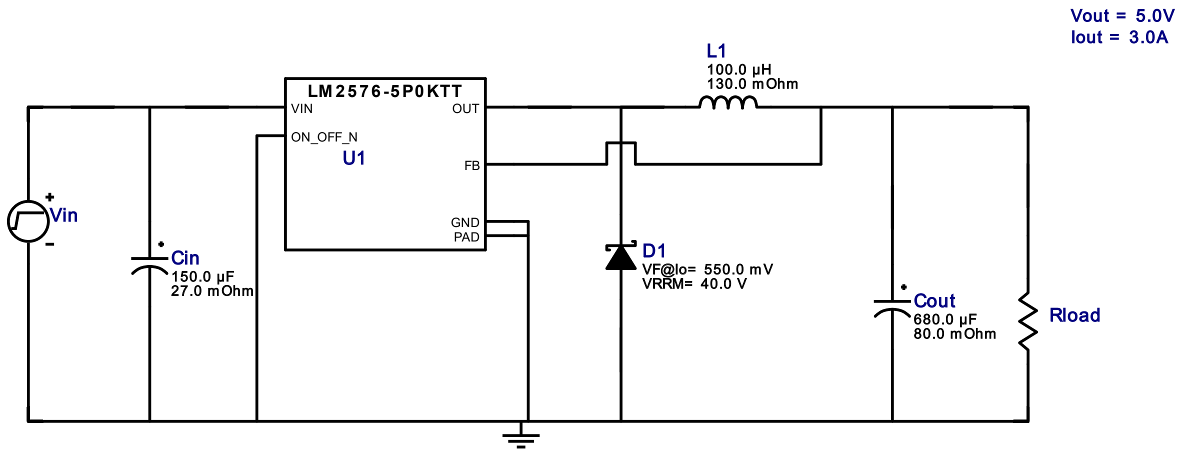
Texas Instruments

WEBENCH® Design Report

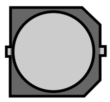
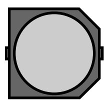
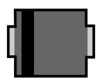
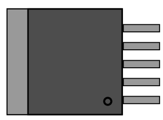
VinMin = 23.5V
VinMax = 24.5V
Vout = 5.0V
Iout = 3.0A

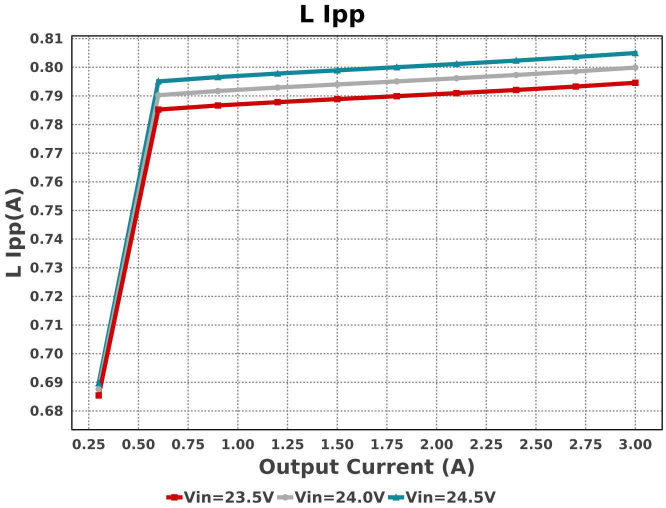
Device = LM2576SX-5.0/NOPB
Topology = Buck
Created = 2025-02-22 13:43:41.448
BOM Cost = NA
BOM Count = 5
Total Pd = 3.32W

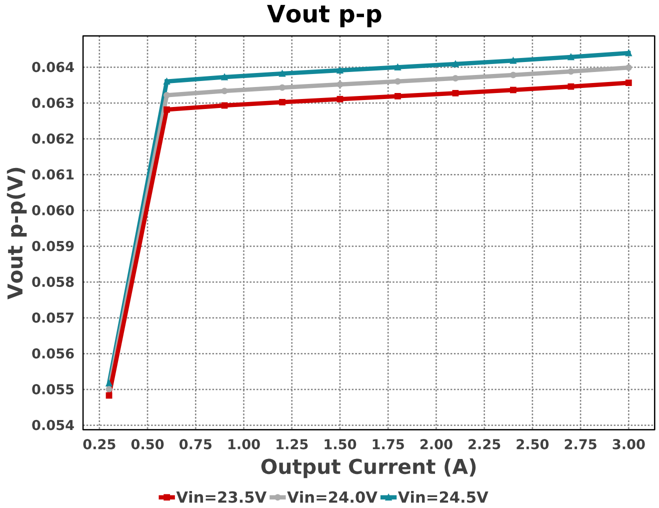
Design : 16 LM2576SX-5.0/NOPB
LM2576SX-5.0/NOPB 23.5V-24.5V to 5.00V @ 3A

