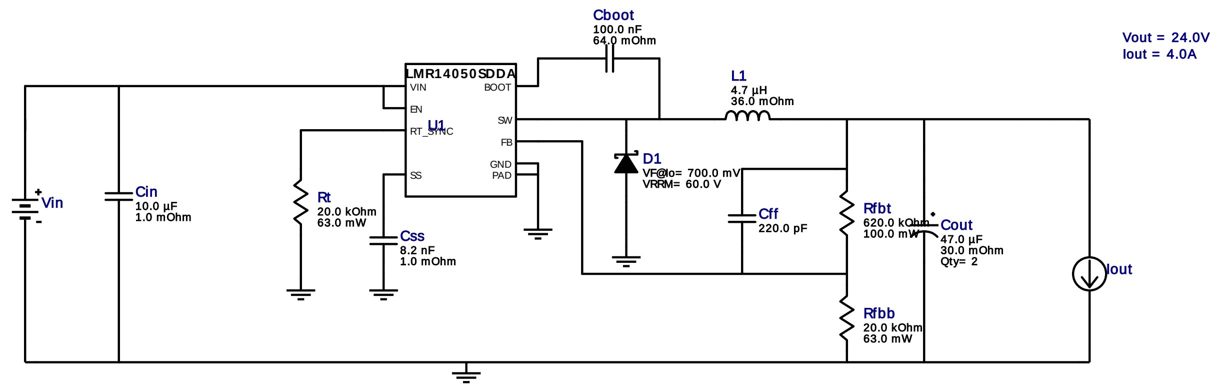
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 26.0V
VinMax = 33.0V
Vout = 24.0V
Iout = 4.0A

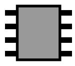
Device = LMR14050SDDAR
Topology = Buck
Created = 2019-12-17 04:27:30.321
BOM Cost = $3.98
BOM Count = 12
Total Pd = 4.23W

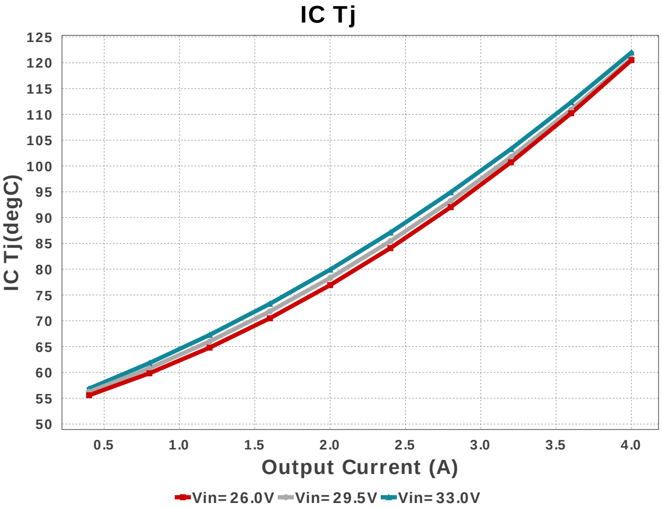
Design : 15 LMR14050SDDAR
LMR14050SDDAR 26V-33V to 24.00V @ 4A

