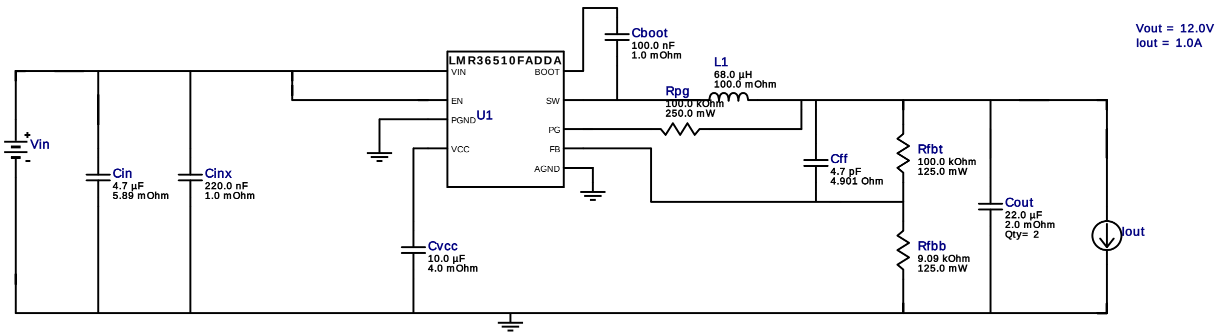
VinMin = 48.0V
VinMax = 51.6V
Vout = 12.0V
Iout = 1.0A

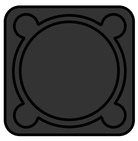
Device = LMR36510FADDAR
Topology = Buck
Created = 2024-10-18 18:34:43.617
BOM Cost = $2.55
BOM Count = 12
Total Pd = 0.85W

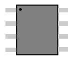
WEBENCH ® Design Report

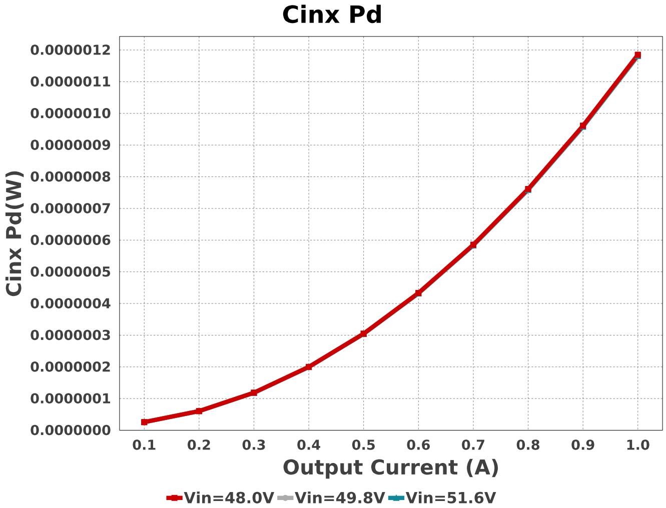
Design : 14 LMR36510FADDAR
LMR36510FADDAR **FINAL** ** FINAL** 48V-51.6V to 12.00V @ 1A

