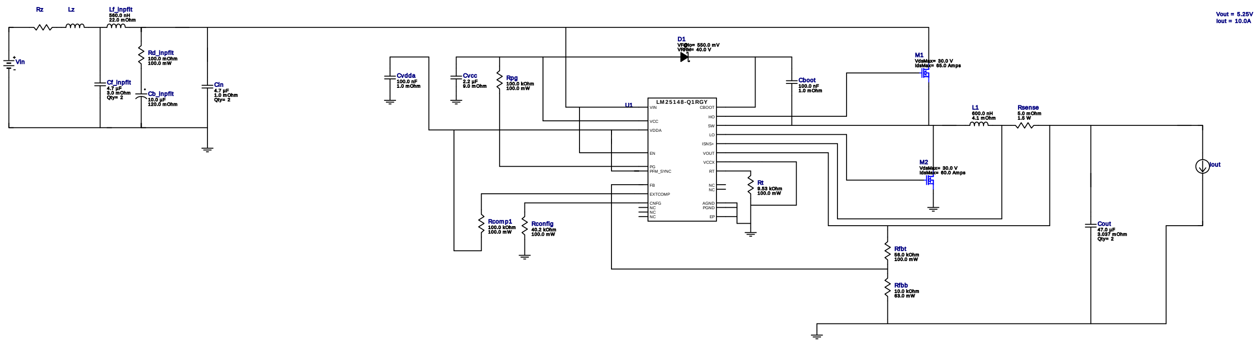
VinMin = 11.0V
VinMax = 24.0V
Vout = 5.25V
Iout = 10.0A

Device = LM25148QRGYRQ1
Topology = Buck
Created = 2023-03-13 10:18:51.839
BOM Cost = $4.17
BOM Count = 24
Total Pd = 4.35W

WEBENCH ® Design Report

Design : 13 LM25148QRGYRQ1
LM25148QRGYRQ1 10V-24V to 5.00V @ 10A



Design Alerts

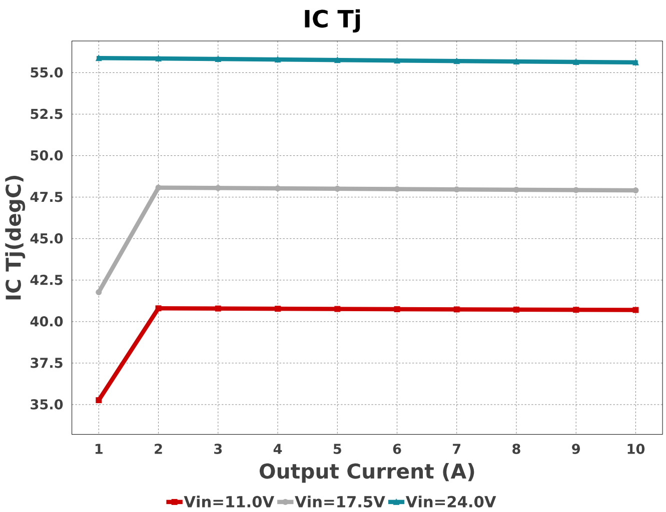
Component Selection Information

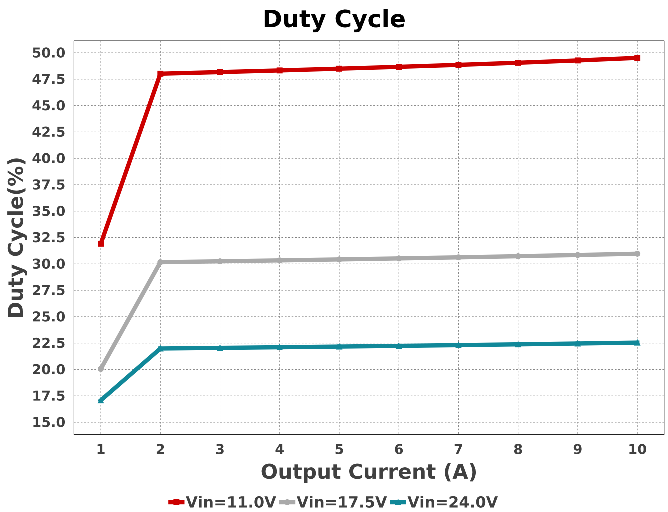
The LM25148-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application.

