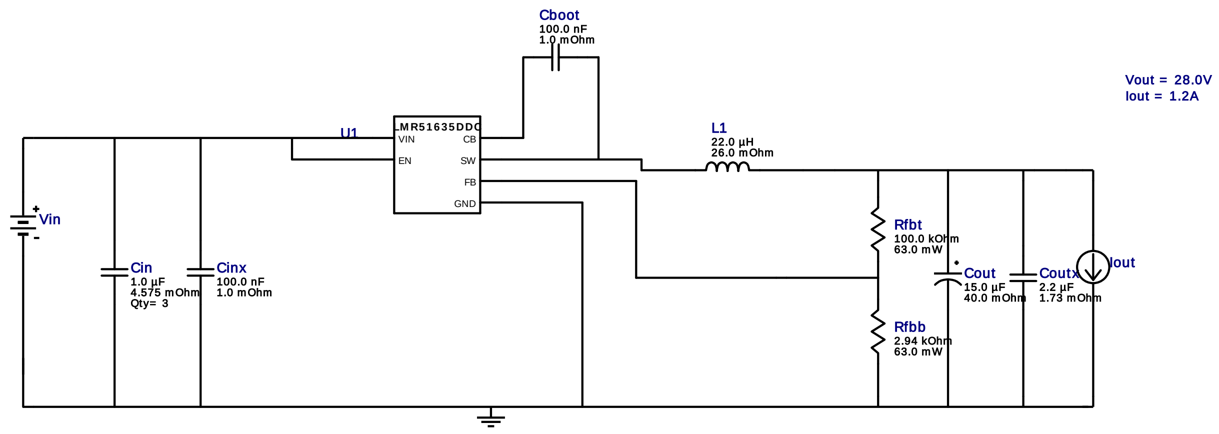
VinMin = 48.0V
VinMax = 48.0V
Vout = 28.0V
Iout = 1.2A

Device = LMR51635DDC
Topology = Buck
Created = 2025-06-05 01:32:35.652
BOM Cost = $4.07
BOM Count = 11
Total Pd = 0.46W

WEBENCH ® Design Report

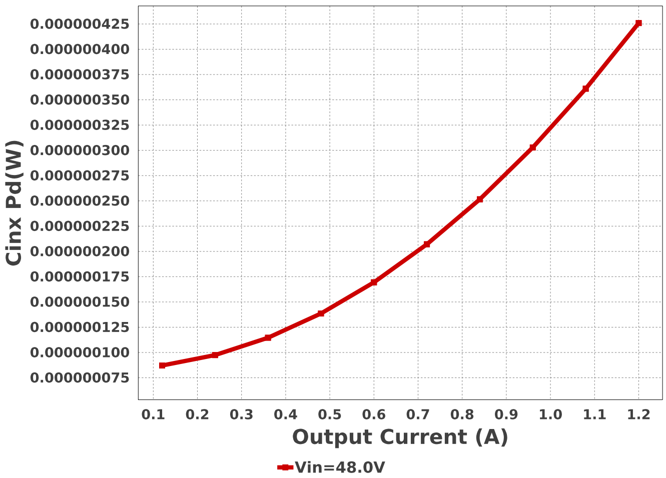
Design : 324 LMR51635DDC
LMR51635DDC 48V-48V to 28.00V @ 1.2A



