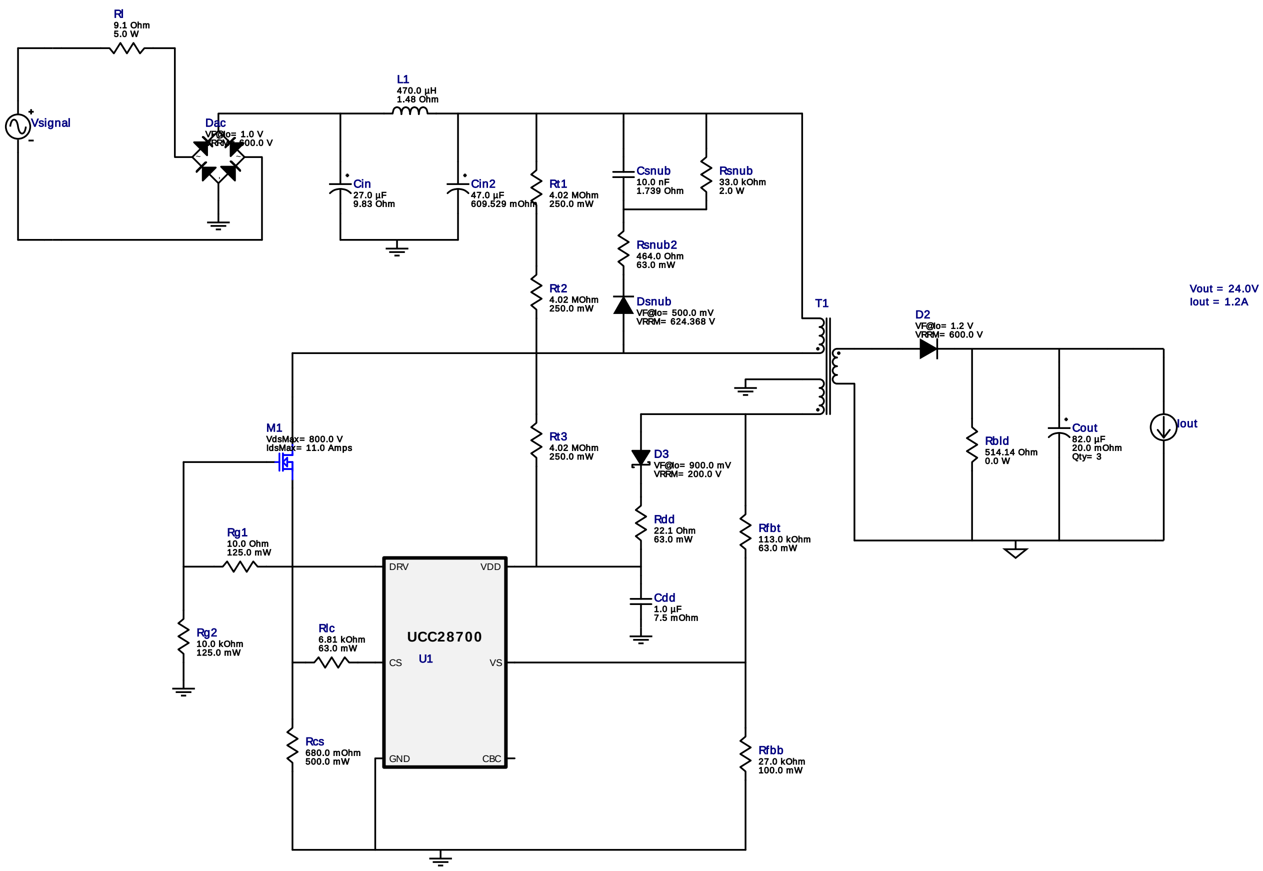
![Texas Instruments]

WEBENCH ® Design Report

VinMin = 130.0V
VinMax = 240.0V
Vout = 24.0V
Iout = 1.2A

Device = UCC28700DBVR
Topology = Flyback
Created = 2020-12-20 21:55:39.367
BOM Cost = NA
BOM Count = 29
Total Pd = 8.13W

Design : 23 UCC28700DBVR
UCC28700DBVR 130V-240V to 25.80V @ 1.2A



1. Rbld is a starting point, but may need to be experimented with in order to get minimum current needed to hold Vout at no load. Rlc and the feedback resistors may also need adjustment based on the actual transformer used. It is recommended to start this device at light load condition. There is an internal series resistance of 28 kOhms to the CBC pin which sets a maximum cable compensation of a 5V output to 400 mV when CBC is shorted to ground. For more information please click the design assistance button.

2. Click on the transformer symbol and select 'Design Transformer' to design using specific transformer cores and bobbin

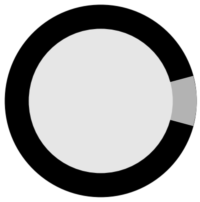
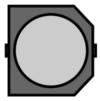
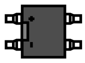
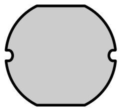
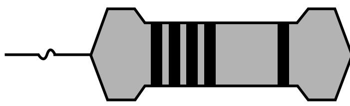
Design Alerts

Component Selection Information

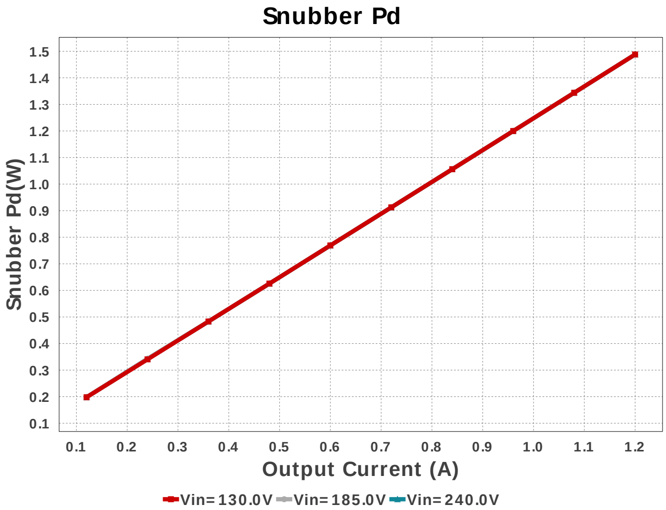
Click on the transformer symbol in the schematic and select "Explore Transformer Core/Bobbin Selection" to design using specific transformer cores and bobbin.

