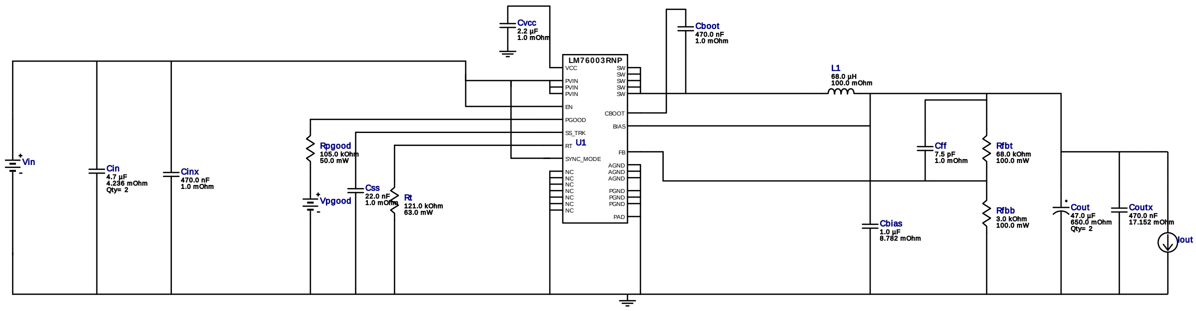
VinMin = 26.0V
VinMax = 55.0V
Vout = 24.0V
Iout = 1.5A

Device = LM76003RNPR
Topology = Buck
Created = 2021-04-07 01:05:53.798
BOM Cost = $4.09
BOM Count = 17
Total Pd = 1.2W

WEBENCH ® Design Report

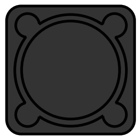
Design : 4 LM76003RNPR
LM76003RNPR 3. Optimierung 68uH 26V-55V to 24.00V @ 1.5A

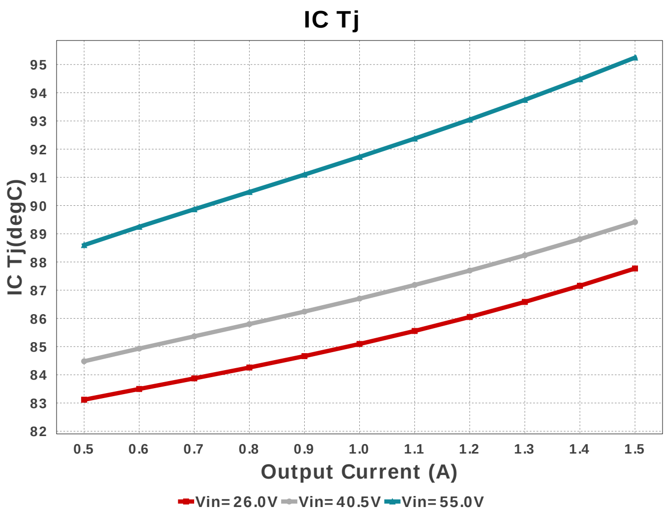


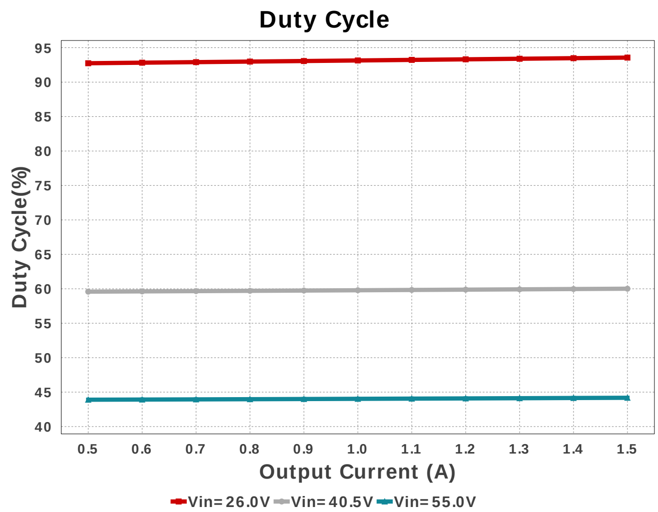
1. The input capacitor included in the BOM only contains a small filter capacitor that should be placed near the IC. Depending on where the power supply is laid out in the system additional bulk capacitance may need to be added to filter the line ripple.

