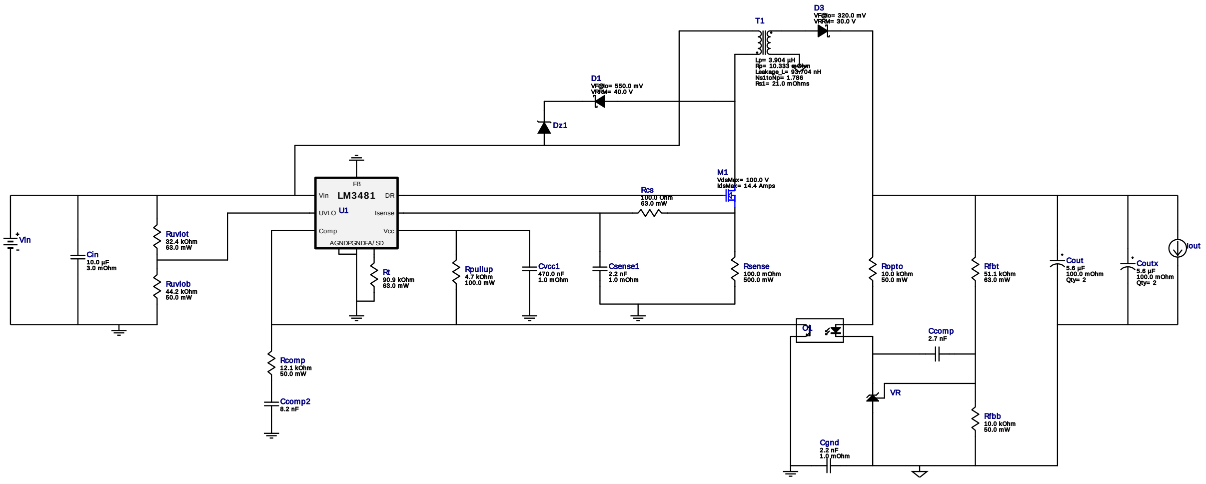
TEXAS INSTRUMENTS

VinMin = 3.6V
VinMax = 4.2V
Vout = 15.0V
Iout = 0.2A

Device = LM3481MM/NOPB
Topology = Flyback
Created = 2021-01-24 10:16:04.186
BOM Cost = NA
BOM Count = 28
Total Pd = 0.25W

WEBENCH ® Design Report

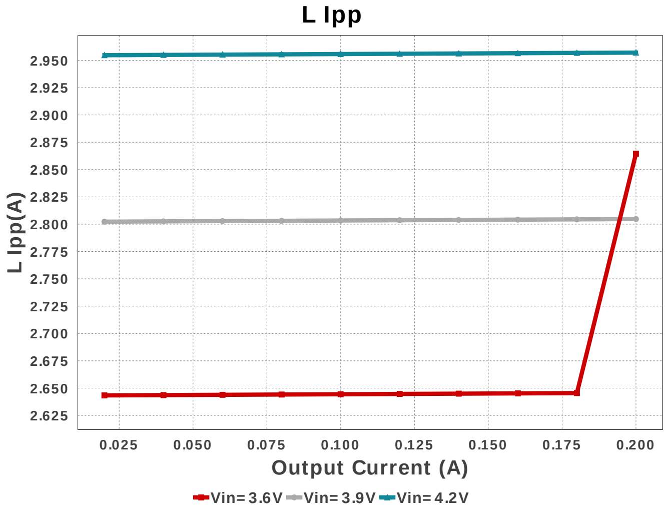
Design : 26 LM3481MM/NOPB
LM3481MM/NOPB 3.6V-4.2V to 15.00V @ 0.2A