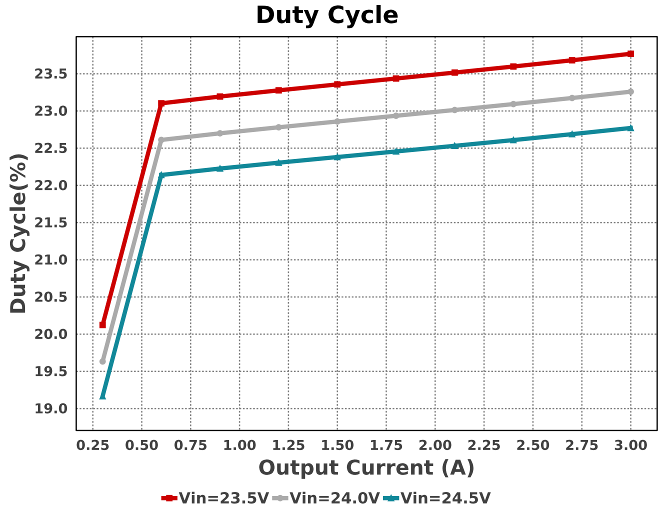


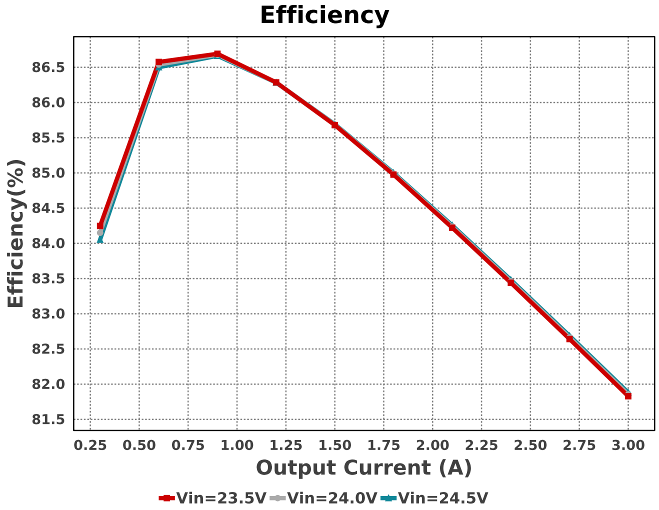
Electrical BOM

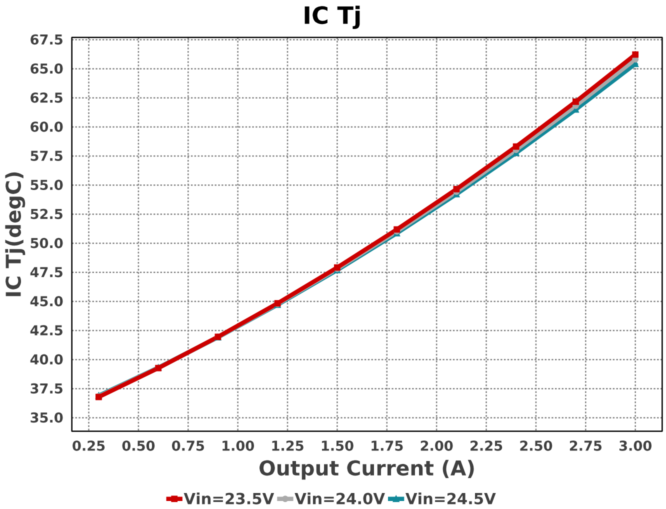
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cin	Panasonic	EEHZA1V151P Series= ZA	Cap= 150.0 uF ESR= 27.0 mOhm VDC= 35.0 V IRMS= 2.3 A	1	$1.15	 SM_RADIAL_8MM 113 mm²
Cout	CUSTOM	CUSTOM Series= MZA	Cap= 680.0 uF ESR= 80.0 mOhm VDC= 10.0 V IRMS= 600.0 mA	1	NA	 CAPSMT_62_HA0 0 mm²
D1	Diodes Inc.	B540C-13-F	VF@Io= 550.0 mV VRRM= 40.0 V	1	$0.19	 SMC 83 mm²
L1	CUSTOM	CUSTOM	L= 100.0 µH 130.0 mOhm	1	NA	CUSTOM 0 mm²
U1	Texas Instruments	LM2576SX-5.0/NOPB	Switcher	1	$1.47	 KTT0005B 198 mm²

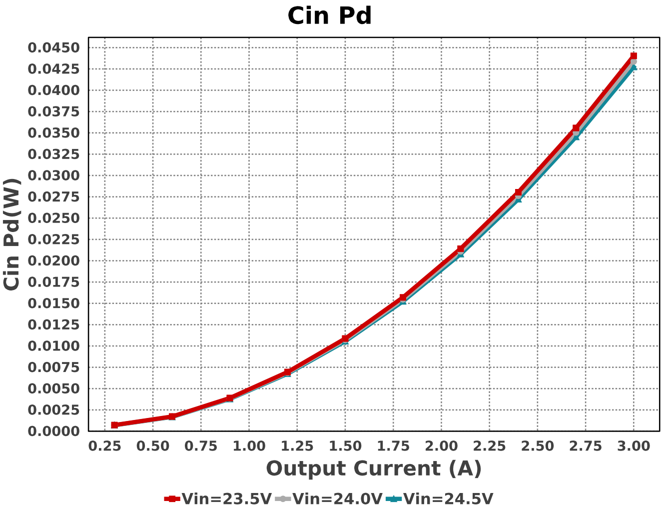

L Ipp
L Ipp(A)
0.81
0.80
0.79
0.78
0.77
0.76
0.75
0.74
0.73
0.72
0.71
0.70
0.69
0.68
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=23.5V Vin=24.0V Vin=24.5V

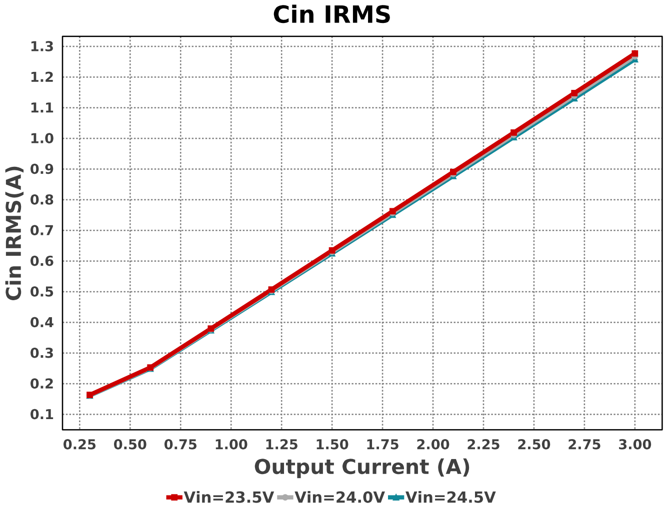

Vout p-p
Vout p-p(V)
0.064
0.063
0.062
0.061
0.060
0.059
0.058
0.057
0.056
0.055
0.054
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=23.5V Vin=24.0V Vin=24.5V

