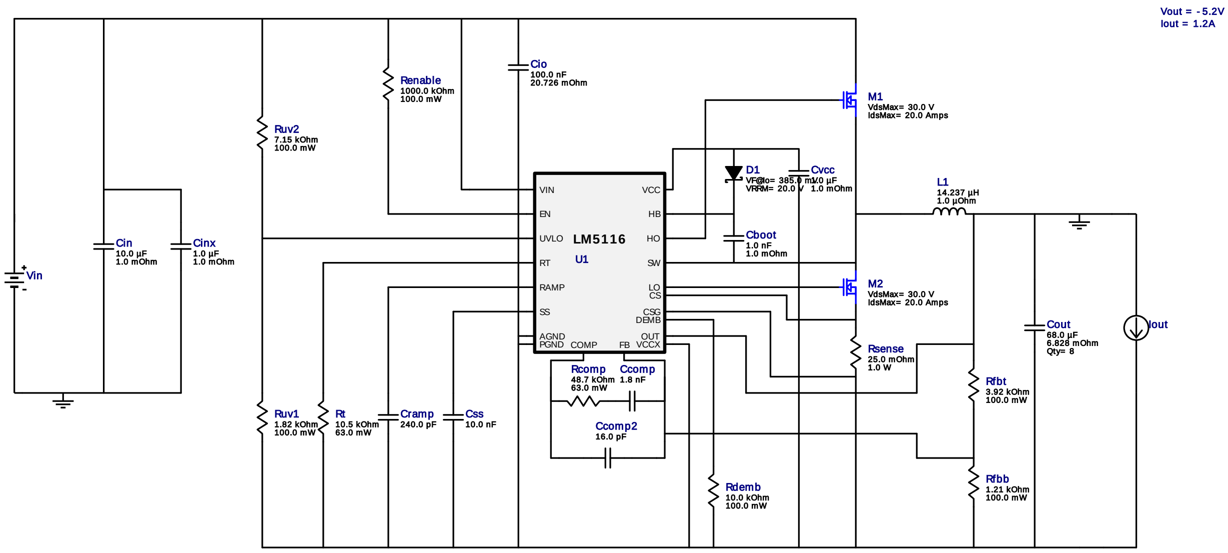
TEXAS INSTRUMENTS

VinMin = 6.0V
VinMax = 12.0V
Vout = -5.2V
Iout = 1.2A

Device = LM5116MH/NOPB
Topology = Inverting_Buck_Boost
Created = 2021-05-23 13:55:40.017
BOM Cost = NA
BOM Count = 31
Total Pd = 0.22W

WEBENCH ® Design Report

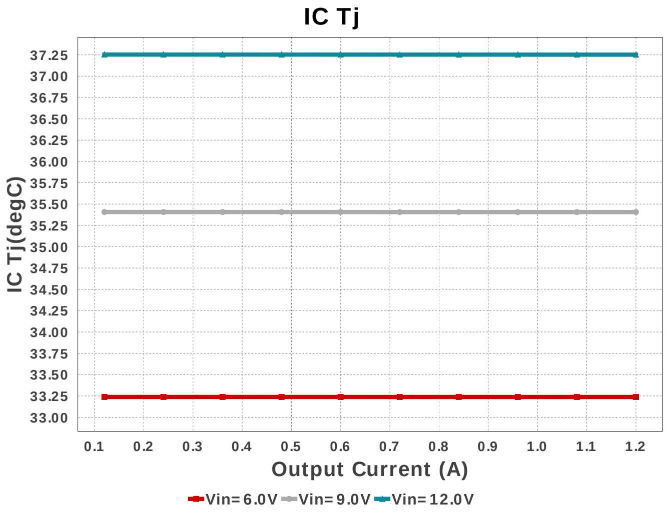
Design : 15 LM5116MH/NOPB
LM5116MH/NOPB 6V-12V to -5.20V @ 1.2A

