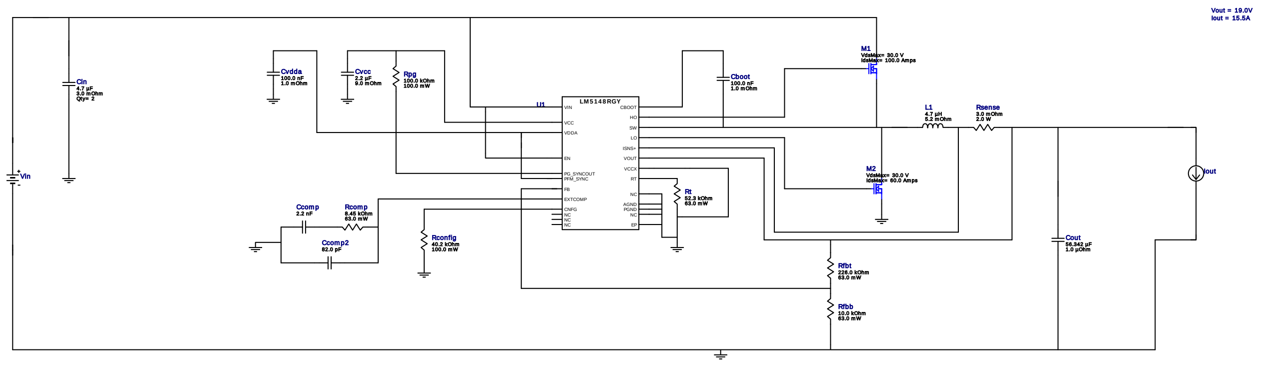
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 24.0V
VinMax = 24.0V
Vout = 19.0V
Iout = 15.5A

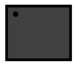
Device = LM5148RGYR
Topology = Buck
Created = 2025-02-24 10:48:52.182
BOM Cost = NA
BOM Count = 19
Total Pd = 4.08W

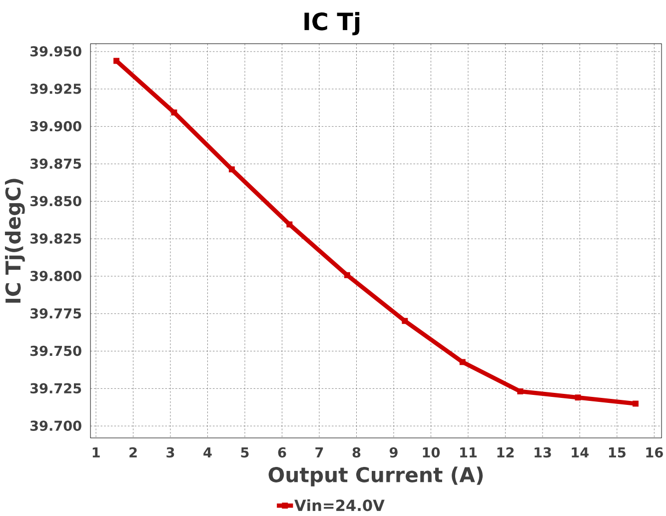
Design : 46 LM5148RGYR
LM5148RGYR 24V-24V to 19.00V @ 15.5A