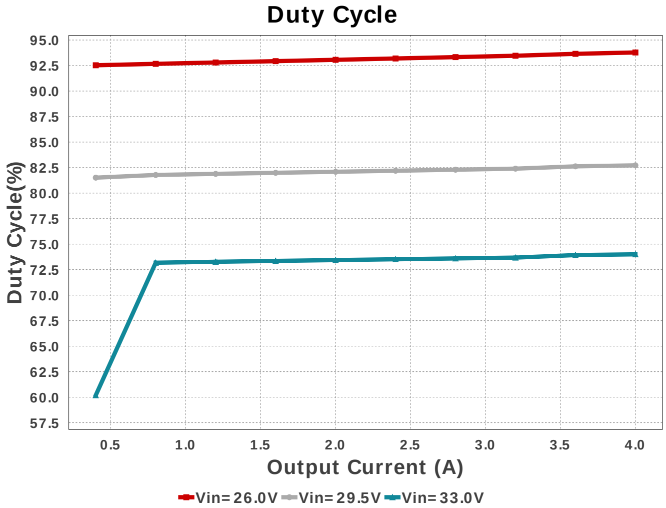


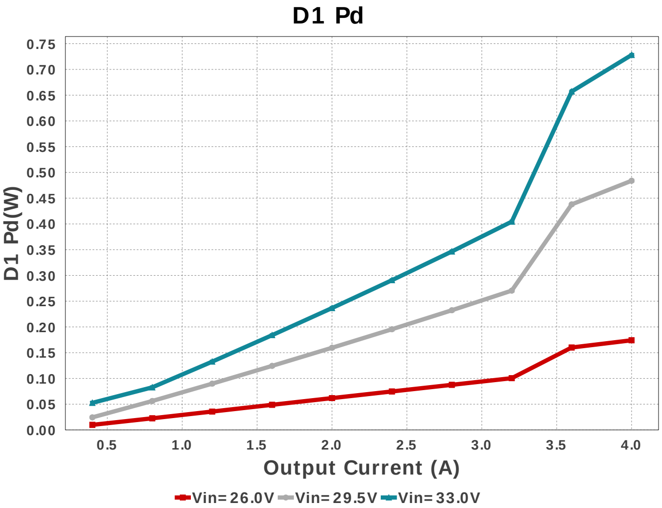
Electrical BOM

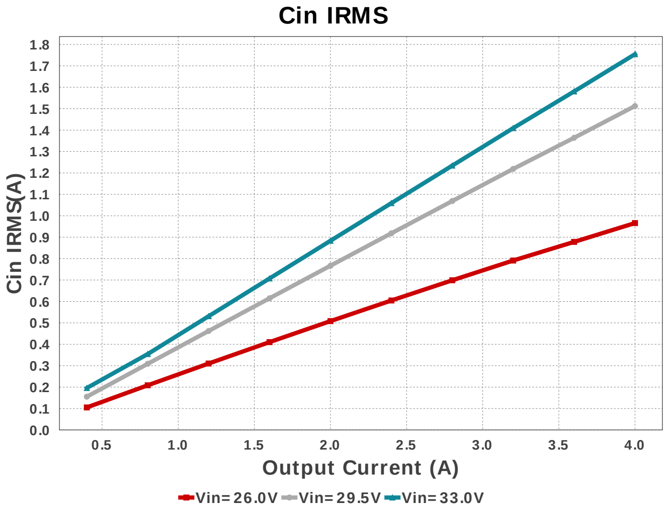
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	Kemet	C0805C104M5RACTU Series= X7R	Cap= 100.0 nF ESR= 64.0 mOhm VDC= 50.0 V IRMS= 1.64 A	1	$0.01	0805 7 mm²
Cff	Samsung Electro-Mechanics	CL21C221JBANNNC Series= C0G/NP0	Cap= 220.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²
Cin	TDK	C3225X7R1H106M250AC Series= X7R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 5.0 A	1	$0.28	1210 15 mm²
Cout	Panasonic	35SVPD47M Series= SVPD	Cap= 47.0 uF ESR= 30.0 mOhm VDC= 35.0 V IRMS= 3.65 A	2	$0.82	SM_RADIAL_10AMM 160 mm²
Css	MuRata	GRM155R71C822KA01D Series= X7R	Cap= 8.2 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
D1	Diodes Inc.	B560C-13-F	VF@Io= 700.0 mV VRRM= 60.0 V	1	$0.17	SMC 83 mm²
L1	Coilcraft	XAL5030-472MEB	L= 4.7 µH 36.0 mOhm	1	$0.63	XAL5030 54 mm²
Rfbb	Vishay-Dale	CRCW040220K0FKED Series= CRCW..e3	Res= 20.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbt	Yageo	RC0603FR-07620KL Series= ?	Res= 620.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rt	Vishay-Dale	CRCW040220K0FKED Series= CRCW..e3	Res= 20.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²

