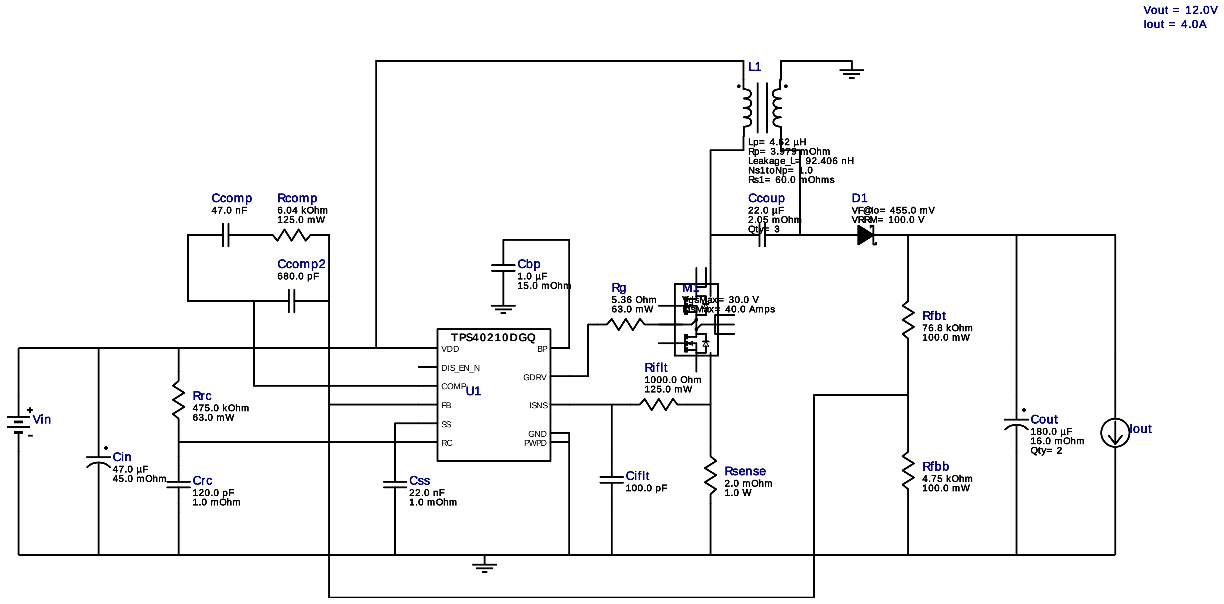
WEBENCH® Design Report

VinMin = 5.0V
VinMax = 12.0V
Vout = 12.0V
Iout = 4.0A

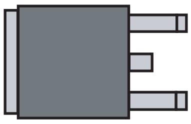
Device = TPS40210DGQR
Topology = SEPIC
Created = 2019-03-08 02:34:31.599
BOM Cost = NA
BOM Count = 23
Total Pd = 4.34W

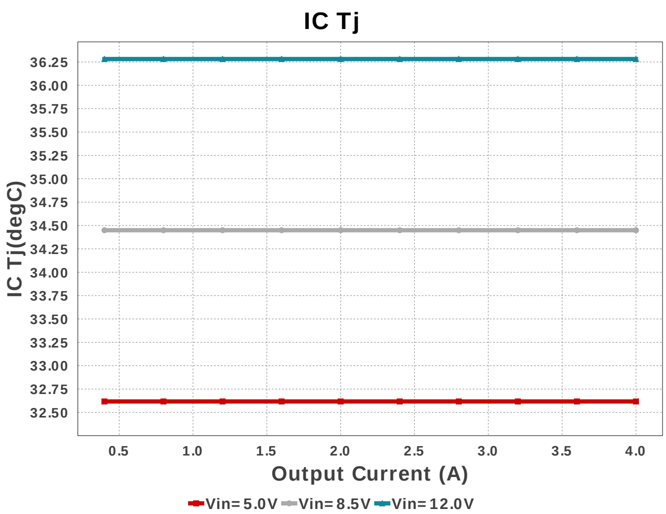
Design : 184 TPS40210DGQR
TPS40210DGQR 5V-12V to 12.00V @ 4A