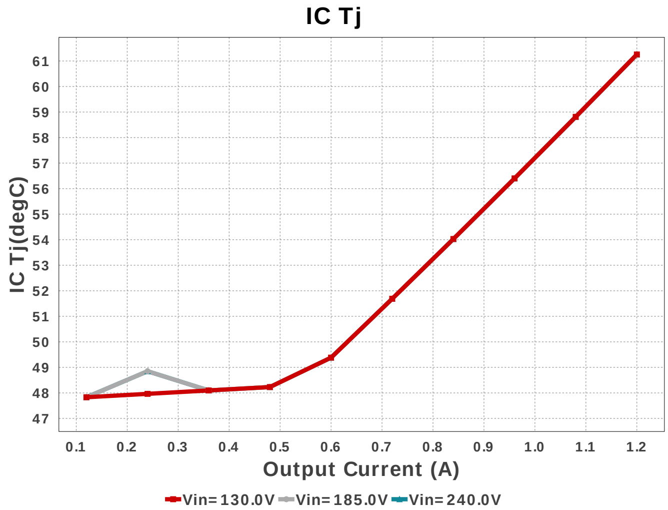
Electrical BOM

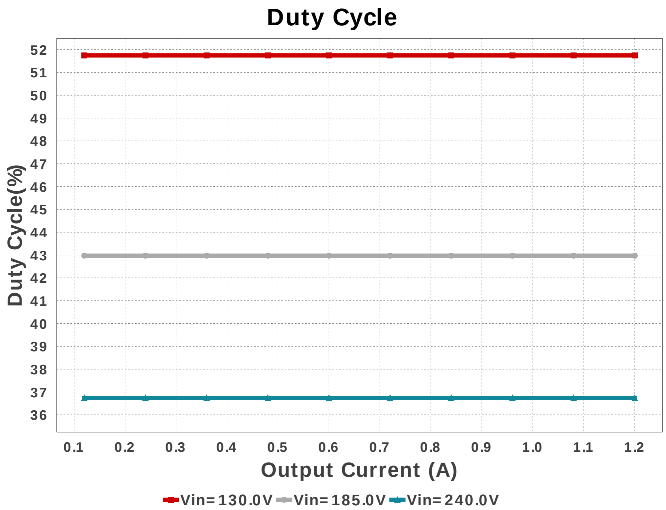
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cdd	TDK	C3216X7R2A105M160AA Series= X7R	Cap= 1.0 uF ESR= 7.5 mOhm VDC= 100.0 V IRMS= 5.9235 A	1	$0.12	1206 11 mm^2
Cin	Rubycon	400BXW27MEFC10X25 Series= BXW	Cap= 27.0 uF ESR= 9.83 Ohm VDC= 400.0 V IRMS= 290.0 mA	1	$0.61	BXW_1000x2500 144 mm^2

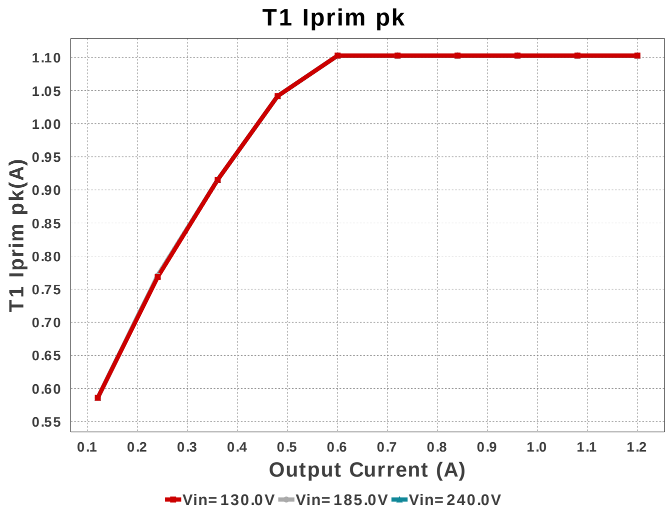
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cin2	Panasonic	EEUED2G470S Series= ED	Cap= 47.0 uF ESR= 609.53 mOhm VDC= 400.0 V IRMS= 840.0 mA	1	$0.73	 CAPPR7.5-18X20 400 mm²
Cout	Panasonic	35SVPF82M Series= SVPF	Cap= 82.0 uF ESR= 20.0 mOhm VDC= 35.0 V IRMS= 4.0 A	3	$0.63	 CAPSMT_62_E12 106 mm²
D2	Bourns	CD214B-F3600	VF@Io= 1.2 V VRRM= 600.0 V	1	$0.14	 SMB 44 mm²
D3	SMC Diode Solutions	SK220ATR	VF@Io= 900.0 mV VRRM= 200.0 V	1	$0.04	 SMA 37 mm²
Dac	Diodes Inc.	HD06-T	VF@Io= 1.0 V VRRM= 600.0 V	1	$0.13	 MiniDIP 62 mm²
L1	NIC Components	NPI105C471MTRF	L= 470.0 µH 1.48 Ohm	1	$0.18	 IND_NPI105C 141 mm²
M1	Infineon Technologies	SPW11N80C3FKSA1	VdsMax= 800.0 V IdsMax= 11.0 Amps	1	$1.54	 TO-247 123 mm²
Rbld	CUSTOM	CUSTOM Series= ?	Res= 514.14 Ohm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm²
Rcs	Rohm	MCR25JZHFLR680 Series= MCR25	Res= 680.0 mOhm Power= 500.0 mW Tolerance= 1.0%	1	$0.03	1210 15 mm²
Rdd	Vishay-Dale	CRCW040222R1FKED Series= CRCW..e3	Res= 22.1 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbb	Yageo	RC0603FR-0727KL Series= ?	Res= 27.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rfbt	Vishay-Dale	CRCW0402113KFKED Series= CRCW..e3	Res= 113.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rg1	Vishay-Dale	CRCW080510R0FKEA Series= CRCW..e3	Res= 10.0 Ohm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²
Rg2	Vishay-Dale	CRCW080510K0FKEA Series= CRCW..e3	Res= 10.0 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²
Rl	Yageo	FKN500JR-91-9R1 Series= F_RES	Res= 9.1 Ohm Power= 5.0 W Tolerance= 5.0%	1	$0.17	 FKN500_7WS 278 mm²
Rlc	Vishay-Dale	CRCW04026K81FKED Series= CRCW..e3	Res= 6.81 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rt1	Vishay-Dale	CRCW12064M02FKEA Series= CRCW..e3	Res= 4.02 MOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm²

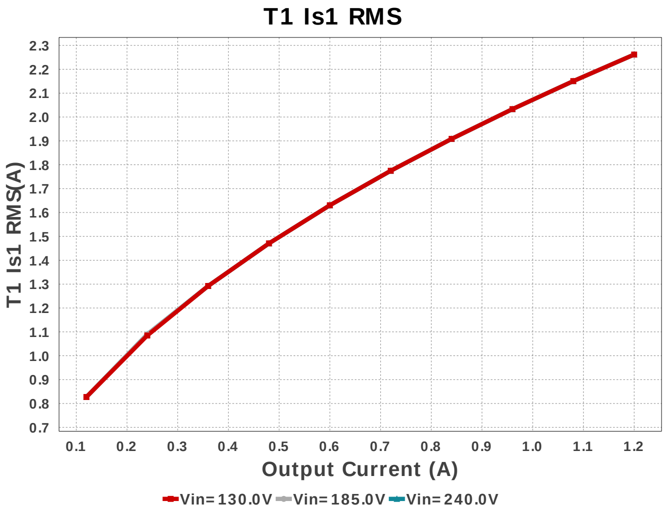
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rt2	Vishay-Dale	CRCW12064M02FKEA Series= CRCW..e3	Res= 4.02 MOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm^2
Rt3	Vishay-Dale	CRCW12064M02FKEA Series= CRCW..e3	Res= 4.02 MOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm^2
T1	Core=TDK , CoilFormer=TDK	Core=B66317G0000X187 , CoilFormer=B66208X1110T001	Lp= 655.0 µH Turns Ratio(Nas)= 10:12 Turns Ratio(Nps)= 69:12 Npri= 69.0 Naux= 10.0 Nsec= 12.0	1	$0.22	TDK_B66305 569 mm^2
U1	Texas Instruments	UCC28700DBVR	Switcher	1	$0.35	SOT-23-6 15 mm^2

