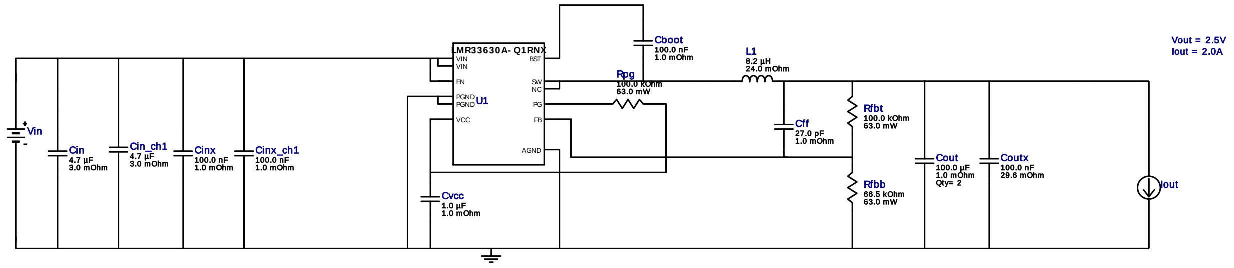
VinMin = 10.0V
VinMax = 22.0V
Vout = 2.5V
Iout = 2.0A

Device = LMR33630AQRNXRQ1
Topology = Buck
Created = 2020-06-11 23:39:33.633
BOM Cost = $3.35
BOM Count = 15
Total Pd = 0.31W

WEBENCH ® Design Report

Design : 12 LMR33630AQRNXRQ1
LMR33630AQRNXRQ1 10V-22V to 2.50V @ 2A



Design Alerts

Component Selection Information

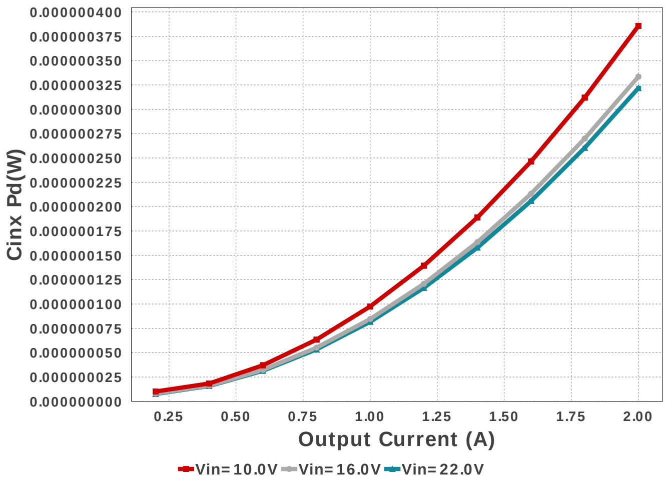
The LMR33630AQ1-WSON is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application.

Electrical BOM

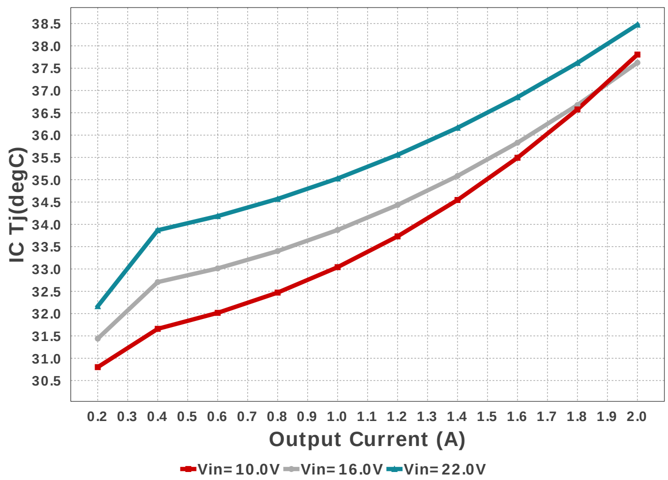
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM155R71C104KA88D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cff	MuRata	GRM1555C1H270JA01D Series= C0G/NP0	Cap= 27.0 pF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cin	MuRata	GRM31CR71H475KA12L Series= X7R	Cap= 4.7 uF ESR= 3.0 mOhm VDC= 50.0 V IRMS= 4.98 A	1	$0.22	1206 11 mm^2
Cin_ch1	MuRata	GRM31CR71H475KA12L Series= X7R	Cap= 4.7 uF ESR= 3.0 mOhm VDC= 50.0 V IRMS= 4.98 A	1	$0.22	1206 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	$0.05	0603 5 mm^2
Cinx_ch1	MuRata	GRM188R72A104KA35D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 3.85 A	1	$0.05	0603 5 mm^2
Cout	MuRata	GRM32ER60J107ME20L Series= X5R	Cap= 100.0 uF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 6.0 A	2	$0.52	1210_270 15 mm^2
Coutx	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 mm^2
Cvcc	Kemet	C0603C105K8PACTU Series= X5R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
L1	Coilcraft	XAL6060-822MEB	L= 8.2 µH 24.0 mOhm	1	$0.82	XAL6060 72 mm²
Rfbb	Vishay-Dale	CRCW040266K5FKED Series= CRCW..e3	Res= 66.5 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
Rpg	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
U1	Texas Instruments	LMR33630AQRNXRQ1	Switcher	1	$0.88	RNX0012B 12 mm²