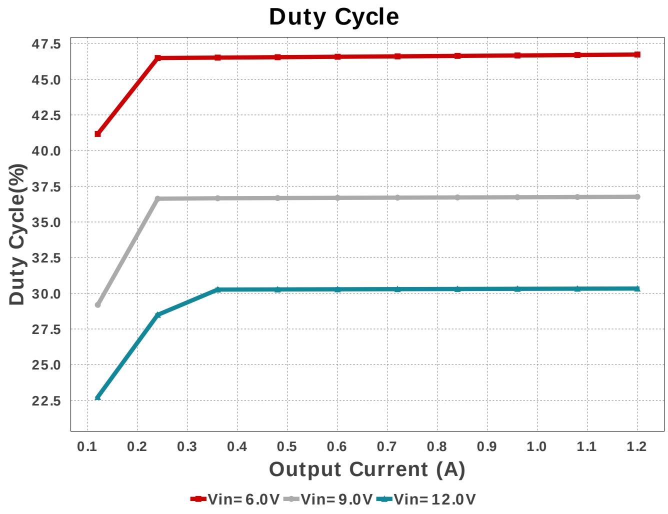


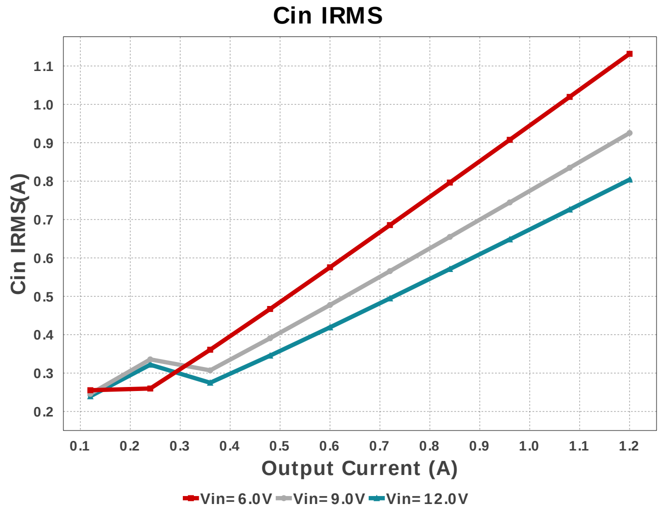
Electrical BOM

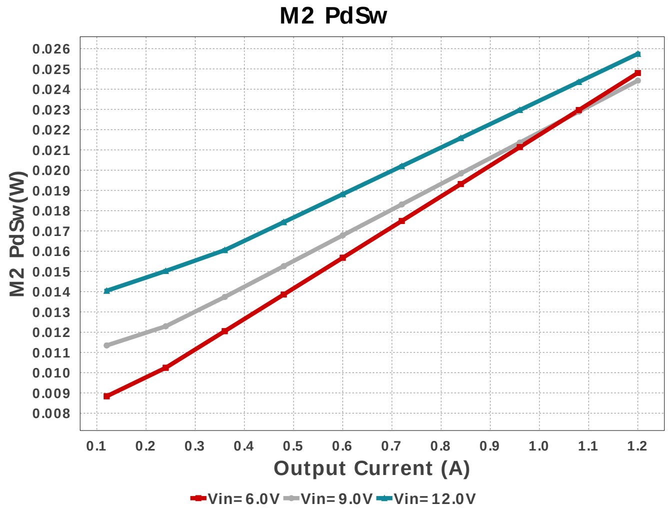
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	Kemet	C0603C102K5RACTU Series= X7R	Cap= 1.0 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Ccomp	MuRata	GRM1885C1H182JA01J Series= C0G/NP0	Cap= 1.8 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.02	0603 5 mm²
Ccomp2	Samsung Electro-Mechanics	CL10C160JB8NNNC Series= C0G/NP0	Cap= 16.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Cin	MuRata	GRM32ER71H106MA12 Series= X7R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.33	1210_270 15 mm²
Cinx	Taiyo Yuden	TMK212B7105KG-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm²
Cio	TDK	C2012X7R2A104K125AA Series= X7R	Cap= 100.0 nF ESR= 20.726 mOhm VDC= 100.0 V IRMS= 1.456 A	1	$0.03	0805 7 mm²
Cout	TDK	C5750X5R1A686M230KA Series= X5R	Cap= 68.0 uF ESR= 6.828 mOhm VDC= 10.0 V IRMS= 3.4939 A	8	$1.07	2220_250 54 mm²
Cramp	Samsung Electro-Mechanics	CL10C241JB8NNNC Series= C0G/NP0	Cap= 240.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Css	Samsung Electro-Mechanics	CL10C103JA8NNNC Series= C0G/NP0	Cap= 10.0 nF VDC= 25.0 V IRMS= 0.0 A	1	$0.05	0603 5 mm²

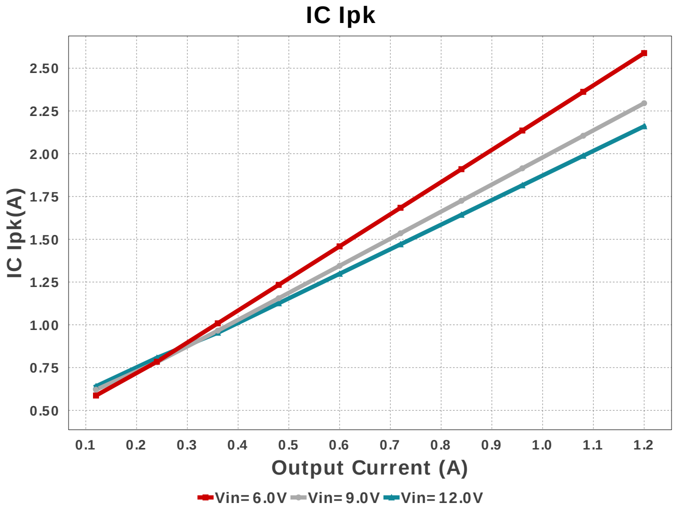
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cvcc	Taiyo Yuden	TMK212B7105KG-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2
D1	ON Semiconductor	MBR0520LT1G	VF@Io= 385.0 mV VRRM= 20.0 V	1	$0.05	SOD-123 13 mm^2
L1	CUSTOM	CUSTOM	L= 14.237 µH 1.0 µOhm	1	NA	CUSTOM 0 mm^2
M1	Texas Instruments	CSD17579Q3A	VdsMax= 30.0 V IdsMax= 20.0 Amps	1	$0.15	DNH0008A 18 mm^2
M2	Texas Instruments	CSD17578Q3A	VdsMax= 30.0 V IdsMax= 20.0 Amps	1	$0.17	DNH0008A 18 mm^2
Rcomp	Vishay-Dale	CRCW040248K7FKED Series= CRCW..e3	Res= 48.7 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rdemb	Vishay-Dale	CRCW060310K0FKEA Series= CRCW..e3	Res= 10.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Renable	Vishay-Dale	CRCW06031M00FKEA Series= CRCW..e3	Res= 1000.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rfbb	Vishay-Dale	CRCW06031K21FKEA Series= CRCW..e3	Res= 1.21 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rfbt	Yageo	RC0603FR-073K92L Series= ?	Res= 3.92 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rsense	Stackpole Electronics Inc	CSRN2010FK25L0 Series= ?	Res= 25.0 mOhm Power= 1.0 W Tolerance= 1.0%	1	$0.16	2010 32 mm^2
Rt	Vishay-Dale	CRCW040210K5FKED Series= CRCW..e3	Res= 10.5 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ruv1	Vishay-Dale	CRCW06031K82FKEA Series= CRCW..e3	Res= 1.82 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Ruv2	Yageo	RC0603FR-077K15L Series= ?	Res= 7.15 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
U1	Texas Instruments	LM5116MH/NOPB	Switcher	1	$2.56	MXA20A 71 mm^2

