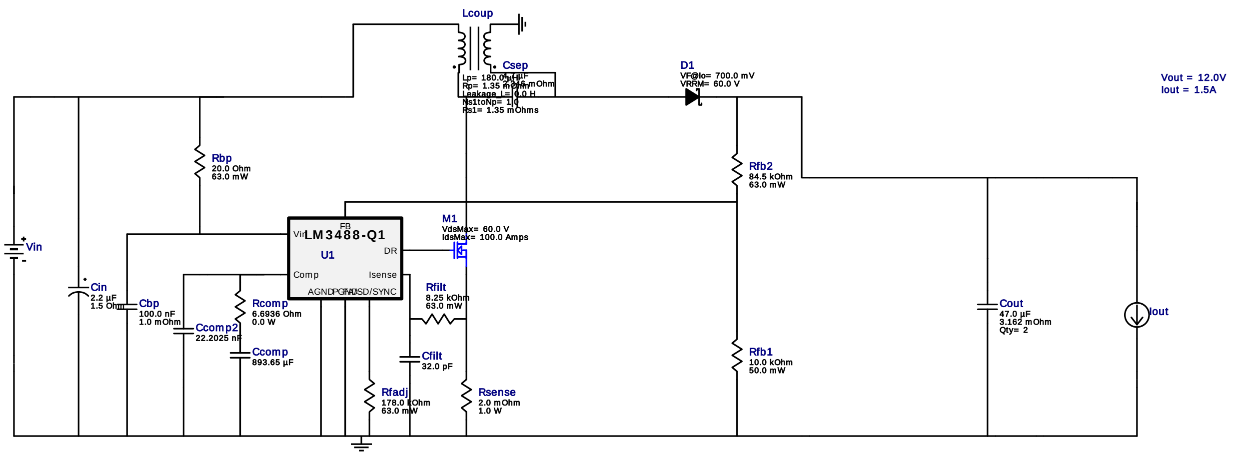
VinMin = 3.0V
VinMax = 24.0V
Vout = 12.0V
Iout = 1.5A

Device = LM3488QMM/NOPB
Topology = SEPIC
Created = 2022-02-09 19:24:12.025
BOM Cost = NA
BOM Count = 19
Total Pd = 3.29W

WEBENCH ® Design Report

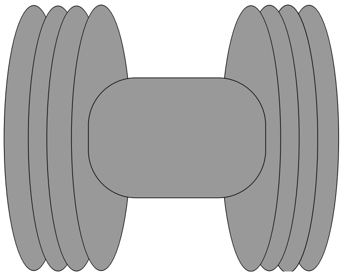
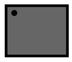
Design : 4 LM3488QMM/NOPB
LM3488QMM/NOPB 3V-22V to 12.00V @ 1A

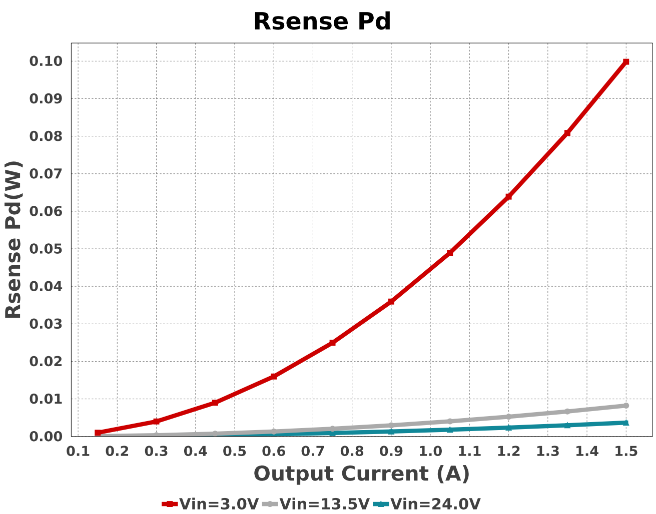


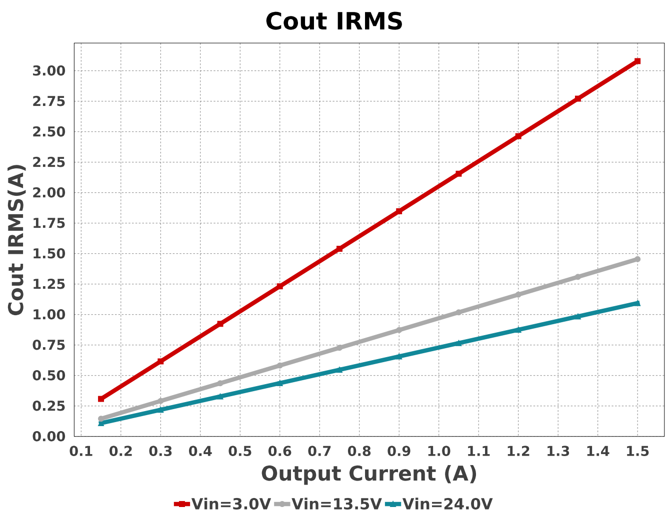
1. Please note that Loop/ stability model has not been implemented for this device.The opertating values and charts related to loop model are disabled.

