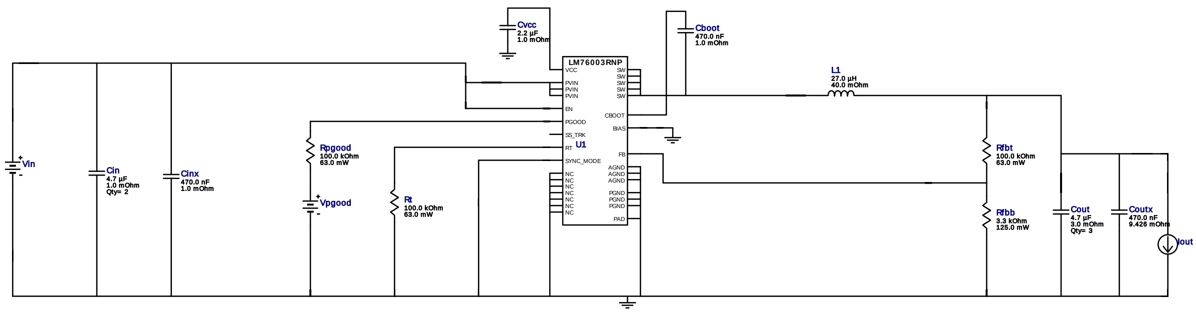
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 50.5V
VinMax = 53.32V
Vout = 32.0V
Iout = 3.5A

Device = LM76003RNPR
Topology = Buck
Created = 2020-02-12 07:16:37.996
BOM Cost = $6.17
BOM Count = 15
Total Pd = 3.21W

Design : 18 LM76003RNPR
LM76003RNPR 5V-60V to 3.30V @ 3.5A

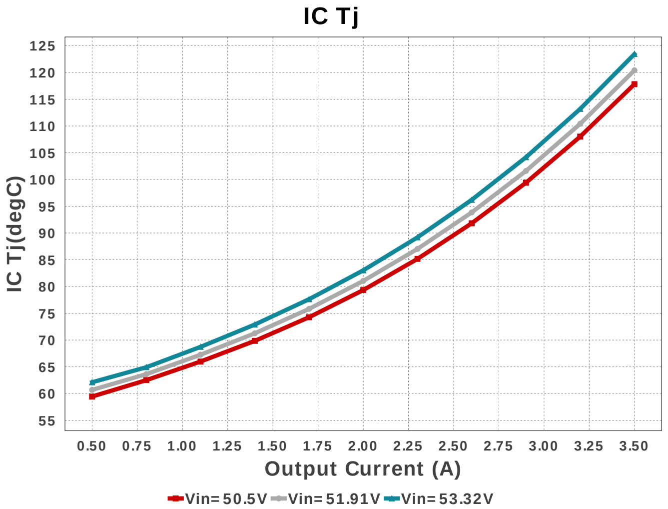


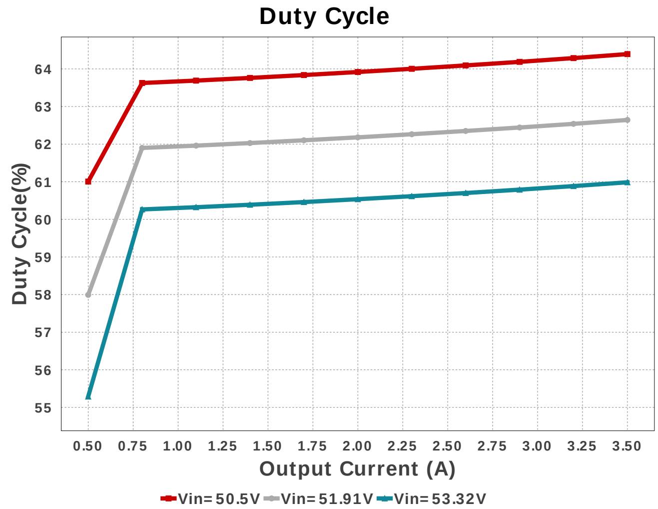
1. The input capacitor included in the BOM only contains a small filter capacitor that should be placed near the IC. Depending on where the power supply is laid out in the system additional bulk capacitance may need to be added to filter the line ripple.

