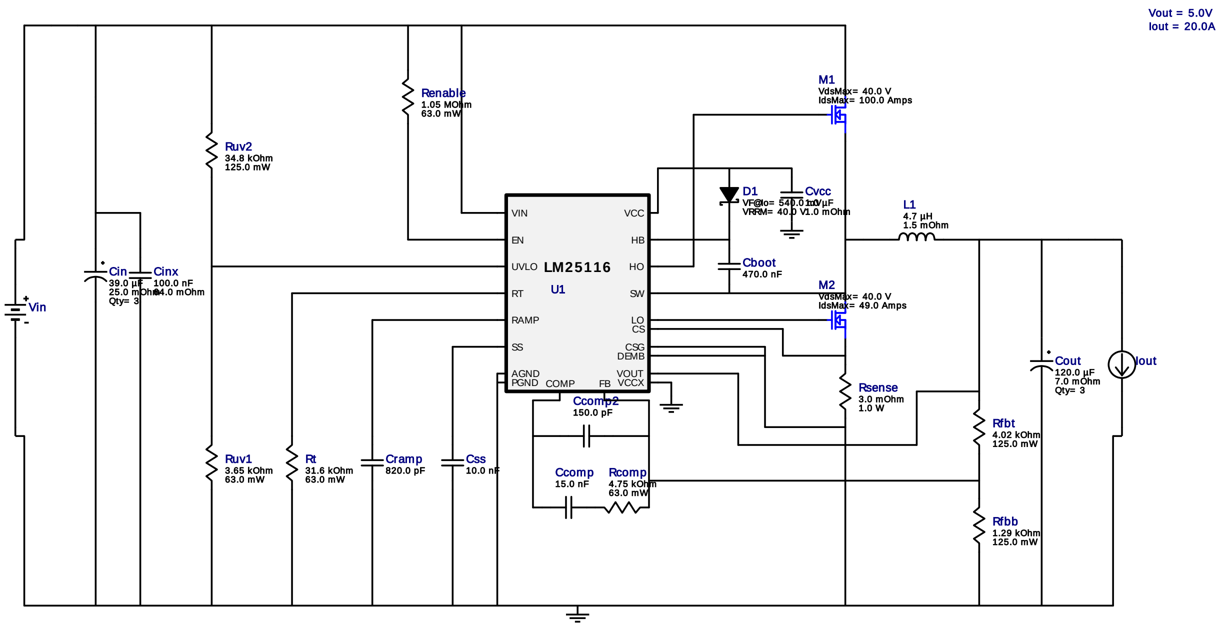
TEXAS INSTRUMENTS

WEBENCH® Design Report

VinMin = 16.0V
VinMax = 32.0V
Vout = 5.0V
Iout = 20.0A

Device = LM25116MHX/NOPB
Topology = Buck
Created = 2019-04-11 01:29:41.621
BOM Cost = $10.24
BOM Count = 26
Total Pd = 6.27W

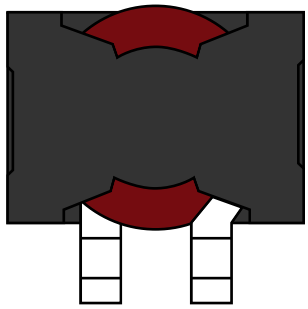
Design : 20 LM25116MHX/NOPB
LM25116MHX/NOPB 16V-32V to 5.00V @ 20A

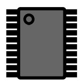


Electrical BOM

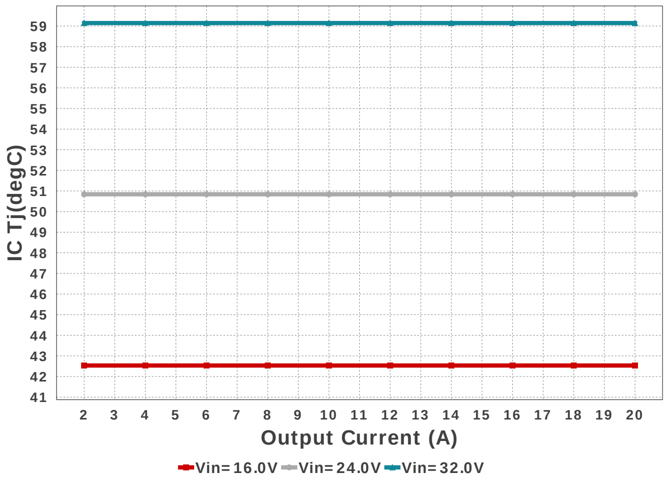
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	Panasonic	ECPU1C474MA5 Series= ECPU(A)	Cap= 470.0 nF VDC= 16.0 V IRMS= 0.0 A	1	$0.20	1206 11 mm²
Ccomp	TDK	CGA4F2C0G1H153J085AA Series= C0G/NP0	Cap= 15.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.07	0805 7 mm²
Ccomp2	Johanson Technology	250R07N151JV4T Series= C0G/NP0	Cap= 150.0 pF VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cin	Panasonic	50SVPF39M Series= SVPF	Cap= 39.0 uF ESR= 25.0 mOhm VDC= 50.0 V IRMS= 3.8 A	3	$0.74	CAPSMT_62_E12 106 mm²
Cinx	Kemet	C0805C104M5RACTU Series= X7R	Cap= 100.0 nF ESR= 64.0 mOhm VDC= 50.0 V IRMS= 1.64 A	1	$0.01	0805 7 mm²
Cout	Panasonic	EEFSX0J121E7 Series= SX	Cap= 120.0 uF ESR= 7.0 mOhm VDC= 6.3 V IRMS= 7.0 A	3	$0.73	7343-20 59 mm²
Cramp	Samsung Electro-Mechanics	CL05C821JB5NNNC Series= C0G/NP0	Cap= 820.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Css	TDK	C2012C0G1H103K060AA Series= C0G/NP0	Cap= 10.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.06	0805 7 mm²

