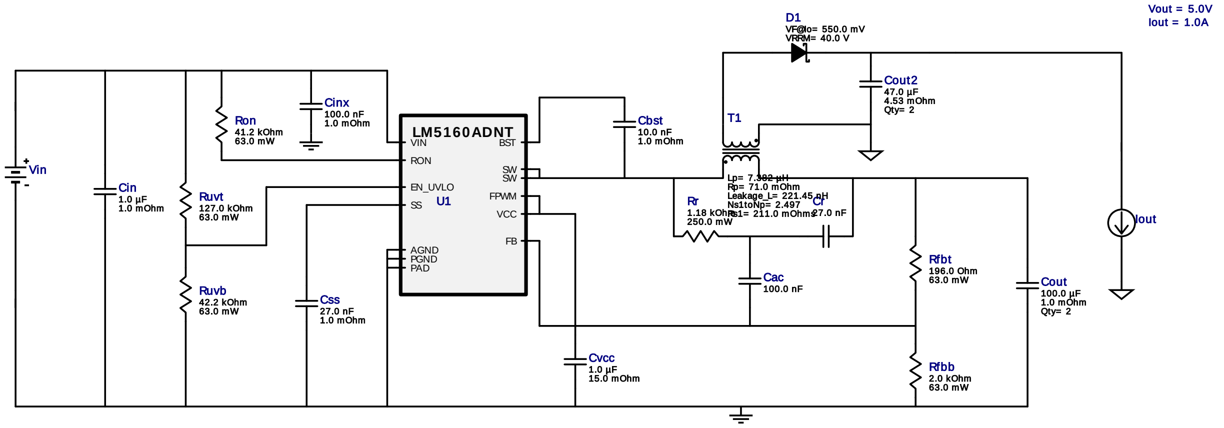
TEXAS INSTRUMENTS

WEBENCH® Design Report

VinMin = 5.0V
VinMax = 7.0V
Vout = 5.0V
Iout = 1.0A

Device = LM5160ADNTR
Topology = Flybuck
Created = 2020-06-29 03:12:26.677
BOM Cost = NA
BOM Count = 20
Total Pd = 2.22W

Design : 4 LM5160ADNTR
LM5160ADNTR 5V-7V to 5.00V @ 2.4975A

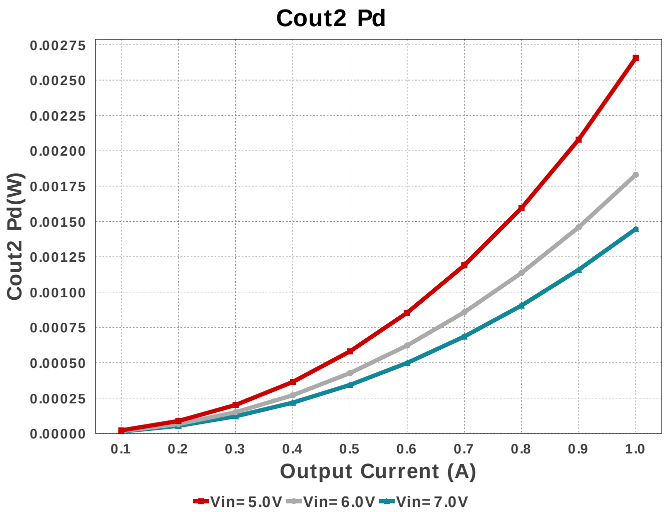


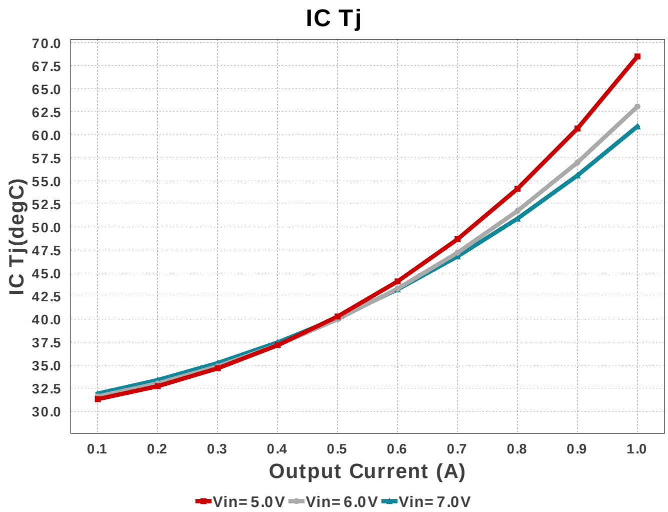
1. Feedback Resistors may need to be further adjusted to get more precise regulation as ripple injection circuit will introduce some amount of DC offset. Use simulation to help adjust.

