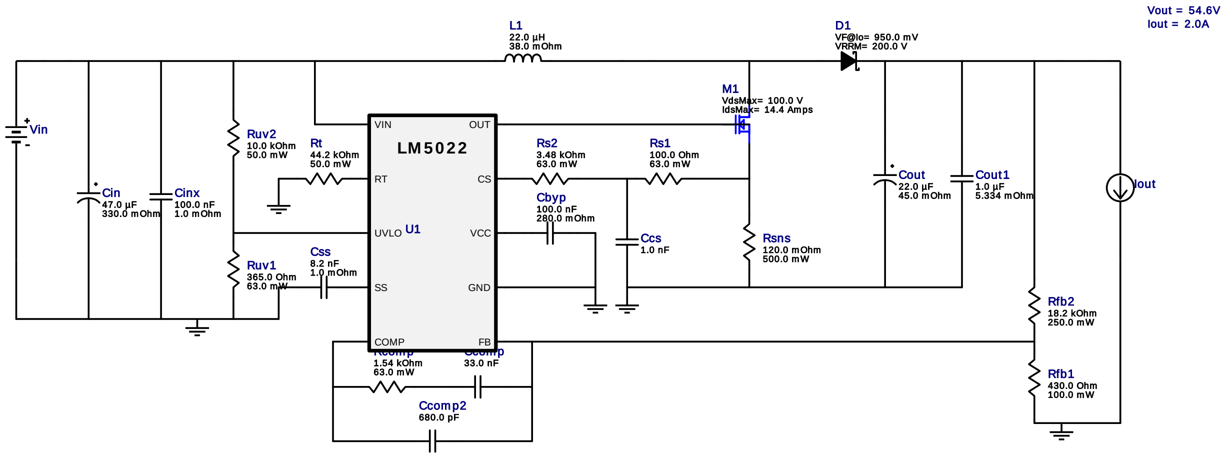
VinMin = 45.0V
VinMax = 48.0V
Vout = 54.6V
Iout = 2.0A

Device = LM5022MM/NOPB
Topology = Boost
Created = 2022-11-15 05:31:09.153
BOM Cost = $4.23
BOM Count = 22
Total Pd = 2.99W

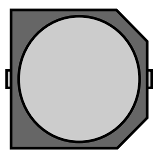
WEBENCH ® Design Report

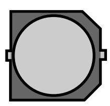
Design : 24 LM5022MM/NOPB
LM5022MM/NOPB 45V-48V to 54.60V @ 2A

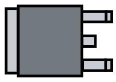
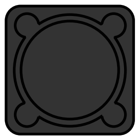


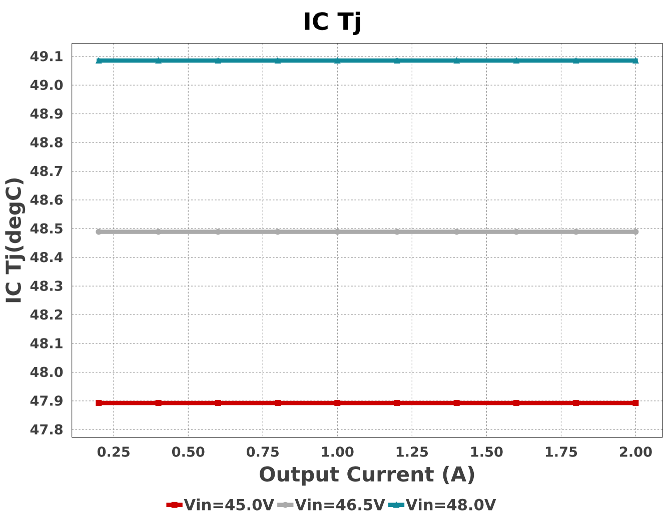
Electrical BOM

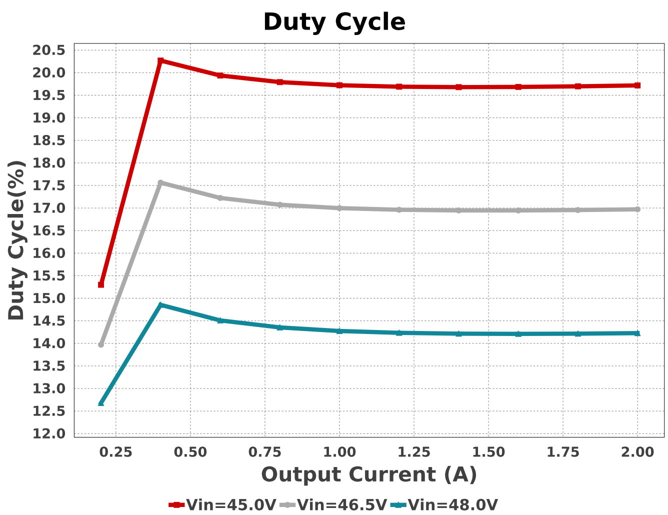
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbyp	AVX	08053C104KAT2A Series= X7R	Cap= 100.0 nF ESR= 280.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Ccomp	TDK	CGA4J2C0G1H333J125AA Series= C0G/NP0	Cap= 33.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.08	0805 7 mm^2
Ccomp2	Samsung Electro-Mechanics	CL05C681JB5NNNC Series= C0G/NP0	Cap= 680.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ccs	Samsung Electro-Mechanics	CL21C102JBCNNNC Series= C0G/NP0	Cap= 1.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Cin	Chemi-Con	EMVY101ATR470MKE0S Series= MVY	Cap= 47.0 uF ESR= 330.0 mOhm VDC= 100.0 V IRMS= 450.0 mA	1	$0.40	CAPSMT_62_KE0 225 mm^2
Cinx	MuRata	GRM188R72A104KA35D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 3.85 A	1	$0.04	0603 5 mm^2
Cout	Panasonic	EEHZA1K220P Series= ZA	Cap= 22.0 uF ESR= 45.0 mOhm VDC= 80.0 V IRMS= 1.55 A	1	$1.31	SM_RADIAL_8MM 113 mm^2
Cout1	MuRata	GRM31CR72A105KA01L Series= X7R	Cap= 1.0 uF ESR= 5.334 mOhm VDC= 100.0 V IRMS= 1.55432 A	1	$0.11	1206_190 11 mm^2
Css	MuRata	GRM155R71E822KA01D Series= X7R	Cap= 8.2 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2