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cvcc	Taiyo Yuden	TMK212BJ105KG-T Series= X5R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.03	0805 7 mm^2
D1	Torex USA Corporation	XBS104S13R-G	VF@Io= 540.0 mV VRRM= 40.0 V	1	$0.12	SOD-323 9 mm^2
L1	Coilcraft	SER2915L-472KL	L= 4.7 µH 1.5 mOhm	1	$1.88	SER2915L 652 mm^2
M1	Texas Instruments	CSD18511Q5A	VdsMax= 40.0 V IdsMax= 100.0 Amps	1	$0.44	TRANS_NexFET_Q5A 55 mm^2
M2	Fairchild Semiconductor	FDMS8460	VdsMax= 40.0 V IdsMax= 49.0 Amps	1	$0.99	TRANS_Fairchild_PQFN08A 56 mm^2
Rcomp	Vishay-Dale	CRCW04024K75FKED Series= CRCW..e3	Res= 4.75 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Renable	Vishay-Dale	CRCW04021M05FKED Series= CRCW..e3	Res= 1.05 MOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb	Yageo	RT0805BRD071K29L Series= RT0805	Res= 1.29 kOhm Power= 125.0 mW Tolerance= 0.1%	1	$0.05	0805 7 mm^2
Rfbt	Panasonic	ERJ-6ENF4021V Series= ERJ-6E	Res= 4.02 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Rsense	Stackpole Electronics Inc	CSNL1206FT3L00 Series= CSNL	Res= 3.0 mOhm Power= 1.0 W Tolerance= 1.0%	1	$0.20	1206 11 mm^2
Rt	Vishay-Dale	CRCW040231K6FKED Series= CRCW..e3	Res= 31.6 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ruv1	Vishay-Dale	CRCW04023K65FKED Series= CRCW..e3	Res= 3.65 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ruv2	Panasonic	ERJ-6ENF3482V Series= ERJ-6E	Res= 34.8 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
U1	Texas Instruments	LM25116MHX/NOPB	Switcher	1	$1.70	MXA20A 71 mm^2

