68W

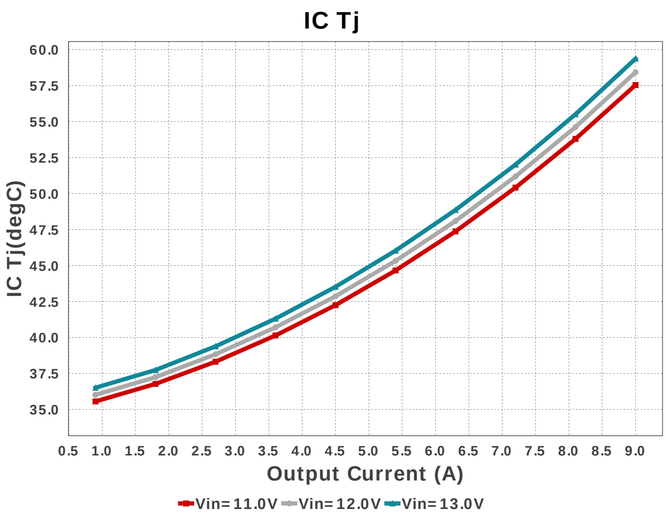
Design : 10083 TPS53319DQPR
TPS53319DQPR 11V-13V to 3.80V @ 9A

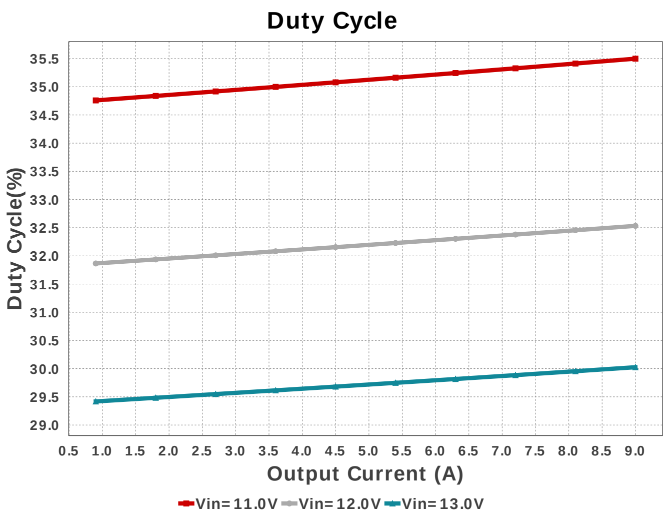


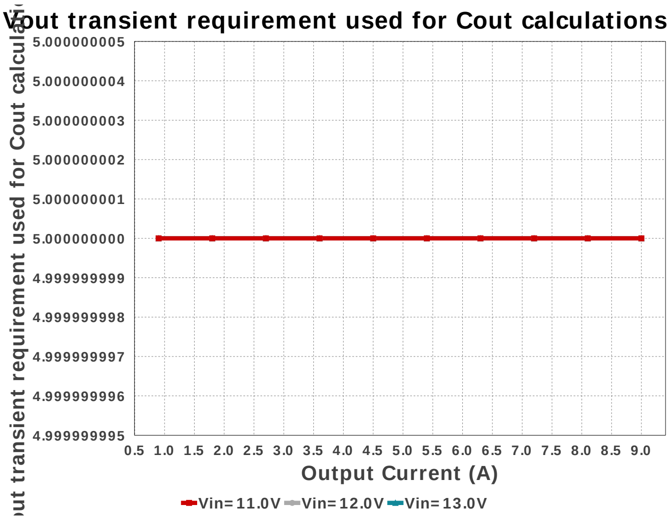
Electrical BOM

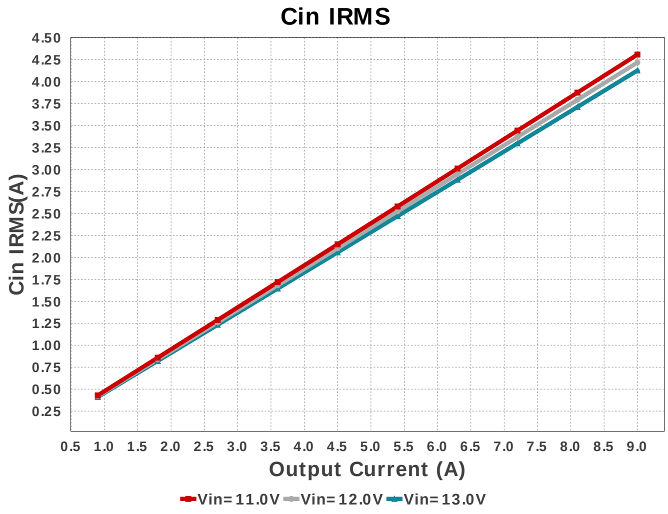
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbst	Kemet	C0805C104M5RACTU Series= X7R	Cap= 100.0 nF ESR= 64.0 mOhm VDC= 50.0 V IRMS= 1.64 A	1	$0.01	0805 7 mm^2
Cin	TDK	C3216X6S1V106K160AC Series= X6S	Cap= 10.0 uF ESR= 2.229 mOhm VDC= 35.0 V IRMS= 4.8593 A	2	$0.18	1206_180 11 mm^2
Clfb	Kemet	C0805C104M5RACTU Series= X7R	Cap= 100.0 nF ESR= 64.0 mOhm VDC= 50.0 V IRMS= 1.64 A	1	$0.01	0805 7 mm^2
Clrfb	Yageo	CC0805KRX7R9BB102 Series= X7R	Cap= 1.0 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Cout	MuRata	GRM188R60J226MEA0D Series= X5R	Cap= 22.0 uF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 6.0 A	2	$0.05	0603 5 mm^2
Cvin	TDK	C1608X5R1V475K080AC Series= X5R	Cap= 4.7 uF ESR= 3.728 mOhm VDC= 35.0 V IRMS= 2.69359 A	1	$0.10	0603 5 mm^2
Cvreg	Taiyo Yuden	TMK212B7105KG-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2
L1	Coilcraft	XAL7070-222MEB	L= 2.2 µH 5.7 mOhm	1	$1.19	XAL7070 87 mm^2
Ren	Vishay-Dale	CRCW04021K00FKED Series= CRCW..e3	Res= 1000.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2