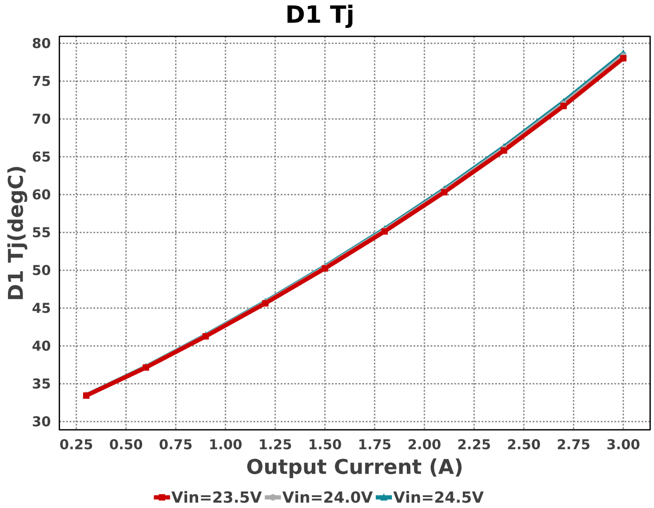

Duty Cycle
Duty Cycle(%)
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=23.5V Vin=24.0V Vin=24.5V

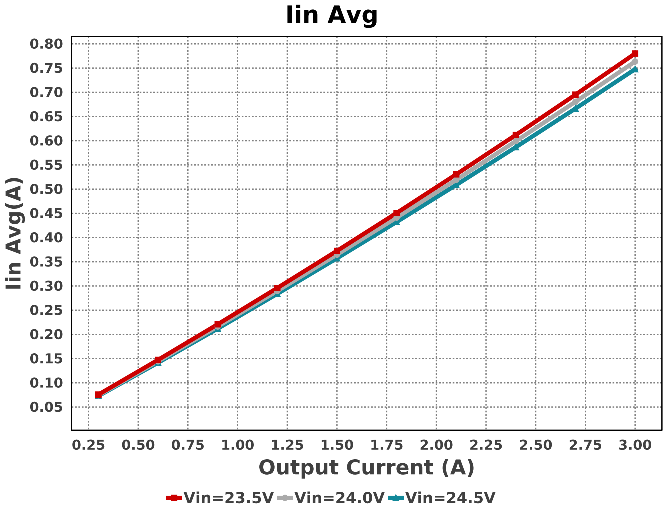

Efficiency
Efficiency(%)
86.5
86.0
85.5
85.0
84.5
84.0
83.5
83.0
82.5
82.0
81.5
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=23.5V Vin=24.0V Vin=24.5V

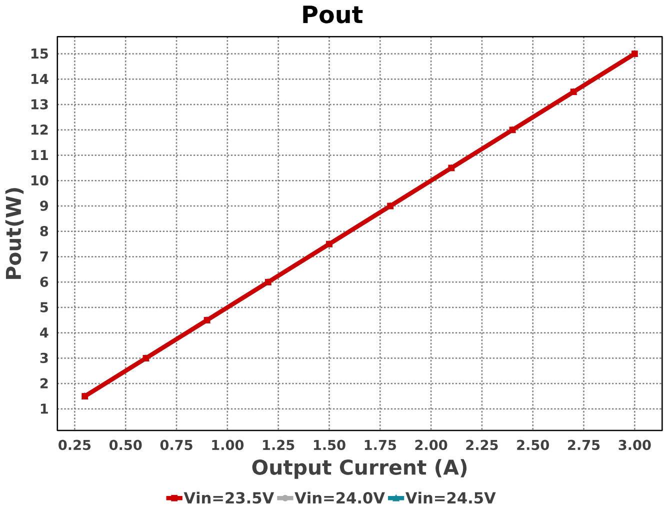

IC Tj
IC Tj(degC)
67.5
65.0
62.5
60.0
57.5
55.0
52.5
50.0
47.5
45.0
42.5
40.0
37.5
35.0
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=23.5V Vin=24.0V Vin=24.5V

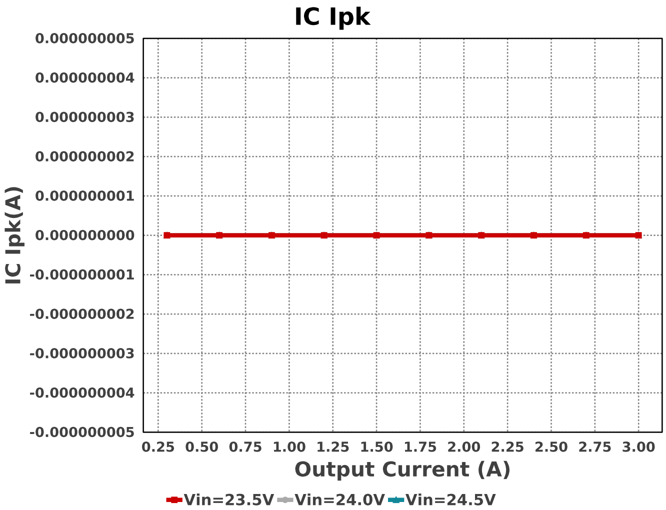

Cin Pd
Cin Pd(W)
0.0450
0.0425
0.0400
0.0375
0.0350
0.0325
0.0300
0.0275
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=23.5V Vin=24.0V Vin=24.5V