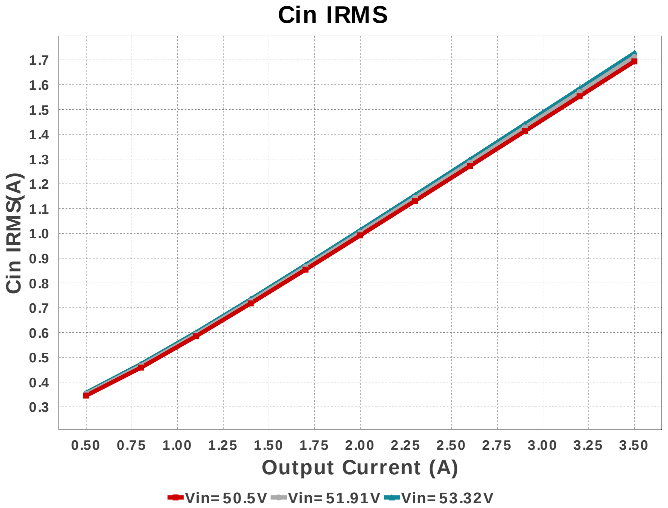
Electrical BOM

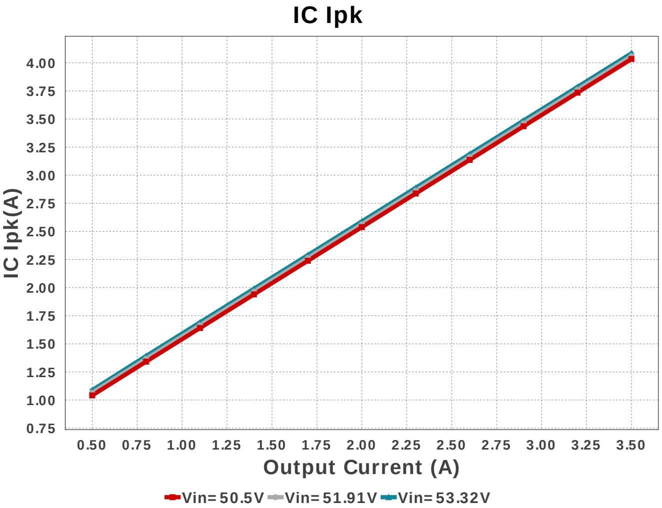
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM155R60J474KE19D Series= X5R	Cap= 470.0 nF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 0.0 A	1	$0.02	0402 3 mm^2
Cin	MuRata	GCM32DC72A475KE02L Series= X7S	Cap= 4.7 uF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 6.0 A	2	$0.60	1210_220 15 mm^2
Cinx	MuRata	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	MuRata	GRM31CR71H475KA12L Series= X7R	Cap= 4.7 uF ESR= 3.0 mOhm VDC= 50.0 V IRMS= 4.98 A	3	$0.22	1206 11 mm^2
Coutx	TDK	CGA5L2X7R1H474K160AA Series= X7R	Cap= 470.0 nF ESR= 9.426 mOhm VDC= 50.0 V IRMS= 2.37046 A	1	$0.05	1206_180 11 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
L1	Wurth Elektronik	7447709270	L= 27.0 µH 40.0 mOhm	1	$1.39	WE-PD_1210 196 mm^2
Rfbb	Susumu Co Ltd	RG2012P-332-B-T5 Series= RG2012	Res= 3.3 kOhm Power= 125.0 mW Tolerance= 0.1%	1	$0.04	0805 7 mm^2
Rfbt	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2

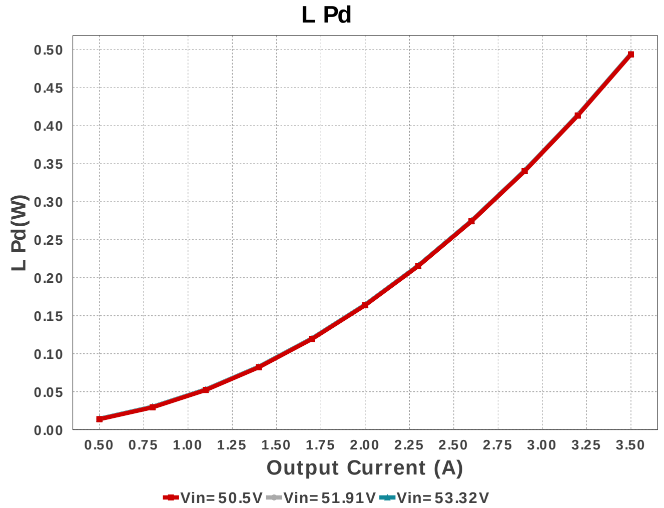
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rpgood	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rt	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
U1	Texas Instruments	LM76003RNPR	Switcher	1	$2.60	RNP0030B 48 mm²

