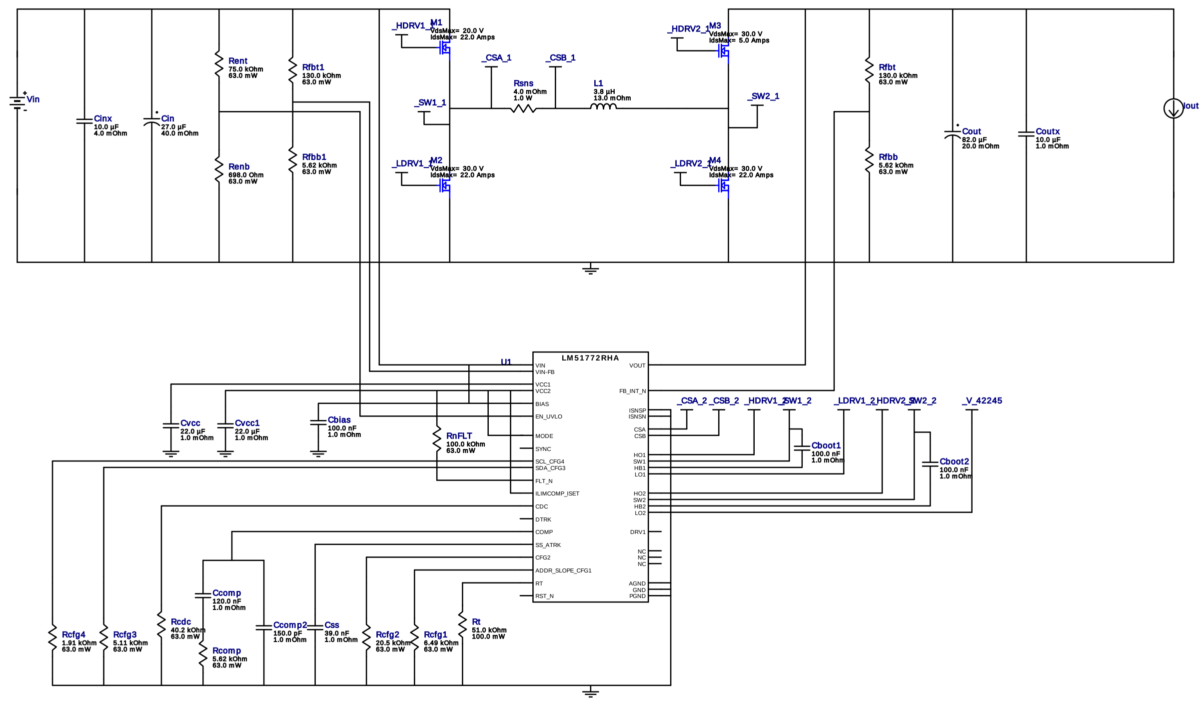
VinMin = 11.0V
VinMax = 15.0V
Vout = 24.0V
Iout = 2.0A

Device = LM51772RHAR
Topology = Buck_Boost
Created = 2024-02-19 19:13:43.021
BOM Cost = $7.13
BOM Count = 34
Total Pd = 2.47W

WEBENCH ® Design Report

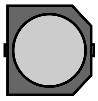
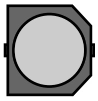
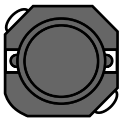
Design : 1 LM51772RHAR
LM51772RHAR 11V-15V to 24.00V @ 2A



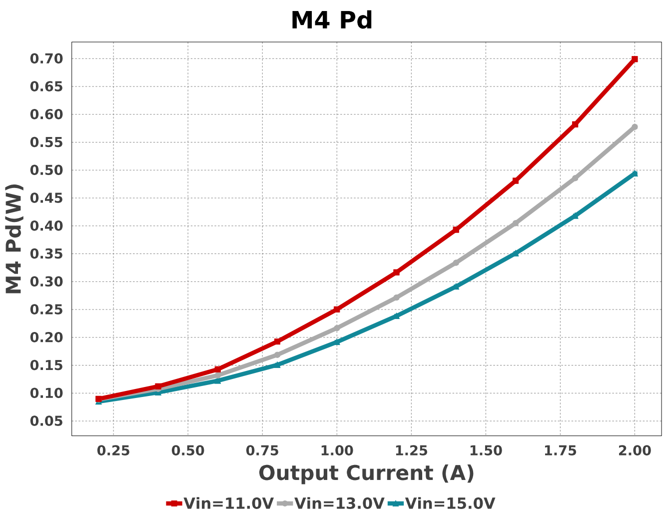
1. The LM51772 feature AutoMode for better light load efficiency. The operating point calculated in AutoMode configuration are estimate.