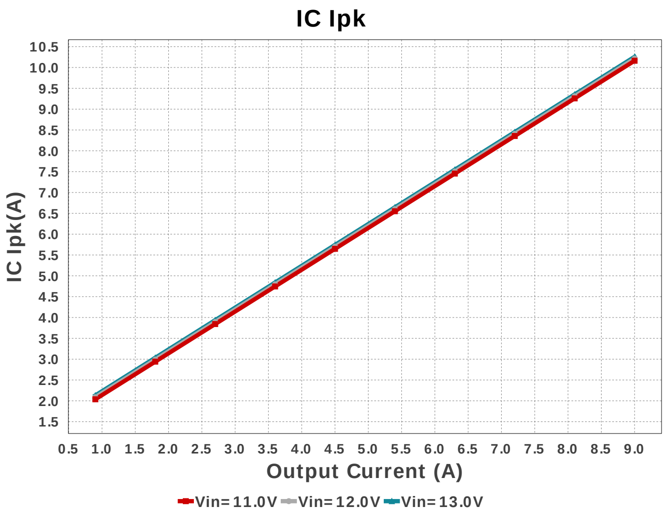
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Renb	Yageo	RC0201FR-0786K6L Series= ?	Res= 86.6 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rent	Vishay-Dale	CRCW0402499KFKED Series= CRCW..e3	Res= 499.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rfbt	CUSTOM	CUSTOM Series= CRCW..e3	Res= 48.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	NA	0402 0 mm^2
Rlbst	CUSTOM	CUSTOM Series= ?	Res= 1.31363 kOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm^2
Rmodepg	Yageo	RC0201FR-07105KL Series= ?	Res= 105.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rpg	Yageo	RC0201FR-07105KL Series= ?	Res= 105.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rtrip	Vishay-Dale	CRCW0402130KFKED Series= CRCW..e3	Res= 130.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
U1	Texas Instruments	TPS53319DQPR	Switcher	1	$1.55	DQP0022A 56 mm^2

