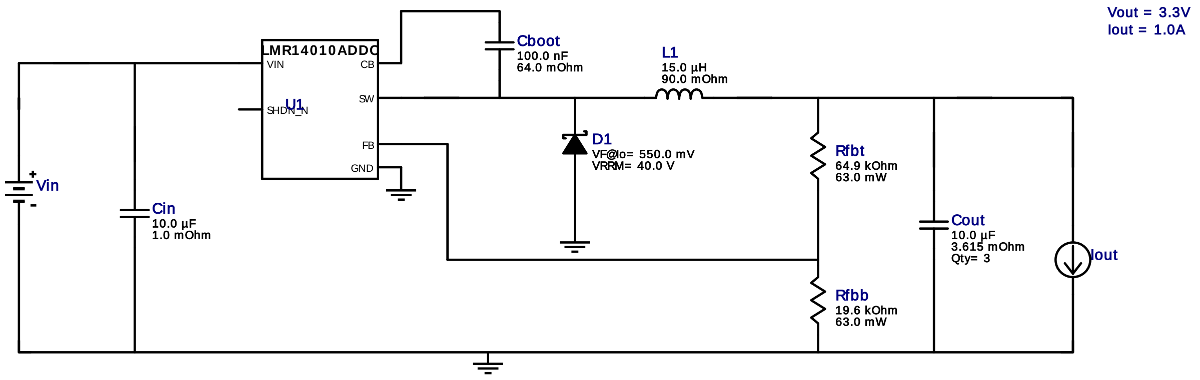
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 5.0V
VinMax = 18.0V
Vout = 3.3V
Iout = 1.0A

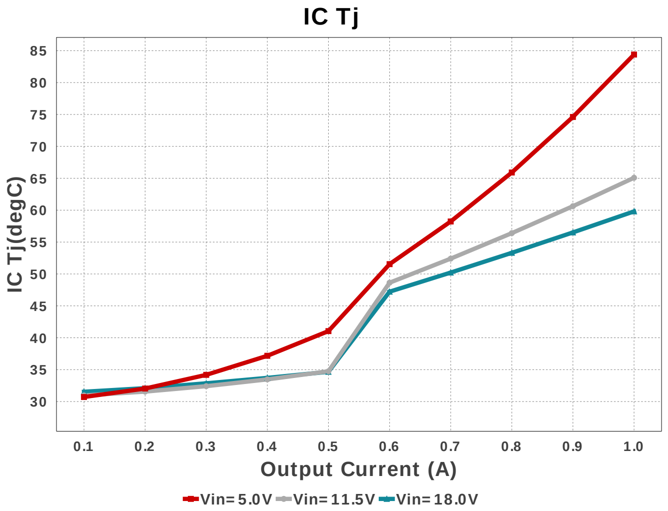
Device = LMR14010ADDCR
Topology = Buck
Created = 2020-04-12 07:19:14.635
BOM Cost = $1.54
BOM Count = 10
Total Pd = 0.92W

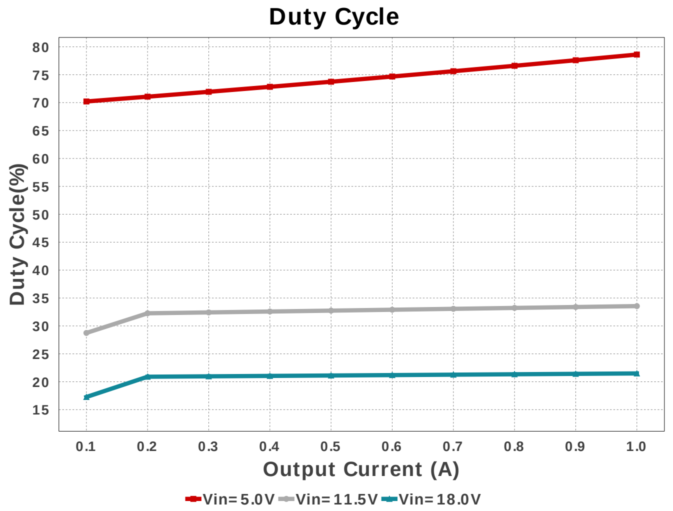
Design : 4 LMR14010ADDCR
LMR14010ADDCR 5V-18V to 3.30V @ 1A

