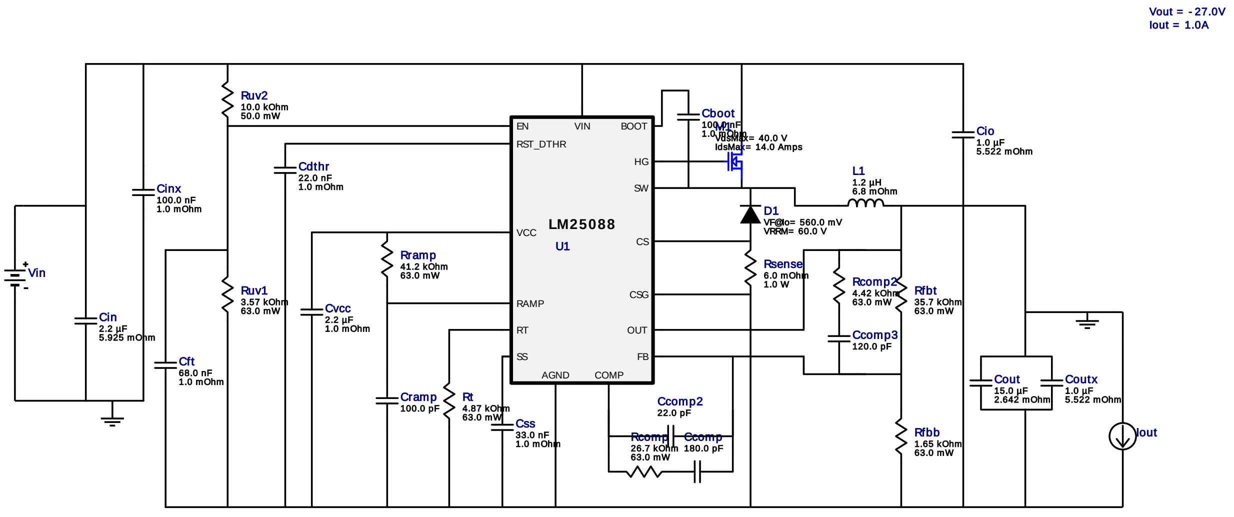
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 4.5V
VinMax = 5.5V
Vout = -27.0V
Iout = 1.0A

Device = LM25088MH-1/NOPB
Topology = Inverting_Buck_Boost
Created = 2019-06-19 12:04:16.036
BOM Cost = $3.31
BOM Count = 23
Total Pd = 5.25W

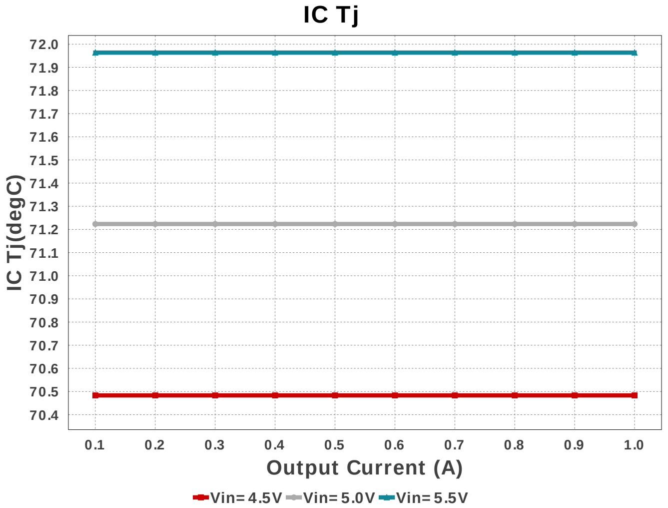
Design : 6 LM25088MH-1/NOPB
LM25088MH-1/NOPB 4.5V-5.5V to -27.00V @ 1A

