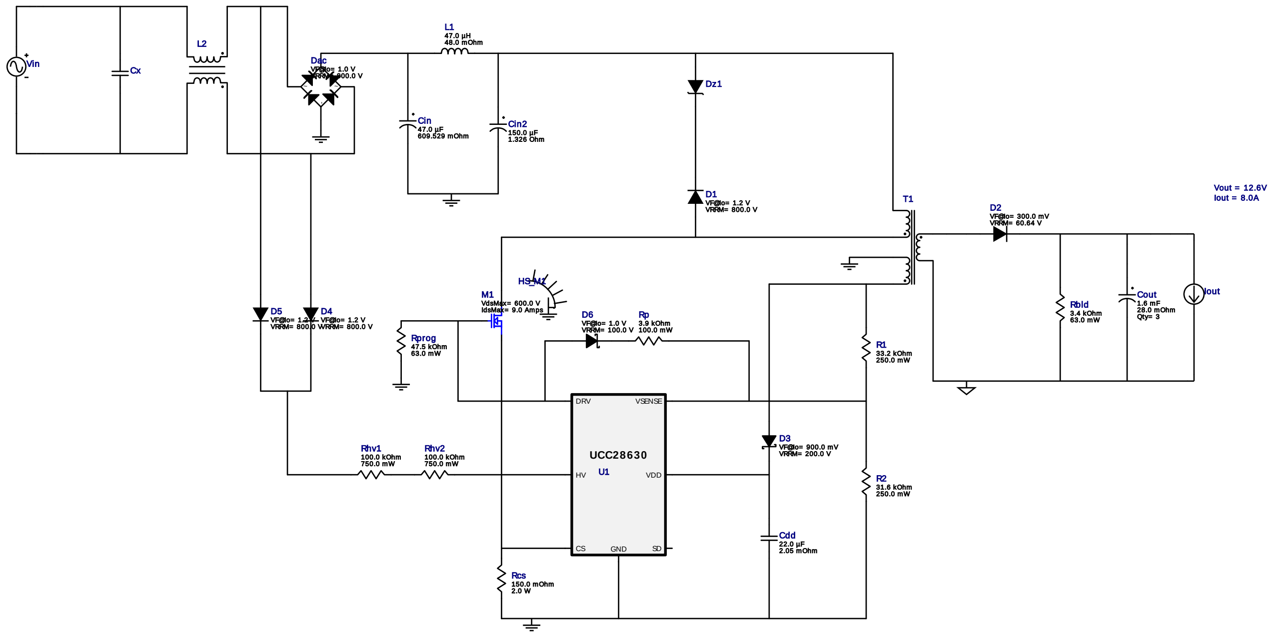
Texas Instruments

WEBENCH ® Design Report

VinMin = 90.0V
VinMax = 265.0V
Vout = 12.6V
Iout = 8.0A

Device = UCC28630DR
Topology = Flyback
Created = 2020-02-02 04:52:20.248
BOM Cost = NA
BOM Count = 27
Total Pd = 18.78W

Design : 31 UCC28630DR
UCC28630DR 90V-265V to 12.60V @ 8A



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. For more information please click the design assistance button.

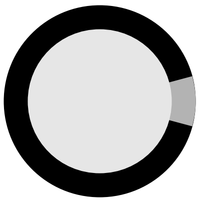
2. Click on the transformer symbol and select 'Design Transformer' to design using specific transformer cores and bobbin

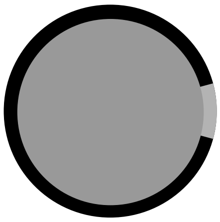
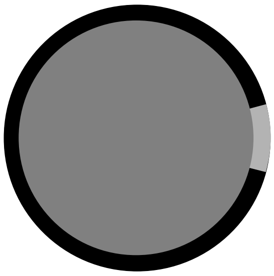
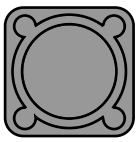
Design Alerts

Component Selection Information

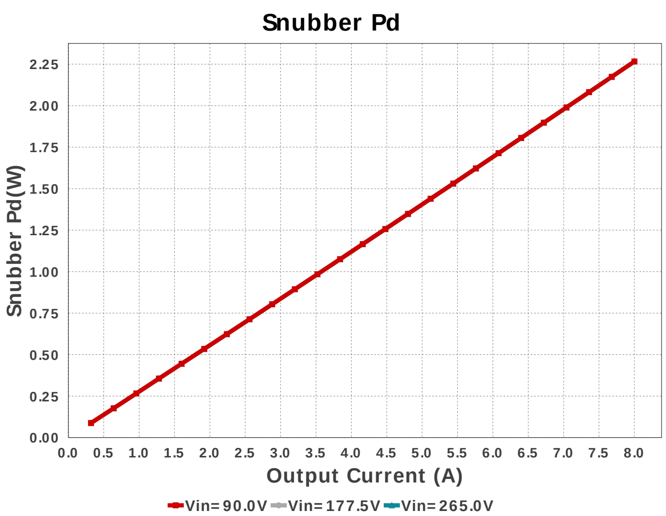
Click on the transformer symbol in the schematic and select "Explore Transformer Core/Bobbin Selection" to design using specific transformer cores and bobbin.

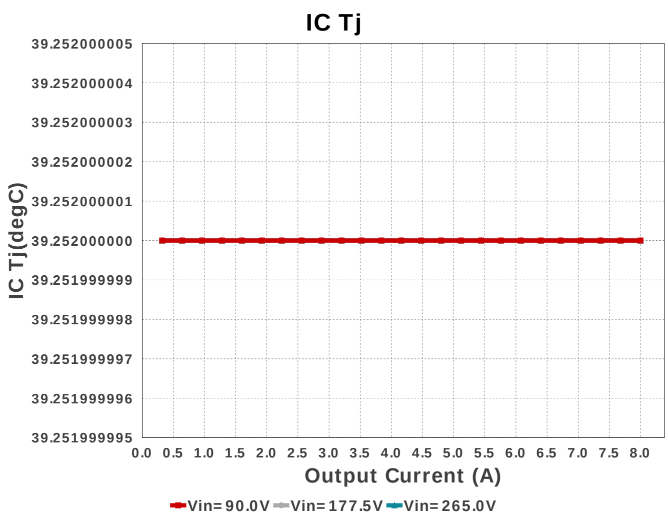
Electrical BOM

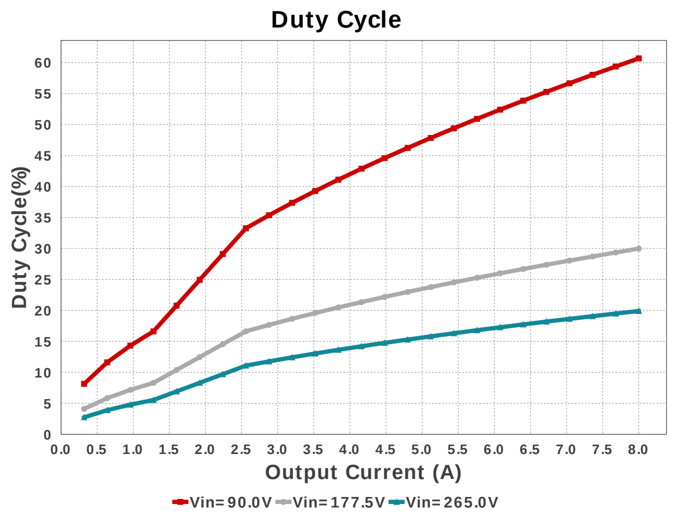
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cdd	TDK	C2012X5R1V226M125AC Series= X5R	Cap= 22.0 uF ESR= 2.05 mOhm VDC= 35.0 V IRMS= 4.5559 A	1	$0.33	0805 7 mm^2
Cin	Panasonic	EEUED2G470S Series= ED	Cap= 47.0 uF ESR= 609.53 mOhm VDC= 400.0 V IRMS= 840.0 mA	1	$0.73	 CAPPR7.5-18X20 400 mm^2

