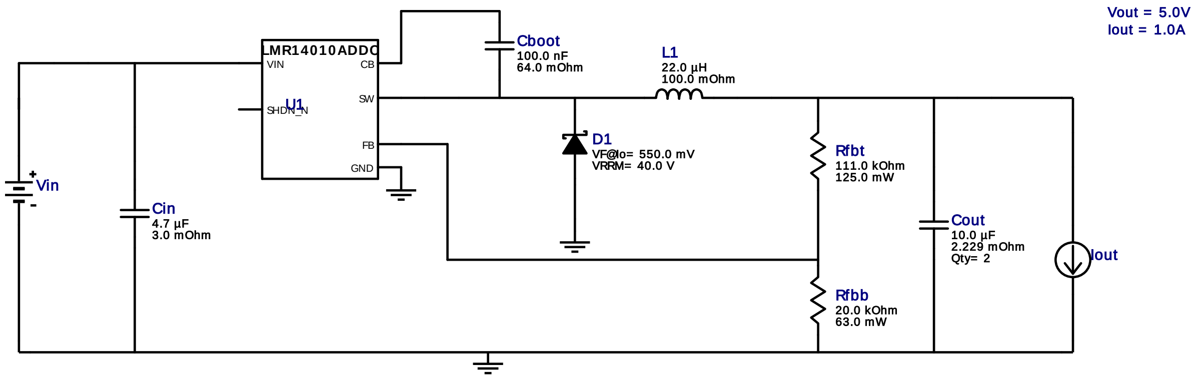
VinMin = 24.0V
VinMax = 24.0V
Vout = 5.0V
Iout = 1.0A

Device = LMR14010ADDCR
Topology = Buck
Created = 2021-02-22 22:31:40.625
BOM Cost = $1.29
BOM Count = 9
Total Pd = 0.95W

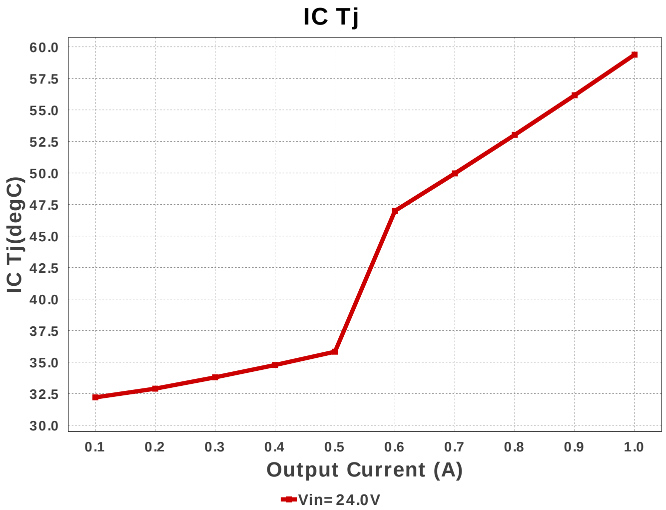
WEBENCH ® Design Report

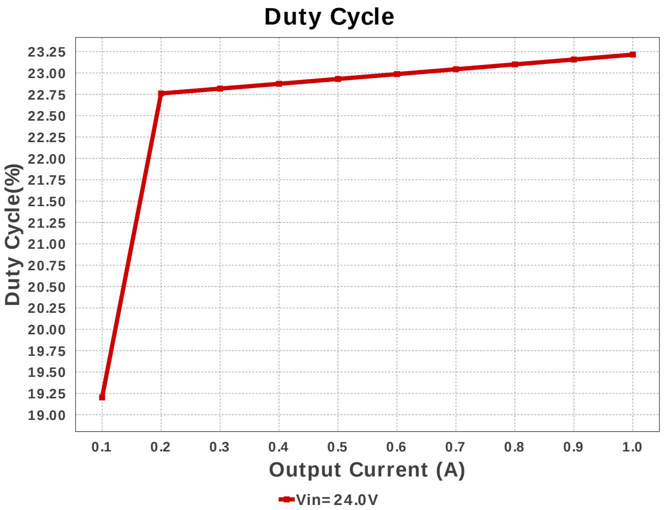
Design : 4 LMR14010ADDCR
LMR14010ADDCR 24V-24V to 5.01V @ 1A