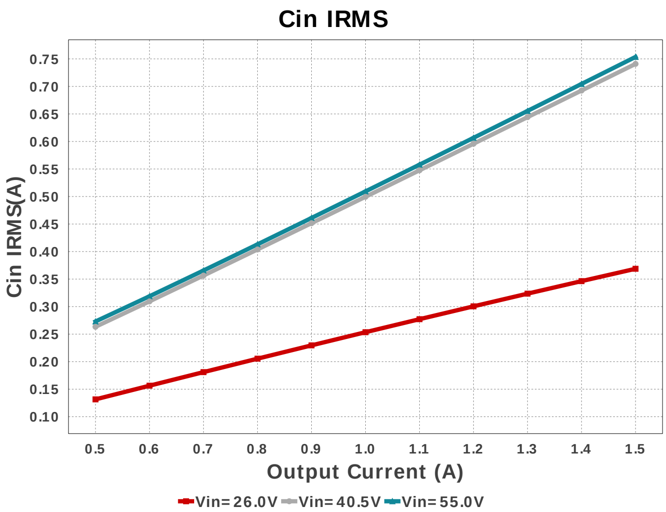
Electrical BOM

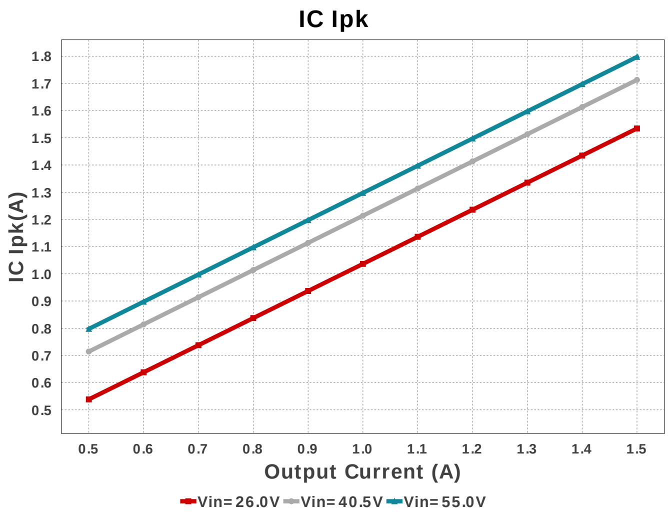
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbias	TDK	C2012X7R1H105K125AB Series= X7R	Cap= 1.0 uF ESR= 8.782 mOhm VDC= 50.0 V IRMS= 2.2049 A	1	$0.08	0805 7 mm^2
Cboot	MuRata	GRM155R60J474KE19D Series= X5R	Cap= 470.0 nF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 0.0 A	1	$0.02	0402 3 mm^2
Cff	MuRata	GRM1555C1H7R5CA01D Series= C0G/NP0	Cap= 7.5 pF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cin	TDK	CGA6M3X7S2A475K200AB Series= X7S	Cap= 4.7 uF ESR= 4.236 mOhm VDC= 100.0 V IRMS= 3.57337 A	2	$0.47	1210_220 15 mm^2
Cinx	MuRata	GRM21BR72A474KA73L Series= X7R	Cap= 470.0 nF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 0.0 A	1	$0.16	0805 7 mm^2
Cout	Panasonic	EEE-FK1J470P Series= FK	Cap= 47.0 uF ESR= 650.0 mOhm VDC= 63.0 V IRMS= 250.0 mA	2	$0.21	SM_RADIAL_F 124 mm^2
Coutx	TDK	C2012X7S2A474K125AB Series= X7S	Cap= 470.0 nF ESR= 17.152 mOhm VDC= 100.0 V IRMS= 1.58068 A	1	$0.11	0805 7 mm^2
Css	MuRata	GRM033R60J223KE01D Series= X5R	Cap= 22.0 nF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 0.0 A	1	$0.01	0201 2 mm^2
Cvcc	Taiyo Yuden	EMK212BJ225KG-T Series= X5R	Cap= 2.2 uF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2

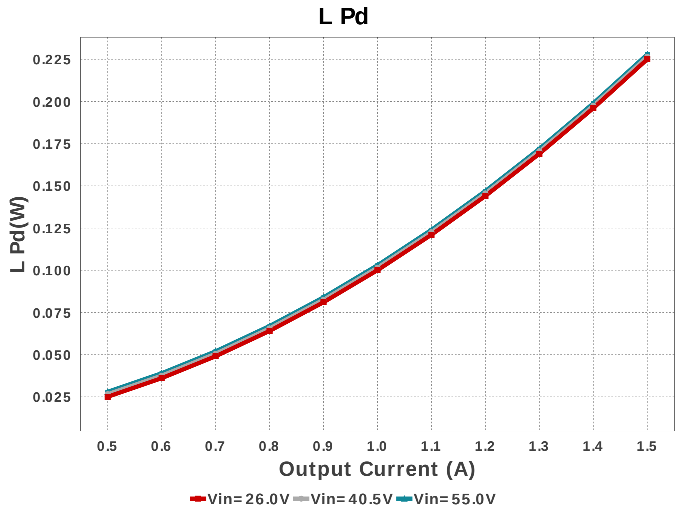
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
L1	Bourns	SRR1210-680M	L= 68.0 µH 100.0 mOhm	1	$0.53	 SRR1210 196 mm²
Rfbb	Yageo	RC0603FR-073KL Series= ?	Res= 3.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rfbt	Yageo	RC0603FR-0768KL Series= ?	Res= 68.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rpgood	Yageo	RC0201FR-07105KL Series= ?	Res= 105.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
Rt	Vishay-Dale	CRCW0402121KFKED Series= CRCW..e3	Res= 121.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
U1	Texas Instruments	LM76003RNPR	Switcher	1	$1.75	RNP0030B 48 mm²

