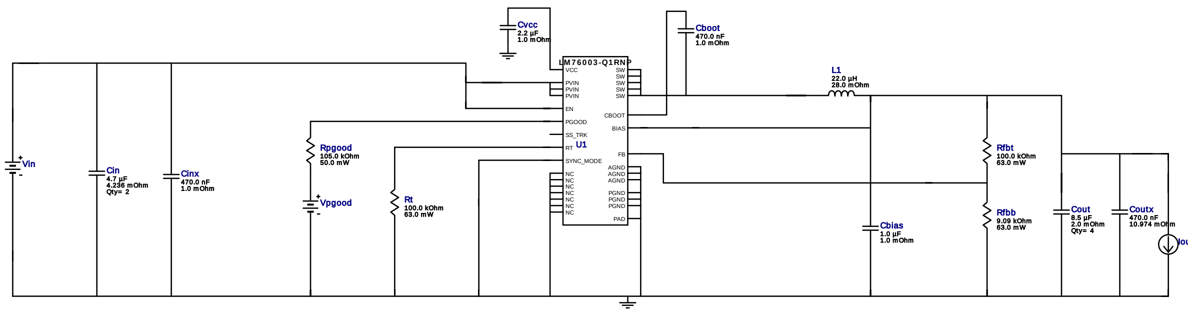
VinMin = 21.0V
VinMax = 49.0V
Vout = 12.0V
Iout = 3.5A

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.

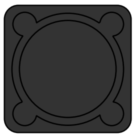
## Design Alerts

### Component Selection Information

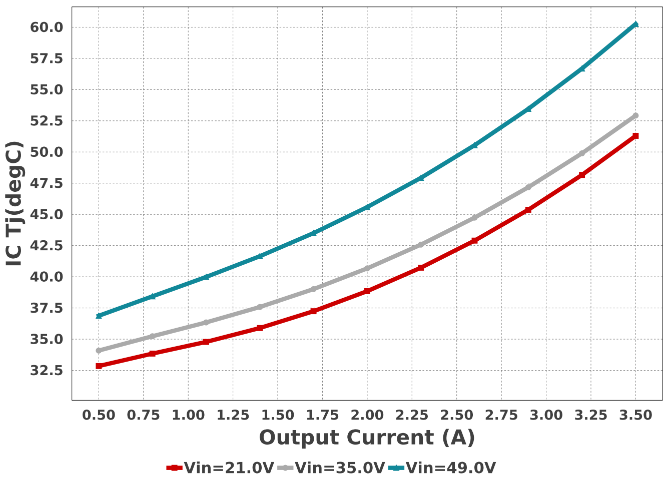
The LM76003-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application.

## Electrical BOM

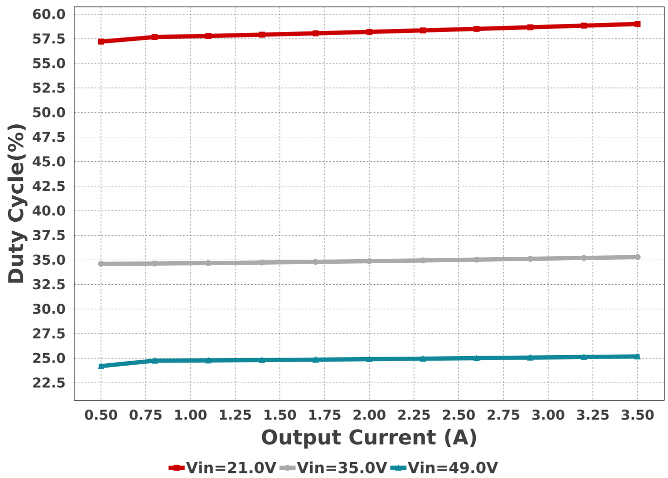
| Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|---|---|---|---|---|---|---|
| Cbias | Taiyo Yuden | TMK212B7105KG-T<br>Series= X7R | Cap= 1.0 uF<br>ESR= 1.0 mOhm<br>VDC= 25.0 V<br>IRMS= 0.0 A | 1 | $0.02 | 0805 7 $mm^2$ |
| Cboot | MuRata | GRM155R60J474KE19D<br>Series= X5R | Cap= 470.0 nF<br>ESR= 1.0 mOhm<br>VDC= 6.3 V<br>IRMS= 0.0 A | 1 | $0.02 | 0402 3 $mm^2$ |
| Cin | TDK | CGA6M3X7S2A475K200AB<br>Series= X7S | Cap= 4.7 uF<br>ESR= 4.236 mOhm<br>VDC= 100.0 V<br>IRMS= 3.57337 A | 2 | $0.47 | 1210_220 15 $mm^2$ |
| Cinx | MuRata | GRM21BR72A474KA73L<br>Series= X7R | Cap= 470.0 nF<br>ESR= 1.0 mOhm<br>VDC= 100.0 V<br>IRMS= 0.0 A | 1 | $0.16 | 0805 7 $mm^2$ |
| Cout | CUSTOM | CUSTOM<br>Series= X5R | Cap= 8.5 uF<br>ESR= 2.0 mOhm<br>VDC= 50.0 V<br>IRMS= 4.6 A | 4 | NA | CKG57N 0 $mm^2$ |
| Coutx | TDK | C1608X7R1H474K080AC<br>Series= X7R | Cap= 470.0 nF<br>ESR= 10.974 mOhm<br>VDC= 50.0 V<br>IRMS= 1.57483 A | 1 | $0.05 | 0603 5 $mm^2$ |
| Cvcc | Taiyo Yuden | EMK212BJ225KG-T<br>Series= X5R | Cap= 2.2 uF<br>ESR= 1.0 mOhm<br>VDC= 16.0 V<br>IRMS= 0.0 A | 1 | $0.02 | 0805 7 $mm^2$ |

| Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|---|---|---|---|---|---|---|
| L1 | Wurth Elektronik | 7447709220 | L= 22.0 µH<br>28.0 mOhm | 1 | $1.39 | <br>WE-PD_1210 196 mm² |
| Rfbb | Vishay-Dale | CRCW04029K09FKED<br>Series= CRCW..e3 | Res= 9.09 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0402 3 mm² |
| Rfbt | Vishay-Dale | CRCW0402100KFKED<br>Series= CRCW..e3 | Res= 100.0 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0402 3 mm² |
| Rpgood | Yageo | RC0201FR-07105KL<br>Series= ? | Res= 105.0 kOhm<br>Power= 50.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0201 2 mm² |
| Rt | Vishay-Dale | CRCW0402100KFKED<br>Series= CRCW..e3 | Res= 100.0 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0402 3 mm² |
| U1 | Texas Instruments | LM76003QRNPRQ1 | Switcher | 1 | $2.27 | RNP0030B 48 mm² |

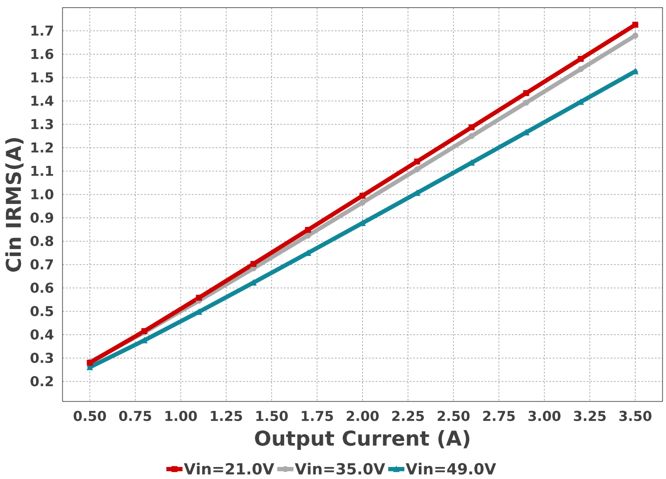
**IC Tj**



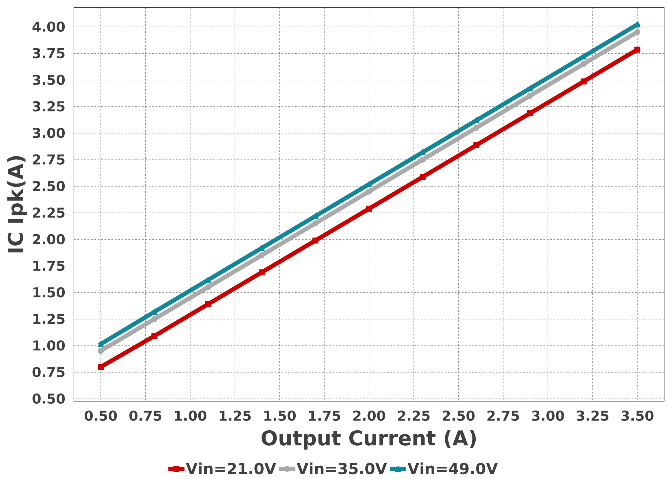

**Duty Cycle**

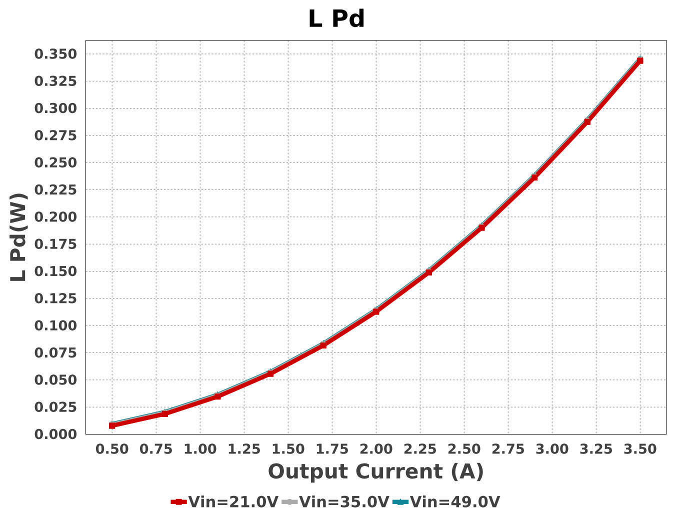


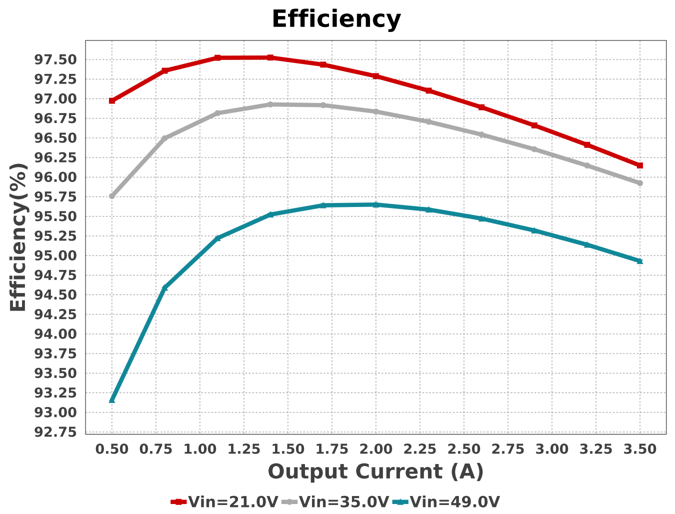

**Cin IRMS**

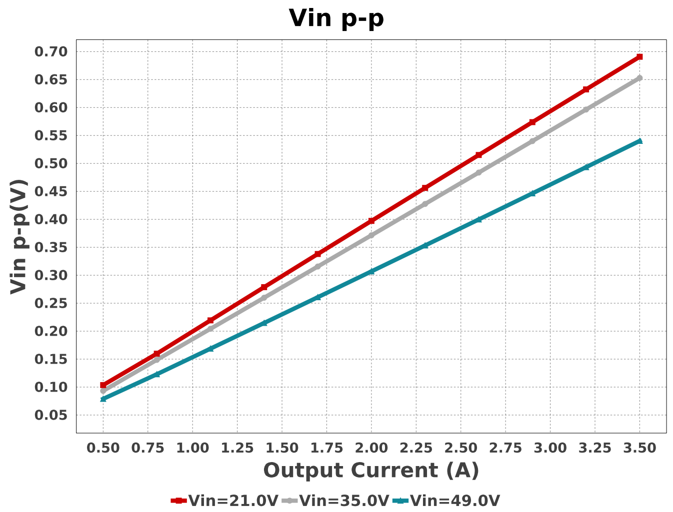


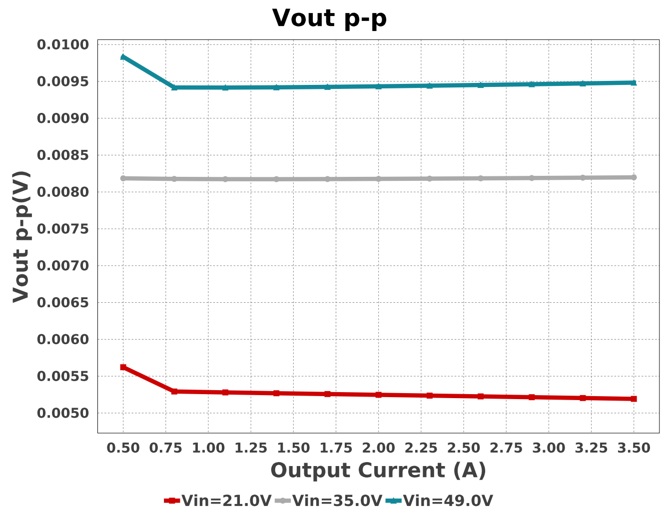