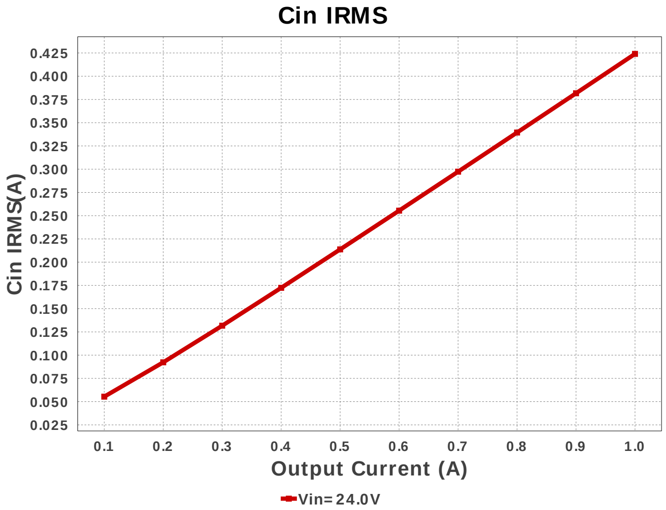


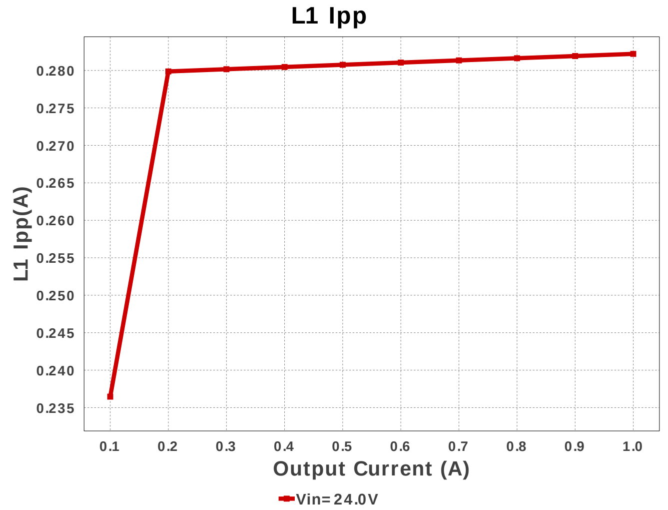
Electrical BOM

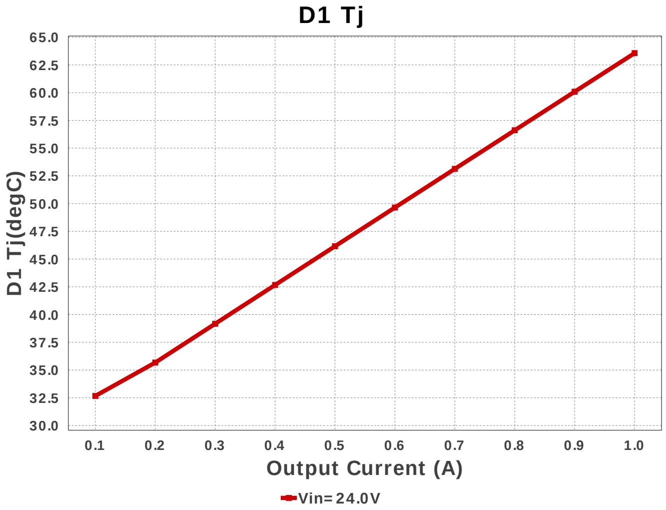
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	Kemet	C0805C104M5RACTU Series= X7R	Cap= 100.0 nF ESR= 64.0 mOhm VDC= 50.0 V IRMS= 1.64 A	1	$0.01	0805 7 mm²
Cin	MuRata	GRM31CR71H475KA12L Series= X7R	Cap= 4.7 uF ESR= 3.0 mOhm VDC= 50.0 V IRMS= 4.98 A	1	$0.22	1206 11 mm²
Cout	TDK	C3216X6S1V106K160AC Series= X6S	Cap= 10.0 uF ESR= 2.229 mOhm VDC= 35.0 V IRMS= 4.8593 A	2	$0.18	1206_180 11 mm²
D1	Fairchild Semiconductor	SS24FL	VF@Io= 550.0 mV VRRM= 40.0 V	1	$0.05	SOD-123F 12 mm²
L1	NIC Components	NPI105C220MTRF	L= 22.0 µH 100.0 mOhm	1	$0.18	IND_NPI105C 141 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	RT0805BRD07111KL Series= RT0805	Res= 111.0 kOhm Power= 125.0 mW Tolerance= 0.1%	1	$0.06	0805 7 mm²
U1	Texas Instruments	LMR14010ADDCR	Switcher	1	$0.40	DDC0006A_N 10 mm²