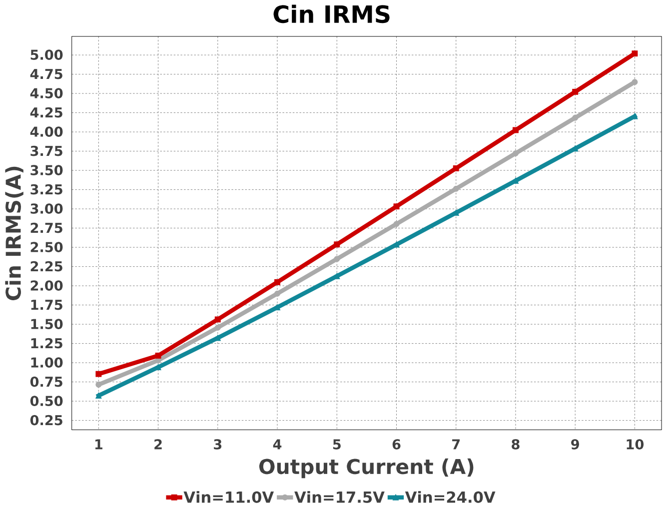
Electrical BOM

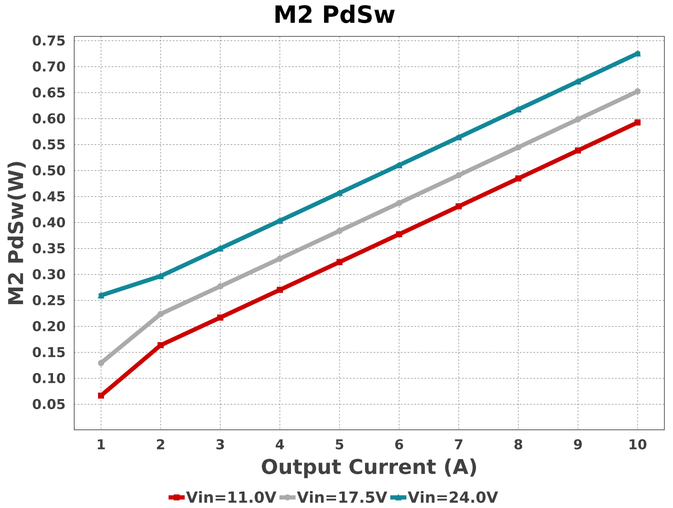
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cb_inpflt	Panasonic	EEHZA1H100R Series= ZA	Cap= 10.0 uF ESR= 120.0 mOhm VDC= 50.0 V IRMS= 750.0 mA	1	$0.46	SM_RADIAL_5MM 58 mm^2
Cboot	MuRata	GRM155R71A104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cf_inpflt	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 mm^2
Cin	TDK	C2012X5R1H475K125AB Series= X5R	Cap= 4.7 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 4.3 A	2	$0.12	0805 7 mm^2
Cout	MuRata	GRM32ER61C476KE15L Series= X5R	Cap= 47.0 uF ESR= 3.037 mOhm VDC= 16.0 V IRMS= 4.59346 A	2	$0.17	1210_280 15 mm^2
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 mm^2
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 mm^2
D1	Fairchild Semiconductor	SS24FL	VF@Io= 550.0 mV VRRM= 40.0 V	1	$0.09	SOD-123F 12 mm^2
L1	Coilcraft	XAL5030-601MEB	L= 600.0 nH 4.1 mOhm	1	$0.63	XAL5030 54 mm^2

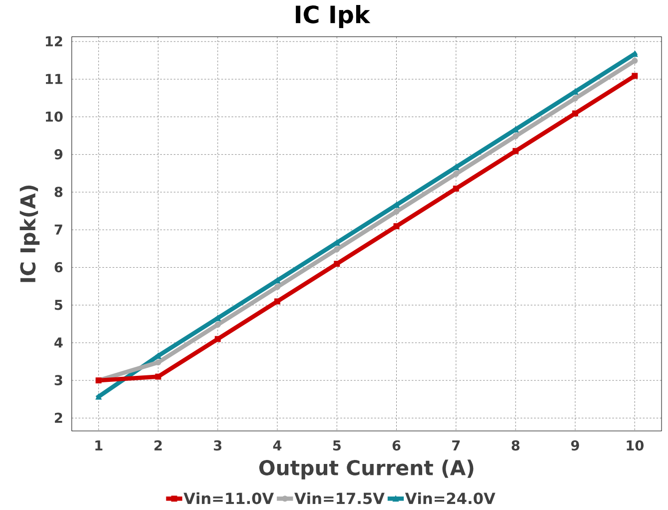
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Lf_inpflt	Vishay-Dale	IFSC1515AHERR56M01	L= 560.0 nH 22.0 mOhm	1	$0.20	ELL6RH 67 mm^2
M1	Texas Instruments	CSD17507Q5A	VdsMax= 30.0 V IdsMax= 65.0 Amps	1	$0.23	TRANS_NexFET_Q5A 55 mm^2
M2	Texas Instruments	CSD17577Q5A	VdsMax= 30.0 V IdsMax= 60.0 Amps	1	$0.20	TRANS_NexFET_Q5A 55 mm^2
Rcomp1	Vishay-Dale	CRCW0603100KFKEA Series= CRCW..e3	Res= 100.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rconfig	Vishay-Dale	CRCW060340K2FKEA Series= CRCW..e3	Res= 40.2 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rd_inpflt	Panasonic	ERJ-3RSFR10V Series= ERJ-3R	Res= 100.0 mOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.03	0603 5 mm^2
Rfbb	Vishay-Dale	CRCW040210K0FKED Series= CRCW..e3	Res= 10.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt	Susumu Co Ltd	RG1608P-563-B-T5 Series= RG1608	Res= 56.0 kOhm Power= 100.0 mW Tolerance= 0.1%	1	$0.06	0603 5 mm^2
Rpg	Vishay-Dale	CRCW0603100KFKEA Series= CRCW..e3	Res= 100.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rsense	Stackpole Electronics Inc	CSNL2010FT5L00 Series= ?	Res= 5.0 mOhm Power= 1.5 W Tolerance= 1.0%	1	$0.19	2010 32 mm^2
Rt	Yageo	RC0603FR-079K53L Series= ?	Res= 9.53 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
U1	Texas Instruments	LM25148QRGYRQ1	Switcher	1	$1.21	RGY0024E-MFG 48 mm^2

