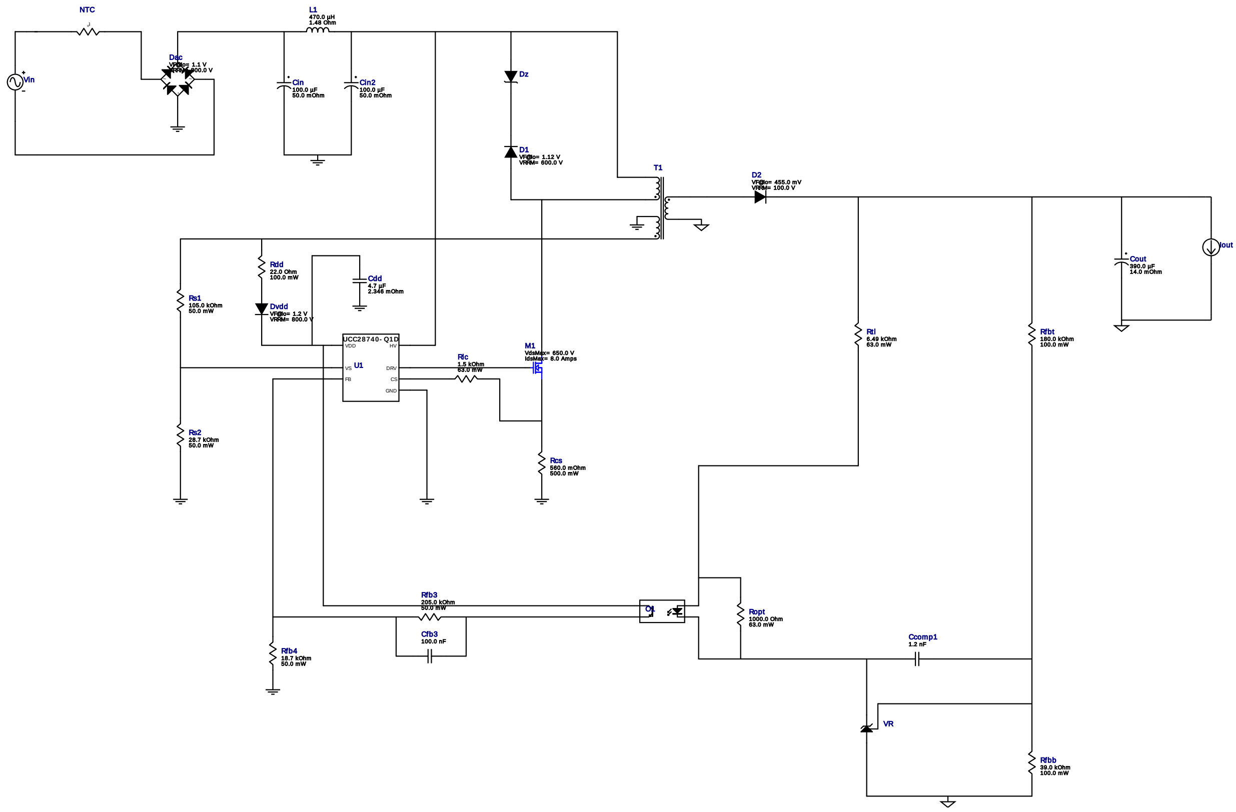
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 90.0V
VinMax = 265.0V
Vout = 14.0V
Iout = 2.0A

Device = UCC28740QDRQ1
Topology = Flyback
Created = 2020-01-03 04:38:27.524
BOM Cost = $10.67
BOM Count = 29
Total Pd = 4.57W

Design : 15 UCC28740QDRQ1
UCC28740QDRQ1 90V-265V to 14.00V @ 2A



1. Rlc, Rtl and the feedback resistors for this design are a starting point, but may need adjustment based on the actual transformer used. 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

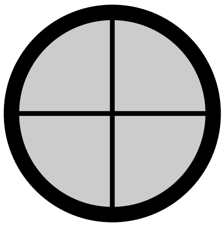
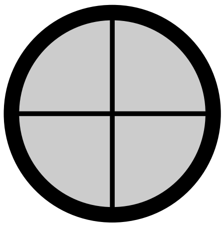
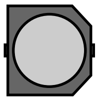
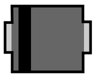
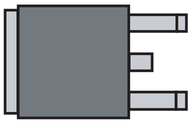
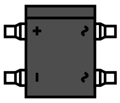
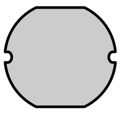
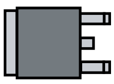
Design Alerts

Component Selection Information

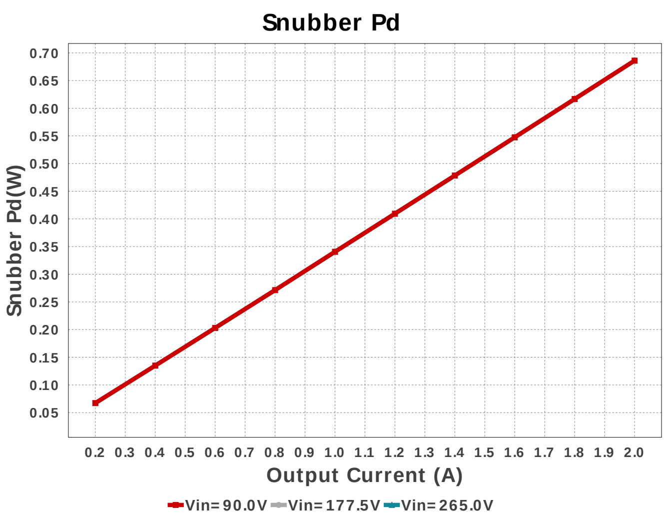
The UCC28740-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application. Click on the transformer symbol in the schematic and select "Explore Transformer Core/Bobbin Selection" to design using specific transformer cores and bobbin.

