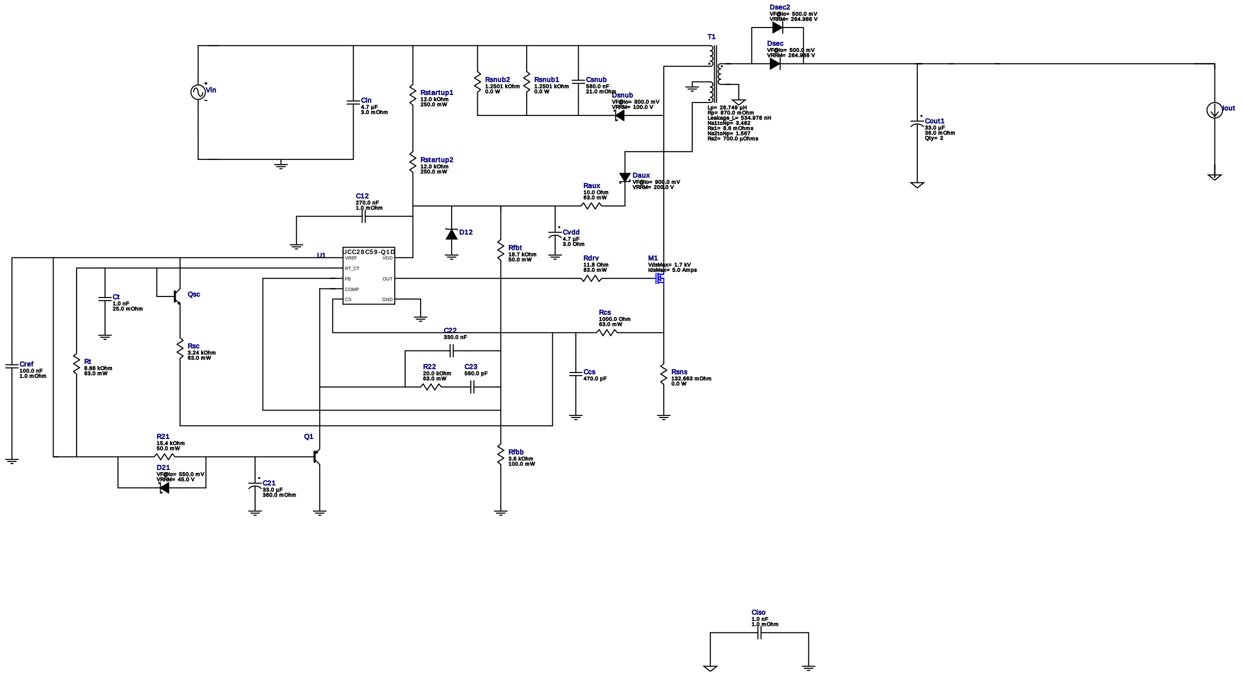
TEXAS INSTRUMENTS	VinMin = 20.0V VinMax = 28.0V Vout = 35.0V Iout = 0.7A	Device = UCC28C59QDRQ1 Topology = Flyback Created = 2025-05-08 05:22:31.496 BOM Cost = NA BOM Count = 38 Total Pd = 3.64W

WEBENCH ® Design Report

Design : 36 UCC28C59QDRQ1
UCC28C59QDRQ1 Isolated_Flyback_CC



1. This regulator device 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.View WEBENCH(R) Disclaimer.

Design Alerts

Component Selection Information

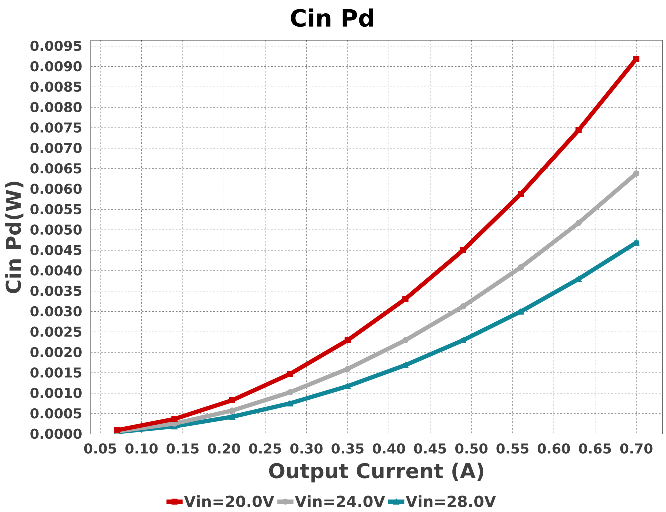
The UCC28C59-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application.

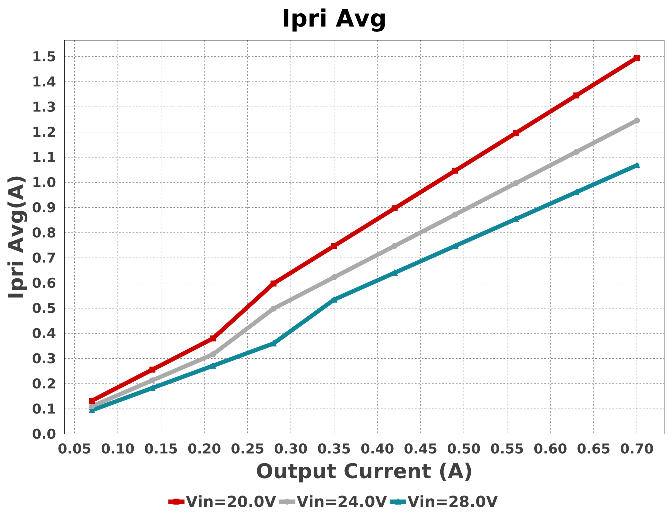
Electrical BOM

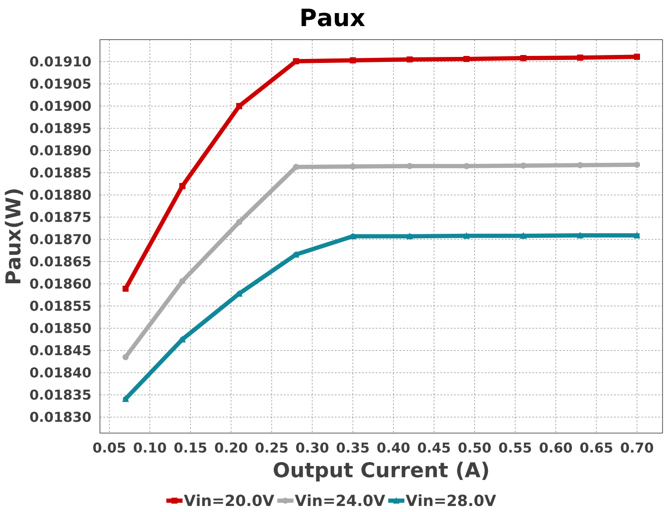
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
C12	MuRata	GRM219R71E274KA01D Series= X7R	Cap= 270.0 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.10	0805 7 mm^2
C21	Chemi-Con	EMZA350ADA330MF61G Series= MZA	Cap= 33.0 uF ESR= 360.0 mOhm VDC= 35.0 V IRMS= 240.0 mA	1	$0.20	CAPSMT_62_F61 74 mm^2
C22	Panasonic	ECPU1C334MA5 Series= ECPU(A)	Cap= 330.0 nF VDC= 16.0 V IRMS= 0.0 A	1	$0.23	1206 11 mm^2
C23	Samsung Electro-Mechanics	CL31C561JBCNNNC Series= C0G/NP0	Cap= 560.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.20	1206 11 mm^2
Ccs	Kemet	C0805X471J5GACTU Series= C0G/NP0	Cap= 470.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.10	0805 7 mm^2