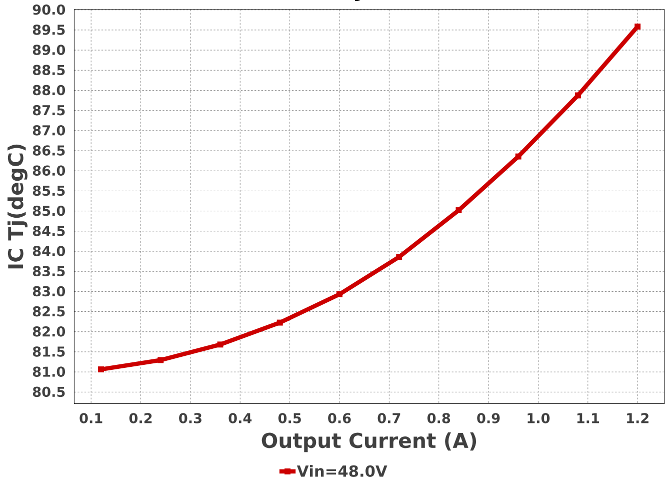
Electrical BOM

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	TDK	C3216X7R2A105K160AA Series= X7R	Cap= 1.0 uF ESR= 4.575 mOhm VDC= 100.0 V IRMS= 3.39639 A	3	$0.11	1206_180 11 mm^2
Cinx	MuRata	GRM188R72A104KA35D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 3.85 A	1	$0.04	0603 5 mm^2
Cout	Panasonic	100SXV15M Series= SXV	Cap= 15.0 uF ESR= 40.0 mOhm VDC= 100.0 V IRMS= 2.35 A	1	$1.95	CAPSMT_62_E12 106 mm^2
Coutx	TDK	C3225X5R2A225K230AB Series= X5R	Cap= 2.2 uF ESR= 1.73 mOhm VDC= 100.0 V IRMS= 5.5932 A	1	$0.21	1210_250 15 mm^2
L1	Coilcraft	MSS1210-223MEB	L= 22.0 µH 26.0 mOhm	1	$0.81	MSS1210 204 mm^2
Rfbb	Vishay-Dale	CRCW04022K94FKED Series= CRCW..e3	Res= 2.94 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
U1	Texas Instruments	LMR51635DDC	Switcher	1	$0.70	DDC0006A 10 mm^2