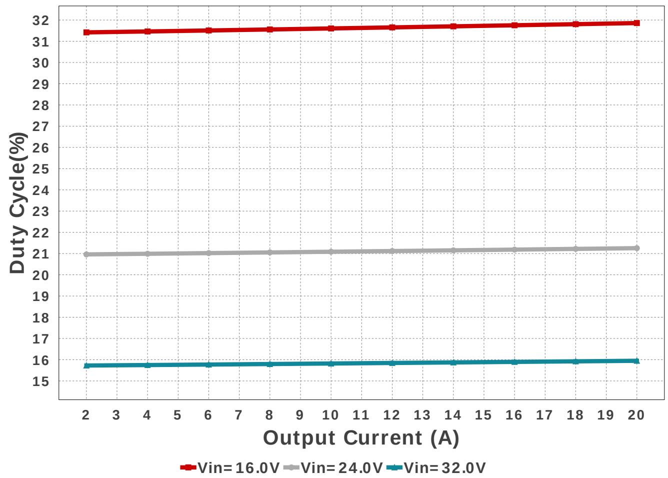




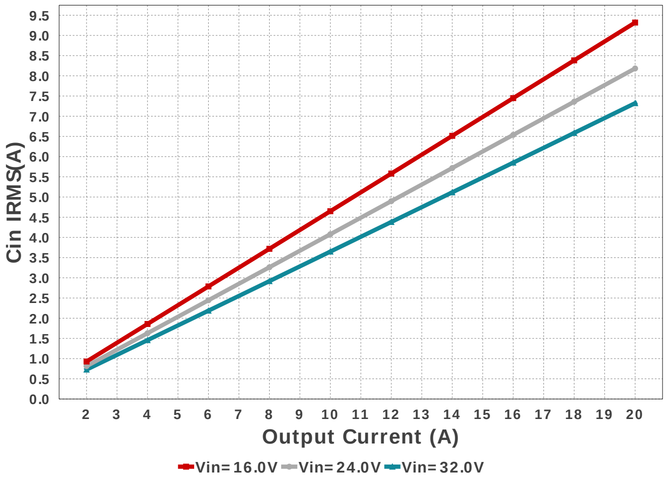
IC Tj



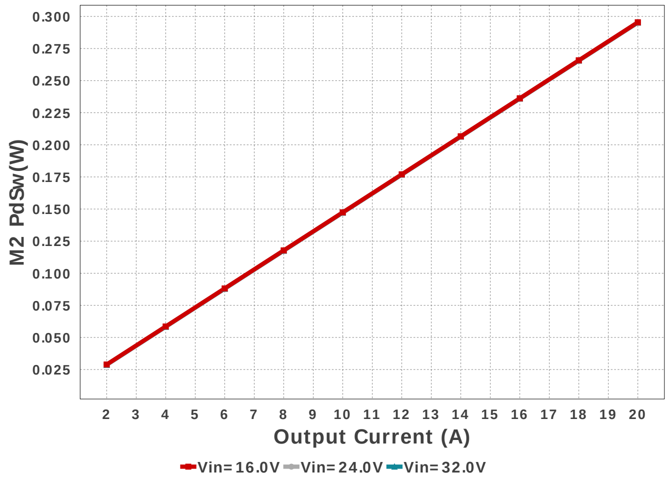
Duty Cycle



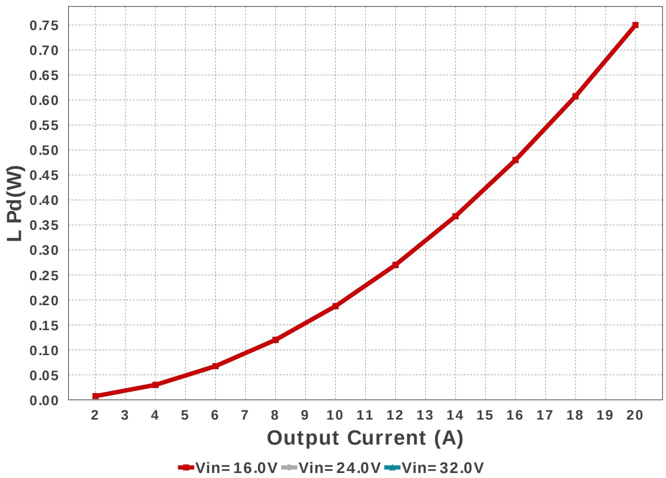
Cin IRMS



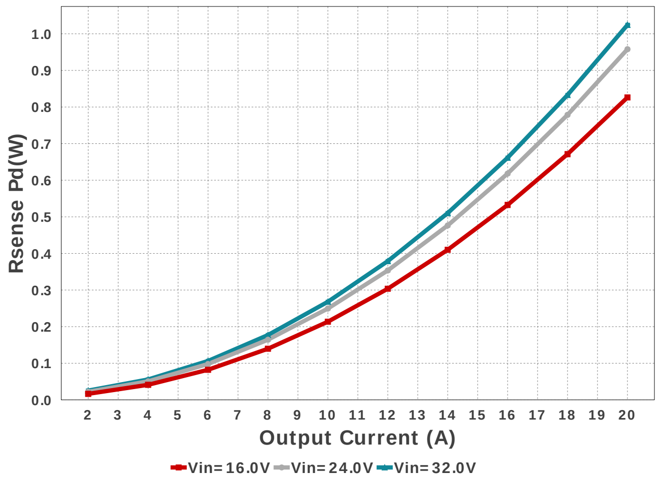
M2 PdSw

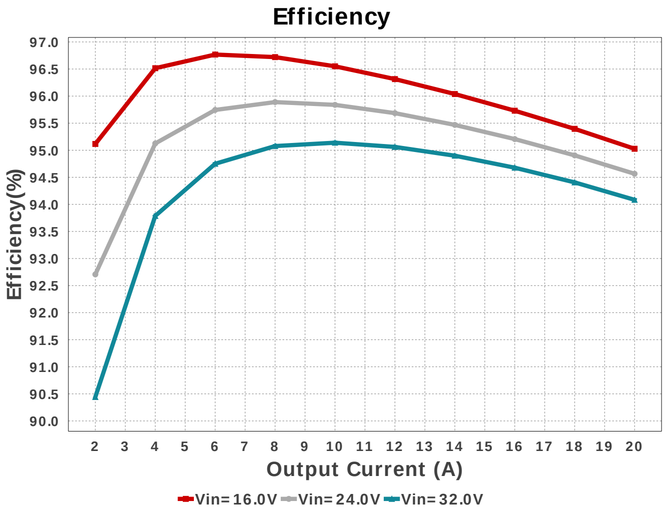


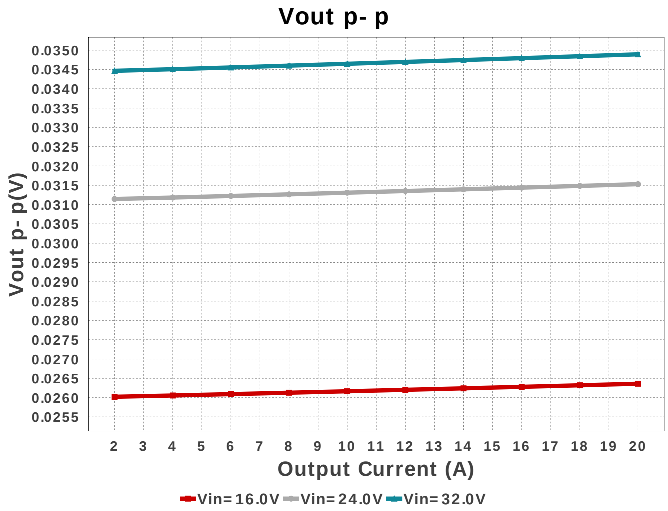
L Pd

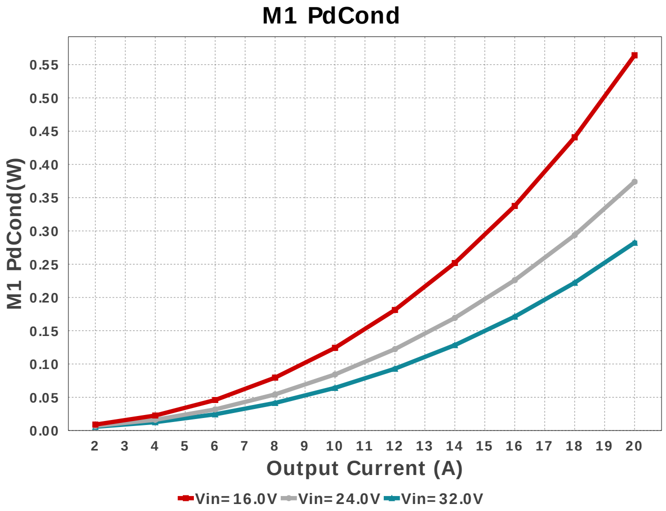


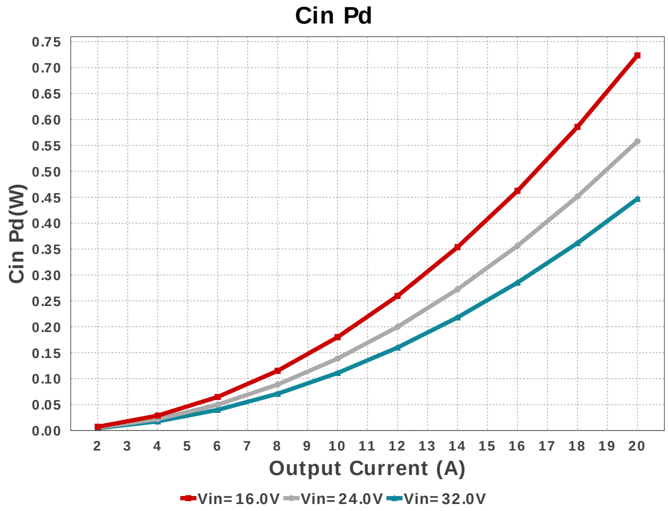
Rsense Pd

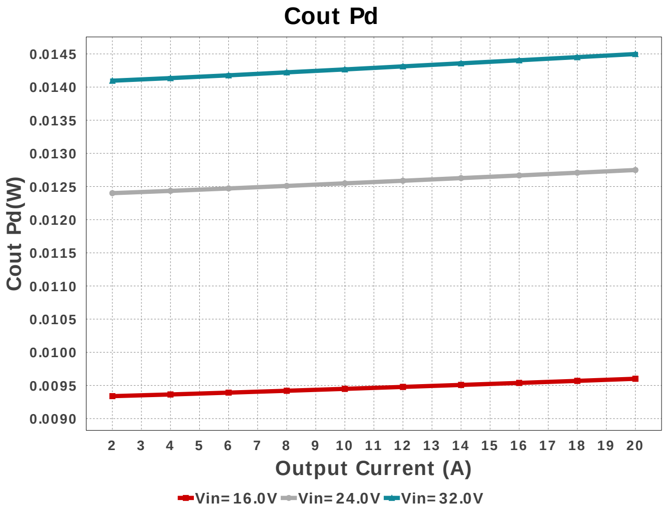


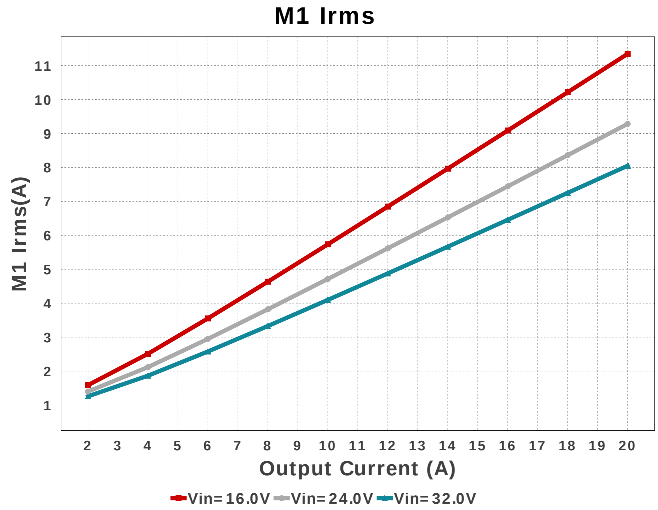

Efficiency
Efficiency(%)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V

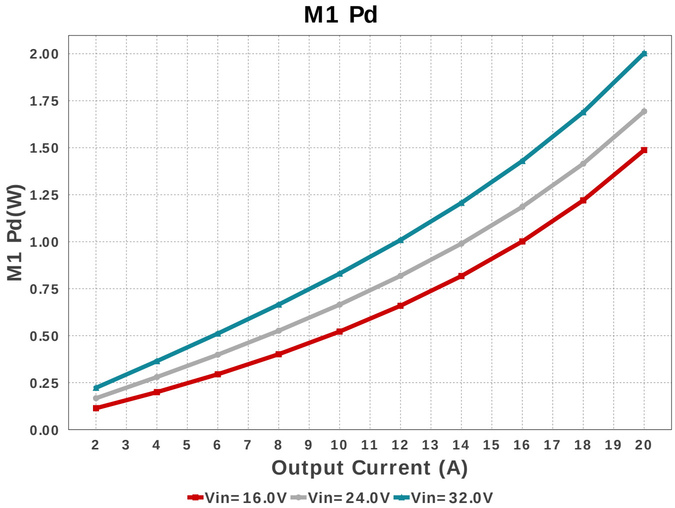

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V

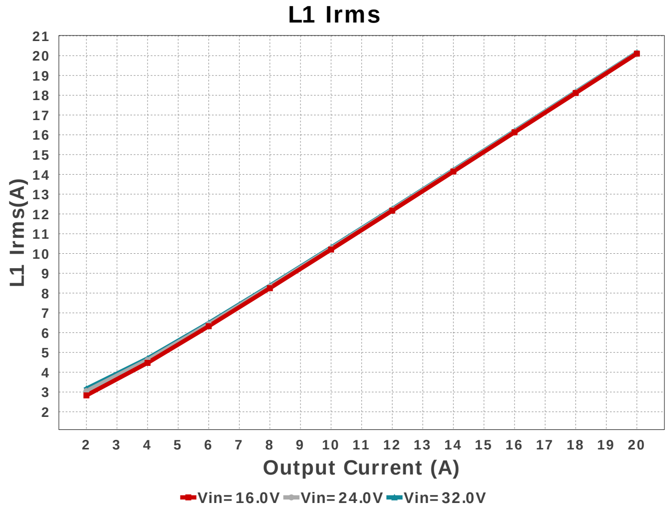

M1 PdCond
M1 PdCond(W)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V

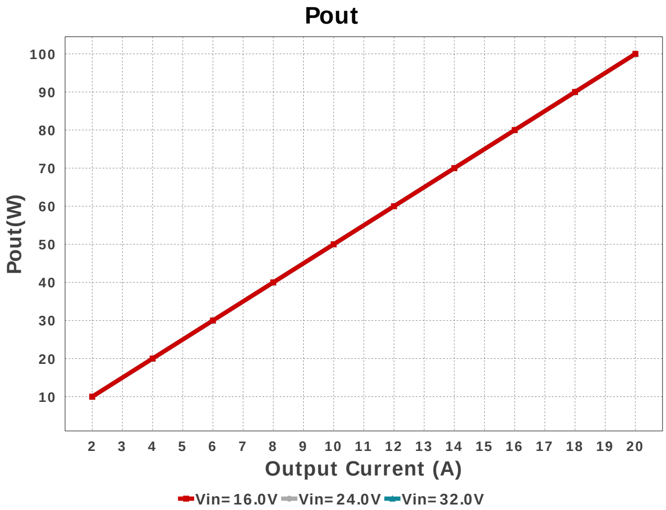

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V

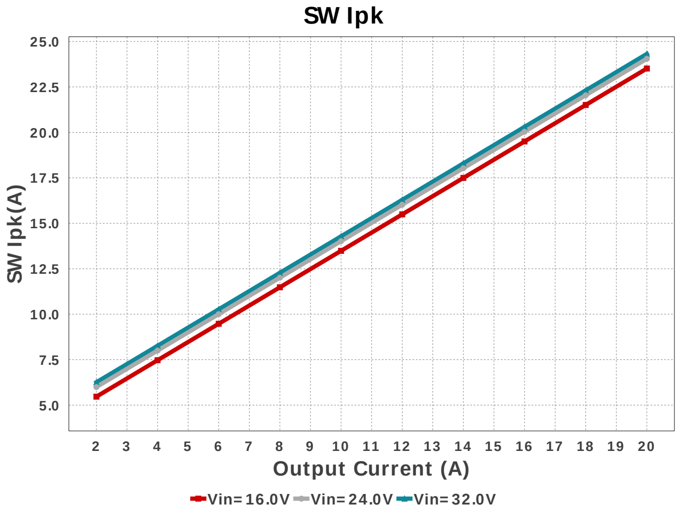

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V

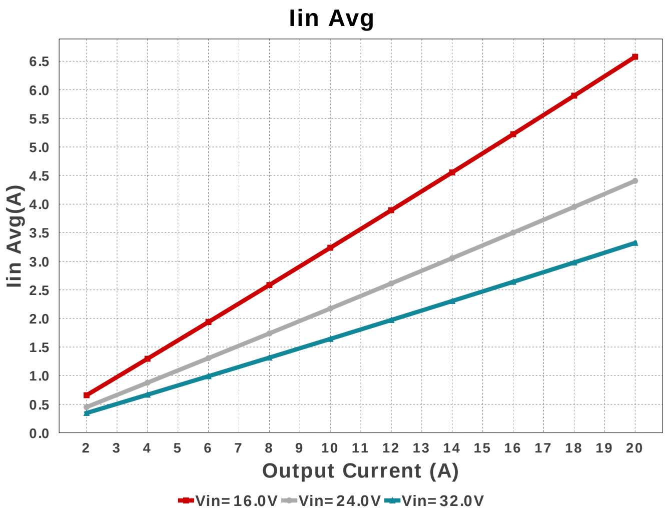

M1 Irms
