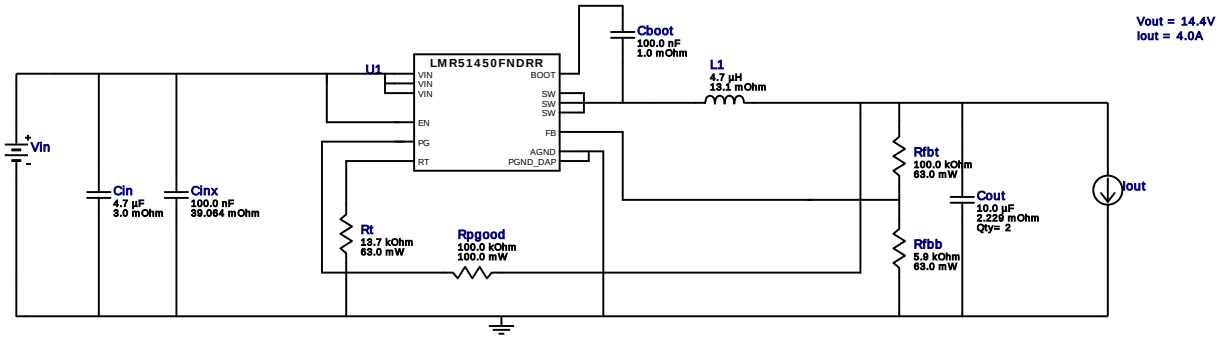
VinMin = 23.9V
VinMax = 24.1V
Vout = 14.4V
Iout = 4.0A

Device = LMR51450FNDRRR
Topology = Buck
Created = 2023-08-29 20:54:41.306
BOM Cost = $2.25
BOM Count = 11
Total Pd = 4.97W

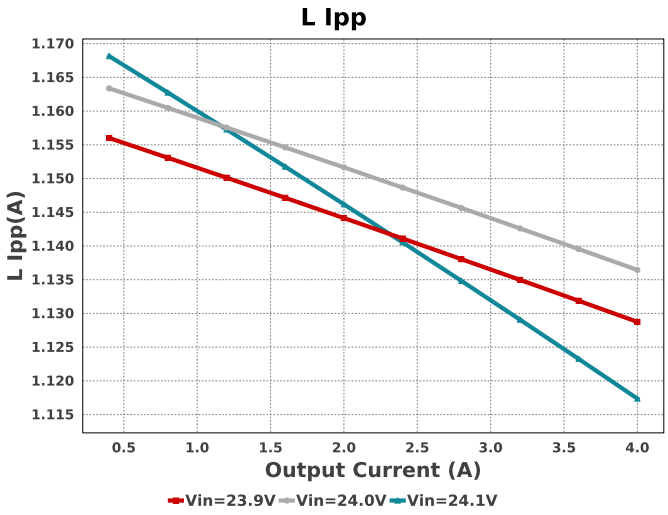
WEBENCH® Design Report

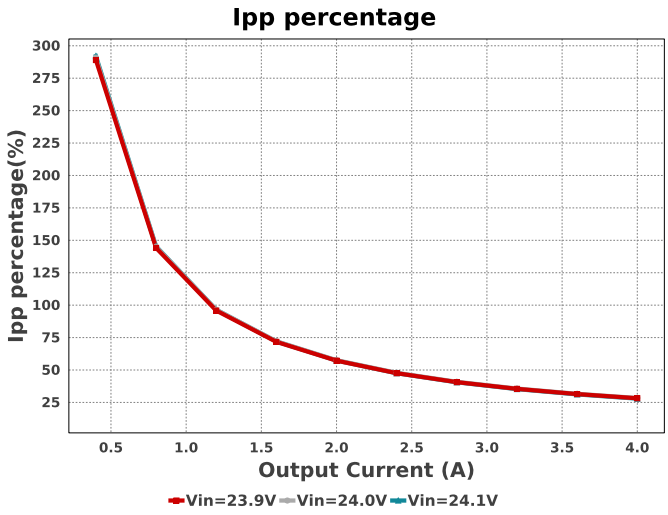
Design : 15 LMR51450FNDRRR
LMR51450FNDRRR 23.9V-24.1V to 14.5V @ 4A