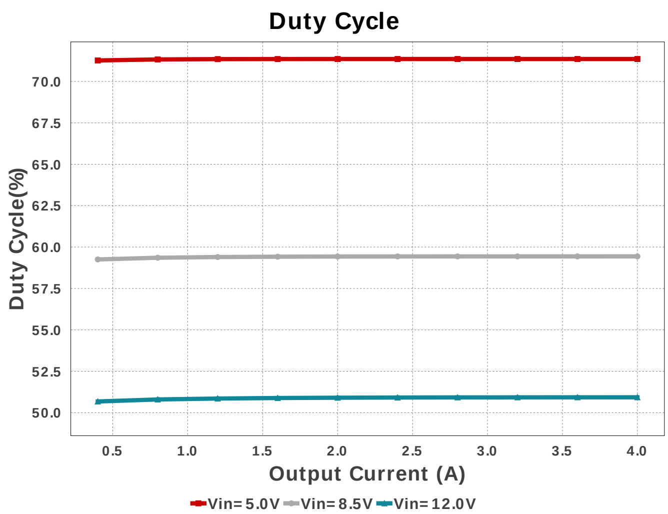


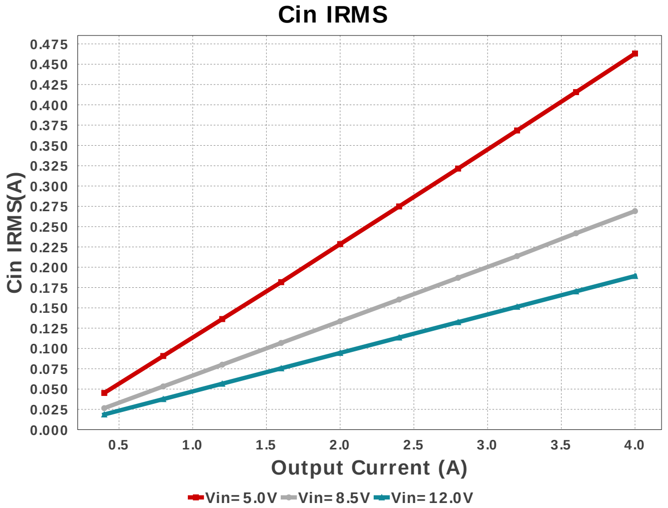
Electrical BOM

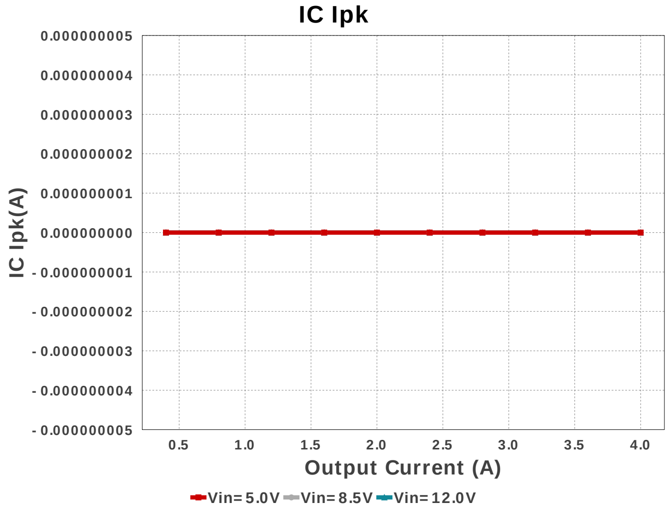
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbp	Kemet	C0805C105K4RACTU Series= X7R	Cap= 1.0 uF ESR= 15.0 mOhm VDC= 16.0 V IRMS= 8.19 A	1	$0.02	0805 7 mm²
Ccomp	Kemet	C0805C473J3GACAUTO Series= C0G/NP0	Cap= 47.0 nF VDC= 5.0 V IRMS= 0.0 A	1	$0.25	0805 7 mm²
Ccomp2	Samsung Electro-Mechanics	CL05C681JB5NNWC Series= C0G/NP0	Cap= 680.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Ccoup	TDK	C2012X5R1V226M125AC Series= X5R	Cap= 22.0 uF ESR= 2.05 mOhm VDC= 35.0 V IRMS= 4.5559 A	3	$0.38	0805 7 mm²
Cflt	Samsung Electro-Mechanics	CL21C101JBANNNC Series= C0G/NP0	Cap= 100.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²
Cin	Panasonic	20SVP47M Series= SVP	Cap= 47.0 uF ESR= 45.0 mOhm VDC= 20.0 V IRMS= 1.89 A	1	$0.51	SM_RADIAL_8MM 113 mm²
Cout	Panasonic	25SVPF180M Series= SVPF	Cap= 180.0 uF ESR= 16.0 mOhm VDC= 25.0 V IRMS= 4.65 A	2	$0.63	CAPSMT_62_E12 106 mm²
Crc	MuRata	GRM033R71E121KA01D Series= X7R	Cap= 120.0 pF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0201 2 mm²

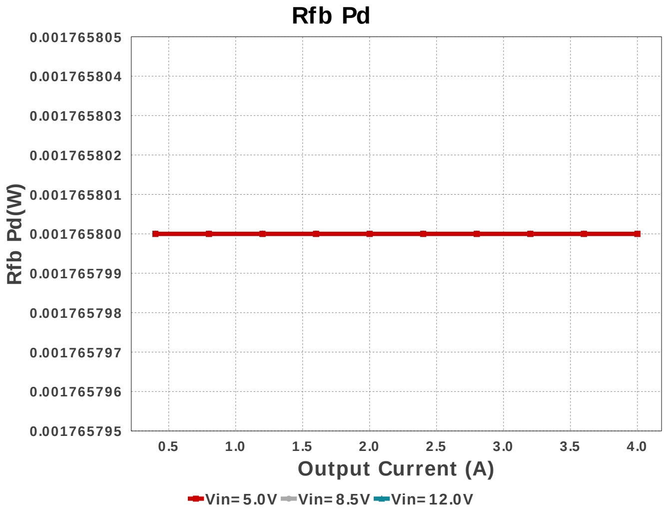
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Css	MuRata	GRM155R71C223KA01D Series= X7R	Cap= 22.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
D1	STMicroelectronics	STPS20M100SG-TR	VF@Io= 455.0 mV VRRM= 100.0 V	1	$1.33	 DDPAK 210 mm^2
L1	CUSTOM	CUSTOM	Lp= 4.62 µH Rp= 3.979 mOhm Leakage_L= 92.406 nH Ns1toNp= 1.0 Rs1= 60.0 mOhms	1	NA	CUSTOM 0 mm^2
M1	Texas Instruments	CSD87350Q5D	VdsMax= 30.0 V IdsMax= 40.0 Amps	1	$1.12	DQY0008A 56 mm^2
Rcomp	Vishay-Dale	CRCW08056K04FKEA Series= CRCW..e3	Res= 6.04 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Rfbb	Susumu Co Ltd	RR1220P-4751-D-M Series= RR12	Res= 4.75 kOhm Power= 100.0 mW Tolerance= 0.5%	1	$0.01	0805 7 mm^2
Rfbt	Susumu Co Ltd	RG1608P-7682-B-T5 Series= RG1608	Res= 76.8 kOhm Power= 100.0 mW Tolerance= 0.1%	1	$0.06	0603 5 mm^2
Rg	Vishay-Dale	CRCW04025R36FKED Series= CRCW..e3	Res= 5.36 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Riflt	Panasonic	ERJ-6ENF1001V Series= ERJ-6E	Res= 1000.0 Ohm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Rrc	Vishay-Dale	CRCW0402475KFKED Series= CRCW..e3	Res= 475.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rsense	Stackpole Electronics Inc	CSNL1206FT2L00 Series= CSNL	Res= 2.0 mOhm Power= 1.0 W Tolerance= 1.0%	1	$0.20	1206 11 mm^2
U1	Texas Instruments	TPS40210DGQR	Switcher	1	$0.75	S-PDSO-G10 24 mm^2