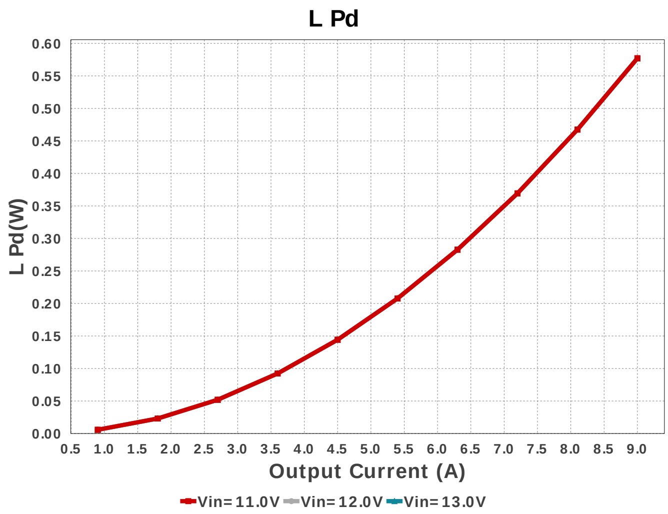


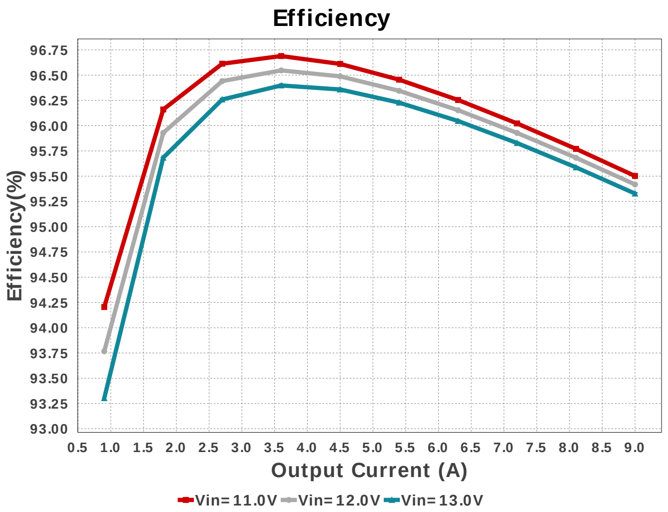


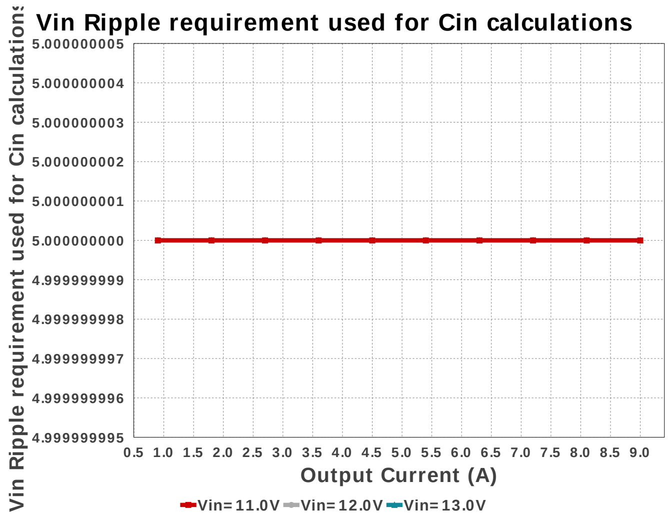

Vout transient requirement used for Cout calculations
Vout transient requirement used for Cout calculations
5.000000005
5.000000004
5.000000003
5.000000002
5.000000001
5.000000000
4.999999999
4.999999998
4.999999997
4.999999996
4.999999995
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0
Output Current (A)
Vin= 11.0V Vin= 12.0V Vin= 13.0V

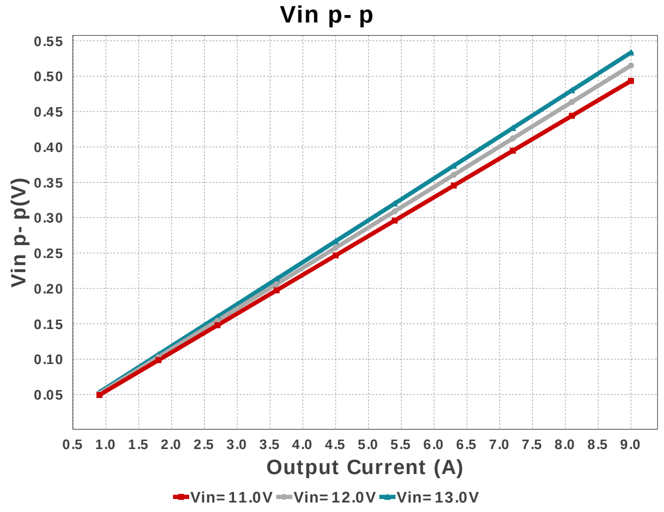

Cin IRMS
Cin IRMS(A)
4.50
4.25
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0
Output Current (A)
Vin= 11.0V Vin= 12.0V Vin= 13.0V

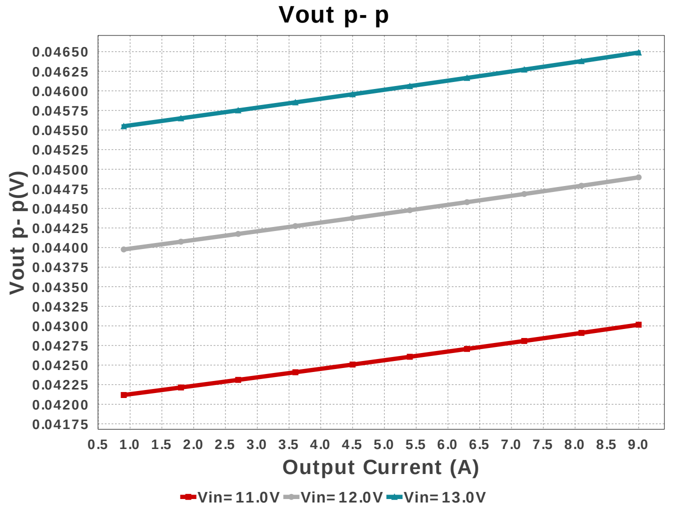

IC Ipk
IC Ipk(A)
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0
Output Current (A)
Vin= 11.0V Vin= 12.0V Vin= 13.0V

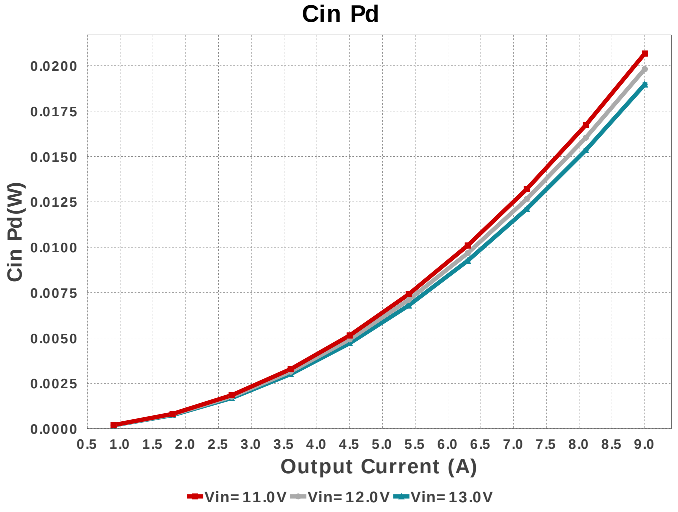

L Pd
L Pd(W)
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0
Output Current (A)
Vin= 11.0V Vin= 12.0V Vin= 13.0V

