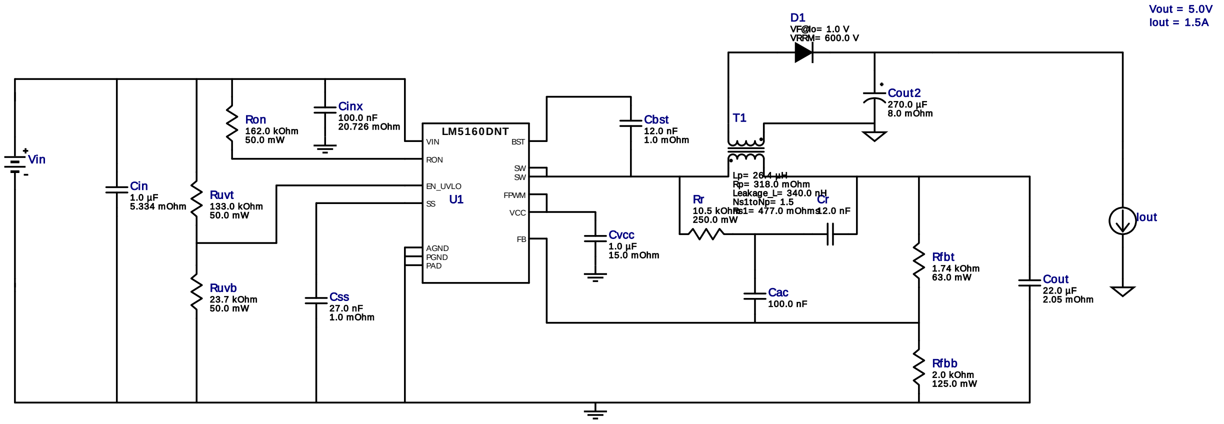
Texas Instruments

WEBENCH ® Design Report

VinMin = 8.5V
VinMax = 65.0V
Vout = 5.0V
Iout = 1.5A

Device = LM5160DNTR
Topology = Flybuck
Created = 2018-07-30 03:57:35.701
BOM Cost = NA
BOM Count = 18
Total Pd = 5.85W

Design : 147 LM5160DNTR
LM5160DNTR 8.5V-65.0V to 5.00V @ 2.2500000420750004A



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	$0.10	0805 7 mm²
Cbst	MuRata	GRM155R71C123KA01D Series= X7R	Cap= 12.0 nF ESR= 1.0 mOhm VDC= 16.0 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	$0.25	1206_190 11 mm²
Cinx	TDK	CGA4J2X7R2A104K125AA Series= X7R	Cap= 100.0 nF ESR= 20.726 mOhm VDC= 100.0 V IRMS= 1.456 A	1	$0.04	0805 7 mm²
Cout	TDK	C2012X6S1C226M125AC Series= X6S	Cap= 22.0 uF ESR= 2.05 mOhm VDC= 16.0 V IRMS= 4.5559 A	1	$0.22	0805 7 mm²
Cout2	Panasonic	16SVPG270M Series= SVPG	Cap= 270.0 uF ESR= 8.0 mOhm VDC= 16.0 V IRMS= 5.8 A	1	$0.70	CAPSMT_62_C10 74 mm²
Cr	AVX	Series= C0G/NP0	Cap= 12.0 nF VDC= 50.0 V IRMS= 0.0 A	1	NA	1206 11 mm²
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 mm²
Cvcc	Kemet	C0805C105K4RACTU Series= X7R	Cap= 1.0 uF ESR= 15.0 mOhm VDC= 16.0 V IRMS= 8.19 A	1	$0.02	0805 7 mm²

