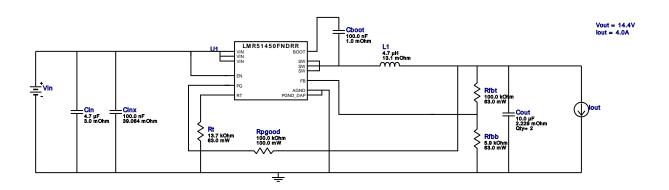
VinMin = 23.9V VinMax = 24.1V Vout = 14.4V Iout = 4.0A Device = LMR51450FNDRRR Topology = Buck Created = 2023-08-29 20:54:41.306 BOM Cost = \$2.25 BOM Count = 11 Total Pd = 4.97W

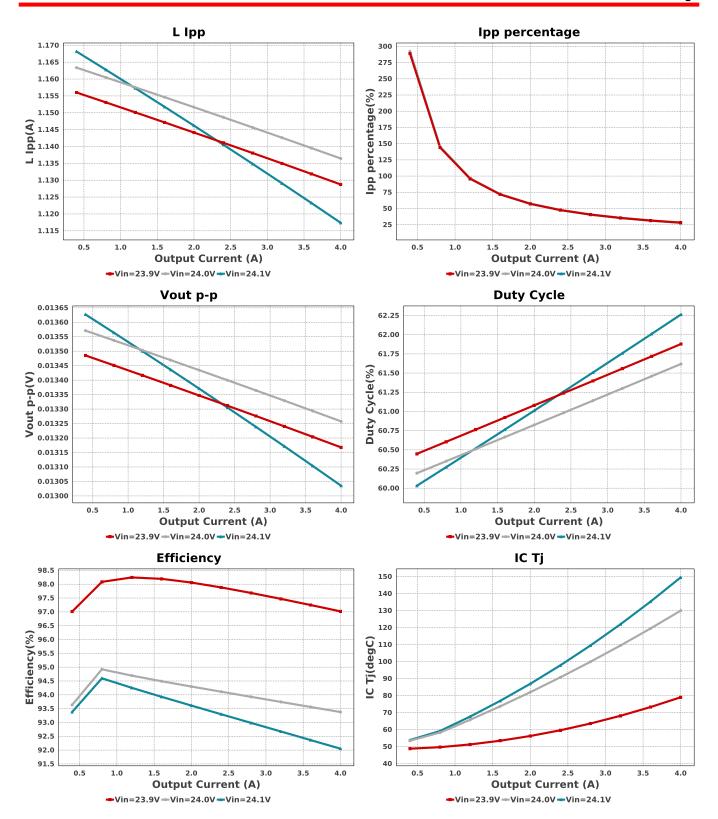
WEBENCH® Design Report

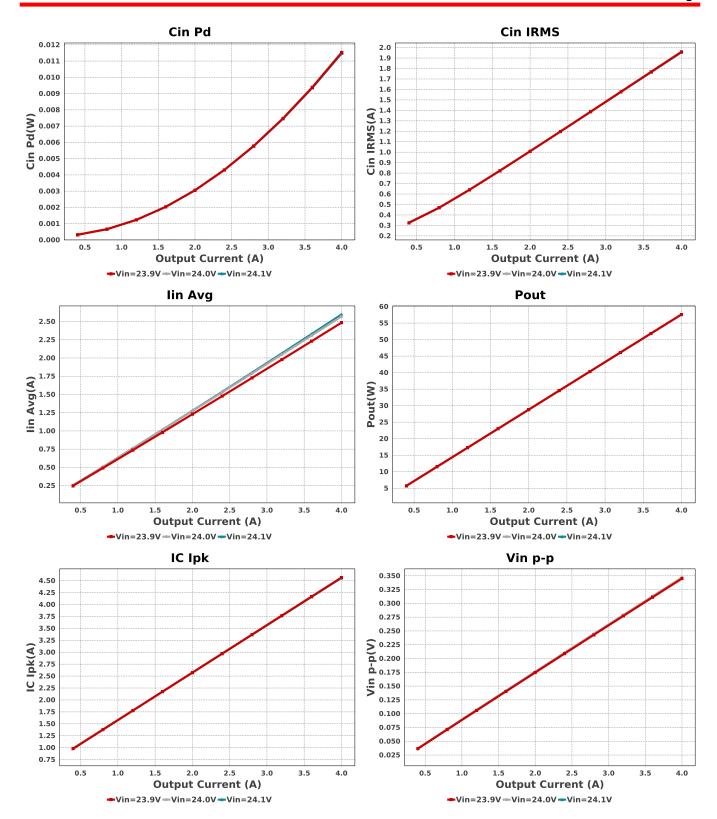
Design: 15 LMR51450FNDRRR LMR51450FNDRRR 23.9V-24.1V to 14.5V @ 4A