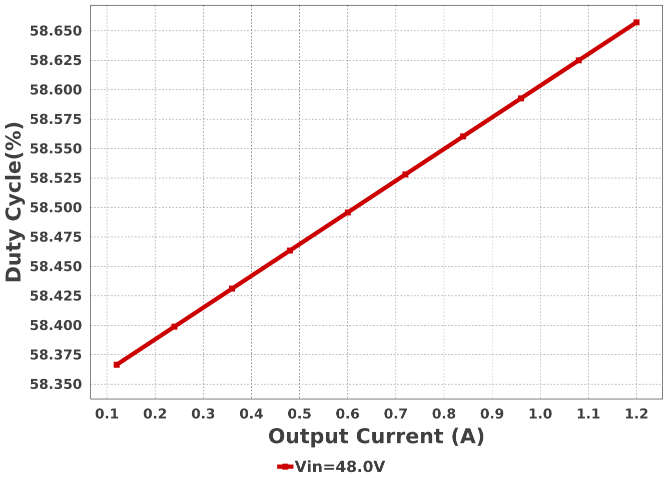
Cinx Pd



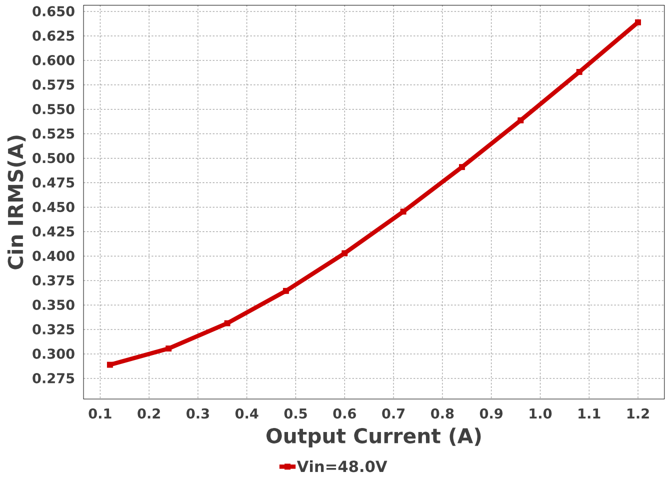
IC Tj



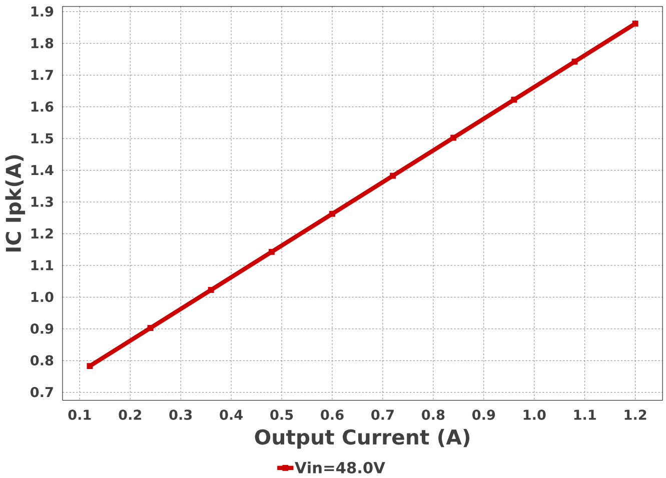
Duty Cycle



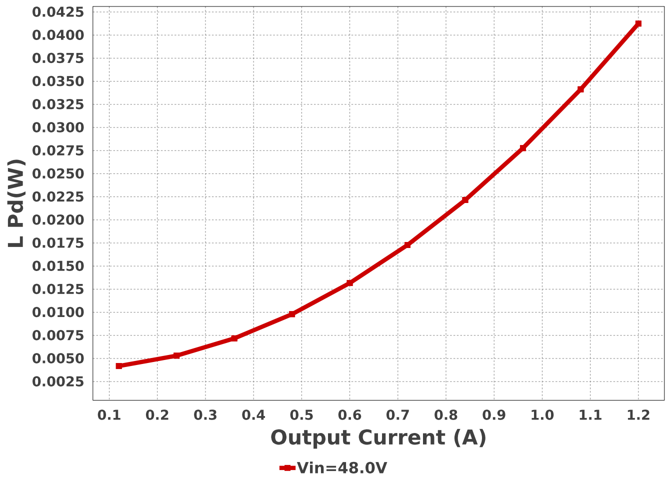
Cin IRMS

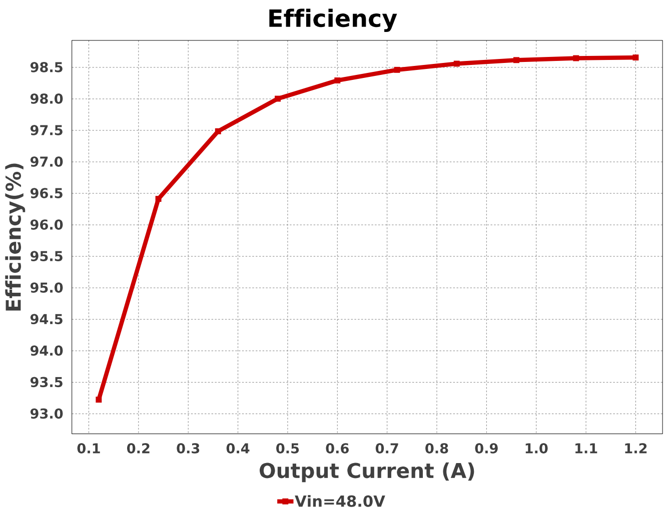


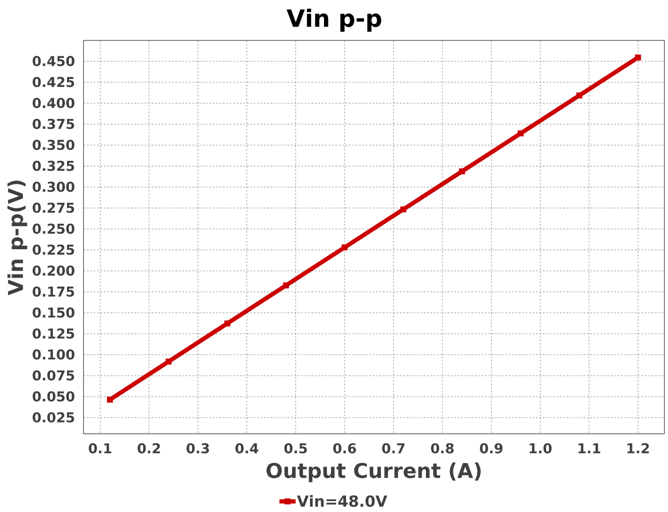
IC Ipk

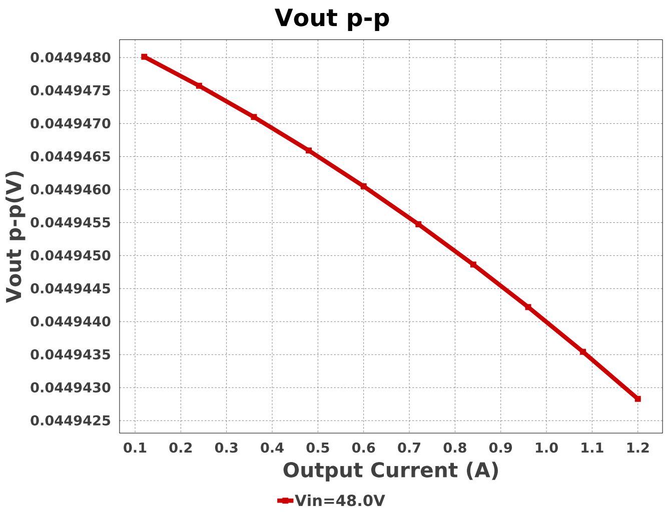


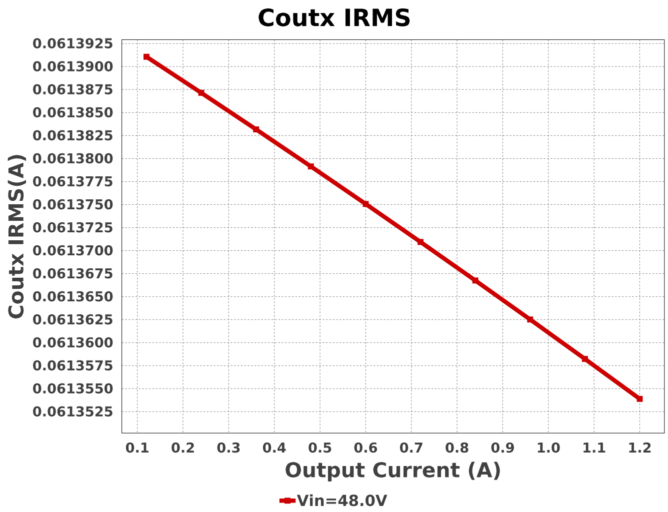
L Pd