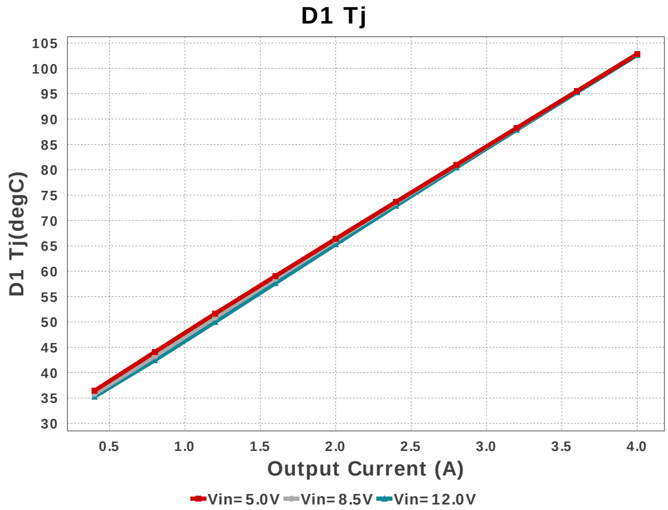


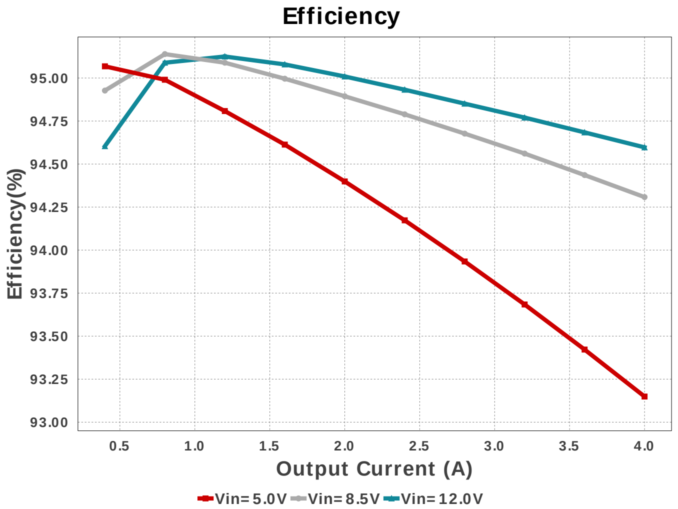


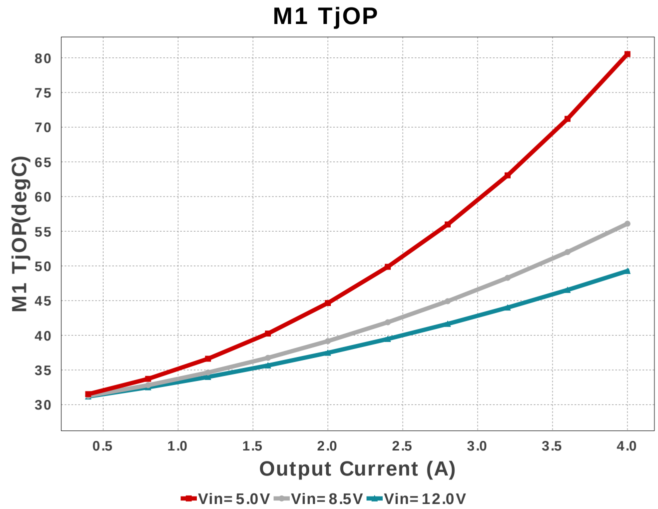

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V


IC Ipk
IC Ipk(A)
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V

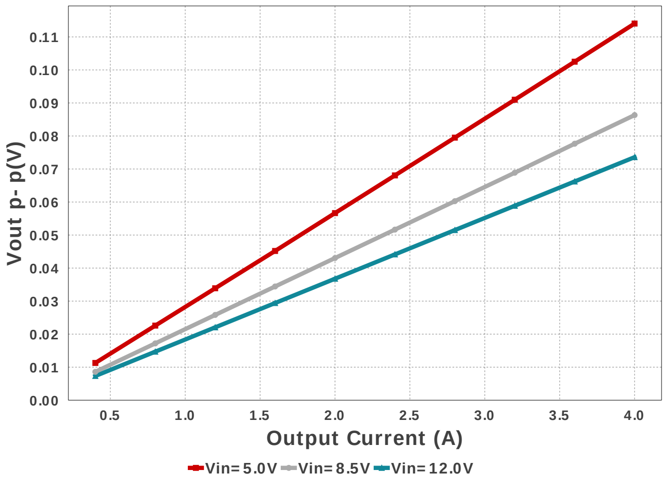

Rfb Pd
Rfb Pd(W)
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V


D1 Tj
D1 Tj(degC)
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V

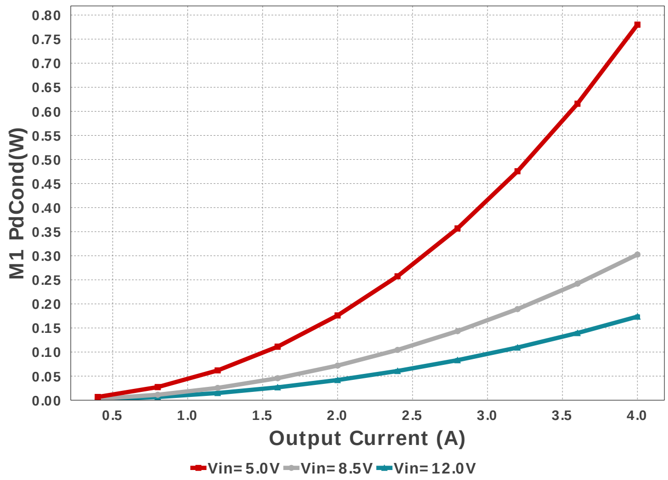

Efficiency
Efficiency(%)
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V


M1 TjOP