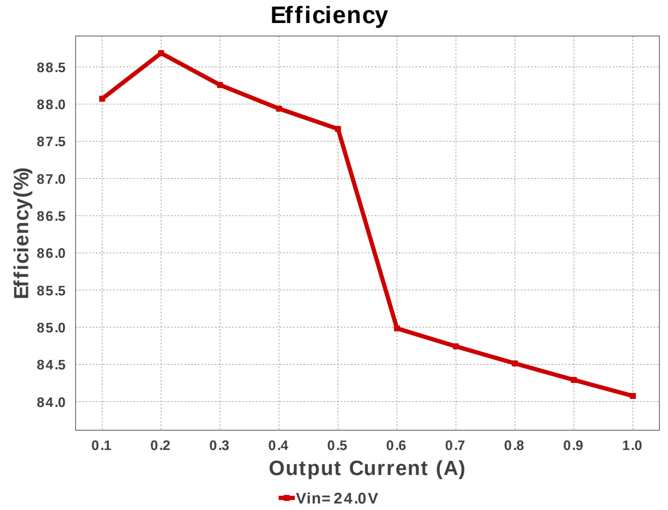

IC Tj
IC Tj(degC)
60.0
57.5
55.0
52.5
50.0
47.5
45.0
42.5
40.0
37.5
35.0
32.5
30.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=24.0V

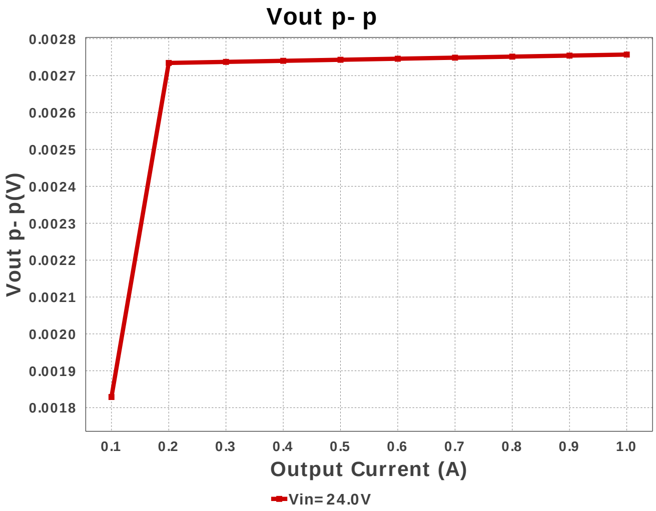

Duty Cycle
Duty Cycle(%)
23.25
23.00
22.75
22.50
22.25
22.00
21.75
21.50
21.25
21.00
20.75
20.50
20.25
20.00
19.75
19.50
19.25
19.00
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=24.0V

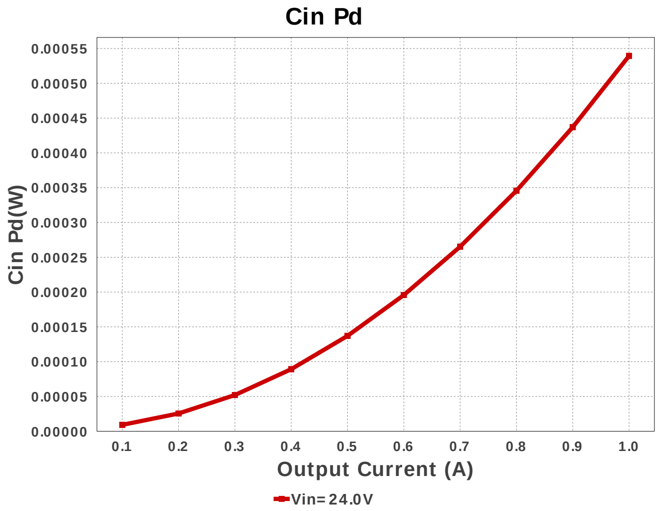

Cin IRMS
Cin IRMS(A)
0.425
0.400
0.375
0.350
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=24.0V

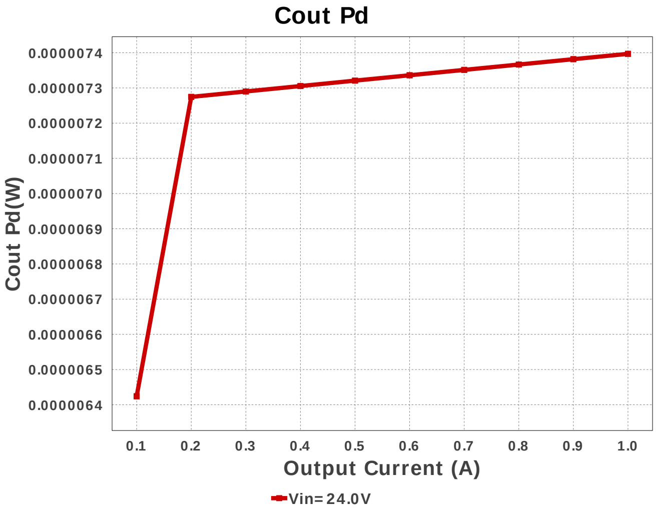

L1 Ipp
L1 Ipp(A)
0.280
0.275
0.270
0.265
0.260
0.255
0.250
0.245
0.240
0.235
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=24.0V

