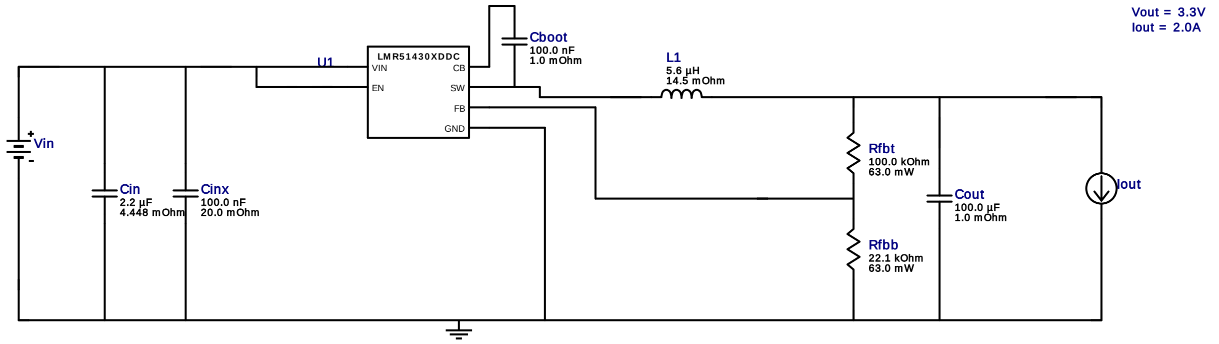
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 9.0V
VinMax = 30.0V
Vout = 3.3V
Iout = 2.0A

Device = LMR51430XDDCR
Topology = Buck
Created = 2024-11-18 15:32:16.017
BOM Cost = $1.60
BOM Count = 8
Total Pd = 1.05W

Design : 35 LMR51430XDDCR
LMR51430XDDCR 9V-30V to 3.30V @ 2A



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 mm²
Cin	MuRata	GRM31CR61H225KA88L Series= X5R	Cap= 2.2 uF ESR= 4.448 mOhm VDC= 50.0 V IRMS= 2.2252 A	1	$0.11	1206_190 11 mm²
Cinx	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
Cout	MuRata	GRM32EC80J107ME20L Series= X6S	Cap= 100.0 uF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 6.0 A	1	$0.17	1210_270 15 mm²
L1	Coilcraft	XAL6060-562MEB	L= 5.6 µH 14.5 mOhm	1	$0.82	XAL6060 72 mm²
Rfbb	Vishay-Dale	CRCW040222K1FKED Series= CRCW..e3	Res= 22.1 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
U1	Texas Instruments	LMR51430XDDCR	Switcher	1	$0.45	DBV0006A 15 mm²