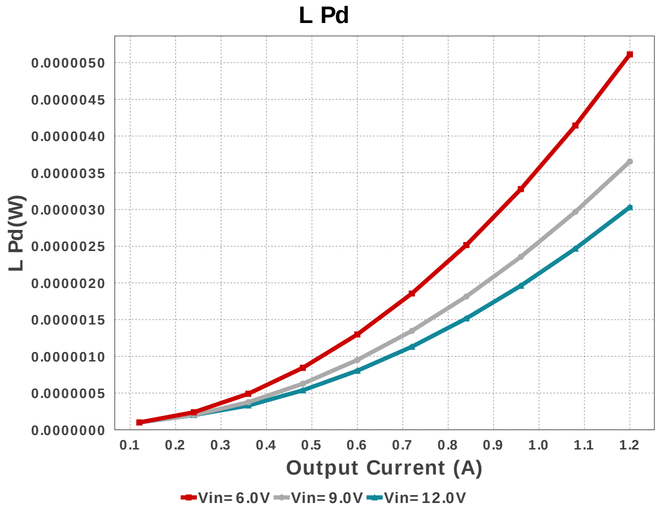

IC Tj
IC Tj(degC)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V

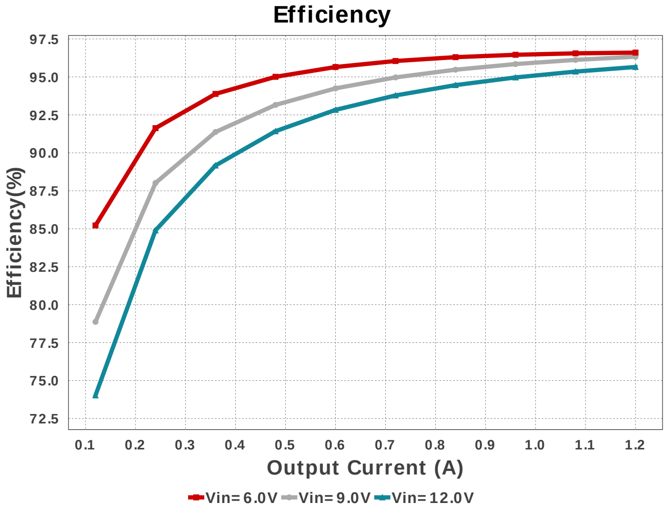

Duty Cycle
Duty Cycle(%)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V

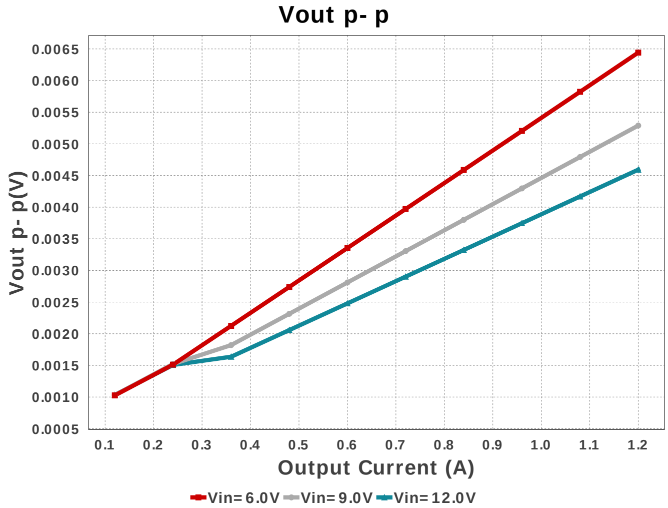

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V

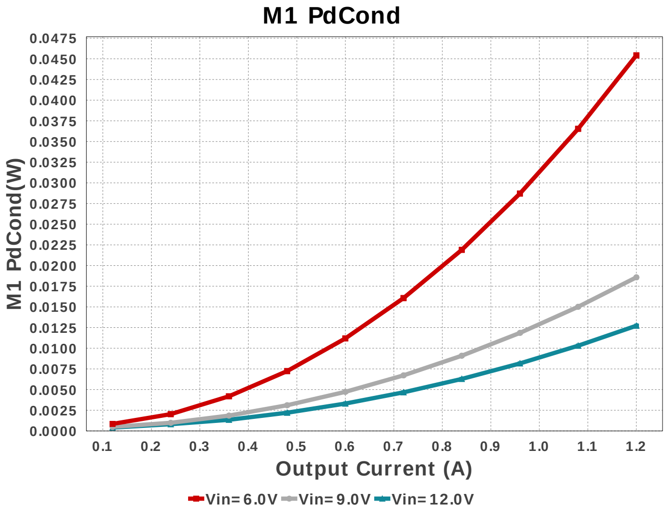

M2 PdSw
M2 PdSw(W)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V