**IC Ipk**

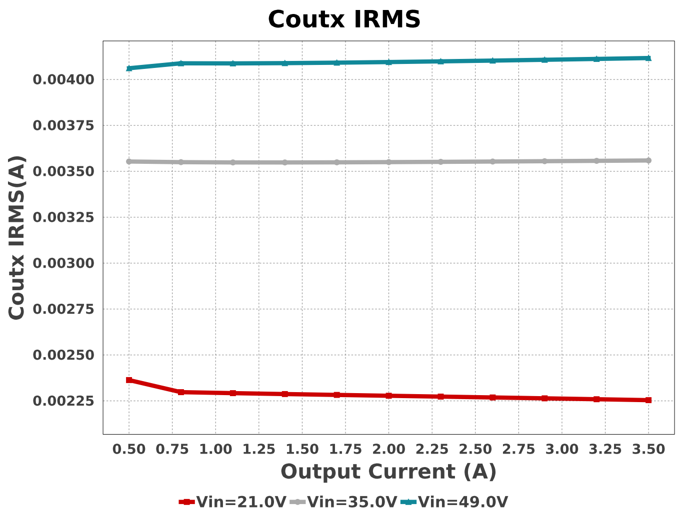


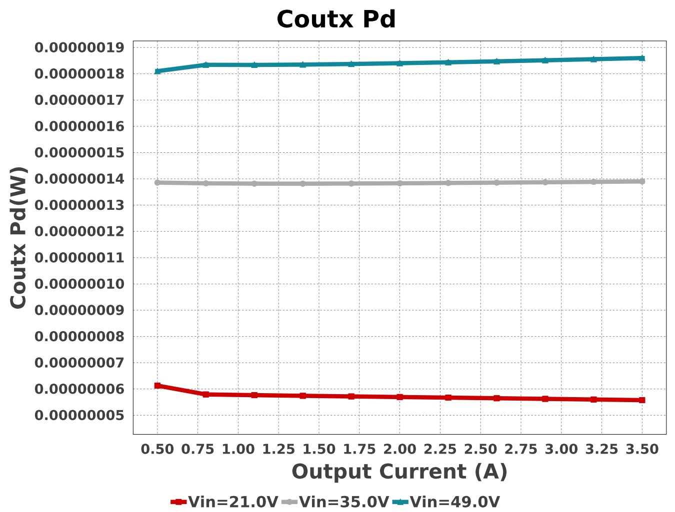

L Pd
L Pd(W)
Output Current (A)
Vin=21.0V Vin=35.0V Vin=49.0V

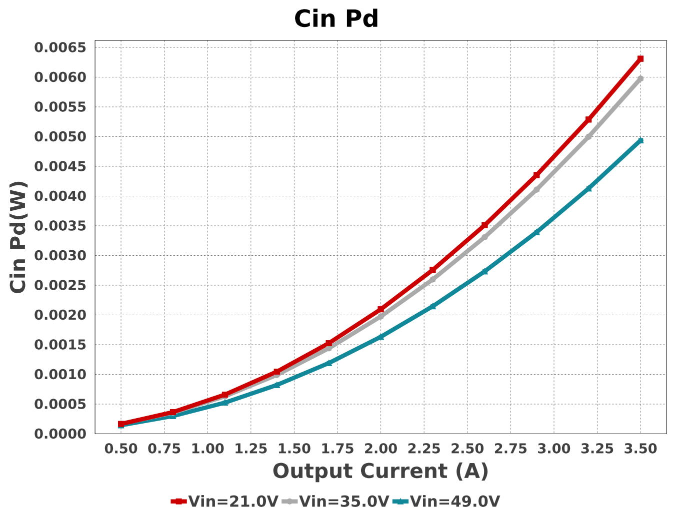

Efficiency
Efficiency(%)
Output Current (A)
Vin=21.0V Vin=35.0V Vin=49.0V

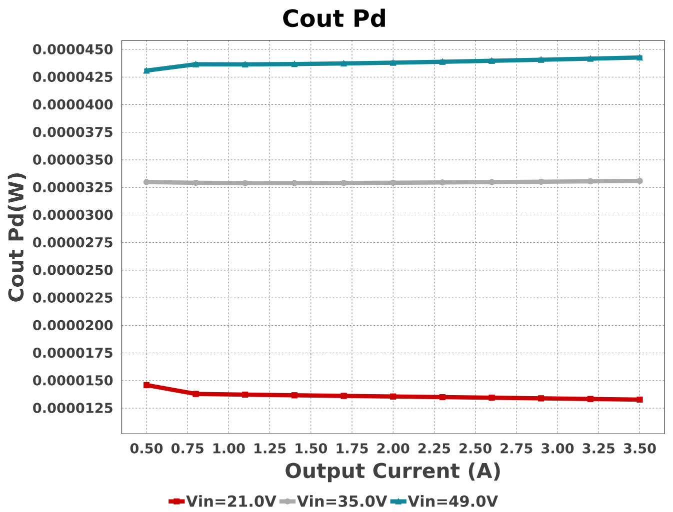

Vin p-p
Vin p-p(V)
Output Current (A)
Vin=21.0V Vin=35.0V Vin=49.0V

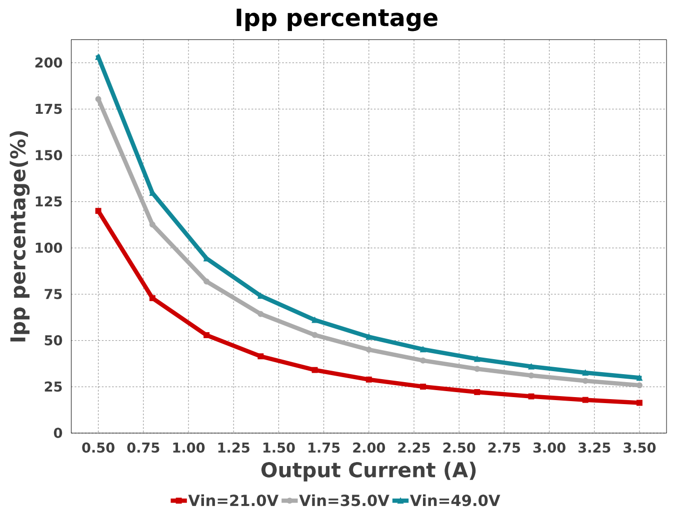

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=21.0V Vin=35.0V Vin=49.0V

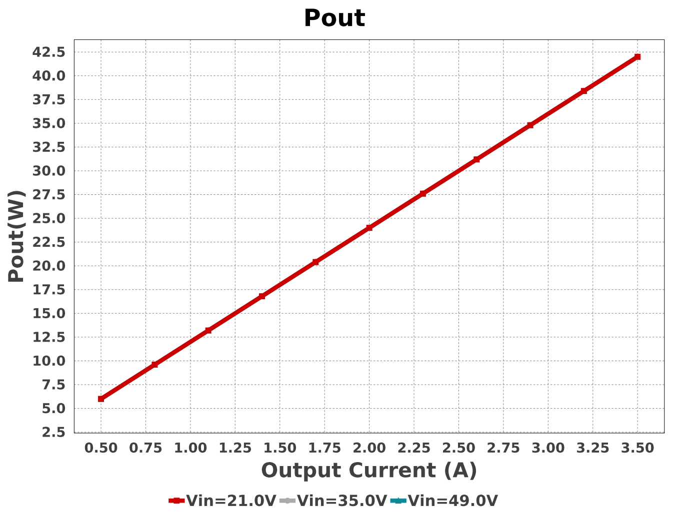