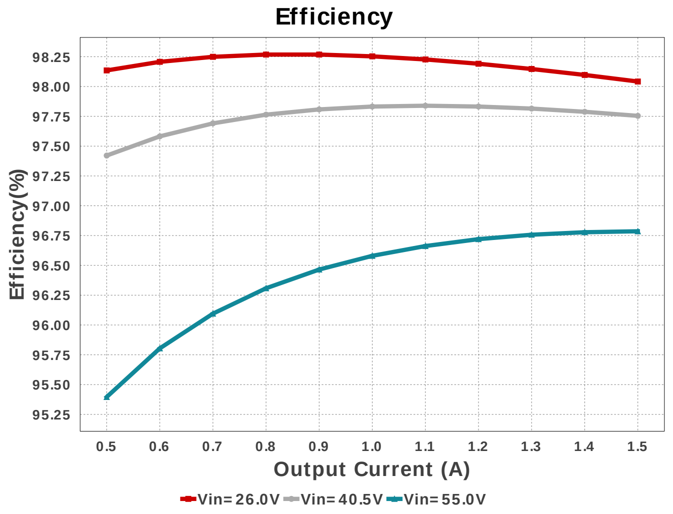


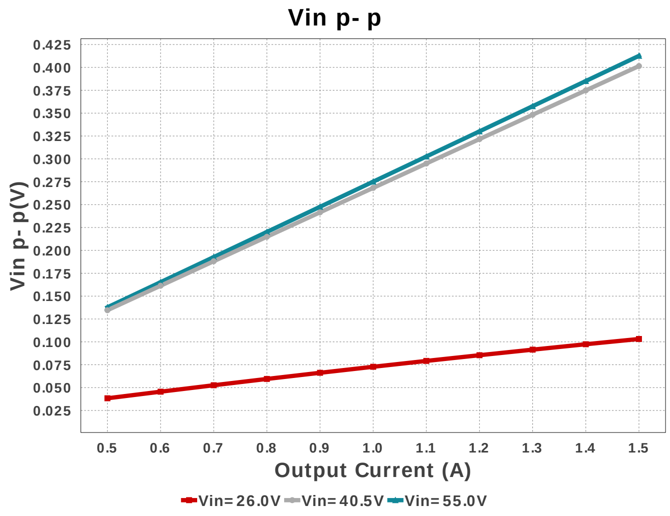


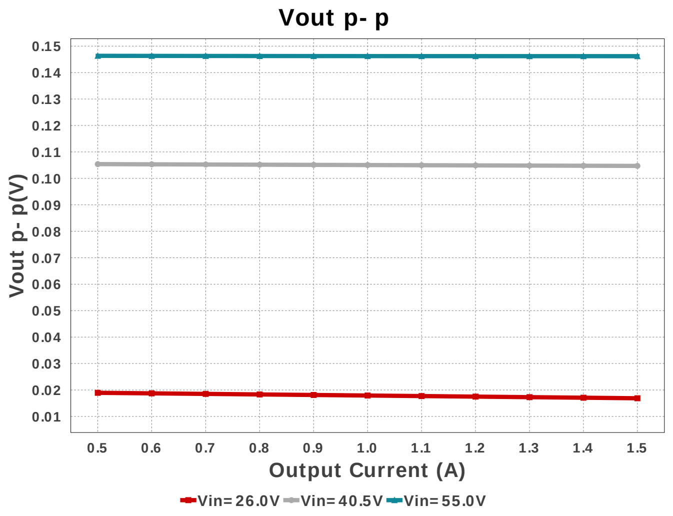


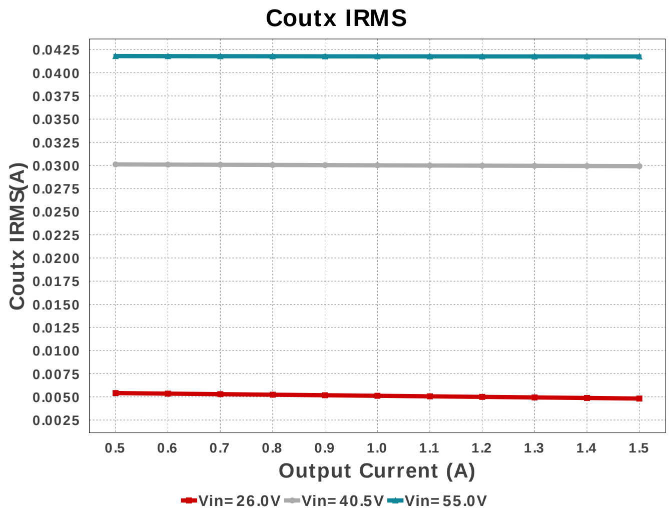


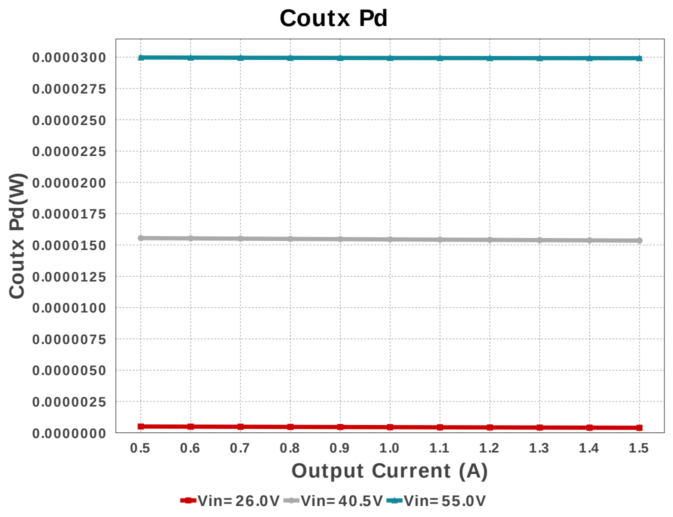

L Pd
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
L Pd(W)
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
Output Current (A)
Vin= 26.0V Vin= 40.5V Vin= 55.0V


Efficiency
98.25
98.00
97.75
97.50
97.25
97.00
96.75
96.50
96.25
96.00
95.75
95.50
95.25
Efficiency(%)
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
Output Current (A)
Vin= 26.0V Vin= 40.5V Vin= 55.0V

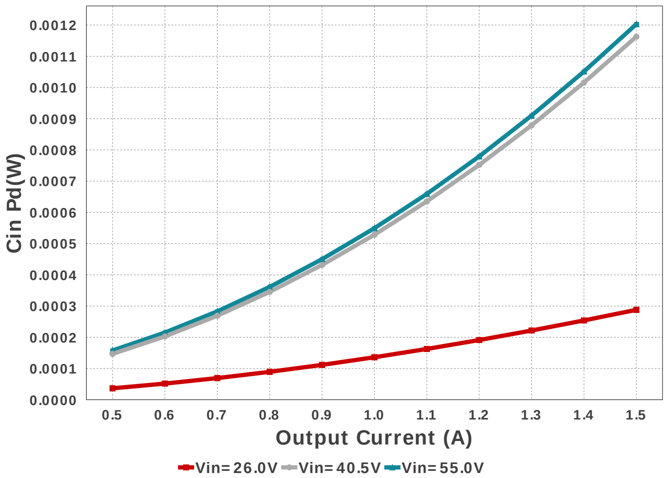

Vin p- p
0.425
0.400
0.375
0.350
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
Vin p- p(V)
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
Output Current (A)
Vin= 26.0V Vin= 40.5V Vin= 55.0V


Vout p- p
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
Vout p- p(V)
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
Output Current (A)
Vin= 26.0V Vin= 40.5V Vin= 55.0V