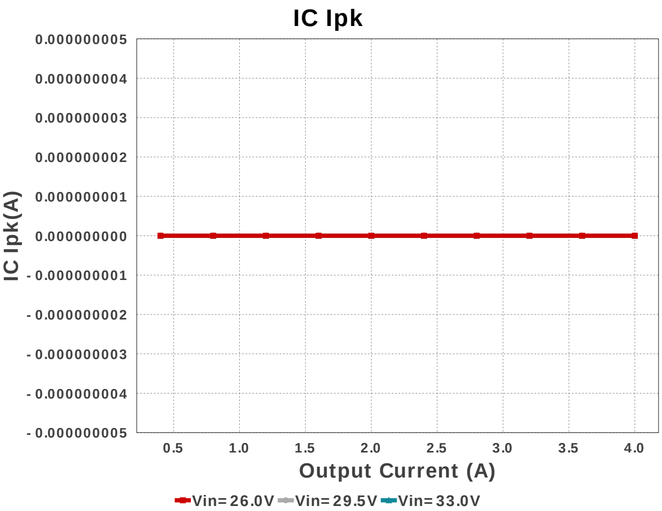
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
U1	Texas Instruments	LMR14050SDDAR	Switcher	1	$1.20	 DDA0008E_N 55 mm²

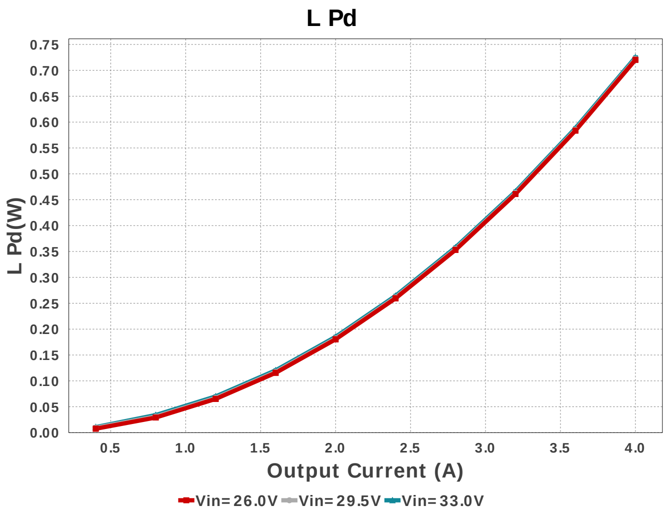


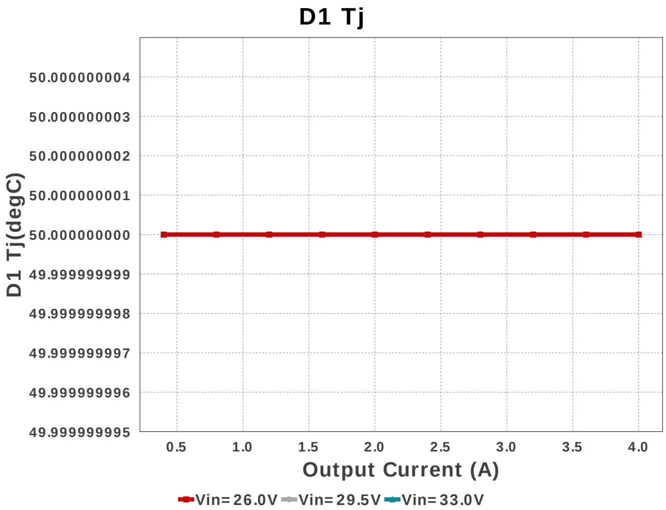


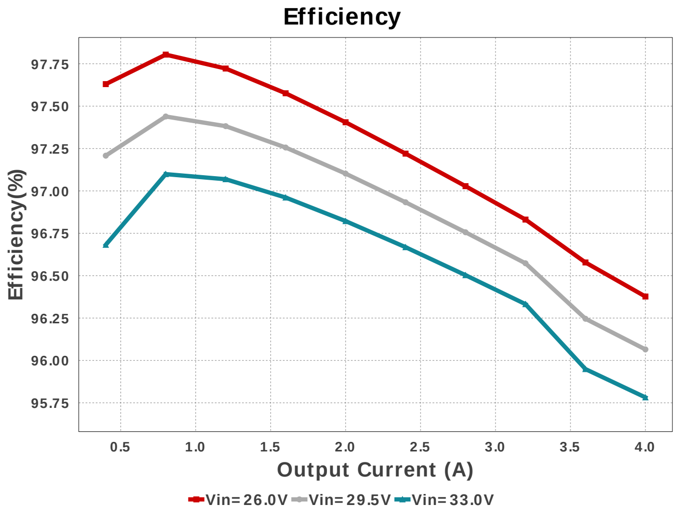


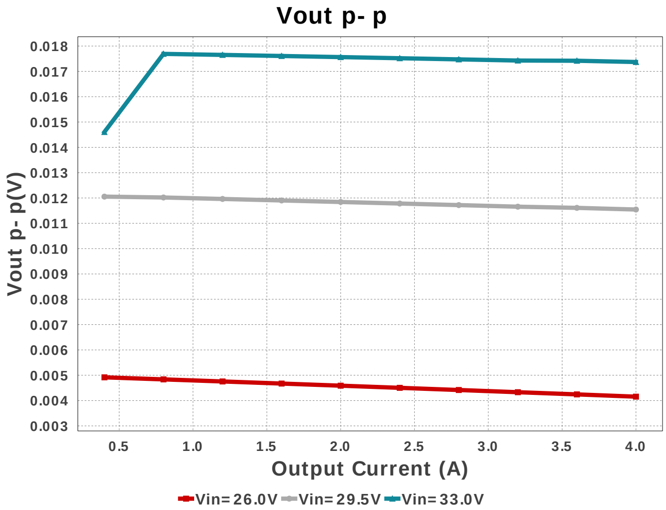


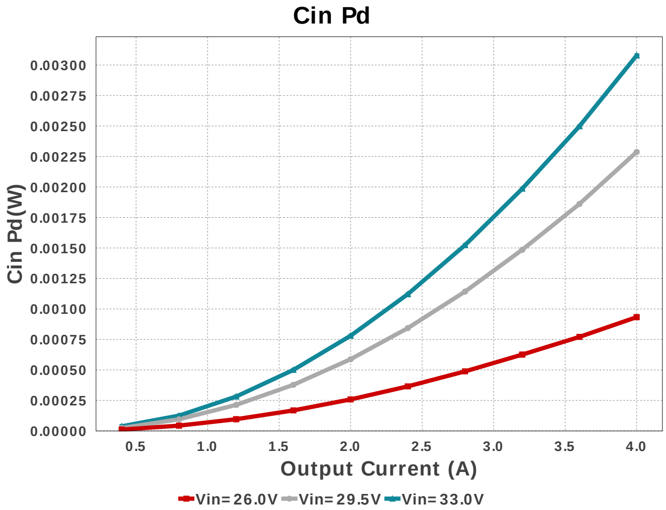