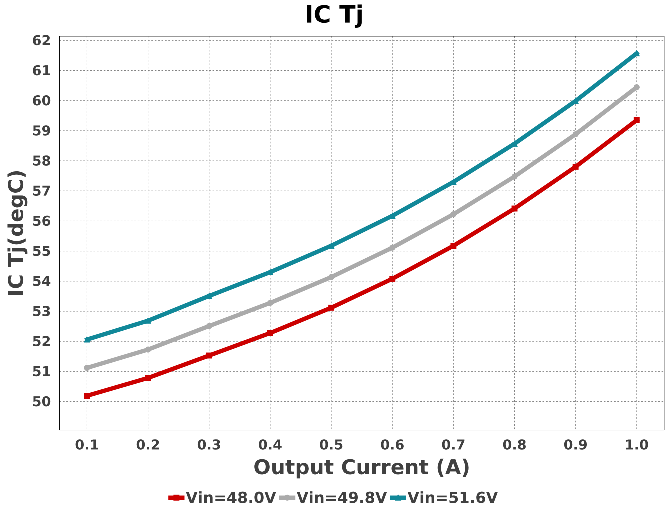


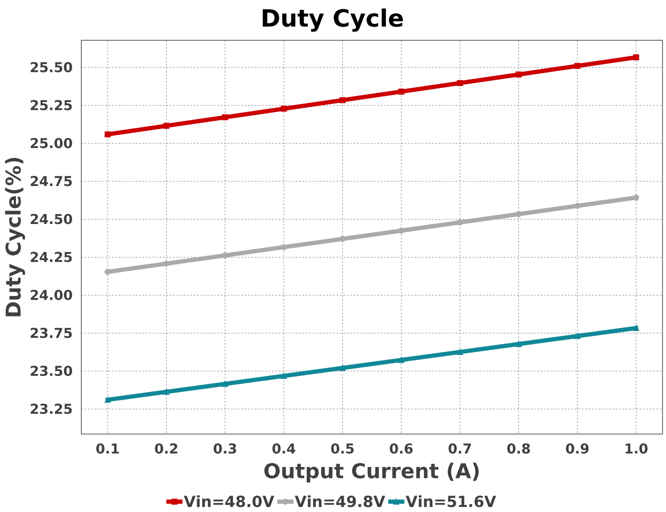
Electrical BOM

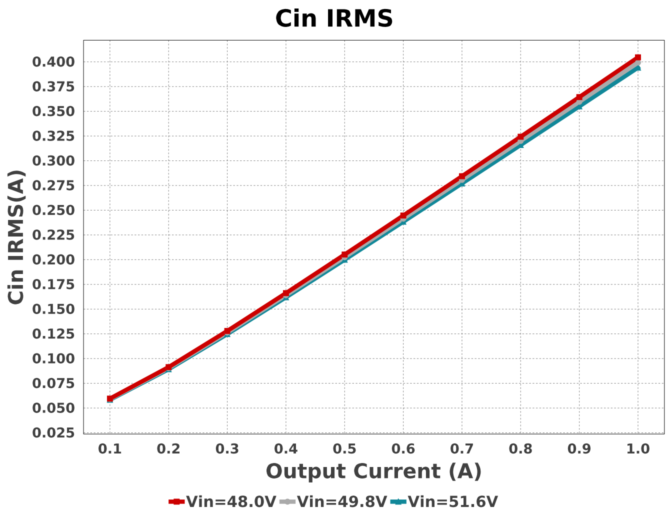
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	Yageo	CC0805KRX7R7BB104 Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2
Cff	AVX	12065A4R7CAT2A Series= C0G/NP0	Cap= 4.7 pF ESR= 4.901 Ohm VDC= 50.0 V IRMS= 0.0 A	1	$0.07	1206 11 mm^2
Cin	TDK	C3225X7S2A475M200AB Series= X7S	Cap= 4.7 uF ESR= 5.89 mOhm VDC= 100.0 V IRMS= 6.7739 A	1	$0.45	1210 15 mm^2
Cinx	MuRata	GRM31MR72A224KA01L Series= X7R	Cap= 220.0 nF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 0.0 A	1	$0.09	1206 11 mm^2
Cout	MuRata	GRM32ER61E226KE15L Series= X5R	Cap= 22.0 uF ESR= 2.0 mOhm VDC= 25.0 V IRMS= 3.67 A	2	$0.23	1210 15 mm^2
Cvcc	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
L1	Bourns	SRR1210-680M	L= 68.0 µH 100.0 mOhm	1	$0.64	 SRR1210 196 mm^2
Rfbb	Vishay-Dale	CRCW08059K09FKEA Series= CRCW..e3	Res= 9.09 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Rfbt	Vishay-Dale	CRCW0805100KFKEA Series= CRCW..e3	Res= 100.0 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Rpg	Vishay-Dale	CRCW1206100KFKEA Series= CRCW..e3	Res= 100.0 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm^2