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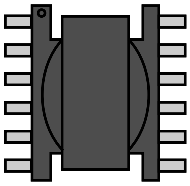
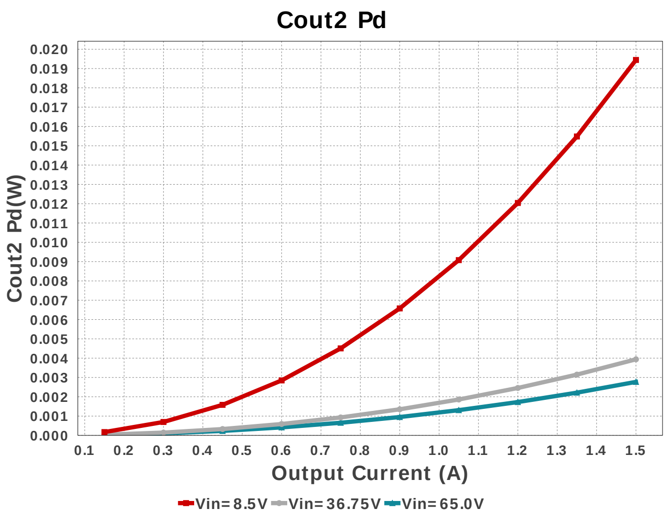
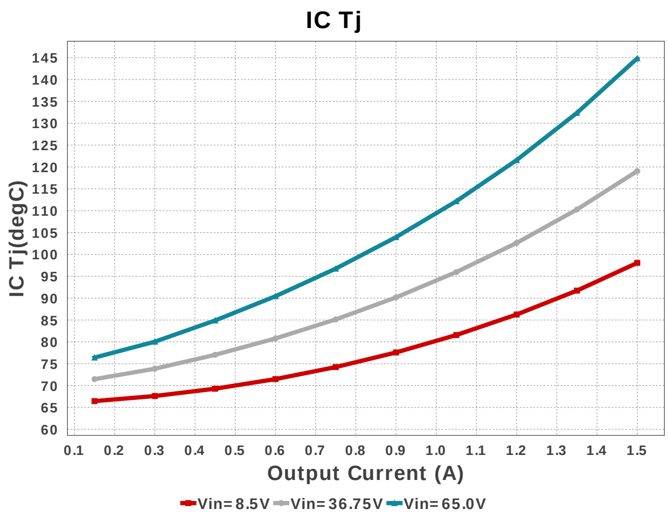
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
D1	Bourns	CD214B-R3600	VF@Io= 1.0 V VRRM= 600.0 V	1	$0.11	SMB 44 mm^2
Rfbb	Panasonic	ERJ-6ENF2001V Series= ERJ-6E	Res= 2.0 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Rfbt	Vishay-Dale	CRCW04021K74FKED Series= CRCW..e3	Res= 1.74 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	Panasonic	