M1 TjOP(degC)
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V

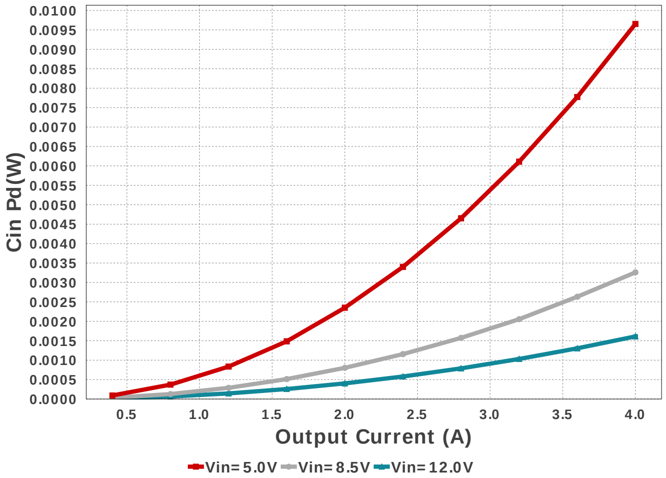
Vout p- p



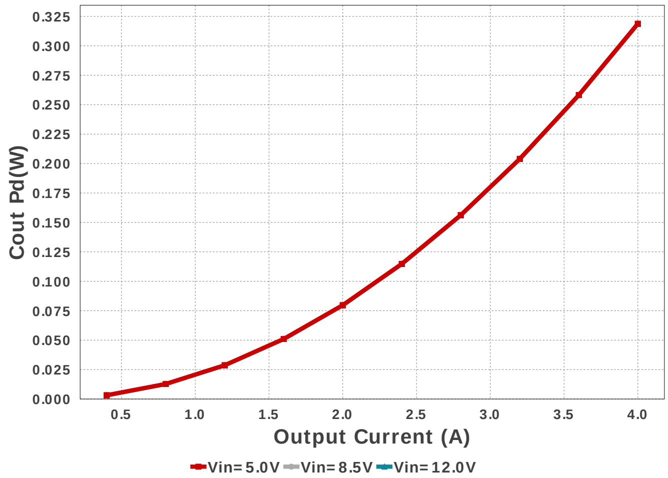
M1 PdCond



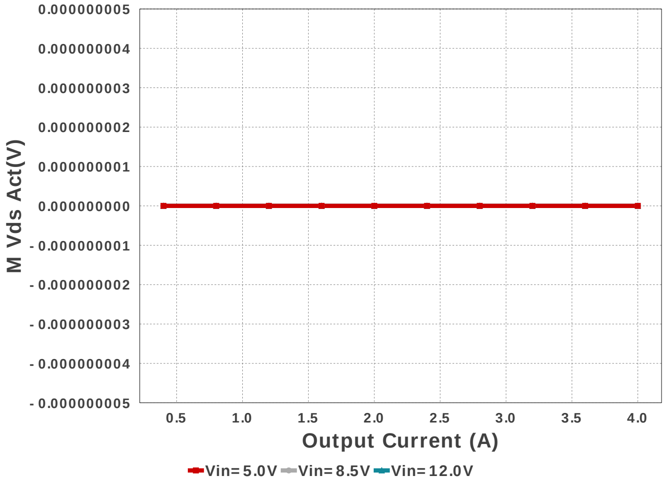
Cin Pd



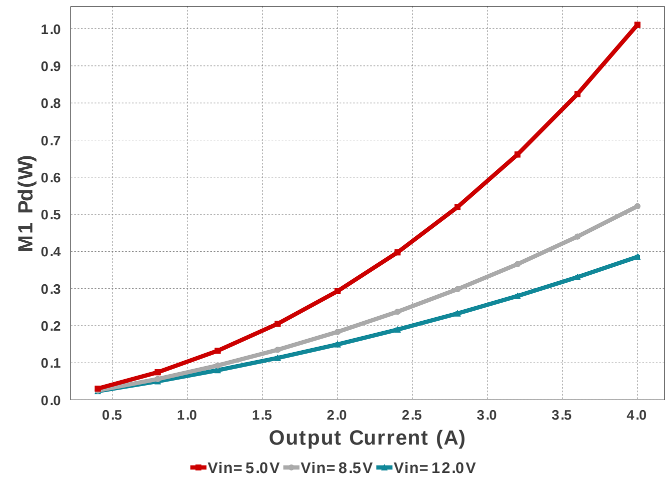
Cout Pd

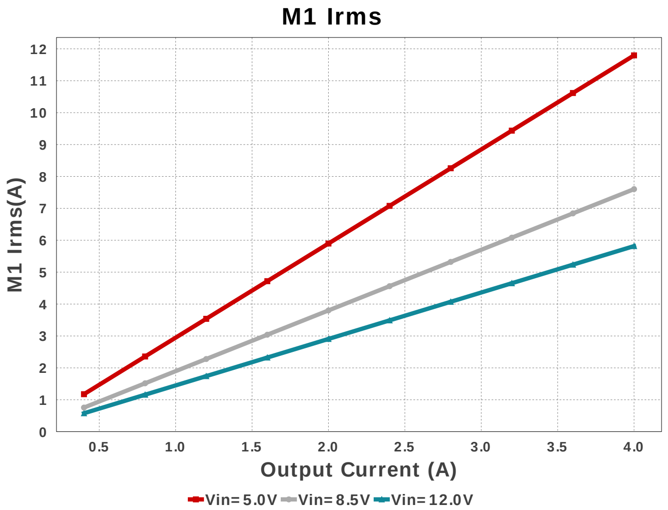


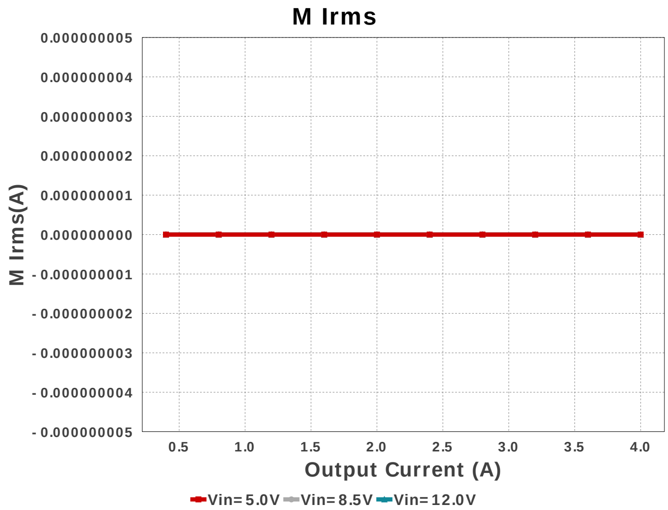
M Vds Act

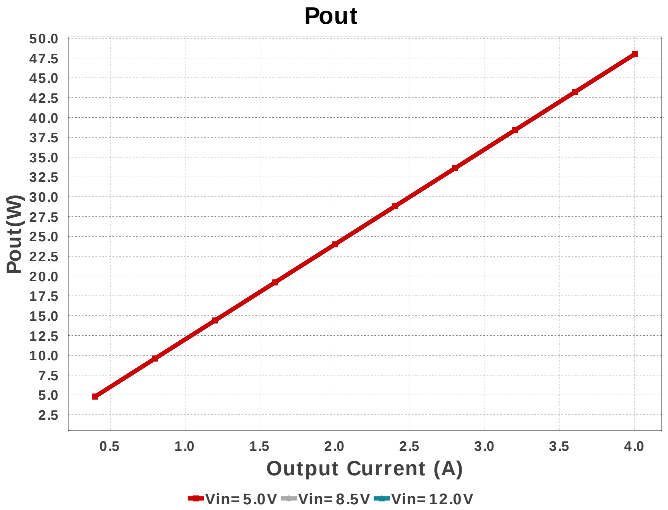


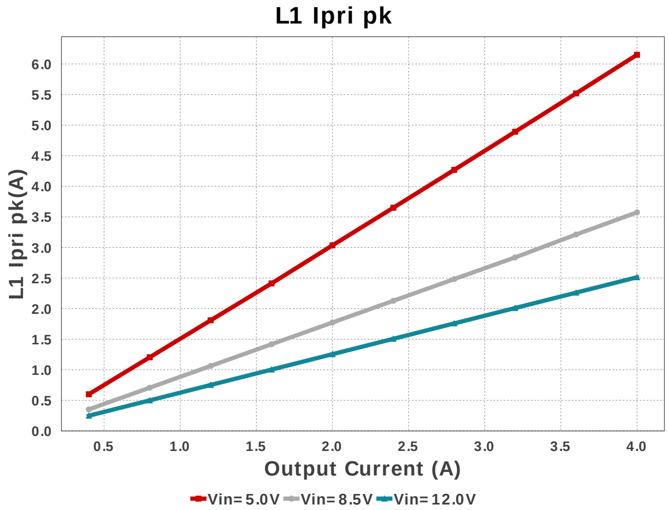
M1 Pd

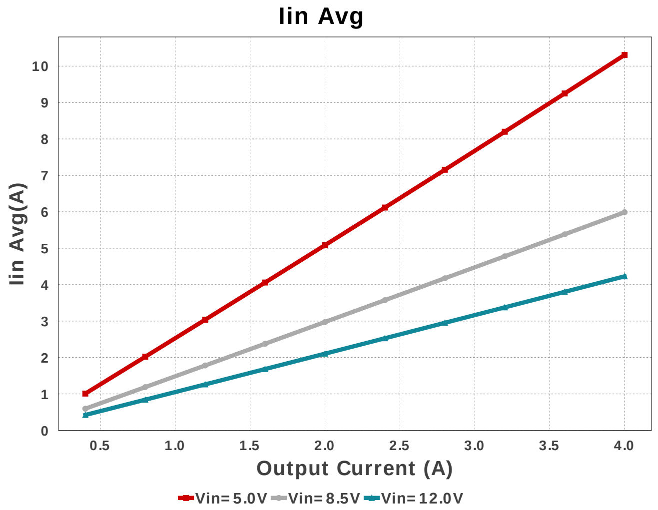


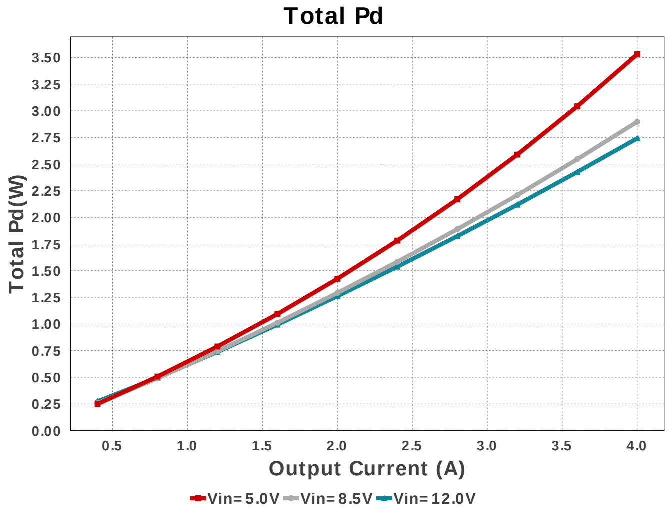

M1 Irms
M1 Irms(A)