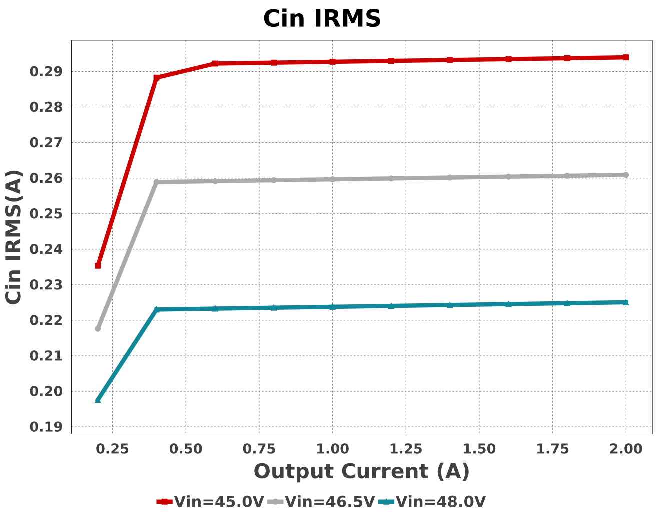


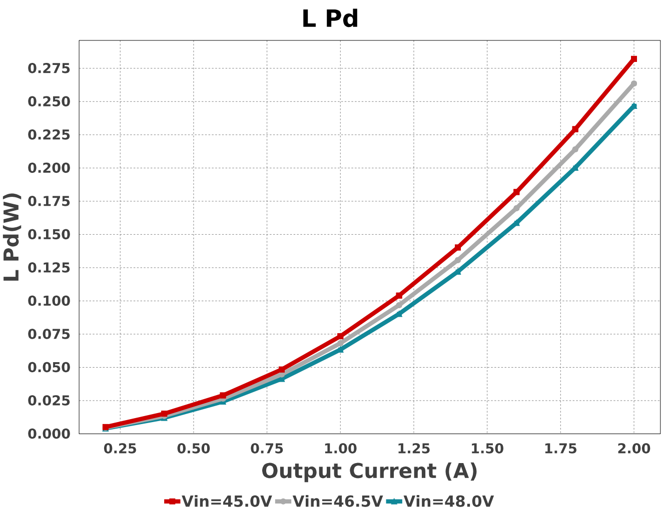


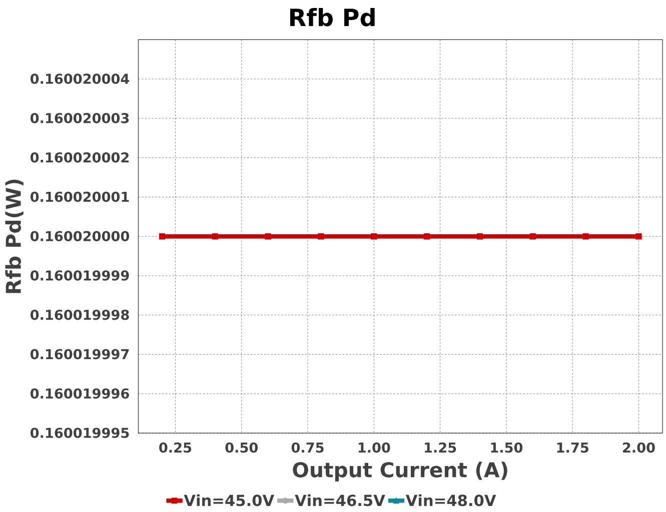
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
D1	SMC Diode Solutions	SBRD10200TR	VF@Io= 950.0 mV VRRM= 200.0 V	1	$0.18	 DPAK 102 mm²
L1	Bourns	SRR1210-220M	L= 22.0 µH 38.0 mOhm	1	$0.64	 SRR1210 196 mm²
M1	Texas Instruments	CSD19538Q2	VdsMax= 100.0 V IdsMax= 14.4 Amps	1	$0.17	DQK0006C 9 mm²
Rcomp	Vishay-Dale	CRCW04021K54FKED Series= CRCW..e3	Res= 1.54 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfb1	Yageo	RC0603FR-07430RL Series= ?	Res= 430.0 Ohm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rfb2	Vishay-Dale	CRCW120618K2FKEA Series= CRCW..e3	Res= 18.2 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm²
Rs1	Vishay-Dale	CRCW0402100RFKED Series= CRCW..e3	Res= 100.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rs2	Vishay-Dale	CRCW04023K48FKED Series= CRCW..e3	Res= 3.48 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rsns	Rohm	MCR25JZHFLR120 Series= MCR25	Res= 120.0 mOhm Power= 500.0 mW Tolerance= 1.0%	1	$0.03	1210 15 mm²
Rt	Vishay-Dale	CRCW020144K2FNED Series= ?	Res= 44.2 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
Ruv1	Vishay-Dale	CRCW0402365RFKED Series= CRCW..e3	Res= 365.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Ruv2	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
U1	Texas Instruments	LM5022MM/NOPB	Switcher	1	$1.15	MUB10A 24 mm²

