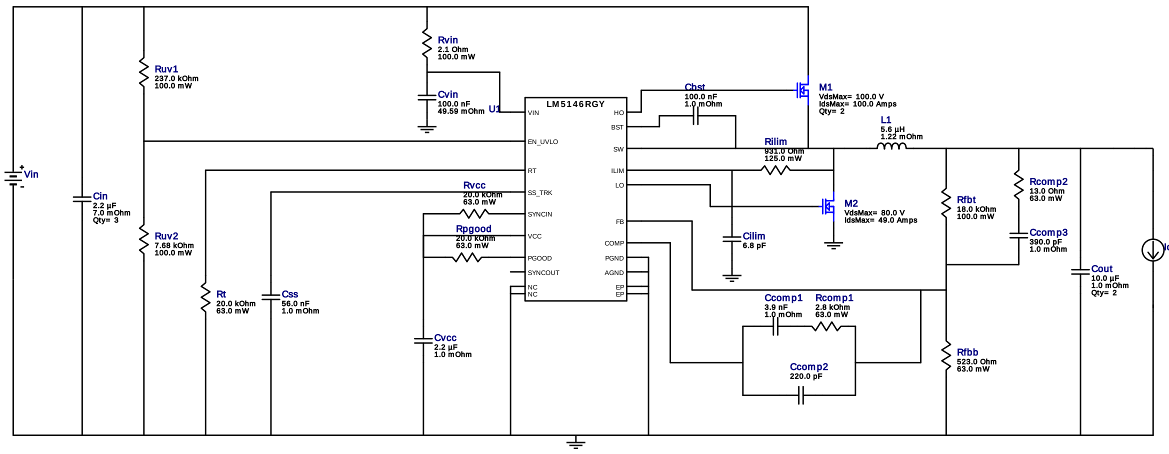
VinMin = 48.0V
VinMax = 52.0V
Vout = 28.0V
Iout = 10.0A

Device = LM5146RGYR
Topology = Buck
Created = 2021-11-05 22:05:16.829
BOM Cost = $7.81
BOM Count = 29
Total Pd = 4.13W

WEBENCH ® Design Report

Design : 18 LM5146RGYR
LM5146RGYR 48V-52V to 28.00V @ 10A



Design Alerts

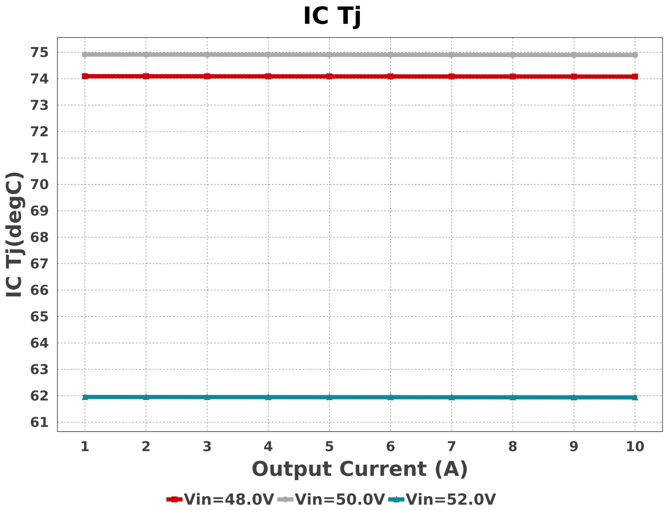
Component Selection Information

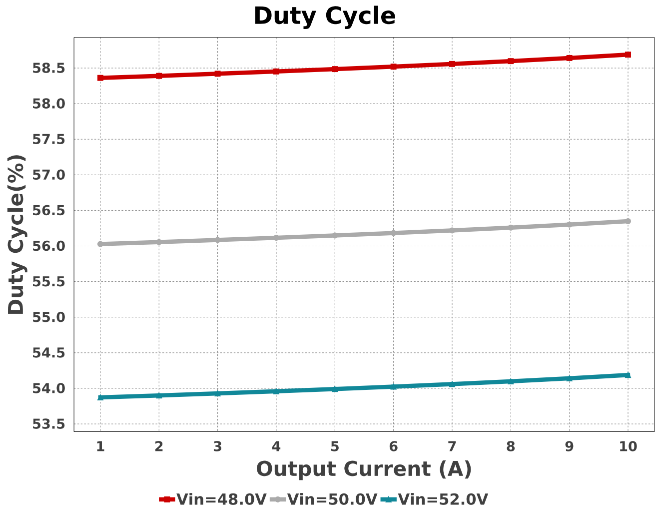
Please note that since parallel FETs have been chosen in this design, schematic and PCB export features will not work