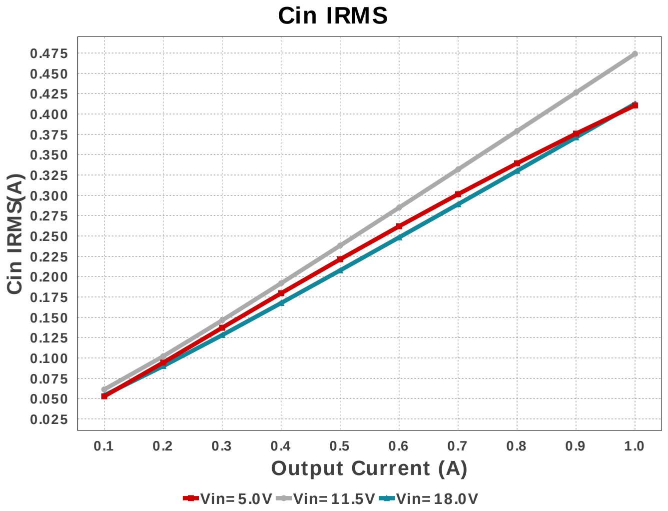


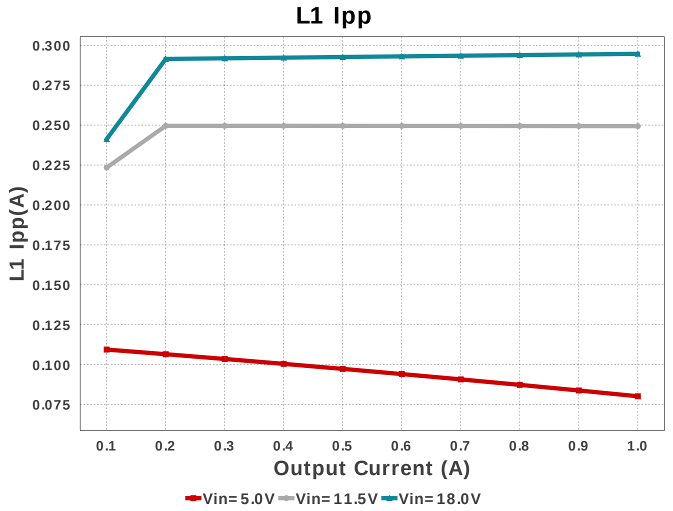
Electrical BOM

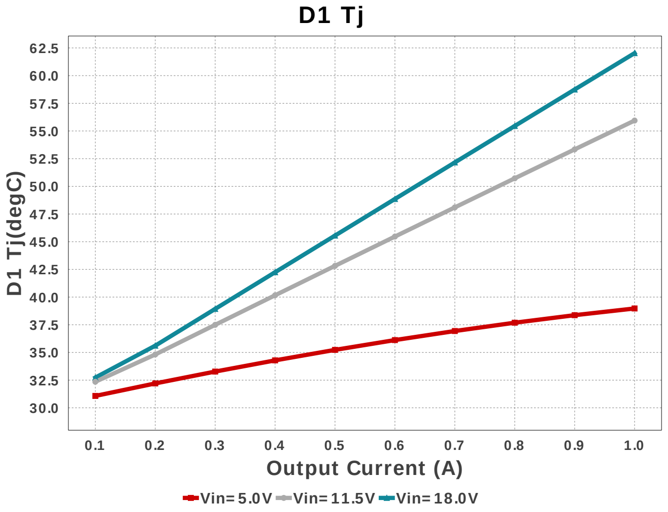
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	Kemet	C0805C104M5RACTU Series= X7R	Cap= 100.0 nF ESR= 64.0 mOhm VDC= 50.0 V IRMS= 1.64 A	1	$0.01	0805 7 mm^2
Cin	TDK	C3225X7R1H106M250AC Series= X7R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 5.0 A	1	$0.28	1210 15 mm^2
Cout	MuRata	GRM31CR61C106KA88L Series= X5R	Cap= 10.0 uF ESR= 3.615 mOhm VDC= 16.0 V IRMS= 3.8281 A	3	$0.08	1206_190 11 mm^2
D1	Fairchild Semiconductor	SS24FL	VF@Io= 550.0 mV VRRM= 40.0 V	1	$0.05	SOD-123F 12 mm^2
L1	NIC Components	NPI75C150MTRF	L= 15.0 µH 90.0 mOhm	1	$0.15	IND_NPI75C 94 mm^2
Rfbb	Vishay-Dale	CRCW040219K6FKED Series= CRCW..e3	Res= 19.6 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt	Vishay-Dale	CRCW040264K9FKED Series= CRCW..e3	Res= 64.9 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
U1	Texas Instruments	LMR14010ADDCR	Switcher	1	$0.79	DDC0006A_N 10 mm^2

