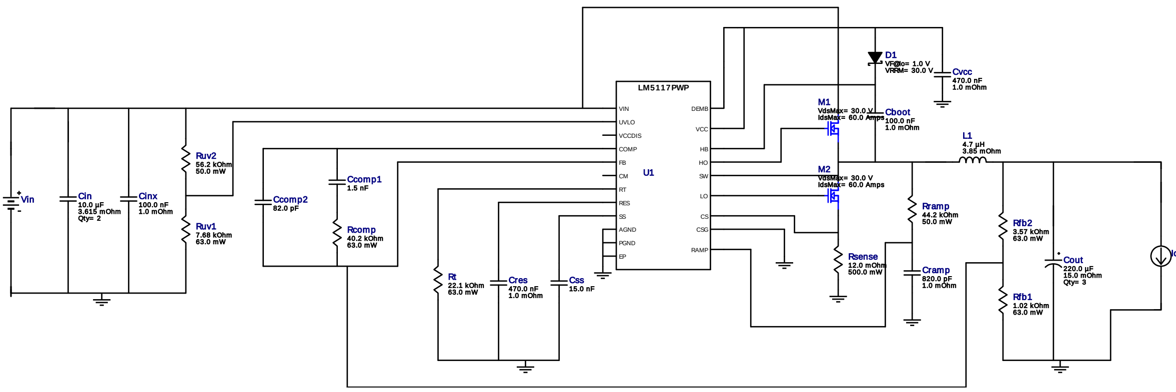
TEXAS INSTRUMENTS

VinMin = 12.0V
VinMax = 12.0V
Vout = 3.6V
Iout = 6.0A

Device = LM5117PMHX/NOPB
Topology = Buck
Created = 2019-12-11 06:36:44.654
BOM Cost = $7.59
BOM Count = 26
Total Pd = 0.93W

WEBENCH ® Design Report

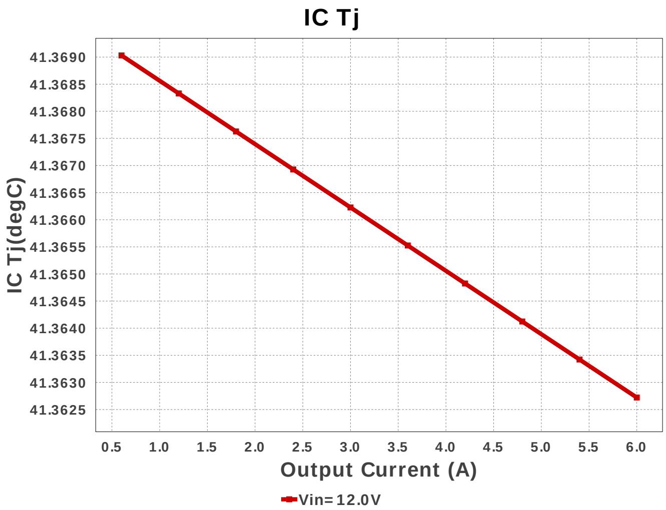
Design : 11 LM5117PMHX/NOPB
LM5117PMHX/NOPB 11-15V to 3.6V @ 7A