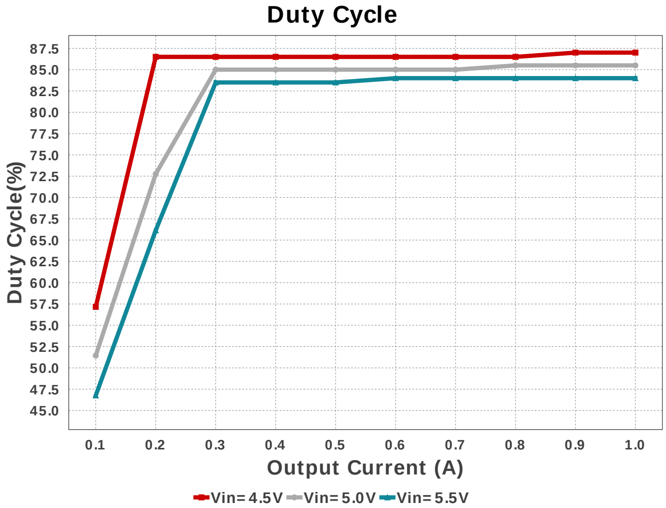


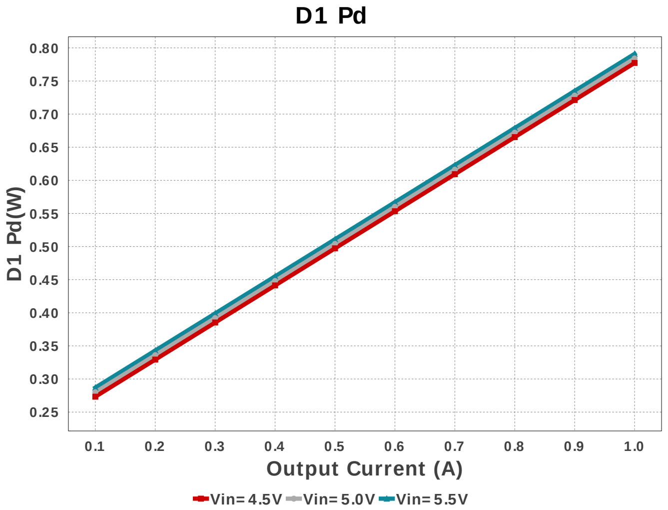
Electrical BOM

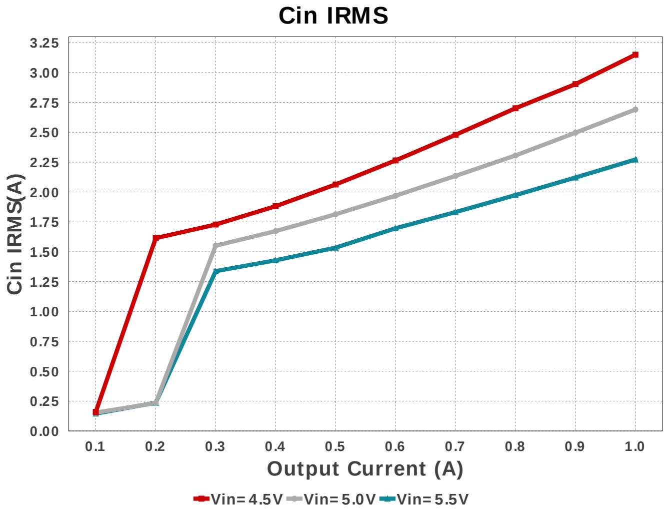
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM155R71C104KA88D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ccomp	Taiyo Yuden	UMK105CG181JV-F Series= C0G/NP0	Cap= 180.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ccomp2	TDK	C0402C0G1C220K020BC Series= C0G/NP0	Cap= 22.0 pF VDC= 16.0 V IRMS= 0.0 A	1	$0.04	01005 2 mm^2
Ccomp3	AVX	0101YA120JAT2A Series= C0G/NP0	Cap= 120.0 pF VDC= 16.0 V IRMS= 0.0 A	1	$0.05	01005 2 mm^2
Cdthr	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
Cft	MuRata	GRM188R71H683KA93D Series= X7R	Cap= 68.0 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.02	0603 5 mm^2
Cin	TDK	C1005X7S1A225K050BC Series= X7S	Cap= 2.2 uF ESR= 5.925 mOhm VDC= 10.0 V IRMS= 2.0559 A	1	$0.08	0402_065 3 mm^2
Cinx	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
Cio	TDK	C1608X5R1H105K080AB Series= X5R	Cap= 1.0 uF ESR= 5.522 mOhm VDC= 50.0 V IRMS= 2.2162 A	1	$0.03	0603 5 mm^2

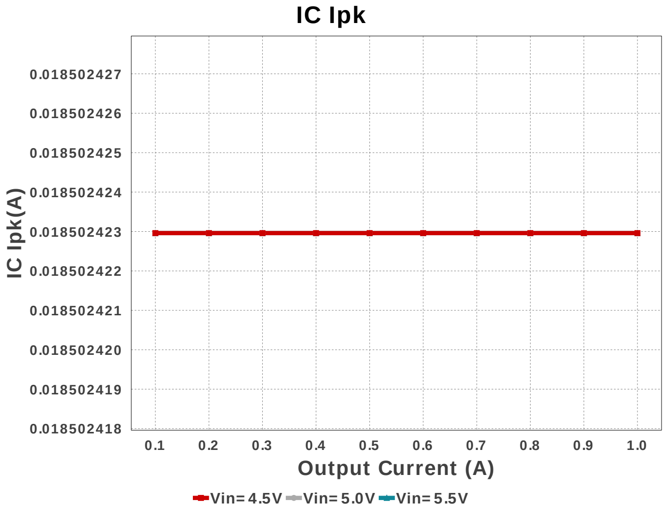
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cout	TDK	C5750X7S2A156M250KB Series= X7S	Cap= 15.0 uF ESR= 2.642 mOhm VDC= 100.0 V IRMS= 5.6162 A	1	$1.34	2220_280 54 mm^2
Coutx	TDK	C1608X5R1H105K080AB Series= X5R	Cap= 1.0 uF ESR= 5.522 mOhm VDC= 50.0 V IRMS= 2.2162 A	1	$0.03	0603 5 mm^2
Cramp	Samsung Electro-Mechanics	CL02C101JQ2ANNC Series= C0G/NP0	Cap= 100.0 pF VDC= 6.3 V IRMS= 0.0 A	1	$0.03	01005 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	TDK	C1005X5R1V225K050BC Series= X5R	Cap= 2.2 uF ESR= 1.0 mOhm VDC= 35.0 V IRMS= 0.0 A	1	$0.08	0402_065 3 mm^2
D1	Diodes Inc.	PDS760-13	VF@Io= 560.0 mV VRRM= 60.0 V	1	$0.63	PowerDI5 50 mm^2
L1	Coilcraft	XAL6030-122MEB	L= 1.2 µH 6.8 mOhm	1	$0.65	XAL6030 72 mm^2
M1	Fairchild Semiconductor	FDD8647L	VdsMax= 40.0 V IdsMax= 14.0 Amps	1	$0.60	DPAK 102 mm^2
Rcomp	Vishay-Dale	CRCW040226K7FKED Series= CRCW..e3	Res= 26.7 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rcomp2	Vishay-Dale	CRCW04024K42FKED Series= CRCW..e3	Res= 4.42 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	CRCW040235K7FKED Series= CRCW..e3	Res= 35.7 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rramp	Vishay-Dale	CRCW040241K2FKED Series= CRCW..e3	Res= 41.2 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rsense	Susumu Co Ltd	PRL1632-R006-F-T1 Series= PRL1632	Res= 6.0 mOhm Power= 1.0 W Tolerance= 1.0%	1	$0.20	0612 11 mm^2
Rt	Vishay-Dale	CRCW04024K87FKED Series= CRCW..e3	Res= 4.87 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ruv1	Vishay-Dale	CRCW04023K57FKED Series= CRCW..e3	Res= 3.57 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	LM25088MH-1/NOPB	Switcher	1	$1.50	MXA16A 59 mm^2