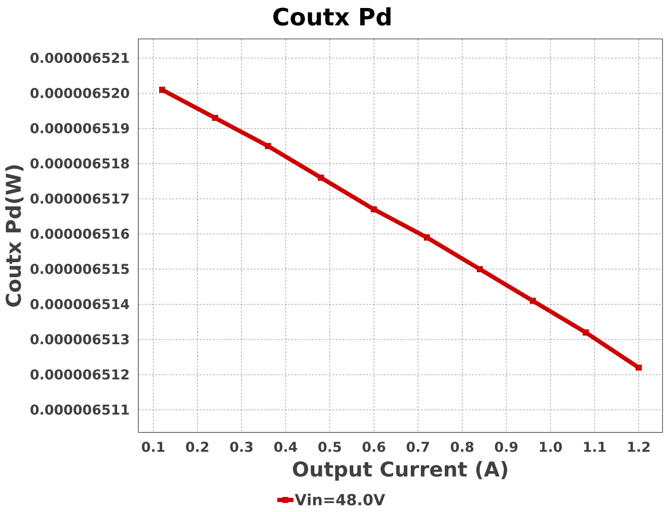


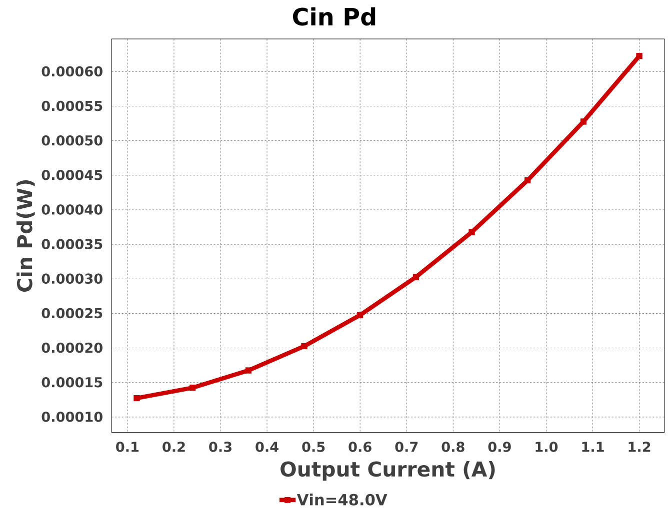

Efficiency
Efficiency(%)
98.5
98.0
97.5
97.0
96.5
96.0
95.5
95.0
94.5
94.0
93.5
93.0
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin=48.0V


Vin p-p
Vin p-p(V)
0.450
0.425
0.400
0.375
0.350
0.325
0.300
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 1.1 1.2
Output Current (A)
Vin=48.0V