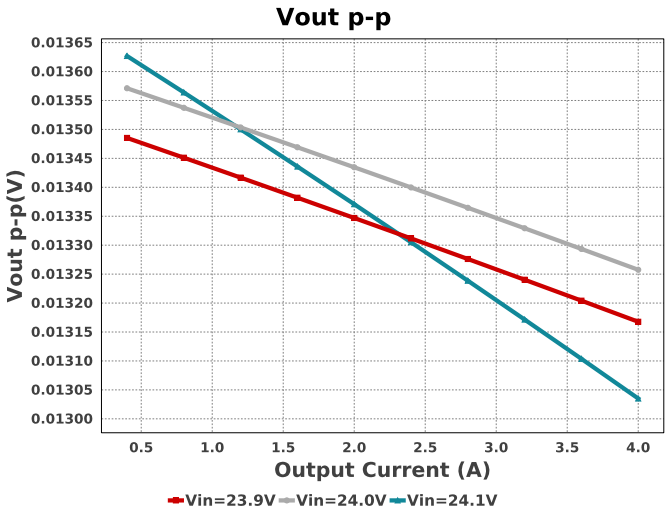


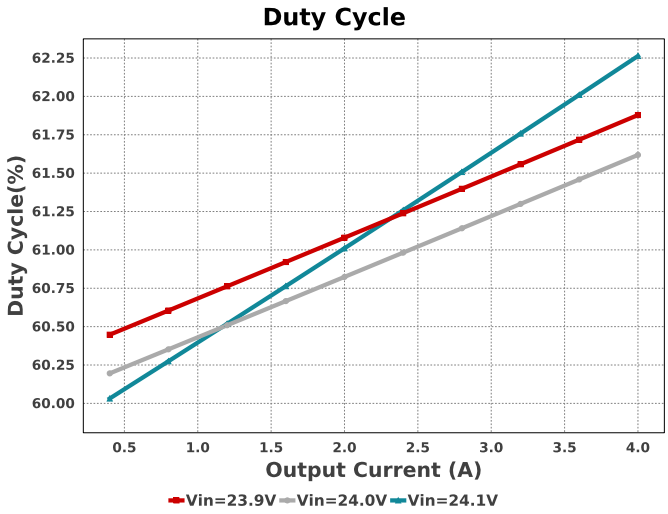
Electrical BOM

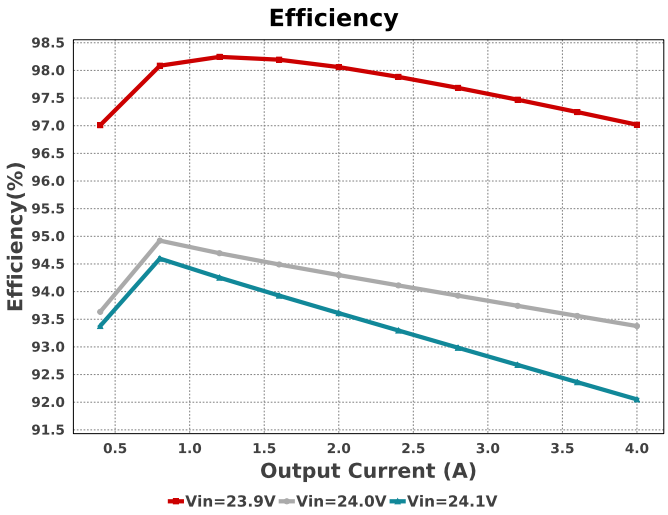
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM155R71C104KA88D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cin	MuRata	GRM31CR71H475KA12L Series= X7R	Cap= 4.7 uF ESR= 3.0 mOhm VDC= 50.0 V IRMS= 4.98 A	1	$0.10	1206 11 mm²
Cinx	TDK	C1005X5R1H104K050BB Series= X5R	Cap= 100.0 nF ESR= 39.064 mOhm VDC= 50.0 V IRMS= 814.67 mA	1	$0.02	0402 3 mm²
Cout	TDK	C3216X7R1V106K160AC Series= X7R	Cap= 10.0 uF ESR= 2.229 mOhm VDC= 35.0 V IRMS= 4.8593 A	2	$0.18	1206_180 11 mm²
L1	Coilcraft	XAL6060-472MEB	L= 4.7 µH 13.1 mOhm	1	$0.82	XAL6060 72 mm²
Rfbb	Vishay-Dale	CRCW04025K90FKED Series= CRCW..e3	Res= 5.9 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbt	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rpgood	Vishay-Dale	CRCW0603100KFKEA Series= CRCW..e3	Res= 100.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rt	Vishay-Dale	CRCW040213K7FKED Series= CRCW..e3	Res= 13.7 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
U1	Texas Instruments	LMR51450FNDRRR	Switcher	1	$0.90	DRR0012E 16 mm²

