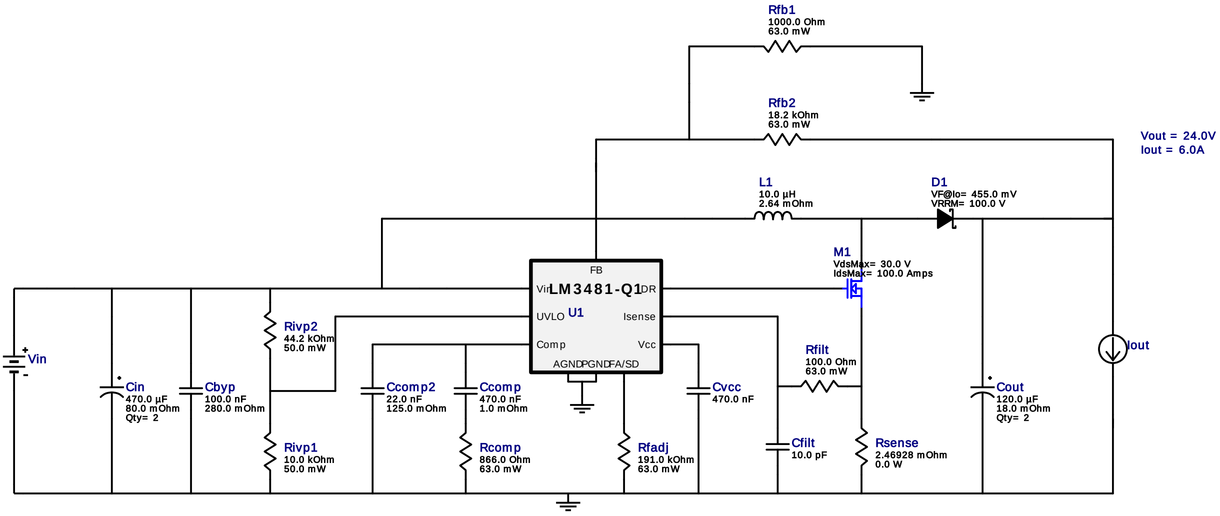
TEXAS INSTRUMENTS

WEBENCH® Design Report

VinMin = 8.0V
VinMax = 16.0V
Vout = 24.0V
Iout = 6.0A

Device = LM3481QMM/NOPB
Topology = Boost
Created = 2024-08-21 20:30:52.066
BOM Cost = NA
BOM Count = 21
Total Pd = 5.27W

Design : 86 LM3481QMM/NOPB
LM3481QMM/NOPB 8V-16V to 24.00V @ 6A



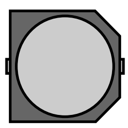
Design Alerts

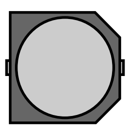
Component Selection Information

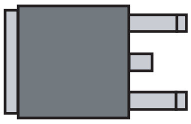
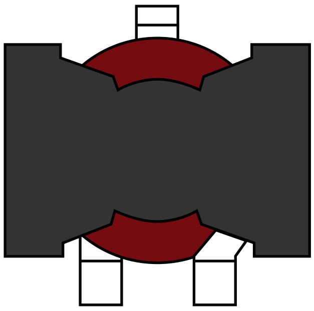
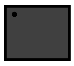
The LM3481-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application.

Electrical BOM

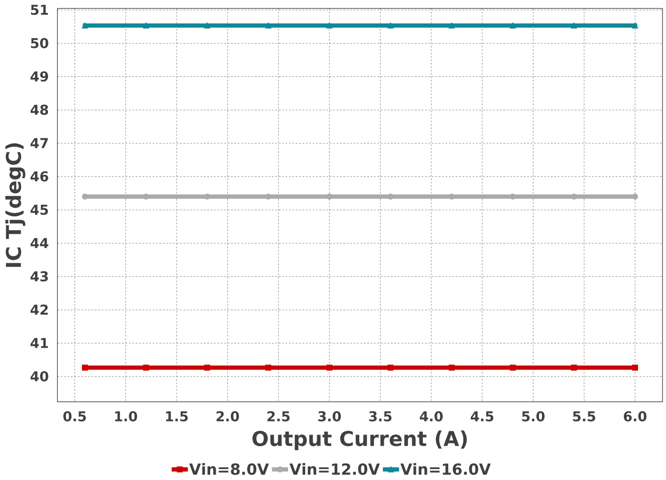
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbyp	AVX	08053C104KAT2A Series= X7R	Cap= 100.0 nF ESR= 280.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Ccomp	Taiyo Yuden	TMK212BJ474KD-T Series= X5R	Cap= 470.0 nF ESR= 1.0 mOhm VDC= 20.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2
Ccomp2	Kemet	C0805C223K5RACTU Series= X7R	Cap= 22.0 nF ESR= 125.0 mOhm VDC= 50.0 V IRMS= 645.0 mA	1	$0.01	0805 7 mm^2
Cfilt	Yageo	CC0805JRNPO9BN100 Series= C0G/NP0	Cap= 10.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Cin	Chemi-Con	EMZA250ADA471MJA0G Series= MZA	Cap= 470.0 uF ESR= 80.0 mOhm VDC= 25.0 V IRMS= 850.0 mA	2	$0.45	CAPSMT_62_JA0 151 mm^2
Cout	Panasonic	35SVPF120M Series= SVPF	Cap= 120.0 uF ESR= 18.0 mOhm VDC= 35.0 V IRMS= 4.4 A	2	$1.33	CAPSMT_62_F12 151 mm^2