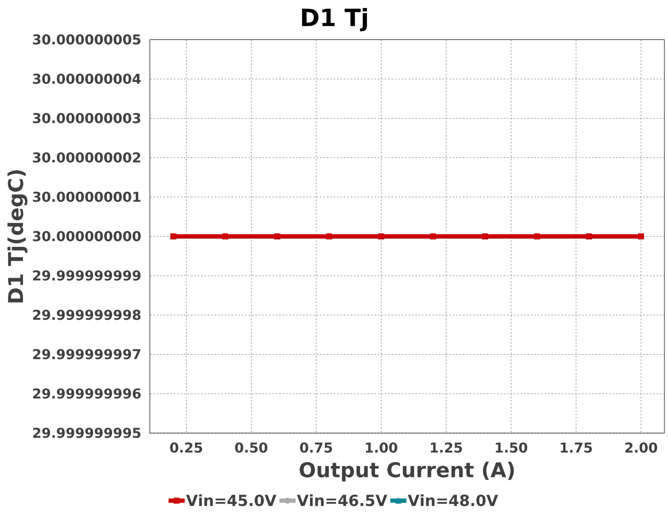


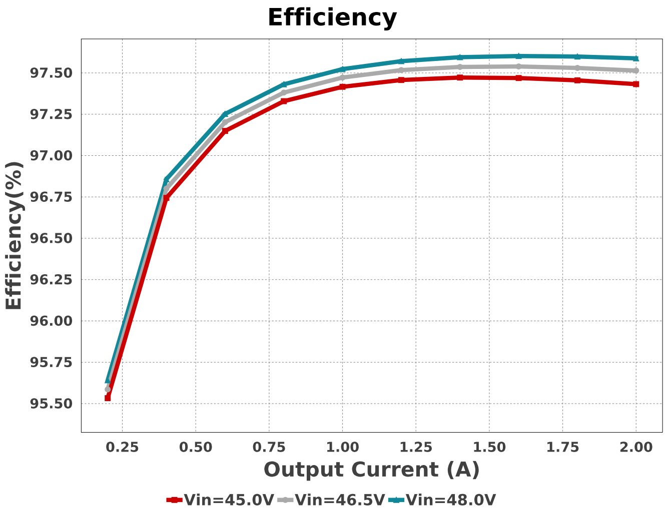


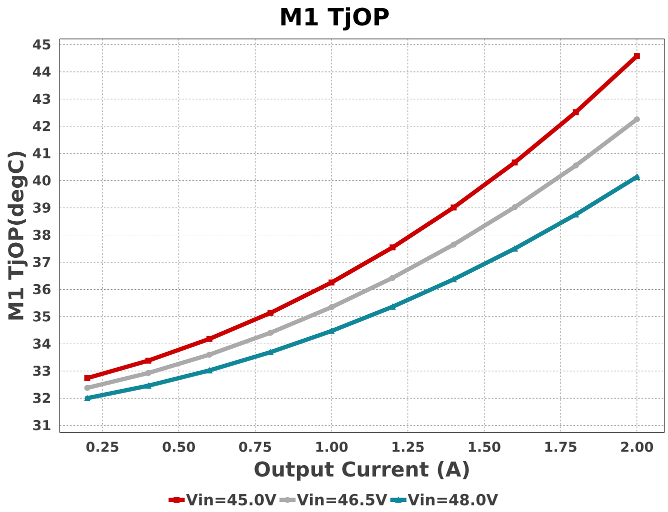

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=45.0V Vin=46.5V Vin=48.0V


L Pd
L Pd(W)
Output Current (A)
Vin=45.0V Vin=46.5V Vin=48.0V

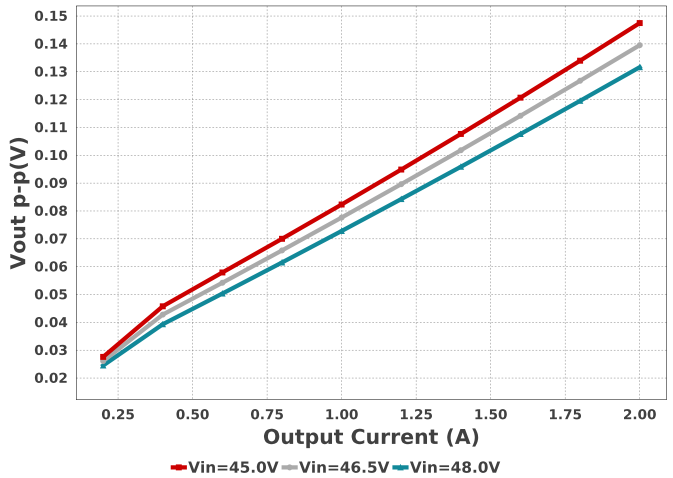

Rfb Pd
Rfb Pd(W)
Output Current (A)
Vin=45.0V Vin=46.5V Vin=48.0V


D1 Tj
D1 Tj(degC)
Output Current (A)
Vin=45.0V Vin=46.5V Vin=48.0V