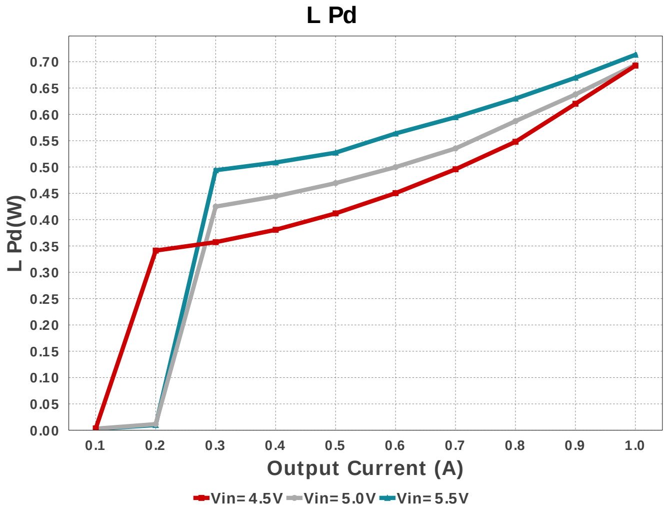

IC Tj
IC Tj(degC)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

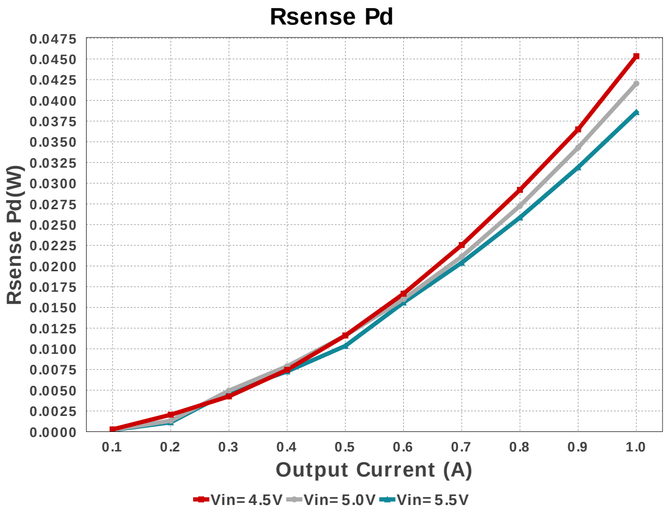

Duty Cycle
Duty Cycle(%)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

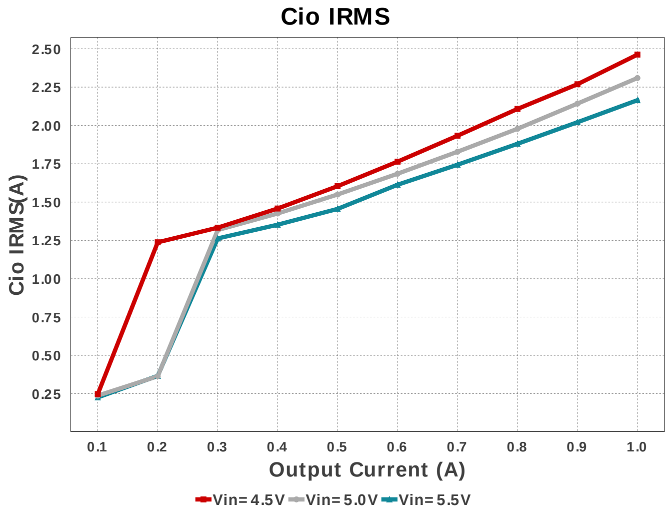

D1 Pd
D1 Pd(W)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

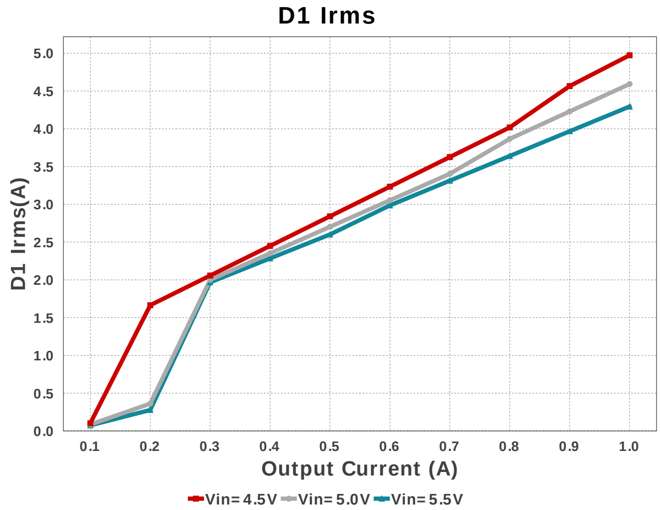

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

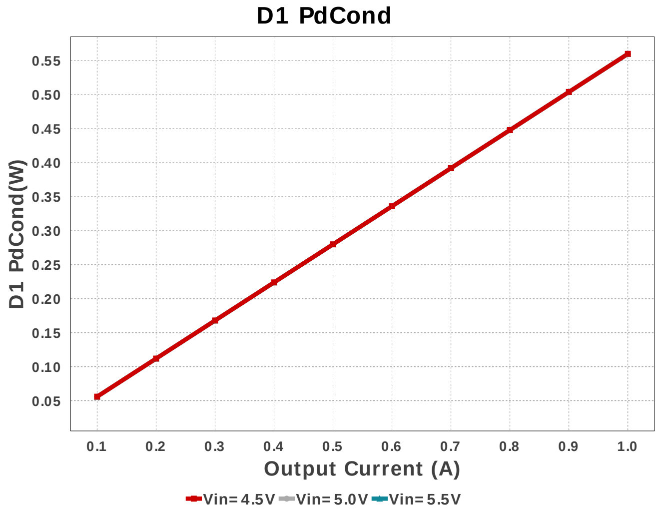

IC Ipk
IC Ipk(A)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

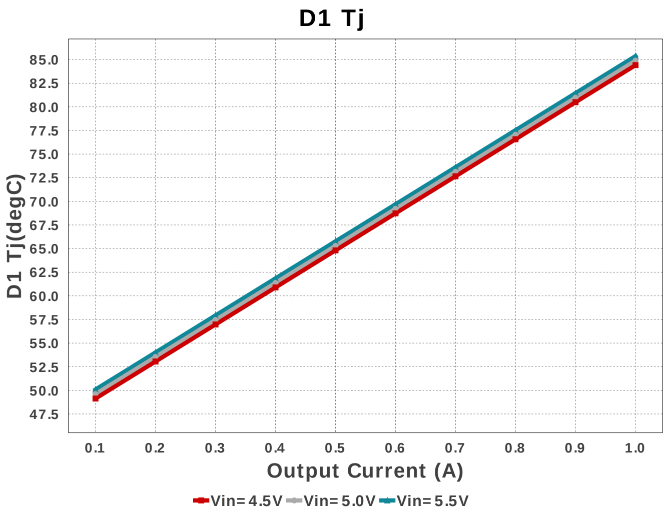

L Pd
L Pd(W)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