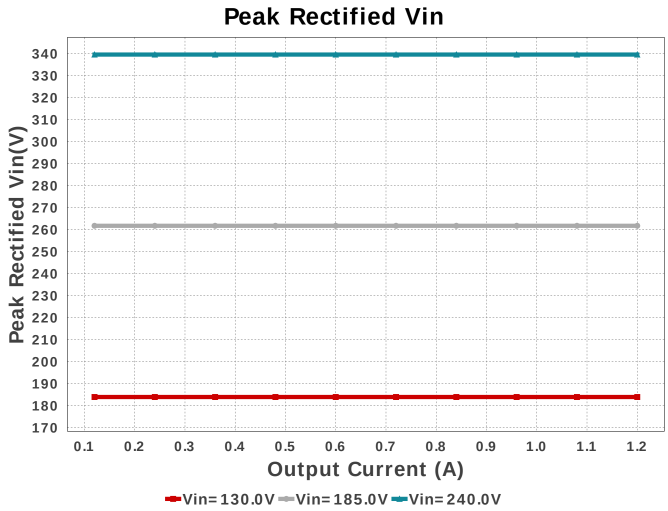


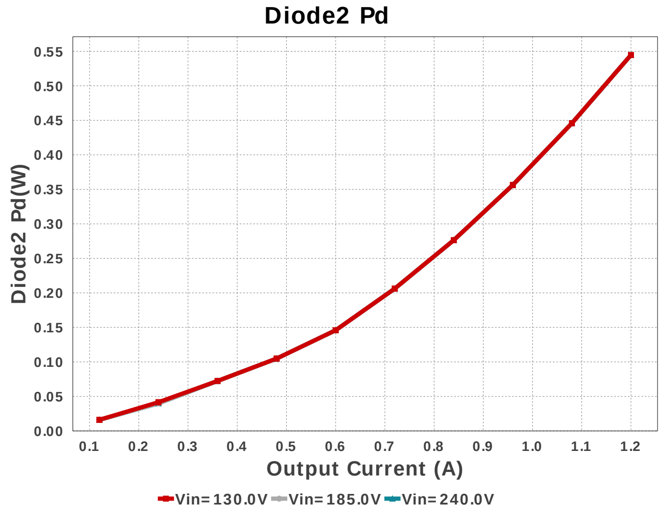


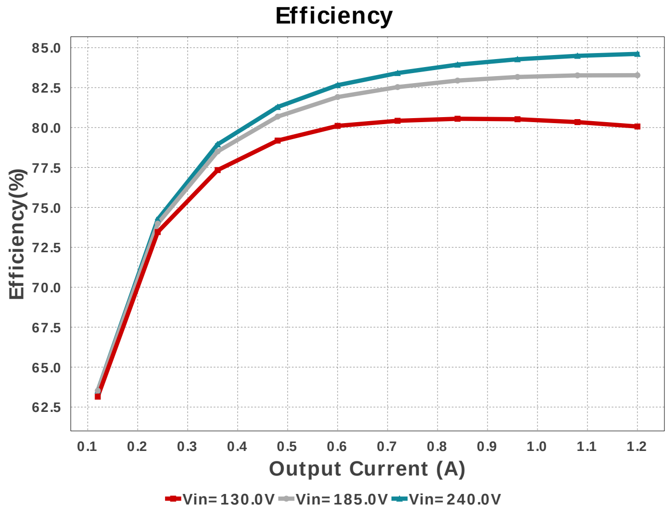


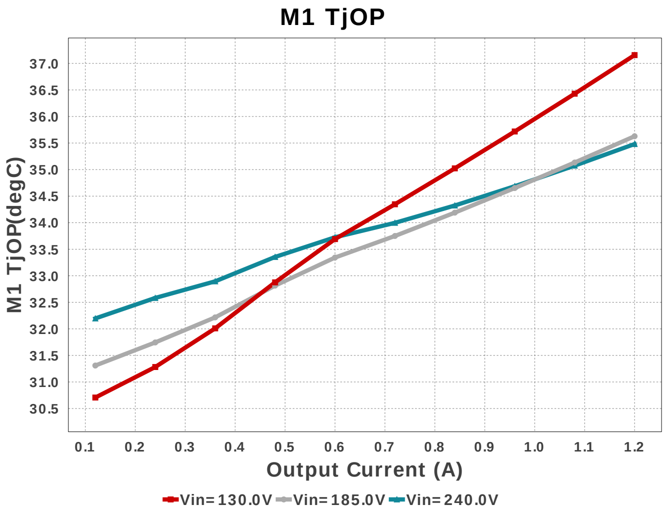


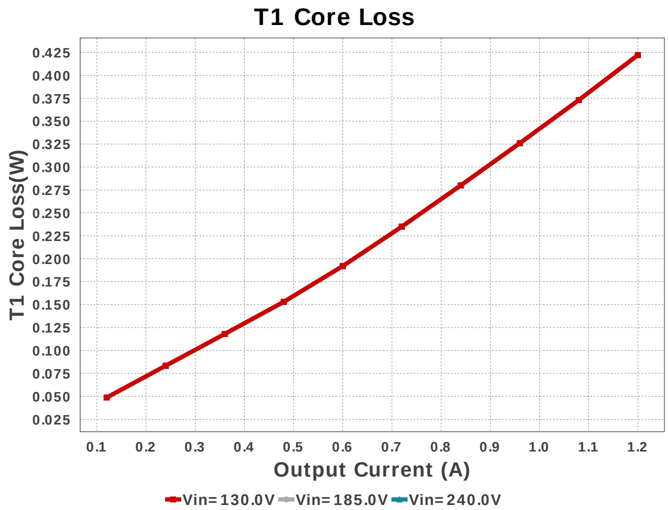

T1 Is1 RMS
T1 Is1 RMS(A)
2.3 2.2 2.1 2.0 1.9 1.8 1.7 1.6 1.5 1.4 1.3 1.2 1.1 1.0 0.9 0.8 0.7
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin= 130.0V Vin= 185.0V Vin= 240.0V


Peak Rectified Vin
Peak Rectified Vin(V)
340 330 320 310 300 290 280 270 260 250 240 230 220 210 200 190 180 170
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin= 130.0V Vin= 185.0V Vin= 240.0V

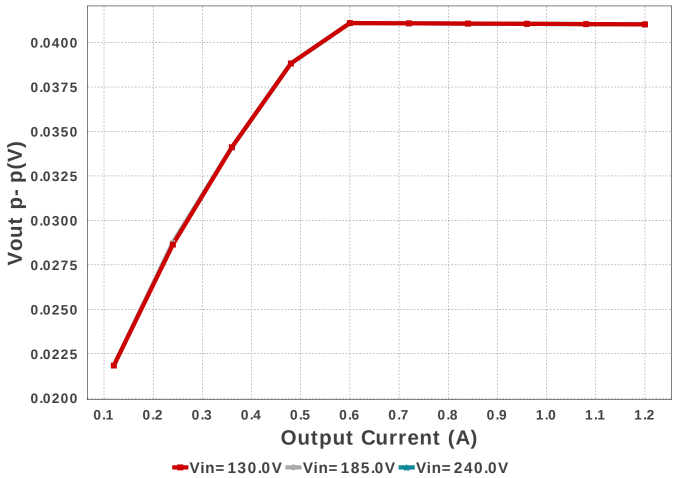

Diode2 Pd
Diode2 Pd(W)
0.55 0.50 0.45 0.40 0.35 0.30 0.25 0.20 0.15 0.10 0.05 0.00
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin= 130.0V Vin= 185.0V Vin= 240.0V