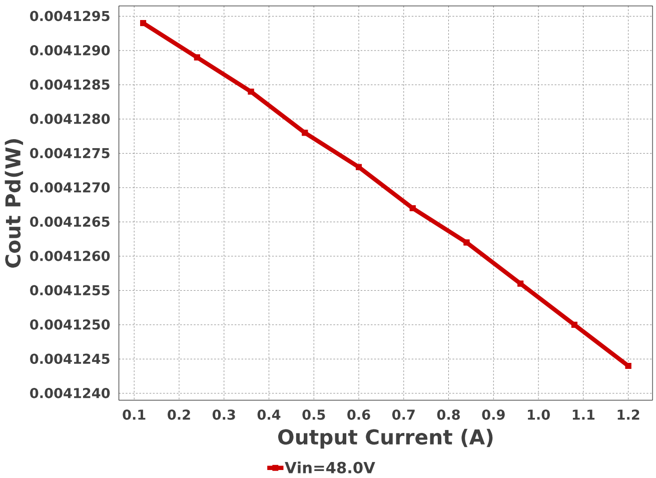

Vout p-p
Vout p-p(V)
0.0449480
0.0449475
0.0449470
0.0449465
0.0449460
0.0449455
0.0449450
0.0449445
0.0449440
0.0449435
0.0449430
0.0449425
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin=48.0V


Coutx IRMS
Coutx IRMS(A)
0.0613925
0.0613900
0.0613875
0.0613850
0.0613825
0.0613800
0.0613775
0.0613750
0.0613725
0.0613700
0.0613675
0.0613650
0.0613625
0.0613600
0.0613575
0.0613550
0.0613525
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin=48.0V

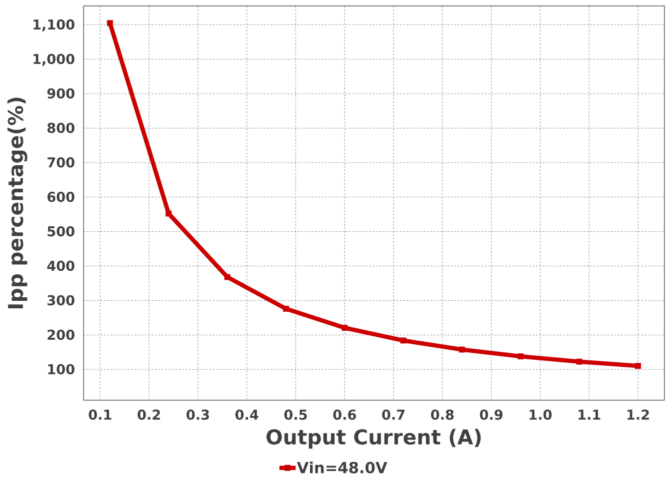

Coutx Pd
Coutx Pd(W)
0.000006521
0.000006520
0.000006519
0.000006518
0.000006517
0.000006516
0.000006515
0.000006514
0.000006513
0.000006512
0.000006511
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin=48.0V


Cin Pd
Cin Pd(W)
0.00060
0.00055
0.00050
0.00045
0.00040
0.00035
0.00030
0.00025
0.00020
0.00015
0.00010
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin=48.0V