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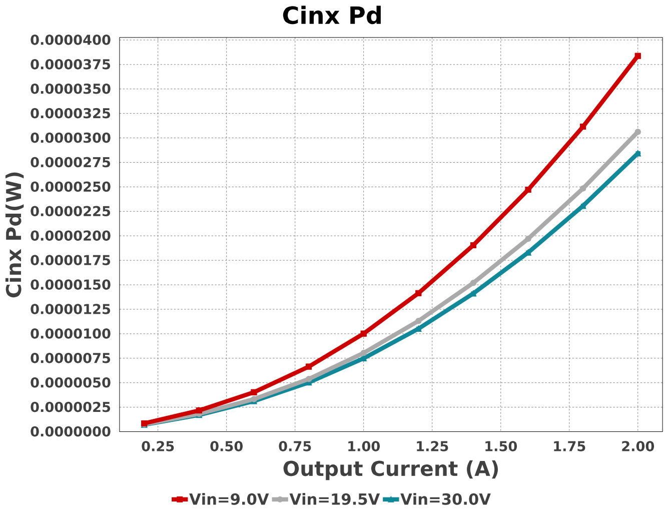
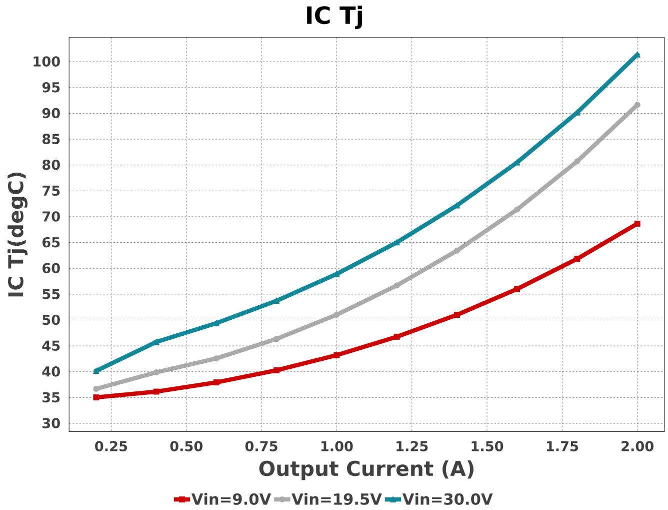
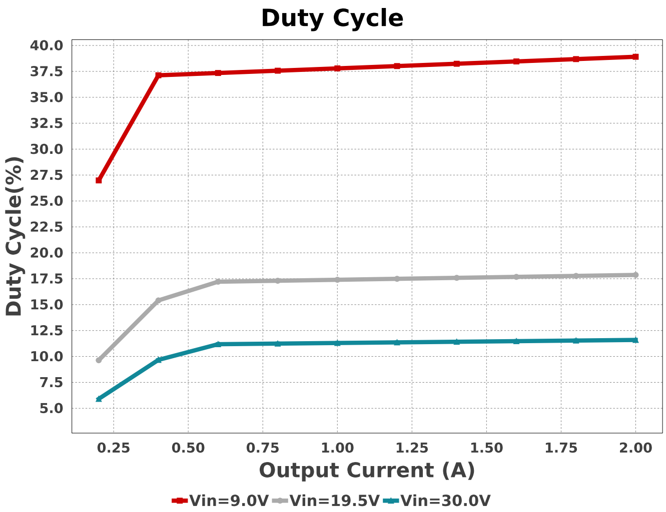
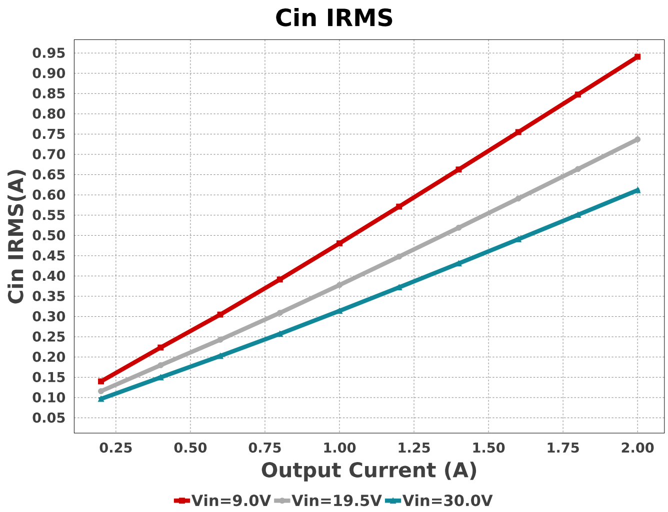
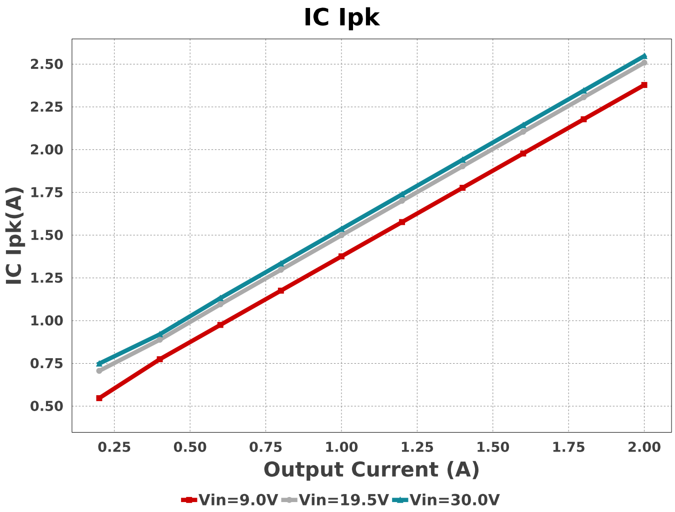
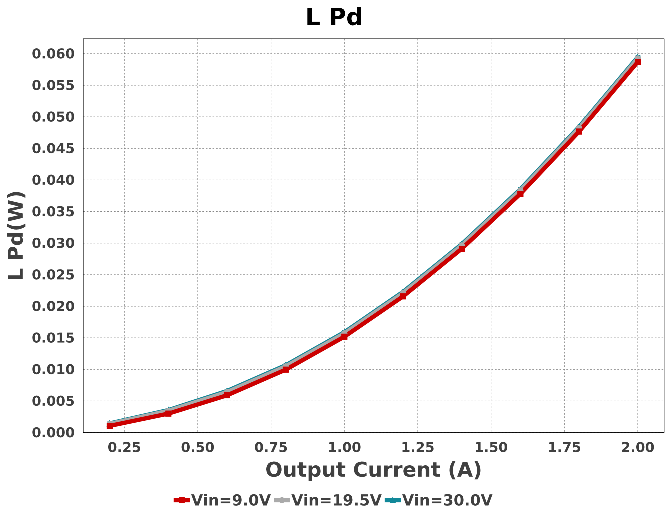