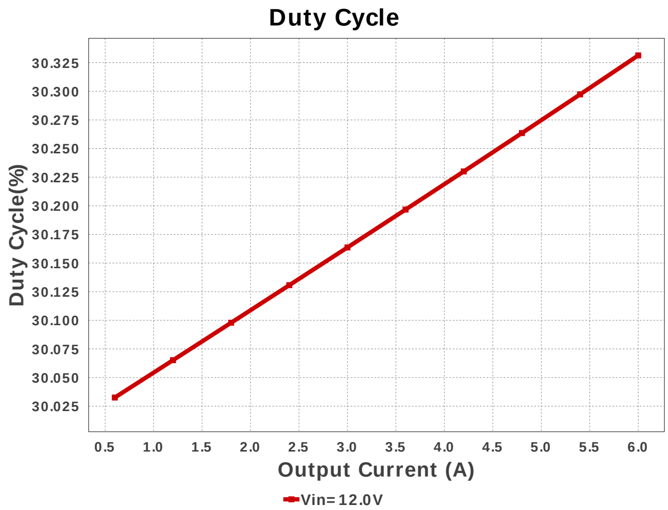


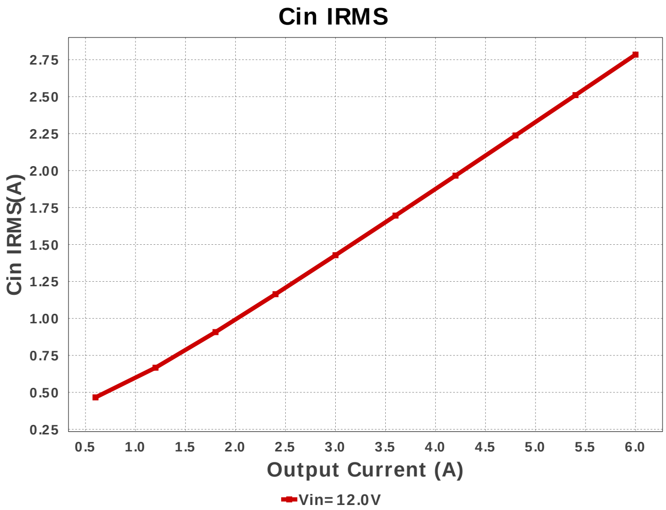
Electrical BOM

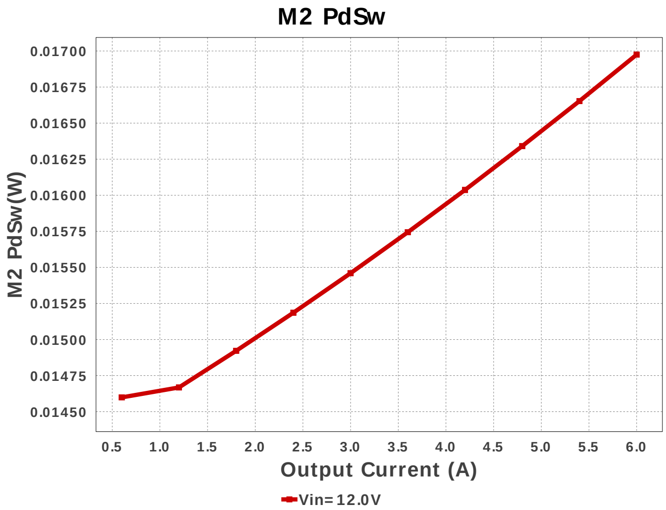
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM155R71A104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ccomp1	TDK	C2012C0G1H152J060AA Series= C0G/NP0	Cap= 1.5 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2
Ccomp2	TDK	CGA1A2C0G1E820J030BA Series= C0G/NP0	Cap= 82.0 pF VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0201 2 mm^2
Cin	MuRata	GRM31CR61C106KA88L Series= X5R	Cap= 10.0 uF ESR= 3.615 mOhm VDC= 16.0 V IRMS= 3.8281 A	2	$0.08	1206_190 11 mm^2
Cinx	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
Cout	Panasonic	6SVPE220MW Series= SVPE	Cap= 220.0 uF ESR= 15.0 mOhm VDC= 6.3 V IRMS= 3.15 A	3	$0.20	CAPSMT_62_E61 53 mm^2
Cramp	MuRata	GRM033R71E821KA01D Series= X7R	Cap= 820.0 pF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0201 2 mm^2
Cres	Taiyo Yuden	TMK212BJ474KD-T Series= X5R	Cap= 470.0 nF ESR= 1.0 mOhm VDC= 20.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2
Css	TDK	CGA4F2C0G1H153J085AA Series= C0G/NP0	Cap= 15.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.07	0805 7 mm^2
Cvcc	Taiyo Yuden	TMK212BJ474KD-T Series= X5R	Cap= 470.0 nF ESR= 1.0 mOhm VDC= 20.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2

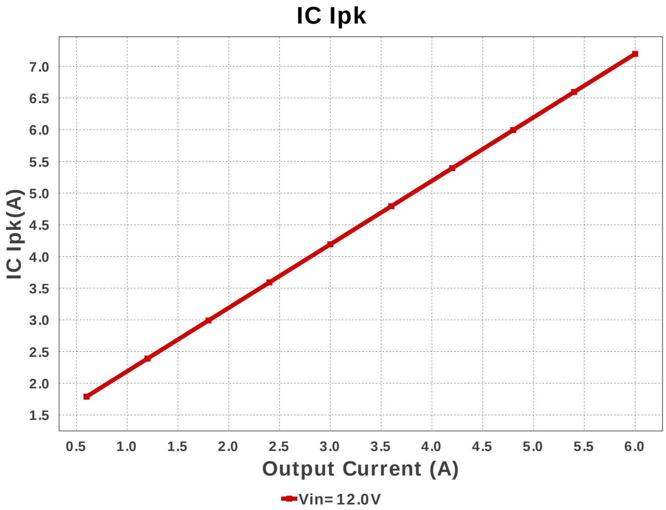
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
D1	SMC Diode Solutions	BAT54WSTR	VF@Io= 1.0 V VRRM= 30.0 V	1	$0.02	SOD-323 9 mm^2
L1	Wurth Elektronik	74439370047	L= 4.7 µH 3.85 mOhm	1	$3.65	WE-XHMI_1510 320 mm^2
M1	Texas Instruments	CSD17575Q3	VdsMax= 30.0 V IdsMax= 60.0 Amps	1	$0.35	DQG0008A 18 mm^2
M2	Texas Instruments	CSD17575Q3	VdsMax= 30.0 V IdsMax= 60.0 Amps	1	$0.35	DQG0008A 18 mm^2
Rcomp	Vishay-Dale	CRCW040240K2FKED Series= CRCW..e3	Res= 40.2 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfb1	Vishay-Dale	CRCW04021K02FKED Series= CRCW..e3	Res= 1.02 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfb2	Vishay-Dale	CRCW04023K57FKED Series= CRCW..e3	Res= 3.57 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rramp	Vishay-Dale	CRCW020144K2FNED Series= ?	Res= 44.2 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rsense	Stackpole Electronics Inc	CSR1206FK12L0 Series= ?	Res= 12.0 mOhm Power= 500.0 mW Tolerance= 1.0%	1	$0.12	1206 11 mm^2
Rt	Vishay-Dale	CRCW040222K1FKED Series= CRCW..e3	Res= 22.1 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ruv1	Vishay-Dale	CRCW04027K68FKED Series= CRCW..e3	Res= 7.68 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ruv2	Yageo	RC0201FR-0756K2L Series= ?	Res= 56.2 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
U1	Texas Instruments	LM5117PMHX/NOPB	Switcher	1	$2.10	PWP0020A 71 mm^2

