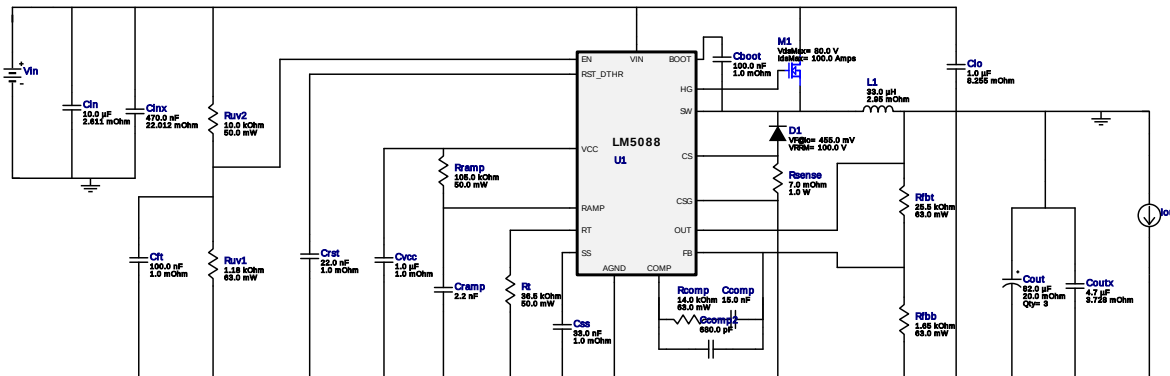


WEBENCH® Design Report

Design : 125 LM5088MH-2/NOPB
LM5088MH-2/NOPB 14V-32V to -20.00V @ 3.5A

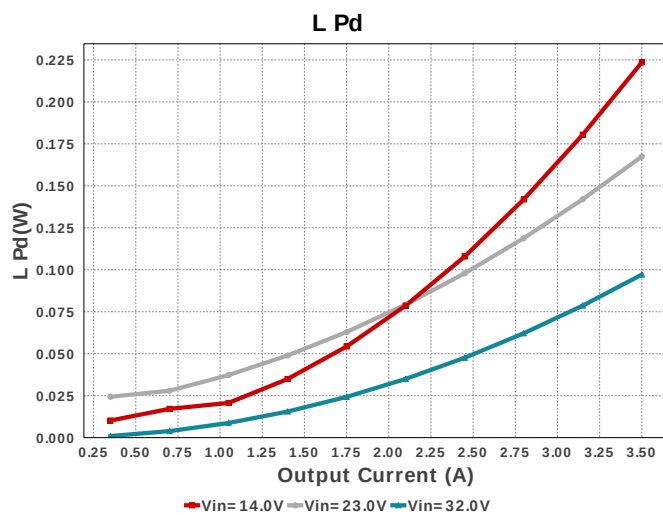
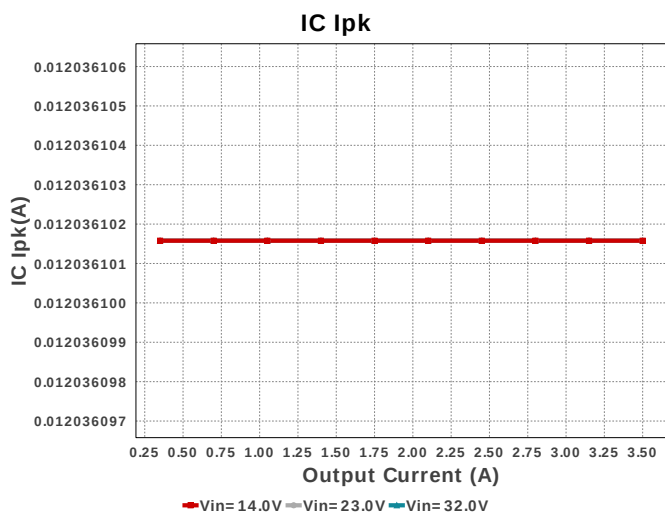
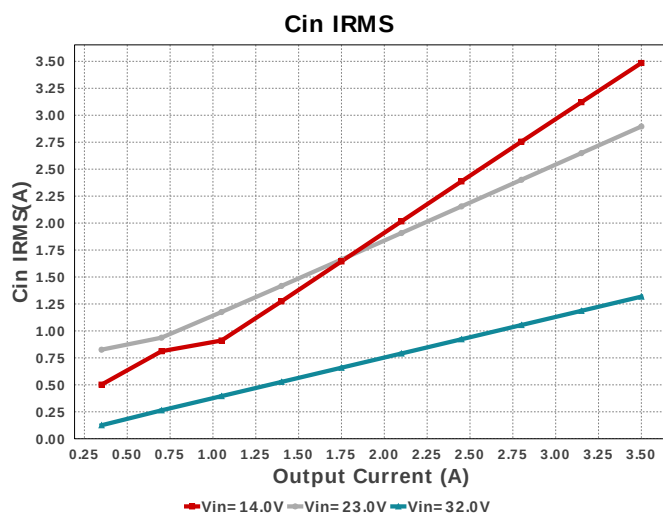
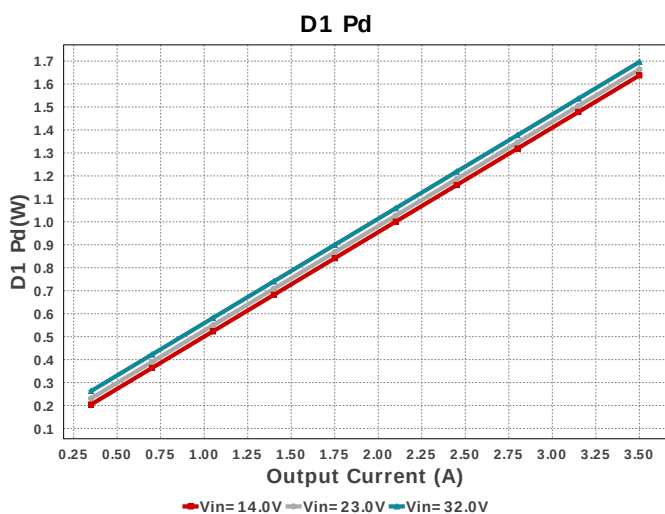
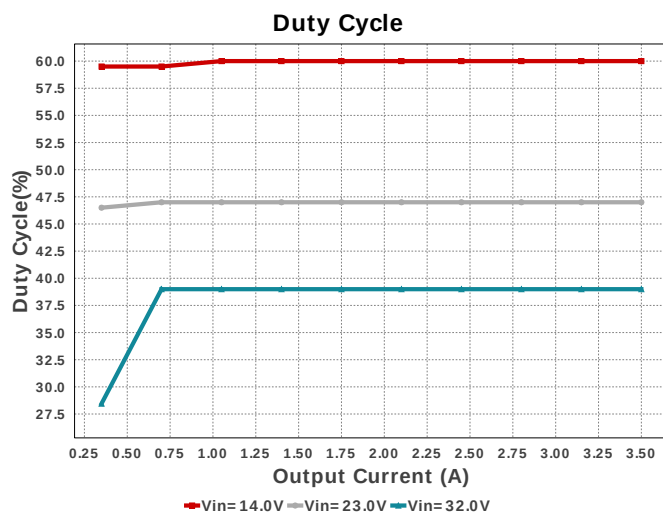
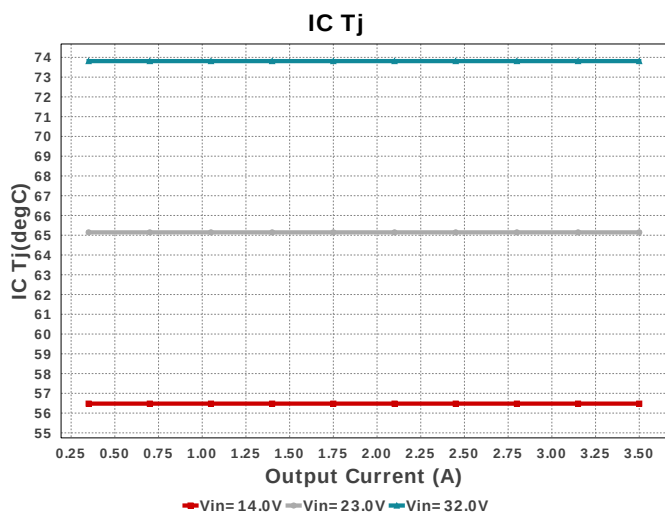
Vout = -20.0V
Iout = 3.5A

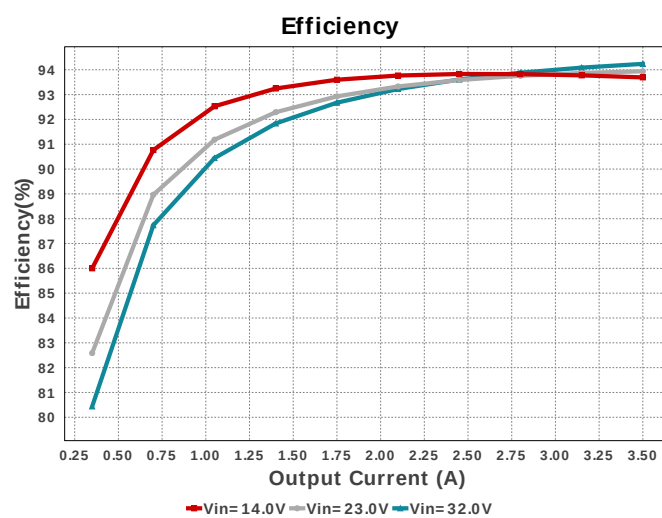
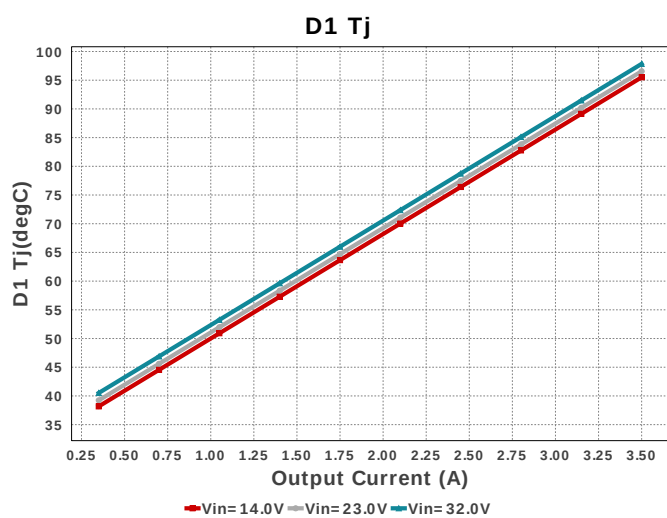
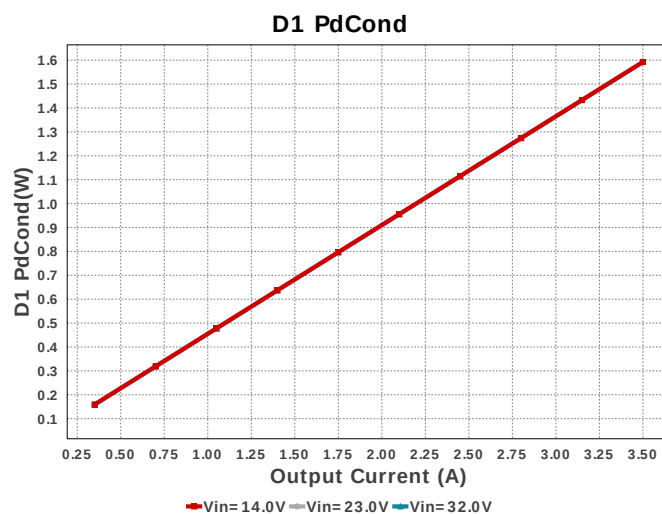
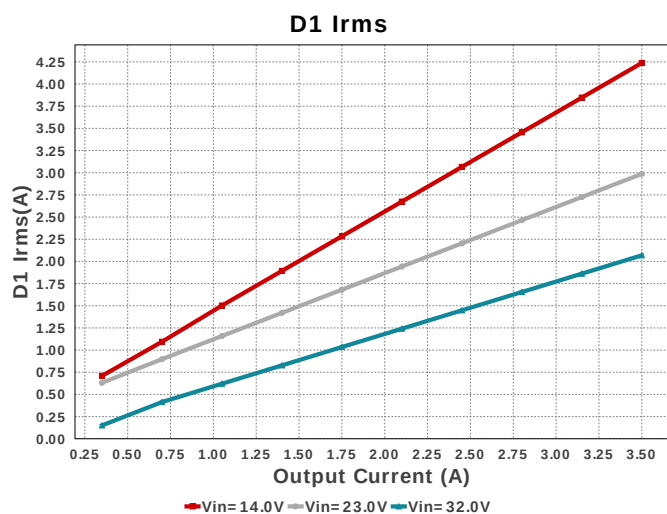
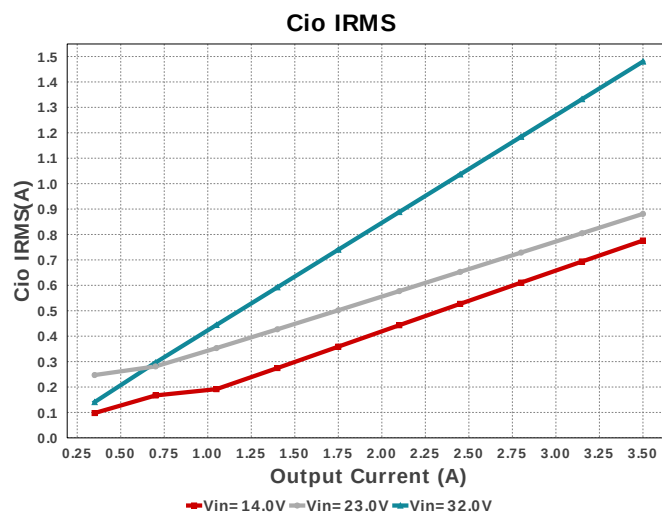
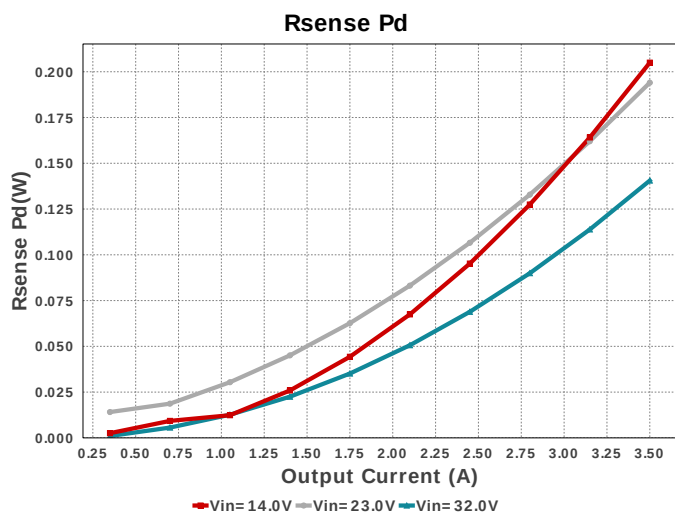


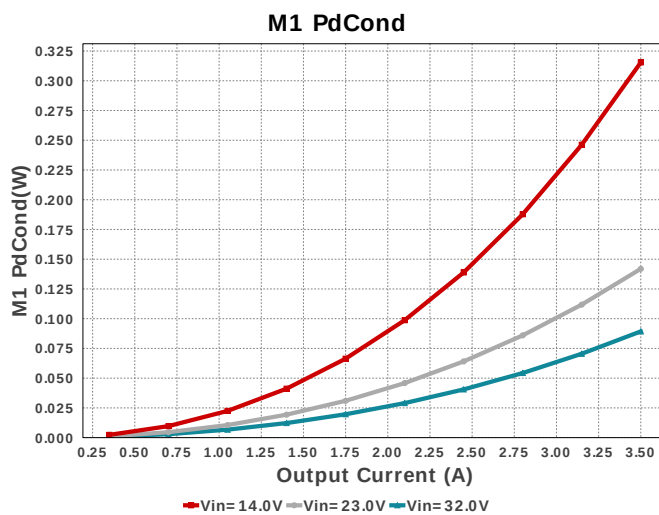
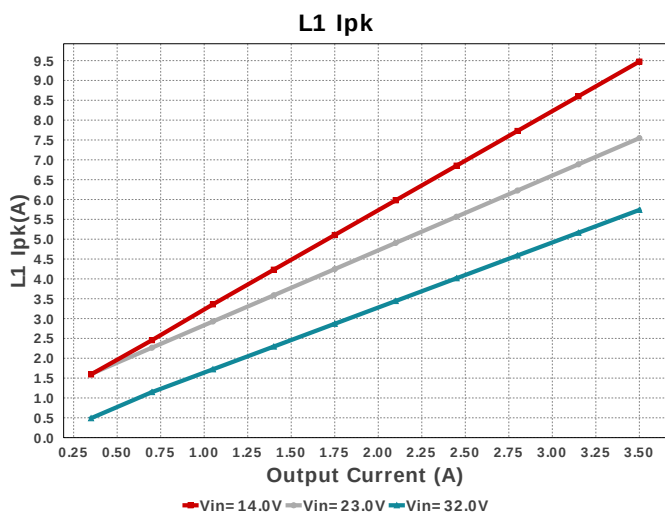
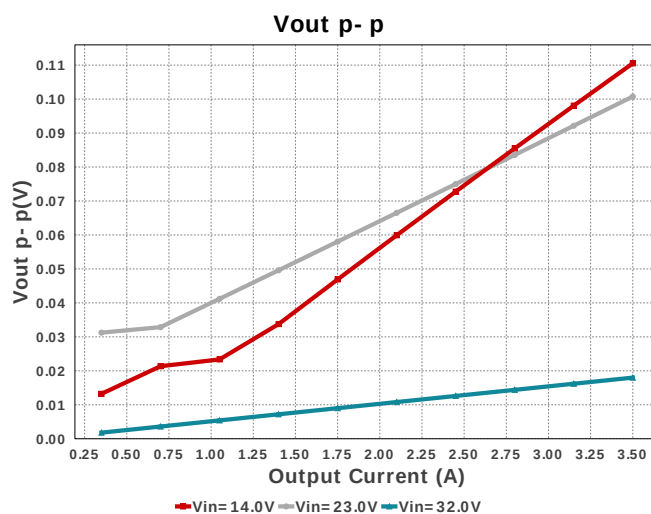
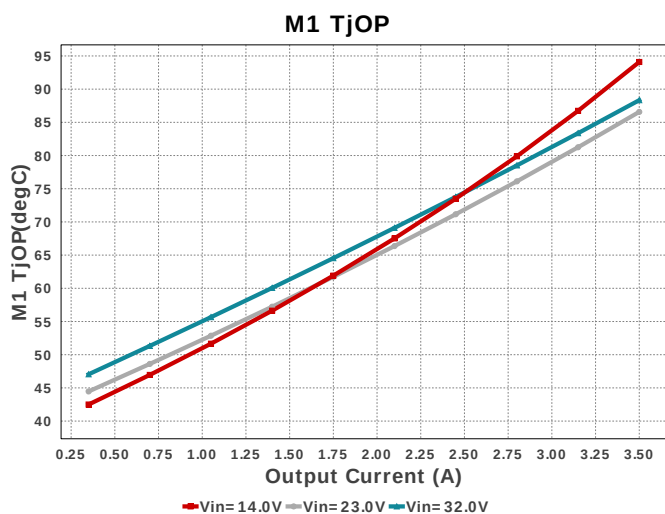
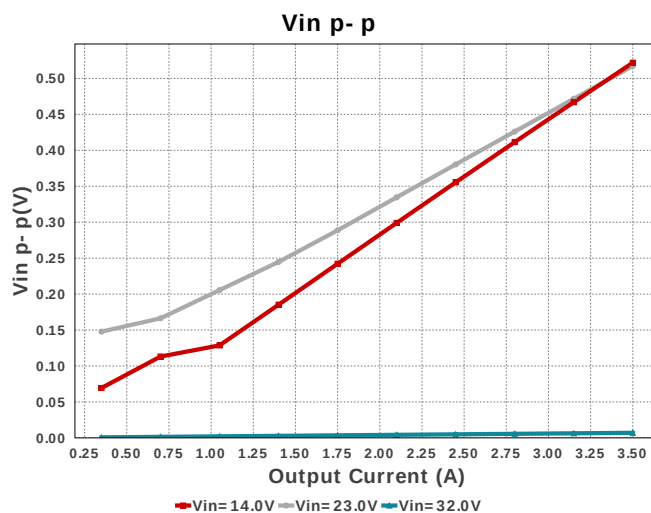
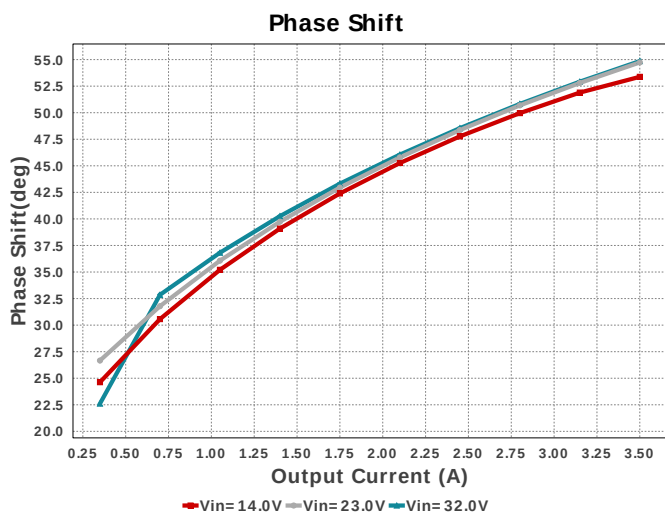
Electrical BOM

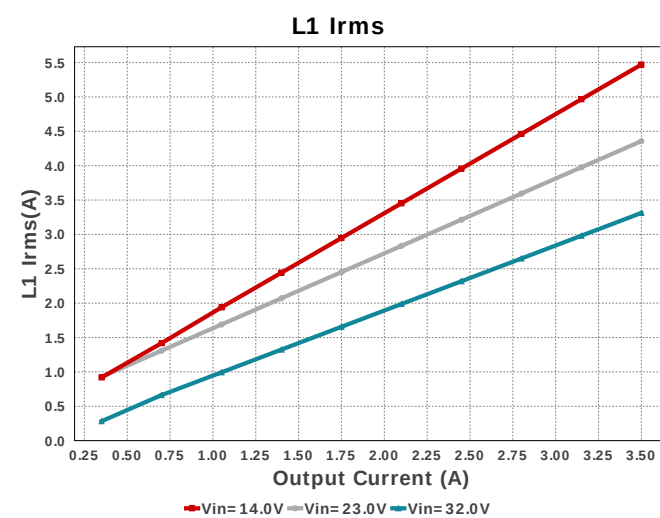
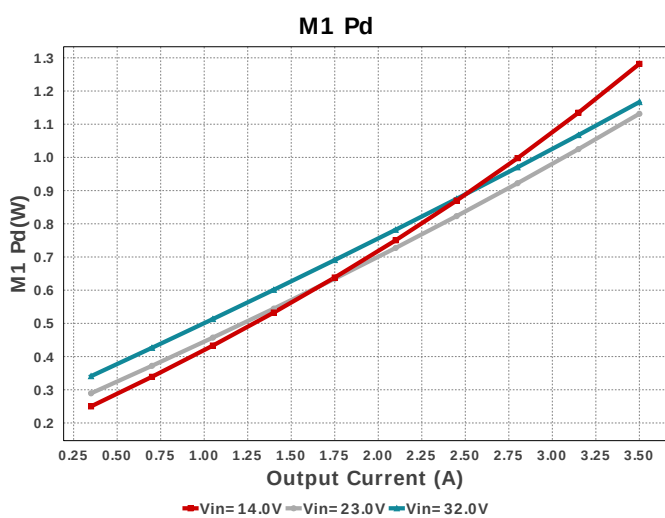