Cinx Pd
Cinx Pd(W)
0.0000400
0.0000375
0.0000350
0.0000325
0.0000300
0.0000275
0.0000250
0.0000225
0.0000200
0.0000175
0.0000150
0.0000125
0.0000100
0.0000075
0.0000050
0.0000025
0.0000000
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V

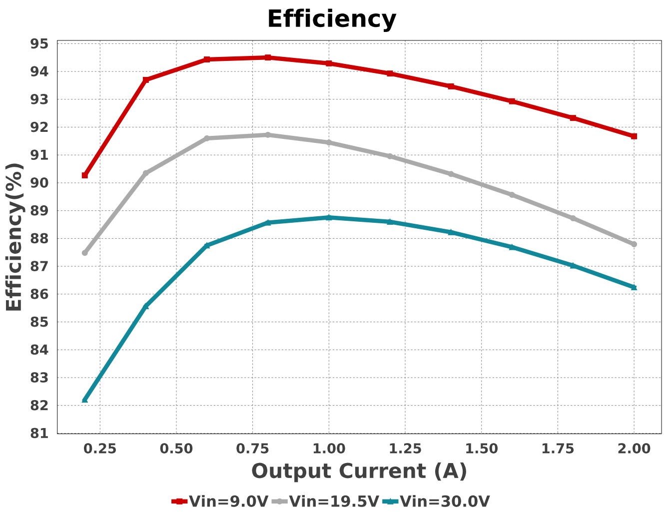

IC Tj
IC Tj(degC)
100 95 90 85 80 75 70 65 60 55 50 45 40 35 30
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V

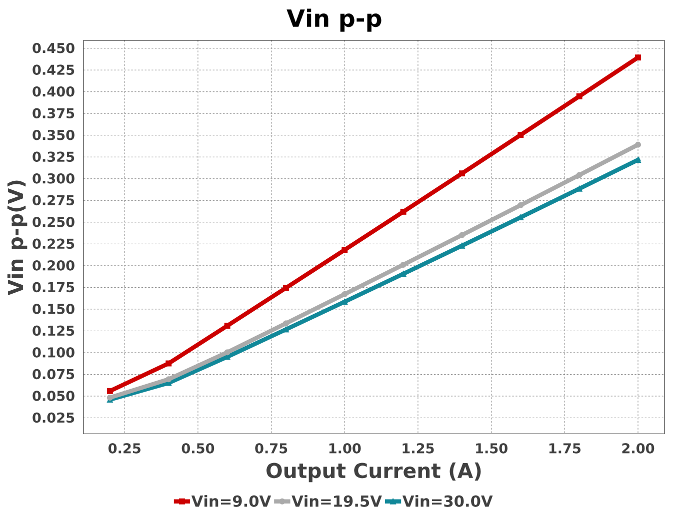

Duty Cycle
Duty Cycle(%)
40.0 37.5 35.0 32.5 30.0 27.5 25.0 22.5 20.0 17.5 15.0 12.5 10.0 7.5 5.0
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V