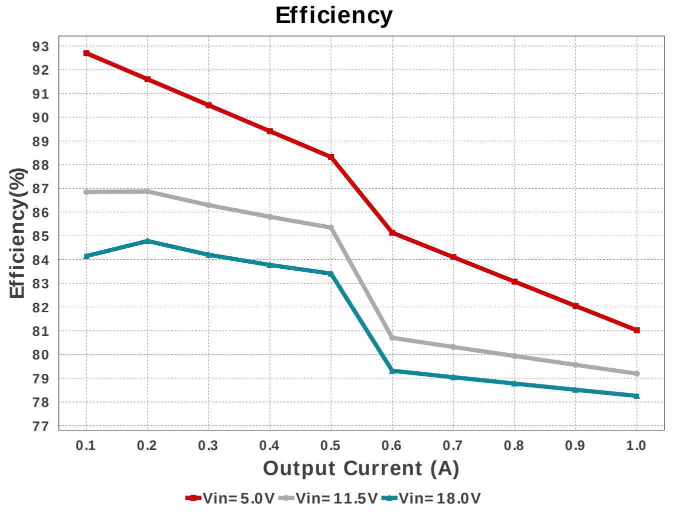

IC Tj
IC Tj(degC)
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V

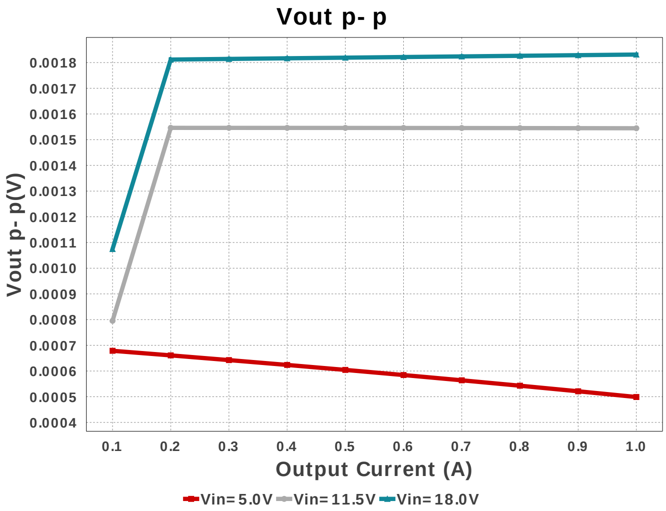

Duty Cycle
Duty Cycle(%)
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V

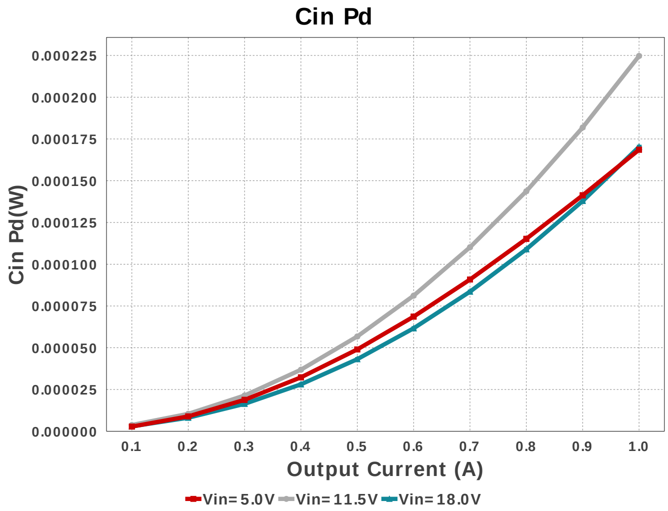

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V

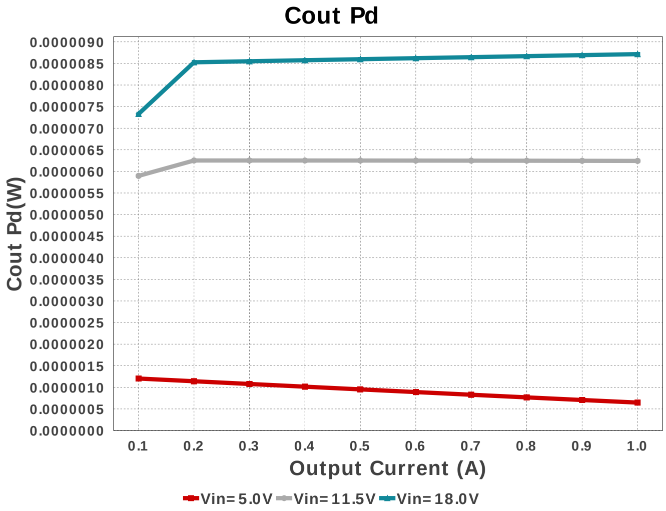

L1 Ipp
L1 Ipp(A)
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V

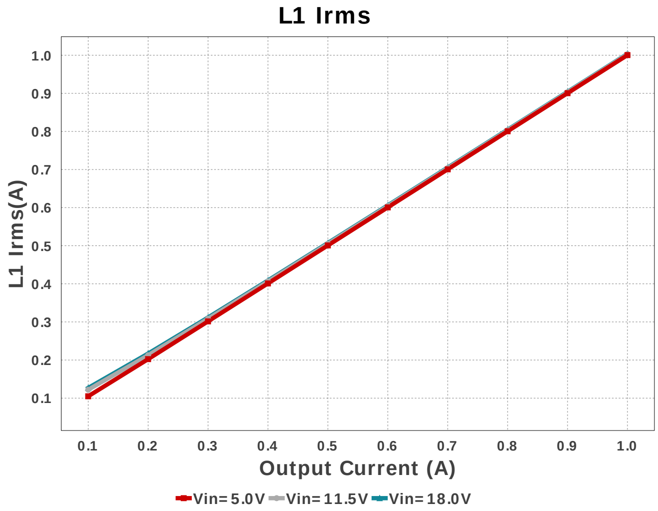