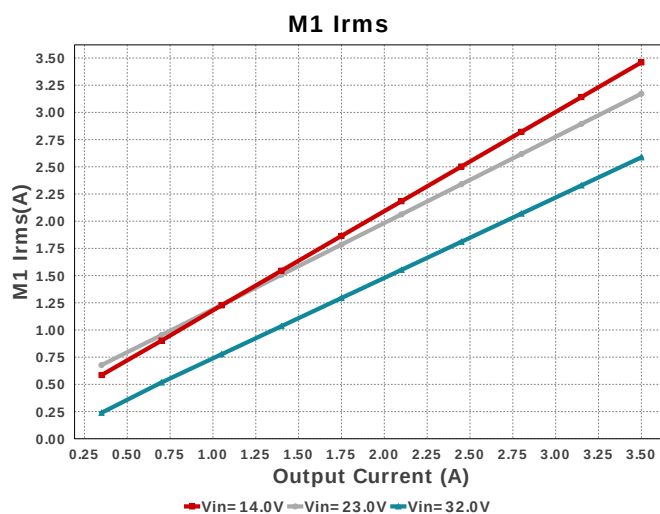
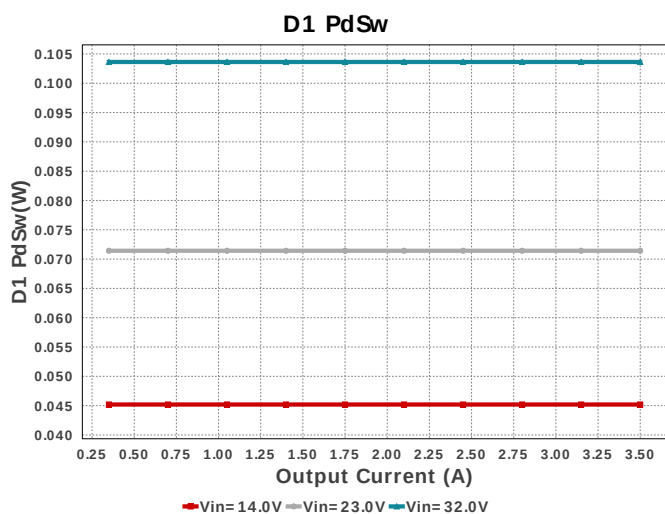
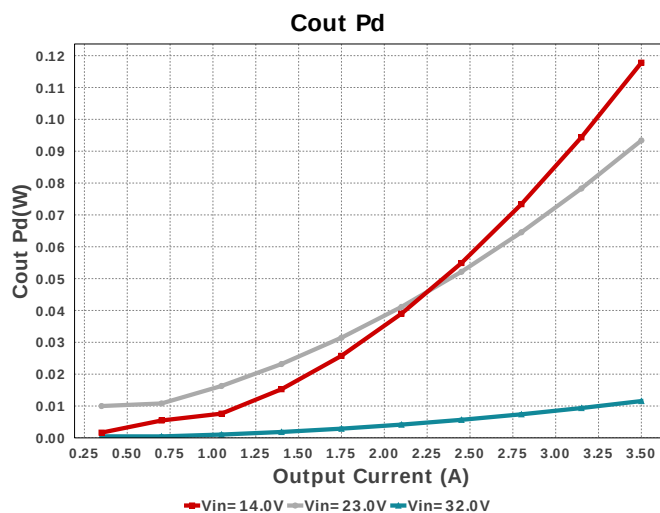
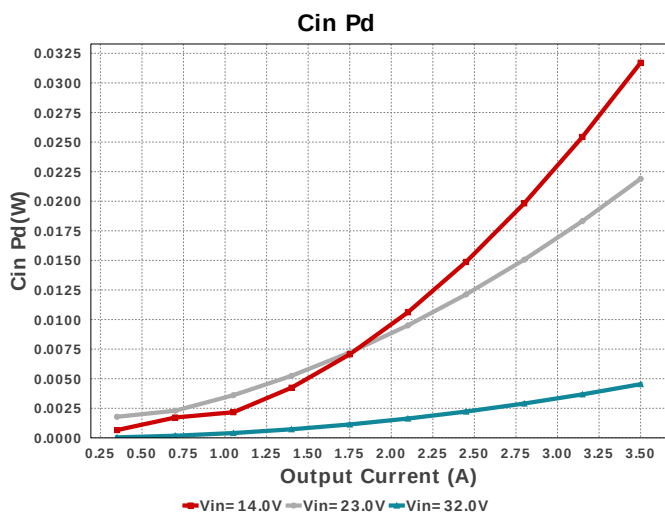
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	Yageo	CC0805KRX7R9BB104 Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	\$0.02	0805 7 mm ²
Ccomp	TDK	CGA4F2C0G1H153J085AA Series= C0G/NP0	Cap= 15.0 nF VDC= 50.0 V IRMS= 0.0 A	1	\$0.07	0805 7 mm ²
Ccomp2	Yageo	CC0805JRNPO9BN681 Series= C0G/NP0	Cap= 680.0 pF VDC= 50.0 V IRMS= 0.0 A	1	\$0.02	0805 7 mm ²
Cft	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
Cin	TDK	C5750X5R1H106K230KA Series= X5R	Cap= 10.0 uF ESR= 2.611 mOhm VDC= 50.0 V IRMS= 5.6501 A	1	\$0.68	2220_250 54 mm ²
Cinx	TDK	CGA4J3X7R1H474K125AB Series= X7R	Cap= 470.0 nF ESR= 22.012 mOhm VDC= 50.0 V IRMS= 1.39566 A	1	\$0.06	0805 7 mm ²
Cio	TDK	C2012X7S2A105K125AB Series= X7S	Cap= 1.0 uF ESR= 8.255 mOhm VDC= 100.0 V IRMS= 2.27442 A	1	\$0.12	0805 7 mm ²
