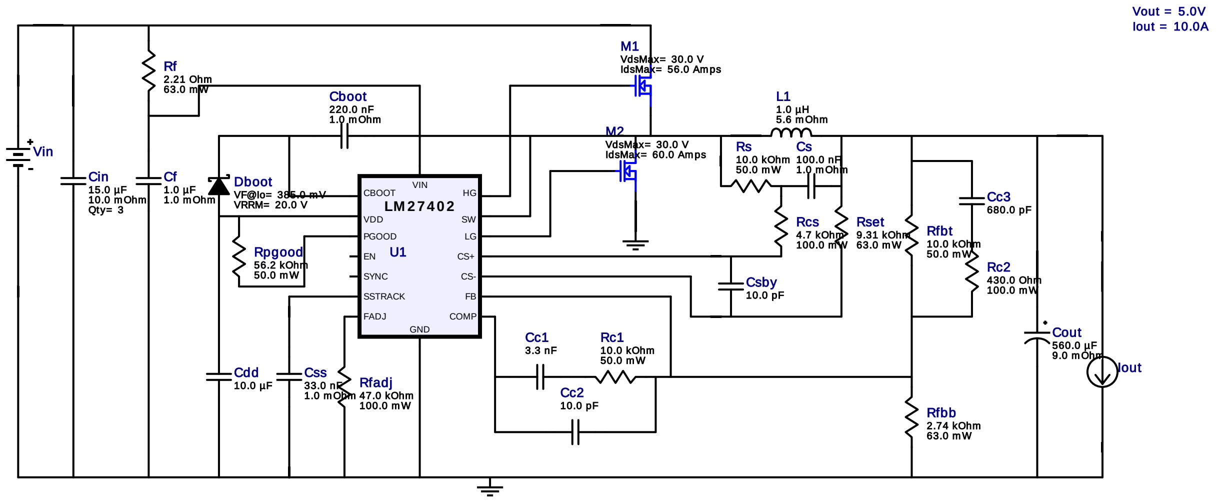
VinMin = 12.0V
VinMax = 20.0V
Vout = 5.0V
Iout = 10.0A

Device = LM27402SQ/NOPB
Topology = Buck
Created = 2023-10-10 06:24:17.958
BOM Cost = $12.14
BOM Count = 28
Total Pd = 3.65W

WEBENCH ® Design Report

Design : 4 LM27402SQ/NOPB
LM27402SQ/NOPB 12V-20V to 5.00V @ 10A



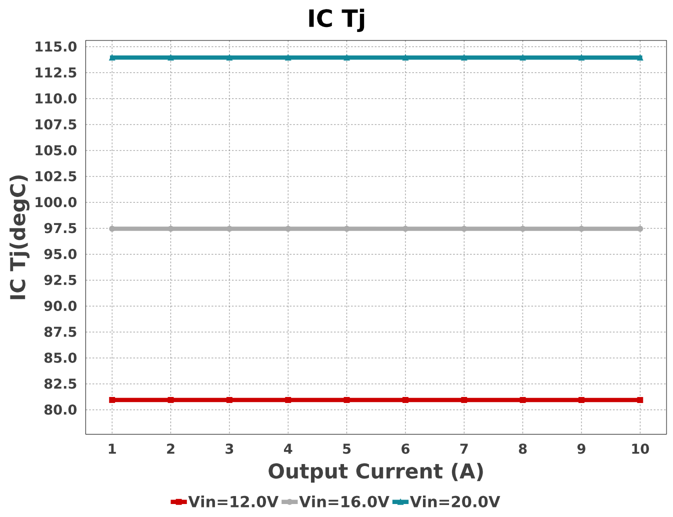
Design Alerts

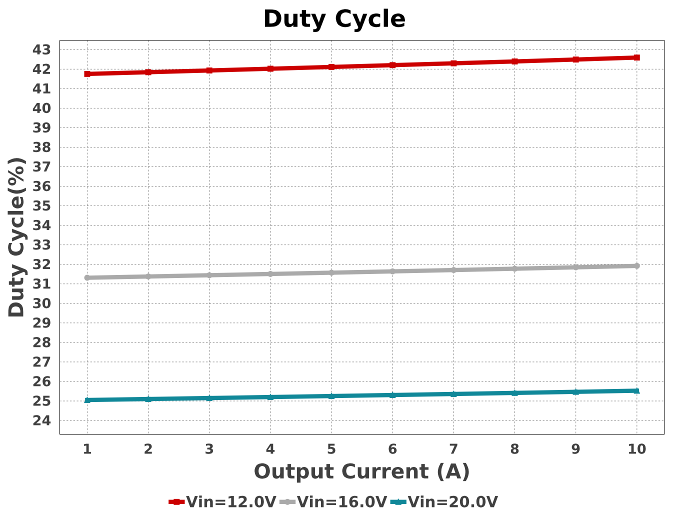
Phase margin is too low
Phase margin: -55.56deg < Specification 35.0deg
This may lead to unstable design. Please click 'APPLY' to auto-recompensate or change your design.