M1 Irms(A)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V

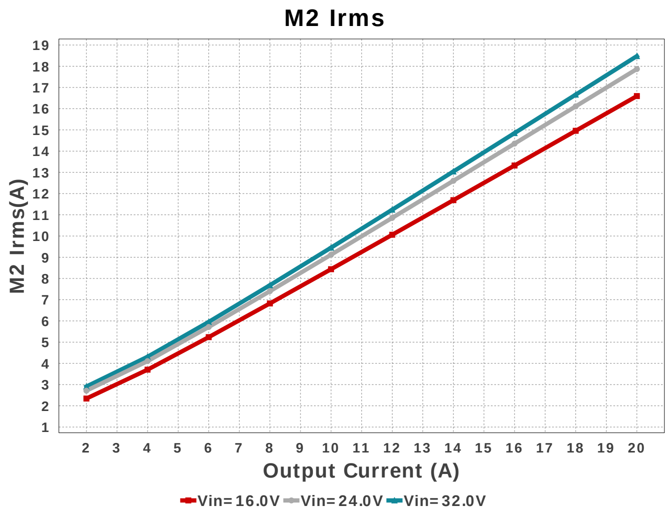

M1 Pd
M1 Pd(W)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V


L1 Irms
L1 Irms(A)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V

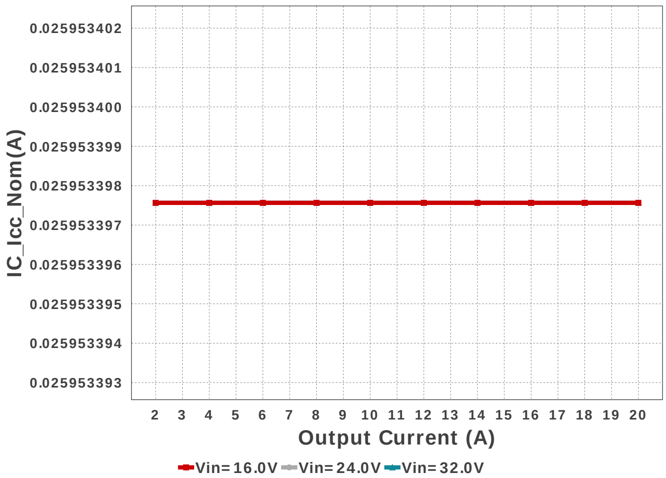

Pout
Pout(W)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V


SW Ipk
SW Ipk(A)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V

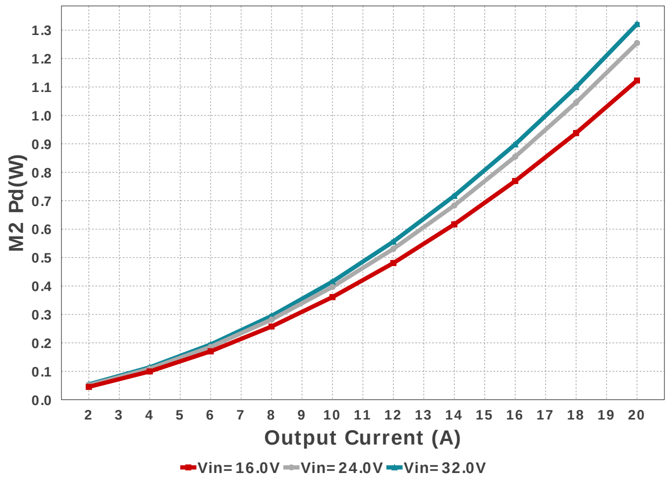

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V


M2 Irms
M2 Irms(A)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V

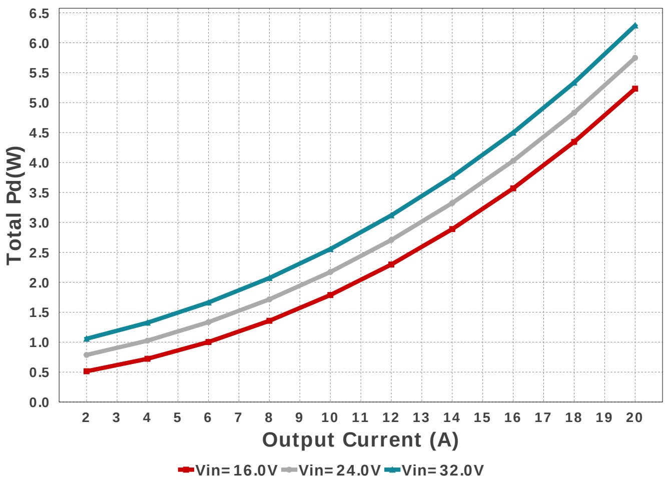
IC_Icc_Nom



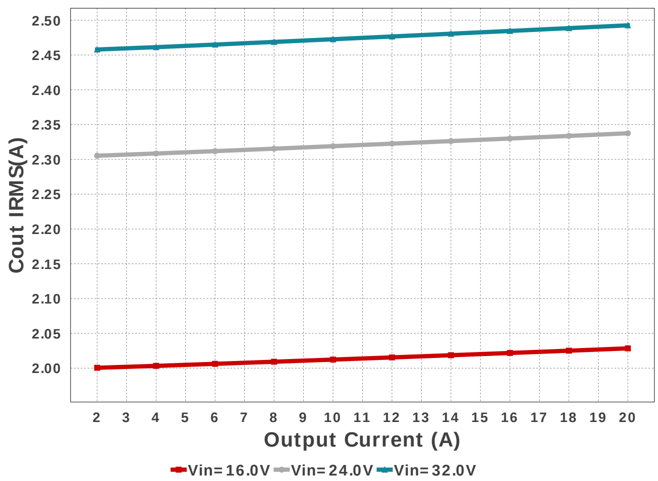
M2 Pd



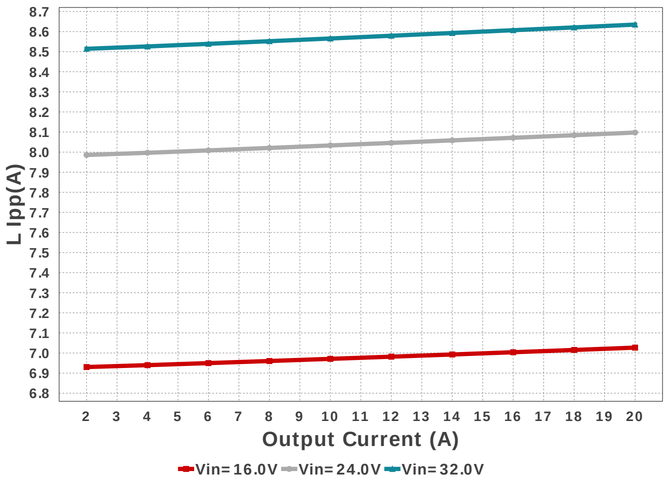
Total Pd



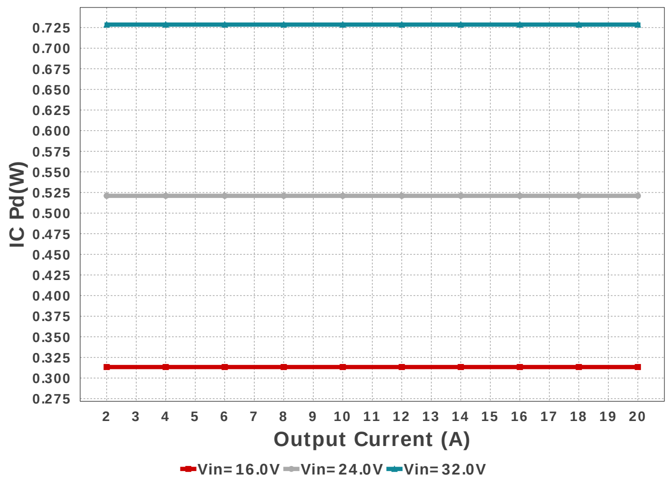
Cout IRMS

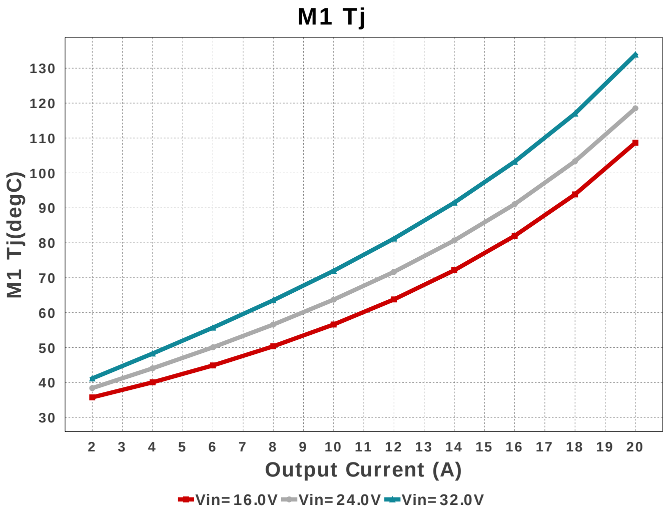


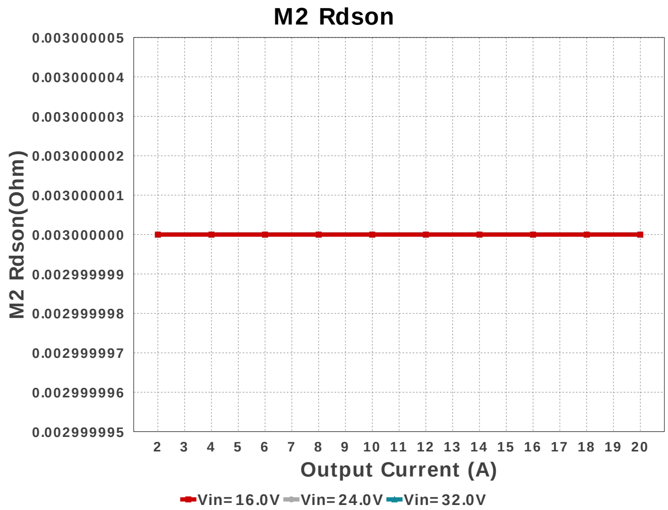
L Ipp

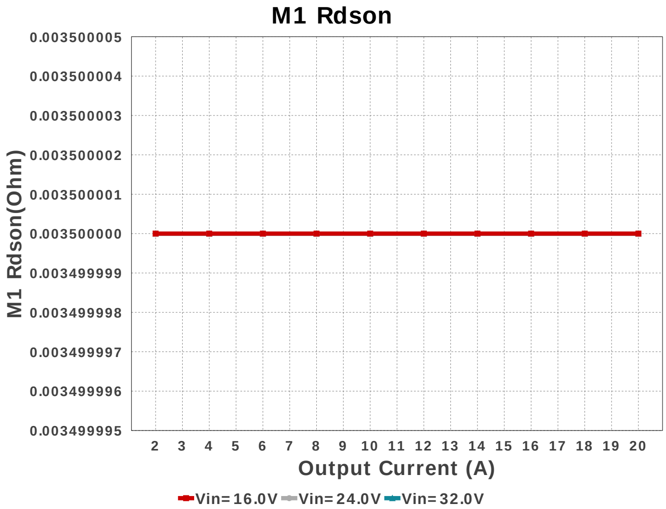


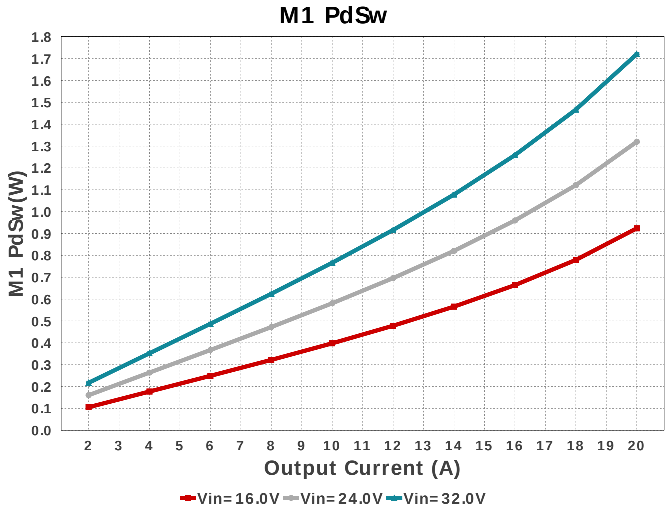
IC Pd

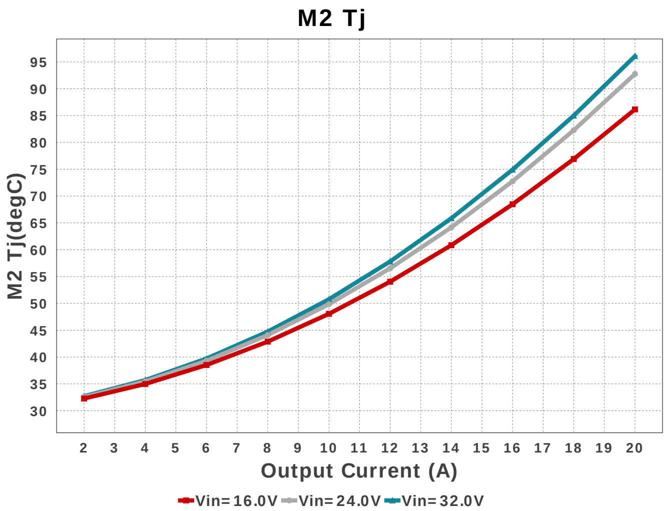


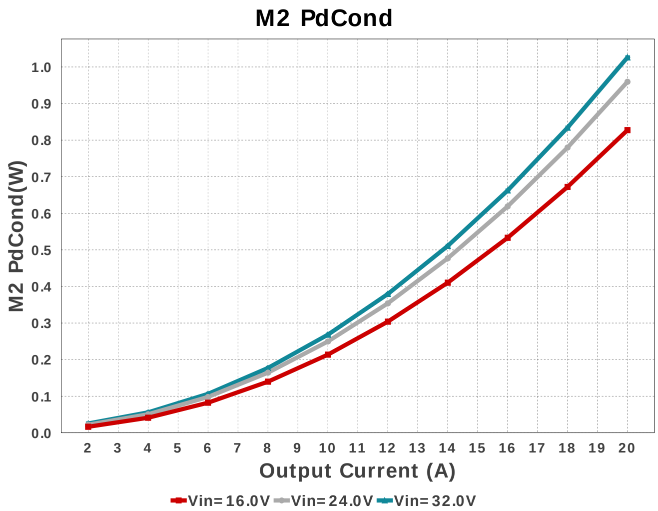

M1 Tj