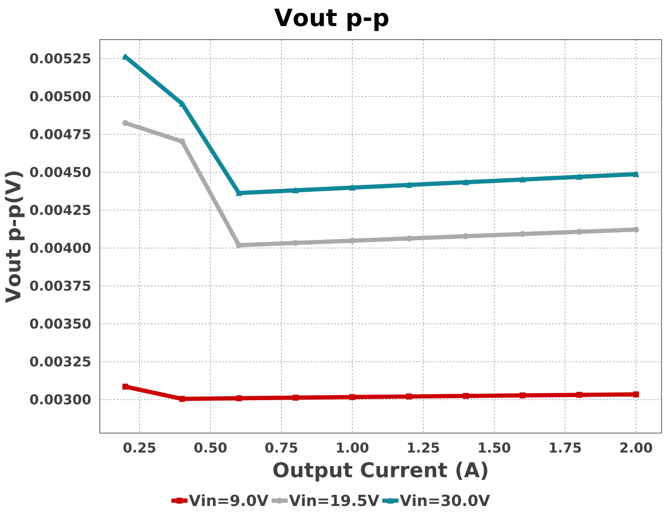

Cin IRMS
Cin IRMS(A)
0.95 0.90 0.85 0.80 0.75 0.70 0.65 0.60 0.55 0.50 0.45 0.40 0.35 0.30 0.25 0.20 0.15 0.10 0.05
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V

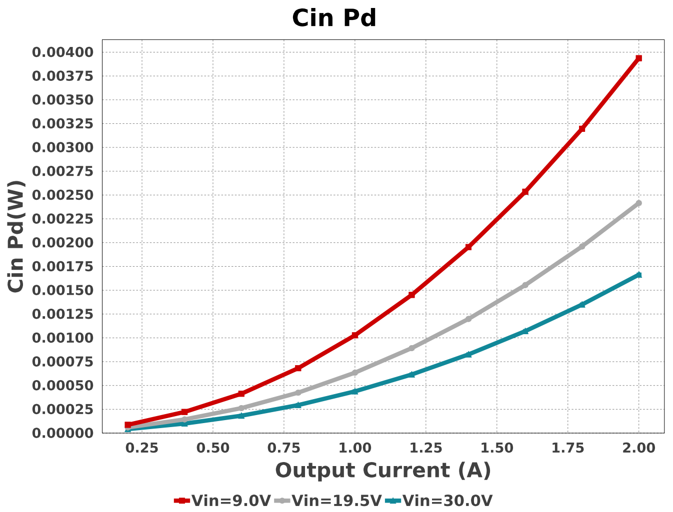

IC Ipk
IC Ipk(A)
2.50 2.25 2.00 1.75 1.50 1.25 1.00 0.75 0.50
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V

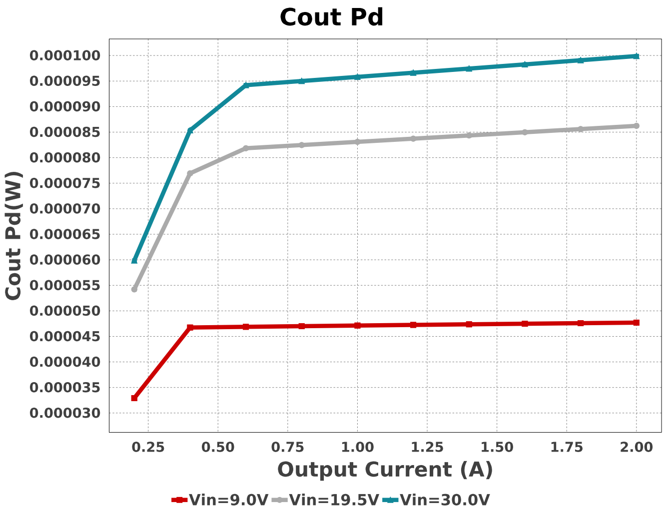

L Pd
L Pd(W)
0.060 0.055 0.050 0.045 0.040 0.035 0.030 0.025 0.020 0.015 0.010 0.005 0.000
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V

