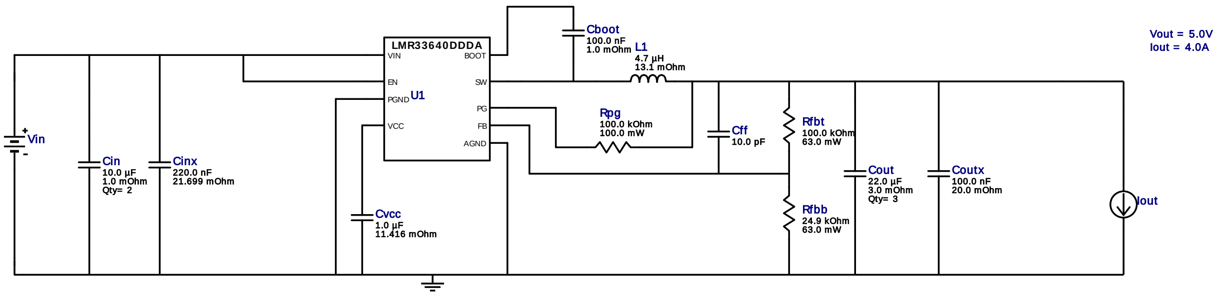
VinMin = 5.6V
VinMax = 28.0V
Vout = 5.0V
Iout = 4.0A

Device = LMR33640DDDAR
Topology = Buck
Created = 2020-12-06 07:43:50.889
BOM Cost = $2.74
BOM Count = 15
Total Pd = 3.01W