Electrical BOM

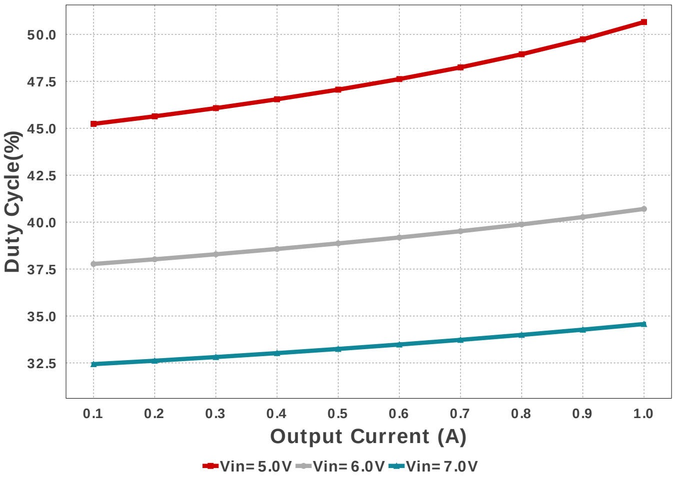
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cac	AVX	08053C104JAZ2A Series= X7R	Cap= 100.0 nF VDC= 25.0 V IRMS= 0.0 A	1	$0.06	0805 7 mm²
Cbst	MuRata	GRM155R71H103KA88D Series= X7R	Cap= 10.0 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cin	Kemet	C0603C105K8PACTU Series= X5R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Cinx	MuRata	GRM155R71C104KA88D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cout	MuRata	GRM32ER60J107ME20L Series= X5R	Cap= 100.0 uF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 6.0 A	2	$0.52	1210_270 15 mm²
Cout2	TDK	C4532X5R1A476M280KA Series= X5R	Cap= 47.0 uF ESR= 4.53 mOhm VDC= 10.0 V IRMS= 3.6038 A	2	$0.47	1812_320 23 mm²
Cr	Kemet	C1812C273J5GACTU Series= C0G/NP0	Cap= 27.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.71	1812 23 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

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
D1	Fairchild Semiconductor	SS24FL	VF@Io= 550.0 mV VRRM= 40.0 V	1	$0.05	SOD-123F 12 mm²
Rfbb	Vishay-Dale	CRCW04022K00FKED Series= CRCW..e3	Res= 2.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbt	Vishay-Dale	CRCW0402196RFKED Series= CRCW..e3	Res= 196.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Ron	Vishay-Dale	CRCW040241K2FKED Series= CRCW..e3	Res= 41.2 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rr	Vishay-Dale	CRCW12061K18FKEA Series= CRCW..e3	Res= 1.18 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm²
Ruvb	Vishay-Dale	CRCW040242K2FKED Series= CRCW..e3	Res= 42.2 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Ruvt	Vishay-Dale	CRCW0402127KFKED Series= CRCW..e3	Res= 127.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
T1	CUSTOM	CUSTOM	Lp= 7.382 µH Rp= 71.0 mOhm Leakage_L= 221.45 nH Ns1toNp= 2.497 Rs1= 211.0 mOhms	1	NA	CUSTOM 0 mm²
U1	Texas Instruments	LM5160ADNTR	Switcher	1	$1.58	DNT0012B 25 mm²