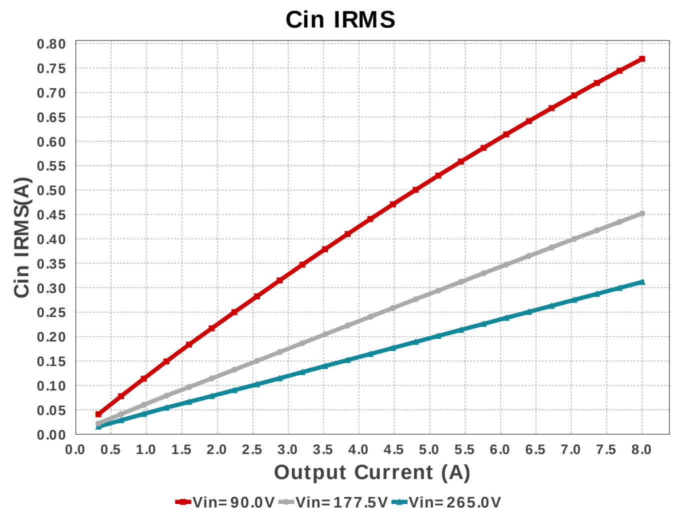
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cin2	Nichicon	LLS2G151MELY Series= 2387	Cap= 150.0 uF ESR= 1.326 Ohm VDC= 400.0 V IRMS= 1.22 A	1	$1.53	 Nichicon_2000x4000_Snap 484 mm^2
Cout	TDK	B41607A8168M008 Series= 2360	Cap= 1.6 mF ESR= 28.0 mOhm VDC= 63.0 V IRMS= 14.5 A	3	$4.79	 B41607_2500x5000_8 729 mm^2
D1	Microsemi	UFS180JE3/TR13	VF@Io= 1.2 V VRRM= 800.0 V	1	$0.73	 DO-214BA 42 mm^2
D2	CUSTOM	CUSTOM	VF@Io= 300.0 mV VRRM= 60.64 V	1	NA	CUSTOM 0 mm^2
D3	SMC Diode Solutions	SK220ATR	VF@Io= 900.0 mV VRRM= 200.0 V	1	$0.04	 SMA 37 mm^2
D4	Microsemi	UFS180JE3/TR13	VF@Io= 1.2 V VRRM= 800.0 V	1	$0.73	 DO-214BA 42 mm^2
D5	Microsemi	UFS180JE3/TR13	VF@Io= 1.2 V VRRM= 800.0 V	1	$0.73	 DO-214BA 42 mm^2
D6	Comchip Technology	CDBW46-G	VF@Io= 1.0 V VRRM= 100.0 V	1	$0.03	 SOD-123 13 mm^2
Dac	Vishay-Semiconductor	GBU4K-E3/45	VF@Io= 1.0 V VRRM= 800.0 V	1	$0.68	 GBU 131 mm^2
Dz1	Diodes Inc.	SMBJ150A-13-F	Zener	1	$0.09	 SMB 44 mm^2
HS_M1	Aavid	576602B00000G	Heatsink	1	$0.59	 576602 403 mm^2
L1	Coilcraft	MSS1210-473MEB	L= 47.0 µH 48.0 mOhm	1	$0.81	 MSS1210 204 mm^2

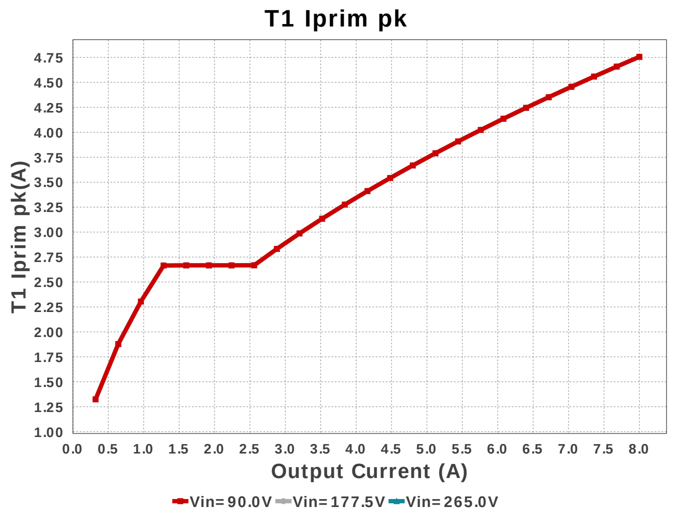
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
M1	Infineon Technologies	IPP60R385CPXKSA1	VdsMax= 600.0 V IdsMax= 9.0 Amps	1	$1.39	TO-220AB 79 mm²
R1	Vishay-Dale	CMF5033K200FHEB Series= CMF50	Res= 33.2 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.20	CMF50 46 mm²
R2	Vishay-Dale	CMF5031K600FHEB Series= CMF50	Res= 31.6 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.20	CMF50 46 mm²
Rbld	Vishay-Dale	CRCW04023K40FKED Series= CRCW..e3	Res= 3.4 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rcs	Stackpole Electronics Inc	CSRN2512FKR150 Series= ?	Res= 150.0 mOhm Power= 2.0 W Tolerance= 1.0%	1	$0.13	2512 43 mm²
Rhv1	Vishay-Dale	CRCW2010100KJNEF Series= CRCW..e3	Res= 100.0 kOhm Power= 750.0 mW Tolerance= 5.0%	1	$0.03	2010 32 mm²
Rhv2	Vishay-Dale	CRCW2010100KJNEF Series= CRCW..e3	Res= 100.0 kOhm Power= 750.0 mW Tolerance= 5.0%	1	$0.03	2010 32 mm²
Rp	Yageo	RC0603FR-073K9L Series= ?	Res= 3.9 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rprog	Vishay-Dale	CRCW040247K5FKED Series= CRCW..e3	Res= 47.5 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
T1	Core=Wurth Elektronik , CoilFormer=Wurth Elektronik	Core=150-2239 , CoilFormer=070-5649	Lp= 167.0 µH Turns Ratio(Nas)= 5:4 Turns Ratio(Nps)= 29:4 Npri= 29.0 Naux= 5.0 Nsec= 4.0	1	NA	PQ2625 1009 mm²
U1	Texas Instruments	UCC28630DR	Switcher	1	$0.68	R-PDSO-G7 55 mm²