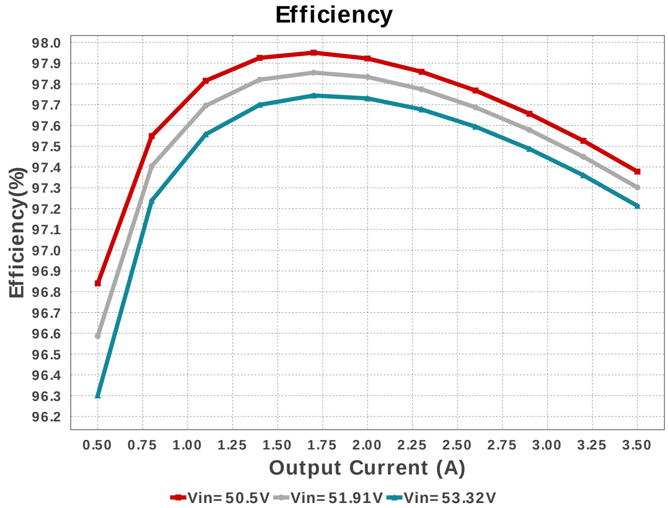


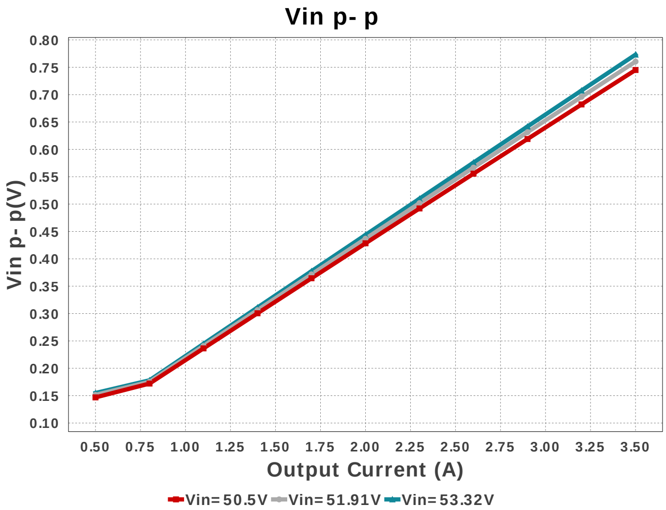


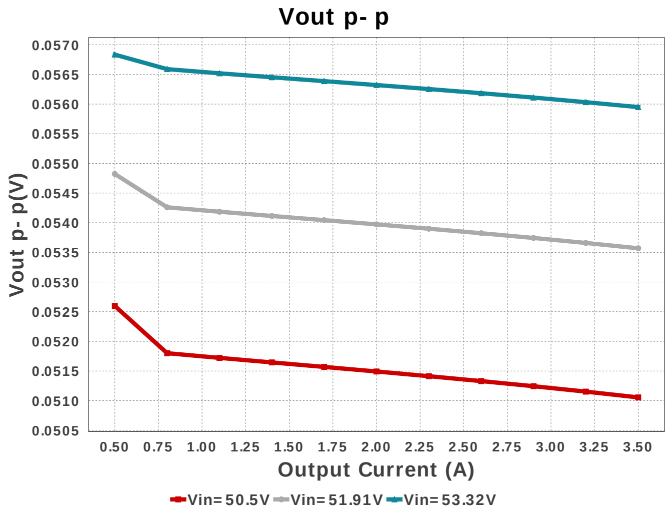


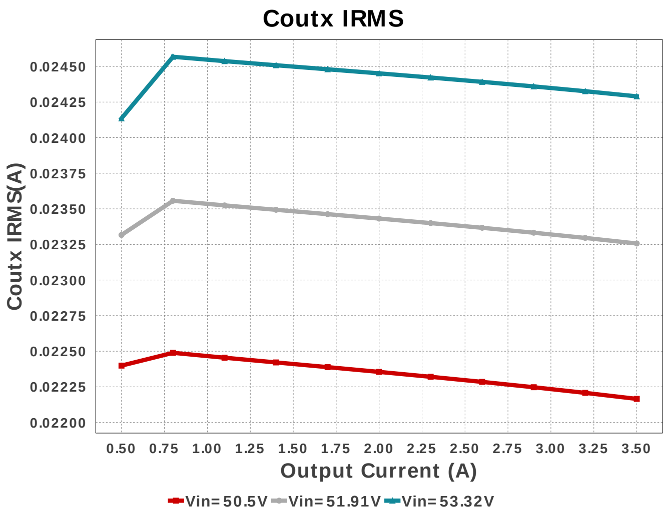


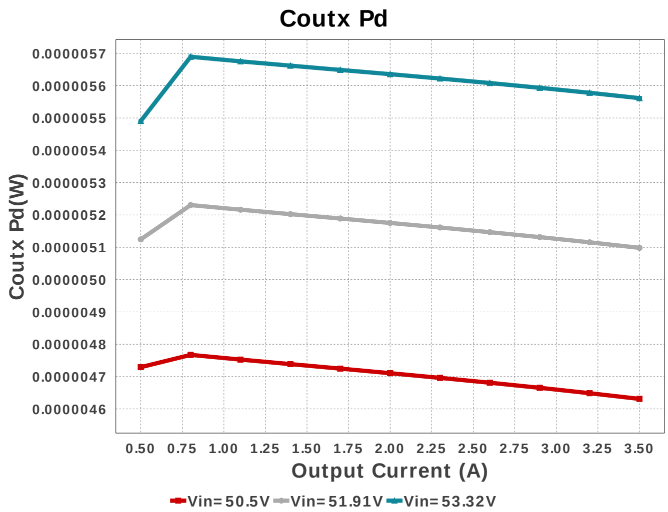


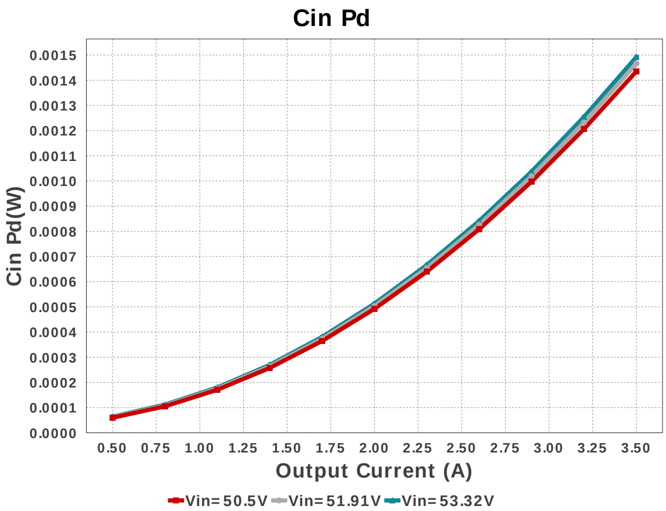


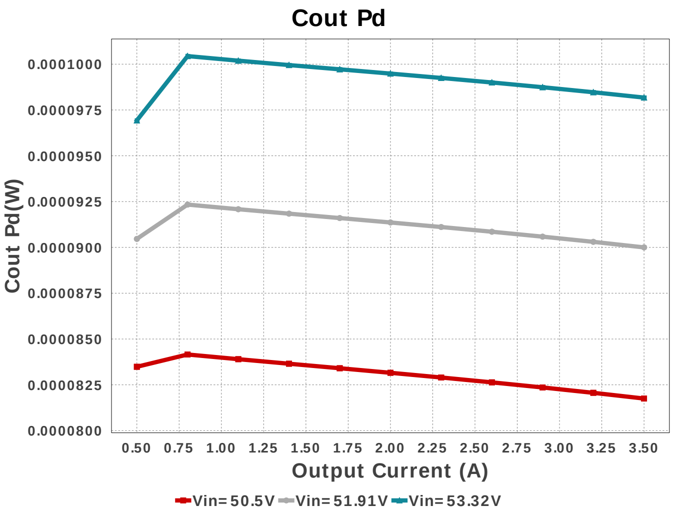

Vin p- p
Vin p- p(V)
Output Current (A)