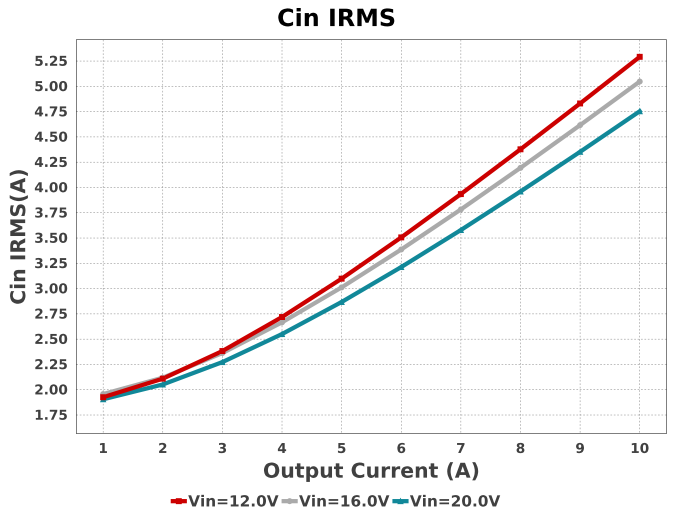
Electrical BOM

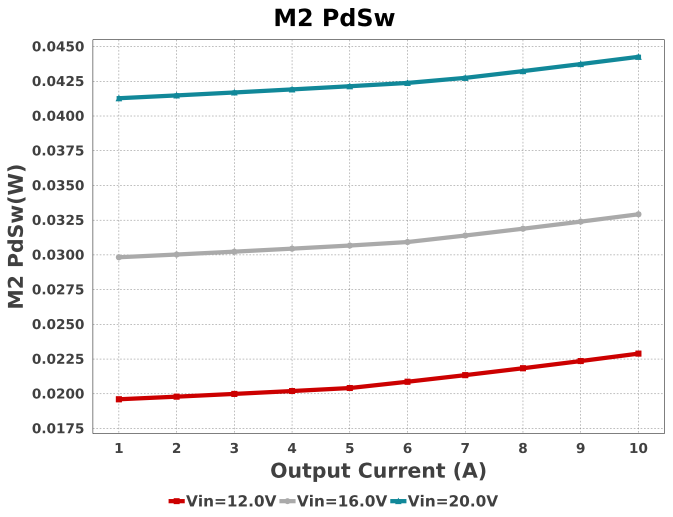
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM188R61C224KA88D Series= X5R	Cap= 220.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.03	0603 5 mm²
Cc1	Samsung Electro-Mechanics	CL21C332JBFNNNE Series= C0G/NP0	Cap= 3.3 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.04	0805 7 mm²
Cc2	Yageo	CC0805JRNPO9BN100 Series= C0G/NP0	Cap= 10.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²
Cc3	Samsung Electro-Mechanics	CL05C681JB5NNNC Series= C0G/NP0	Cap= 680.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cdd	MuRata	KCM55QR71J106KH01K Series= X7R	Cap= 10.0 uF VDC= 63.0 V IRMS= 0.0 A	1	$1.65	KCM55Q 59 mm²
Cf	Taiyo Yuden	TMK212BJ105KG-T Series= X5R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.03	0805 7 mm²
Cin	MuRata	KCM55WR72A156MH01K Series= X7R	Cap= 15.0 uF ESR= 10.0 mOhm VDC= 100.0 V IRMS= 0.0 A	3	$2.43	KCM55W 59 mm²

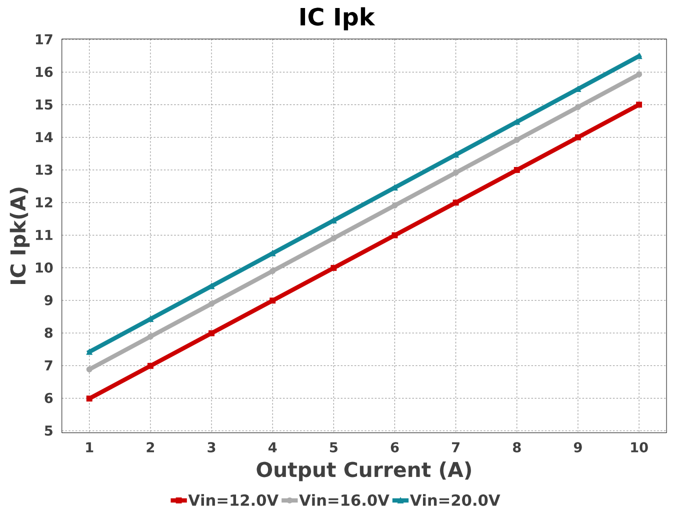
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cout	Chemi-Con	APXF6R3ARA561MH80G Series= PXF	Cap= 560.0 uF ESR= 9.0 mOhm VDC= 6.3 V IRMS= 4.5 A	1	$0.44	CAPSMT_62_H80 106 mm^2
Cs	MuRata	GRM155R71C104KA88D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Csby	MuRata	GRM0335C1E100JA01D Series= C0G/NP0	Cap= 10.0 pF VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0201 2 mm^2
Css	MuRata	GRM216R71E333KA01D Series= X7R	Cap= 33.0 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2
Dboot	Comchip Technology	CDBK0520L-HF	VF@Io= 385.0 mV VRRM= 20.0 V	1	$0.07	SOD-123F 12 mm^2
L1	Coilcraft	XAL6030-102MEB	L= 1.0 µH 5.6 mOhm	1	$0.65	XAL6030 72 mm^2
M1	Texas Instruments	CSD17304Q3	VdsMax= 30.0 V IdsMax= 56.0 Amps	1	$0.25	DQG0008A 18 mm^2
M2	Texas Instruments	CSD17575Q3	VdsMax= 30.0 V IdsMax= 60.0 Amps	1	$0.31	DQG0008A 18 mm^2
Rc1	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rc2	Yageo	RC0603FR-07430RL Series= ?	Res= 430.0 Ohm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rcs	Yageo	RC0603FR-074K7L Series= ?	Res= 4.7 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rf	Vishay-Dale	CRCW04022R21FKED Series= CRCW..e3	Res= 2.21 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfadj	Yageo	RC0603FR-0747KL Series= ?	Res= 47.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rfbb	Vishay-Dale	CRCW04022K74FKED Series= CRCW..e3	Res= 2.74 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rpgood	Yageo	RC0201FR-0756K2L Series= ?	Res= 56.2 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rs	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rset	Vishay-Dale	CRCW04029K31FKED Series= CRCW..e3	Res= 9.31 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
U1	Texas Instruments	LM27402SQ/NOPB	Switcher	1	$1.22	SQB16A 25 mm^2