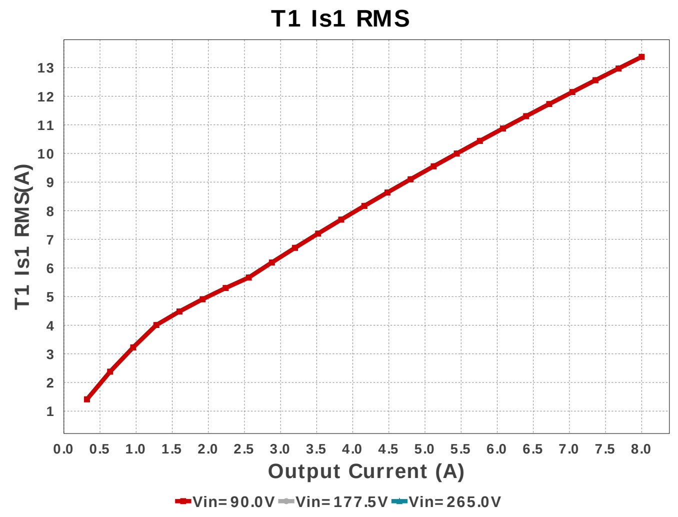


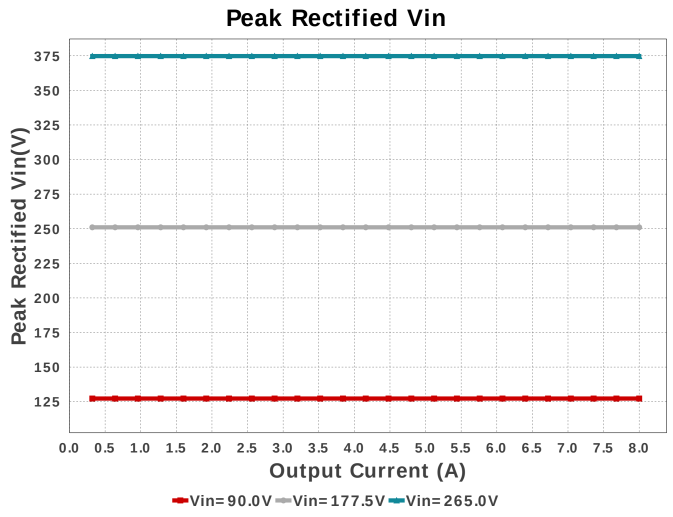


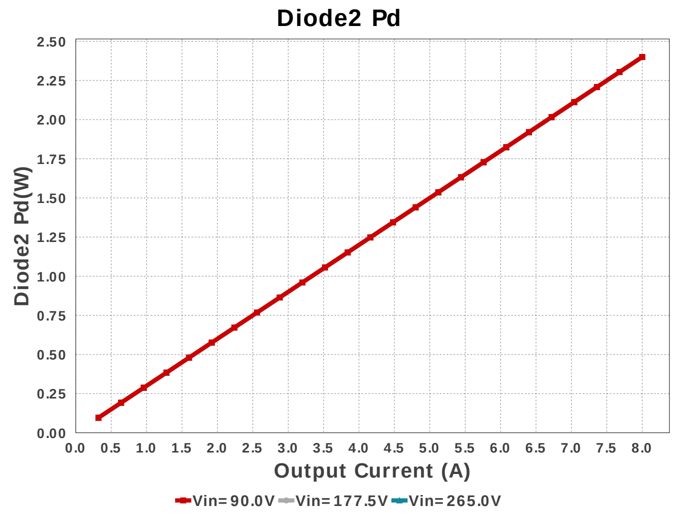

Duty Cycle
Duty Cycle(%)
Output Current (A)
Vin=90.0V Vin=177.5V Vin=265.0V

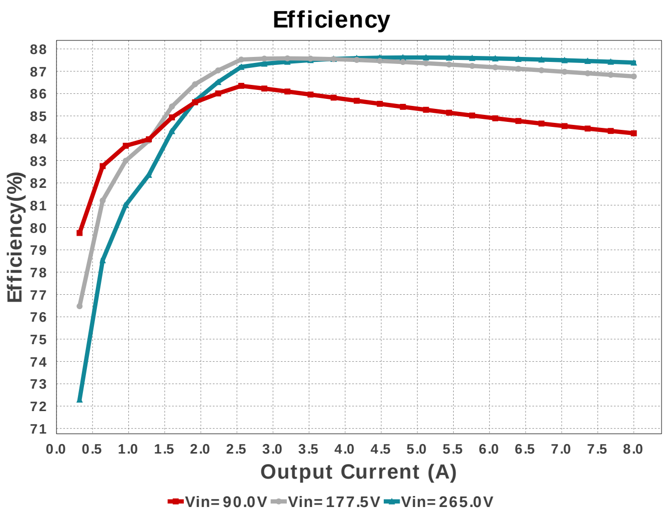

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=90.0V Vin=177.5V Vin=265.0V

