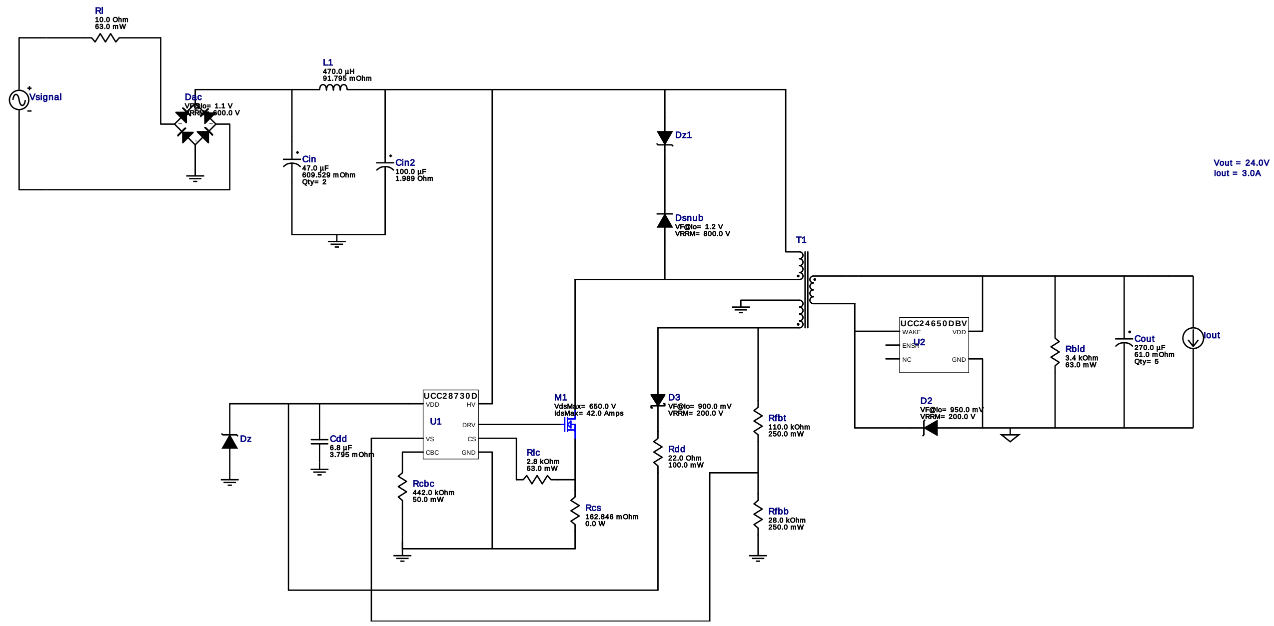
VinMin = 85.0V
VinMax = 265.0V
Vout = 24.0V
Iout = 3.0A

Device = UCC28730DR
Topology = Flyback
Created = 2024-01-06 13:34:51.617
BOM Cost = NA
BOM Count = 28
Total Pd = 30.28W

WEBENCH ® Design Report

Design : 16 UCC28730DR
UCC28730DR 85V-265V to 24.00V @ 3A



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

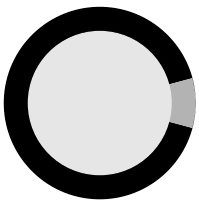
Design Alerts

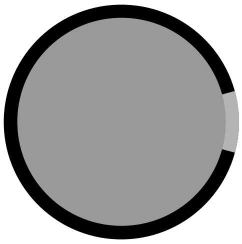
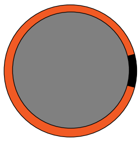
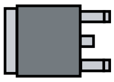
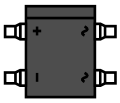
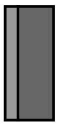
Component Selection Information

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

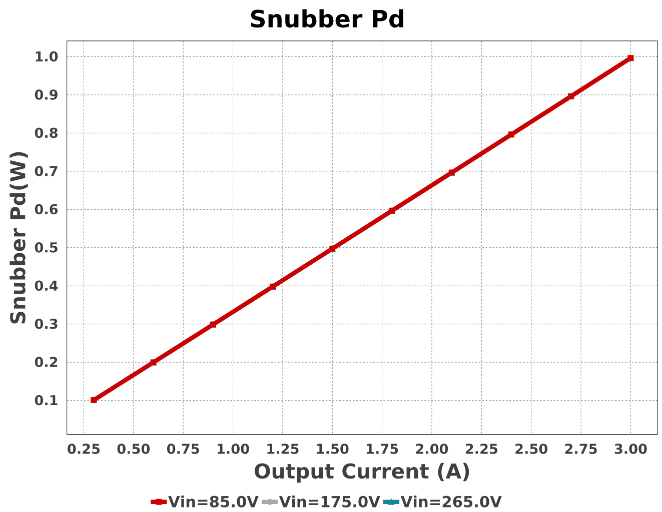
Electrical BOM

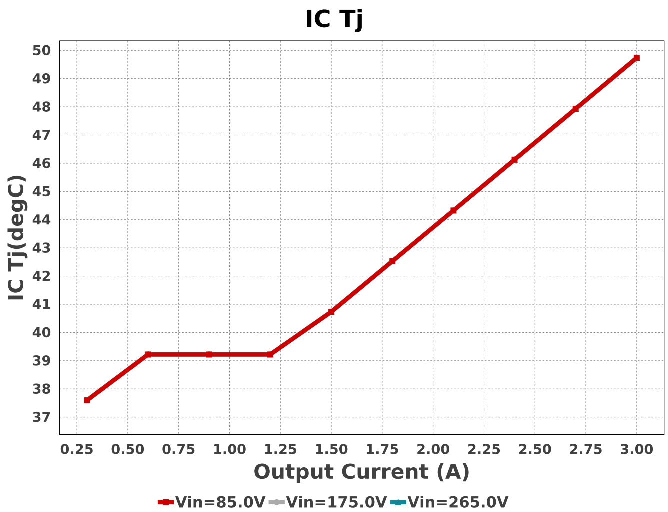
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cdd	TDK	C2012X5R1V685K125AC Series= X5R	Cap= 6.8 uF ESR= 3.795 mOhm VDC= 35.0 V IRMS= 3.3493 A	1	$0.17	0805 7 mm^2
Cin	Panasonic	EEUED2G470S Series= ED	Cap= 47.0 uF ESR= 609.53 mOhm VDC= 400.0 V IRMS= 840.0 mA	2	$1.05	CAPPR7.5-18X20 400 mm^2

