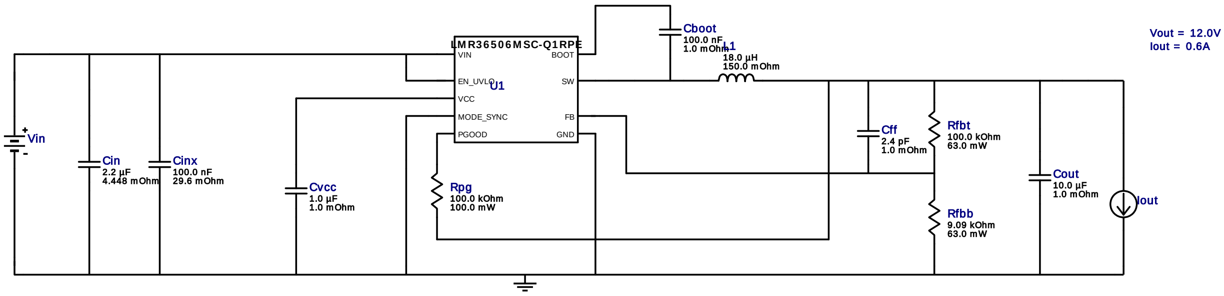
VinMin = 24.0V
VinMax = 24.0V
Vout = 12.0V
Iout = 0.6A

Device = LMR36506MSCQRPERQ1
Topology = Buck
Created = 2022-04-15 01:19:27.096
BOM Cost = $1.51
BOM Count = 11
Total Pd = 0.22W

WEBENCH ® Design Report

Design : 39 LMR36506MSCQRPERQ1
LMR36506MSCQRPERQ1 24V-24V to 12.00V @ 0.6A



Design Alerts

Component Selection Information

The LMR36506MSC-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application.

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 mm²
Cff	MuRata	GRM1555C1H2R4CA01D Series= C0G/NP0	Cap= 2.4 pF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cin	MuRata	GRM31CR61H225KA88L Series= X5R	Cap= 2.2 uF ESR= 4.448 mOhm VDC= 50.0 V IRMS= 2.2252 A	1	$0.10	1206_190 11 mm²
Cinx	TDK	CGA3E2X7R1H104K080AA Series= X7R	Cap= 100.0 nF ESR= 29.6 mOhm VDC= 50.0 V IRMS= 971.99 mA	1	$0.01	0603 5 mm²
Cout	TDK	C3225X7R1H106M250AC Series= X7R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 5.0 A	1	$0.28	1210 15 mm²
Cvcc	Taiyo Yuden	EMK107B7105KA-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.02	0603 5 mm²
L1	NIC Components	NPI54C180MTRF	L= 18.0 µH 150.0 mOhm	1	$0.12	IND_NPI54C 61 mm²
Rfbb	Vishay-Dale	CRCW04029K09FKED Series= CRCW..e3	Res= 9.09 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