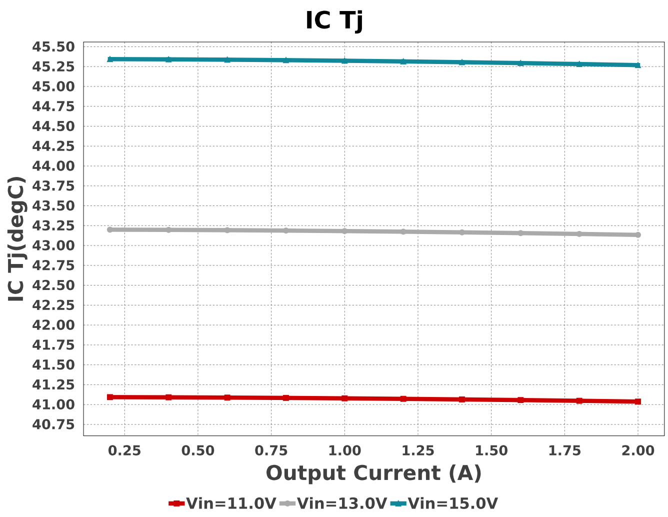
Electrical BOM

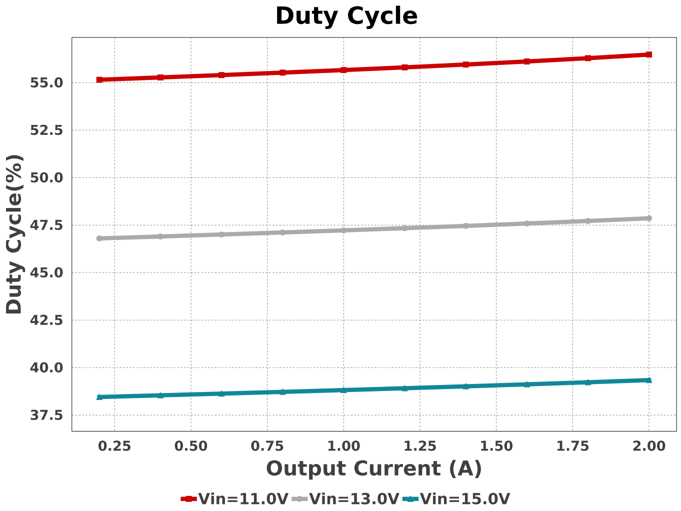
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbias	MuRata	GRM155R71A104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cboot1	Taiyo Yuden	EMK107B7104KA-T Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2
Cboot2	Taiyo Yuden	EMK107B7104KA-T Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2
Ccomp	MuRata	GRM188R71C124KA01D Series= X7R	Cap= 120.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.02	0603 5 mm^2
Ccomp2	MuRata	GRM1555C1H151JA01D Series= C0G/NP0	Cap= 150.0 pF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cin	Panasonic	25SVPF27MX Series= SVPF	Cap= 27.0 uF ESR= 40.0 mOhm VDC= 25.0 V IRMS= 2.45 A	1	$0.47	CAPSMT_62_E61 53 mm^2

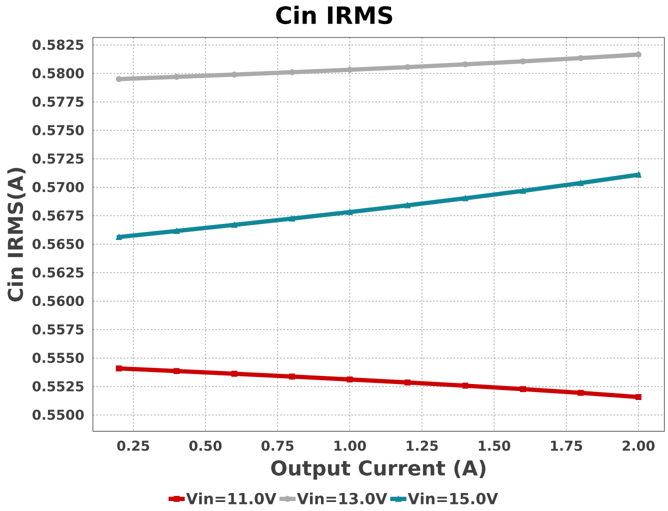
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cinx	MuRata	GRM21BR61E106MA73L Series= X5R	Cap= 10.0 uF ESR= 4.0 mOhm VDC= 25.0 V IRMS= 2.8 A	1	$0.04	0805 7 mm^2
Cout	Panasonic	35SVPF82M Series= SVPF	Cap= 82.0 uF ESR= 20.0 mOhm VDC= 35.0 V IRMS= 4.0 A	1	$1.17	 CAPSMT_62_E12 106 mm^2
Cout	Panasonic	35SVPF82M Series= SVPF	Cap= 82.0 uF ESR= 20.0 mOhm VDC= 35.0 V IRMS= 4.0 A	1	$1.17	 CAPSMT_62_E12 106 mm^2
Coutx	TDK	C3225X7R1H106M250AC Series= X7R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 5.0 A	1	$0.27	1210 15 mm^2
Css	MuRata	GRM155R71C393KA01D Series= X7R	Cap= 39.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cvcc	MuRata	GRM188R60J226MEA0D Series= X5R	Cap= 22.0 uF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 6.0 A	1	$0.04	0603 5 mm^2
Cvcc1	MuRata	GRM188R60J226MEA0D Series= X5R	Cap= 22.0 uF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 6.0 A	1	$0.04	0603 5 mm^2
L1	Coiltronics	DR1040-3R8-R	L= 3.8 µH 13.0 mOhm	1	$0.49	 DR1040 154 mm^2
M1	Texas Instruments	CSD15571Q2	VdsMax= 20.0 V IdsMax= 22.0 Amps	1	$0.08	DQK0006C 9 mm^2
M2	Texas Instruments	CSD17571Q2	VdsMax= 30.0 V IdsMax= 22.0 Amps	1	$0.08	DQK0006C 9 mm^2
M3	Texas Instruments	CSD17313Q2	VdsMax= 30.0 V IdsMax= 5.0 Amps	1	$0.11	DQK0006C 9 mm^2
M4	Texas Instruments	CSD17571Q2	VdsMax= 30.0 V IdsMax= 22.0 Amps	1	$0.08	DQK0006C 9 mm^2
Rcdc	Vishay-Dale	CRCW040240K2FKED Series= CRCW..e3	Res= 40.2 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rcfg1	Vishay-Dale	CRCW04026K49FKED Series= CRCW..e3	Res= 6.49 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rcfg2	Vishay-Dale	CRCW040220K5FKED Series= CRCW..e3	Res= 20.5 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rcfg3	Vishay-Dale	CRCW04025K11FKED Series= CRCW..e3	Res= 5.11 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rcfg4	Vishay-Dale	CRCW04021K91FKED Series= CRCW..e3	Res= 1.91 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rcomp	Vishay-Dale	CRCW04025K62FKED Series= CRCW..e3	Res= 5.62 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2