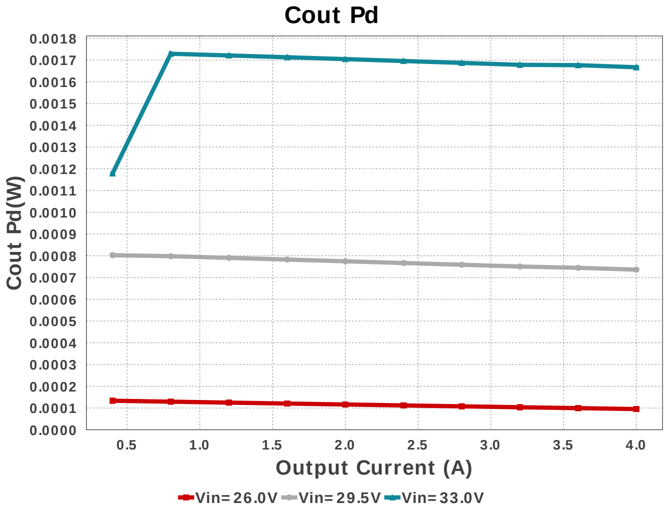


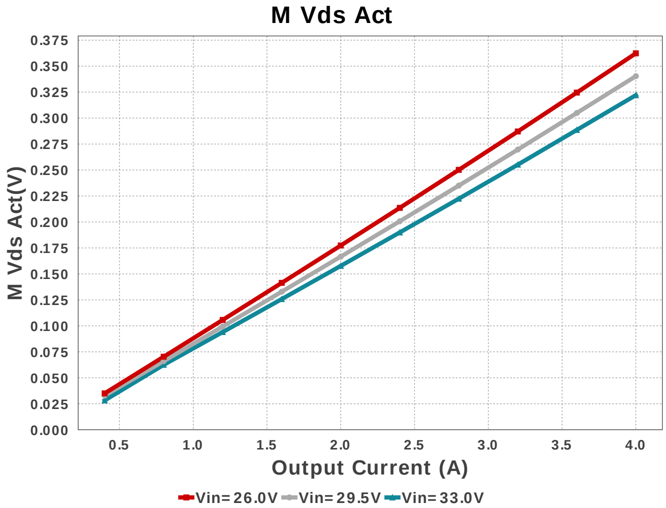

D1 Tj
D1 Tj(degC)
50.000000004
50.000000003
50.000000002
50.000000001
50.000000000
49.999999999
49.999999998
49.999999997
49.999999996
49.999999995
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Output Current (A)
Vin=26.0V
Vin=29.5V
Vin=33.0V

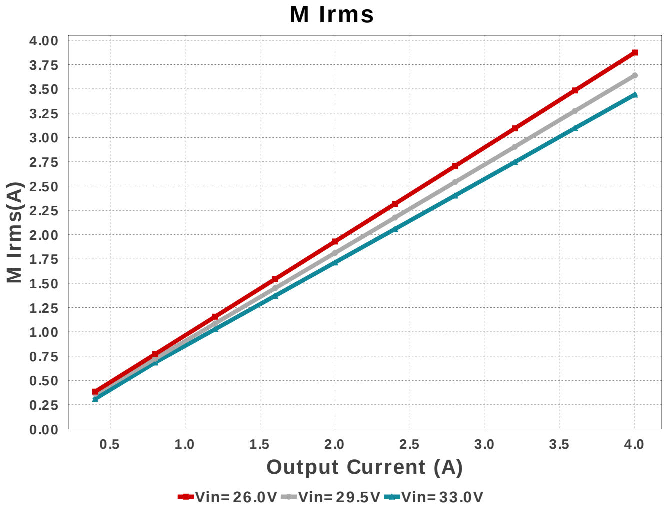

Efficiency
