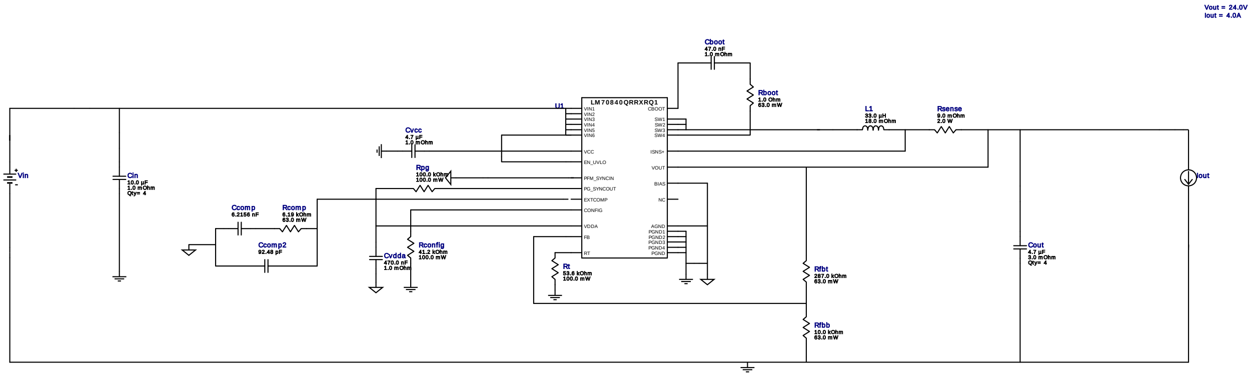
VinMin = 35.0V
VinMax = 60.0V
Vout = 24.0V
Iout = 4.0A

Device = LM70840QRRXRQ1
Topology = Buck
Created = 2025-03-06 02:25:23.844
BOM Cost = NA
BOM Count = 24
Total Pd = 2.98W

WEBENCH ® Design Report

Design : 4 LM70840QRRXRQ1
LM70840QRRXRQ1 35V-60V to 24.00V @ 4A



Design Alerts

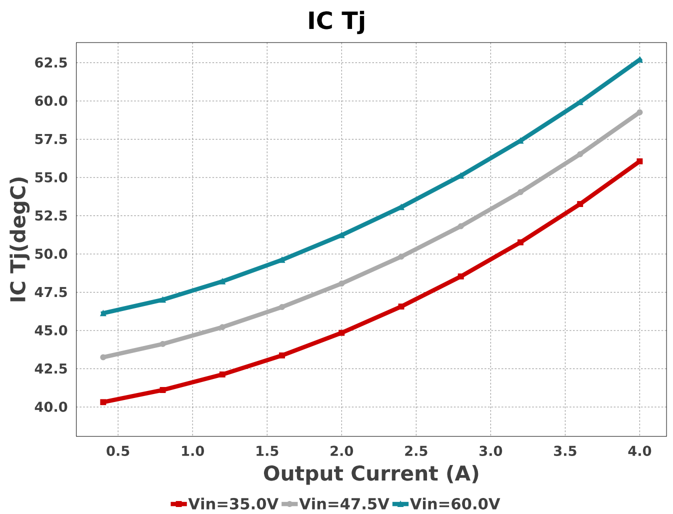
Component Selection Information

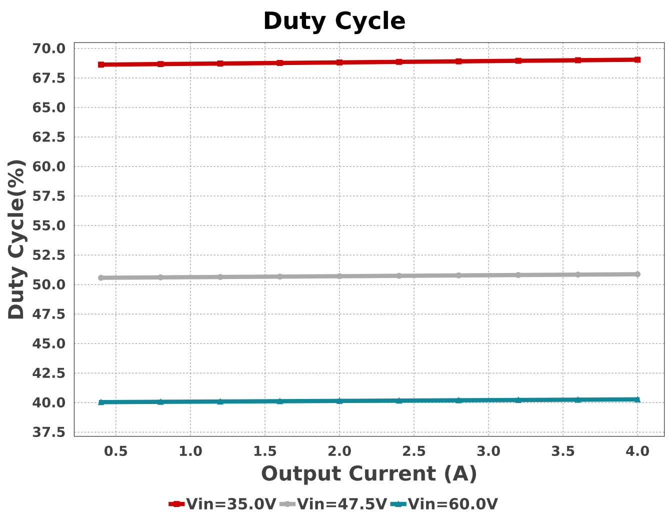
The LM70840-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application.