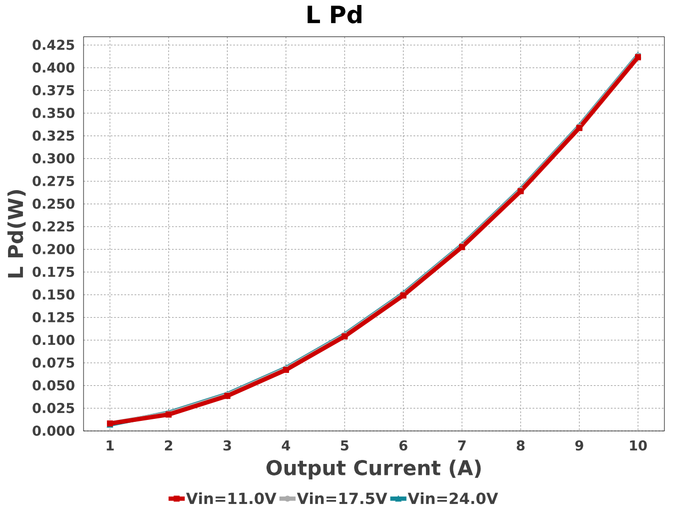


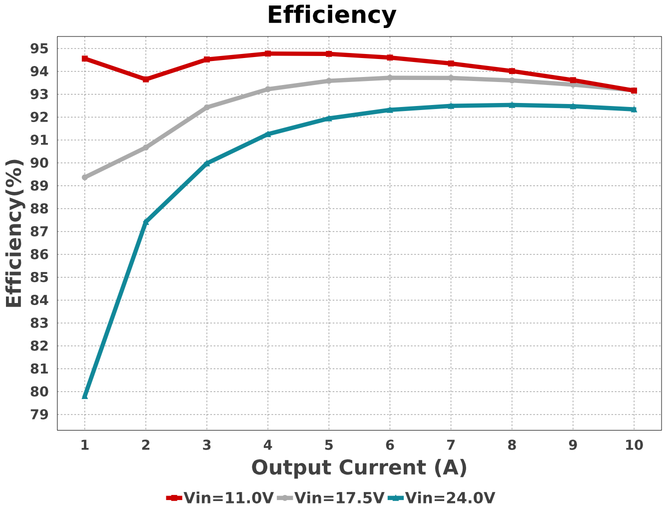


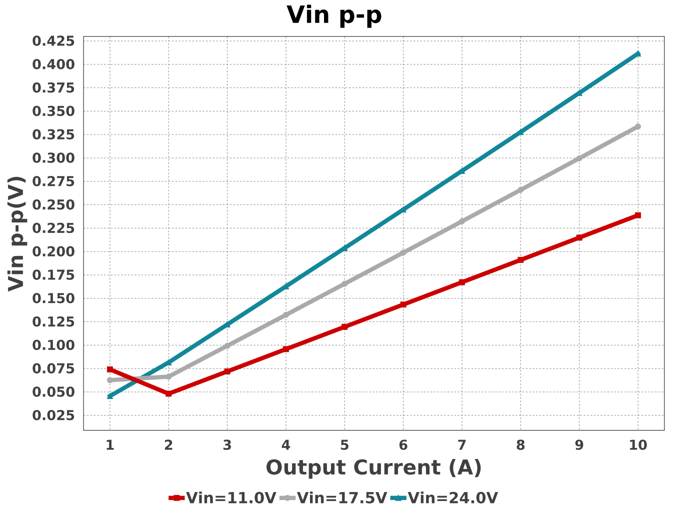

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V


M2 PdSw
M2 PdSw(W)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V

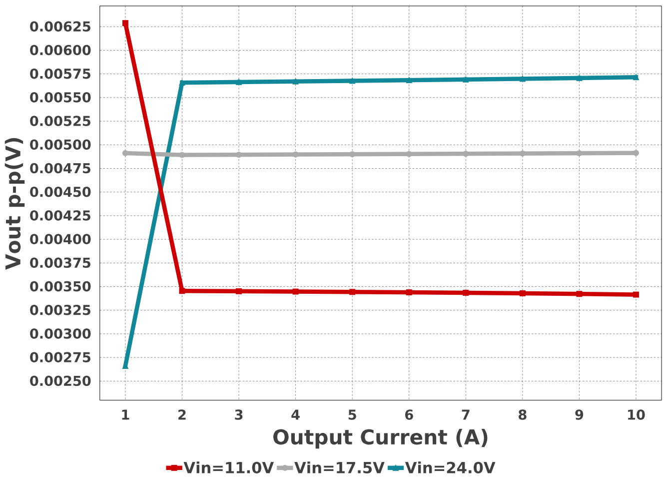

IC Ipk
IC Ipk(A)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V


L Pd
L Pd(W)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V

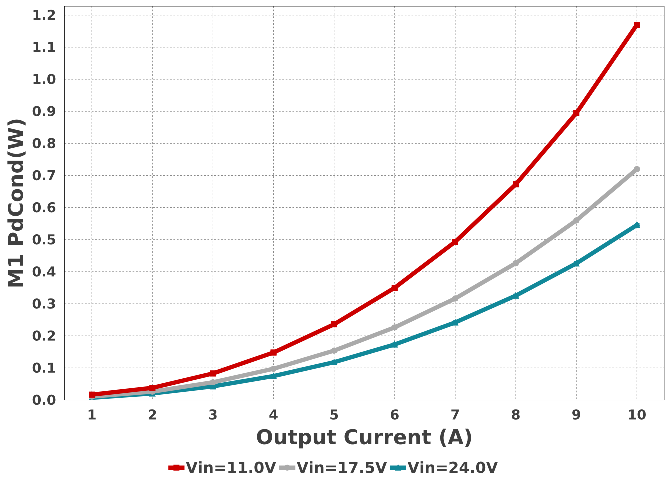

Efficiency
Efficiency(%)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V