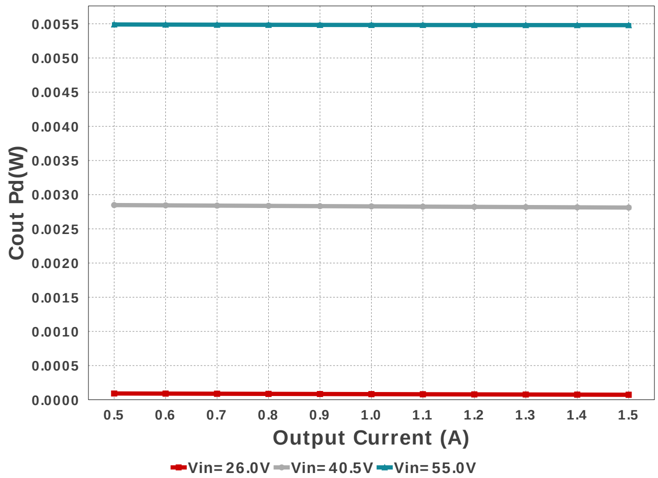

Coutx IRMS
0.0425
0.0400
0.0375
0.0350
0.0325
0.0300
0.0275
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
Coutx IRMS(A)
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
Output Current (A)
Vin= 26.0V Vin= 40.5V Vin= 55.0V


Coutx Pd
0.0000300
0.0000275
0.0000250
0.0000225
0.0000200
0.0000175
0.0000150
0.0000125
0.0000100
0.0000075
0.0000050
0.0000025
0.0000000
Coutx Pd(W)
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
Output Current (A)
Vin= 26.0V Vin= 40.5V Vin= 55.0V