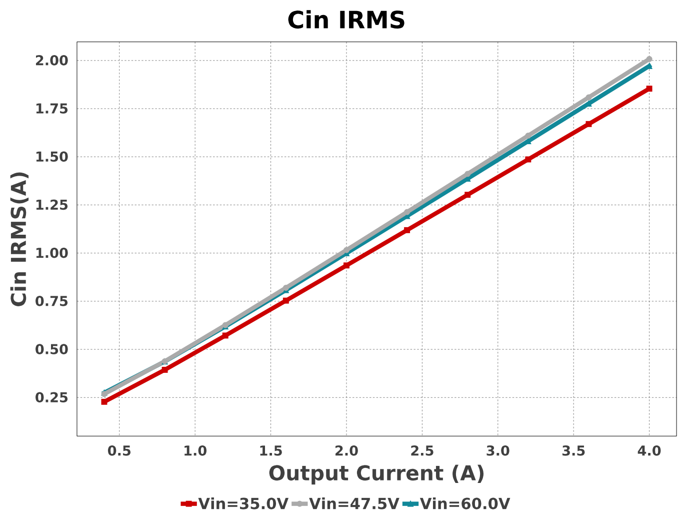
Electrical BOM

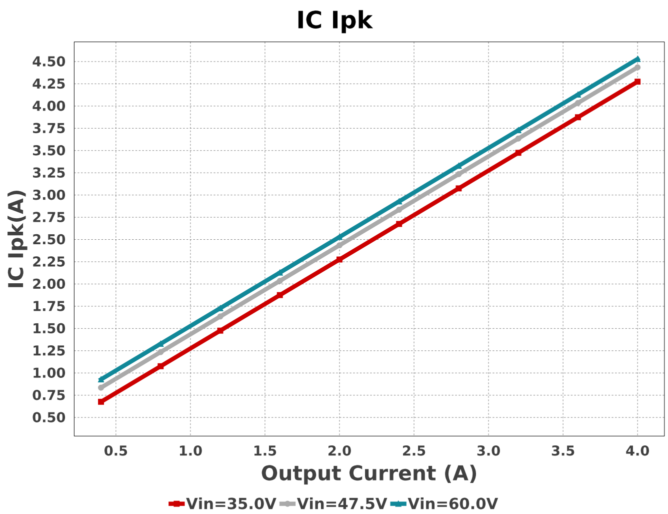
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM155R71A473KA01D Series= X7R	Cap= 47.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ccomp	CUSTOM	CUSTOM Series= ?	Cap= 6.2156 nF VDC= 26.4 V IRMS= 0.0 A	1	NA	CUSTOM 0 mm^2
Ccomp2	CUSTOM	CUSTOM Series= ?	Cap= 92.48 pF VDC= 26.4 V IRMS= 0.0 A	1	NA	CUSTOM 0 mm^2
Cin	MuRata	GRM32ER71J106KA12L Series= X7R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 63.0 V IRMS= 6.0 A	4	$0.30	1210_280 15 mm^2
Cinx	TDK	C2012X7R2A104K125AA Series= X7R	Cap= 100.0 nF ESR= 20.726 mOhm VDC= 100.0 V IRMS= 1.456 A	1	$0.03	0805 7 mm^2
Cout	MuRata	GRM31CR71H475KA12L Series= X7R	Cap= 4.7 uF ESR= 3.0 mOhm VDC= 50.0 V IRMS= 4.98 A	4	$0.10	1206 11 mm^2
Cvcc	MuRata	GRM155R61A475MEAAD Series= X5R	Cap= 4.7 uF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.02	0402_065 3 mm^2
Cvdda	MuRata	GRM155R61A474KE15D Series= X5R	Cap= 470.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.02	0402 3 mm^2
L1	Wurth Elektronik	74439370330	L= 33.0 µH 18.0 mOhm	1	$4.19	WE-XHMI_1510 320 mm^2