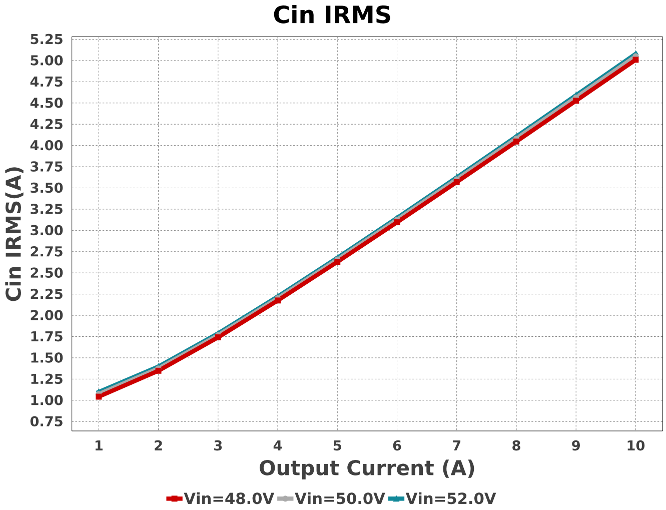
Electrical BOM

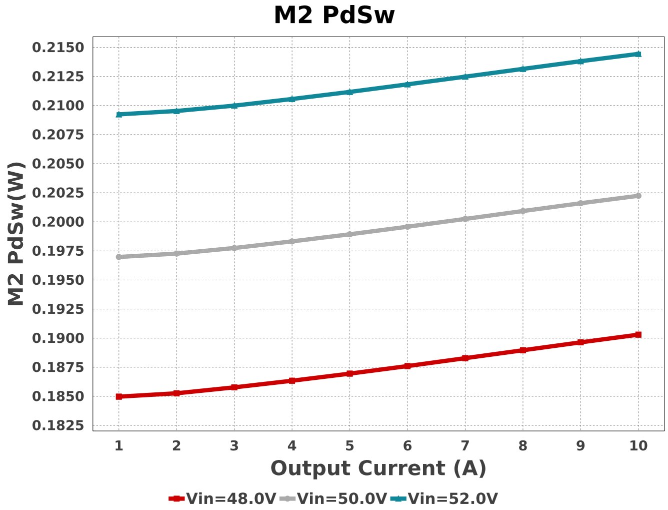
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbst	Kemet	C0603C104Z3VACTU Series= Y5V	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Ccomp1	MuRata	GRM155R71H392KA01D Series= X7R	Cap= 3.9 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Ccomp2	Samsung Electro-Mechanics	CL05C221JA5NNNC Series= C0G/NP0	Cap= 220.0 pF VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Ccomp3	MuRata	GRM155R71H391KA01D Series= X7R	Cap= 390.0 pF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cilim	AVX	06031U6R8BAT2A Series= C0G/NP0	Cap= 6.8 pF VDC= 100.0 V IRMS= 0.0 A	1	$0.07	0603 5 mm²
Cin	MuRata	GRM32ER72A225KA35L Series= X7R	Cap= 2.2 uF ESR= 7.0 mOhm VDC= 100.0 V IRMS= 4.4 A	3	$0.63	1210 15 mm²
Cout	TDK	C3225X7R1H106M250AC Series= X7R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 5.0 A	2	$0.28	1210 15 mm²
Css	MuRata	GRM155R71C563KA88D Series= X7R	Cap= 56.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²

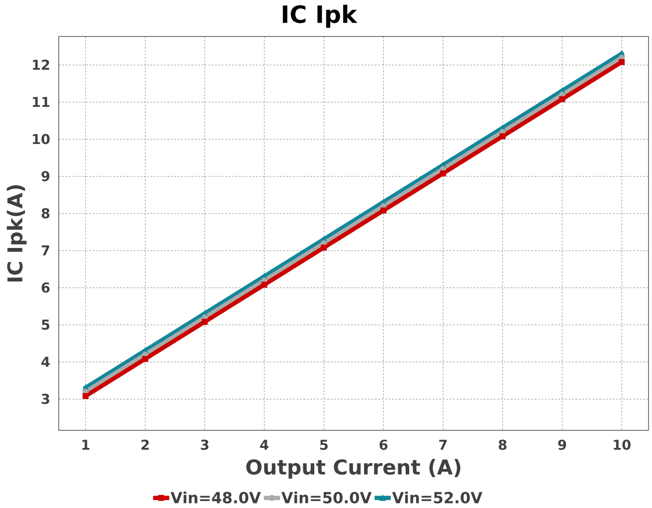
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cvcc	TDK	C1005X5R1V225K050BC Series= X5R	Cap= 2.2 uF ESR= 1.0 mOhm VDC= 35.0 V IRMS= 0.0 A	1	$0.07	0402_065 3 mm^2
Cvin	TDK	C1608X7S2A104K080AB Series= X7S	Cap= 100.0 nF ESR= 49.59 mOhm VDC= 100.0 V IRMS= 751.62 mA	1	$0.03	0603 5 mm^2
L1	Vishay-Dale	IHLP6767DZER5R6M11	L= 5.6 µH 1.22 mOhm	1	$2.54	IHLP-6767DZ 369 mm^2
M1	Texas Instruments	CSD19534Q5A	VdsMax= 100.0 V IdsMax= 100.0 Amps	2	$0.34	TRANS_NexFET_Q5A 55 mm^2
M2	Infineon Technologies	BSC117N08NS5ATMA1	VdsMax= 80.0 V IdsMax= 49.0 Amps	1	$0.52	PG-TDSON-8 55 mm^2
Rcomp1	Vishay-Dale	CRCW04022K80FKED Series= CRCW..e3	Res= 2.8 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rcomp2	Vishay-Dale	CRCW040213R0FKED Series= CRCW..e3	Res= 13.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb	Vishay-Dale	CRCW0402523RFKED Series= CRCW..e3	Res= 523.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt	Yageo	RC0603FR-0718KL Series= ?	Res= 18.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rilim	Panasonic	ERJ-6ENF9310V Series= ERJ-6E	Res= 931.0 Ohm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Rpgood	Vishay-Dale	CRCW040220K0FKED Series= CRCW..e3	Res= 20.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rt	Vishay-Dale	CRCW040220K0FKED Series= CRCW..e3	Res= 20.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ruv1	Vishay-Dale	CRCW0603237KFKEA Series= CRCW..e3	Res= 237.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Ruv2	Yageo	RC0603FR-077K68L Series= ?	Res= 7.68 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rvcc	Vishay-Dale	CRCW040220K0FKED Series= CRCW..e3	Res= 20.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rvin	Vishay-Dale	CRCW06032R10FKEA Series= CRCW..e3	Res= 2.1 Ohm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
U1	Texas Instruments	LM5146RGYR	Switcher	1	$1.29	RGY0020B 25 mm^2