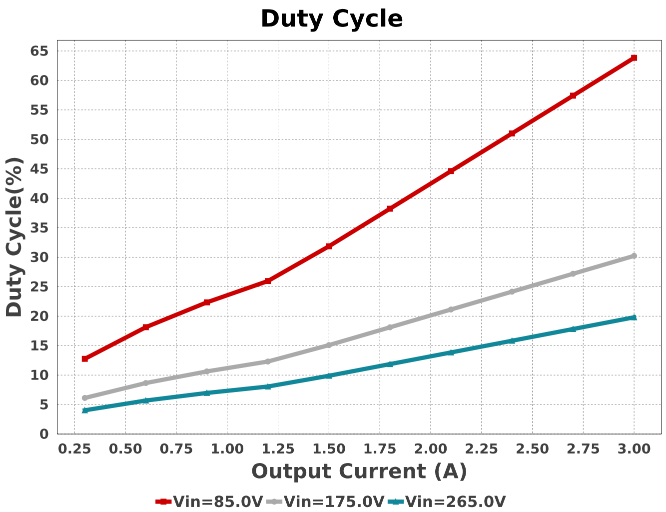


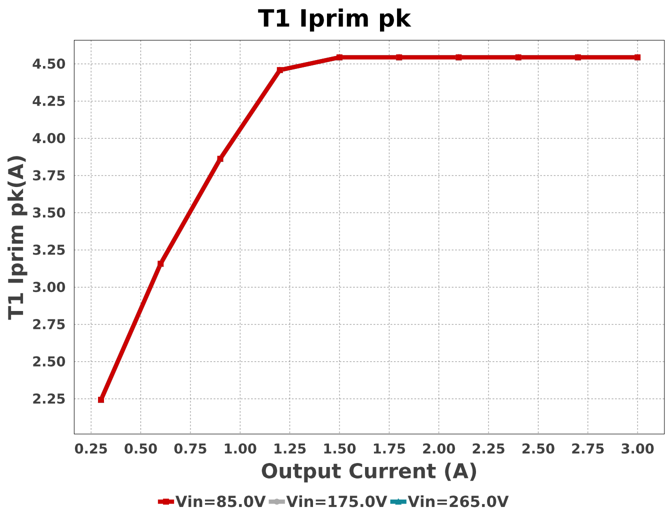
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cin2	Nichicon	LLS2G101MELZ Series= 2387	Cap= 100.0 uF ESR= 1.989 Ohm VDC= 400.0 V IRMS= 950.0 mA	1	$1.09	 Nichicon_2200x2500_Snap 576 mm²
Cout	TDK	B41896C6277M000 Series= 2355	Cap= 270.0 uF ESR= 61.0 mOhm VDC= 50.0 V IRMS= 1.82 A	5	$1.57	 B41896_1250x2000 210 mm²
D2	SMC Diode Solutions	SBRD10200TR	VF@Io= 950.0 mV VRRM= 200.0 V	1	$0.18	 DPAK 102 mm²
D3	SMC Diode Solutions	SK220ATR	VF@Io= 900.0 mV VRRM= 200.0 V	1	$0.06	 SMA 37 mm²
Dac	Diodes Inc.	DF1506S-T	VF@Io= 1.1 V VRRM= 600.0 V	1	$0.24	 DF-S 99 mm²
Dsnub	Microsemi	UFS180JE3/TR13	VF@Io= 1.2 V VRRM= 800.0 V	1	$0.95	 DO-214BA 42 mm²
Dz	Diodes Inc.	SMBJ22A-13-F	Zener	1	$0.10	 SMB 44 mm²
Dz1	ON Semiconductor	1SMB5952BT3G	Zener	1	$0.11	 SMB 44 mm²
L1	Wurth Elektronik	74437529203471	L= 470.0 µH 91.795 mOhm	1	$6.72	WE-HCF Round_2920 0 mm²
M1	STMicroelectronics	STP57N65M5	VdsMax= 650.0 V IdsMax= 42.0 Amps	1	$8.98	 TO-220AB 79 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	CUSTOM	CUSTOM Series= ?	Res= 162.846 mOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm²
Rdd	Yageo	RC0603FR-0722RL Series= ?	Res= 22.0 Ohm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rfbb	Vishay-Dale	CMF5028K000FHEB Series= CMF50	Res= 28.0 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.33	CMF50 46 mm²
Rfbt	Vishay-Dale	CMF50110K00FHEB Series= CMF50	Res= 110.0 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.52	CMF50 46 mm²

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rl	Vishay-Dale	CRCW040210R0FKED Series= CRCW..e3	Res= 10.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rlc	Vishay-Dale	CRCW04022K80FKED Series= CRCW..e3	Res= 2.8 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
T1	Core=TDK , CoilFormer=TDK	Core=B66317G0000X187 , CoilFormer=B66208X1110T001	Lp= 143.0 µH Turns Ratio(Nas)= 8:10 Turns Ratio(Nps)= 32:10 Npri= 32.0 Naux= 8.0 Nsec= 10.0	1	$0.30	TDK_B66305 569 mm^2
U1	Texas Instruments	UCC28730DR	Switcher	1	$0.46	D0007A 55 mm^2
U2	Texas Instruments	UCC24650DBVR	Switcher	1	$0.16	MPDS018R 15 mm^2