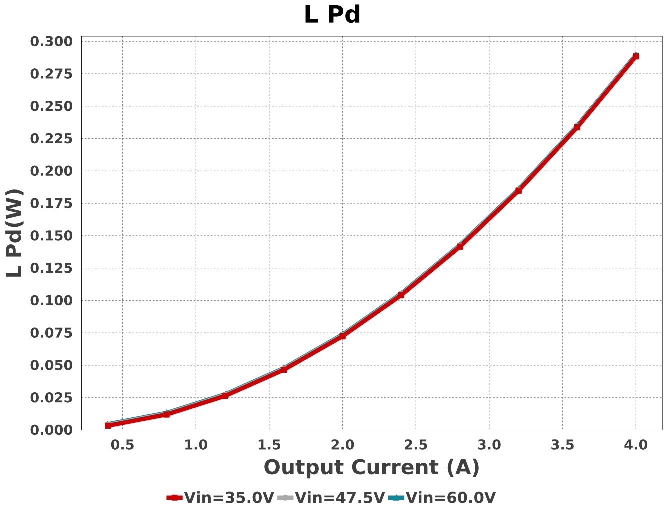
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rboot	Vishay-Dale	CRCW04021R00FKED Series= CRCW..e3	Res= 1.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rcomp	Vishay-Dale	CRCW04026K19FKED Series= CRCW..e3	Res= 6.19 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rconfig	Vishay-Dale	CRCW060341K2FKEA Series= CRCW..e3	Res= 41.2 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rfbb	Vishay-Dale	CRCW040210K0FKED Series= CRCW..e3	Res= 10.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbt	Vishay-Dale	CRCW0402287KFKED Series= CRCW..e3	Res= 287.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rpg	Vishay-Dale	CRCW0603100KFKEA Series= CRCW..e3	Res= 100.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rsense	Rohm	PMR100HZPFU9L00 Series= PMR100	Res= 9.0 mOhm Power= 2.0 W Tolerance= 1.0%	1	$0.19	2512 43 mm²
Rt	Vishay-Dale	CRCW060353K6FKEA Series= CRCW..e3	Res= 53.6 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
U1	Texas Instruments	LM70840QRRXRQ1	Switcher	1	$2.63	RRX0029B 64 mm²