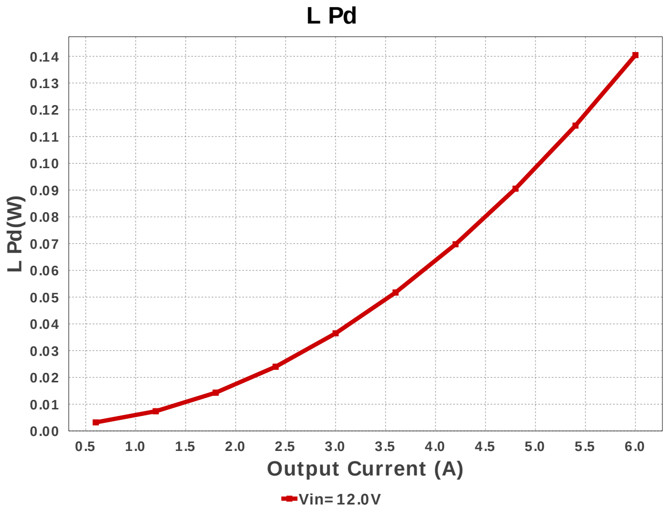


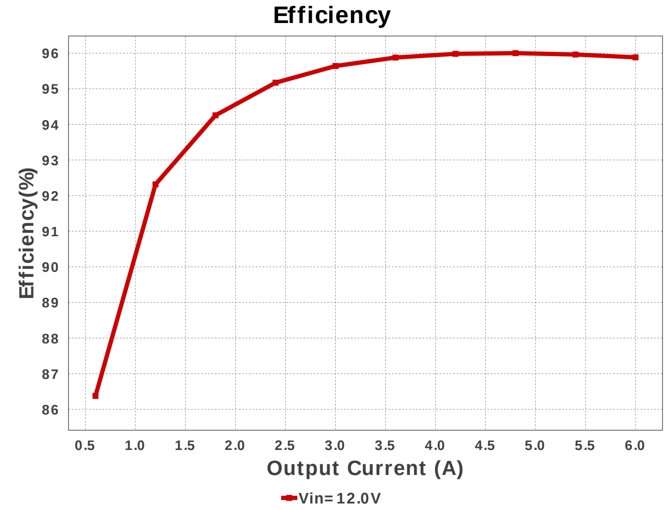


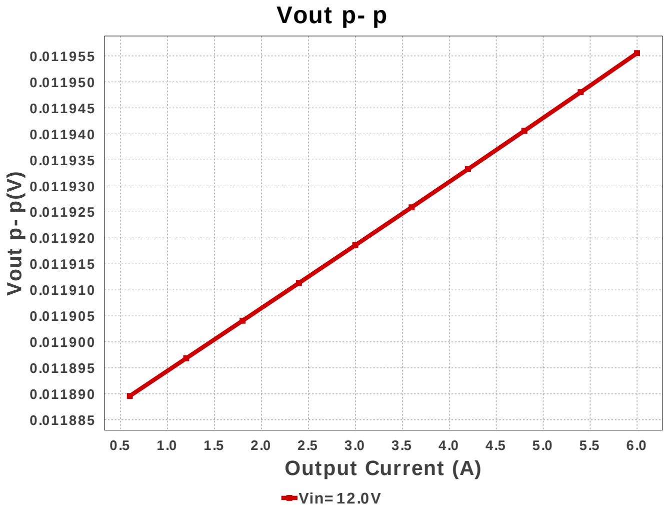

Cin IRMS
Cin IRMS(A)
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V

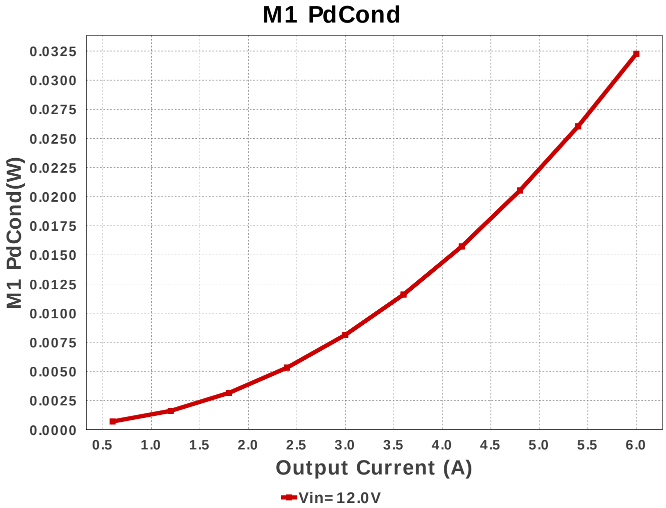

M2 PdSw
M2 PdSw(W)
0.01700
0.01675
0.01650
0.01625
0.01600
0.01575
0.01550
0.01525
0.01500
0.01475
0.01450
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V