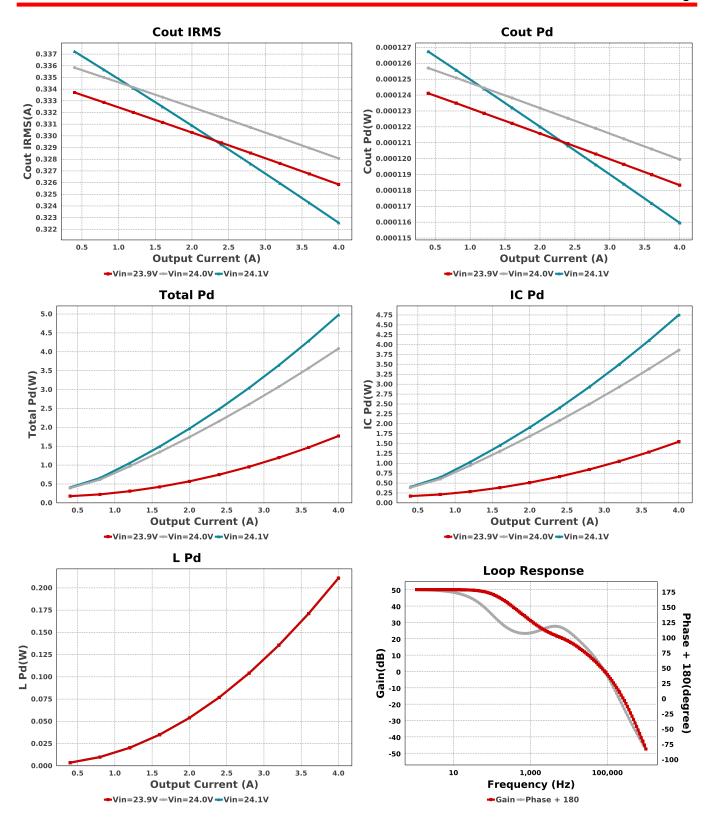


Electrical BOM

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 mm ²
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 mm ²
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 mm ²
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 mm ²
L1	Coilcraft	XAL6060-472MEB	L= 4.7 μH 13.1 mOhm	1	\$0.82	XAL6060 72 mm ²
Rfbb	Vishay-Dale	CRCW04025K90FKED Series= CRCWe3	Res= 5.9 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	0402 3 mm ²
Rfbt	Vishay-Dale	CRCW0402100KFKED Series= CRCWe3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	0402 3 mm ²
Rpgood	Vishay-Dale	CRCW0603100KFKEA Series= CRCWe3	Res= 100.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	\$0.01	0603 5 mm ²
Rt	Vishay-Dale	CRCW040213K7FKED Series= CRCWe3	Res= 13.7 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	0402 3 mm ²
U1	Texas Instruments	LMR51450FNDRRR	Switcher	1	\$0.90	DRR0012E 16 mm ²







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 lpk	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.	lin Avg	2.596 A	IC	Average input current

