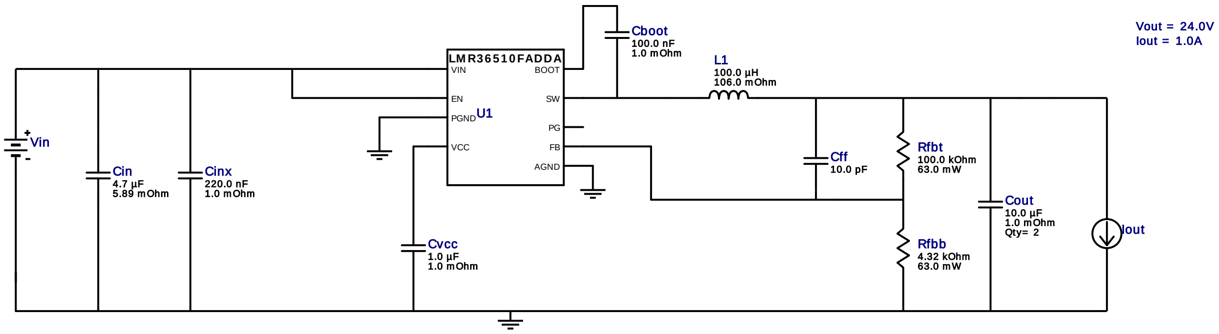
VinMin = 36.0V
VinMax = 56.0V
Vout = 24.0V
Iout = 1.0A

Device = LMR36510FADDAR
Topology = Buck
Created = 2024-01-22 12:56:46.177
BOM Cost = $2.68
BOM Count = 11
Total Pd = 0.93W

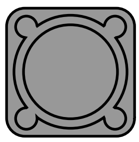
WEBENCH ® Design Report

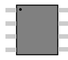
Design : 653 LMR36510FADDAR
LMR36510FADDAR 36V-56V to 24.00V @ 1A