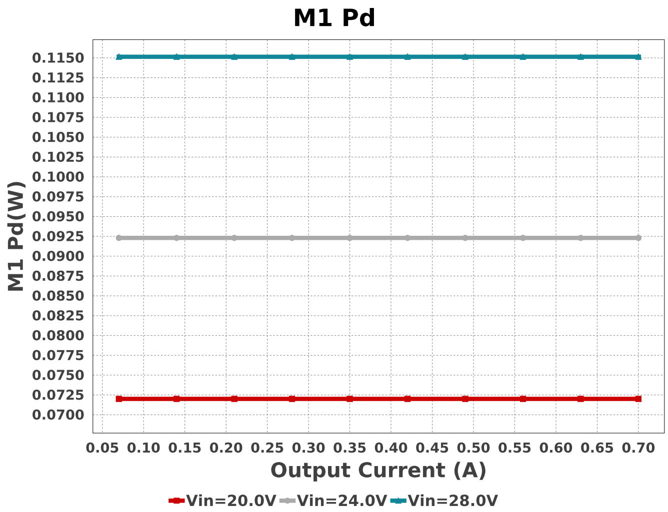
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cin	MuRata	GRM31CR71H475KA12L Series= X7R	Cap= 4.7 uF ESR= 3.0 mOhm VDC= 50.0 V IRMS= 4.98 A	1	$0.10	1206 11 mm^2
Ciso	Johanson Technology	202R18W102KV4E Series= X7R	Cap= 1.0 nF ESR= 1.0 mOhm VDC= 2.0 kV IRMS= 0.0 A	1	$0.06	1206_190 11 mm^2
Cout1	Panasonic	EEHZA1K330P Series= ZA	Cap= 33.0 uF ESR= 36.0 mOhm VDC= 80.0 V IRMS= 1.7 A	2	$1.34	SM_RADIAL_10BMM 160 mm^2
Cref	MuRata	LLL315R71E104MA11L Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.10	0612 11 mm^2
Csnub	Kemet	C0805C564K3RACTU Series= X7R	Cap= 560.0 nF ESR= 21.0 mOhm VDC= 25.0 V IRMS= 5.57 A	1	$0.20	0805 7 mm^2
Ct	Kemet	C0805C102J5GACTU Series= C0G/NP0	Cap= 1.0 nF ESR= 25.0 mOhm VDC= 50.0 V IRMS= 1.71 A	1	$0.02	0805 7 mm^2
Cvdd	Chemi-Con	EMVY350ADA4R7MD55G Series= MVY	Cap= 4.7 uF ESR= 3.0 Ohm VDC= 35.0 V IRMS= 60.0 mA	1	$0.10	CAPSMT_62_D55 28 mm^2
D12	Diodes Inc.	MMSZ5251B-7-F	Zener	1	$0.03	SOD-123 13 mm^2
D21	Bourns	CD0603-B0240	VF@Io= 550.0 mV VRRM= 45.0 V	1	$0.10	Diode_0603 5 mm^2
Daux	Fairchild Semiconductor	S320	VF@Io= 900.0 mV VRRM= 200.0 V	1	$0.33	SMB 44 mm^2
Dsec	CUSTOM	CUSTOM	VF@Io= 500.0 mV VRRM= 264.986 V	1	NA	CUSTOM 0 mm^2
Dsec2	CUSTOM	CUSTOM	VF@Io= 500.0 mV VRRM= 264.986 V	1	NA	CUSTOM 0 mm^2
Dsnub	Fairchild Semiconductor	SSA210	VF@Io= 800.0 mV VRRM= 100.0 V	1	$0.19	SMA 37 mm^2
M1	Cree	C2M1000170D	VdsMax= 1.7 kV IdsMax= 5.0 Amps	1	$5.32	TO-247 123 mm^2
Q1	Diodes Inc.	MMBT3906-7-F	Bipolar Transistor	1	$0.02	SOT-23 14 mm^2
Qsc	STMicroelectronics	2N2222A	Bipolar Transistor	1	$1.19	TO-18 57 mm^2
R21	Yageo	RC0201FR-0715K4L Series= ?	Res= 15.4 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
R22	Vishay-Dale	CRCW040220K0FKED Series= CRCW..e3	Res= 20.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2

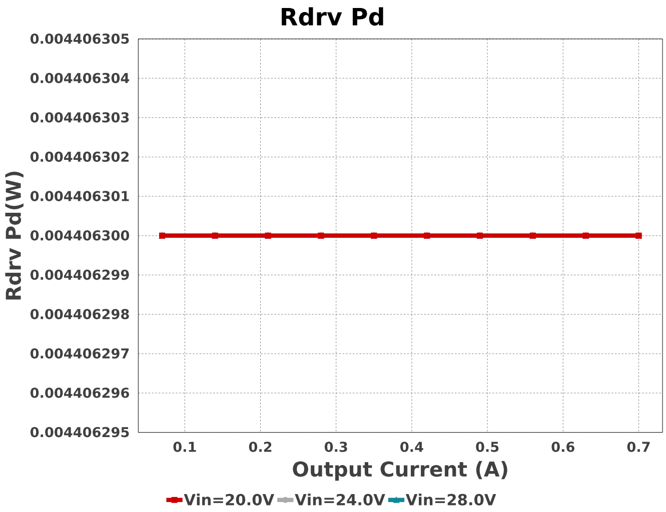
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Raux	Vishay-Dale	CRCW040210R0FKED Series= CRCW..e3	Res= 10.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rcs	Vishay-Dale	CRCW04021K00FKED Series= CRCW..e3	Res= 1000.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rdrv	Vishay-Dale	CRCW040211R8FKED Series= CRCW..e3	Res= 11.8 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb	Yageo	RC0603FR-073K6L Series= ?	Res= 3.6 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rfbt	Yageo	RC0201FR-0718K7L Series= ?	Res= 18.7 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rsc	Vishay-Dale	CRCW04023K24FKED Series= CRCW..e3	Res= 3.24 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rsns	CUSTOM	CUSTOM Series= ?	Res= 132.663 mOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm^2
Rsnub1	CUSTOM	CUSTOM Series= ?	Res= 1.2501 kOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm^2
Rsnub2	CUSTOM	CUSTOM Series= ?	Res= 1.2501 kOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm^2
Rstartup1	Yageo	RC1206FR-0712KL Series= ?	Res= 12.0 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm^2
Rstartup2	Yageo	RC1206FR-0712KL Series= ?	Res= 12.0 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm^2
Rt	Vishay-Dale	CRCW04028K66FKED Series= CRCW..e3	Res= 8.66 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
T1	CUSTOM	CUSTOM	Lp= 26.749 µH Rp= 870.0 mOhm Leakage_L= 534.978 nH Ns1toNp= 3.482 Rs1= 8.6 mOhms Ns2toNp= 1.567 Rs2= 700.0 µOhms	1	NA	CUSTOM 0 mm^2
U1	Texas Instruments	UCC28C59QDRQ1	Switcher	1	$0.63	D0008A 57 mm^2