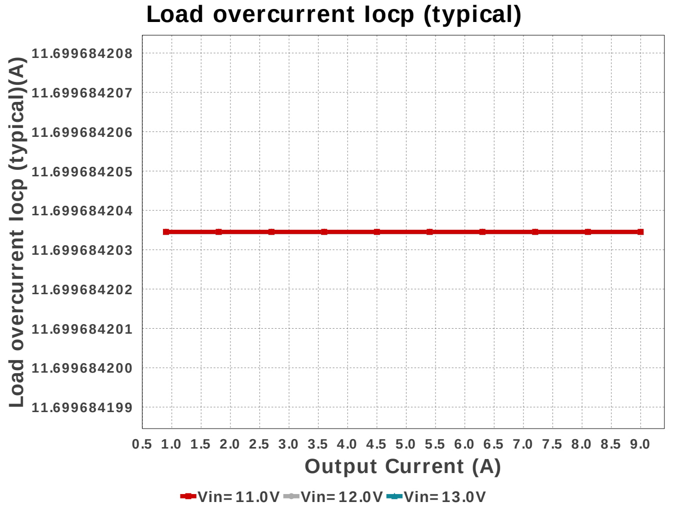

Efficiency
Efficiency(%)
96.75
96.50
96.25
96.00
95.75
95.50
95.25
95.00
94.75
94.50
94.25
94.00
93.75
93.50
93.25
93.00
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0
Output Current (A)
Vin= 11.0V Vin= 12.0V Vin= 13.0V

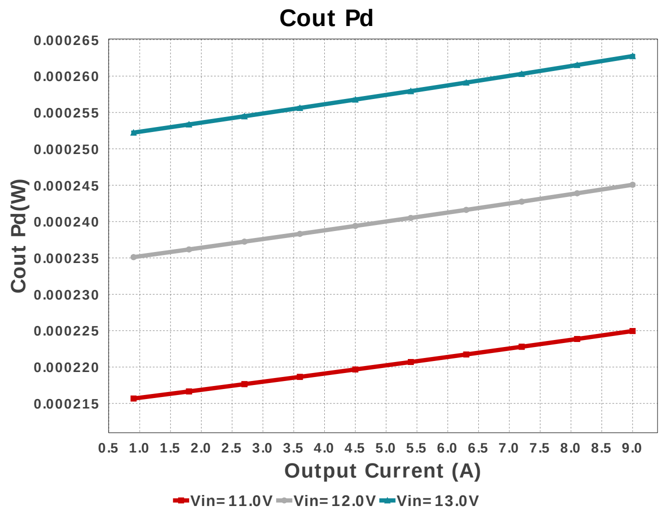

Vin Ripple requirement used for Cin calculations
Vin Ripple requirement used for Cin calculations
5.000000005
5.000000004
5.000000003
5.000000002
5.000000001
5.000000000
4.999999999
4.999999998
4.999999997
4.999999996
4.999999995
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0
Output Current (A)
Vin= 11.0V Vin= 12.0V Vin= 13.0V