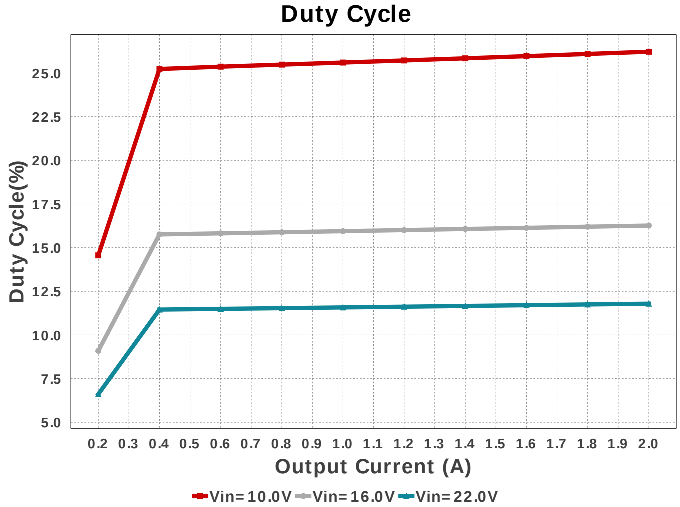
Cinx Pd



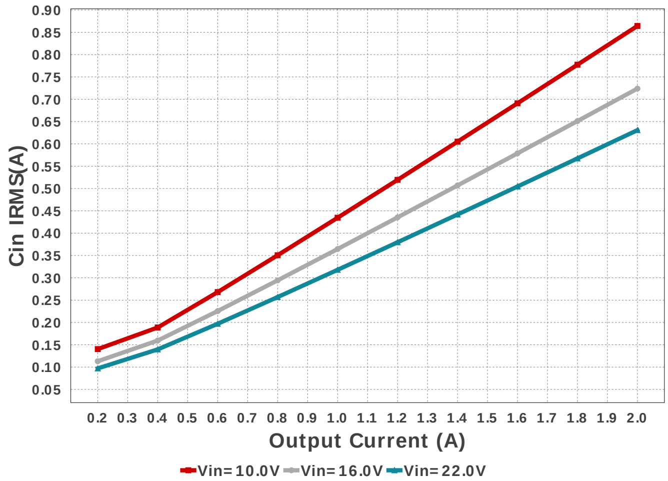
IC Tj



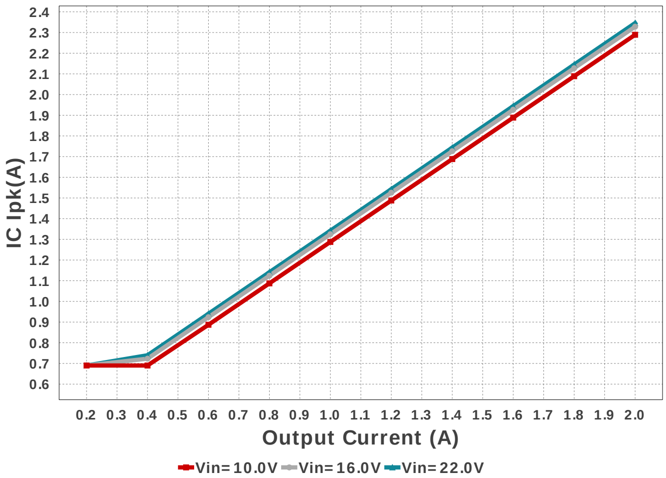
Duty Cycle



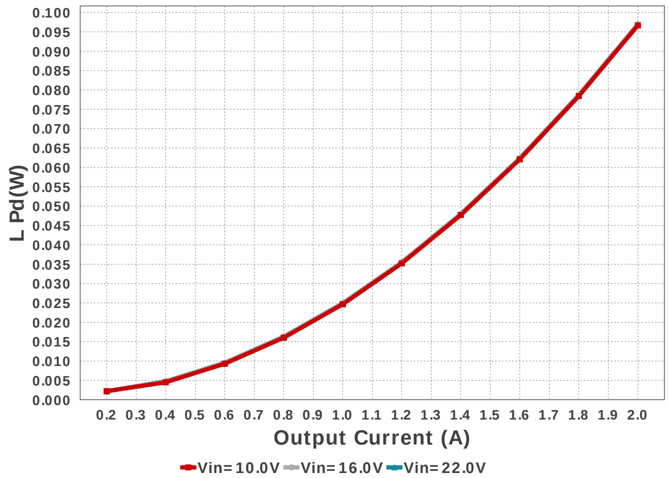
Cin IRMS



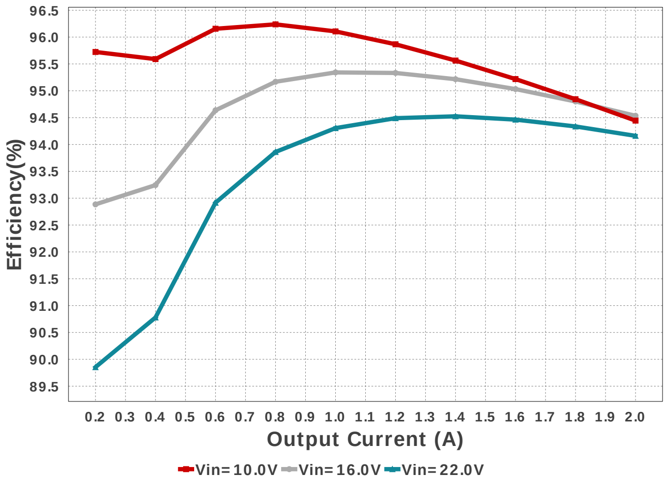
IC Ipk



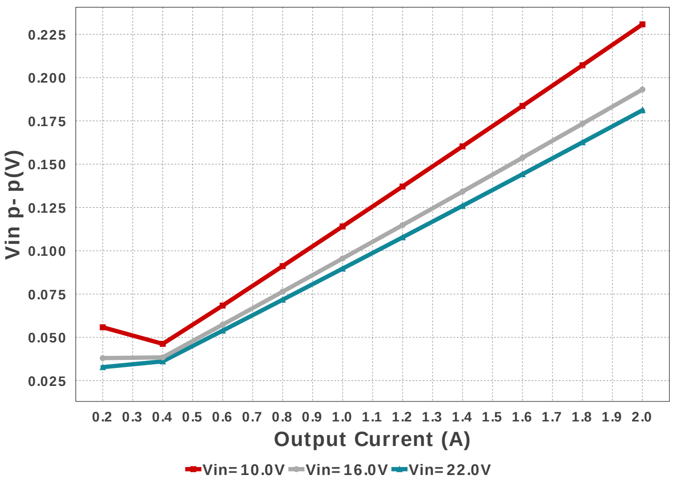
L Pd