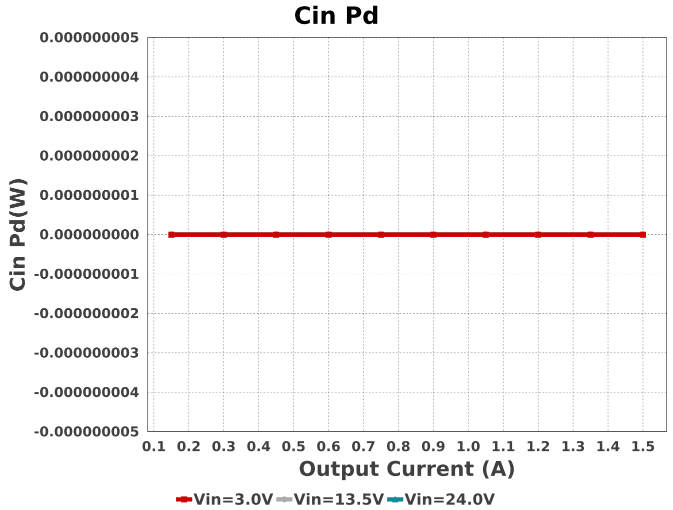
Electrical BOM

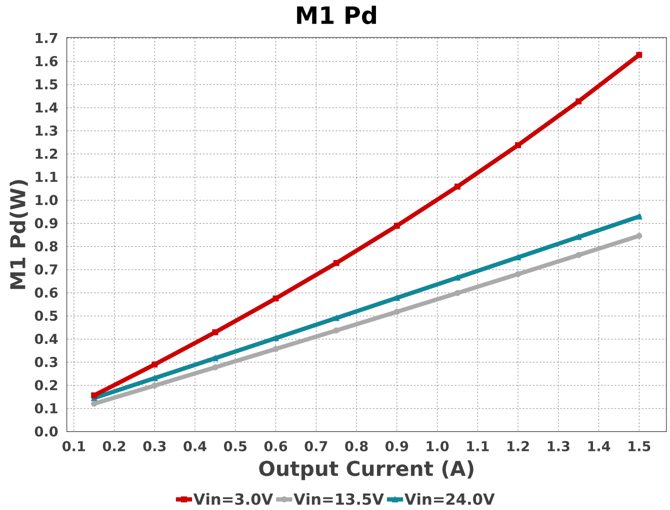
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbp	Yageo	CC0805KRX7R9BB104 Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2
Ccomp	CUSTOM	CUSTOM Series= ?	Cap= 893.65 uF VDC= 0.0 V IRMS= 0.0 A	1	NA	CUSTOM 0 mm^2
Ccomp2	CUSTOM	CUSTOM Series= ?	Cap= 22.2025 nF VDC= 0.0 V IRMS= 0.0 A	1	NA	CUSTOM 0 mm^2
Cfilt	AVX	06033A320FAT2A Series= C0G/NP0	Cap= 32.0 pF VDC= 25.0 V IRMS= 0.0 A	1	$0.11	0603 5 mm^2
Cin	AVX	TPSA225K035R1500 Series= TPS	Cap= 2.2 uF ESR= 1.5 Ohm VDC= 35.0 V IRMS= 201.0 mA	1	$0.22	3216-18 11 mm^2
Cout	TDK	C5750X5R1C476M230KA Series= X5R	Cap= 47.0 uF ESR= 3.162 mOhm VDC= 16.0 V IRMS= 5.1344 A	2	$0.72	2220_250 54 mm^2
Csep	TDK	CGA4J1X7R1V475K125AC Series= X7R	Cap= 4.7 uF ESR= 2.346 mOhm VDC= 35.0 V IRMS= 4.2602 A	1	$0.16	0805 7 mm^2
D1	Diodes Inc.	B560C-13-F	VF@Io= 700.0 mV VRRM= 60.0 V	1	$0.17	SMC 83 mm^2

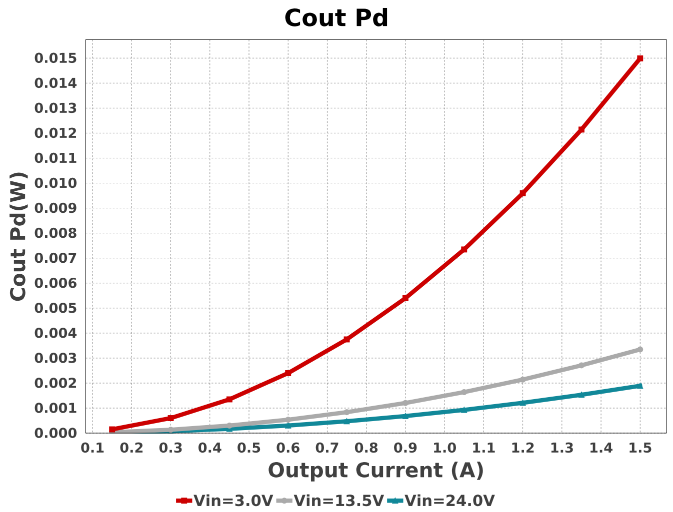
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Lcoup	Laird-Signal Integrity Products	CMX1211Z181B-10	Lp= 180.0 µH Rp= 1.35 mOhm Leakage_L= 0.0 H Ns1toNp= 1.0 Rs1= 1.35 mOhms	1	$3.81	 CMX1211Z181B 904 mm²
M1	Texas Instruments	CSD18540Q5B	VdsMax= 60.0 V IdsMax= 100.0 Amps	1	$0.86	 DNK0008A 56 mm²
Rbp	Vishay-Dale	CRCW040220R0FKED Series= CRCW..e3	Res= 20.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rcomp	CUSTOM	CUSTOM Series= ?	Res= 6.6936 Ohm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm²
Rfadj	Vishay-Dale	CRCW0402178KFKED Series= CRCW..e3	Res= 178.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfb1	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
Rfb2	Vishay-Dale	CRCW040284K5FKED Series= CRCW..e3	Res= 84.5 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfilt	Vishay-Dale	CRCW04028K25FKED Series= CRCW..e3	Res= 8.25 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rsense	Stackpole Electronics Inc	CSNL1206FT2L00 Series= CSNL	Res= 2.0 mOhm Power= 1.0 W Tolerance= 1.0%	1	$0.20	 1206 11 mm²
U1	Texas Instruments	LM3488QMM/NOPB	Switcher	1	$1.18	 MUA08A 24 mm²