Vin= 50.5V Vin= 51.91V Vin= 53.32V

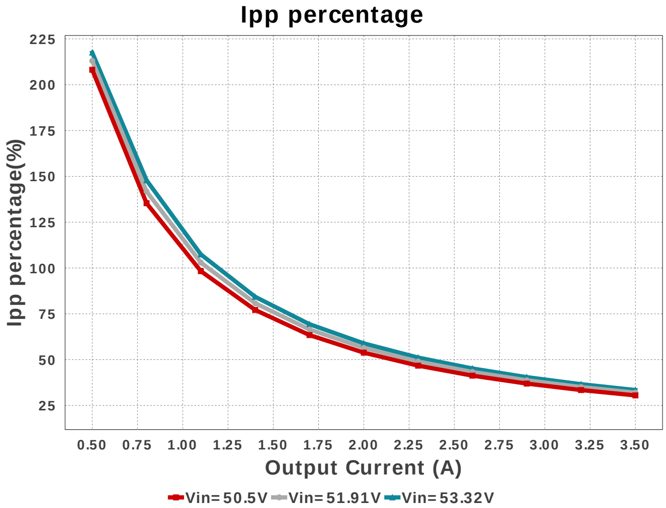

Vout p- p
Vout p- p(V)
Output Current (A)
Vin= 50.5V Vin= 51.91V Vin= 53.32V

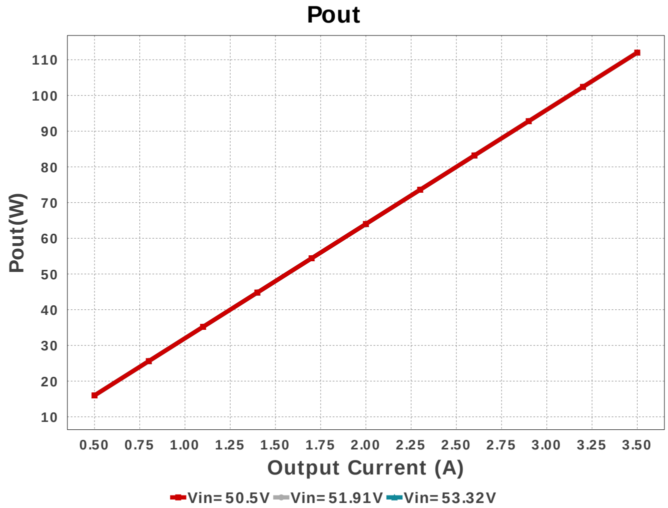

Coutx IRMS
Coutx IRMS(A)
Output Current (A)
Vin= 50.5V Vin= 51.91V Vin= 53.32V

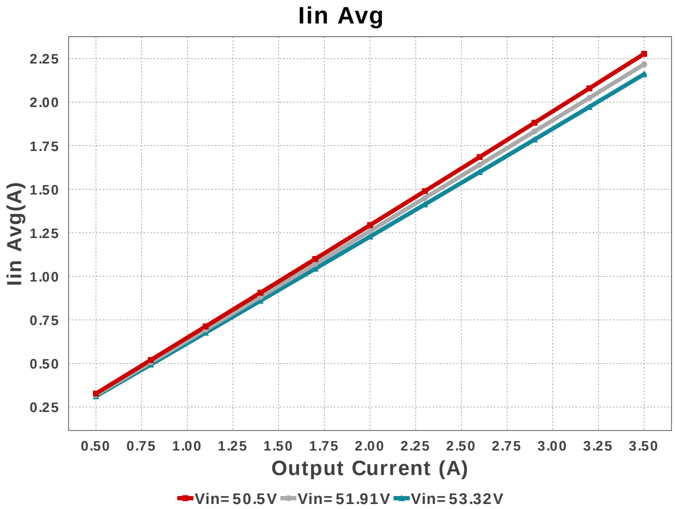