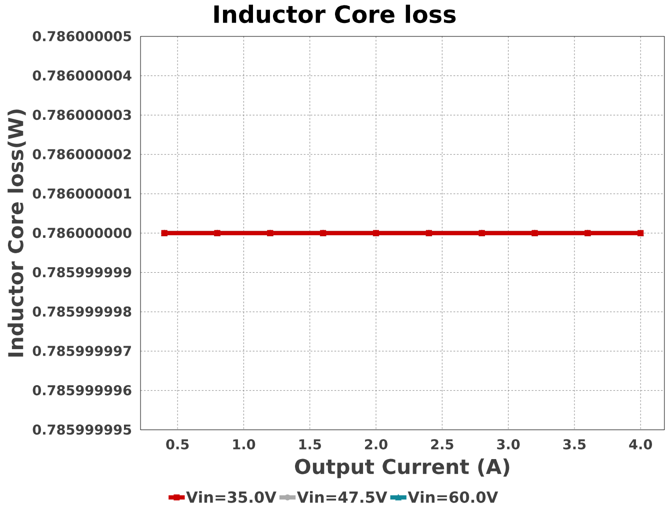


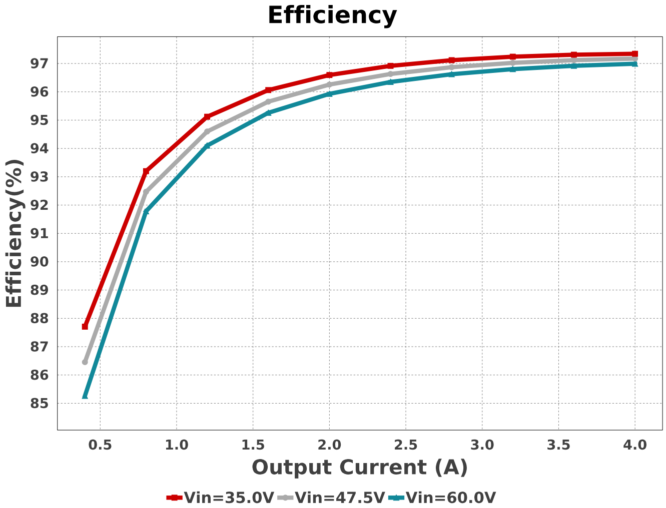


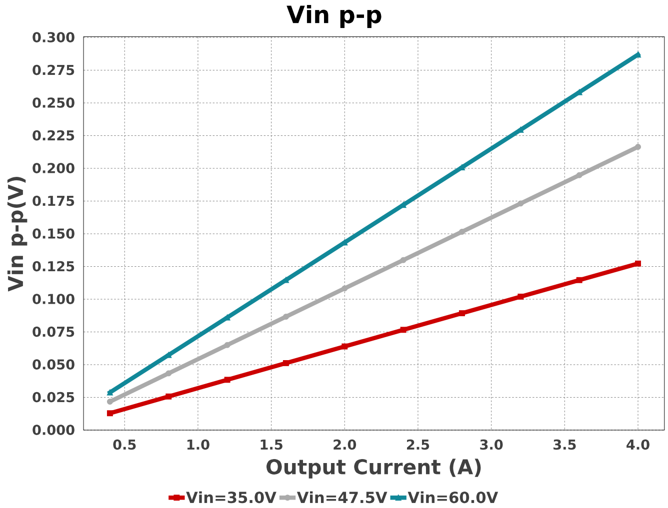


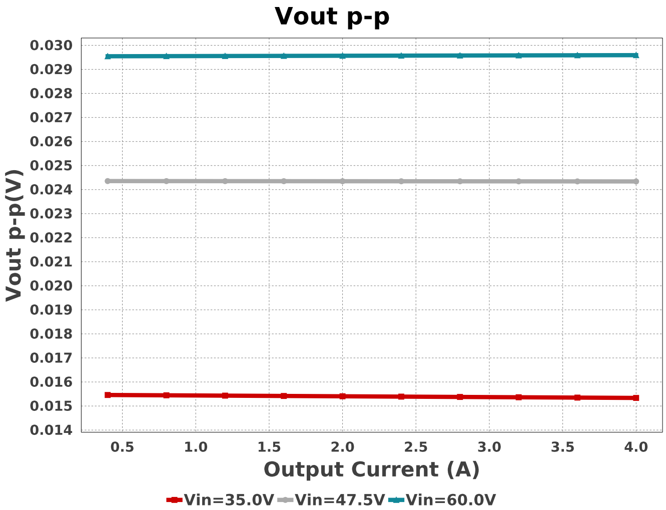


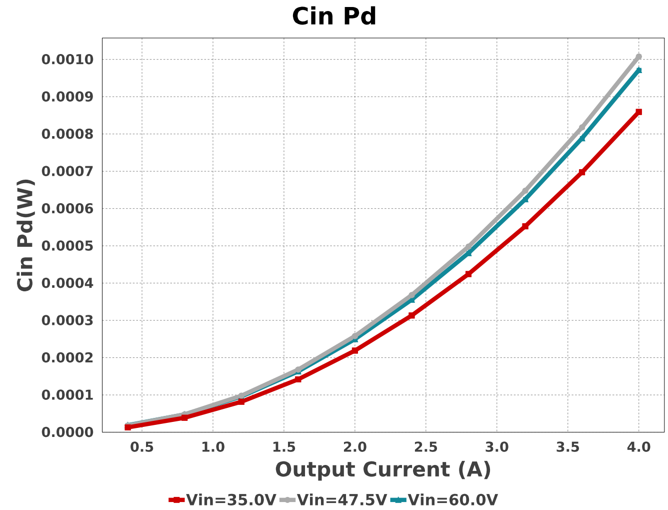

L Pd
L Pd(W)
Output Current (A)
Vin=35.0V Vin=47.5V Vin=60.0V

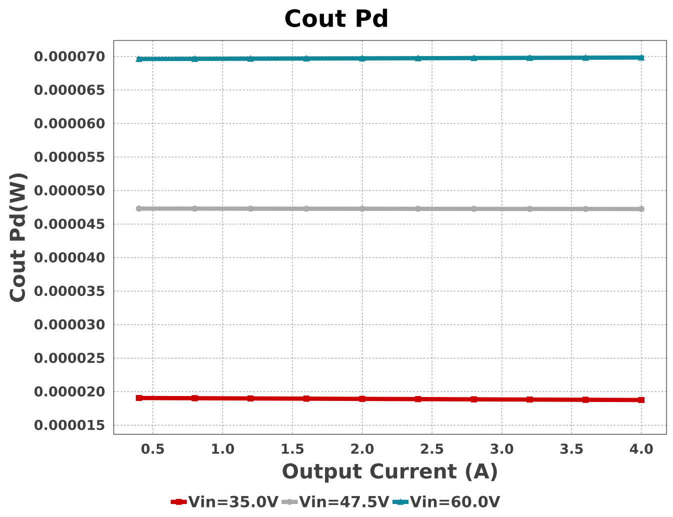

Inductor Core loss
Inductor Core loss(W)
Output Current (A)
Vin=35.0V Vin=47.5V Vin=60.0V