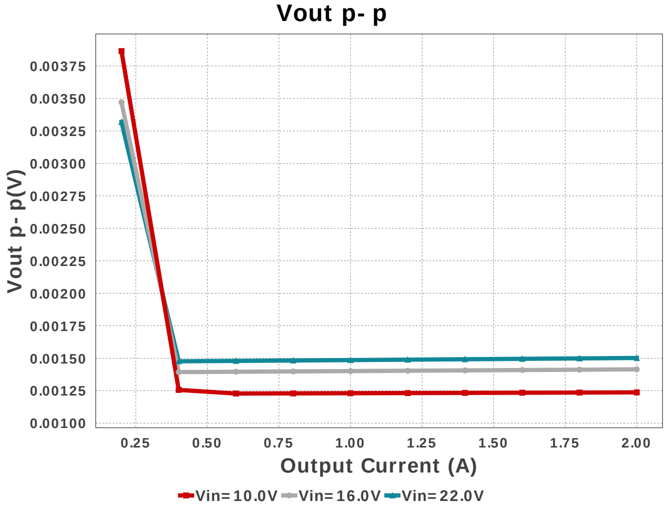
Efficiency



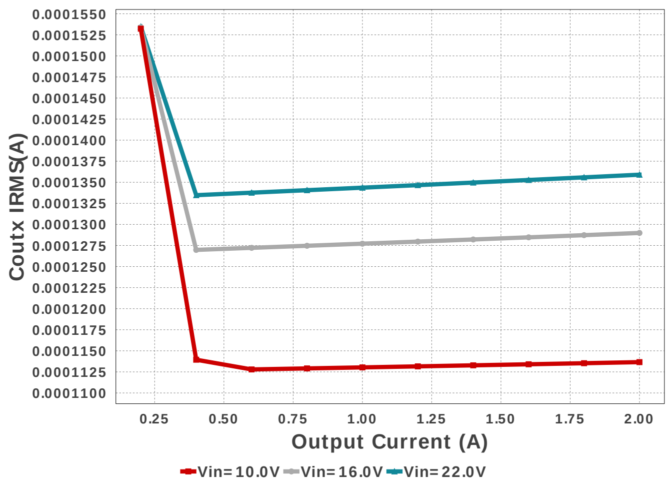
Vin p- p



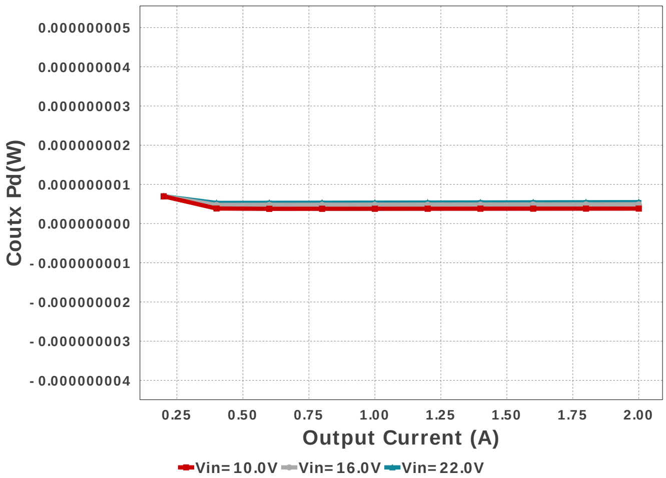
Vout p- p



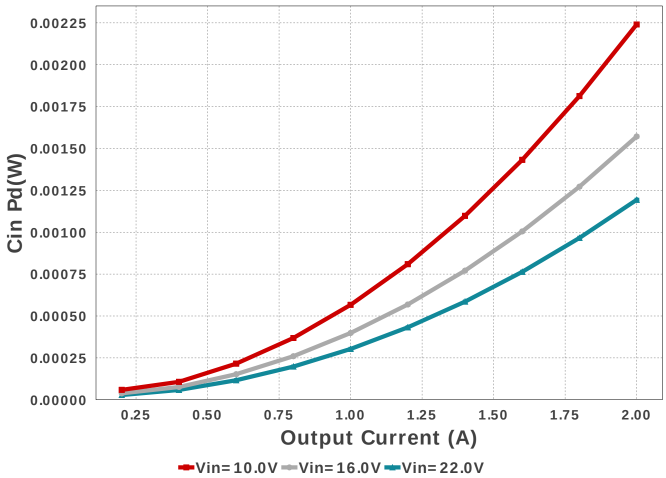
Coutx IRMS



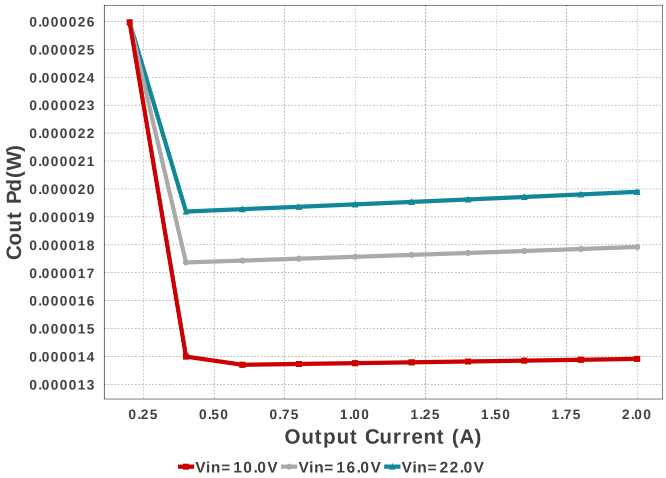
Coutx Pd



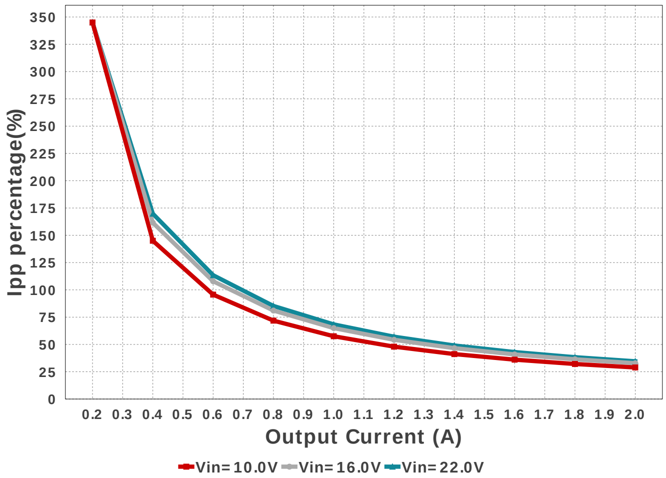
Cin Pd



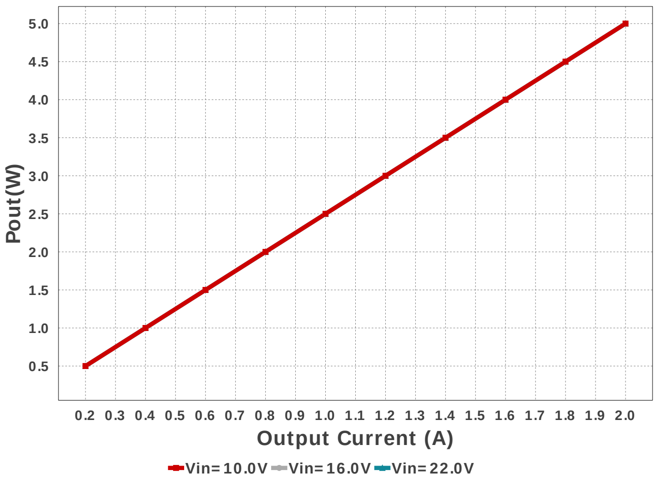