Coutx Pd
Coutx Pd(W)
Output Current (A)
Vin= 50.5V Vin= 51.91V Vin= 53.32V

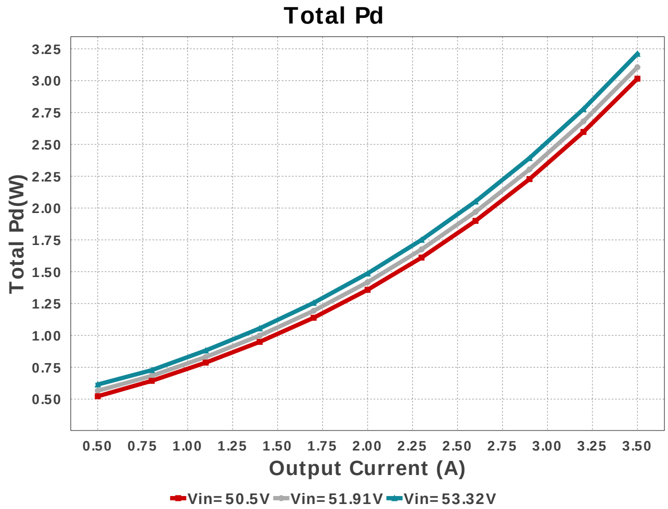

Cin Pd
Cin Pd(W)
Output Current (A)
Vin= 50.5V Vin= 51.91V Vin= 53.32V

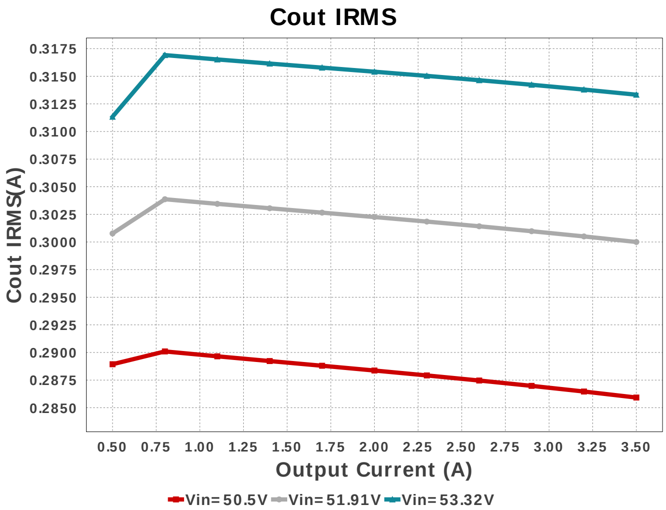

Cout Pd
Cout Pd(W)
Output Current (A)
Vin= 50.5V Vin= 51.91V Vin= 53.32V

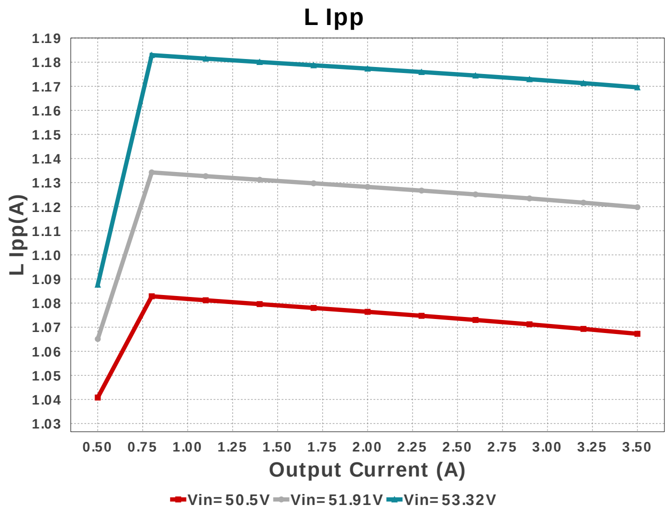