D1 Tj
D1 Tj(degC)
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V

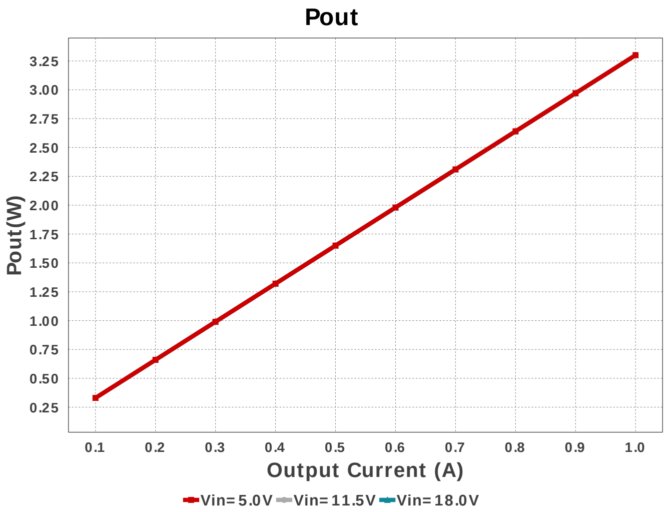

Efficiency
Efficiency(%)
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V

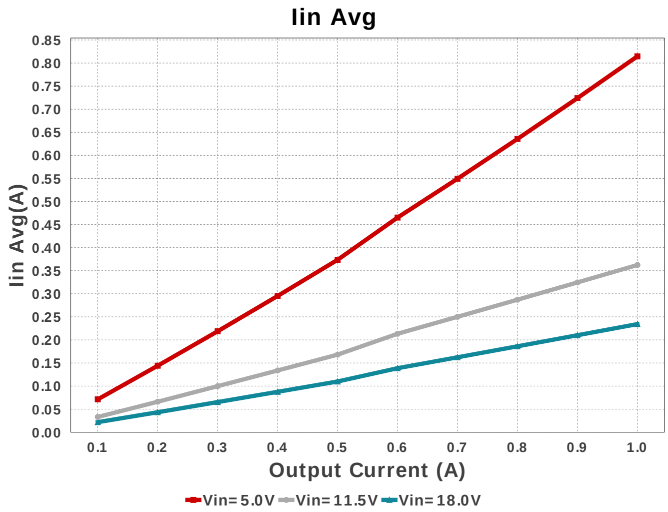

Vout p- p
Vout p- p(V)
0.0018
0.0017
0.0016
0.0015
0.0014
0.0013
0.0012
0.0011
0.0010
0.0009
0.0008
0.0007
0.0006
0.0005
0.0004
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V

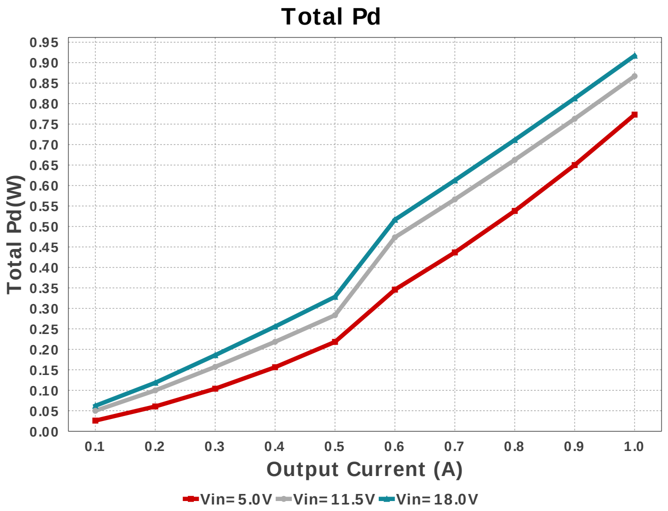