Efficiency(%)
97.75
97.50
97.25
97.00
96.75
96.50
96.25
96.00
95.75
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Output Current (A)
Vin=26.0V
Vin=29.5V
Vin=33.0V

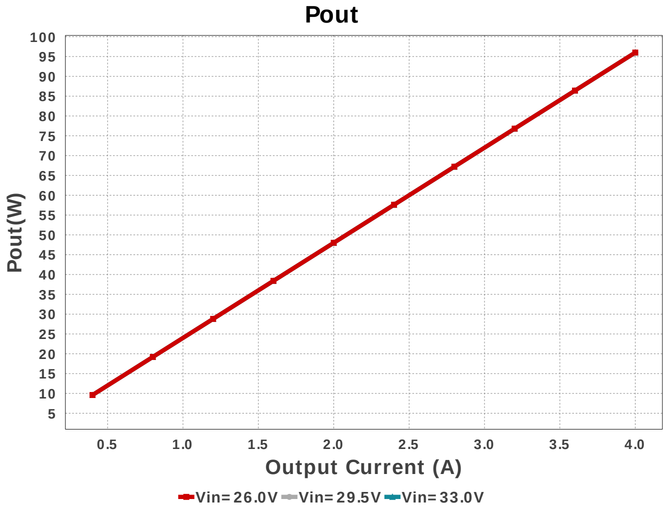

Vout p- p
Vout p- p(V)
0.018
0.017
0.016
0.015
0.014
0.013
0.012
0.011
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Output Current (A)
Vin=26.0V
Vin=29.5V
Vin=33.0V