μ	Name	Value	Catagon	Description
# 11		Value 27.934 %	Category Inductor	Description Inductor ripple current percentage (with respect to average inductor
11.	Ipp percentage	21.934 %	mauctor	current)
	L lpp	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
	L Pd	210.96 mW	Power	Inductor power dissipation
18.	Total Pd	4.974 W	Power	Total Power Dissipation
19.	BOM Count	11	System	Total Design BOM count
			Information	
20.	Cross Freq	85.832 kHz	System	Bode plot crossover frequency
	5 . 6 .		Information	
21.	Duty Cycle	62.263 %	System Information	Duty cycle
22.	Efficiency	92.051 %	System	Steady state efficiency
22.	Linciency	92.031 /0	Information	Steady State emiciency
23.	FootPrint	140.0 mm ²	System	Total Foot Print Area of BOM components
		0.0 111111	Information	
24.	Frequency	1.052 MHz	System	Switching frequency
=	- 17	·	Information	○ - 11 - • 7
25.	Gain Marg	-12.447 dB	System	Bode Plot Gain Margin
_0.	···g		Information	
26.	Inductor ripple current	30.0 %	System	Custom Inductor ripple current (% of average inductor current)
_0.	requirement used for	00.0 70	Information	requirement used for Inductor selection
	Inductor selection		omation	
27.	lout	4.0 A	System	lout operating point
			Information	
28.	lout transient step used	d 2.0 A	System	Custom Transient current step requirement that was used for Cout
_0.	for Cout calculations		Information	selection (A).
29.	Low Freq Gain	50.07 dB	System	Gain at 1Hz
_0.			Information	
30.	Mode	CCM	System	Conduction Mode
		-	Information	
31.	Overshoot Value	63.905 mV	System	Theoretical Vout Overshoot Value
٠			Information	
32.	Phase Marg	44.401 deg	System	Bode Plot Phase Margin
J2.	acc mary		Information	2000 - 10t i iliado margin
33.	Pout	57.6 W	System	Total output power
50.	- ===		Information	- mark to the mark
34.	Total BOM	\$2.25	System	Total BOM Cost
٠			Information	
35.	Undershoot Value	169.813 mV	System	Theoretical Vout Undershoot Value
00.		. 55.5.5	Information	
36.	Vin	24.1 V	System	Vin operating point
00.			Information	
37.	Vin p-p	346.016 mV	System	Peak-to-peak input voltage
	· F F		Information	
38.	Vout	14.4 V	System	Operational Output Voltage
50.			Information	-
39.	Vout Actual	14.359 V	System	Vout Actual calculated based on selected voltage divider resistors
			Information	
40.	Vout Ripple	1.0 %	System	Custom maximum output ripple requirement that was used for Cout
.0.	requirement used for		Information	selection(% of Vout).
	Cout calculations			
41.	Vout Tolerance	2.545 %	System	Vout Tolerance based on IC Tolerance (no load) and voltage divider
	. 551 . 510141100	,0	Information	resistors if applicable
42.	Vout p-p	13.035 mV	System	Peak-to-peak output ripple voltage
-TL.	· out p p	10.000 1114	Information	1 San to pour output rippio voltago
43.	Vout transient	3.0 %	System	Custom Transient voltage change requirement that was used for Cout
10.	requirement used for	J.J /0	Information	selection (% of Vout).
	Cout calculations		omadon	Sold and the sold
	2 3 dt Galodiation io			

Design Inputs

Name	Value	Description
lout	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
Та	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

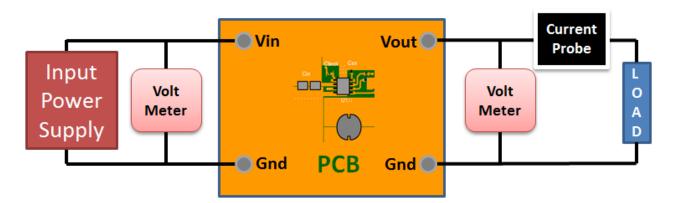
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins.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

Important Notice and Disclaimer

TI provides technical and reliability data (including datasheets), design resources (including reference designs), application or other design advice, web tools, safety information, and other resources AS IS and with all faults, and disclaims all warranties. These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

Providing these resources does not expand or otherwise alter TI's applicable Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with TI products.