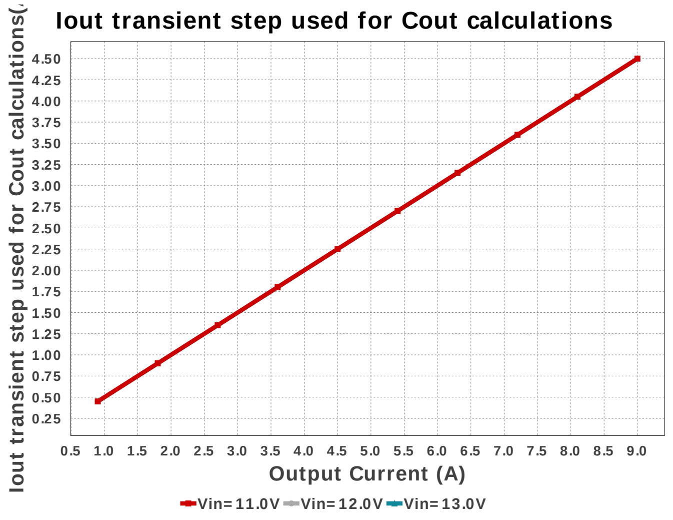

Vin p- p
Vin p- p(V)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

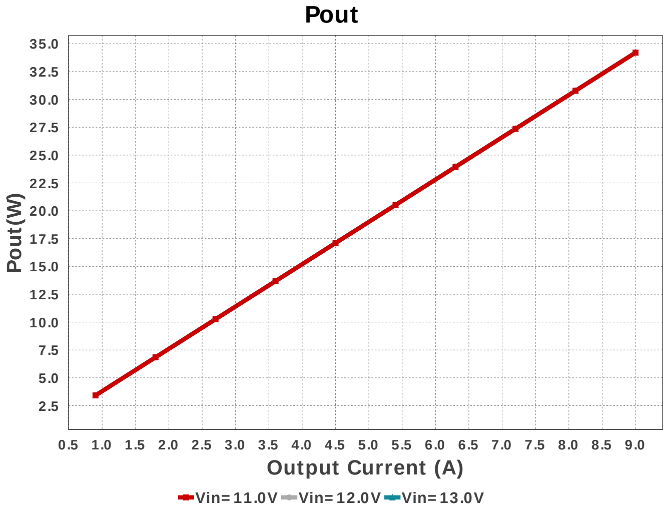

Vout p- p
Vout p- p(V)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

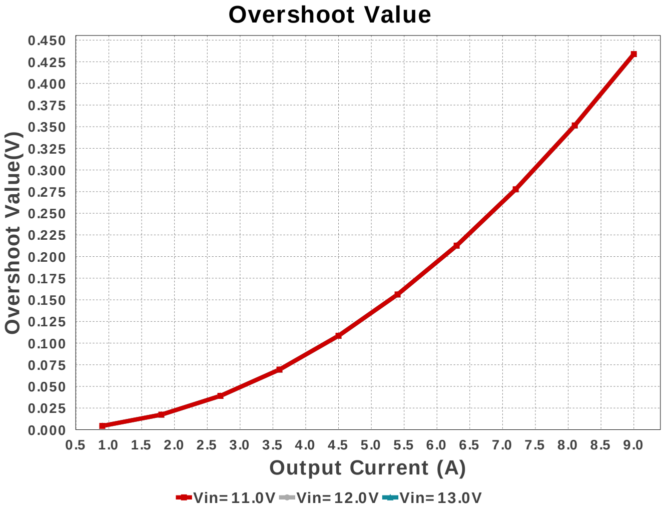

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

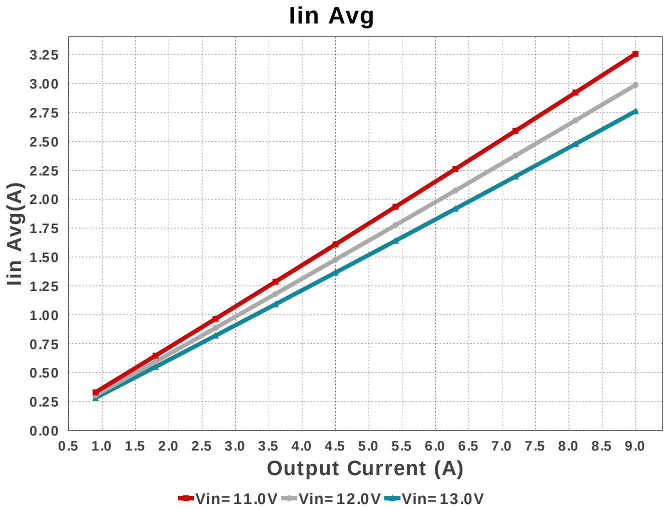

Load overcurrent Iocp (typical)
Load overcurrent Iocp (typical)(A)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

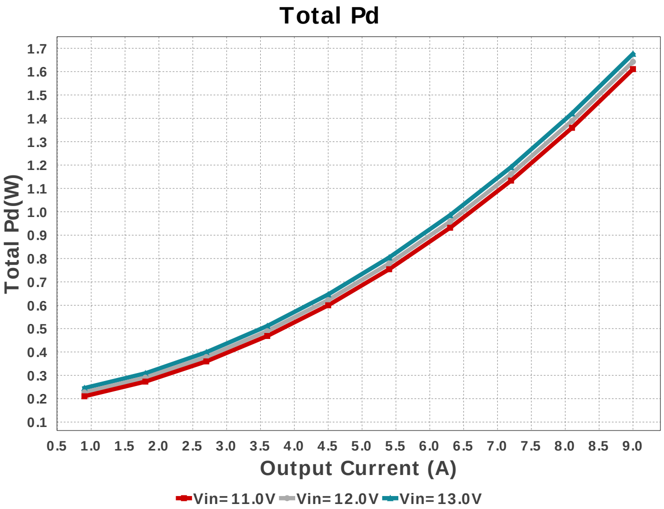

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

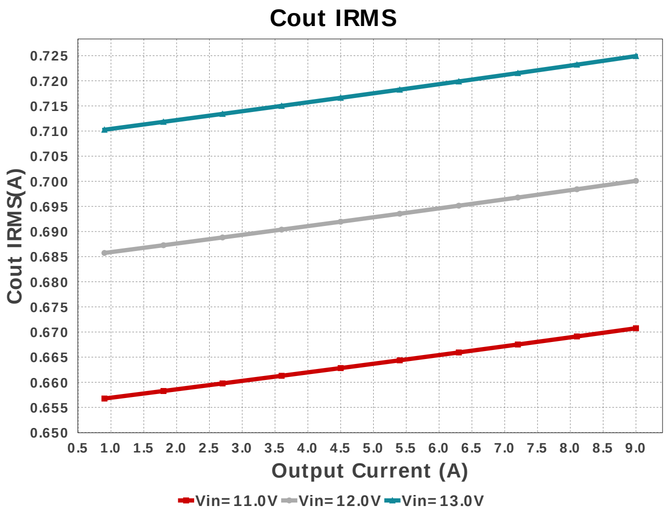

Iout transient step used for Cout calculations
Iout transient step used for Cout calculations(
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