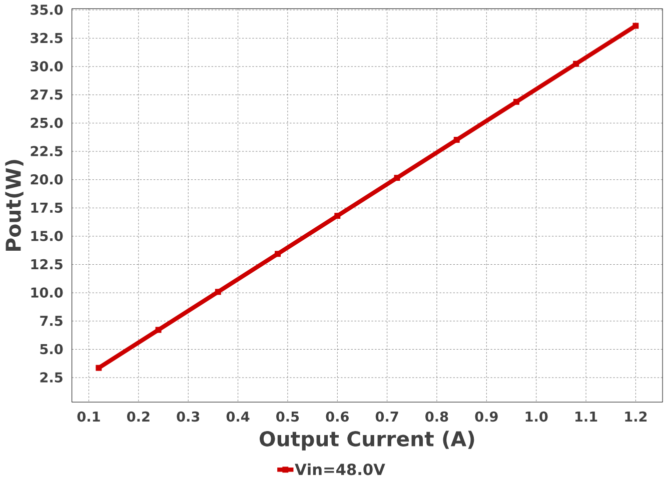
Cout Pd



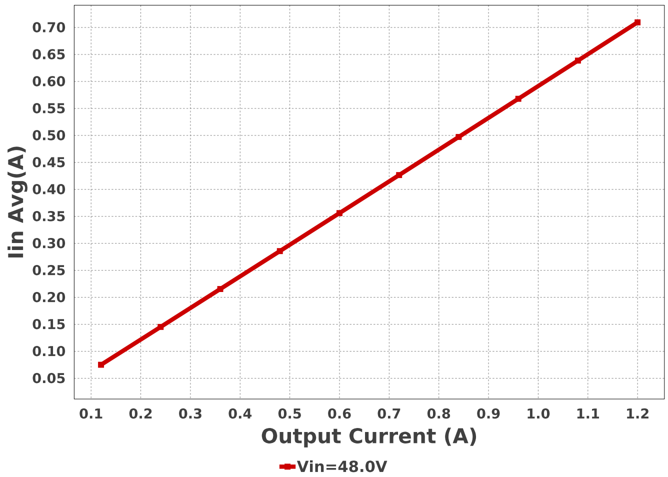
Ipp percentage



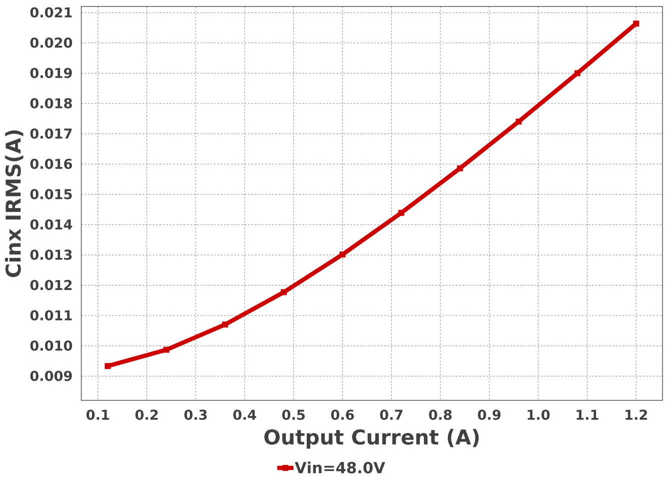
Pout



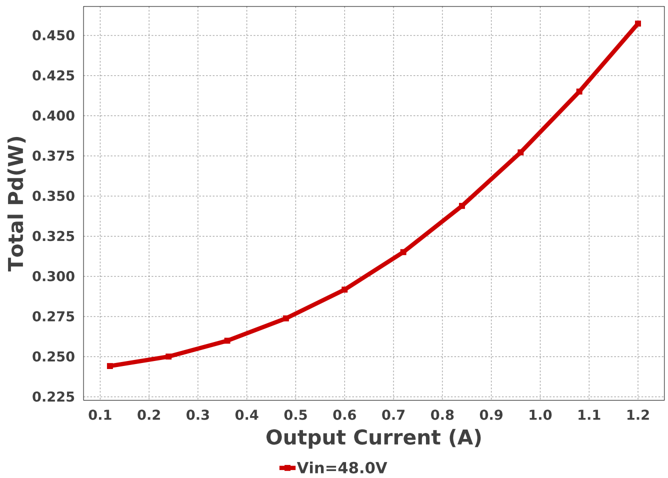
Iin Avg

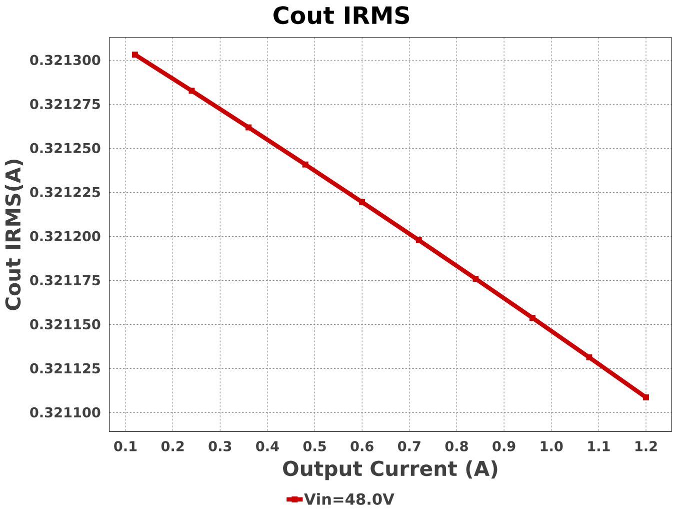


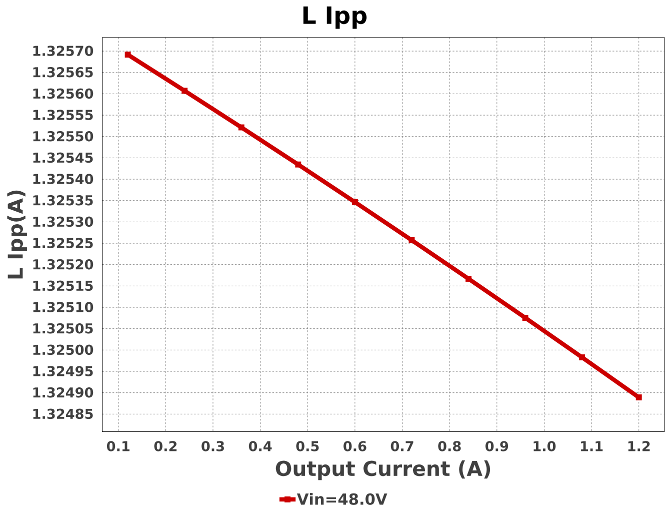
Cinx IRMS

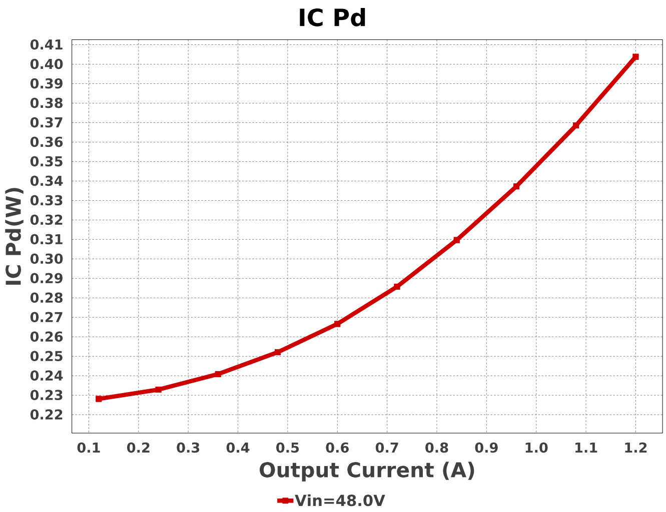


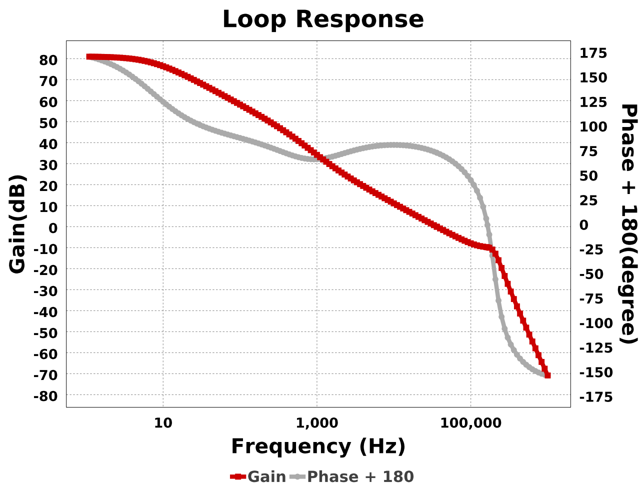
Total Pd











Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	638.915 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	622.52 µW	Capacitor	Input capacitor power dissipation
3.	Cinx IRMS	20.638 mA	Capacitor	Bulk capacitor RMS ripple current
4.	Cinx Pd	425.92 nW	Capacitor	Bulk capacitor power dissipation
5.	Cout IRMS	321.109 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	4.124 mW	Capacitor	Output capacitor power dissipation
7.	Coutx IRMS	61.354 mA	Capacitor	Output capacitor_x RMS ripple current
8.	Coutx Pd	6.512 µW	Capacitor	Output capacitor_x power loss
9.	IC Ipk	1.862 A	IC	Peak switch current in IC