Cin Pd
Cin Pd(W)
0.000225
0.000200
0.000175
0.000150
0.000125
0.000100
0.000075
0.000050
0.000025
0.000000
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V

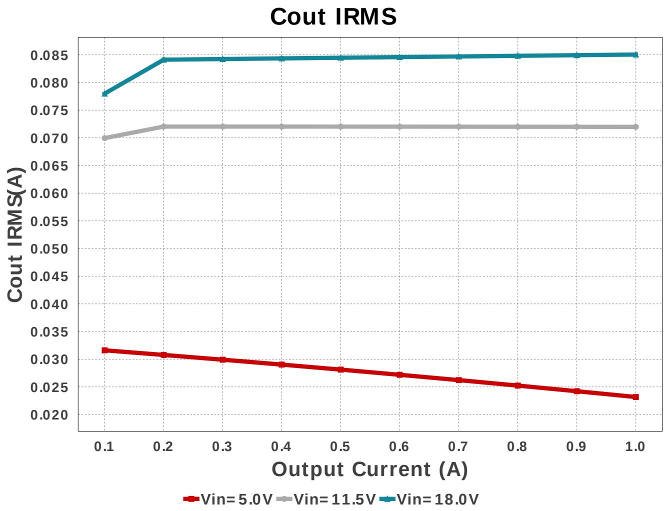

Cout Pd
Cout Pd(W)
0.0000090
0.0000085
0.0000080
0.0000075
0.0000070
0.0000065
0.0000060
0.0000055
0.0000050
0.0000045
0.0000040
0.0000035
0.0000030
0.0000025
0.0000020
0.0000015
0.0000010
0.0000005
0.0000000
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V