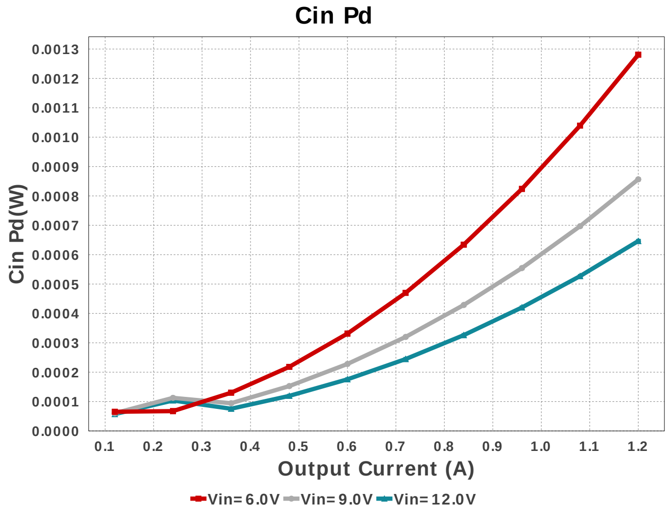

IC Ipk
IC Ipk(A)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V

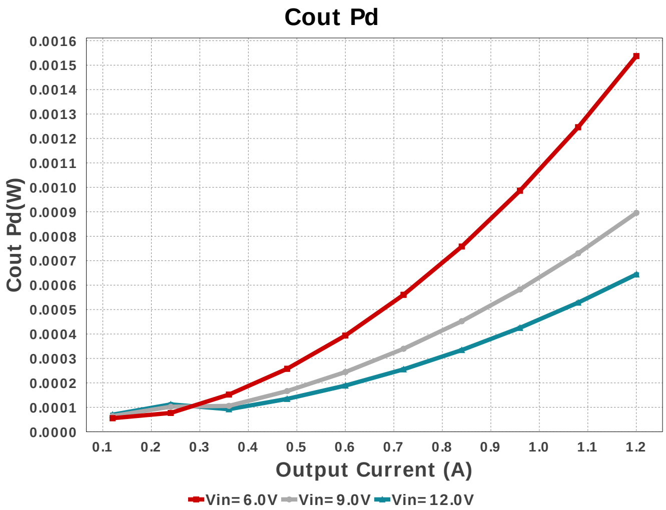

L Pd
L Pd(W)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V

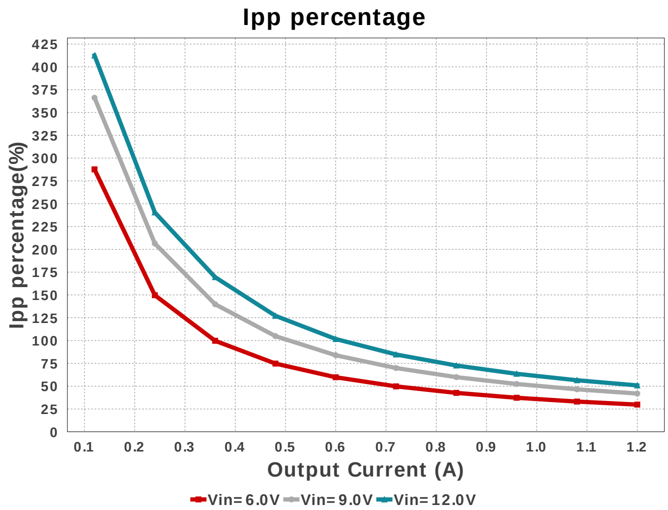

Efficiency
Efficiency(%)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V

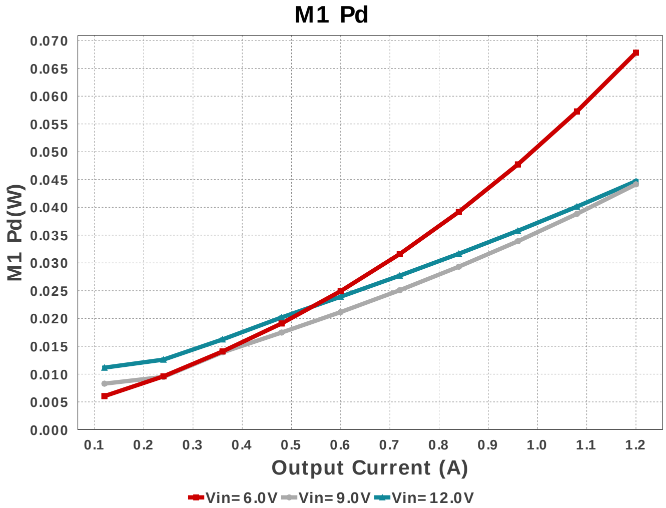

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V