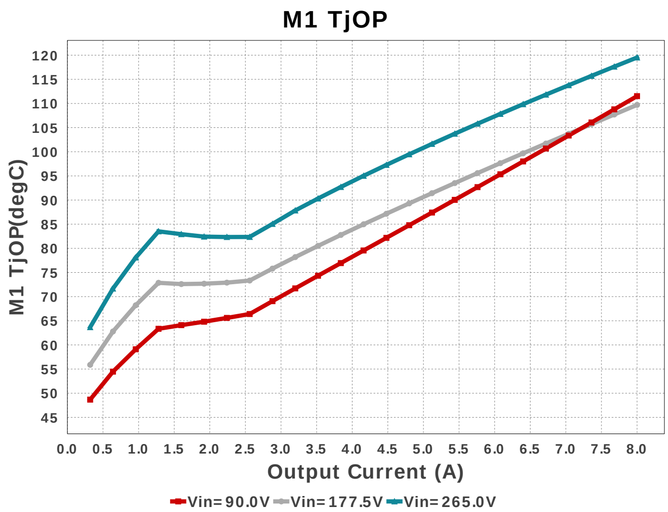

T1 Iprim pk
T1 Iprim pk(A)
Output Current (A)
Vin=90.0V Vin=177.5V Vin=265.0V

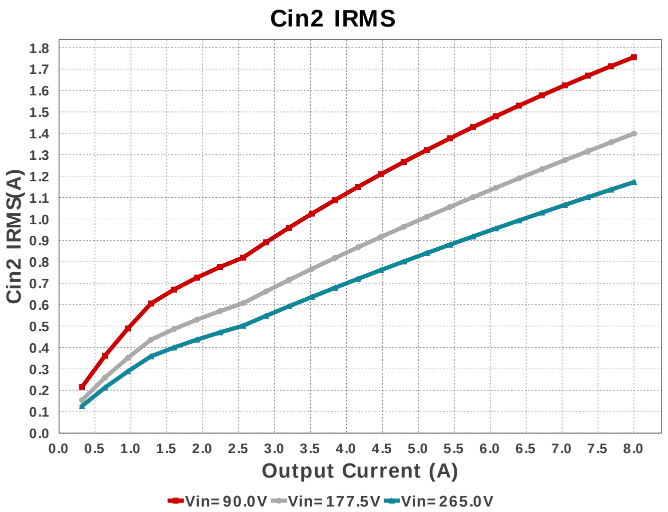

T1 Is1 RMS
T1 Is1 RMS(A)
Output Current (A)
Vin=90.0V Vin=177.5V Vin=265.0V

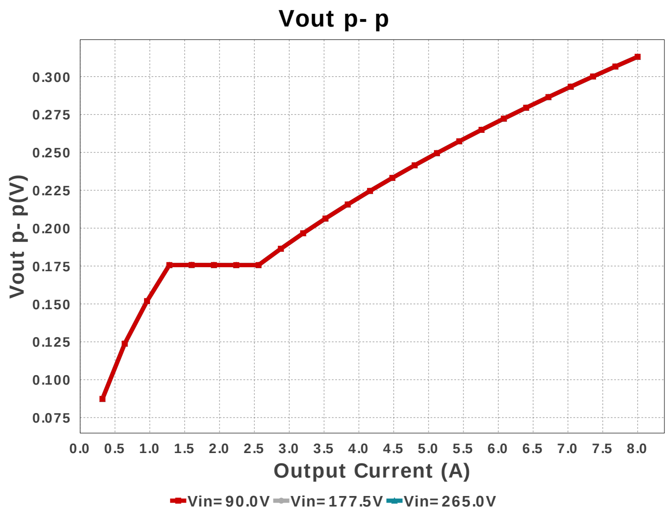

Peak Rectified Vin
Peak Rectified Vin(V)
Output Current (A)
Vin=90.0V Vin=177.5V Vin=265.0V

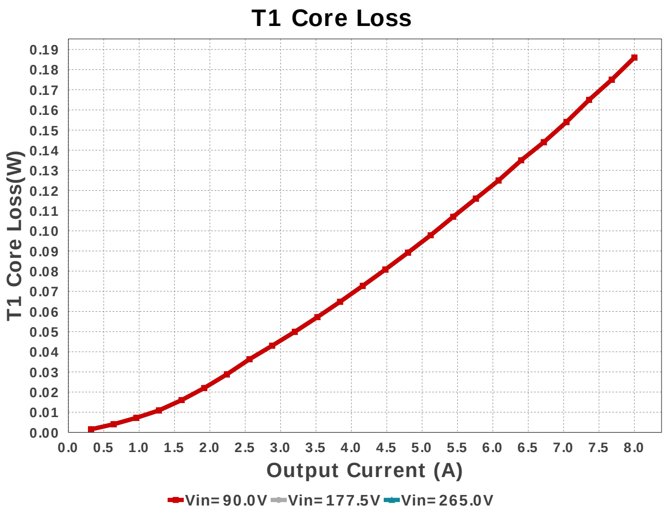

Diode2 Pd
Diode2 Pd(W)
Output Current (A)
Vin=90.0V Vin=177.5V Vin=265.0V

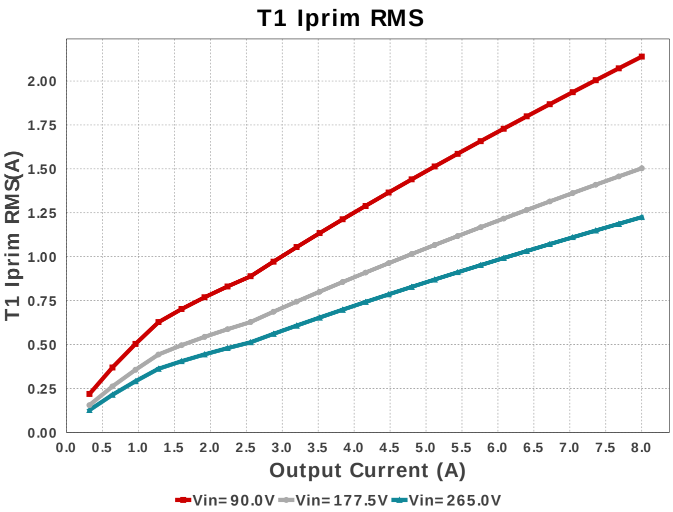

Efficiency
Efficiency(%)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V


M1 TjOP
M1 TjOP(degC)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V

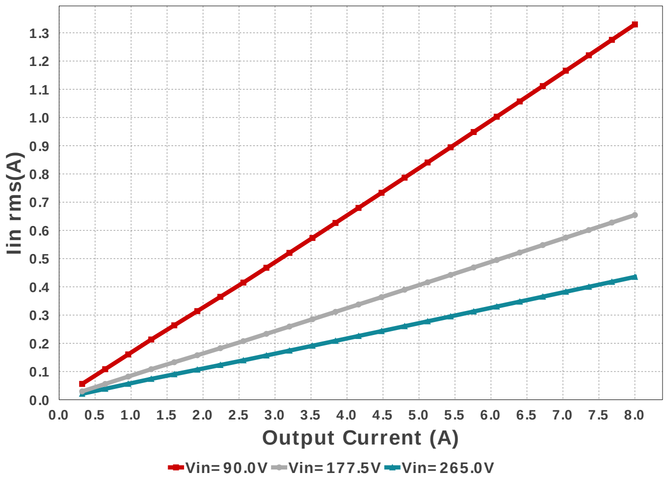

Cin2 IRMS
Cin2 IRMS(A)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V


Vout p- p
Vout p- p(V)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V

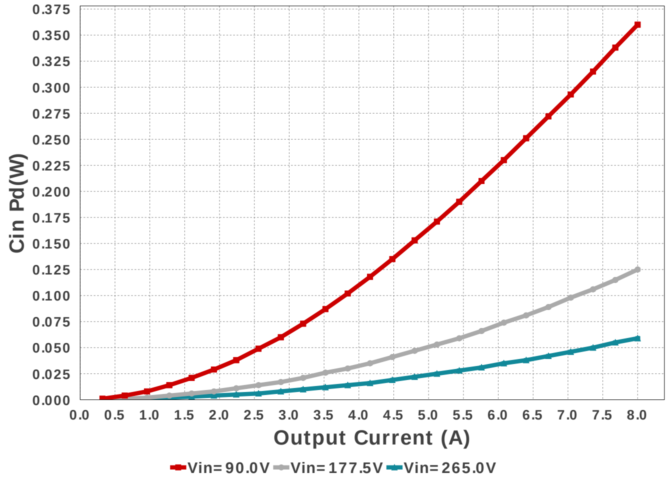

T1 Core Loss
T1 Core Loss(W)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V


T1 Iprim RMS
T1 Iprim RMS(A)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V