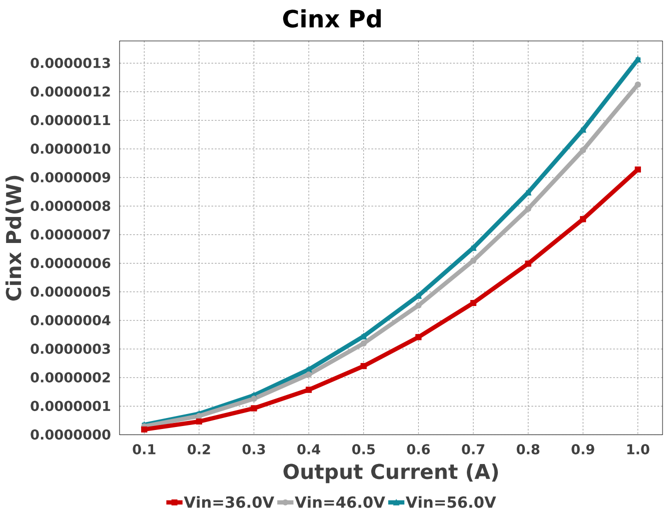


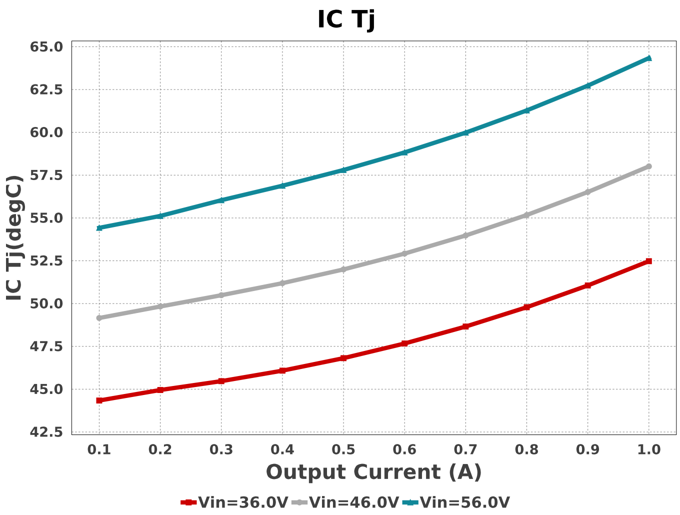
Electrical BOM

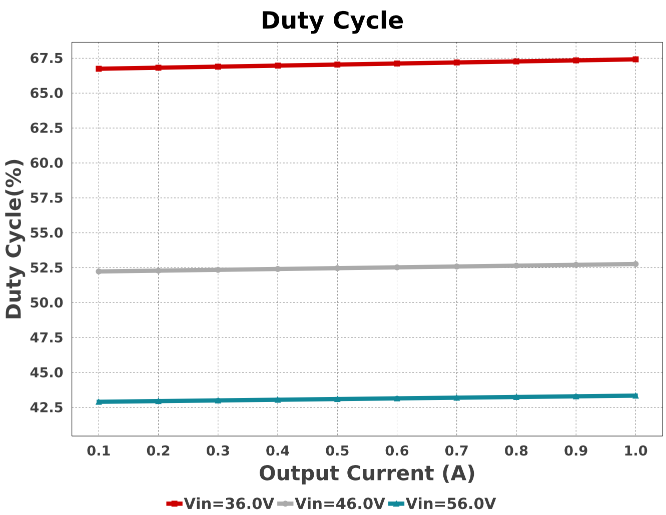
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM155R71A104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cff	Yageo	CC0805JRNPO9BN100 Series= C0G/NP0	Cap= 10.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Cin	TDK	C3225X7S2A475M200AB 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	GRM21AR72A224KAC5L Series= X7R	Cap= 220.0 nF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 0.0 A	1	$0.08	0805 7 mm^2
Cout	TDK	C3225X7R1H106M250AC Series= X7R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 5.0 A	2	$0.27	1210 15 mm^2
Cvcc	Taiyo Yuden	EMK107B7105KA-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2
L1	Coilcraft	MSS1210-104KEB	L= 100.0 µH 106.0 mOhm	1	$0.81	MSS1210 204 mm^2
Rfbb	Vishay-Dale	CRCW04024K32FKED Series= CRCW..e3	Res= 4.32 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2

