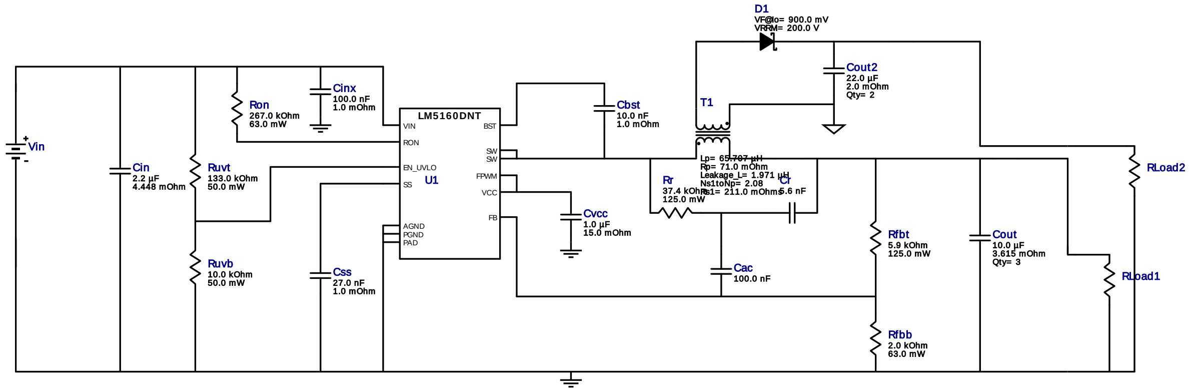
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 18.0V
VinMax = 32.0V
Vout = 8.0V
Iout = 0.4A

Device = LM5160DNTR
Topology = Flybuck
Created = 2020-12-31 10:51:00.172
BOM Cost = NA
BOM Count = 21
Total Pd = 1.12W

Design : 840 LM5160DNTR
LM5160DNTR 18V-32V to 8.00V @ 1.2A

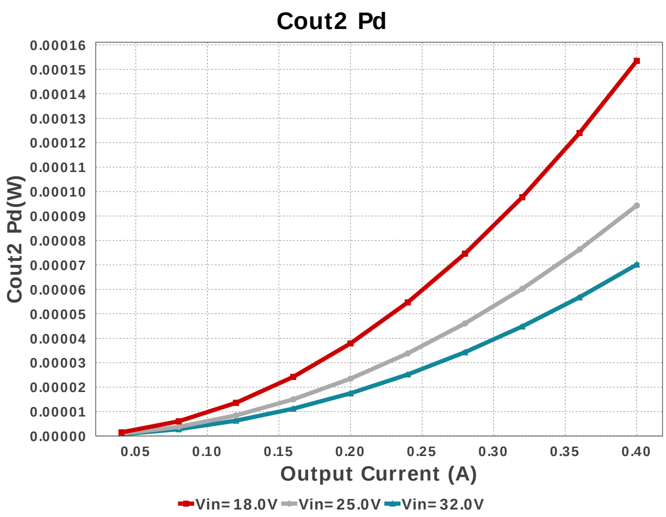


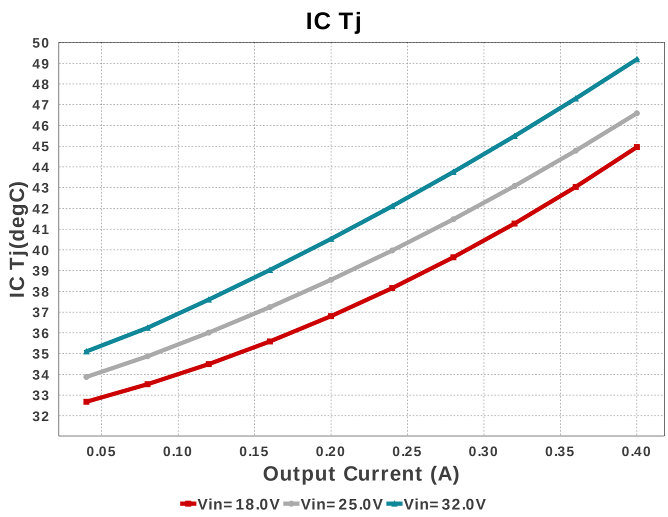
1. Feedback Resistors may need to be further adjusted to get more precise regulation as ripple injection circuit will introduce some amount of DC offset. Use simulation to help adjust.