M1 Tj(degC)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V

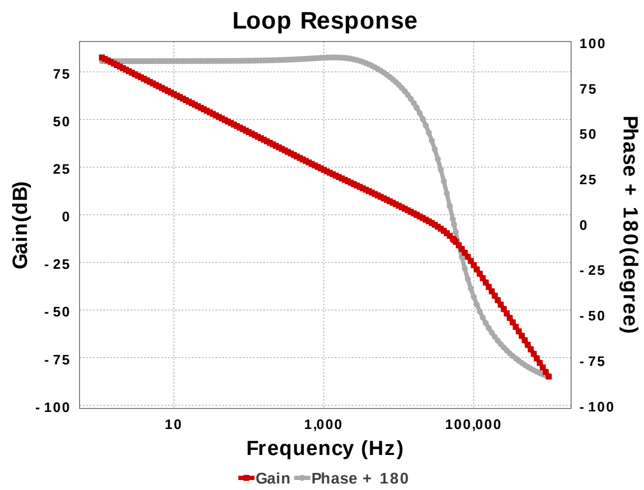

M2 Rdson
M2 Rdson(Ohm)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V


M1 Rdson
M1 Rdson(Ohm)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V


M1 PdSw
M1 PdSw(W)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V


M2 Tj
M2 Tj(degC)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V


M2 PdCond
M2 PdCond(W)
Output Current (A)
Vin=16.0V Vin=24.0V Vin=32.0V



Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	7.322 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	446.82 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	2.492 A	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	14.496 mW	Capacitor	Output capacitor power dissipation
5.	IC Pd	728.6 mW	IC	IC power dissipation
6.	IC Tj	59.144 degC	IC	IC junction temperature
7.	IC Tolerance	16.0 mV	IC	IC Feedback Tolerance
8.	IC Icc Nom	25.953 mA	IC	IC Icc gate driver current
9.	Iin Avg	3.321 A	IC	Average input current
10.	L Ipp	8.634 A	Inductor	Peak-to-peak inductor ripple current