Cout Pd



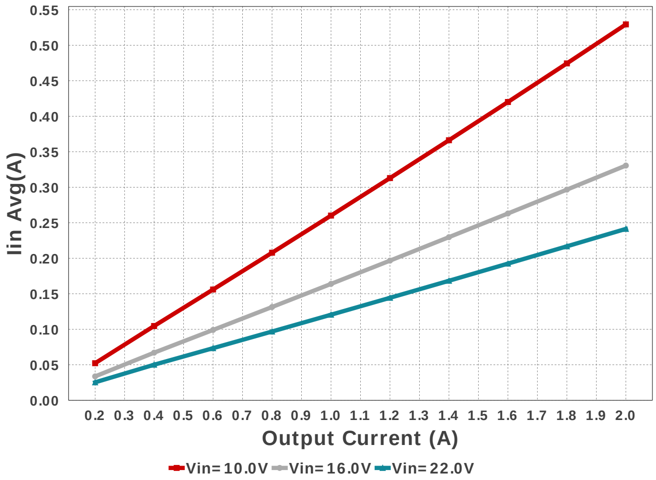
Ipp percentage

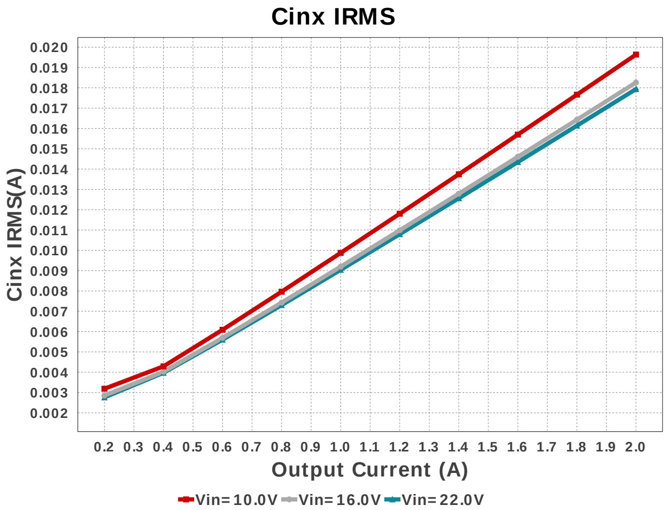


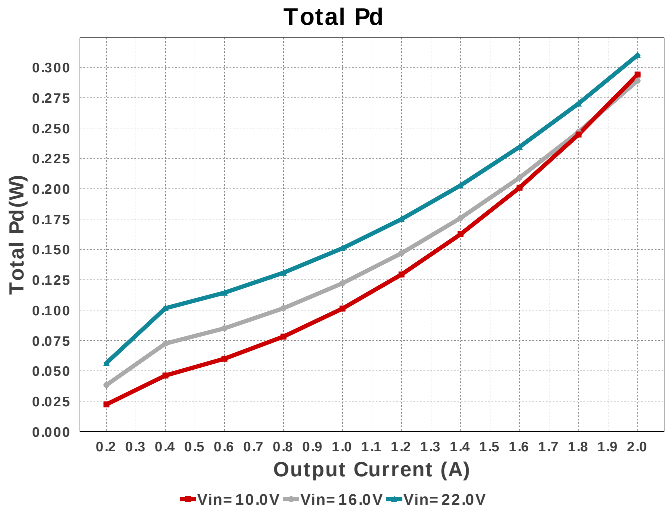
Pout

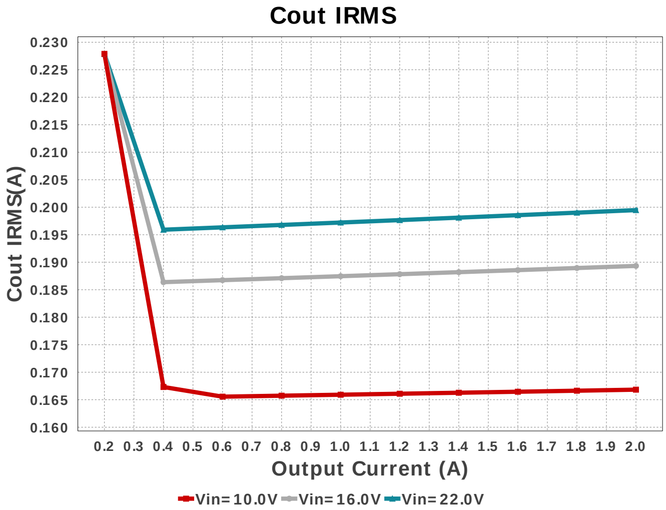


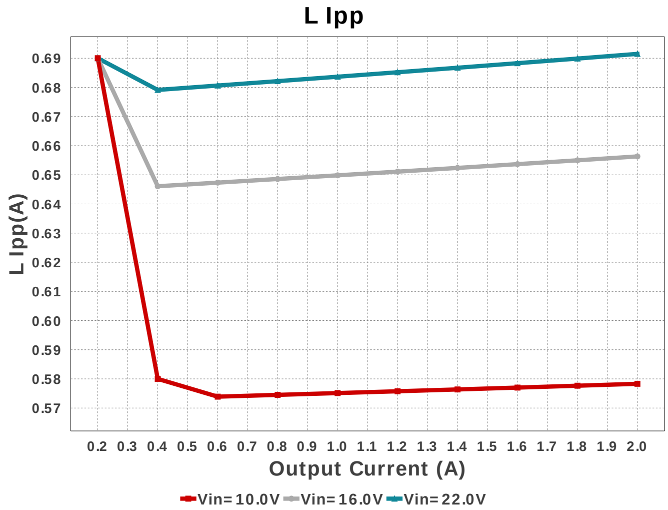
Iin Avg

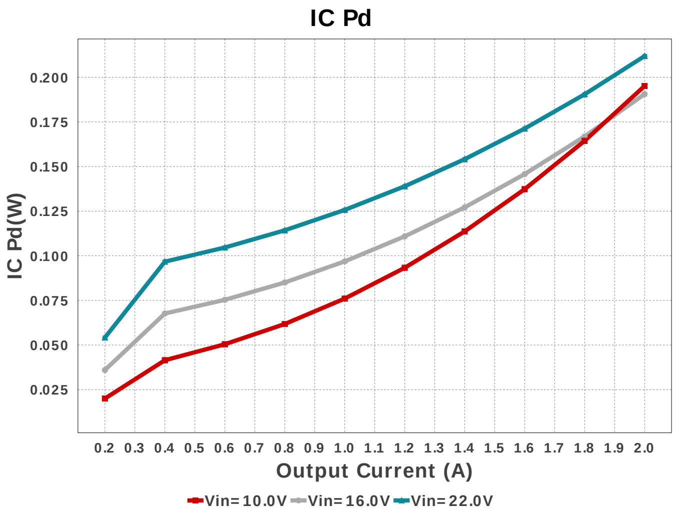