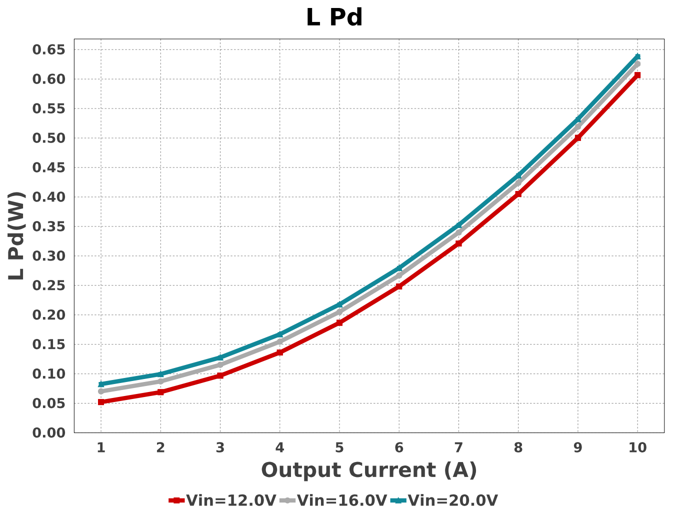

IC Tj
IC Tj(degC)
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V

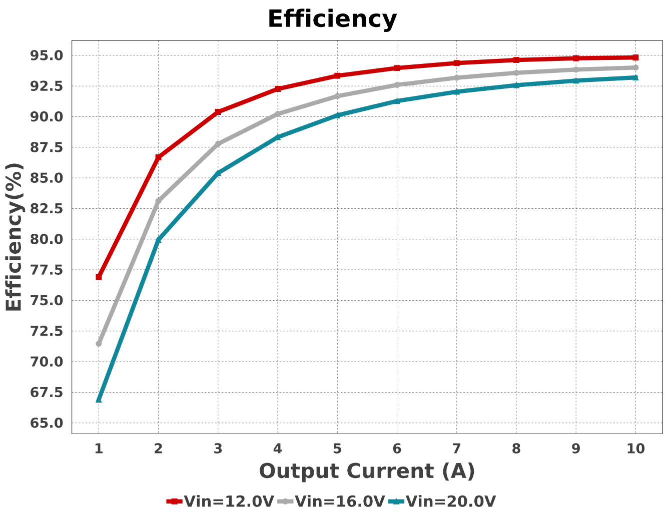

Duty Cycle
Duty Cycle(%)
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V

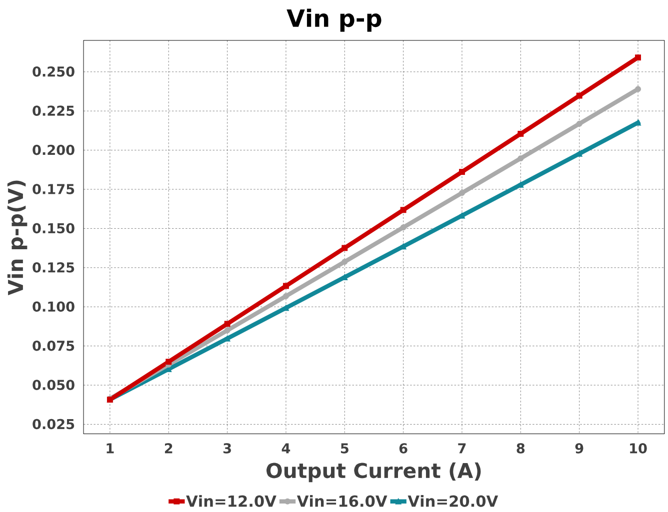

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V

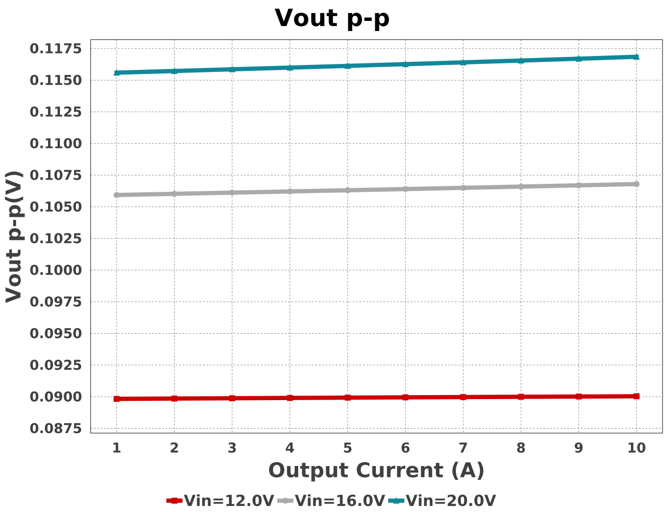

M2 PdSw
M2 PdSw(W)
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V

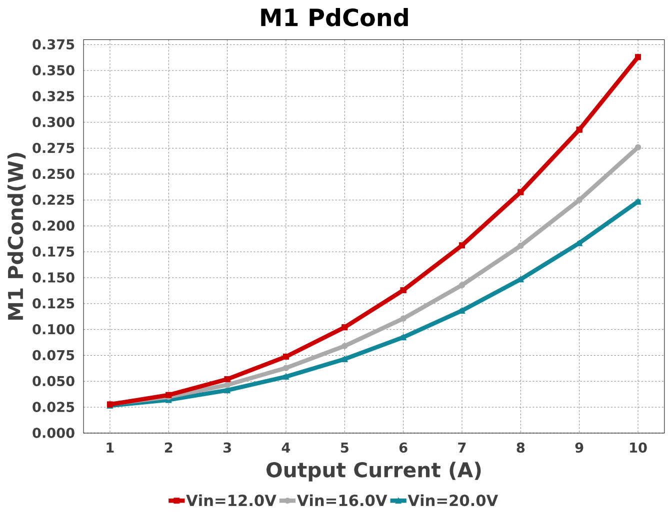

IC Ipk
IC Ipk(A)
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V

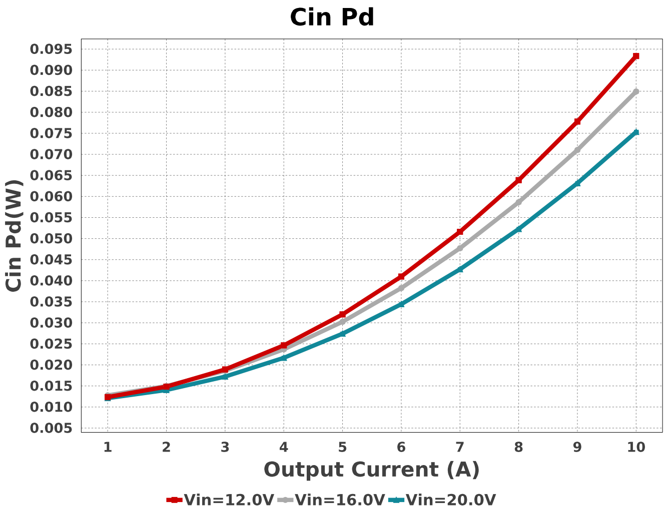

L Pd
L Pd(W)
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V