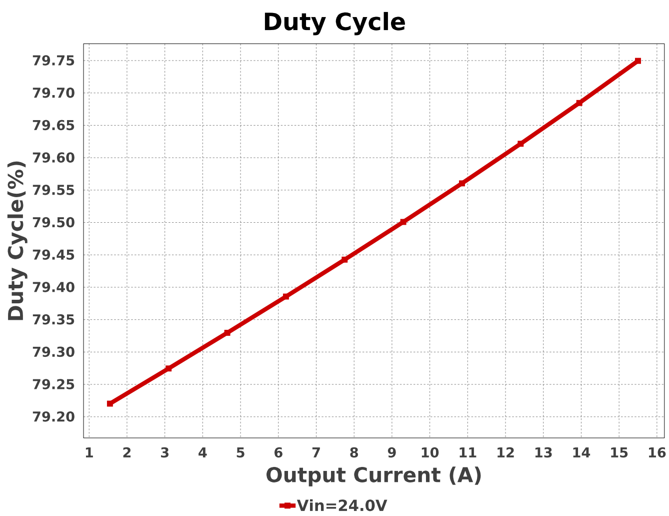


Electrical BOM

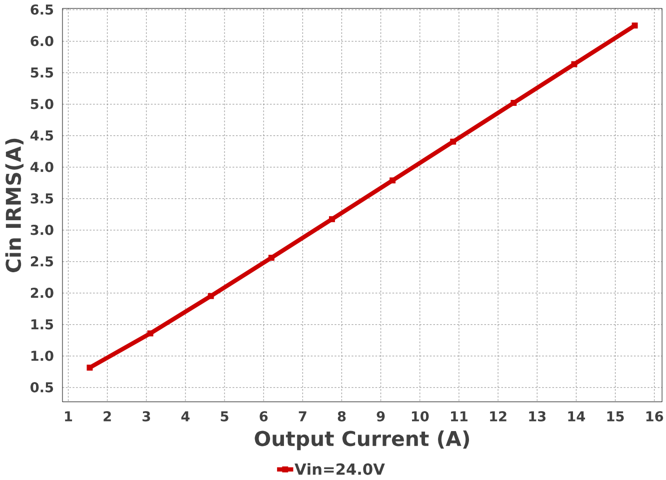
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM155R71A104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Ccomp	Samsung Electro-Mechanics	CL21C222JBFNNNE Series= C0G/NP0	Cap= 2.2 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm²
Ccomp2	Yageo	CC0805JRNPO9BN820 Series= C0G/NP0	Cap= 82.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²
Cin	MuRata	GRM31CR71H475KA12L Series= X7R	Cap= 4.7 uF ESR= 3.0 mOhm VDC= 50.0 V IRMS= 4.98 A	2	$0.10	1206 11 mm²
Cout	CUSTOM	CUSTOM Series= ?	Cap= 56.342 uF ESR= 1.0 uOhm VDC= 28.5 V IRMS= 631.85 mA	1	NA	CUSTOM 0 mm²
Cvcc	MuRata	GRM188R71A225KE15D Series= X7R	Cap= 2.2 uF ESR= 9.0 mOhm VDC= 10.0 V IRMS= 3.3 A	1	$0.02	0603 5 mm²
Cvdda	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 mm²
L1	Coilcraft	XAL1010-472MEB	L= 4.7 µH 5.2 mOhm	1	$1.71	XAL1010 160 mm²
M1	Texas Instruments	CSD17303Q5	VdsMax= 30.0 V IdsMax= 100.0 Amps	1	$0.56	TRANS_NexFET_Q5 55 mm²

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
M2	Texas Instruments	CSD17577Q5A	VdsMax= 30.0 V IdsMax= 60.0 Amps	1	$0.17	 TRANS_NexFET_Q5A 55 mm²
Rcomp	Vishay-Dale	CRCW04028K45FKED Series= CRCW..e3	Res= 8.45 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rconfig	Vishay-Dale	CRCW060340K2FKEA Series= CRCW..e3	Res= 40.2 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rfbb	Vishay-Dale	CRCW040210K0FKED Series= CRCW..e3	Res= 10.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbt	Vishay-Dale	CRCW0402226KFKED Series= CRCW..e3	Res= 226.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rpg	Vishay-Dale	CRCW0603100KFKEA Series= CRCW..e3	Res= 100.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rsense	Vishay-Dale	WSR23L000FEA Series= WSR	Res= 3.0 mOhm Power= 2.0 W Tolerance= 1.0%	1	$0.74	 4527 122 mm²
Rt	Vishay-Dale	CRCW040252K3FKED Series= CRCW..e3	Res= 52.3 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
U1	Texas Instruments	LM5148RGYR	Switcher	1	$0.60	RGY0024F 43 mm²