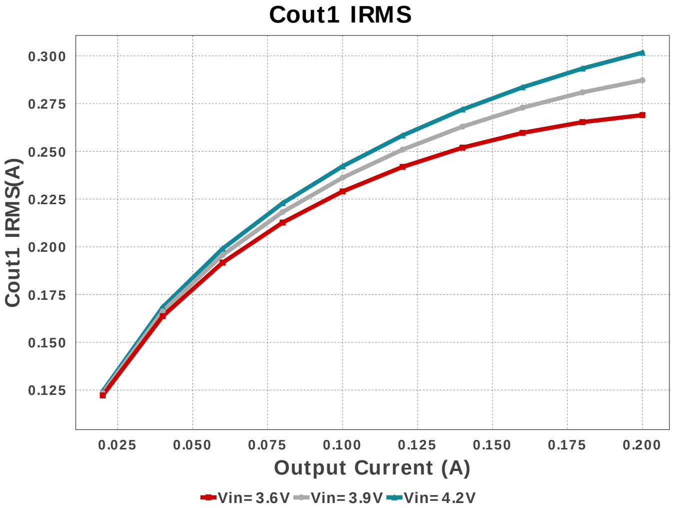


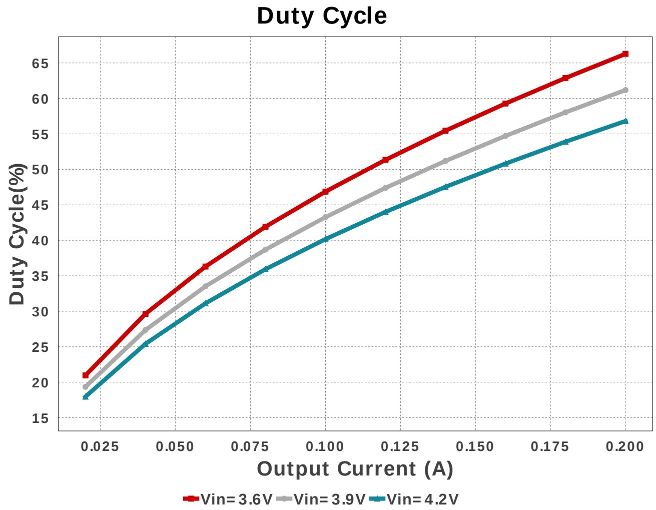
Electrical BOM

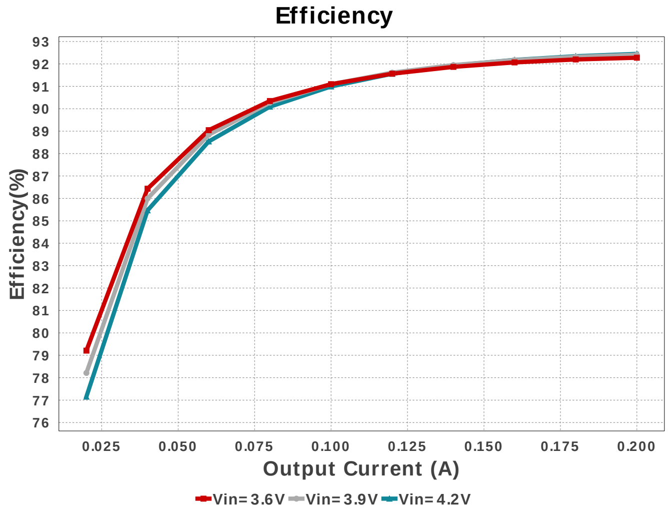
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Ccomp	TDK	C2012C0G1H272J060AA Series= C0G/NP0	Cap= 2.7 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.03	0805 7 mm²
Ccomp2	TDK	C2012C0G1H822K060AA Series= C0G/NP0	Cap= 8.2 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.05	0805 7 mm²
Cgnd	Johanson Technology	202S41W222KV4E Series= X7R	Cap= 2.2 nF ESR= 1.0 mOhm VDC= 2.0 kV IRMS= 0.0 A	1	$0.23	1210_280 15 mm²
Cin	Kemet	C0805C106K8PACTU Series= X5R	Cap= 10.0 uF ESR= 3.0 mOhm VDC= 10.0 V IRMS= 11.43 A	1	$0.03	0805 7 mm²
Cout	Panasonic	25TQC5R6M Series= TQC	Cap= 5.6 uF ESR= 100.0 mOhm VDC= 25.0 V IRMS= 800.0 mA	2	$0.61	3528-21 17 mm²
Coutx	Panasonic	25TQC5R6M Series= TQC	Cap= 5.6 uF ESR= 100.0 mOhm VDC= 25.0 V IRMS= 800.0 mA	2	$0.61	3528-21 17 mm²
Csense1	MuRata	GRM033R71A222KA01D Series= X7R	Cap= 2.2 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0201 2 mm²
Cvcc1	MuRata	GRM155C80G474KE01D Series= X6S	Cap= 470.0 nF ESR= 1.0 mOhm VDC= 4.0 V IRMS= 0.0 A	1	$0.02	0402 3 mm²
D1	Fairchild Semiconductor	SS14FL	VF@Io= 550.0 mV VRRM= 40.0 V	1	$0.04	SOD-123F 12 mm²

