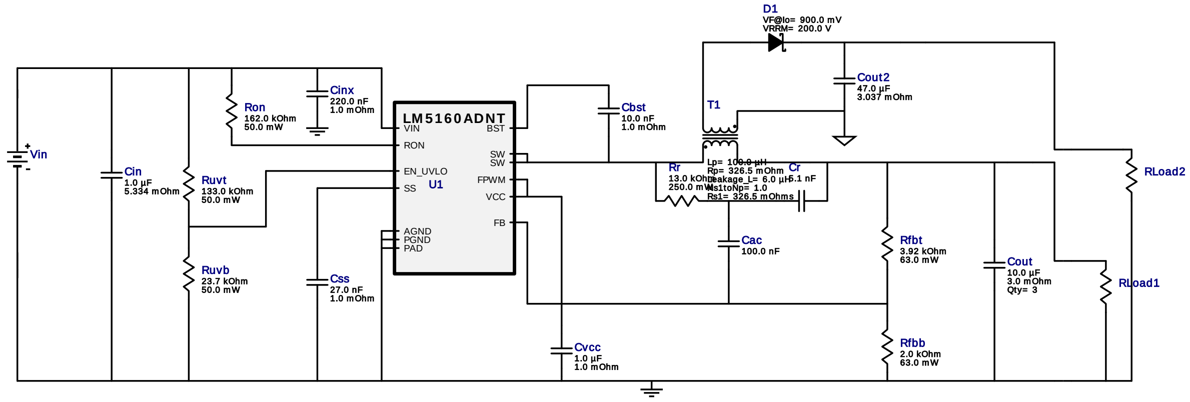
VinMin = 8.5V
VinMax = 56.0V
Vout = 6.0V
Iout = 0.2A

Device = LM5160ADNTR
Topology = Flybuck
Created = 2024-10-06 13:13:58.966
BOM Cost = $3.47
BOM Count = 20
Total Pd = 0.68W

WEBENCH ® Design Report

Design : 13 LM5160ADNTR
LM5160ADNTR 8.5V-56V to 6.00V @ 0.4A

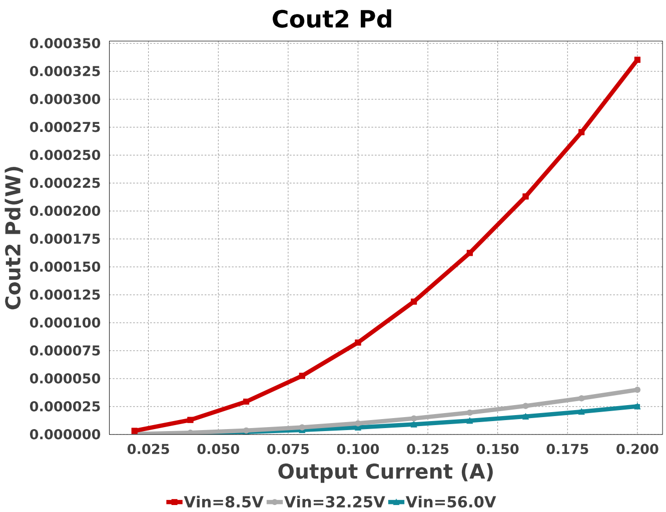


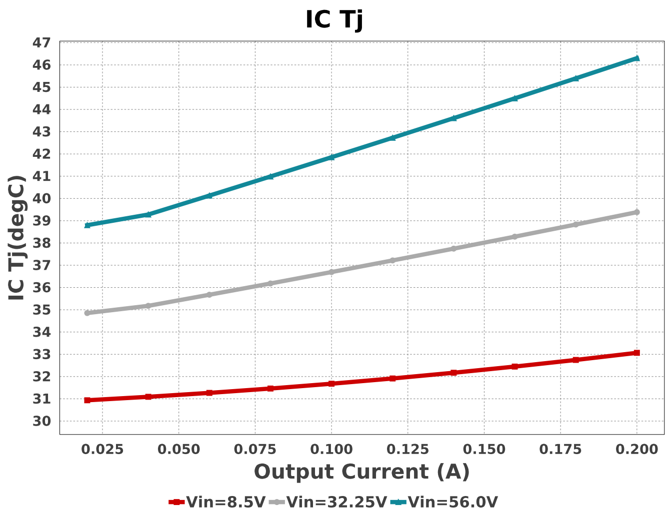
1. Feedback Resistors may need to be further adjusted to get more precise regulation as ripple injection circuit will introduce some amount of DC offset. Use simulation to help adjust.