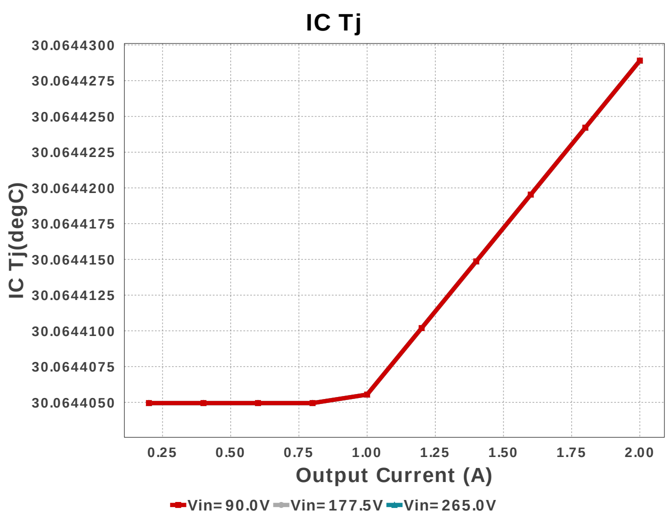
Electrical BOM

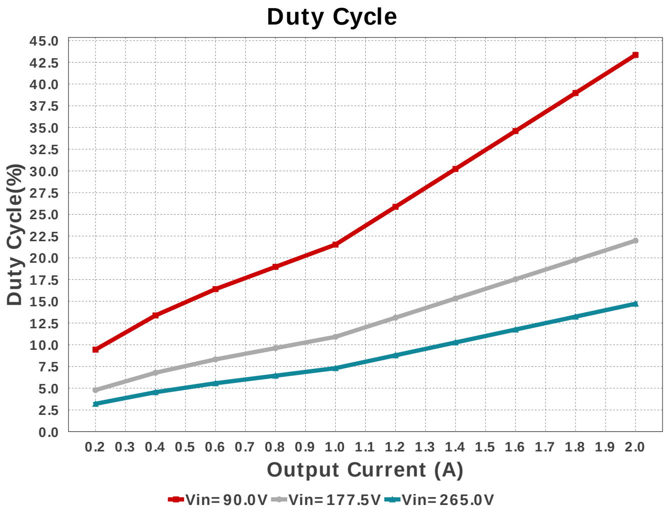
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Ccomp1	Samsung Electro-Mechanics	CL21C122JBFNNNE Series= C0G/NP0	Cap= 1.2 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2
Cdd	TDK	C2012X7R1V475K125AC Series= X7R	Cap= 4.7 uF ESR= 2.346 mOhm VDC= 35.0 V IRMS= 4.2602 A	1	$0.18	0805 7 mm^2
Cfb3	AVX	08053C104JAZ2A Series= X7R	Cap= 100.0 nF VDC= 25.0 V IRMS= 0.0 A	1	$0.06	0805 7 mm^2

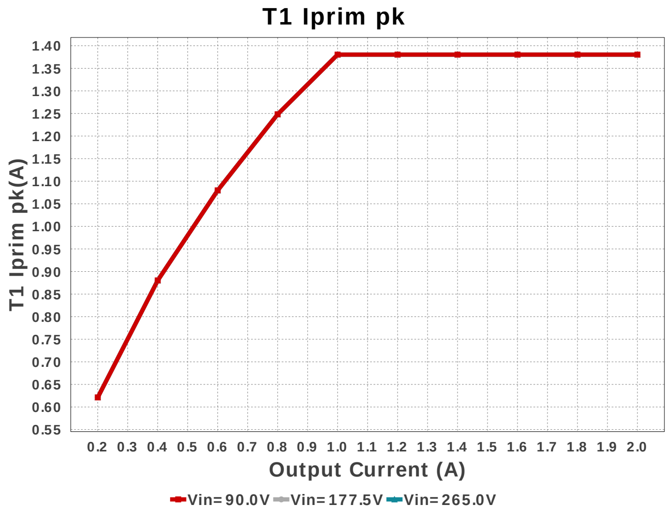
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cin	Nichicon	UPW2W101MRD Series= PW	Cap= 100.0 uF ESR= 50.0 mOhm VDC= 450.0 V IRMS= 350.0 mA	1	$2.11	 CAPPR12.5-25x50 484 mm^2
Cin2	Nichicon	UPW2W101MRD Series= PW	Cap= 100.0 uF ESR= 50.0 mOhm VDC= 450.0 V IRMS= 350.0 mA	1	$2.11	 CAPPR12.5-25x50 484 mm^2
Cout	Panasonic	20SVPF390M Series= SVPF	Cap= 390.0 uF ESR= 14.0 mOhm VDC= 20.0 V IRMS= 4.95 A	1	$0.65	 CAPSMT_62_E12 106 mm^2
D1	Bourns	CD214C-F3600	VF@Io= 1.12 V VRRM= 600.0 V	1	$0.23	 SMC 83 mm^2
D2	STMicroelectronics	STPS20M100SG-TR	VF@Io= 455.0 mV VRRM= 100.0 V	1	$1.33	 DDPAK 210 mm^2
Dac	Vishay-Semiconductor	DF08SA	VF@Io= 1.1 V VRRM= 800.0 V	1	$0.24	 DF-S 99 mm^2
Dvdd	Microsemi	UFS180JE3/TR13	VF@Io= 1.2 V VRRM= 800.0 V	1	$0.73	 DO-214BA 42 mm^2
Dz	Diodes Inc.	SMBJ120A-13-F	Zener	1	$0.09	 SMB 44 mm^2
L1	NIC Components	NPI105C471MTRF	L= 470.0 µH 1.48 Ohm	1	$0.18	 IND_NPI105C 141 mm^2
M1	STMicroelectronics	STD12N65M2	VdsMax= 650.0 V IdsMax= 8.0 Amps	1	$0.65	 DPAK 102 mm^2
NTC	GE Sensing	CL-40 Series= CL	Thermistor	1	$0.72	 Thermistor_CL-40 164 mm^2
O1	California Eastern Laboratories	PS2811-1	Optocoupler	1	$0.41	 SSOP-4 111 mm^2
Rcs	Rohm	MCR25JZHFLR560 Series= MCR25	Res= 560.0 mOhm Power= 500.0 mW Tolerance= 1.0%	1	$0.03	1210 15 mm^2

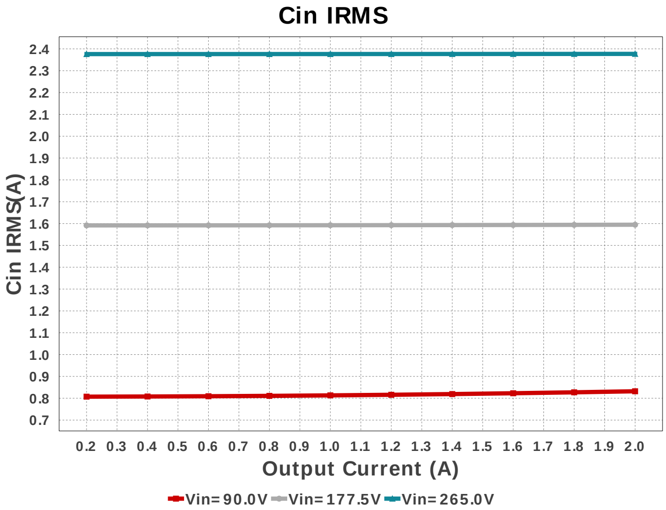
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rdd	Yageo	RC0603FR-0722RL Series= ?	Res= 22.0 Ohm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rfb3	Yageo	RC0201FR-07205KL Series= ?	Res= 205.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
Rfb4	Yageo	RC0201FR-0718K7L Series= ?	Res= 18.7 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
Rfbb	Yageo	RC0603FR-0739KL Series= ?	Res= 39.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rfbt	Yageo	RC0603FR-07180KL Series= ?	Res= 180.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rlc	Vishay-Dale	CRCW04021K50FKED Series= CRCW..e3	Res= 1.5 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Ropt	Vishay-Dale	CRCW04021K00FKED Series= CRCW..e3	Res= 1000.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rs1	Yageo	RC0201FR-07105KL Series= ?	Res= 105.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
Rs2	Yageo	RC0201FR-0728K7L Series= ?	Res= 28.7 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
Rtl	Vishay-Dale	CRCW04026K49FKED Series= CRCW..e3	Res= 6.49 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
T1	Core=TDK , CoilFormer=TDK	Core=B66317G0000X187 , CoilFormer=B66208W1010T001	Lp= 544.0 µH Turns Ratio(Nas)= 13:10 Turns Ratio(Nps)= 68:10 Npri= 68.0 Naux= 13.0 Nsec= 10.0	1	$0.22	TDK_B66305 569 mm²
U1	Texas Instruments	UCC28740QDRQ1	Switcher	1	$0.55	UCC28740QDRQ1 0 mm²
VR	Texas Instruments	TL431IDBVR	Voltage References	1	$0.07	R-PDSO-G3 16 mm²