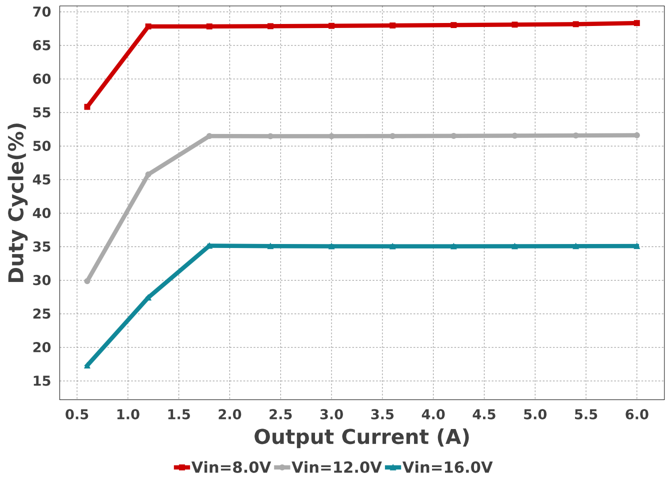


Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cvcc	Panasonic	ECPU1C474MA5 Series= ECPU(A)	Cap= 470.0 nF VDC= 16.0 V IRMS= 0.0 A	1	\$0.27	1206 11 mm^2
D1	STMicroelectronics	STPS20M100SG-TR	VF@Io= 455.0 mV VRRM= 100.0 V	1	\$1.94	 DDPAK 210 mm^2
L1	Wurth Elektronik	7443641000	L= 10.0 µH 2.64 mOhm	1	\$7.28	 WE-HCF_2818 656 mm^2
M1	Texas Instruments	CSD17303Q5	VdsMax= 30.0 V IdsMax= 100.0 Amps	1	\$0.56	 TRANS_NexFET_Q5 55 mm^2
Rcomp	Vishay-Dale	CRCW0402866RFKED Series= CRCW..e3	Res= 866.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	0402 3 mm^2
Rfadj	Vishay-Dale	CRCW0402191KFKED Series= CRCW..e3	Res= 191.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	0402 3 mm^2
Rfb1	Vishay-Dale	CRCW04021K00FKED Series= CRCW..e3	Res= 1000.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	0402 3 mm^2
Rfb2	Vishay-Dale	CRCW040218K2FKED Series= CRCW..e3	Res= 18.2 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	0402 3 mm^2
Rfilt	Vishay-Dale	CRCW0402100RFKED Series= CRCW..e3	Res= 100.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	0402 3 mm^2
Rivp1	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	\$0.01	0201 2 mm^2
Rivp2	Vishay-Dale	CRCW020144K2FNED Series= ?	Res= 44.2 kOhm Power= 50.0 mW Tolerance= 1.0%	1	\$0.01	0201 2 mm^2
Rsense	CUSTOM	CUSTOM Series= ?	Res= 2.46928 mOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm^2
U1	Texas Instruments	LM3481QMM/NOPB	Switcher	1	\$0.83	 MUB10A 24 mm^2