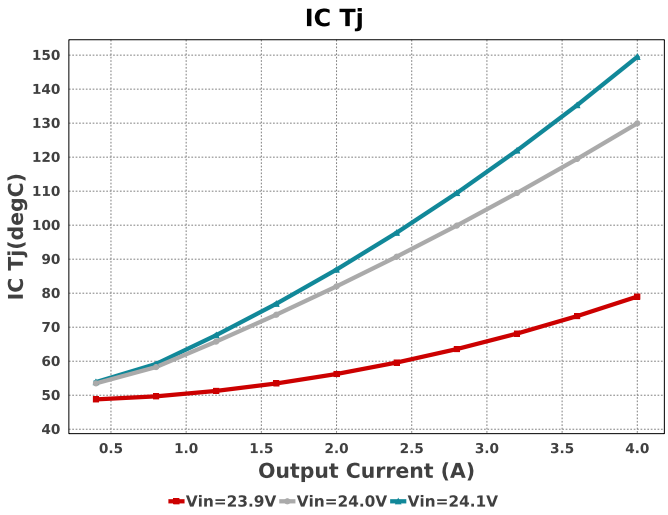


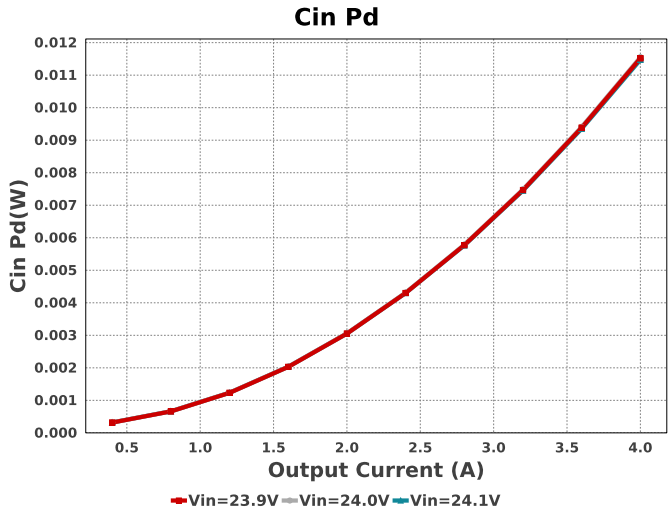


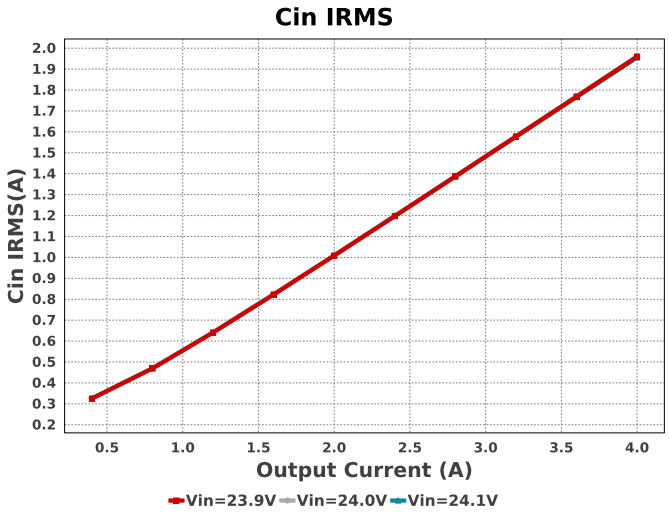


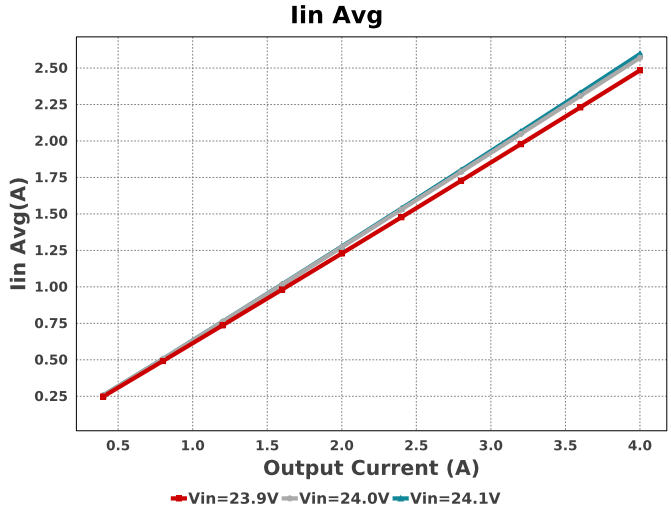


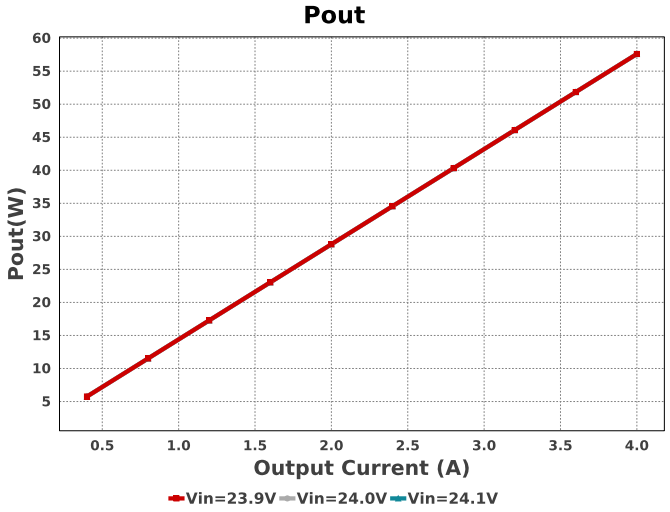


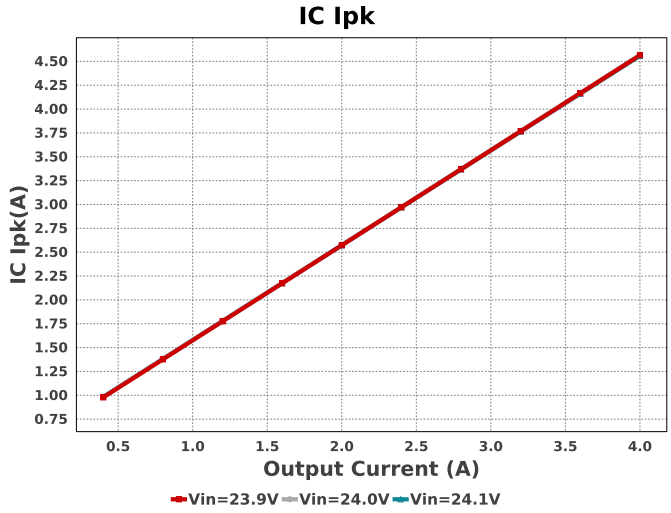


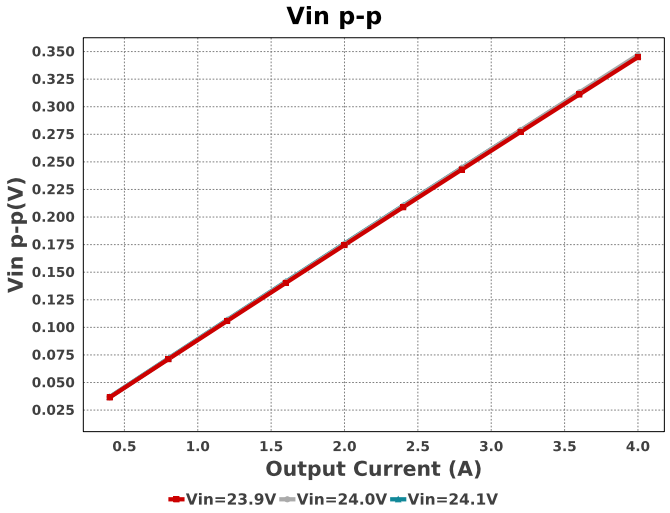