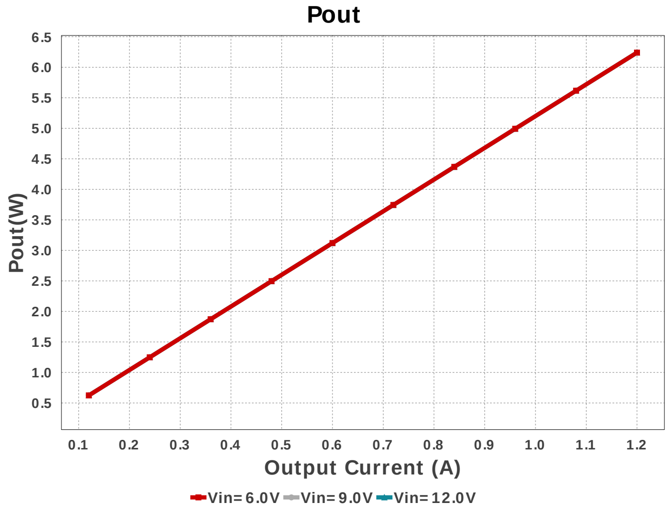

M1 PdCond
M1 PdCond(W)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V

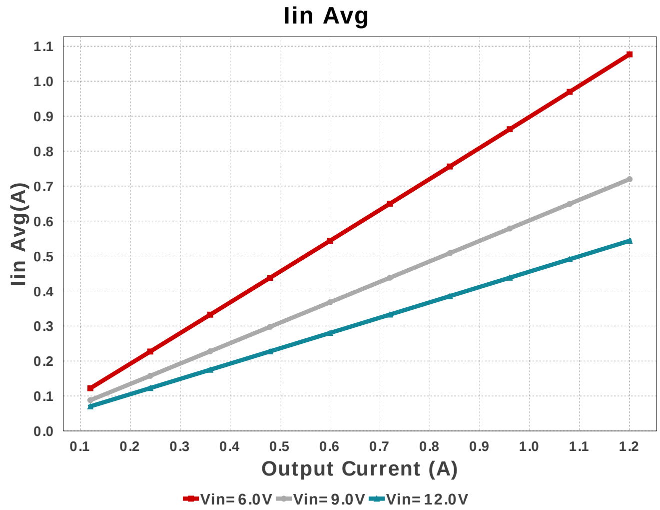

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V

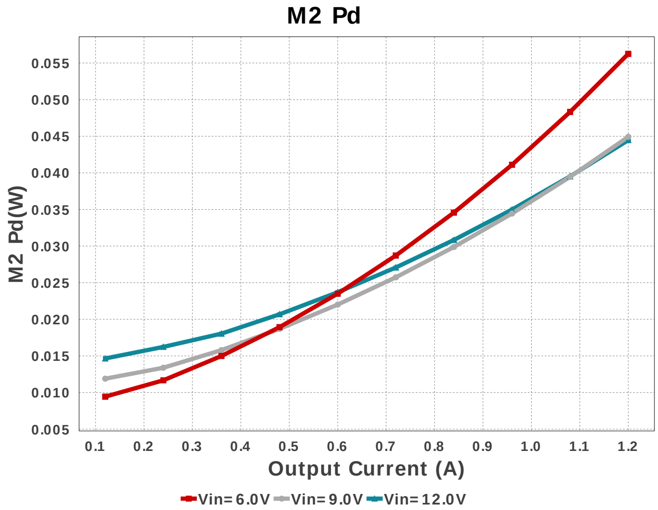

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V

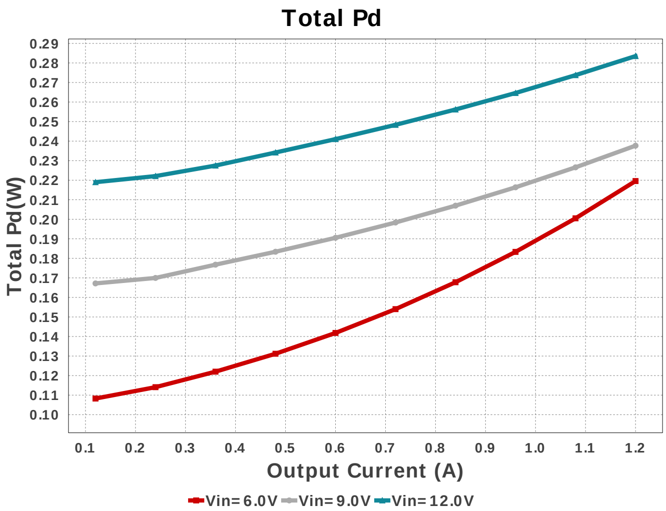

Ipp percentage
Ipp percentage(%)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V