Ipp percentage
Ipp percentage(%)
Output Current (A)
Vin=50.5V Vin=51.91V Vin=53.32V

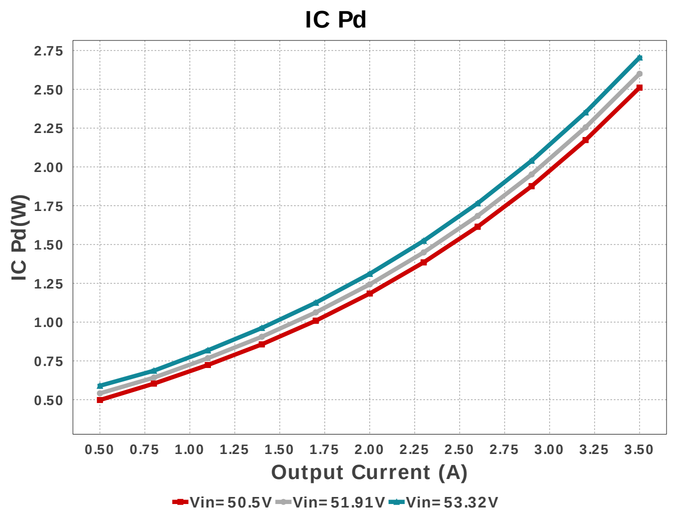

Pout
Pout(W)
Output Current (A)
Vin=50.5V Vin=51.91V Vin=53.32V

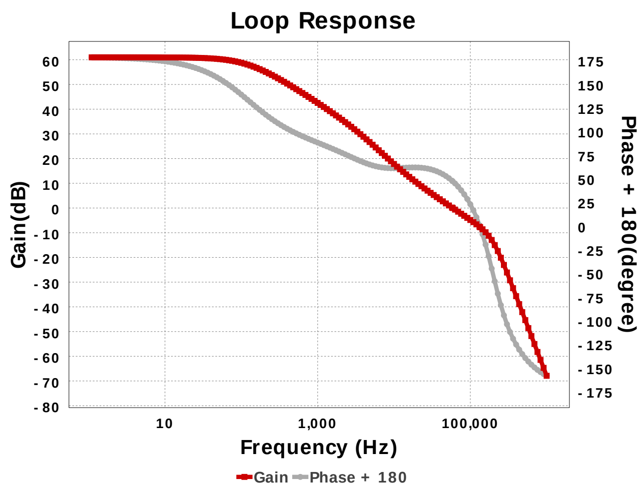

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=50.5V Vin=51.91V Vin=53.32V