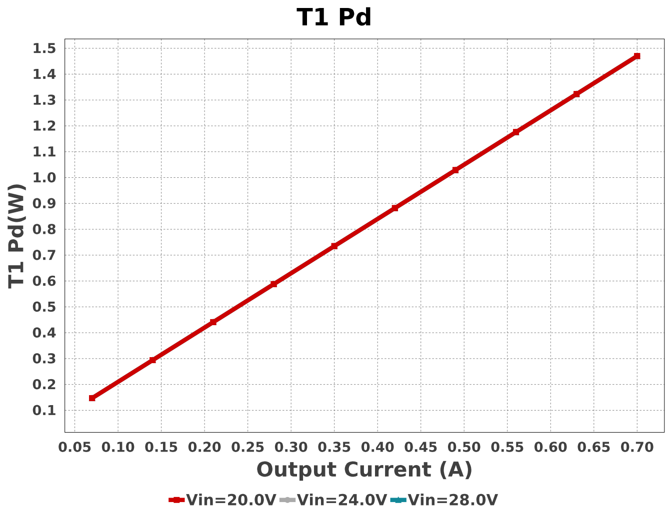

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

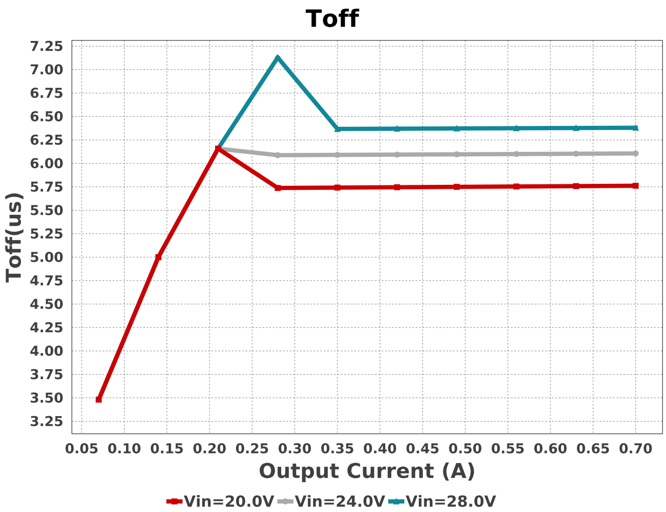

Ipri Avg
Ipri Avg(A)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

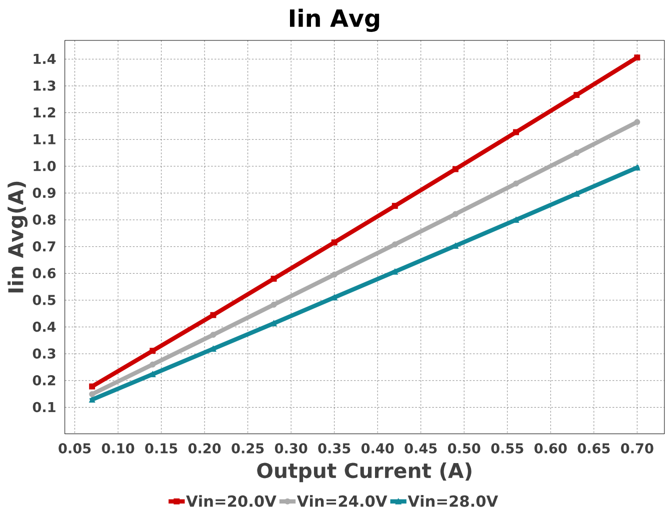

Paux
Paux(W)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

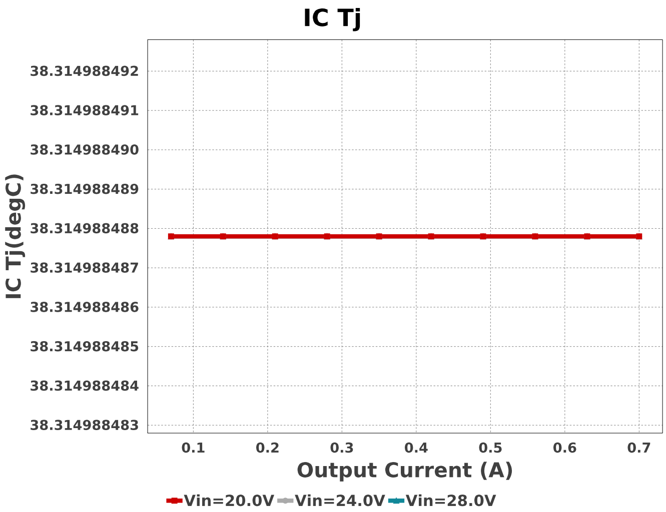

M1 Pd
M1 Pd(W)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

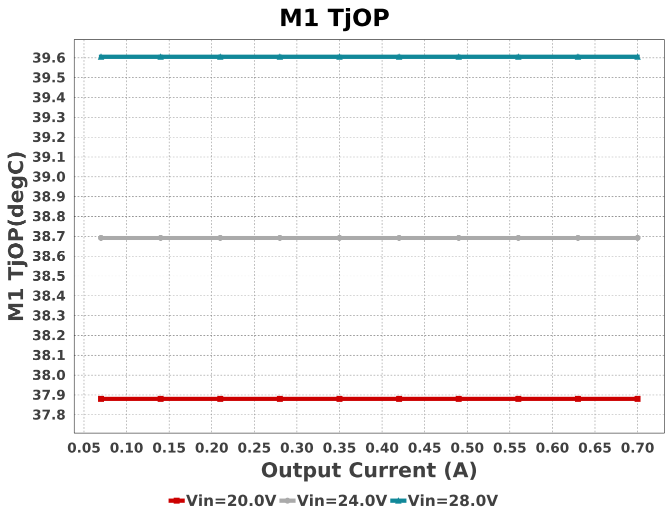

Rdrv Pd
Rdrv Pd(W)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

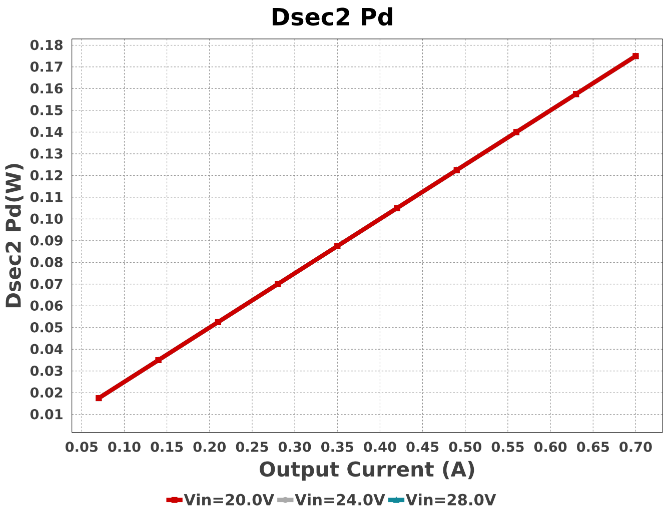

T1 Pd
T1 Pd(W)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