ERJ-8ENF1052V Series= ERJ-8E	Res= 10.5 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 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	Wurth Elektronik	749196241	Lp= 26.4 µH Rp= 318.0 mOhm Leakage_L= 340.0 nH Ns1toNp= 1.5 Rs1= 477.0 mOhms	1	NA	 ER14.5-6 344 mm^2
U1	Texas Instruments	LM5160DNTR	Switcher	1	$1.80	DNT0012B 25 mm^2





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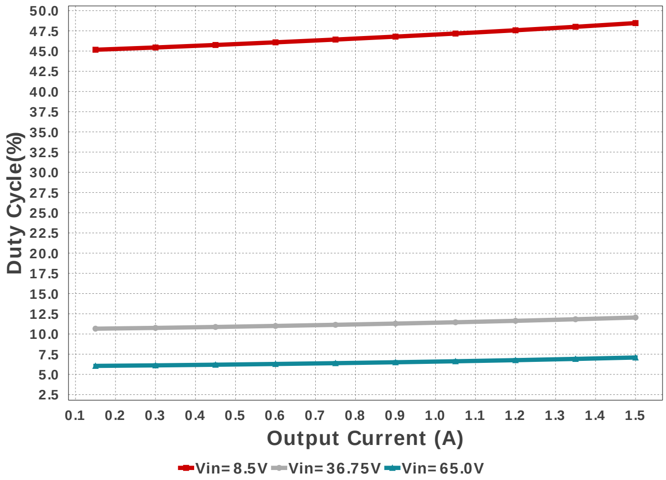
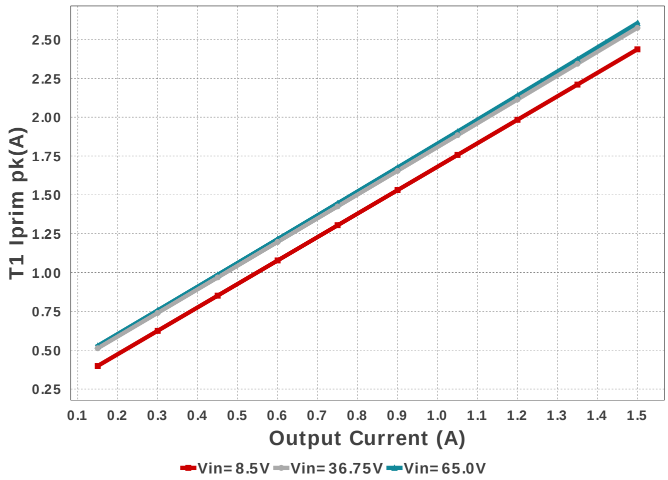
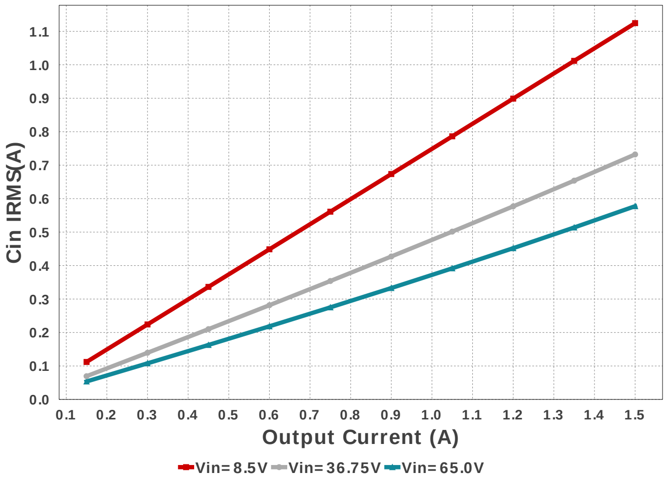
Duty Cycle