Total Pd
Total Pd(W)
Output Current (A)
Vin=50.5V Vin=51.91V Vin=53.32V


Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=50.5V Vin=51.91V Vin=53.32V


L Ipp
L Ipp(A)
Output Current (A)
Vin=50.5V Vin=51.91V Vin=53.32V





Operating Values

#	Name	Value	Category	Description
1.	BOM Count	15		Total Design BOM count
2.	Total BOM	$6.17		Total BOM Cost
3.	Cin IRMS	1.727 A	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	1.492 mW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	313.331 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	98.176 µW	Capacitor	Output capacitor power dissipation
7.	Coutx IRMS	24.29 mA	Capacitor	Output capacitor_x RMS ripple current
8.	Coutx Pd	5.561 µW	Capacitor	Output capacitor_x power loss
9.	IC Ipk	4.085 A	IC	Peak switch current in IC
10.	IC Pd	2.705 W	IC	IC power dissipation
11.	IC Tj	123.432 degC	IC	IC junction temperature
12.	IC Tolerance	19.0 mV	IC	IC Feedback Tolerance
13.	ICThetaJA	29.0 degC/W	IC	IC junction-to-ambient thermal resistance
14.	Iin Avg	2.161 A	IC	Average input current
15.	Ipp percentage	33.416 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
16.	L Ipp	1.17 A	Inductor	Peak-to-peak inductor ripple current
17.	L Pd	494.56 mW	Inductor	Inductor power dissipation
18.	Cin Pd	1.492 mW	Power	Input capacitor power dissipation
19.	Cout Pd	98.176 µW	Power	Output capacitor power dissipation
20.	Coutx Pd	5.561 µW	Power	Output capacitor_x power loss
21.	IC Pd	2.705 W	Power	IC power dissipation
22.	L Pd	494.56 mW	Power	Inductor power dissipation
23.	Total Pd	3.211 W	Power	Total Power Dissipation
24.	Cross Freq	58.811 kHz	System Information	Bode plot crossover frequency
25.	Duty Cycle	60.985 %	System Information	Duty cycle
26.	Efficiency	97.213 %	System Information	Steady state efficiency
27.	FootPrint	349.0 mm^2	System Information	Total Foot Print Area of BOM components
28.	Frequency	400.0 kHz	System Information	Switching frequency
29.	Gain Marg	-7.784 dB	System Information	Bode Plot Gain Margin
30.	Iout	3.5 A	System Information	Iout operating point
31.	Low Freq Gain	60.98 dB	System Information	Gain at 1Hz
32.	Mode	CCM	System Information	Conduction Mode
33.	Phase Marg	48.411 deg	System Information	Bode Plot Phase Margin
34.	Pout	112.0 W	System Information	Total output power
35.	Vin	53.32 V	System Information	Vin operating point
36.	Vin p-p	773.118 mV	System Information	Peak-to-peak input voltage
37.	Vout	32.0 V	System Information	Operational Output Voltage

#	Name	Value	Category	Description
38.	Vout Actual	31.303 V	System Information	Vout Actual calculated based on selected voltage divider resistors
39.	Vout Tolerance	2.986 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
40.	Vout p-p	55.949 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	3.5	Maximum Output Current
VinMax	53.32	Maximum input voltage
VinMin	50.5	Minimum input voltage
Vout	32.0	Output Voltage
base_pn	LM76003	Base Product Number
source	DC	Input Source Type
Ta	45.0	Ambient temperature
UserFsw	400.0 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