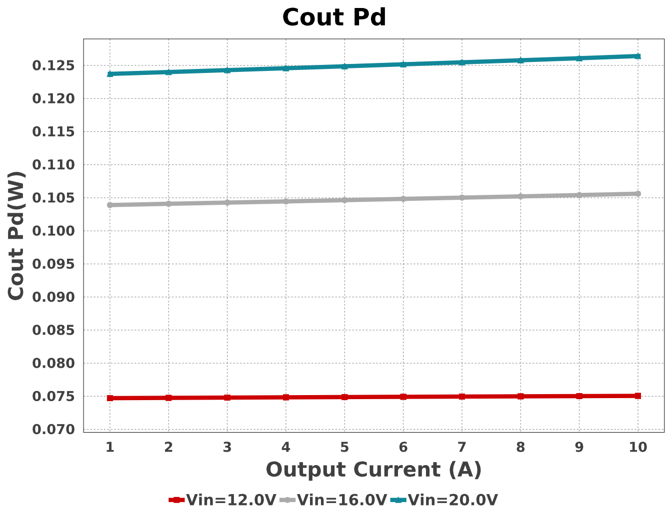

Efficiency
Efficiency(%)
95.0
92.5
90.0
87.5
85.0
82.5
80.0
77.5
75.0
72.5
70.0
67.5
65.0
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V

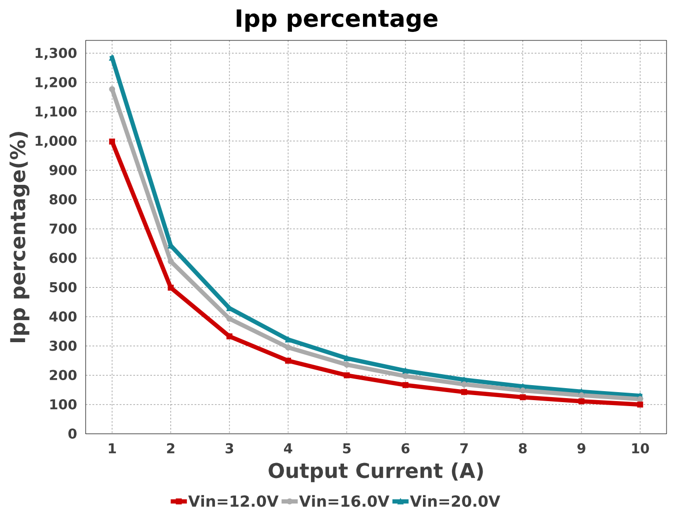

Vin p-p
Vin p-p(V)
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V

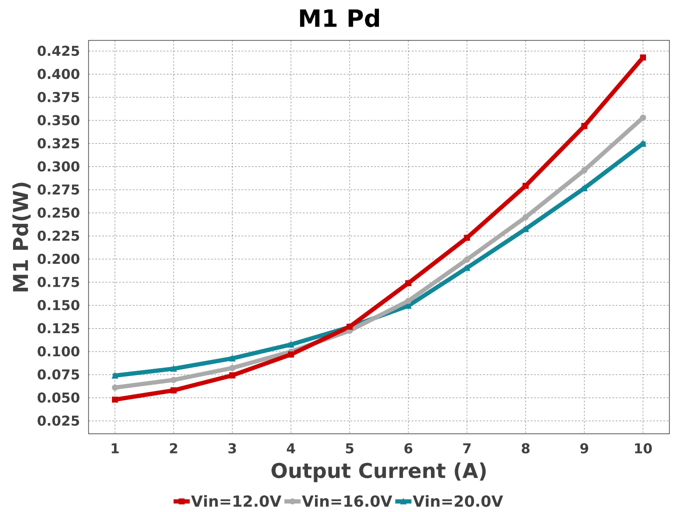

Vout p-p
Vout p-p(V)
0.1175
0.1150
0.1125
0.1100
0.1075
0.1050
0.1025
0.1000
0.0975
0.0950
0.0925
0.0900
0.0875
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V

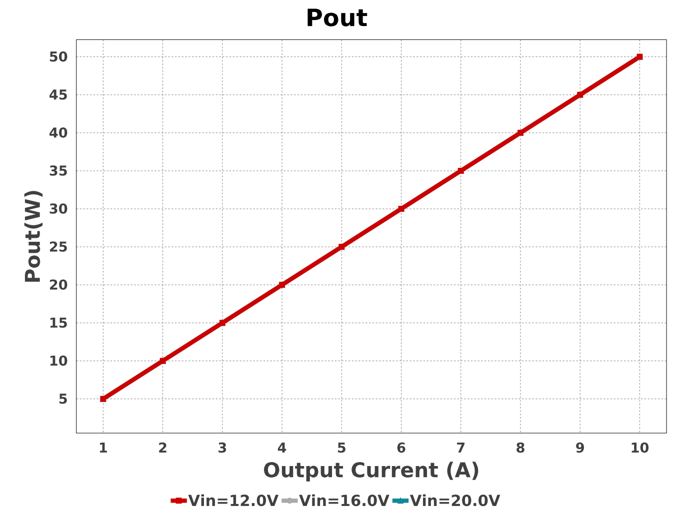

M1 PdCond
M1 PdCond(W)
0.375
0.350
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V