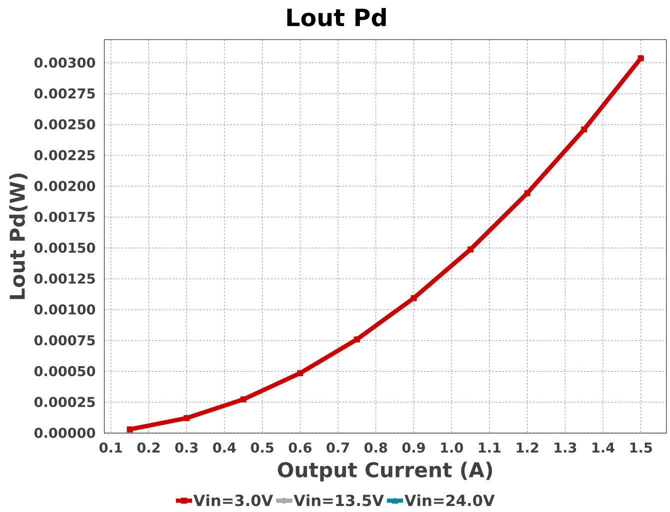


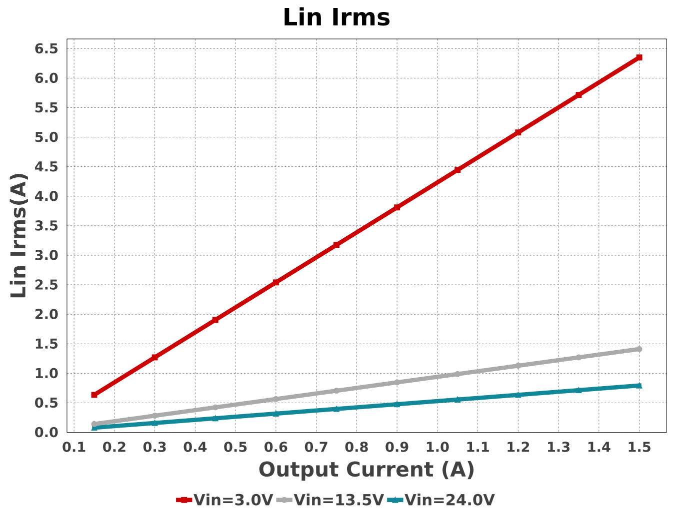


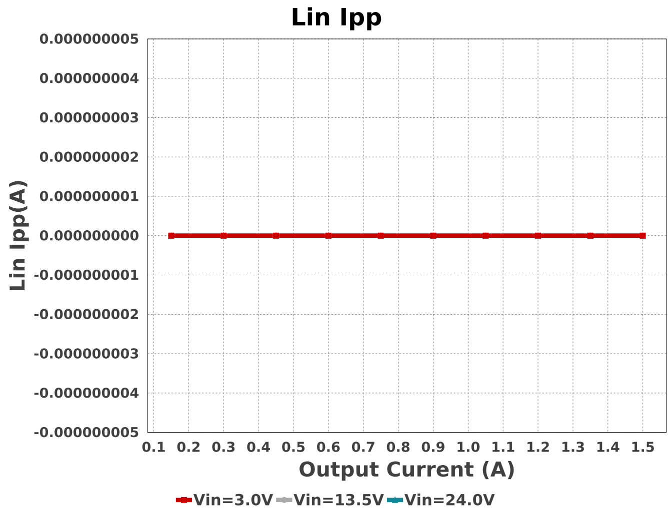

Cin Pd
Cin Pd(W)
0.000000005
0.000000004
0.000000003
0.000000002
0.000000001
0.000000000
-0.000000001
-0.000000002
-0.000000003
-0.000000004
-0.000000005
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

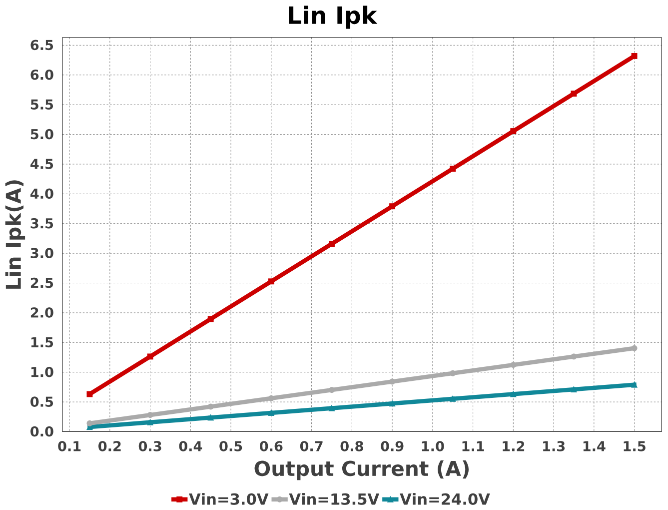

M1 Pd
M1 Pd(W)
1.7 1.6 1.5 1.4 1.3 1.2 1.1 1.0 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0.0
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

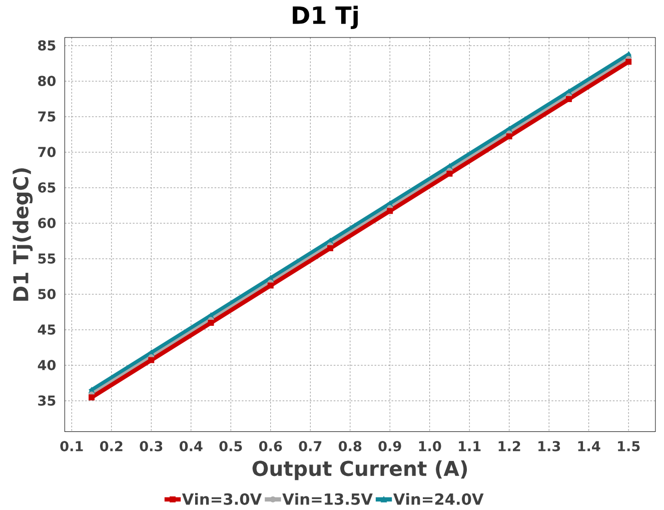

Cout Pd
Cout Pd(W)
0.015 0.014 0.013 0.012 0.011 0.010 0.009 0.008 0.007 0.006 0.005 0.004 0.003 0.002 0.001 0.000
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

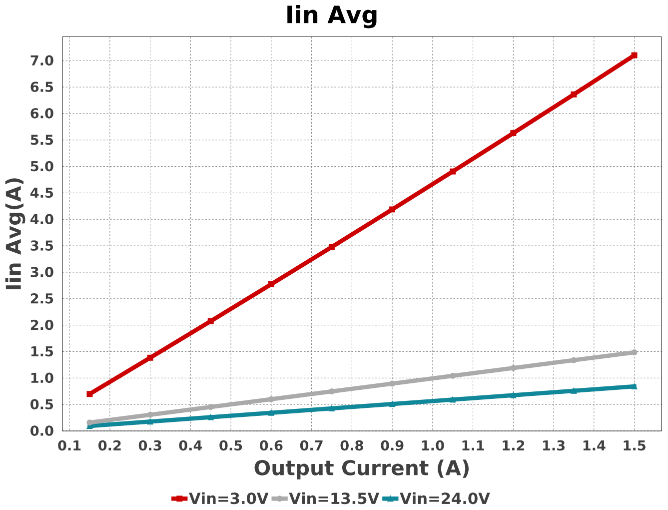

Lout Pd
Lout Pd(W)
0.00300 0.00275 0.00250 0.00225 0.00200 0.00175 0.00150 0.00125 0.00100 0.00075 0.00050 0.00025 0.00000
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