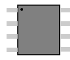
WEBENCH ® Design Report

Design : 6 LMR33640DDDAR
LMR33640DDDAR 5.6V-28V to 5.00V @ 4A

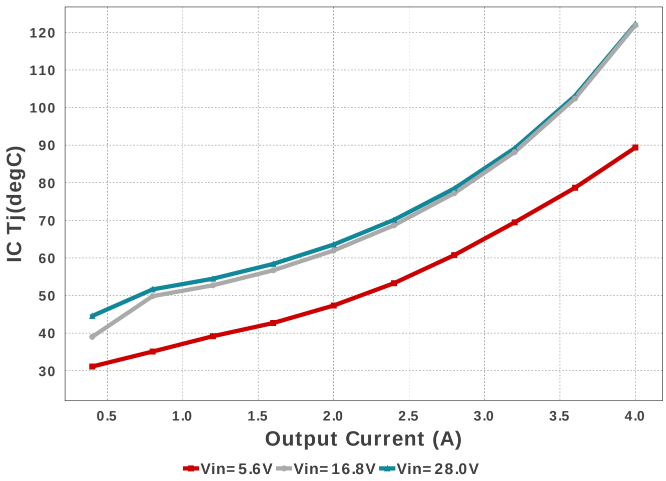


Electrical BOM

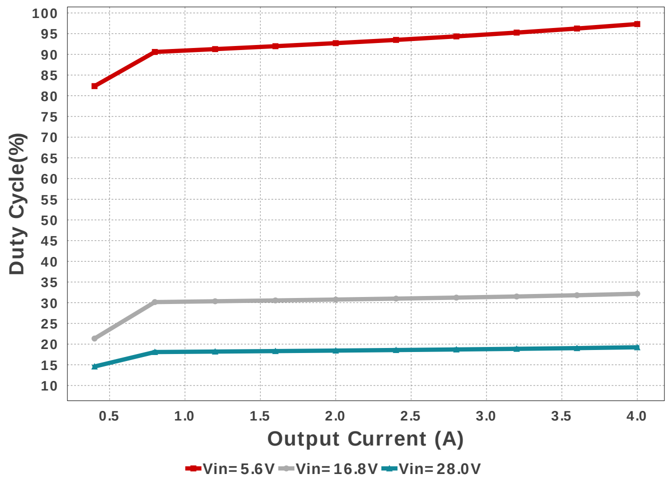
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM155R71A104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cff	Kemet	C0402C100J3GACTU Series= C0G/NP0	Cap= 10.0 pF VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cin	TDK	C3225X7R1H106M250AC Series= X7R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 5.0 A	2	$0.28	1210 15 mm²
Cinx	TDK	C1608X5R1H224K080AB Series= X5R	Cap= 220.0 nF ESR= 21.699 mOhm VDC= 50.0 V IRMS= 1.125 A	1	$0.03	0603 5 mm²
Cout	MuRata	GRM21BR61A226ME44L Series= X5R	Cap= 22.0 uF ESR= 3.0 mOhm VDC= 10.0 V IRMS= 3.84 A	3	$0.13	0805 7 mm²
Coutx	MuRata	GRM188R71H104KA93D Series= X7R	Cap= 100.0 nF ESR= 20.0 mOhm VDC= 50.0 V IRMS= 3.8 A	1	$0.02	0603 5 mm²
Cvcc	TDK	C1005X6S1C105K050BC Series= X6S	Cap= 1.0 uF ESR= 11.416 mOhm VDC= 16.0 V IRMS= 1.483 A	1	$0.02	0402 3 mm²
L1	Coilcraft	XAL6060-472MEB	L= 4.7 µH 13.1 mOhm	1	$0.82	XAL6060 72 mm²
Rfbb	Vishay-Dale	CRCW040224K9FKED Series= CRCW..e3	Res= 24.9 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	CRCW0603100KFKEA Series= CRCW..e3	Res= 100.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
U1	Texas Instruments	LMR33640DDDAR	Switcher	1	$0.85	 DDA0008J 55 mm[2]