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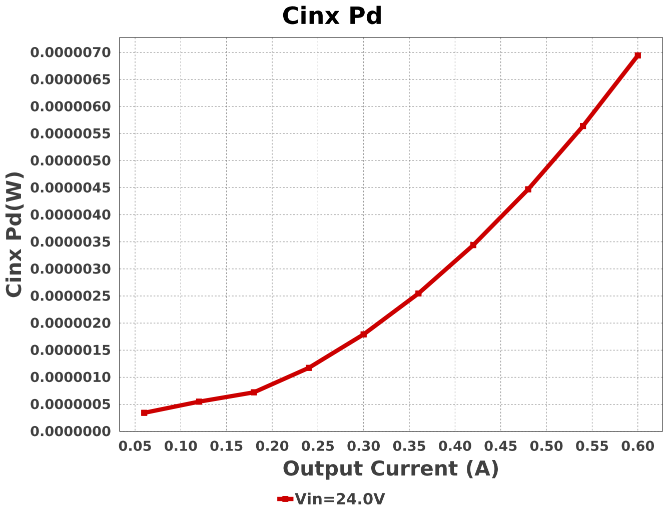
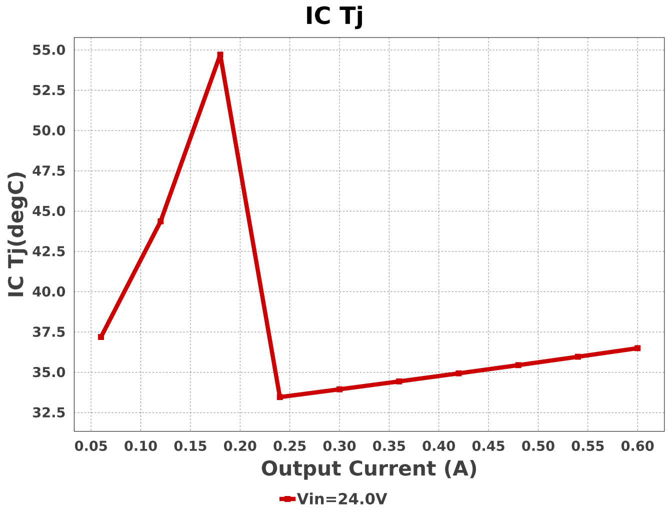
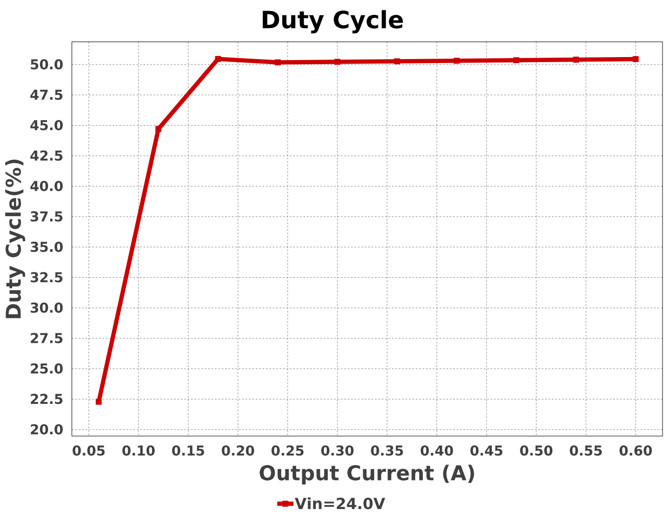
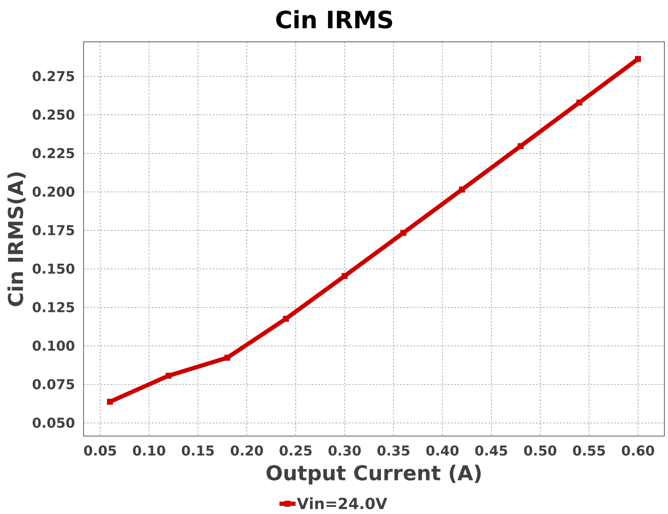
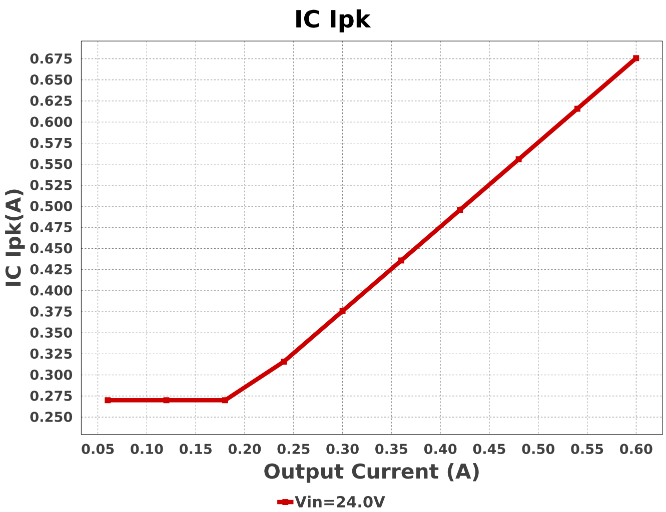
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rpg	Vishay-Dale	CRCW0603100KFKEA Series= CRCW..e3	Res= 100.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
U1	Texas Instruments	LMR36506MSCQRPERQ1	Switcher	1	$0.93	RPE0009A 9 mm^2