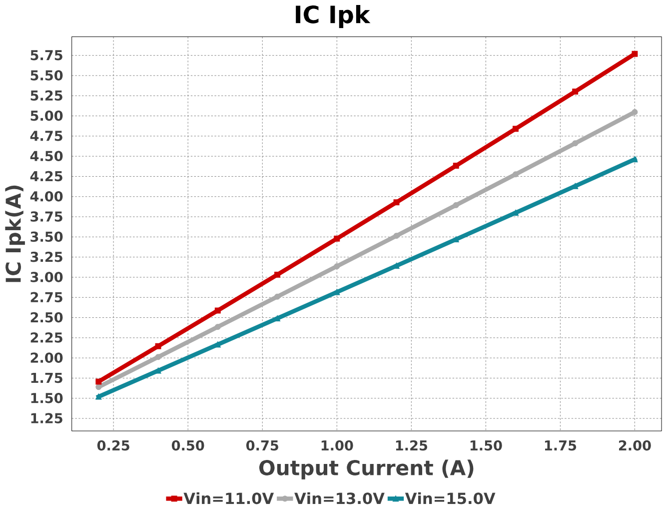
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Renb	Vishay-Dale	CRCW0402698RFKED Series= CRCW..e3	Res= 698.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rent	Vishay-Dale	CRCW040275K0FKED Series= CRCW..e3	Res= 75.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb	Vishay-Dale	CRCW04025K62FKED Series= CRCW..e3	Res= 5.62 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb1	Vishay-Dale	CRCW04025K62FKED Series= CRCW..e3	Res= 5.62 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt	Vishay-Dale	CRCW0402130KFKED Series= CRCW..e3	Res= 130.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt1	Vishay-Dale	CRCW0402130KFKED Series= CRCW..e3	Res= 130.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
RnFLT	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rsns	Panasonic	ERJ-M1WTF4M0U Series= ERJ	Res= 4.0 mOhm Power= 1.0 W Tolerance= 1.0%	1	$0.17	2512 43 mm^2
Rt	Yageo	RC0603FR-0751KL Series= ?	Res= 51.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
U1	Texas Instruments	LM51772RHAR	Switcher	1	$2.71	RHA0040P 64 mm^2