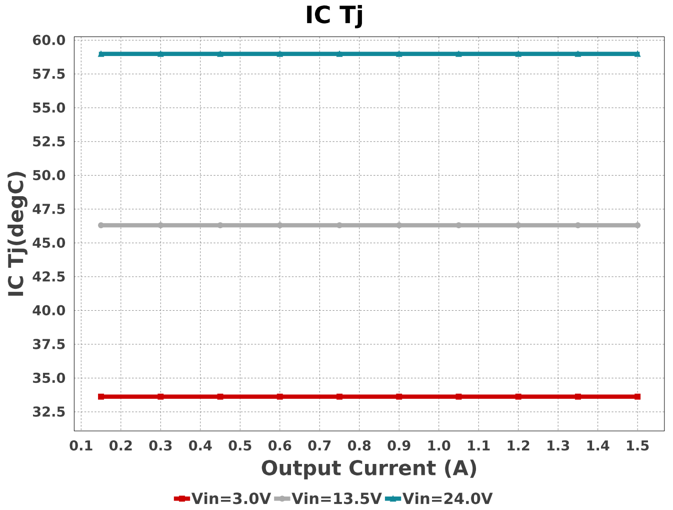

Lin Irms
Lin Irms(A)
6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

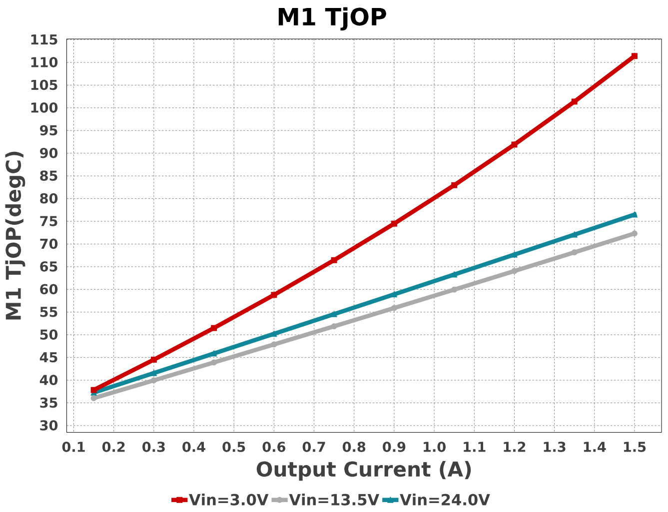

Lin Ipp
Lin Ipp(A)
0.000000005
0.000000004
0.000000003
0.000000002
0.000000001
0.000000000
-0.000000001
-0.000000002
-0.000000003
-0.000000004
-0.000000005
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

