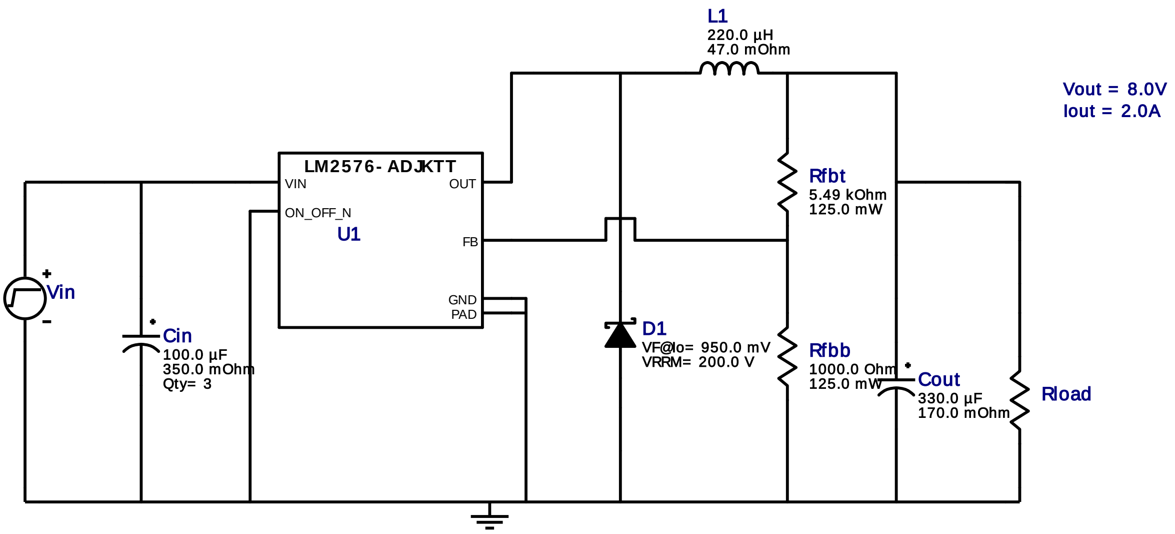
TEXAS INSTRUMENTS

WEBENCH® Design Report

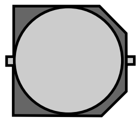
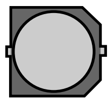
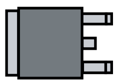
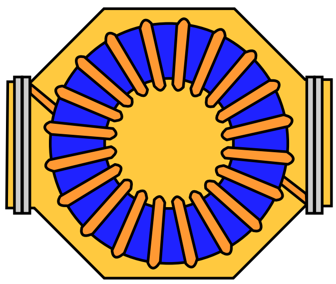
VinMin = 35.0V
VinMax = 40.0V
Vout = 8.0V
Iout = 2.0A

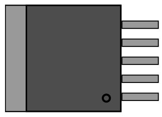
Device = LM2576SX-ADJ/NOPB
Topology = Buck
Created = 2019-04-05 10:36:35.155
BOM Cost = $3.66
BOM Count = 9
Total Pd = 2.55W