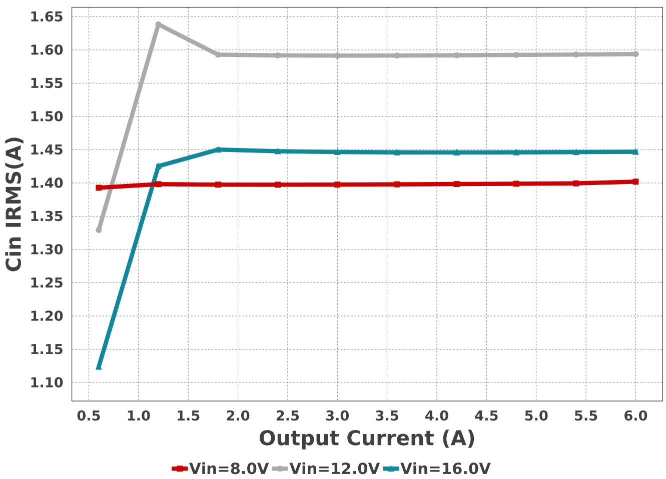
IC Tj



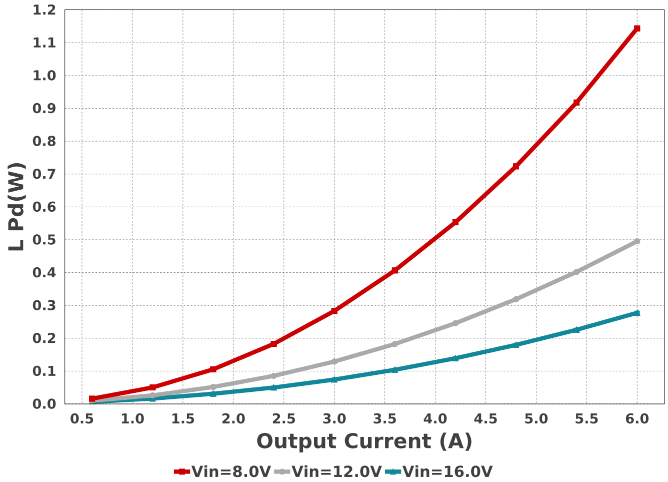
Duty Cycle



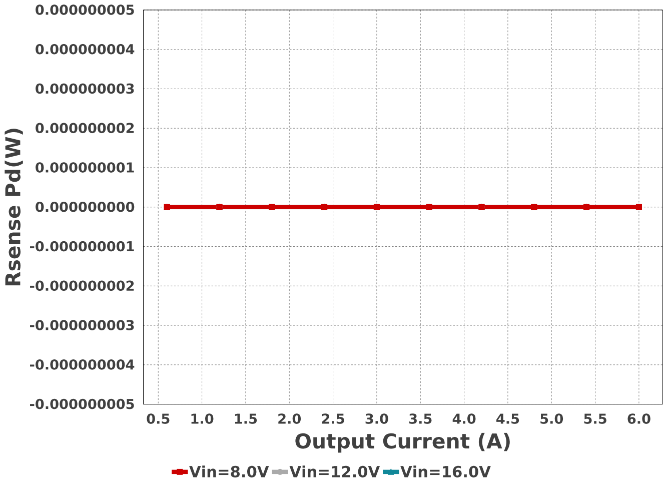
Cin IRMS



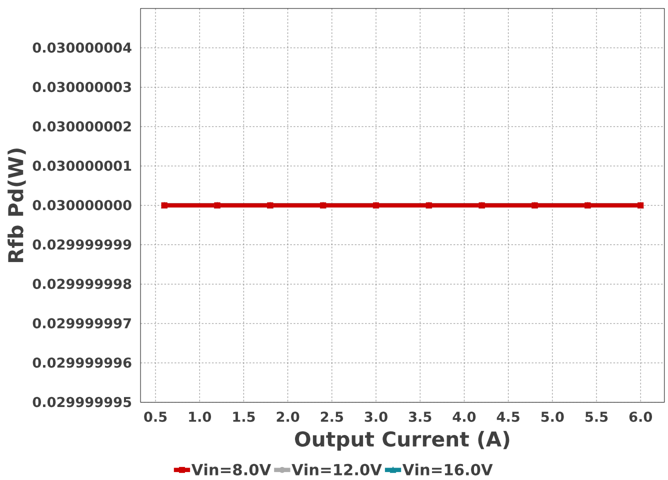
L Pd

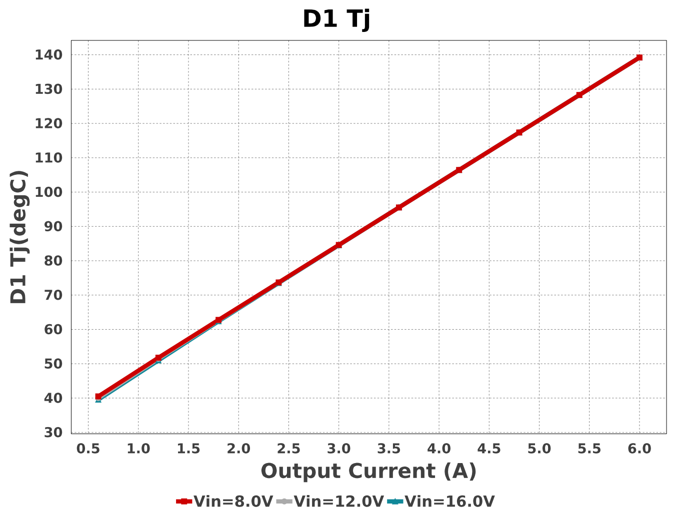


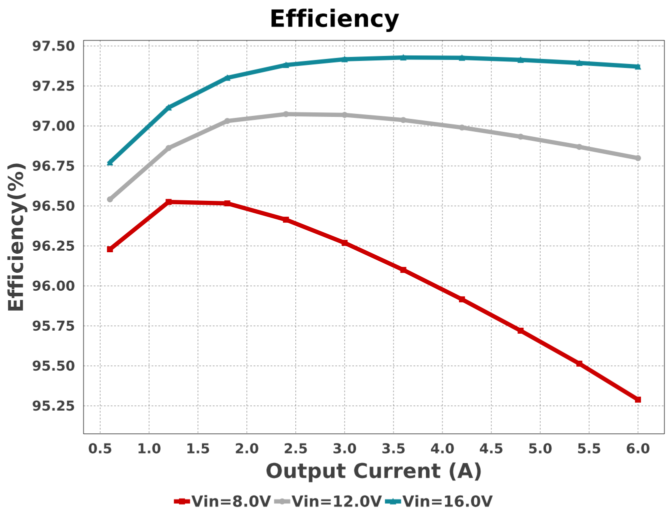
Rsense Pd

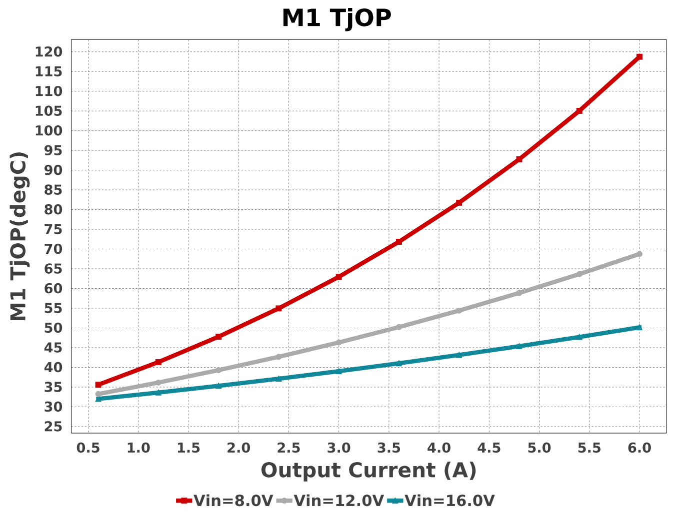


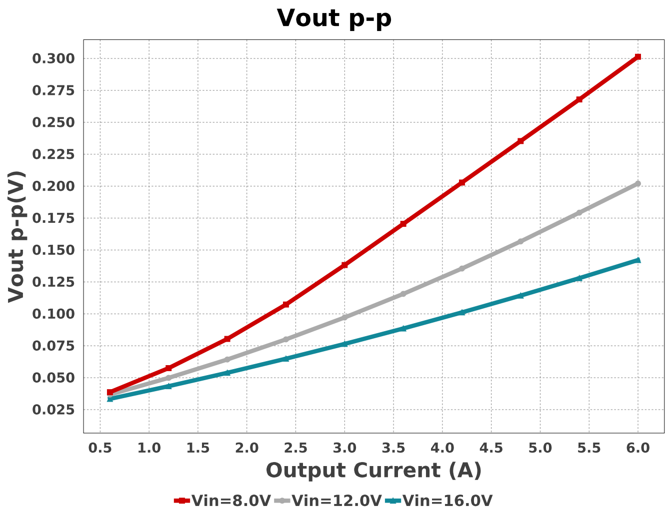
Rfb Pd

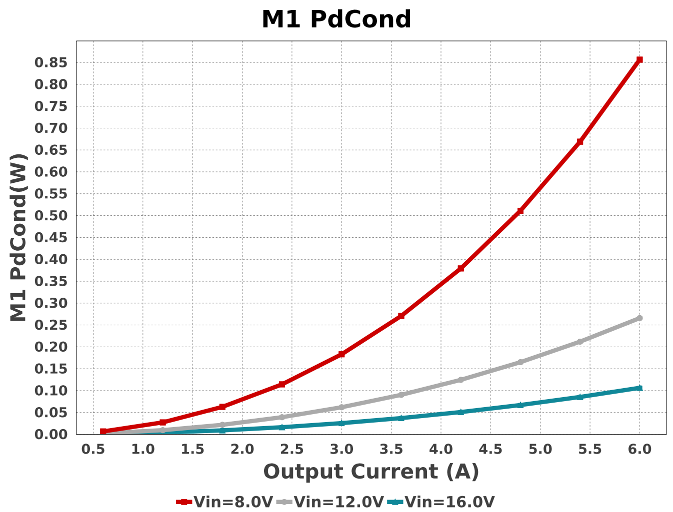


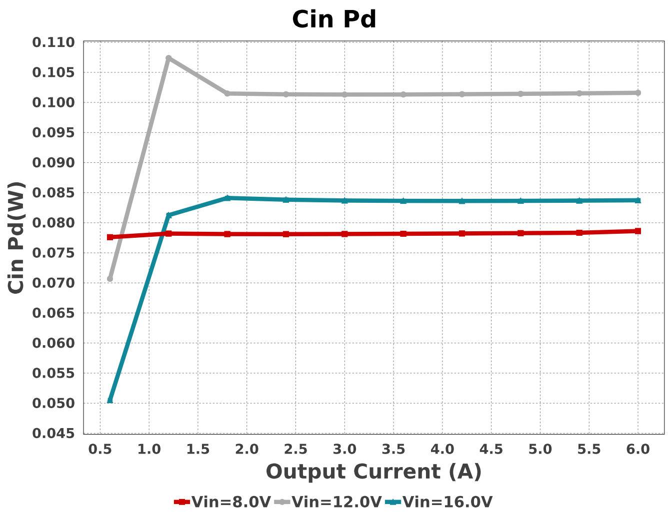

D1 Tj
D1 Tj(degC)
140
130
120
110
100
90
80
70
60
50
40
30