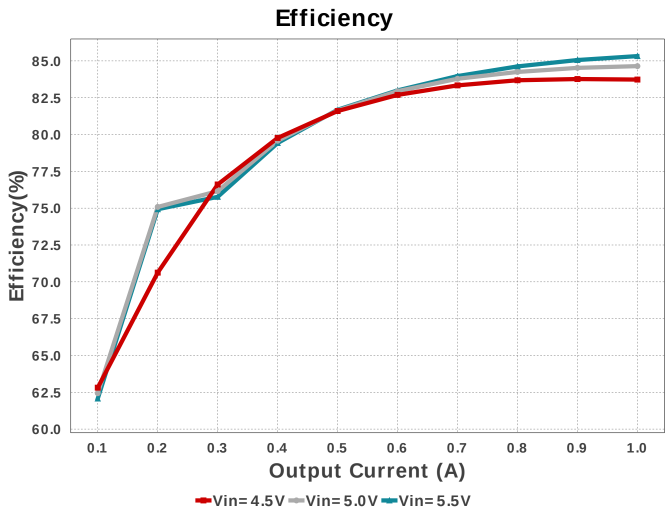

Rsense Pd
Rsense Pd(W)
Output Current (A)
Vin=4.5V Vin=5.0V Vin=5.5V

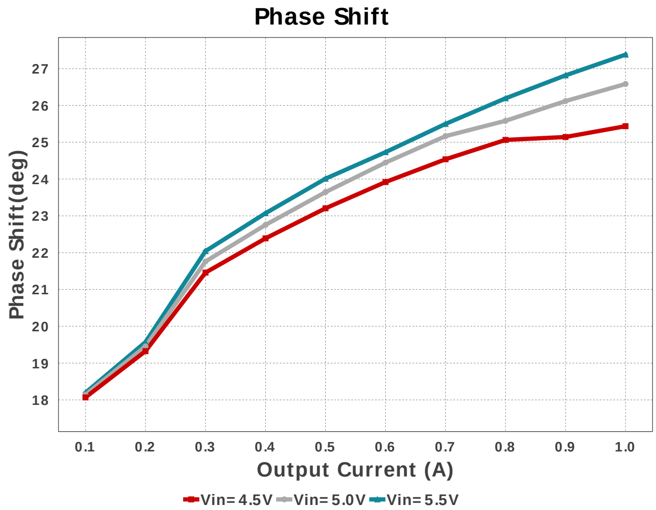

Cio IRMS
Cio IRMS(A)
Output Current (A)
Vin=4.5V Vin=5.0V Vin=5.5V

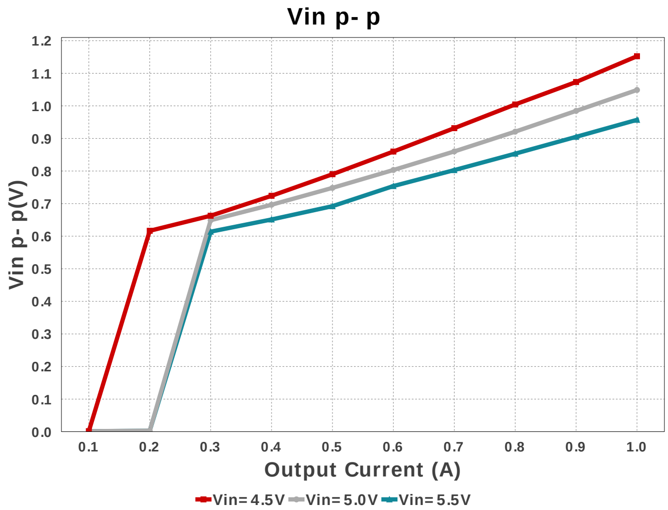

D1 Irms
D1 Irms(A)
Output Current (A)
Vin=4.5V Vin=5.0V Vin=5.5V

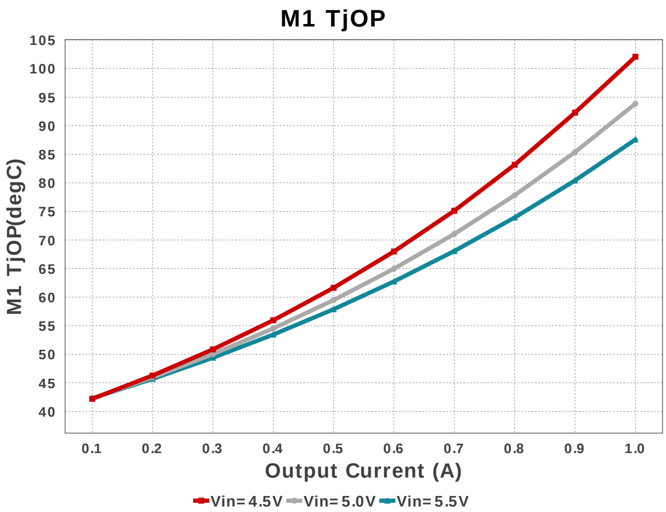

D1 PdCond
D1 PdCond(W)
Output Current (A)
Vin=4.5V Vin=5.0V Vin=5.5V

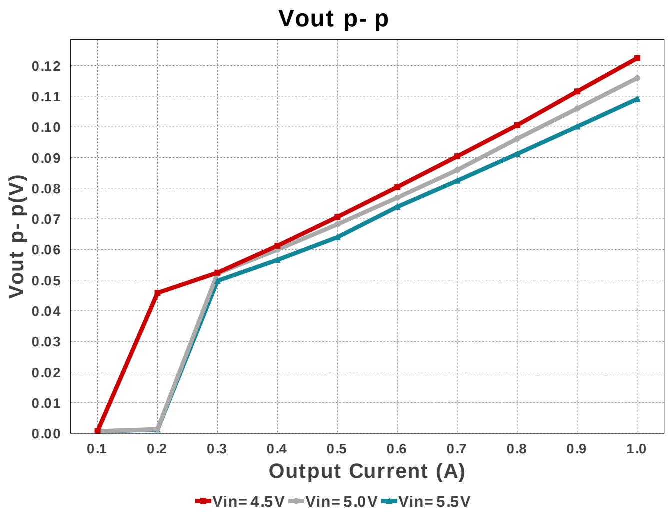

D1 Tj
D1 Tj(degC)
Output Current (A)
Vin=4.5V Vin=5.0V Vin=5.5V

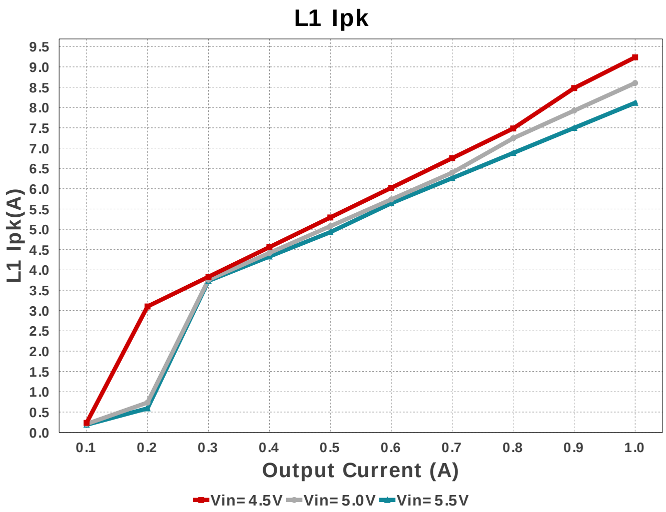

Efficiency
Efficiency(%)
Output Current (A)
Vin=4.5V Vin=5.0V Vin=5.5V