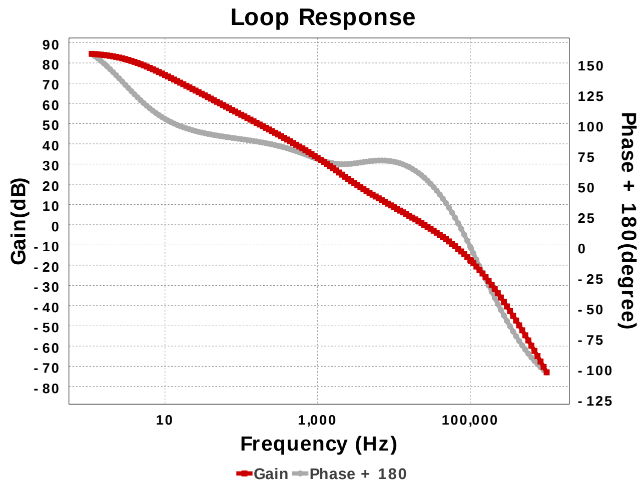

Cinx IRMS
Cinx IRMS(A)
0.020
0.019
0.018
0.017
0.016
0.015
0.014
0.013
0.012
0.011
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin=10.0V Vin=16.0V Vin=22.0V

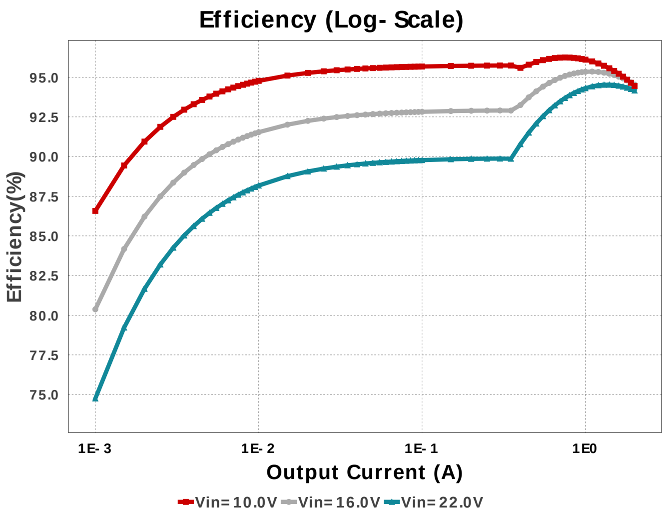

Total Pd
Total Pd(W)
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin=10.0V Vin=16.0V Vin=22.0V


Cout IRMS
Cout IRMS(A)
0.230
0.225
0.220
0.215
0.210
0.205
0.200
0.195
0.190
0.185
0.180
0.175
0.170
0.165
0.160
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin=10.0V Vin=16.0V Vin=22.0V


L Ipp
L Ipp(A)
0.69
0.68
0.67
0.66
0.65
0.64
0.63
0.62
0.61
0.60
0.59
0.58
0.57
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin=10.0V Vin=16.0V Vin=22.0V


IC Pd
IC Pd(W)
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin=10.0V Vin=16.0V Vin=22.0V


Loop Response
Gain(dB)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
Phase + 180(degree)
150
125
100
75
50
25
0
-25
-50
-75
-100
-125
10
1,000
100,000
Frequency (Hz)
Gain Phase + 180



Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	630.72 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	1.193 mW	Capacitor	Input capacitor power dissipation
3.	Cinx IRMS	17.937 mA	Capacitor	Bulk capacitor RMS ripple current
4.	Cinx Pd	321.74 nW	Capacitor	Bulk capacitor power dissipation
5.	Cout IRMS	199.478 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	19.896 µW	Capacitor	Output capacitor power dissipation
7.	Coutx IRMS	135.9 µA	Capacitor	Output capacitor_x RMS ripple current
8.	Coutx Pd	546.67 pW	Capacitor	Output capacitor_x power loss
9.	IC Ipk	2.346 A	IC	Peak switch current in IC
10.	IC Pd	211.87 mW	IC	IC power dissipation
11.	IC Tj	38.475 degC	IC	IC junction temperature
12.	IC Tolerance	15.0 mV	IC	IC Feedback Tolerance
13.	ICThetaJA Effective	40.0 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
14.	Iin Avg	241.37 mA	IC	Average input current
15.	Ipp percentage	34.574 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
16.	L Ipp	691.48 mA	Inductor	Peak-to-peak inductor ripple current
17.	L Pd	96.956 mW	Inductor	Inductor power dissipation
18.	Cin Pd	1.193 mW	Power	Input capacitor power dissipation
19.	Cinx Pd	321.74 nW	Power	Bulk capacitor power dissipation
20.	Cout Pd	19.896 µW	Power	Output capacitor power dissipation
21.	Coutx Pd	546.67 pW	Power	Output capacitor_x power loss
22.	IC Pd	211.87 mW	Power	IC power dissipation
23.	L Pd	96.956 mW	Power	Inductor power dissipation
24.	Total Pd	310.059 mW	Power	Total Power Dissipation
25.	BOM Count	15	System Information	Total Design BOM count
26.	Cross Freq	24.935 kHz	System Information	Bode plot crossover frequency
27.	Duty Cycle	11.792 %	System Information	Duty cycle
28.	Efficiency	94.161 %	System Information	Steady state efficiency
29.	FootPrint	169.0 mm^2	System Information	Total Foot Print Area of BOM components
30.	Frequency	400.0 kHz	System Information	Switching frequency
31.	Gain Marg	-17.804 dB	System Information	Bode Plot Gain Margin
32.	Iout	2.0 A	System Information	Iout operating point
33.	Low Freq Gain	84.487 dB	System Information	Gain at 1Hz
34.	Mode	CCM	System Information	Conduction Mode
35.	Phase Marg	57.876 deg	System Information	Bode Plot Phase Margin
36.	Pout	5.0 W	System Information	Total output power
37.	Total BOM	$3.35	System Information	Total BOM Cost

#	Name	Value	Category	Description
38.	Vin	22.0 V	System Information	Vin operating point
39.	Vin p-p	181.146 mV	System Information	Peak-to-peak input voltage
40.	Vout	2.5 V	System Information	Operational Output Voltage
41.	Vout Actual	2.504 V	System Information	Vout Actual calculated based on selected voltage divider resistors
42.	Vout Tolerance	2.732 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
43.	Vout p-p	1.502 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	2.0	Maximum Output Current
VinMax	22.0	Maximum input voltage
VinMin	10.0	Minimum input voltage
VinTyp	12.0	Typical input voltage
Vout	2.5	Output Voltage
base_pn	LMR33630AQ1-WSON	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

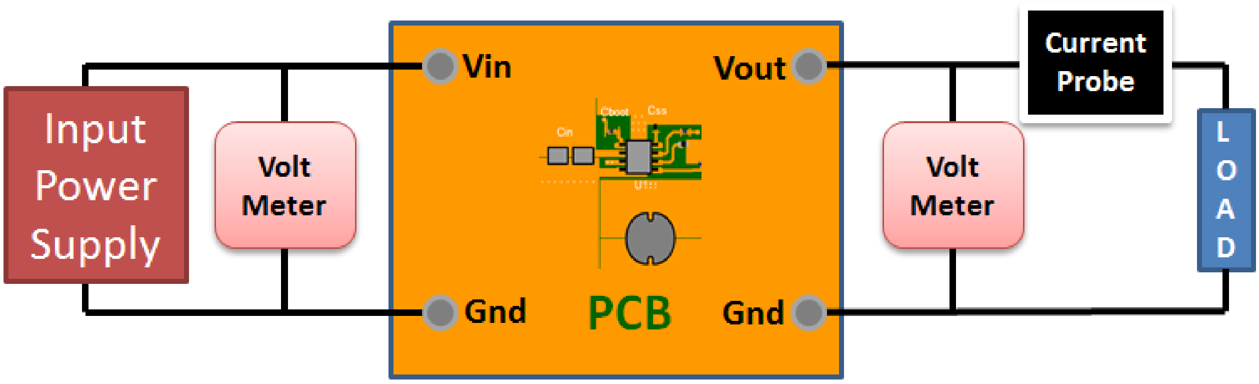
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 10.0V 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 : 84E05F9E8AACC473[v1]

2. **LMR33630AQ1-WSON** Product Folder : http://www.ti.com/product/LMR33630%2DQ1 : contains the data sheet and other resources.