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=8.0V Vin=12.0V Vin=16.0V

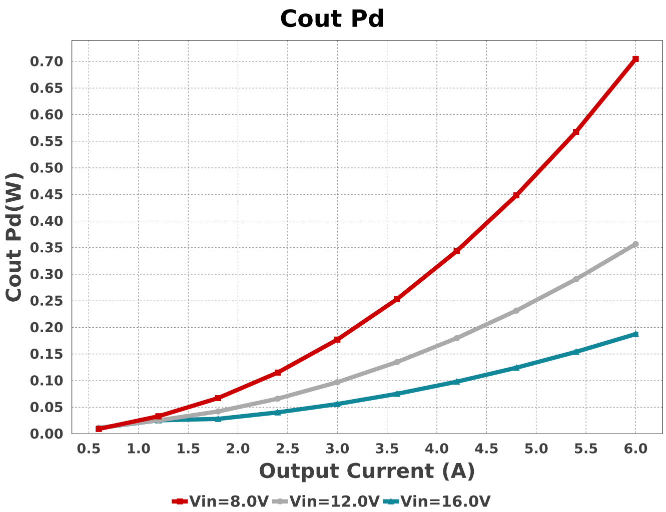

Efficiency
Efficiency(%)
97.50
97.25
97.00
96.75
96.50
96.25
96.00
95.75
95.50
95.25
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=8.0V Vin=12.0V Vin=16.0V

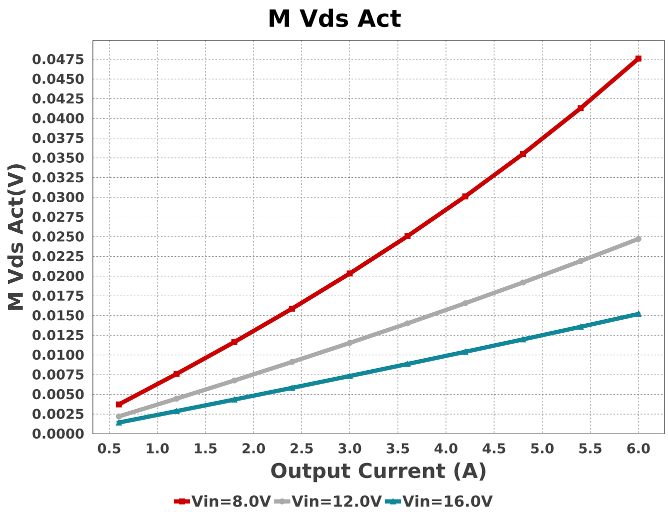

M1 TjOP
M1 TjOP(degC)
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=8.0V Vin=12.0V Vin=16.0V

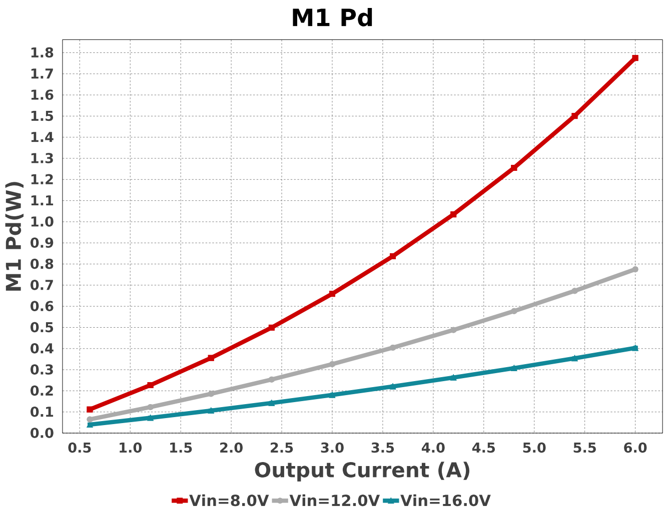

Vout p-p
Vout p-p(V)
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=8.0V Vin=12.0V Vin=16.0V