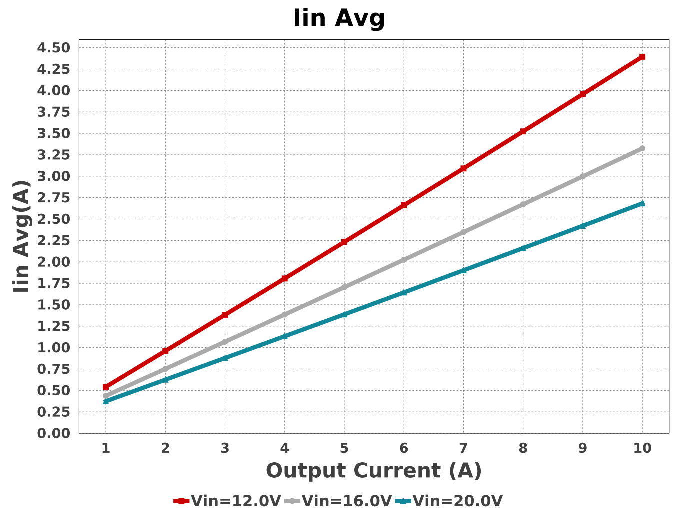

Cin Pd
Cin Pd(W)
0.095
0.090
0.085
0.080
0.075
0.070
0.065
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V

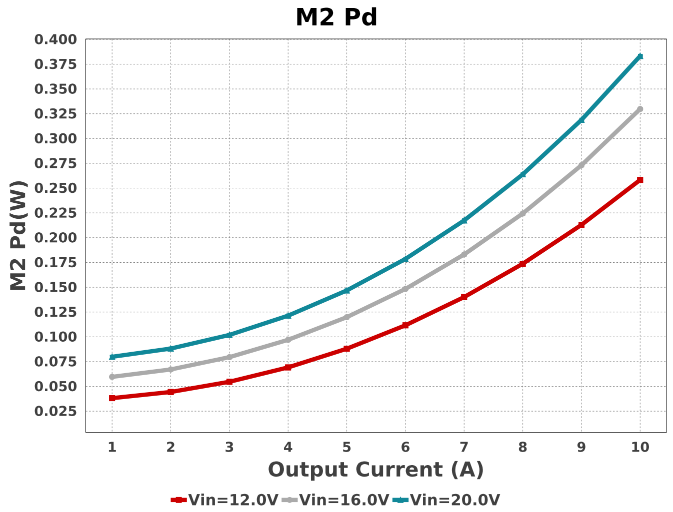

Cout Pd
Cout Pd(W)
0.125
0.120
0.115
0.110
0.105
0.100
0.095
0.090
0.085
0.080
0.075
0.070
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V

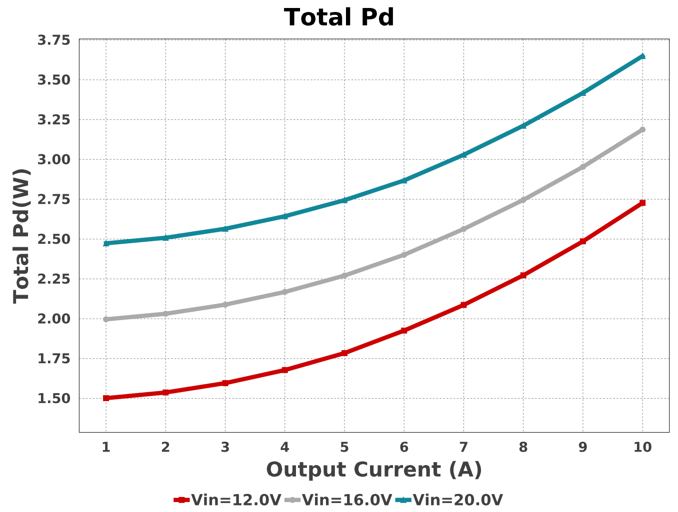

Ipp percentage
Ipp percentage(%)
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V