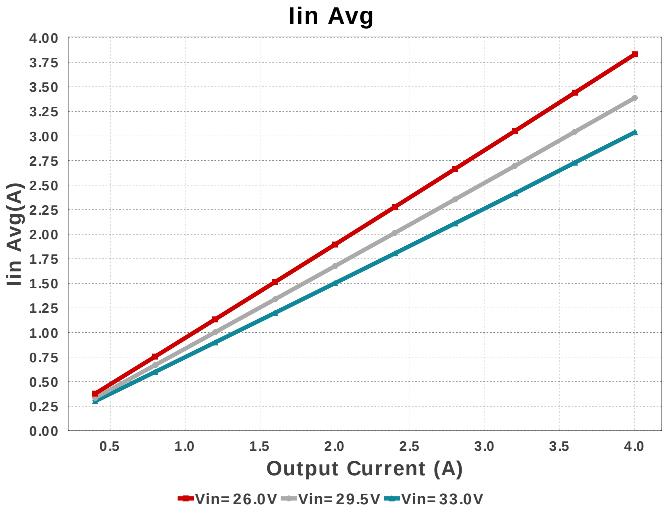

Cin Pd
Cin Pd(W)
0.00300
0.00275
0.00250
0.00225
0.00200
0.00175
0.00150
0.00125
0.00100
0.00075
0.00050
0.00025
0.00000
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Output Current (A)
Vin=26.0V
Vin=29.5V
Vin=33.0V

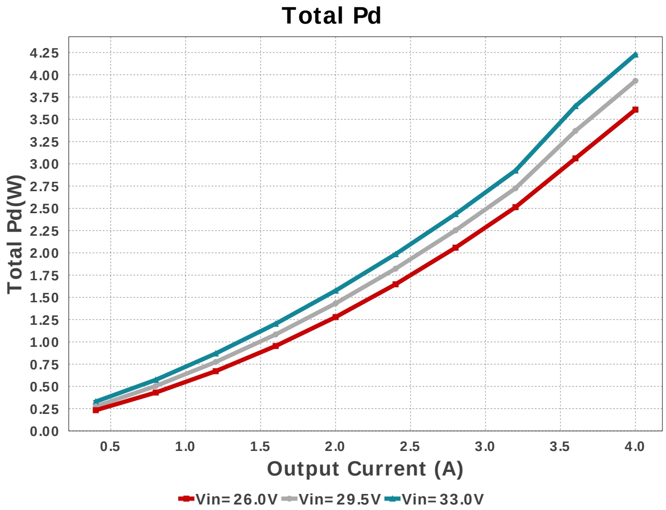

Cout Pd
Cout Pd(W)
0.0018
0.0017
0.0016
0.0015
0.0014
0.0013
0.0012
0.0011
0.0010
0.0009
0.0008
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0.0000
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Output Current (A)
Vin=26.0V
Vin=29.5V
Vin=33.0V

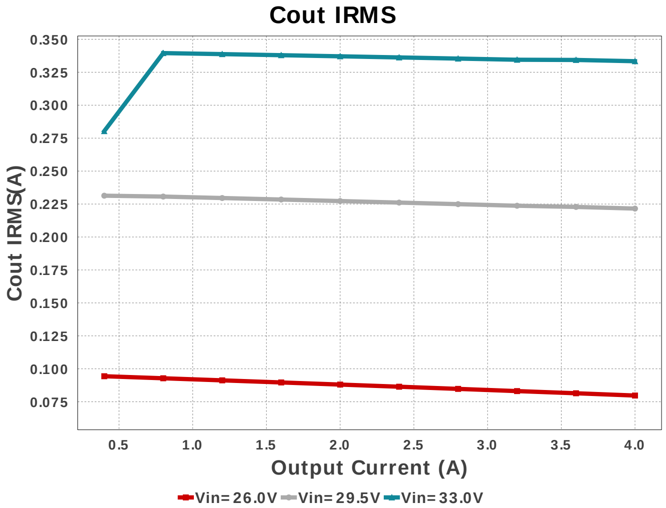

M Vds Act
M Vds Act(V)
0.375
0.350
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Output Current (A)
Vin=26.0V
Vin=29.5V
Vin=33.0V