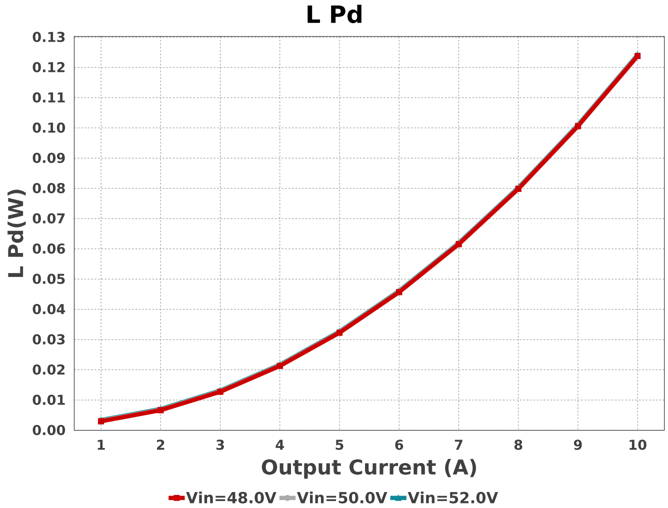

IC Tj
IC Tj(degC)
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

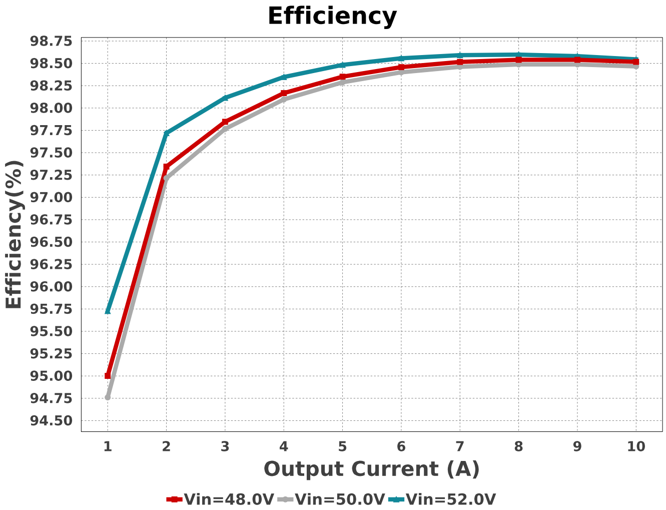

Duty Cycle
Duty Cycle(%)
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

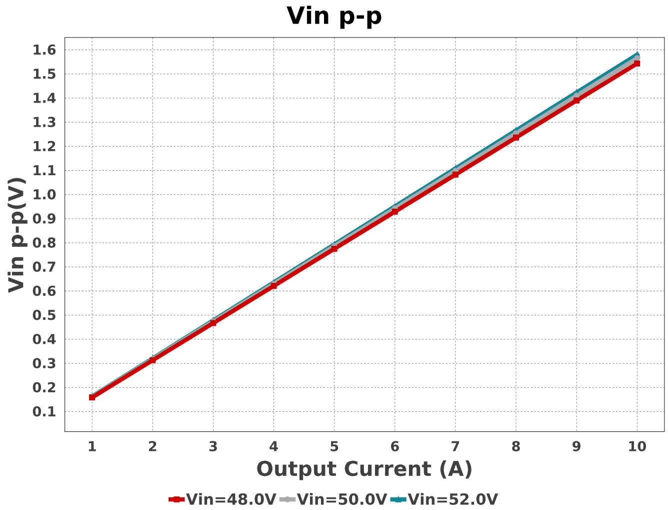

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

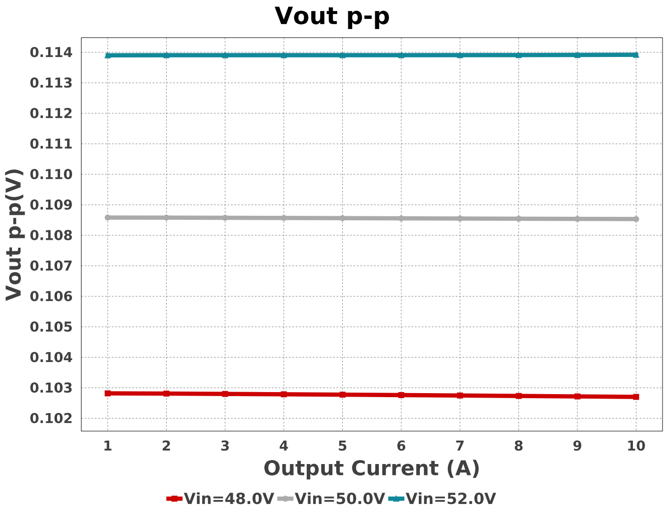

M2 PdSw
M2 PdSw(W)
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

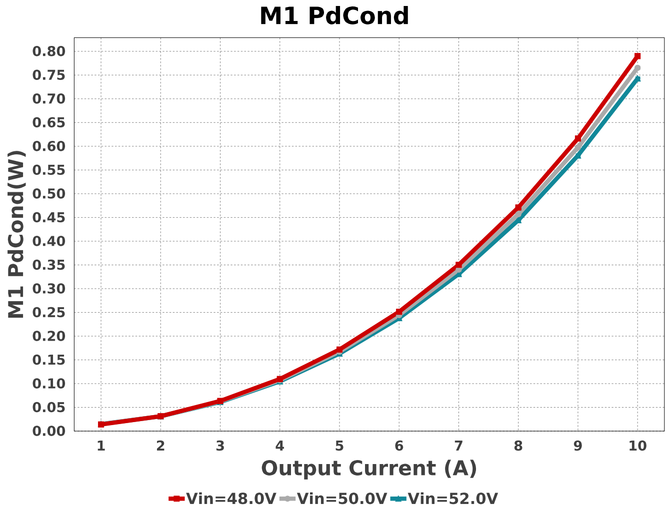