M1 Pd
M1 Pd(W)
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V

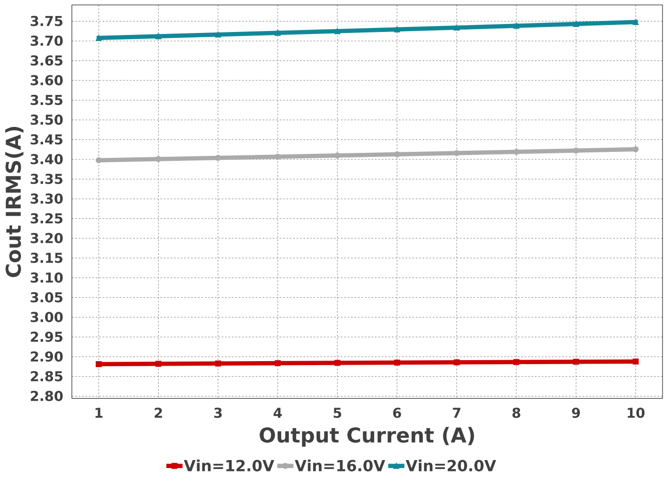

Pout
Pout(W)
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V


Iin Avg
Iin Avg(A)
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V

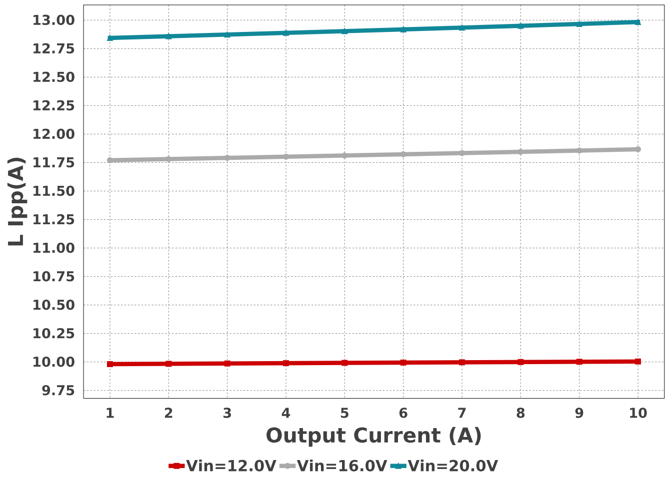

M2 Pd
M2 Pd(W)
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V


Total Pd
Total Pd(W)
Output Current (A)
Vin=12.0V Vin=16.0V Vin=20.0V

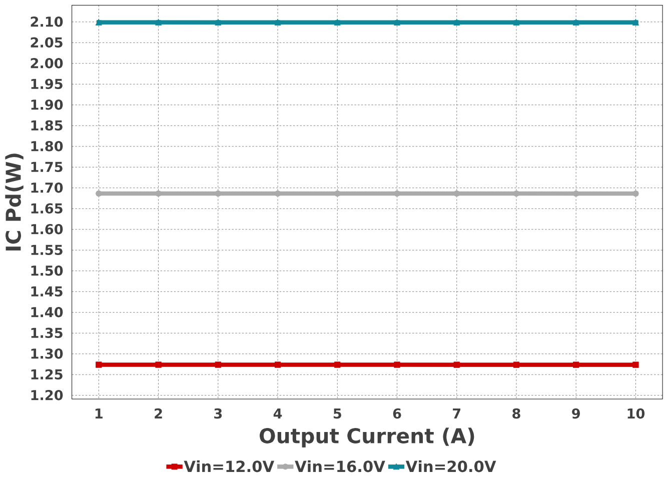
Cout IRMS



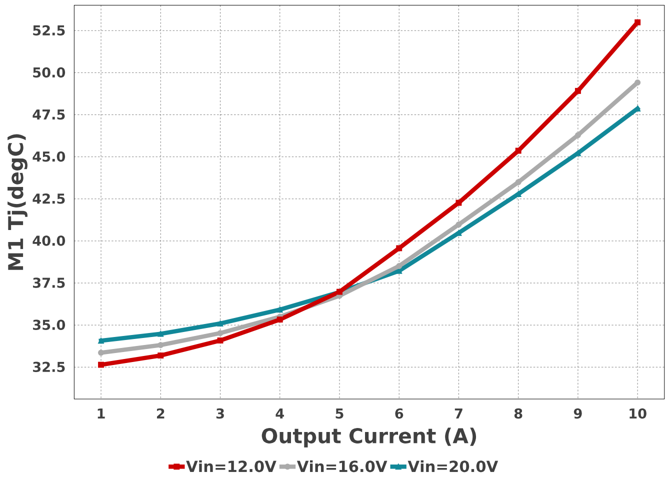
L Ipp



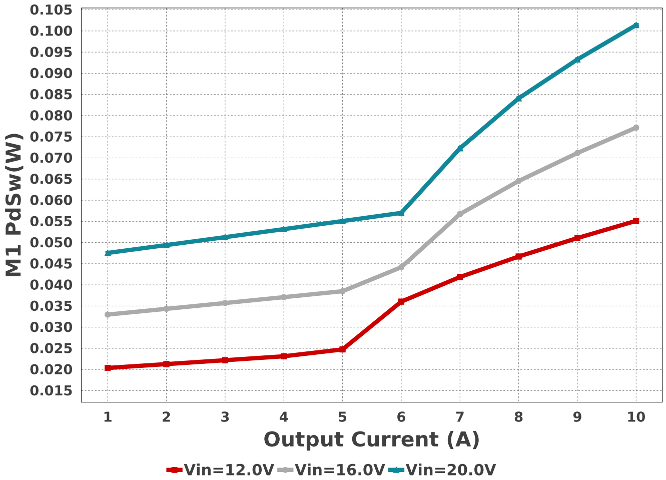
IC Pd



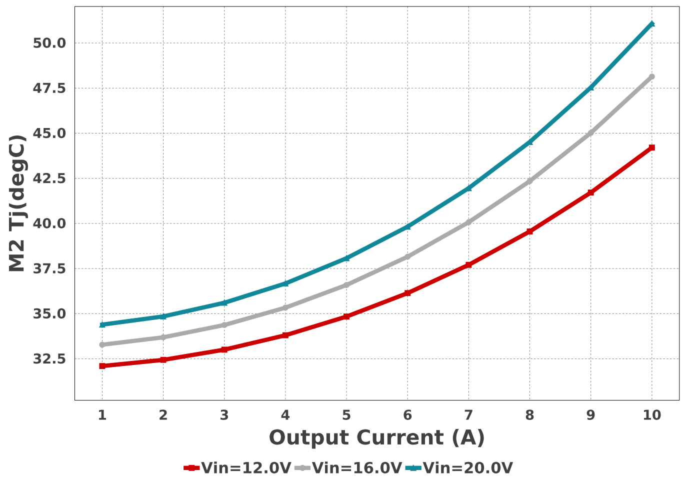
M1 Tj

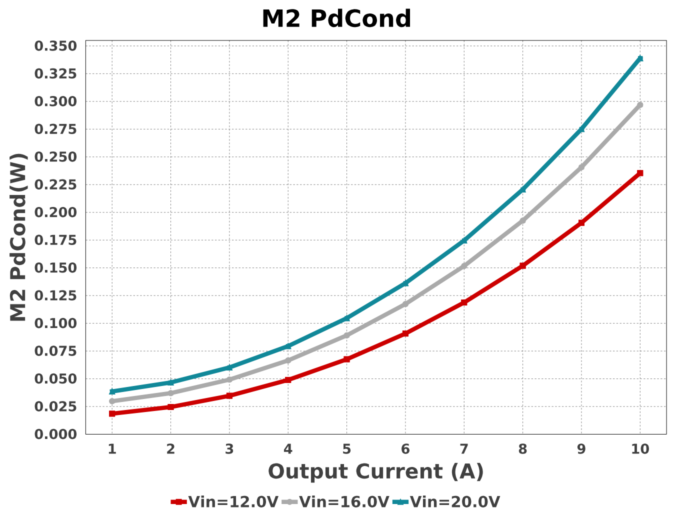


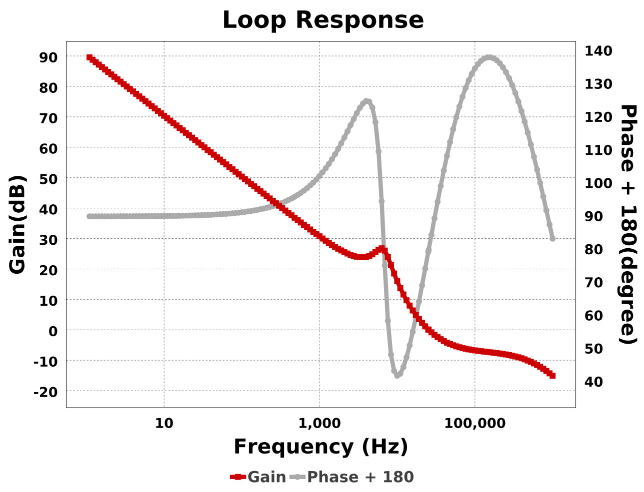
M1 PdSw



M2 Tj







Operating Values

#	Name	Value	Category	Description
1.	BOM Count	28		Total Design BOM count
2.	Total BOM	$12.139		Total BOM Cost
3.	Cin IRMS	4.754 A	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	75.321 mW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	3.748 A	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	126.42 mW	Capacitor	Output capacitor power dissipation
7.	IC Ipk	16.492 A	IC	Peak switch current in IC
8.	IC Pd	2.099 W	IC	IC power dissipation
9.	IC Tj	113.955 degC	IC	IC junction temperature
10.	IC Tolerance	6.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA	40.0 degC/W	IC	IC junction-to-ambient thermal resistance
12.	Iin Avg	2.682 A	IC	Average input current
13.	Ipp percentage	129.832 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
14.	L Ipp	12.983 A	Inductor	Peak-to-peak inductor ripple current
15.	L Pd	638.66 mW	Inductor	Inductor power dissipation
16.	M1 Pd	324.88 mW	Mosfet	M1 MOSFET total power dissipation
17.	M1 PdCond	223.5 mW	Mosfet	M1 MOSFET conduction losses
18.	M1 PdSw	101.38 mW	Mosfet	M1 MOSFET switching losses
19.	M1 Tj	47.869 degC	Mosfet	M1 MOSFET junction temperature
20.	M2 Pd	383.2 mW	Mosfet	M2 MOSFET total power dissipation
21.	M2 PdCond	338.94 mW	Mosfet	M2 MOSFET conduction losses
22.	M2 PdSw	44.261 mW	Mosfet	M2 MOSFET switching losses
23.	M2 Tj	51.076 degC	Mosfet	M2 MOSFET junction temperature