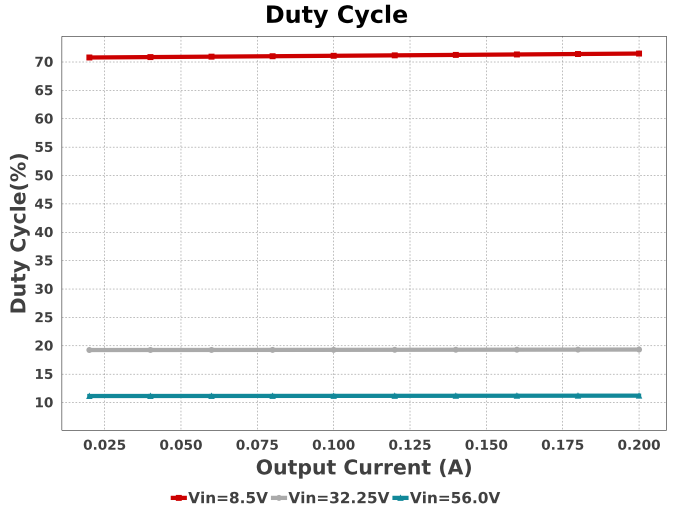
Electrical BOM

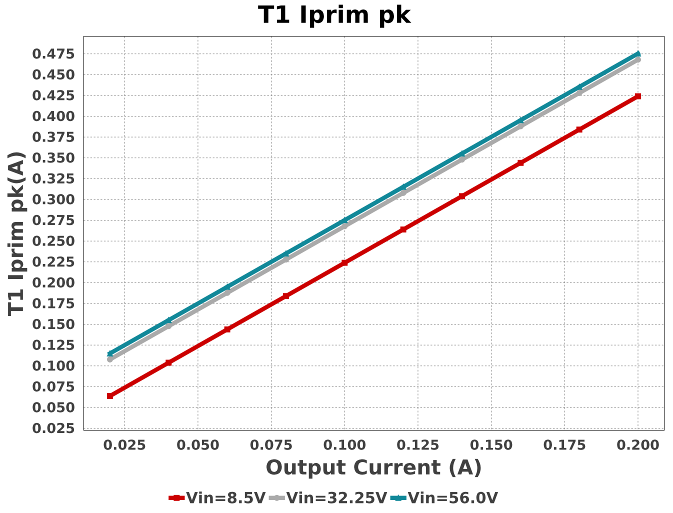
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cac	AVX	08053C104JAZ2A Series= X7R	Cap= 100.0 nF VDC= 25.0 V IRMS= 0.0 A	1	$0.07	0805 7 mm²
Cbst	MuRata	GRM155R71H103KA88D Series= X7R	Cap= 10.0 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cin	MuRata	GRM31CR72A105KA01L Series= X7R	Cap= 1.0 uF ESR= 5.334 mOhm VDC= 100.0 V IRMS= 1.55432 A	1	$0.11	1206_190 11 mm²
Cinx	MuRata	GRM21AR72A224KAC5L Series= X7R	Cap= 220.0 nF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 0.0 A	1	$0.08	0805 7 mm²
Cout	Kemet	C0805C106K8PACTU Series= X5R	Cap= 10.0 uF ESR= 3.0 mOhm VDC= 10.0 V IRMS= 11.43 A	3	$0.03	0805 7 mm²
Cout2	MuRata	GRM32ER61C476KE15L Series= X5R	Cap= 47.0 uF ESR= 3.037 mOhm VDC= 16.0 V IRMS= 4.59346 A	1	$0.17	1210_280 15 mm²

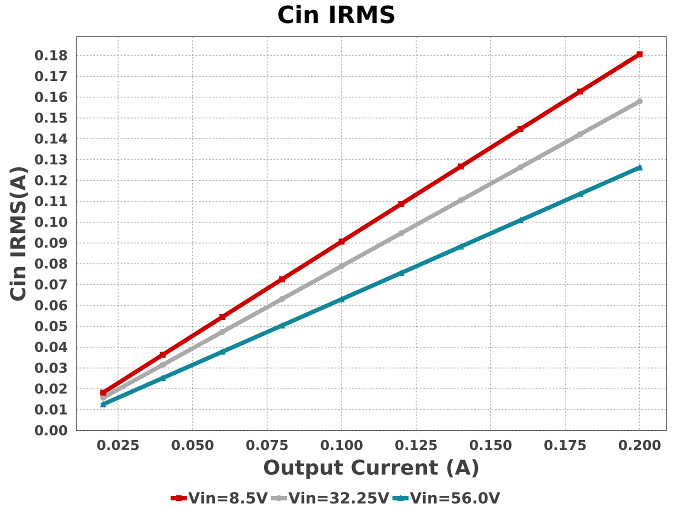
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cr	Kemet	C0603C512J5GAC7867 Series= C0G/NP0	Cap= 5.1 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.09	0603 5 mm^2
Css	MuRata	GRM155R71C273KA01D Series= X7R	Cap= 27.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cvcc	Taiyo Yuden	EMK107B7105KA-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2
D1	SMC Diode Solutions	SK220ATR	VF@Io= 900.0 mV VRRM= 200.0 V	1	$0.06	SMA 37 mm^2
Rfbb	Vishay-Dale	CRCW04022K00FKED Series= CRCW..e3	Res= 2.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt	Vishay-Dale	CRCW04023K92FKED Series= CRCW..e3	Res= 3.92 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ron	Yageo	RC0201FR-07162KL Series= ?	Res= 162.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rr	Vishay-Dale	CMF5013K000FHEB Series= CMF50	Res= 13.0 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.33	CMF50 46 mm^2
Ruvb	Yageo	RC0201FR-0723K7L Series= ?	Res= 23.7 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Ruvt	Yageo	RC0201FR-07133KL Series= ?	Res= 133.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
T1	Coiltronics	DRQ127-101-R	Lp= 100.0 µH Rp= 326.5 mOhm Leakage_L= 6.0 µH Ns1toNp= 1.0 Rs1= 326.5 mOhms	1	$1.49	DRQ127 210 mm^2
U1	Texas Instruments	LM5160ADNTR	Switcher	1	$0.90	DNT0012B 25 mm^2