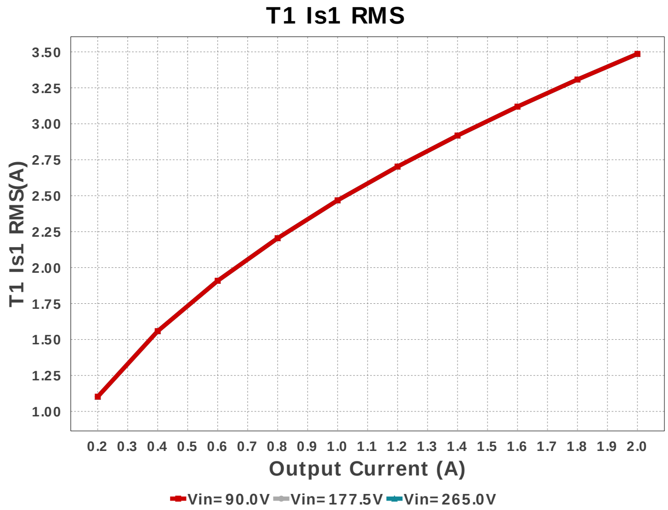


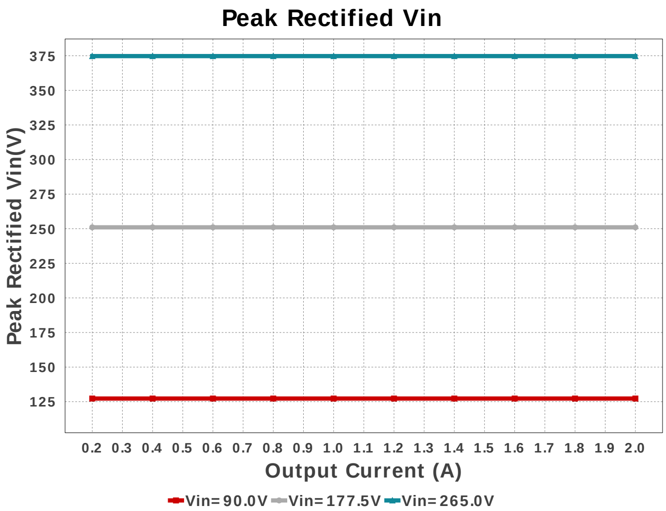


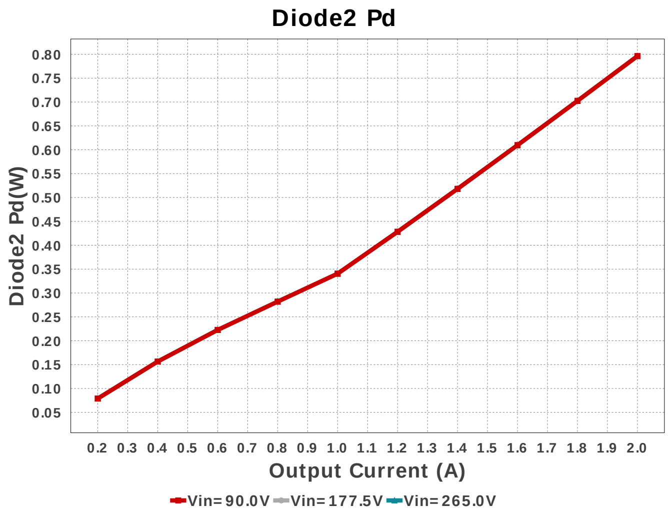

Duty Cycle
Duty Cycle(%)
Output Current (A)
Vin= 90.0V
Vin= 177.5V
Vin= 265.0V

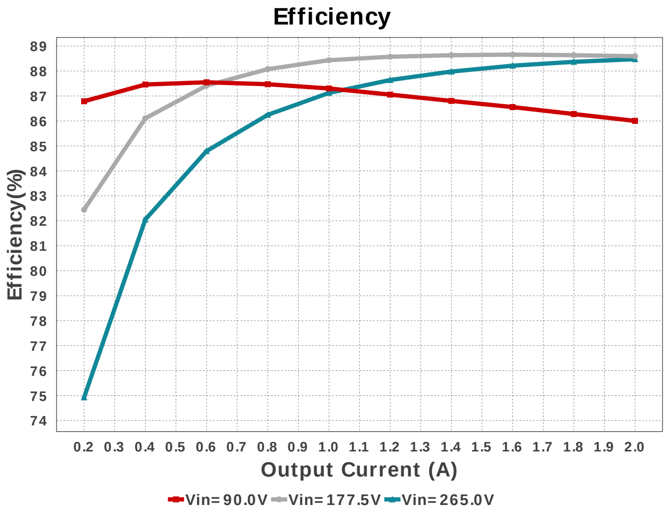

T1 Iprim pk
T1 Iprim pk(A)
Output Current (A)
Vin= 90.0V
Vin= 177.5V
Vin= 265.0V

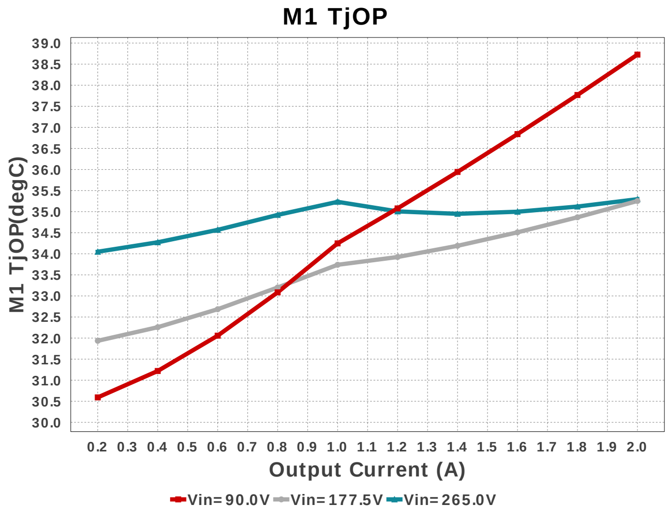

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin= 90.0V
Vin= 177.5V
Vin= 265.0V