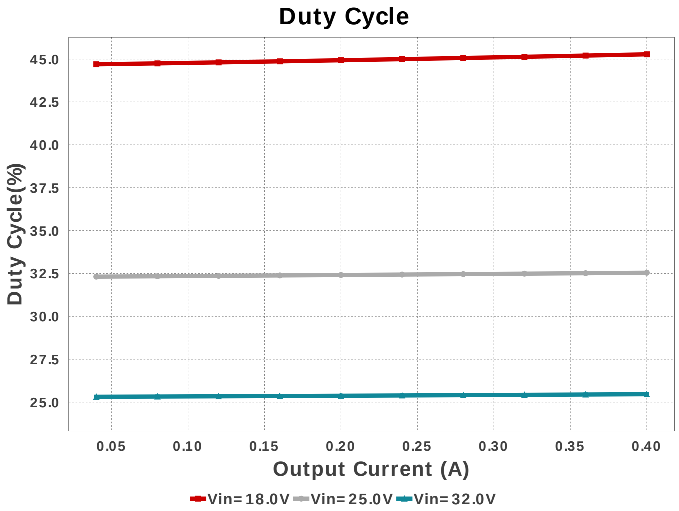
Electrical BOM

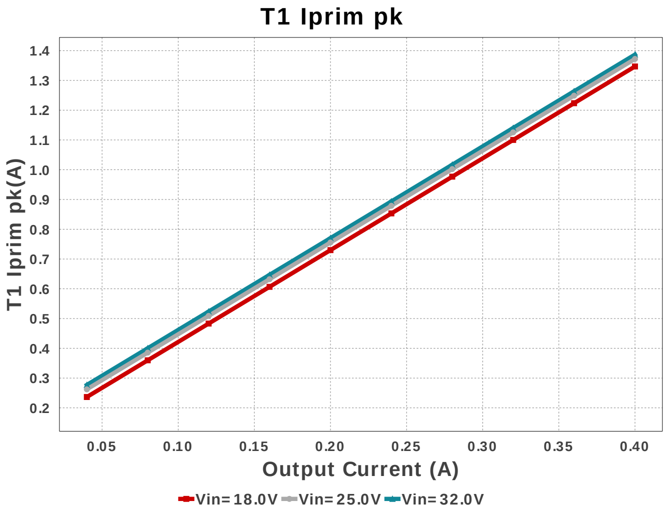
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cac	AVX	08053C104JAZ2A Series= X7R	Cap= 100.0 nF VDC= 25.0 V IRMS= 0.0 A	1	$0.06	0805 7 mm²
Cbst	MuRata	GRM155R71H103KA88D Series= X7R	Cap= 10.0 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cin	MuRata	GRM31CR61H225KA88L Series= X5R	Cap= 2.2 uF ESR= 4.448 mOhm VDC= 50.0 V IRMS= 2.2252 A	1	$0.10	1206_190 11 mm²
Cinx	Yageo	CC0805KRX7R9BB104 Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm²
Cout	MuRata	GRM31CR61C106KA88L Series= X5R	Cap= 10.0 uF ESR= 3.615 mOhm VDC= 16.0 V IRMS= 3.8281 A	3	$0.08	1206_190 11 mm²
Cout2	MuRata	GRM32ER61E226KE15L Series= X5R	Cap= 22.0 uF ESR= 2.0 mOhm VDC= 25.0 V IRMS= 3.67 A	2	$0.65	1210 15 mm²
Cr	AVX	12065A562JAT2A Series= C0G/NP0	Cap= 5.6 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.07	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

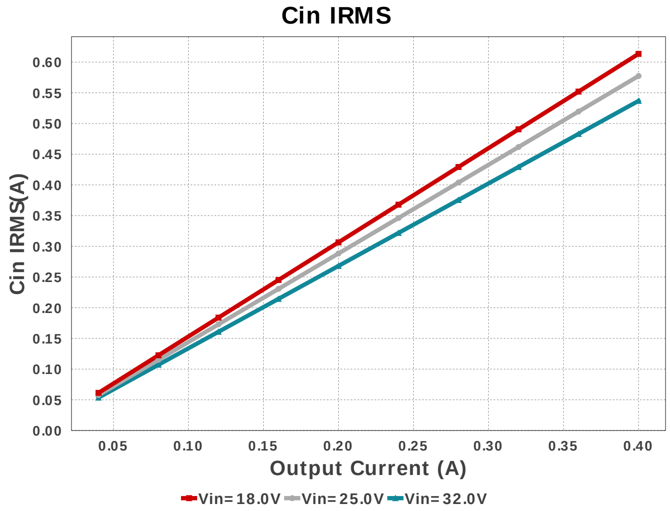
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
D1	SMC Diode Solutions	SK220ATR	VF@Io= 900.0 mV VRRM= 200.0 V	1	$0.04	SMA 37 mm^2
Rfbb	Vishay-Dale	CRCW04022K00FKED Series= CRCW..e3	Res= 2.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt	Panasonic	ERJ-6ENF5901V Series= ERJ-6E	Res= 5.9 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Ron	Vishay-Dale	CRCW0402267KFKED Series= CRCW..e3	Res= 267.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rr	Panasonic	ERJ-6ENF3742V Series= ERJ-6E	Res= 37.4 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Ruvb	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 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	CUSTOM	CUSTOM	Lp= 65.707 µH Rp= 71.0 mOhm Leakage_L= 1.971 µH Ns1toNp= 2.08 Rs1= 211.0 mOhms	1	NA	CUSTOM 0 mm^2
U1	Texas Instruments	LM5160DNTR	Switcher	1	$1.58	DNT0012B 25 mm^2