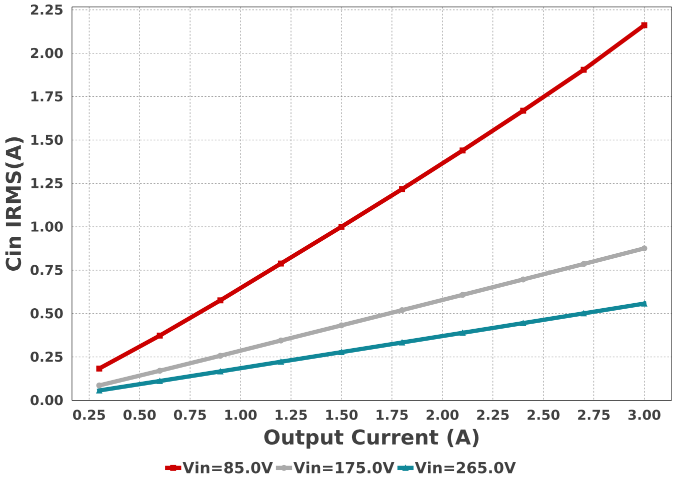




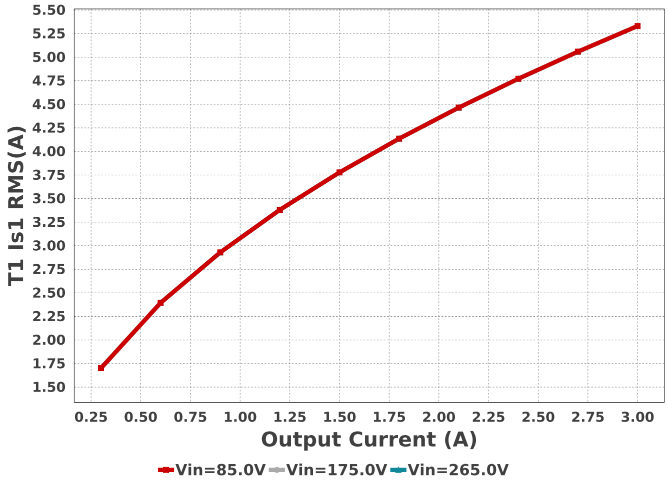




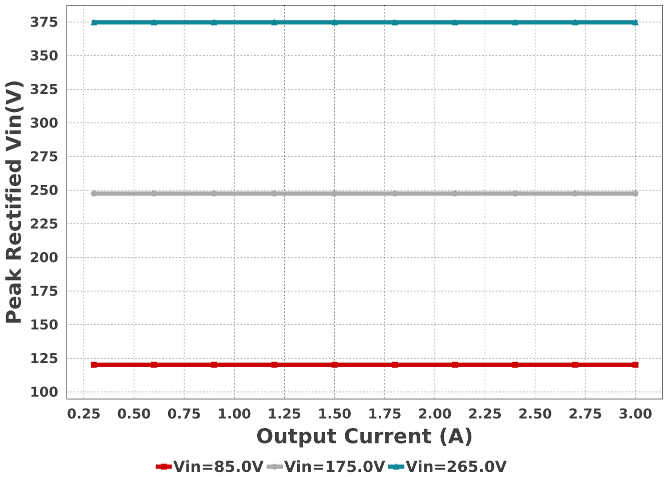
Cin IRMS



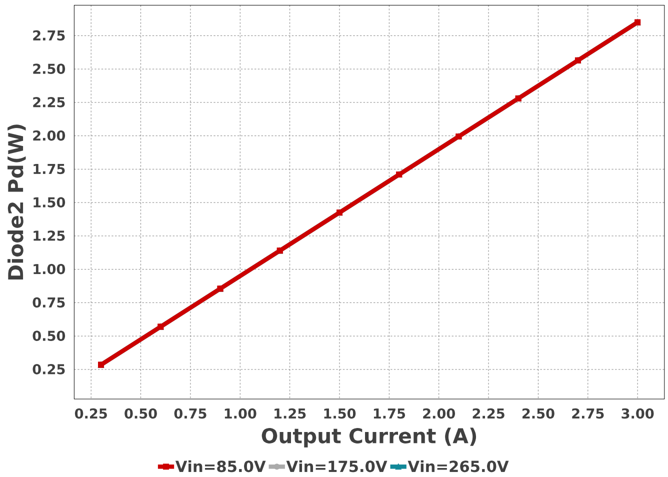
T1 Is1 RMS



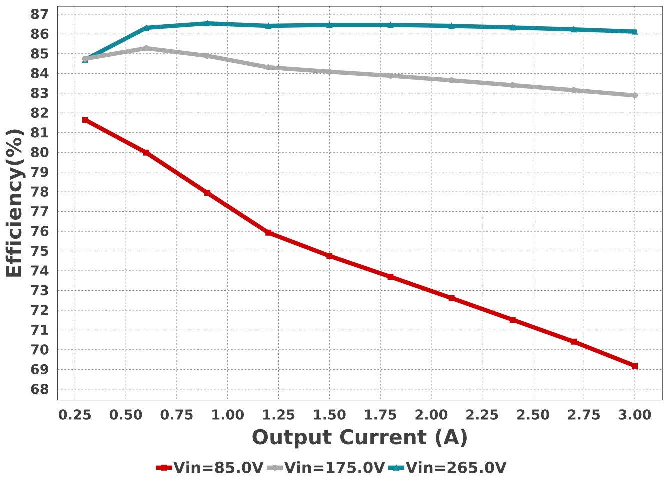
Peak Rectified Vin



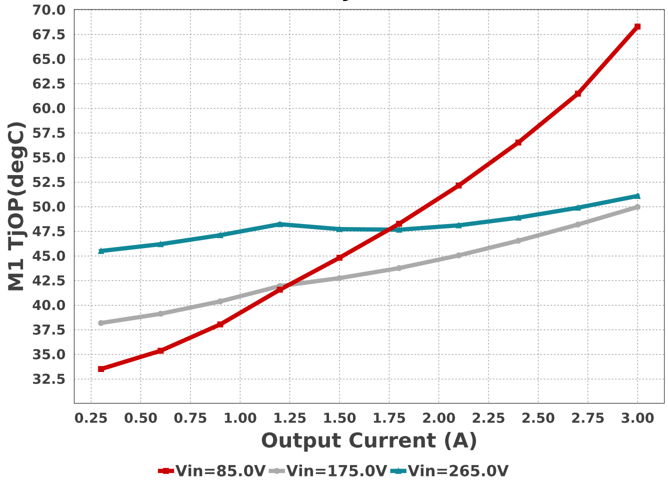
Diode2 Pd



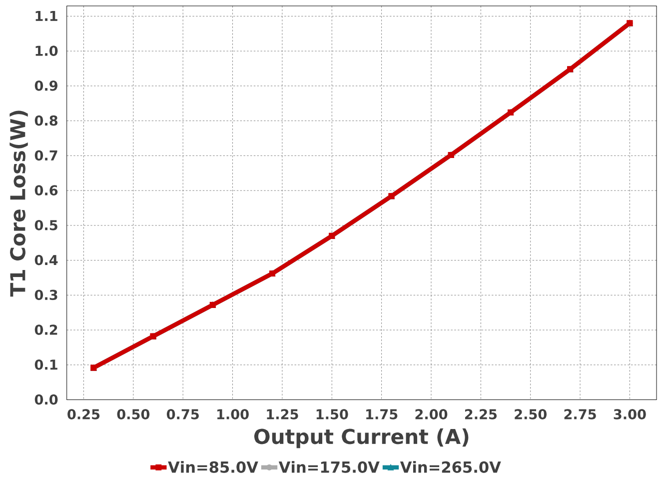
Efficiency



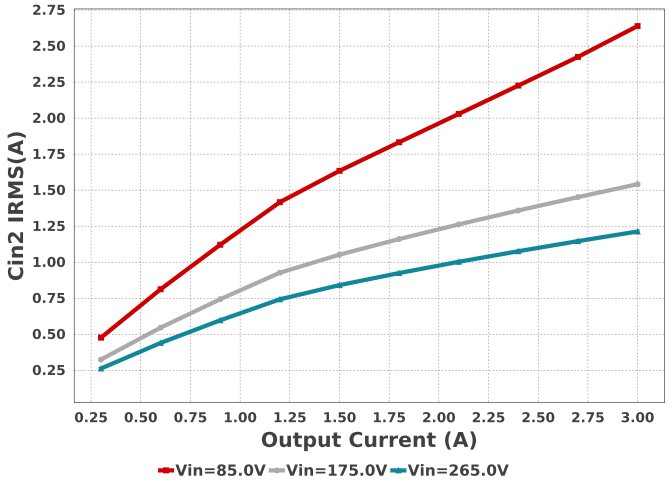
M1 TjOP



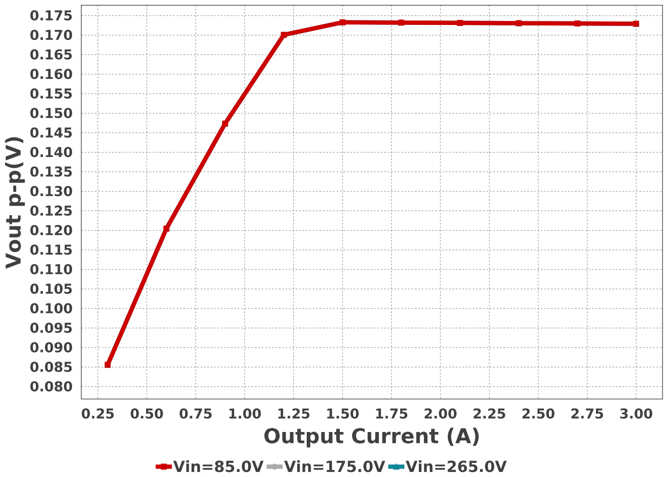
T1 Core Loss



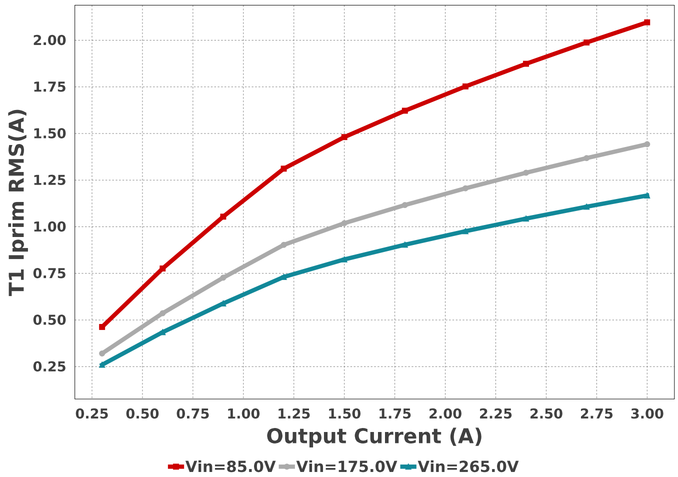
Cin2 IRMS



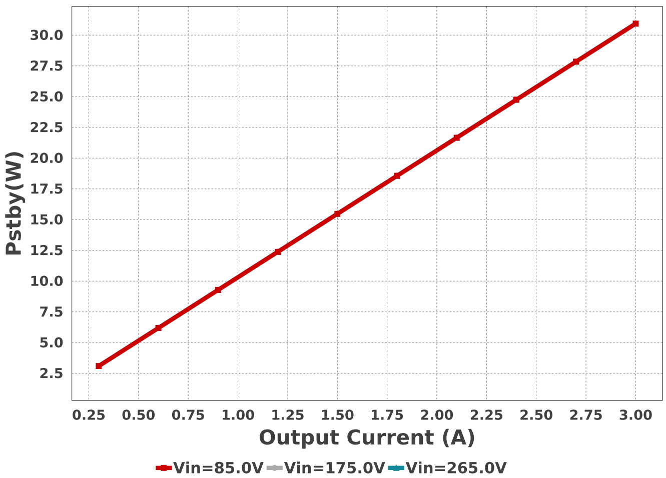
Vout p-p



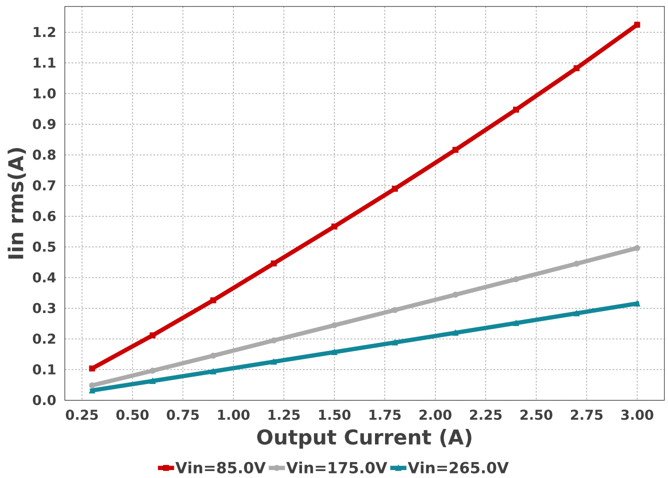
T1 Iprim RMS



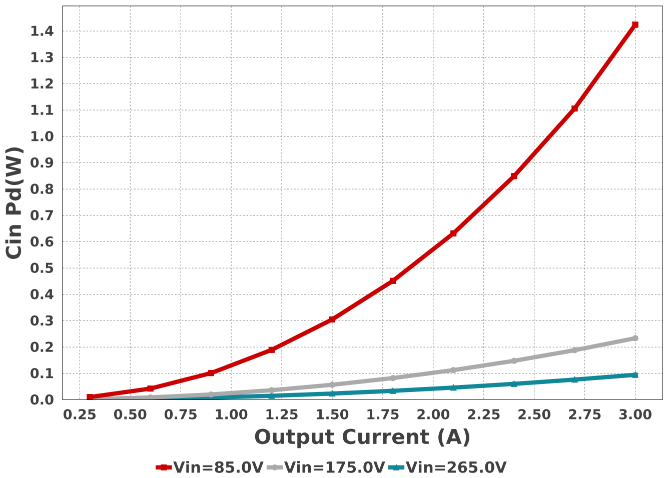