Vin p-p
Vin p-p(V)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V

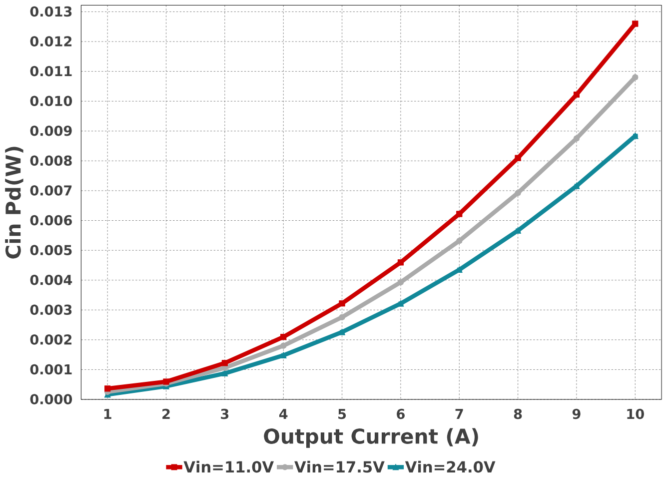
Vout p-p



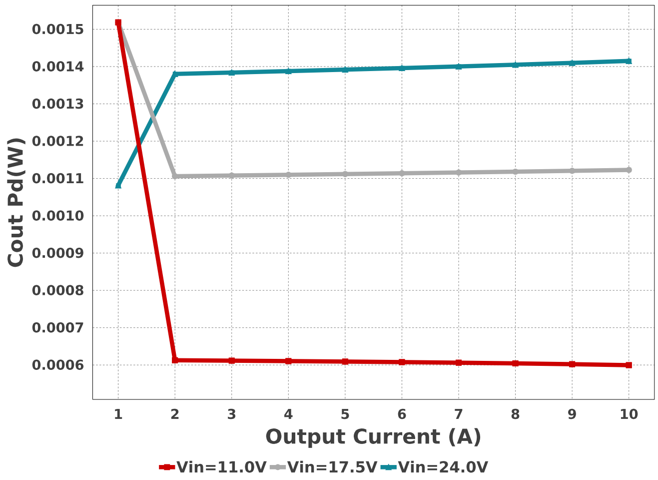
M1 PdCond



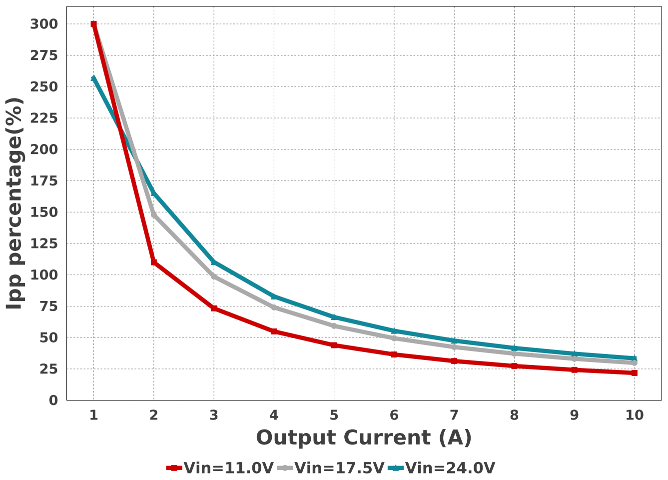
Cin Pd



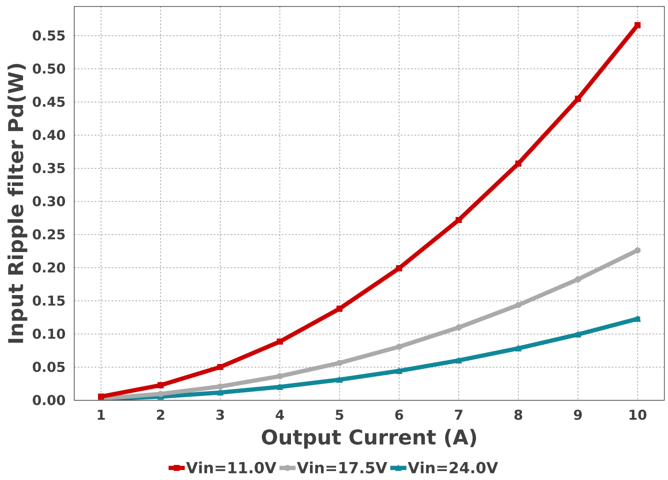
Cout Pd

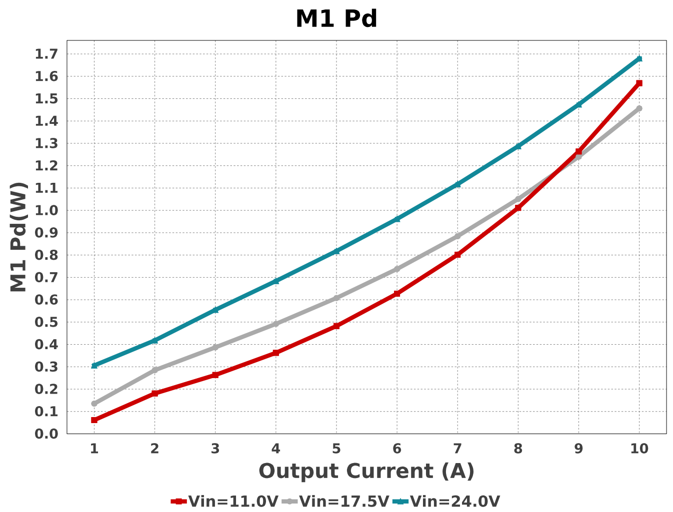


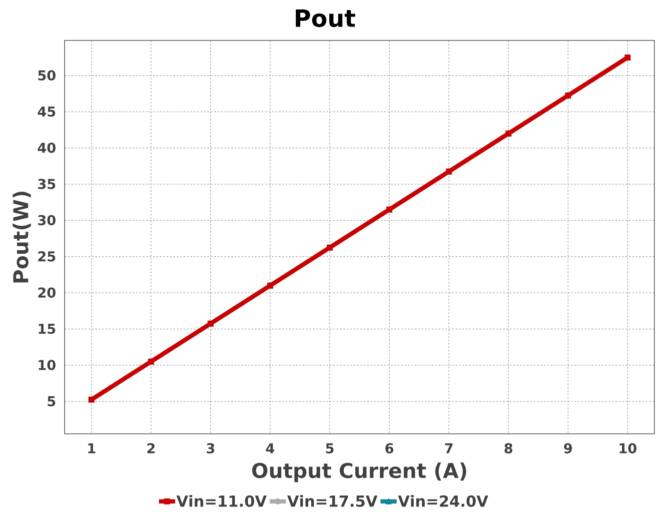
Ipp percentage

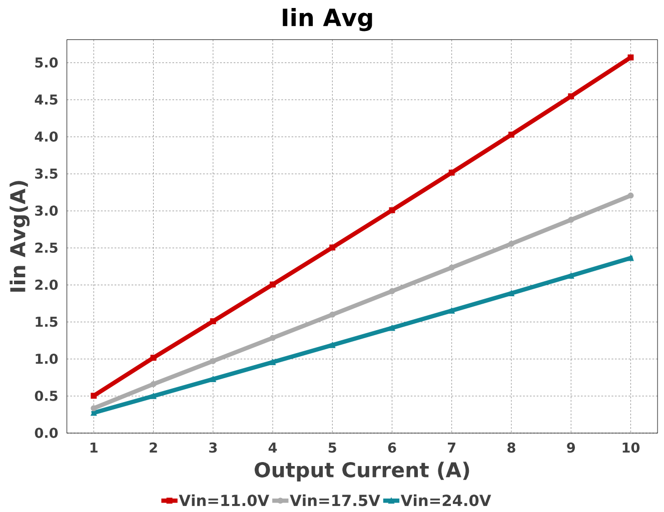


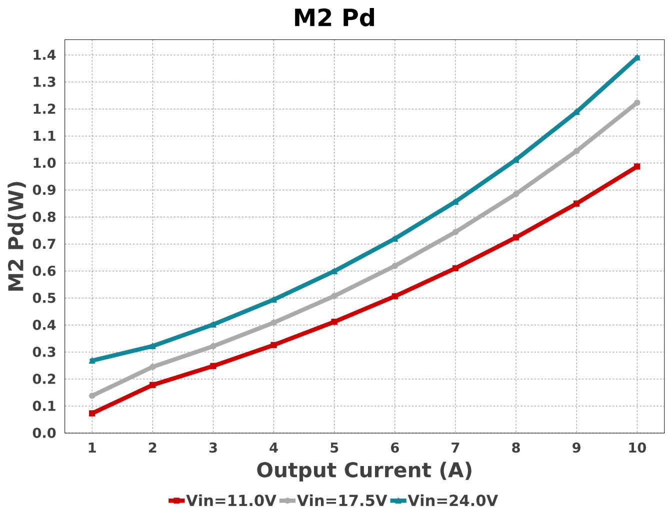
Input Ripple filter Pd

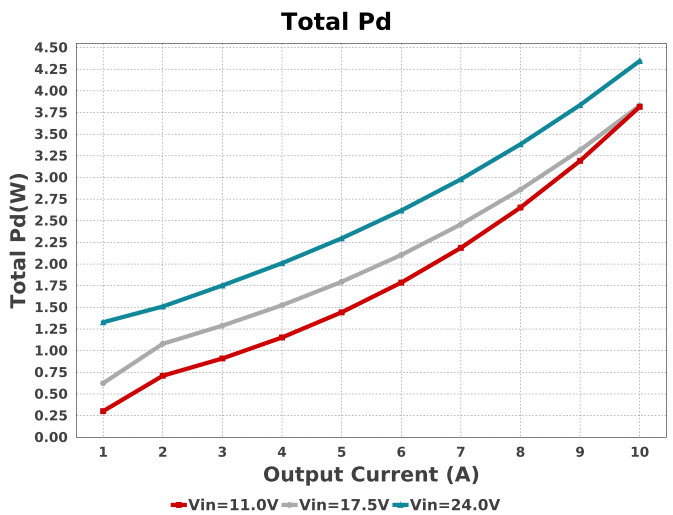