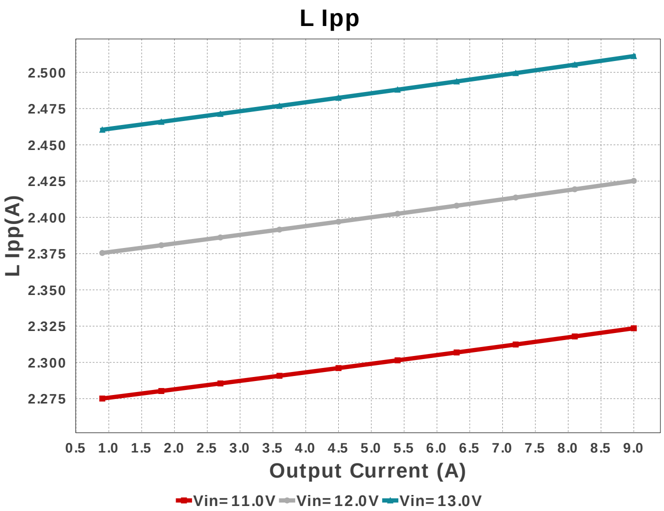

Pout
Pout(W)
35.0
32.5
30.0
27.5
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0
Output Current (A)
Vin=11.0V
Vin=12.0V
Vin=13.0V

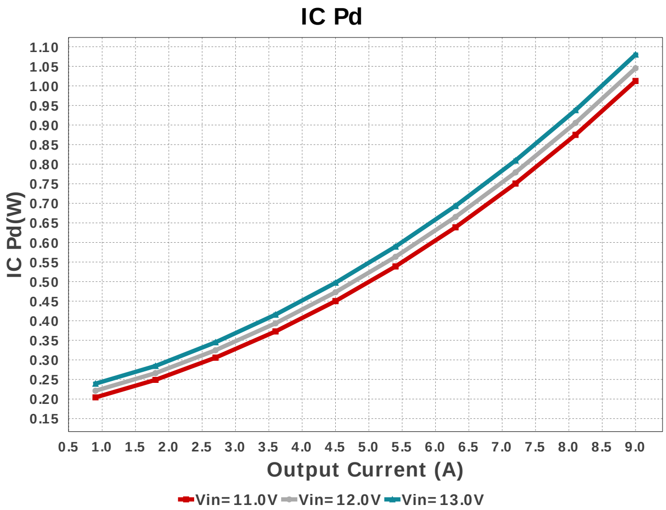

Overshoot Value
Overshoot Value(V)
0.450
0.425
0.400
0.375
0.350
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0
Output Current (A)
Vin=11.0V
Vin=12.0V
Vin=13.0V

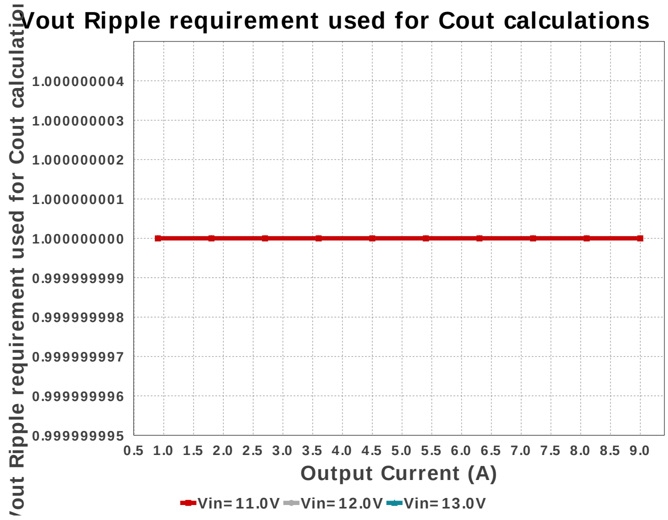

Iin Avg
Iin Avg(A)
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0
Output Current (A)
Vin=11.0V
Vin=12.0V
Vin=13.0V

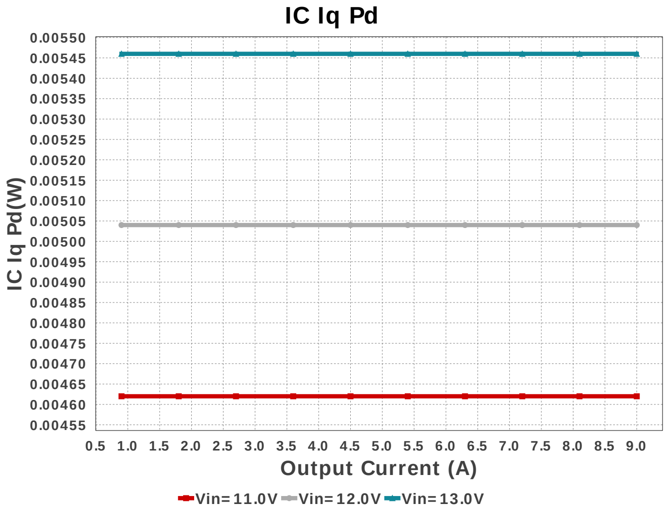

Total Pd
Total Pd(W)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0
Output Current (A)
Vin=11.0V
Vin=12.0V
Vin=13.0V