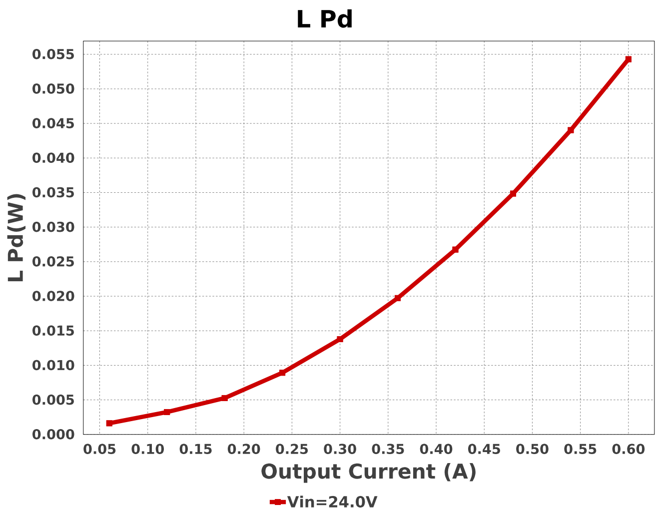


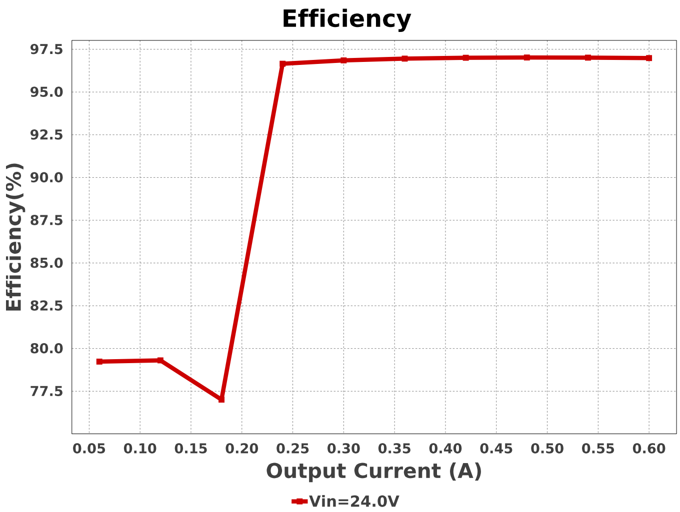


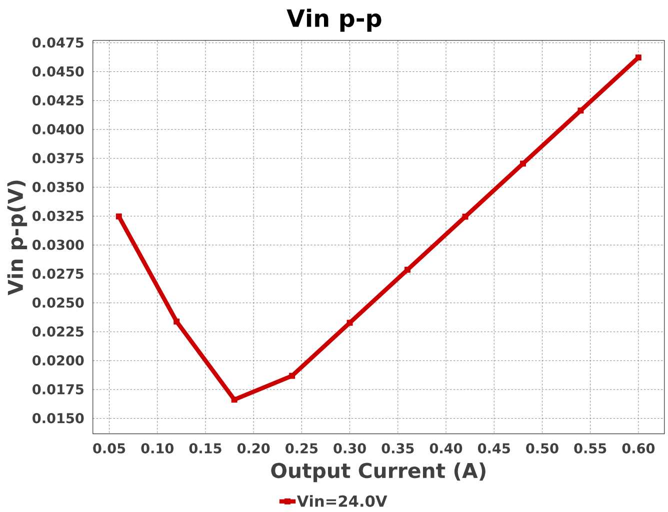


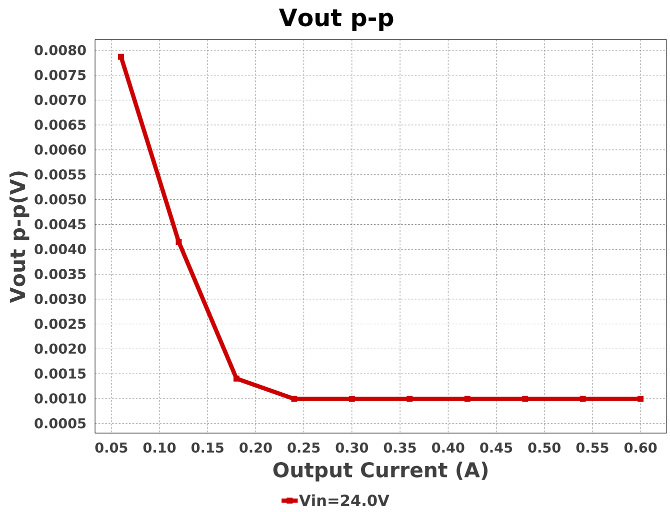


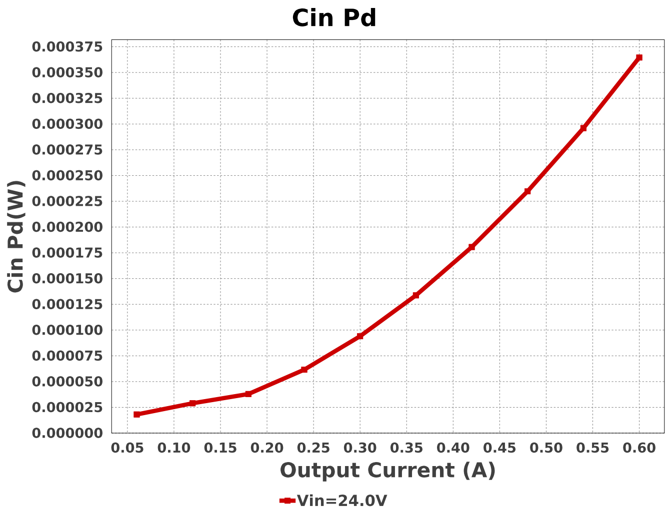