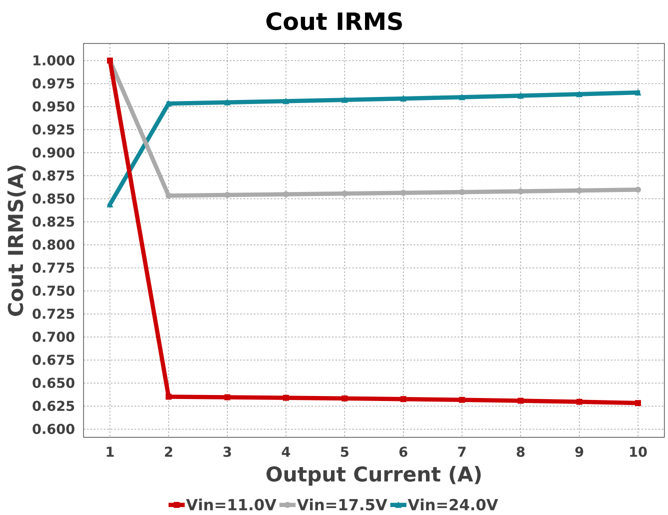

M1 Pd
M1 Pd(W)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V

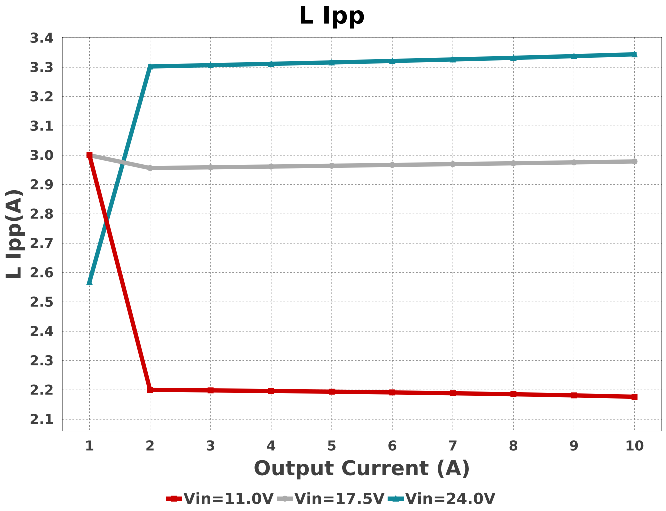

Pout
Pout(W)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V

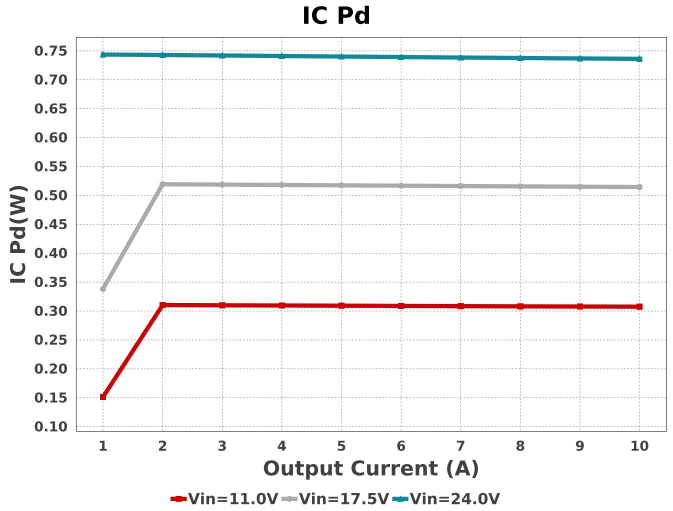

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V

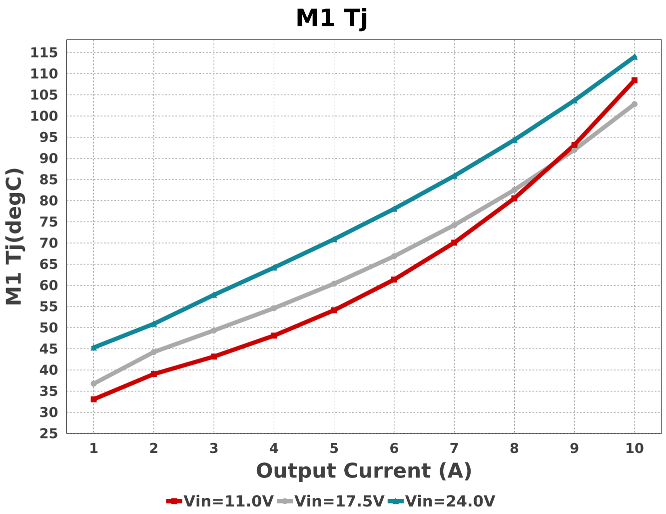

M2 Pd
M2 Pd(W)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V

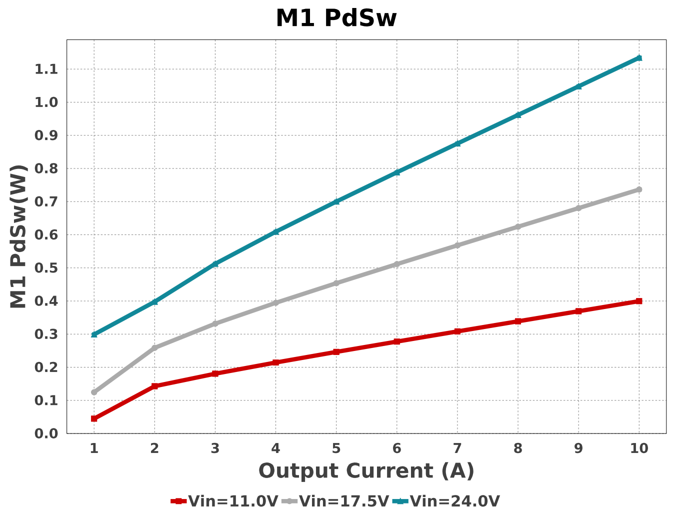

Total Pd
Total Pd(W)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V