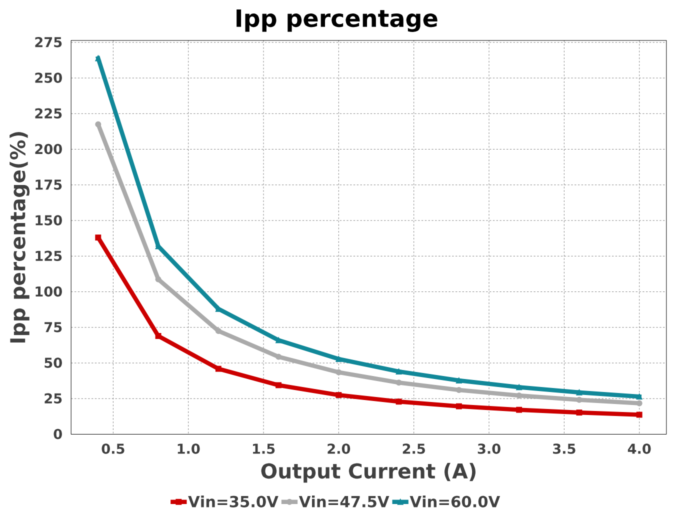

Efficiency
Efficiency(%)
Output Current (A)
Vin=35.0V Vin=47.5V Vin=60.0V

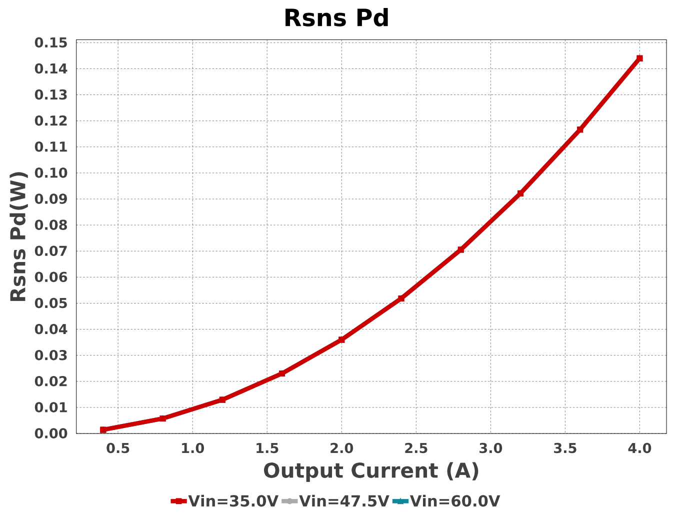

Vin p-p
Vin p-p(V)
Output Current (A)
Vin=35.0V Vin=47.5V Vin=60.0V

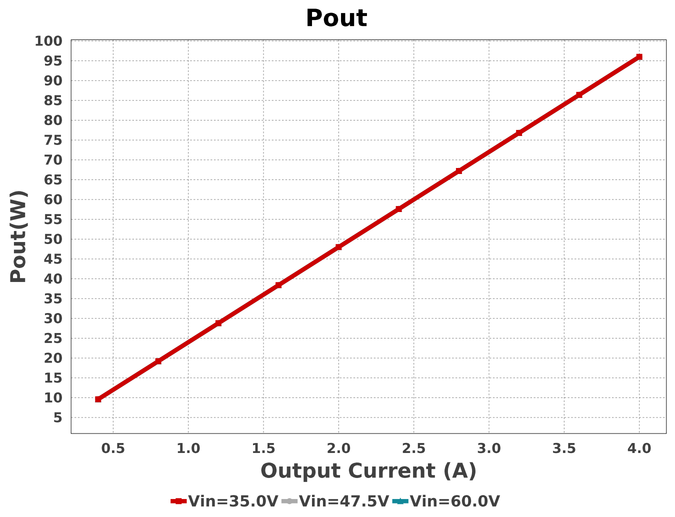

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=35.0V Vin=47.5V Vin=60.0V

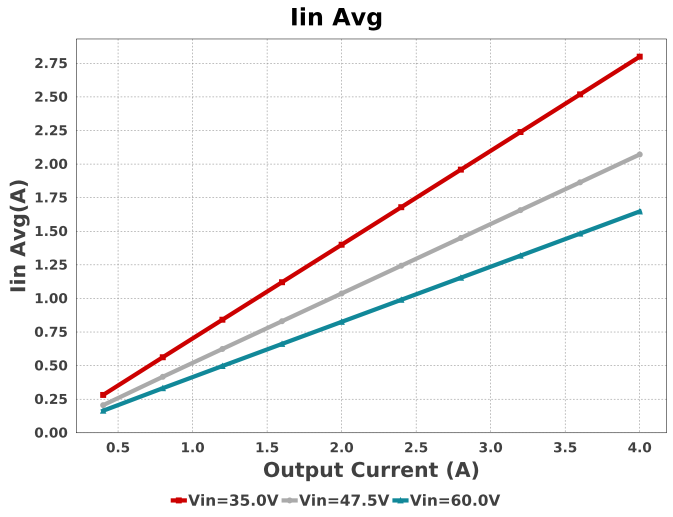

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=35.0V Vin=47.5V Vin=60.0V

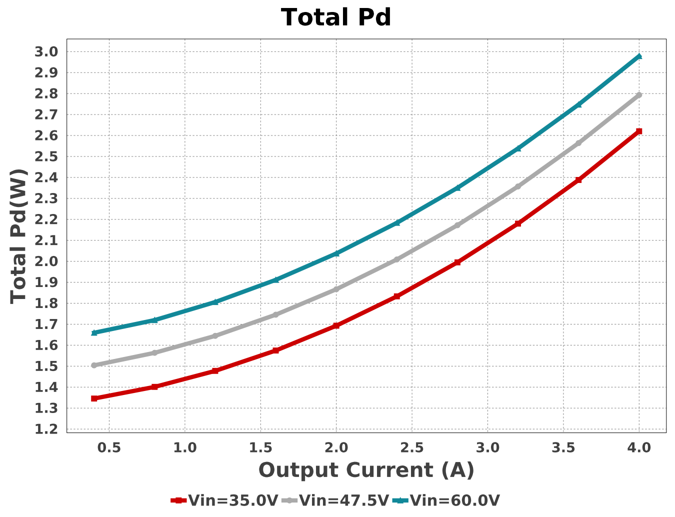

Cout Pd
Cout Pd(W)
0.000070
0.000065
0.000060
0.000055