11.	L Pd	750.0 mW	Inductor	Inductor power dissipation
12.	L1 Irms	20.155 A	Inductor	Inductor ripple current
13.	M1 Irms	8.049 A	Mosfet	MOSFET RMS ripple current
14.	M1 Pd	1.984 W	Mosfet	M1 MOSFET total power dissipation
15.	M1 PdCond	263.2 mW	Mosfet	M1 MOSFET conduction losses
16.	M1 PdSw	1.72 W	Mosfet	M1 MOSFET switching losses
17.	M1 Rdson	3.5 mOhm	Mosfet	Drain-Source On-resistance
18.	M1 Tj	133.88 degC	Mosfet	M1 MOSFET junction temperature
19.	M2 Irms	18.478 A	Mosfet	MOSFET RMS ripple current
20.	M2 Pd	1.321 W	Mosfet	M2 MOSFET total power dissipation
21.	M2 PdCond	1.026 W	Mosfet	M2 MOSFET conduction losses
22.	M2 PdSw	295.19 mW	Mosfet	M2 MOSFET switching losses
23.	M2 Rdson	3.0 mOhm	Mosfet	Drain-Source On-resistance
24.	M2 Tj	96.082 degC	Mosfet	M2 MOSFET junction temperature
25.	Cin Pd	446.82 mW	Power	Input capacitor power dissipation
26.	Cout Pd	14.496 mW	Power	Output capacitor power dissipation
27.	IC Pd	728.6 mW	Power	IC power dissipation
28.	L Pd	750.0 mW	Power	Inductor power dissipation
29.	M1 Pd	1.984 W	Power	M1 MOSFET total power dissipation