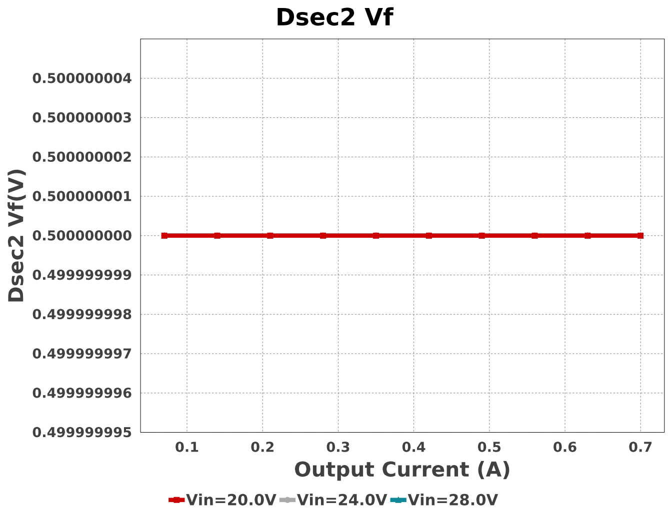

Toff
Toff(us)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V


Iin Avg
Iin Avg(A)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

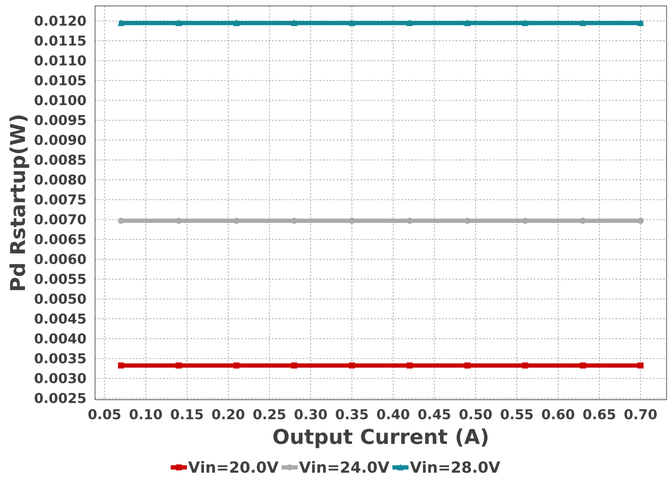

IC Tj
IC Tj(degC)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V


M1 TjOP
M1 TjOP(degC)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

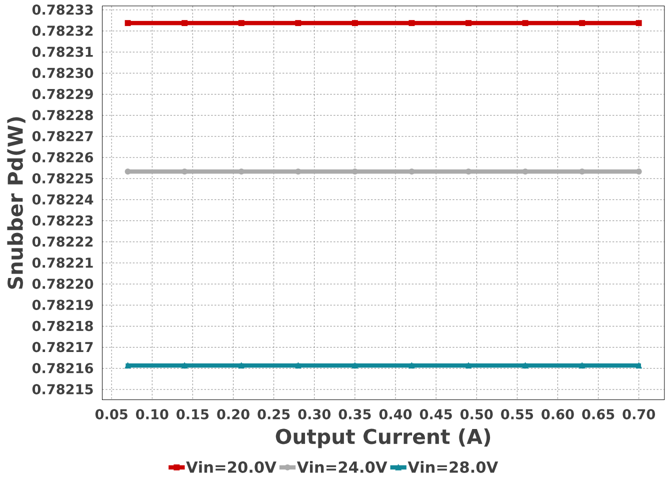

Dsec2 Pd
Dsec2 Pd(W)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V


Dsec2 Vf
Dsec2 Vf(V)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

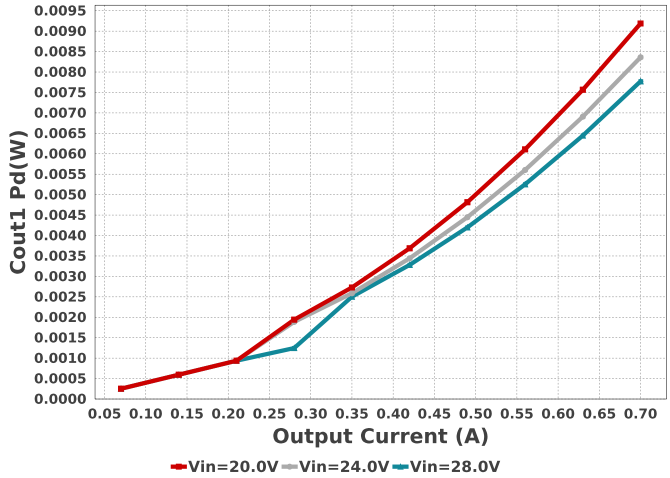
Pd Rstartup



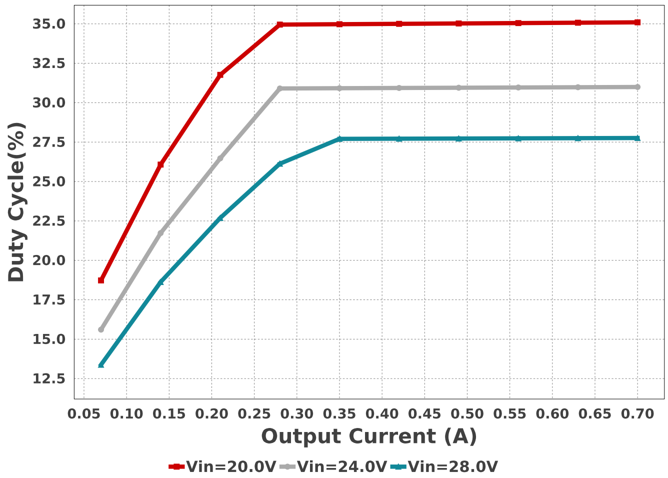
Snubber Pd