IC Ipk
IC Ipk(A)
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

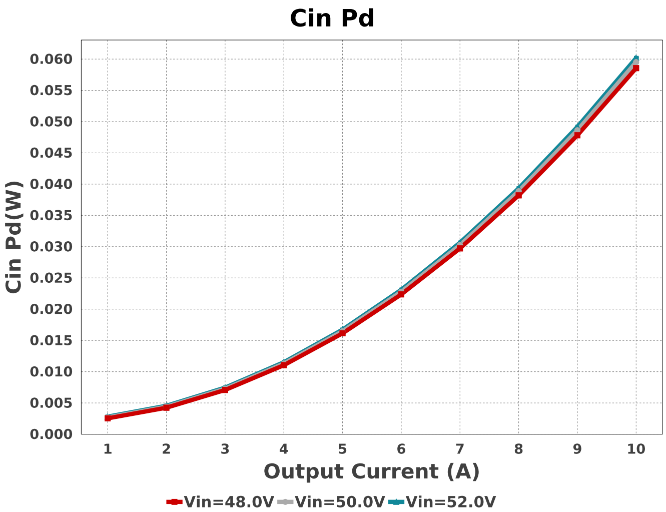

L Pd
L Pd(W)
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

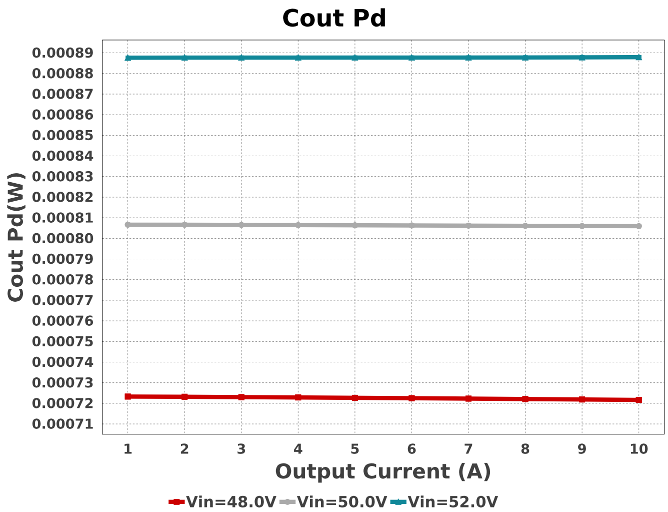

Efficiency
Efficiency(%)
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

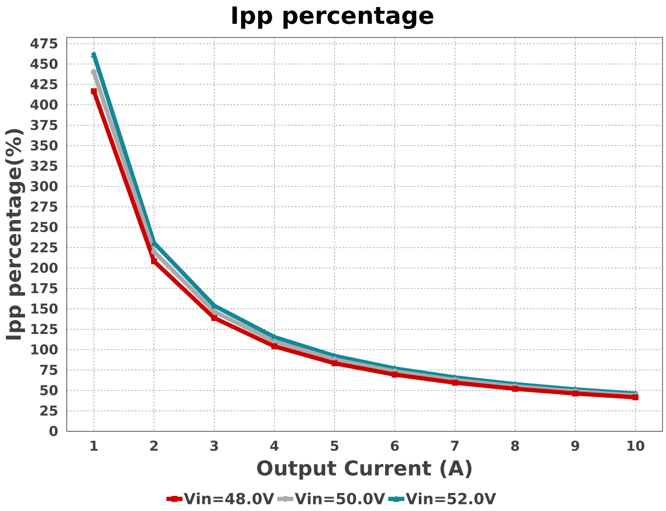

Vin p-p
Vin p-p(V)
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

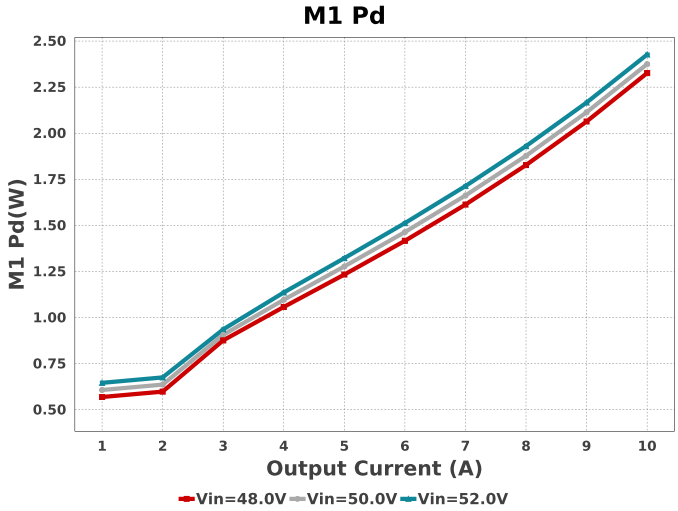