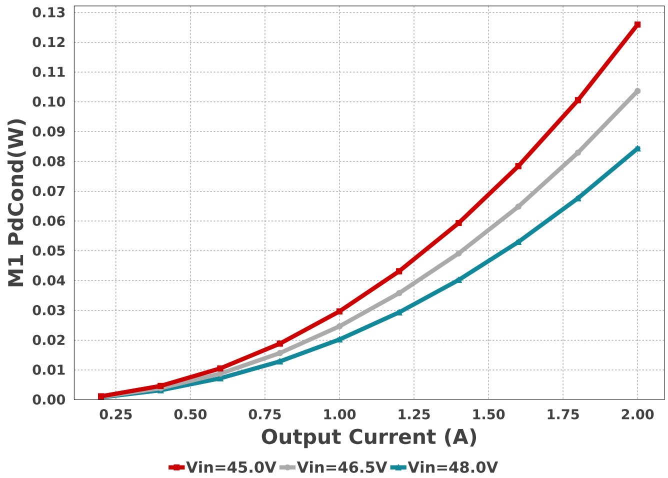

Efficiency
Efficiency(%)
Output Current (A)
Vin=45.0V Vin=46.5V Vin=48.0V


M1 TjOP
M1 TjOP(degC)
Output Current (A)
Vin=45.0V Vin=46.5V Vin=48.0V

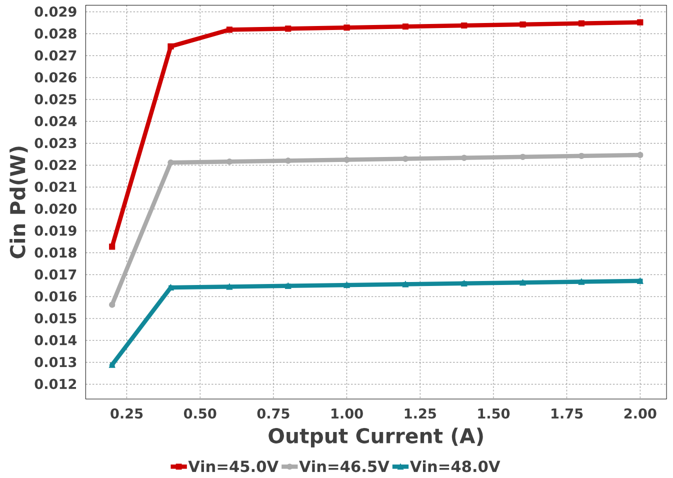
Vout p-p



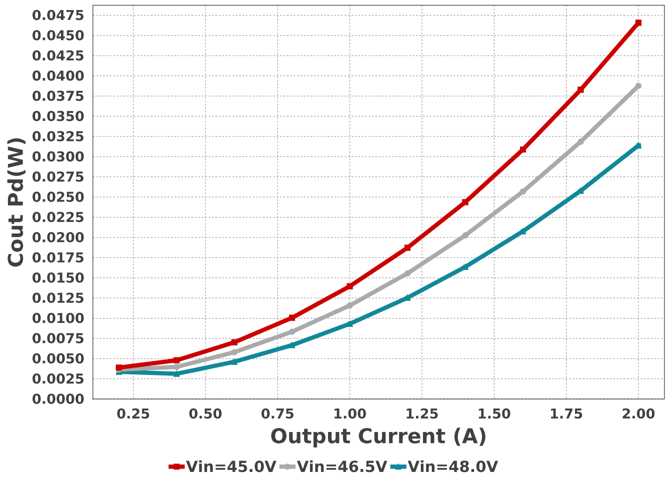
M1 PdCond



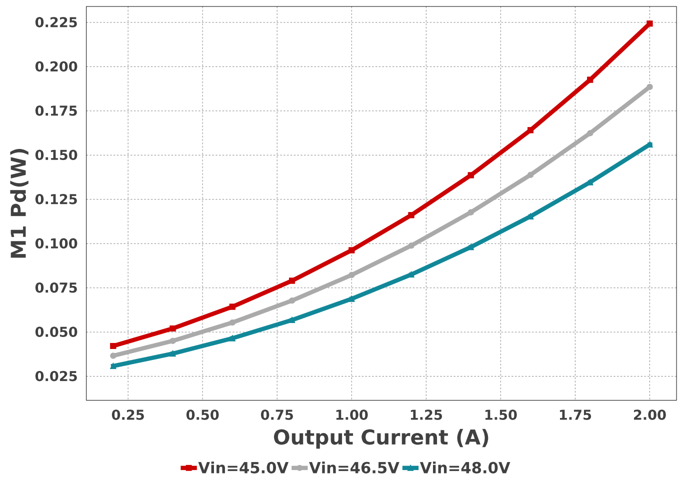
Cin Pd



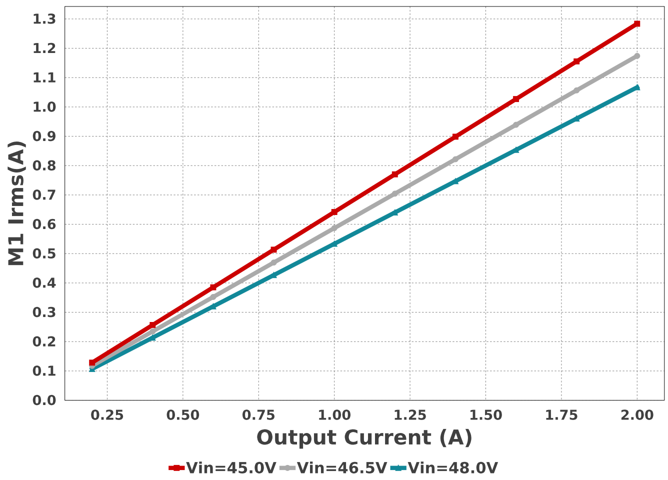
Cout Pd

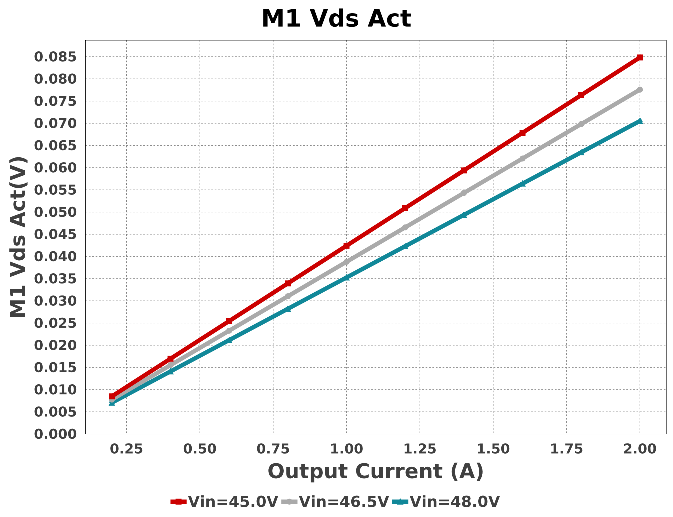