Efficiency
Efficiency(%)
85.0 82.5 80.0 77.5 75.0 72.5 70.0 67.5 65.0 62.5
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin= 130.0V Vin= 185.0V Vin= 240.0V

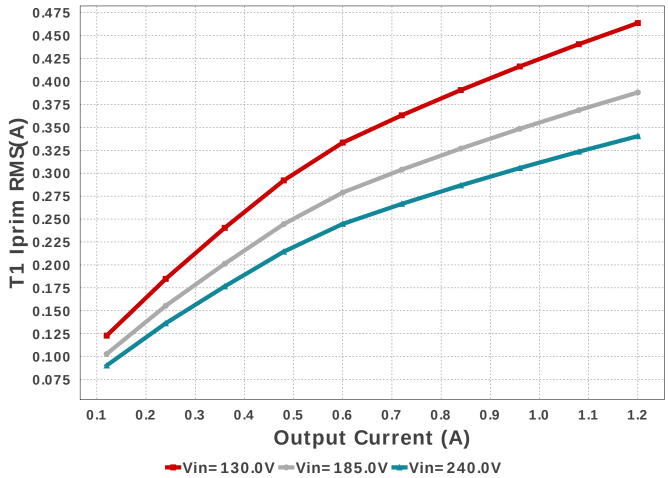

M1 TjOP
M1 TjOP(degC)
37.0 36.5 36.0 35.5 35.0 34.5 34.0 33.5 33.0 32.5 32.0 31.5 31.0 30.5
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin= 130.0V Vin= 185.0V Vin= 240.0V


T1 Core Loss
T1 Core Loss(W)
0.425 0.400 0.375 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
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin= 130.0V Vin= 185.0V Vin= 240.0V