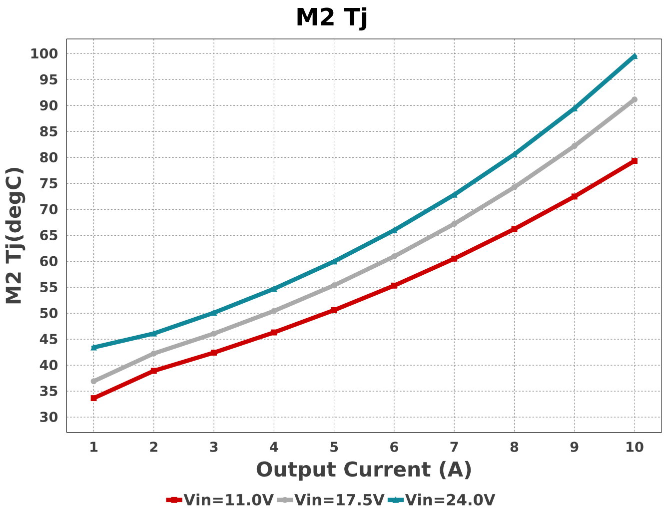

Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V

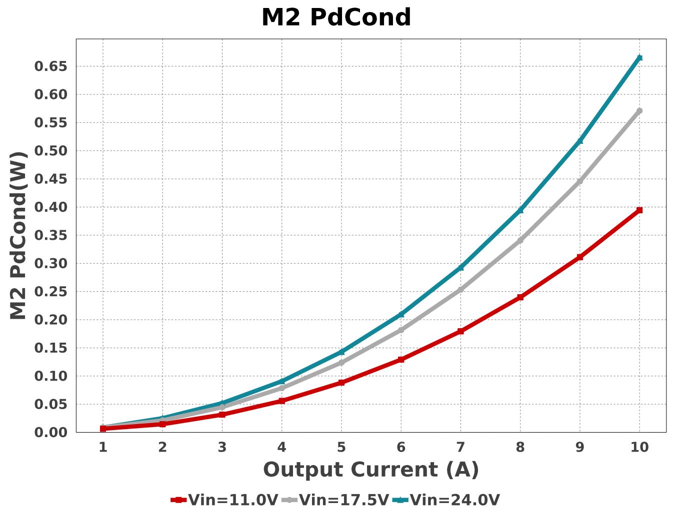

L Ipp
L Ipp(A)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V


IC Pd
IC Pd(W)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V

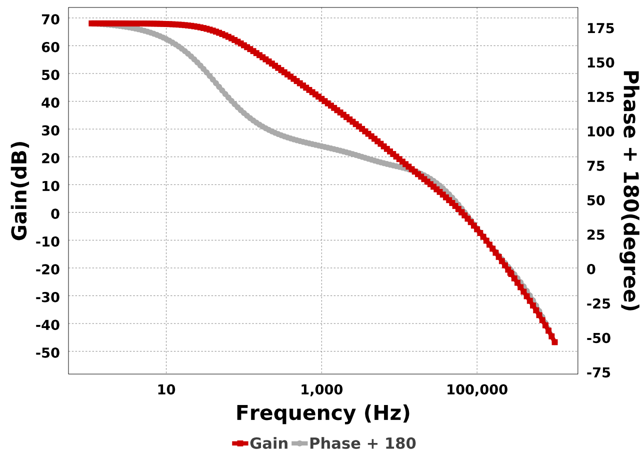

M1 Tj
M1 Tj(degC)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V


M1 PdSw
M1 PdSw(W)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V

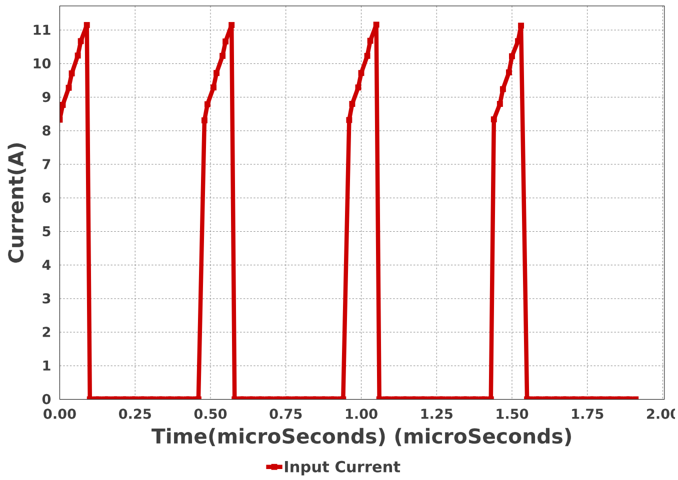

M2 Tj