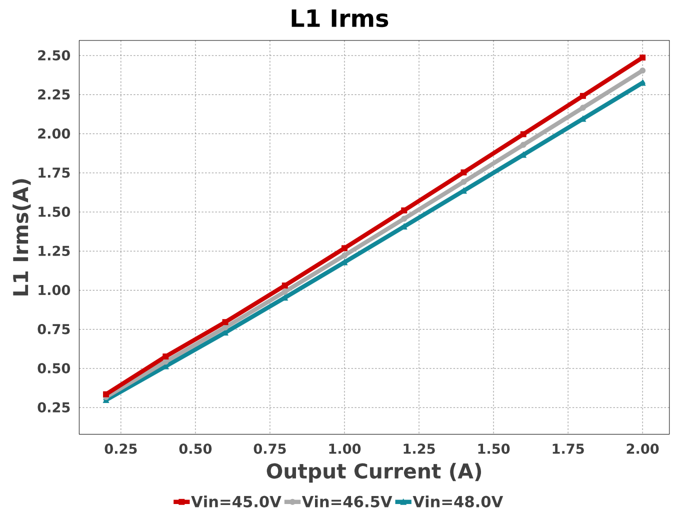
M1 Pd

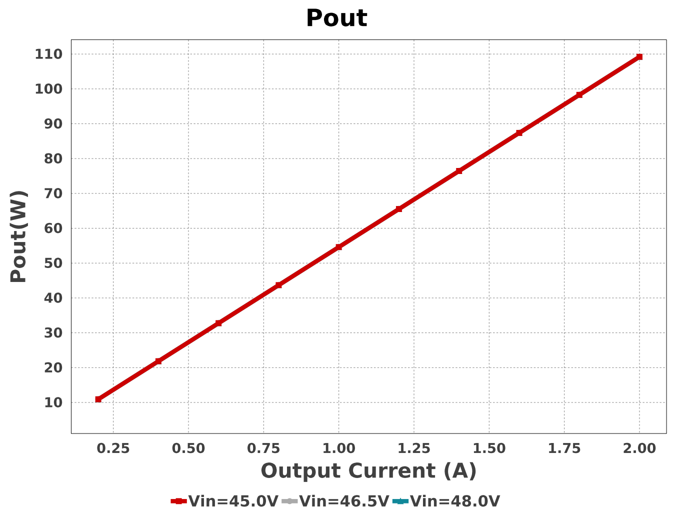


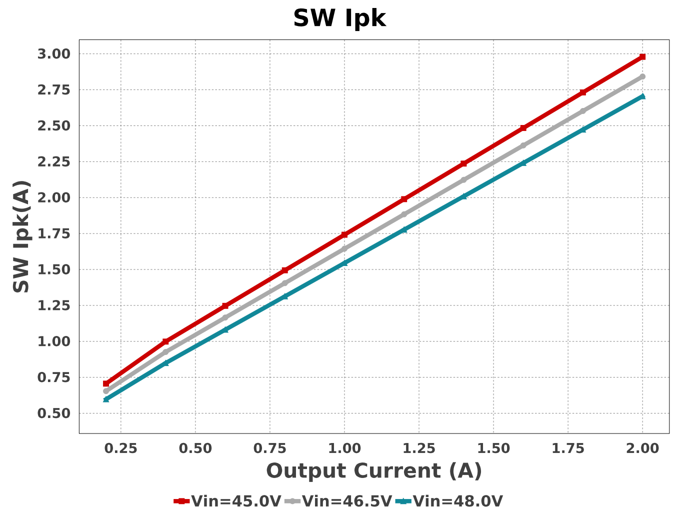
M1 Irms

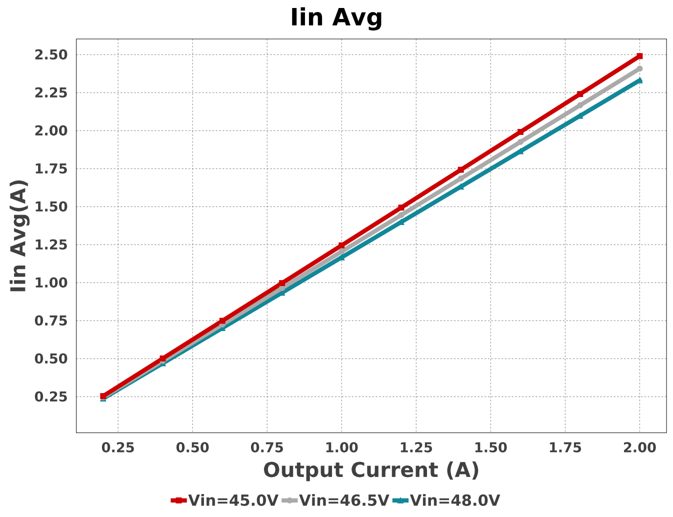


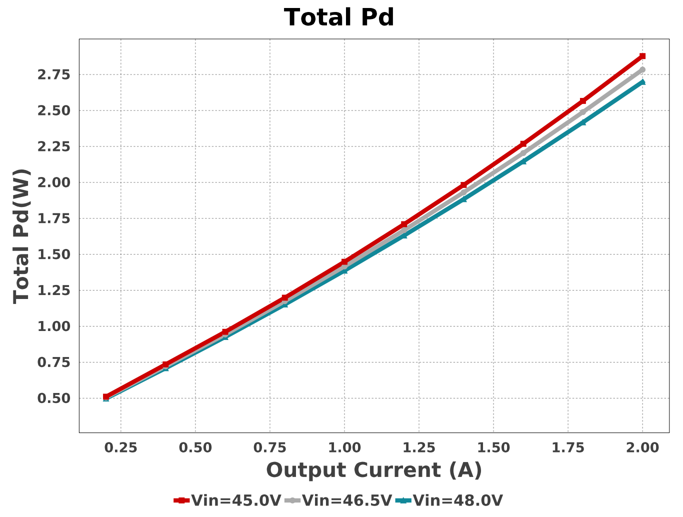

M1 Vds Act
0.085
0.080
0.075
0.070
0.065
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
M1 Vds Act(V)
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Output Current (A)
Vin=45.0V
Vin=46.5V
Vin=48.0V