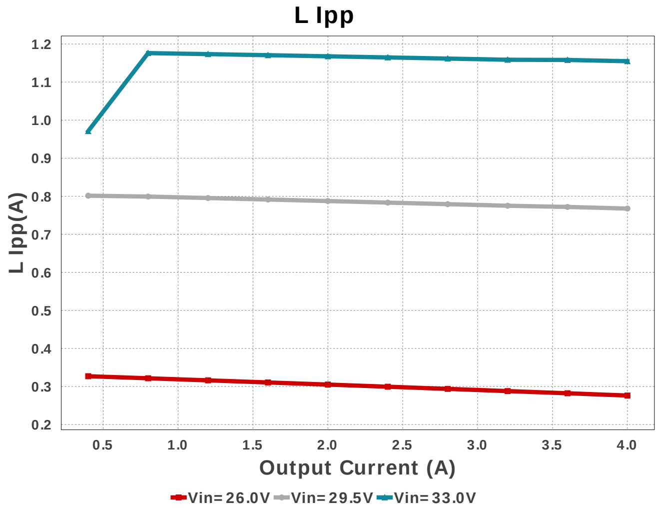

M Irms
M Irms(A)
Output Current (A)
Vin=26.0V Vin=29.5V Vin=33.0V

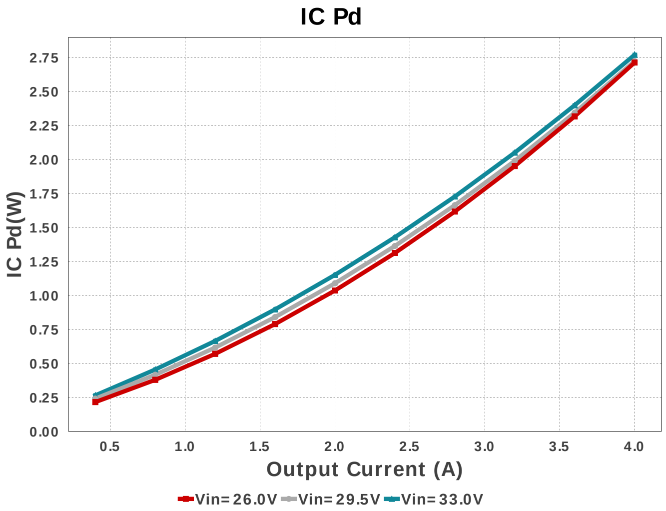

Pout
Pout(W)
Output Current (A)
Vin=26.0V Vin=29.5V Vin=33.0V

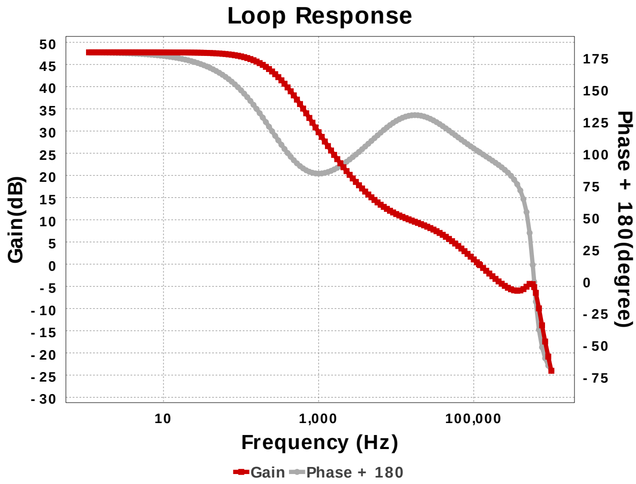

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=26.0V Vin=29.5V Vin=33.0V


Total Pd
Total Pd(W)
Output Current (A)
Vin=26.0V Vin=29.5V Vin=33.0V


Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=26.0V Vin=29.5V Vin=33.0V


L Ipp
L Ipp(A)
Output Current (A)
Vin=26.0V Vin=29.5V Vin=33.0V





Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	1.755 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	3.078 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	333.355 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	1.667 mW	Capacitor	Output capacitor power dissipation
5.	D1 Pd	727.97 mW	Diode	Output Diode Power Dissipation
6.	D1 Tj	86.399 degC	Diode	D1 junction temperature
7.	IC Ipk	0.0 A	IC	Peak switch current in IC
8.	IC Pd	2.769 W	IC	IC power dissipation
9.	IC Tj	121.992 degC	IC	IC junction temperature
10.	IC Tolerance	18.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA	26.0 degC/W	IC	IC junction-to-ambient thermal resistance
12.	Iin Avg	3.037 A	IC	Average input current
13.	L Ipp	1.155 A	Inductor	Peak-to-peak inductor ripple current
14.	L Pd	725.0 mW	Inductor	Inductor power dissipation
15.	M Irms	3.441 A	Mosfet	MOSFET RMS ripple current
16.	M Vds Act	322.031 mV	Mosfet	Voltage drop across the MosFET
17.	Cin Pd	3.078 mW	Power	Input capacitor power dissipation
18.	Cout Pd	1.667 mW	Power	Output capacitor power dissipation
19.	D1 Pd	727.97 mW	Power	Output Diode Power Dissipation
20.	IC Pd	2.769 W	Power	IC power dissipation
21.	L Pd	725.0 mW	Power	Inductor power dissipation
22.	Total Pd	4.228 W	Power	Total Power Dissipation