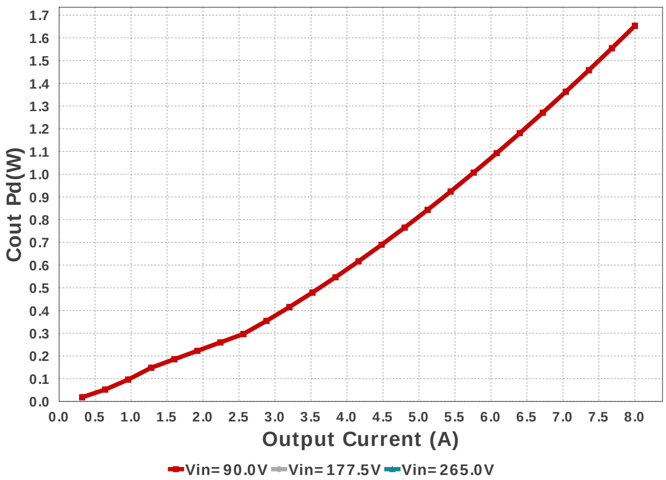
Iin rms



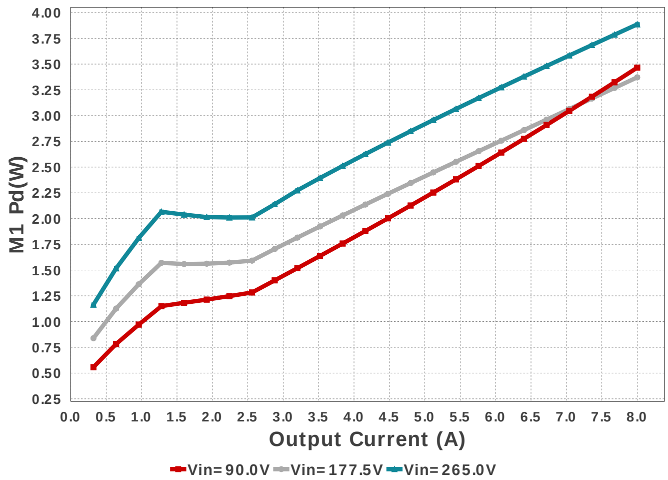
Cin Pd



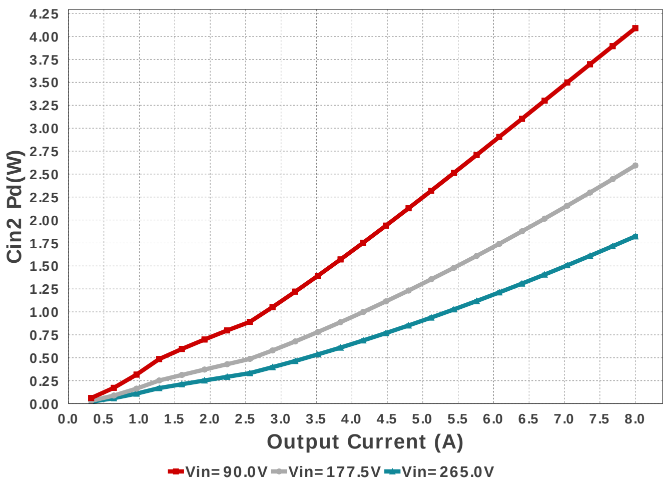
Cout Pd



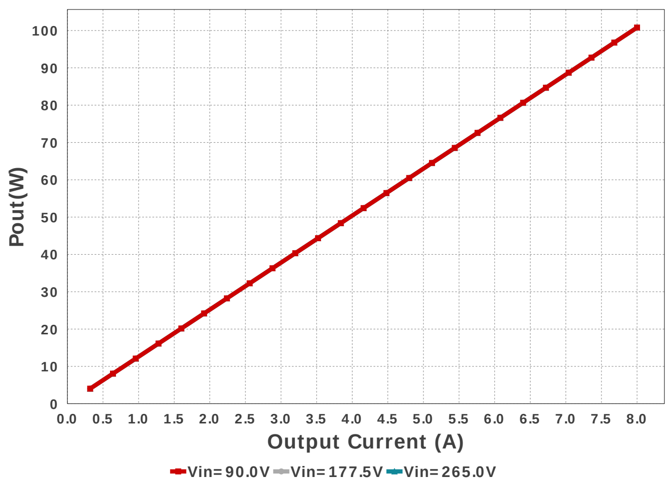
M1 Pd

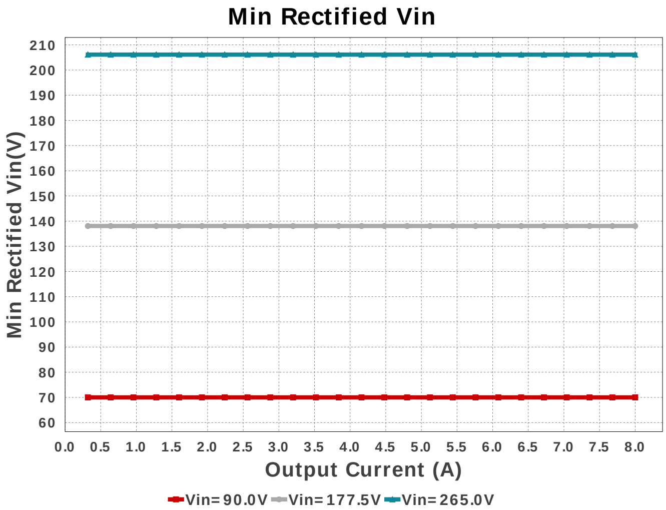


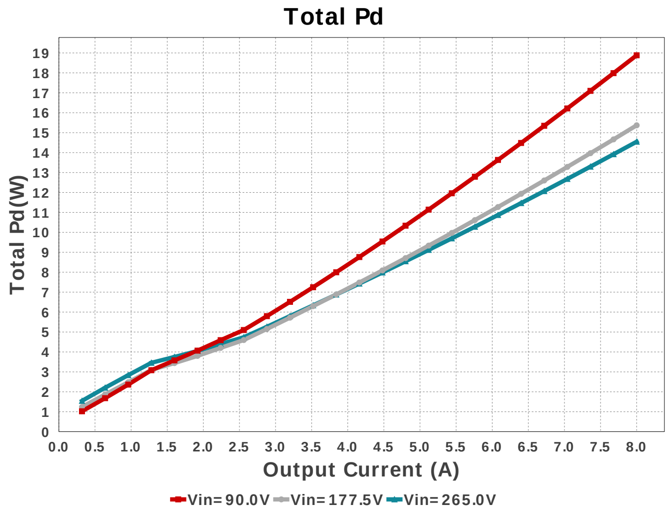
Cin2 Pd

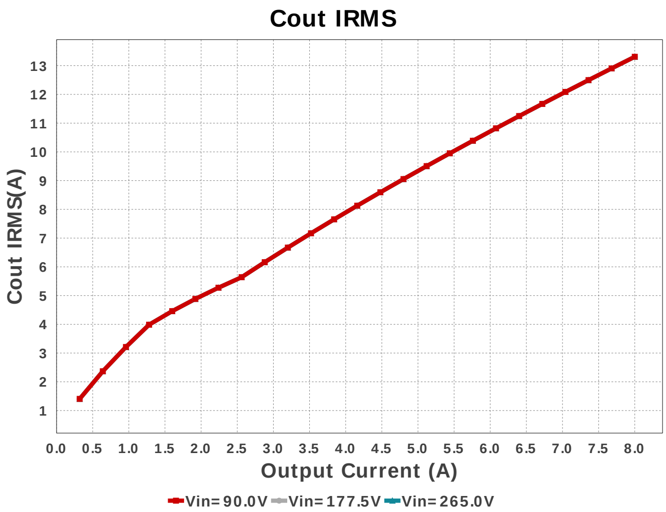


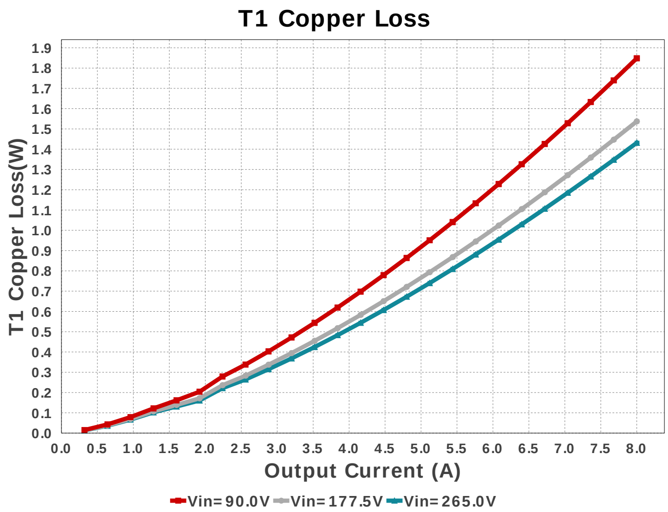
Pout

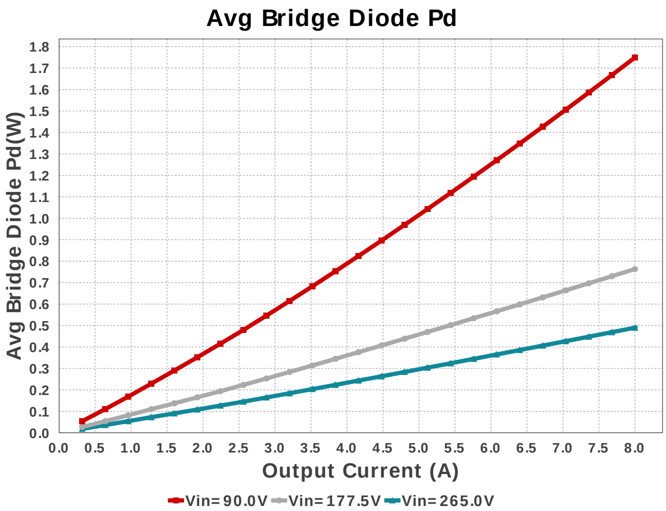


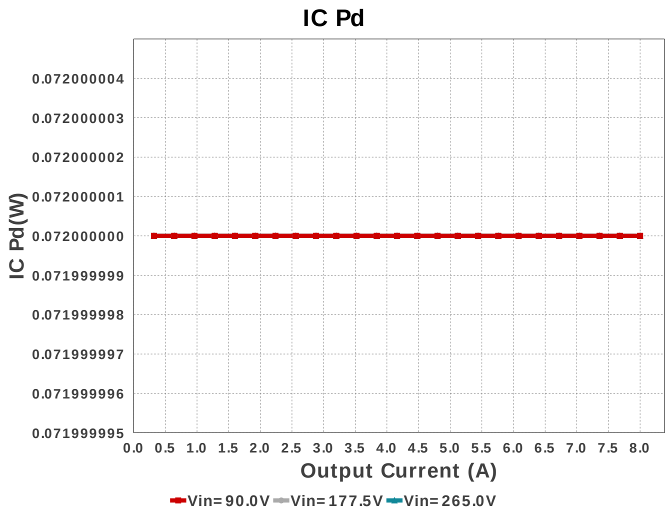