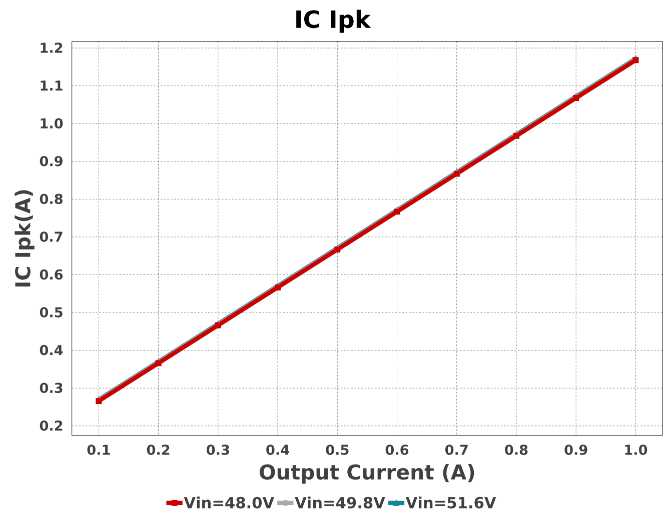
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
U1	Texas Instruments	LMR36510FADDAR	Switcher	1	$0.75	 DDA0008J 55 mm^2

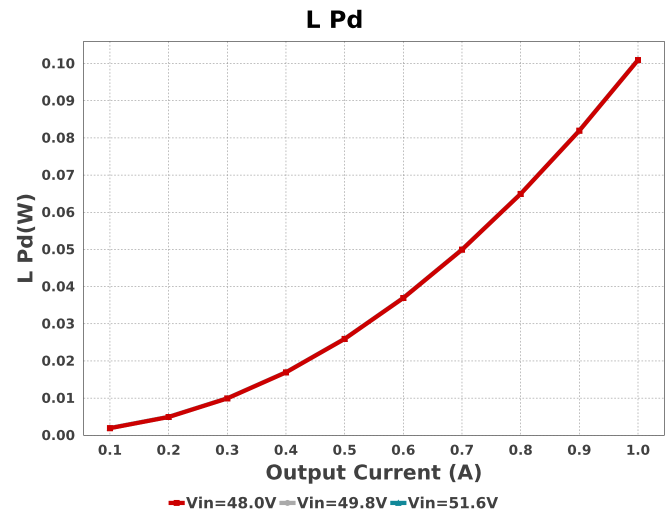