23.	BOM Count	12	System Information	Total Design BOM count
24.	Cross Freq	116.717 kHz	System Information	Bode plot crossover frequency
25.	Duty Cycle	74.001 %	System Information	Duty cycle
26.	Efficiency	95.782 %	System Information	Steady state efficiency
27.	FootPrint	555.0 mm^2	System Information	Total Foot Print Area of BOM components
28.	Frequency	1.183 MHz	System Information	Switching frequency
29.	Gain Marg	-5.166 dB	System Information	Bode Plot Gain Margin
30.	Iout	4.0 A	System Information	Iout operating point
31.	Low Freq Gain	47.735 dB	System Information	Gain at 1Hz
32.	Mode	CCM	System Information	Conduction Mode
33.	Phase Marg	101.77 deg	System Information	Bode Plot Phase Margin
34.	Pout	96.0 W	System Information	Total output power
35.	Total BOM	$3.98	System Information	Total BOM Cost
36.	Vin	33.0 V	System Information	Vin operating point

#	Name	Value	Category	Description
37.	Vout	24.0 V	System Information	Operational Output Voltage
38.	Vout Actual	24.0 V	System Information	Vout Actual calculated based on selected voltage divider resistors
39.	Vout Tolerance	4.404 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
40.	Vout p-p	17.37 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	4.0	Maximum Output Current
VinMax	33.0	Maximum input voltage
VinMin	26.0	Minimum input voltage
Vout	24.0	Output Voltage
base_pn	LMR14050S	Base Product Number
source	DC	Input Source Type
Ta	50.0	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

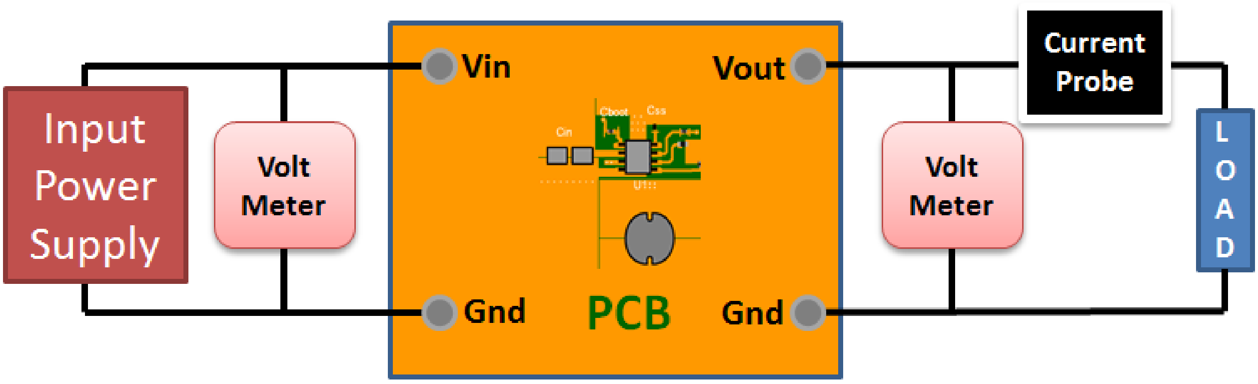
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 26.0V 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 : 94D7AF49B62BD255[v1]

2. **LMR14050S** Product Folder : http://www.ti.com/product/LMR14050 : contains the data sheet and other resources.

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