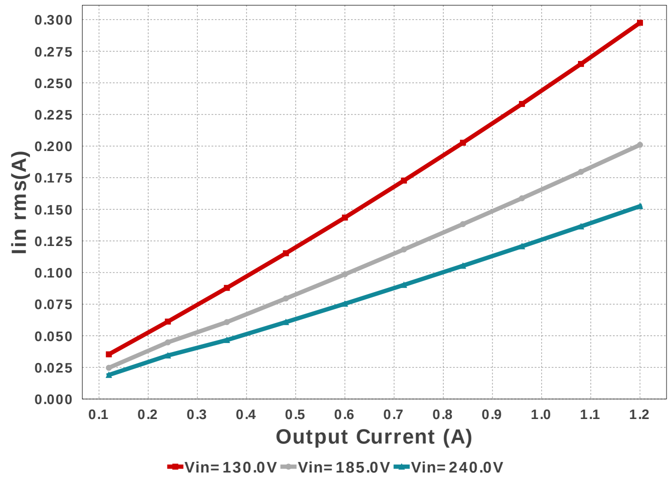
Vout p- p



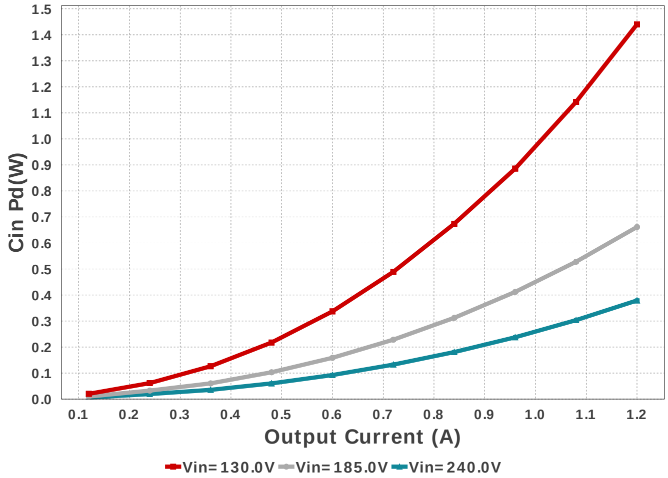
T1 Iprim RMS



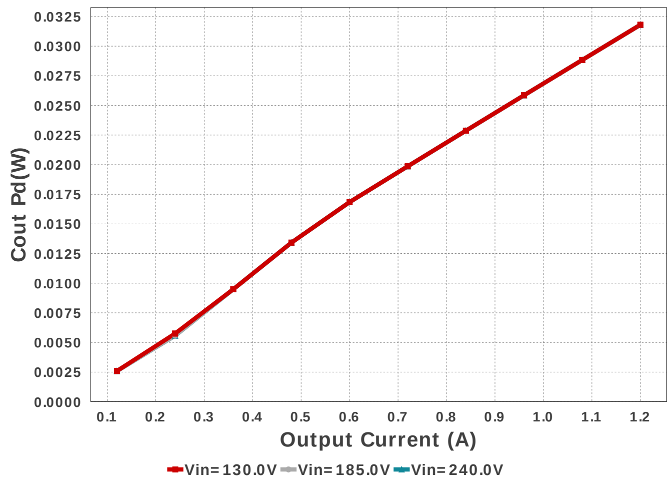
Iin rms



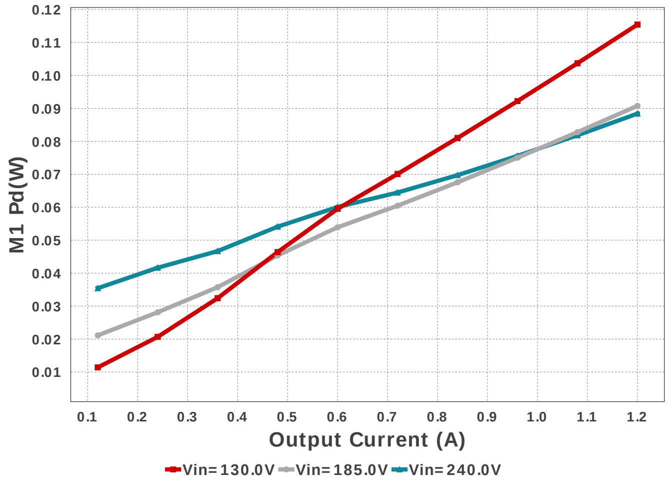
Cin Pd

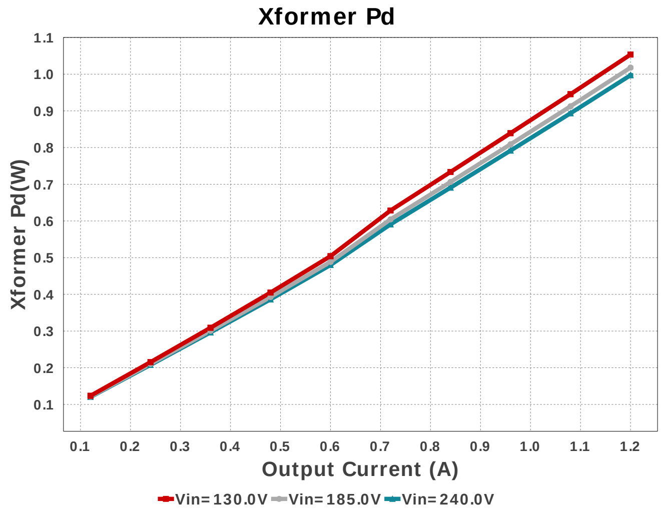


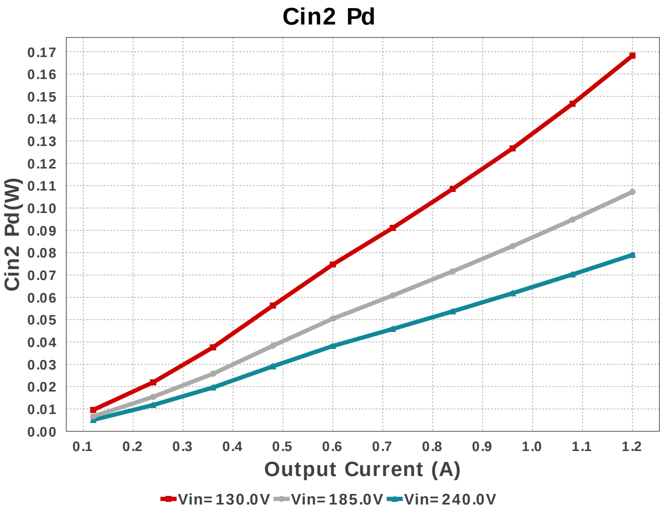
Cout Pd

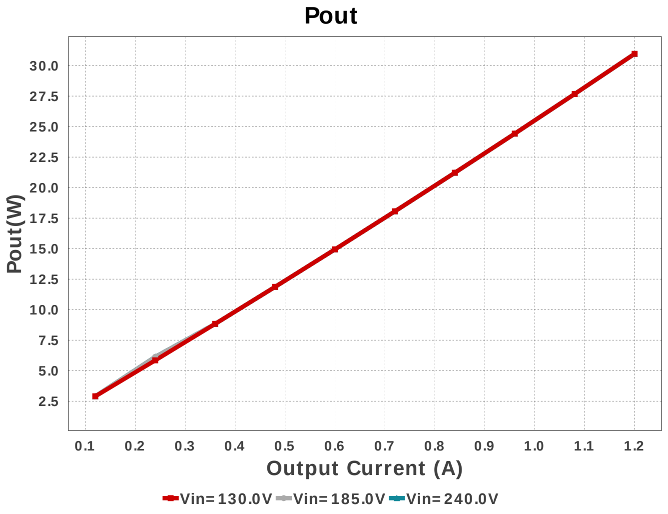


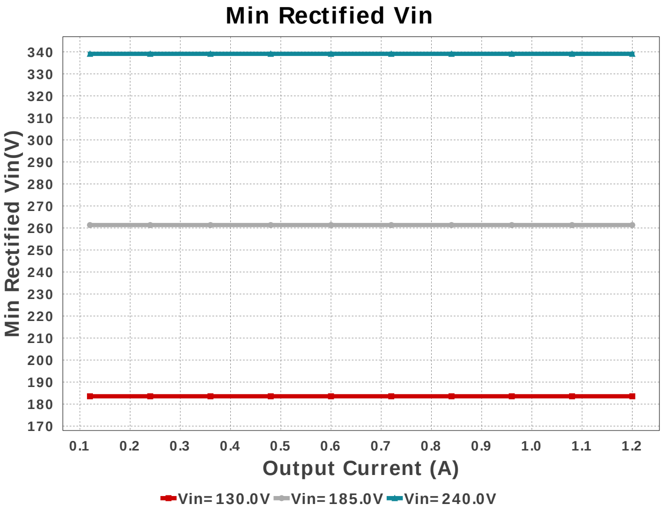
M1 Pd

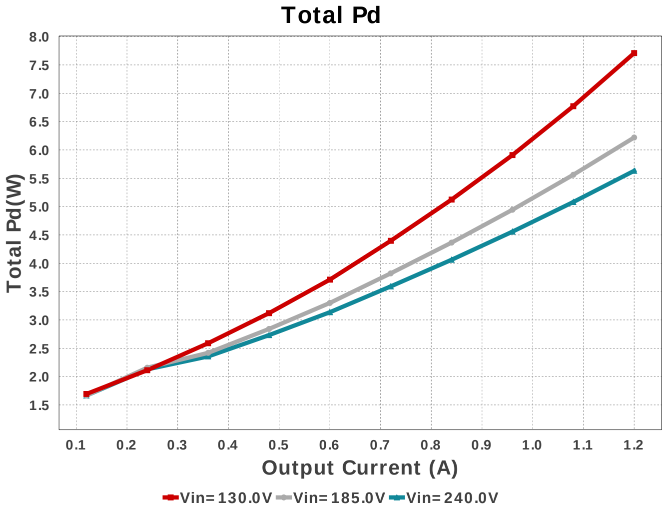


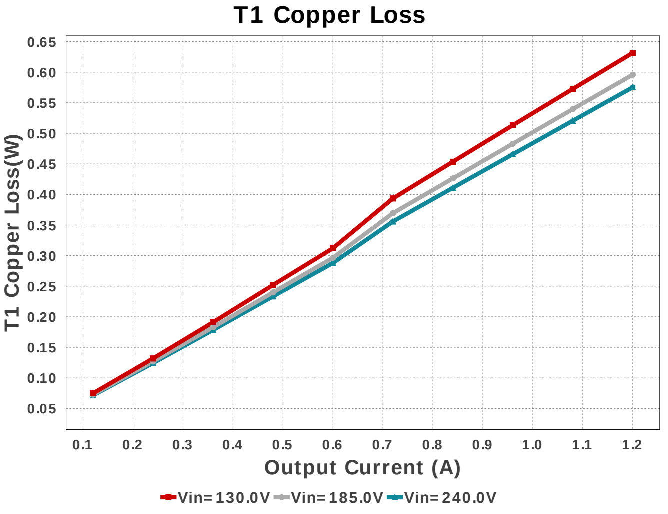

Xformer Pd
Xformer Pd(W)
Output Current (A)
Vin=130.0V Vin=185.0V Vin=240.0V

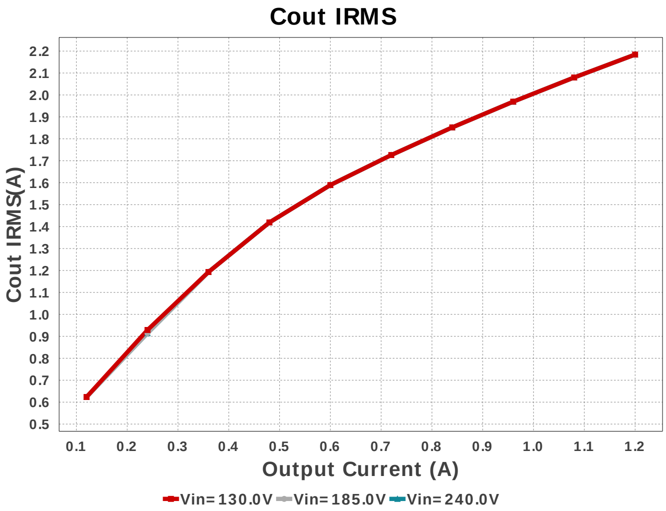

Cin2 Pd
Cin2 Pd(W)
Output Current (A)
Vin=130.0V Vin=185.0V Vin=240.0V