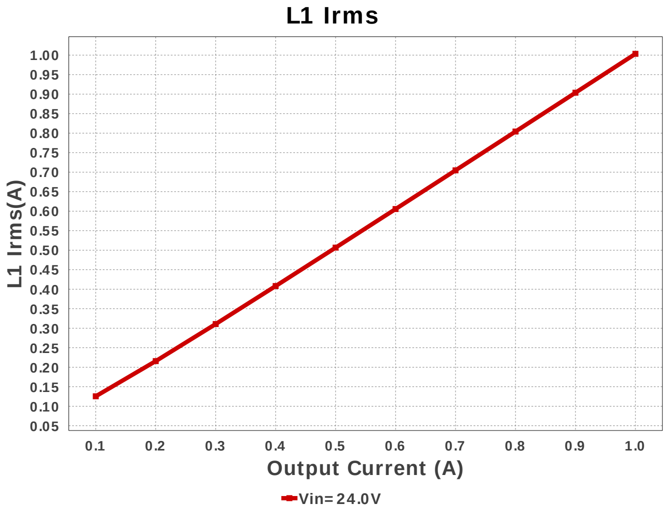

D1 Tj
D1 Tj(degC)
65.0
62.5
60.0
57.5
55.0
52.5
50.0
47.5
45.0
42.5
40.0
37.5
35.0
32.5
30.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=24.0V

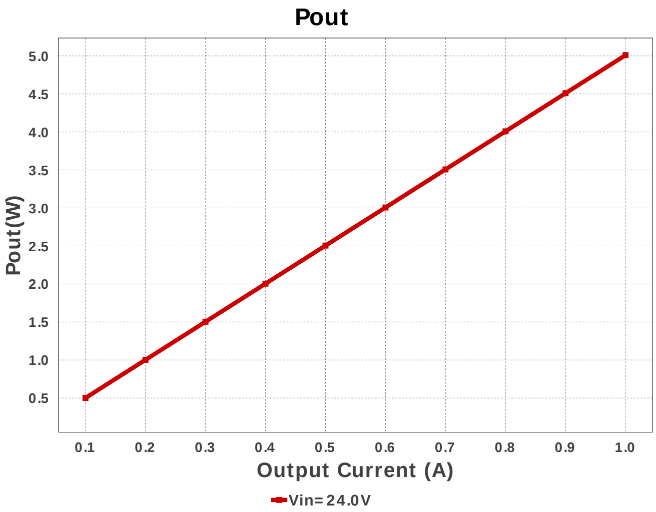

Efficiency
Efficiency(%)
88.5
88.0
87.5
87.0
86.5
86.0
85.5
85.0
84.5
84.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=24.0V

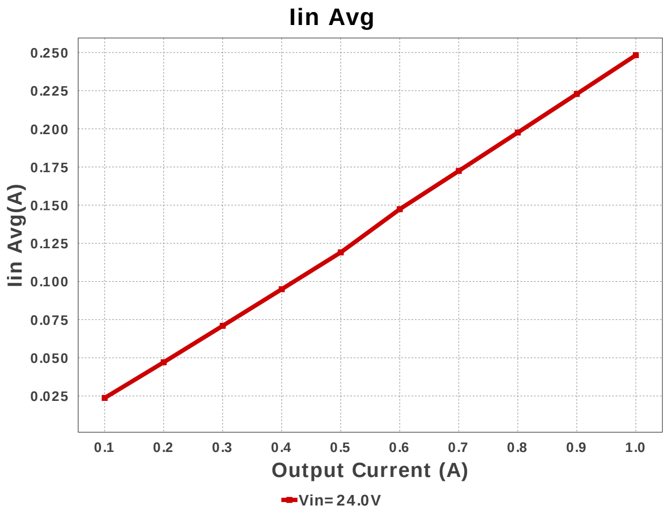

Vout p- p
0.0028
0.0027
0.0026
0.0025
0.0024
0.0023
0.0022
0.0021
0.0020
0.0019
0.0018
Vout p- p(V)
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=24.0V

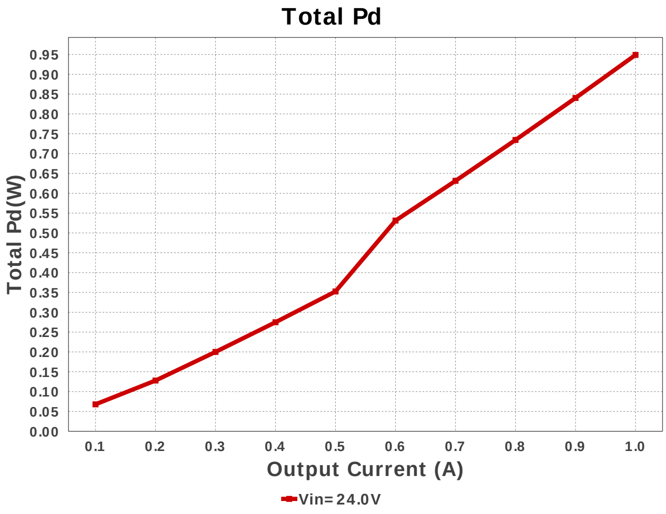

Cin Pd
0.00055
0.00050
0.00045
0.00040
0.00035
0.00030
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
Cin Pd(W)
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=24.0V