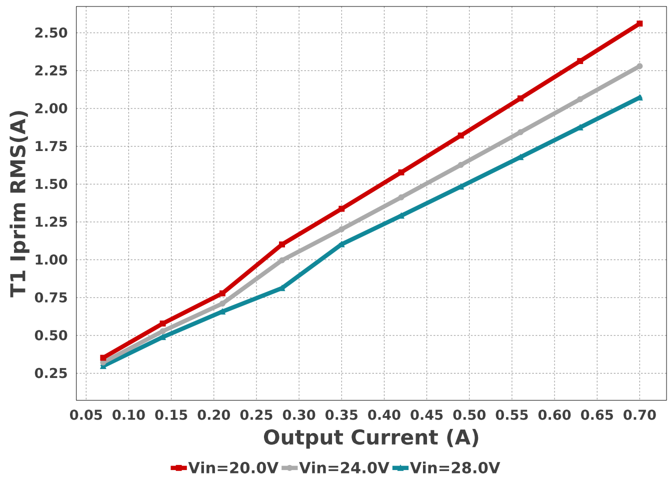
Cout1 Pd



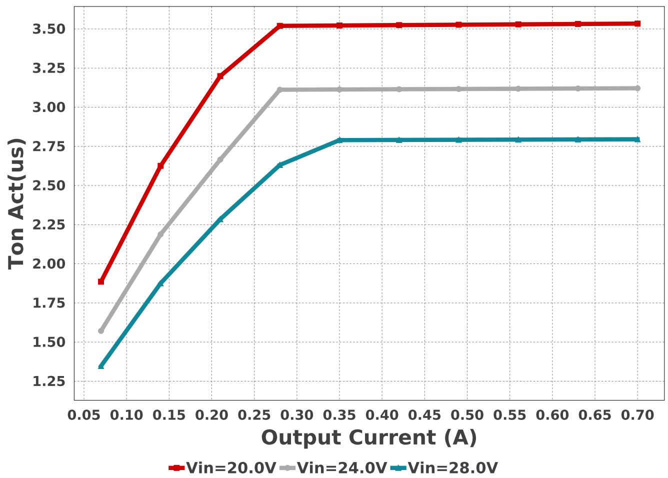
Duty Cycle



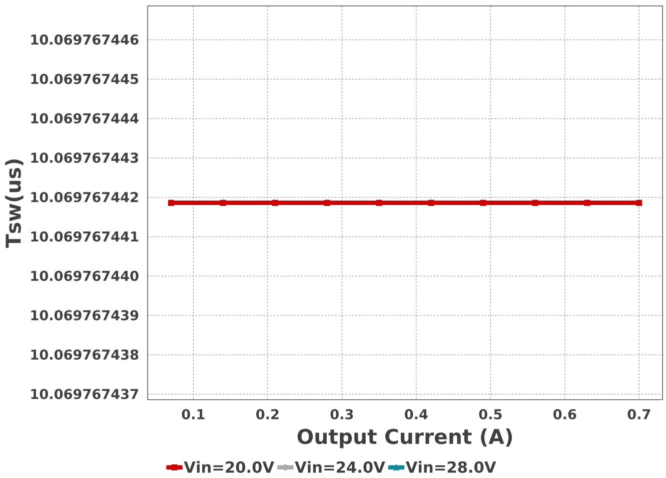
T1 Iprim RMS



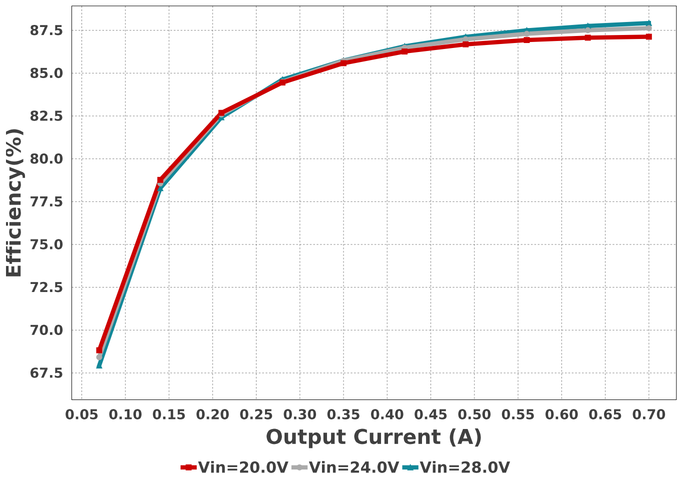
Ton Act



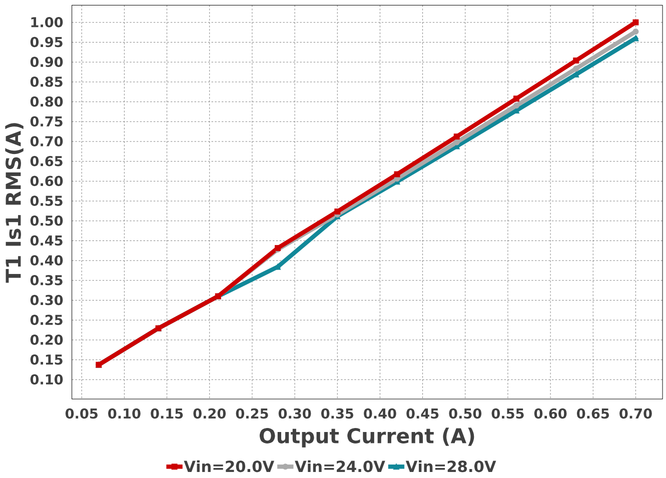
Tsw



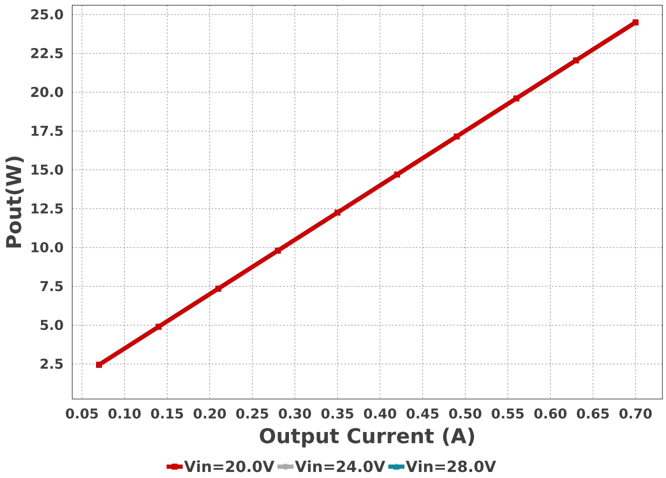
Efficiency



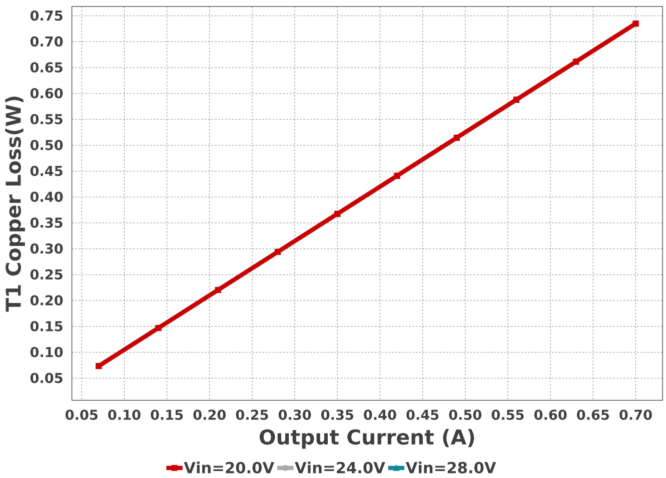
T1 Is1 RMS



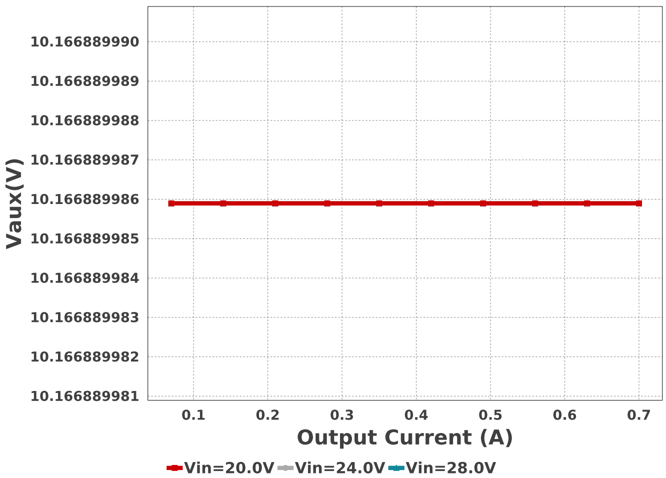
Pout

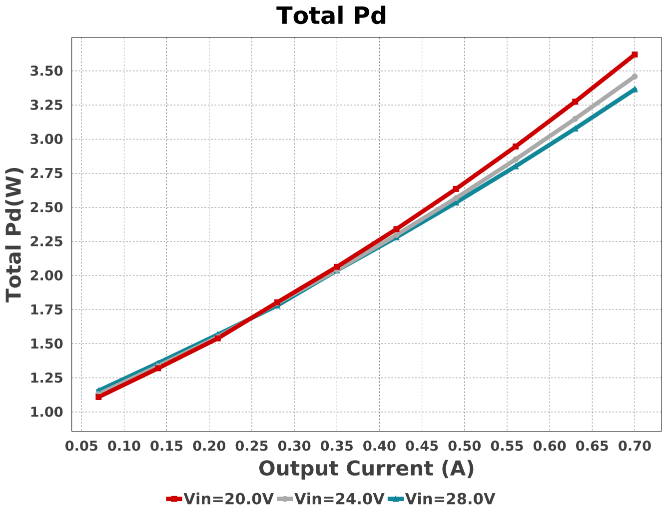


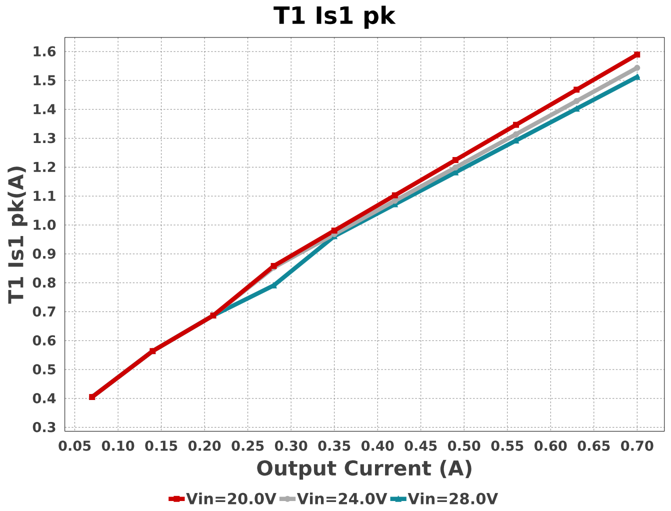
T1 Copper Loss

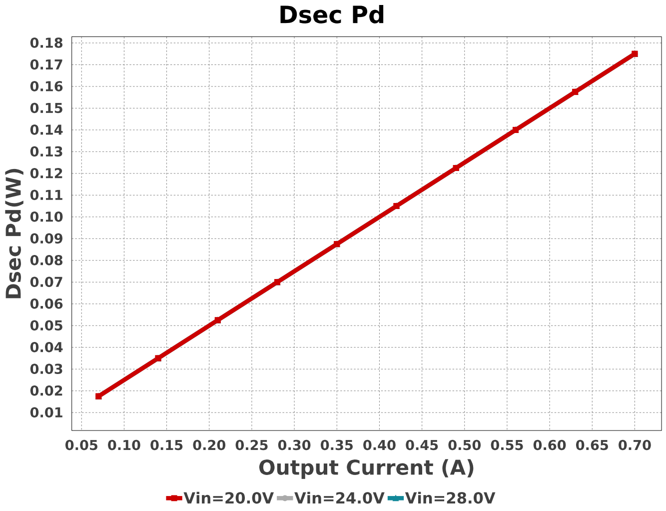


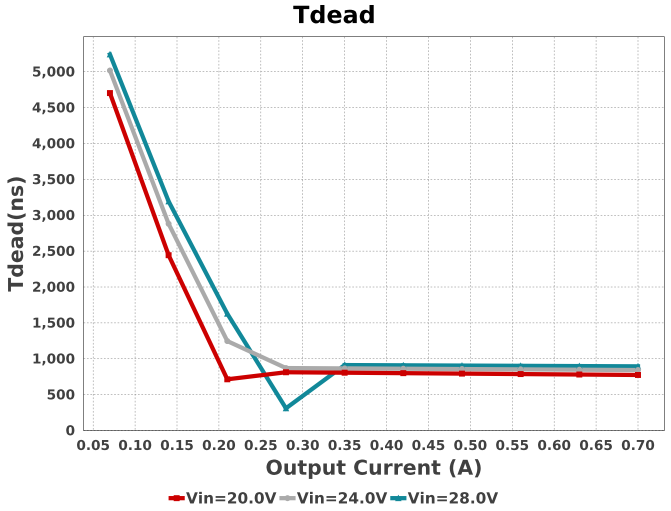
Vaux

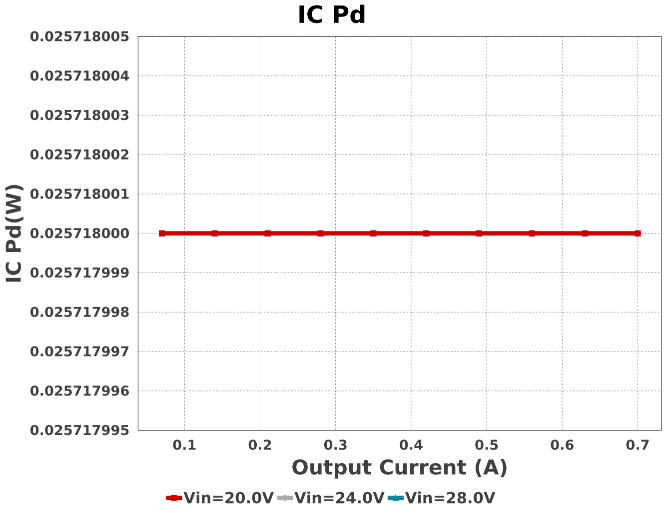


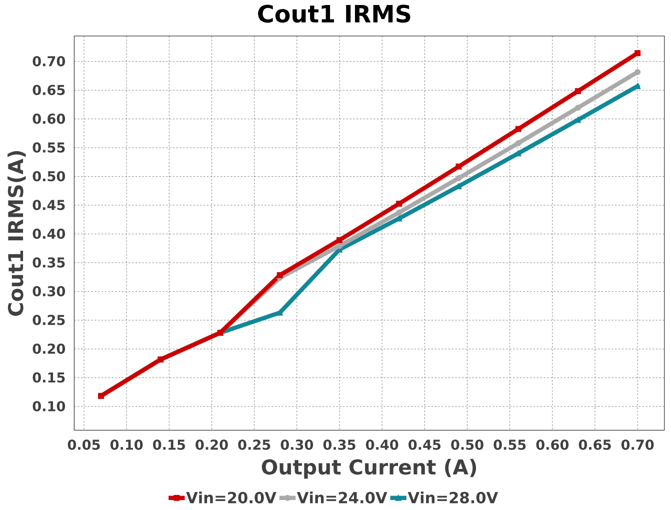