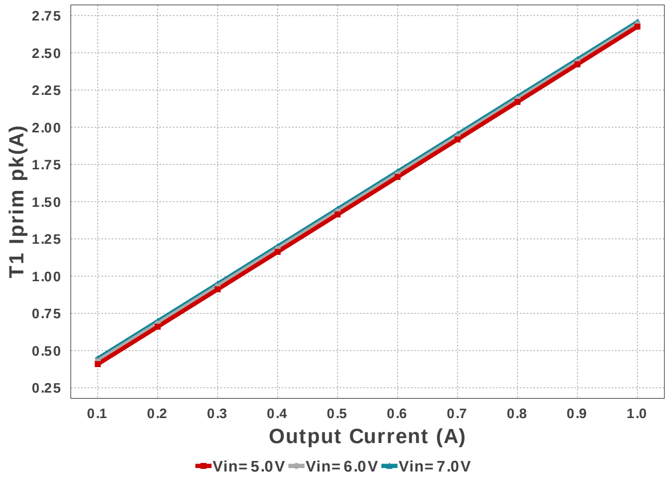




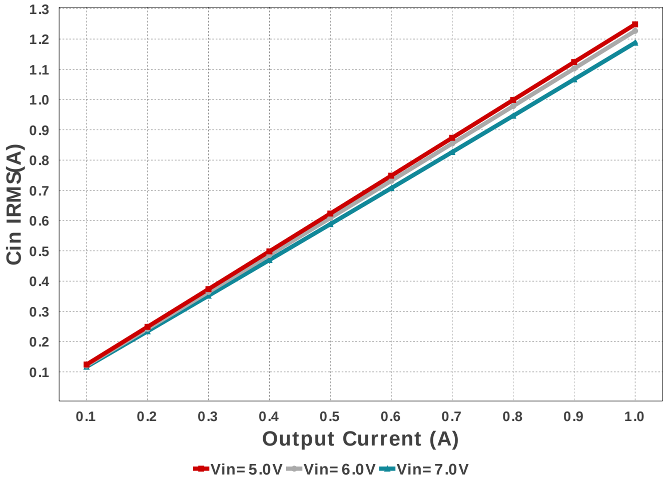
Duty Cycle



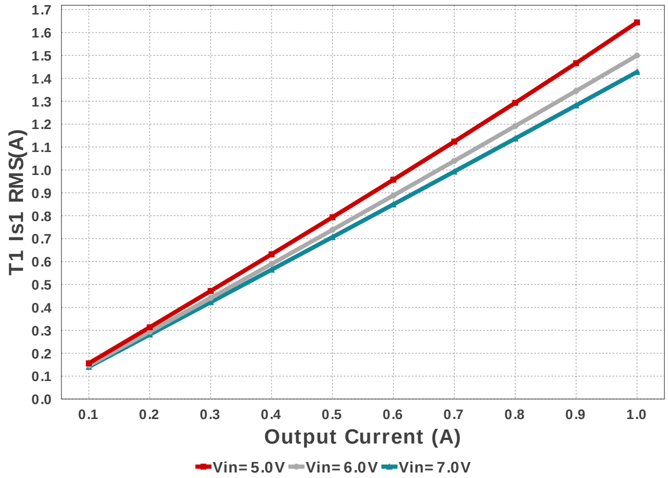
T1 Iprim pk



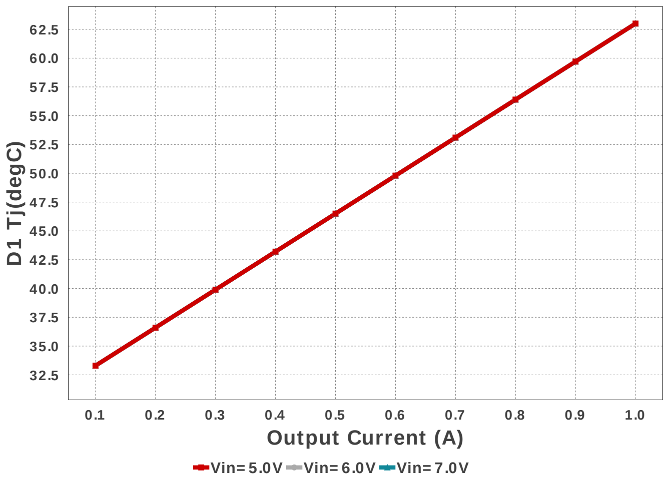
Cin IRMS



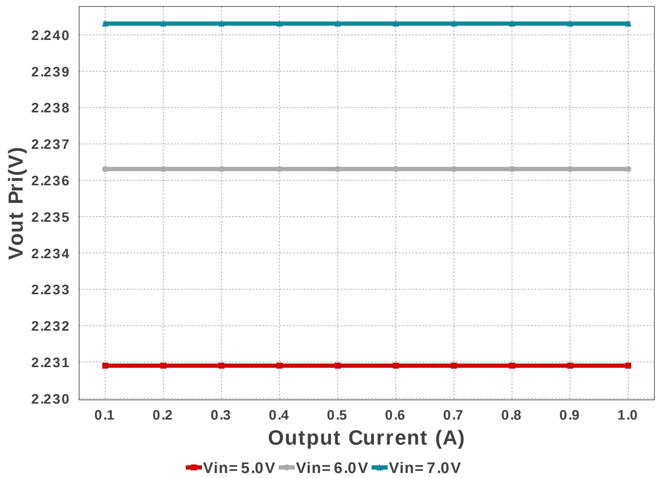
T1 Is1 RMS

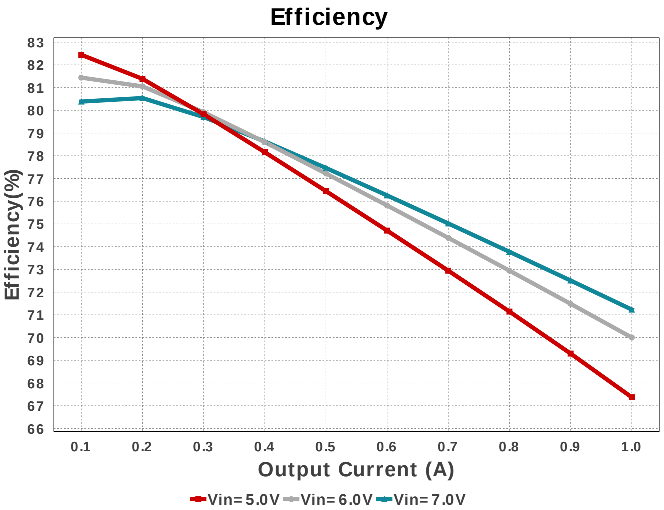


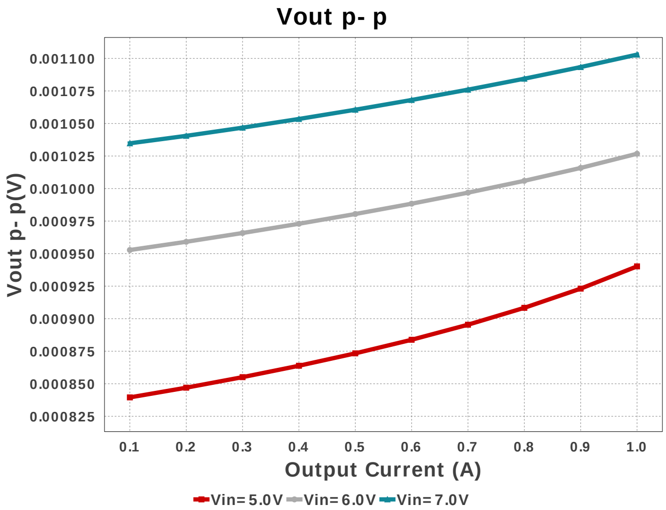
D1 Tj

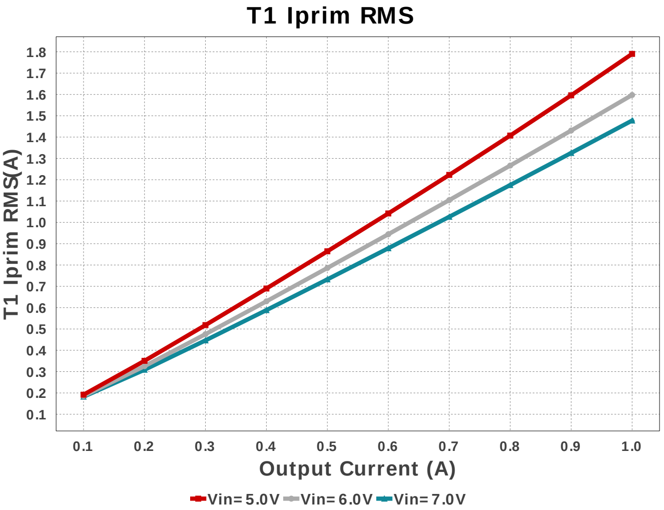


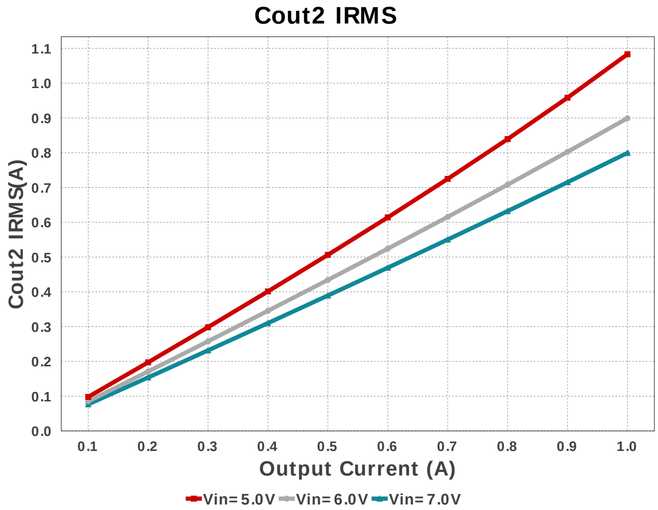
Vout Pri

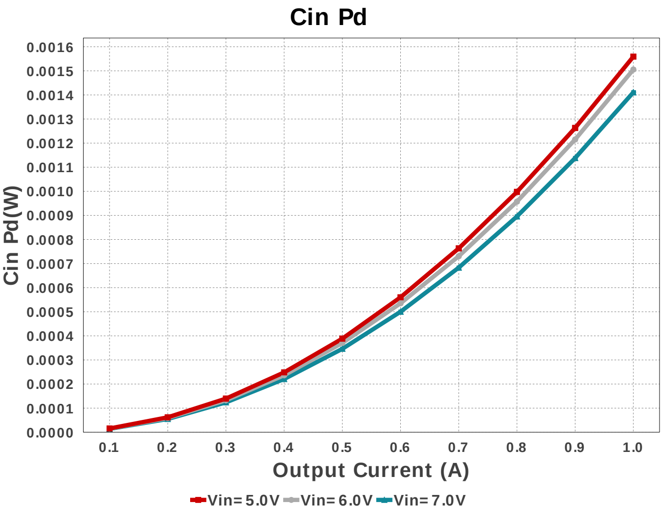


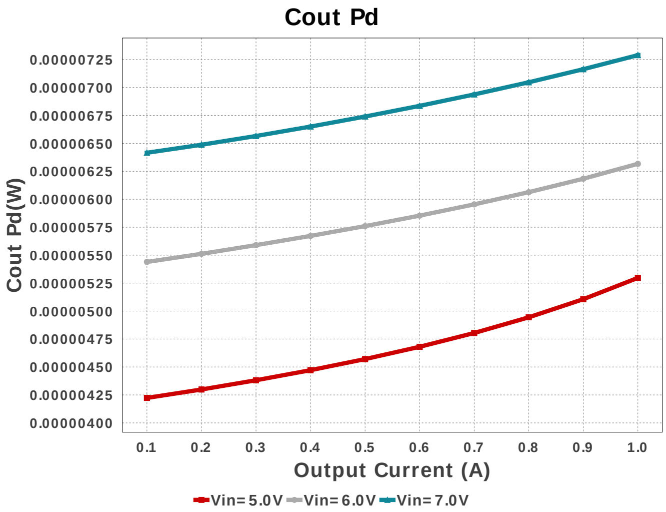

Efficiency
Efficiency(%)
Output Current (A)
Vin=5.0V Vin=6.0V Vin=7.0V

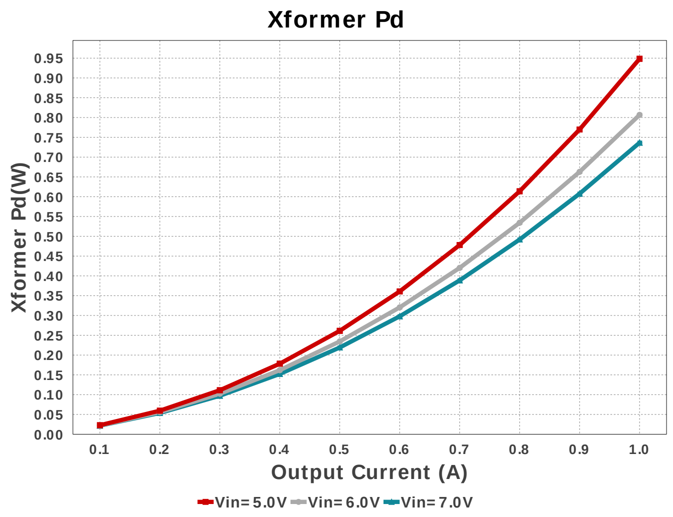

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=5.0V Vin=6.0V Vin=7.0V

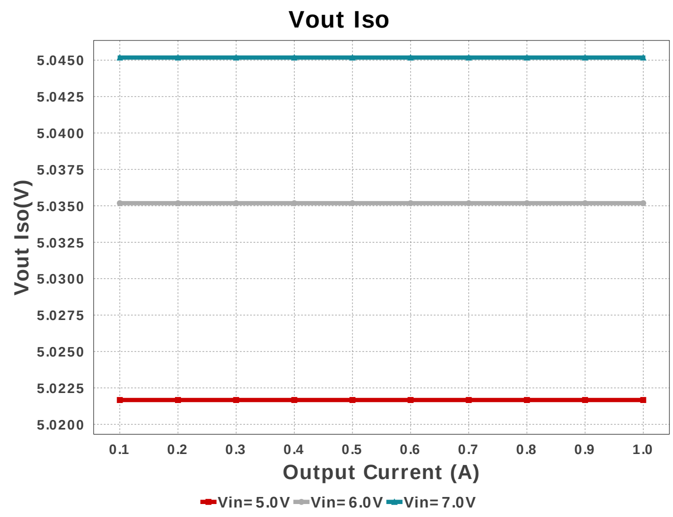

T1 Iprim RMS