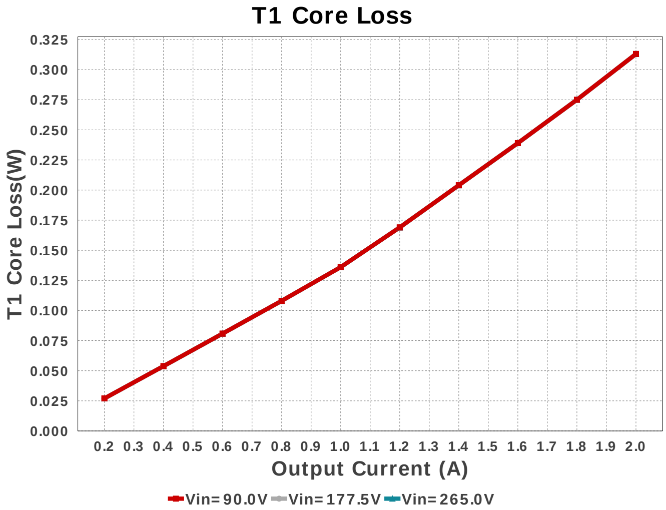

T1 Is1 RMS
T1 Is1 RMS(A)
Output Current (A)
Vin= 90.0V
Vin= 177.5V
Vin= 265.0V

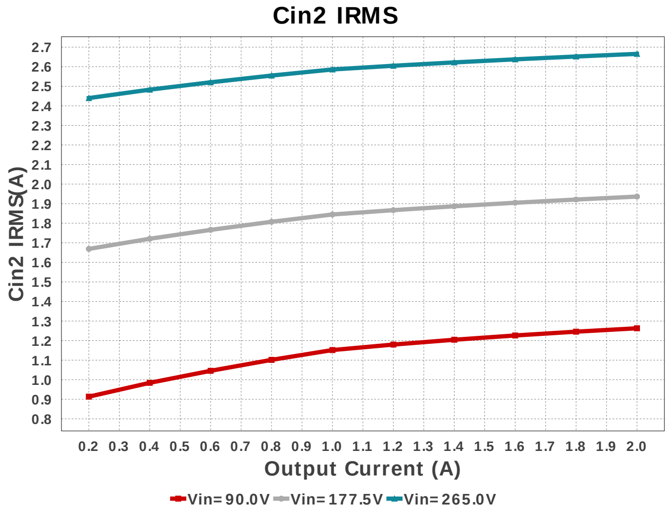

Peak Rectified Vin
Peak Rectified Vin(V)
Output Current (A)
Vin= 90.0V
Vin= 177.5V
Vin= 265.0V

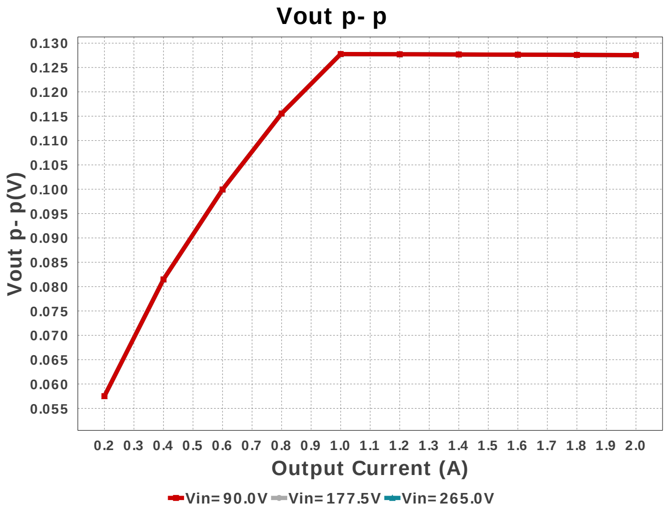

Diode2 Pd
Diode2 Pd(W)
Output Current (A)
Vin= 90.0V
Vin= 177.5V
Vin= 265.0V

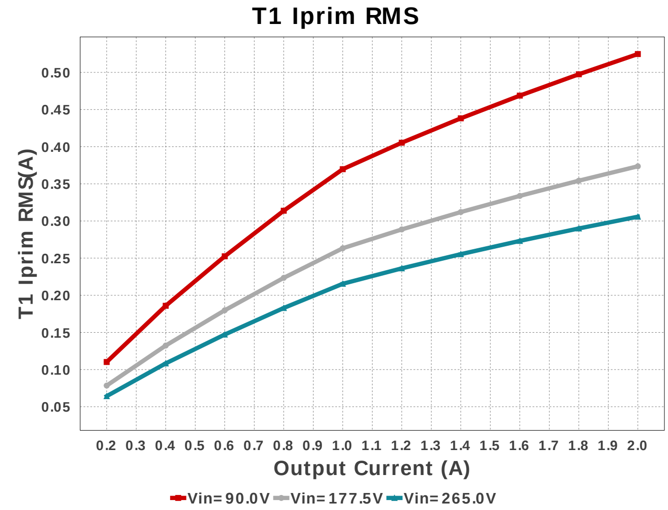

Efficiency
Efficiency(%)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V

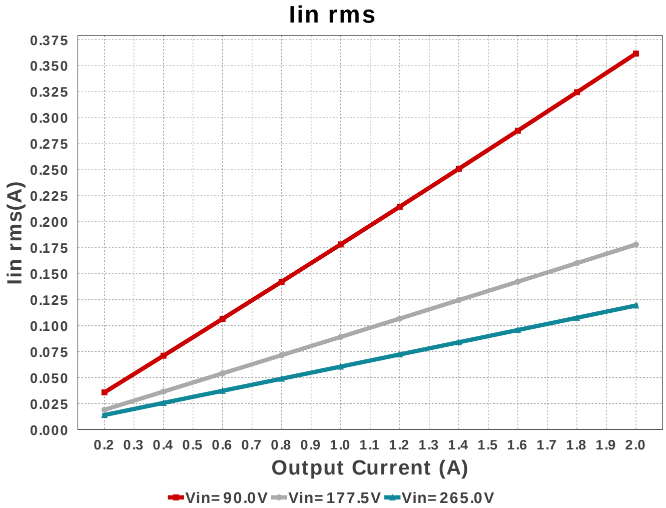

M1 TjOP
M1 TjOP(degC)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V

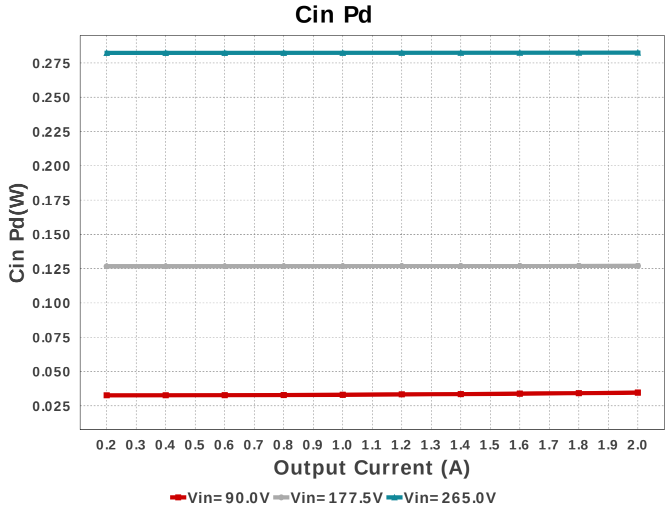

T1 Core Loss
T1 Core Loss(W)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V