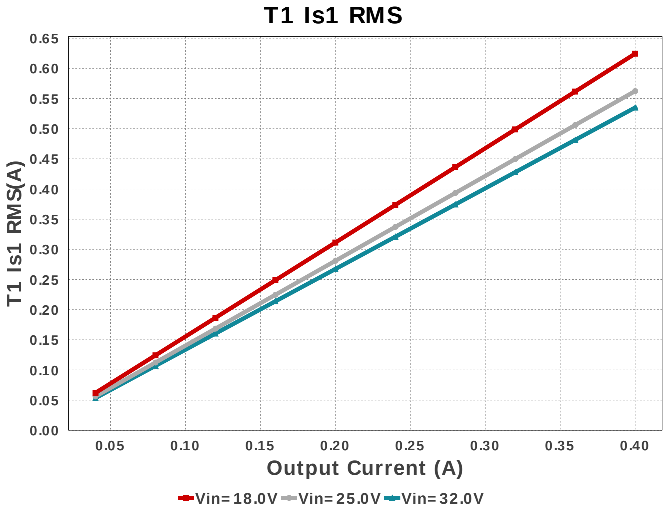


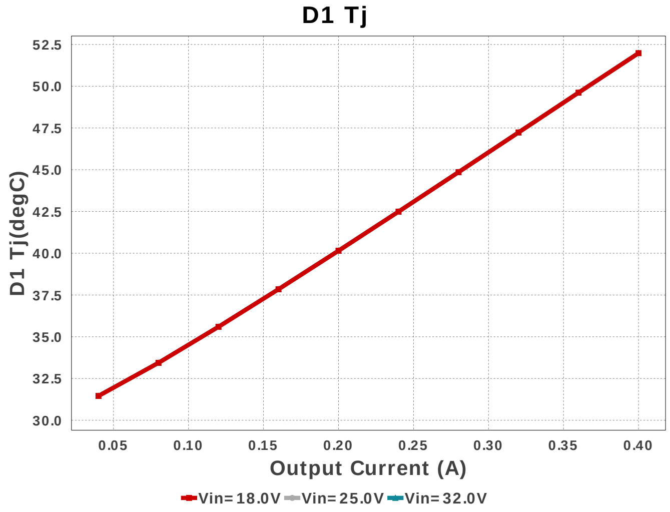


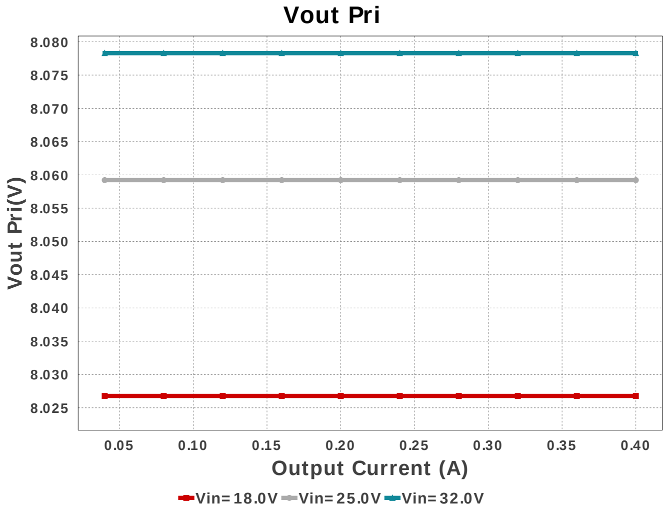

Duty Cycle
Duty Cycle(%)
45.0
42.5
40.0
37.5
35.0
32.5
30.0
27.5
25.0
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40
Output Current (A)
Vin=18.0V Vin=25.0V Vin=32.0V