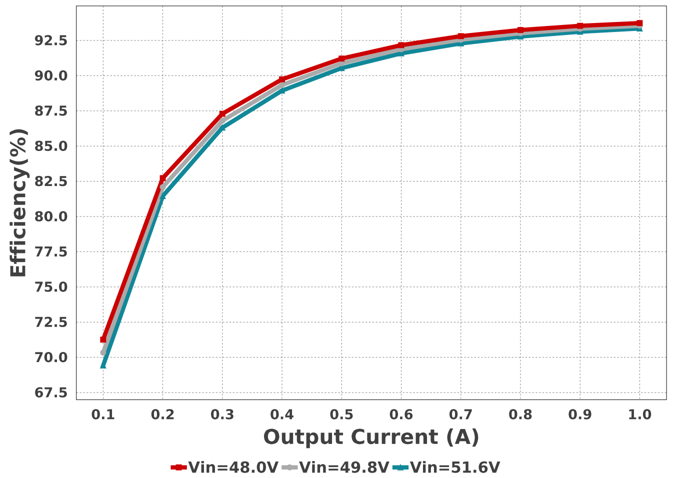




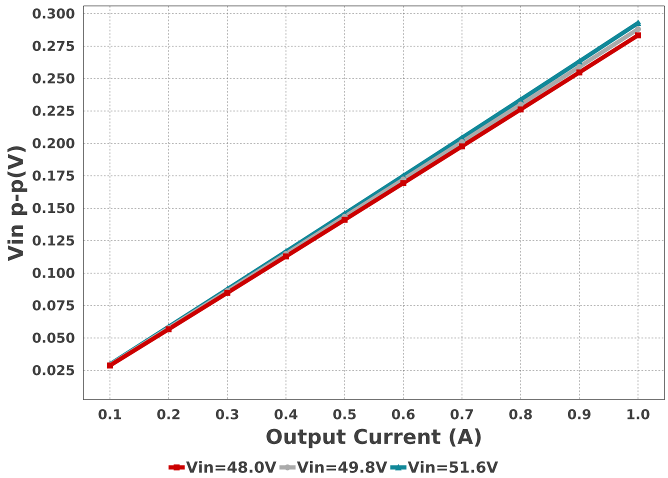




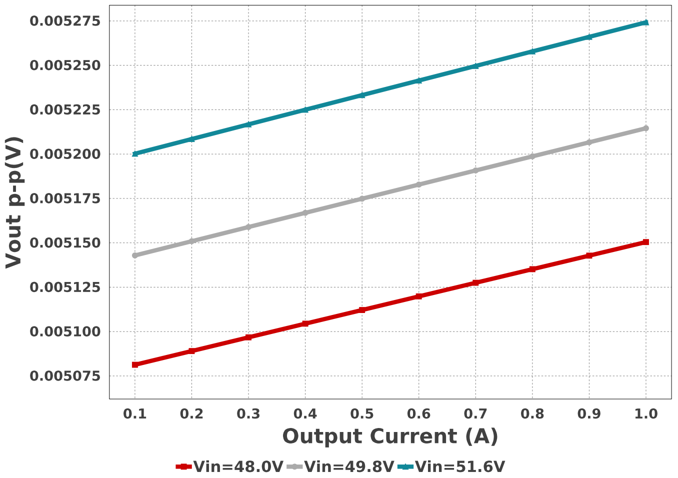
Efficiency



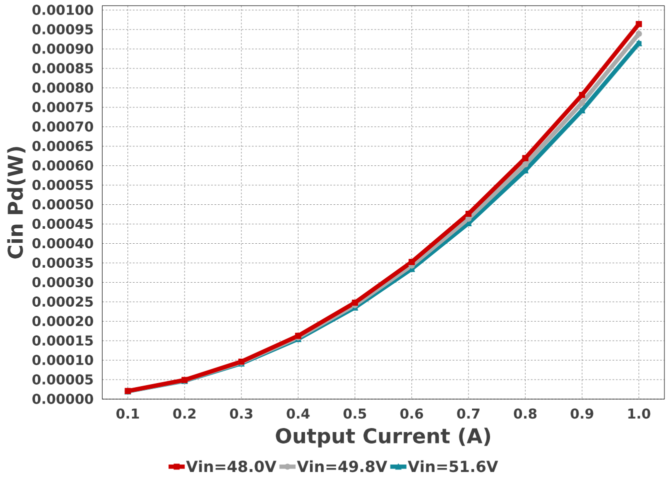
Vin p-p



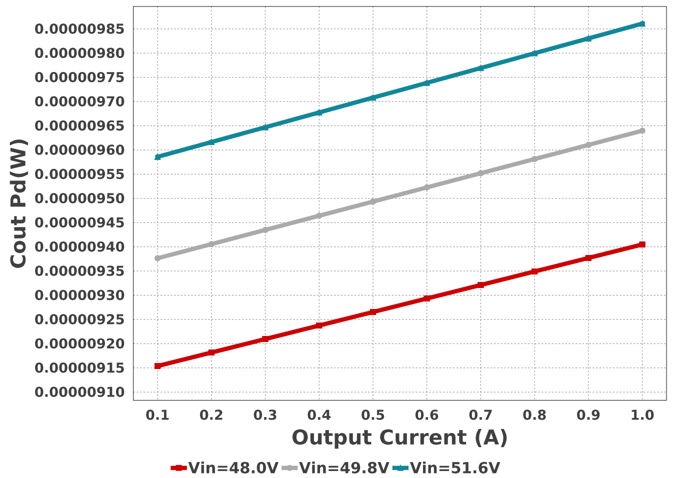