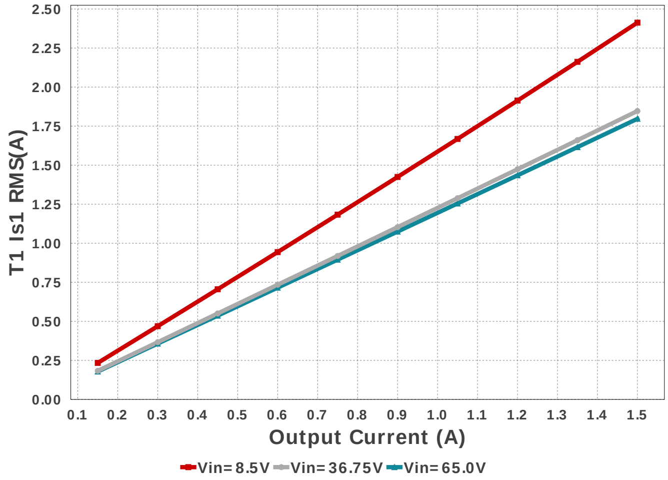
T1 Iprim pk



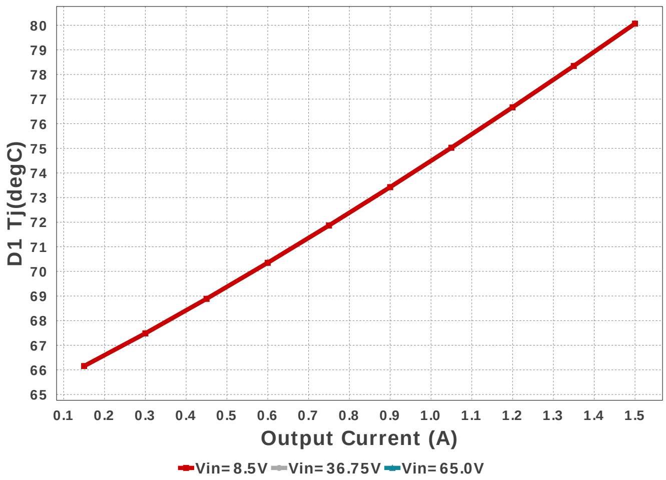
Cin IRMS



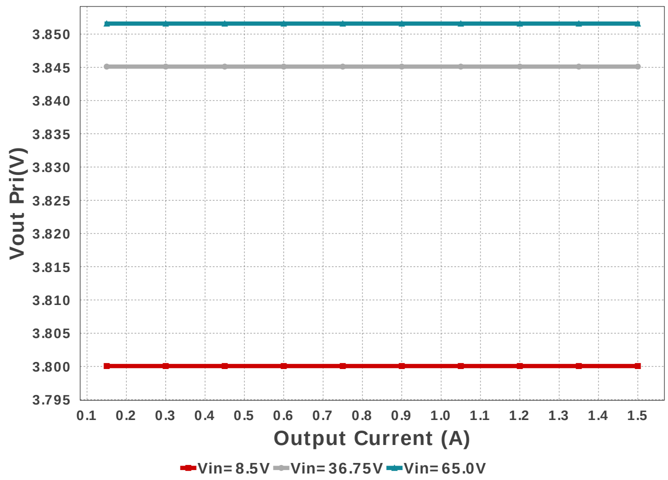
T1 Is1 RMS



D1 Tj



Vout Pri



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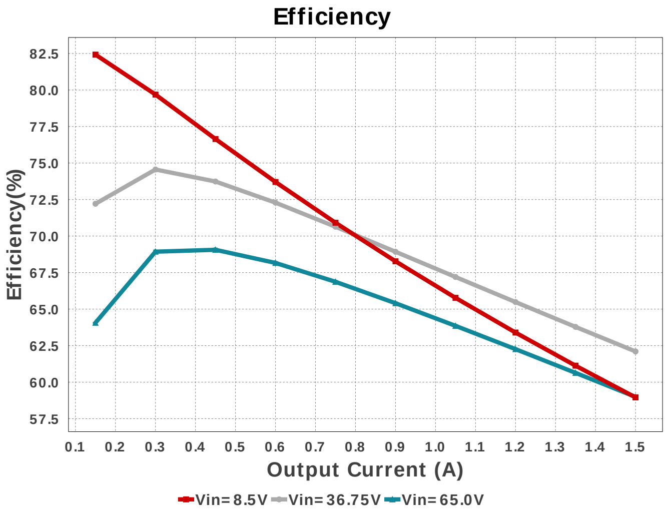