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

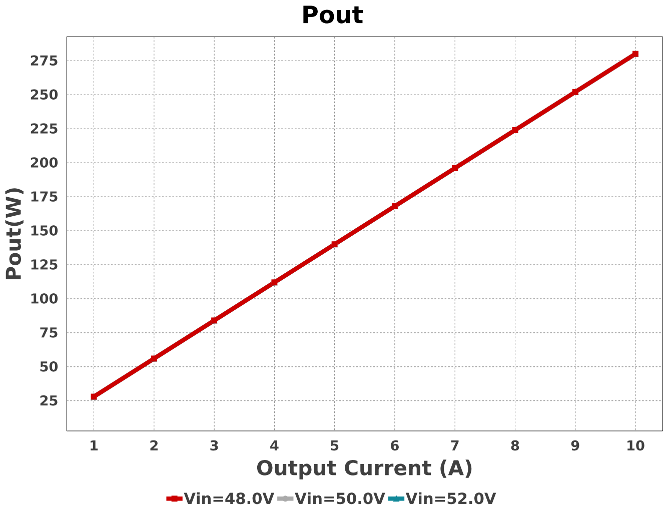

M1 PdCond
M1 PdCond(W)
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

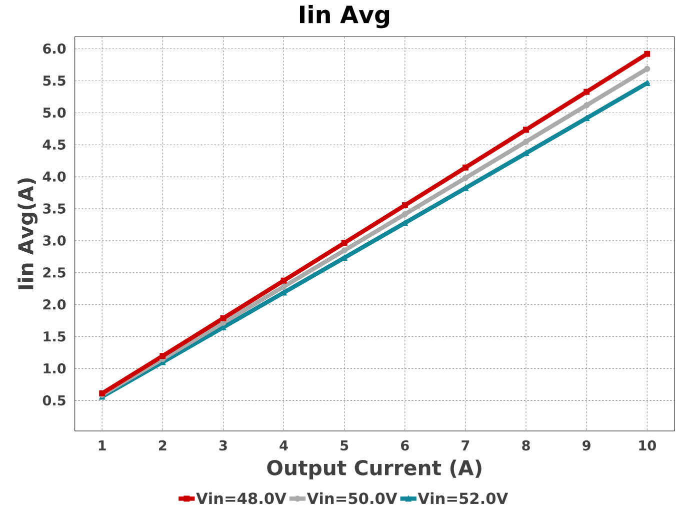

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

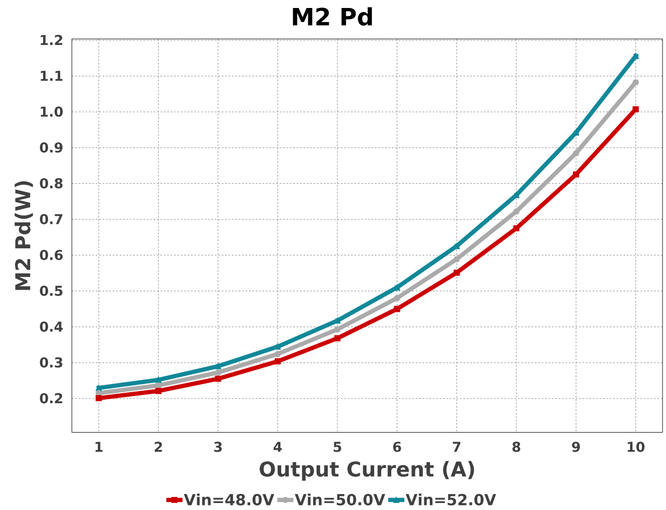

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

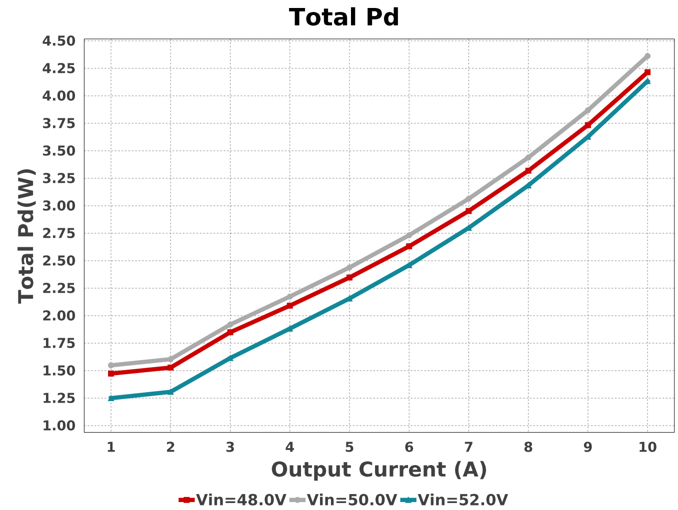

Ipp percentage
Ipp percentage(%)
475
450
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

