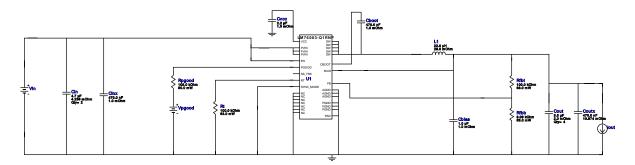
VinMin = 21.0V VinMax = 49.0V Vout = 12.0V Iout = 3.5A Device = LM76003QRNPRQ1 Topology = Buck Created = 2022-04-21 03:38:22.725 BOM Cost = NA BOM Count = 17 Total Pd = 2.24W

WEBENCH® Design Report

Design: 107 LM76003QRNPRQ1 LM76003QRNPRQ1 21V-49V to 12.00V @ 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.
- 2. This regulator device is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application. View WEBENCH(R) Disclaimer.

Design Alerts

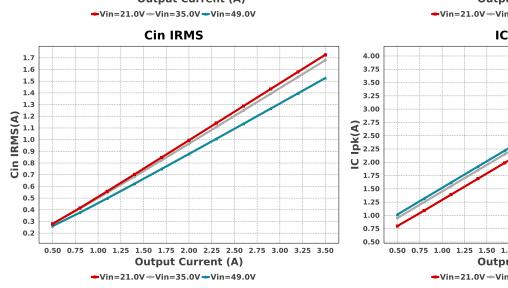
Component Selection Information

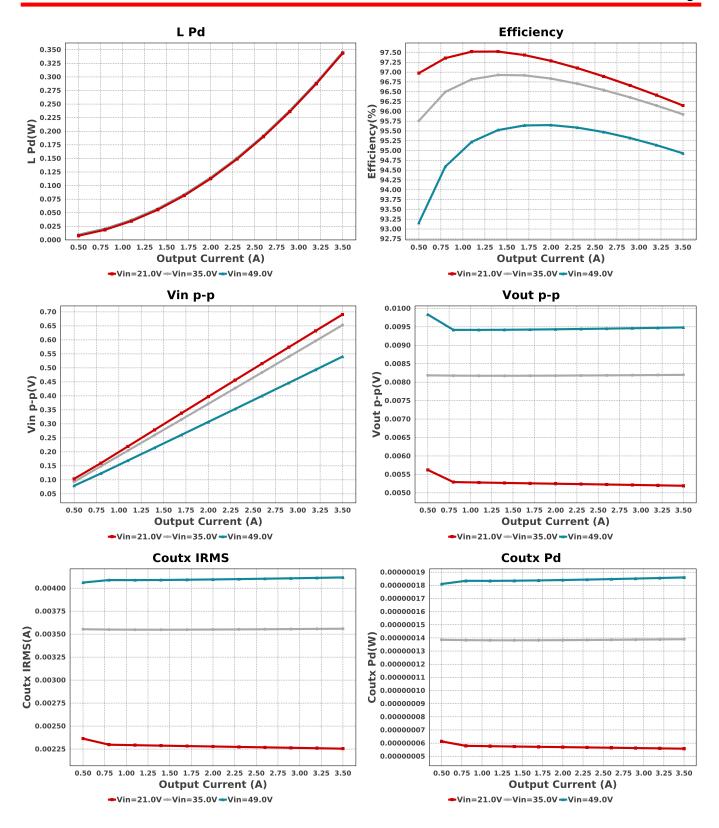
The LM76003-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application.