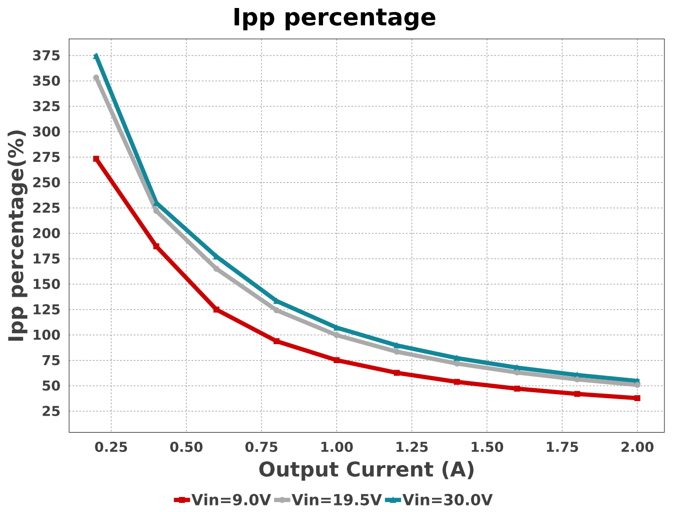

Efficiency
Efficiency(%)
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V

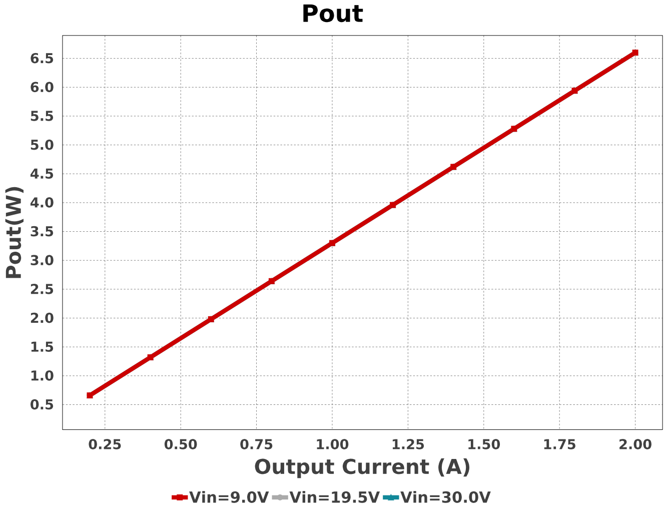

Vin p-p
Vin p-p(V)
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V

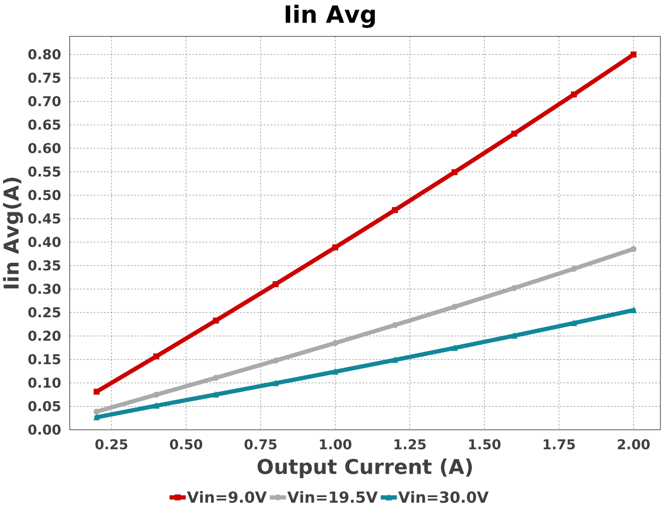

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V

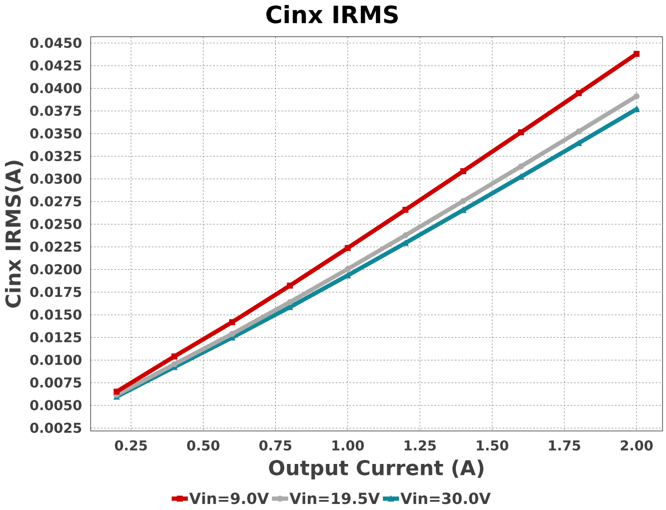

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V