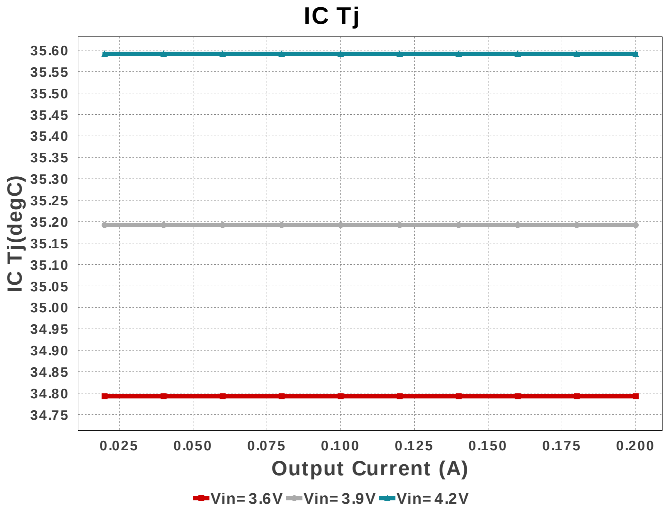
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
D3	Toshiba	CMS06	VF@Io= 320.0 mV VRRM= 30.0 V	1	$0.19	M-FLAT 19 mm^2
Dz1	Nexperia	BZX585-C22,115	Zener	1	$0.02	SOD-523 5 mm^2
M1	Texas Instruments	CSD19538Q2	VdsMax= 100.0 V IdsMax= 14.4 Amps	1	$0.15	DQK0006C 9 mm^2
O1	California Eastern Laboratories	PS2811-1	Optocoupler	1	$0.41	SSOP-4 111 mm^2
Rcomp	Yageo	RC0201FR-0712K1L Series= ?	Res= 12.1 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rcs	Vishay-Dale	CRCW0402100RFKED Series= CRCW..e3	Res= 100.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rfbt	Vishay-Dale	CRCW040251K1FKED Series= CRCW..e3	Res= 51.1 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ropto	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rpullup	Yageo	RC0603FR-074K7L Series= ?	Res= 4.7 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rsense	Rohm	MCR25JZHFLR100 Series= MCR25	Res= 100.0 mOhm Power= 500.0 mW Tolerance= 1.0%	1	$0.03	1210 15 mm^2
Rt	Vishay-Dale	CRCW040290K9FKED Series= CRCW..e3	Res= 90.9 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ruvlob	Vishay-Dale	CRCW020144K2FNED Series= ?	Res= 44.2 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Ruvlot	Vishay-Dale	CRCW040232K4FKED Series= CRCW..e3	Res= 32.4 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
T1	CUSTOM	CUSTOM	Lp= 3.904 µH Rp= 10.333 mOhm Leakage_L= 93.704 nH Ns1toNp= 1.786 Rs1= 21.0 mOhms	1	NA	CUSTOM 0 mm^2
U1	Texas Instruments	LM3481MM/NOPB	Switcher	1	$0.70	MUB10A 24 mm^2
VR	Texas Instruments	TL431IDBVR	Voltage References	1	$0.06	R-PDSO-G3 16 mm^2

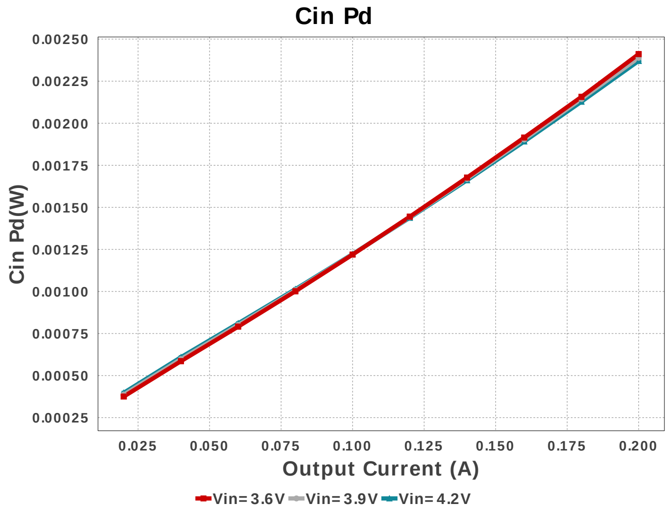

L Ipp
L Ipp(A)
2.950
2.925
2.900
2.875
2.850
2.825
2.800
2.775
2.750
2.725
2.700
2.675
2.650
2.625
0.025 0.050 0.075 0.100 0.125 0.150 0.175 0.200
Output Current (A)
Vin= 3.6V Vin= 3.9V Vin= 4.2V