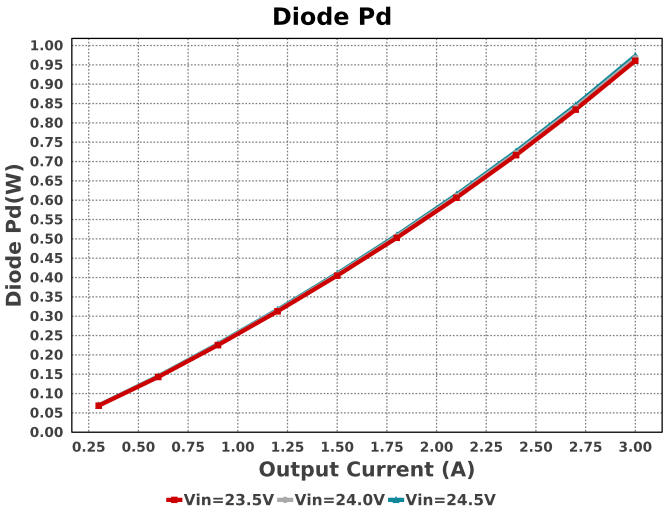

Cin IRMS
Cin IRMS(A)
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=23.5V Vin=24.0V Vin=24.5V

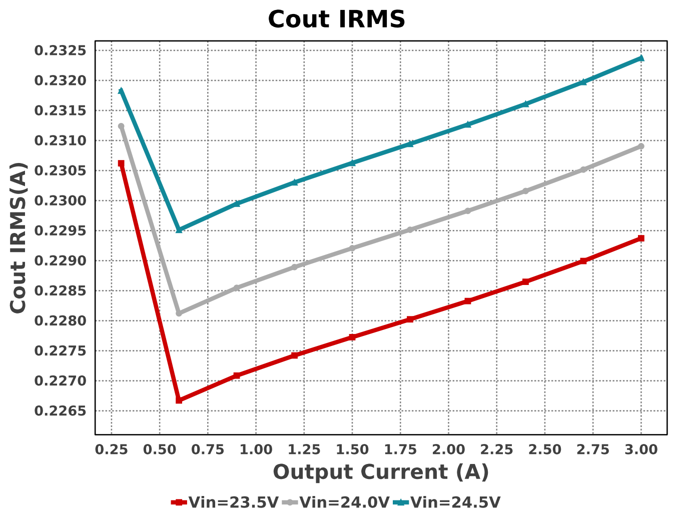

D1 Tj
D1 Tj(degC)
80
75
70
65
60
55
50
45
40
35
30
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=23.5V Vin=24.0V Vin=24.5V

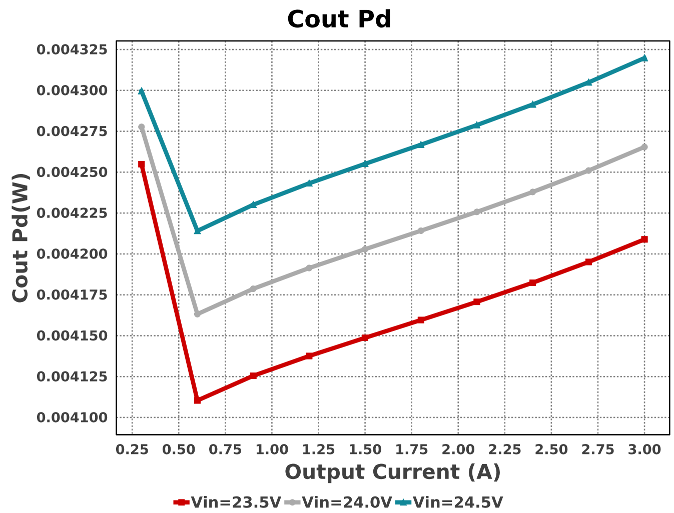

Iin Avg
Iin Avg(A)
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=23.5V Vin=24.0V Vin=24.5V

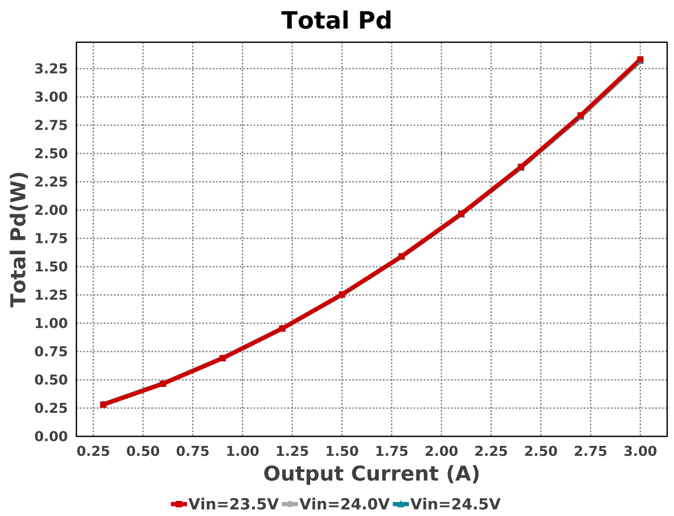

Pout
Pout(W)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=23.5V Vin=24.0V Vin=24.5V