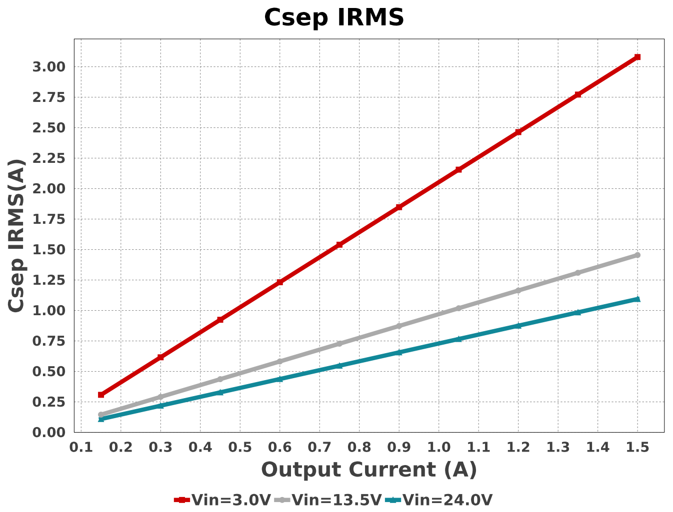

Lin Ipk
Lin Ipk(A)
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V


D1 Tj
D1 Tj(degC)
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

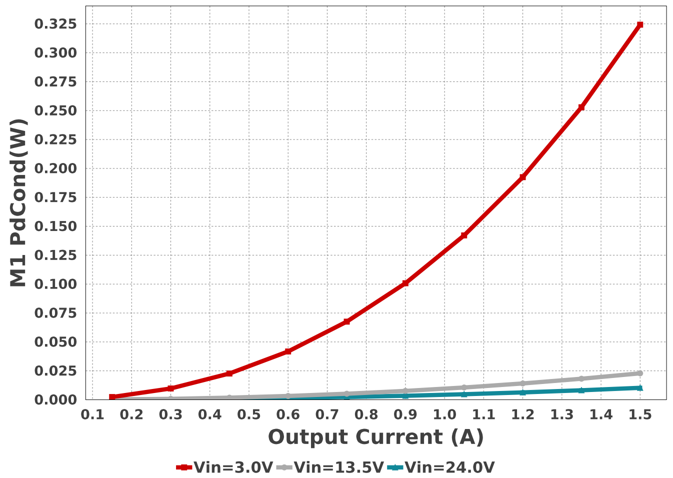

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V


IC Tj
IC Tj(degC)
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

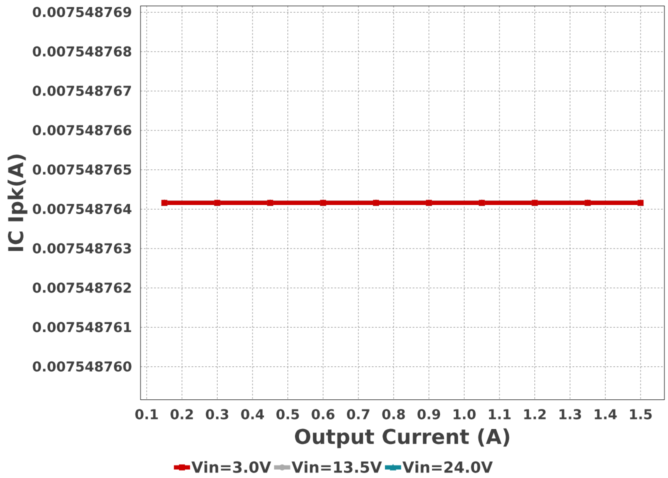

M1 TjOP
M1 TjOP(degC)
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V


Csep IRMS
Csep IRMS(A)
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

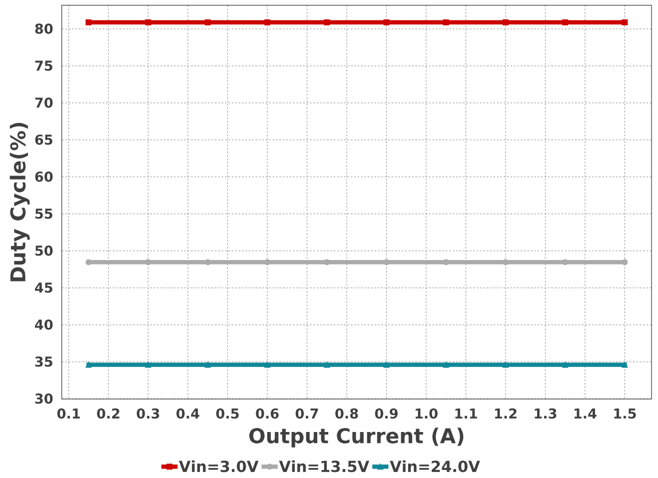
M1 PdCond