0.000050
0.000045
0.000040
0.000035
0.000030
0.000025
0.000020
0.000015
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
Output Current (A)
Vin=35.0V Vin=47.5V Vin=60.0V

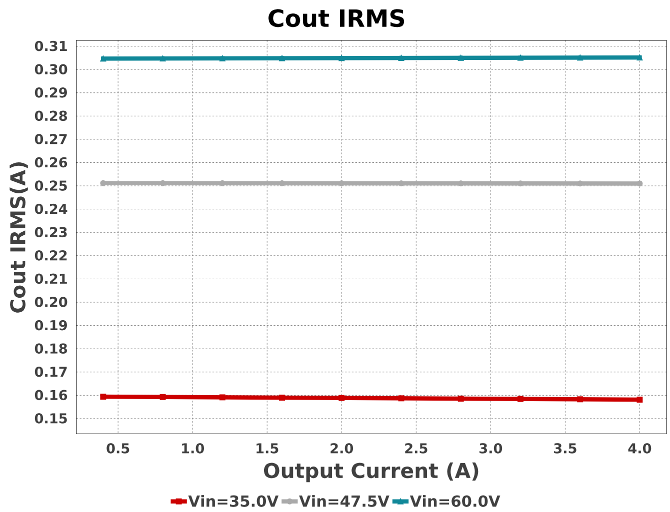

Ipp percentage
Ipp percentage(%)
275
250
225
200
175
150
125
100
75
50
25
0
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
Output Current (A)
Vin=35.0V Vin=47.5V Vin=60.0V

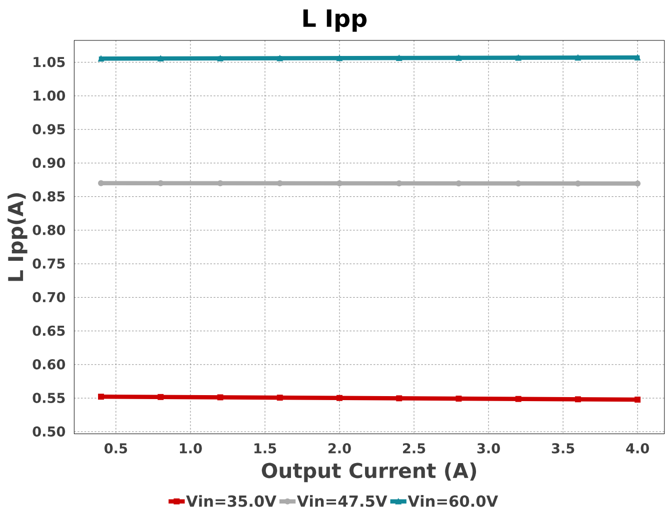

Rsns Pd
Rsns Pd(W)
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
Output Current (A)
Vin=35.0V Vin=47.5V Vin=60.0V