Design : 12 LM2576SX-ADJ/NOPB
LM2576SX-ADJ/NOPB 35V-40V to 8.00V @ 2A

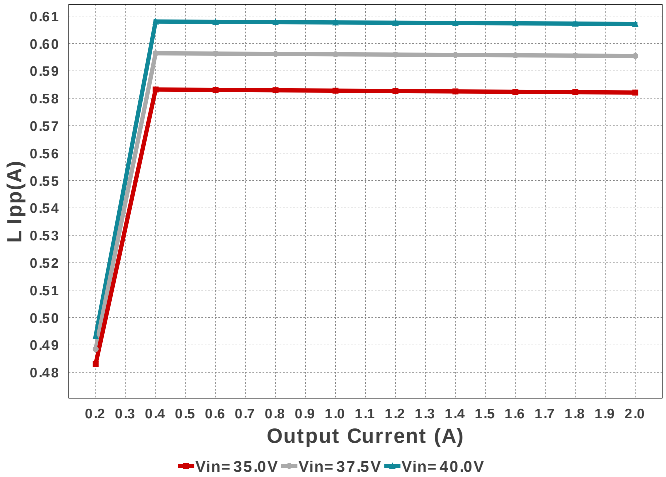


Electrical BOM

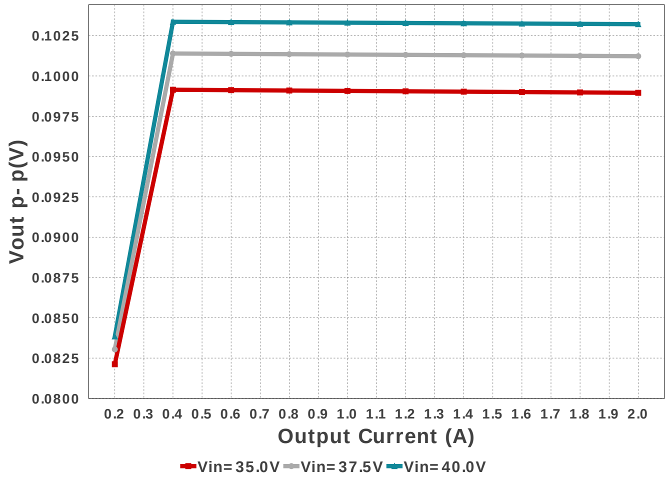
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cin	Panasonic	EEE-FK1J101P Series= FK	Cap= 100.0 uF ESR= 350.0 mOhm VDC= 63.0 V IRMS= 400.0 mA	3	$0.25	 SM_RADIAL_G 172 mm²
Cout	Nichicon	UUD1C331MNL1GS Series= uD	Cap= 330.0 uF ESR= 170.0 mOhm VDC= 16.0 V IRMS= 450.0 mA	1	$0.21	 SM_RADIAL_8MM 113 mm²
D1	SMC Diode Solutions	SBRD10200TR	VF@Io= 950.0 mV VRRM= 200.0 V	1	$0.12	 DPAK 102 mm²
L1	Bourns	PM2110-221K-RC	L= 220.0 µH 47.0 mOhm	1	$1.37	 PM2110 890 mm²
Rfbb	Panasonic	ERJ-6ENF1001V Series= ERJ-6E	Res= 1000.0 Ohm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²
Rfbt	Panasonic	ERJ-6ENF5491V Series= ERJ-6E	Res= 5.49 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
U1	Texas Instruments	LM2576SX-ADJ/NOPB	Switcher	1	$1.19	 KTT0005B 198 mm^2