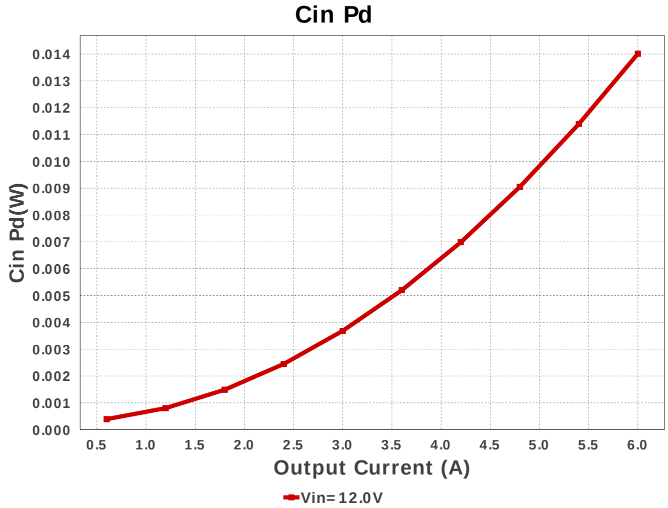

IC Ipk
IC Ipk(A)
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V

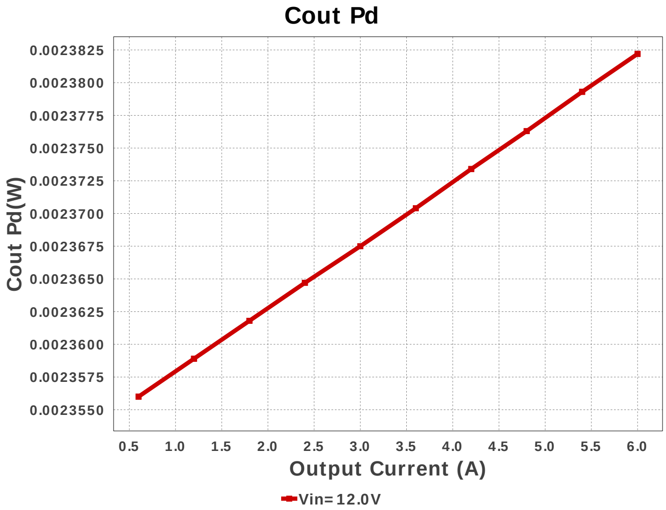

L Pd
L Pd(W)
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V

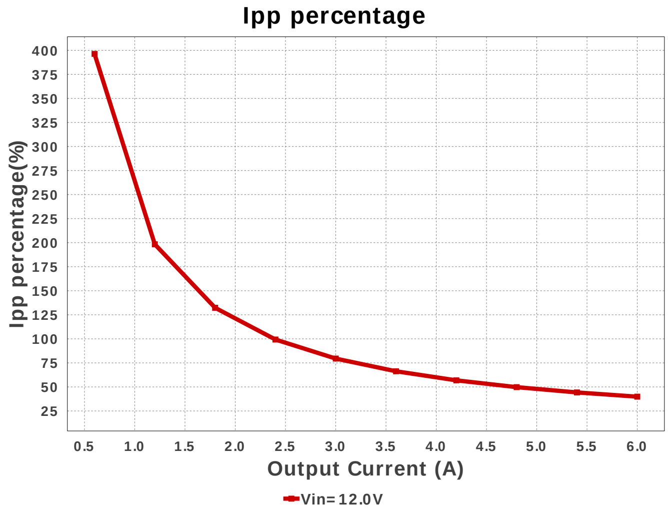

Efficiency
Efficiency(%)
96
95
94
93
92
91
90
89
88
87
86
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V

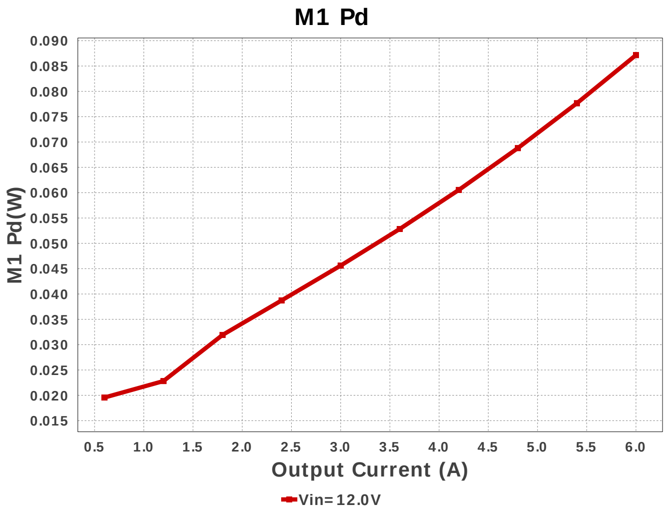

Vout p-p
Vout p-p(V)
0.011955
0.011950
0.011945
0.011940
0.011935
0.011930
0.011925
0.011920
0.011915
0.011910
0.011905
0.011900
0.011895
0.011890
0.011885
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V