Cout	Panasonic	35SVPF82M Series= SVPF	Cap= 82.0 uF ESR= 20.0 mOhm VDC= 35.0 V IRMS= 4.0 A	3	\$0.63	CAPSMT_62_E12 106 mm ²
Coutx	TDK	C1608X5R1V475K080AC Series= X5R	Cap= 4.7 uF ESR= 3.728 mOhm VDC= 35.0 V IRMS= 2.69359 A	1	\$0.10	0603 5 mm ²
Cramp	Samsung Electro-Mechanics	CL21C222JBFNNNE Series= C0G/NP0	Cap= 2.2 nF VDC= 50.0 V IRMS= 0.0 A	1	\$0.03	0805 7 mm ²

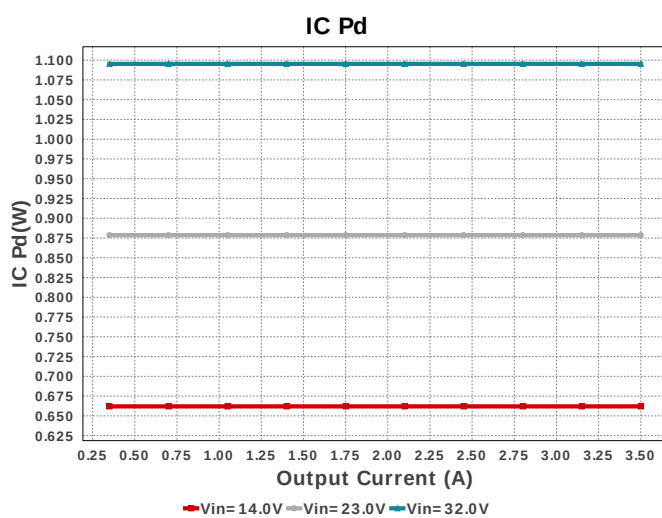
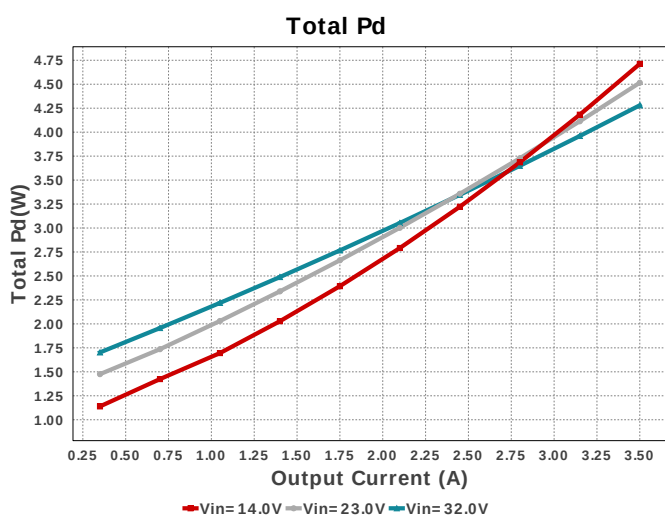
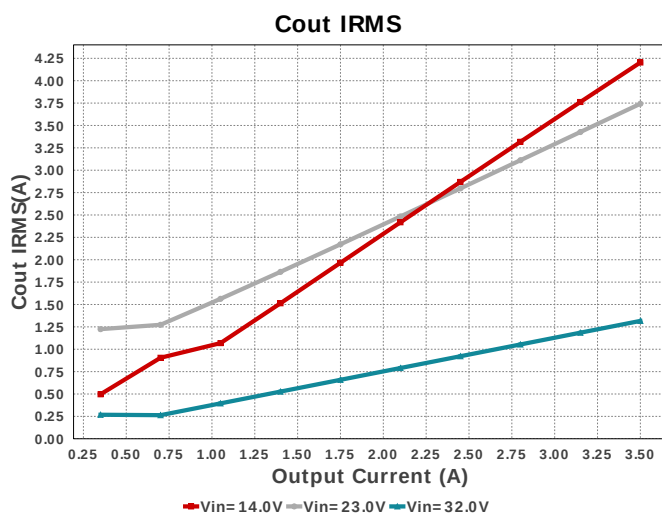
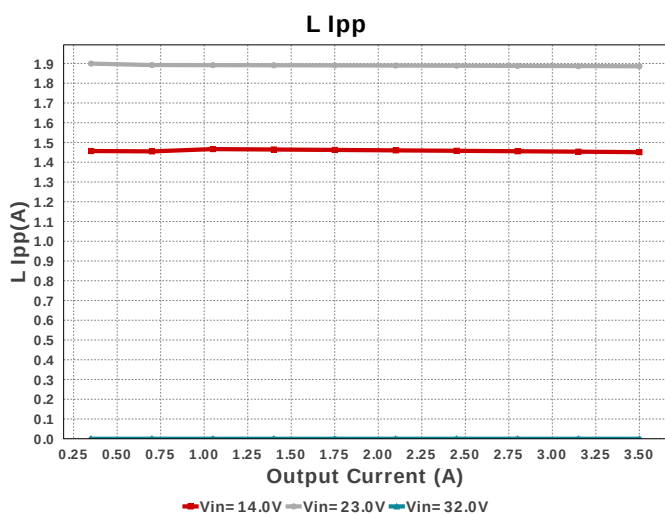
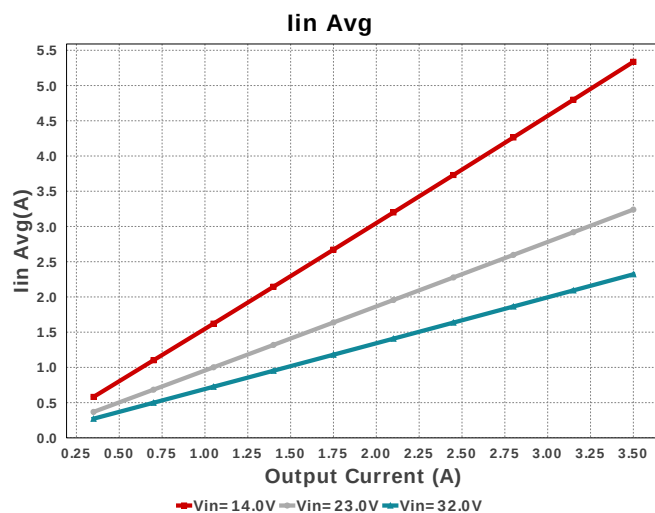
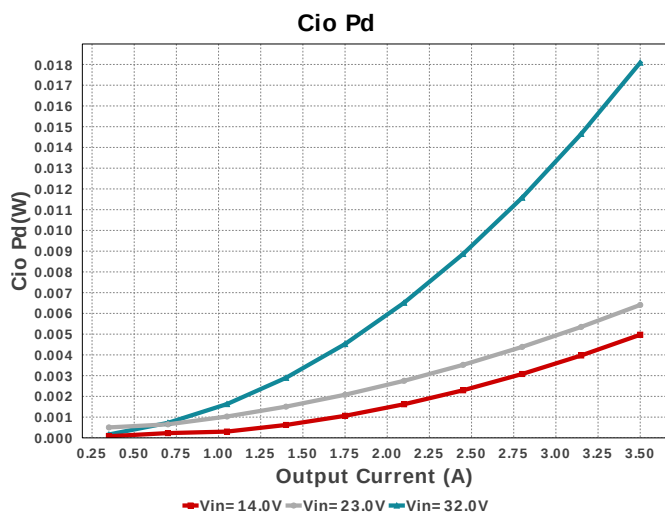
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Crst	MuRata	GRM033R60J223KE01D Series= X5R	Cap= 22.0 nF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 0.0 A	1	\$0.01	 0201 2 mm ²
Css	MuRata	GRM155R71E333KA88D Series= X7R	Cap= 33.0 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	\$0.01	 0402 3 mm ²
Cvcc	Taiyo Yuden	EMK107B7105KA-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	\$0.02	 0603 5 mm ²