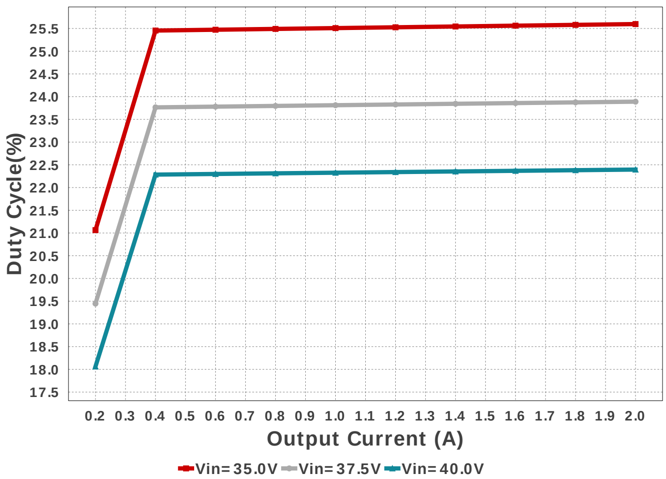
L Ipp



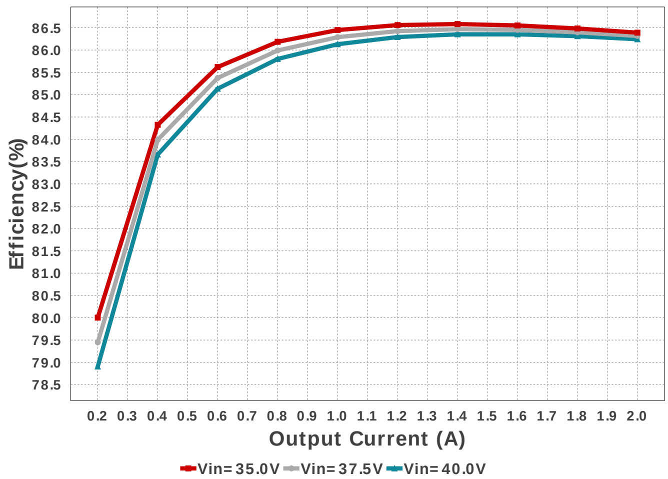
Vout p- p



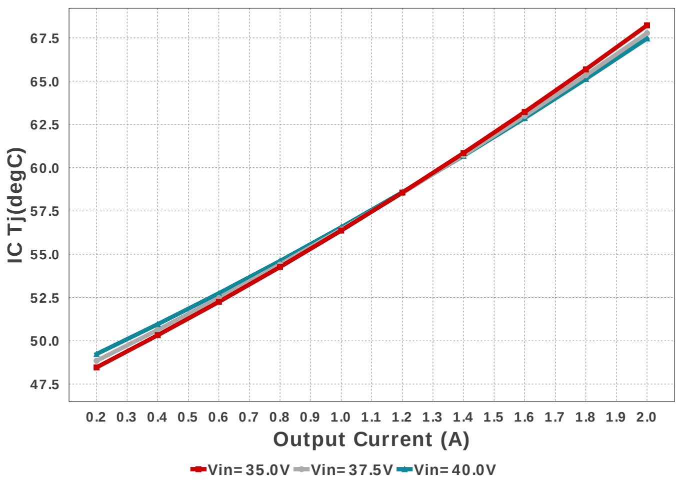
Duty Cycle



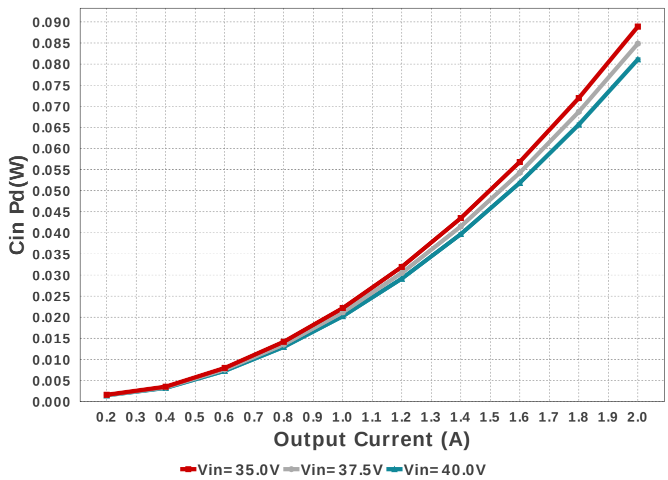
Efficiency

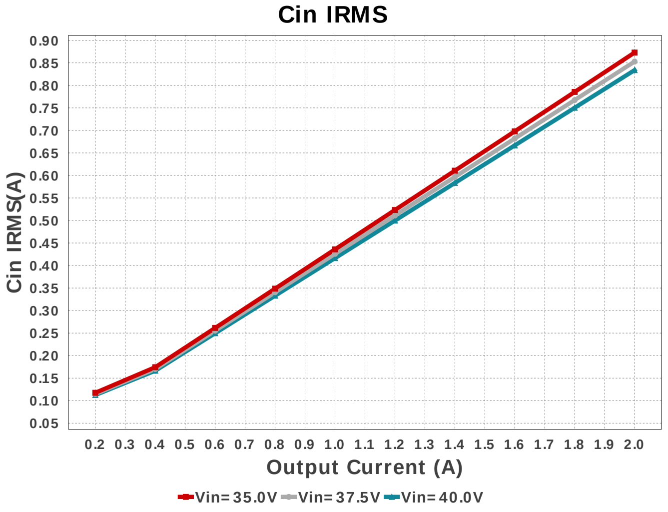


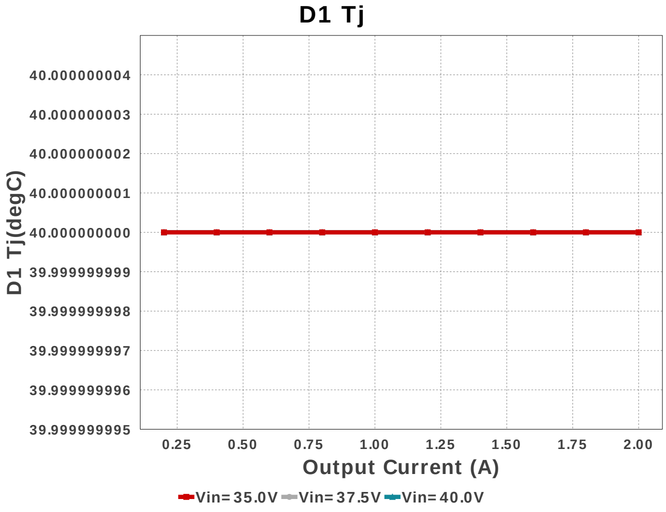
IC Tj

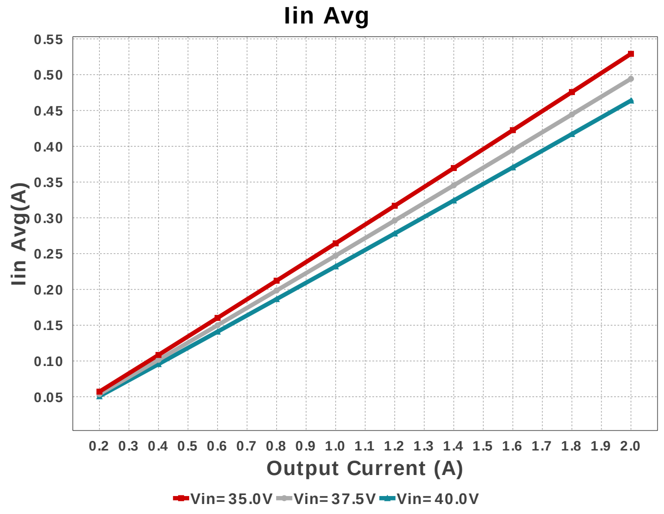