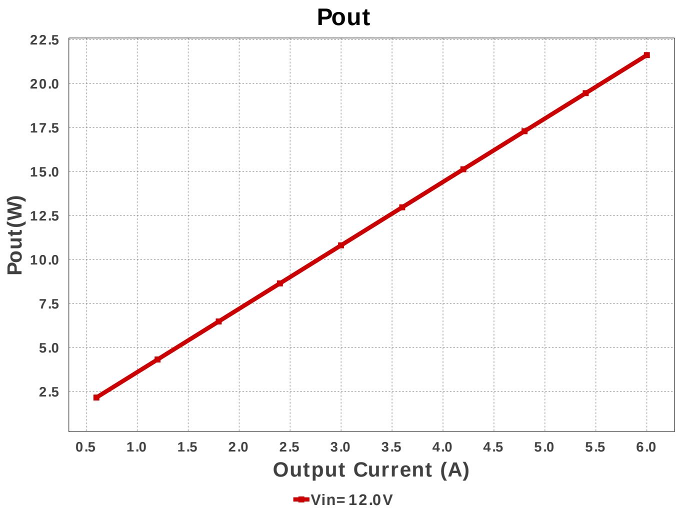

M1 PdCond
M1 PdCond(W)
0.0325
0.0300
0.0275
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V

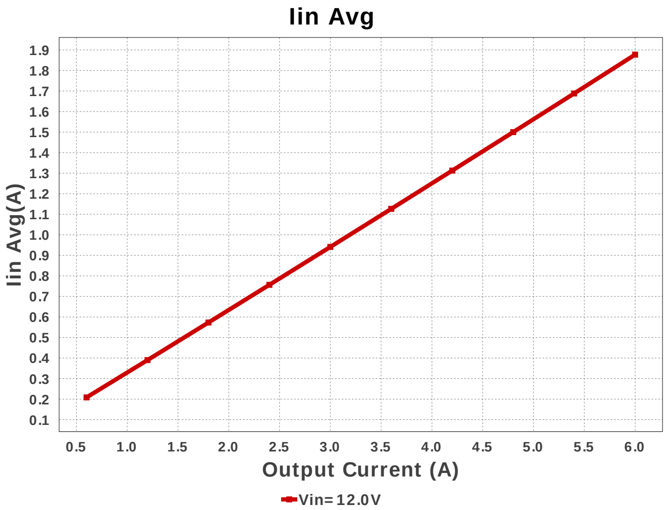

Cin Pd
Cin Pd(W)
0.014
0.013
0.012
0.011
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V

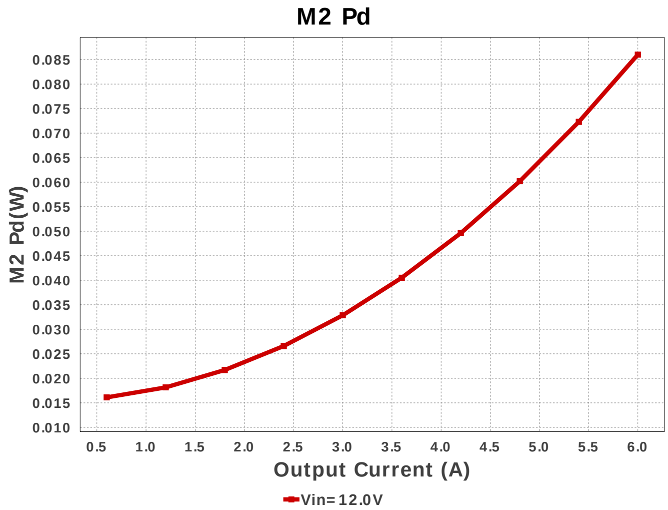

Cout Pd
Cout Pd(W)
0.0023825
0.0023800
0.0023775
0.0023750
0.0023725
0.0023700
0.0023675
0.0023650
0.0023625
0.0023600
0.0023575
0.0023550
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V

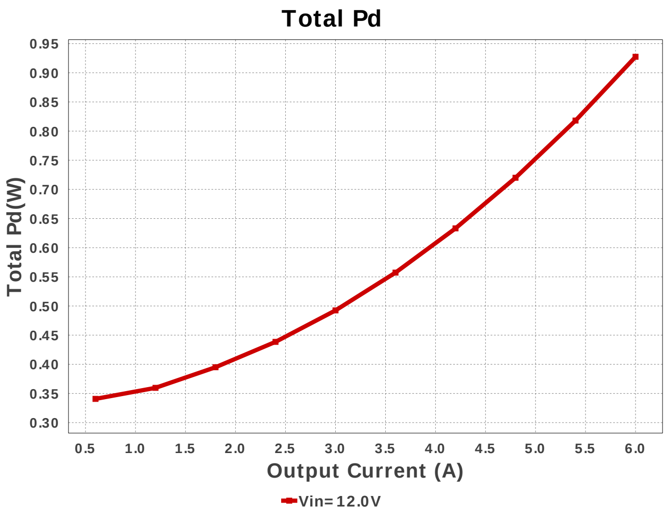

Ipp percentage
Ipp percentage(%)
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V