Vout p-p



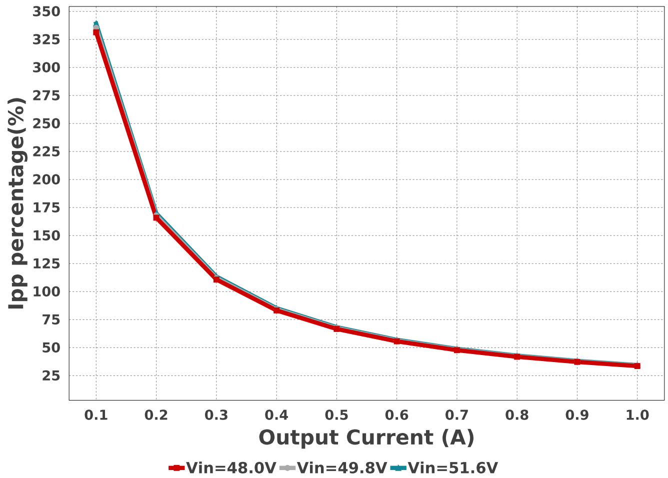
Cin Pd

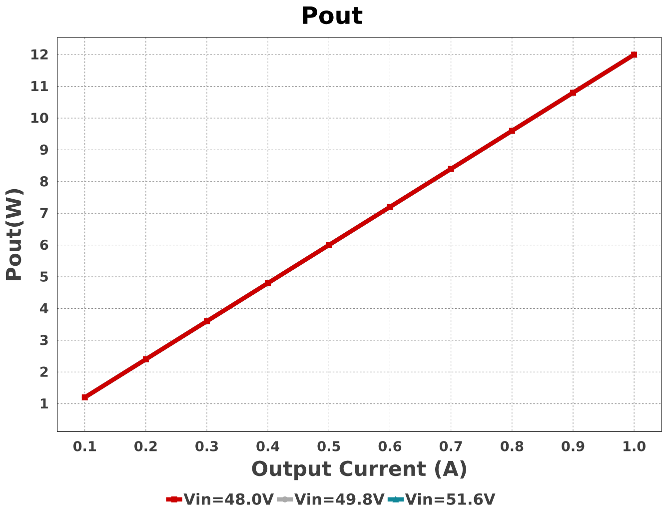


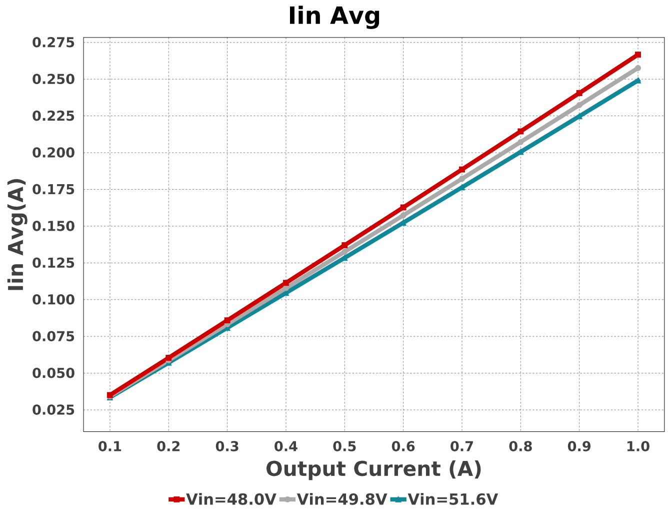
Cout Pd

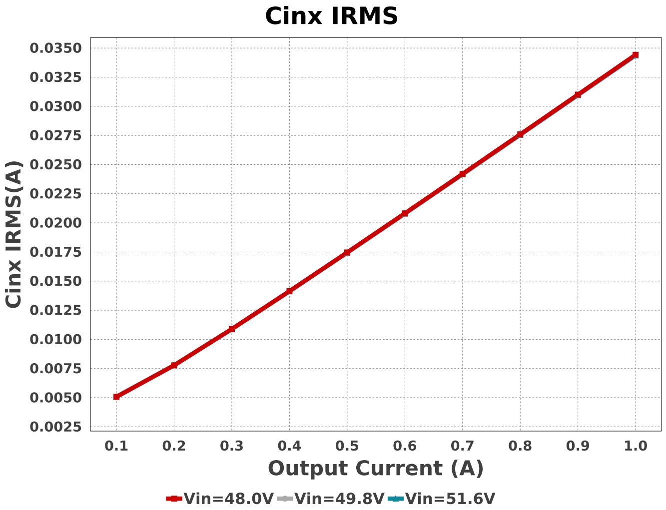


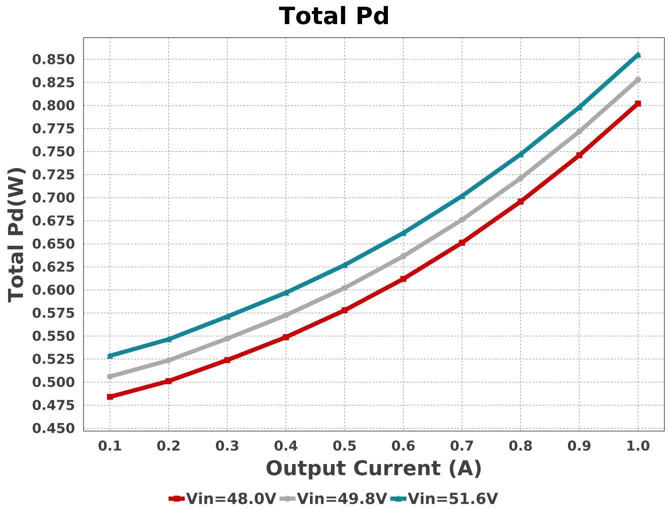