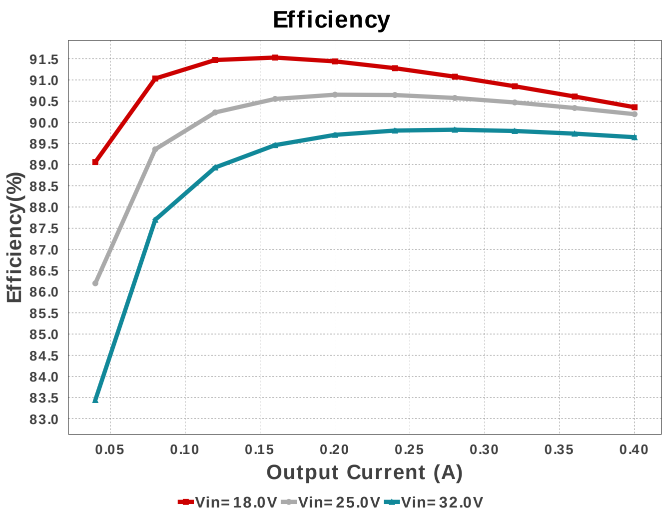

T1 Iprim pk
T1 Iprim pk(A)
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40
Output Current (A)
Vin=18.0V Vin=25.0V Vin=32.0V

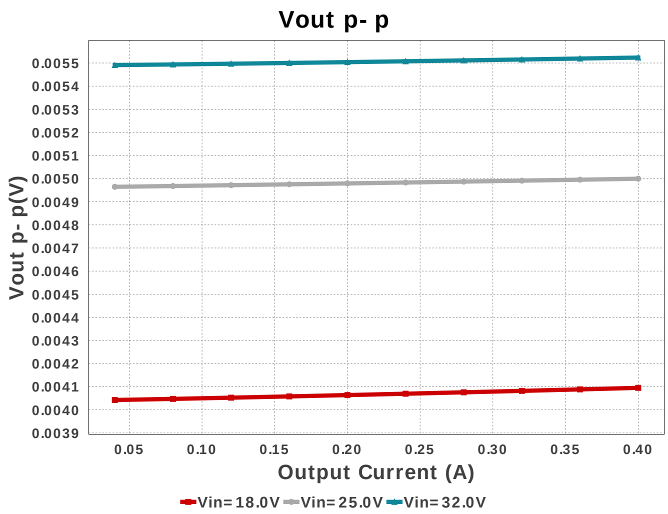

Cin IRMS
Cin IRMS(A)
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40
Output Current (A)
Vin=18.0V Vin=25.0V Vin=32.0V

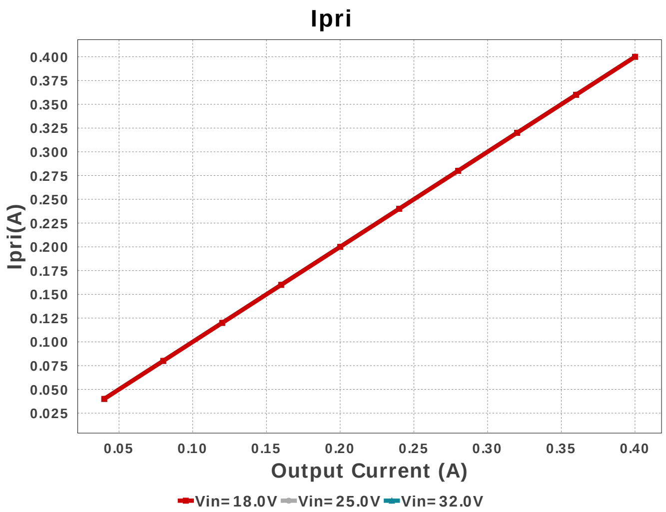

T1 Is1 RMS
T1 Is1 RMS(A)
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40
Output Current (A)
Vin=18.0V Vin=25.0V Vin=32.0V

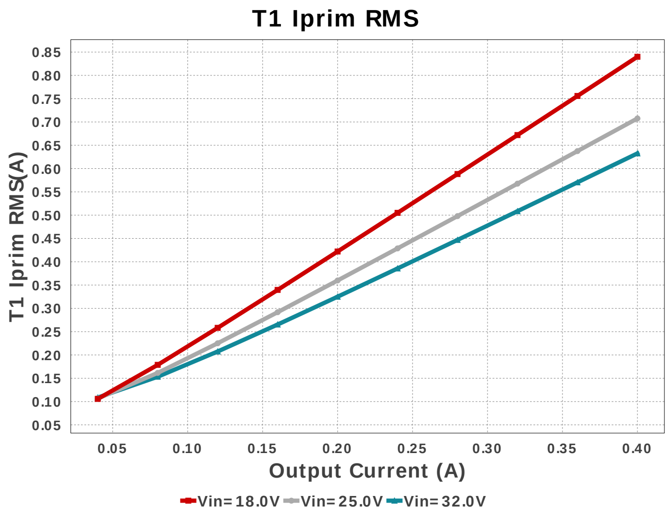

D1 Tj
D1 Tj(degC)
52.5
50.0
47.5
45.0
42.5
40.0
37.5
35.0
32.5
30.0
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40
Output Current (A)
Vin=18.0V Vin=25.0V Vin=32.0V