10.	IC Pd	403.81 mW	IC	IC power dissipation
11.	IC Tj	89.585 degC	IC	IC junction temperature
12.	IC Tolerance	12.0 mV	IC	IC Feedback Tolerance
13.	ICThetaJA Effective	48.5 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
14.	Iin Avg	709.53 mA	IC	Average input current
15.	Ipp percentage	110.407 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
16.	L Ipp	1.325 A	Inductor	Peak-to-peak inductor ripple current
17.	L Pd	41.243 mW	Inductor	Inductor power dissipation
18.	Cin Pd	622.52 µW	Power	Input capacitor power dissipation
19.	Cinx Pd	425.92 nW	Power	Bulk capacitor power dissipation
20.	Cout Pd	4.124 mW	Power	Output capacitor power dissipation
21.	Coutx Pd	6.512 µW	Power	Output capacitor_x power loss
22.	IC Pd	403.81 mW	Power	IC power dissipation
23.	L Pd	41.243 mW	Power	Inductor power dissipation
24.	Total Pd	457.391 mW	Power	Total Power Dissipation
25.	BOM Count	11	System Information	Total Design BOM count
26.	Cross Freq	36.014 kHz	System Information	Bode plot crossover frequency
27.	Duty Cycle	58.657 %	System Information	Duty cycle