T1 Iprim RMS(A)
Output Current (A)
Vin=5.0V Vin=6.0V Vin=7.0V

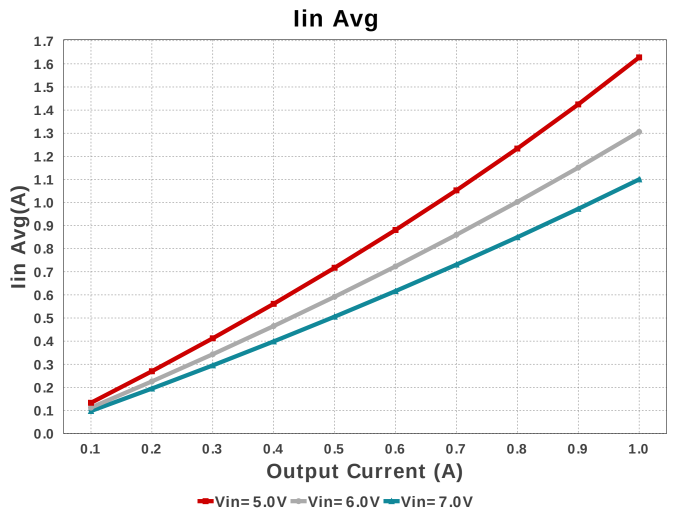

Cout2 IRMS
Cout2 IRMS(A)
Output Current (A)
Vin=5.0V Vin=6.0V Vin=7.0V

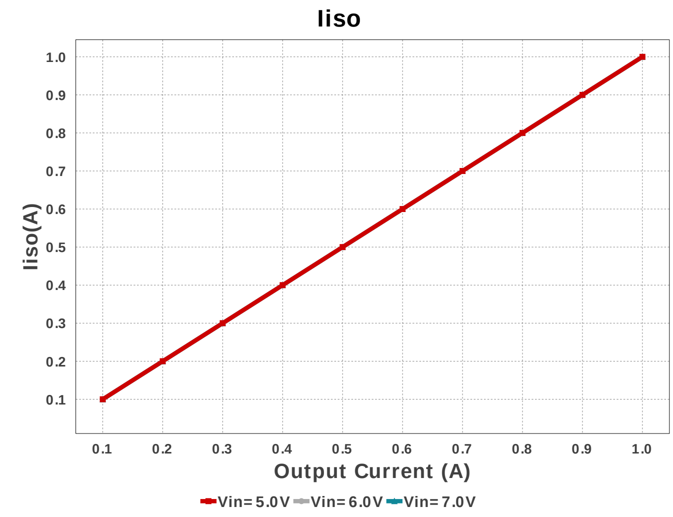

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=5.0V Vin=6.0V Vin=7.0V

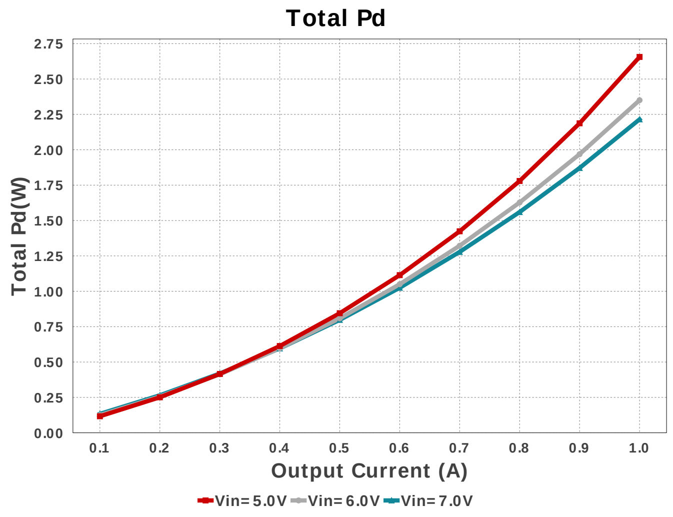

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=5.0V Vin=6.0V Vin=7.0V

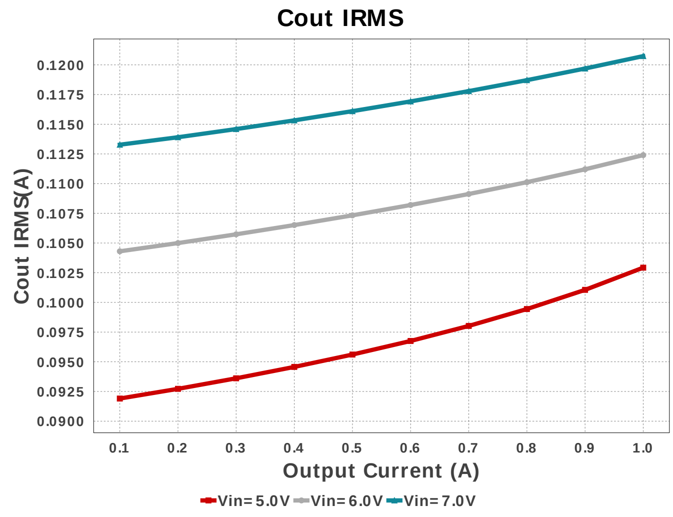

Xformer Pd
Xformer Pd(W)
Output Current (A)
Vin=5.0V Vin=6.0V Vin=7.0V

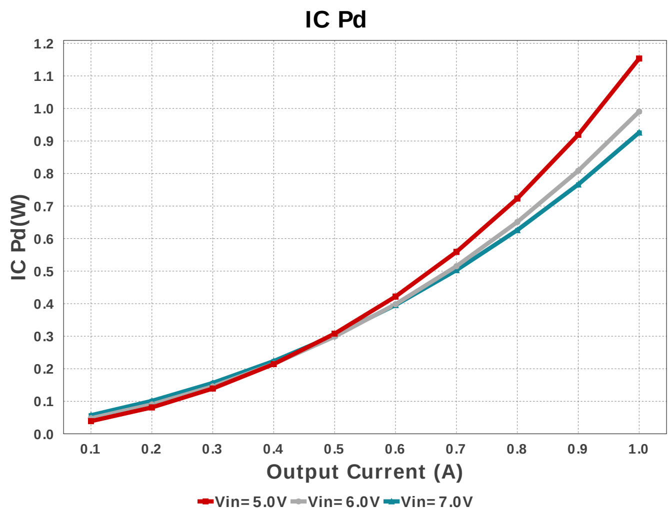

Vout Iso
Vout Iso(V)
Output Current (A)
Vin=5.0V Vin=6.0V Vin=7.0V

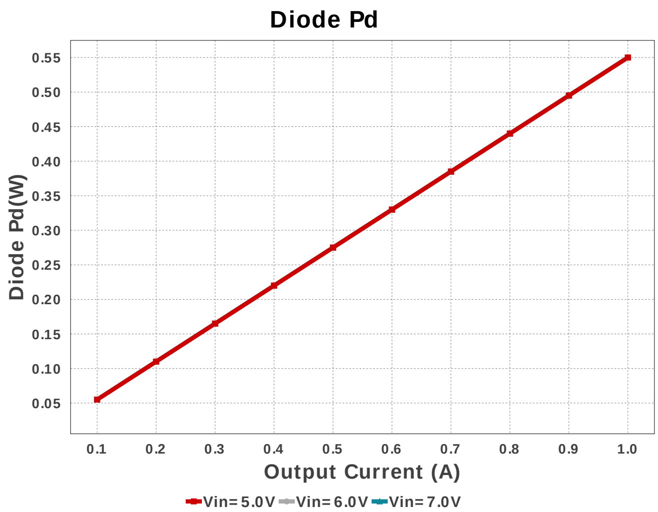

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=5.0V Vin=6.0V Vin=7.0V


Iiso