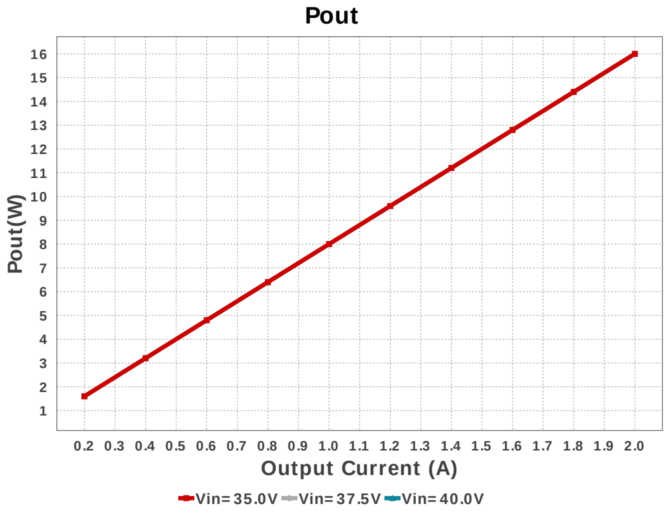
Cin Pd

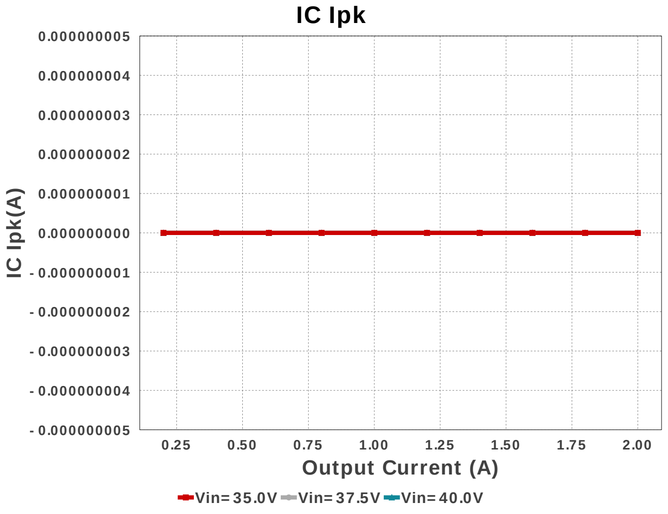


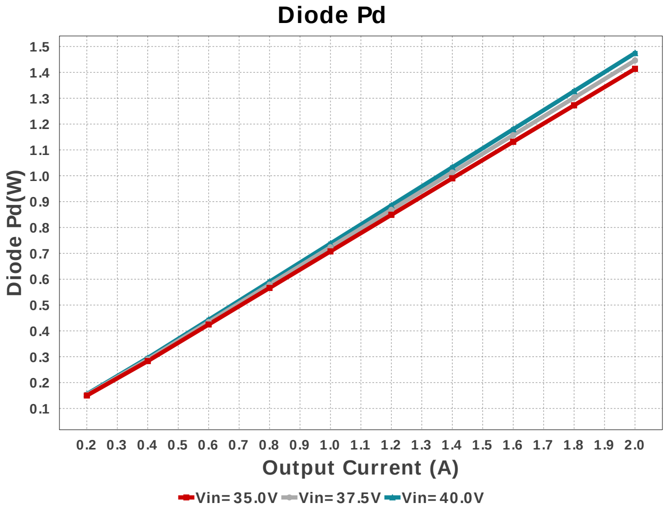

Cin IRMS
Cin IRMS(A)
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin=35.0V Vin=37.5V Vin=40.0V

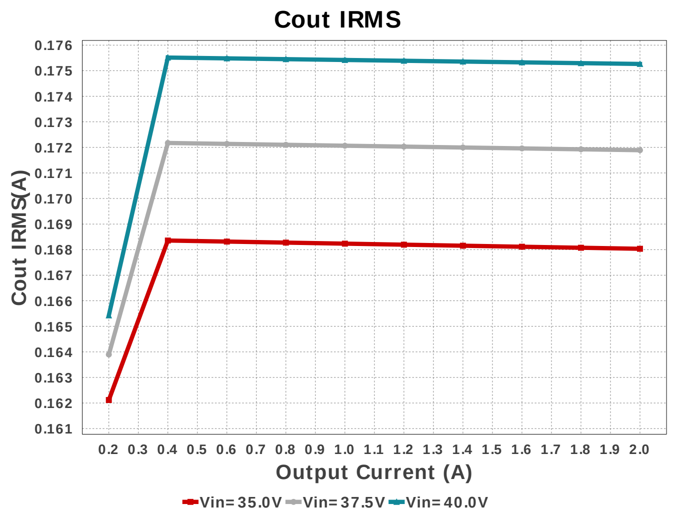

D1 Tj
D1 Tj(degC)
40.000000004
40.000000003