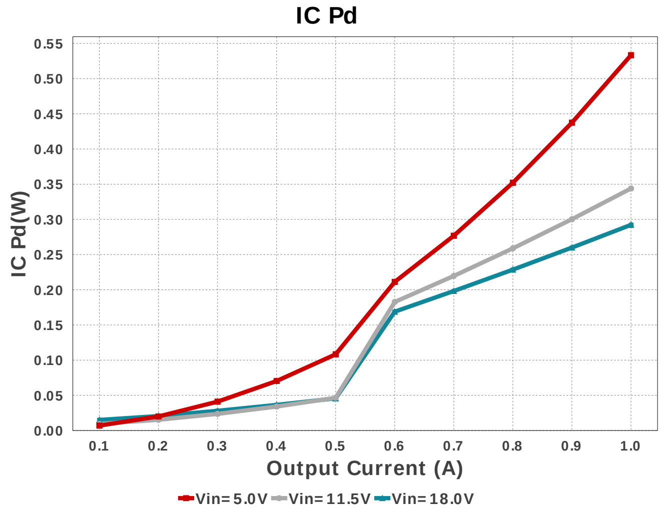

L1 Irms
L1 Irms(A)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V

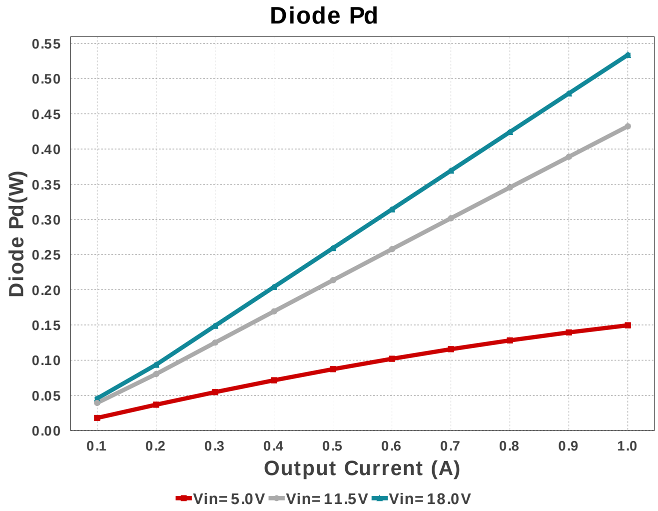

Pout
Pout(W)
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V

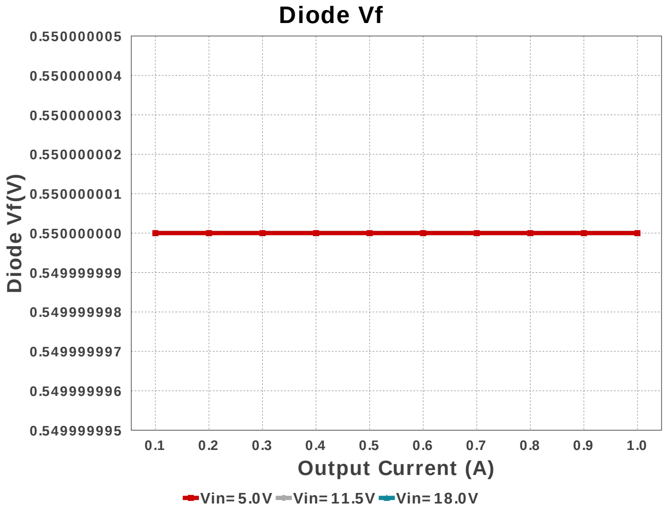

Iin Avg
Iin Avg(A)
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V

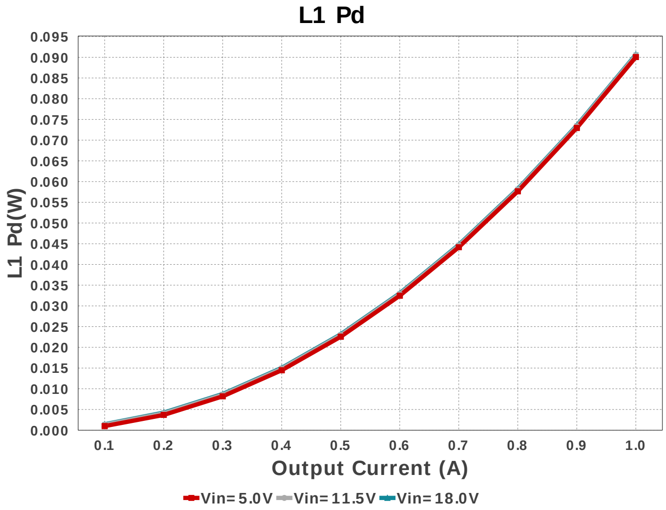

Total Pd
Total Pd(W)
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V

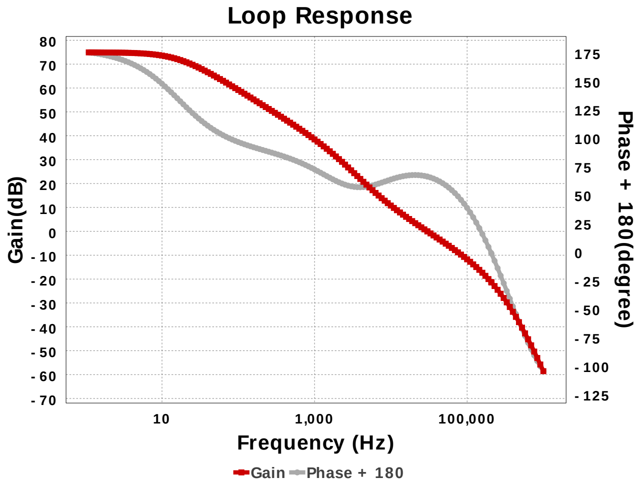

Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V

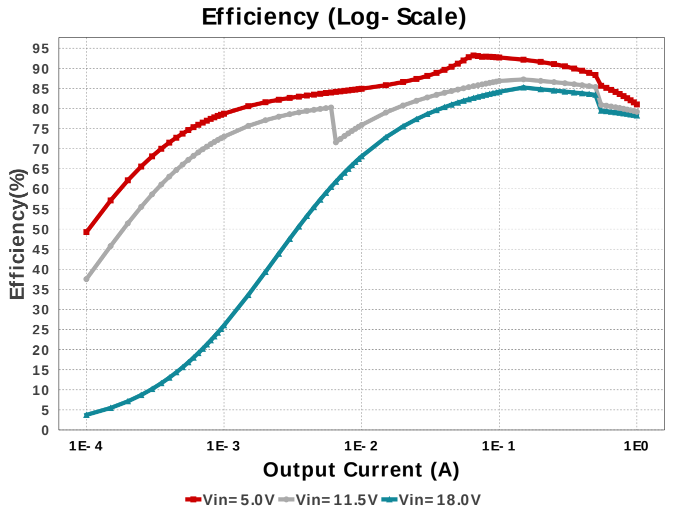

IC Pd
IC Pd(W)
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V


Diode Pd
Diode Pd(W)
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V


Diode Vf
Diode Vf(V)
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V


L1 Pd
L1 Pd(W)
Output Current (A)
Vin=5.0V Vin=11.5V Vin=18.0V





Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	412.636 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	170.27 µW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	85.044 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	8.715 µW	Capacitor	Output capacitor power dissipation
5.	D1 Tj	62.029 degC	Diode	D1 junction temperature
6.	Diode Pd	533.82 mW	Diode	Diode power dissipation
7.	Diode Vf	550.0 mV	Diode	Forward voltage drop of diode D1
8.	IC Pd	292.24 mW	IC	IC power dissipation
9.	IC Tj	59.809 degC	IC	IC junction temperature