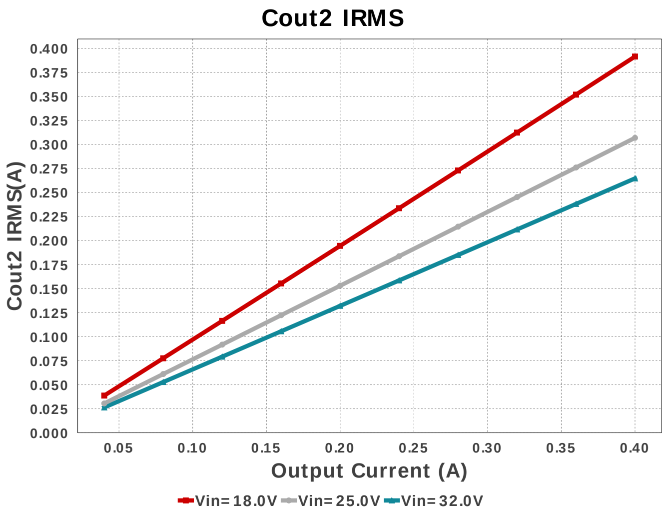

Vout Pri
Vout Pri(V)
8.080
8.075
8.070
8.065
8.060
8.055
8.050
8.045
8.040
8.035
8.030
8.025
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40
Output Current (A)
Vin=18.0V Vin=25.0V Vin=32.0V