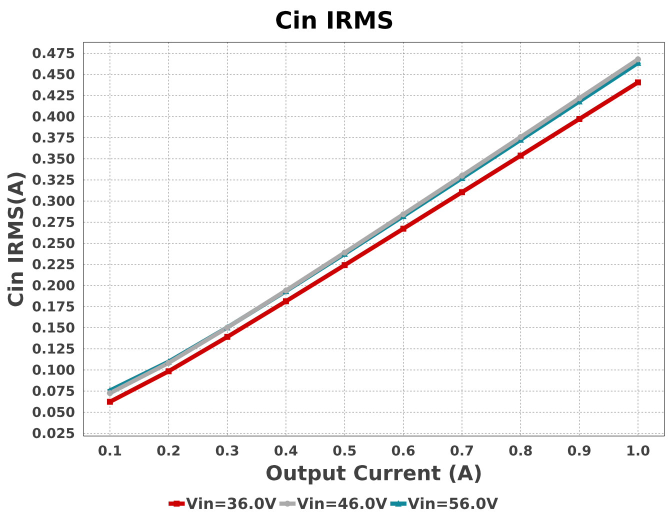


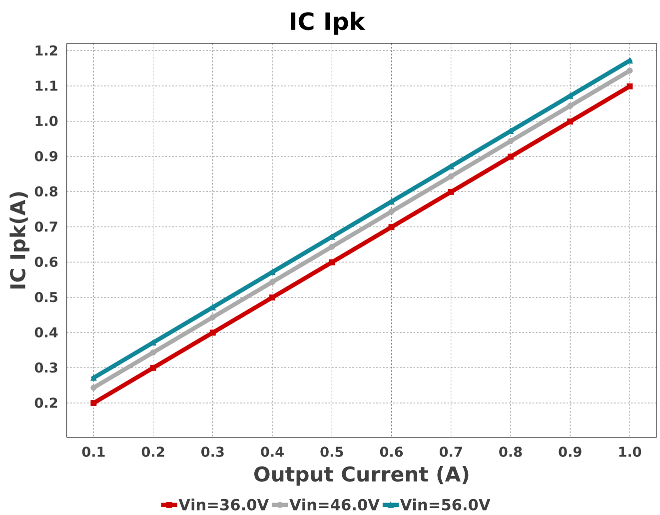
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
U1	Texas Instruments	LMR36510FADDAR	Switcher	1	$0.75	 DDA0008J 55 mm^2