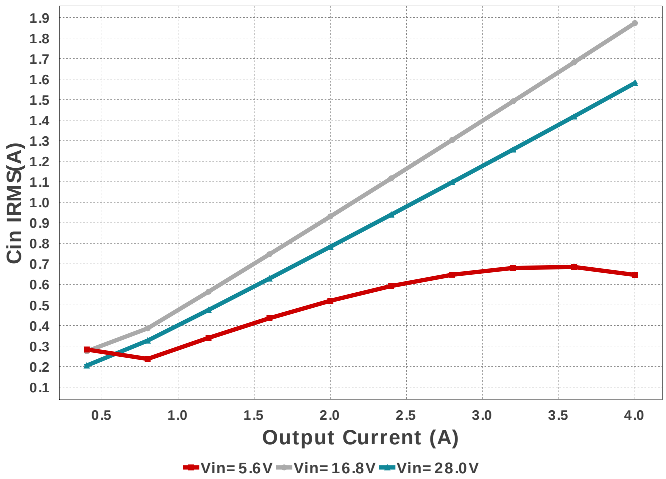
IC Tj



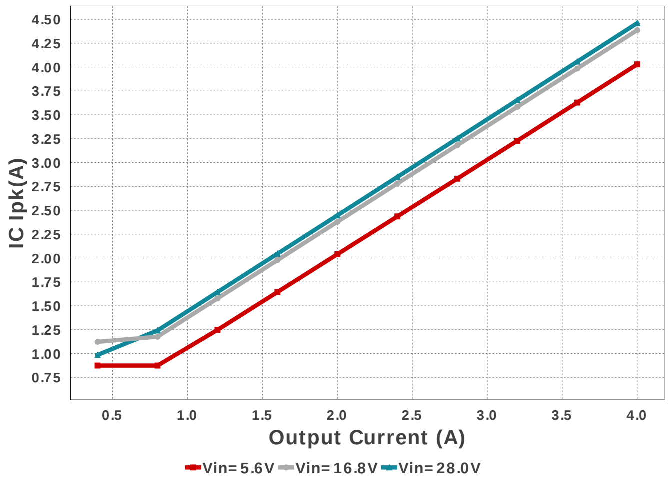
Duty Cycle



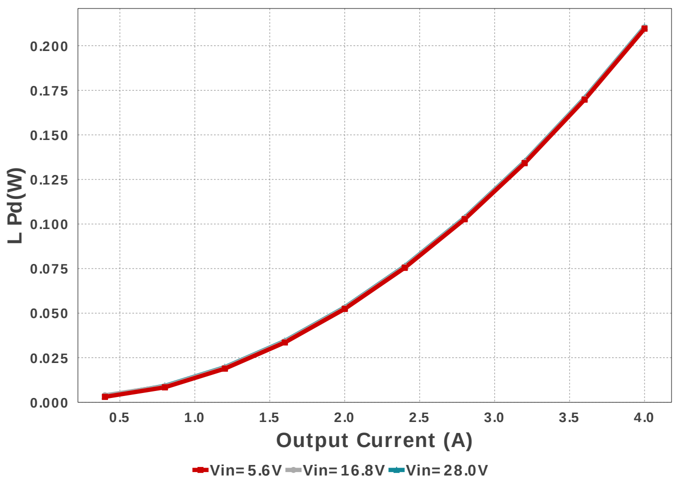
Cin IRMS



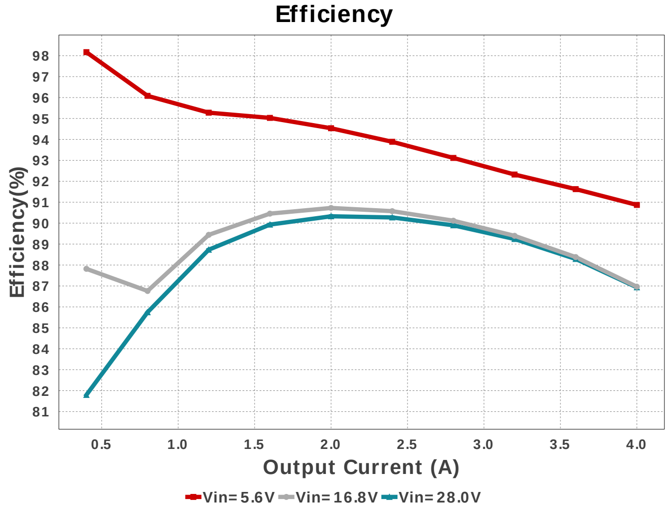
IC Ipk



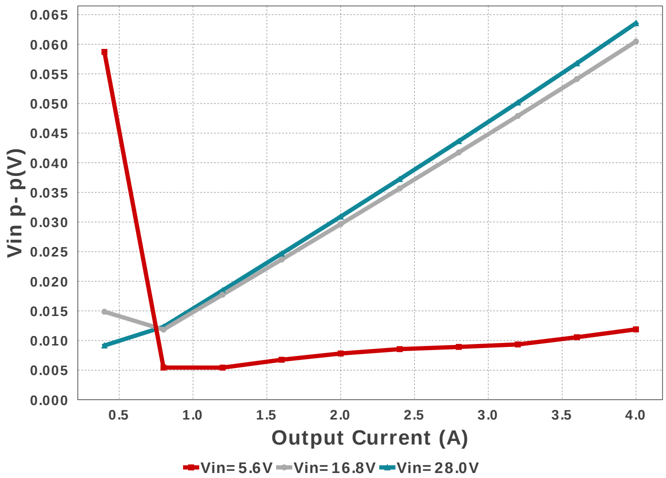