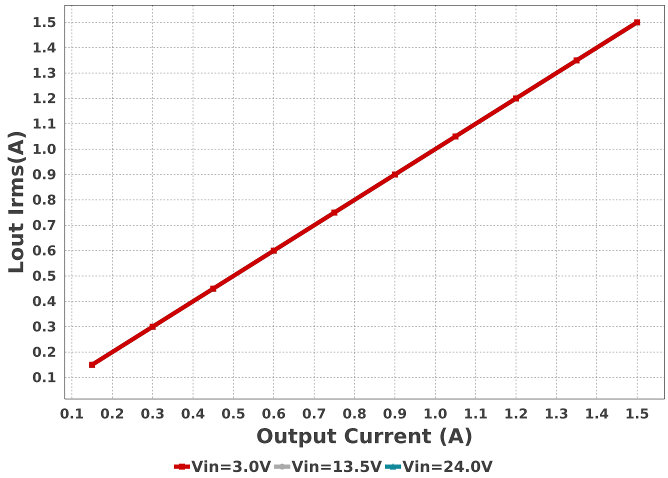
IC Ipk



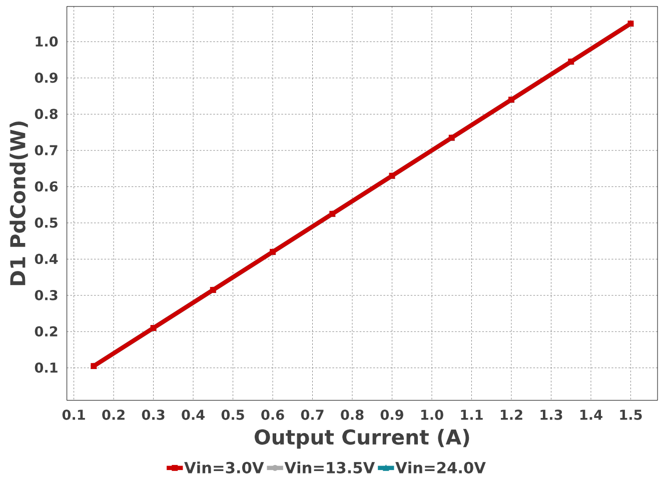
Duty Cycle



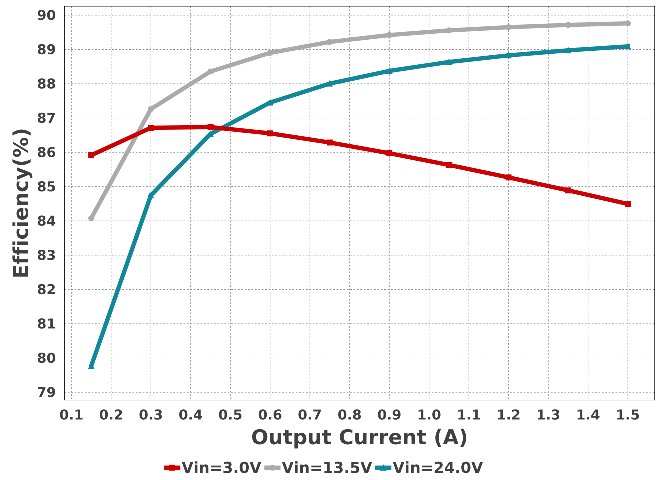
Lout Irms

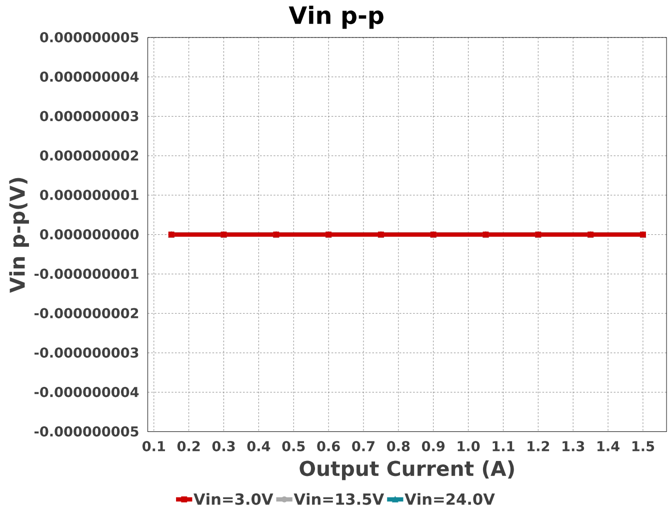


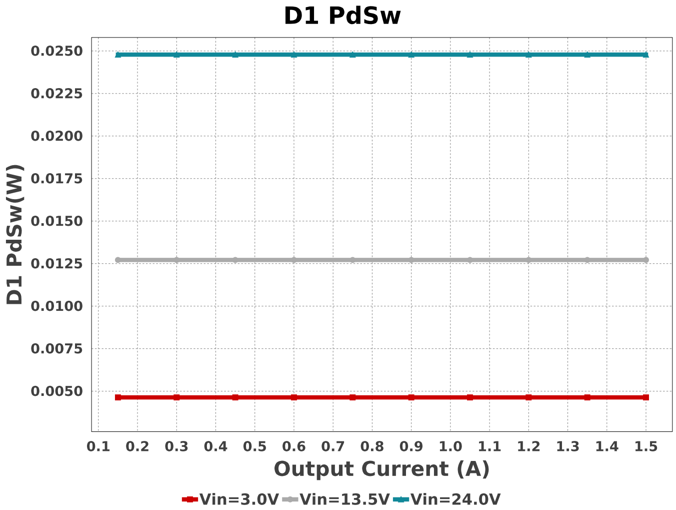
D1 PdCond

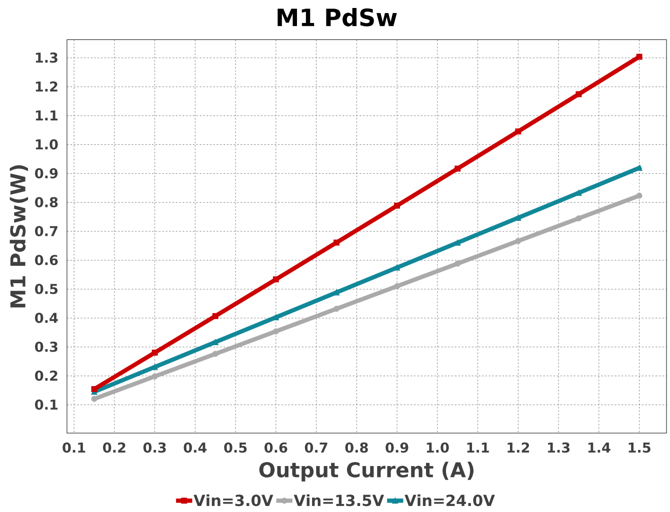


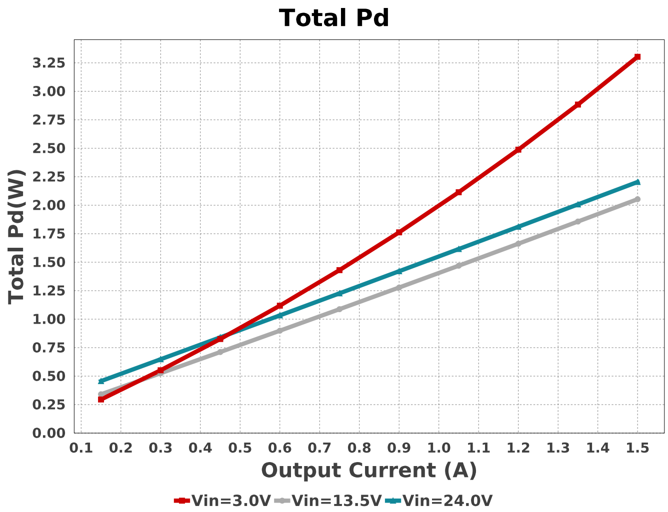
Efficiency

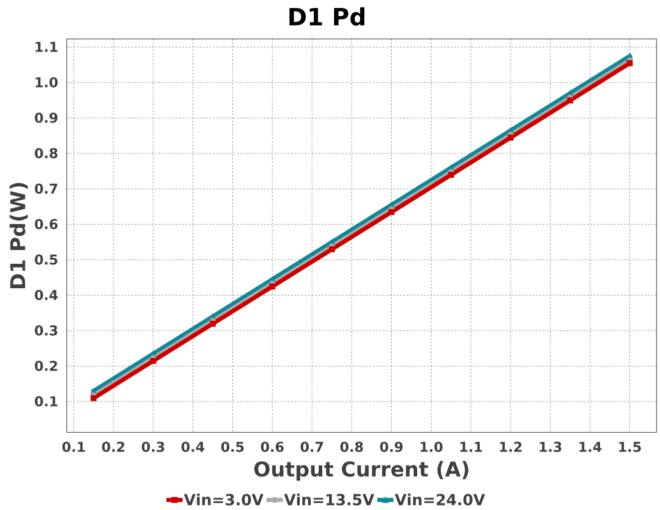


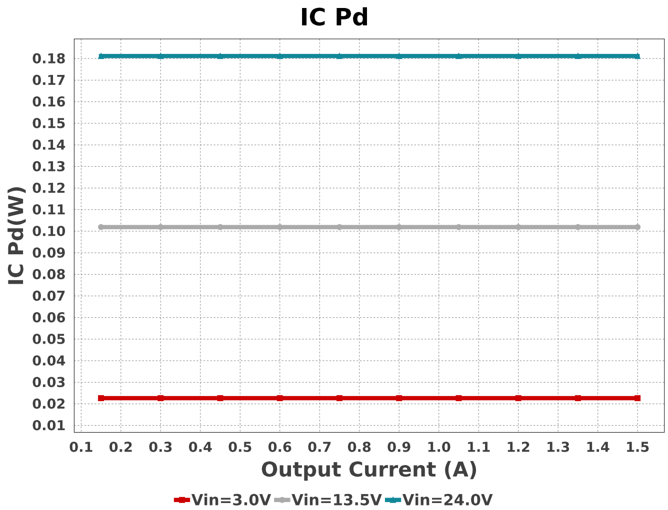

Vin p-p
Vin p-p(V)
0.000000005
0.000000004
0.000000003
0.000000002
0.000000001
0.000000000
-0.000000001
-0.000000002
-0.000000003
-0.000000004
-0.000000005
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