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V

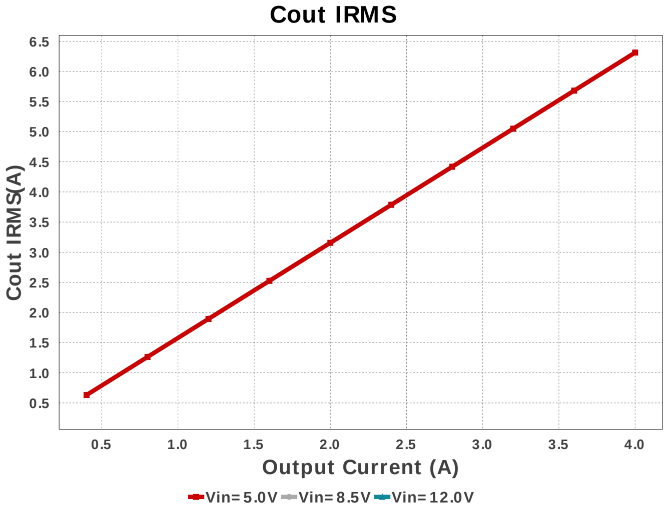

M Irms
M Irms(A)
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V

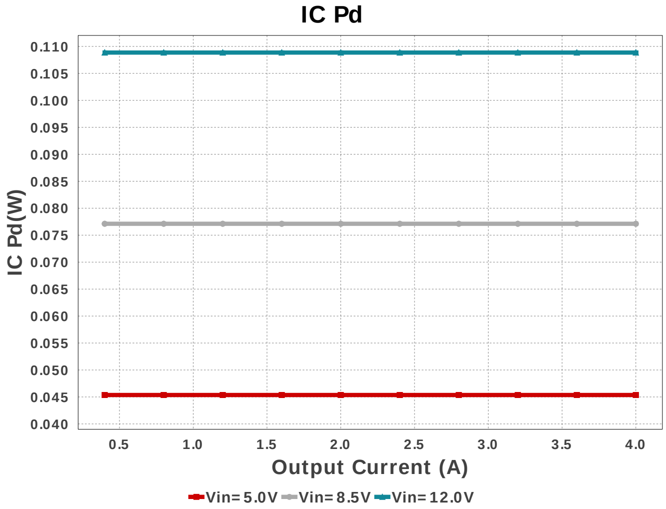

Pout
Pout(W)
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V

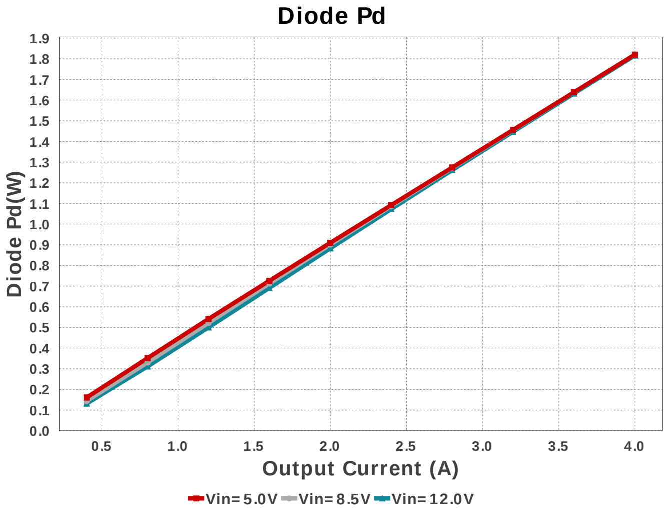

L1 Ipri pk
L1 Ipri pk(A)
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V

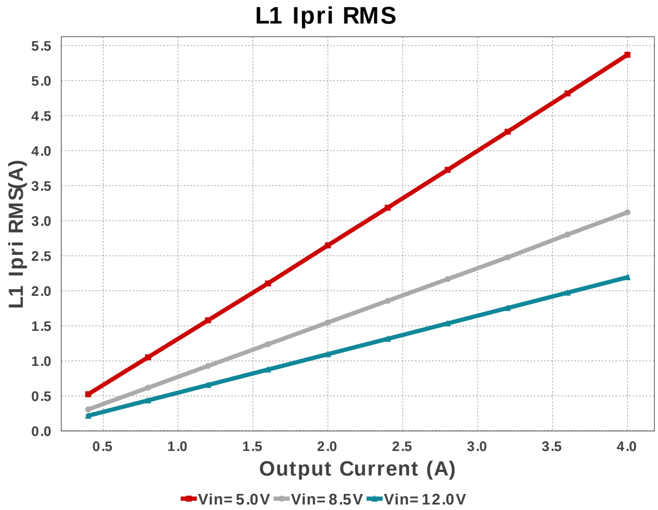

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V

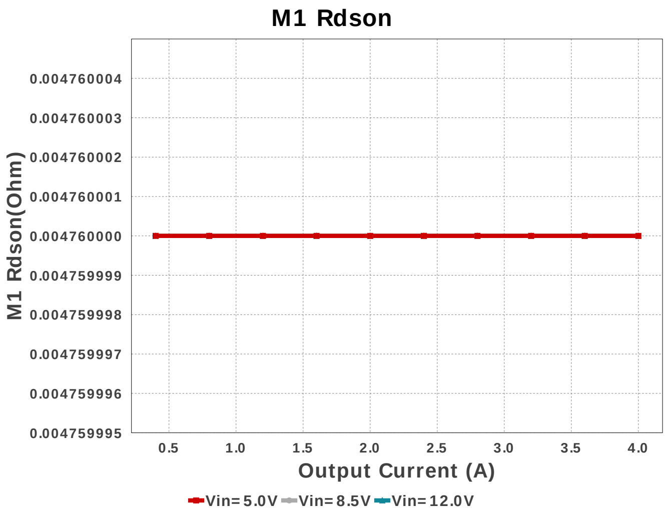

Total Pd
Total Pd(W)
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V