L Pd



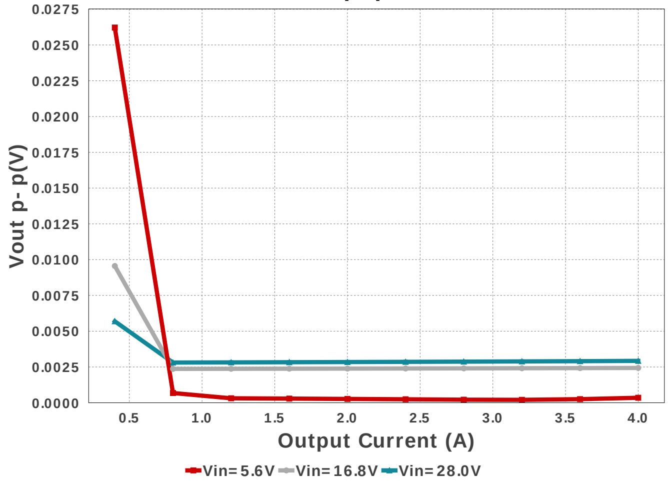
Efficiency



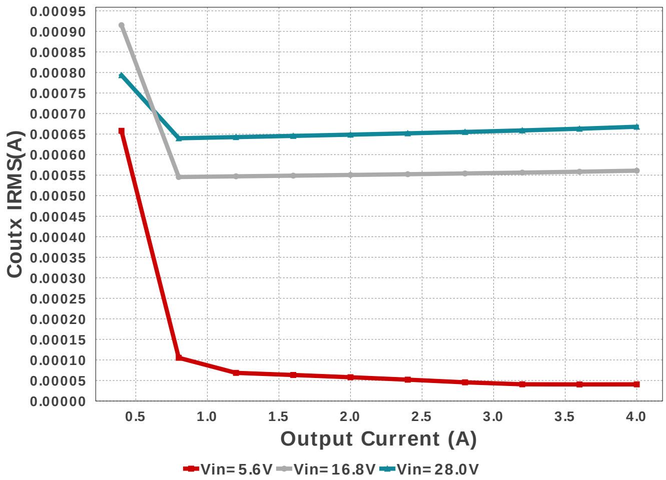
Vin p- p



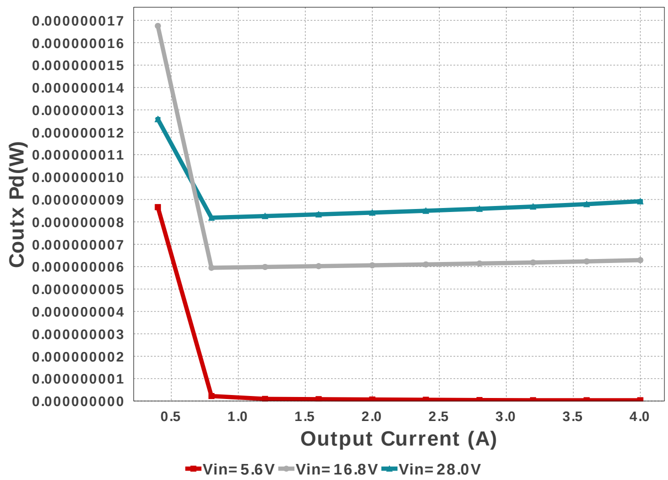
Vout p- p



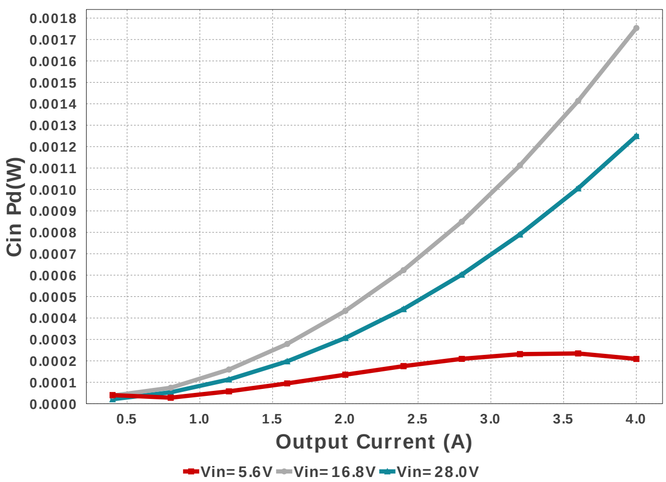
Coutx IRMS