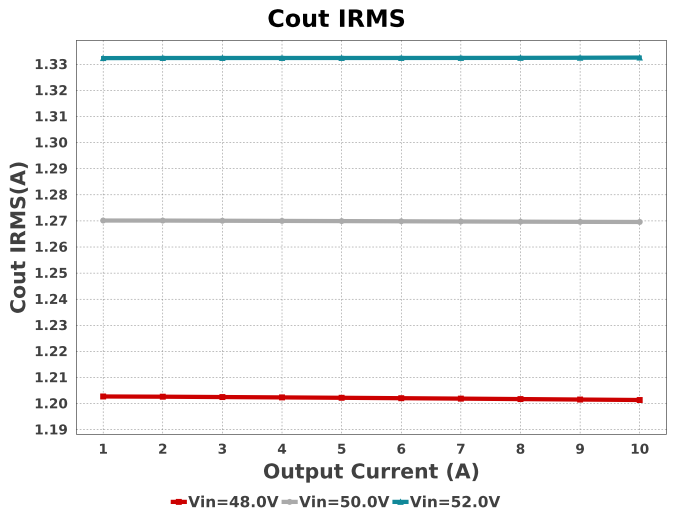

M1 Pd
M1 Pd(W)
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

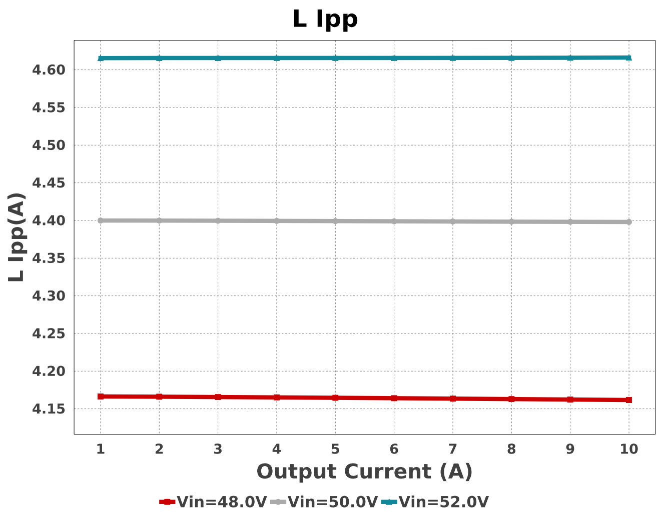

Pout
Pout(W)
275
250
225
200
175
150
125
100
75
50
25
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

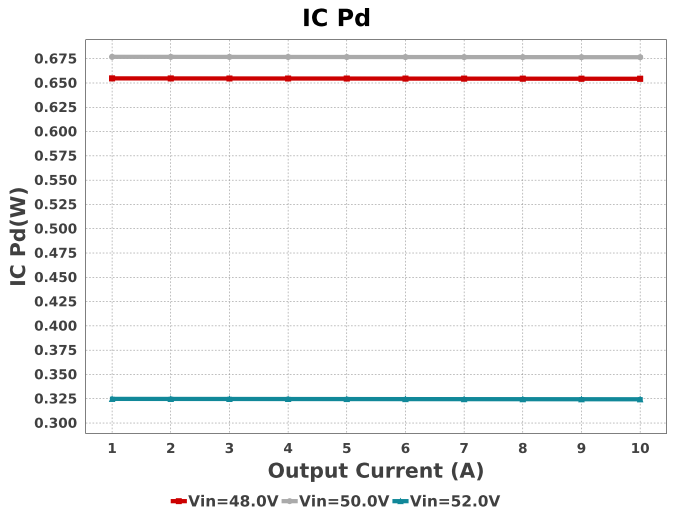

Iin Avg
Iin Avg(A)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

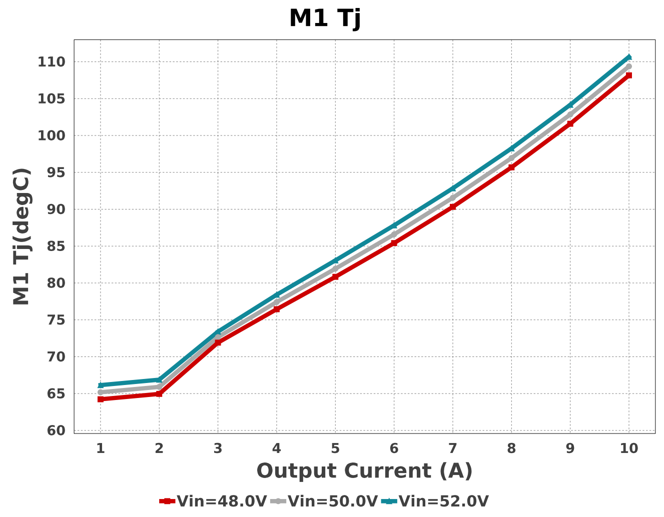

M2 Pd
M2 Pd(W)
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

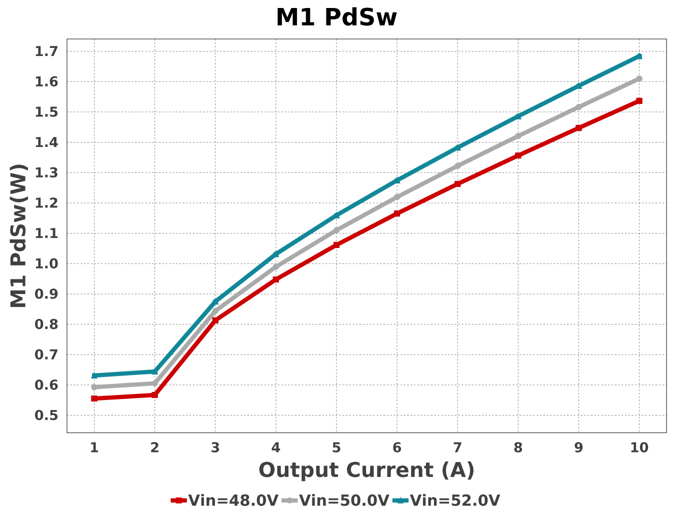

Total Pd
Total Pd(W)
4.50
4.25
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