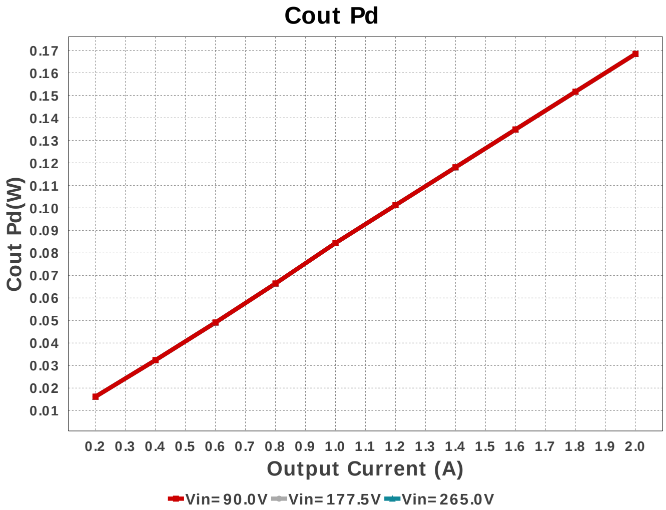

Cin2 IRMS
Cin2 IRMS(A)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V

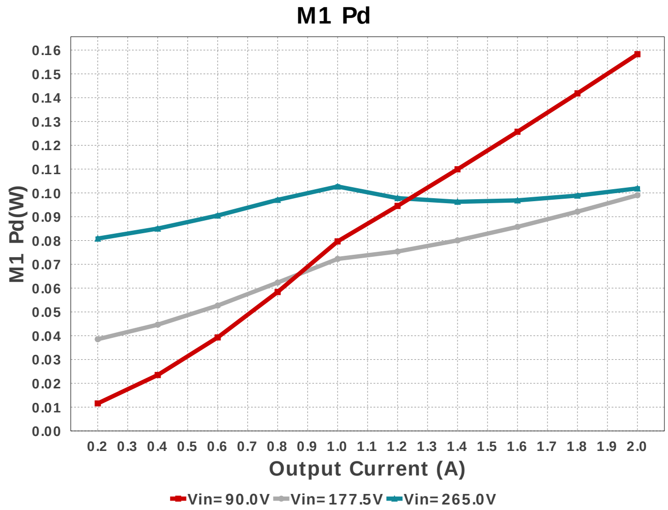

Vout p- p
Vout p- p(V)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V

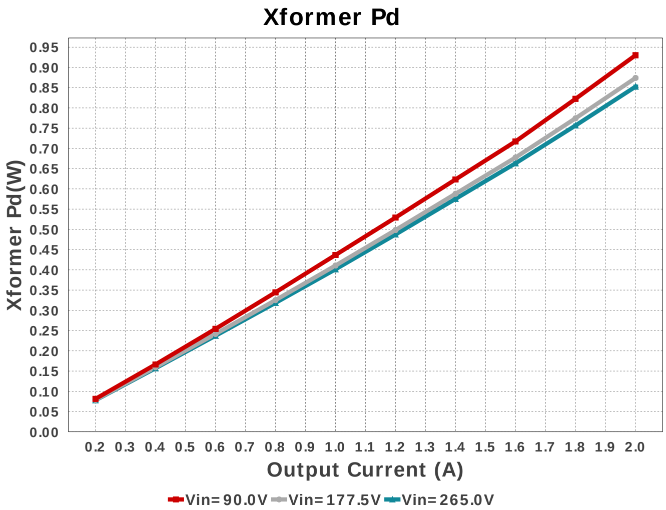

T1 Iprim RMS
T1 Iprim RMS(A)
Output Current (A)
Vin= 90.0V Vin= 177.5V Vin= 265.0V