40.000000002
40.000000001
40.000000000
39.999999999
39.999999998
39.999999997
39.999999996
39.999999995
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin=35.0V Vin=37.5V Vin=40.0V

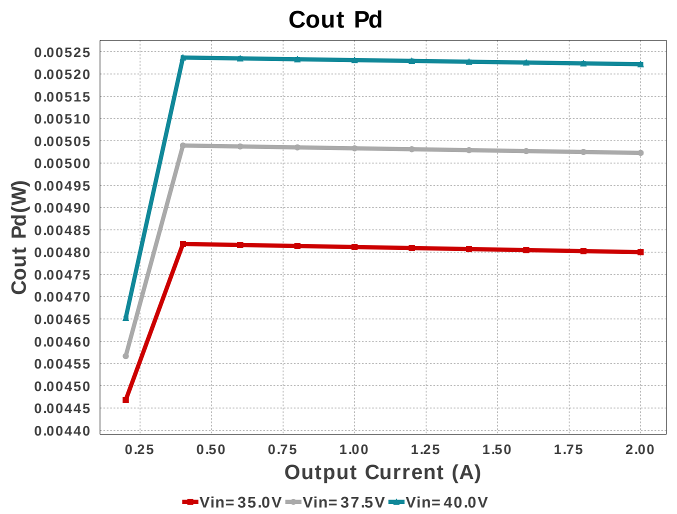

Iin Avg
Iin Avg(A)
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin=35.0V Vin=37.5V Vin=40.0V