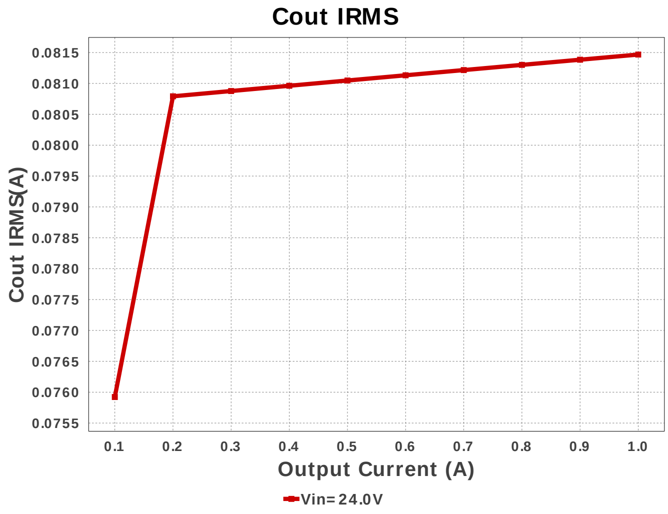

Cout Pd
0.0000074
0.0000073
0.0000072
0.0000071
0.0000070
0.0000069
0.0000068
0.0000067
0.0000066
0.0000065
0.0000064
Cout Pd(W)
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=24.0V

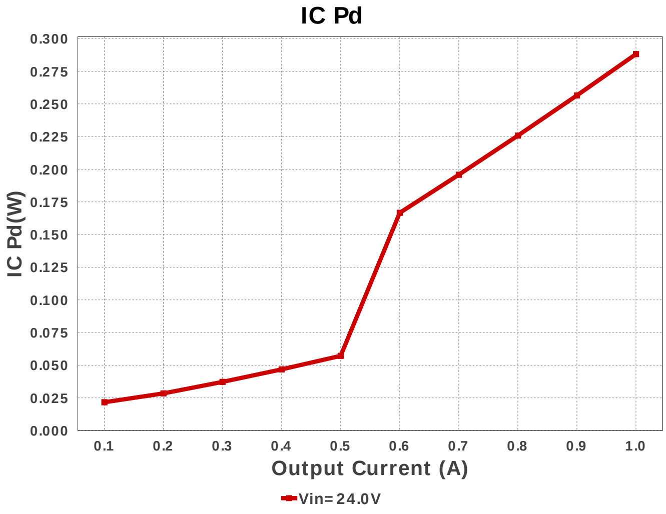

L1 Irms
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
L1 Irms(A)
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=24.0V

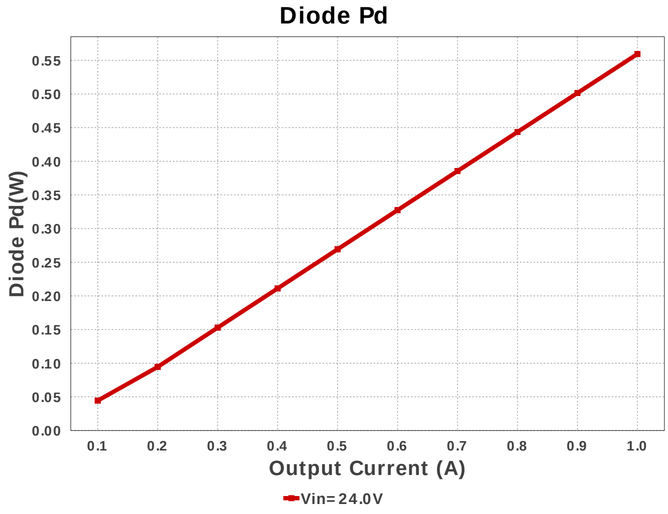

Pout
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Pout(W)
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=24.0V