#	Name	Value	Category	Description
28.	Efficiency	98.657 %	System Information	Steady state efficiency
29.	FootPrint	382.0 mm^2	System Information	Total Foot Print Area of BOM components
30.	Frequency	400.0 kHz	System Information	Switching frequency
31.	Gain Marg	-9.814 dB	System Information	Bode Plot Gain Margin
32.	Iout	1.2 A	System Information	Iout operating point
33.	Iout transient step used for Cout calculations	1.5 A	System Information	Custom Transient current step requirement that was used for Cout selection (A).
34.	Low Freq Gain	80.952 dB	System Information	Gain at 1Hz
35.	Mode	CCM	System Information	Conduction Mode
36.	Overshoot Value	53.3 mV	System Information	Theoretical Vout Overshoot Value
37.	Phase Marg	73.613 deg	System Information	Bode Plot Phase Margin
38.	Pout	33.6 W	System Information	Total output power
39.	Total BOM	$4.07	System Information	Total BOM Cost
40.	Undershoot Value	168.837 mV	System Information	Theoretical Vout Undershoot Value
41.	Vin	48.0 V	System Information	Vin operating point
42.	Vin p-p	454.515 mV	System Information	Peak-to-peak input voltage
43.	Vout	28.0 V	System Information	Operational Output Voltage
44.	Vout Actual	28.011 V	System Information	Vout Actual calculated based on selected voltage divider resistors
45.	Vout Ripple requirement used for Cout calculations	3.0 %	System Information	Custom maximum output ripple requirement that was used for Cout selection(% of Vout).
46.	Vout Tolerance	3.492 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
47.	Vout p-p	44.943 mV	System Information	Peak-to-peak output ripple voltage
48.	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	1.2	Maximum Output Current
VinMax	48.0	Maximum input voltage
VinMin	48.0	Minimum input voltage
Vout	28.0	Output Voltage
base_pn	LMR51635	Base Product Number
source	DC	Input Source Type
Ta	70.0	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

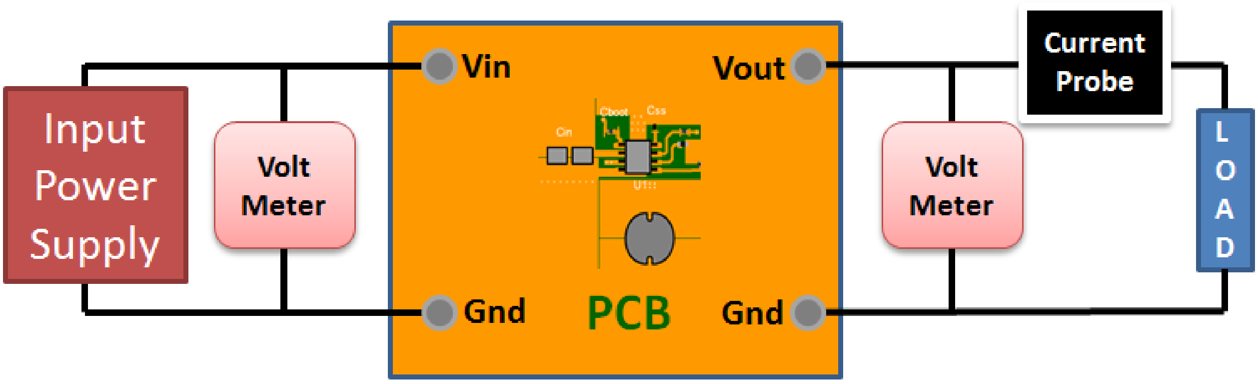
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 : 3AC91911FABB984D[v1]

2. **LMR51635** Product Folder : https://www.ti.com/product/LMR51635 : contains the data sheet and other resources.

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