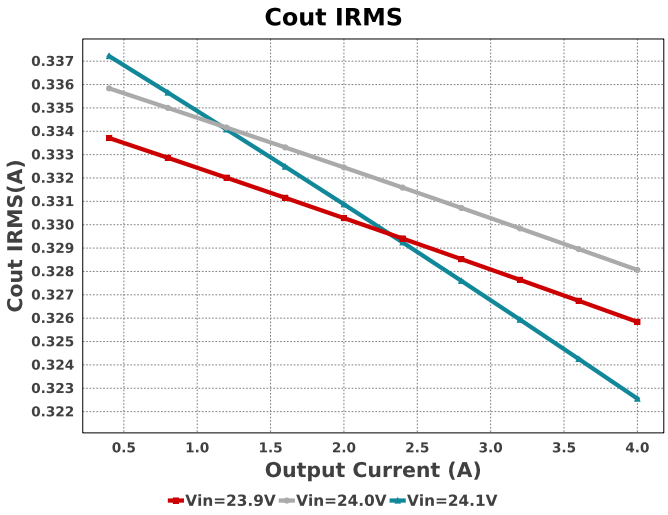


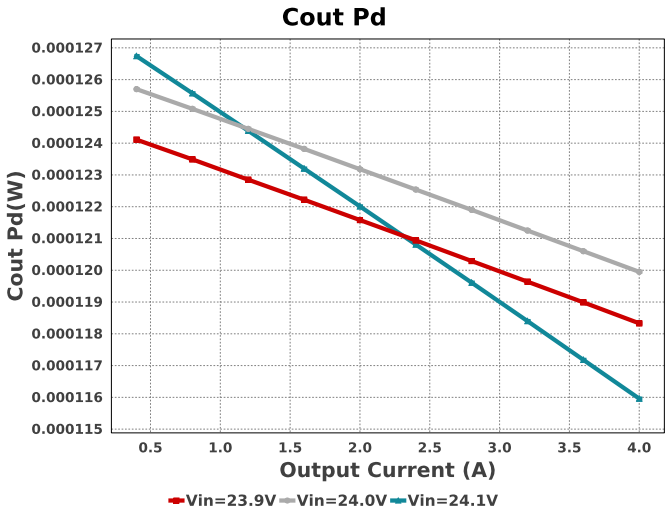


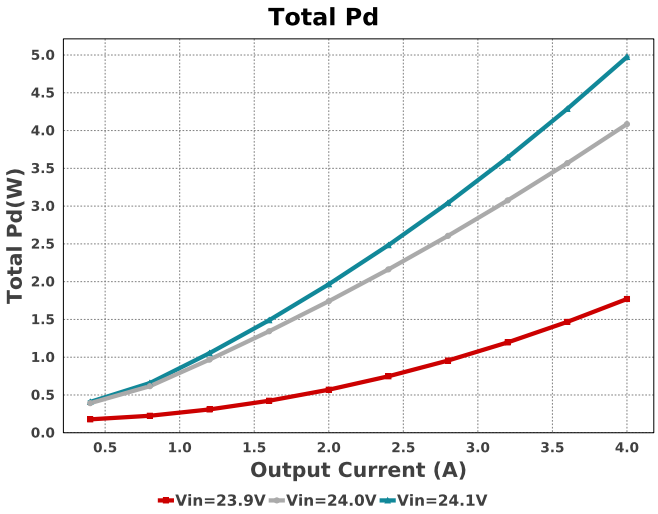


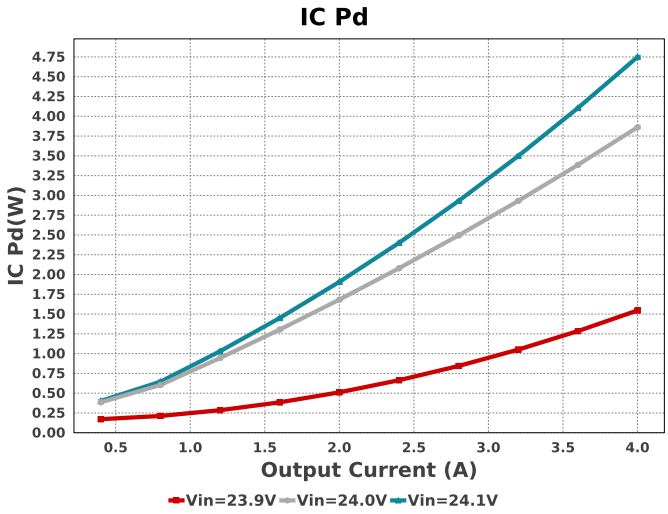


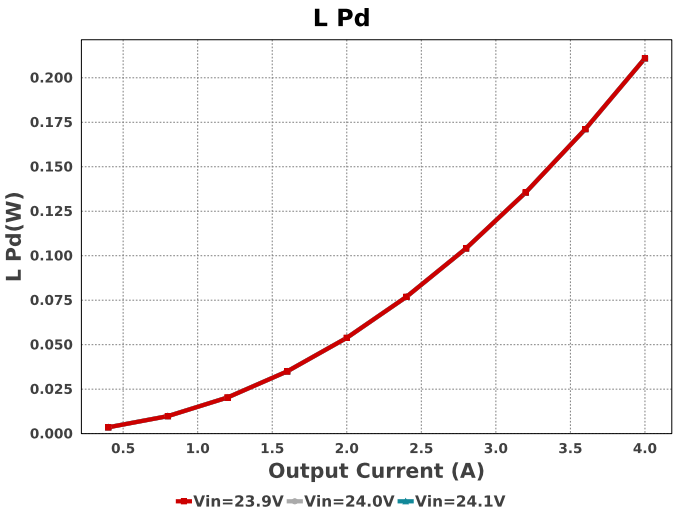


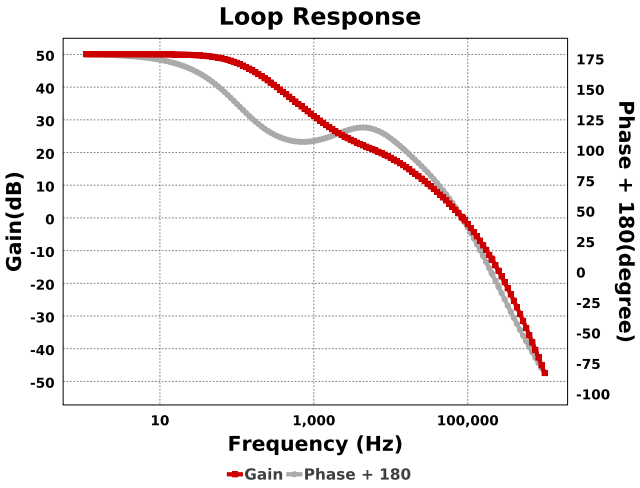












Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	1.956 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	11.472 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	322.556 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	115.96 µW	Capacitor	Output capacitor power dissipation
5.	IC Ipk	4.559 A	IC	Peak switch current in IC
6.	IC Pd	4.75 W	IC	IC power dissipation
7.	IC Tj	149.491 degC	IC	IC junction temperature
8.	IC Tolerance	5.0 mV	IC	IC Feedback Tolerance
9.	ICThetaJA Effective	22.0 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
10.	Iin Avg	2.596 A	IC	Average input current