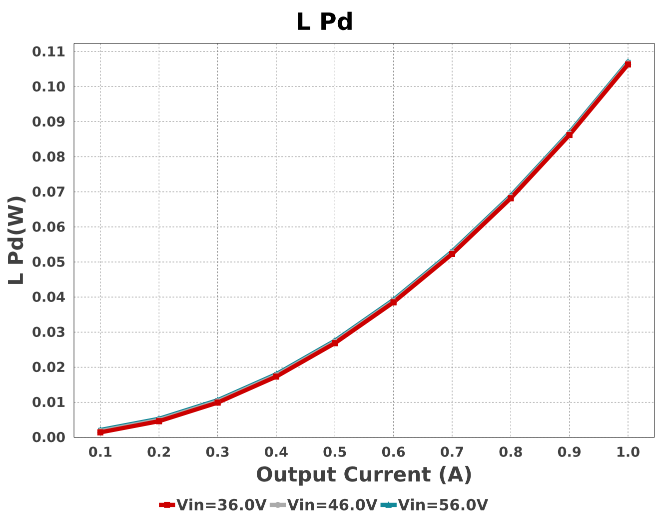


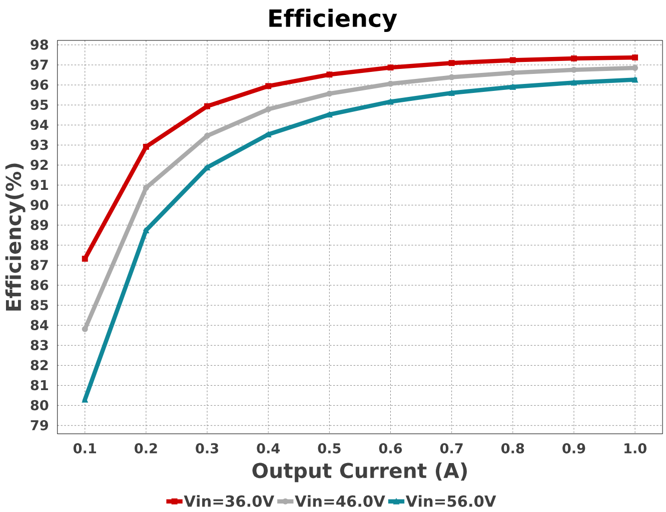


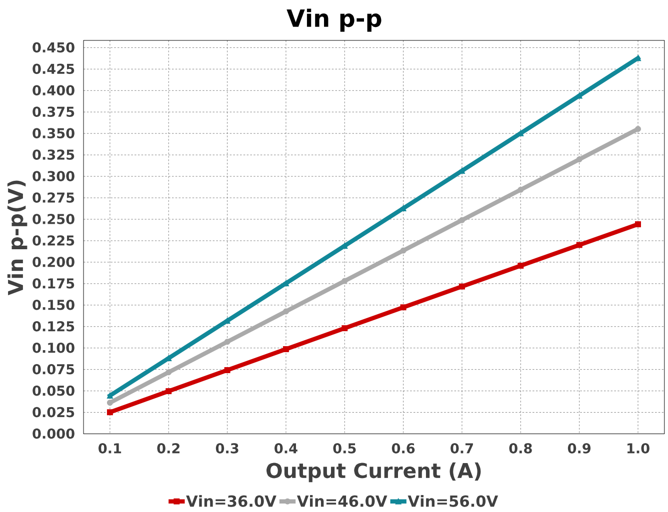


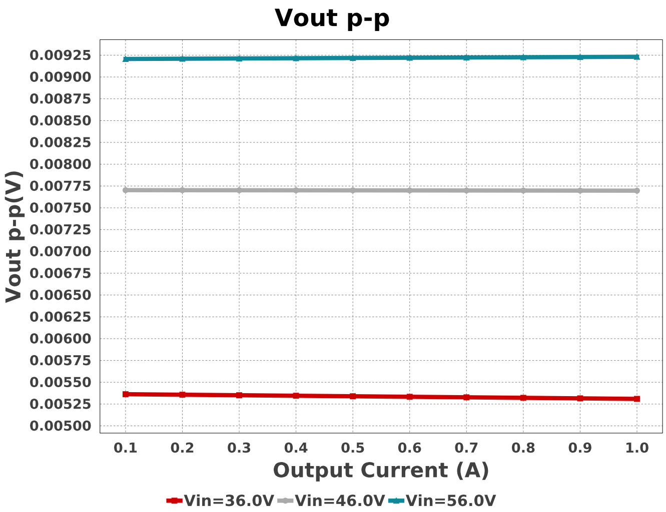


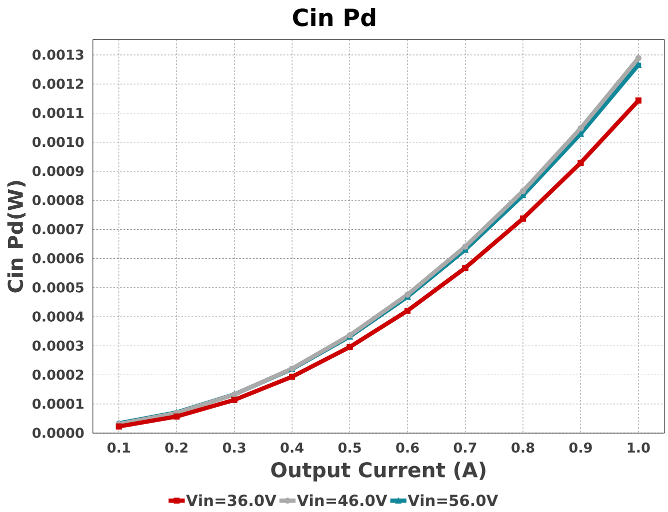


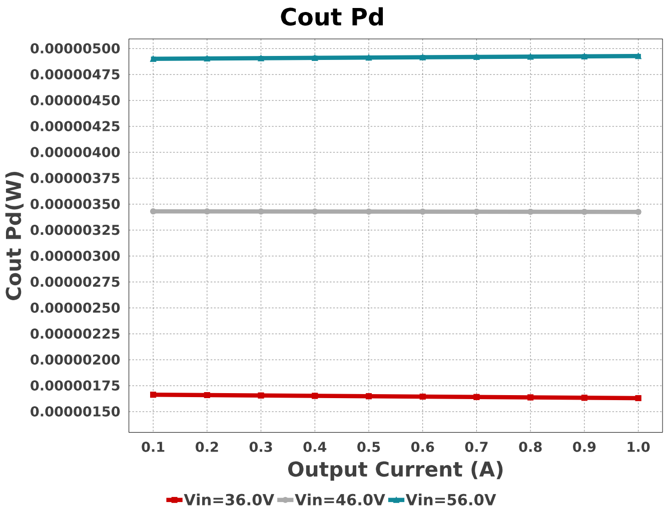


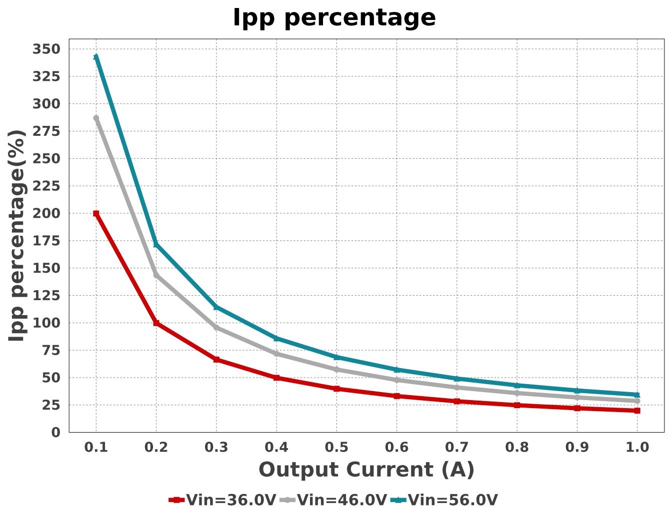

Efficiency
Efficiency(%)