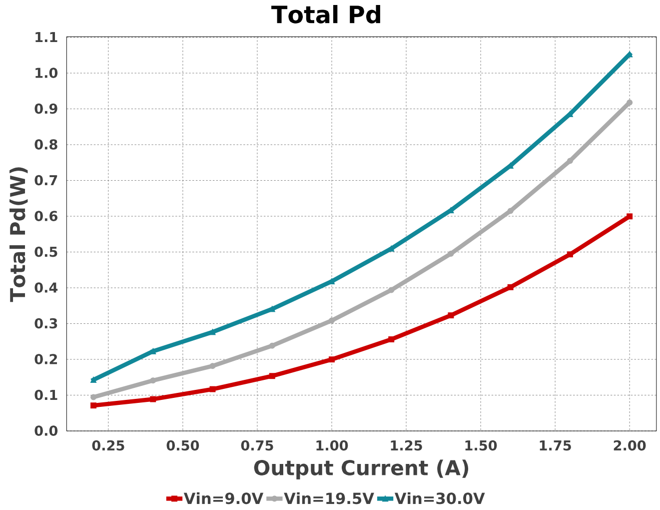

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V

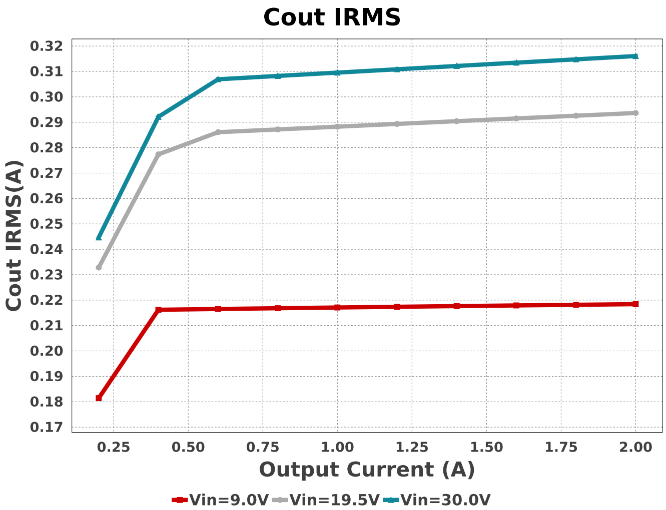

Ipp percentage
Ipp percentage(%)
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V

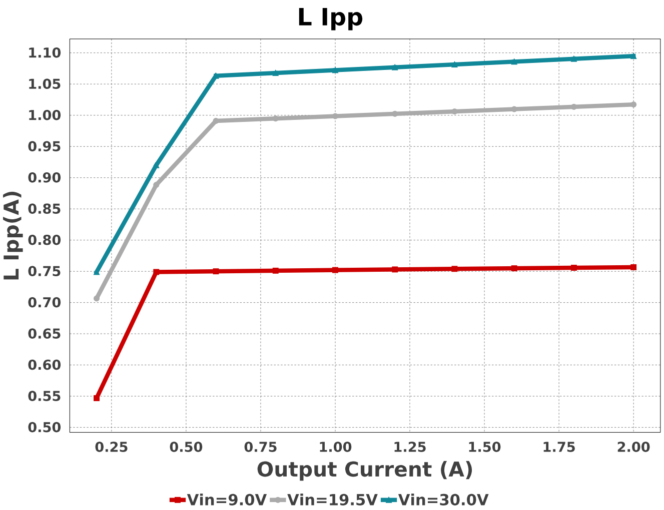

Pout
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Pout(W)
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V