M2 Tj(degC)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V


M2 PdCond
M2 PdCond(W)
Output Current (A)
Vin=11.0V Vin=17.5V Vin=24.0V

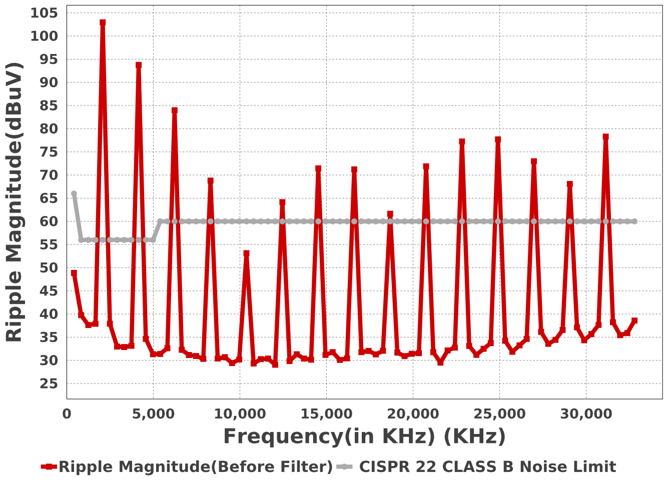
Loop Response



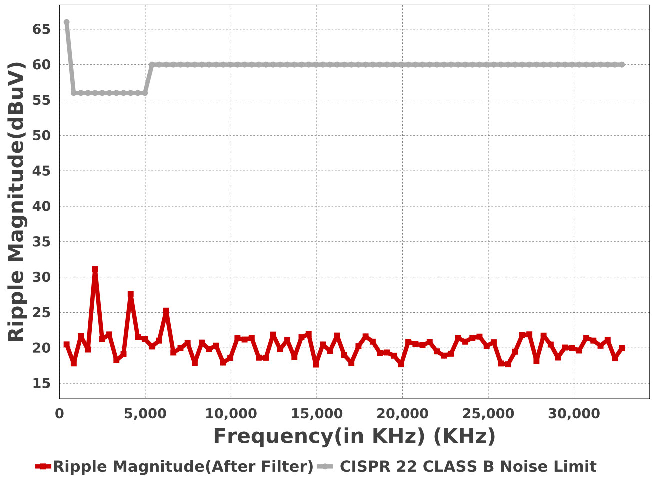
Input Current



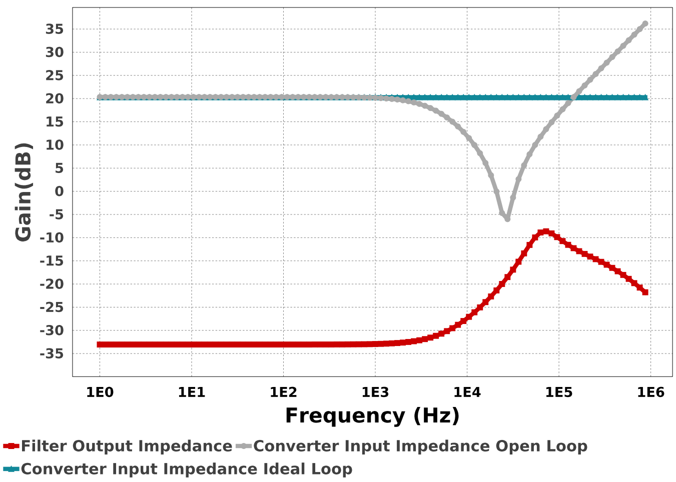
Ripple Freq Spectrum(Before Filter)



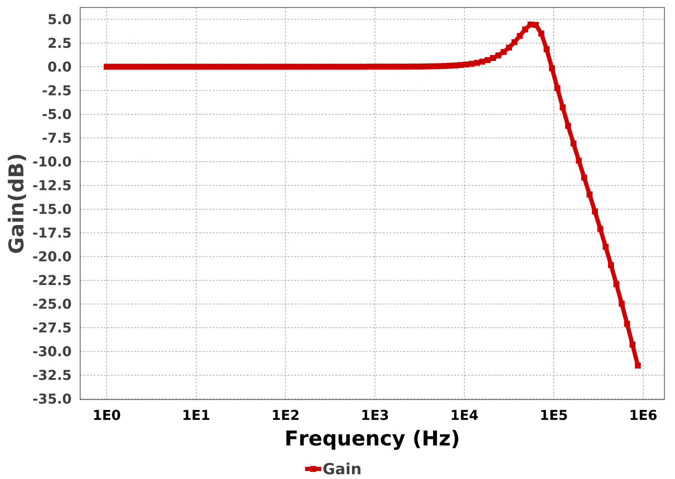
Ripple Freq Spectrum(After Filter)

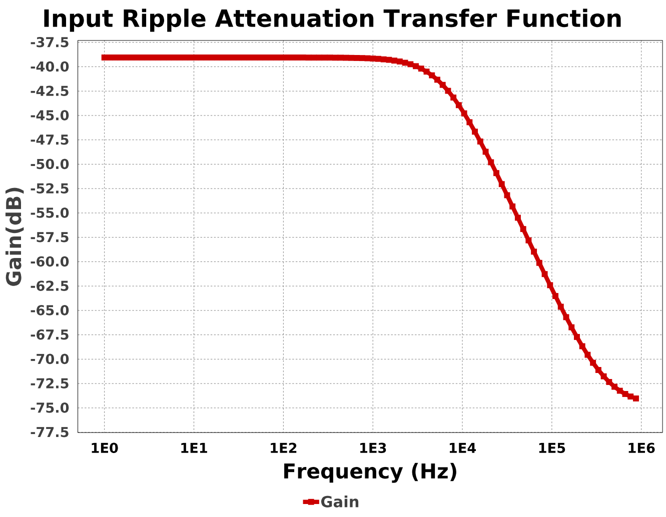


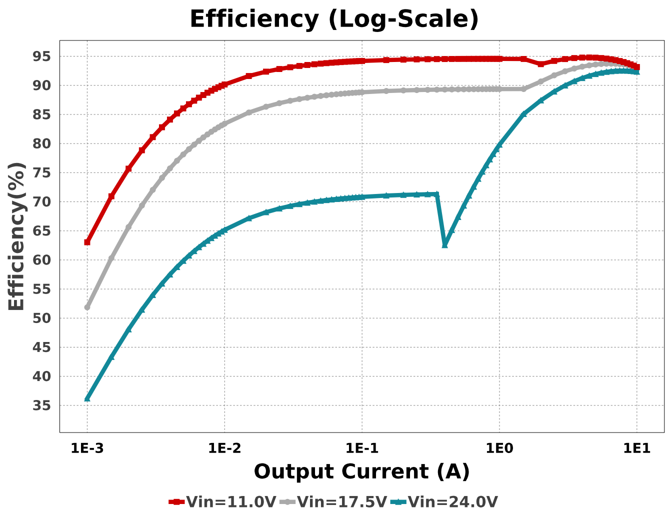
Filter vs Converter Impedance Comparison