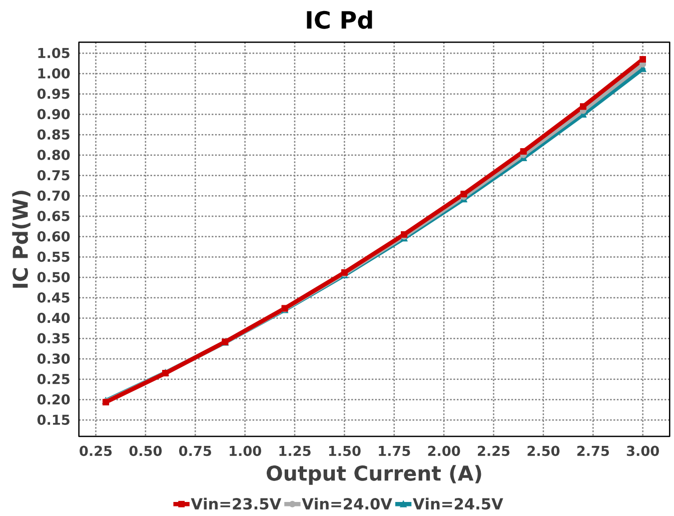

IC Ipk
IC Ipk(A)
0.000000005
0.000000004
0.000000003
0.000000002
0.000000001
0.000000000
-0.000000001
-0.000000002
-0.000000003
-0.000000004
-0.000000005
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=23.5V Vin=24.0V Vin=24.5V

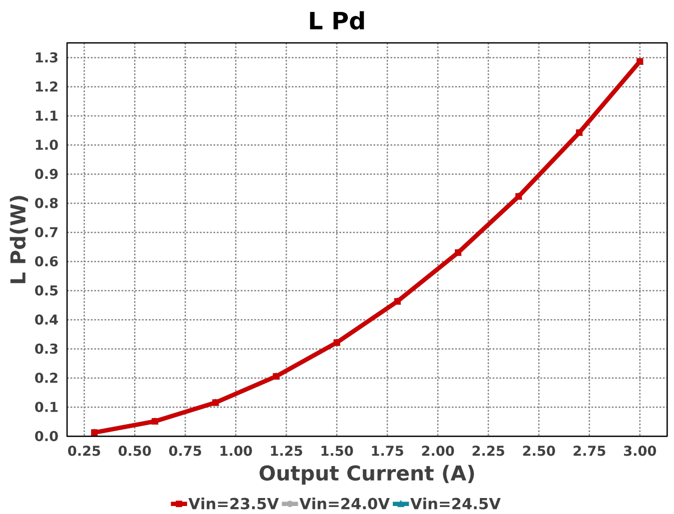

Diode Pd
Diode Pd(W)
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
Output Current (A)
Vin=23.5V Vin=24.0V Vin=24.5V











Operating Values

#	Name	Value	Category	Description
1.	BOM Count	5		Total Design BOM count
2.	Total BOM	NA		Total BOM Cost
3.	Cin IRMS	1.258 A	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	42.734 mW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	232.373 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	4.32 mW	Capacitor	Output capacitor power dissipation
7.	D1 Tj	78.658 degC	Diode	D1 junction temperature
8.	Diode Pd	973.17 mW	Diode	Diode power dissipation
9.	IC Ipk	0.0 A	IC	Peak switch current in IC
10.	IC Pd	1.012 W	IC	IC power dissipation
11.	IC Tj	65.424 degC	IC	IC junction temperature

#	Name	Value	Category	Description
12.	IC Tolerance	13.0 mV	IC	IC Feedback Tolerance
13.	ICThetaJA	35.0 degC/W	IC	IC junction-to-ambient thermal resistance
14.	Iin Avg	747.73 mA	IC	Average input current
15.	L Ipp	804.965 mA	Inductor	Peak-to-peak inductor ripple current
16.	L Pd	1.287 W	Inductor	Inductor power dissipation
17.	Cin Pd	42.734 mW	Power	Input capacitor power dissipation
18.	Cout Pd	4.32 mW	Power	Output capacitor power dissipation
19.	Diode Pd	973.17 mW	Power	Diode power dissipation
20.	IC Pd	1.012 W	Power	IC power dissipation
21.	L Pd	1.287 W	Power	Inductor power dissipation
22.	Total Pd	3.319 W	Power	Total Power Dissipation
23.	Duty Cycle	22.771 %	System Information	Duty cycle
24.	Efficiency	81.881 %	System Information	Steady state efficiency
25.	FootPrint	676.0 mm^2	System Information	Total Foot Print Area of BOM components
26.	Frequency	52.0 kHz	System Information	Switching frequency
27.	Iout	3.0 A	System Information	Iout operating point
28.	Mode	CCM	System Information	Conduction Mode
29.	Pout	15.0 W	System Information	Total output power
30.	Vin	24.5 V	System Information	Vin operating point
31.	Vout	5.0 V	System Information	Operational Output Voltage
32.	Vout Tolerance	260.0 m%	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
33.	Vout p-p	64.397 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	3.0	Maximum Output Current
VinMax	24.5	Maximum input voltage
VinMin	23.5	Minimum input voltage
Vout	5.0	Output Voltage
base_pn	LM2576	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

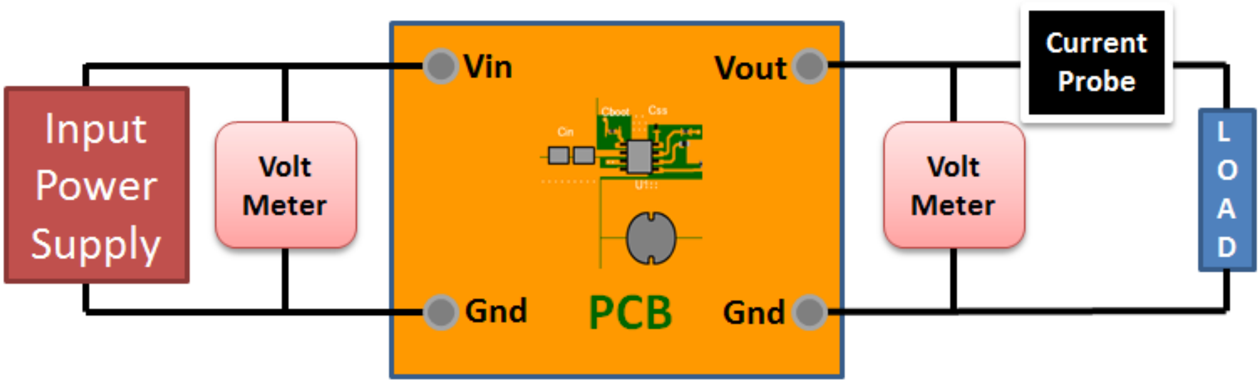
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 23.5V 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.