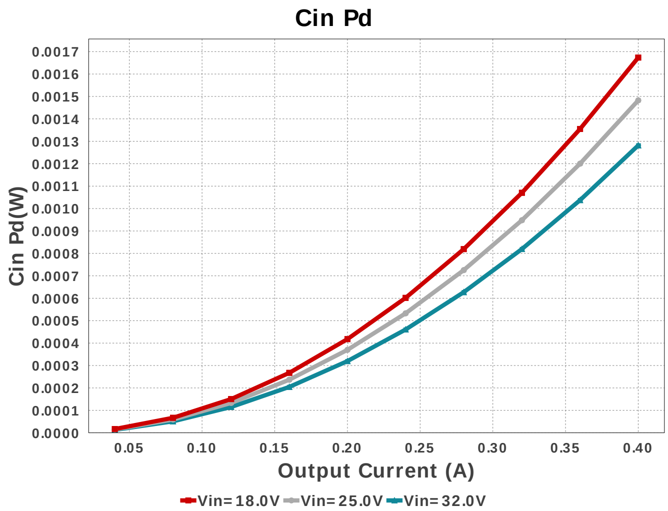

Efficiency
Efficiency(%)
Output Current (A)
Vin=18.0V Vin=25.0V Vin=32.0V


Vout p- p
Vout p- p(V)
Output Current (A)
Vin=18.0V Vin=25.0V Vin=32.0V

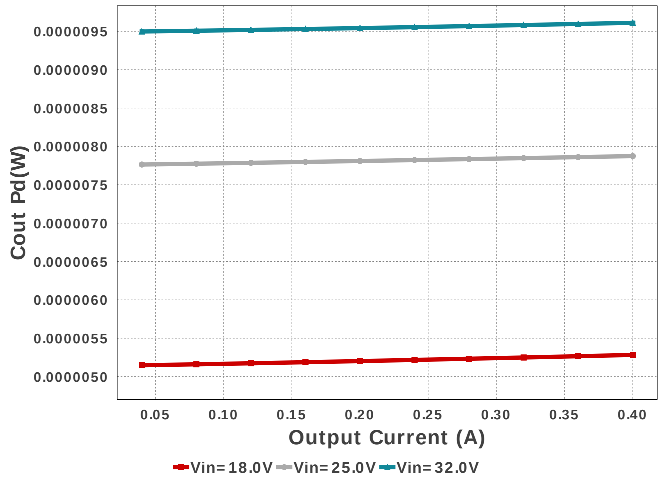

Ipri
Ipri(A)
Output Current (A)
Vin=18.0V Vin=25.0V Vin=32.0V


T1 Iprim RMS
T1 Iprim RMS(A)
Output Current (A)
Vin=18.0V Vin=25.0V Vin=32.0V

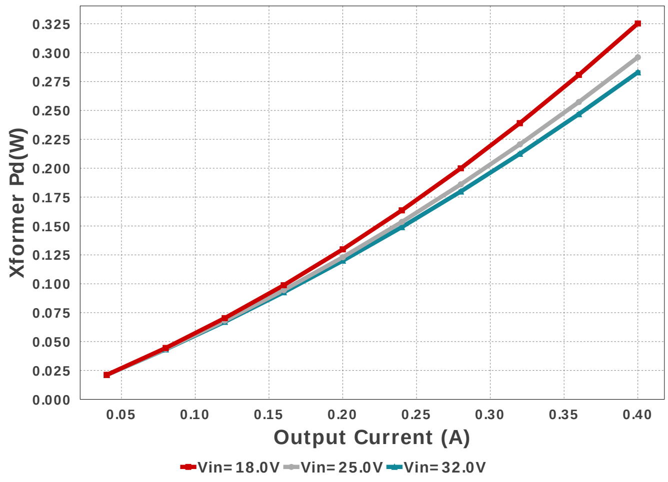

Cout2 IRMS
Cout2 IRMS(A)
Output Current (A)
Vin=18.0V Vin=25.0V Vin=32.0V


Cin Pd
Cin Pd(W)
Output Current (A)
Vin=18.0V Vin=25.0V Vin=32.0V

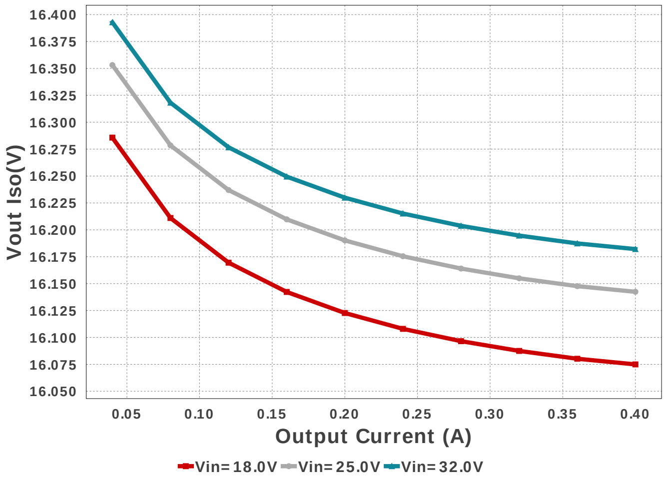
Cout Pd



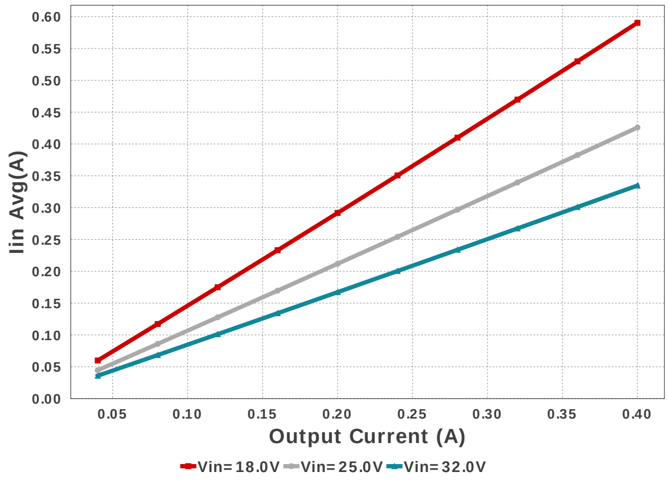
Xformer Pd



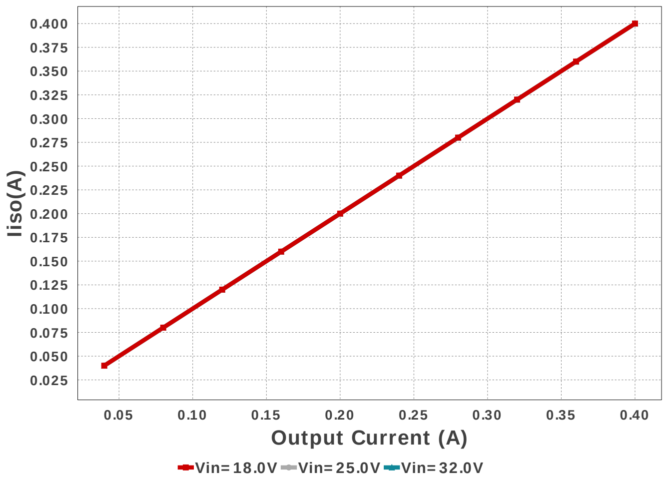
Vout Iso



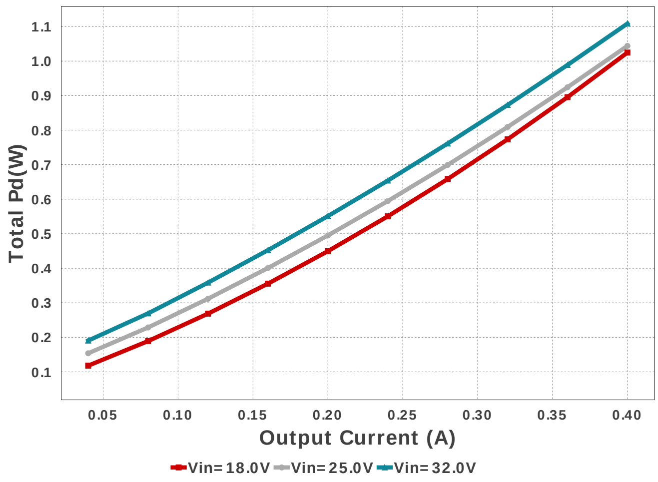
Iin Avg

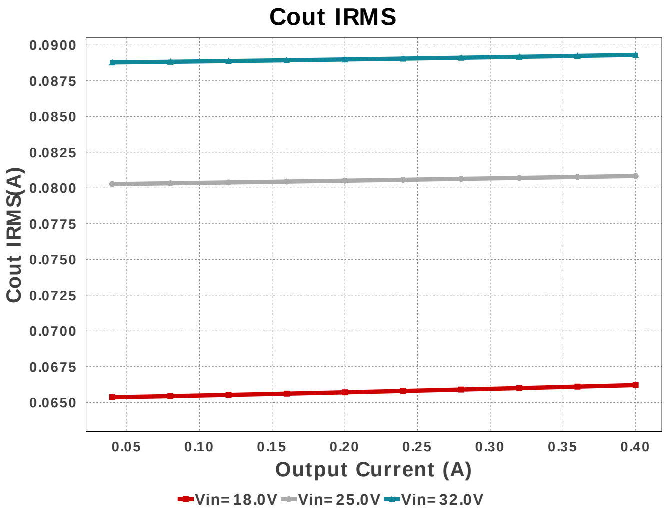


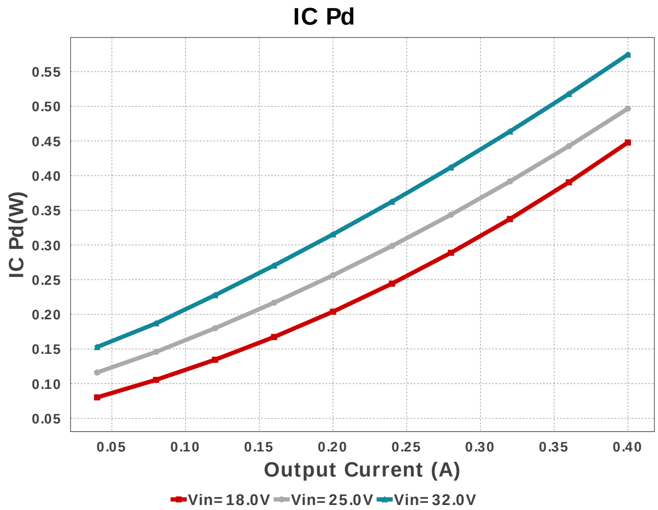
Iiso

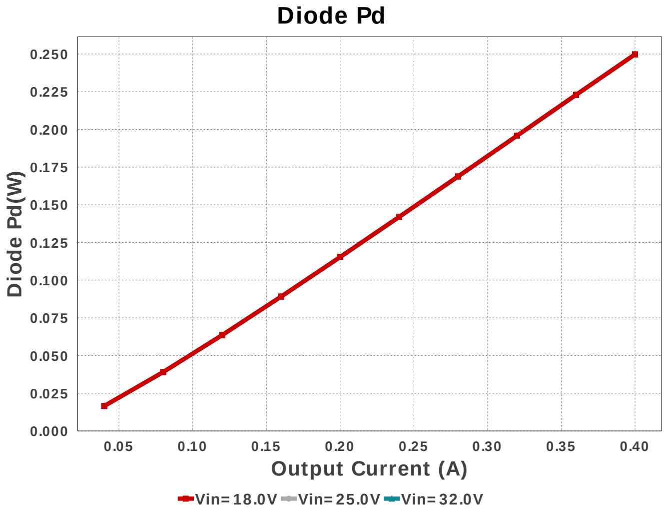


Total Pd









Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	536.792 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	1.282 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	89.308 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	9.611 µW	Capacitor	Output capacitor power dissipation
5.	Cout2 IRMS	264.848 mA	Capacitor	Output capacitor2 RMS ripple current
6.	Cout2 Pd	70.145 µW	Capacitor	Output capacitor2 power dissipation