Total Pd
Total Pd(W)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

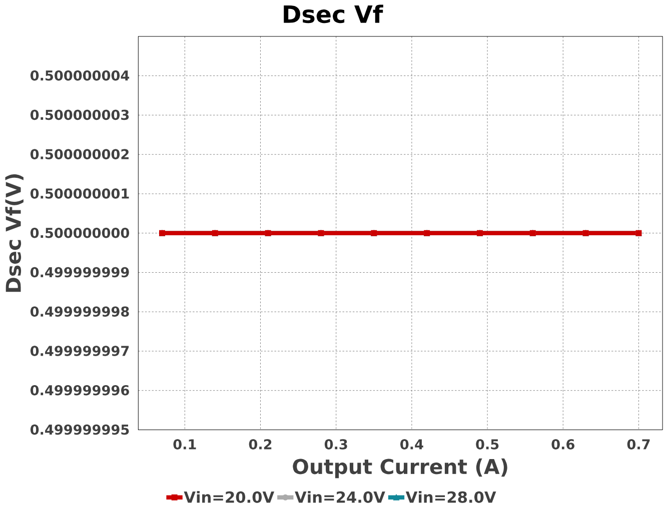

T1 Is1 pk
T1 Is1 pk(A)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

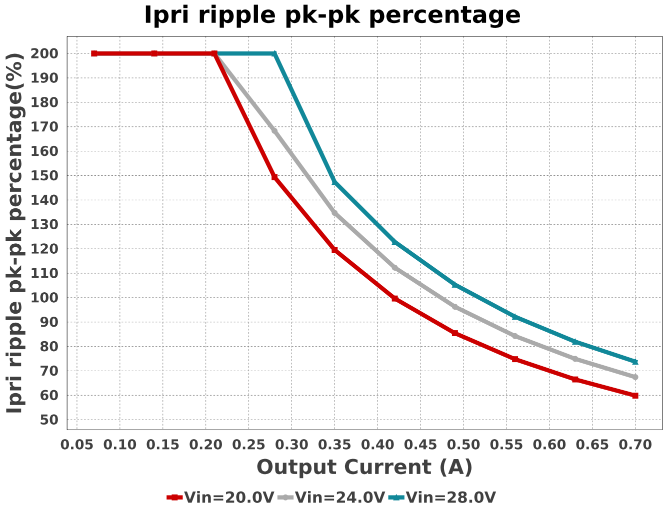

Dsec Pd
Dsec Pd(W)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

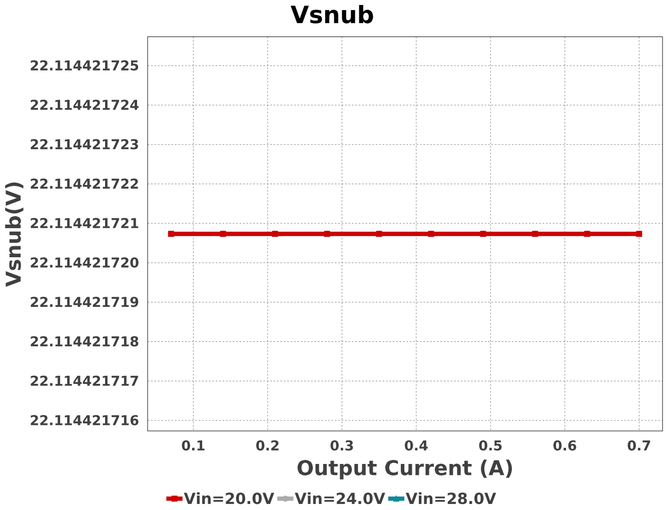

Tdead
Tdead(ns)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

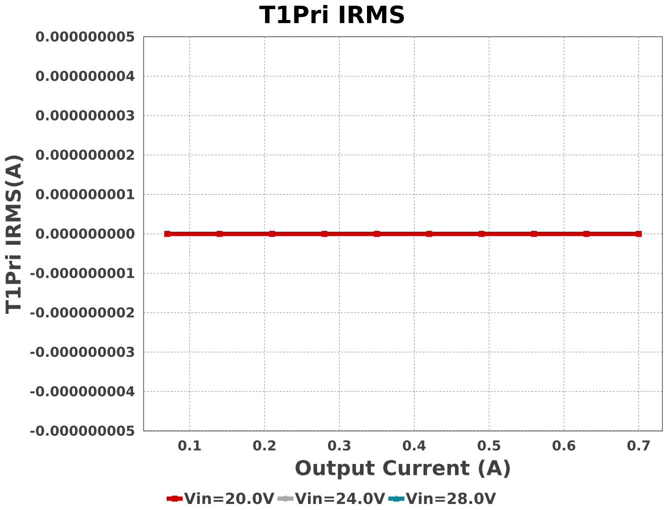

IC Pd
IC Pd(W)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

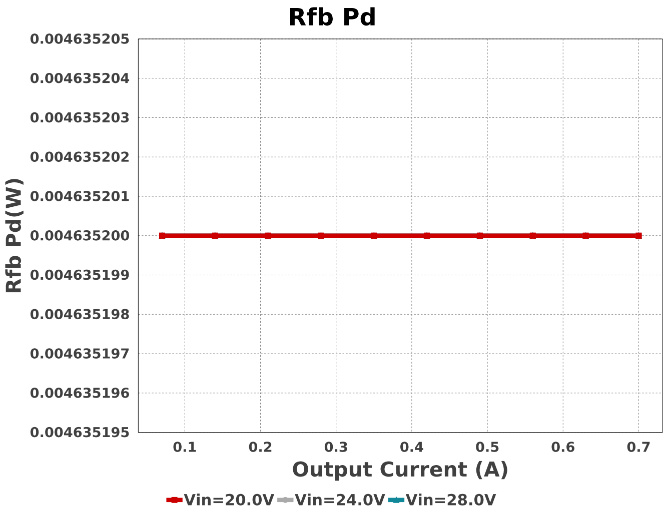

Cout1 IRMS
Cout1 IRMS(A)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