Filter Forward Transfer Function







Operating Values

#	Name	Value	Category	Description
1.	BOM Count	24		Total Design BOM count
2.	Total BOM	$4.167		Total BOM Cost
3.	Cin IRMS	4.204 A	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	8.836 mW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	965.35 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	1.415 mW	Capacitor	Output capacitor power dissipation
7.	Input Ripple Noise After input filter	31.08 dBuV	EMI Noise	Input Ripple Noise after filter at switching frequency
8.	Input Ripple Noise before input filter	102.96 dBuV	EMI Noise	Input Ripple Noise before filter at switching frequency
9.	Input Ripple filter Pd	122.93 mW	EMI Noise	Input Ripple Filter Power Dissipation
10.	Noise limits defined by CISPR Standards	56.0 dBuV	EMI Noise	Noise limits for CLASS B of CISPR 22 standard
11.	IC Ipk	11.672 A	IC	Peak switch current in IC
12.	IC Pd	736.21 mW	IC	IC power dissipation
13.	IC Tj	55.62 degC	IC	IC junction temperature
14.	IC Tolerance	10.0 mV	IC	IC Feedback Tolerance
15.	ICThetaJA Effective	34.8 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
16.	Iin Avg	2.364 A	IC	Average input current
17.	Ipp percentage	33.441 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
18.	L Ipp	3.344 A	Inductor	Peak-to-peak inductor ripple current
19.	L Pd	413.82 mW	Inductor	Inductor power dissipation
20.	M1 Pd	1.68 W	Mosfet	M1 MOSFET total power dissipation
21.	M1 PdCond	545.49 mW	Mosfet	M1 MOSFET conduction losses
22.	M1 PdSw	1.134 W	Mosfet	M1 MOSFET switching losses
23.	M1 Tj	113.984 degC	Mosfet	M1 MOSFET junction temperature
24.	M2 Pd	1.391 W	Mosfet	M2 MOSFET total power dissipation
25.	M2 PdCond	665.49 mW	Mosfet	M2 MOSFET conduction losses
26.	M2 PdSw	725.41 mW	Mosfet	M2 MOSFET switching losses
27.	M2 Tj	99.545 degC	Mosfet	M2 MOSFET junction temperature
28.	Cin Pd	8.836 mW	Power	Input capacitor power dissipation
29.	Cout Pd	1.415 mW	Power	Output capacitor power dissipation
30.	IC Pd	736.21 mW	Power	IC power dissipation
31.	Input Ripple filter Pd	122.93 mW	Power	Input Ripple Filter Power Dissipation
32.	L Pd	413.82 mW	Power	Inductor power dissipation
33.	M1 Pd	1.68 W	Power	M1 MOSFET total power dissipation
34.	M1 PdCond	545.49 mW	Power	M1 MOSFET conduction losses
35.	M1 PdSw	1.134 W	Power	M1 MOSFET switching losses
36.	M2 Pd	1.391 W	Power	M2 MOSFET total power dissipation
37.	M2 PdCond	665.49 mW	Power	M2 MOSFET conduction losses
38.	M2 PdSw	725.41 mW	Power	M2 MOSFET switching losses
39.	Total Pd	4.345 W	Power	Total Power Dissipation
40.	Cross Freq	63.608 kHz	System Information	Bode plot crossover frequency
41.	Duty Cycle	22.546 %	System Information	Duty cycle
42.	Efficiency	92.341 %	System Information	Steady state efficiency
43.	FootPrint	488.0 mm^2	System Information	Total Foot Print Area of BOM components

#	Name	Value	Category	Description
44.	Frequency	2.075 MHz	System Information	Switching frequency
45.	Gain Marg	-21.712 dB	System Information	Bode Plot Gain Margin
46.	Iout	10.0 A	System Information	Iout operating point
47.	Iout transient step used for Cout calculations	5.0 A	System Information	Custom Transient current step requirement that was used for Cout selection (A).
48.	Low Freq Gain	68.039 dB	System Information	Gain at 1Hz
49.	Mode	CCM	System Information	Conduction Mode
50.	Overshoot Value	23.28 mV	System Information	Theoretical Vout Overshoot Value
51.	Phase Marg	43.946 deg	System Information	Bode Plot Phase Margin
52.	Pout	52.5 W	System Information	Total output power
53.	Undershoot Value	37.191 mV	System Information	Theoretical Vout Undershoot Value
54.	Vin	24.0 V	System Information	Vin operating point
55.	Vin p-p	411.512 mV	System Information	Peak-to-peak input voltage
56.	Vout	5.25 V	System Information	Operational Output Voltage
57.	Vout Actual	5.28 V	System Information	Vout Actual calculated based on selected voltage divider resistors
58.	Vout Ripple requirement used for Cout calculations	1.0 %	System Information	Custom maximum output ripple requirement that was used for Cout selection(% of Vout).
59.	Vout Tolerance	2.205 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
60.	Vout p-p	5.715 mV	System Information	Peak-to-peak output ripple voltage
61.	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	10.0	Maximum Output Current
VinMax	24.0	Maximum input voltage
VinMin	11.0	Minimum input voltage
Vout	5.25	Output Voltage
base_pn	LM25148-Q1	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature
UserFsw	2.075 M	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

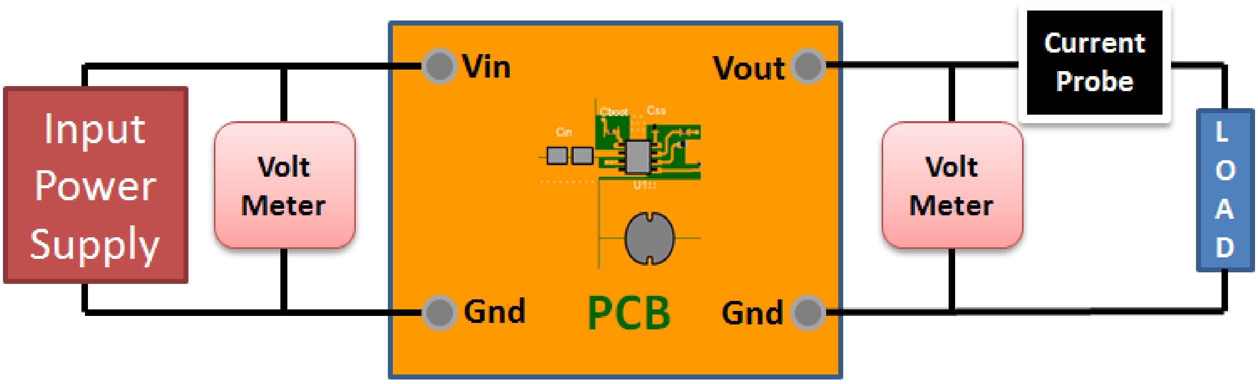
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 11.0V 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 : A19392E5572167559A9A1E772277F17F[v1]

2. **LM25148-Q1** Product Folder : http://www.ti.com/product/LM25148%2DQ1 : contains the data sheet and other resources.

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