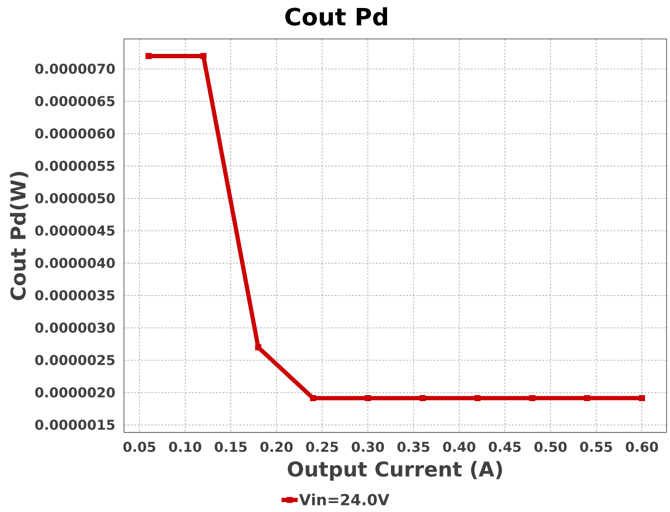


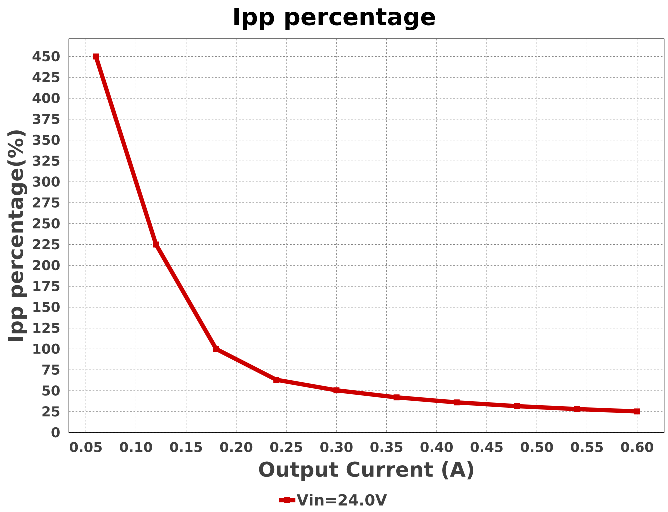

Efficiency
Efficiency(%)
97.5
95.0
92.5
90.0
87.5
85.0
82.5
80.0
77.5
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60
Output Current (A)
Vin=24.0V