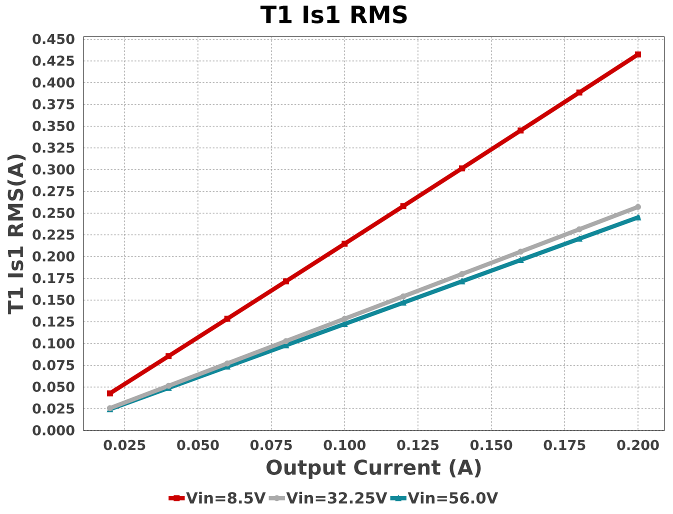


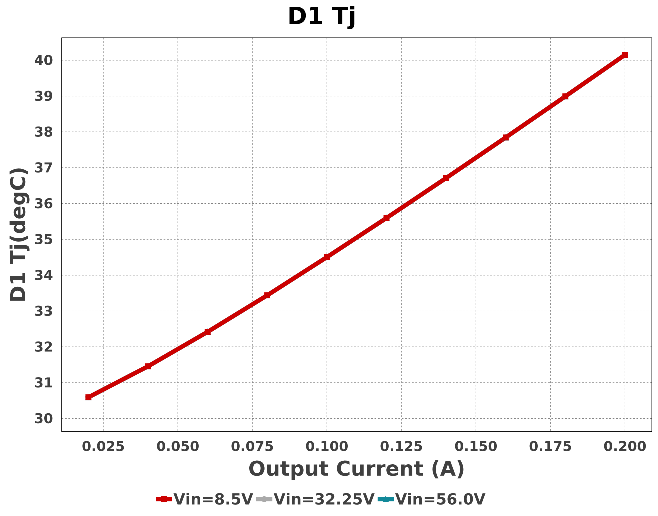


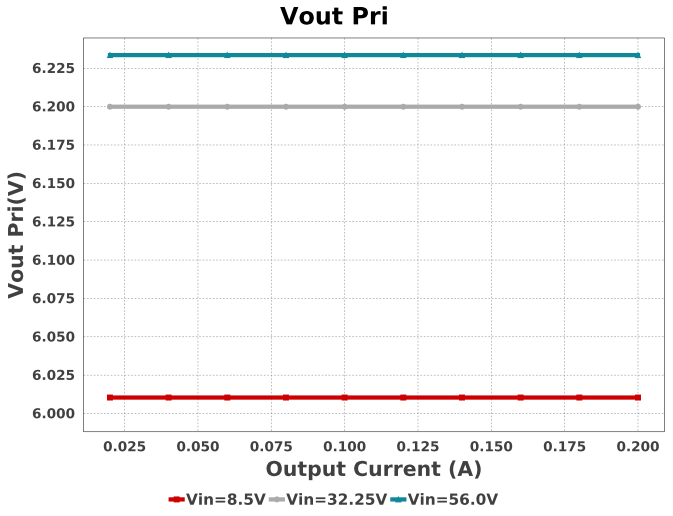

Duty Cycle
Duty Cycle(%)
Output Current (A)
Vin=8.5V Vin=32.25V Vin=56.0V

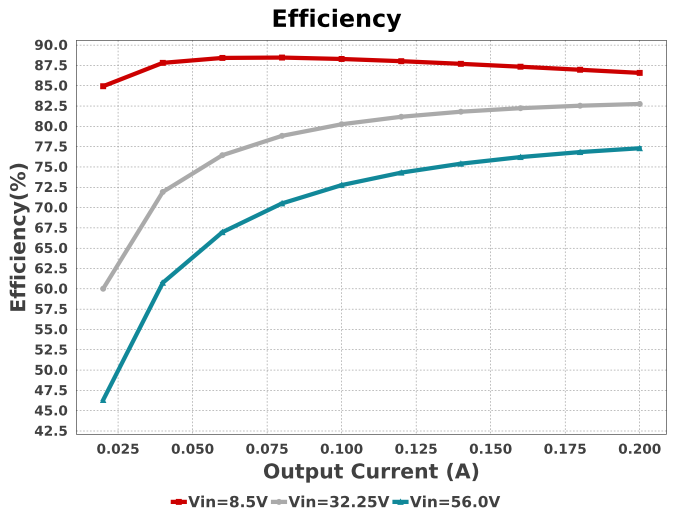

T1 Iprim pk
T1 Iprim pk(A)
Output Current (A)
Vin=8.5V Vin=32.25V Vin=56.0V

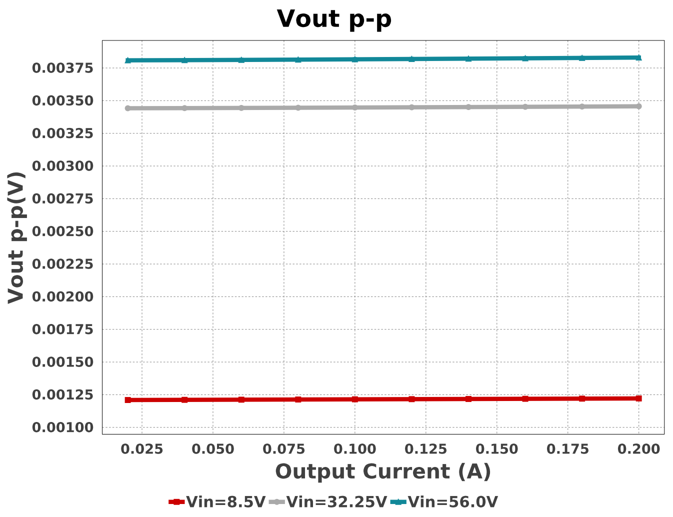

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=8.5V Vin=32.25V Vin=56.0V

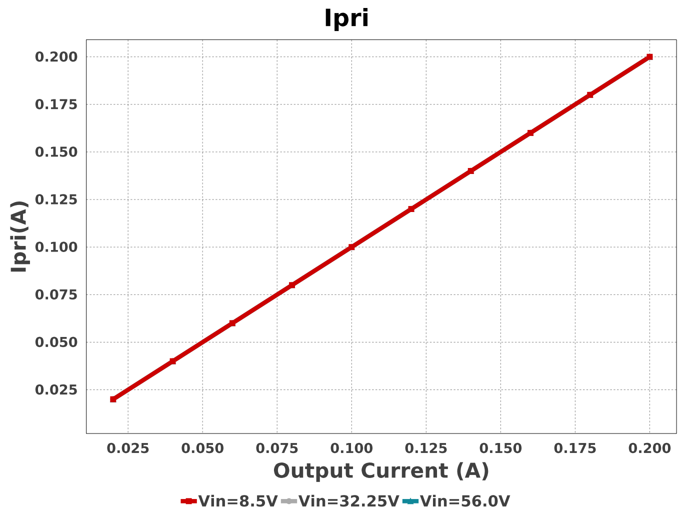

T1 Is1 RMS