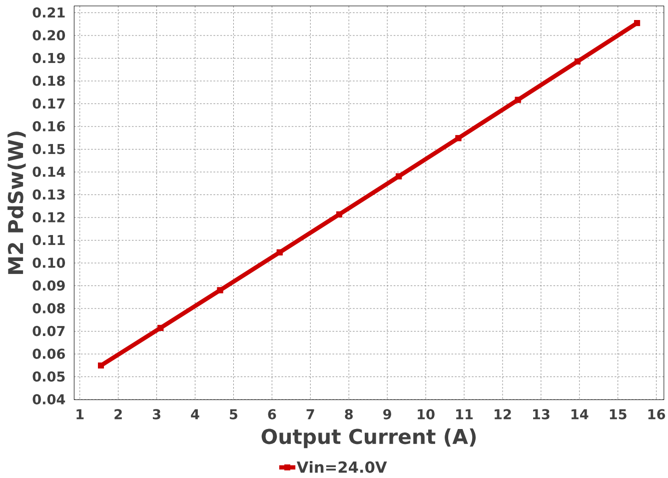




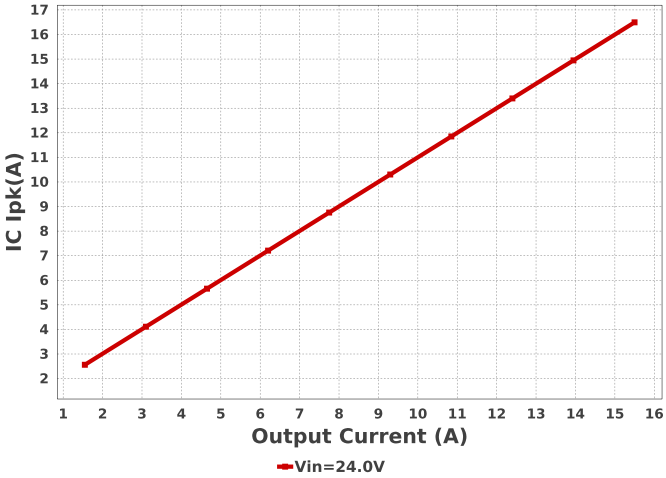
Cin IRMS



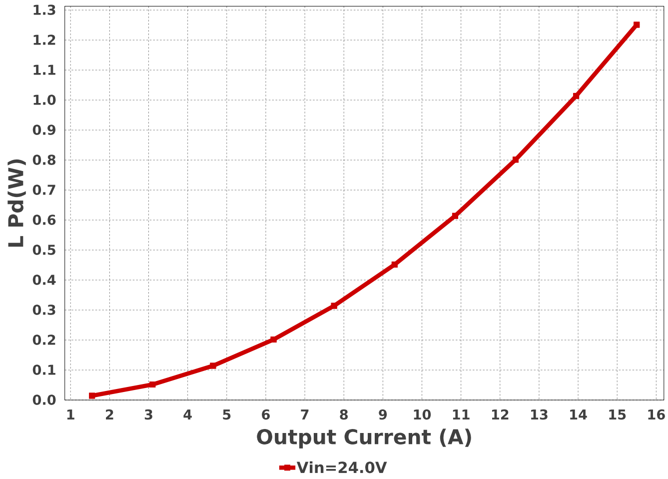
M2 PdSw



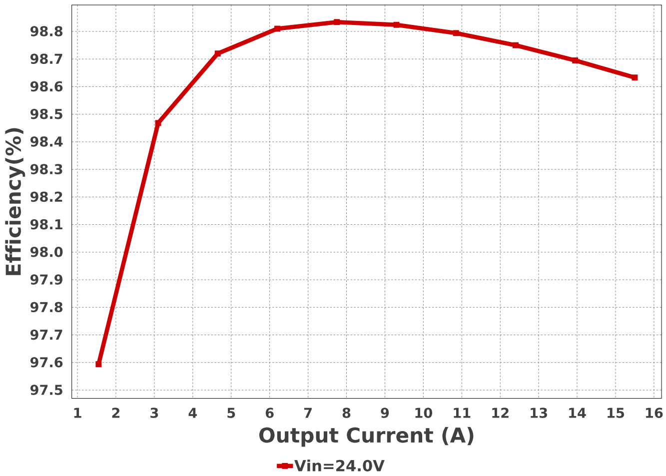
IC Ipk



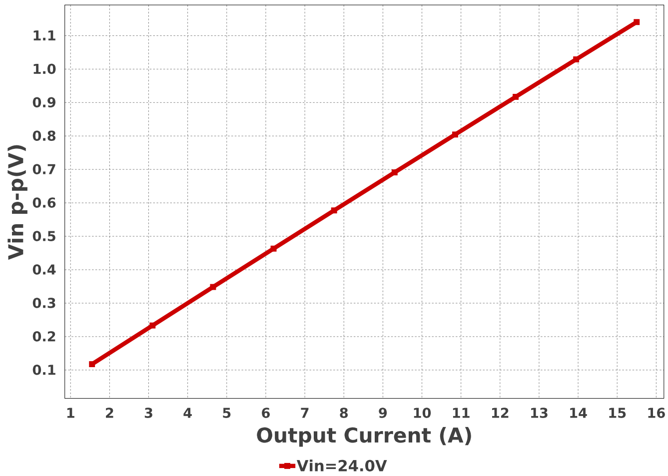
L Pd

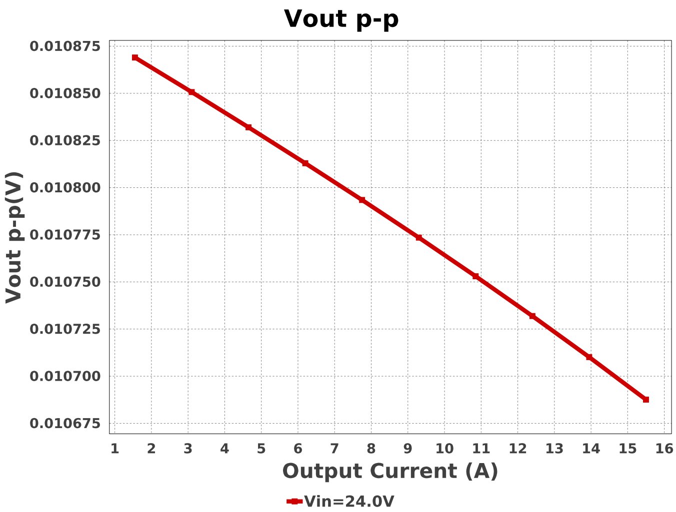


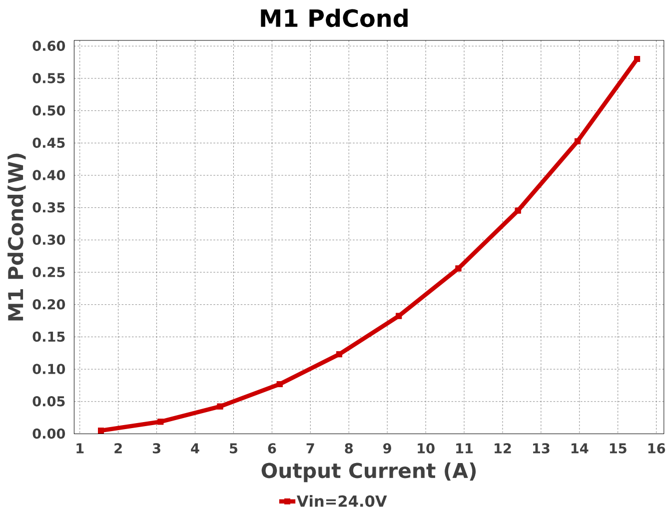
Efficiency

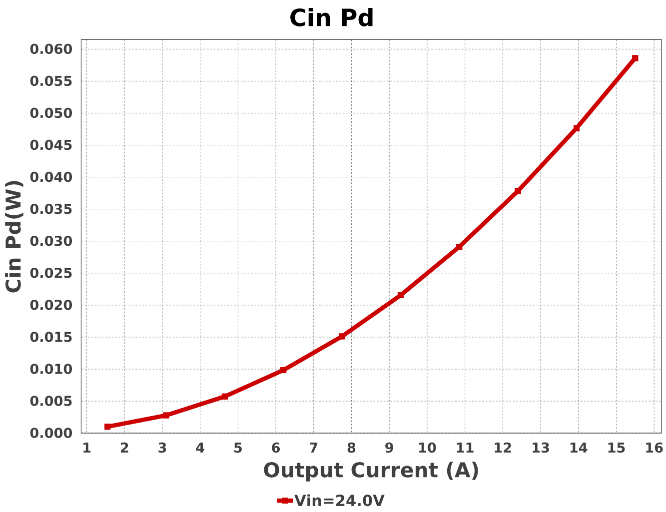


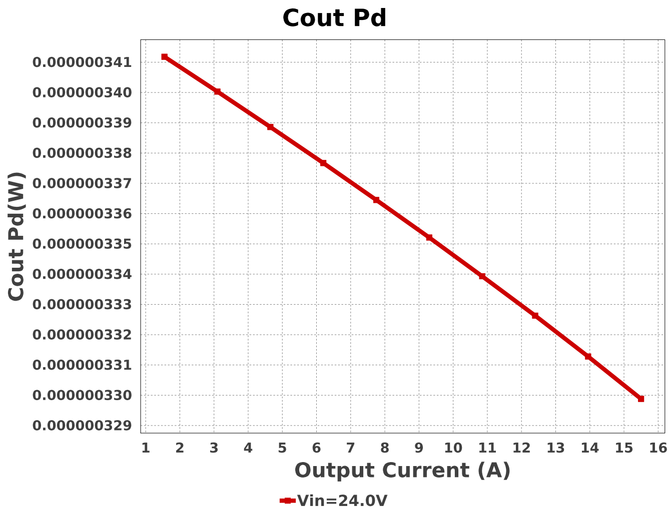