30.	M1 PdCond	263.2 mW	Power	M1 MOSFET conduction losses
31.	M1 PdSw	1.72 W	Power	M1 MOSFET switching losses
32.	M2 Pd	1.321 W	Power	M2 MOSFET total power dissipation
33.	M2 PdCond	1.026 W	Power	M2 MOSFET conduction losses
34.	M2 PdSw	295.19 mW	Power	M2 MOSFET switching losses
35.	Rsense Pd	1.024 W	Power	LED Current Rsns Power Dissipation
36.	Total Pd	6.269 W	Power	Total Power Dissipation
37.	Rsense Pd	1.024 W	Resistor	LED Current Rsns Power Dissipation
38.	BOM Count	26	System Information	Total Design BOM count
39.	Cross Freq	17.243 kHz	System Information	Bode plot crossover frequency
40.	Duty Cycle	15.948 %	System Information	Duty cycle
41.	Efficiency	94.101 %	System Information	Steady state efficiency
42.	FootPrint	1.424 k mm^2	System Information	Total Foot Print Area of BOM components
43.	Frequency	106.108 kHz	System Information	Switching frequency
44.	Gain Marg	-13.249 dB	System Information	Bode Plot Gain Margin

#	Name	Value	Category	Description
45.	Iout	20.0 A	System Information	Iout operating point
46.	Low Freq Gain	82.561 dB	System Information	Gain at 1Hz