Output Current (A)
Vin=36.0V Vin=46.0V Vin=56.0V

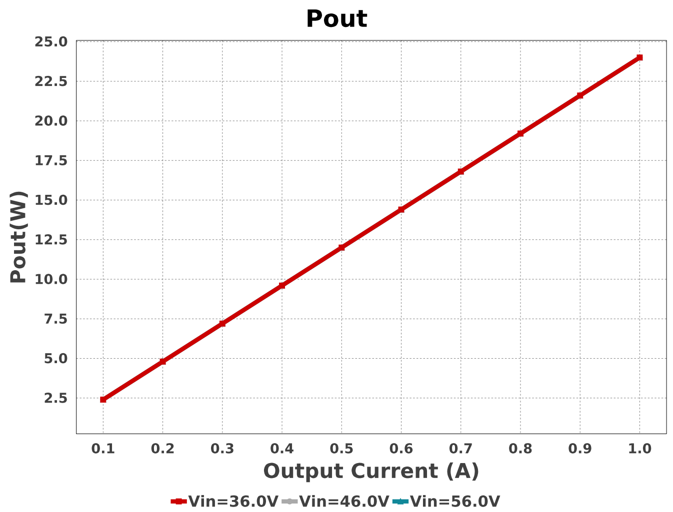

Vin p-p
Vin p-p(V)
Output Current (A)
Vin=36.0V Vin=46.0V Vin=56.0V

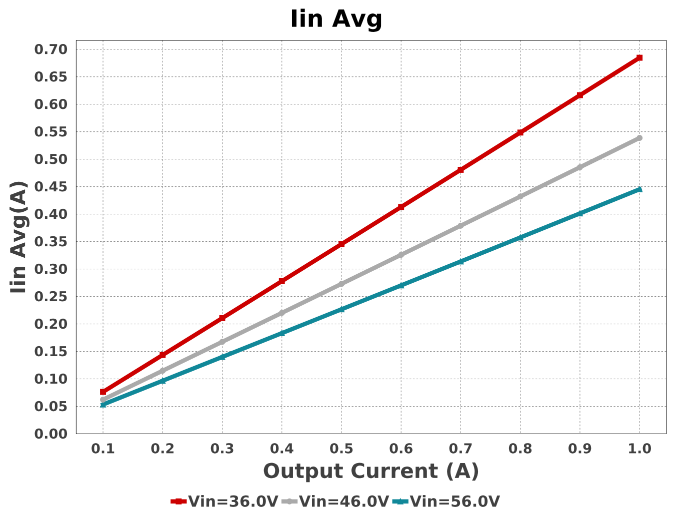

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=36.0V Vin=46.0V Vin=56.0V

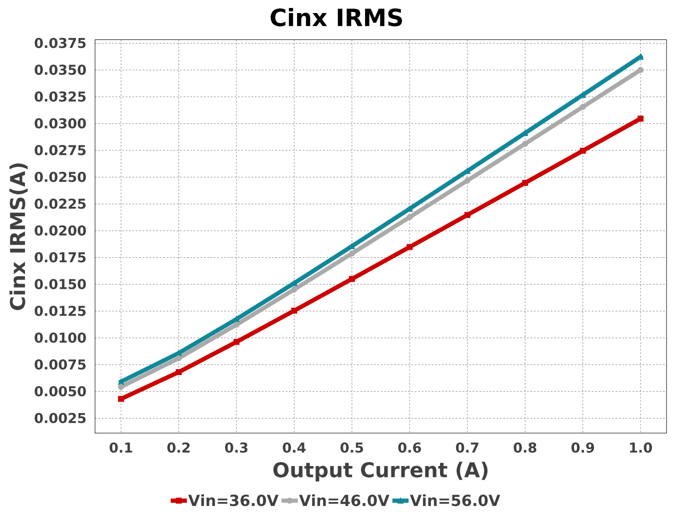