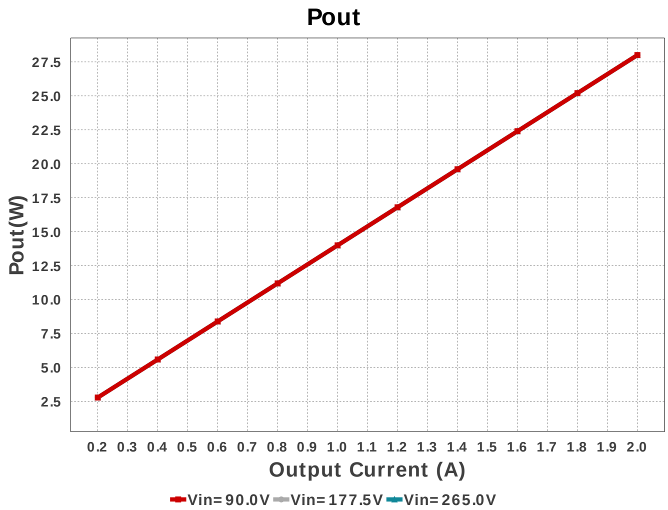

Iin rms
Iin rms(A)
Output Current (A)
Vin= 90.0V
Vin= 177.5V
Vin= 265.0V

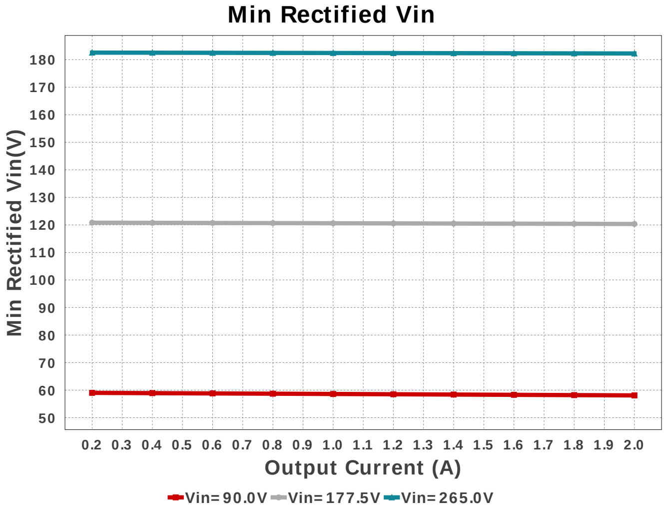

Cin Pd
Cin Pd(W)
Output Current (A)
Vin= 90.0V
Vin= 177.5V
Vin= 265.0V

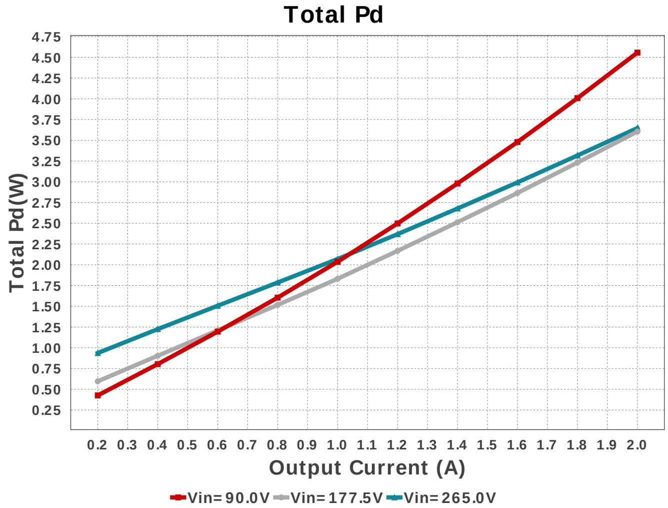

Cout Pd
Cout Pd(W)
Output Current (A)
Vin= 90.0V
Vin= 177.5V
Vin= 265.0V

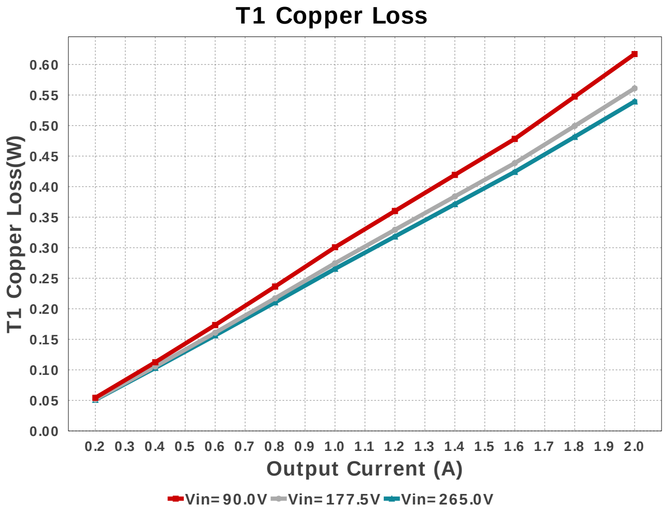

M1 Pd
M1 Pd(W)
Output Current (A)
Vin= 90.0V
Vin= 177.5V
Vin= 265.0V

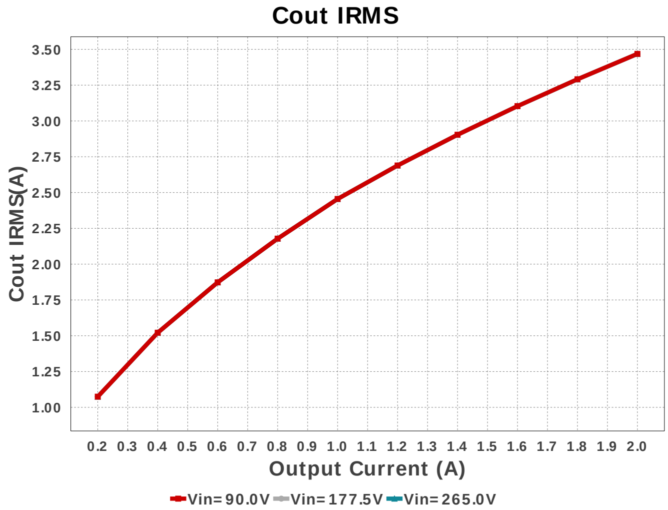

Xformer Pd
Xformer Pd(W)
Output Current (A)
Vin= 90.0V
Vin= 177.5V
Vin= 265.0V

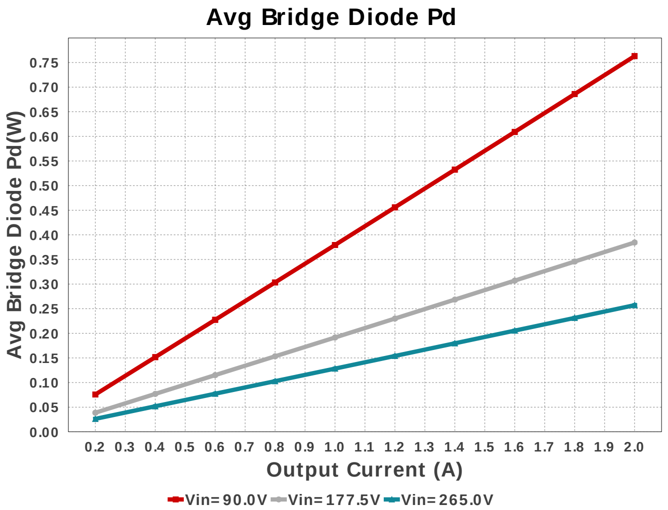

Pout
Pout(W)
Output Current (A)
Vin= 90.0V
Vin= 177.5V
Vin= 265.0V

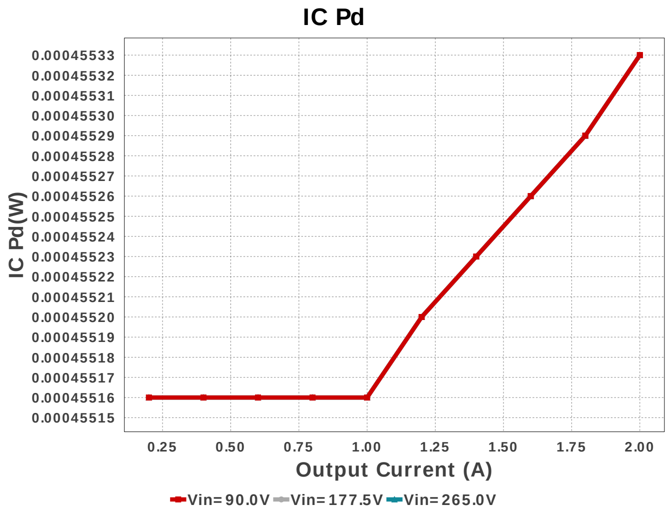

Min Rectified Vin
Min Rectified Vin(V)
Output Current (A)
Vin=90.0V Vin=177.5V Vin=265.0V