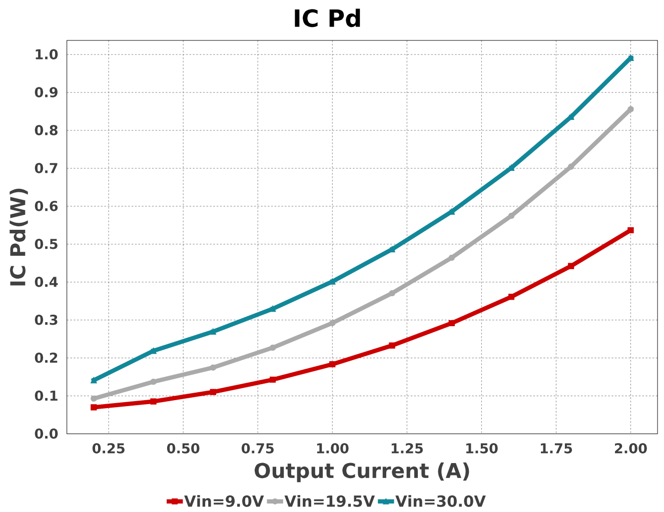

Iin Avg
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Iin Avg(A)
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V

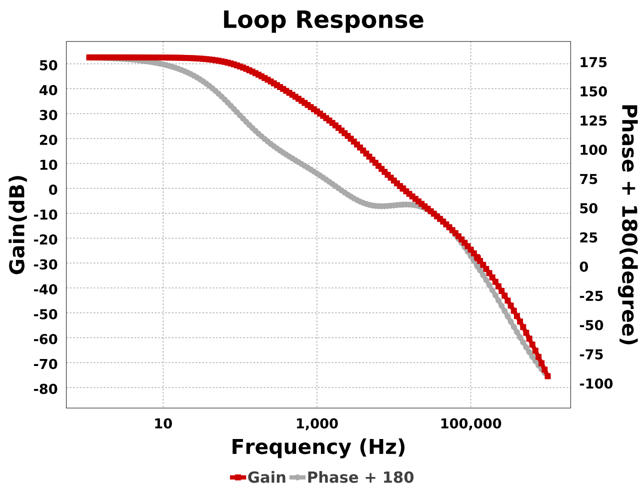

Cinx IRMS
0.0450
0.0425
0.0400
0.0375
0.0350
0.0325
0.0300
0.0275
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
Cinx IRMS(A)
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V

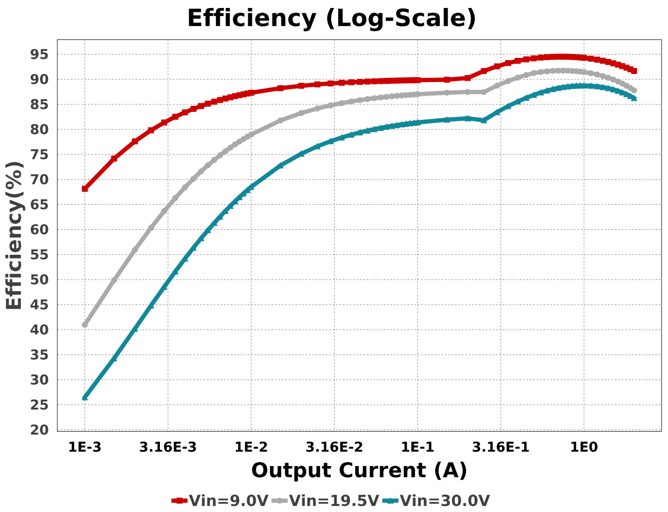

Total Pd
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Total Pd(W)
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V


Cout IRMS
0.32
0.31
0.30
0.29
0.28
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.20
0.19
0.18
0.17
Cout IRMS(A)
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V


L Ipp
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
L Ipp(A)
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Output Current (A)
Vin=9.0V Vin=19.5V Vin=30.0V