Ipp percentage

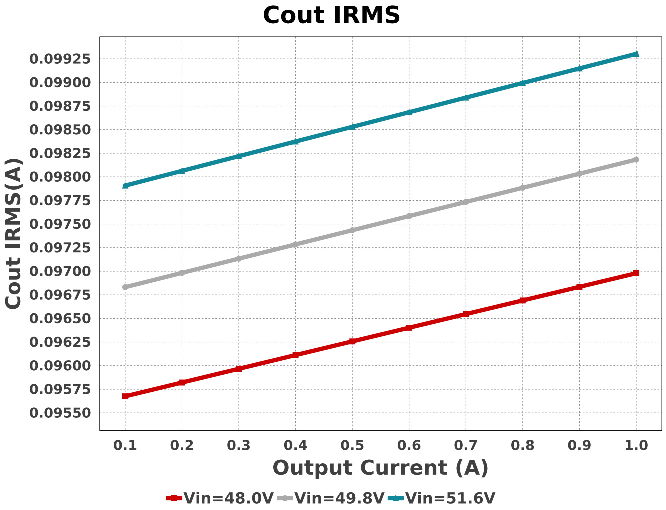


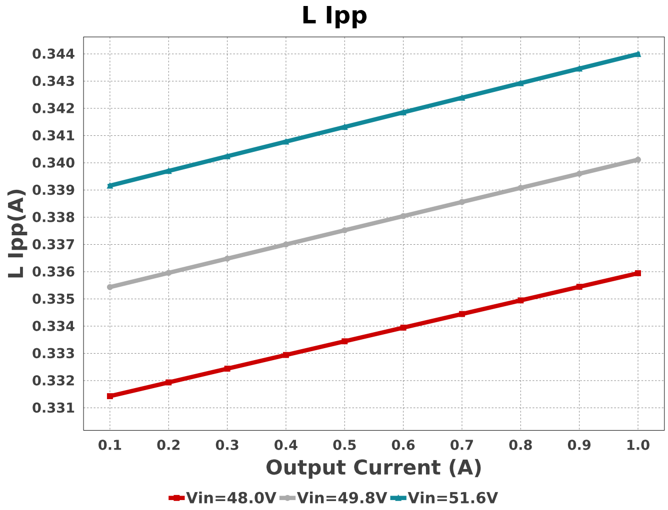

Pout
Pout(W)
12
11
10
9
8
7
6
5
4
3
2
1
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=48.0V
Vin=49.8V
Vin=51.6V