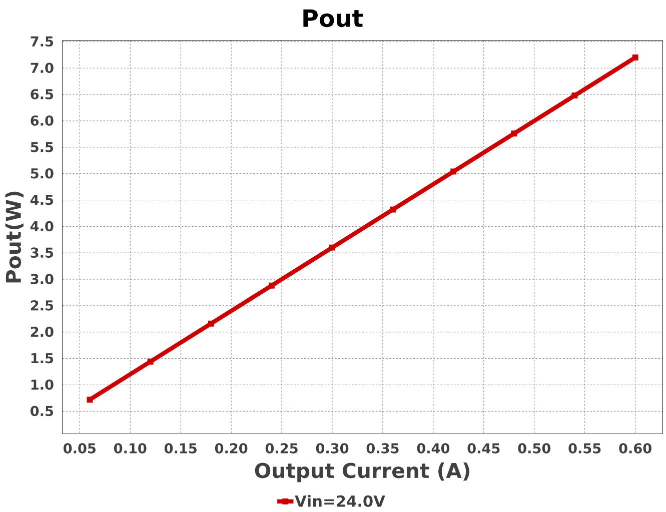

Vin p-p
Vin p-p(V)
0.0475
0.0450
0.0425
0.0400
0.0375
0.0350
0.0325
0.0300
0.0275
0.0250
0.0225
0.0200
0.0175
0.0150
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60
Output Current (A)
Vin=24.0V

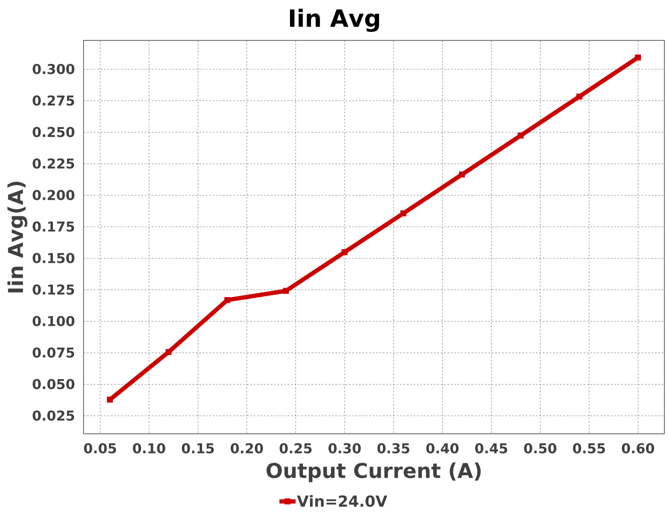

Vout p-p
Vout p-p(V)
0.0080
0.0075
0.0070
0.0065
0.0060
0.0055
0.0050
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60
Output Current (A)
Vin=24.0V

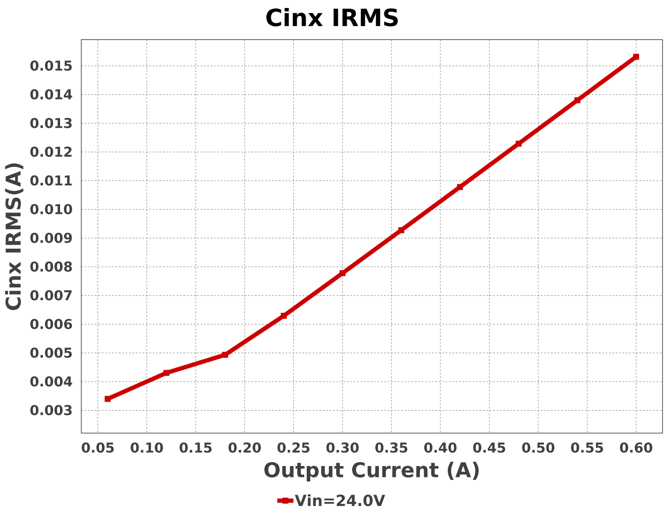

Cin Pd
Cin Pd(W)
0.000375
0.000350
0.000325
0.000300
0.000275
0.000250
0.000225
0.000200
0.000175
0.000150
0.000125
0.000100
0.000075
0.000050
0.000025
0.000000
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60
Output Current (A)
Vin=24.0V