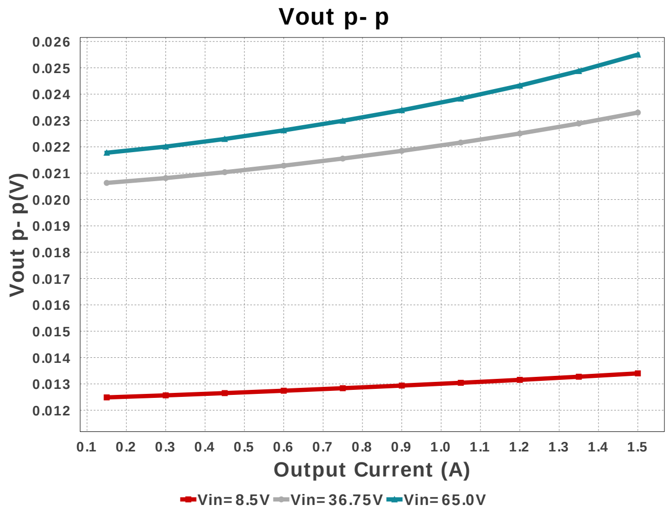

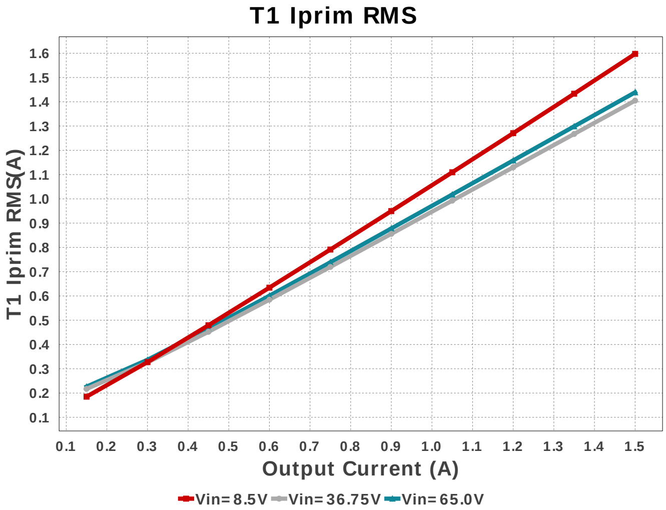

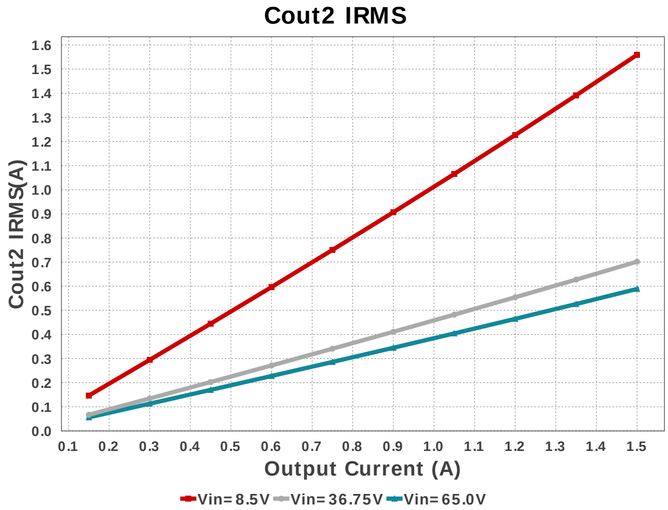

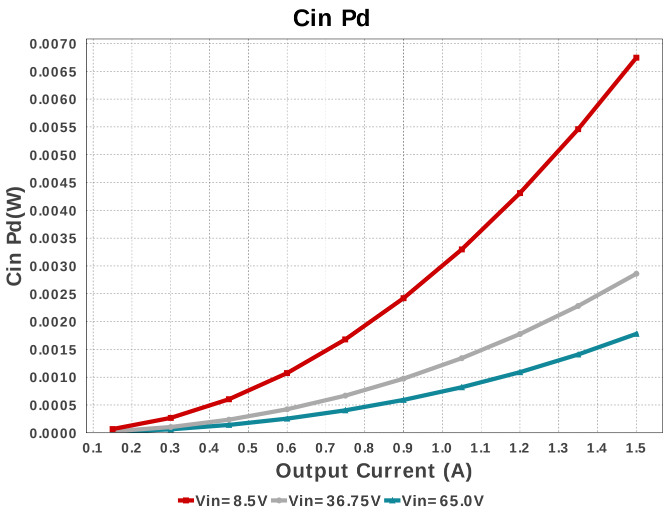

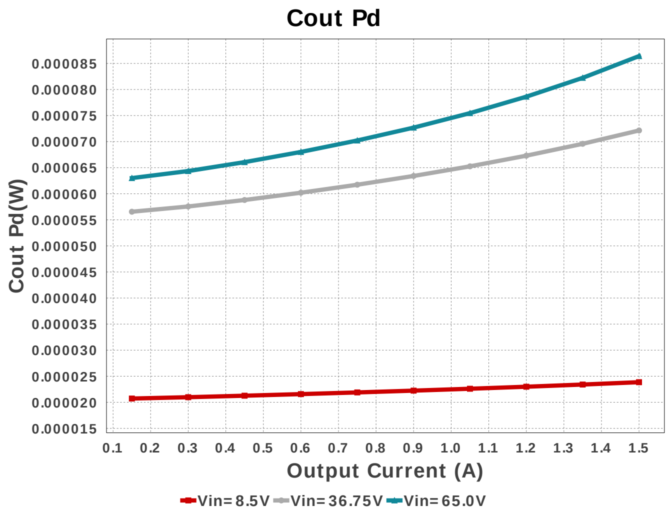