T1 Is1 RMS(A)
Output Current (A)
Vin=8.5V Vin=32.25V Vin=56.0V

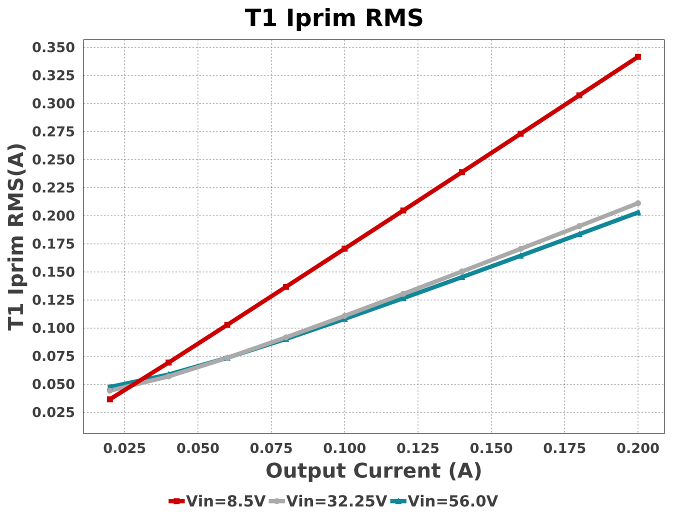

D1 Tj
D1 Tj(degC)
Output Current (A)
Vin=8.5V Vin=32.25V Vin=56.0V

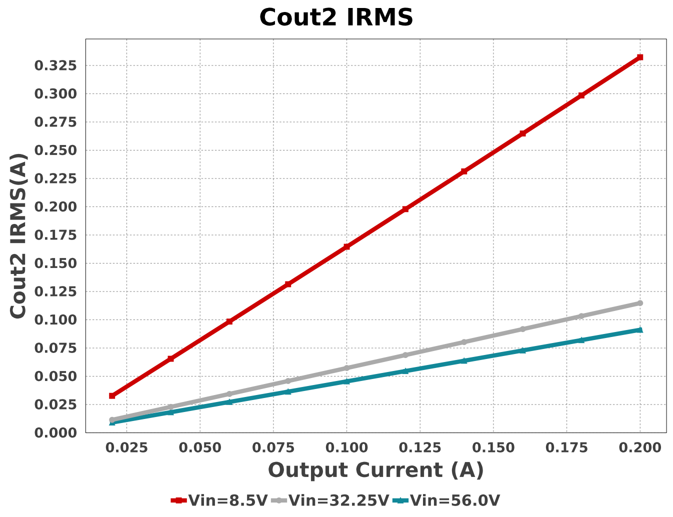

Vout Pri
Vout Pri(V)
Output Current (A)
Vin=8.5V Vin=32.25V Vin=56.0V

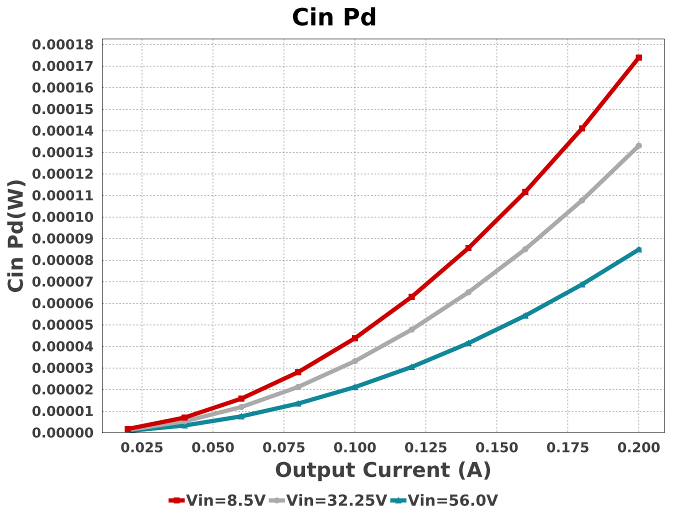

Efficiency
Efficiency(%)
90.0
87.5
85.0
82.5
80.0
77.5
75.0
72.5
70.0
67.5
65.0
62.5
60.0
57.5
55.0
52.5
50.0
47.5
45.0
42.5
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