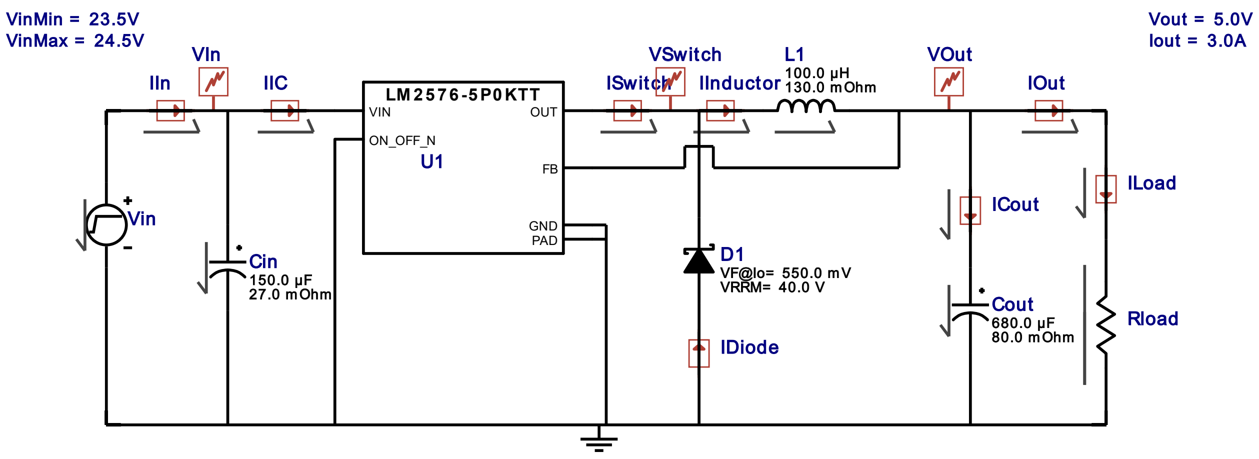


WEBENCH® Electrical Simulation Report

Design Id = 16

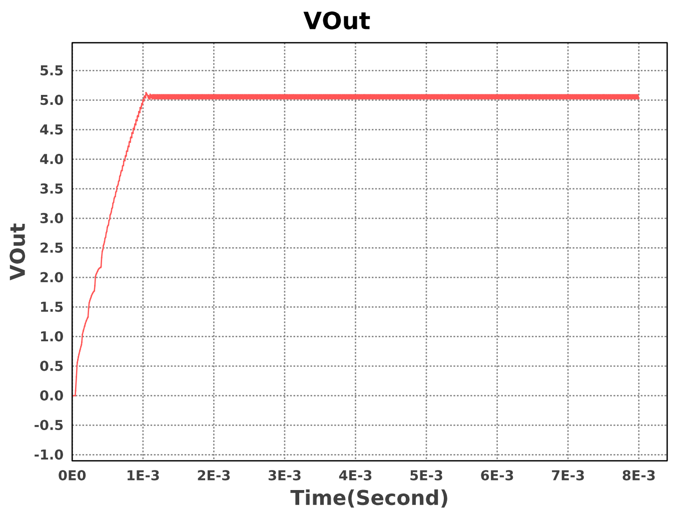
sim_id = 9

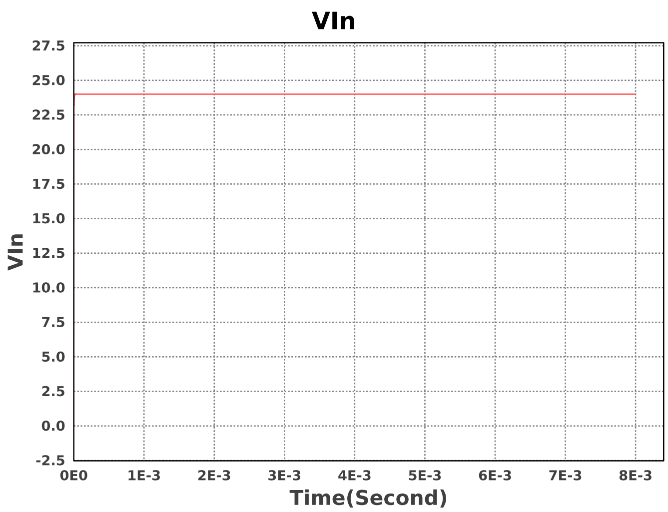
Simulation Type = Startup



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Rload	R	Load Resistance	1.6666666666666667 Ohm