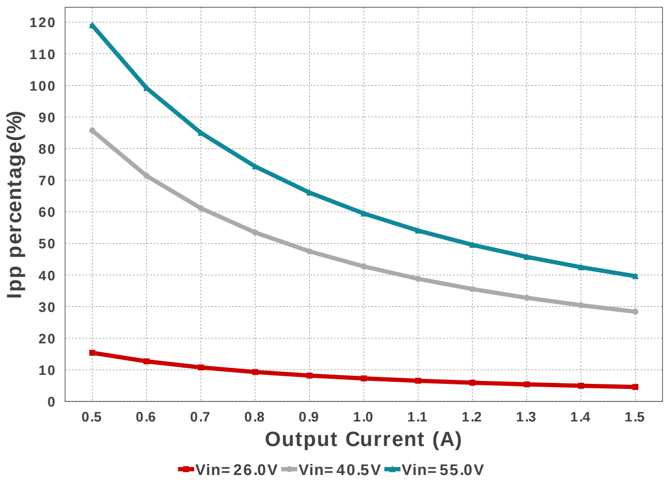
Cin Pd



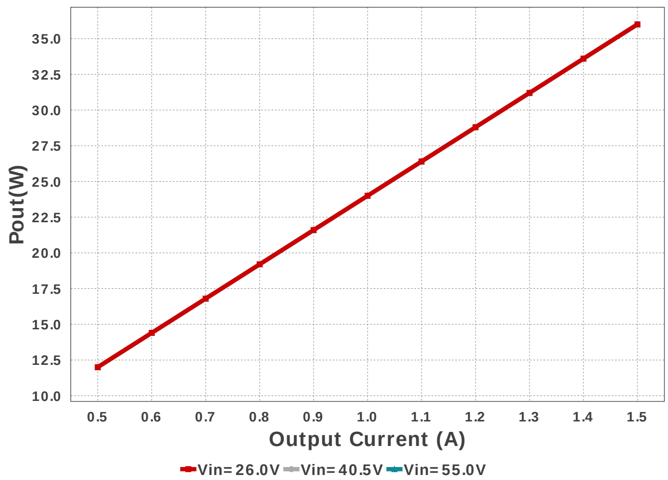
Cout Pd



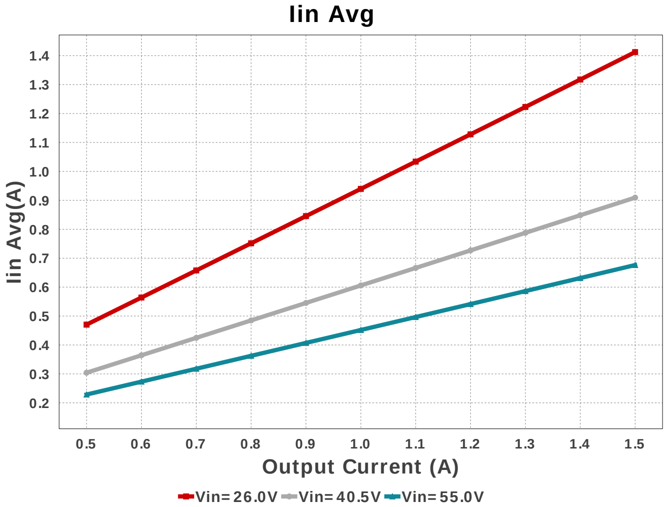
Ipp percentage



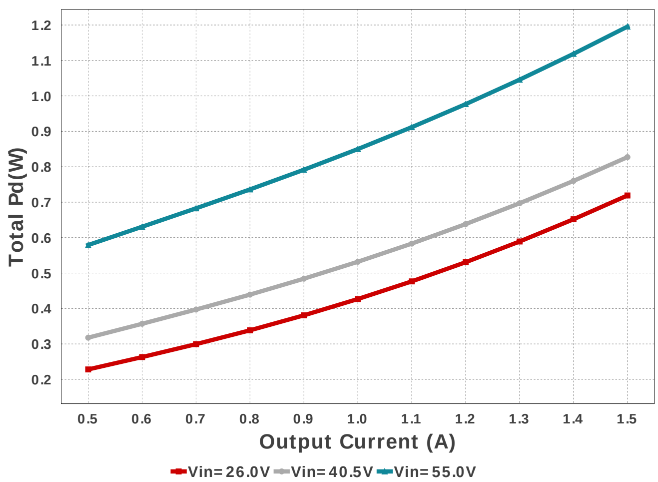
Pout

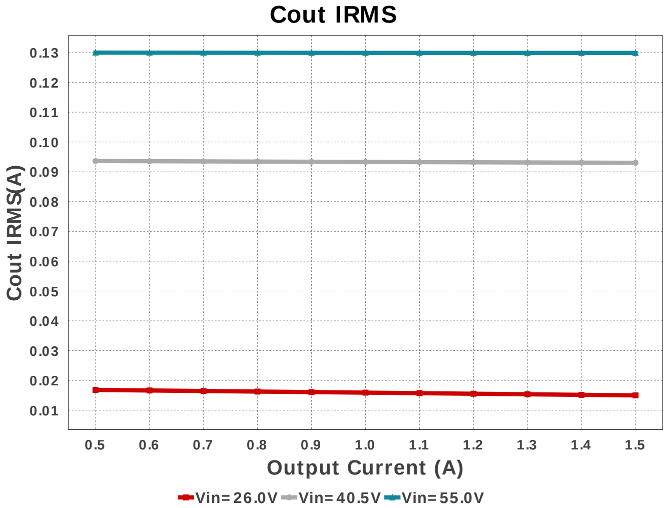


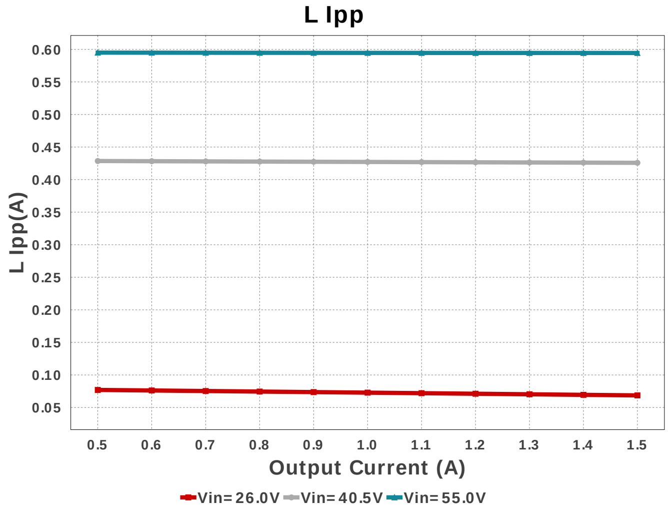
Iin Avg

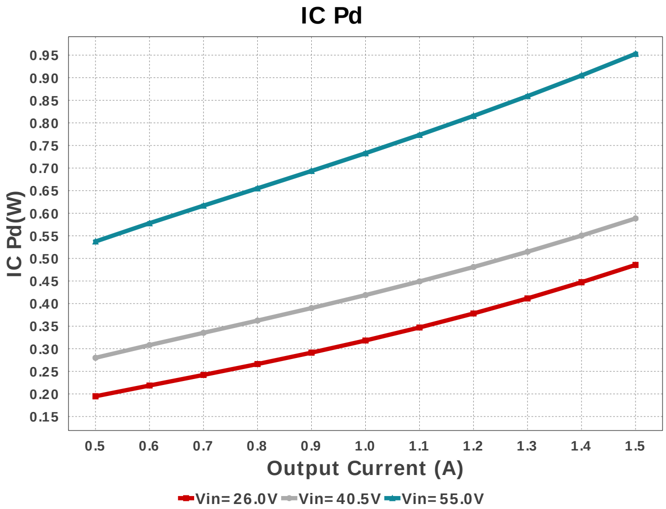


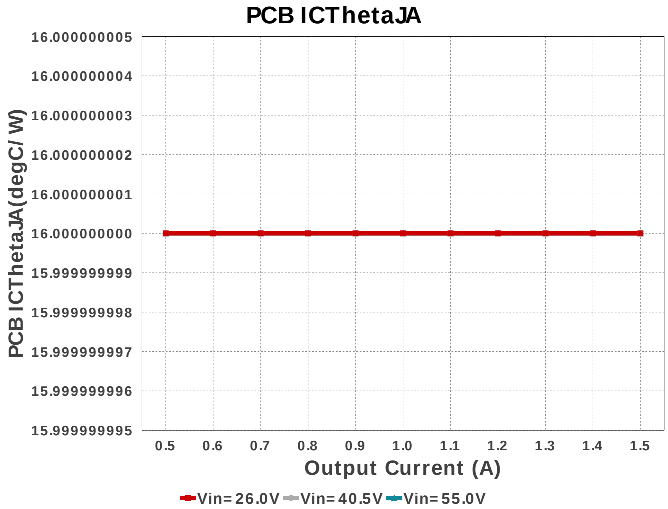
Total Pd

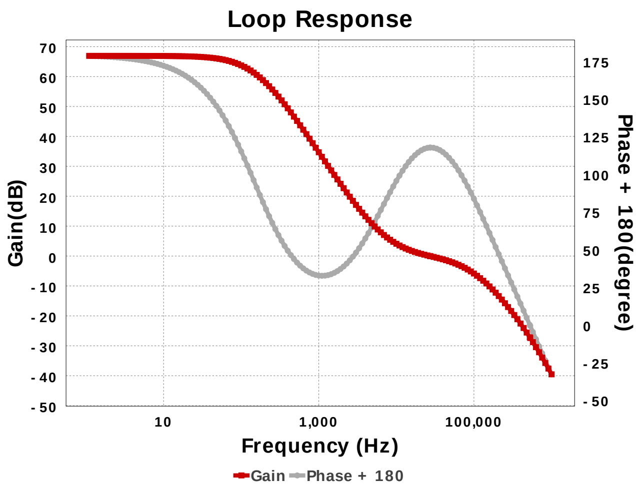












Operating Values

#	Name	Value	Category	Description
1.	BOM Count	17		Total Design BOM count
2.	Total BOM	$4.09		Total BOM Cost
3.	Cin IRMS	753.584 mA	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	1.203 mW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	129.857 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	5.48 mW	Capacitor	Output capacitor power dissipation
7.	Coutx IRMS	41.765 mA	Capacitor	Output capacitor_x RMS ripple current
8.	Coutx Pd	29.919 µW	Capacitor	Output capacitor_x power loss
9.	IC Ipk	1.797 A	IC	Peak switch current in IC
10.	IC Pd	952.86 mW	IC	IC power dissipation
11.	IC Tj	95.246 degC	IC	IC junction temperature