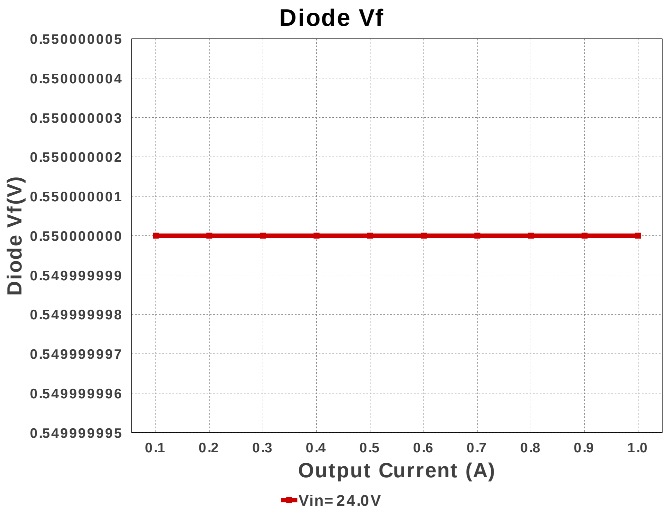

Iin Avg
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
Iin Avg(A)
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=24.0V

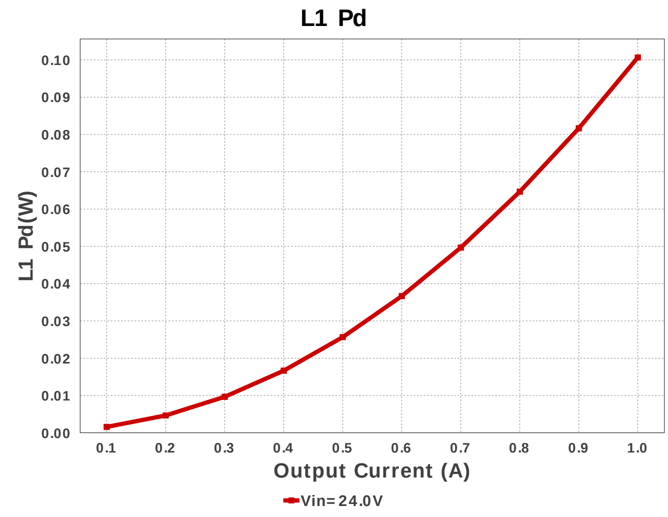

Total Pd
Total Pd(W)
0.95 0.90 0.85 0.80 0.75 0.70 0.65 0.60 0.55 0.50 0.45 0.40 0.35 0.30 0.25 0.20 0.15 0.10 0.05 0.00
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=24.0V

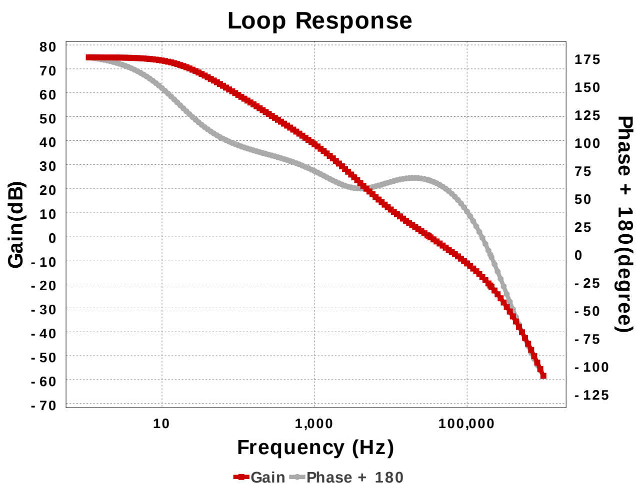

Cout IRMS
Cout IRMS(A)
0.0815 0.0810 0.0805 0.0800 0.0795 0.0790 0.0785 0.0780 0.0775 0.0770 0.0765 0.0760 0.0755
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=24.0V

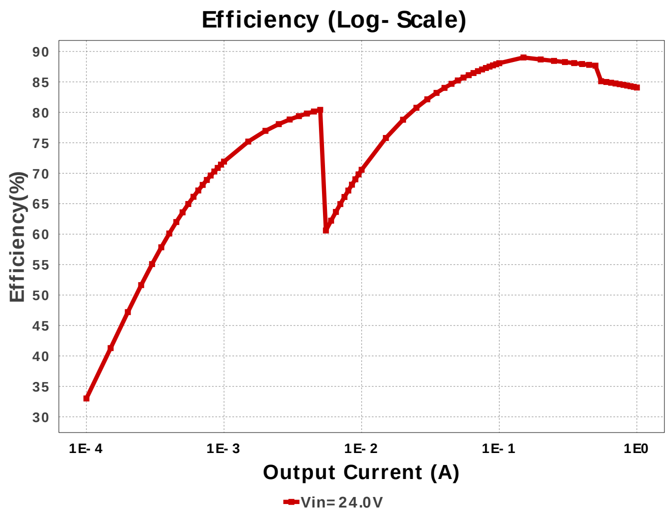

IC Pd
IC Pd(W)
0.300 0.275 0.250 0.225 0.200 0.175 0.150 0.125 0.100 0.075 0.050 0.025 0.000
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=24.0V