Iiso(A)
Output Current (A)
Vin=5.0V Vin=6.0V Vin=7.0V


Total Pd
Total Pd(W)
Output Current (A)
Vin=5.0V Vin=6.0V Vin=7.0V


Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=5.0V Vin=6.0V Vin=7.0V





Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	1.188 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	1.411 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	119.309 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	7.117 µW	Capacitor	Output capacitor power dissipation
5.	Cout2 IRMS	799.193 mA	Capacitor	Output capacitor2 RMS ripple current
6.	Cout2 Pd	1.447 mW	Capacitor	Output capacitor2 power dissipation
7.	Iiso	1.0 A	Current	Secondary Side Output Current
8.	D1 Tj	63.0 degC	Diode	D1 junction temperature
9.	Diode Pd	550.0 mW	Diode	Diode power dissipation
10.	IC Pd	929.45 mW	IC	IC power dissipation
11.	IC Tj	61.044 degC	IC	IC junction temperature
12.	ICThetaJA	33.4 degC/W	IC	IC junction-to-ambient thermal resistance
13.	Iin Avg	1.1 A	IC	Average input current
14.	Vout Iso	5.045 V	Op Point	Secondary Side Output Voltage
15.	Vout Pri	2.24 V	Op Point	Primary Side Output Voltage
16.	Cin Pd	1.411 mW	Power	Input capacitor power dissipation
17.	Cout Pd	7.117 µW	Power	Output capacitor power dissipation
18.	Cout2 Pd	1.447 mW	Power	Output capacitor2 power dissipation
19.	Diode Pd	550.0 mW	Power	Diode power dissipation
20.	IC Pd	929.45 mW	Power	IC power dissipation
21.	Total Pd	2.219 W	Power	Total Power Dissipation
22.	Xformer Pd	736.33 mW	Power	Transformer power dissipation
23.	BOM Count	20	System Information	Total Design BOM count