#	Name	Value	Category	Description
12.	IC Tolerance	19.0 mV	IC	IC Feedback Tolerance
13.	Iin Avg	676.28 mA	IC	Average input current
14.	Ipp percentage	39.635 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
15.	L Ipp	594.518 mA	Inductor	Peak-to-peak inductor ripple current
16.	L Pd	227.95 mW	Inductor	Inductor power dissipation
17.	Cin Pd	1.203 mW	Power	Input capacitor power dissipation
18.	Cout Pd	5.48 mW	Power	Output capacitor power dissipation
19.	Coutx Pd	29.919 µW	Power	Output capacitor_x power loss
20.	IC Pd	952.86 mW	Power	IC power dissipation
21.	L Pd	227.95 mW	Power	Inductor power dissipation
22.	Total Pd	1.195 W	Power	Total Power Dissipation
23.	Cross Freq	27.093 kHz	System Information	Bode plot crossover frequency
24.	Duty Cycle	44.179 %	System Information	Duty cycle
25.	Efficiency	96.786 %	System Information	Steady state efficiency
26.	FootPrint	570.0 mm^2	System Information	Total Foot Print Area of BOM components
27.	Frequency	335.12 kHz	System Information	Switching frequency
28.	Gain Marg	-27.405 dB	System Information	Bode Plot Gain Margin
29.	Iout	1.5 A	System Information	Iout operating point
30.	Low Freq Gain	66.919 dB	System Information	Gain at 1Hz
31.	Mode	CCM	System Information	Conduction Mode
32.	Phase Marg	118.334 deg	System Information	Bode Plot Phase Margin
33.	Pout	36.0 W	System Information	Total output power
34.	Vin	55.0 V	System Information	Vin operating point
35.	Vin p-p	412.635 mV	System Information	Peak-to-peak input voltage
36.	Vout	24.0 V	System Information	Operational Output Voltage
37.	Vout Actual	23.667 V	System Information	Vout Actual calculated based on selected voltage divider resistors
38.	Vout Tolerance	3.872 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
39.	Vout p-p	146.198 mV	System Information	Peak-to-peak output ripple voltage
40.	PCB ICThetaJA	16.0 degC/W		Effective PCB ThetaJA

Design Inputs

Name	Value	Description
Iout	1.5	Maximum Output Current
SoftStart	10.0 ms	Soft Start Time (ms)
VinMax	55.0	Maximum input voltage
VinMin	26.0	Minimum input voltage
Vout	24.0	Output Voltage
base_pn	LM76003	Base Product Number
source	DC	Input Source Type
Ta	80.0	Ambient temperature
UserFsw	335.0 k	Customer Selected Frequency

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

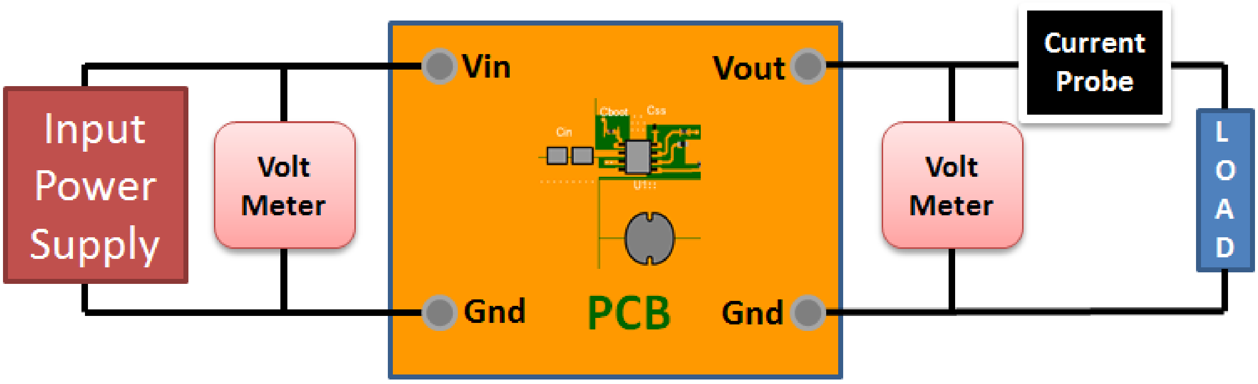
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 26.0V 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.