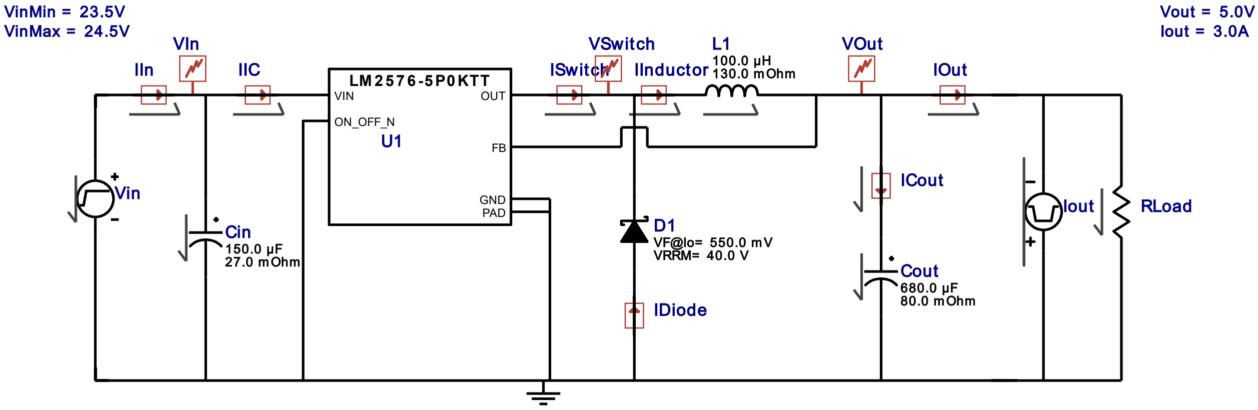




Design Id = 16

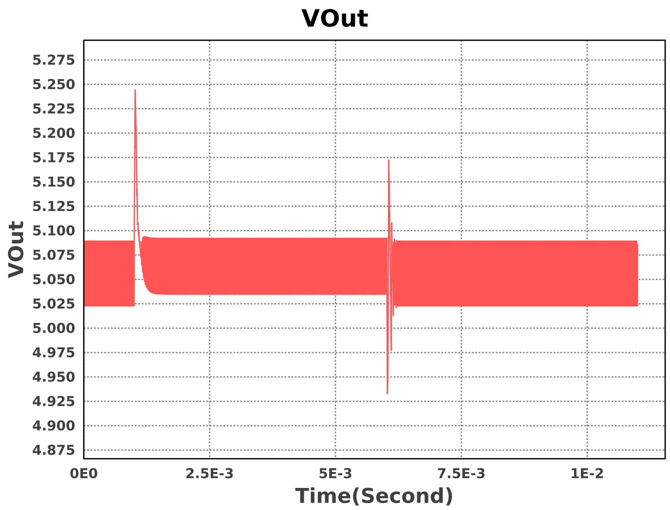
sim_id = 10

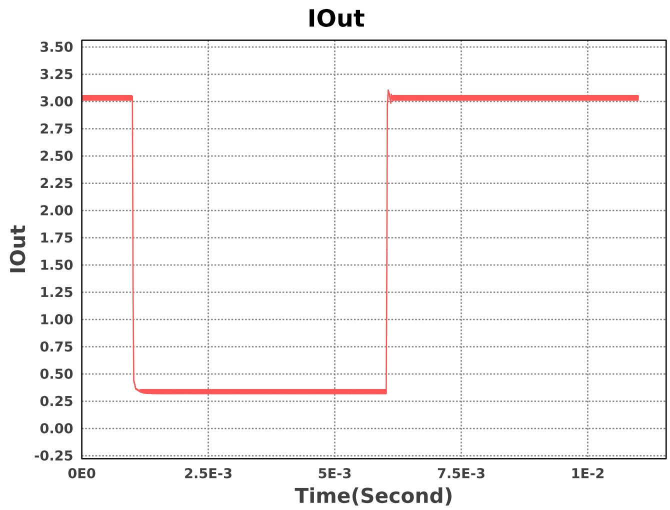
Simulation Type = Load Transient



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Iout	signal_type	Signal Type	PULSE
		I1	Initial Load Current	0 A
		I2	Minimum Load Current	2.7 A
		Td	Initial Time Delay	1E-3 s
		Tf	Fall Time	20u s
		Tr	Rise Time	20u s
		Pw	Pulse Width	5E-3 s
2.	RLoad	R	Load Resistance	1.6666666666666667 Ohm