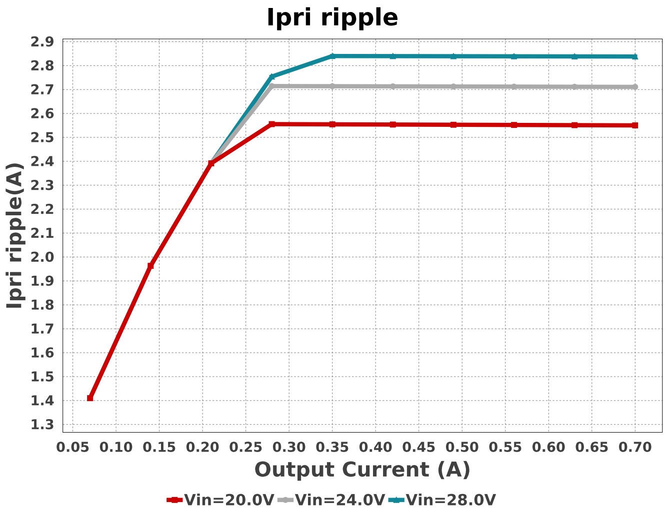

Dsec Vf
Dsec Vf(V)
0.500000004
0.500000003
0.500000002
0.500000001
0.500000000
0.499999999
0.499999998
0.499999997
0.499999996
0.499999995
0.1 0.2 0.3 0.4 0.5 0.6 0.7
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

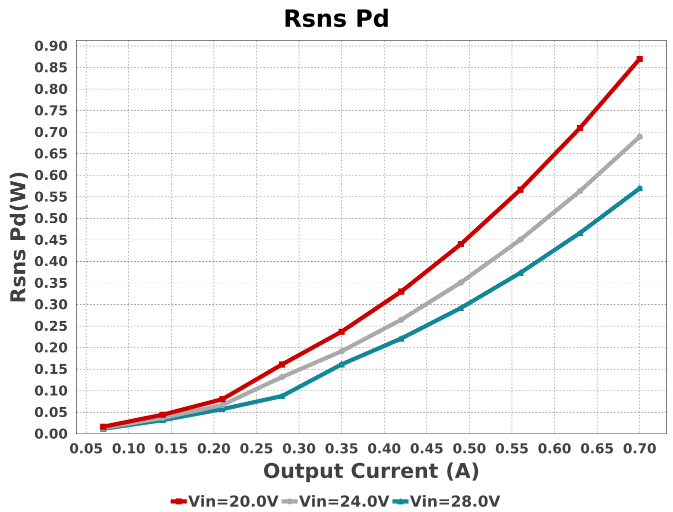

Ipri ripple pk-pk percentage
Ipri ripple pk-pk percentage(%)
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

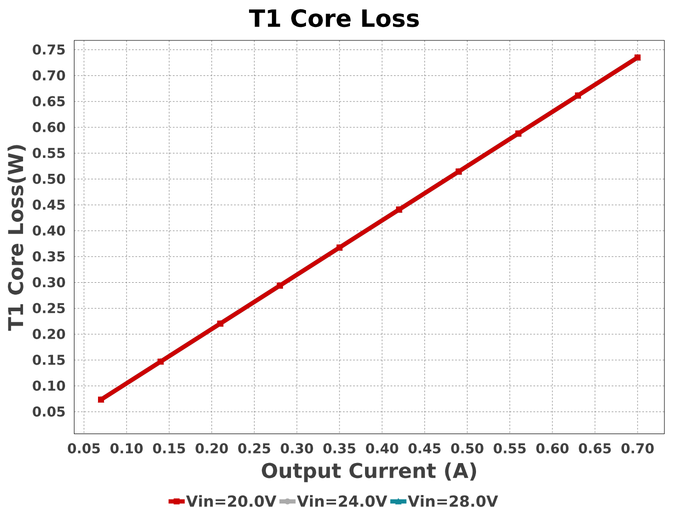

Vsnub
Vsnub(V)
22.114421725
22.114421724
22.114421723
22.114421722
22.114421721
22.114421720
22.114421719
22.114421718
22.114421717
22.114421716
0.1 0.2 0.3 0.4 0.5 0.6 0.7
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