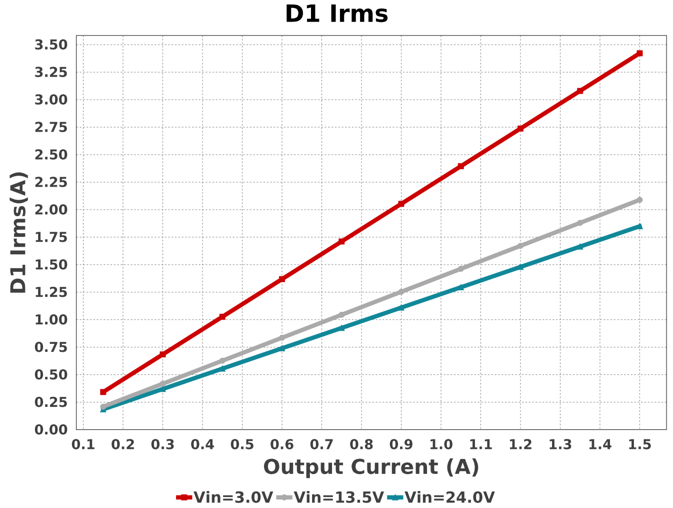

D1 PdSw
D1 PdSw(W)
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

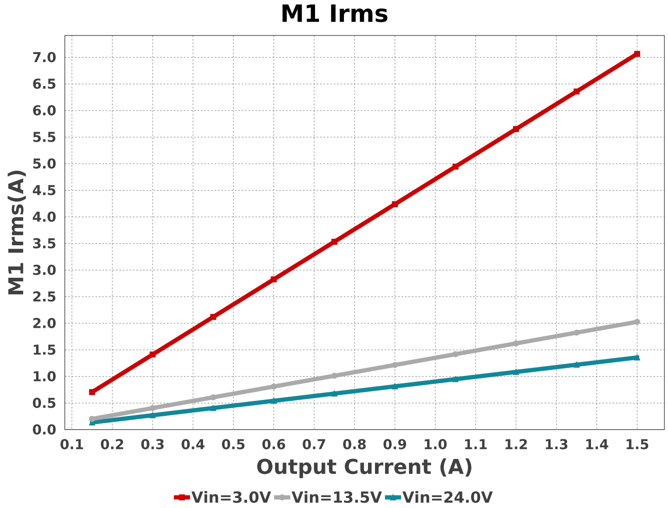

M1 PdSw
M1 PdSw(W)
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

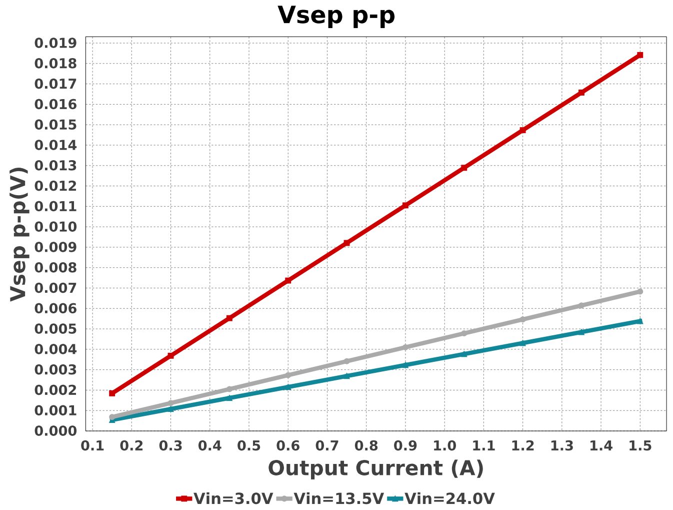

Total Pd
Total Pd(W)
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

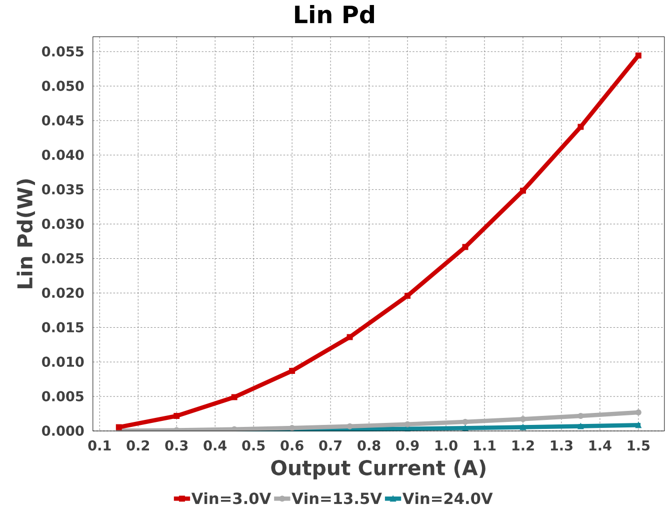

D1 Pd
D1 Pd(W)
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

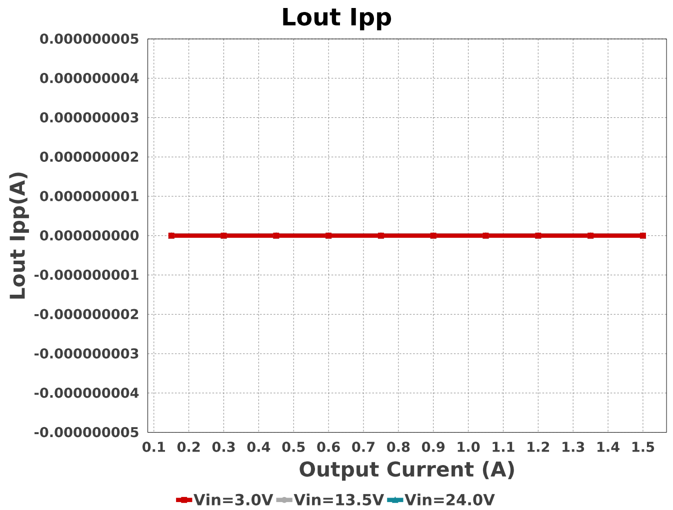

IC Pd
IC Pd(W)
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

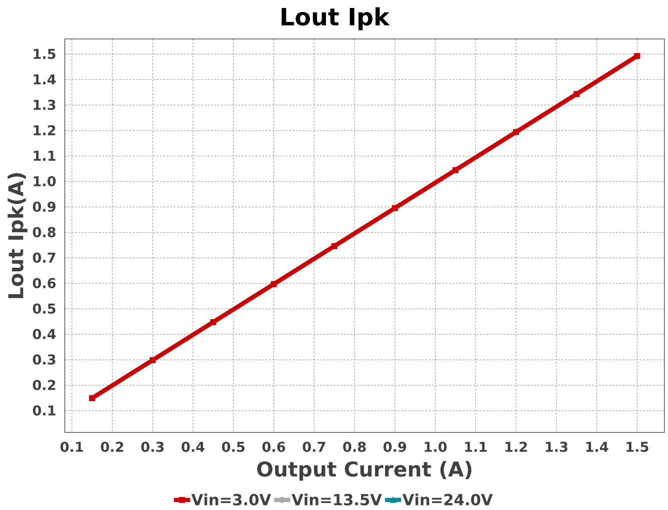

D1 Irms
D1 Irms(A)
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

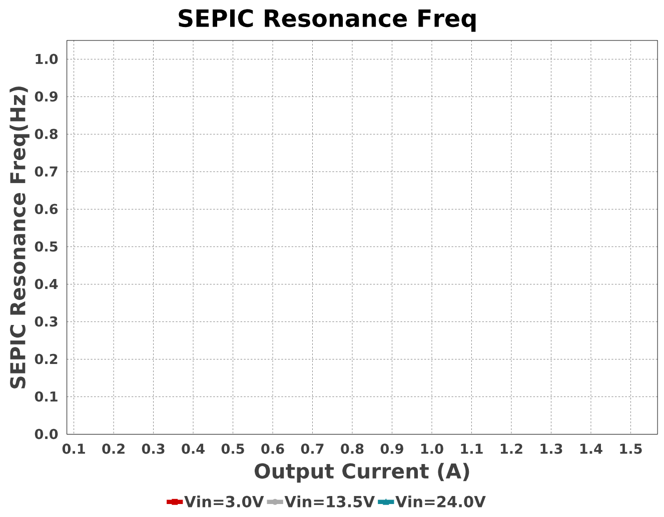

M1 Irms
M1 Irms(A)
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

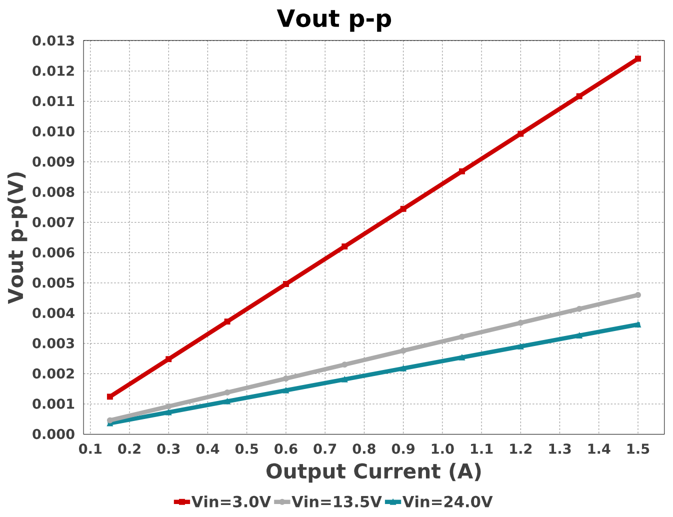

Vsep p-p
Vsep p-p(V)
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

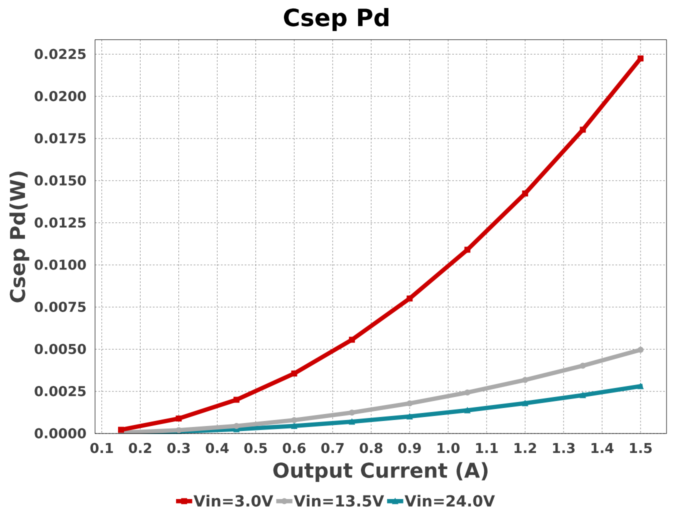

Lin Pd
Lin Pd(W)
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V

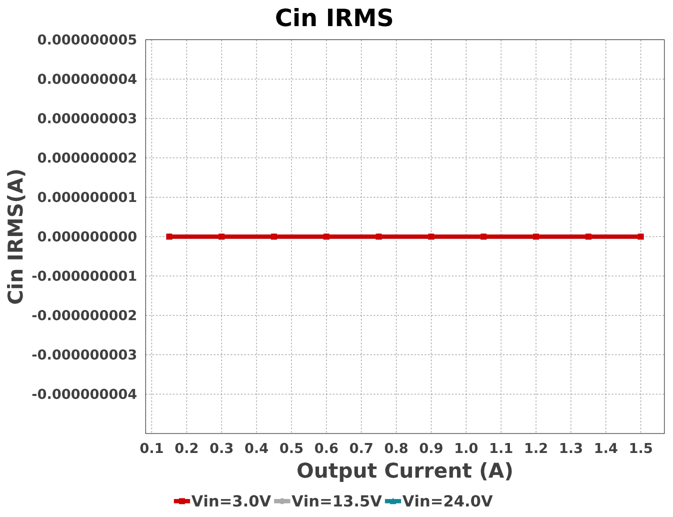

Lout Ipp
Lout Ipp(A)
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V


Lout Ipk
Lout Ipk(A)
Output Current (A)
Vin=3.0V Vin=13.5V Vin=24.0V









Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	31.974 fA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	0.0 fW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	3.079 A	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	14.988 mW	Capacitor	Output capacitor power dissipation
5.	Csep IRMS	3.08 A	Capacitor	SEPIC capacitor RMS ripple current
6.	Csep Pd	22.249 mW	Capacitor	SEPIC capacitor power dissipation
7.	D1 Irms	3.422 A	Current	D1 Irms
8.	Lin Ipk	6.318 A	Current	Lin peak current
9.	Lin Irms	6.35 A	Current	Lin ripple current
10.	Lout Ipk	1.493 A	Current	Lout peak current
11.	Lout Irms	1.5 A	Current	Lout ripple current
12.	D1 Pd	1.055 W	Diode	Diode power dissipation
13.	D1 PdCond	1.05 W	Diode	Diode conduction losses
14.	D1 PdSw	4.608 mW	Diode	Diode switching losses
15.	D1 Tj	82.73 degC	Diode	D1 junction temperature
16.	IC Ipk	7.52 mA	IC	Peak switch current in IC