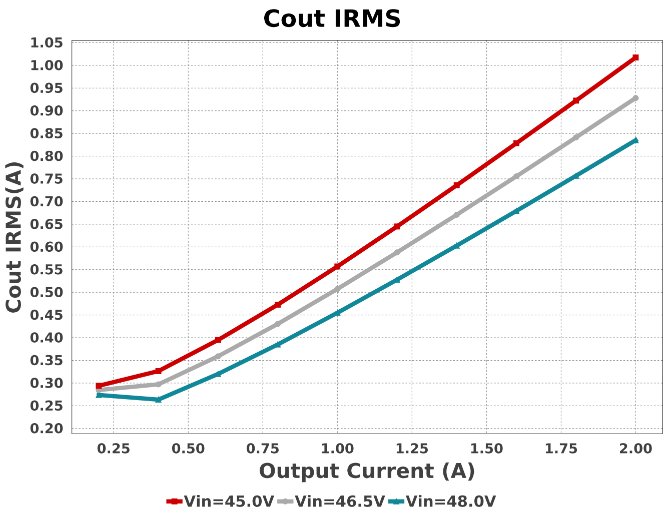

L1 Irms
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
L1 Irms(A)
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Output Current (A)
Vin=45.0V
Vin=46.5V
Vin=48.0V

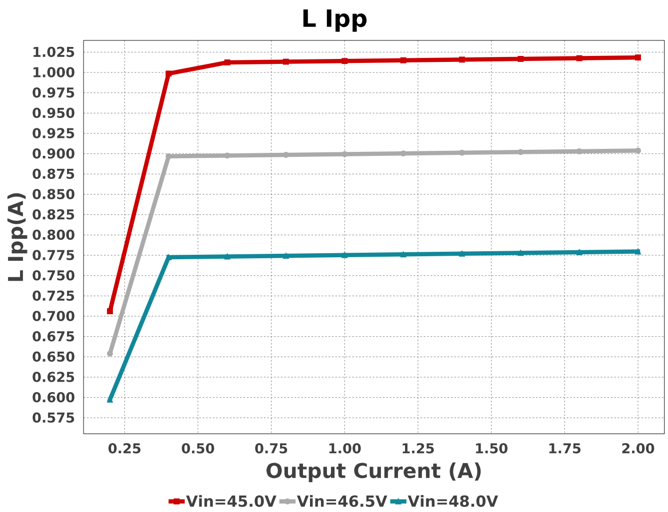

Pout
110
100
90
80
70
60
50
40
30
20
10
Pout(W)
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Output Current (A)
Vin=45.0V
Vin=46.5V
Vin=48.0V

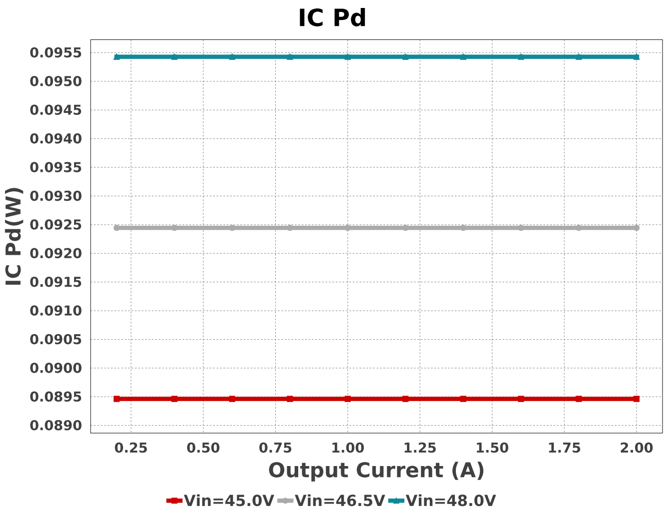

SW Ipk
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
SW Ipk(A)
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Output Current (A)
Vin=45.0V
Vin=46.5V
Vin=48.0V

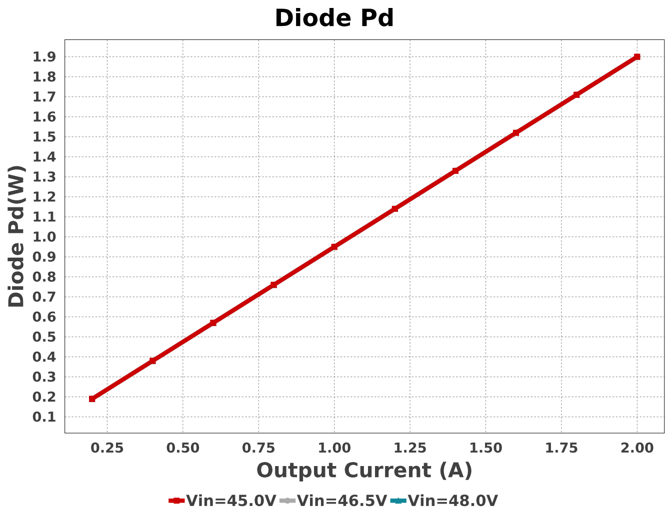

Iin Avg
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
Iin Avg(A)
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Output Current (A)
Vin=45.0V
Vin=46.5V
Vin=48.0V