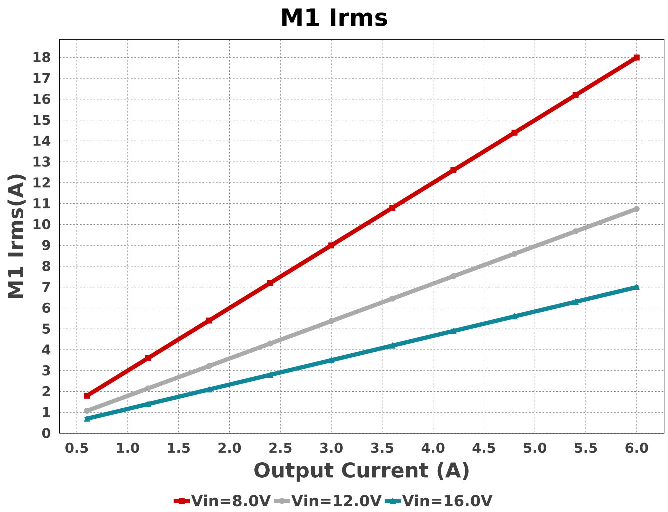

M1 PdCond
M1 PdCond(W)
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=8.0V Vin=12.0V Vin=16.0V

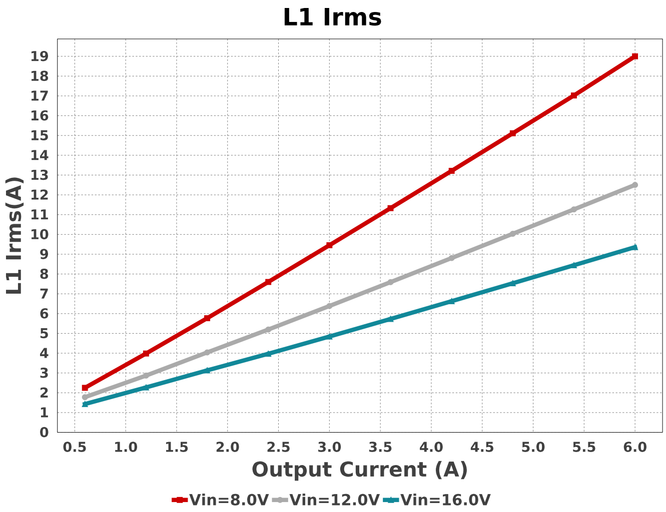

Cin Pd
Cin Pd(W)
0.110
0.105
0.100
0.095
0.090
0.085
0.080
0.075
0.070
0.065
0.060
0.055
0.050
0.045
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=8.0V Vin=12.0V Vin=16.0V