Coutx IRMS
Coutx IRMS(A)
Output Current (A)
Vin=21.0V Vin=35.0V Vin=49.0V

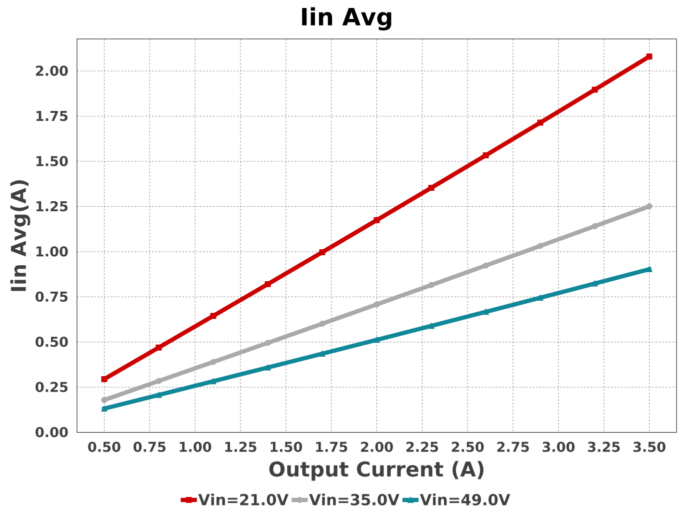

Coutx Pd
Coutx Pd(W)
Output Current (A)
Vin=21.0V Vin=35.0V Vin=49.0V

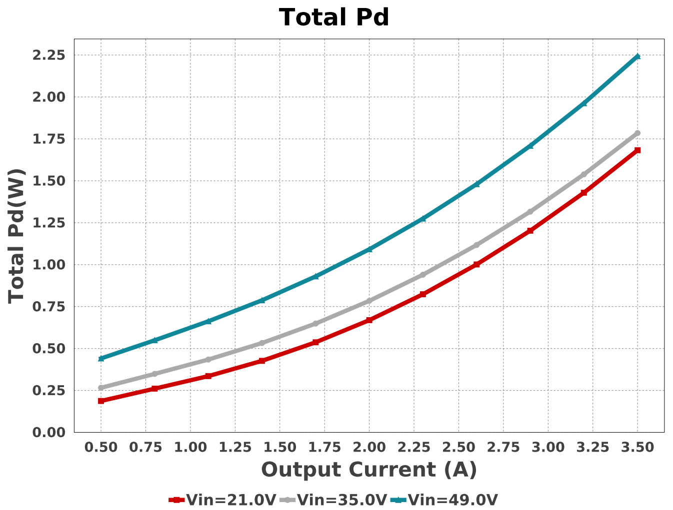

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=21.0V Vin=35.0V Vin=49.0V

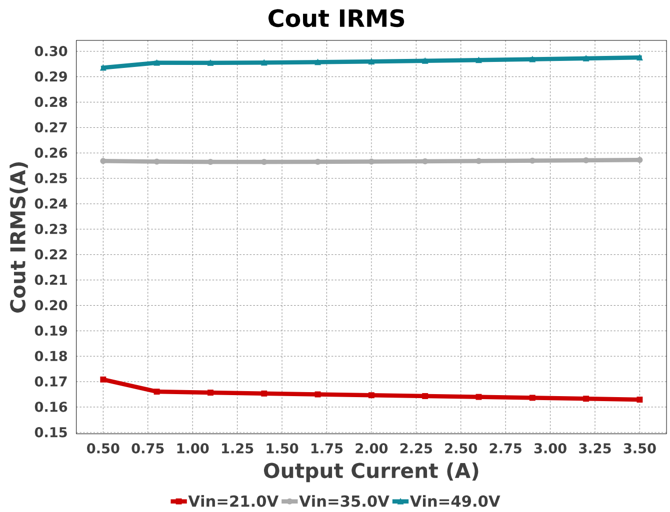

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=21.0V Vin=35.0V Vin=49.0V

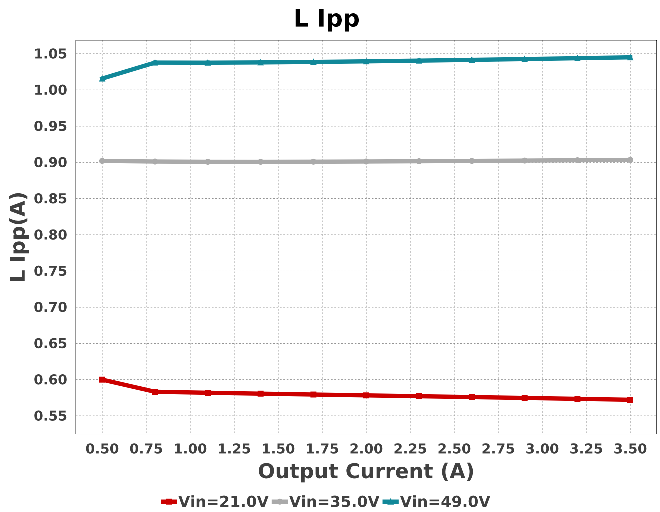

Ipp percentage
Ipp percentage(%)
Output Current (A)
Vin=21.0V Vin=35.0V Vin=49.0V