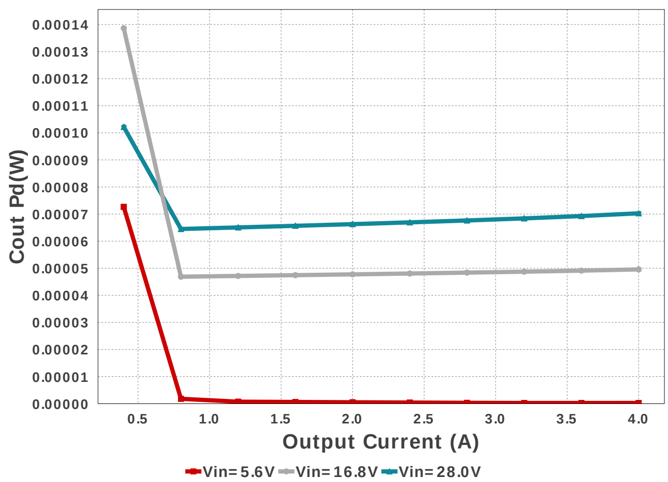
Coutx Pd

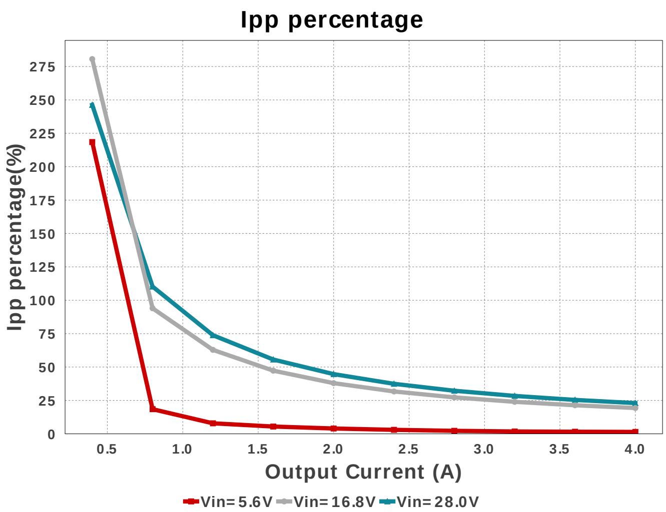


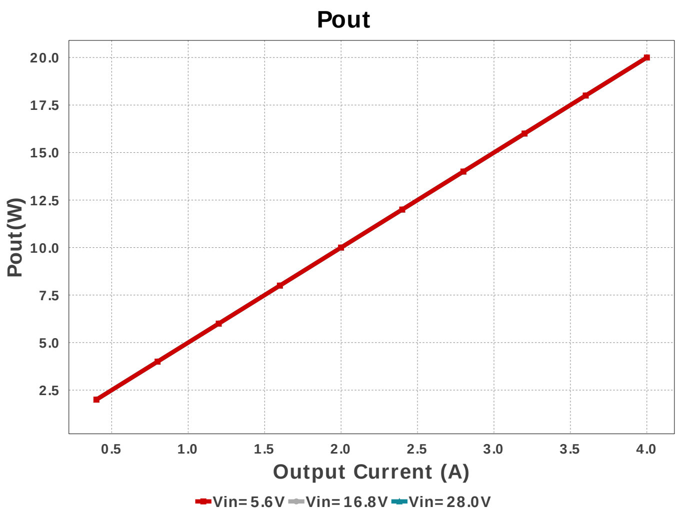
Cin Pd

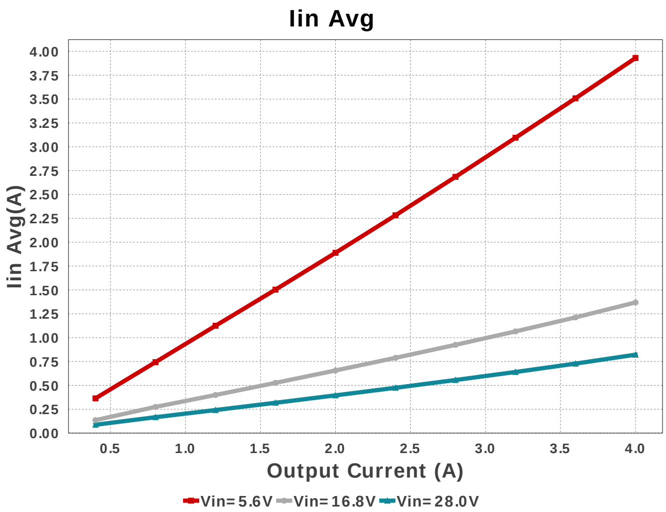


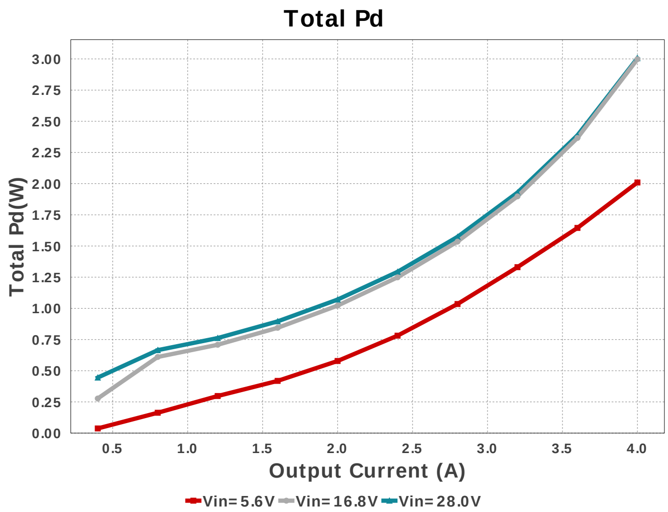
Cout Pd