Pstby



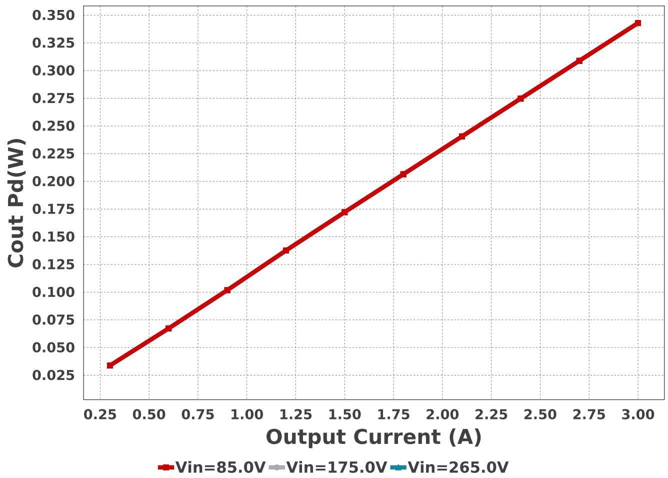
Iin rms



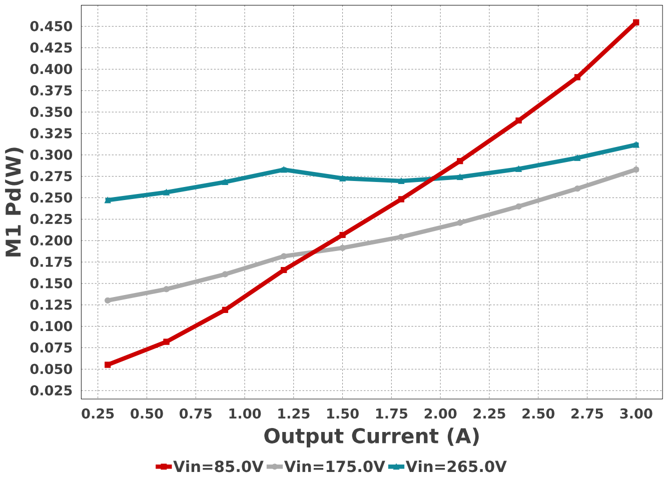
Cin Pd



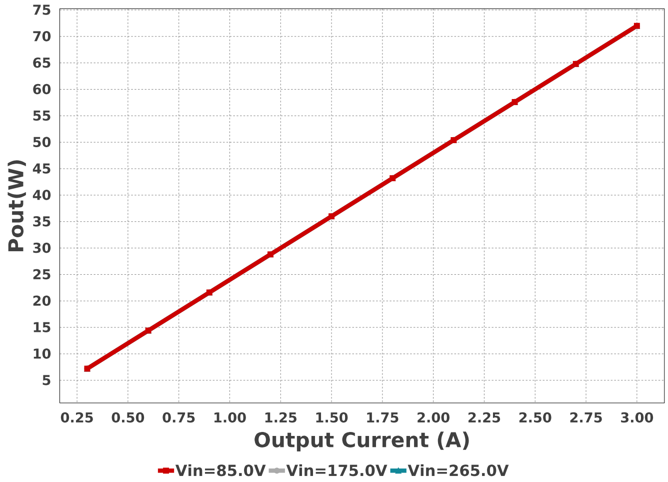
Cout Pd



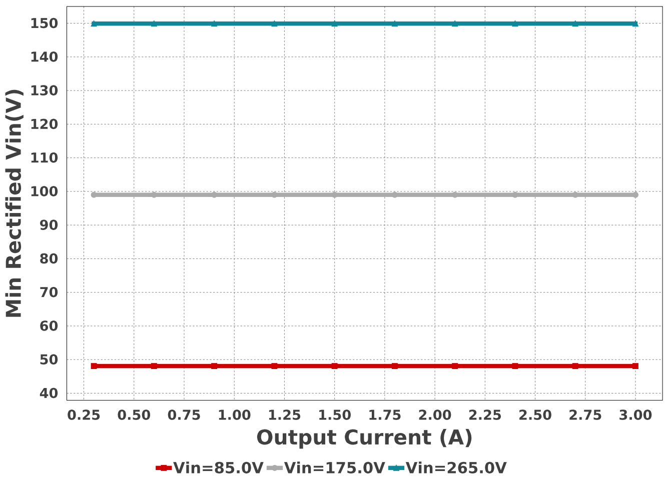
M1 Pd



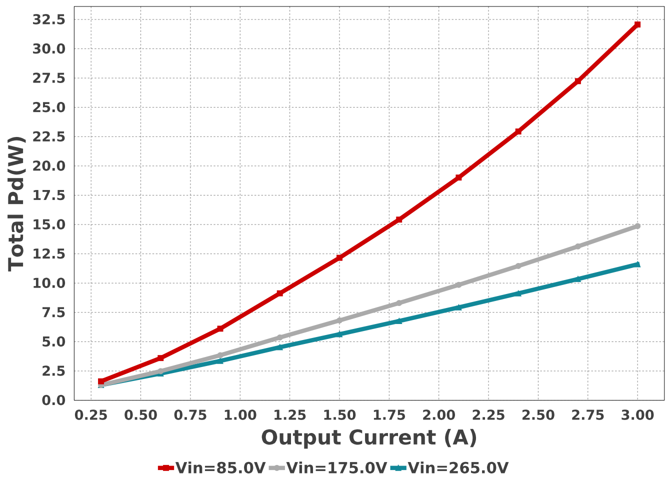
Pout



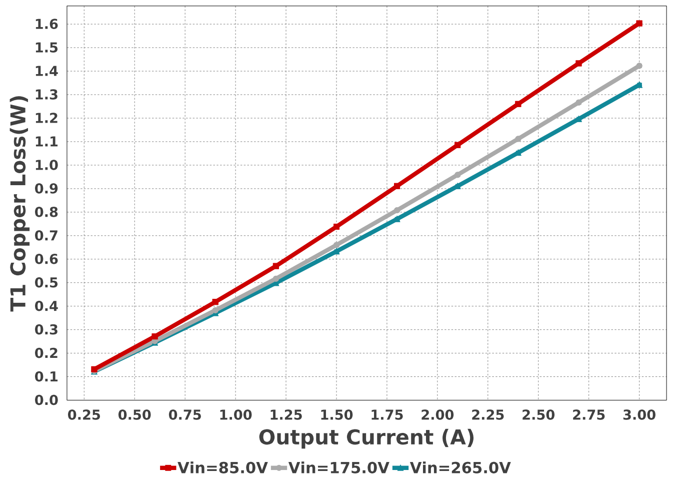
Min Rectified Vin



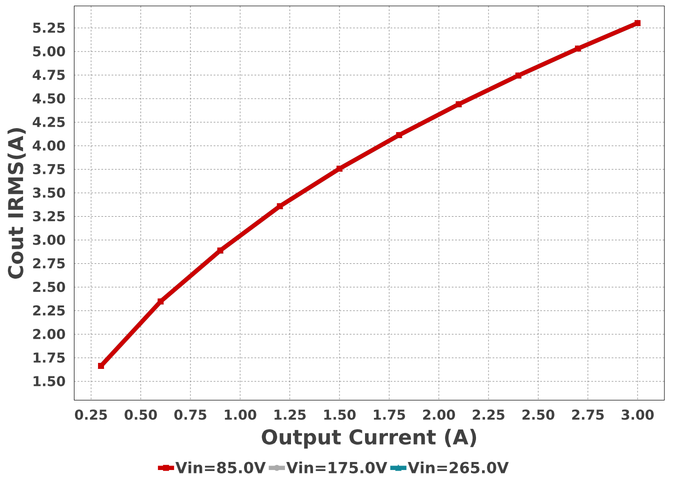
Total Pd



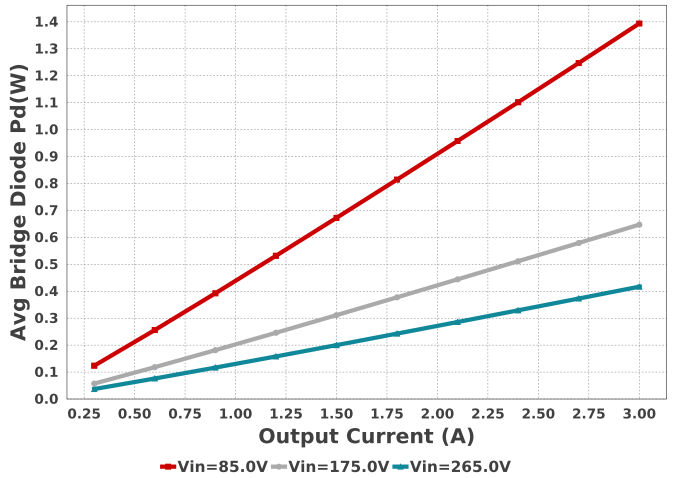
T1 Copper Loss



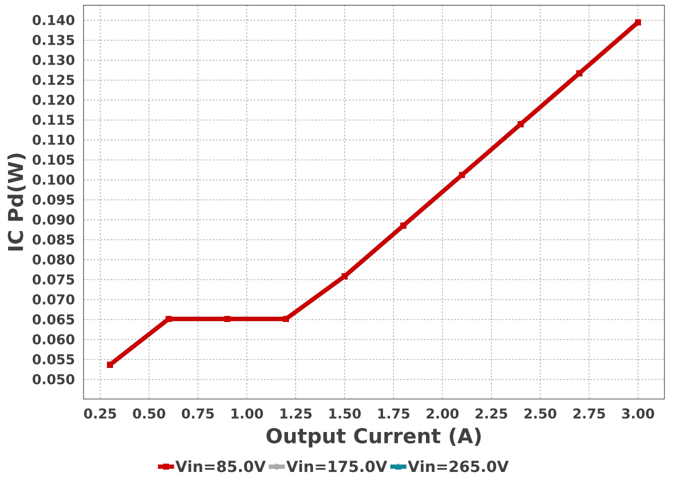
Cout IRMS



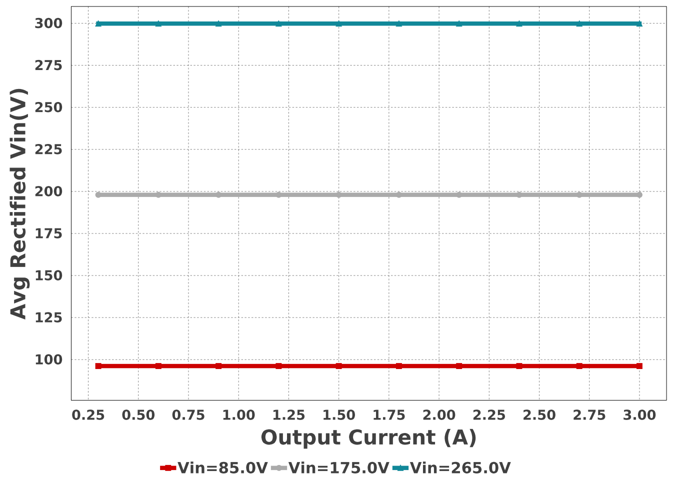
Avg Bridge Diode Pd



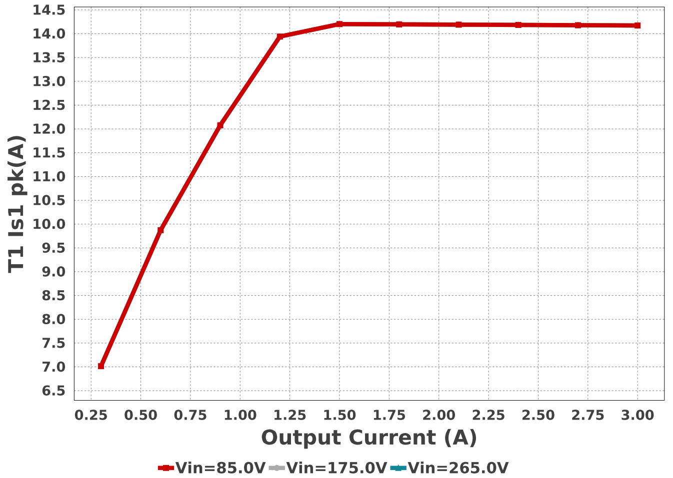
IC Pd

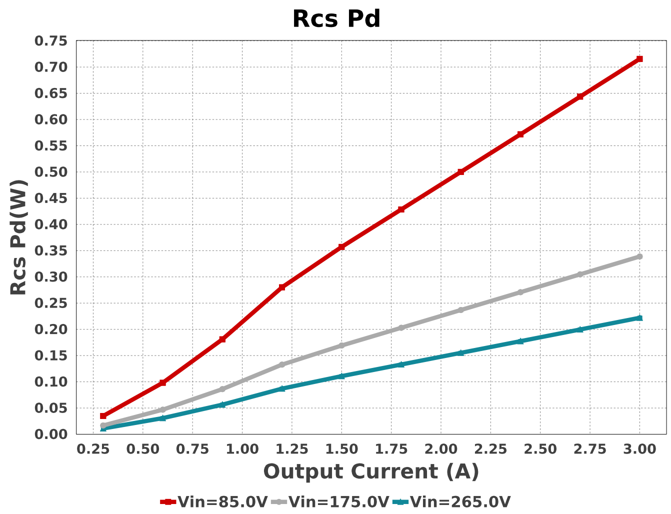


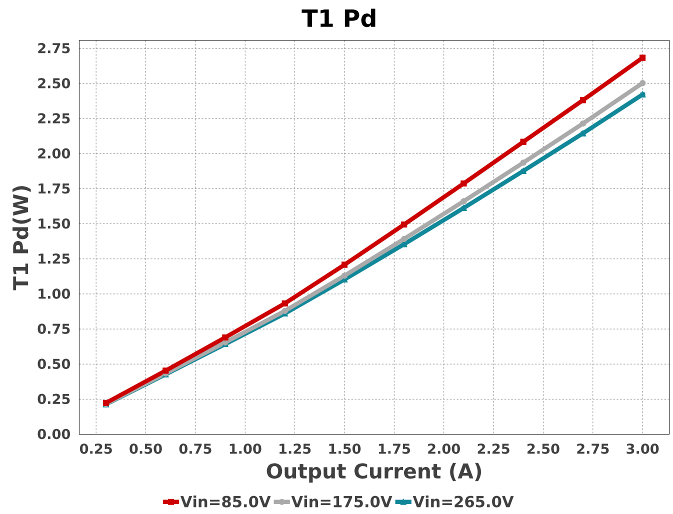