24.	Cin Pd	75.321 mW	Power	Input capacitor power dissipation
25.	Cout Pd	126.42 mW	Power	Output capacitor power dissipation
26.	IC Pd	2.099 W	Power	IC power dissipation
27.	L Pd	638.66 mW	Power	Inductor power dissipation
28.	M1 Pd	324.88 mW	Power	M1 MOSFET total power dissipation
29.	M1 PdCond	223.5 mW	Power	M1 MOSFET conduction losses
30.	M1 PdSw	101.38 mW	Power	M1 MOSFET switching losses
31.	M2 Pd	383.2 mW	Power	M2 MOSFET total power dissipation
32.	M2 PdCond	338.94 mW	Power	M2 MOSFET conduction losses
33.	M2 PdSw	44.261 mW	Power	M2 MOSFET switching losses
34.	Total Pd	3.649 W	Power	Total Power Dissipation
35.	Cross Freq	25.413 kHz	System Information	Bode plot crossover frequency
36.	Duty Cycle	25.527 %	System Information	Duty cycle
37.	Efficiency	93.198 %	System Information	Steady state efficiency
38.	FootPrint	559.0 mm^2	System Information	Total Foot Print Area of BOM components
39.	Frequency	292.308 kHz	System Information	Switching frequency
40.	Gain Marg	-27.28 dB	System Information	Bode Plot Gain Margin
41.	Iout	10.0 A	System Information	Iout operating point
42.	Low Freq Gain	89.548 dB	System Information	Gain at 1Hz

#	Name	Value	Category	Description
43.	Mode	CCM	System Information	Conduction Mode
44.	Phase Marg	79.939 deg	System Information	Bode Plot Phase Margin
45.	Pout	50.0 W	System Information	Total output power
46.	Vin	20.0 V	System Information	Vin operating point
47.	Vin p-p	217.562 mV	System Information	Peak-to-peak input voltage
48.	Vout	5.0 V	System Information	Operational Output Voltage
49.	Vout Actual	2.79 V	System Information	Vout Actual calculated based on selected voltage divider resistors
50.	Vout Tolerance	2.602 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
51.	Vout p-p	116.849 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	10.0	Maximum Output Current
VinMax	20.0	Maximum input voltage
VinMin	12.0	Minimum input voltage
Vout	5.0	Output Voltage
base_pn	LM27402	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

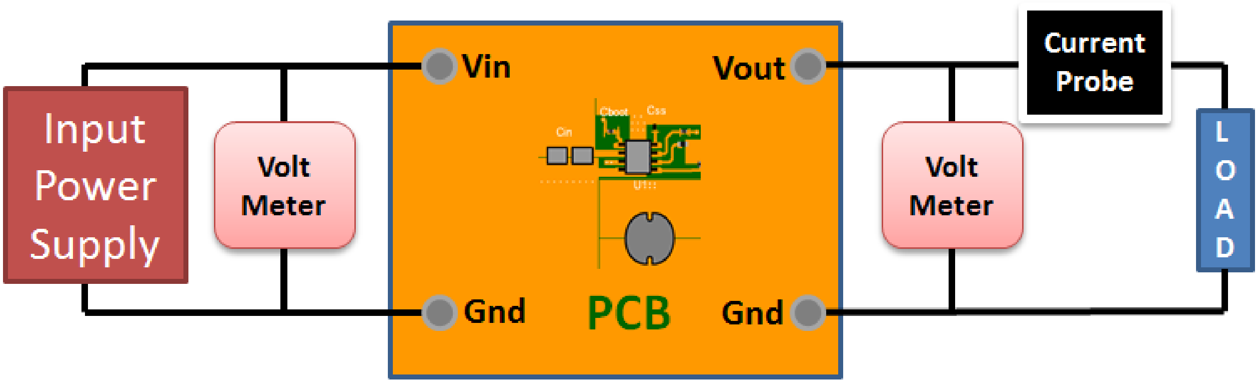
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 12.0V 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.