Operating Values

#	Name	Value	Category	Description
1.	BOM Count	8		Total Design BOM count
2.	Total BOM	$1.6		Total BOM Cost
3.	Cin IRMS	611.558 mA	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	1.664 mW	Capacitor	Input capacitor power dissipation
5.	Cinx IRMS	37.698 mA	Capacitor	Bulk capacitor RMS ripple current
6.	Cinx Pd	28.423 µW	Capacitor	Bulk capacitor power dissipation
7.	Cout IRMS	316.06 mA	Capacitor	Output capacitor RMS ripple current
8.	Cout Pd	99.894 µW	Capacitor	Output capacitor power dissipation
9.	IC Ipk	2.547 A	IC	Peak switch current in IC
10.	IC Pd	991.17 mW	IC	IC power dissipation
11.	IC Tj	101.364 degC	IC	IC junction temperature
12.	IC Tolerance	10.0 mV	IC	IC Feedback Tolerance
13.	ICThetaJA Effective	72.0 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
14.	Iin Avg	255.08 mA	IC	Average input current
15.	Ipp percentage	54.743 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
16.	L Ipp	1.095 A	Inductor	Peak-to-peak inductor ripple current
17.	L Pd	59.448 mW	Inductor	Inductor power dissipation
18.	Cin Pd	1.664 mW	Power	Input capacitor power dissipation
19.	Cinx Pd	28.423 µW	Power	Bulk capacitor power dissipation
20.	Cout Pd	99.894 µW	Power	Output capacitor power dissipation
21.	IC Pd	991.17 mW	Power	IC power dissipation
22.	L Pd	59.448 mW	Power	Inductor power dissipation
23.	Total Pd	1.053 W	Power	Total Power Dissipation
24.	Cross Freq	13.024 kHz	System Information	Bode plot crossover frequency
25.	Duty Cycle	11.593 %	System Information	Duty cycle
26.	Efficiency	86.246 %	System Information	Steady state efficiency
27.	FootPrint	126.0 mm^2	System Information	Total Foot Print Area of BOM components

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#	Name	Value	Category	Description
28.	Frequency	500.0 kHz	System Information	Switching frequency
29.	Gain Marg	-28.074 dB	System Information	Bode Plot Gain Margin
30.	Iout	2.0 A	System Information	Iout operating point
31.	Low Freq Gain	52.592 dB	System Information	Gain at 1Hz
32.	Mode	CCM	System Information	Conduction Mode
33.	Phase Marg	53.292 deg	System Information	Bode Plot Phase Margin
34.	Pout	6.6 W	System Information	Total output power
35.	Vin	30.0 V	System Information	Vin operating point
36.	Vin p-p	321.692 mV	System Information	Peak-to-peak input voltage
37.	Vout	3.3 V	System Information	Operational Output Voltage
38.	Vout Actual	3.315 V	System Information	Vout Actual calculated based on selected voltage divider resistors
39.	Vout Tolerance	3.349 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
40.	Vout p-p	4.488 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	2.0	Maximum Output Current
VinMax	30.0	Maximum input voltage
VinMin	9.0	Minimum input voltage
Vout	3.3	Output Voltage
base_pn	LMR51430X	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

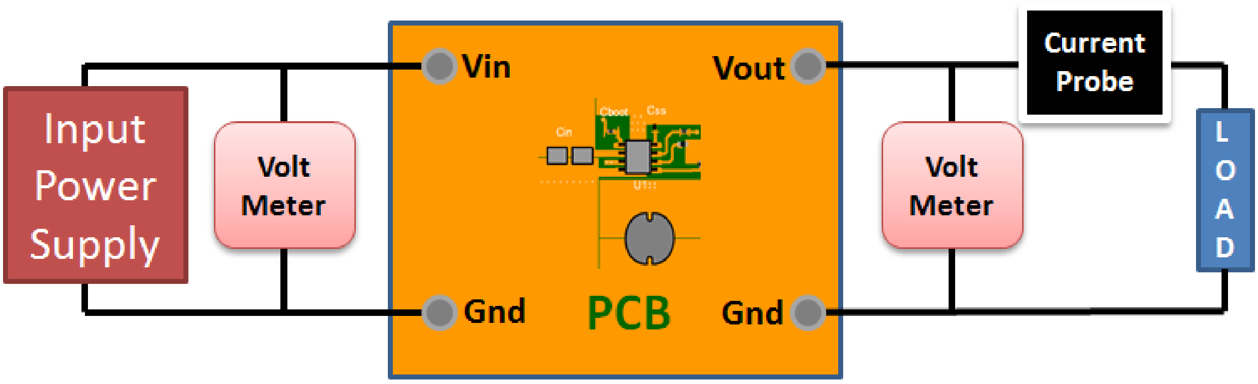
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 9.0V 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 : C387A8EF837FAA2B19BF62FA6C18F1E4[v1]

2. **LMR51430X** Product Folder : http://www.ti.com/product/LMR51430 : contains the data sheet and other resources.

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