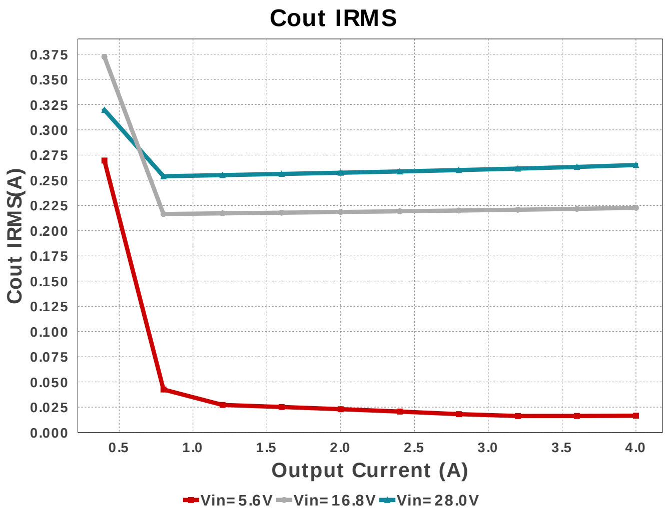


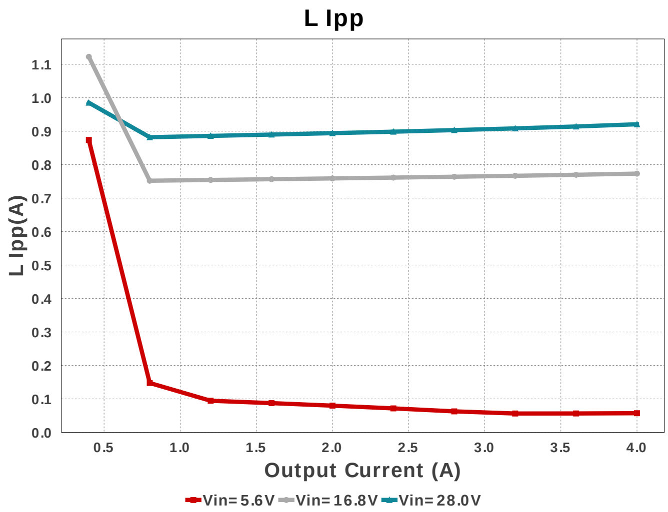

Ipp percentage
Ipp percentage(%)
275
250
225
200
175
150
125
100
75
50
25
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Output Current (A)
Vin=5.6V
Vin=16.8V
Vin=28.0V