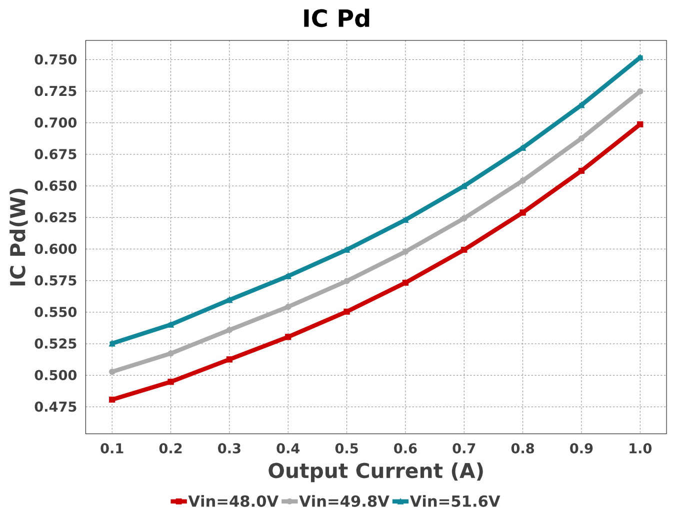

Iin Avg
Iin Avg(A)
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=48.0V
Vin=49.8V
Vin=51.6V

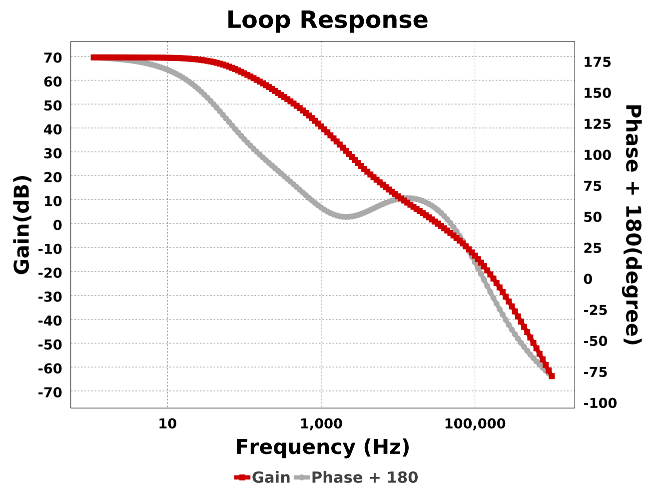

Cinx IRMS
Cinx IRMS(A)
0.0350
0.0325
0.0300
0.0275
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=48.0V
Vin=49.8V
Vin=51.6V


Total Pd
Total Pd(W)
0.850
0.825
0.800
0.775
0.750
0.725
0.700
0.675
0.650
0.625
0.600
0.575
0.550
0.525
0.500
0.475
0.450
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=48.0V
Vin=49.8V
Vin=51.6V


Cout IRMS
Cout IRMS(A)
0.09925
0.09900
0.09875
0.09850
0.09825
0.09800
0.09775
0.09750
0.09725
0.09700
0.09675
0.09650
0.09625
0.09600
0.09575
0.09550
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=48.0V
Vin=49.8V
Vin=51.6V


L Ipp
L Ipp(A)
0.344
0.343
0.342
0.341
0.340
0.339
0.338
0.337
0.336
0.335
0.334
0.333
0.332
0.331
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=48.0V
Vin=49.8V
Vin=51.6V