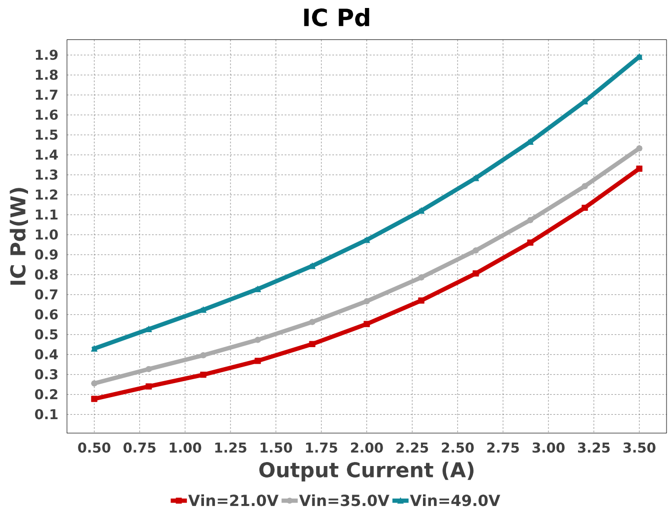

Pout
Pout(W)
Output Current (A)
Vin=21.0V Vin=35.0V Vin=49.0V

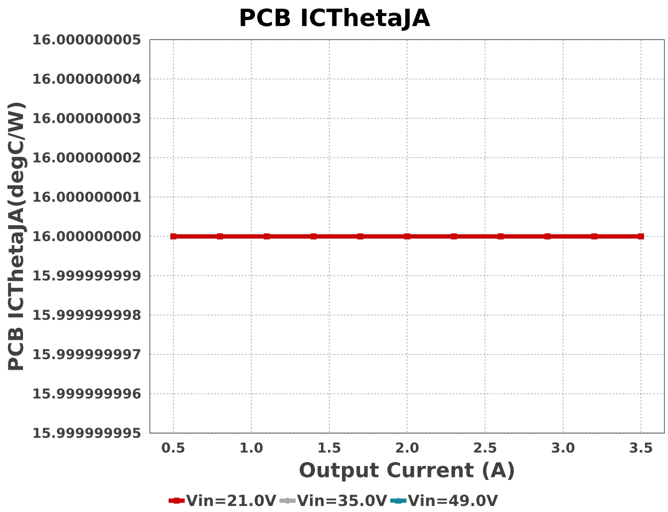

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=21.0V Vin=35.0V Vin=49.0V

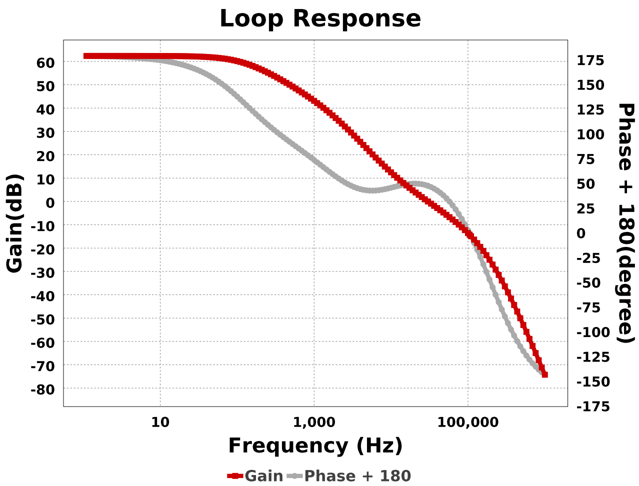

Total Pd
Total Pd(W)
Output Current (A)
Vin=21.0V Vin=35.0V Vin=49.0V




## 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 Ipk | 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. | Iin Avg | 902.92 mA | IC | Average input current |
| 14. | Ipp percentage | 29.859 % | Inductor | Inductor ripple current percentage (with respect to average inductor current) |
| 15. | L Ipp | 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 Information | Bode plot crossover frequency |
| 24. | Duty Cycle | 25.181 % | System Information | Duty cycle |
| 25. | Efficiency | 94.93 % | System Information | Steady state efficiency |
| 26. | FootPrint | 536.0 $mm^2$ | System Information | Total Foot Print Area of BOM components |
| 27. | Frequency | 400.0 kHz | System Information | Switching frequency |
| 28. | Gain Marg | -14.293 dB | System Information | Bode Plot Gain Margin |