10.	IC Tolerance	18.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA	102.0 degC/W	IC	IC junction-to-ambient thermal resistance
12.	Iin Avg	234.28 mA	IC	Average input current
13.	L1 Irms	1.004 A	Inductor	Inductor ripple current
14.	L1 Pd	90.651 mW	Inductor	Inductor power dissipation
15.	Cin Pd	170.27 µW	Power	Input capacitor power dissipation
16.	Cout Pd	8.715 µW	Power	Output capacitor power dissipation
17.	Diode Pd	533.82 mW	Power	Diode power dissipation
18.	IC Pd	292.24 mW	Power	IC power dissipation
19.	L1 Pd	90.651 mW	Power	Inductor power dissipation
20.	Total Pd	917.038 mW	Power	Total Power Dissipation
21.	BOM Count	10	System Information	Total Design BOM count
22.	Cross Freq	30.111 kHz	System Information	Bode plot crossover frequency
23.	Duty Cycle	21.489 %	System Information	Duty cycle
24.	Efficiency	78.254 %	System Information	Steady state efficiency
25.	FootPrint	176.0 mm^2	System Information	Total Foot Print Area of BOM components
26.	Frequency	700.0 kHz	System Information	Switching frequency
27.	Gain Marg	-21.262 dB	System Information	Bode Plot Gain Margin
28.	Iout	1.0 A	System Information	Iout operating point
29.	L1 Ipp	294.602 mA	System Information	
30.	Low Freq Gain	74.911 dB	System Information	Gain at 1Hz
31.	Mode	CCM	System Information	Conduction Mode
32.	Phase Marg	67.105 deg	System Information	Bode Plot Phase Margin
33.	Pout	3.3 W	System Information	Total output power