Output Current (A)
Vin=8.5V
Vin=32.25V
Vin=56.0V

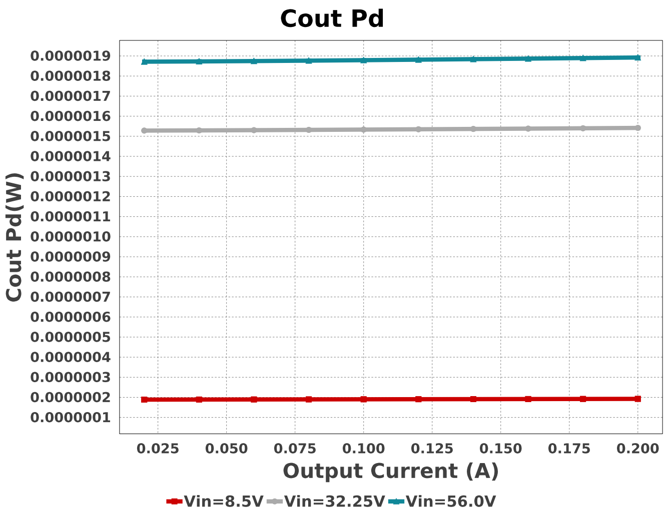

Vout p-p
Vout p-p(V)
0.00375
0.00350
0.00325
0.00300
0.00275
0.00250
0.00225
0.00200
0.00175
0.00150
0.00125
0.00100
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
Output Current (A)
Vin=8.5V
Vin=32.25V
Vin=56.0V

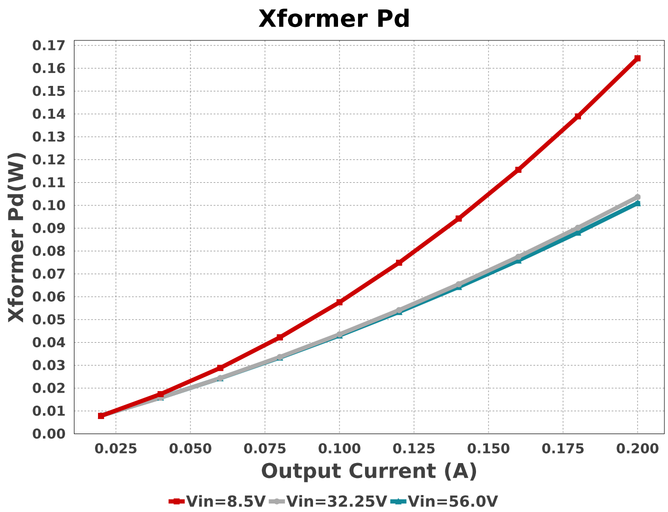

Ipri
Ipri(A)
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
Output Current (A)
Vin=8.5V
Vin=32.25V
Vin=56.0V