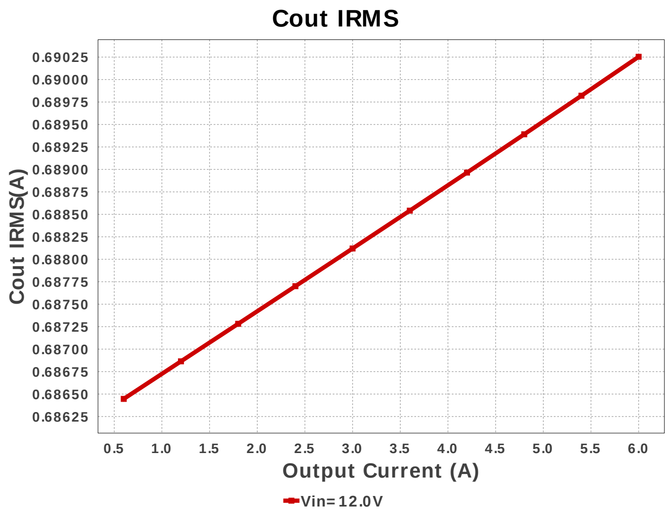

M1 Pd
M1 Pd(W)
0.090
0.085
0.080
0.075
0.070
0.065
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V

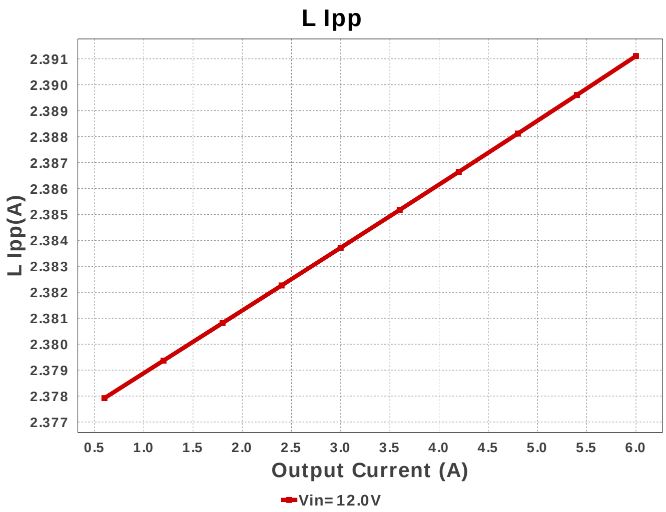

Pout
Pout(W)
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V

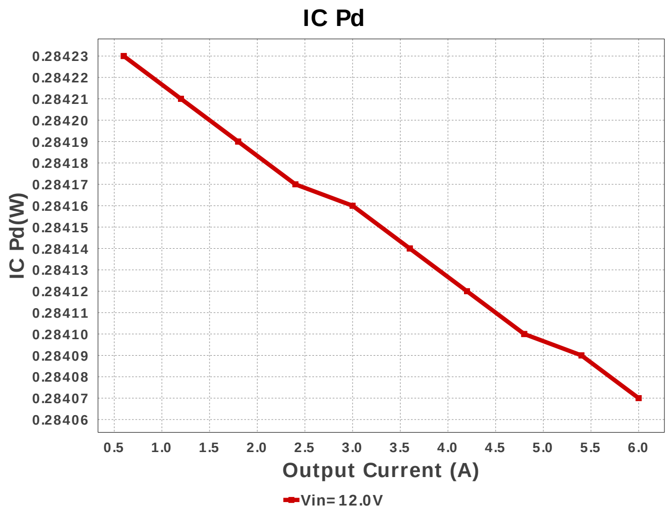

Iin Avg
Iin Avg(A)
1.9 1.8 1.7 1.6 1.5 1.4 1.3 1.2 1.1 1.0 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V

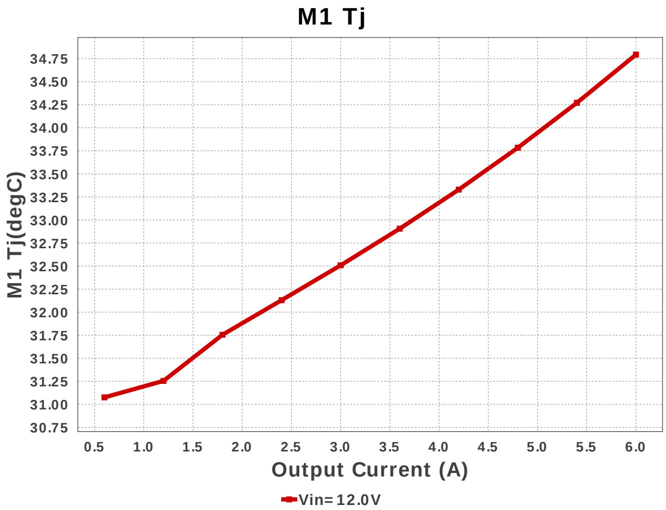

M2 Pd
M2 Pd(W)
0.085 0.080 0.075 0.070 0.065 0.060 0.055 0.050 0.045 0.040 0.035 0.030 0.025 0.020 0.015 0.010
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V