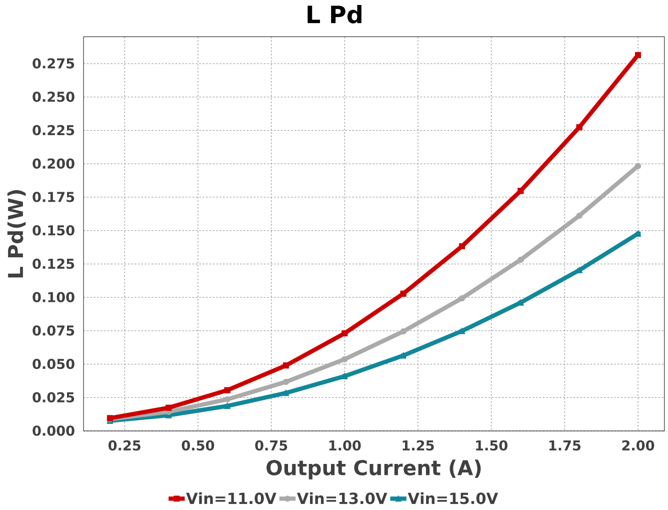


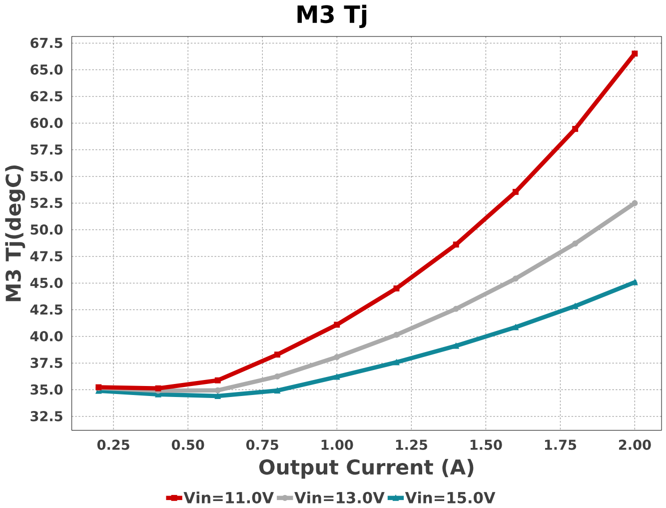


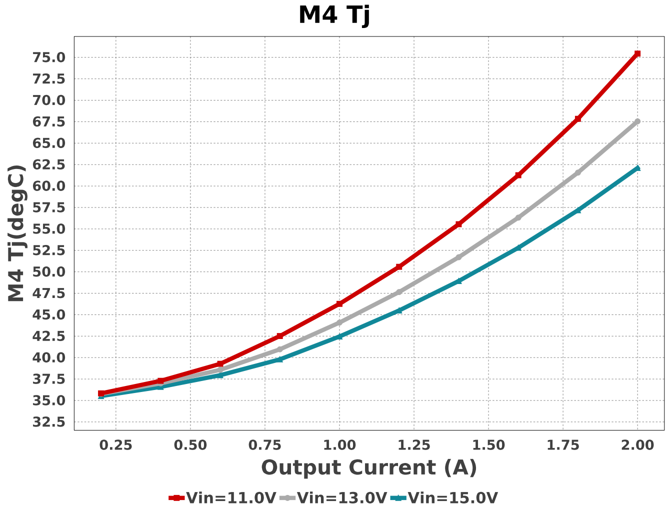

Duty Cycle
Duty Cycle(%)
Output Current (A)
Vin=11.0V Vin=13.0V Vin=15.0V

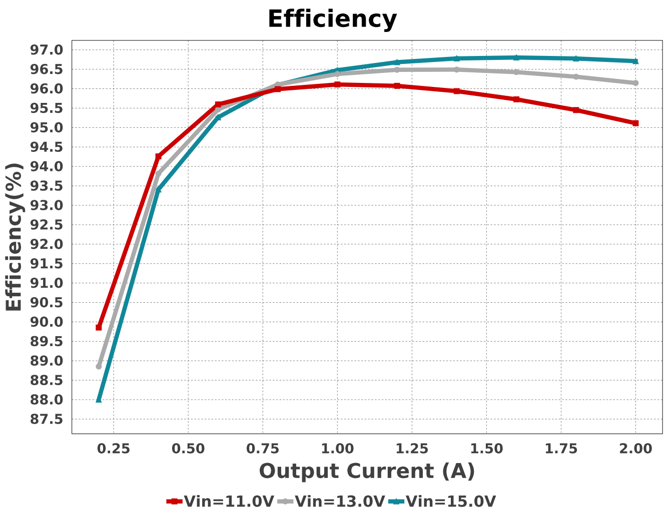

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=11.0V Vin=13.0V Vin=15.0V

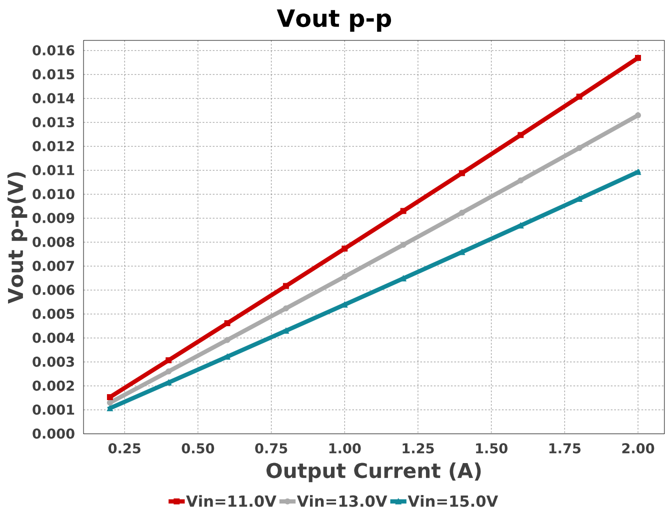

IC Ipk
IC Ipk(A)
Output Current (A)
Vin=11.0V Vin=13.0V Vin=15.0V

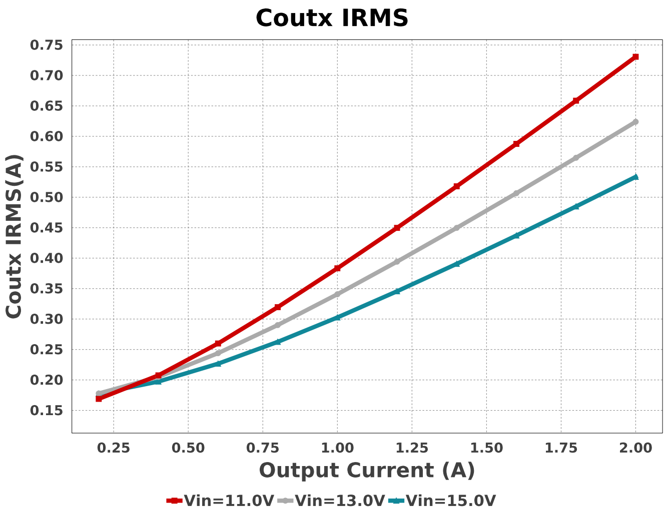

L Pd
L Pd(W)
Output Current (A)
Vin=11.0V Vin=13.0V Vin=15.0V

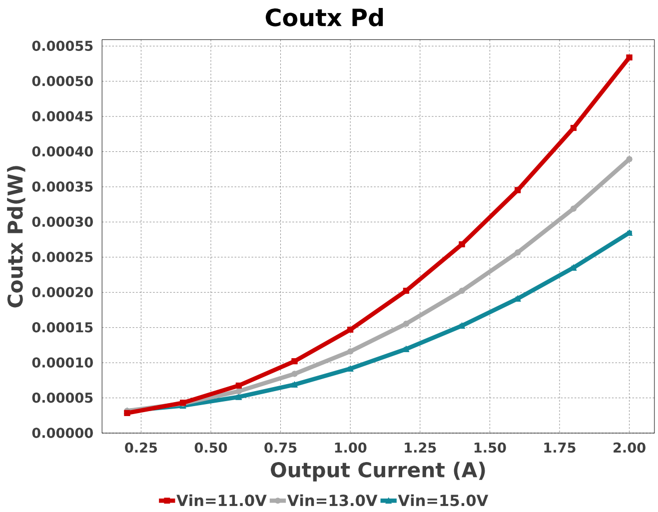

M3 Tj
M3 Tj(degC)
Output Current (A)