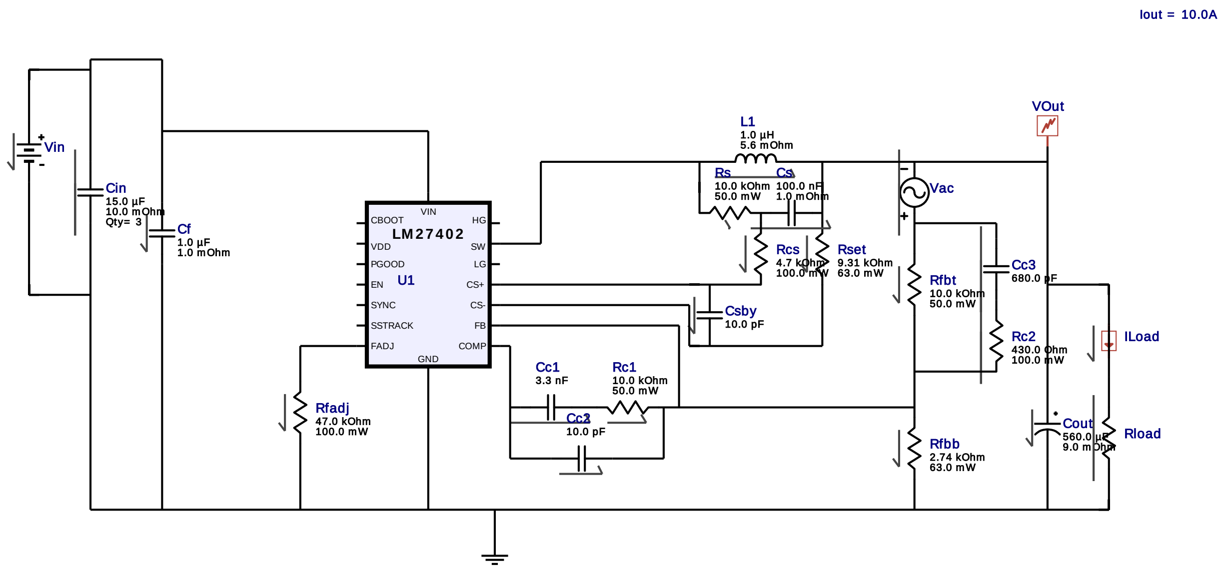


WEBENCH® Electrical Simulation Report

Design Id = 4

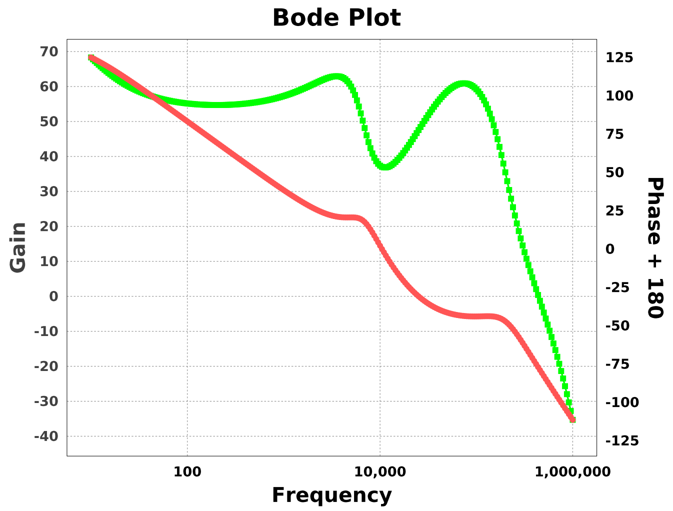
sim_id = 2

Simulation Type = Bode Plot



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Cinj	C	Injection Isolation Capacitance	100 F
2.	Linj	L	Injection Isolation Inductance	100 H
3.	Vinj	AC	AC Voltage Source Amplitude	1 V
4.	Rload	R	Load Resistance	0.5 Ohm



Design Assistance

1. Tip: LM27402 High Current PCB Layout Design Guidance For higher current designs, please take care in designing the PCB layout. Consider good thermal management practices and proper routing of traces. Please see the following for more guidelines. Best Layout Practices for Switching Power Supplies http://sva.ti.com/assets/en/appnotes/national_power_designer114.pdf SIMPLE SWITCHER Layout Guidelines http://www.ti.com/lit/an/snva054c/snva054c.pdf Thermal Design by Insight, not Hindsight http://www.ti.com/lit/an/snva419c/snva419c.pdf

2. General Description: The LM27402 is a synchronous voltage mode buck controller with inductor DCR current sense capability. Sensing the inductor current eliminates the need to add resistive powertrain elements which increases overall efficiency and allows for accurate continuous current limit sensing. A 0.6V +/-1% voltage reference permits high accuracy and low voltage capability at the output. An operating voltage range

of 3V to 20V makes the LM27402 suitable for a large variety of input rails. The LM27402 voltage mode control loop incorporates input voltage feed-forward to maintain stability throughout the entire input voltage range. The switching frequency is adjustable from 200 kHz to 1.2 MHz allowing a flexible design space. A power good indicator provides power rail sequencing capability and output fault detection. Programmable external softstart capability limits inrush current and provides monotonic output control at startup. Other features include external tracking of other power supplies, integrated LDO bias supply, and synchronization capability.

3. General Description: The LM27402 is offered in a 16 pin eTSSOP package and a 4mm x 4mm 16 pin exposed LLP.

4. Master key : 3AE7B0111CD2919F[v1]

5. **LM27402** Product Folder : http://www.ti.com/product/LM27402 : contains the data sheet and other resources.