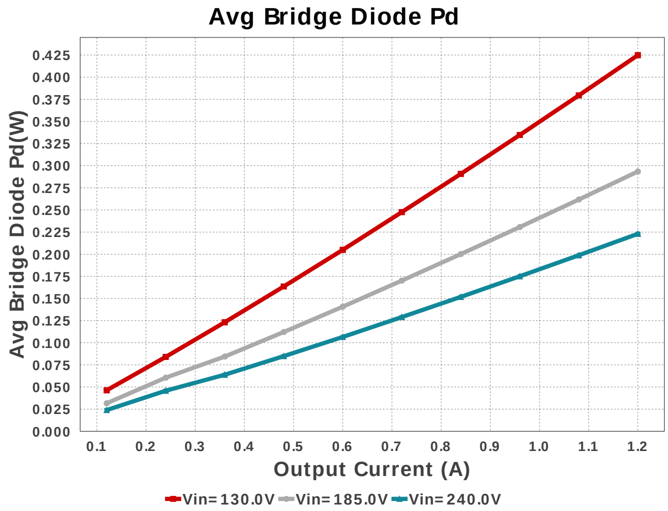

Pout
Pout(W)
Output Current (A)
Vin=130.0V Vin=185.0V Vin=240.0V

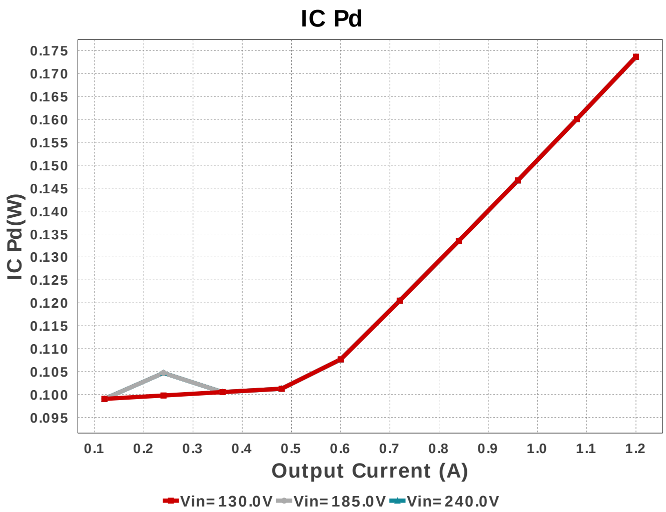

Min Rectified Vin
Min Rectified Vin(V)
Output Current (A)
Vin=130.0V Vin=185.0V Vin=240.0V

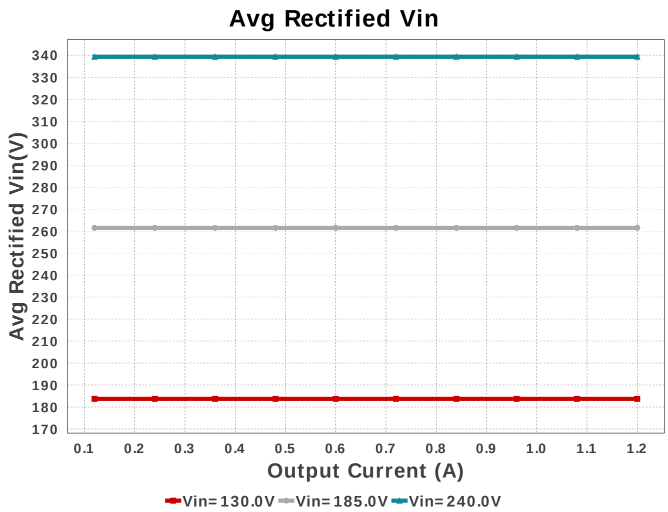

Total Pd
Total Pd(W)
Output Current (A)
Vin=130.0V Vin=185.0V Vin=240.0V

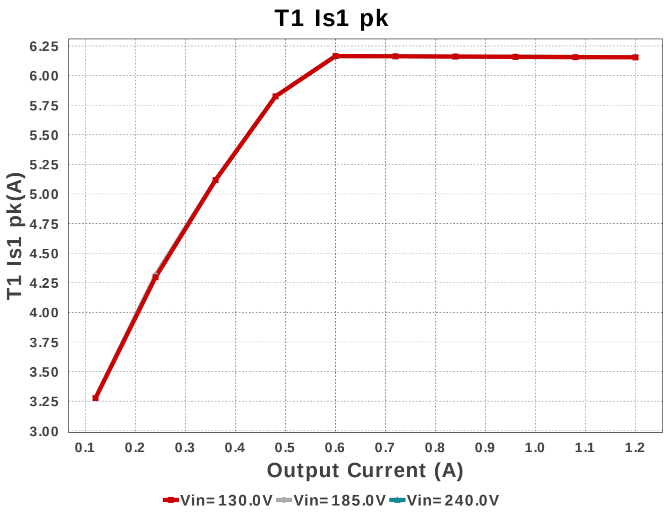

T1 Copper Loss
T1 Copper Loss(W)
Output Current (A)
Vin=130.0V Vin=185.0V Vin=240.0V

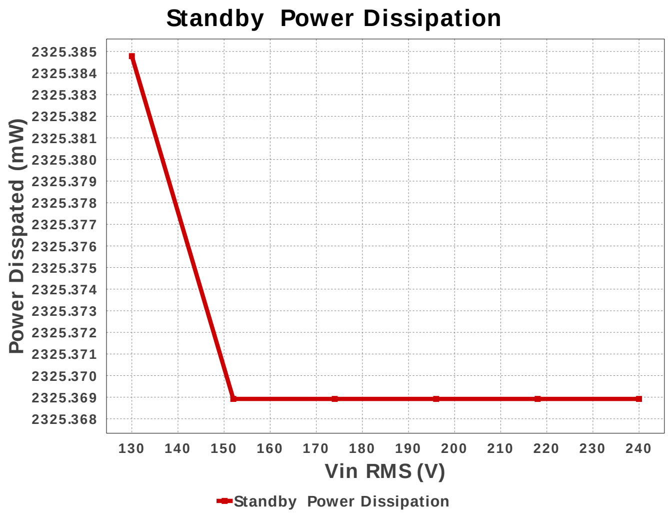

Cout IRMS
Cout IRMS(A)
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin= 130.0V Vin= 185.0V Vin= 240.0V