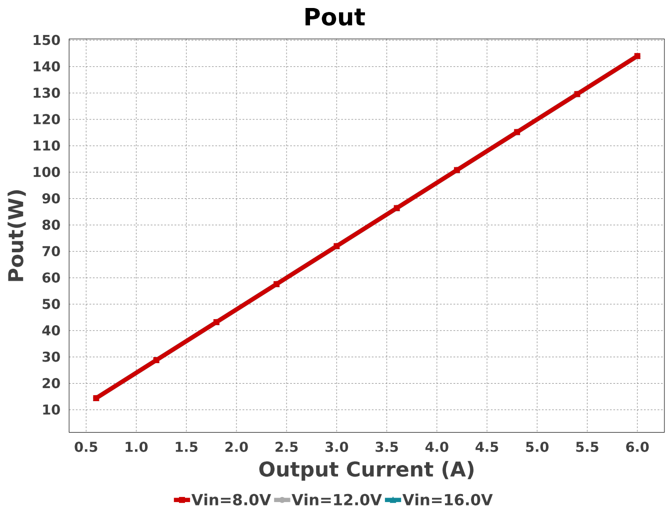

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=8.0V
Vin=12.0V
Vin=16.0V

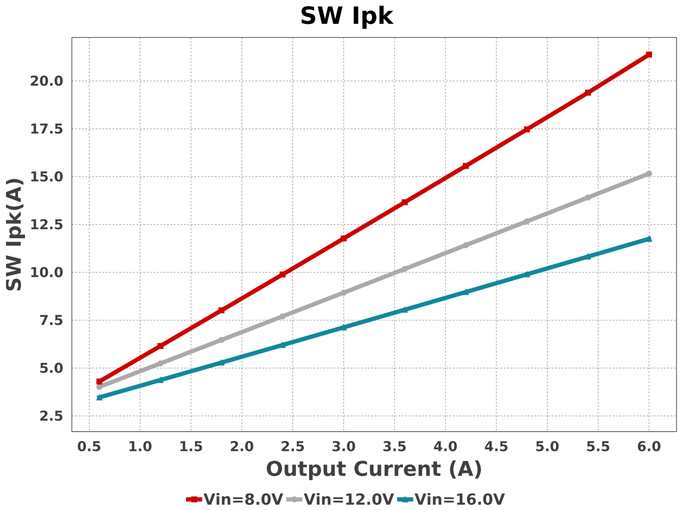

M Vds Act
M Vds Act(V)
Output Current (A)
Vin=8.0V
Vin=12.0V
Vin=16.0V

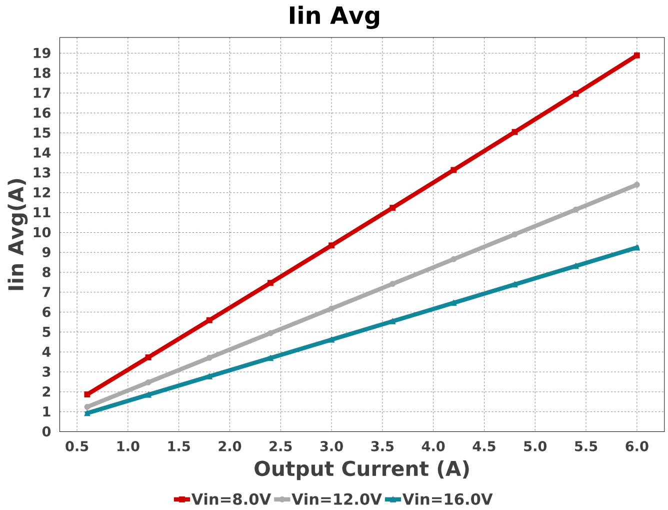

M1 Pd
M1 Pd(W)
Output Current (A)
Vin=8.0V
Vin=12.0V
Vin=16.0V

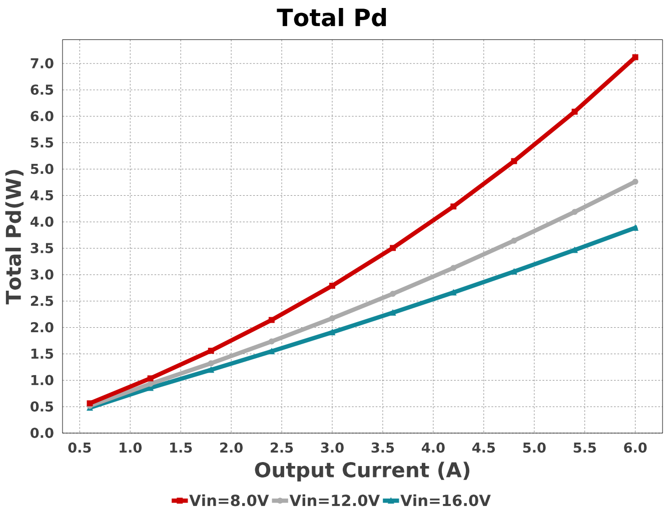

M1 Irms
M1 Irms(A)
Output Current (A)
Vin=8.0V
Vin=12.0V
Vin=16.0V

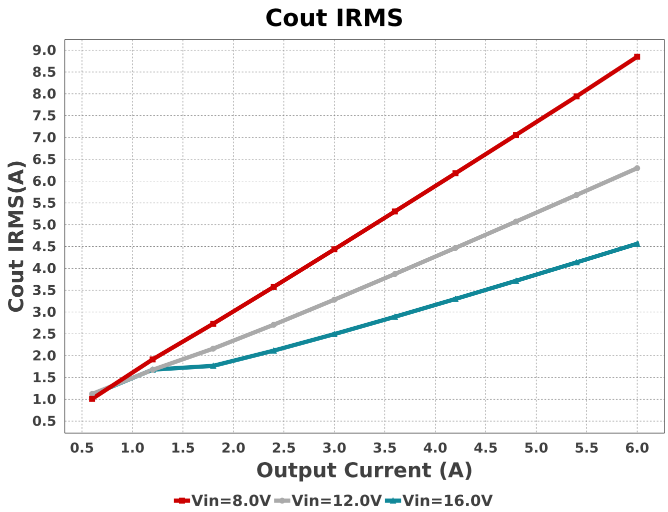

L1 Irms
L1 Irms(A)
Output Current (A)
Vin=8.0V
Vin=12.0V
Vin=16.0V

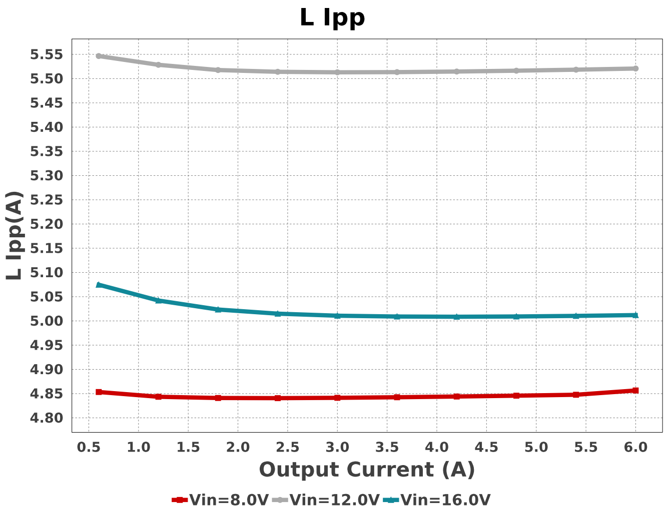

Pout
Pout(W)
Output Current (A)
Vin=8.0V
Vin=12.0V
Vin=16.0V

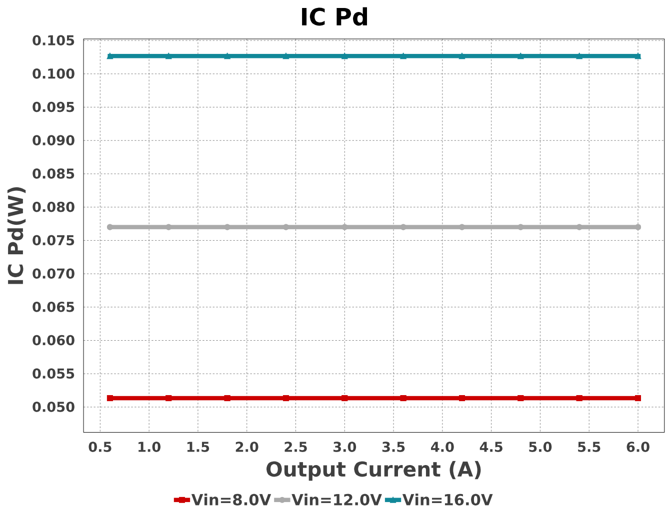

SW Ipk
SW Ipk(A)
Output Current (A)
Vin=8.0V Vin=12.0V Vin=16.0V

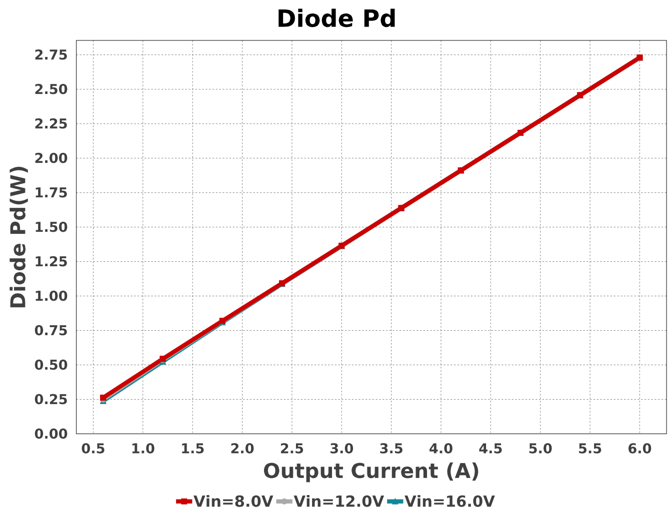

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=8.0V Vin=12.0V Vin=16.0V

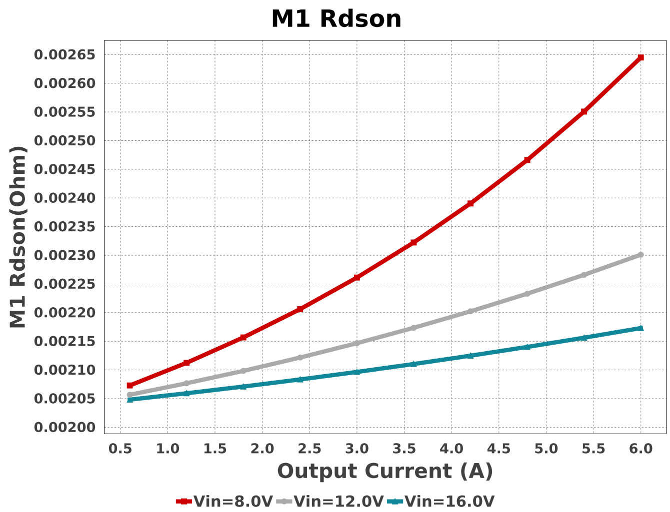

Total Pd
Total Pd(W)
Output Current (A)
Vin=8.0V Vin=12.0V Vin=16.0V