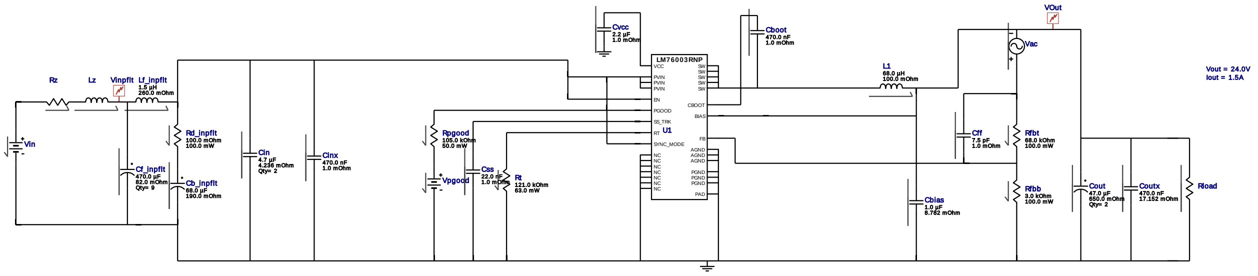


WEBENCH® Electrical Simulation Report

Design Id = 4

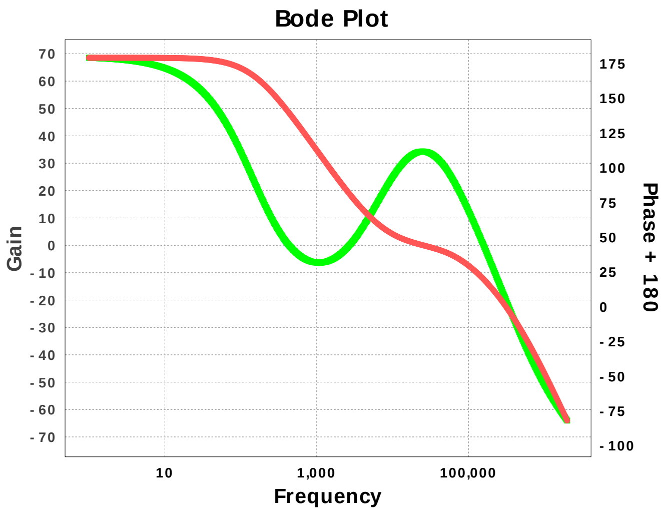
sim_id = 10

Simulation Type = Bode Plot



Simulation Parameters

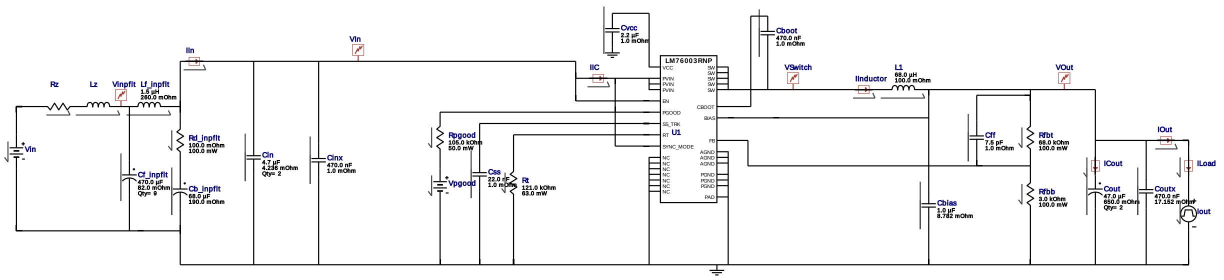
#	Name	Parameter Name	Description	Values
1.	Vpgood	V	Supply Voltage	5 V
2.	Cin	IC	Initial condition	40.5 V
3.	Cinx	IC	Initial condition	40.5 V
4.	Coutx	IC	Initial condition	24.0 V
5.	Cout	IC	Initial condition	24.0 V
6.	Cinj	C	Injection isolation capacitance	10000000 F
7.	Linj	L	Injection isolation inductance	10000000 H
8.	Vinj	AC	AC signal	1 V
9.	Rload	R	Load_Resistance	16.0 ohm
10.	Rz	R	no description	0.732 Ohm
11.	Lz	L	no description	1.0E-6 H



Design Id = 4

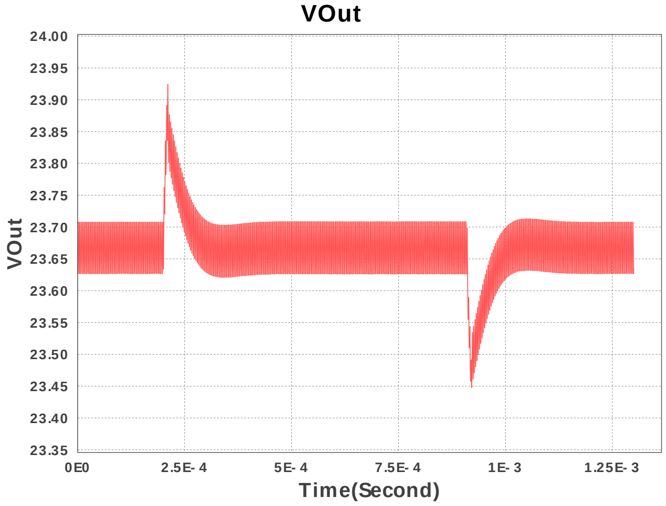
sim_id = 11

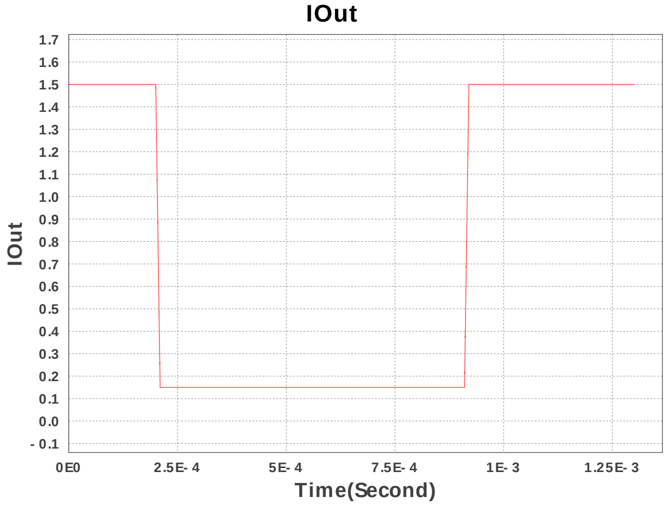
Simulation Type = Load Transient



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Vpgood	V	Supply Voltage	5 V
2.	L1	IC	Initial condition	-1.5 V
3.	Cboot	IC	Initial condition	10 V
4.	Iout	signal_type	Signal Type	PULSE
		I1	Initial Load Current	1.5 A
		I2	Minimum Load Current	0.15 A
		Td	Initial Time Delay	2.0E-4 s
		Tf	Fall Time	10u s
		Tr	Rise Time	10u s
		Pw	Pulse Width	7.0E-4 s
5.	Rz	R	no description	0.732 Ohm
6.	Lz	L	no description	1.0E-6 H