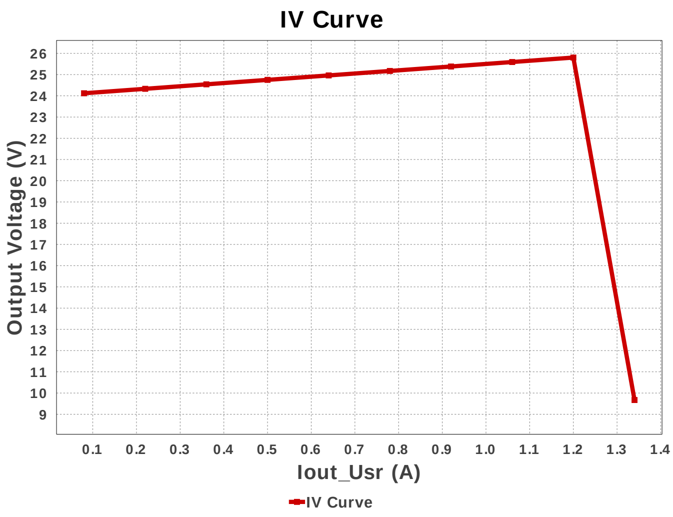

Avg Bridge Diode Pd
Avg Bridge Diode Pd(W)
0.425
0.400
0.375
0.350
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin= 130.0V Vin= 185.0V Vin= 240.0V


IC Pd
IC Pd(W)
0.175
0.170
0.165
0.160
0.155
0.150
0.145
0.140
0.135
0.130
0.125
0.120
0.115
0.110
0.105
0.100
0.095
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin= 130.0V Vin= 185.0V Vin= 240.0V


Avg Rectified Vin
Avg Rectified Vin(V)
340
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin= 130.0V Vin= 185.0V Vin= 240.0V


T1 Is1 pk
T1 Is1 pk(A)
6.25
6.00
5.75
5.50
5.25
5.00
4.75
4.50
4.25
4.00
3.75
3.50
3.25
3.00
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2
Output Current (A)
Vin= 130.0V Vin= 185.0V Vin= 240.0V


Standby Power Dissipation
Power Disspated (mW)
2325.385
2325.384
2325.383
2325.382
2325.381
2325.380
2325.379
2325.378
2325.377
2325.376
2325.375
2325.374
2325.373
2325.372
2325.371
2325.370
2325.369
2325.368
130 140 150 160 170 180 190 200 210 220 230 240
Vin RMS (V)
Standby Power Dissipation



Operating Values

#	Name	Value	Category	Description
1.	Cin Pd	1.472 W	Capacitors	Input capacitor power dissipation
2.	Cin2 Pd	170.19 mW	Capacitors	Average Power Dissipation in the Input Capacitor Cin2
3.	Cout IRMS	2.184 A	Capacitors	Output capacitor RMS ripple current
4.	Cout Pd	31.802 mW	Capacitors	Output capacitor power dissipation
5.	Avg Bridge Diode Pd	429.2 mW	Diode	Average Power Dissipation in the Bridge Diode over the AC Line Period
6.	Diode2 Pd	544.64 mW	Diodes	Diode2 power dissipation
7.	IC Pd	173.64 mW	IC	IC power dissipation
8.	IC Tj	61.255 degC	IC	IC junction temperature
9.	ICThetaJA	180.0 degC/W	IC	IC junction-to-ambient thermal resistance
10.	M1 Pd	115.42 mW	Mosfet	M1 MOSFET total power dissipation
11.	M1 TjOP	37.156 degC	Mosfet	M1 MOSFET junction temperature
12.	Avg Bridge Diode Pd	429.2 mW	Power	Average Power Dissipation in the Bridge Diode over the AC Line Period
13.	Cin Pd	1.472 W	Power	Input capacitor power dissipation
14.	Cin2 Pd	170.19 mW	Power	Average Power Dissipation in the Input Capacitor Cin2
15.	Cout Pd	31.802 mW	Power	Output capacitor power dissipation
16.	Diode2 Pd	544.64 mW	Power	Diode2 power dissipation
17.	IC Pd	173.64 mW	Power	IC power dissipation
18.	M1 Pd	115.42 mW	Power	M1 MOSFET total power dissipation
19.	Snubber Pd	1.488 W	Power	Snubber Power Dissipation
20.	T1 Copper Loss	710.82 mW	Power	Transformer Copper Loss Power Dissipation
21.	T1 Core Loss	710.82 mW	Power	Transformer Core Loss Power Dissipation
22.	Total Pd	8.131 W	Power	Total Power Dissipation
23.	Xformer Pd	1.422 W	Power	Transformer power dissipation
24.	Avg Rectified Vin	183.696 V	System Information	Average Rectified Voltage for the AC Line Period
25.	BOM Count	29	System Information	Total Design BOM count
26.	Duty Cycle	51.745 %	System Information	Duty cycle
27.	Efficiency	79.201 %	System Information	Steady state efficiency
28.	FootPrint	2.355 k mm^2	System Information	Total Foot Print Area of BOM components
29.	Frequency	93.37 kHz	System Information	Switching frequency
30.	Frequency	93.37 kHz	System Information	Switching frequency
31.	Iin rms	300.72 mA	System Information	RMS Input Current
32.	Iout	1.2 A	System Information	Iout operating point
33.	Min Rectified Vin	183.546 V	System Information	Minimum voltage seen at rectified input
34.	Mode	DCM	System Information	Conduction Mode
35.	Peak Rectified Vin	183.846 V	System Information	Peak voltage seen at rectified input
36.	Pout	30.962 W	System Information	Total output power
37.	Total BOM	NA	System Information	Total BOM Cost

#	Name	Value	Category	Description
38.	Vin_RMS	130.0 V	System Information	Vin operating point
39.	Vout	25.802 V	System Information	Operational Output Voltage
40.	Vout Actual	25.802 V	System Information	Vout Actual calculated based on selected voltage divider resistors
41.	Vout Tolerance	1.49 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
42.	Vout p-p	41.026 mV	System Information	Peak-to-peak output ripple voltage
43.	T1 Copper Loss	710.82 mW	Transformer	Transformer Copper Loss Power Dissipation
44.	T1 Core Loss	710.82 mW	Transformer	Transformer Core Loss Power Dissipation
45.	T1 Iprim RMS	463.646 mA	Transformer	Transformer Primary RMS Current
46.	T1 Iprim pk	1.103 A	Transformer	Transformer Primary Peak Current
47.	T1 Is1 RMS	2.262 A	Transformer	Transformer Secondary1 RMS Current
48.	T1 Is1 pk	6.154 A	Transformer	Transformer Secondary1 Peak Current
49.	Xformer Pd	1.422 W	Transformer	Transformer power dissipation

Design Inputs

Name	Value	Description
Iout	1.2	Maximum Output Current
VinMax	240.0	Maximum input voltage
VinMin	130.0	Minimum input voltage
Vout	24.0	Output Voltage
acFrequency	60.0	AC Frequency
base_pn	UCC28700	Base Product Number
source	AC	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

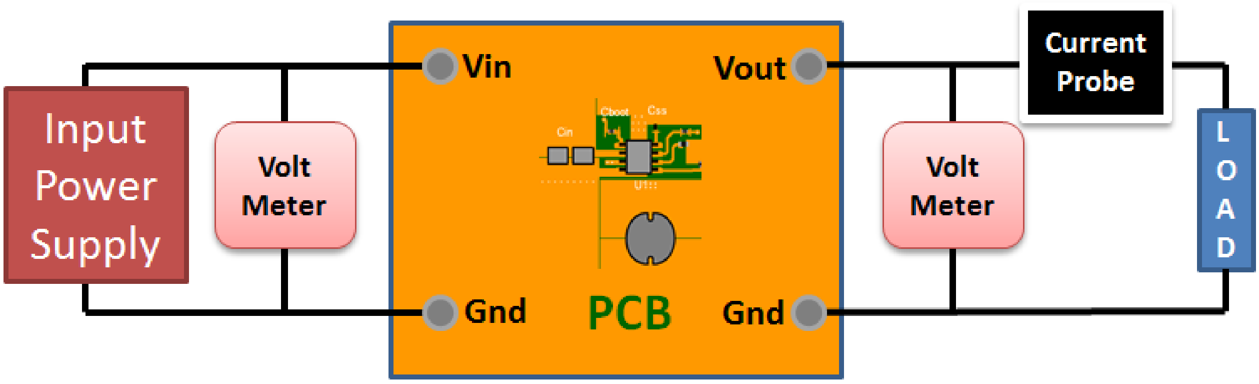
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 130.0V 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.