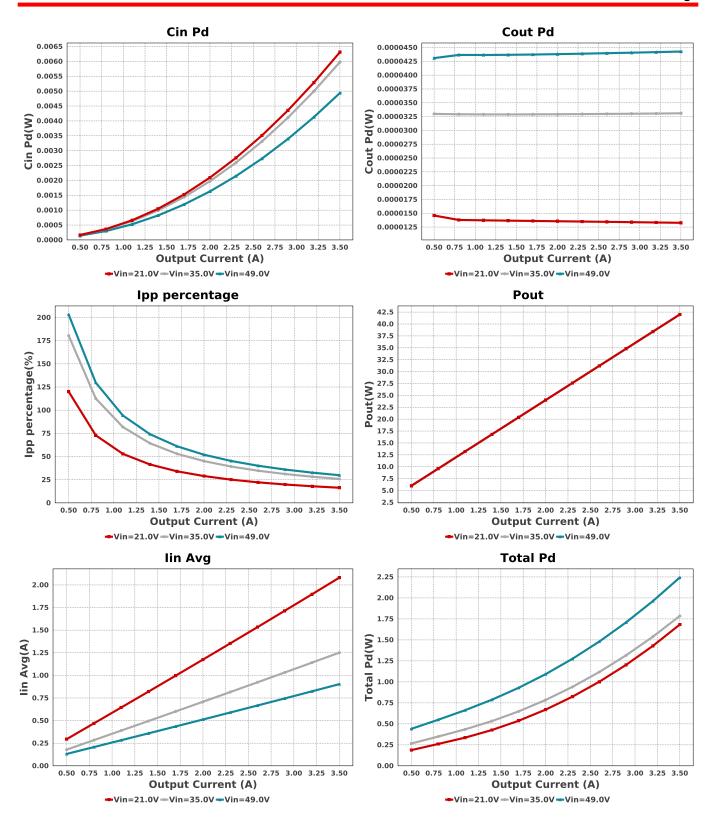
Electrical BOM

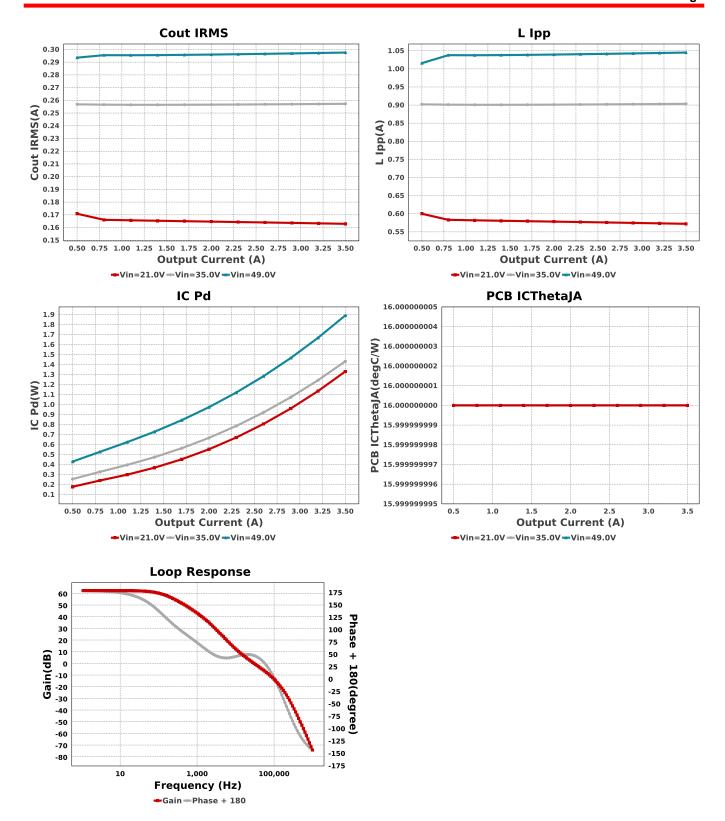
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbias	Taiyo Yuden	TMK212B7105KG-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	\$0.02	0805 7 mm ²
Cboot	MuRata	GRM155R60J474KE19D Series= X5R	Cap= 470.0 nF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 0.0 A	1	\$0.02	0402 3 mm ²
Cin	TDK	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	CUSTOM	CUSTOM Series= X5R	Cap= 8.5 uF ESR= 2.0 mOhm VDC= 50.0 V IRMS= 4.6 A	4	NA	CKG57N 0 mm ²
Coutx	TDK	C1608X7R1H474K080AC Series= X7R	Cap= 470.0 nF ESR= 10.974 mOhm VDC= 50.0 V IRMS= 1.57483 A	1	\$0.05	0603 5 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 7447709220		Manufacturer	Part Number	Properties	Qtv	Price	Footprint
Ribb Vishay-Dale CRCW04029K09FKED Series= CRCW.e3 Power= 63.0 mW Tolerance= 1.0% 0402 3 mm² 0402 3 mm	L1	-		 L= 22.0 μH			
Series = CRCWe3	Rfbb	Vishay-Dale		Power= 63.0 mW	1	\$0.01	
Series= ? Power= 50.0 mW Tolerance= 1.0% Rt Vishay-Dale CRCW0402100KFKED Series= CRCWe3 Power= 63.0 mW Tolerance= 1.0% U1 Texas Instruments LM76003QRNPRQ1 Switcher 1 \$2.27 RNP0030B 48 mm² IC Tj Duty Cycle 60.0 57.5 55.0 52.5 55.0 74.5 55.0 74.5 75.5 55.0 75.0 7	Rfbt	Vishay-Dale		Power= 63.0 mW	1	\$0.01	0402 3 mm ²
Series= CRCWe3 Power= 63.0 mW Tolerance= 1.0% U1 Texas Instruments LM76003QRNPRQ1 Switcher 1 \$2.27 RNP0030B 48 mm² IC Tj Duty Cycle 60.0 57.5 55.0 64.5 60.0 77.5 61.0 78.7 61.0 79.7 61.	Rpgood	Yageo		Power= 50.0 mW	1	\$0.01	0201 2 mm ²
IC Tj Duty Cycle 10.0	Rt	Vishay-Dale		Power= 63.0 mW	1	\$0.01	