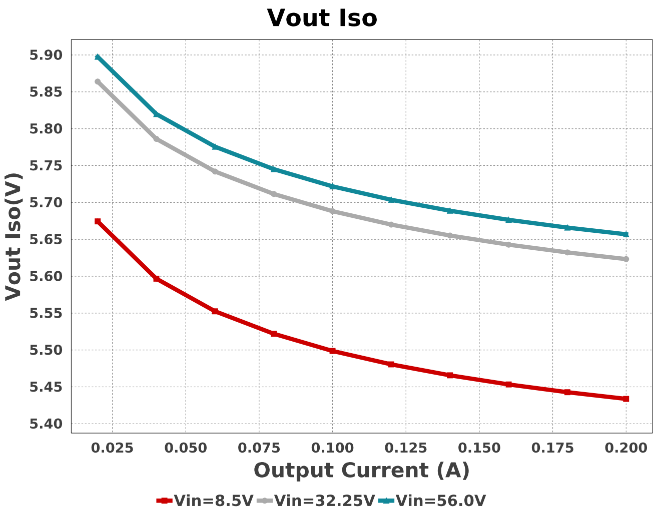

T1 Iprim RMS
T1 Iprim RMS(A)
0.350
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
Output Current (A)
Vin=8.5V
Vin=32.25V
Vin=56.0V

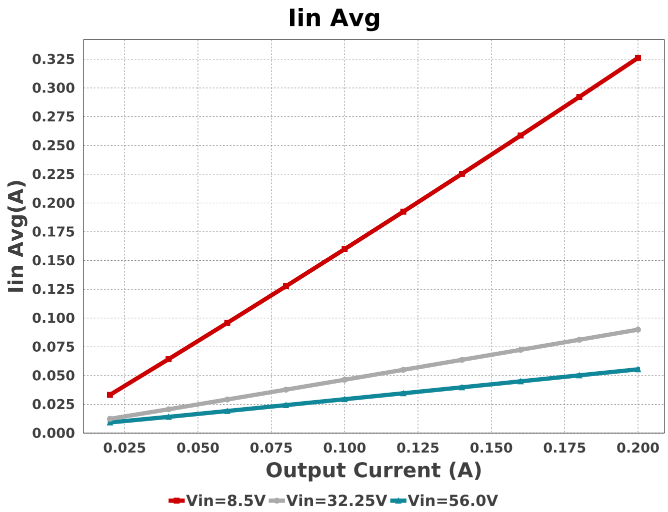

Cout2 IRMS
Cout2 IRMS(A)
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
Output Current (A)
Vin=8.5V
Vin=32.25V
Vin=56.0V

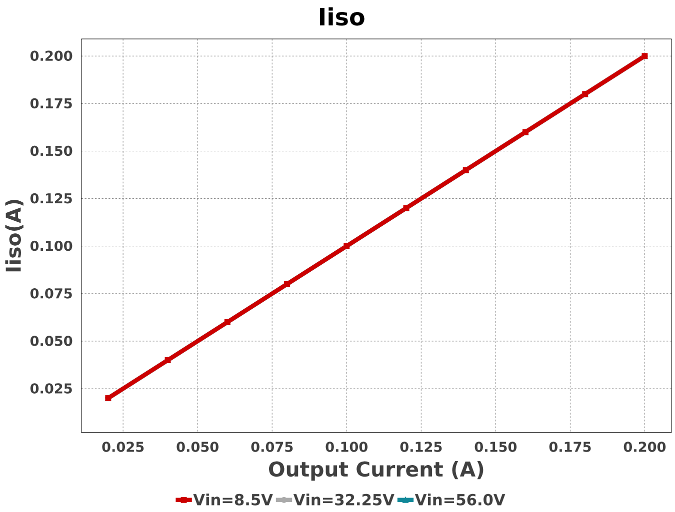

Cin Pd
Cin Pd(W)
0.00018
0.00017
0.00016
0.00015
0.00014
0.00013
0.00012
0.00011
0.00010
0.00009
0.00008
0.00007
0.00006
0.00005
0.00004
0.00003
0.00002
0.00001
0.00000
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
Output Current (A)
Vin=8.5V
Vin=32.25V
Vin=56.0V