34.	Total BOM	$1.536	System Information	Total BOM Cost
35.	Vin	18.0 V	System Information	Vin operating point
36.	Vout	3.3 V	System Information	Operational Output Voltage

#	Name	Value	Category	Description
37.	Vout Actual	3.298 V	System Information	Vout Actual calculated based on selected voltage divider resistors
38.	Vout Tolerance	3.941 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
39.	Vout p-p	1.831 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	1.0	Maximum Output Current
VinMax	18.0	Maximum input voltage
VinMin	5.0	Minimum input voltage
Vout	3.3	Output Voltage
base_pn	LMR14010A	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

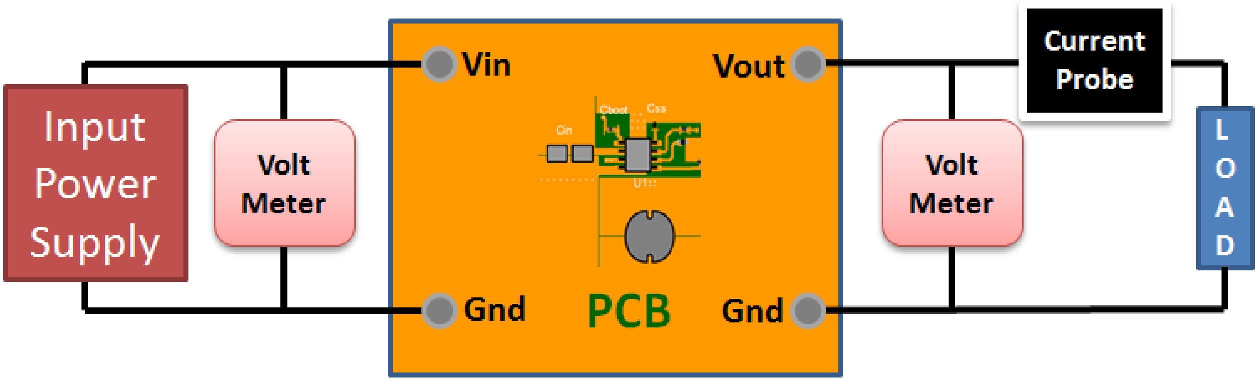
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 5.0V 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 : 405C0D4BC8FE04E1[v1]

2. **LMR14010A** Product Folder : http://www.ti.com/product/LMR14010A : contains the data sheet and other resources.

Important Notice and Disclaimer

TI provides technical and reliability data (including datasheets), design resources (including reference designs), application or other design advice, web tools, safety information, and other resources AS IS and with all faults, and disclaims all warranties. These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

Providing these resources does not expand or otherwise alter TI's applicable Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with TI products.