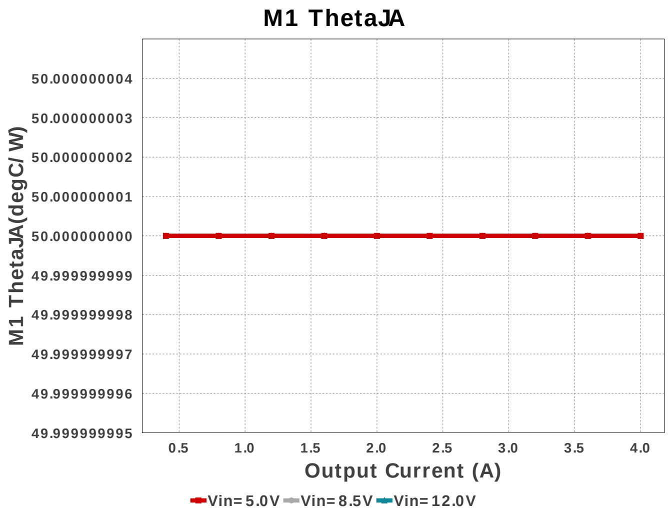

Cout IRMS
Cout IRMS(A)
6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V

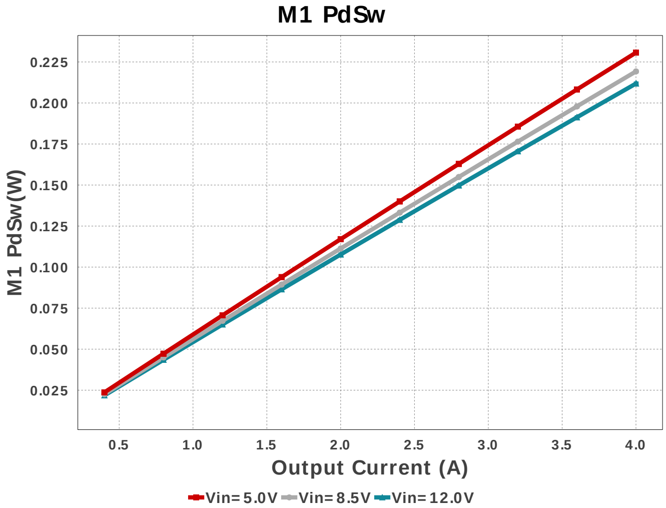

IC Pd
IC Pd(W)
0.110 0.105 0.100 0.095 0.090 0.085 0.080 0.075 0.070 0.065 0.060 0.055 0.050 0.045 0.040
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V

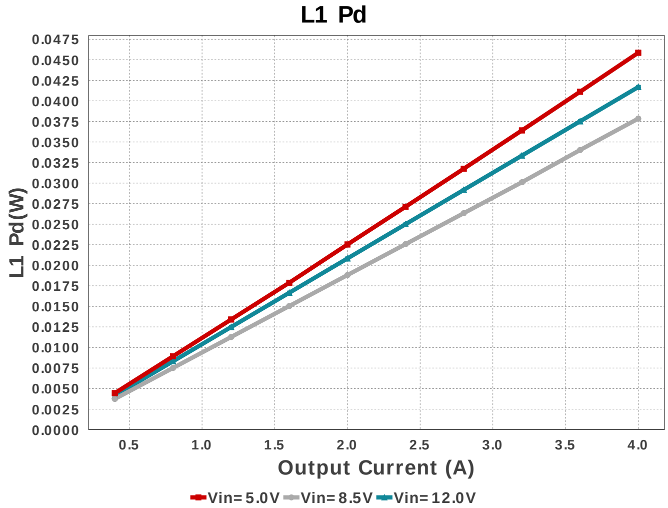

Diode Pd
Diode Pd(W)
1.9 1.8 1.7 1.6 1.5 1.4 1.3 1.2 1.1 1.0 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0.0
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V