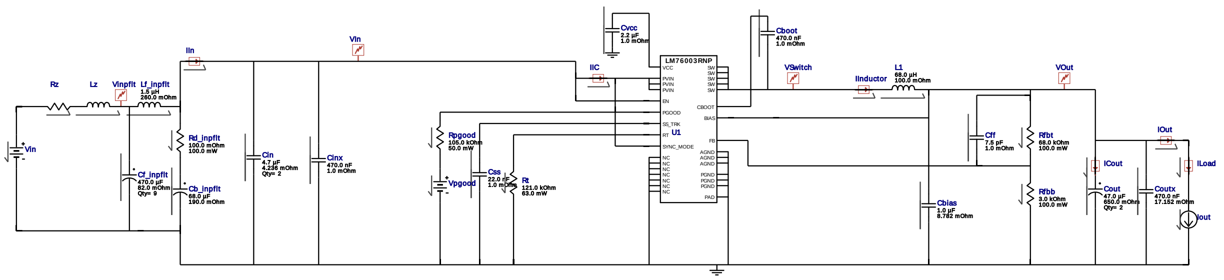




Design Id = 4

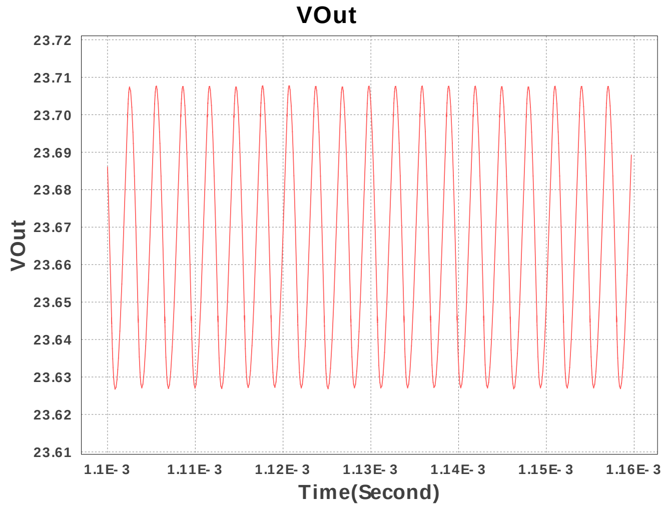
sim_id = 13

Simulation Type = Steady State



Simulation Parameters

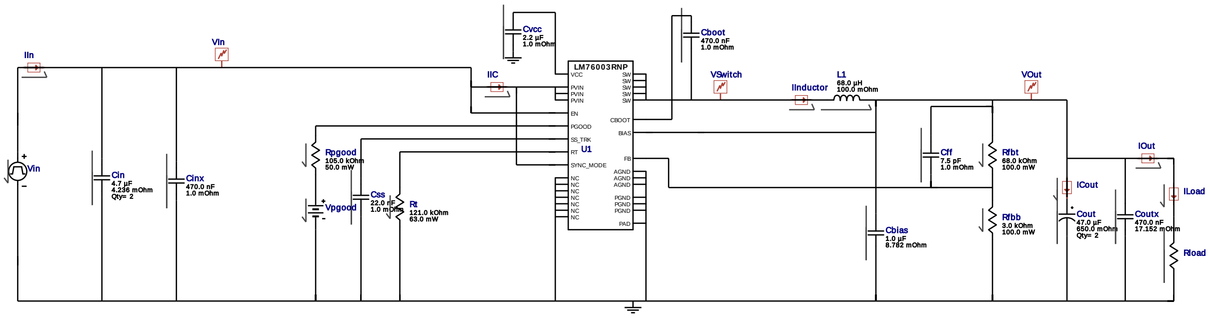
#	Name	Parameter Name	Description	Values
1.	Vpgood	V	Pgood Voltage	5
2.	L1	IC	Initial Current	-1.5
3.	Cboot	IC	Initial condition	10 V
4.	Iout	I	Load Current	1.5 A
5.	Rz	R	no description	0.732 Ohm
6.	Lz	L	no description	1.0E-6 H



Design Id = 4

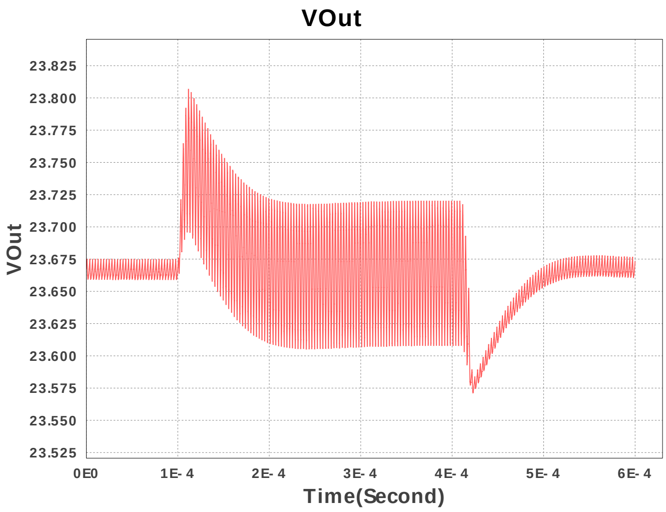
sim_id = 16

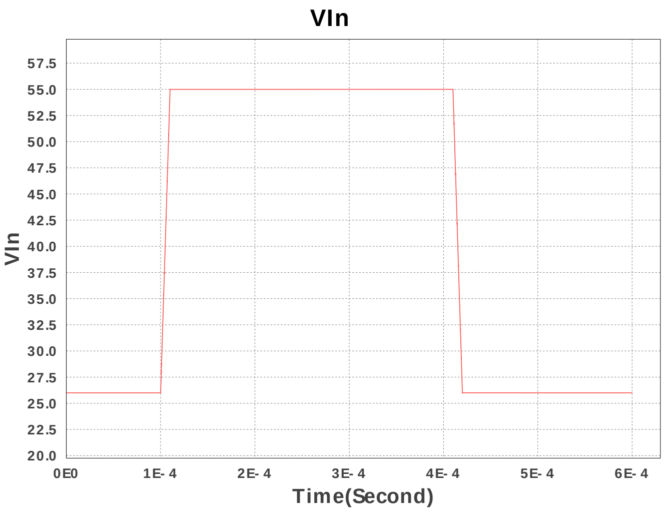
Simulation Type = Input Transient



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Vpgood	V	no description	5 V
2.	Cvcc	IC	Initial condition	3.15 V
3.	L1	IC	Initial condition	0 V
4.	Cboot	IC	Initial condition	10 V
5.	Rload	R	Load Resistance	16.0 Ohm





Design Assistance

1. Master key : E18E995B3DF050F7[v1]

2. **LM76003** Product Folder : http://www.ti.com/product/LM76003 : contains the data sheet and other resources.

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