D1	STMicroelectronics	STPS20M100SG-TR	VF@Io= 455.0 mV VRRM= 100.0 V	1	\$1.33	 DDPAK 210 mm ²
L1	Coilcraft	AGP4233-333ME	L= 33.0 uH 2.95 mOhm	1	\$7.84	AGP4233_Mid 1671 mm ²
M1	Texas Instruments	CSD19502Q5B	VdsMax= 80.0 V IdsMax= 100.0 Amps	1	\$0.97	DQK0006C 9 mm ²
Rcomp	Vishay-Dale	CRCW040214K0FKED Series= CRCW..e3	Res= 14.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
Rfbb	Vishay-Dale	CRCW04021K65FKED Series= CRCW..e3	Res= 1.65 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
Rfbt	Vishay-Dale	CRCW040225K5FKED Series= CRCW..e3	Res= 25.5 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
Rramp	Yageo	RC0201FR-07105KL Series= ?	Res= 105.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	\$0.01	 0201 2 mm ²
Rsense	Susumu Co Ltd	PRL1632-R007-F-T1 Series= PRL1632	Res= 7.0 mOhm Power= 1.0 W Tolerance= 1.0%	1	\$0.20	 0612 11 mm ²
Rt	Yageo	RC0201FR-0736K5L Series= ?	Res= 36.5 kOhm Power= 50.0 mW Tolerance= 1.0%	1	\$0.01	 0201 2 mm ²