Min Rectified Vin
Min Rectified Vin(V)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V

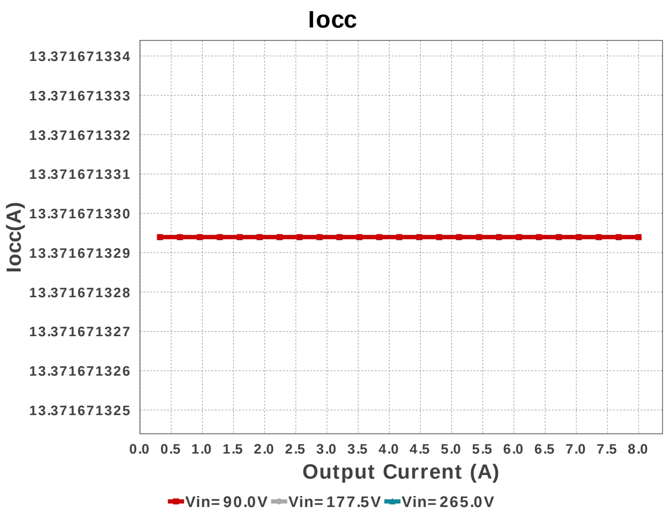

Total Pd
Total Pd(W)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V

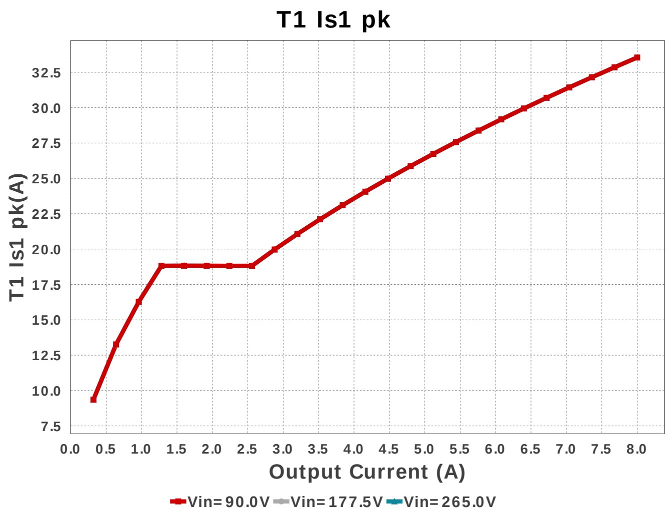

Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V

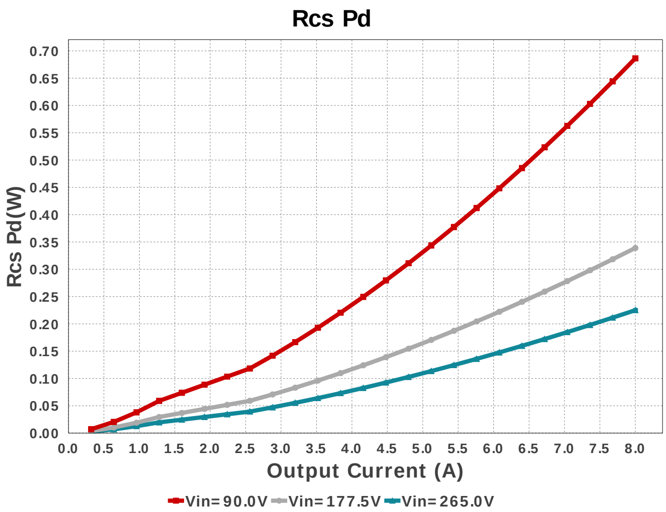

T1 Copper Loss
T1 Copper Loss(W)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V