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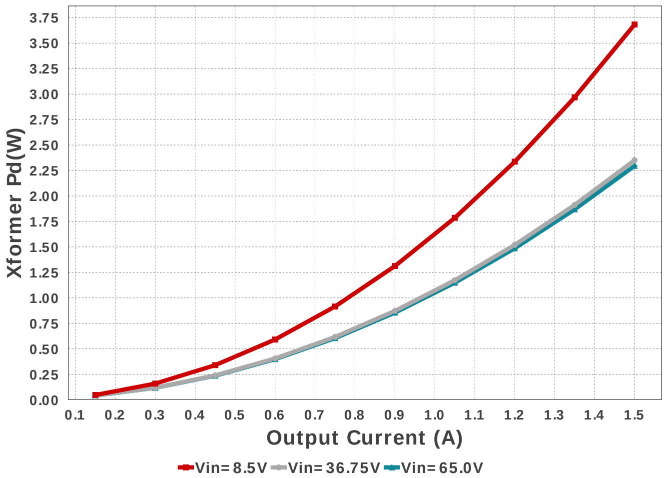
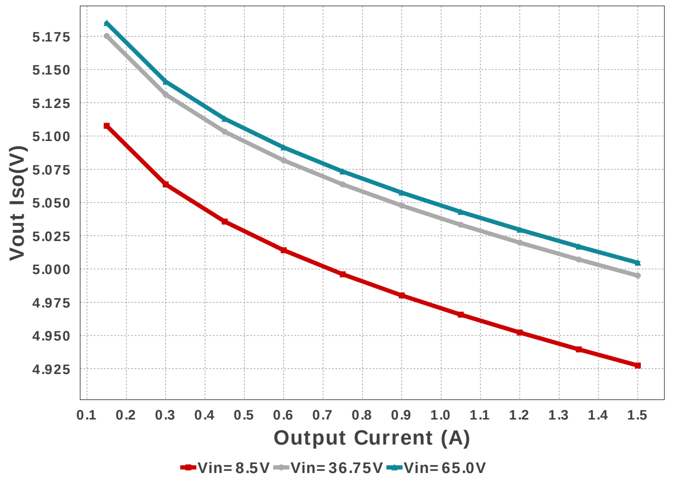
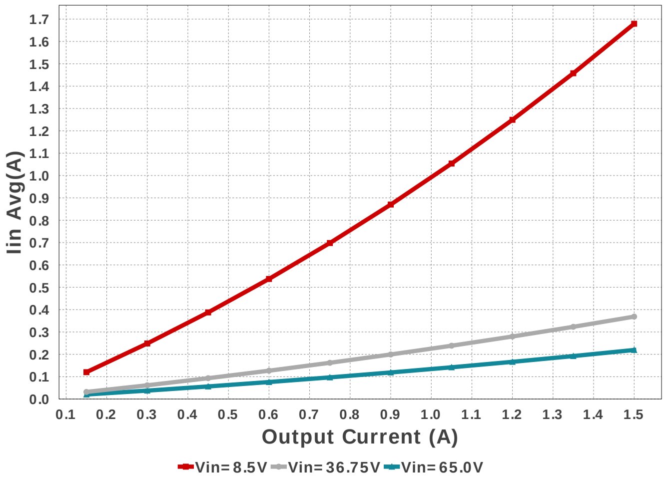
Xformer Pd