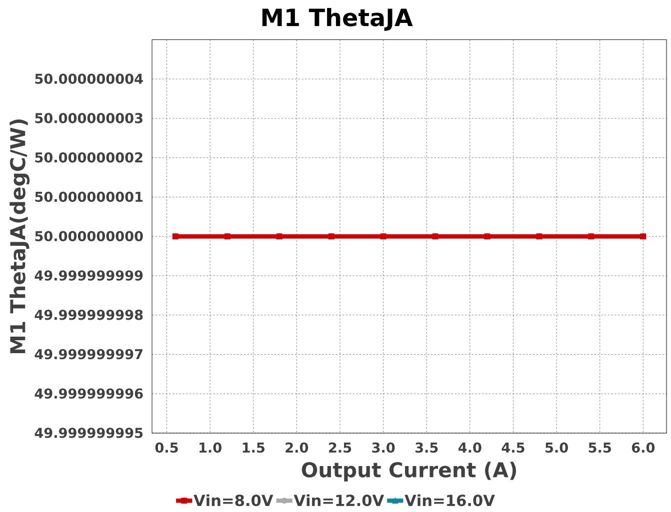

Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=8.0V Vin=12.0V Vin=16.0V

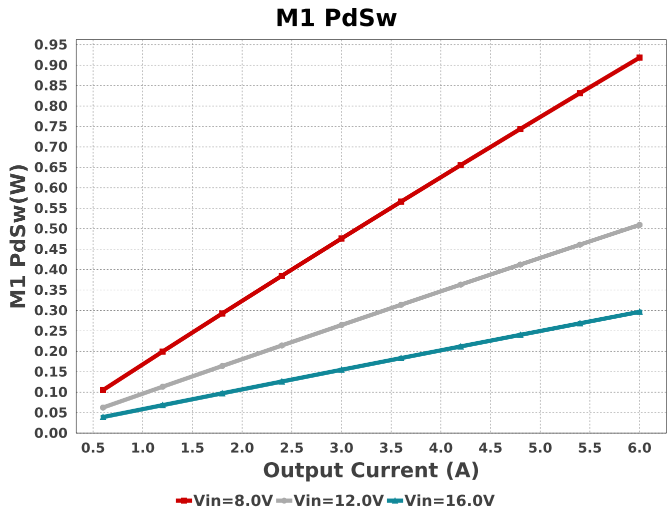

L Ipp
L Ipp(A)
Output Current (A)
Vin=8.0V Vin=12.0V Vin=16.0V

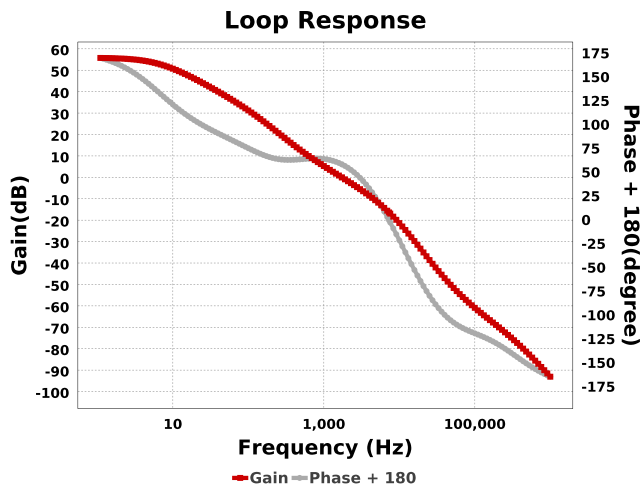

IC Pd
IC Pd(W)
Output Current (A)
Vin=8.0V Vin=12.0V Vin=16.0V











Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	1.392 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	77.546 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	8.754 A	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	689.68 mW	Capacitor	Output capacitor power dissipation
5.	D1 Tj	139.2 degC	Diode	D1 junction temperature
6.	Diode Pd	2.73 W	Diode	Diode power dissipation
7.	IC Pd	51.008 mW	IC	IC power dissipation
8.	IC Tj	40.202 degC	IC	IC junction temperature
9.	IC Tolerance	19.0 mV	IC	IC Feedback Tolerance
10.	ICThetaJA	200.0 degC/W	IC	IC junction-to-ambient thermal resistance
11.	Iin Avg	18.659 A	IC	Average input current