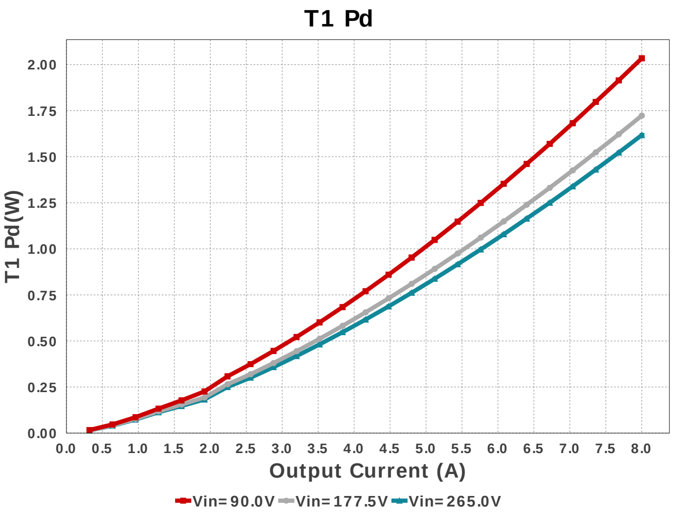

Avg Bridge Diode Pd
Avg Bridge Diode Pd(W)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V


IC Pd
IC Pd(W)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V









Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	768.174 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	360.0 mW	Capacitor	Input capacitor power dissipation
3.	Cin2 IRMS	1.757 A	Capacitor	Input Capacitor Cin2 RMS Ripple Current
4.	Cin2 Pd	4.094 W	Capacitor	Average Power Dissipation in the Input Capacitor Cin2
5.	Cout IRMS	13.316 A	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	1.655 W	Capacitor	Output capacitor power dissipation
7.	Avg Bridge Diode Pd	1.743 W	Diode	Average Power Dissipation in the Bridge Diode over the AC Line Period
8.	Diode2 Pd	2.4 W	Diode	Diode2 power dissipation
9.	IC Pd	72.0 mW	IC	IC power dissipation
10.	IC Tj	39.252 degC	IC	IC junction temperature
11.	ICThetaJA	128.5 degC/W	IC	IC junction-to-ambient thermal resistance
12.	M1 Pd	3.467 W	Mosfet	M1 MOSFET total power dissipation
13.	M1 TjOP	111.55 degC	Mosfet	M1 MOSFET junction temperature
14.	Avg Bridge Diode Pd	1.743 W	Power	Average Power Dissipation in the Bridge Diode over the AC Line Period
15.	Cin Pd	360.0 mW	Power	Input capacitor power dissipation
16.	Cin2 Pd	4.094 W	Power	Average Power Dissipation in the Input Capacitor Cin2
17.	Cout Pd	1.655 W	Power	Output capacitor power dissipation
18.	Diode2 Pd	2.4 W	Power	Diode2 power dissipation
19.	IC Pd	72.0 mW	Power	IC power dissipation
20.	M1 Pd	3.467 W	Power	M1 MOSFET total power dissipation
21.	Rcs Pd	687.05 mW	Power	Current Limit Sense Resistor Power Dissipation
22.	Snubber Pd	2.266 W	Power	Snubber Power Dissipation
23.	T1 Copper Loss	1.723 W	Power	Transformer Copper Loss Power Dissipation
24.	T1 Core Loss	204.0 mW	Power	Transformer Core Loss Power Dissipation
25.	T1 Pd	1.927 W	Power	Estimated Losses in Transformer
26.	Total Pd	18.778 W	Power	Total Power Dissipation
27.	Rcs Pd	687.05 mW	Resistor	Current Limit Sense Resistor Power Dissipation
28.	BOM Count	27	System Information	Total Design BOM count
29.	Duty Cycle	60.64 %	System Information	Duty cycle

#	Name	Value	Category	Description
30.	Efficiency	84.296 %	System Information	Steady state efficiency
31.	FootPrint	5.487 k mm^2	System Information	Total Foot Print Area of BOM components
32.	Frequency	60.0 kHz	System Information	Switching frequency
33.	Iin rms	1.329 A	System Information	RMS Input Current
34.	Iocc	14.481 A	System Information	Constant Current Limit
35.	Iout	8.0 A	System Information	Iout operating point
36.	Min Rectified Vin	70.003 V	System Information	Minimum voltage seen at rectified input
37.	Mode	DCM	System Information	Conduction Mode
38.	Peak Rectified Vin	127.278 V	System Information	Peak voltage seen at rectified input
39.	Pout	100.8 W	System Information	Total output power
40.	Total BOM	NA	System Information	Total BOM Cost
41.	Vin_RMS	90.0 V	System Information	Vin operating point
42.	Vout	12.6 V	System Information	Operational Output Voltage
43.	Vout p-p	313.415 mV	System Information	Peak-to-peak output ripple voltage
44.	T1 Copper Loss	1.723 W	Transformer	Transformer Copper Loss Power Dissipation
45.	T1 Core Loss	204.0 mW	Transformer	Transformer Core Loss Power Dissipation
46.	T1 Iprim RMS	2.14 A	Transformer	Transformer Primary RMS Current
47.	T1 Iprim pk	4.76 A	Transformer	Transformer Primary Peak Current
48.	T1 Is1 RMS	13.383 A	Transformer	Transformer Secondary1 RMS Current
49.	T1 Is1 pk	33.58 A	Transformer	Transformer Secondary1 Peak Current
50.	T1 Pd	1.927 W	Transformer	Estimated Losses in Transformer

Design Inputs

Name	Value	Description
Iout	8.0	Maximum Output Current
VinMax	265.0	Maximum input voltage
VinMin	90.0	Minimum input voltage
Vout	12.6	Output Voltage
acFrequency	50.0	AC Frequency
base_pn	UCC28630	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

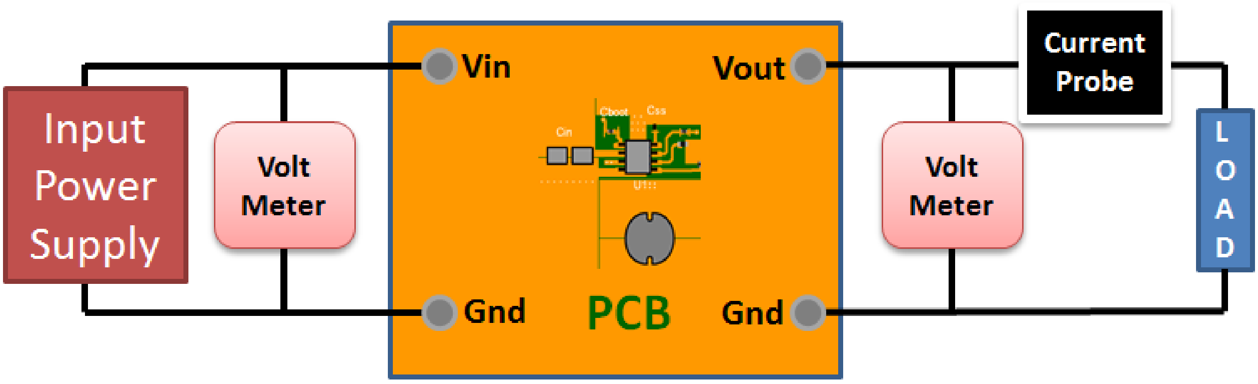
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 90.0V 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	150-2239
2.	Core Manufacturer	Wurth Elektronik
3.	Coil Former Part Number	070-5649
4.	Coil Former Manufacturer	Wurth Elektronik