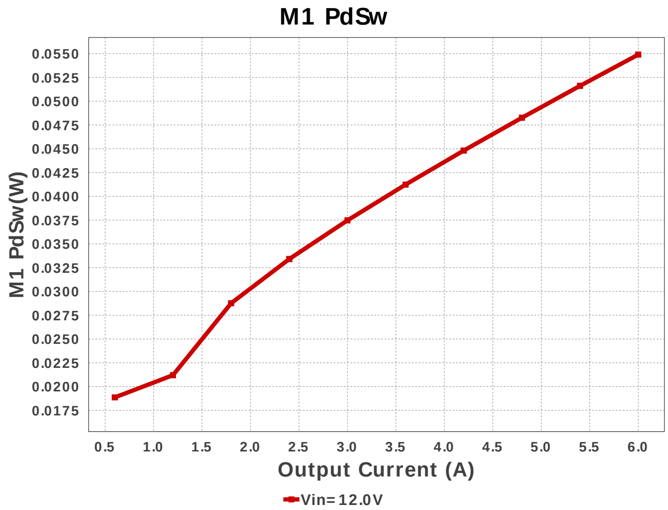

Total Pd
Total Pd(W)
0.95 0.90 0.85 0.80 0.75 0.70 0.65 0.60 0.55 0.50 0.45 0.40 0.35 0.30
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V

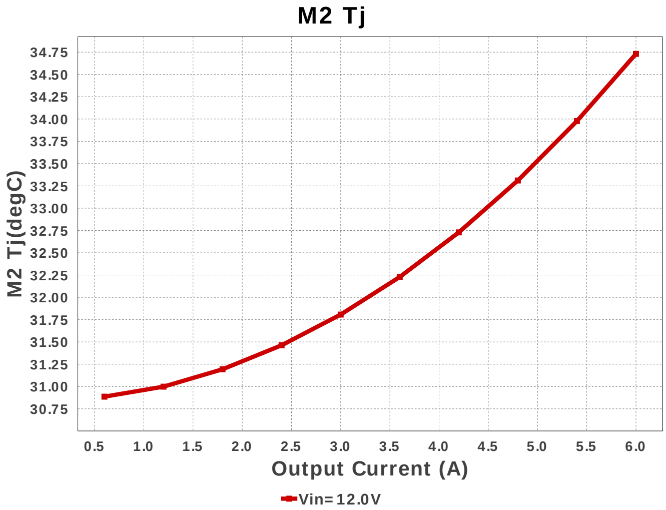

Cout IRMS
Cout IRMS(A)
0.69025 0.69000 0.68975 0.68950 0.68925 0.68900 0.68875 0.68850 0.68825 0.68800 0.68775 0.68750 0.68725 0.68700 0.68675 0.68650 0.68625
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V

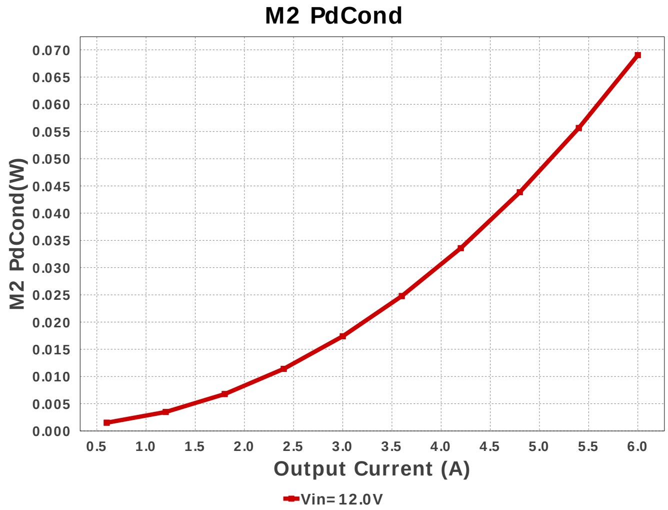

L Ipp
L Ipp(A)
2.391 2.390 2.389 2.388 2.387 2.386 2.385 2.384 2.383 2.382 2.381 2.380 2.379 2.378 2.377
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V


IC Pd
IC Pd(W)
0.28423 0.28422 0.28421 0.28420 0.28419 0.28418 0.28417 0.28416 0.28415 0.28414 0.28413 0.28412 0.28411 0.28410 0.28409 0.28408 0.28407 0.28406
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Output Current (A)
Vin=12.0V