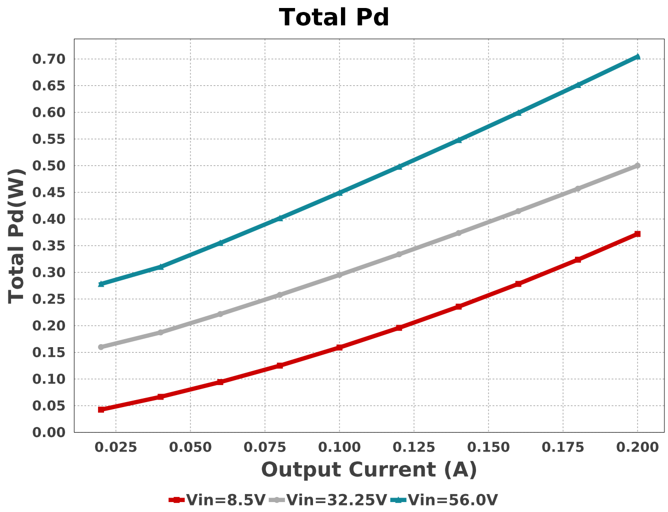

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=8.5V Vin=32.25V Vin=56.0V

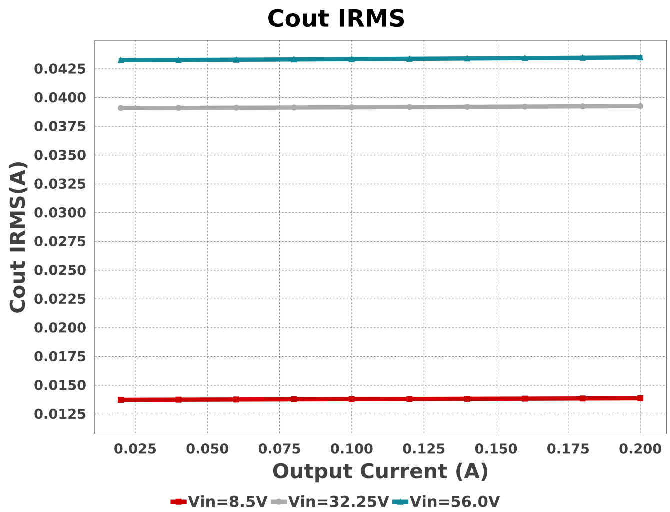

Xformer Pd
Xformer Pd(W)
Output Current (A)
Vin=8.5V Vin=32.25V Vin=56.0V

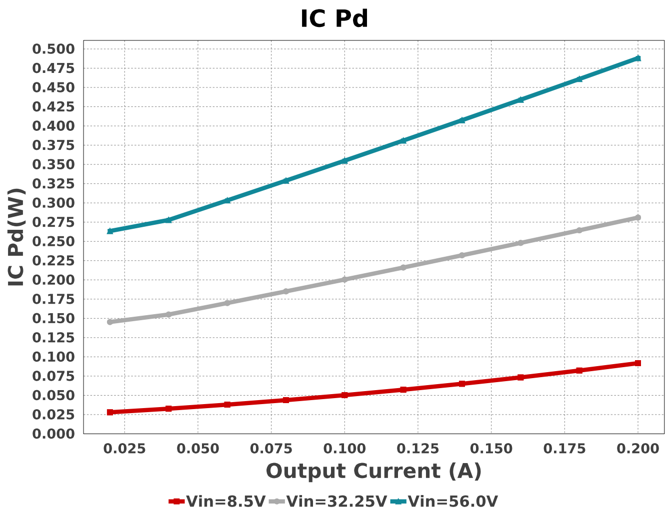

Vout Iso
Vout Iso(V)
Output Current (A)
Vin=8.5V Vin=32.25V Vin=56.0V

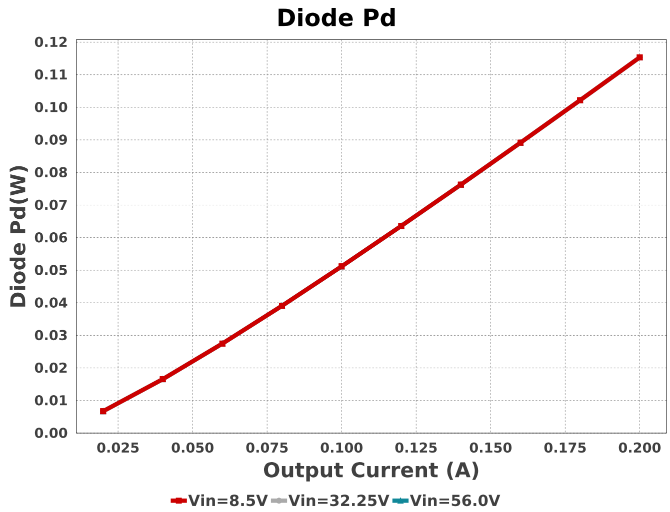

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=8.5V Vin=32.25V Vin=56.0V


Iiso
Iiso(A)
Output Current (A)
Vin=8.5V Vin=32.25V Vin=56.0V


Total Pd
Total Pd(W)
Output Current (A)
Vin=8.5V Vin=32.25V Vin=56.0V







Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	126.217 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	84.974 µW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	43.499 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	1.892 µW	Capacitor	Output capacitor power dissipation
5.	Cout2 IRMS	91.124 mA	Capacitor	Output capacitor2 RMS ripple current
6.	Cout2 Pd	25.218 µW	Capacitor	Output capacitor2 power dissipation
7.	Iiso	200.0 mA	Current	Secondary Side Output Current
8.	Ipri	200.0 mA	Current	Primary Side Output Current
9.	D1 Tj	41.307 degC	Diode	D1 junction temperature
10.	Diode Pd	128.49 mW	Diode	Diode power dissipation
11.	IC Pd	488.11 mW	IC	IC power dissipation
12.	IC Tj	46.303 degC	IC	IC junction temperature
13.	ICThetaJA	33.4 degC/W	IC	IC junction-to-ambient thermal resistance
14.	Iin Avg	55.029 mA	IC	Average input current
15.	Vout Iso	5.591 V	Op Point	Secondary Side Output Voltage
16.	Vout Pri	6.234 V	Op Point	Primary Side Output Voltage
17.	Cin Pd	84.974 µW	Power	Input capacitor power dissipation
18.	Cout Pd	1.892 µW	Power	Output capacitor power dissipation
19.	Cout2 Pd	25.218 µW	Power	Output capacitor2 power dissipation
20.	Diode Pd	128.49 mW	Power	Diode power dissipation
21.	IC Pd	488.11 mW	Power	IC power dissipation
22.	Total Pd	681.624 mW	Power	Total Power Dissipation
23.	Xformer Pd	64.909 mW	Power	Transformer power dissipation
24.	BOM Count	20	System Information	Total Design BOM count
25.	Duty Cycle	11.214 %	System Information	Duty cycle
26.	Efficiency	77.881 %	System Information	Steady state efficiency
27.	FootPrint	405.0 mm^2	System Information	Total Foot Print Area of BOM components