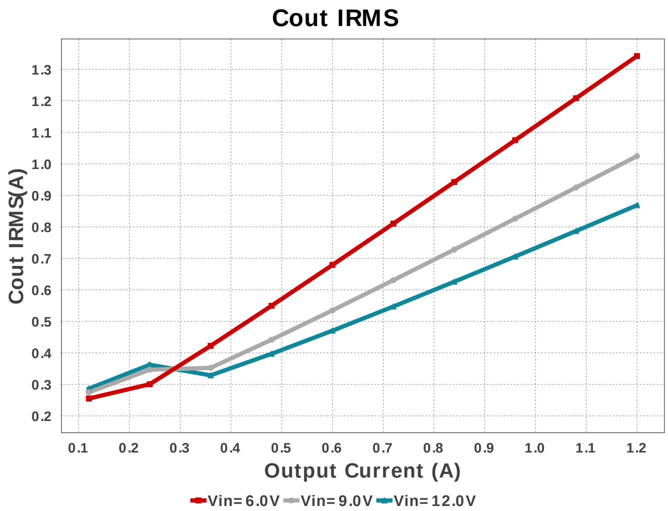

M1 Pd
M1 Pd(W)
0.070 0.065 0.060 0.055 0.050 0.045 0.040 0.035 0.030 0.025 0.020 0.015 0.010 0.005 0.000
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin= 6.0V Vin= 9.0V Vin= 12.0V

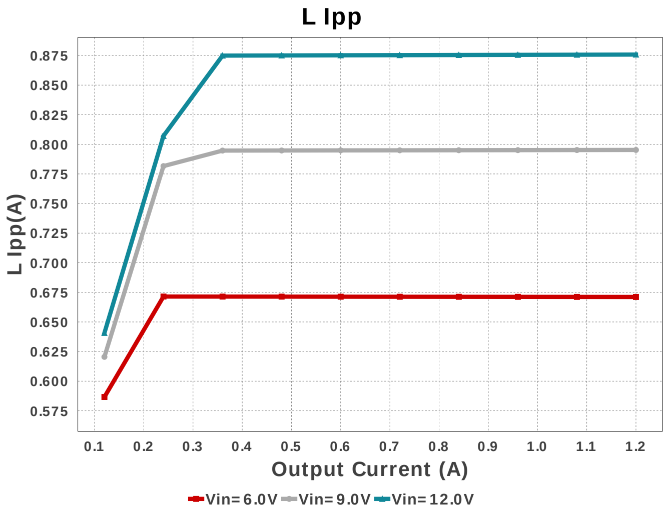

Pout
Pout(W)
6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin= 6.0V Vin= 9.0V Vin= 12.0V

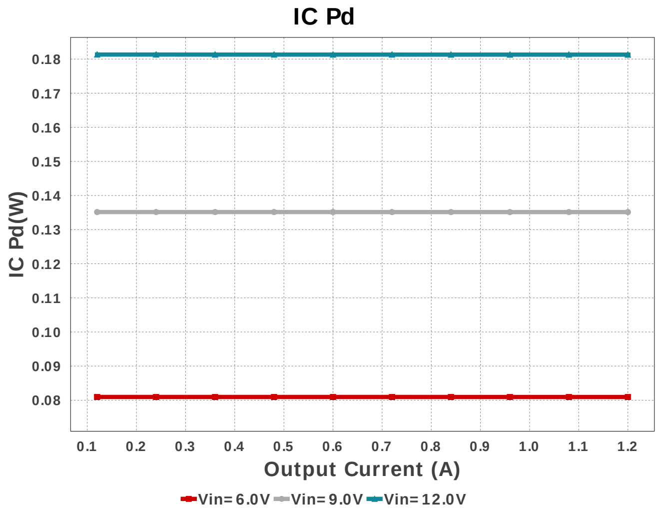

Iin Avg
Iin Avg(A)
1.1 1.0 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0.0
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin= 6.0V Vin= 9.0V Vin= 12.0V

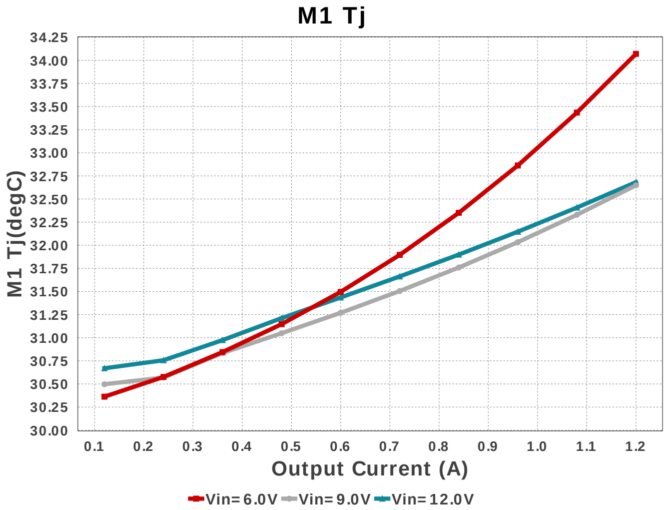

M2 Pd
M2 Pd(W)
0.055 0.050 0.045 0.040 0.035 0.030 0.025 0.020 0.015 0.010 0.005
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin= 6.0V Vin= 9.0V Vin= 12.0V