| 29. | Iout | 3.5 A | System Information | Iout operating point |
| 30. | Low Freq Gain | 62.356 dB | System Information | Gain at 1Hz |
| 31. | Mode | CCM | System Information | Conduction Mode |
| 32. | Phase Marg | 48.162 deg | System Information | Bode Plot Phase Margin |
| 33. | Pout | 42.0 W | System Information | Total output power |
| 34. | Vin | 49.0 V | System Information | Vin operating point |
| 35. | Vin p-p | 540.305 mV | System Information | Peak-to-peak input voltage |
| 36. | Vout | 12.0 V | System Information | Operational Output Voltage |
| 37. | Vout Actual | 12.001 V | System Information | Vout Actual calculated based on selected voltage divider resistors |
| 38. | Vout Tolerance | 3.787 % | System Information | Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable |
| 39. | Vout p-p | 9.484 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 | 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 |
| Ta | 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

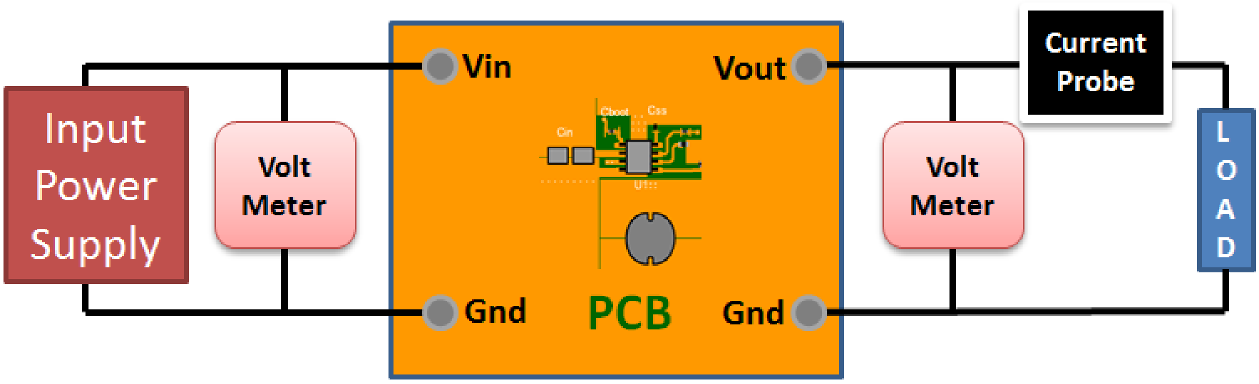
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins.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