Vin p-p

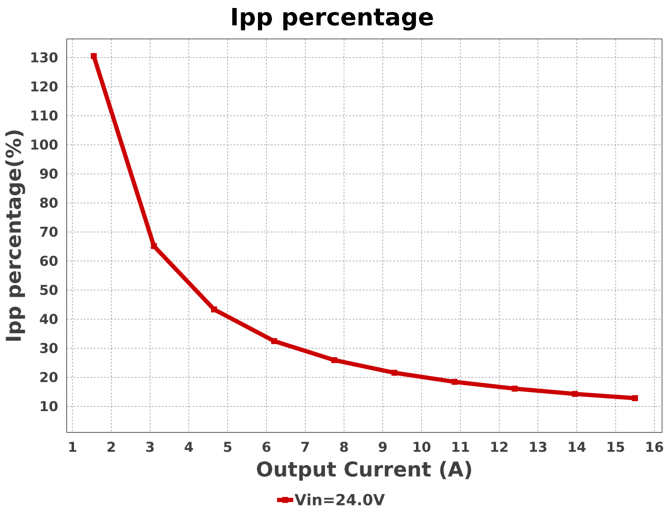


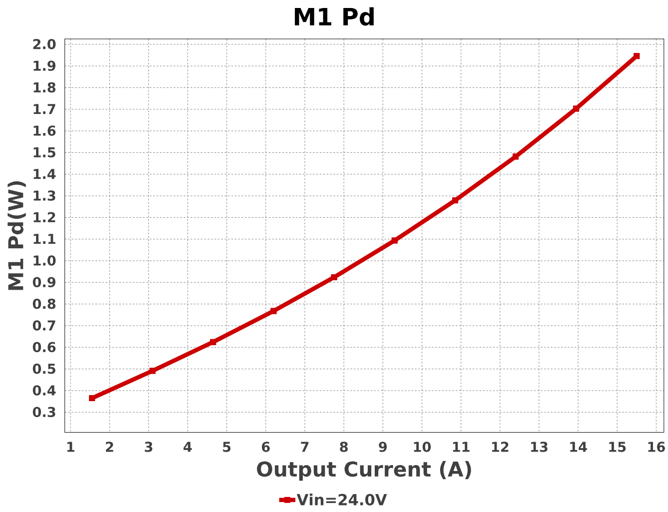

Vout p-p
Vout p-p(V)
0.010875
0.010850
0.010825
0.010800
0.010775
0.010750
0.010725
0.010700
0.010675
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Output Current (A)
Vin=24.0V

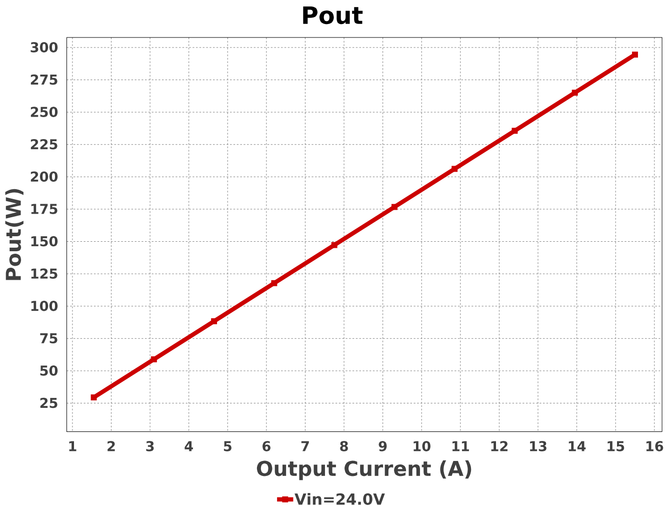

M1 PdCond
M1 PdCond(W)
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Output Current (A)
Vin=24.0V