47.	Mode	CCM	System Information	Conduction Mode
48.	Phase Marg	64.471 deg	System Information	Bode Plot Phase Margin
49.	Pout	100.0 W	System Information	Total output power
50.	SW Ipk	24.317 A	System Information	Peak switch current
51.	Total BOM	$10.24	System Information	Total BOM Cost
52.	Vin	32.0 V	System Information	Vin operating point
53.	Vout Actual	5.001 V	System Information	Vout Actual calculated based on selected voltage divider resistors
54.	Vout Tolerance	2.162 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
55.	Vout p-p	34.89 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	20.0	Maximum Output Current
VinMax	32.0	Maximum input voltage
VinMin	16.0	Minimum input voltage
Vout	5.0	Output Voltage
base_pn	LM25116	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

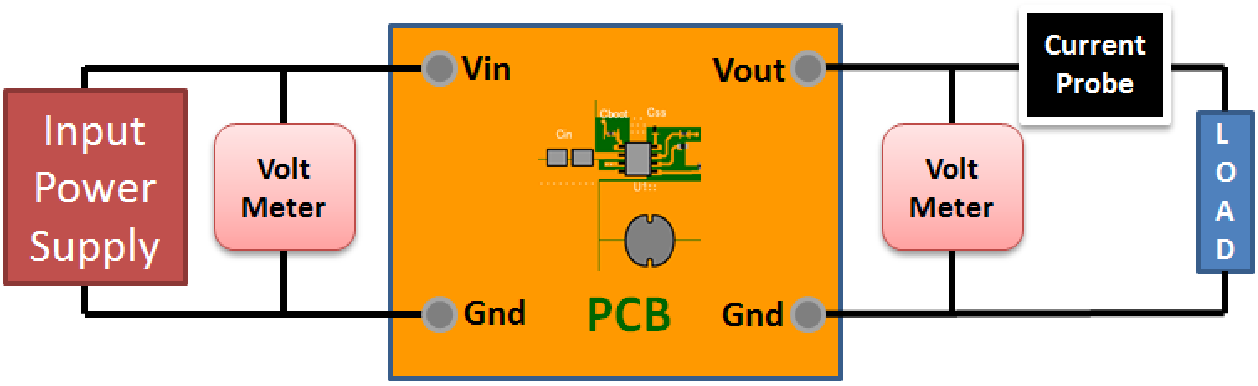
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 16.0V 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 : CC8ADF8FCCECDEF8[v1]

2. **LM25116** Product Folder : http://www.ti.com/product/LM25116 : contains the data sheet and other resources.