Avg Rectified Vin

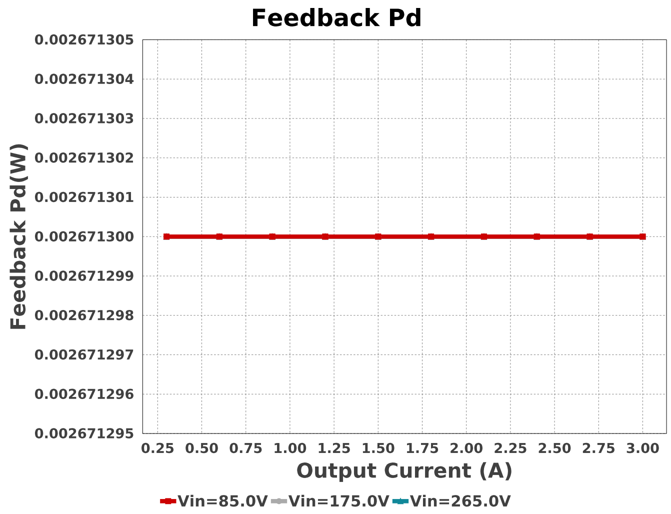


T1 Is1 pk









Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	2.125 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	1.376 W	Capacitor	Input capacitor power dissipation
3.	Cin2 IRMS	2.609 A	Capacitor	Input Capacitor Cin2 RMS Ripple Current
4.	Cout IRMS	5.302 A	Capacitor	Output capacitor RMS ripple current
5.	Cout Pd	342.91 mW	Capacitor	Output capacitor power dissipation
6.	Avg Bridge Diode Pd	1.373 W	Diode	Average Power Dissipation in the Bridge Diode over the AC Line Period
7.	Diode2 Pd	2.85 W	Diode	Diode2 power dissipation
8.	IC Pd	139.48 mW	IC	IC power dissipation
9.	IC Tj	49.736 degC	IC	IC junction temperature