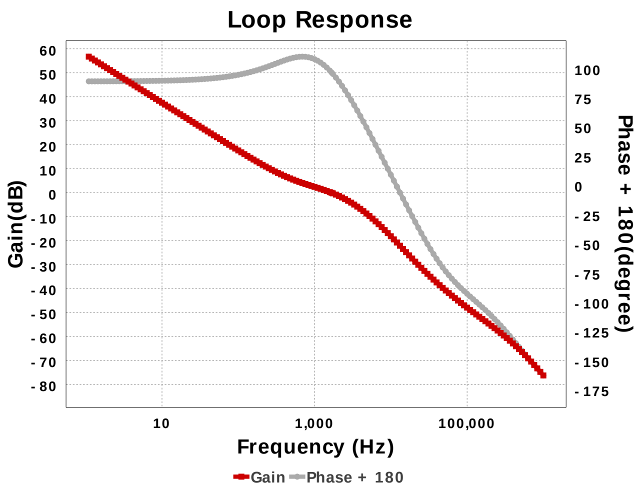

L1 Ipri RMS
L1 Ipri RMS(A)
5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V


M1 Rdson
M1 Rdson(Ohm)
0.004760004 0.004760003 0.004760002 0.004760001 0.004760000 0.004759999 0.004759998 0.004759997 0.004759996 0.004759995
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V


M1 ThetaJA
M1 ThetaJA(degC/W)
50.000000004 50.000000003 50.000000002 50.000000001 50.000000000 49.999999999 49.999999998 49.999999997 49.999999996 49.999999995
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
Output Current (A)
Vin=5.0V Vin=8.5V Vin=12.0V







Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	470.412 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	9.958 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	6.312 A	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	318.72 mW	Capacitor	Output capacitor power dissipation
5.	D1 Tj	102.8 degC	Diode	D1 junction temperature
6.	Diode Pd	1.82 W	Diode	Diode power dissipation
7.	IC Pd	69.464 mW	IC	IC power dissipation
8.	IC Tj	34.008 degC	IC	IC junction temperature
9.	IC Tolerance	14.0 mV	IC	IC Feedback Tolerance
10.	ICThetaJA	57.7 degC/W	IC	IC junction-to-ambient thermal resistance
11.	Iin Avg	10.467 A	IC	Average input current
12.	M1 Irms	11.796 A	Mosfet	M1 MOSFET Irms
13.	M1 Pd	1.792 W	Mosfet	M1 MOSFET total power dissipation
14.	M1 PdCond	486.88 mW	Mosfet	M1 MOSFET conduction losses
15.	M1 PdSw	1.305 W	Mosfet	M1 MOSFET switching losses
16.	M1 Rdson	2.8 mOhm	Mosfet	Drain-Source On-resistance
17.	M1 ThetaJA	50.0 degC/W	Mosfet	MOSFET junction-to-ambient thermal resistance
18.	M1 TjOP	119.6 degC	Mosfet	M1 MOSFET junction temperature
19.	Cin Pd	9.958 mW	Power	Input capacitor power dissipation
20.	Cout Pd	318.72 mW	Power	Output capacitor power dissipation
21.	Diode Pd	1.82 W	Power	Diode power dissipation
22.	IC Pd	69.464 mW	Power	IC power dissipation
23.	L1 Pd	46.793 mW	Power	Power Dissipation in the Inductor
24.	M1 Pd	1.792 W	Power	M1 MOSFET total power dissipation
25.	M1 PdCond	486.88 mW	Power	M1 MOSFET conduction losses
26.	M1 PdSw	1.305 W	Power	M1 MOSFET switching losses
27.	Rfb Pd	1.766 mW	Power	Rfb Power Dissipation
28.	Total Pd	4.337 W	Power	Total Power Dissipation
29.	Rfb Pd	1.766 mW	Resistor	Rfb Power Dissipation
30.	BOM Count	23	System Information	Total Design BOM count

#	Name	Value	Category	Description
31.	Cross Freq	1.152 kHz	System Information	Bode plot crossover frequency
32.	Duty Cycle	71.355 %	System Information	Duty cycle
33.	Efficiency	91.713 %	System Information	Steady state efficiency
34.	FootPrint	905.0 mm^2	System Information	Total Foot Print Area of BOM components
35.	Frequency	287.697 kHz	System Information	Switching frequency
36.	Gain Marg	-17.101 dB	System Information	Bode Plot Gain Margin
37.	Iout	4.0 A	System Information	Iout operating point
38.	Low Freq Gain	61.157 dB	System Information	Gain at 1Hz
39.	Mode	CCM	System Information	Conduction Mode
40.	Phase Marg	76.203 deg	System Information	Bode Plot Phase Margin
41.	Pout	48.0 W	System Information	Total output power
42.	Total BOM	NA	System Information	Total BOM Cost
43.	Vin	5.0 V	System Information	Vin operating point
44.	Vout	12.0 V	System Information	Operational Output Voltage
45.	Vout Actual	12.018 V	System Information	Vout Actual calculated based on selected voltage divider resistors
46.	Vout Tolerance	2.579 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
47.	Vout p-p	116.049 mV	System Information	Peak-to-peak output ripple voltage
48.	L1 Ipri RMS	5.452 A	Transformer	RMS current in primary of PFC-Coil L1.
49.	L1 Ipri pk	6.247 A	Transformer	Peak current in primary of PFC-Coil L1.
50.	L1 Pd	46.793 mW	Transformer	Power Dissipation in the Inductor

Design Inputs

Name	Value	Description
Iout	4.0	Maximum Output Current
VinMax	12.0	Maximum input voltage
VinMin	5.0	Minimum input voltage
Vout	12.0	Output Voltage
base_pn	TPS40210	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

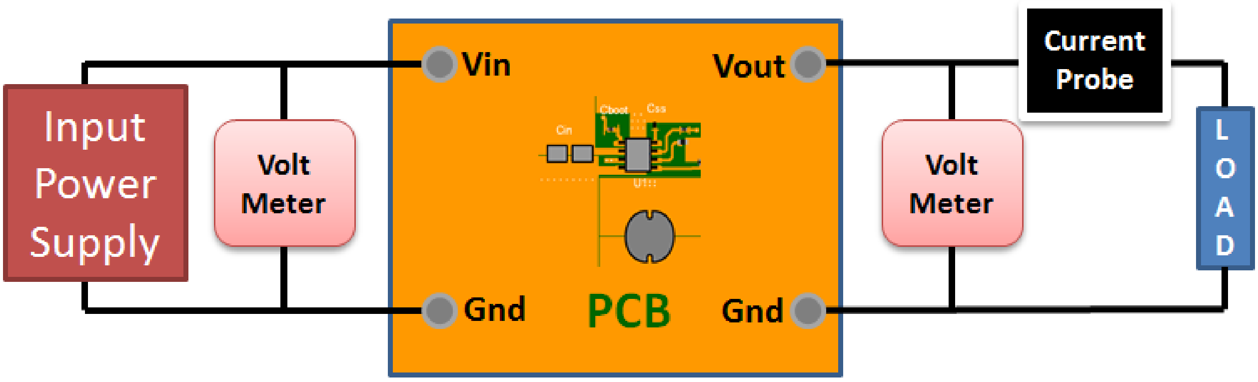
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 5.0V 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 : CC6D3C58E5E882D7[v1]

2. **TPS40210** Product Folder : http://www.ti.com/product/TPS40210 : contains the data sheet and other resources.