17.	IC Pd	180.48 mW	IC	IC power dissipation
18.	IC Tj	58.877 degC	IC	IC junction temperature
19.	IC Tolerance	15.3 mV	IC	IC Feedback Tolerance
20.	Iin Avg	7.098 A	IC	Average input current
21.	SEPIC Resonance Freq	Infinity	IC	SEPIC Resonance Frequency
22.	Vsep p-p	18.416 mV	IC	Peak-to-peak sepic voltage
23.	Lin Ipp	0.0 A	Inductor	Peak-to-peak input inductor ripple current
24.	Lout Ipp	0.0 A	Inductor	Peak-to-peak output inductor ripple current
25.	M1 Irms	7.065 A	Mosfet	M1 MOSFET Irms
26.	M1 Pd	1.62 W	Mosfet	M1 MOSFET total power dissipation
27.	M1 PdCond	323.8 mW	Mosfet	M1 MOSFET conduction losses
28.	M1 PdSw	1.296 W	Mosfet	M1 MOSFET switching losses
29.	M1 TjOP	111.003 degC	Mosfet	M1 MOSFET junction temperature
30.	IOUT_OP	1.5 A	Op Point	Iout operating point
31.	VIN_OP	3.0 V	Op Point	Vin operating point

#	Name	Value	Category	Description
32.	Lin Pd	54.435 mW	Power	Lin power dissipation
33.	Lout Pd	3.038 mW	Power	Lout power dissipation
34.	Total Pd	3.295 W	Power	Total Power Dissipation
35.	Rsense Pd	99.828 mW	Resistor	LED Current Rsns Power Dissipation
36.	BOM Count	19	System Information	Total Design BOM count
37.	Duty Cycle	80.892 %	System Information	Duty cycle
38.	Efficiency	84.527 %	System Information	Steady state efficiency
39.	FootPrint	1.244 k mm^2	System Information	Total Foot Print Area of BOM components
40.	Frequency	120.0 kHz	System Information	Switching frequency
41.	Mode	CCM	System Information	Conduction Mode
42.	Total BOM	NA	System Information	Total BOM Cost
43.	Vin p-p	0.0 V	System Information	Peak-to-peak input voltage
44.	Vout p-p	12.408 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	1.5	Maximum Output Current
VinMax	24.0	Maximum input voltage
VinMin	3.0	Minimum input voltage
Vout	12.0	Output Voltage
base_pn	LM3488-Q1	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

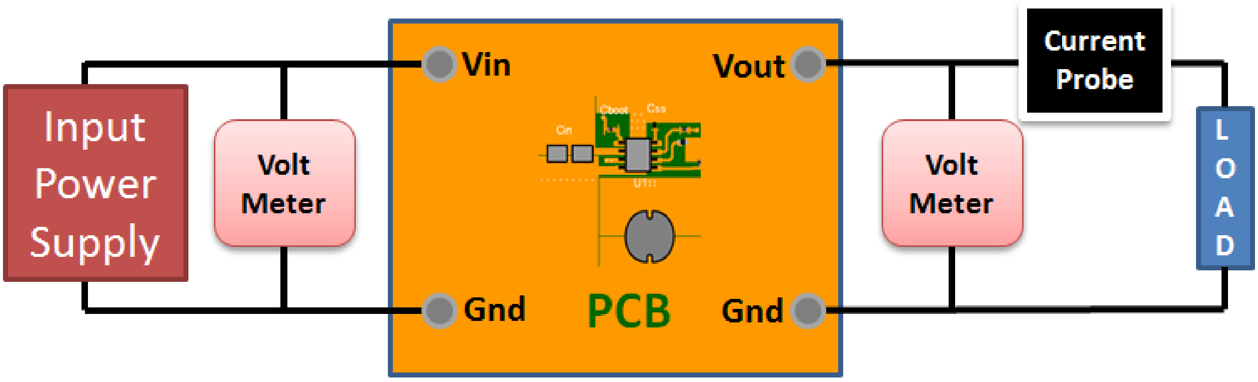
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 3.0V 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 : 65BC0DD889F4D082[v1]

2. **LM3488-Q1** Product Folder : http://www.ti.com/product/LM3488Q%2DQ1 : contains the data sheet and other resources.