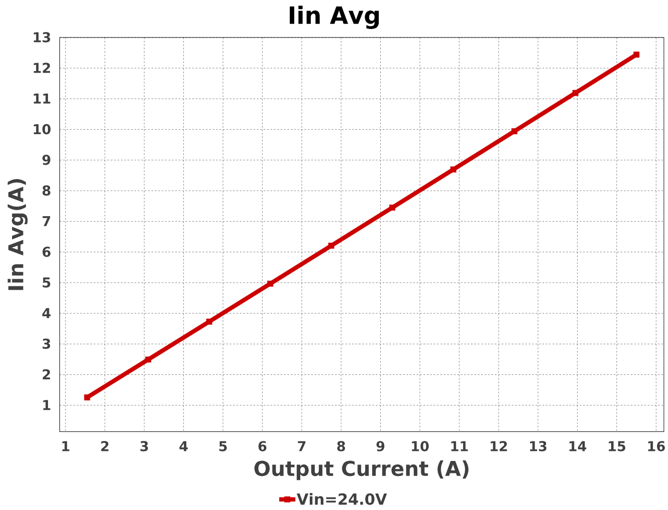

Cin Pd
Cin Pd(W)
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Output Current (A)
Vin=24.0V

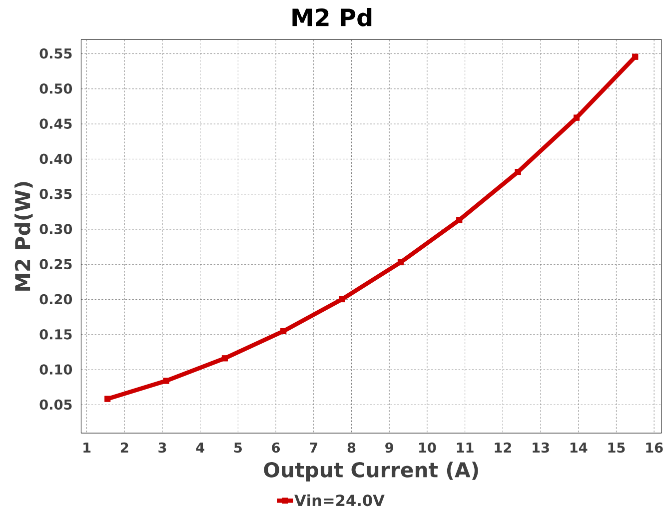

Cout Pd
Cout Pd(W)
0.000000341
0.000000340
0.000000339
0.000000338
0.000000337
0.000000336
0.000000335
0.000000334
0.000000333
0.000000332
0.000000331
0.000000330
0.000000329
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Output Current (A)
Vin=24.0V

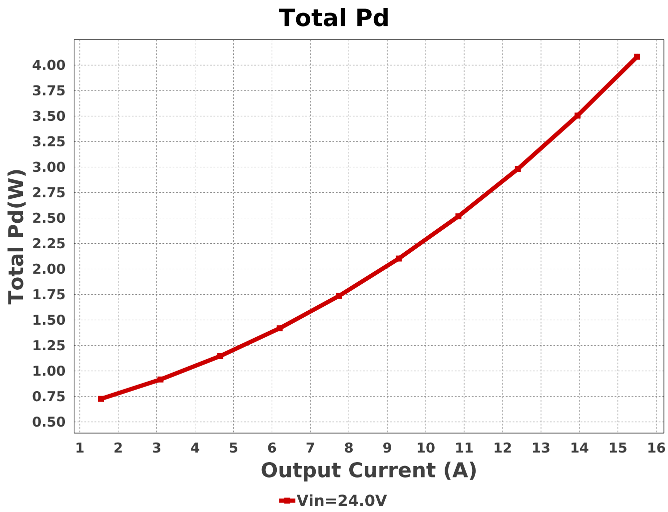

Ipp percentage
Ipp percentage(%)
130
120
110
100
90
80
70
60
50
40
30
20
10
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Output Current (A)
Vin=24.0V

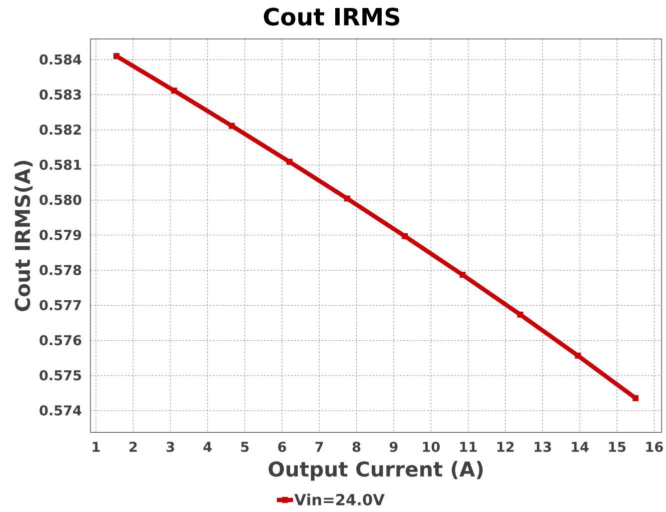

M1 Pd
M1 Pd(W)
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Output Current (A)
Vin=24.0V