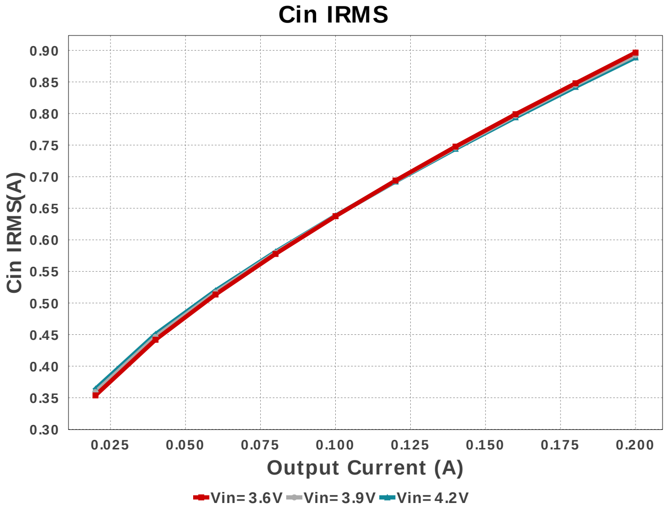

Cout1 IRMS
Cout1 IRMS(A)
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.025 0.050 0.075 0.100 0.125 0.150 0.175 0.200
Output Current (A)
Vin= 3.6V Vin= 3.9V Vin= 4.2V

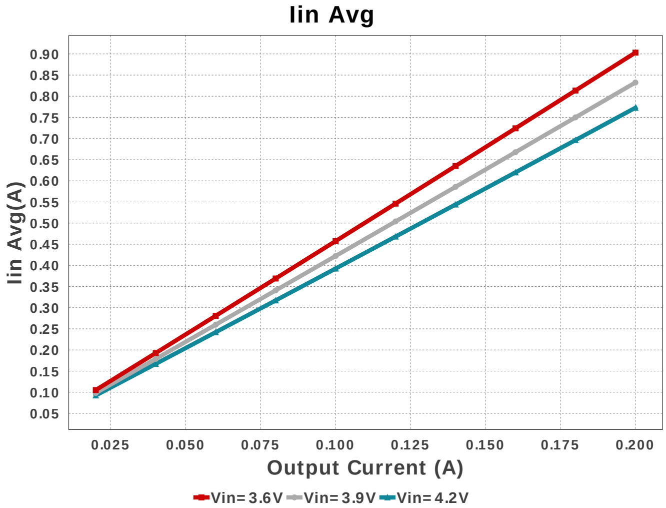

Duty Cycle
Duty Cycle(%)
65
60
55
50
45
40
35
30
25
20
15
0.025 0.050 0.075 0.100 0.125 0.150 0.175 0.200
Output Current (A)
Vin= 3.6V Vin= 3.9V Vin= 4.2V

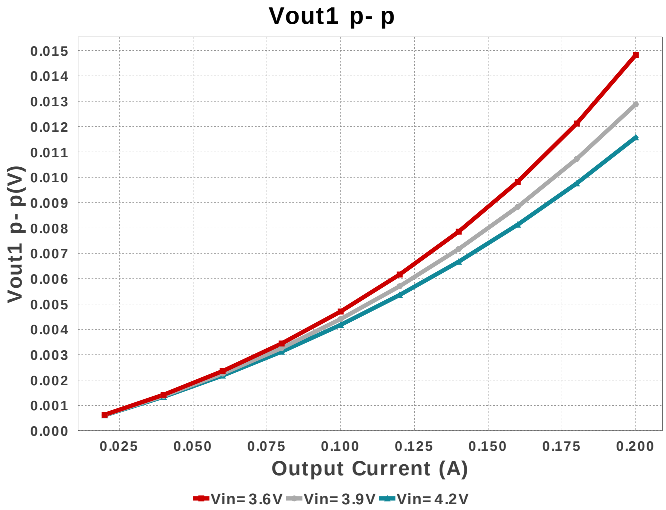

Efficiency
Efficiency(%)
93
92
91
90
89
88
87
86
85
84
83
82
81
80
79
78
77
76
0.025 0.050 0.075 0.100 0.125 0.150 0.175 0.200
Output Current (A)
Vin= 3.6V Vin= 3.9V Vin= 4.2V