Operating Values

#	Name	Value	Category	Description
1.	BOM Count	26		Total Design BOM count
2.	Total BOM	$7.59		Total BOM Cost
3.	Cin IRMS	2.784 A	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	14.011 mW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	690.253 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	2.382 mW	Capacitor	Output capacitor power dissipation
7.	IC Ipk	7.196 A	IC	Peak switch current in IC
8.	IC Pd	284.07 mW	IC	IC power dissipation
9.	IC Tj	41.363 degC	IC	IC junction temperature
10.	IC Tolerance	12.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA	40.0 degC/W	IC	IC junction-to-ambient thermal resistance
12.	Iin Avg	1.877 A	IC	Average input current
13.	Ipp percentage	39.852 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
14.	L Ipp	2.391 A	Inductor	Peak-to-peak inductor ripple current
15.	L Pd	140.43 mW	Inductor	Inductor power dissipation
16.	M1 Pd	87.158 mW	Mosfet	M1 MOSFET total power dissipation
17.	M1 PdCond	32.258 mW	Mosfet	M1 MOSFET conduction losses
18.	M1 PdSw	54.9 mW	Mosfet	M1 MOSFET switching losses
19.	M1 Tj	34.794 degC	Mosfet	M1 MOSFET junction temperature
20.	M2 Pd	86.009 mW	Mosfet	M2 MOSFET total power dissipation
21.	M2 PdCond	69.033 mW	Mosfet	M2 MOSFET conduction losses
22.	M2 PdSw	16.975 mW	Mosfet	M2 MOSFET switching losses
23.	M2 Tj	34.73 degC	Mosfet	M2 MOSFET junction temperature
24.	Cin Pd	14.011 mW	Power	Input capacitor power dissipation
25.	Cout Pd	2.382 mW	Power	Output capacitor power dissipation
26.	IC Pd	284.07 mW	Power	IC power dissipation
27.	L Pd	140.43 mW	Power	Inductor power dissipation
28.	M1 Pd	87.158 mW	Power	M1 MOSFET total power dissipation
29.	M1 PdCond	32.258 mW	Power	M1 MOSFET conduction losses
30.	M1 PdSw	54.9 mW	Power	M1 MOSFET switching losses
31.	M2 Pd	86.009 mW	Power	M2 MOSFET total power dissipation

#	Name	Value	Category	Description
32.	M2 PdCond	69.033 mW	Power	M2 MOSFET conduction losses
33.	M2 PdSw	16.975 mW	Power	M2 MOSFET switching losses
34.	Total Pd	927.461 mW	Power	Total Power Dissipation
35.	Duty Cycle	30.331 %	System Information	Duty cycle
36.	Efficiency	95.883 %	System Information	Steady state efficiency
37.	FootPrint	686.0 mm^2	System Information	Total Foot Print Area of BOM components
38.	Frequency	225.616 kHz	System Information	Switching frequency
39.	Iout	6.0 A	System Information	Iout operating point
40.	Mode	CCM	System Information	Conduction Mode
41.	Pout	21.6 W	System Information	Total output power
42.	Vin	12.0 V	System Information	Vin operating point
43.	Vout	3.6 V	System Information	Operational Output Voltage
44.	Vout Actual	3.6 V	System Information	Vout Actual calculated based on selected voltage divider resistors
45.	Vout Tolerance	3.095 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
46.	Vout p-p	11.956 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	6.0	Maximum Output Current
VinMax	12.0	Maximum input voltage
VinMin	12.0	Minimum input voltage
Vout	3.6	Output Voltage
base_pn	LM5117	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

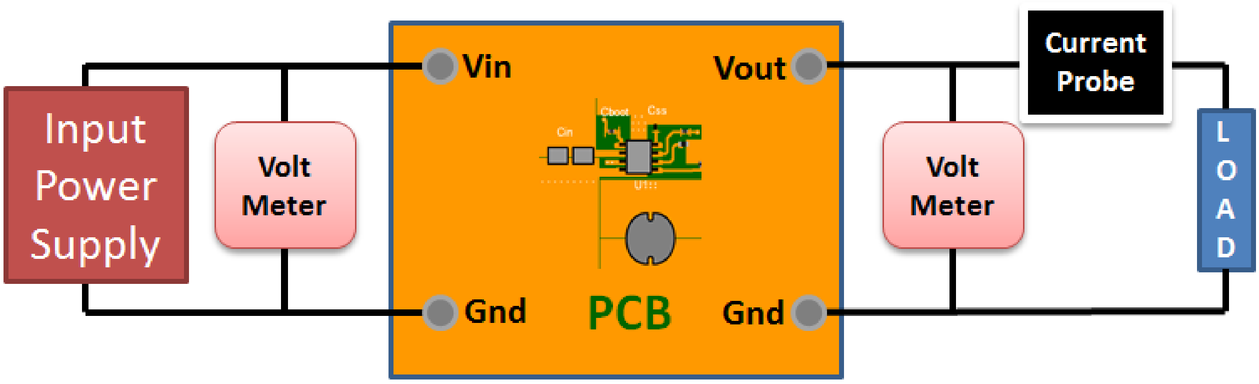
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 12.0V 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. Outline The LM5117 is a synchronous buck controller intended for step-down regulator applications from a high voltage or widely varying input supply. The control method is based upon current mode control utilizing an emulated current ramp. Current mode control provides inherent line feed-forward, cycle-by-cycle current limiting and ease of loop compensation. The use of an emulated control ramp reduces noise sensitivity of the pulse-width modulation circuit, allowing reliable control of very small duty cycles necessary in high input voltage applications. External Vcc An output voltage derived bias supply can be applied to the VCC pin to reduce the controller power dissipation at higher input voltage. This can also relax constraints on the driver supply current if your external source can supply more than the LM5117 internal regulator. Please see Datasheet for more information. Diode Emulation A fully synchronous buck regulator implemented with a freewheel MOSFET rather than a diode has the capability to sink current from the output in certain conditions such as light load, over-voltage or pre-bias startup. The LM5117 provides a diode emulation feature that can be enabled to prevent reverse (drain to source) current flow in the low side free-wheel MOSFET.

2. Master key : 9A55F716FAF5A76B[v1]

3. **LM5117** Product Folder : http://www.ti.com/product/LM5117 : contains the data sheet and other resources.

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