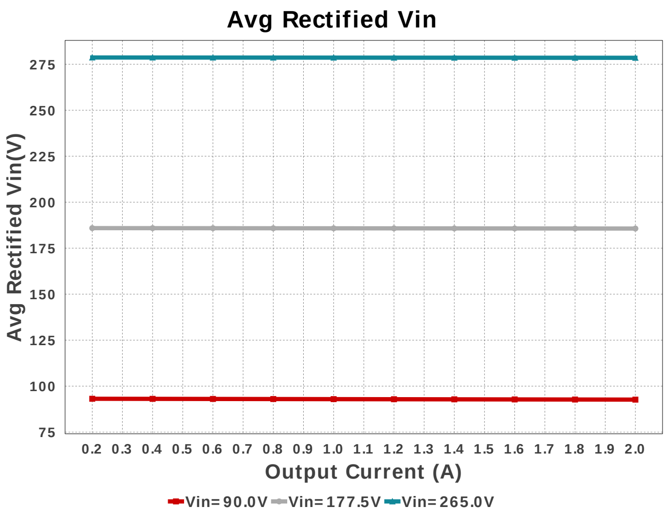

Total Pd
Total Pd(W)
Output Current (A)
Vin=90.0V Vin=177.5V Vin=265.0V

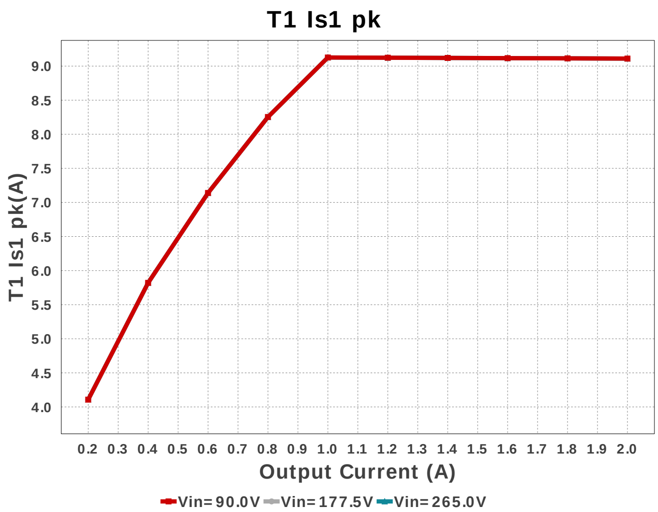

T1 Copper Loss
T1 Copper Loss(W)
Output Current (A)
Vin=90.0V Vin=177.5V Vin=265.0V


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


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	831.977 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	34.609 mW	Capacitor	Input capacitor power dissipation
3.	Cin2 IRMS	1.263 A	Capacitor	Input Capacitor Cin2 RMS Ripple Current
4.	Cout IRMS	3.468 A	Capacitor	Output capacitor RMS ripple current
5.	Cout Pd	168.41 mW	Capacitor	Output capacitor power dissipation
6.	Avg Bridge Diode Pd	763.27 mW	Diode	Average Power Dissipation in the Bridge Diode over the AC Line Period
7.	Diode2 Pd	796.24 mW	Diode	Diode2 power dissipation
8.	IC Pd	455.33 µW	IC	IC power dissipation
9.	IC Tj	30.064 degC	IC	IC junction temperature
10.	ICThetaJA	141.5 degC/W	IC	IC junction-to-ambient thermal resistance
11.	M1 Pd	158.25 mW	Mosfet	M1 MOSFET total power dissipation
12.	M1 TjOP	38.725 degC	Mosfet	M1 MOSFET junction temperature
13.	Avg Bridge Diode Pd	763.27 mW	Power	Average Power Dissipation in the Bridge Diode over the AC Line Period
14.	Cin Pd	34.609 mW	Power	Input capacitor power dissipation
15.	Cout Pd	168.41 mW	Power	Output capacitor power dissipation
16.	Diode2 Pd	796.24 mW	Power	Diode2 power dissipation
17.	IC Pd	455.33 µW	Power	IC power dissipation
18.	M1 Pd	158.25 mW	Power	M1 MOSFET total power dissipation
19.	Snubber Pd	685.643 mW	Power	Snubber Power Dissipation
20.	T1 Copper Loss	649.21 mW	Power	Transformer Copper Loss Power Dissipation
21.	T1 Core Loss	292.0 mW	Power	Transformer Core Loss Power Dissipation
22.	Total Pd	4.568 W	Power	Total Power Dissipation
23.	Xformer Pd	941.21 mW	Power	Transformer power dissipation
24.	Avg Rectified Vin	92.681 V	System Information	Average Rectified Voltage for the AC Line Period
25.	BOM Count	29	System Information	Total Design BOM count
26.	Duty Cycle	43.347 %	System Information	Duty cycle
27.	Efficiency	85.973 %	System Information	Steady state efficiency
28.	FootPrint	2.746 k mm^2	System Information	Total Foot Print Area of BOM components
29.	Frequency	66.148 kHz	System Information	Switching frequency
30.	Frequency	66.148 kHz	System Information	Switching frequency
31.	Iin rms	361.87 mA	System Information	RMS Input Current
32.	Iout	2.0 A	System Information	Iout operating point
33.	Min Rectified Vin	58.084 V	System Information	Minimum voltage seen at rectified input
34.	Mode	DCM	System Information	Conduction Mode
35.	Peak Rectified Vin	127.278 V	System Information	Peak voltage seen at rectified input
36.	Pout	28.0 W	System Information	Total output power
37.	Total BOM	$10.67	System Information	Total BOM Cost

#	Name	Value	Category	Description
38.	Vin_RMS	90.0 V	System Information	Vin operating point
39.	Vout	14.0 V	System Information	Operational Output Voltage
40.	Vout Actual	14.038 V	System Information	Vout Actual calculated based on selected voltage divider resistors
41.	Vout Tolerance	1.986 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
42.	Vout p-p	127.545 mV	System Information	Peak-to-peak output ripple voltage
43.	T1 Copper Loss	649.21 mW	Transformer	Transformer Copper Loss Power Dissipation
44.	T1 Core Loss	292.0 mW	Transformer	Transformer Core Loss Power Dissipation
45.	T1 Iprim RMS	524.699 mA	Transformer	Transformer Primary RMS Current
46.	T1 Iprim pk	1.38 A	Transformer	Transformer Primary Peak Current
47.	T1 Is1 RMS	3.486 A	Transformer	Transformer Secondary1 RMS Current
48.	T1 Is1 pk	9.11 A	Transformer	Transformer Secondary1 Peak Current
49.	Xformer Pd	941.21 mW	Transformer	Transformer power dissipation

Design Inputs

Name	Value	Description
Iout	2.0	Maximum Output Current
VinMax	265.0	Maximum input voltage
VinMin	90.0	Minimum input voltage
Vout	14.0	Output Voltage
acFrequency	50.0	AC Frequency
base_pn	UCC28740-Q1	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