10.	ICThetaJA	141.5 degC/W	IC	IC junction-to-ambient thermal resistance
11.	M1 Pd	454.69 mW	Mosfet	M1 MOSFET total power dissipation
12.	M1 TjOP	68.306 degC	Mosfet	M1 MOSFET junction temperature
13.	Avg Bridge Diode Pd	1.373 W	Power	Average Power Dissipation in the Bridge Diode over the AC Line Period
14.	Cin Pd	1.376 W	Power	Input capacitor power dissipation
15.	Cout Pd	342.91 mW	Power	Output capacitor power dissipation
16.	Diode2 Pd	2.85 W	Power	Diode2 power dissipation
17.	Feedback Pd	2.671 mW	Power	Power Dissipation in Feedback Resistors
18.	IC Pd	139.48 mW	Power	IC power dissipation
19.	M1 Pd	454.69 mW	Power	M1 MOSFET total power dissipation
20.	Rcs Pd	715.51 mW	Power	Power Dissipation in Current Sense Resistors
21.	Snubber Pd	996.507 mW	Power	Snubber Power Dissipation
22.	T1 Copper Loss	1.234 W	Power	Transformer Copper Loss Power Dissipation
23.	T1 Core Loss	252.0 mW	Power	Transformer Core Loss Power Dissipation
24.	T1 Pd	1.486 W	Power	Estimated Losses in Transformer
25.	Total Pd	30.28 W	Power	Total Power Dissipation
26.	Feedback Pd	2.671 mW	Resistor	Power Dissipation in Feedback Resistors
27.	Rcs Pd	715.51 mW	Resistor	Power Dissipation in Current Sense Resistors
28.	Avg Rectified Vin	96.166 V	System Information	Average Rectified Voltage for the AC Line Period
29.	BOM Count	28	System Information	Total Design BOM count