Vin=11.0V Vin=13.0V Vin=15.0V

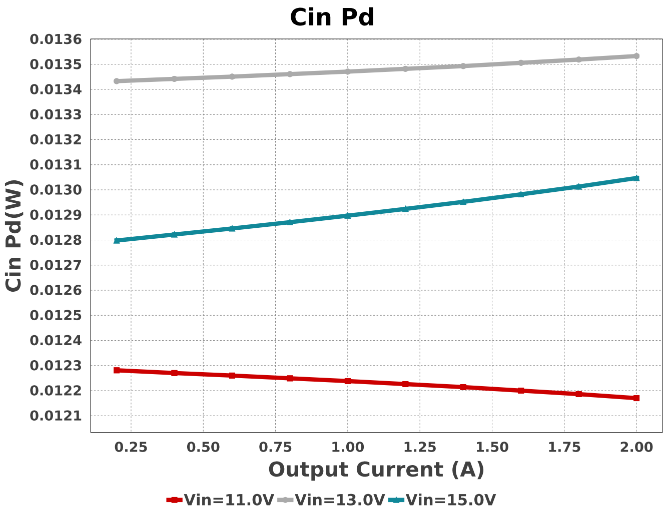

M4 Tj
M4 Tj(degC)
Output Current (A)
Vin=11.0V Vin=13.0V Vin=15.0V

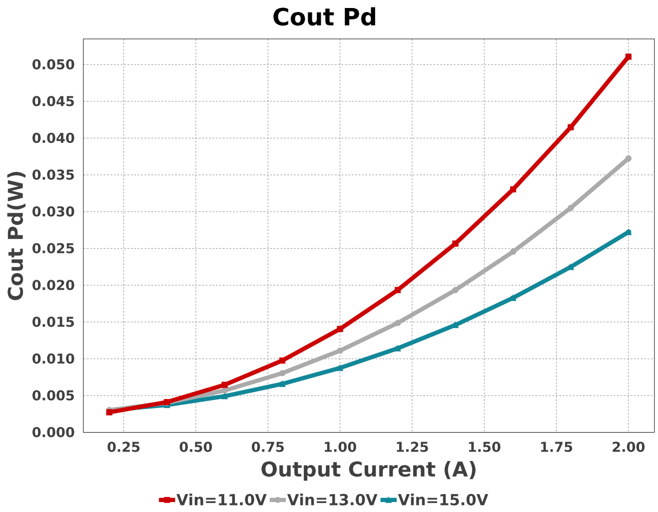

Efficiency
Efficiency(%)
Output Current (A)
Vin=11.0V Vin=13.0V Vin=15.0V


Vout p-p
Vout p-p(V)
Output Current (A)
Vin=11.0V Vin=13.0V Vin=15.0V

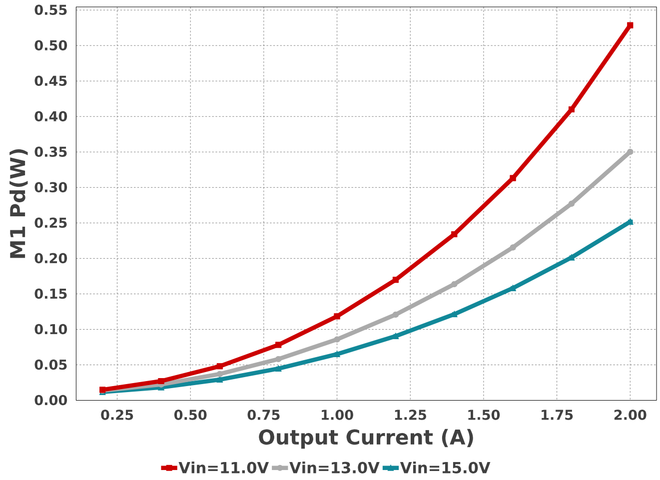

Coutx IRMS
Coutx IRMS(A)
Output Current (A)
Vin=11.0V Vin=13.0V Vin=15.0V


Coutx Pd
Coutx Pd(W)
Output Current (A)
Vin=11.0V Vin=13.0V Vin=15.0V

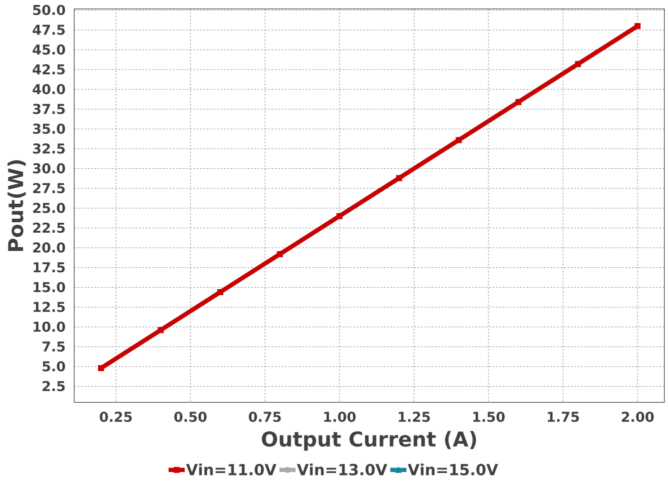

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=11.0V Vin=13.0V Vin=15.0V