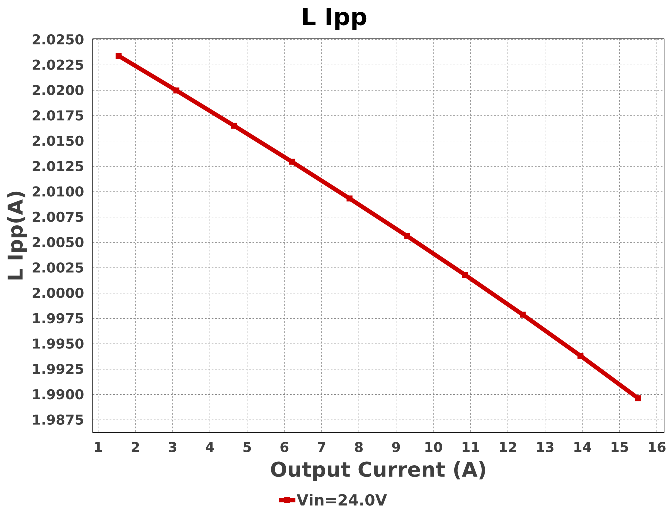

Pout
Pout(W)
Output Current (A)
Vin=24.0V

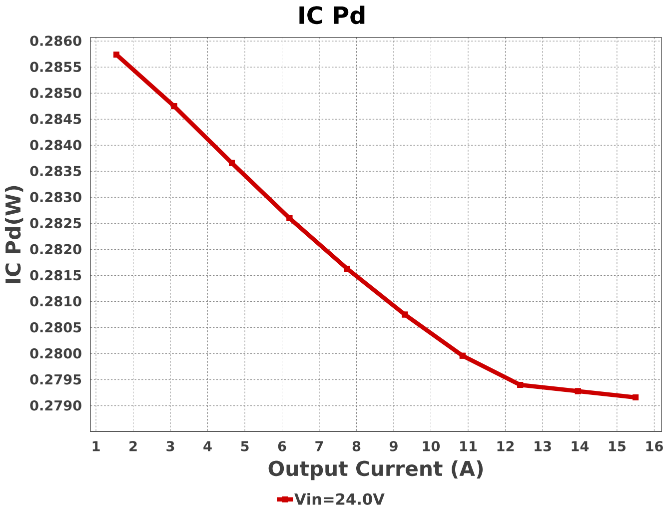

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=24.0V

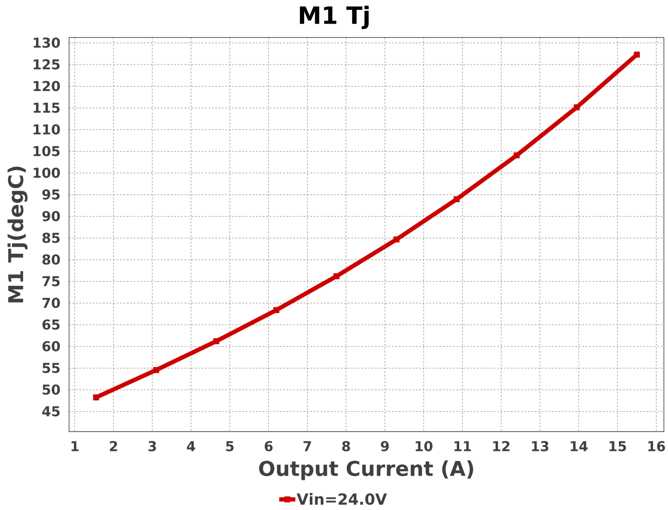

M2 Pd
M2 Pd(W)
Output Current (A)
Vin=24.0V

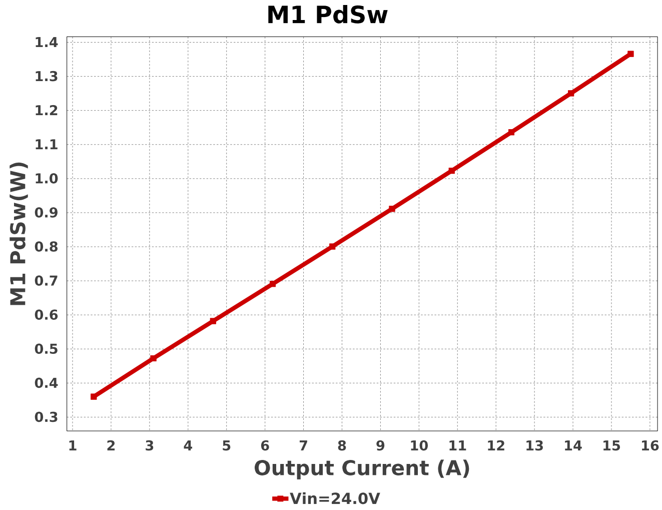

Total Pd
Total Pd(W)
Output Current (A)
Vin=24.0V

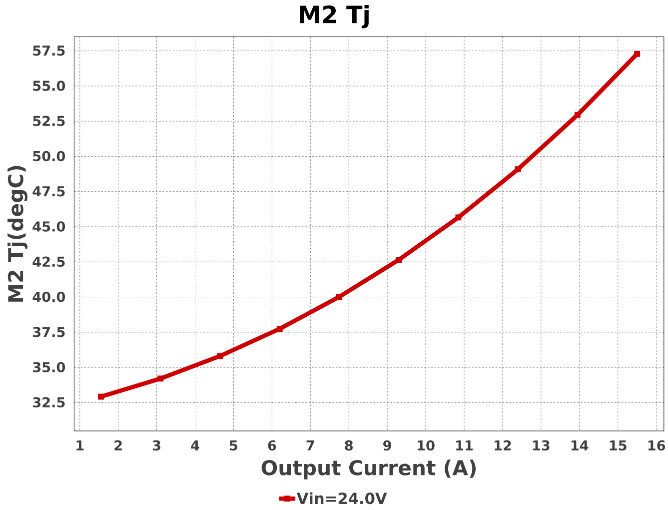

Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=24.0V

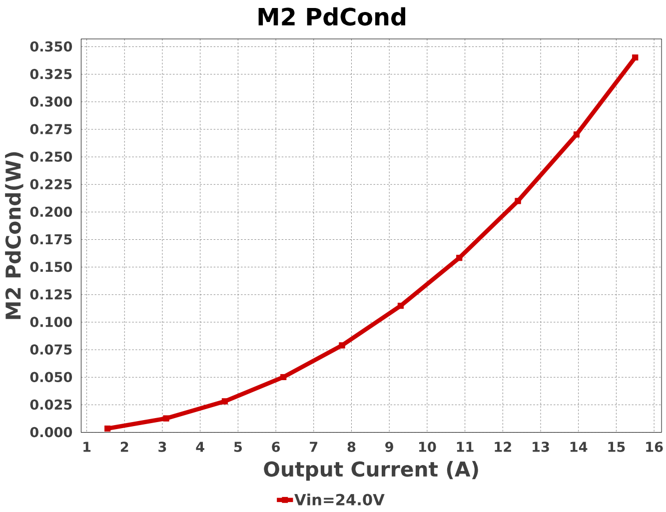

L Ipp
L Ipp(A)
Output Current (A)
Vin=24.0V

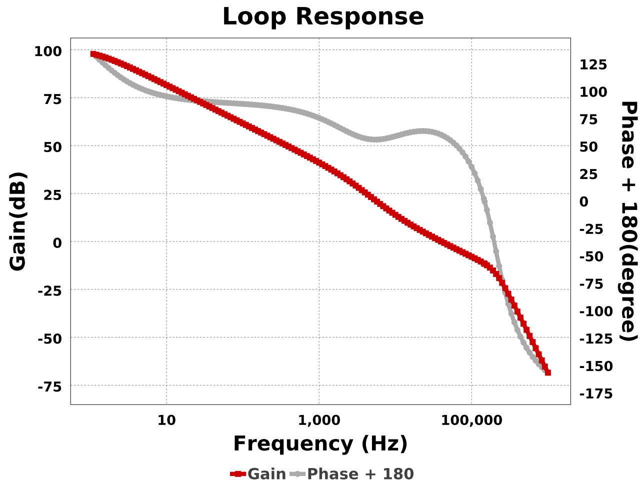

IC Pd
IC Pd(W)
0.2860
0.2855
0.2850
0.2845
0.2840
0.2835
0.2830
0.2825
0.2820
0.2815
0.2810
0.2805
0.2800
0.2795
0.2790