#	Name	Value	Category	Description
12.	L Ipp	4.823 A	Inductor	Peak-to-peak inductor ripple current
13.	L Pd	1.11 W	Inductor	Inductor power dissipation
14.	L1 Irms	18.72 A	Inductor	Inductor ripple current
15.	M Vds Act	47.485 mV	Mosfet	M Vds
16.	M1 Irms	17.994 A	Mosfet	M1 MOSFET Irms
17.	M1 Pd	1.757 W	Mosfet	M1 MOSFET total power dissipation
18.	M1 PdCond	854.46 mW	Mosfet	M1 MOSFET conduction losses
19.	M1 PdSw	902.8 mW	Mosfet	M1 MOSFET switching losses
20.	M1 Rdson	2.639 mOhm	Mosfet	Drain-Source On-resistance
21.	M1 ThetaJA	50.0 degC/W	Mosfet	MOSFET junction-to-ambient thermal resistance
22.	M1 TjOP	117.86 degC	Mosfet	M1 MOSFET junction temperature
23.	Cin Pd	77.546 mW	Power	Input capacitor power dissipation
24.	Cout Pd	689.68 mW	Power	Output capacitor power dissipation
25.	Diode Pd	2.73 W	Power	Diode power dissipation
26.	IC Pd	51.008 mW	Power	IC power dissipation
27.	L Pd	1.11 W	Power	Inductor power dissipation
28.	M1 Pd	1.757 W	Power	M1 MOSFET total power dissipation
29.	M1 PdCond	854.46 mW	Power	M1 MOSFET conduction losses
30.	M1 PdSw	902.8 mW	Power	M1 MOSFET switching losses
31.	Rfb Pd	30.0 mW	Power	Rfb Power Dissipation
32.	Rsense Pd	800.05 mW	Power	LED Current Rsns Power Dissipation
33.	Total Pd	5.272 W	Power	Total Power Dissipation
34.	Rfb Pd	30.0 mW	Resistor	Rfb Power Dissipation
35.	Rsense Pd	800.05 mW	Resistor	LED Current Rsns Power Dissipation
36.	BOM Count	21	System Information	Total Design BOM count
37.	Cross Freq	928.838 Hz	System Information	Bode plot crossover frequency
38.	Duty Cycle	67.859 %	System Information	Duty cycle
39.	Efficiency	96.468 %	System Information	Steady state efficiency
40.	FootPrint	1.611 k mm^2	System Information	Total Foot Print Area of BOM components
41.	Frequency	111.905 kHz	System Information	Switching frequency
42.	Gain Marg	-15.206 dB	System Information	Bode Plot Gain Margin
43.	Iout	6.0 A	System Information	Iout operating point
44.	Low Freq Gain	49.641 dB	System Information	Gain at 1Hz
45.	Mode	CCM	System Information	Conduction Mode
46.	Phase Marg	59.575 deg	System Information	Bode Plot Phase Margin
47.	Pout	144.0 W	System Information	Total output power
48.	SW Ipk	21.08 A	System Information	Peak switch current
49.	Total BOM	NA	System Information	Total BOM Cost
50.	Vin	8.0 V	System Information	Vin operating point
51.	Vout	24.0 V	System Information	Operational Output Voltage
52.	Vout Actual	24.192 V	System Information	Vout Actual calculated based on selected voltage divider resistors
53.	Vout Tolerance	3.452 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
54.	Vout p-p	297.908 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	6.0	Maximum Output Current
VinMax	16.0	Maximum input voltage
VinMin	8.0	Minimum input voltage
Vout	24.0	Output Voltage
base_pn	LM3481-Q1	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

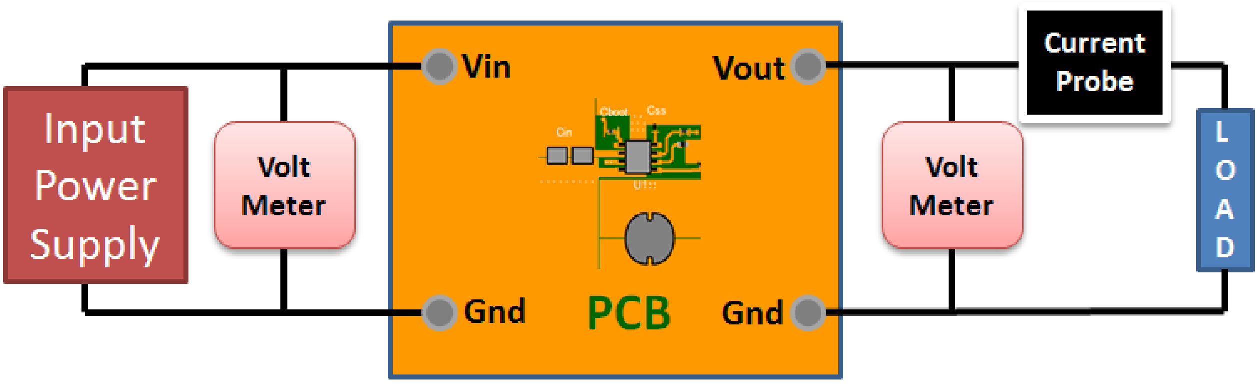
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 8.0V 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.



Design Assistance

1. Feature Highlights: Automotive Qualified, Wide supply voltage range Operation of 2.97V to 48V, 1A High Frequency Low side N-FET versatile High Performance Controller

2. Master key : 6DBEC7B690BB700F[v1]

3. **LM3481-Q1** Product Folder : http://www.ti.com/product/LM3481%2DQ1 : contains the data sheet and other resources.

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