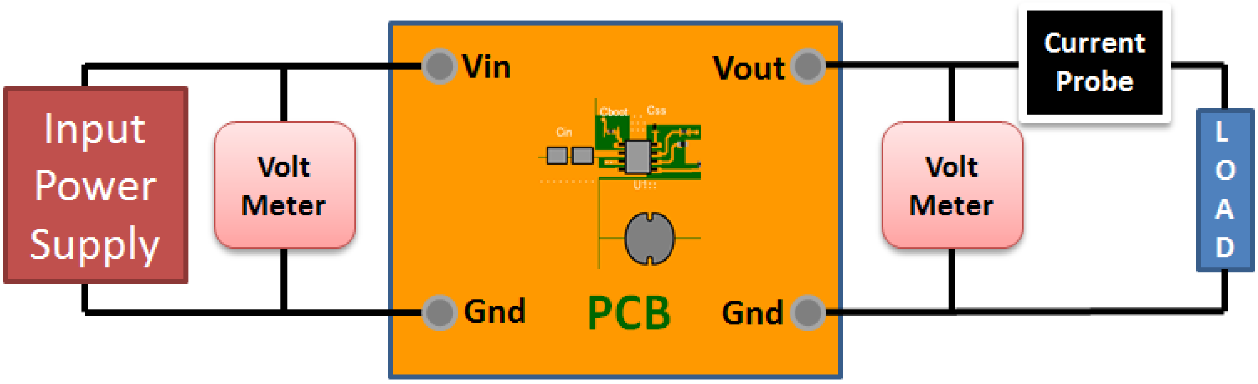
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 50.5V 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.

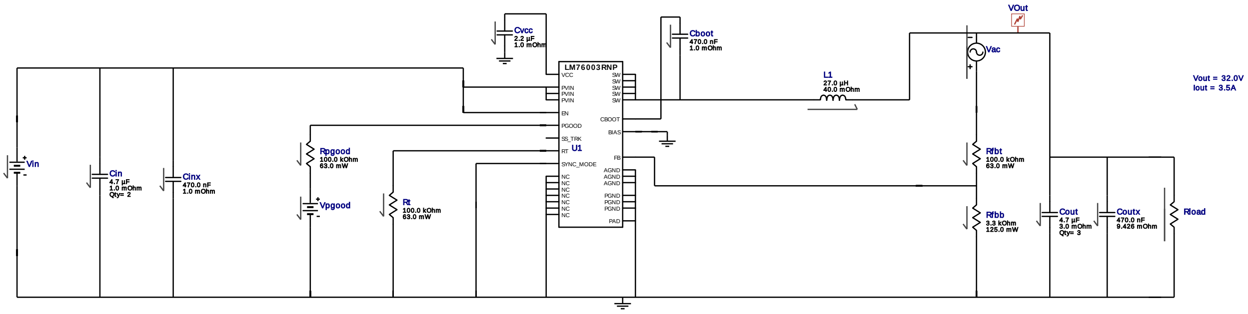


WEBENCH® Electrical Simulation Report

Design Id = 18

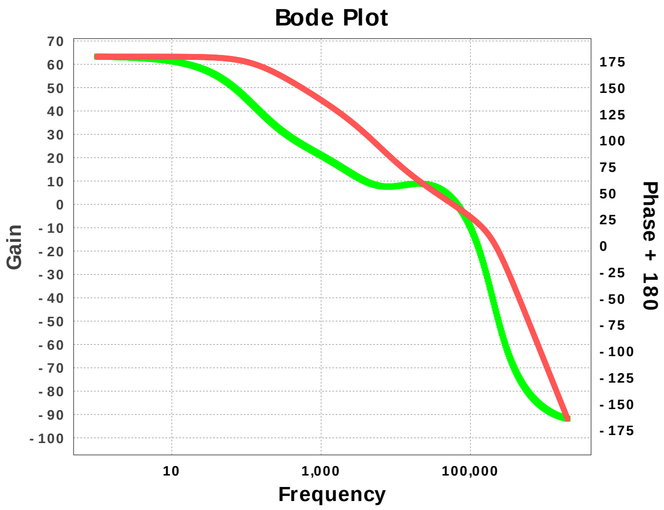
sim_id = 1

Simulation Type = Bode Plot



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Vpgood	V	Supply Voltage	5 V
2.	Cin	IC	Initial condition	51.91 V
3.	Cinx	IC	Initial condition	51.91 V
4.	Coutx	IC	Initial condition	32.0 V
5.	Cout	IC	Initial condition	32.0 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	9.142857142857142 ohm



Design Assistance

1. Master key : 2B38B5A914D55C2B[v1]

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

Important Notice and Disclaimer

TI provides technical and reliability data (including datasheets), design resources (including reference designs), application or other design advice, web tools, safety information, and other resources AS IS and with all faults, and disclaims all warranties. These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

Providing these resources does not expand or otherwise alter TI's applicable Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with TI products.