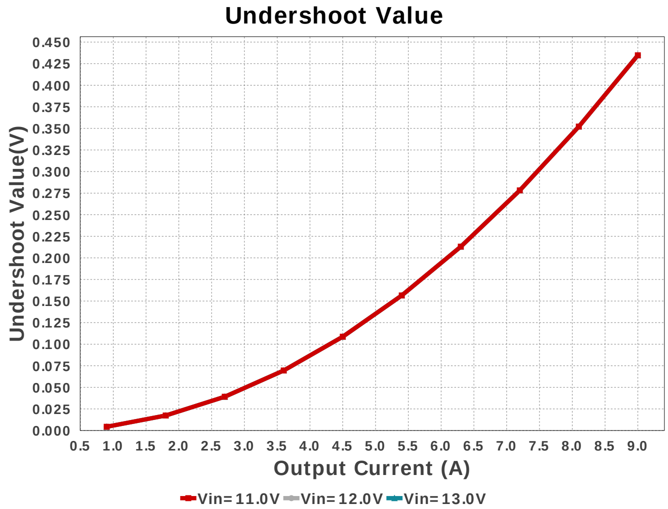

Cout IRMS
Cout IRMS(A)
0.725
0.720
0.715
0.710
0.705
0.700
0.695
0.690
0.685
0.680
0.675
0.670
0.665
0.660
0.655
0.650
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0
Output Current (A)
Vin=11.0V
Vin=12.0V
Vin=13.0V


L Ipp
L Ipp(A)
2.500
2.475
2.450
2.425
2.400
2.375
2.350
2.325
2.300
2.275
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0
Output Current (A)
Vin=11.0V
Vin=12.0V
Vin=13.0V









Operating Values

#	Name	Value	Category	Description
1.	BOM Count	20		Total Design BOM count
2.	Total BOM	NA		Total BOM Cost
3.	Cin IRMS	4.125 A	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	18.967 mW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	724.918 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	262.75 µW	Capacitor	Output capacitor power dissipation
7.	IC Ipk	10.256 A	IC	Peak switch current in IC
8.	IC Iq Pd	5.46 mW	IC	IC Iq Pd
9.	IC Pd	1.08 W	IC	IC power dissipation
10.	IC Tj	59.374 degC	IC	IC junction temperature
11.	ICThetaJA	27.2 degC/W	IC	IC junction-to-ambient thermal resistance
12.	Iin Avg	2.76 A	IC	Average input current
13.	L Ipp	2.511 A	Inductor	Peak-to-peak inductor ripple current
14.	L Pd	577.12 mW	Inductor	Inductor power dissipation
15.	Cin Pd	18.967 mW	Power	Input capacitor power dissipation
16.	Cout Pd	262.75 µW	Power	Output capacitor power dissipation
17.	IC Pd	1.08 W	Power	IC power dissipation
18.	L Pd	577.12 mW	Power	Inductor power dissipation
19.	Total Pd	1.676 W	Power	Total Power Dissipation
20.	Duty Cycle	30.025 %	System Information	Duty cycle
21.	Efficiency	95.328 %	System Information	Steady state efficiency
22.	FootPrint	232.0 mm^2	System Information	Total Foot Print Area of BOM components
23.	Frequency	500.0 kHz	System Information	Switching frequency
24.	Iout	9.0 A	System Information	Iout operating point
25.	Iout transient step used for Cout calculations	4.5 A	System Information	Custom Transient current step requirement that was used for Cout selection (A).

#	Name	Value	Category	Description
26.	Load overcurrent Iocp (typical)	11.7 A	System Information	Over current protection threshold
27.	Mode	CCM	System Information	Conduction Mode
28.	Overshoot Value	433.916 mV	System Information	Theoretical Vout Overshoot Value
29.	Pout	34.2 W	System Information	Total output power
30.	Undershoot Value	434.706 mV	System Information	Theoretical Vout Undershoot Value
31.	Vin	13.0 V	System Information	Vin operating point
32.	Vin Ripple requirement used for Cin calculations	5.0 %	System Information	Custom maximum input ripple requirement that was used for Cin selection(% of Minimum Vin).
33.	Vin p-p	533.401 mV	System Information	Peak-to-peak input voltage
34.	Vout	3.8 V	System Information	Operational Output Voltage
35.	Vout Actual	3.737 V	System Information	Vout Actual calculated based on selected voltage divider resistors
36.	Vout Ripple requirement used for Cout calculations	1.0 %	System Information	Custom maximum output ripple requirement that was used for Cout selection(% of Vout).
37.	Vout Tolerance	1.776 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
38.	Vout p-p	46.489 mV	System Information	Peak-to-peak output ripple voltage
39.	Vout transient requirement used for Cout calculations	5.0 %	System Information	Custom Transient voltage change requirement that was used for Cout selection (% of Vout).