Cout Pd
Cout Pd(W)
Output Current (A)
Vin=11.0V Vin=13.0V Vin=15.0V

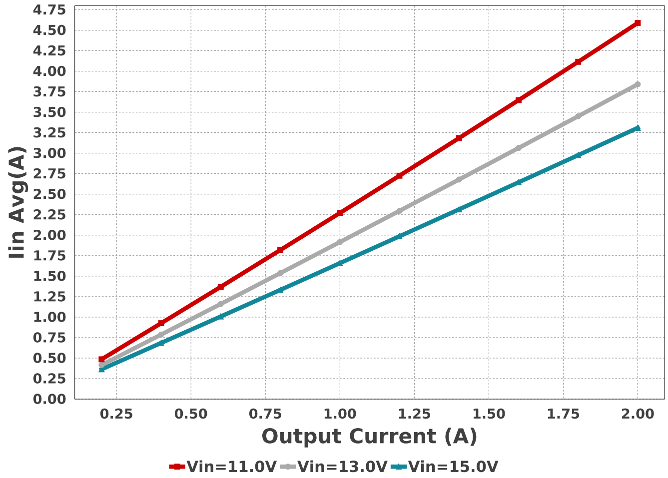
M1 Pd



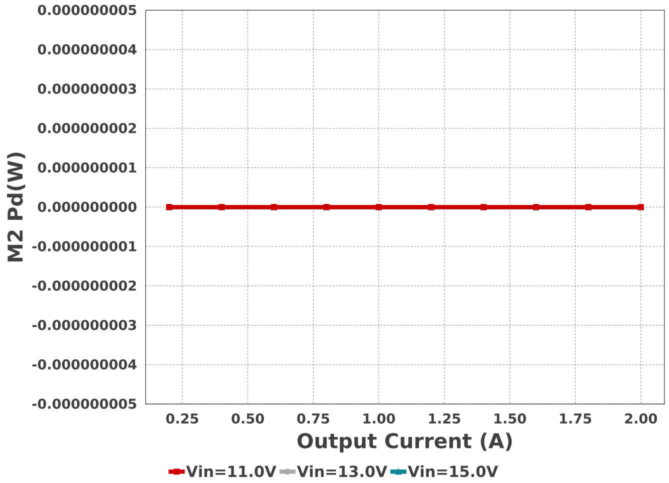
Pout



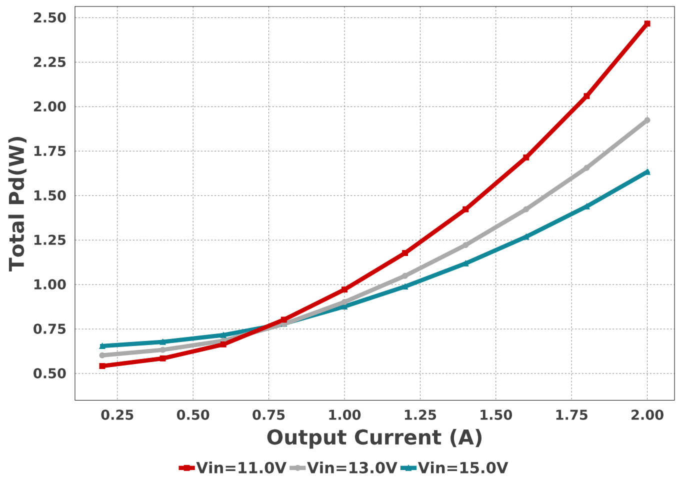
Iin Avg



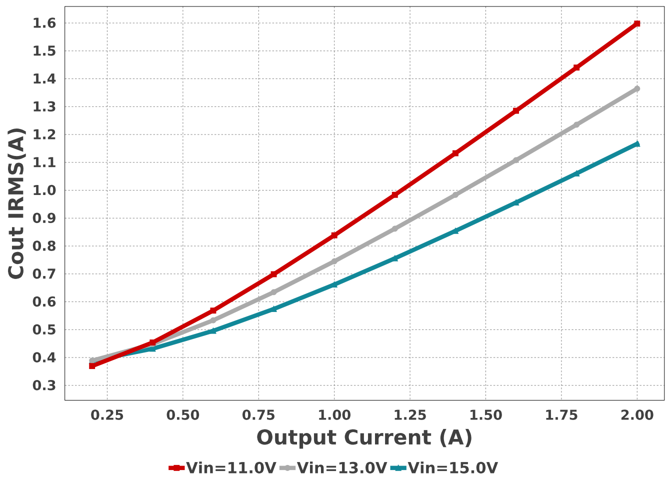
M2 Pd

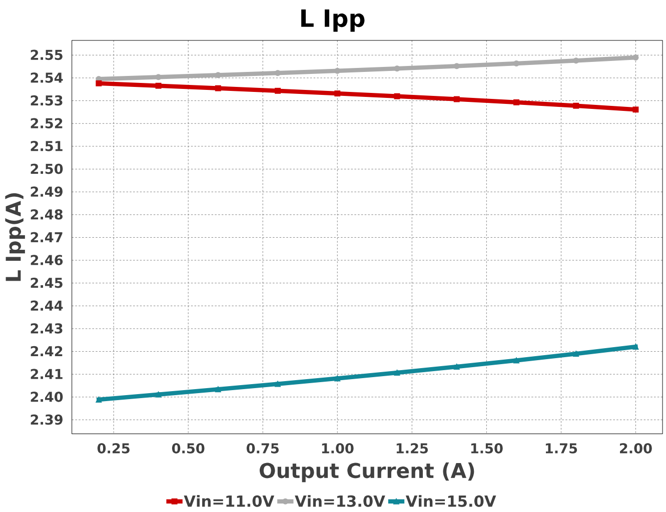


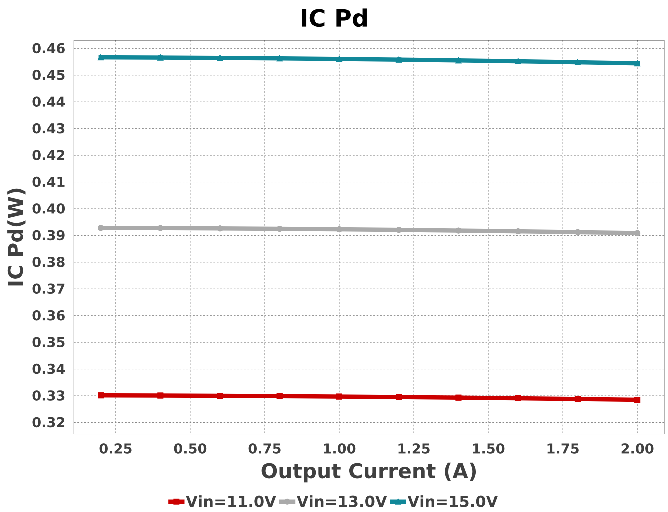
Total Pd

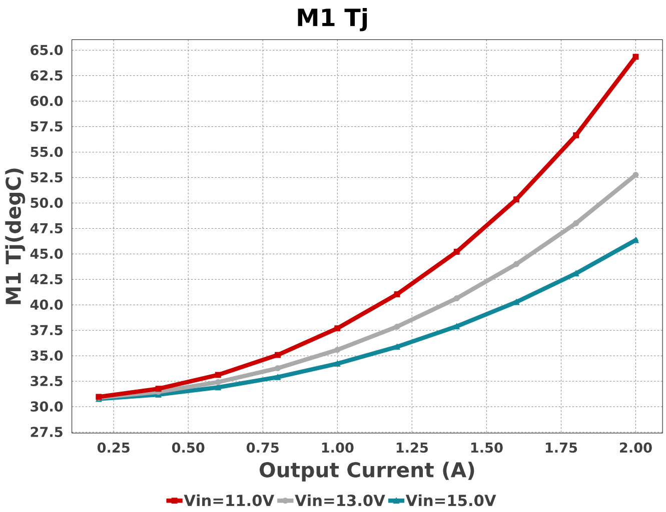


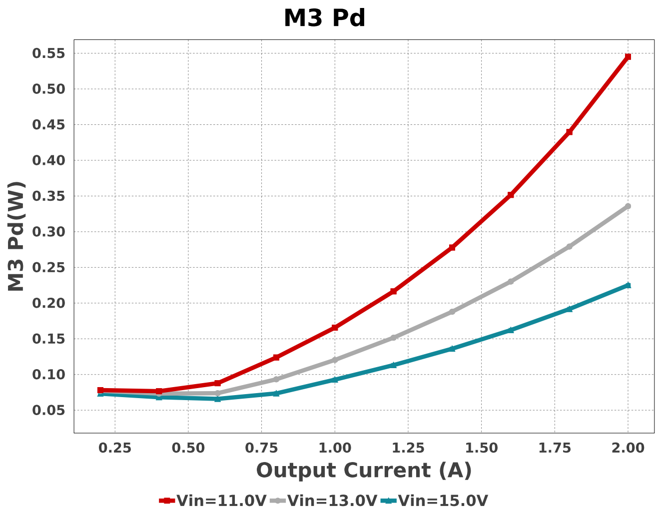
Cout IRMS

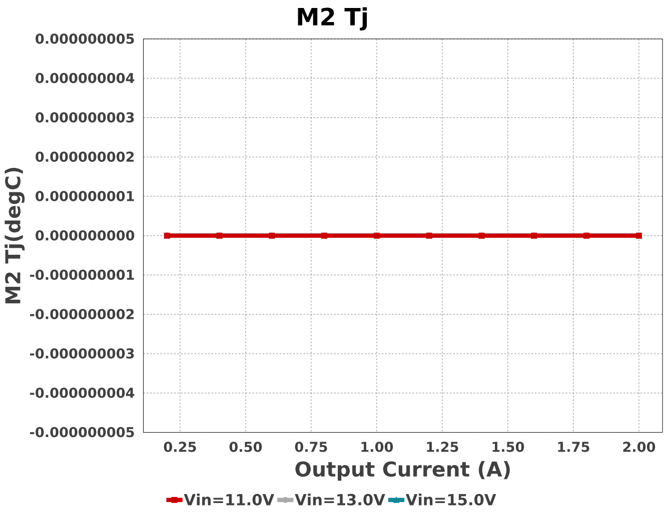


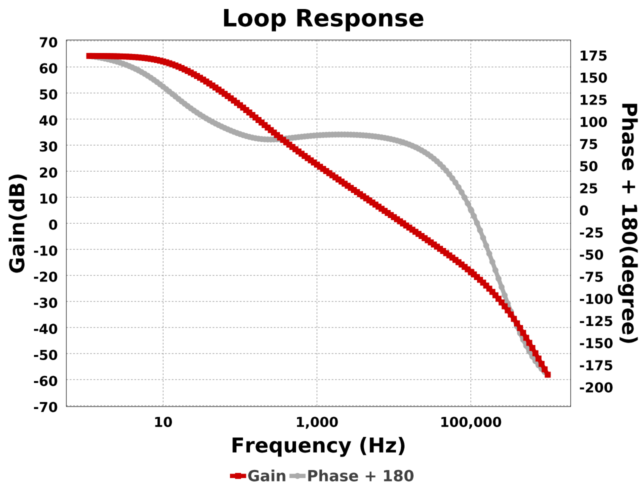












Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	551.581 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	12.17 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	1.598 A	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	51.065 mW	Capacitor	Output capacitor power dissipation
5.	Coutx IRMS	730.644 mA	Capacitor	Output capacitor_x RMS ripple current
6.	Coutx Pd	533.84 µW	Capacitor	Output capacitor_x power loss
7.	IC Ipk	5.769 A	IC	Peak switch current in IC
8.	IC Pd	328.5 mW	IC	IC power dissipation
9.	IC Tj	41.038 degC	IC	IC junction temperature
10.	IC Tolerance	10.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA	33.6 degC/W	IC	IC junction-to-ambient thermal resistance