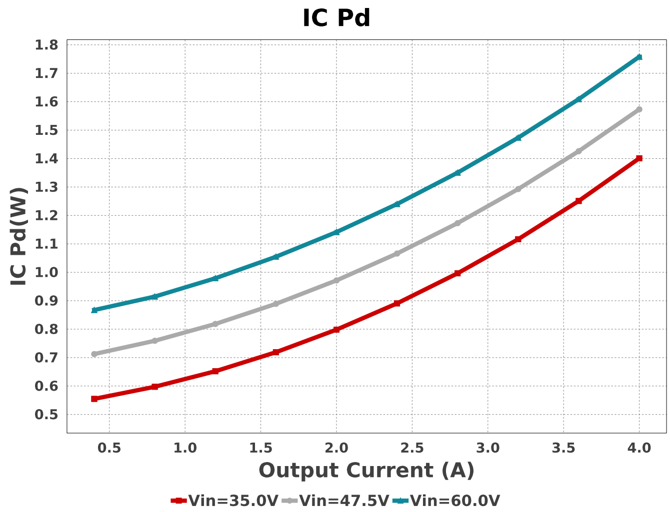

Pout
Pout(W)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
Output Current (A)
Vin=35.0V Vin=47.5V Vin=60.0V

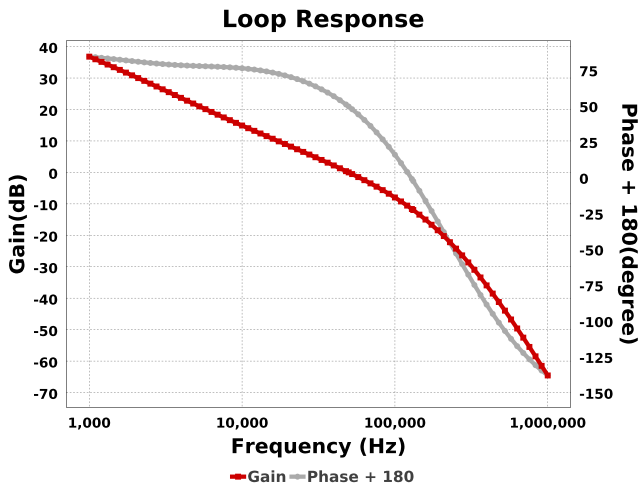

Iin Avg
Iin Avg(A)
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
Output Current (A)
Vin=35.0V Vin=47.5V Vin=60.0V


Total Pd
Total Pd(W)
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
Output Current (A)
Vin=35.0V Vin=47.5V Vin=60.0V









Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	1.971 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	971.54 µW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	305.155 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	69.84 µW	Capacitor	Output capacitor power dissipation
5.	IC Ipk	4.529 A	IC	Peak switch current in IC
6.	IC Pd	1.758 W	IC	IC power dissipation
7.	IC Tj	62.699 degC	IC	IC junction temperature
8.	IC Tolerance	10.0 mV	IC	IC Feedback Tolerance
9.	ICThetaJA Effective	18.6 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
10.	Iin Avg	1.647 A	IC	Average input current
11.	Inductor Core loss	786.0 mW	Inductor	Inductor Core Losses(Assumed to be constant)
12.	Ipp percentage	26.427 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
13.	L Ipp	1.057 A	Inductor	Peak-to-peak inductor ripple current
14.	L Pd	289.68 mW	Inductor	Inductor power dissipation
15.	Cin Pd	971.54 µW	Power	Input capacitor power dissipation
16.	Cout Pd	69.84 µW	Power	Output capacitor power dissipation
17.	IC Pd	1.758 W	Power	IC power dissipation
18.	Inductor Core loss	786.0 mW	Power	Inductor Core Losses(Assumed to be constant)
19.	L Pd	289.68 mW	Power	Inductor power dissipation
20.	Rsns Pd	144.0 mW	Power	Current Limit Sense Resistor Power Dissipation
21.	Total Pd	2.979 W	Power	Total Power Dissipation
22.	Rsns Pd	144.0 mW	Resistor	Current Limit Sense Resistor Power Dissipation
23.	BOM Count	24	System Information	Total Design BOM count
24.	Cross Freq	49.835 kHz	System Information	Bode plot crossover frequency
25.	Duty Cycle	40.274 %	System Information	Duty cycle
26.	Efficiency	96.991 %	System Information	Steady state efficiency