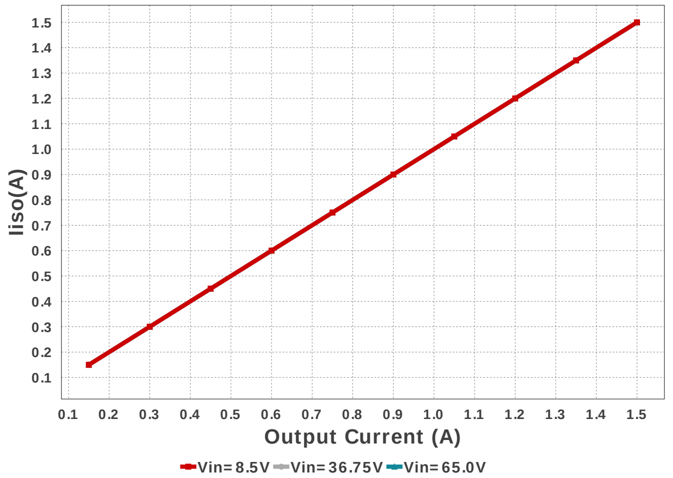
Vout Iso



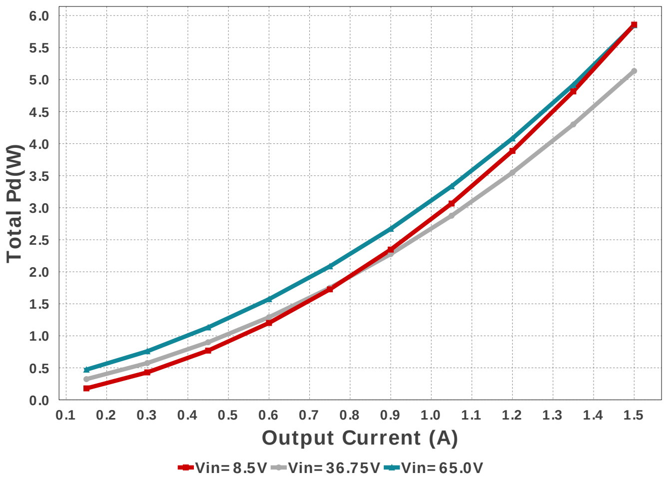
Iin Avg



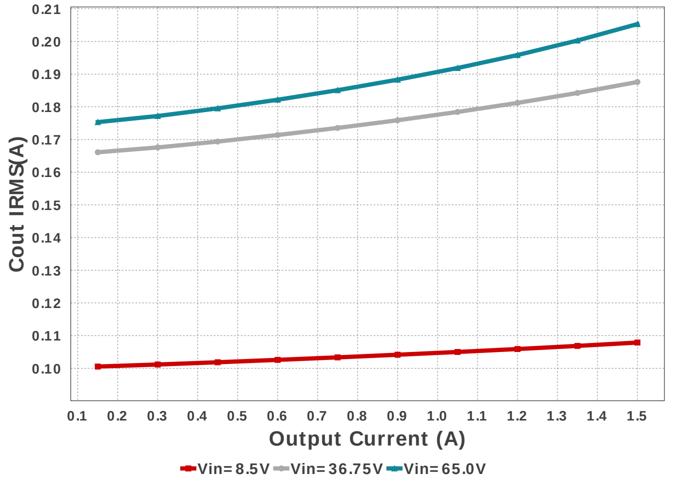
Iiso



Total Pd



Cout IRMS



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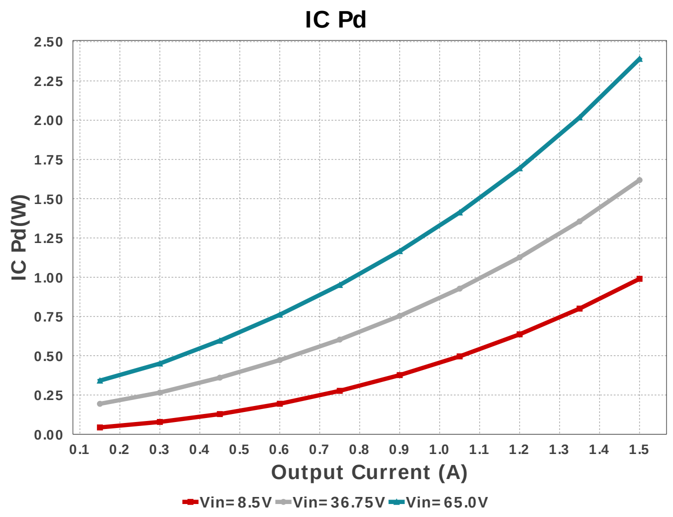