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=36.0V Vin=46.0V Vin=56.0V

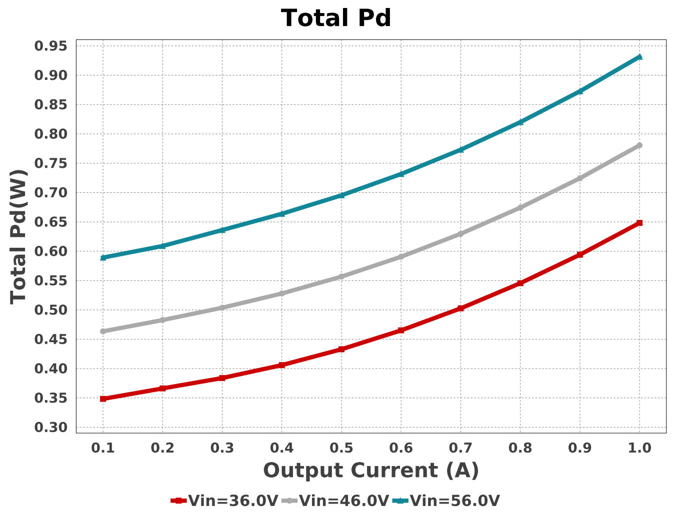

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=36.0V Vin=46.0V Vin=56.0V

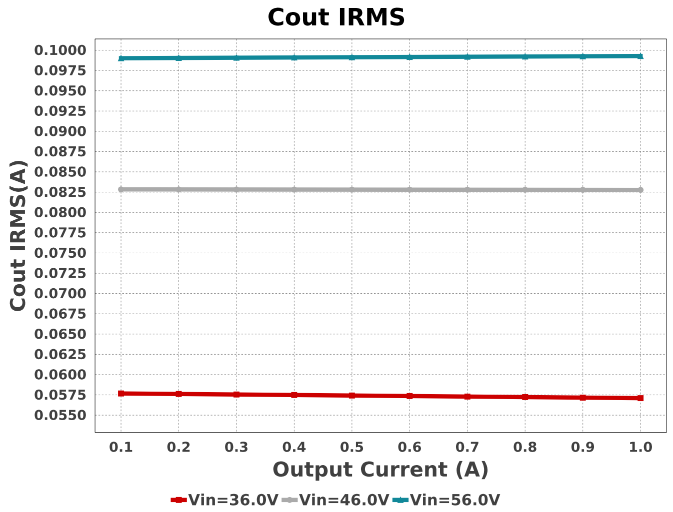

Ipp percentage
Ipp percentage(%)
Output Current (A)
Vin=36.0V Vin=46.0V Vin=56.0V