#	Name	Value	Category	Description
27.	FootPrint	582.0 mm^2	System Information	Total Foot Print Area of BOM components
28.	Frequency	413.665 kHz	System Information	Switching frequency
29.	Gain Marg	-11.625 dB	System Information	Bode Plot Gain Margin
30.	Iout	4.0 A	System Information	Iout operating point
31.	Iout transient step used for Cout calculations	2.0 A	System Information	Custom Transient current step requirement that was used for Cout selection (A).
32.	Low Freq Gain	36.775 dB	System Information	Gain at 1Hz
33.	Mode	CCM	System Information	Conduction Mode
34.	Overshoot Value	254.708 mV	System Information	Theoretical Vout Overshoot Value
35.	Phase Marg	50.527 deg	System Information	Bode Plot Phase Margin
36.	Pout	96.0 W	System Information	Total output power
37.	Total BOM	NA	System Information	Total BOM Cost
38.	Undershoot Value	438.49 mV	System Information	Theoretical Vout Undershoot Value
39.	Vin	60.0 V	System Information	Vin operating point
40.	Vin p-p	286.908 mV	System Information	Peak-to-peak input voltage
41.	Vout	24.0 V	System Information	Operational Output Voltage
42.	Vout Actual	23.76 V	System Information	Vout Actual calculated based on selected voltage divider resistors
43.	Vout Ripple requirement used for Cout calculations	1.0 %	System Information	Custom maximum output ripple requirement that was used for Cout selection(% of Vout).
44.	Vout Tolerance	3.227 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
45.	Vout p-p	29.591 mV	System Information	Peak-to-peak output ripple voltage
46.	Vout transient requirement used for Cout calculations	3.0 %	System Information	Custom Transient voltage change requirement that was used for Cout selection (% of Vout).

Design Inputs

Name	Value	Description
Iout	4.0	Maximum Output Current
VinMax	60.0	Maximum input voltage
VinMin	35.0	Minimum input voltage
Vout	24.0	Output Voltage
base_pn	LM70840-Q1	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

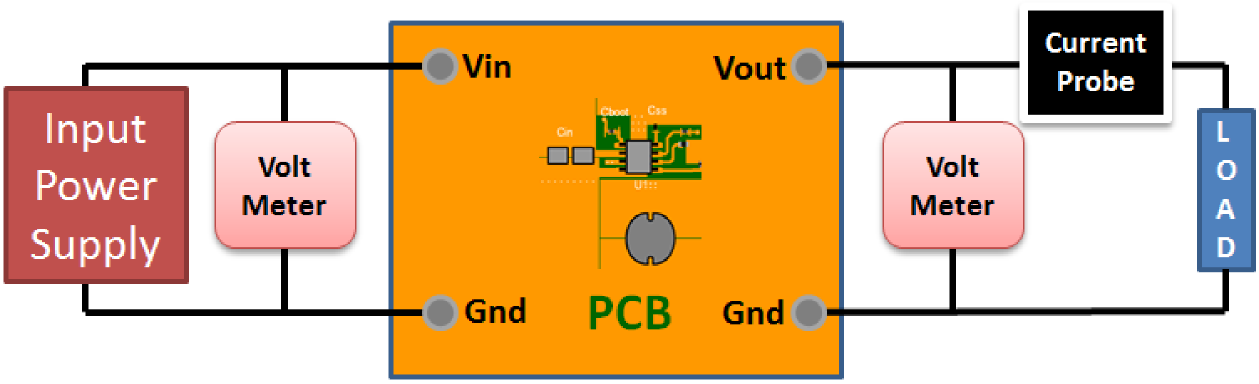
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 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 : 0209EA348B3D83DCE990F5E46D9B39F8[v1]

2. **LM70840-Q1** Product Folder : http://www.ti.com/product/LM70840%2DQ1 : contains the data sheet and other resources.