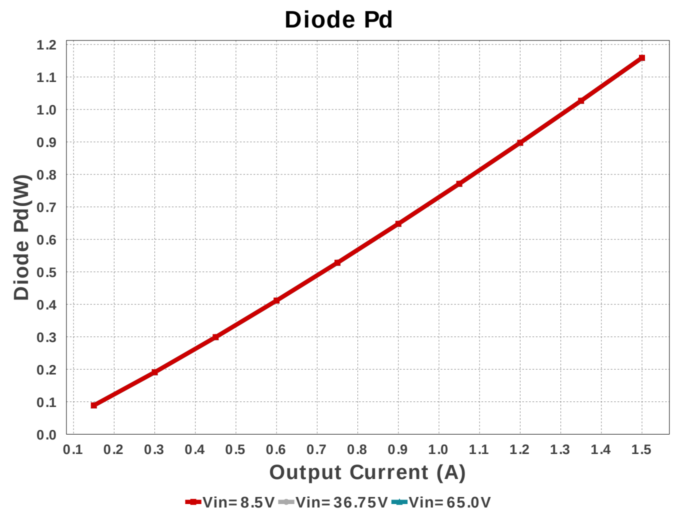

Operating Values

#	Name	Value	Category	Description
1.	BOM Count	18		Total Design BOM count
2.	Total BOM	NA		Total BOM Cost
3.	Cin IRMS	577.43 mA	Current	Input capacitor RMS ripple current
4.	Cout IRMS	205.305 mA	Current	Output capacitor RMS ripple current
5.	Cout2 IRMS	588.585 mA	Current	Output capacitor2 RMS ripple current
6.	Iin Avg	219.45 mA	Current	Average input current
7.	Iiso	1.5 A	Current	Secondary Side Output Current
8.	T1 Iprim RMS	1.439 A	Current	Transformer Primary RMS Current
9.	T1 Iprim pk	2.606 A	Current	Transformer Primary Peak Current
10.	T1 Is1 RMS	1.797 A	Current	Transformer Secondary1 RMS Current
11.	FootPrint	569.0 mm^2	General	Total Foot Print Area of BOM components
12.	Frequency	230.864 kHz	General	Switching frequency
13.	D1 Tj	80.067 degC	Op Point	D1 junction temperature
14.	Duty Cycle	7.089 %	Op Point	Duty cycle
15.	Efficiency	58.993 %	Op Point	Steady state efficiency
16.	IC Tj	144.843 degC	Op Point	IC junction temperature
17.	ICThetaJA	33.4 degC/W	Op Point	IC junction-to-ambient thermal resistance
18.	VIN_OP	65.0 V	Op Point	Vin operating point
19.	Vout Actual	3.74 V	Op Point	Vout Actual calculated based on selected voltage divider resistors
20.	Vout Iso	5.005 V	Op Point	Secondary Side Output Voltage
21.	Vout Pri	3.852 V	Op Point	Primary Side Output Voltage
22.	Vout Tolerance	2.202 %	Op Point	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
23.	Vout p-p	25.501 mV	Op Point	Peak-to-peak output ripple voltage
24.	Cin Pd	1.778 mW	Power	Input capacitor power dissipation
25.	Cout Pd	86.408 µW	Power	Output capacitor power dissipation
26.	Cout2 Pd	2.771 mW	Power	Output capacitor2 power dissipation
27.	Diode Pd	1.159 W	Power	Diode power dissipation
28.	IC Pd	2.391 W	Power	IC power dissipation
29.	Total Pd	5.849 W	Power	Total Power Dissipation
30.	Xformer Pd	2.295 W	Power	Transformer power dissipation

Design Inputs

Name	Value	Description
Iout	1.5	Maximum Output Current
VinMax	65.0	Maximum input voltage
VinMin	8.5	Minimum input voltage
Vout	5.0	Output Voltage
base_pn	LM5160	Base Product Number
source	DC	Input Source Type
Ta	65.0	Ambient temperature

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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

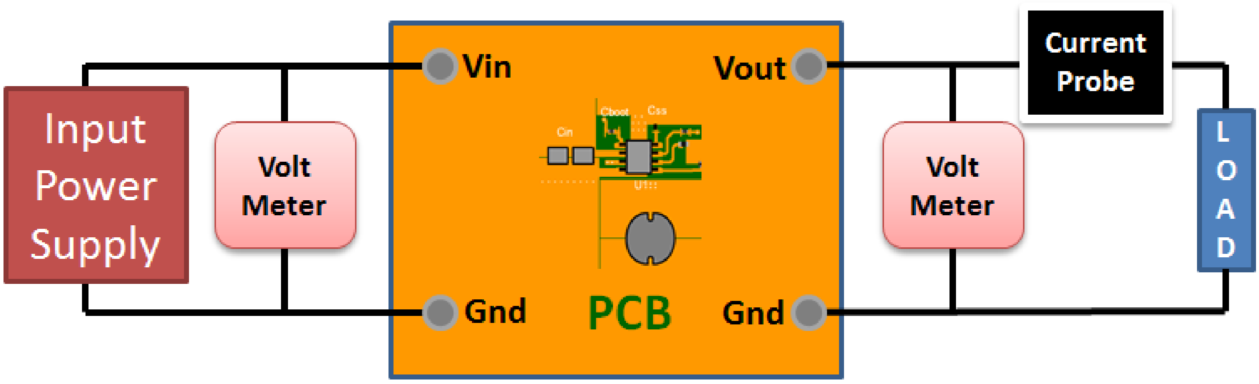
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 : E3D58C8BFBF48FAC[v1]

3. **LM5160** Product Folder : http://www.ti.com/product/LM5160 : contains the data sheet and other resources.

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