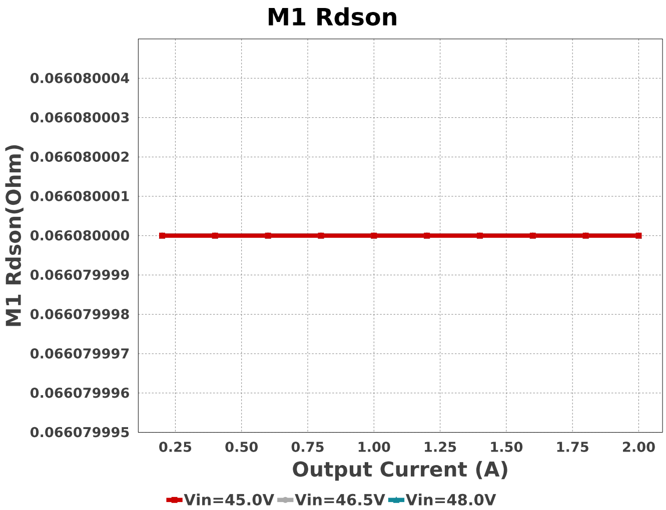

Total Pd
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
Total Pd(W)
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Output Current (A)
Vin=45.0V
Vin=46.5V
Vin=48.0V

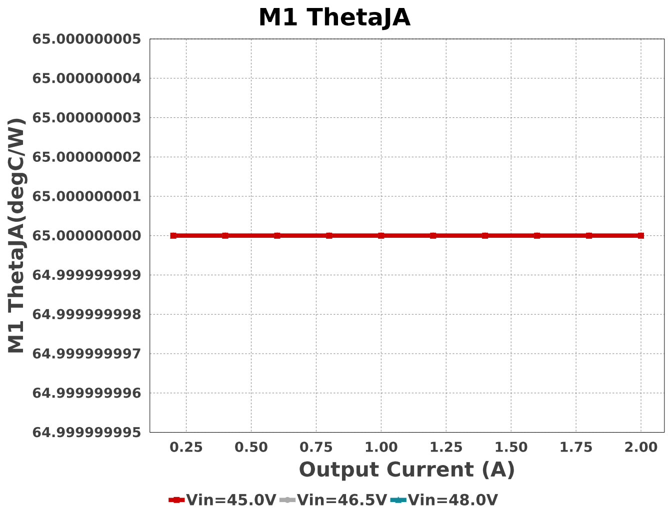

Cout IRMS
Cout IRMS(A)
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin=45.0V Vin=46.5V Vin=48.0V

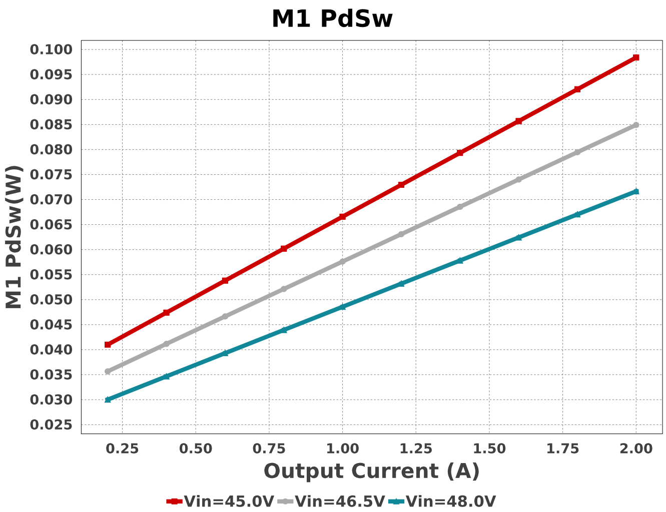

L Ipp
L Ipp(A)
1.025
1.000
0.975
0.950
0.925
0.900
0.875
0.850
0.825
0.800
0.775
0.750
0.725
0.700
0.675
0.650
0.625
0.600
0.575
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin=45.0V Vin=46.5V Vin=48.0V

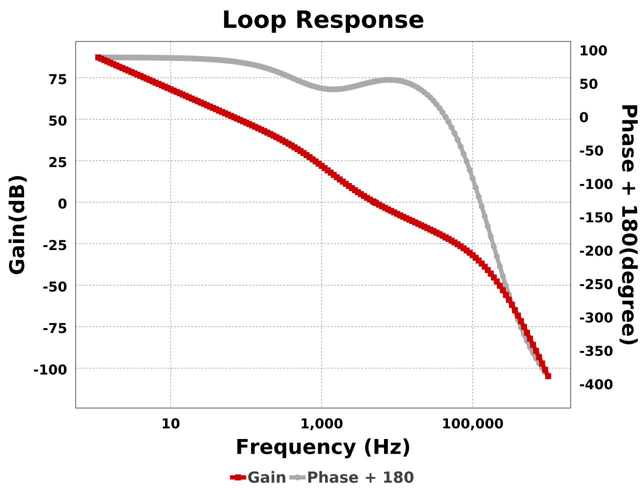

IC Pd
IC Pd(W)
0.0955
0.0950
0.0945
0.0940
0.0935
0.0930
0.0925
0.0920
0.0915
0.0910
0.0905
0.0900
0.0895
0.0890
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin=45.0V Vin=46.5V Vin=48.0V


Diode Pd
Diode Pd(W)
1.9
1.8
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
0.4
0.3
0.2
0.1
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin=45.0V Vin=46.5V Vin=48.0V


M1 Rdson
M1 Rdson(Ohm)
0.066080004
0.066080003
0.066080002
0.066080001
0.066080000
0.066079999
0.066079998
0.066079997
0.066079996
0.066079995
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin=45.0V Vin=46.5V Vin=48.0V


M1 ThetaJA
M1 ThetaJA(degC/W)
65.000000005
65.000000004
65.000000003
65.000000002
65.000000001
65.000000000
64.999999999
64.999999998
64.999999997
64.999999996
64.999999995
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin=45.0V Vin=46.5V Vin=48.0V





Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	282.747 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	26.382 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	1.016 A	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	46.464 mW	Capacitor	Output capacitor power dissipation
5.	D1 Tj	30.0 degC	Diode	D1 junction temperature
6.	Diode Pd	1.9 W	Diode	Diode power dissipation
7.	IC Pd	139.45 mW	IC	IC power dissipation
8.	IC Tj	57.891 degC	IC	IC junction temperature
9.	IC Tolerance	25.0 mV	IC	IC Feedback Tolerance
10.	ICThetaJA	200.0 degC/W	IC	IC junction-to-ambient thermal resistance
11.	Iin Avg	2.493 A	IC	Average input current
12.	L Ipp	979.47 mA	Inductor	Peak-to-peak inductor ripple current
13.	L Pd	281.8 mW	Inductor	Inductor power dissipation
14.	L1 Irms	2.486 A	Inductor	Inductor ripple current
15.	M1 Irms	1.281 A	Mosfet	M1 MOSFET Irms
16.	M1 Pd	284.44 mW	Mosfet	M1 MOSFET total power dissipation
17.	M1 PdCond	128.81 mW	Mosfet	M1 MOSFET conduction losses
18.	M1 PdSw	155.63 mW	Mosfet	M1 MOSFET switching losses
19.	M1 Rdson	66.08 mOhm	Mosfet	Drain-Source On-resistance
20.	M1 ThetaJA	65.0 degC/W	Mosfet	MOSFET junction-to-ambient thermal resistance
21.	M1 TjOP	48.489 degC	Mosfet	M1 MOSFET junction temperature
22.	Cin Pd	26.382 mW	Power	Input capacitor power dissipation
23.	Cout Pd	46.464 mW	Power	Output capacitor power dissipation
24.	Diode Pd	1.9 W	Power	Diode power dissipation
25.	IC Pd	139.45 mW	Power	IC power dissipation
26.	L Pd	281.8 mW	Power	Inductor power dissipation
27.	M1 Pd	284.44 mW	Power	M1 MOSFET total power dissipation
28.	M1 PdCond	128.81 mW	Power	M1 MOSFET conduction losses
29.	M1 PdSw	155.63 mW	Power	M1 MOSFET switching losses
30.	Rfb Pd	160.02 mW	Power	Rfb Power Dissipation
31.	Total Pd	2.986 W	Power	Total Power Dissipation
32.	Rfb Pd	160.02 mW	Resistor	Rfb Power Dissipation
33.	BOM Count	22	System Information	Total Design BOM count
34.	Cross Freq	4.765 kHz	System Information	Bode plot crossover frequency
35.	Duty Cycle	19.794 %	System Information	Duty cycle
36.	Efficiency	97.338 %	System Information	Steady state efficiency
37.	FootPrint	757.0 mm^2	System Information	Total Foot Print Area of BOM components
38.	Frequency	400.0 kHz	System Information	Switching frequency
39.	Gain Marg	-21.958 dB	System Information	Bode Plot Gain Margin
40.	Iout	2.0 A	System Information	Iout operating point
41.	Low Freq Gain	86.691 dB	System Information	Gain at 1Hz
42.	Mode	CCM	System Information	Conduction Mode

#	Name	Value	Category	Description
43.	Phase Marg	53.9 deg	System Information	Bode Plot Phase Margin
44.	Pout	109.2 W	System Information	Total output power
45.	SW Ipk	2.96 A	System Information	Peak switch current
46.	Total BOM	$4.23	System Information	Total BOM Cost
47.	Vin	45.0 V	System Information	Vin operating point
48.	Vout	54.6 V	System Information	Operational Output Voltage
49.	Vout Actual	54.59 V	System Information	Vout Actual calculated based on selected voltage divider resistors
50.	Vout Tolerance	3.997 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
51.	Vout p-p	145.869 mV	System Information	Peak-to-peak output ripple voltage
52.	M1 Vds Act	84.648 mV		M Vds

Design Inputs

Name	Value	Description
Iout	2.0	Maximum Output Current
VinMax	48.0	Maximum input voltage
VinMin	45.0	Minimum input voltage
Vout	54.6	Output Voltage
base_pn	LM5022	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

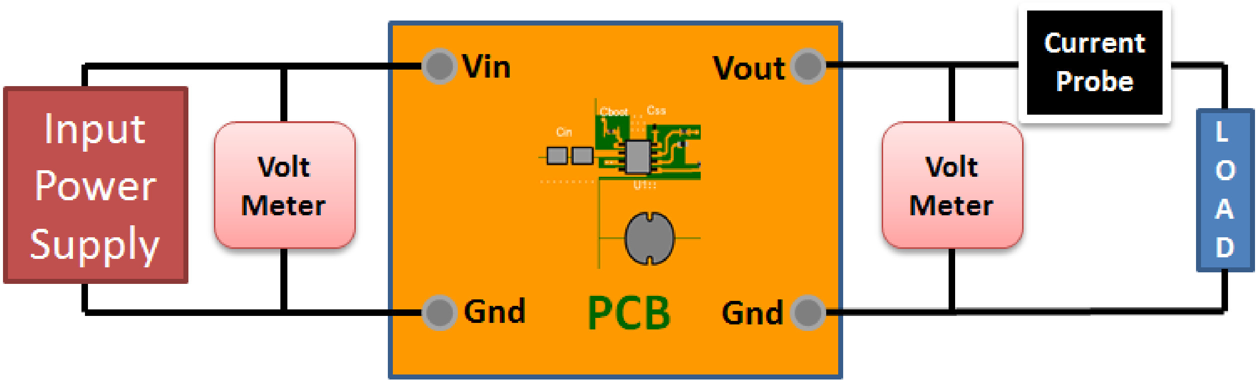
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 45.0V 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. Master key : E9A37A4B0947D528[v1]
2. **LM5022** Product Folder : http://www.ti.com/product/LM5022 : contains the data sheet and other resources.

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