Operating Values

#	Name	Value	Category	Description
1.	BOM Count	12		Total Design BOM count
2.	Total BOM	$2.549		Total BOM Cost
3.	Cin IRMS	394.136 mA	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	914.97 µW	Capacitor	Input capacitor power dissipation
5.	Cinx IRMS	34.368 mA	Capacitor	Bulk capacitor RMS ripple current
6.	Cinx Pd	1.181 µW	Capacitor	Bulk capacitor power dissipation
7.	Cout IRMS	99.303 mA	Capacitor	Output capacitor RMS ripple current
8.	Cout Pd	9.861 µW	Capacitor	Output capacitor power dissipation
9.	IC Ipk	1.172 A	IC	Peak switch current in IC
10.	IC Pd	751.69 mW	IC	IC power dissipation
11.	IC Tj	61.571 degC	IC	IC junction temperature
12.	IC Tolerance	15.0 mV	IC	IC Feedback Tolerance
13.	ICThetaJA Effective	42.0 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
14.	Iin Avg	249.13 mA	IC	Average input current
15.	Ipp percentage	34.399 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
16.	L Ipp	343.995 mA	Inductor	Peak-to-peak inductor ripple current
17.	L Pd	100.99 mW	Inductor	Inductor power dissipation
18.	Cin Pd	914.97 µW	Power	Input capacitor power dissipation
19.	Cinx Pd	1.181 µW	Power	Bulk capacitor power dissipation
20.	Cout Pd	9.861 µW	Power	Output capacitor power dissipation
21.	IC Pd	751.69 mW	Power	IC power dissipation
22.	L Pd	100.99 mW	Power	Inductor power dissipation
23.	Total Pd	854.993 mW	Power	Total Power Dissipation
24.	Cross Freq	32.918 kHz	System Information	Bode plot crossover frequency
25.	Duty Cycle	23.784 %	System Information	Duty cycle
26.	Efficiency	93.349 %	System Information	Steady state efficiency
27.	FootPrint	355.0 mm^2	System Information	Total Foot Print Area of BOM components
28.	Frequency	400.0 kHz	System Information	Switching frequency
29.	Gain Marg	-17.683 dB	System Information	Bode Plot Gain Margin
30.	Iout	1.0 A	System Information	Iout operating point
31.	Low Freq Gain	69.523 dB	System Information	Gain at 1Hz
32.	Mode	FCCM	System Information	Conduction Mode
33.	Phase Marg	55.648 deg	System Information	Bode Plot Phase Margin
34.	Pout	12.0 W	System Information	Total output power
35.	Vin	51.6 V	System Information	Vin operating point
36.	Vin p-p	292.809 mV	System Information	Peak-to-peak input voltage
37.	Vout	12.0 V	System Information	Operational Output Voltage

#	Name	Value	Category	Description
38.	Vout Actual	12.001 V	System Information	Vout Actual calculated based on selected voltage divider resistors
39.	Vout Tolerance	3.38 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
40.	Vout p-p	5.274 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	1.0	Maximum Output Current
VinMax	51.6	Maximum input voltage
VinMin	48.0	Minimum input voltage
Vout	12.0	Output Voltage
base_pn	LMR36510FA	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

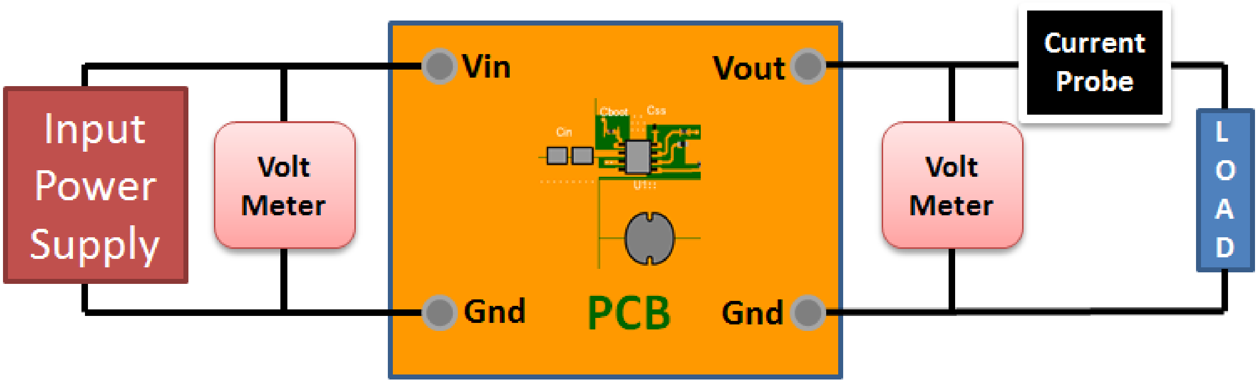
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 48.0V 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 : 8D46410E296FCE97B33F99C6313555A5[v1]

2. **LMR36510FA** Product Folder : http://www.ti.com/product/LMR36510 : contains the data sheet and other resources.