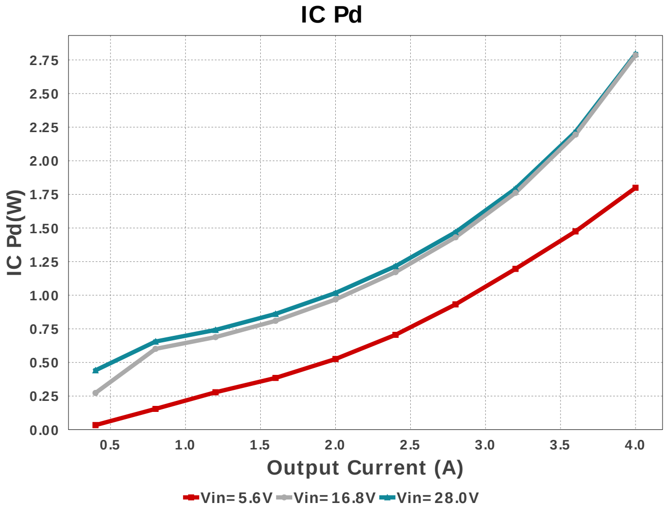

Pout
Pout(W)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Output Current (A)
Vin=5.6V
Vin=16.8V
Vin=28.0V

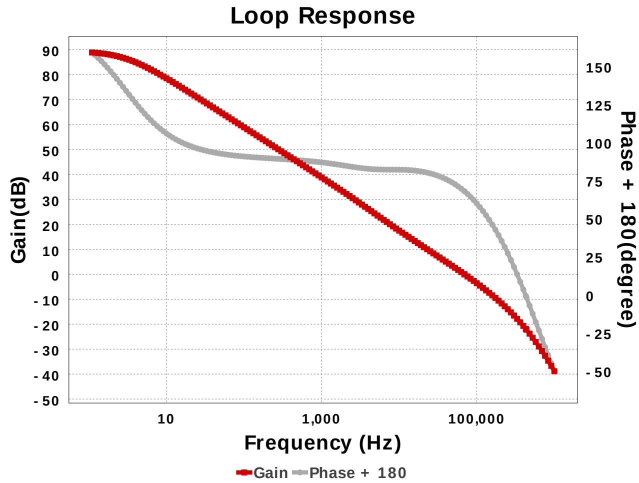

Iin Avg
Iin Avg(A)
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Output Current (A)
Vin=5.6V
Vin=16.8V
Vin=28.0V

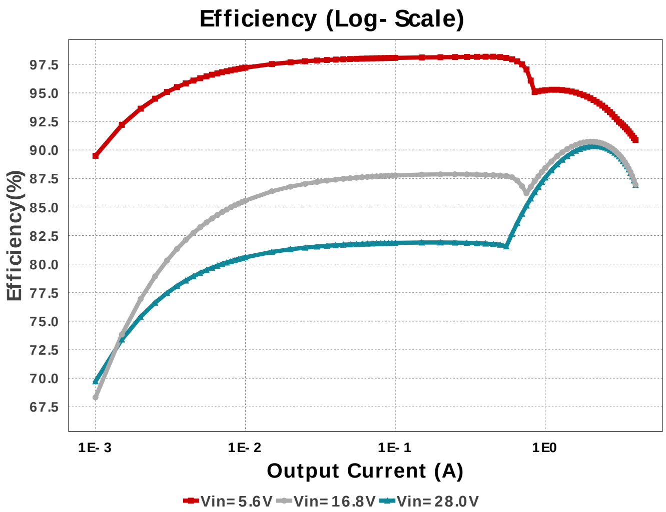

Total Pd
Total Pd(W)
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Output Current (A)
Vin=5.6V
Vin=16.8V
Vin=28.0V


Cout IRMS
Cout IRMS(A)
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
0.000
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Output Current (A)
Vin=5.6V
Vin=16.8V
Vin=28.0V


L Ipp
L Ipp(A)
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Output Current (A)
Vin=5.6V
Vin=16.8V
Vin=28.0V







Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	1.581 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	1.25 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	265.114 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	70.285 µW	Capacitor	Output capacitor power dissipation
5.	Coutx IRMS	667.816 µA	Capacitor	Output capacitor_x RMS ripple current
6.	Coutx Pd	8.92 nW	Capacitor	Output capacitor_x power loss
7.	IC Ipk	4.46 A	IC	Peak switch current in IC
8.	IC Pd	2.794 W	IC	IC power dissipation
9.	IC Tj	122.202 degC	IC	IC junction temperature
10.	IC Tolerance	15.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA	33.0 degC/W	IC	IC junction-to-ambient thermal resistance
12.	Iin Avg	821.64 mA	IC	Average input current
13.	Ipp percentage	23.017 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
14.	L Ipp	920.694 mA	Inductor	Peak-to-peak inductor ripple current
15.	L Pd	210.53 mW	Inductor	Inductor power dissipation
16.	Cin Pd	1.25 mW	Power	Input capacitor power dissipation
17.	Cout Pd	70.285 µW	Power	Output capacitor power dissipation
18.	Coutx Pd	8.92 nW	Power	Output capacitor_x power loss
19.	IC Pd	2.794 W	Power	IC power dissipation
20.	L Pd	210.53 mW	Power	Inductor power dissipation
21.	Total Pd	3.006 W	Power	Total Power Dissipation
22.	BOM Count	15	System Information	Total Design BOM count
23.	Cross Freq	69.205 kHz	System Information	Bode plot crossover frequency
24.	Duty Cycle	19.234 %	System Information	Duty cycle
25.	Efficiency	86.934 %	System Information	Steady state efficiency
26.	FootPrint	205.0 mm^2	System Information	Total Foot Print Area of BOM components

#	Name	Value	Category	Description
27.	Frequency	1000.0 kHz	System Information	Switching frequency
28.	Gain Marg	-21.91 dB	System Information	Bode Plot Gain Margin
29.	Iout	4.0 A	System Information	Iout operating point
30.	Low Freq Gain	88.89 dB	System Information	Gain at 1Hz
31.	Mode	CCM	System Information	Conduction Mode
32.	Phase Marg	68.636 deg	System Information	Bode Plot Phase Margin
33.	Pout	20.0 W	System Information	Total output power
34.	Total BOM	$2.74	System Information	Total BOM Cost
35.	Vin	28.0 V	System Information	Vin operating point
36.	Vin p-p	63.562 mV	System Information	Peak-to-peak input voltage
37.	Vout	5.0 V	System Information	Operational Output Voltage
38.	Vout Actual	5.016 V	System Information	Vout Actual calculated based on selected voltage divider resistors
39.	Vout Tolerance	3.142 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
40.	Vout p-p	2.926 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	4.0	Maximum Output Current
VinMax	28.0	Maximum input voltage
VinMin	5.6	Minimum input voltage
Vout	5.0	Output Voltage
base_pn	LMR33640D-SOIC	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

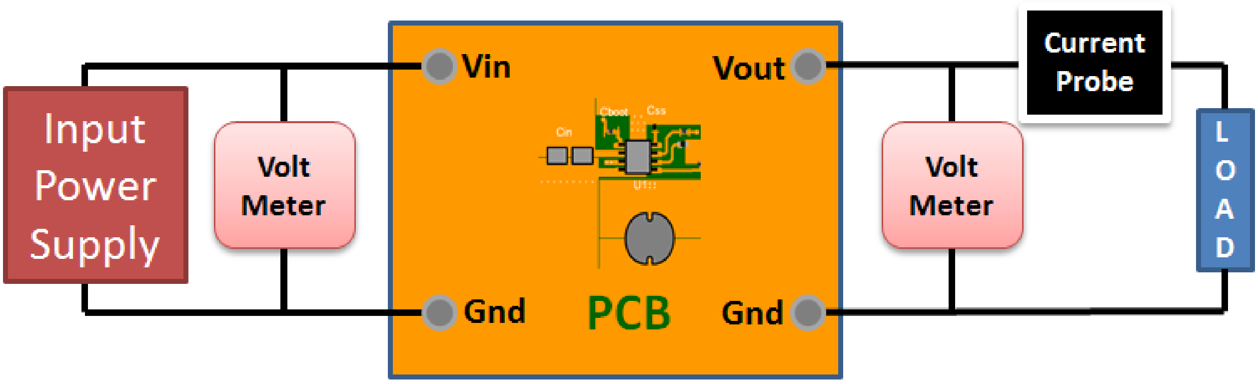
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 5.6V 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 : D339A36C6F52F618[v1]

2. **LMR33640D-SOIC** Product Folder : http://www.ti.com/product/LMR33640 : contains the data sheet and other resources.