Ruv1	Vishay-Dale	CRCW04021K18FKED Series= CRCW..e3	Res= 1.18 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
Ruv2	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	\$0.01	 0201 2 mm ²
U1	Texas Instruments	LM5088MH-2/NOPB	Switcher	1	\$1.76	 MXA16A 59 mm ²

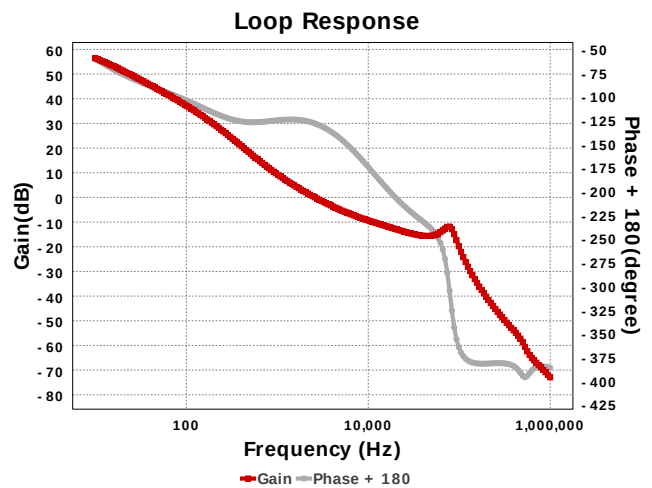
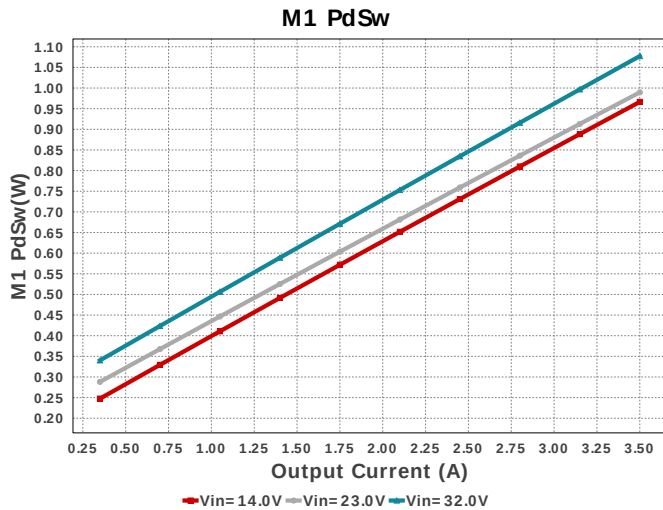












Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	1.992 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	10.358 mW	Capacitor	Input capacitor power dissipation
3.	Cio IRMS	2.237 A	Capacitor	Input to output capacitor RMS ripple current
4.	Cio Pd	41.297 mW	Capacitor	Input to output capacitor power dissipation
5.	Cout IRMS	1.989 A	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	26.386 mW	Capacitor	Output capacitor power dissipation
7.	D1 Irms	3.832 A	Current	D1 Irms
8.	D1 Pd	1.635 W	Diode	Diode power dissipation
9.	D1 PdCond	1.592 W	Diode	Diode conduction losses
10.	D1 PdSw	42.14 mW	Diode	Diode switching losses