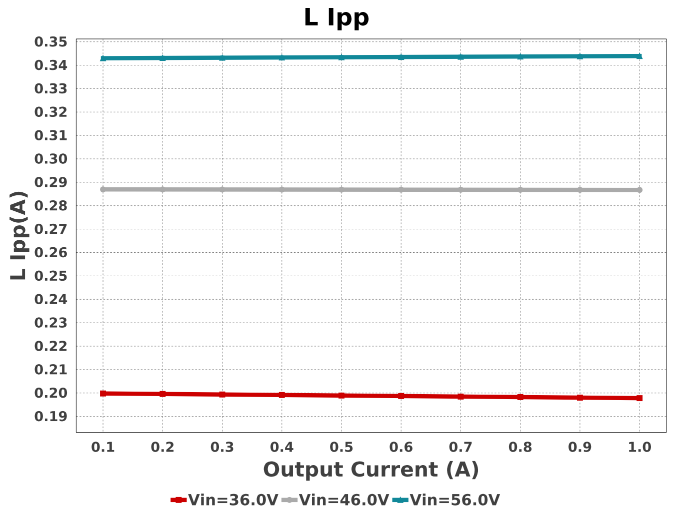

Pout
Pout(W)
Output Current (A)
Vin=36.0V Vin=46.0V Vin=56.0V

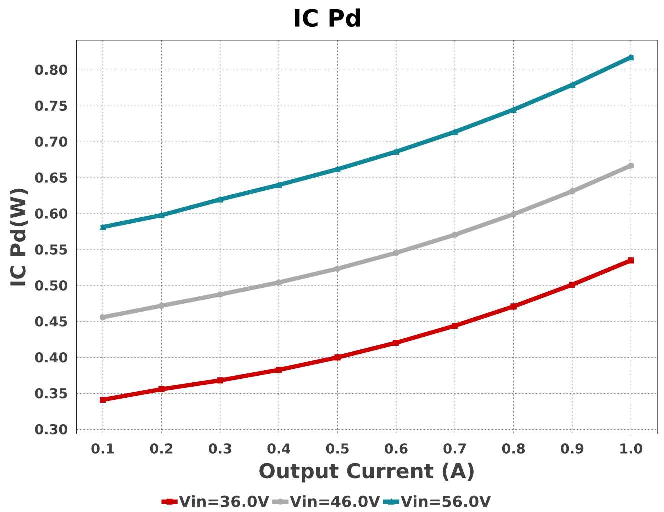

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=36.0V Vin=46.0V Vin=56.0V

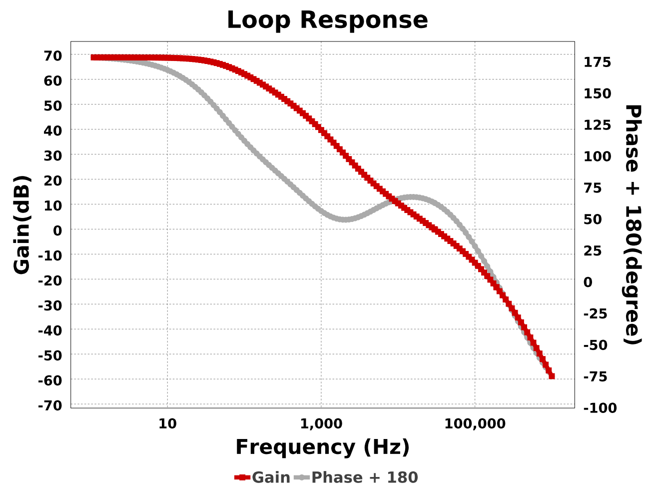

Cinx IRMS
Cinx IRMS(A)
Output Current (A)
Vin=36.0V Vin=46.0V Vin=56.0V


Total Pd
Total Pd(W)
Output Current (A)
Vin=36.0V Vin=46.0V Vin=56.0V


Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=36.0V Vin=46.0V Vin=56.0V


L Ipp
L Ipp(A)
Output Current (A)
Vin=36.0V Vin=46.0V Vin=56.0V





Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	463.613 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	1.266 mW	Capacitor	Input capacitor power dissipation
3.	Cinx IRMS	36.235 mA	Capacitor	Bulk capacitor RMS ripple current
4.	Cinx Pd	1.313 µW	Capacitor	Bulk capacitor power dissipation
5.	Cout IRMS	99.279 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	4.928 µW	Capacitor	Output capacitor power dissipation
7.	IC Ipk	1.172 A	IC	Peak switch current in IC
8.	IC Pd	817.59 mW	IC	IC power dissipation
9.	IC Tj	64.339 degC	IC	IC junction temperature
10.	IC Tolerance	15.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA Effective	42.0 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
12.	Iin Avg	445.2 mA	IC	Average input current
13.	Ipp percentage	34.391 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
14.	L Ipp	343.91 mA	Inductor	Peak-to-peak inductor ripple current
15.	L Pd	107.04 mW	Inductor	Inductor power dissipation
16.	Cin Pd	1.266 mW	Power	Input capacitor power dissipation
17.	Cinx Pd	1.313 µW	Power	Bulk capacitor power dissipation
18.	Cout Pd	4.928 µW	Power	Output capacitor power dissipation
19.	IC Pd	817.59 mW	Power	IC power dissipation
20.	L Pd	107.04 mW	Power	Inductor power dissipation