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Output Current (A)
Vin=24.0V

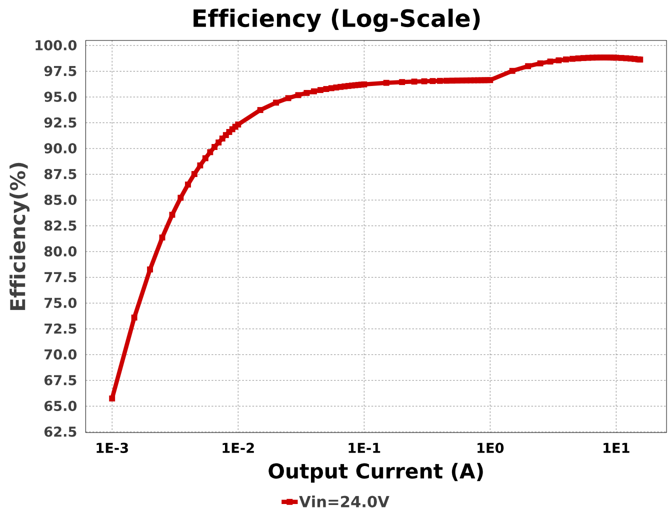

M1 Tj
M1 Tj(degC)
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Output Current (A)
Vin=24.0V


M1 PdSw
M1 PdSw(W)
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Output Current (A)
Vin=24.0V


M2 Tj
M2 Tj(degC)
57.5
55.0
52.5
50.0
47.5
45.0
42.5
40.0
37.5
35.0
32.5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Output Current (A)
Vin=24.0V


M2 PdCond
M2 PdCond(W)
0.350
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Output Current (A)
Vin=24.0V


Loop Response
Gain(dB)
100
75
50
25
0
-25
-50
-75
Phase + 180(degree)
125
100
75
50
25
0
-25
-50
-75
-100
-125
-150
-175
10
1,000
100,000
Frequency (Hz)
Gain
Phase + 180