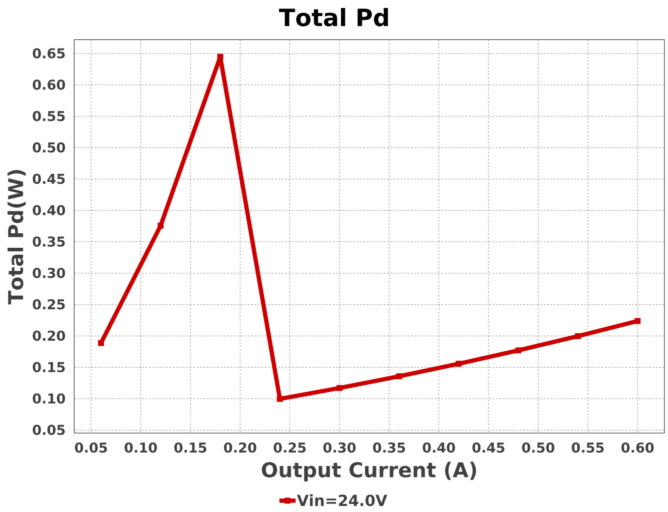

Cout Pd
Cout Pd(W)
0.0000070
0.0000065
0.0000060
0.0000055
0.0000050
0.0000045
0.0000040
0.0000035
0.0000030
0.0000025
0.0000020
0.0000015
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60
Output Current (A)
Vin=24.0V

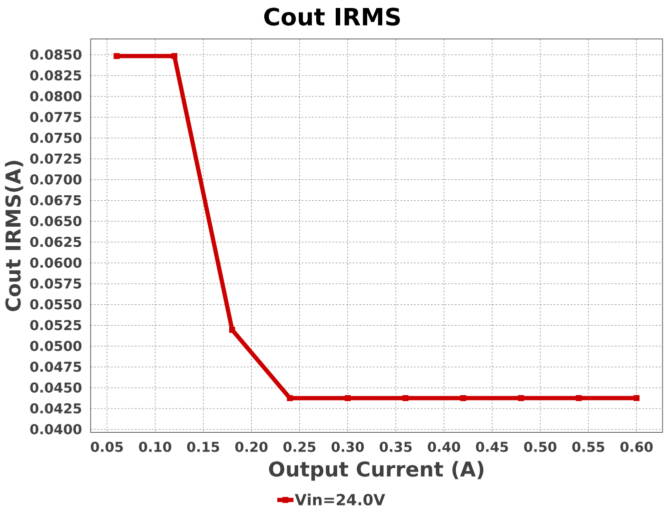

Ipp percentage
Ipp percentage(%)
450
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60
Output Current (A)
Vin=24.0V