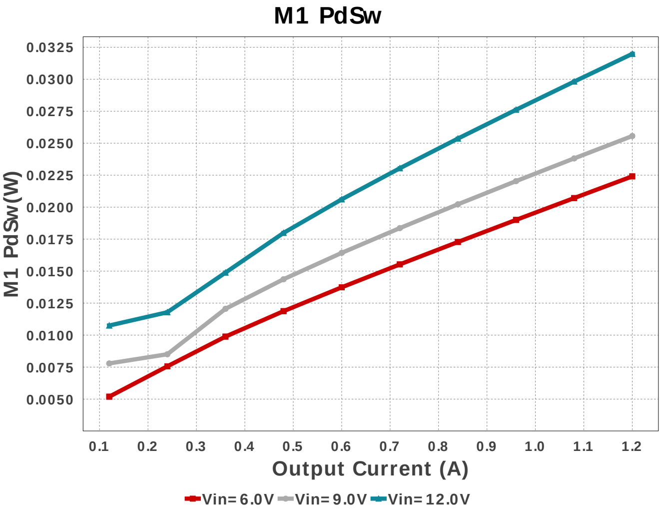

Total Pd
Total Pd(W)
0.29 0.28 0.27 0.26 0.25 0.24 0.23 0.22 0.21 0.20 0.19 0.18 0.17 0.16 0.15 0.14 0.13 0.12 0.11 0.10
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin= 6.0V Vin= 9.0V Vin= 12.0V

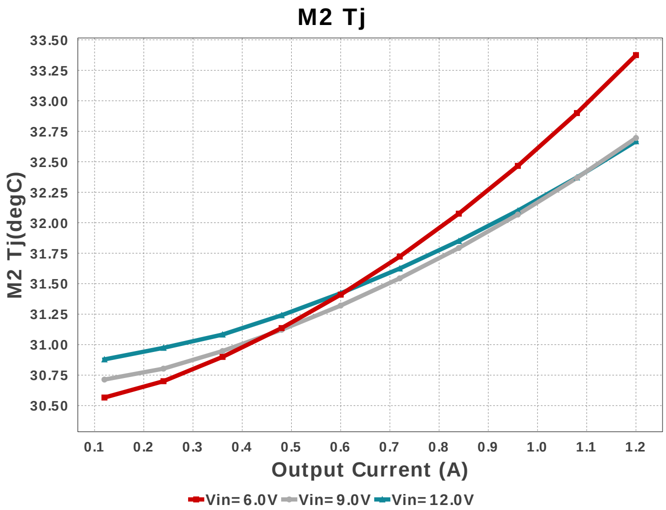

Cout IRMS
Cout IRMS(A)
1.3 1.2 1.1 1.0 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin= 6.0V Vin= 9.0V Vin= 12.0V