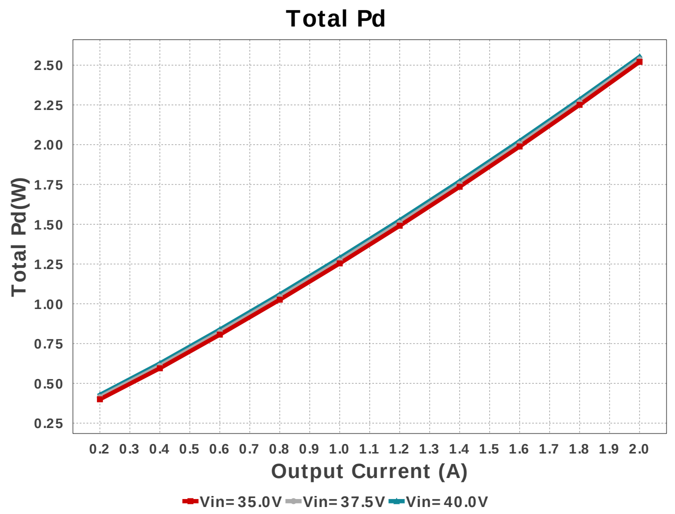

Pout
Pout(W)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin=35.0V Vin=37.5V Vin=40.0V

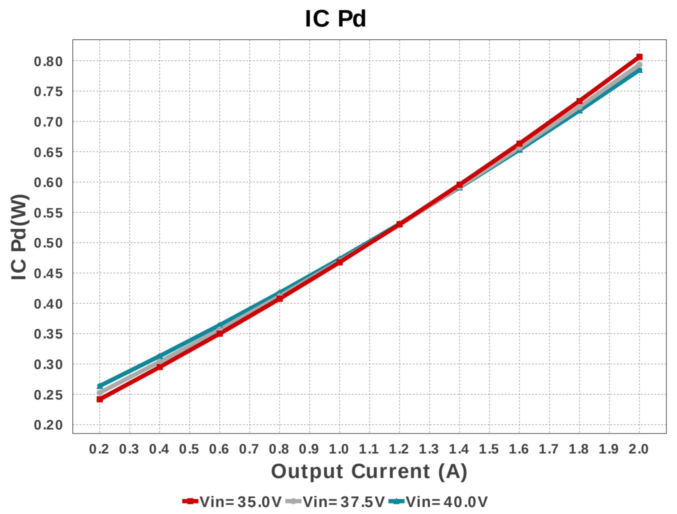

IC Ipk
IC Ipk(A)
0.000000005
0.000000004
0.000000003
0.000000002
0.000000001
0.000000000
-0.000000001
-0.000000002
-0.000000003
-0.000000004
-0.000000005
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin=35.0V Vin=37.5V Vin=40.0V

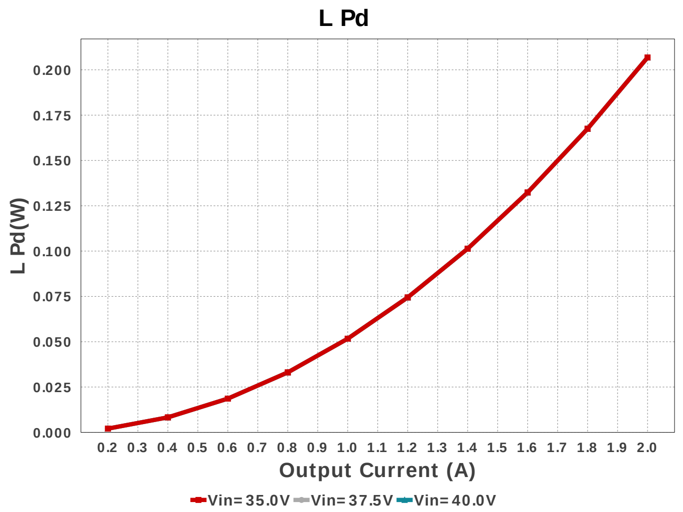

Diode Pd
Diode Pd(W)
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin=35.0V Vin=37.5V Vin=40.0V











Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	833.786 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	81.106 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	175.264 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	5.222 mW	Capacitor	Output capacitor power dissipation
5.	D1 Tj	40.0 degC	Diode	D1 junction temperature
6.	Diode Pd	1.474 W	Diode	Diode power dissipation
7.	IC Ipk	0.0 A	IC	Peak switch current in IC
8.	IC Pd	784.7 mW	IC	IC power dissipation
9.	IC Tj	67.464 degC	IC	IC junction temperature
10.	IC Tolerance	13.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA	35.0 degC/W	IC	IC junction-to-ambient thermal resistance

#	Name	Value	Category	Description
12.	Iin Avg	463.81 mA	IC	Average input current
13.	L Ipp	607.13 mA	Inductor	Peak-to-peak inductor ripple current
14.	L Pd	206.8 mW	Inductor	Inductor power dissipation
15.	Cin Pd	81.106 mW	Power	Input capacitor power dissipation
16.	Cout Pd	5.222 mW	Power	Output capacitor power dissipation
17.	Diode Pd	1.474 W	Power	Diode power dissipation
18.	IC Pd	784.7 mW	Power	IC power dissipation
19.	L Pd	206.8 mW	Power	Inductor power dissipation
20.	Total Pd	2.552 W	Power	Total Power Dissipation
21.	BOM Count	9	System Information	Total Design BOM count
22.	Duty Cycle	22.396 %	System Information	Duty cycle
23.	Efficiency	86.243 %	System Information	Steady state efficiency
24.	FootPrint	1.834 k mm^2	System Information	Total Foot Print Area of BOM components
25.	Frequency	52.0 kHz	System Information	Switching frequency
26.	Iout	2.0 A	System Information	Iout operating point
27.	Mode	CCM	System Information	Conduction Mode
28.	Pout	16.0 W	System Information	Total output power
29.	Total BOM	$3.66	System Information	Total BOM Cost
30.	Vin	40.0 V	System Information	Vin operating point
31.	Vout	8.0 V	System Information	Operational Output Voltage
32.	Vout Actual	7.983 V	System Information	Vout Actual calculated based on selected voltage divider resistors
33.	Vout Tolerance	2.784 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
34.	Vout p-p	103.213 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	2.0	Maximum Output Current
VinMax	40.0	Maximum input voltage
VinMin	35.0	Minimum input voltage
Vout	8.0	Output Voltage
base_pn	LM2576	Base Product Number
source	DC	Input Source Type
Ta	40.0	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

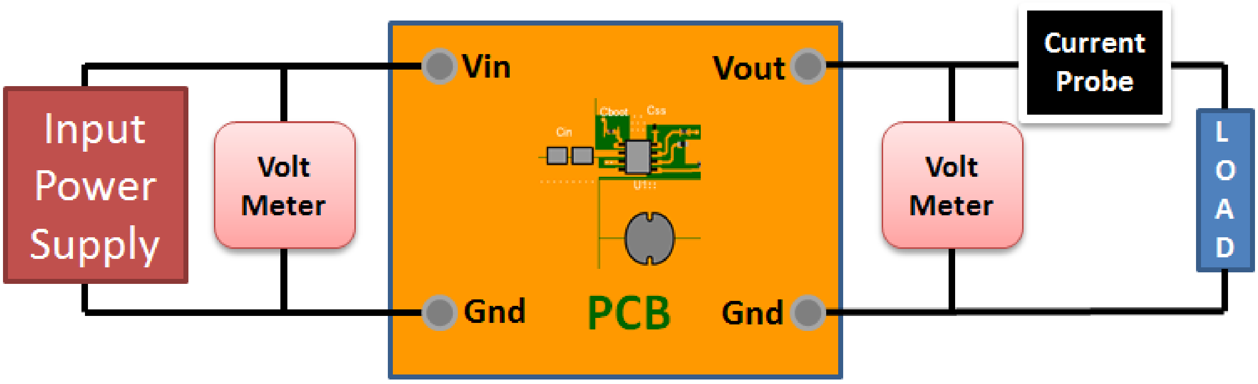
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 35.0V 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 : F94F151332F15CC5[v1]

2. **LM2576** Product Folder : http://www.ti.com/product/LM2576 : contains the data sheet and other resources.

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