Diode Pd
Diode Pd(W)
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=24.0V


Diode Vf
Diode Vf(V)
0.550000005 0.550000004 0.550000003 0.550000002 0.550000001 0.550000000 0.549999999 0.549999998 0.549999997 0.549999996 0.549999995
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=24.0V


L1 Pd
L1 Pd(W)
0.10 0.09 0.08 0.07 0.06 0.05 0.04 0.03 0.02 0.01 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=24.0V





Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	424.023 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	539.39 µW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	81.467 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	7.397 µW	Capacitor	Output capacitor power dissipation
5.	D1 Tj	63.56 degC	Diode	D1 junction temperature
6.	Diode Pd	559.33 mW	Diode	Diode power dissipation
7.	Diode Vf	550.0 mV	Diode	Forward voltage drop of diode D1
8.	IC Pd	288.09 mW	IC	IC power dissipation
9.	IC Tj	59.385 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	248.28 mA	IC	Average input current
13.	L1 Irms	1.003 A	Inductor	Inductor ripple current
14.	L1 Pd	100.66 mW	Inductor	Inductor power dissipation
15.	Cin Pd	539.39 µW	Power	Input capacitor power dissipation
16.	Cout Pd	7.397 µW	Power	Output capacitor power dissipation
17.	Diode Pd	559.33 mW	Power	Diode power dissipation
18.	IC Pd	288.09 mW	Power	IC power dissipation
19.	L1 Pd	100.66 mW	Power	Inductor power dissipation
20.	Total Pd	948.807 mW	Power	Total Power Dissipation
21.	BOM Count	9	System Information	Total Design BOM count
22.	Cross Freq	31.447 kHz	System Information	Bode plot crossover frequency
23.	Duty Cycle	23.215 %	System Information	Duty cycle
24.	Efficiency	84.077 %	System Information	Steady state efficiency
25.	FootPrint	213.0 mm^2	System Information	Total Foot Print Area of BOM components
26.	Frequency	700.0 kHz	System Information	Switching frequency
27.	Gain Marg	-20.656 dB	System Information	Bode Plot Gain Margin
28.	Iout	1.0 A	System Information	Iout operating point
29.	L1 Ipp	282.211 mA	System Information	
30.	Low Freq Gain	74.822 dB	System Information	Gain at 1Hz
31.	Mode	CCM	System Information	Conduction Mode
32.	Phase Marg	66.506 deg	System Information	Bode Plot Phase Margin
33.	Pout	5.01 W	System Information	Total output power
34.	Total BOM	$1.29	System Information	Total BOM Cost
35.	Vin	24.0 V	System Information	Vin operating point
36.	Vout	5.0 V	System Information	Operational Output Voltage

#	Name	Value	Category	Description
37.	Vout Actual	5.011 V	System Information	Vout Actual calculated based on selected voltage divider resistors
38.	Vout Tolerance	3.317 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
39.	Vout p-p	2.758 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	1.0	Maximum Output Current
VinMax	24.0	Maximum input voltage
VinMin	24.0	Minimum input voltage
Vout	5.0	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

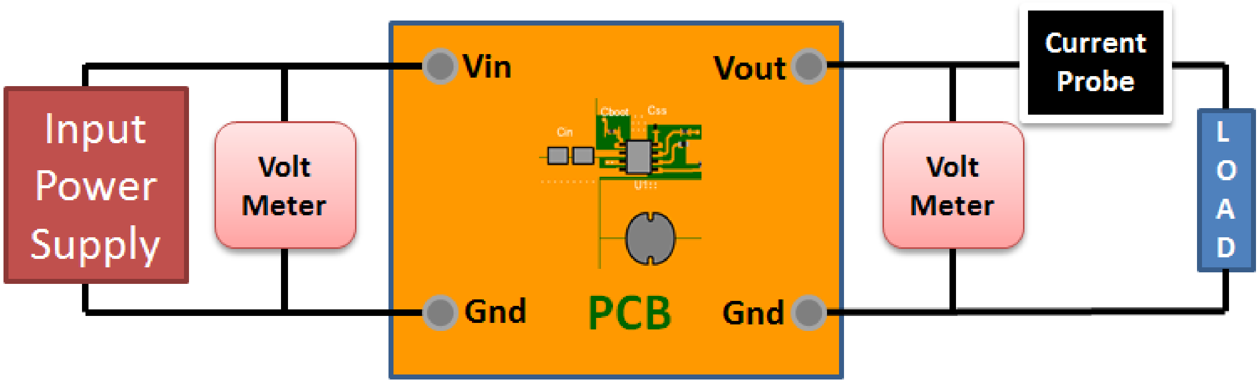
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 24.0V 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.