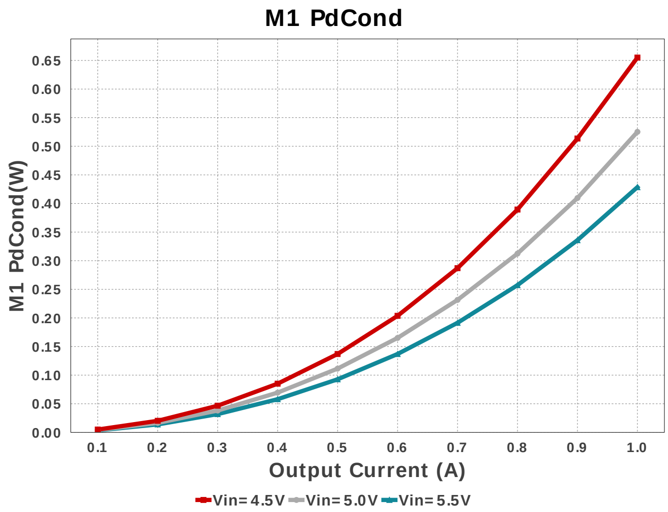

Phase Shift
Phase Shift(deg)
27
26
25
24
23
22
21
20
19
18
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=4.5V Vin=5.0V Vin=5.5V

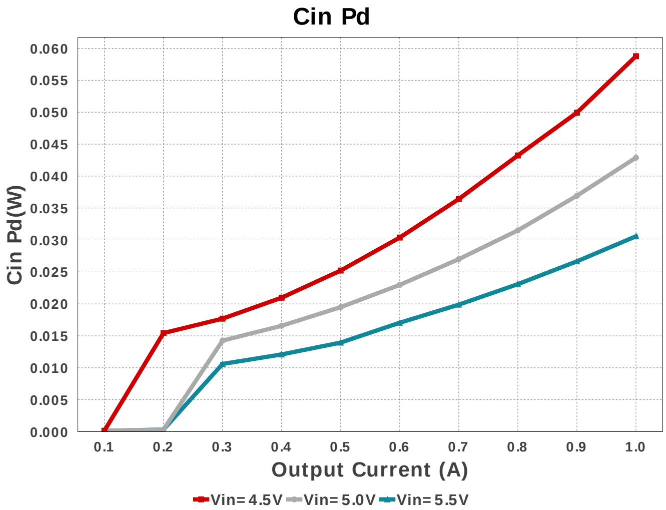

Vin p-p
Vin p-p(V)
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=4.5V Vin=5.0V Vin=5.5V

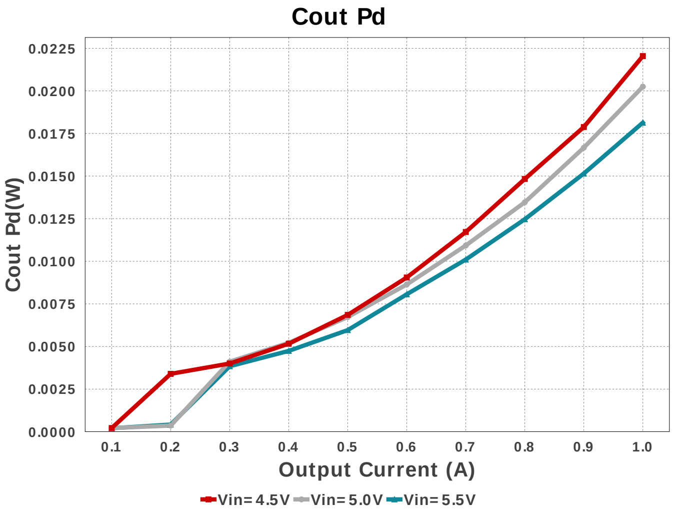

M1 TjOP
M1 TjOP(degC)
105
100
95
90
85
80
75
70
65
60
55
50
45
40
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=4.5V Vin=5.0V Vin=5.5V

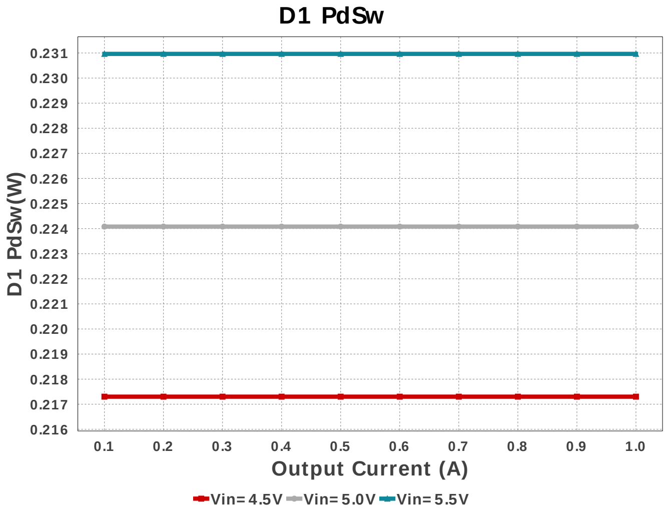

Vout p-p
Vout p-p(V)
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=4.5V Vin=5.0V Vin=5.5V