#	Name	Value	Category	Description
11.	Ipp percentage	27.934 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
12.	L Ipp	1.117 A	Inductor	Peak-to-peak inductor ripple current
13.	L Pd	210.96 mW	Inductor	Inductor power dissipation
14.	Cin Pd	11.472 mW	Power	Input capacitor power dissipation
15.	Cout Pd	115.96 µW	Power	Output capacitor power dissipation
16.	IC Pd	4.75 W	Power	IC power dissipation
17.	L Pd	210.96 mW	Power	Inductor power dissipation
18.	Total Pd	4.974 W	Power	Total Power Dissipation
19.	BOM Count	11	System Information	Total Design BOM count
20.	Cross Freq	85.832 kHz	System Information	Bode plot crossover frequency
21.	Duty Cycle	62.263 %	System Information	Duty cycle
22.	Efficiency	92.051 %	System Information	Steady state efficiency
23.	FootPrint	140.0 mm^2	System Information	Total Foot Print Area of BOM components
24.	Frequency	1.052 MHz	System Information	Switching frequency
25.	Gain Marg	-12.447 dB	System Information	Bode Plot Gain Margin
26.	Inductor ripple current requirement used for Inductor selection	30.0 %	System Information	Custom Inductor ripple current (% of average inductor current) requirement used for Inductor selection
27.	Iout	4.0 A	System Information	Iout operating point
28.	Iout transient step used for Cout calculations	2.0 A	System Information	Custom Transient current step requirement that was used for Cout selection (A).
29.	Low Freq Gain	50.07 dB	System Information	Gain at 1Hz
30.	Mode	CCM	System Information	Conduction Mode
31.	Overshoot Value	63.905 mV	System Information	Theoretical Vout Overshoot Value
32.	Phase Marg	44.401 deg	System Information	Bode Plot Phase Margin
33.	Pout	57.6 W	System Information	Total output power
34.	Total BOM	$2.25	System Information	Total BOM Cost
35.	Undershoot Value	169.813 mV	System Information	Theoretical Vout Undershoot Value
36.	Vin	24.1 V	System Information	Vin operating point
37.	Vin p-p	346.016 mV	System Information	Peak-to-peak input voltage
38.	Vout	14.4 V	System Information	Operational Output Voltage
39.	Vout Actual	14.359 V	System Information	Vout Actual calculated based on selected voltage divider resistors
40.	Vout Ripple requirement used for Cout calculations	1.0 %	System Information	Custom maximum output ripple requirement that was used for Cout selection(% of Vout).
41.	Vout Tolerance	2.545 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
42.	Vout p-p	13.035 mV	System Information	Peak-to-peak output ripple voltage
43.	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	4.0	Maximum Output Current
VinMax	24.1	Maximum input voltage
VinMin	23.9	Minimum input voltage
Vout	14.4	Output Voltage
base_pn	LMR51450FN	Base Product Number
source	DC	Input Source Type
Ta	45.0	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

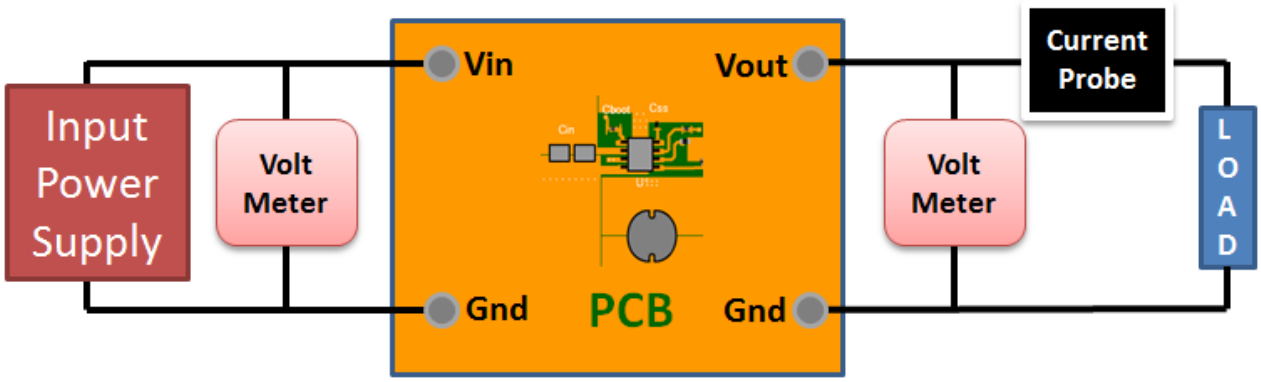
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 23.9V 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 : 4CFAC7BF9631D80D70757860491C8EE2[v1]
2. **LMR51450FN** Product Folder : http://www.ti.com/product/LMR51450 : contains the data sheet and other resources.