#	Name	Value	Category	Description
30.	Duty Cycle	63.834 %	System Information	Duty cycle
31.	Efficiency	70.395 %	System Information	Steady state efficiency
32.	FootPrint	4.032 k mm^2	System Information	Total Foot Print Area of BOM components
33.	Frequency	67.494 kHz	System Information	Switching frequency
34.	Iin rms	1.203 A	System Information	RMS Input Current
35.	Iout	3.0 A	System Information	Iout operating point
36.	Min Rectified Vin	48.083 V	System Information	Minimum voltage seen at rectified input
37.	Mode	DCM	System Information	Conduction Mode
38.	Peak Rectified Vin	120.207 V	System Information	Peak voltage seen at rectified input
39.	Pout	72.0 W	System Information	Total output power
40.	Total BOM	NA	System Information	Total BOM Cost
41.	Vin_RMS	85.0 V	System Information	Vin operating point
42.	Vout	24.0 V	System Information	Operational Output Voltage
43.	Vout p-p	172.911 mV	System Information	Peak-to-peak output ripple voltage
44.	T1 Copper Loss	1.234 W	Transformer	Transformer Copper Loss Power Dissipation
45.	T1 Core Loss	252.0 mW	Transformer	Transformer Core Loss Power Dissipation
46.	T1 Iprim RMS	2.096 A	Transformer	Transformer Primary RMS Current
47.	T1 Iprim pk	4.544 A	Transformer	Transformer Primary Peak Current
48.	T1 Is1 RMS	5.33 A	Transformer	Transformer Secondary1 RMS Current
49.	T1 Is1 pk	14.173 A	Transformer	Transformer Secondary1 Peak Current
50.	T1 Pd	1.486 W	Transformer	Estimated Losses in Transformer
51.	Pstby	30.938 W	power	Pstby

Design Inputs

Name	Value	Description
Iout	3.0	Maximum Output Current
VinMax	265.0	Maximum input voltage
VinMin	85.0	Minimum input voltage
Vout	24.0	Output Voltage
acFrequency	60.0	AC Frequency
base_pn	UCC28730	Base Product Number
source	AC	Input Source Type
Ta	30.0	Ambient temperature
UserFsw	65.0 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

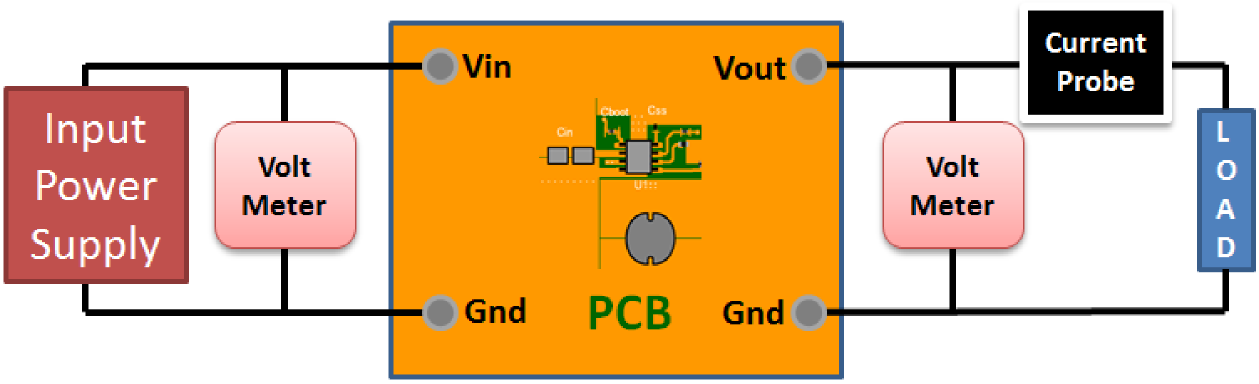
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 85.0V 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	32.0
AWG	24.0
Layers	4.0
Strands	3.0
Insulation Type	Heavy Insulated Magnet Wire

Secondary

Turns	10.0
AWG	27.0
Layers	1.0
Strands	2.0
Insulation Type	Triple Insulated

Auxiliary

Turns	8.0
AWG	28.0
Layers	1.0
Strands	4.0
Insulation Type	Heavy Insulated Magnet Wire

Transformer Construction Diagram

Winding Instruction

Winding	AWG	Turns	Winding Orientation
Primary First 2/4.0	24.0	16	Clockwise
Triple Insulated Secondary	27.0	10.0	Counter Clockwise
Auxiliary	28.0	8.0	Counter Clockwise
Primary Second 2/4.0	24.0	16	Clockwise

Transformer Parameters

#	Name	Value
1.	Lpri	1.43E-4H
2.	Inductance Factor(Al)	140.0nH
3.	Npri	32.0
4.	Nsec	10.0
5.	Naux	8.0
6.	Core Type	E25/13/7
7.	Core Material	N87

#	Name	Value
8.	Bmax	0.20T
9.	Switching Frequency	61.65kHz
10.	DMax	0.51
11.	Ipk(Primary)	2.32A
12.	Irms(Primary)	1.65A
13.	Ipk(Secondary)	7.42A
14.	Irms(Secondary)	4.84A

Design Assistance

1. Application Hints: 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. 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. Rwake: To avoid exceeding the maximum source-current rating for WAKE on the UCC24650, a series resistor, Rwake, may be required to limit the WAKE current. For more information regarding Rwake, please refer to the UCC24650 datasheet. 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 UCC28730 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. The UCC24650 is an easy to use secondary-side voltage monitor that can provided a wake-up alert singal to a primary-side regulation (PSR) controller, such as the UCC28730, to help acheive <5mW Zero-Power standby loss in many applications and provide excellent load transient performance. Please see the datasheet for further design guidance. http://www.ti.com/lit/ds/symlink/ucc28730.pdf http://www.ti.com/lit/ds/symlink/ucc24650.pdf

2. Master key : 326A8F055D54C160[v1]

3. **UCC28730** Product Folder : http://www.ti.com/product/UCC28730 : contains the data sheet and other resources.