#	Name	Value	Category	Description
12.	Iin Avg	4.588 A	IC	Average input current
13.	L Ipp	2.526 A	Inductor	Peak-to-peak inductor ripple current
14.	L Pd	281.43 mW	Inductor	Inductor power dissipation
15.	M1 Pd	528.57 mW	Mosfet	M1 MOSFET total power dissipation
16.	M1 Tj	64.357 degC	Mosfet	M1 MOSFET junction temperature
17.	M2 Pd	0.0 W	Mosfet	M2 MOSFET total power dissipation
18.	M2 Tj	0.0 degC	Mosfet	M2 MOSFET junction temperature
19.	M3 Pd	545.05 mW	Mosfet	M1 MOSFET total power dissipation
20.	M3 Tj	66.519 degC	Mosfet	M1 MOSFET junction temperature
21.	M4 Pd	699.08 mW	Mosfet	M2 MOSFET total power dissipation
22.	M4 Tj	75.44 degC	Mosfet	M2 MOSFET junction temperature
23.	Cin Pd	12.17 mW	Power	Input capacitor power dissipation
24.	Cout Pd	51.065 mW	Power	Output capacitor power dissipation
25.	Coutx Pd	533.84 µW	Power	Output capacitor_x power loss
26.	IC Pd	328.5 mW	Power	IC power dissipation
27.	L Pd	281.43 mW	Power	Inductor power dissipation
28.	M1 Pd	528.57 mW	Power	M1 MOSFET total power dissipation
29.	M2 Pd	0.0 W	Power	M2 MOSFET total power dissipation
30.	M3 Pd	545.05 mW	Power	M1 MOSFET total power dissipation
31.	M4 Pd	699.08 mW	Power	M2 MOSFET total power dissipation
32.	Total Pd	2.467 W	Power	Total Power Dissipation
33.	BOM Count	34	System Information	Total Design BOM count
34.	Cross Freq	9.632 kHz	System Information	Bode plot crossover frequency
35.	Duty Cycle	56.477 %	System Information	Duty cycle
36.	Efficiency	95.112 %	System Information	Steady state efficiency
37.	FootPrint	660.0 mm^2	System Information	Total Foot Print Area of BOM components
38.	Frequency	617.64 kHz	System Information	Switching frequency
39.	Gain Marg	-17.926 dB	System Information	Bode Plot Gain Margin
40.	Iout	2.0 A	System Information	Iout operating point
41.	Low Freq Gain	61.518 dB	System Information	Gain at 1Hz
42.	Mode	CCM	System Information	Conduction Mode
43.	Phase Marg	77.604 deg	System Information	Bode Plot Phase Margin
44.	Pout	48.0 W	System Information	Total output power
45.	Total BOM	$7.13	System Information	Total BOM Cost
46.	Vin	11.0 V	System Information	Vin operating point
47.	Vout	24.0 V	System Information	Operational Output Voltage
48.	Vout Actual	24.132 V	System Information	Vout Actual calculated based on selected voltage divider resistors
49.	Vout Tolerance	2.956 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
50.	Vout p-p	15.692 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	2.0	Maximum Output Current
VinMax	15.0	Maximum input voltage
VinMin	11.0	Minimum input voltage
Vout	24.0	Output Voltage
base_pn	LM51772	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

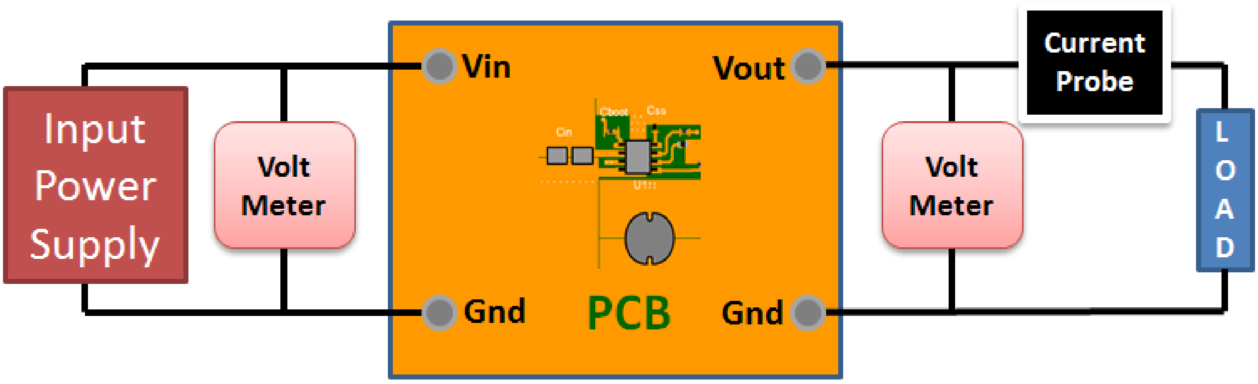
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 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 : 11390F3AE7B8F8E2AEC6E0F2D701EB1E[v1]

2. **LM51772** Product Folder : http://www.ti.com/product/LM51772 : contains the data sheet and other resources.

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