11.	D1 Tj	95.386 degC	Diode	D1 junction temperature
12.	IC Ipk	11.48 mA	IC	Peak switch current in IC
13.	IC Pd	1.045 W	IC	IC power dissipation
14.	IC Tj	71.787 degC	IC	IC junction temperature
15.	IC Tolerance	18.0 mV	IC	IC Feedback Tolerance
16.	Iin Avg	5.303 A	IC	Average input current
17.	L Ipp	0.0 A	Inductor	Peak-to-peak output inductor ripple current
18.	L Pd	218.88 mW	Inductor	Inductor power dissipation
19.	L1 Ipk	8.614 A	Inductor	Inductor peak current
20.	L1 Irms	4.973 A	Inductor	Inductor ripple current
21.	M1 Irms	3.17 A	Mosfet	M1 MOSFET Irms
22.	M1 Pd	1.211 W	Mosfet	M1 MOSFET total power dissipation
23.	M1 PdCond	309.904 mW	Mosfet	M1 MOSFET conduction losses
24.	M1 PdSw	901.103 mW	Mosfet	M1 MOSFET switching losses
25.	M1 TjOP	90.551 degC	Mosfet	M1 MOSFET junction temperature
26.	IOUT_OP	3.5 A	Op Point	Iout operating point
27.	VIN_OP	14.0 V	Op Point	Vin operating point
28.	Total Pd	4.246 W	Power	Total Power Dissipation
29.	Rsense Pd	210.348 mW	Resistor	LED Current Rns Power Dissipation