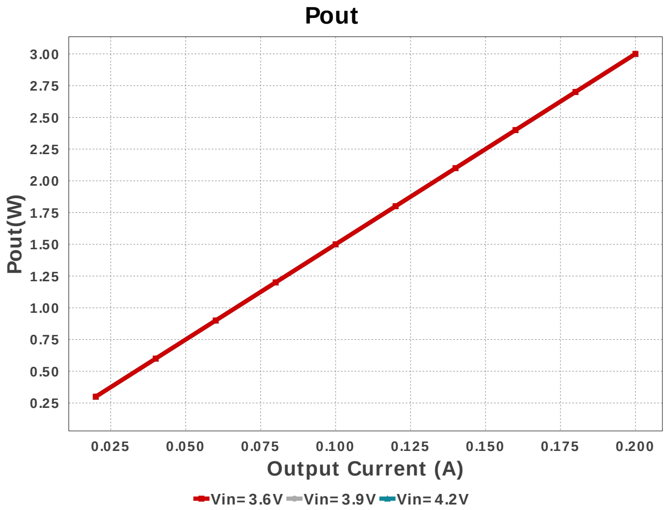

IC Tj
IC Tj(degC)
35.60
35.55
35.50
35.45
35.40
35.35
35.30
35.25
35.20
35.15
35.10
35.05
35.00
34.95
34.90
34.85
34.80
34.75
0.025 0.050 0.075 0.100 0.125 0.150 0.175 0.200
Output Current (A)
Vin= 3.6V Vin= 3.9V Vin= 4.2V

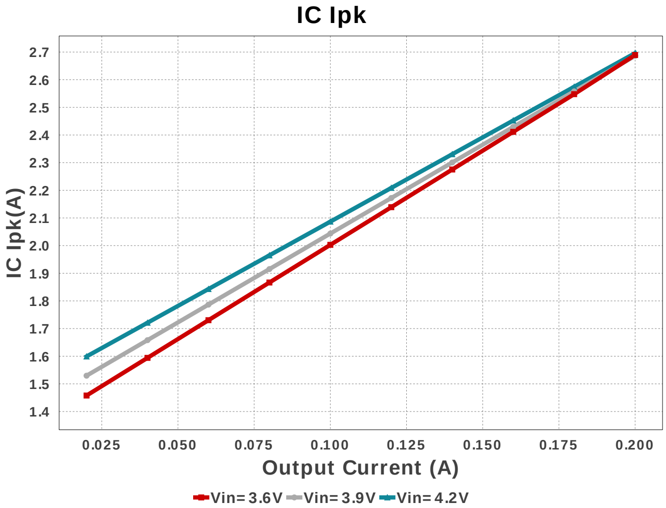

Cin Pd
Cin Pd(W)
0.00250
0.00225
0.00200
0.00175
0.00150
0.00125
0.00100
0.00075
0.00050
0.00025
0.025 0.050 0.075 0.100 0.125 0.150 0.175 0.200
Output Current (A)
Vin= 3.6V Vin= 3.9V Vin= 4.2V