#	Name	Value	Category	Description
28.	Frequency	370.37 kHz	System Information	Switching frequency
29.	Total BOM	$3.47	System Information	Total BOM Cost
30.	Vin	56.0 V	System Information	Vin operating point
31.	Vout Actual	5.92 V	System Information	Vout Actual calculated based on selected voltage divider resistors
32.	Vout Tolerance	2.604 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
33.	Vout p-p	3.83 mV	System Information	Peak-to-peak output ripple voltage
34.	T1 Iprim RMS	202.99 mA	Transformer	Transformer Primary RMS Current
35.	T1 Iprim pk	475.343 mA	Transformer	Transformer Primary Peak Current
36.	T1 Is1 RMS	245.091 mA	Transformer	Transformer Secondary1 RMS Current
37.	Xformer Pd	64.909 mW	Transformer	Transformer power dissipation

Design Inputs

Name	Value	Description
Iout	200.0 m	Maximum Output Current
Iout1	200.0 m	Output Current #1
Iout2	200.0 m	Output Current #2
VinMax	56.0	Maximum input voltage
VinMin	8.5	Minimum input voltage
Vout	6.0	Output Voltage
Vout1	6.0	Output Voltage #1
Vout2	6.0	Output Voltage #2
base_pn	LM5160A	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

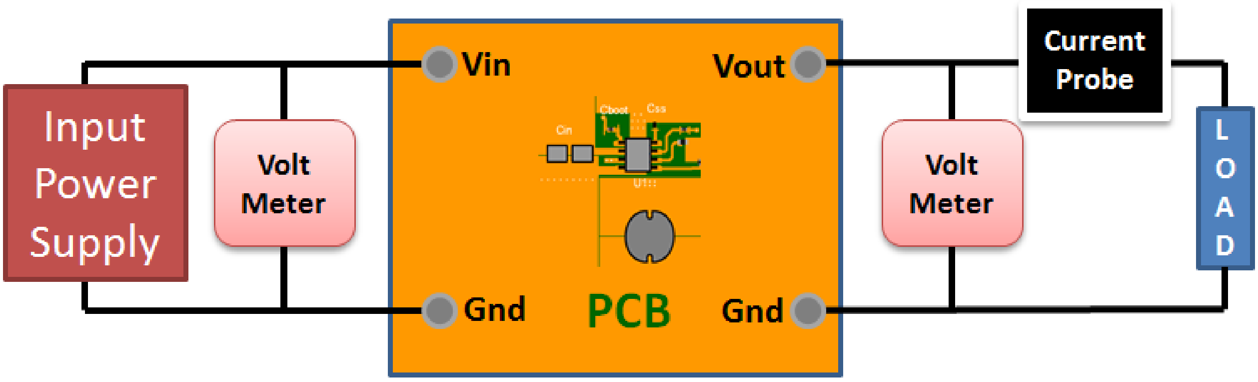
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 8.5V 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. For a Constant On Time device to be stable, we need to provide a ripple at the feedback comparator. There are various methods to implement the ripple. Depending on the circuit complexity vs. the allowable ripple, we have three options to choose from. The simplest option, 'Low Complexity', would require only a high ESR cap at the output. This means that the BOM count will be small, but the output voltage ripple will be quite large. The 'Optimal Solution' would require a feed-forward cap in parallel with the upper feedback resistor to AC couple the ripple to the feedback node. This increases the BOM count slightly, but now we have more control over the output voltage ripple. If the output voltage requirement is very tight, then the best option is to go for the 'Low Output Ripple' solution. In this option we can go with very low ESR output caps and have very good control over the output voltage ripple.

2. Master key : E03FC439211E3F9A5803B0C08B508BCF[v1]

3. **LM5160A** Product Folder : http://www.ti.com/product/LM5160A : contains the data sheet and other resources.