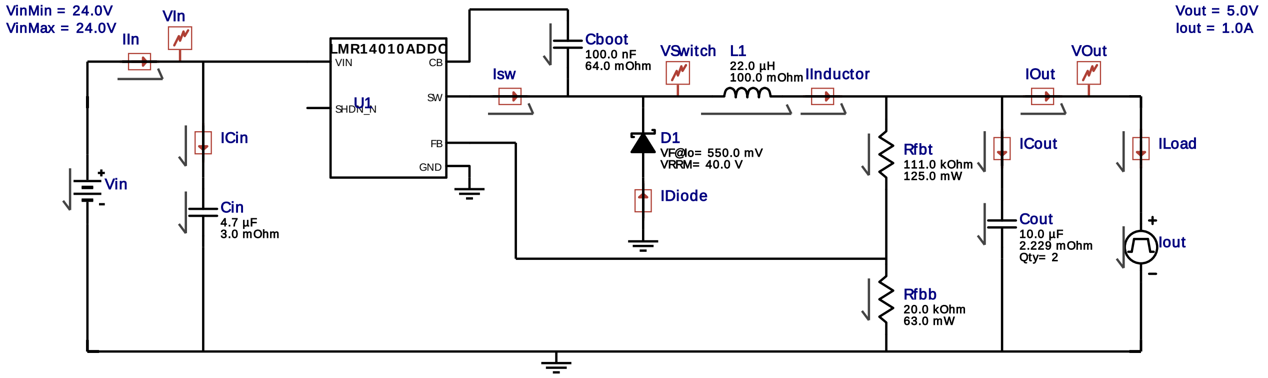


WEBENCH® Electrical Simulation Report

Design Id = 4

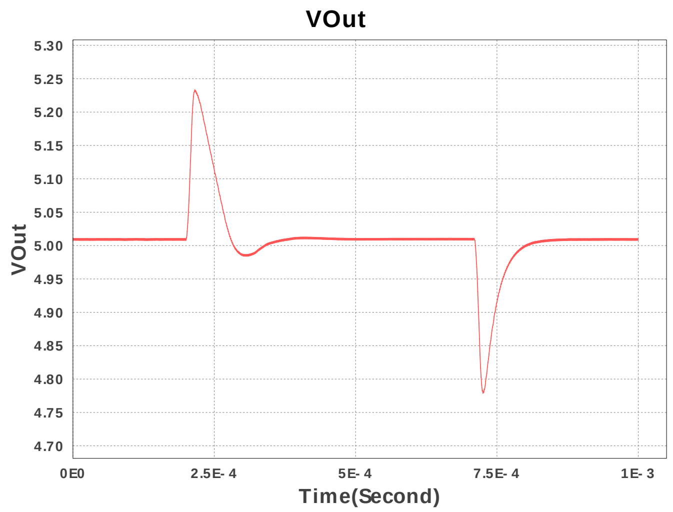
sim_id = 2

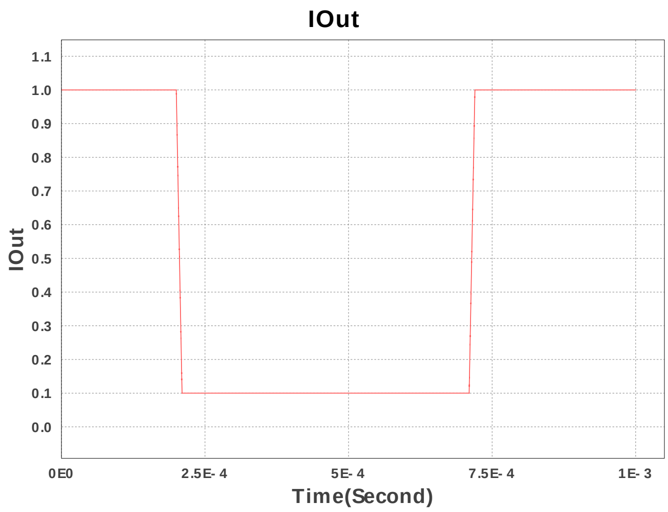
Simulation Type = Load Transient



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Cboot	IC	Initial Voltage	7 V
2.	Iout	signal_type	Signal Type	PULSE
		I1	Initial Current	1.0 A
		I2	Peak Current	0.1 A
		Td	Initial Delay Time	0.2m Sec
		Tr	Rise Time	10u Sec
		Tf	Fall Time	10u Sec
		Pw	Pulse Width	500u Sec





Design Assistance

1. Master key : 9810EF8B6453D2AE[v1]
2. **LMR14010A** Product Folder : http://www.ti.com/product/LMR14010A : contains the data sheet and other resources.

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