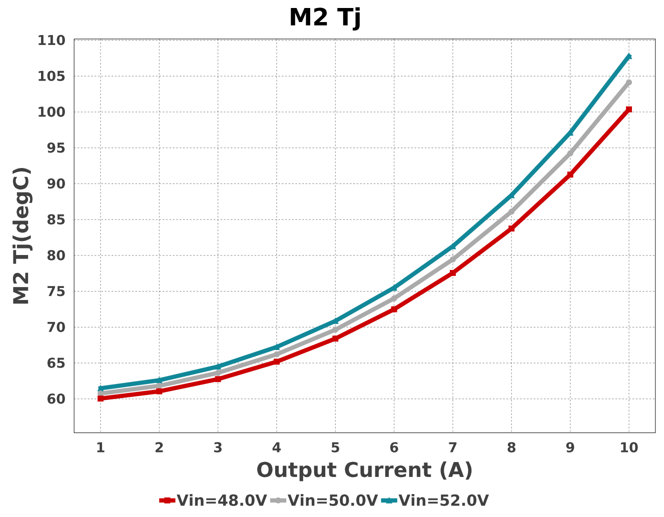

Cout IRMS
Cout IRMS(A)
1.33
1.32
1.31
1.30
1.29
1.28
1.27
1.26
1.25
1.24
1.23
1.22
1.21
1.20
1.19
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

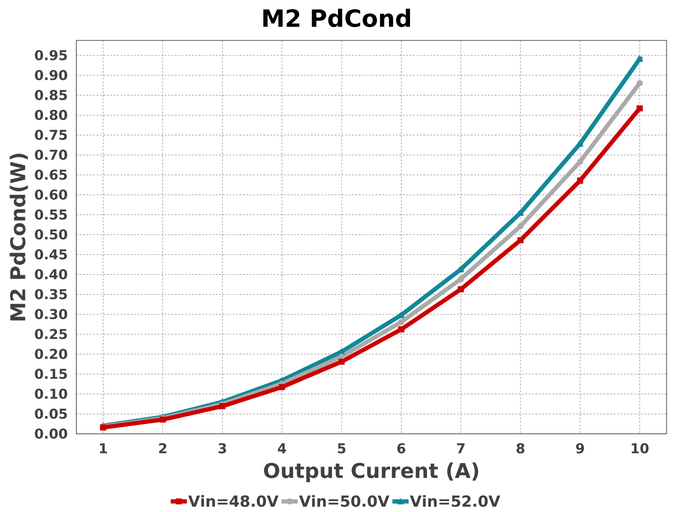

L Ipp
L Ipp(A)
4.60
4.55
4.50
4.45
4.40
4.35
4.30
4.25
4.20
4.15
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V

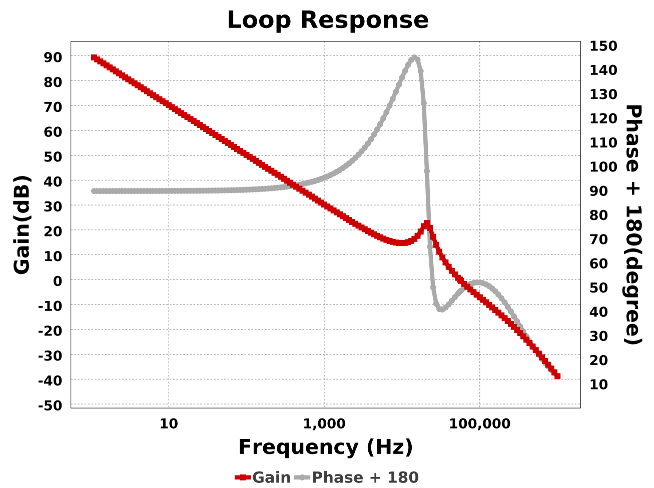

IC Pd
IC Pd(W)
0.675
0.650
0.625
0.600
0.575
0.550
0.525
0.500
0.475
0.450
0.425
0.400
0.375
0.350
0.325
0.300
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V


M1 Tj
M1 Tj(degC)
110
105
100
95
90
85
80
75
70
65
60
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V


M1 PdSw
M1 PdSw(W)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V


M2 Tj
M2 Tj(degC)
110
105
100
95
90
85
80
75
70
65
60
1 2 3 4 5 6 7 8 9 10
Output Current (A)
Vin=48.0V Vin=50.0V Vin=52.0V





Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	5.078 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	60.169 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	1.333 A	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	887.91 µW	Capacitor	Output capacitor power dissipation
5.	IC Ipk	12.308 A	IC	Peak switch current in IC
6.	IC Pd	324.45 mW	IC	IC power dissipation
7.	IC Tj	61.291 degC	IC	IC junction temperature
8.	IC Tolerance	8.0 mV	IC	IC Feedback Tolerance
9.	ICThetaJA	34.8 degC/W	IC	IC junction-to-ambient thermal resistance
10.	Iin Avg	5.464 A	IC	Average input current
11.	Ipp percentage	46.162 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
12.	L Ipp	4.616 A	Inductor	Peak-to-peak inductor ripple current
13.	L Pd	124.17 mW	Inductor	Inductor power dissipation
14.	M1 Pd	2.427 W	Mosfet	M1 MOSFET total power dissipation
15.	M1 PdCond	742.68 mW	Mosfet	M1 MOSFET conduction losses
16.	M1 PdSw	1.684 W	Mosfet	M1 MOSFET switching losses
17.	M1 Tj	110.67 degC	Mosfet	M1 MOSFET junction temperature
18.	M2 Pd	1.156 W	Mosfet	M2 MOSFET total power dissipation
19.	M2 PdCond	941.41 mW	Mosfet	M2 MOSFET conduction losses
20.	M2 PdSw	214.44 mW	Mosfet	M2 MOSFET switching losses
21.	M2 Tj	107.79 degC	Mosfet	M2 MOSFET junction temperature
22.	Cin Pd	60.169 mW	Power	Input capacitor power dissipation
23.	Cout Pd	887.91 µW	Power	Output capacitor power dissipation
24.	IC Pd	324.45 mW	Power	IC power dissipation
25.	L Pd	124.17 mW	Power	Inductor power dissipation
26.	M1 Pd	2.427 W	Power	M1 MOSFET total power dissipation
27.	M1 PdCond	742.68 mW	Power	M1 MOSFET conduction losses
28.	M1 PdSw	1.684 W	Power	M1 MOSFET switching losses
29.	M2 Pd	1.156 W	Power	M2 MOSFET total power dissipation
30.	M2 PdCond	941.41 mW	Power	M2 MOSFET conduction losses
31.	M2 PdSw	214.44 mW	Power	M2 MOSFET switching losses
32.	Total Pd	4.134 W	Power	Total Power Dissipation
33.	BOM Count	29	System Information	Total Design BOM count
34.	Duty Cycle	54.188 %	System Information	Duty cycle
35.	Efficiency	98.545 %	System Information	Steady state efficiency
36.	FootPrint	706.0 mm^2	System Information	Total Foot Print Area of BOM components
37.	Frequency	500.0 kHz	System Information	Switching frequency
38.	Iout	10.0 A	System Information	Iout operating point
39.	Mode	FCCM	System Information	Conduction Mode
40.	Pout	280.0 W	System Information	Total output power
41.	Total BOM	$7.81	System Information	Total BOM Cost

#	Name	Value	Category	Description
42.	Vin	52.0 V	System Information	Vin operating point
43.	Vin p-p	1.571 V	System Information	Peak-to-peak input voltage
44.	Vout	28.0 V	System Information	Operational Output Voltage
45.	Vout Actual	28.333 V	System Information	Vout Actual calculated based on selected voltage divider resistors
46.	Vout Tolerance	2.983 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
47.	Vout p-p	113.919 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	10.0	Maximum Output Current
SoftStart	4.0 ms	Soft Start Time (ms)
VinMax	52.0	Maximum input voltage
VinMin	48.0	Minimum input voltage
Vout	28.0	Output Voltage
base_pn	LM5146	Base Product Number
source	DC	Input Source Type
Ta	50.0	Ambient temperature
UserFsw	500.0 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

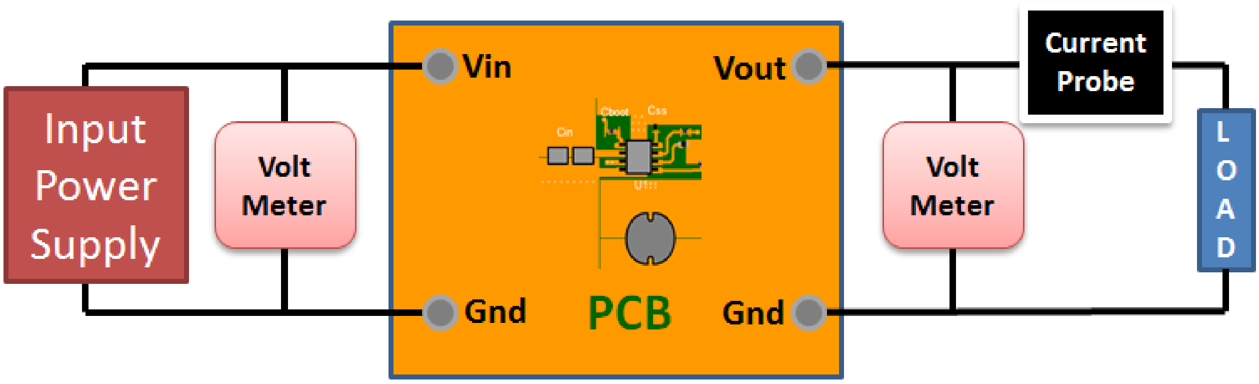
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 48.0V 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. Please note that since parallel FETs have been chosen in this design, schematic and PCB export features will not work
2. Master key : E8972043B38D6425[v1]
3. **LM5146** Product Folder : http://www.ti.com/product/lm5146 : contains the data sheet and other resources.

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