7.	Iiso	400.0 mA	Current	Secondary Side Output Current
8.	Ipri	400.0 mA	Current	Primary Side Output Current
9.	D1 Tj	52.657 degC	Diode	D1 junction temperature
10.	Diode Pd	257.47 mW	Diode	Diode power dissipation
11.	IC Pd	574.48 mW	IC	IC power dissipation
12.	IC Tj	49.187 degC	IC	IC junction temperature
13.	ICThetaJA	33.4 degC/W	IC	IC junction-to-ambient thermal resistance
14.	Iin Avg	334.88 mA	IC	Average input current
15.	Vout Iso	16.163 V	Op Point	Secondary Side Output Voltage
16.	Vout Pri	8.078 V	Op Point	Primary Side Output Voltage
17.	Cin Pd	1.282 mW	Power	Input capacitor power dissipation
18.	Cout Pd	9.611 µW	Power	Output capacitor power dissipation
19.	Cout2 Pd	70.145 µW	Power	Output capacitor2 power dissipation
20.	Diode Pd	257.47 mW	Power	Diode power dissipation
21.	IC Pd	574.48 mW	Power	IC power dissipation
22.	Total Pd	1.116 W	Power	Total Power Dissipation
23.	Xformer Pd	282.75 mW	Power	Transformer power dissipation
24.	BOM Count	21	System Information	Total Design BOM count
25.	Duty Cycle	25.461 %	System Information	Duty cycle
26.	Efficiency	89.585 %	System Information	Steady state efficiency
27.	FootPrint	201.0 mm^2	System Information	Total Foot Print Area of BOM components

#	Name	Value	Category	Description
28.	Frequency	299.625 kHz	System Information	Switching frequency
29.	Total BOM	NA	System Information	Total BOM Cost