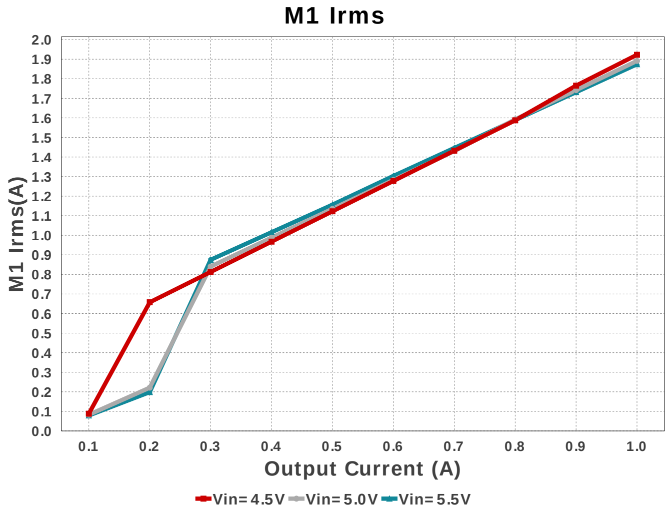

L1 Ipk
L1 Ipk(A)
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=4.5V Vin=5.0V Vin=5.5V

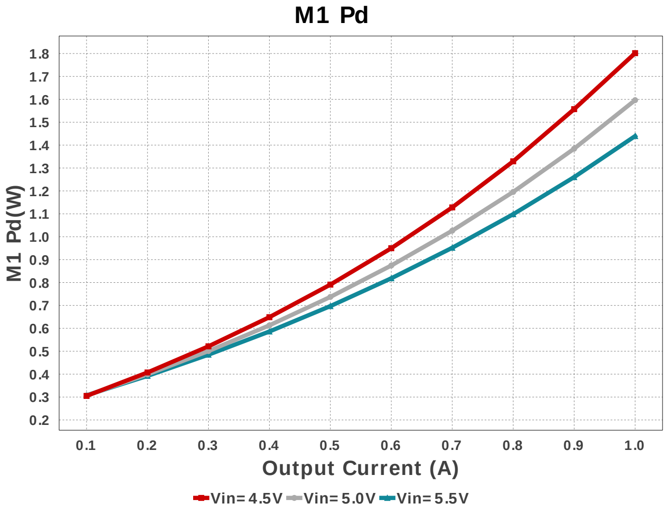

M1 PdCond
M1 PdCond(W)
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=4.5V Vin=5.0V Vin=5.5V

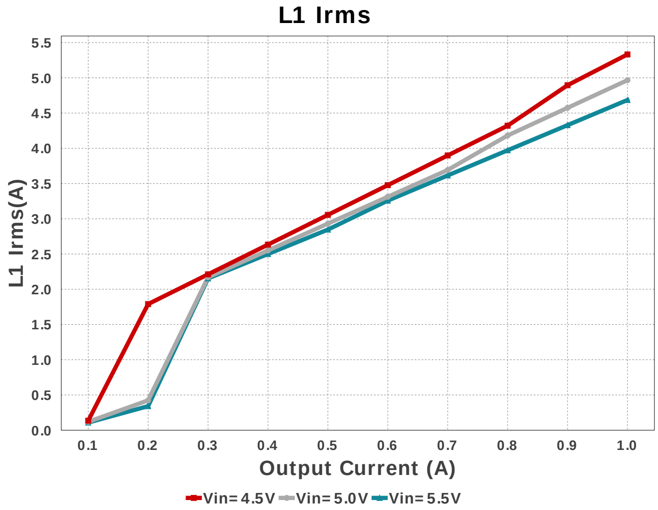

Cin Pd
Cin Pd(W)
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

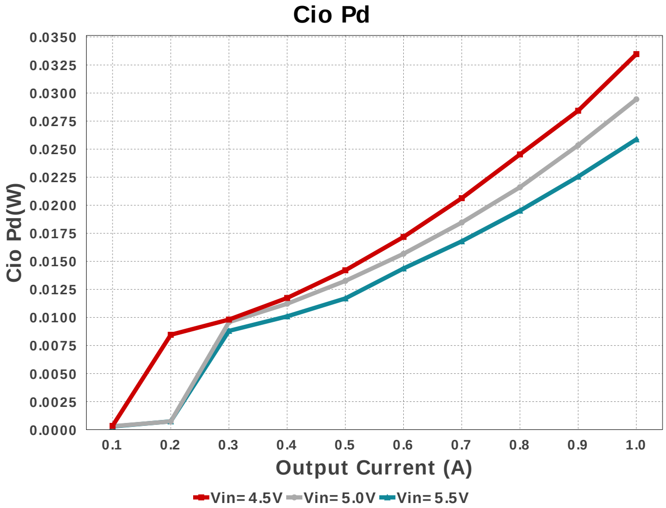

Cout Pd
Cout Pd(W)
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

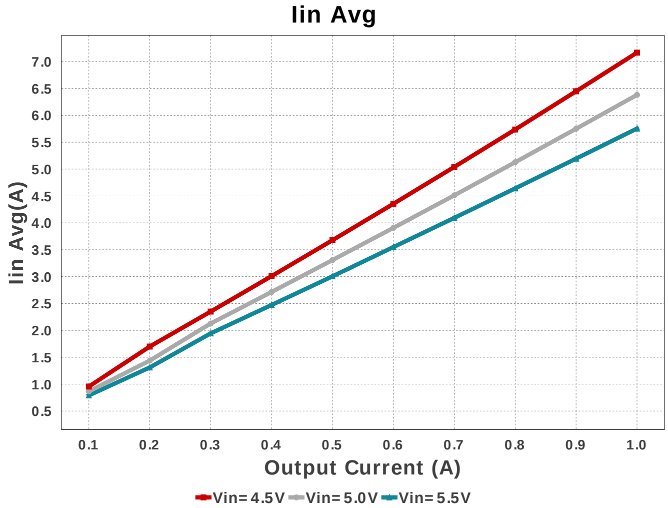

D1 PdSw
D1 PdSw(W)
0.231
0.230
0.229
0.228
0.227
0.226
0.225
0.224
0.223
0.222
0.221
0.220
0.219
0.218
0.217
0.216
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