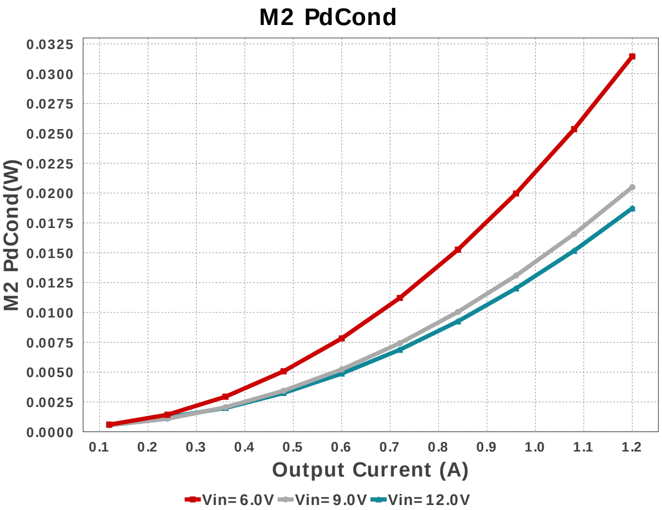

L Ipp
L Ipp(A)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V

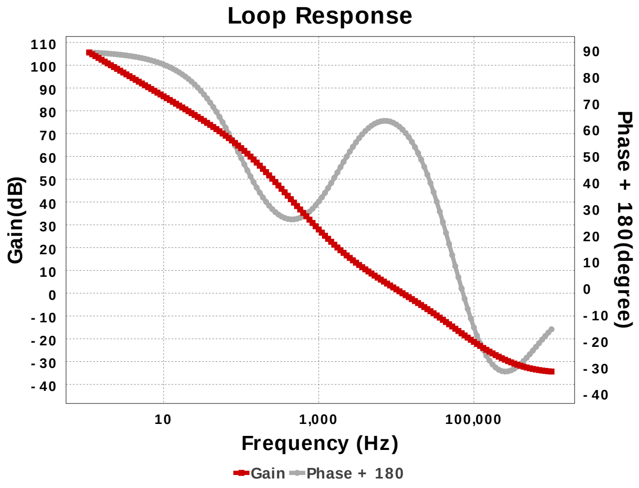

IC Pd
IC Pd(W)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V


M1 Tj
M1 Tj(degC)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V


M1 PdSw
M1 PdSw(W)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V


M2 Tj
M2 Tj(degC)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V


M2 PdCond
M2 PdCond(W)
Output Current (A)
Vin=6.0V Vin=9.0V Vin=12.0V



Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	1.132 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	1.281 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	1.342 A	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	1.537 mW	Capacitor	Output capacitor power dissipation
5.	IC Pd	80.936 mW	IC	IC power dissipation
6.	IC Tj	33.237 degC	IC	IC junction temperature
7.	ICThetaJA	40.0 degC/W	IC	IC junction-to-ambient thermal resistance
8.	Iin Avg	1.077 A	IC	Average input current
9.	Ipp percentage	29.791 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
10.	L Ipp	675.88 mA	Inductor	Peak-to-peak inductor ripple current
11.	L Pd	5.112 µW	Inductor	Inductor power dissipation
12.	M1 Pd	67.828 mW	Mosfet	M1 MOSFET total power dissipation
13.	M1 Tj	34.07 degC	Mosfet	M1 MOSFET junction temperature
14.	M2 Pd	56.249 mW	Mosfet	M2 MOSFET total power dissipation
15.	M2 Tj	33.375 degC	Mosfet	M2 MOSFET junction temperature
16.	Cin Pd	1.281 mW	Power	Input capacitor power dissipation
17.	Cout Pd	1.537 mW	Power	Output capacitor power dissipation
18.	IC Pd	80.936 mW	Power	IC power dissipation
19.	L Pd	5.112 µW	Power	Inductor power dissipation
20.	M1 Pd	67.828 mW	Power	M1 MOSFET total power dissipation
21.	M2 Pd	56.249 mW	Power	M2 MOSFET total power dissipation
22.	Total Pd	219.562 mW	Power	Total Power Dissipation
23.	BOM Count	31	System Information	Total Design BOM count
24.	Cross Freq	10.289 kHz	System Information	Bode plot crossover frequency
25.	Duty Cycle	46.729 %	System Information	Duty cycle
26.	Efficiency	96.601 %	System Information	Steady state efficiency
27.	FootPrint	1.477 k mm^2	System Information	Total Foot Print Area of BOM components
28.	Frequency	291.375 kHz	System Information	Switching frequency
29.	Gain Marg	-8.734 dB	System Information	Bode Plot Gain Margin
30.	Iout	1.2 A	System Information	Iout operating point
31.	Low Freq Gain	102.902 dB	System Information	Gain at 1Hz
32.	Mode	CCM	System Information	Conduction Mode
33.	Phase Marg	47.288 deg	System Information	Bode Plot Phase Margin
34.	Pout	6.24 W	System Information	Total output power
35.	Total BOM	NA	System Information	Total BOM Cost
36.	Vin	6.0 V	System Information	Vin operating point

#	Name	Value	Category	Description
37.	Vout	-5.2 V	System Information	Operational Output Voltage
38.	Vout Actual	5.151 V	System Information	Vout Actual calculated based on selected voltage divider resistors
39.	Vout Tolerance	2.881 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
40.	Vout p-p	6.442 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	1.2	Maximum Output Current
VinMax	12.0	Maximum input voltage
VinMin	6.0	Minimum input voltage
Vout	-5.2	Output Voltage
base_pn	LM5116	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

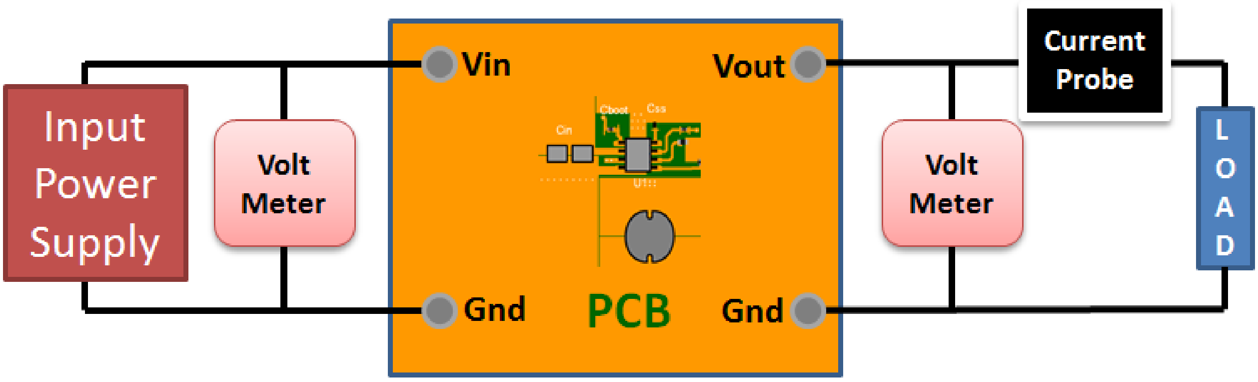
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 6.0V 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 : 17E312EF2778B210[v1]

2. **LM5116** Product Folder : http://www.ti.com/product/LM5116 : contains the data sheet and other resources.

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