Operating Values

#	Name	Value	Category	Description
1.	BOM Count	19		Total Design BOM count
2.	Total BOM	NA		Total BOM Cost
3.	Cin IRMS	6.25 A	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	58.594 mW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	574.356 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	329.88 nW	Capacitor	Output capacitor power dissipation
7.	IC Ipk	16.495 A	IC	Peak switch current in IC
8.	IC Pd	279.16 mW	IC	IC power dissipation
9.	IC Tj	39.715 degC	IC	IC junction temperature
10.	IC Tolerance	10.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA Effective	34.8 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
12.	Iin Avg	12.441 A	IC	Average input current
13.	Ipp percentage	12.836 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
14.	L Ipp	1.99 A	Inductor	Peak-to-peak inductor ripple current
15.	L Pd	1.251 W	Inductor	Inductor power dissipation
16.	M1 Pd	1.946 W	Mosfet	M1 MOSFET total power dissipation
17.	M1 PdCond	580.02 mW	Mosfet	M1 MOSFET conduction losses
18.	M1 PdSw	1.366 W	Mosfet	M1 MOSFET switching losses
19.	M1 Tj	127.302 degC	Mosfet	M1 MOSFET junction temperature
20.	M2 Pd	545.67 mW	Mosfet	M2 MOSFET total power dissipation
21.	M2 PdCond	340.22 mW	Mosfet	M2 MOSFET conduction losses
22.	M2 PdSw	205.46 mW	Mosfet	M2 MOSFET switching losses
23.	M2 Tj	57.284 degC	Mosfet	M2 MOSFET junction temperature
24.	Cin Pd	58.594 mW	Power	Input capacitor power dissipation
25.	Cout Pd	329.88 nW	Power	Output capacitor power dissipation
26.	IC Pd	279.16 mW	Power	IC power dissipation
27.	L Pd	1.251 W	Power	Inductor power dissipation
28.	M1 Pd	1.946 W	Power	M1 MOSFET total power dissipation
29.	M1 PdCond	580.02 mW	Power	M1 MOSFET conduction losses
30.	M1 PdSw	1.366 W	Power	M1 MOSFET switching losses
31.	M2 Pd	545.67 mW	Power	M2 MOSFET total power dissipation
32.	M2 PdCond	340.22 mW	Power	M2 MOSFET conduction losses
33.	M2 PdSw	205.46 mW	Power	M2 MOSFET switching losses
34.	Total Pd	4.082 W	Power	Total Power Dissipation
35.	Cross Freq	39.907 kHz	System Information	Bode plot crossover frequency
36.	Duty Cycle	79.75 %	System Information	Duty cycle
37.	Efficiency	98.633 %	System Information	Steady state efficiency
38.	FootPrint	602.0 mm^2	System Information	Total Foot Print Area of BOM components
39.	Frequency	415.541 kHz	System Information	Switching frequency
40.	Gain Marg	-11.663 dB	System Information	Bode Plot Gain Margin
41.	Iout	15.5 A	System Information	Iout operating point
42.	Iout transient step used for Cout calculations	7.75 A	System Information	Custom Transient current step requirement that was used for Cout selection (A).

#	Name	Value	Category	Description
43.	Low Freq Gain	97.827 dB	System Information	Gain at 1Hz
44.	Mode	CCM	System Information	Conduction Mode
45.	Overshoot Value	132.657 mV	System Information	Theoretical Vout Overshoot Value
46.	Phase Marg	60.981 deg	System Information	Bode Plot Phase Margin
47.	Pout	294.5 W	System Information	Total output power
48.	Undershoot Value	573.48 mV	System Information	Theoretical Vout Undershoot Value
49.	Vin	24.0 V	System Information	Vin operating point
50.	Vin p-p	1.141 V	System Information	Peak-to-peak input voltage
51.	Vout	19.0 V	System Information	Operational Output Voltage
52.	Vout Actual	18.88 V	System Information	Vout Actual calculated based on selected voltage divider resistors
53.	Vout Ripple requirement used for Cout calculations	1.0 %	System Information	Custom maximum output ripple requirement that was used for Cout selection(% of Vout).
54.	Vout Tolerance	3.209 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
55.	Vout p-p	10.688 mV	System Information	Peak-to-peak output ripple voltage
56.	Vout transient requirement used for Cout calculations	3.0 %	System Information	Custom Transient voltage change requirement that was used for Cout selection (% of Vout).

Design Inputs

Name	Value	Description
Iout	15.5	Maximum Output Current
VinMax	24.0	Maximum input voltage
VinMin	24.0	Minimum input voltage
Vout	19.0	Output Voltage
base_pn	LM5148	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

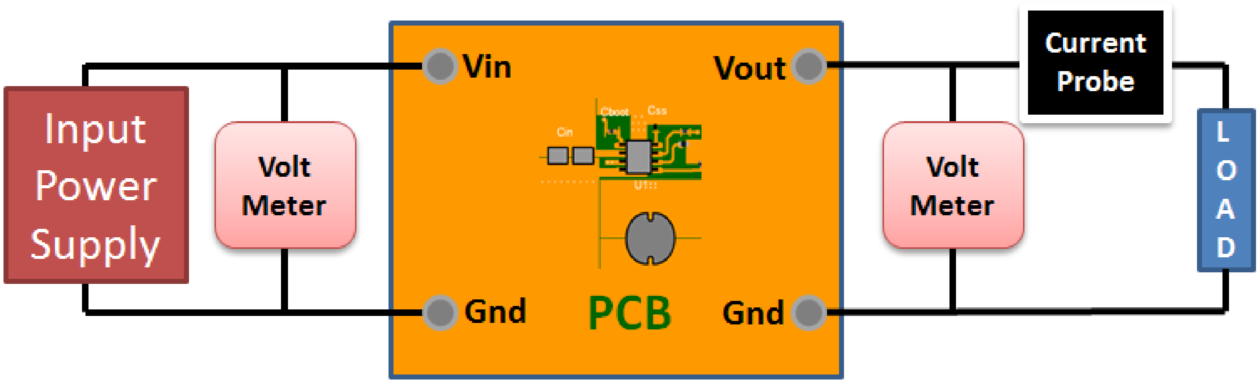
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 24.0V 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 : F99F3073C415E694101A56F6FF7B20CC[v1]

2. **LM5148** Product Folder : http://www.ti.com/product/LM5148 : contains the data sheet and other resources.