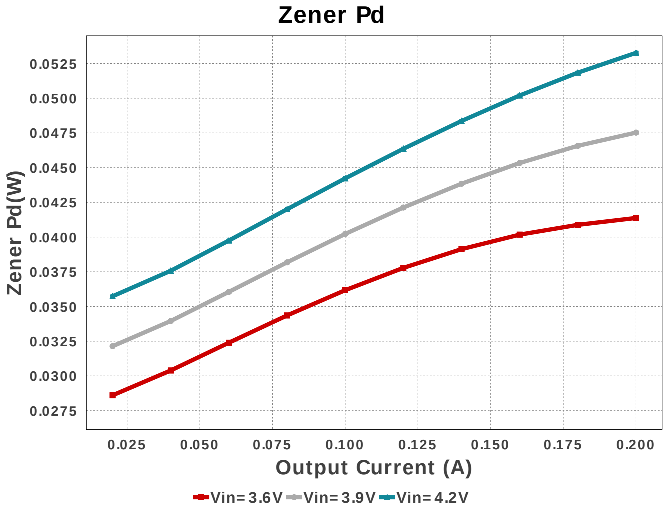

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=3.6V Vin=3.9V Vin=4.2V

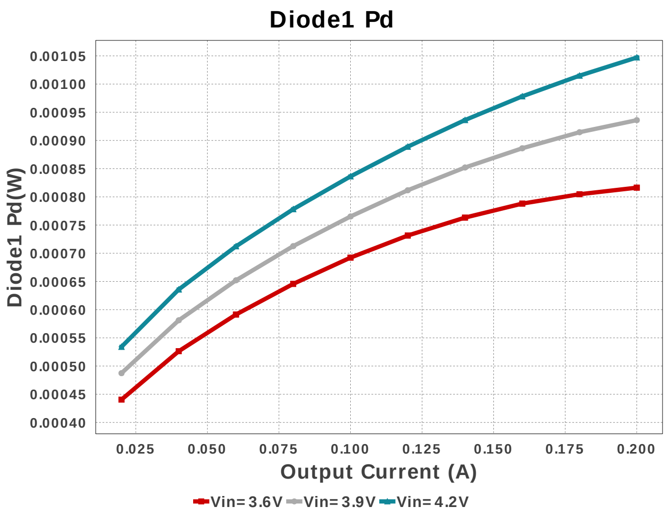

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=3.6V Vin=3.9V Vin=4.2V

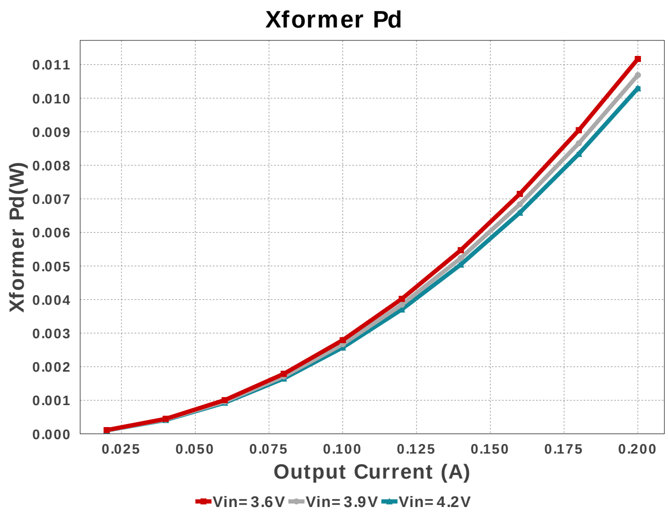

Vout1 p-p
Vout1 p-p(V)
Output Current (A)
Vin=3.6V Vin=3.9V Vin=4.2V

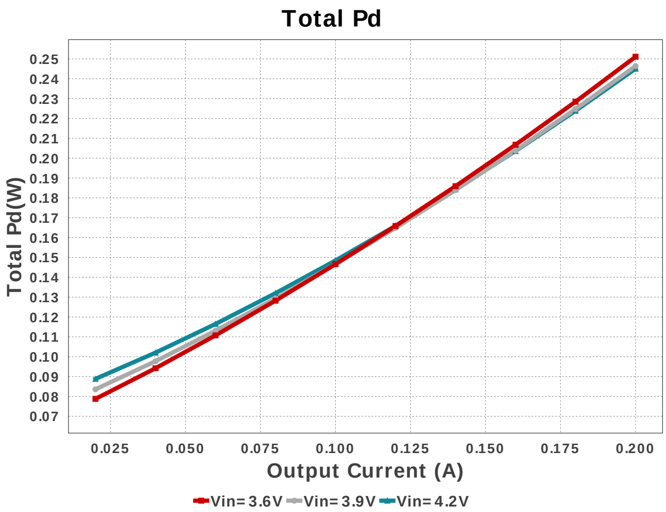

Pout
Pout(W)
Output Current (A)
Vin=3.6V Vin=3.9V Vin=4.2V

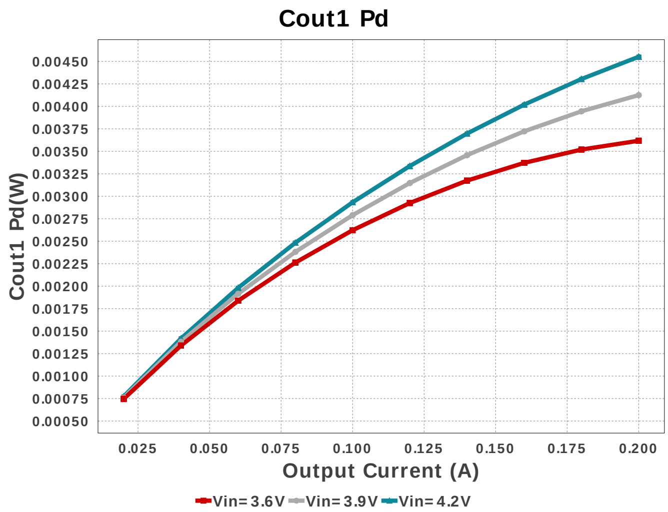

IC Ipk
IC Ipk(A)
Output Current (A)
Vin=3.6V Vin=3.9V Vin=4.2V

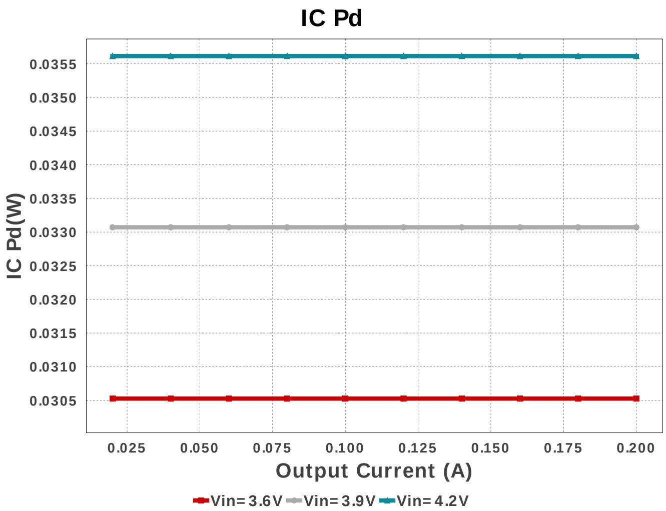

Zener Pd
Zener Pd(W)
Output Current (A)
Vin=3.6V Vin=3.9V Vin=4.2V

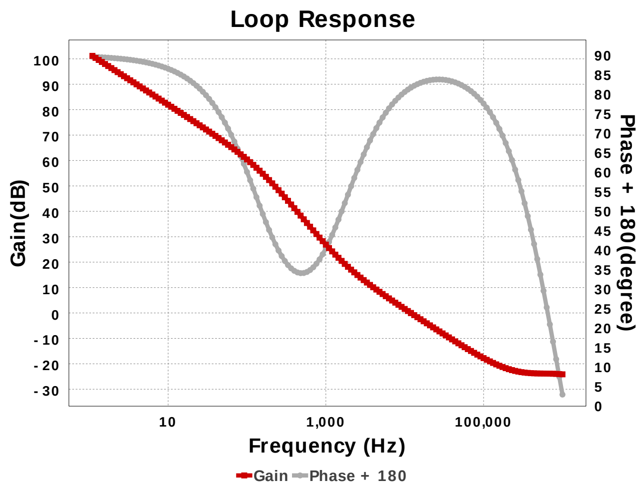












Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	896.434 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	2.408 mW	Capacitor	Input capacitor power dissipation
3.	Cout1 IRMS	268.988 mA	Capacitor	Output capacitor1 RMS ripple current
4.	Cout1 Pd	3.618 mW	Capacitor	Output capacitor1 power dissipation
5.	Cout1 Pd	3.618 mW	Capacitor	Output capacitor1 power dissipation
6.	Diode1 Pd	815.27 µW	Diode	Diode1 power dissipation
7.	IC Ipk	2.689 A	IC	Peak switch current
8.	IC Pd	30.527 mW	IC	IC power dissipation
9.	IC Tj	34.793 degC	IC	IC junction temperature
10.	IC Tolerance	19.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA	157.0 degC/W	IC	IC junction-to-ambient thermal resistance