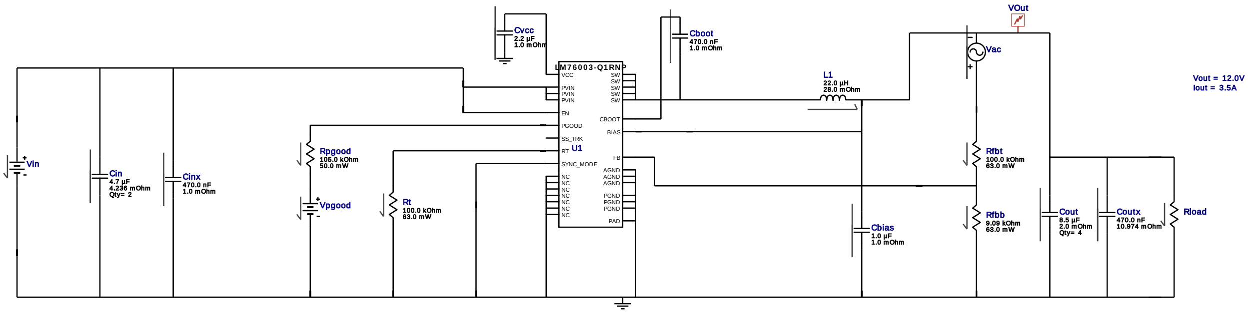


# WEBENCH® Electrical Simulation Report

Design Id = 107

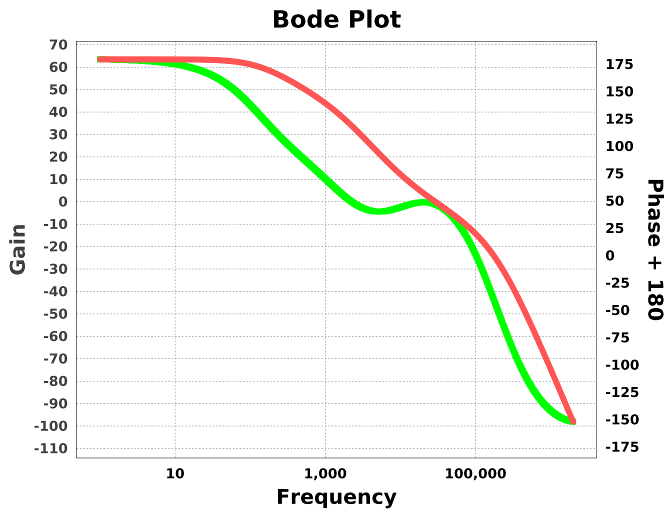
sim_id = 1

Simulation Type = Bode Plot




## Simulation Parameters

| # | Name | Parameter Name | Description | Values |
|---|---|---|---|---|
| 1. | Vpgood | V | Supply voltage | 5 V |
| 2. | Cinj | C | 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 |

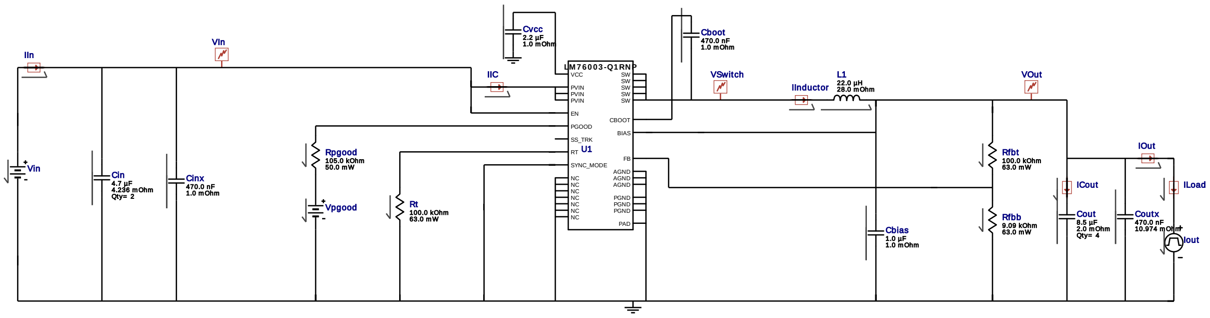


Design Id = 107

sim_id = 2

Simulation Type = Load Transient



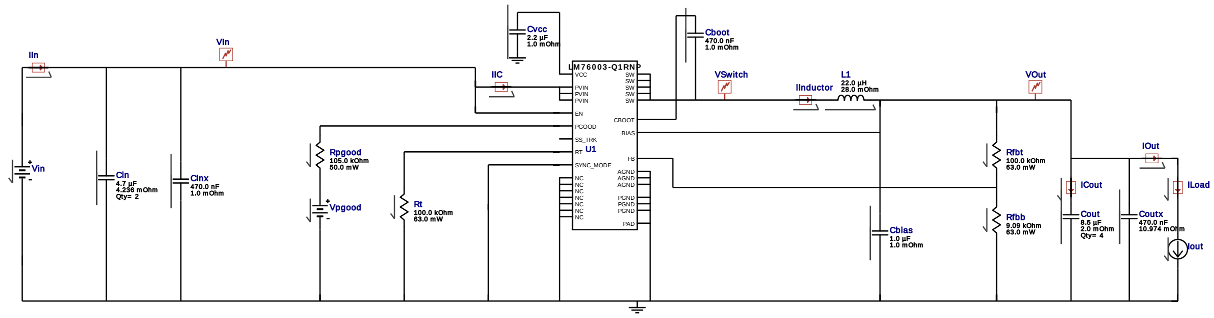

## Simulation Parameters

| # | Name | Parameter Name | Description | Values |
|---|---|---|---|---|
| 1. | Vpgood | V | Pgood voltage | 5 V |
| 2. | L1 | IC | Initial current | -3.5 A |
| 3. | Cboot | IC | Initial voltage | 10 V |
| 4. | Iout | signal_type | Signal Type | PULSE |
| | | I1 | Initial Load Current | 3.5 A |
| | | I2 | Minimum Load Current | 0.35 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 |

Design Id = 107

sim_id = 3

Simulation Type = Steady State




## Simulation Parameters

| # | Name | Parameter Name | Description | Values |
|---|---|---|---|---|
| 1. | Vpgood | V | Pgood Voltage | 5 V |
| 2. | L1 | IC | Initial current | -3.5 A |
| 3. | Cboot | IC | Initial voltage | 10 V |
| 4. | Iout | I | 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.