30.	BOM Count	27	System	Total Design BOM count
31.	Cross Freq	2.583 kHz	System Information	Bode plot crossover frequency
32.	Duty Cycle	59.367 %	System Information	Duty cycle
33.	Efficiency	94.281 %	System Information	Steady state efficiency
34.	FootPrint	2.408 k mm ²	System Information	Total Foot Print Area of BOM components
35.	Frequency	160.0 kHz	System Information	Switching frequency
36.	Gain Marg	10.092 db	System Information	Bode Plot Gain Margin
37.	Mode	DCM	System Information	Conduction Mode
38.	Phase Marg	52.458 deg	System Information	Bode Plot Phase Margin
39.	Phase Shift	53.27 deg	System Information	Bode Plot Phase Shift
40.	Total BOM	\$15.39	System Information	Total BOM Cost

#	Name	Value	Category	Description
41.	Vin p-p	10.594 mV	System Information	Peak-to-peak input voltage
42.	Vout p-p	27.018 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	3.5	Maximum Output Current
VinMax	32.0	Maximum input voltage
VinMin	14.0	Minimum input voltage
Vout	-20.0	Output Voltage
base_pn	LM5088	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 C_{in} and C_{out} , 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

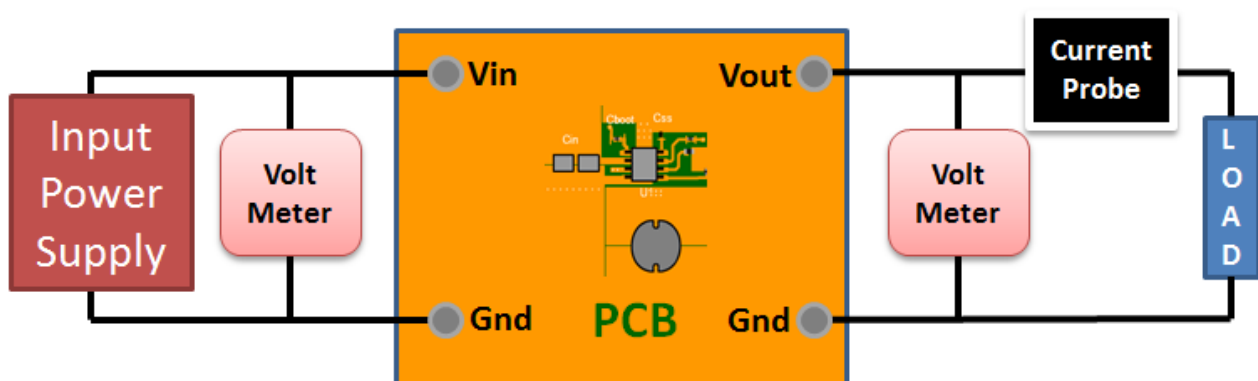
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. To solder the tab down 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 14.0V and set the input supply's current limit to zero. With the input supply off connect up the input supply to V_{in} and GND. Connect a digital volt meter and a load if needed to set the minimum load of the design from V_{out} 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 V_{in} and GND, a load is connected between V_{out} and GND and a current meter is connected in series between V_{out} 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 : FB23B92CE18A4990[v1]
2. **LM5088** Product Folder : <http://www.ti.com/product/LM5088> : contains the data sheet and other resources.

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