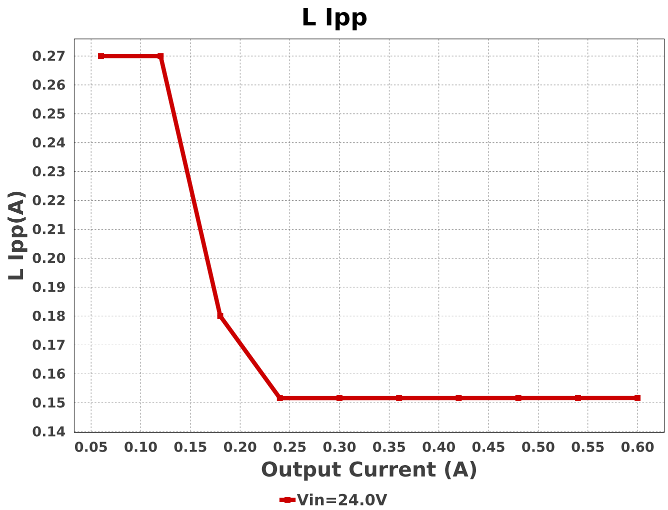

Pout
Pout(W)
Output Current (A)
Vin=24.0V

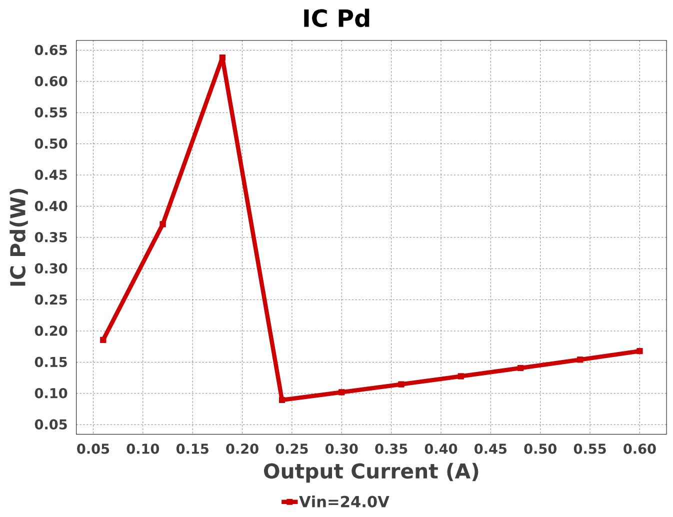

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=24.0V

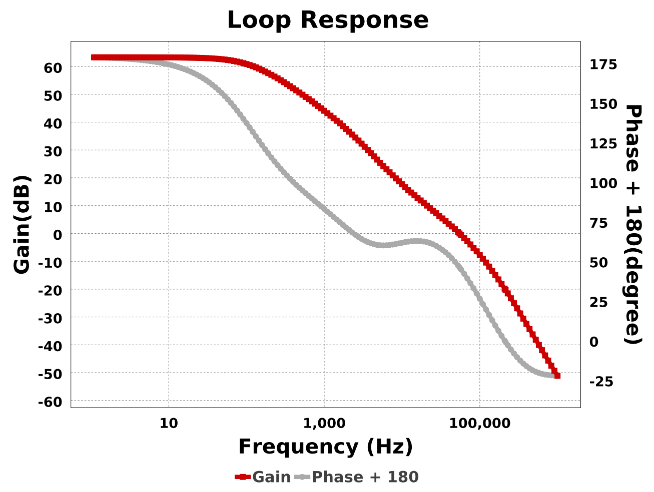

Cinx IRMS
Cinx IRMS(A)
Output Current (A)
Vin=24.0V

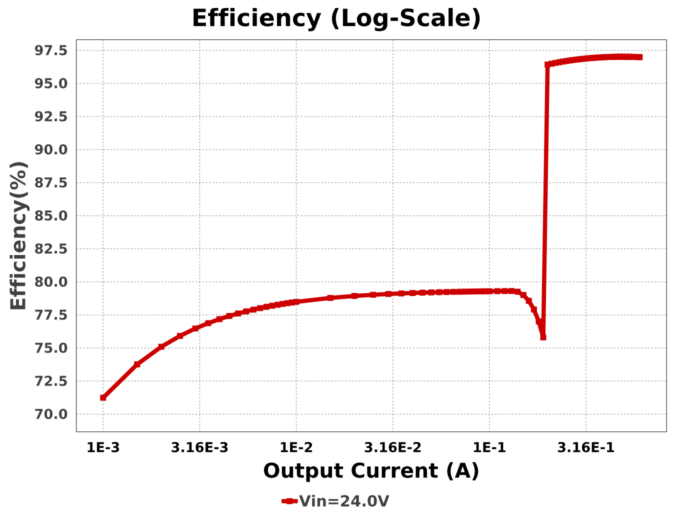

Total Pd
Total Pd(W)
Output Current (A)
Vin=24.0V


Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=24.0V


L Ipp
L Ipp(A)
Output Current (A)
Vin=24.0V







Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	286.278 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	364.54 µW	Capacitor	Input capacitor power dissipation
3.	Cinx IRMS	15.316 mA	Capacitor	Bulk capacitor RMS ripple current
4.	Cinx Pd	6.944 µW	Capacitor	Bulk capacitor power dissipation
5.	Cout IRMS	43.766 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	1.915 µW	Capacitor	Output capacitor power dissipation
7.	IC Ipk	675.804 mA	IC	Peak switch current in IC
8.	IC Pd	167.82 mW	IC	IC power dissipation
9.	IC Tj	36.498 degC	IC	IC junction temperature
10.	IC Tolerance	15.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA Effective	38.72 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
12.	Iin Avg	309.33 mA	IC	Average input current
13.	Ipp percentage	25.268 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
14.	L Ipp	151.61 mA	Inductor	Peak-to-peak inductor ripple current
15.	L Pd	54.287 mW	Inductor	Inductor power dissipation
16.	Cin Pd	364.54 µW	Power	Input capacitor power dissipation
17.	Cinx Pd	6.944 µW	Power	Bulk capacitor power dissipation
18.	Cout Pd	1.915 µW	Power	Output capacitor power dissipation
19.	IC Pd	167.82 mW	Power	IC power dissipation
20.	L Pd	54.287 mW	Power	Inductor power dissipation
21.	Total Pd	223.831 mW	Power	Total Power Dissipation
22.	BOM Count	11	System Information	Total Design BOM count