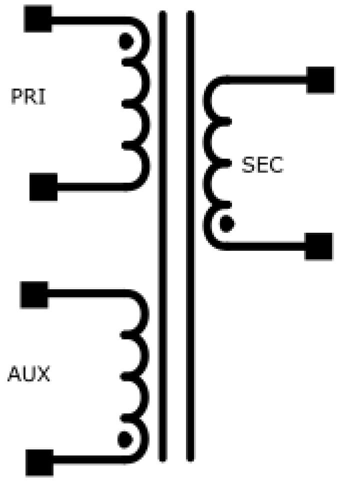
Transformer Electrical Diagram

Primary

Turns	29.0
AWG	24.0
Layers	4.0
Strands	3.0
Insulation Type	Heavy Insulated Magnet Wire

Auxiliary

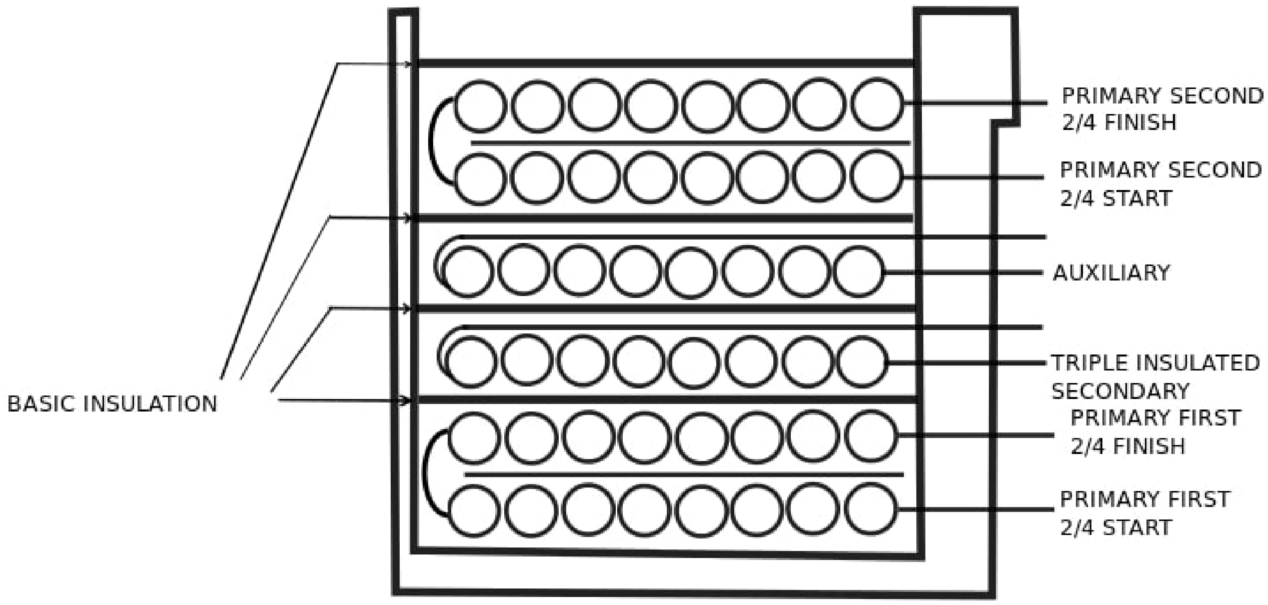
Turns	5.0
AWG	28.0
Layers	1.0
Strands	4.0
Insulation Type	Heavy Insulated Magnet Wire



Secondary

Turns	4.0
AWG	25.0
Layers	1.0
Strands	4.0
Insulation Type	Triple Insulated

Transformer Construction Diagram



Winding Instruction

Winding	AWG	Turns	Winding Orientation
Primary First 2/4.0	24.0	15	Clockwise
Triple Insulated Secondary	25.0	4.0	Counter Clockwise
Auxiliary	28.0	5.0	Counter Clockwise
Primary Second 2/4.0	24.0	14	Clockwise

Transformer Parameters

#	Name	Value
1.	Lpri	1.67E-4H
2.	Inductance Factor(Al)	199.0nH
3.	Npri	29.0
4.	Nsec	4.0
5.	Naux	5.0
6.	Core Type	PQ2625
7.	Core Material	TP4A
8.	Bmax	0.24T
9.	Switching Frequency	60.00kHz
10.	DMax	0.56
11.	Ipk(Primary)	4.92A
12.	Irms(Primary)	2.13A
13.	Ipk(Secondary)	35.7A
14.	Irms(Secondary)	13.7A

Design Assistance

1. Leakage inductance is considered as 2% of Primary inductance

2. Application Hints High Power Operation The UCC28630 allows a peak power delivery up to 200% the nominal rating with only a modest increase in peak current. The combination of up to 2x frequency increase and 1.25x peak current increase in CCM allows up to 2x peak power delivery capability for a given transformer size. Rbld 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. Active X-Cap Discharge The X-capacitor discharge function discharges the X-capacitor to the SELV 60V level in 1 sec. When adjusting the components for the design, ensure that the bulk capacitance value is not too large for the power level desired, which ensures that the bulk capacitor discharge rate is fast enough to discharge the X-capacitor to meet the 1-second discharge target. The VSENSE terminal In order to protect the VSENSE terminal from excessive negative current, an additional series limiting resistor and clamping diode can be added on the VSENSE terminal. The DRV pull up diode can be combined with the clamping diode in a single package common-cathode diode to reduce the component count of the circuit (see Figure 24 in the datasheet for illustration). Magnetic Sense Resistor Network When adjusting components for the design, check that the equivalent Thevenin resistance (Rth) of the R1/R2 falls within the required range of 10kOhm and 20kOhm. If the Rth is outside of this range, it triggers the VSENSE terminal open or short terminal check at start-up. Peak Current Mode Control and the CS Terminal Depending on the PCB layout, an additional RC filter may be required on the CS terminal, as show in Figure 30 of the datasheet. The capacitor, Ccs, should be positioned as close as possible to terminals 3 and 4 and tracked directly to the terminals. Rcs2 should also be located close to terminal 3 to minimize noise, and should not exceed 20kOhms since larger values could be detected as a possible open circuit on the CS terminal during the start-up terminal checks. The time constant for this RC filter should no be excessive so that the filter does not reduce the measured peak current. Typical time values would fall between 100ns and 200ns. Primary-Side Overload Timer An internal overload timer tracks the power stage thermal stress and protects the power stage against output overload. The overload timer trip level and time constant are both selectable from a defined list of combinations (See Table 1 in datasheet for combinations), and is set using a pull-down resistance, Rprog, on the DRV terminal. The values of the Rprog resistor that corresponds to specific trip levels and time constants can also be seen in Table 1 in the datasheet. Please see the datasheet for further design guidance and recommendations. http://www.ti.com/lit/ds/symlink/ucc28630.pdf

3. Master key : 5E76CE7B44FBB6CA[v1]

4. **UCC28630** Product Folder : http://www.ti.com/product/UCC28630 : contains the data sheet and other resources.

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