60.0 57.5 55.0 55.0 55.5 55.0 55.5 55.0 55.5 55.0 55.5 55.0 55.0 55.5 55.0 55.0 55.5 55.0 55.0 55.5 55.0 5	U1	Texas Instruments	LM76003QRNPRQ1	Switcher	1	\$2.27	RNP0030B 48 mm ²
57.5 55.0 52.5 50.0 52.5 53.0		IC Tj			Duty (Cycle	
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52.5 50.0 47.5 45.0 74.5 45.0 74.5 40.0 77.5 40.0	7.5						
9 47.5 9 45.0 0 40.0 12.5 15.0 10.0	55.0						
12.5 10.0 17.5 18.0 19.0	2.5			50.0			
12.5 10.0 17.5 18.0 19.0	0.0			% 47.5 45.0			
12.5 10.0 17.5 18.0 19.0	17.5			0 42.5			
12.5 10.0 17.5 18.0 19.0	15.0			₹ 40.0			
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37.5 35.0 35.0 35.0 30.0 27.5 25.0 22.5 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50	10.0						
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	3.30						
		-Vin=21.0V -Vin=35.0	0V - Vin=49.0V	- Vin=21.0	OV≔Vin=:	35.0V V	in=49.0V









Operating Values

#	Name	Value	Category	Description	
1.	BOM Count	17		Total Design BOM count	_
2.	Total BOM	NA		Total BOM Cost	
3.	Cin IRMS	1.527 A	Capacitor	Input capacitor RMS ripple current	
4.	Cin Pd	4.937 mW	Capacitor	Input capacitor power dissipation	
5.	Cout IRMS	297.565 mA	Capacitor	Output capacitor RMS ripple current	
6.	Cout Pd	44.272 μW	Capacitor	Output capacitor power dissipation	
7.	Coutx IRMS	4.117 mA	Capacitor	Output capacitor_x RMS ripple current	
8.	Coutx Pd	185.99 nW	Capacitor	Output capacitor_x power loss	
9.	IC lpk	4.023 A	IC	Peak switch current in IC	
10.	IC Pd	1.891 W	IC	IC power dissipation	
11.	IC Tj	60.259 degC	IC	IC junction temperature	