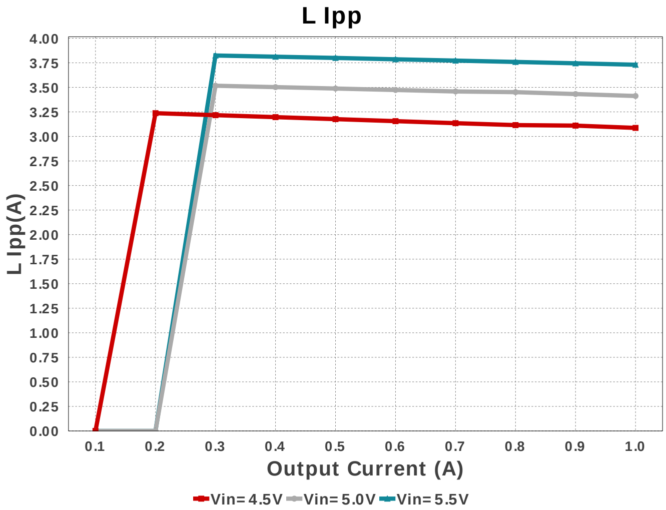

M1 Irms
M1 Irms(A)
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

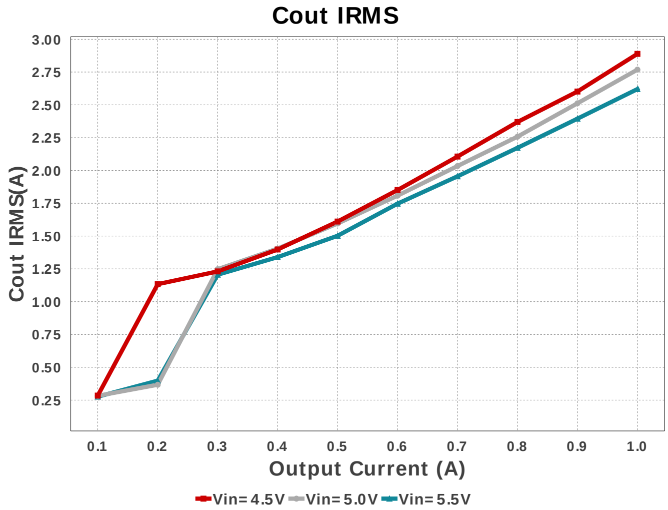

M1 Pd
M1 Pd(W)
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

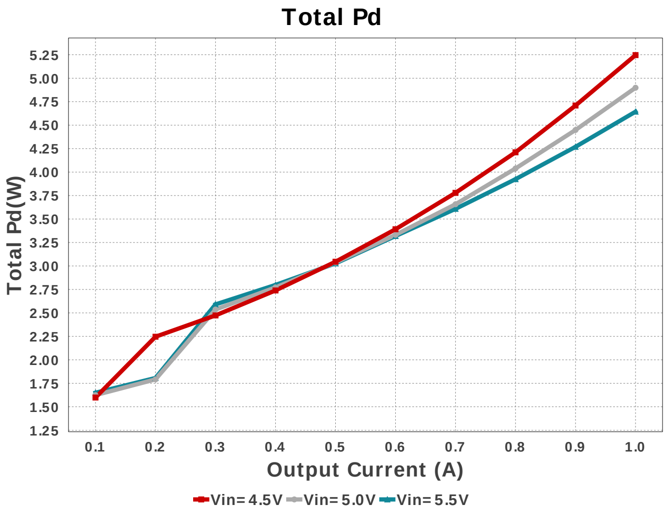

L1 Irms
L1 Irms(A)
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

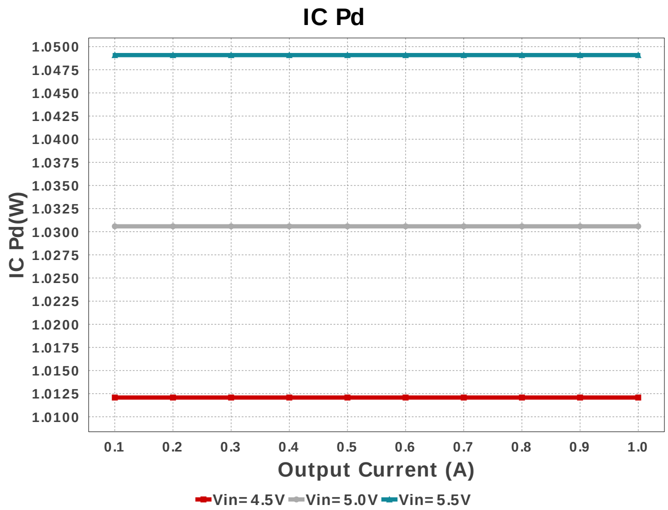

Cio Pd
Cio Pd(W)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

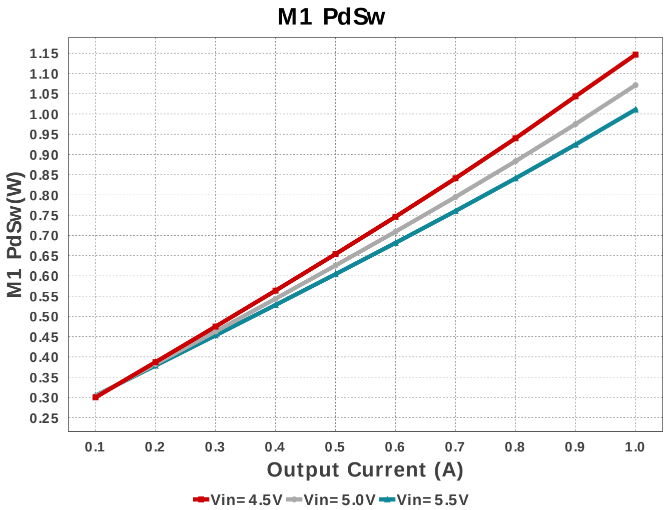

Iin Avg
Iin Avg(A)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

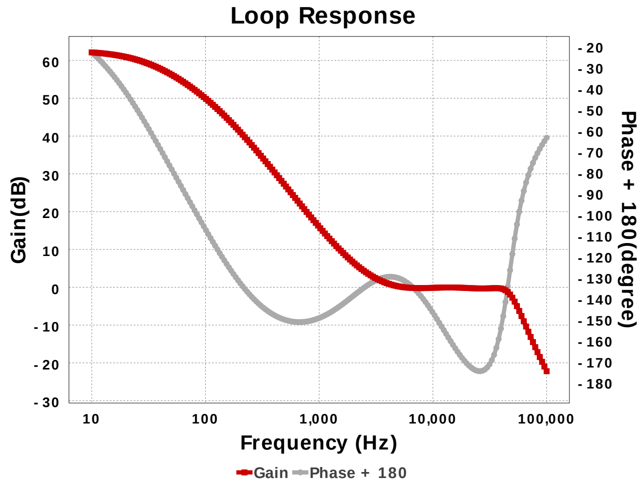

L Ipp
L Ipp(A)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V


Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V


Total Pd
Total Pd(W)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V


IC Pd
IC Pd(W)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V





Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	3.149 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	58.765 mW	Capacitor	Input capacitor power dissipation
3.	Cio IRMS	2.462 A	Capacitor	Input to output capacitor RMS ripple current
4.	Cio Pd	33.472 mW	Capacitor	Input to output capacitor power dissipation
5.	Cout IRMS	2.888 A	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	22.043 mW	Capacitor	Output capacitor power dissipation
7.	D1 Irms	4.974 A	Current	D1 Irms
8.	D1 Pd	777.301 mW	Diode	Diode power dissipation
9.	D1 PdCond	560.0 mW	Diode	Diode conduction losses
10.	D1 PdSw	217.301 mW	Diode	Diode switching losses
11.	D1 Tj	84.411 degC	Diode	D1 junction temperature
12.	IC Ipk	18.502 mA	IC	Peak switch current in IC
13.	IC Pd	1.012 W	IC	IC power dissipation
14.	IC Tj	70.483 degC	IC	IC junction temperature
15.	IC Tolerance	18.0 mV	IC	IC Feedback Tolerance
16.	Iin Avg	7.166 A	IC	Average input current
17.	L Ipp	3.087 A	Inductor	Peak-to-peak output inductor ripple current
18.	L Pd	692.567 mW	Inductor	Inductor power dissipation
19.	L1 Ipk	9.236 A	Inductor	Inductor peak current
20.	L1 Irms	5.332 A	Inductor	Inductor ripple current