30.	Vin	32.0 V	System Information	Vin operating point
31.	Vout Actual	7.9 V	System Information	Vout Actual calculated based on selected voltage divider resistors
32.	Vout Tolerance	2.778 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
33.	Vout p-p	5.524 mV	System Information	Peak-to-peak output ripple voltage
34.	T1 Iprim RMS	632.526 mA	Transformer	Transformer Primary RMS Current
35.	T1 Iprim pk	1.387 A	Transformer	Transformer Primary Peak Current
36.	T1 Is1 RMS	534.981 mA	Transformer	Transformer Secondary1 RMS Current
37.	Xformer Pd	282.75 mW	Transformer	Transformer power dissipation

Design Inputs

Name	Value	Description
Iout	400.0 m	Maximum Output Current
Iout1	400.0 m	Output Current #1
Iout2	400.0 m	Output Current #2
SoftStart	5.0 ms	Soft Start Time (ms)
VinMax	32.0	Maximum input voltage
VinMin	18.0	Minimum input voltage
Vout	8.0	Output Voltage
Vout1	8.0	Output Voltage #1
Vout2	16.0	Output Voltage #2
base_pn	LM5160	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature
UserFsw	300.0 k	Customer Selected Frequency

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

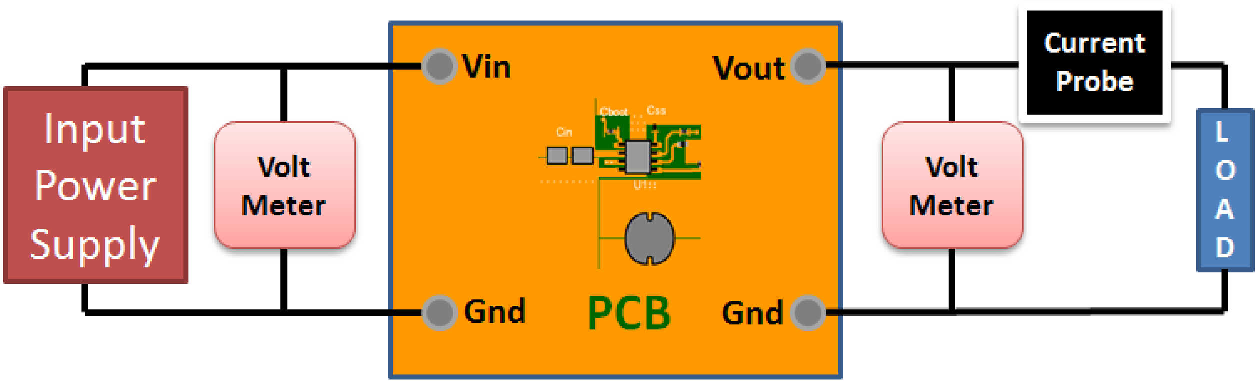
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 18.0V 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 : DC9BE5AA912B6F5A[v1]

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

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