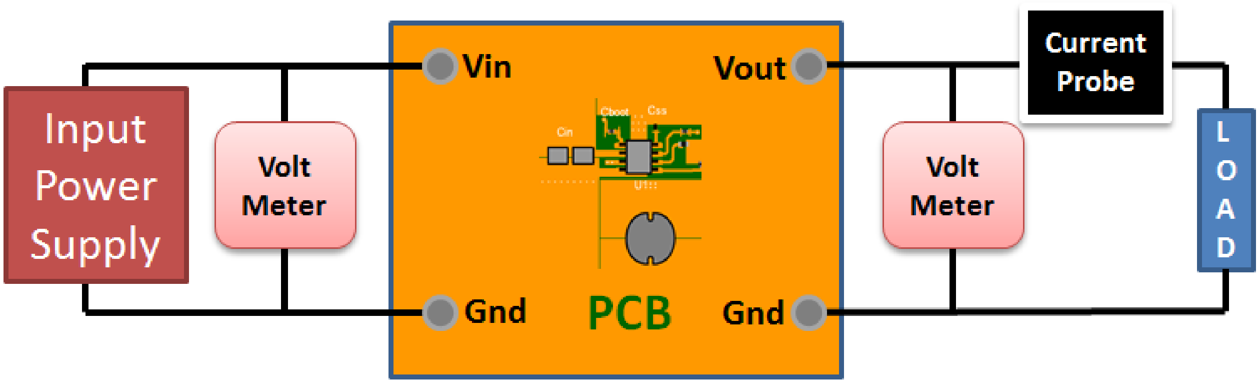
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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	B66317G0000X187
2.	Core Manufacturer	TDK
3.	Coil Former Part Number	B66208W1010T001
4.	Coil Former Manufacturer	TDK

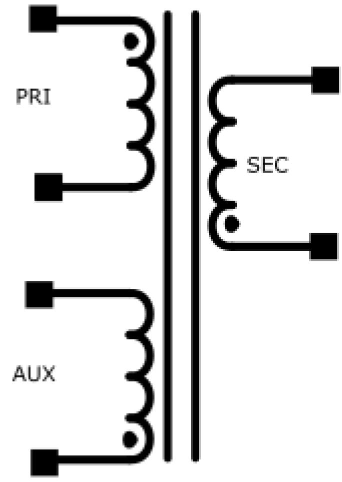
Transformer Electrical Diagram

Primary

Turns	68.0
AWG	27.0
Layers	4.0
Strands	2.0
Insulation Type	Heavy Insulated Magnet Wire

Auxiliary

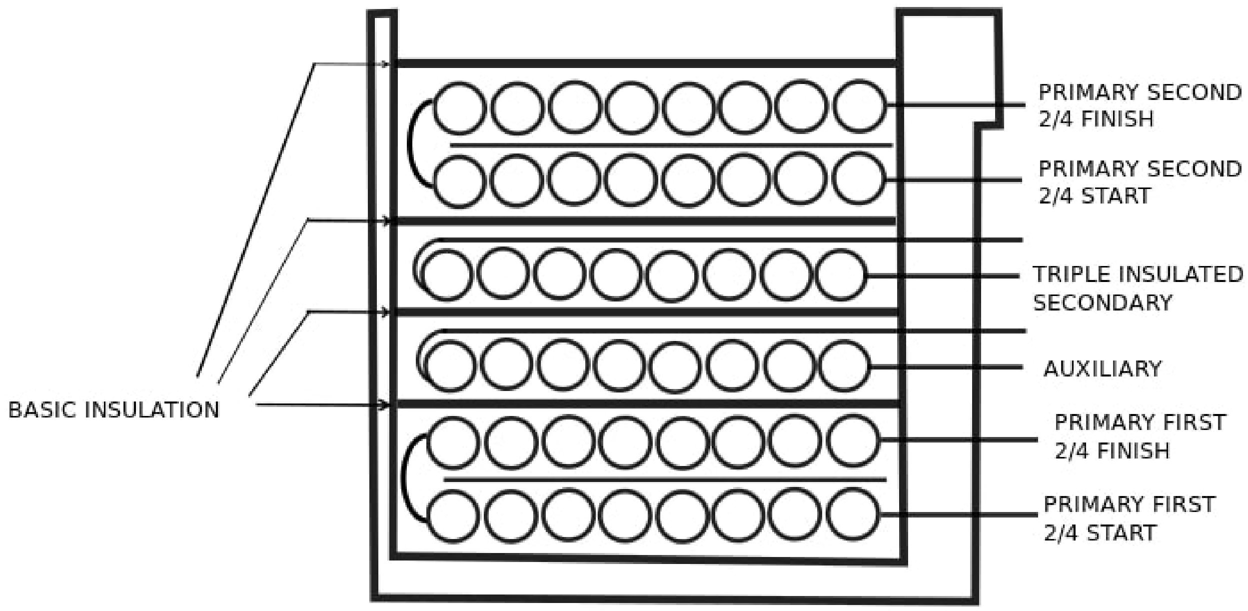
Turns	13.0
AWG	28.0
Layers	1.0
Strands	3.0
Insulation Type	Heavy Insulated Magnet Wire



Secondary

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

Transformer Construction Diagram



Winding Instruction

Winding	AWG	Turns	Winding Orientation
Primary First 2/4.0	27.0	34	Clockwise
Auxiliary	28.0	13.0	Counter Clockwise
Triple Insulated Secondary	27.0	10.0	Counter Clockwise
Primary Second 2/4.0	27.0	34	Clockwise

Transformer Parameters

#	Name	Value
1.	Lpri	5.44E-4H
2.	Inductance Factor(Al)	118.0nH
3.	Npri	68.0
4.	Nsec	10.0
5.	Naux	13.0
6.	Core Type	E25/13/7
7.	Core Material	N87
8.	Bmax	0.21T
9.	Switching Frequency	63.00kHz
10.	DMax	0.51
11.	Ipk(Primary)	1.38A
12.	Irms(Primary)	0.57A
13.	Ipk(Secondary)	9.39A
14.	Irms(Secondary)	3.53A

Design Assistance

1. Application Hints 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. Rtl Rtl is added to prevent excessive diode current and limit Iopt to the maximum value necessary for regulationThe Rtl value may be adjusted for optimal limiting later during the porotype evaluation process. 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. Rfb3 & Cfb3 Rfb3 is necessary to limit the current into FB and to avoid excess draining of Cvdd during this type of transient situation.The value of Rfb3 is chosen to limit the excess Ifb and Rfb4 current to an acceptable level when the optocoupler is saturatedCfb3 helps improve the transient response and is estimated initially by equating the time constant to 1ms. This can later beadjusted for optimal performance during prototype evaluation Rfb4 Rfb4 speeds up the turnoff time of the optocoupler in the case of a heavy load-step transient condition. This value tends to fallwithin the range of 10k and 100k. A tradeoff must be made between a lower value for faster transient response and a higher value forlower standby power. Rfb4 also serves to set a minimum bias current for the optocoupler and to drain dark current Part Description The UCC28740-Q1 isolated-flyback controller provides Constant-Voltage (CV) using an optical coupler toimprove transient response. Constant-Current (CC) regulation is accomplished through Primary Side Regulation (PSR) techniques. Please see the datasheet for further design guidance. http://www.ti.com/lit/ds/symlink/ucc28740-Q1.pdf

2. Master key : BE5D32129D021133[v1]

3. **UCC28740-Q1** Product Folder : http://www.ti.com/product/UCC28740%2DQ1 : contains the data sheet and other resources.