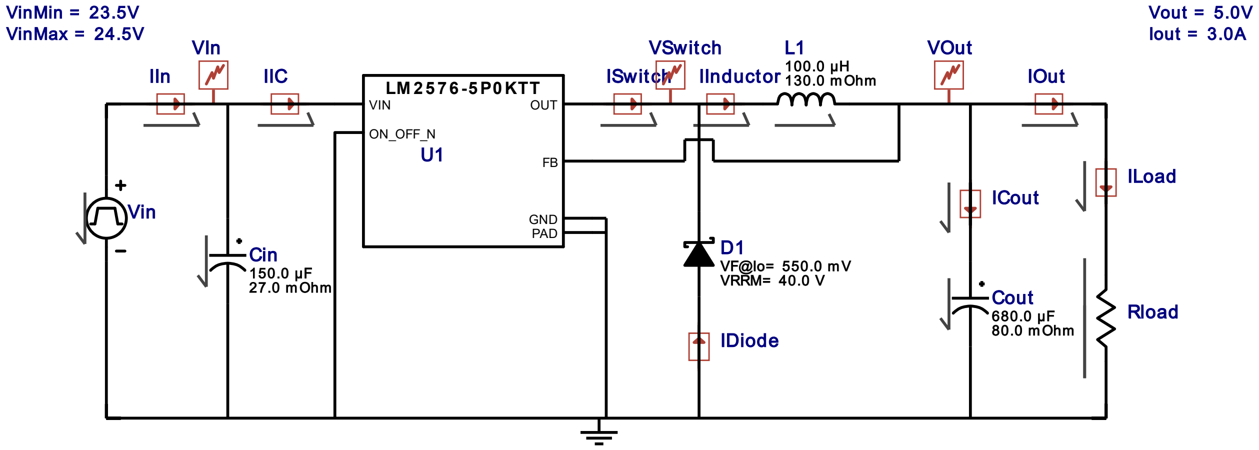




Design Id = 16

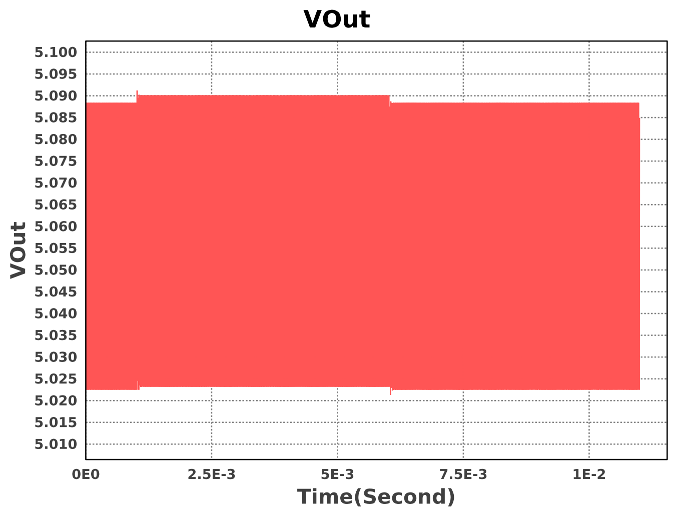
sim_id = 11

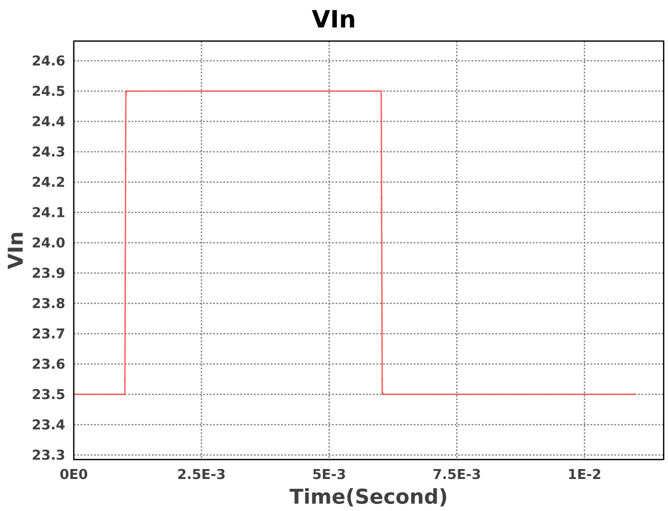
Simulation Type = Input Transient



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Rload	R	Load resistance	1.6666666666666667

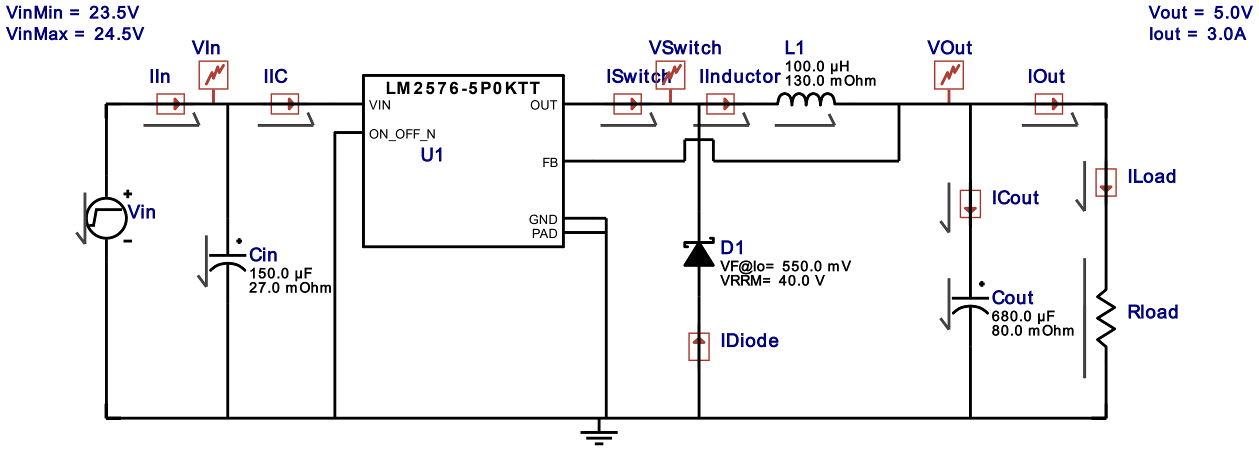




Design Id = 16

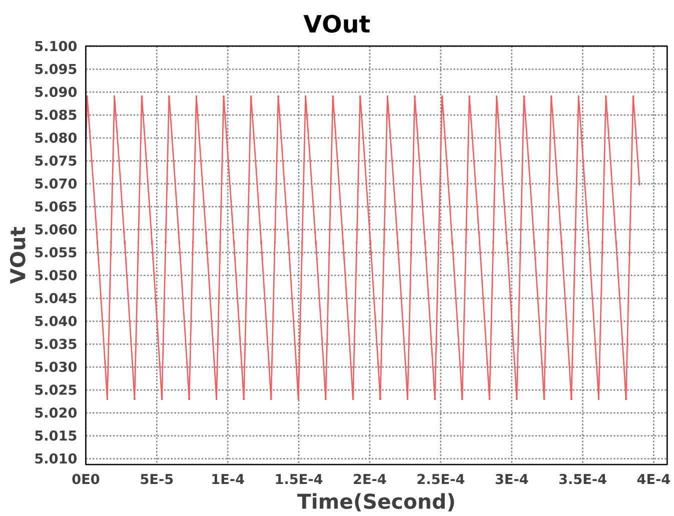
sim_id = 12

Simulation Type = Steady State



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Rload	R	Load Resistance	1.6666666666666667 ohm



Design Assistance

1. Master key : 45076AF7C8794EC6F4699B15A6C86FD7[v1]
2. **LM2576** Product Folder : http://www.ti.com/product/LM2576 : contains the data sheet and other resources.

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