21.	M1 Irms	1.923 A	Mosfet	M1 MOSFET Irms
22.	M1 Pd	1.802 W	Mosfet	M1 MOSFET total power dissipation
23.	M1 PdCond	655.015 mW	Mosfet	M1 MOSFET conduction losses
24.	M1 PdSw	1.147 W	Mosfet	M1 MOSFET switching losses
25.	M1 TjOP	102.064 degC	Mosfet	M1 MOSFET junction temperature
26.	IOUT_OP	1.0 A	Op Point	Iout operating point
27.	VIN_OP	4.5 V	Op Point	Vin operating point
28.	Total Pd	5.246 W	Power	Total Power Dissipation
29.	Rsense Pd	45.339 mW	Resistor	LED Current Rsns Power Dissipation
30.	BOM Count	23	System Information	Total Design BOM count
31.	Cross Freq	32.93 kHz	System Information	Bode plot crossover frequency
32.	Duty Cycle	87.0 %	System Information	Duty cycle
33.	Efficiency	83.731 %	System Information	Steady state efficiency
34.	FootPrint	276.0 mm^2	System Information	Total Foot Print Area of BOM components
35.	Frequency	980.162 kHz	System Information	Switching frequency
36.	Gain Marg	16.753 db	System Information	Bode Plot Gain Margin
37.	Mode	DCM	System Information	Conduction Mode
38.	Phase Marg	49.016 deg	System Information	Bode Plot Phase Margin
39.	Phase Shift	25.436 deg	System Information	Bode Plot Phase Shift
40.	Total BOM	$3.31	System Information	Total BOM Cost

#	Name	Value	Category	Description
41.	Vin p-p	1.152 V	System Information	Peak-to-peak input voltage
42.	Vout p-p	122.424 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	1.0	Maximum Output Current
VinMax	5.5	Maximum input voltage
VinMin	4.5	Minimum input voltage
VinTyp	5.0	Typical input voltage
Vout	-27.0	Output Voltage
base_pn	LM25088	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature
UserFsw	535.0 k	Customer Selected Frequency

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

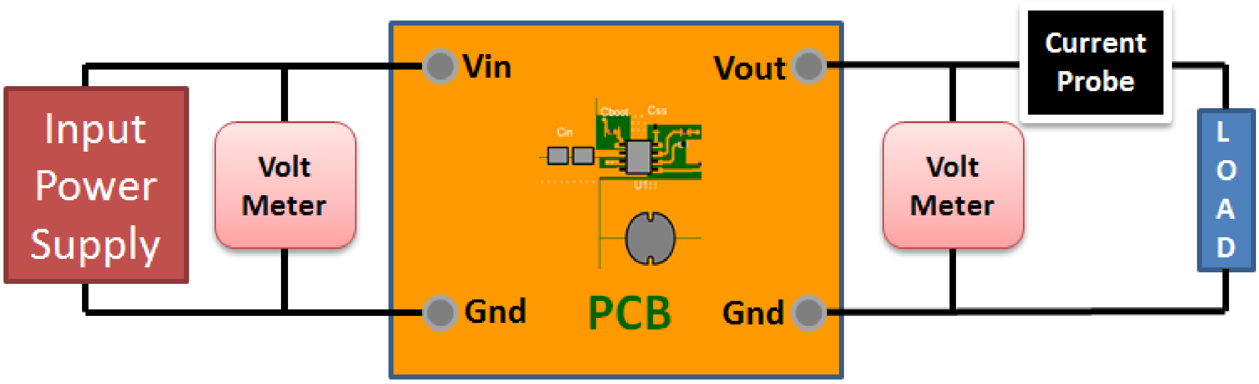
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 4.5V 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 : E56AD4253327D321[v1]

2. **LM25088** Product Folder : http://www.ti.com/product/LM25088 : contains the data sheet and other resources.

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