Design Inputs

Name	Value	Description
Iout	9.0	Maximum Output Current
VinMax	13.0	Maximum input voltage
VinMin	11.0	Minimum input voltage
Vout	3.8	Output Voltage
base_pn	TPS53319	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

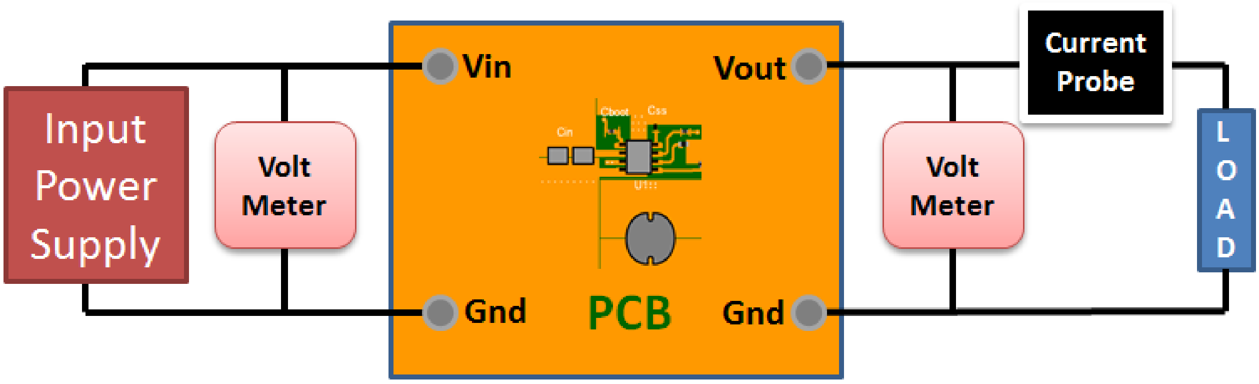
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 11.0V 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.

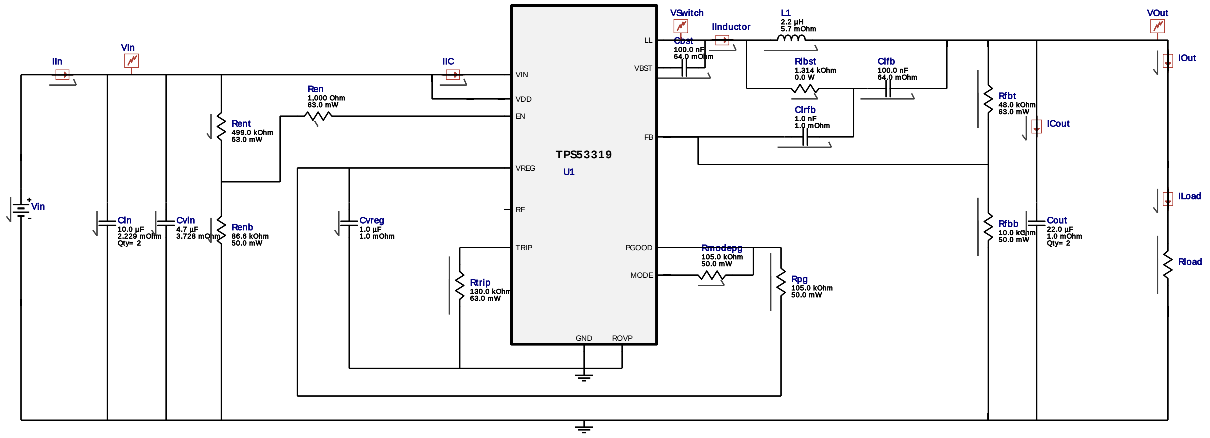


WEBENCH® Electrical Simulation Report

Design Id = 10083

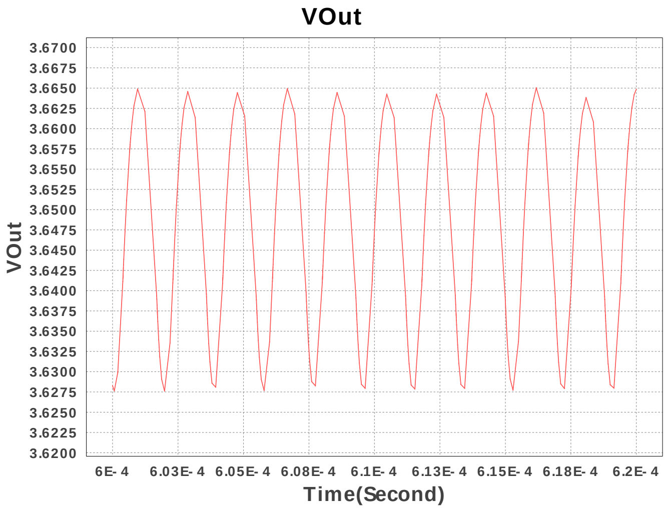
sim_id = 1

Simulation Type = Steady State



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Rload	R	Load Resistance	0.4222222222222222 ohm



Design Assistance

1. Master key : 9323268074580801[v1]

2. **TPS53319** Product Folder : http://www.ti.com/product/TPS53319 : contains the data sheet and other resources.