WEBENCH® Transformer Report

#	Name	Value
1.	Core Part Number	B66317G0000X187
2.	Core Manufacturer	TDK
3.	Coil Former Part Number	B66208X1110T001
4.	Coil Former Manufacturer	TDK

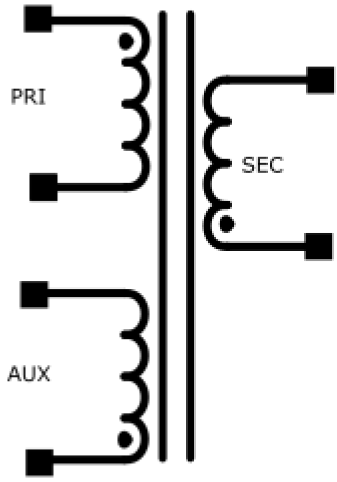
Transformer Electrical Diagram

Primary

Turns	69.0
AWG	31.0
Layers	4.0
Strands	3.0
Insulation Type	Heavy Insulated Magnet Wire

Auxiliary

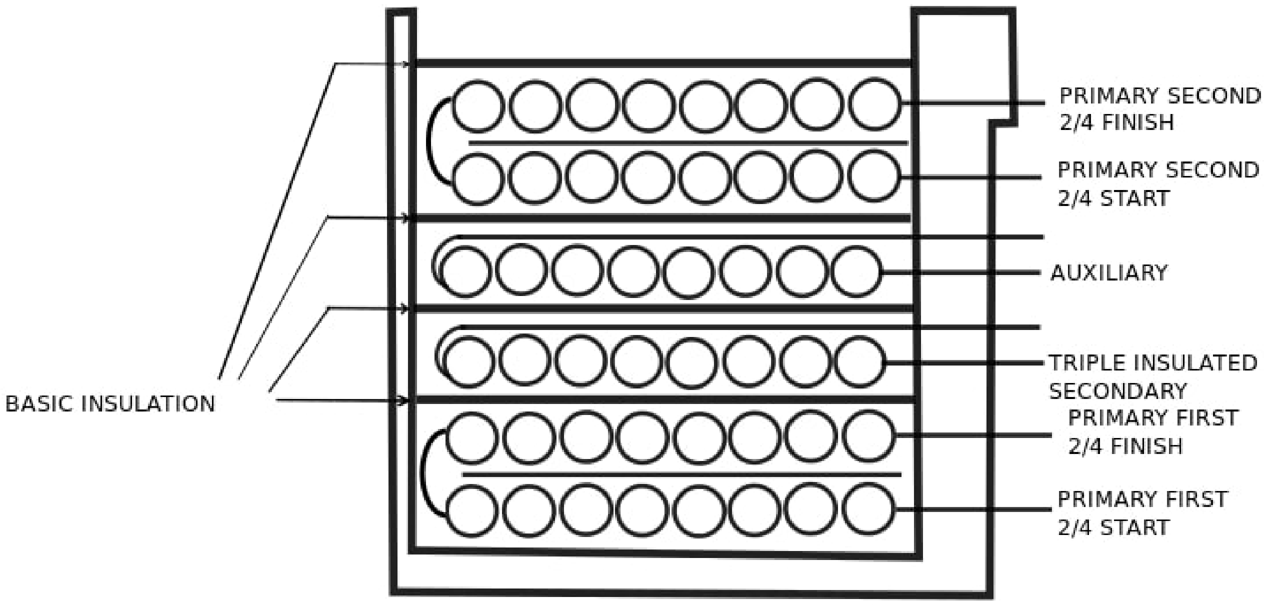
Turns	10.0
AWG	28.0
Layers	1.0
Strands	4.0
Insulation Type	Heavy Insulated Magnet Wire



Secondary

Turns	12.0
AWG	30.0
Layers	1.0
Strands	2.0
Insulation Type	Triple Insulated

Transformer Construction Diagram



Winding Instruction

Winding	AWG	Turns	Winding Orientation
Primary First 2/4.0	31.0	35	Clockwise
Triple Insulated Secondary	30.0	12.0	Counter Clockwise
Auxiliary	28.0	10.0	Counter Clockwise
Primary Second 2/4.0	31.0	34	Clockwise

Transformer Parameters

#	Name	Value
1.	Lpri	6.55E-4H
2.	Inductance Factor(Al)	138.0nH
3.	Npri	69.0
4.	Nsec	12.0
5.	Naux	10.0
6.	Core Type	E25/13/7
7.	Core Material	N87
8.	Bmax	0.21T
9.	Switching Frequency	87.50kHz
10.	DMax	0.49
11.	Ipk(Primary)	1.14A
12.	Irms(Primary)	0.46A
13.	Ipk(Secondary)	6.55A
14.	Irms(Secondary)	2.47A

Design Assistance

1. Application Hints Rbld Rdd is set to 22 Ohms by default. it can be varied between 1 Ohm to 47 Ohms depending on transformer selected and Vdd expected Rg1 is set to 10 Ohms by default, it can be adjusted according to mosfet selected Rbld is used to to set a minimum load for the circuit, so that in standby the output voltage does not float up. The value chosen by WEBENCH should be a good starting point but may need to be adjusted to achieve minimum power dissipation at standby as well. Rlc Rlc provides the function of feed-forward line compensation to eliminate change in IPP due to change in di/dt and the propagation delay of the internal comparator and MOSFET turn-off time. For best results the chosen value may need to be adjusted based on board, FET and transformer parasitics. Rfbt & Rfbb The feedback resistors will set the output voltage of the circuit. The values chosen may need to be fined tuned based on the final Transformer turns ratios and the voltage across the output diode at close to zero current. Cdd Cdd supplies the device operating current until the output of the converter reaches the target minimum operating voltage. The value calculated by WEBENCH for Cdd is a good starting point since it assumes that the output current of the Flyback is available to charge the output capacitance until the minimum output voltage is acheived, but may need to be adjusted. Part Description The UCC28700 family of flyback power supply controllers provides Constant-Voltage (CV) and Constant-Current (CC) output regulation. Primary-Side Regulation (PSR) eliminates the use of an Opto-Coupler. Please see the datasheet for further design guidance(For non Q1 parts). http://www.ti.com/lit/ds/symlink/ucc28700.pdfFor non Q1 partshttp://www.ti.com/lit/ds/symlink/ucc28700-q1.pdf

2. Master key : 3A81EC28EDE504E4[v1]

3. **UCC28700** Product Folder : http://www.ti.com/product/UCC28700 : contains the data sheet and other resources.