21.	Total Pd	931.43 mW	Power	Total Power Dissipation
22.	BOM Count	11	System Information	Total Design BOM count
23.	Cross Freq	29.729 kHz	System Information	Bode plot crossover frequency
24.	Duty Cycle	43.348 %	System Information	Duty cycle
25.	Efficiency	96.264 %	System Information	Steady state efficiency
26.	FootPrint	331.0 mm^2	System Information	Total Foot Print Area of BOM components
27.	Frequency	400.0 kHz	System Information	Switching frequency
28.	Gain Marg	-23.213 dB	System Information	Bode Plot Gain Margin
29.	Iout	1.0 A	System Information	Iout operating point
30.	Low Freq Gain	68.759 dB	System Information	Gain at 1Hz
31.	Mode	FCCM	System Information	Conduction Mode
32.	Phase Marg	63.155 deg	System Information	Bode Plot Phase Margin
33.	Pout	24.0 W	System Information	Total output power
34.	Total BOM	$2.68	System Information	Total BOM Cost
35.	Vin	56.0 V	System Information	Vin operating point
36.	Vin p-p	437.793 mV	System Information	Peak-to-peak input voltage

#	Name	Value	Category	Description
37.	Vout	24.0 V	System Information	Operational Output Voltage
38.	Vout Actual	24.148 V	System Information	Vout Actual calculated based on selected voltage divider resistors
39.	Vout Tolerance	3.466 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
40.	Vout p-p	9.232 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	1.0	Maximum Output Current
VinMax	56.0	Maximum input voltage
VinMin	36.0	Minimum input voltage
Vout	24.0	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

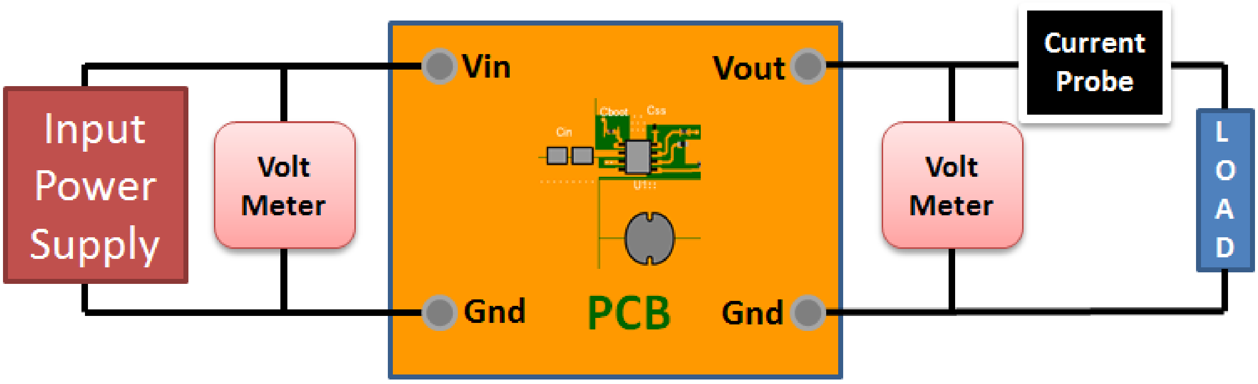
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 36.0V 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 : 40EE3F1E021441DB[v1]

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

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