#	Name	Value	Category	Description
12.	Iin Avg	903.08 mA	IC	Average input current
13.	L Ipp	2.864 A	Inductor	Peak-to-peak inductor ripple current
14.	Vout1 OP	15.0 V	Op Point	Operational Voltage 1
15.	Vout1 p-p	14.826 mV	Op Point	Peak-to-peak output1 ripple voltage
16.	Cin Pd	2.411 mW	Power	Input capacitor power dissipation
17.	Cout1 Pd	3.618 mW	Power	Output capacitor1 power dissipation
18.	Cout1 Pd	3.618 mW	Power	Output capacitor1 power dissipation
19.	Diode1 Pd	816.31 µW	Power	Diode1 power dissipation
20.	IC Pd	30.527 mW	Power	IC power dissipation
21.	Total Pd	251.082 mW	Power	Total Power Dissipation
22.	Xformer Pd	11.168 mW	Power	Transformer power dissipation
23.	Zener Pd	41.375 mW	Power	Zener power dissipation
24.	BOM Count	28	System Information	Total Design BOM count
25.	Cross Freq	9.41 kHz	System Information	Bode plot crossover frequency
26.	Duty Cycle	66.276 %	System Information	Duty cycle
27.	Efficiency	92.277 %	System Information	Steady state efficiency
28.	FootPrint	349.0 mm^2	System Information	Total Foot Print Area of BOM components
29.	Frequency	227.818 kHz	System Information	Switching frequency
30.	Gain Marg	-21.205 dB	System Information	Bode Plot Gain Margin
31.	Gain Marg	-21.188 dB	System Information	Bode Plot Gain Margin
32.	Iout	200.0 mA	System Information	Iout operating point
33.	Low Freq Gain	98.51 dB	System Information	Gain at 1Hz
34.	Low Freq Gain	98.51 dB	System Information	Gain at 1Hz
35.	Mode	DCM	System Information	Conduction Mode
36.	Phase Marg	78.624 deg	System Information	Bode Plot Phase Margin
37.	Pout	3.0 W	System Information	Total output power
38.	Total BOM	NA	System Information	Total BOM Cost
39.	Vin	3.6 V	System Information	Vin operating point
40.	Vout Actual	15.244 V	System Information	Vout Actual calculated based on selected voltage divider resistors
41.	Vout Tolerance	2.464 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
42.	Xformer Pd	11.168 mW	Transformer	Transformer power dissipation
43.	Zener Pd	41.323 mW	Zener diode	Zener power dissipation

Design Inputs

Name	Value	Description
Iout	200.0 m	Maximum Output Current
VinMax	4.2	Maximum input voltage
VinMin	3.6	Minimum input voltage
Vout	15.0	Output Voltage
base_pn	LM3481	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature
UserFsw	130.0 k	Customer Selected Frequency

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

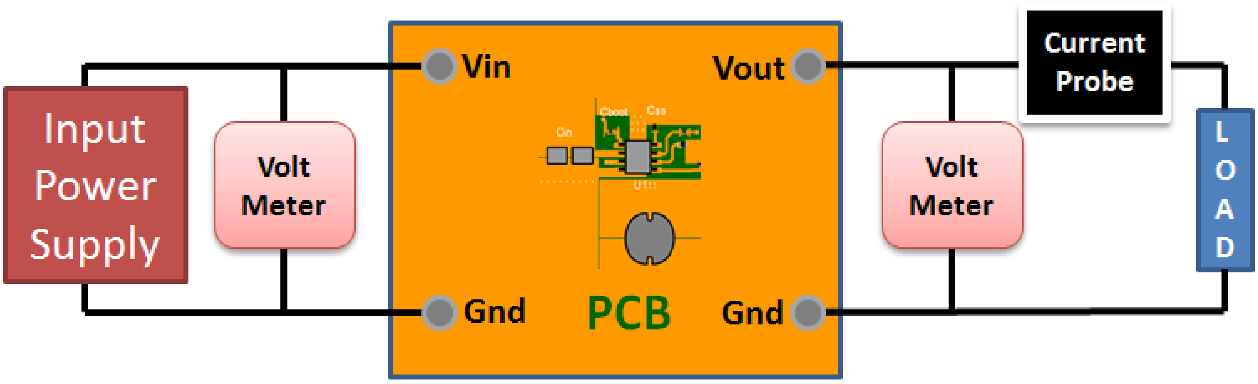
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 3.6V 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 : DBF23269794A0BE1[v1]

2. **LM3481** Product Folder : http://www.ti.com/product/LM3481 : contains the data sheet and other resources.

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