23.	Cross Freq	54.845 kHz	System Information	Bode plot crossover frequency
24.	Duty Cycle	50.449 %	System Information	Duty cycle
25.	Efficiency	96.985 %	System Information	Steady state efficiency
26.	FootPrint	121.0 mm^2	System Information	Total Foot Print Area of BOM components

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#	Name	Value	Category	Description
27.	Frequency	2.2 MHz	System Information	Switching frequency
28.	Gain Marg	-20.326 dB	System Information	Bode Plot Gain Margin
29.	Iout	600.0 mA	System Information	Iout operating point
30.	Low Freq Gain	63.287 dB	System Information	Gain at 1Hz
31.	Mode	CCM	System Information	Conduction Mode
32.	Phase Marg	47.009 deg	System Information	Bode Plot Phase Margin
33.	Pout	7.2 W	System Information	Total output power
34.	Total BOM	$1.51	System Information	Total BOM Cost
35.	Vin	24.0 V	System Information	Vin operating point
36.	Vin p-p	46.227 mV	System Information	Peak-to-peak input voltage
37.	Vout	12.0 V	System Information	Operational Output Voltage
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	994.93 µV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	600.0 m	Maximum Output Current
VinMax	24.0	Maximum input voltage
VinMin	24.0	Minimum input voltage
Vout	12.0	Output Voltage
base_pn	LMR36506MSC-Q1	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature

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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

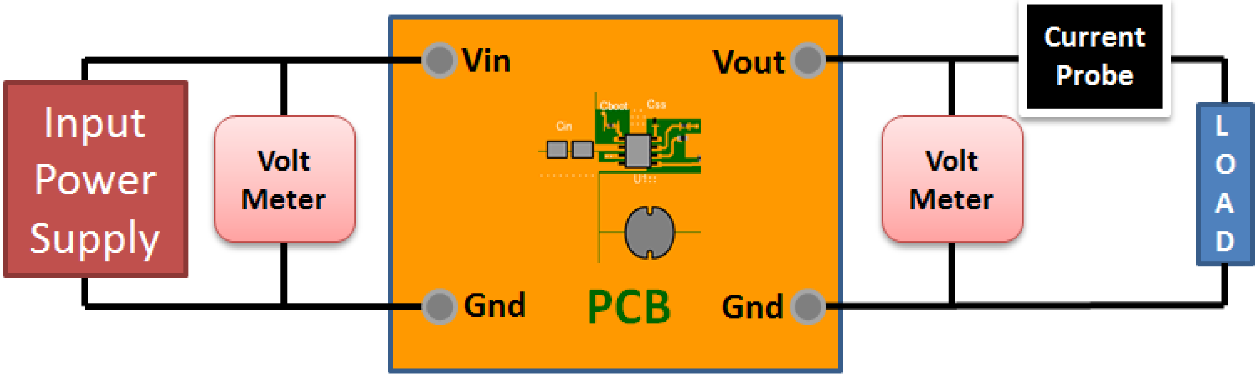
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 24.0V 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

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2. Master key : 6B17F01A3E488602[v1]

3. **LMR36506MSC-Q1** Product Folder : http://www.ti.com/product/LMR36506%2DQ1 : contains the data sheet and other resources.

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