24.	Duty Cycle	34.572 %	System Information	Duty cycle
25.	Efficiency	71.198 %	System Information	Steady state efficiency
26.	FootPrint	194.0 mm^2	System Information	Total Foot Print Area of BOM components
27.	Frequency	539.374 kHz	System Information	Switching frequency
28.	Total BOM	NA	System Information	Total BOM Cost
29.	Vin	7.0 V	System Information	Vin operating point
30.	Vout Actual	2.196 V	System Information	Vout Actual calculated based on selected voltage divider resistors
31.	Vout Tolerance	1.433 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
32.	Vout p-p	1.077 mV	System Information	Peak-to-peak output ripple voltage
33.	T1 Iprim RMS	1.477 A	Transformer	Transformer Primary RMS Current
34.	T1 Iprim pk	2.704 A	Transformer	Transformer Primary Peak Current
35.	T1 Is1 RMS	1.428 A	Transformer	Transformer Secondary1 RMS Current
36.	Xformer Pd	736.33 mW	Transformer	Transformer power dissipation

Design Inputs

Name	Value	Description
Iout	1.0	Maximum Output Current
VinMax	7.0	Maximum input voltage

Name	Value	Description
VinMin	5.0	Minimum input voltage
VinTyp	6.0	Typical input voltage
Vout	5.0	Output Voltage
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

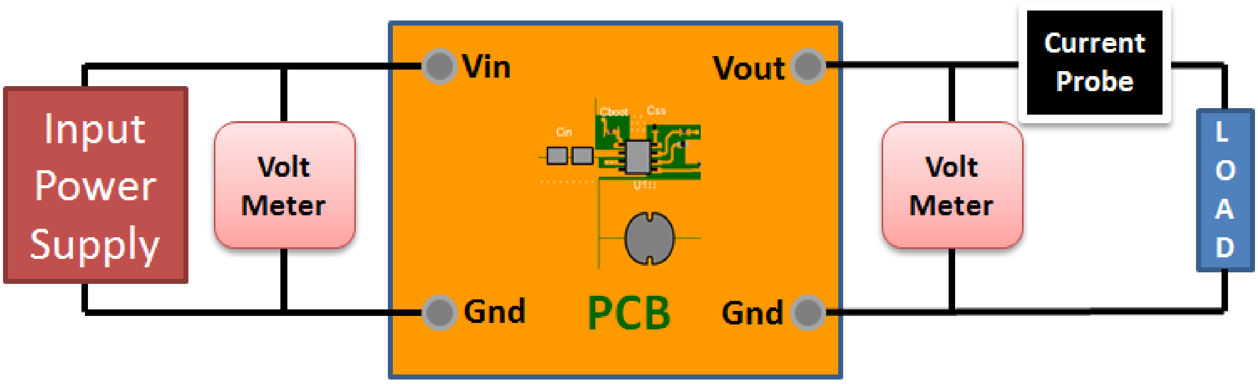
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 5.0V 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. 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 : F013646B43206BA9[v1]

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

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