#	Name	Value	Category	Description
12.	IC Tolerance	19.0 mV	IC	IC Feedback Tolerance
13.	lin Avg	902.92 mA	IC IC	Average input current
14.	Ipp percentage	29.859 %	Inductor	Inductor ripple current percentage (with respect to average inductor
14.	ipp percentage	29.659 %	maactor	current)
15.	L lpp	1.045 A	Inductor	Peak-to-peak inductor ripple current
16.	L Pd	345.55 mW	Inductor	Inductor power dissipation
17.	Cin Pd	4.937 mW	Power	Input capacitor power dissipation
18.	Cout Pd	44.272 µW	Power	Output capacitor power dissipation
19.	Coutx Pd	185.99 nW	Power	Output capacitor_x power loss
20.	IC Pd	1.891 W	Power	IC power dissipation
21.	L Pd	345.55 mW	Power	Inductor power dissipation
22.	Total Pd	2.243 W	Power	Total Power Dissipation
23.	Cross Freq	30.143 kHz	System	Bode plot crossover frequency
	·		Information	
24.	Duty Cycle	25.181 %	System	Duty cycle
	., ., .		Information	
25.	Efficiency	94.93 %	System	Steady state efficiency
_0.		0 1100 70	Information	Cloudy clair children
26.	FootPrint	536.0 mm ²	System	Total Foot Print Area of BOM components
20.	1 0001 11110	330.0 11111	Information	Total Total Tilla of Bolin componente
27.	Frequency	400.0 kHz	System	Switching frequency
	rioquorioy	100.0 1012	Information	Simoning inequality
28.	Gain Marg	-14.293 dB	System	Bode Plot Gain Margin
_0.	Cam marg	1 1.200 GB	Information	Bodo Flot Gailt Margin
29.	lout	3.5 A	System	lout operating point
25.	lout	5.5 A	Information	lout operating point
30.	Low Freq Gain	62.356 dB	System	Gain at 1Hz
50.	Low ricq Gain	02.330 dD	Information	Gaill at 1112
31.	Mode	CCM	System	Conduction Mode
51.	Wode	COIVI	Information	Conduction Wode
32.	Phase Marg	48.162 deg	System	Bode Plot Phase Margin
JZ.	i ilasc ivialg	40.102 dcg	Information	Bode Flot Flase Margin
33.	Pout	42.0 W	System	Total output power
55.	1 Out	42.0 VV	Information	Total output power
34.	Vin	49.0 V	System	Vin operating point
34.	VIII	49.0 V	Information	viii operating point
25	\/in n n	E40 20E m\/		Dook to pook input voltage
35.	Vin p-p	540.305 mV	System	Peak-to-peak input voltage
20	1/2	40.01/	Information	On anational Output Valtage
36.	Vout	12.0 V	System	Operational Output Voltage
07		40.004.1/	Information	
37.	Vout Actual	12.001 V	System	Vout Actual calculated based on selected voltage divider resistors
			Information	
38.	Vout Tolerance	3.787 %	System	Vout Tolerance based on IC Tolerance (no load) and voltage divider
			Information	resistors if applicable
39.	Vout p-p	9.484 mV	System	Peak-to-peak output ripple voltage
			Information	
40.	PCB ICThetaJA	16.0 degC/W		Effective PCB ThetaJA

Design Inputs

Name	Value	Description	
lout	3.5	Maximum Output Current	
VinMax	49.0	Maximum input voltage	
VinMin	21.0	Minimum input voltage	
Vout	12.0	Output Voltage	
base_pn	LM76003-Q1	Base Product Number	
source	DC	Input Source Type	
Та	30.0	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

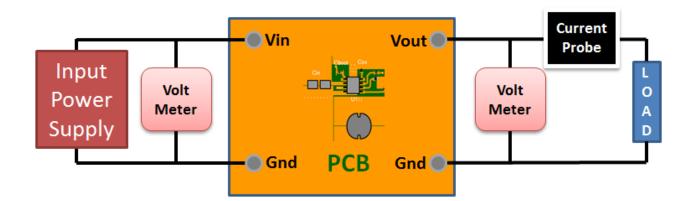
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 21.0V 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 lout 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.

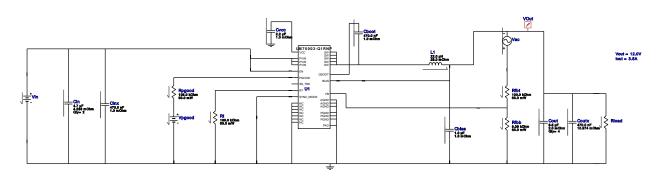


WEBENCH[®] Electrical Simulation Report

Design Id = 107

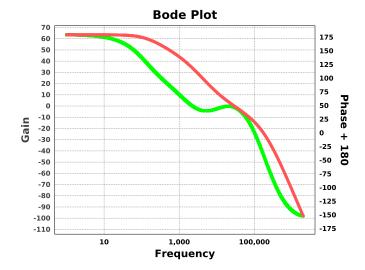
 $sim_id = 1$

Simulation Type = Bode Plot



Simulation Parameters

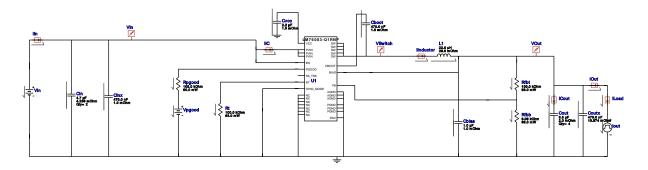
#	Name	Parameter Name	Description	Values
1.	Vpgood	V	Supply voltage	5 V
2.	Cinj	С	Injection isolation capacitance	10000000 F
3.	Linj	L	Injection isolation inductance	10000000 H
4.	Vinj	AC	AC signal	1 V
5.	Rload	R	Load Resistance	3.4285714285714284 ohm



Design Id = 107

sim_id = 2

Simulation Type = Load Transient



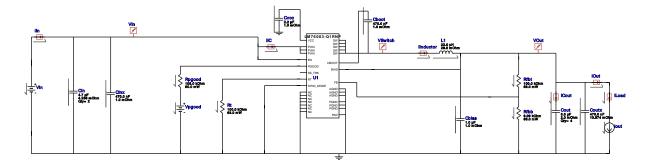
Simulation Parameters

# Name	e Parameter Name	Description	Values
1. Vpgd	ood V	Pgood voltage	5 V
2. L1	IC	Initial current	-3.5 A
3. Cboo	ot IC	Initial voltage	10 V
4. lout	signal_type I1 I2 Td Tf Tr Pw	Signal Type Initial Load Current Minimum Load Current Initial Time Delay Fall Time Rise Time Pulse Width	PULSE 3.5 A 0.35 A 2.0E-4 s 10u s 10u s 7.0E-4 s

Design Id = 107

 $sim_id = 3$

Simulation Type = Steady State



Simulation Parameters

	Name	Parameter Name	Description	Values
	Vpgood	V	Pgood Voltage	5 V
2.	L1	IC	Initial current	-3.5 A
3.	Cboot	IC	Initial voltage	10 V
4.	lout	1	Load Current	3.5 A

Design Assistance

- 1. The LM76003-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application.
- 2. Master key: 15882B5FF9AD5C05[v1]
- 3. LM76003-Q1 Product Folder: http://www.ti.com/product/LM76003%2DQ1: contains the data sheet and other resources.

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