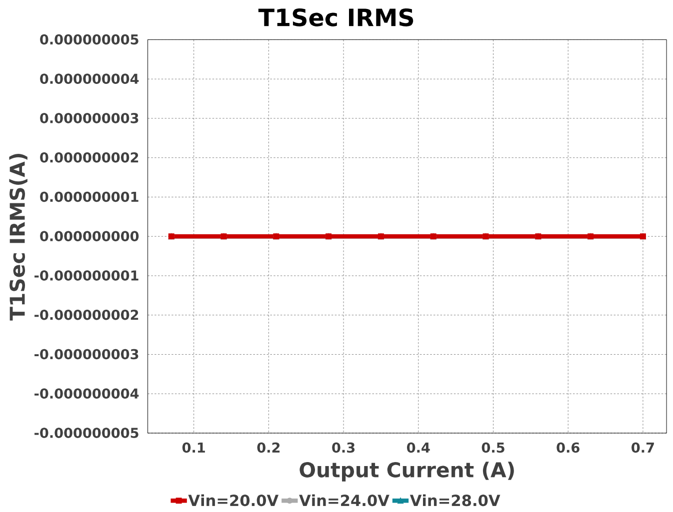

T1Pri IRMS
T1Pri IRMS(A)
0.000000005
0.000000004
0.000000003
0.000000002
0.000000001
0.000000000
-0.000000001
-0.000000002
-0.000000003
-0.000000004
-0.000000005
0.1 0.2 0.3 0.4 0.5 0.6 0.7
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

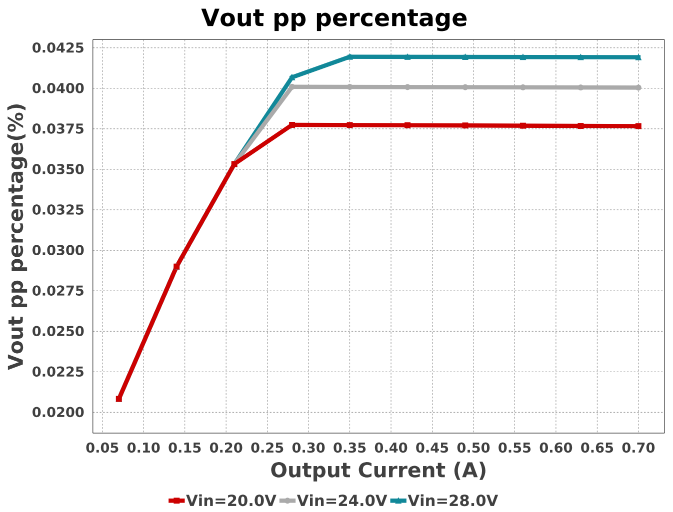

Rfb Pd
Rfb Pd(W)
0.004635205
0.004635204
0.004635203
0.004635202
0.004635201
0.004635200
0.004635199
0.004635198
0.004635197
0.004635196
0.004635195
0.1 0.2 0.3 0.4 0.5 0.6 0.7
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

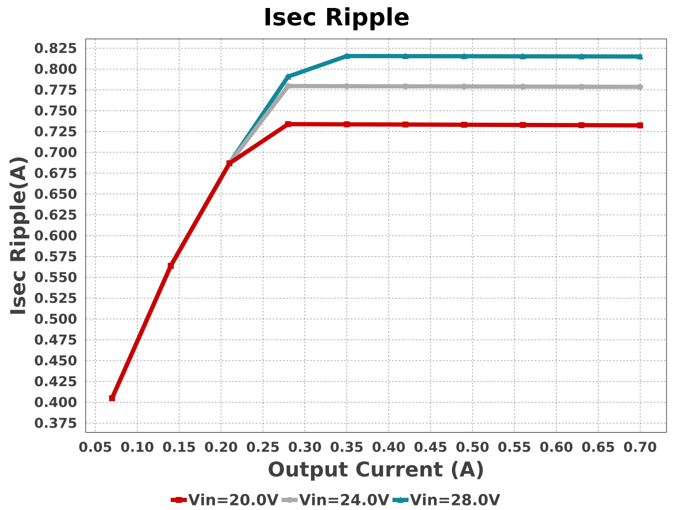

Ipri ripple
Ipri ripple(A)
2.9 2.8 2.7 2.6 2.5 2.4 2.3 2.2 2.1 2.0 1.9 1.8 1.7 1.6 1.5 1.4 1.3
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

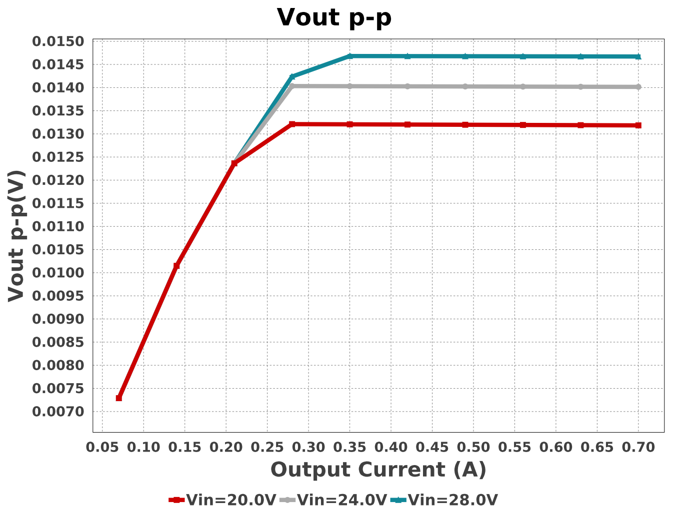

Rsns Pd
Rsns Pd(W)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V

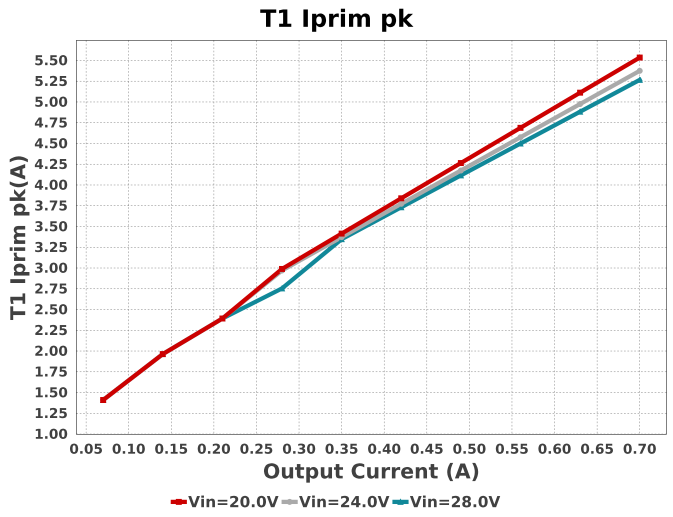

T1 Core Loss
T1 Core Loss(W)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V


T1Sec IRMS
T1Sec IRMS(A)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V


Vout pp percentage
Vout pp percentage(%)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V


Isec Ripple
Isec Ripple(A)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V


Vout p-p
Vout p-p(V)
Output Current (A)
Vin=20.0V Vin=24.0V Vin=28.0V



Operating Values

#	Name	Value	Category	Description
1.	Cin Pd	9.188 mW	Capacitor	Input capacitor power dissipation
2.	Cout1 IRMS	714.454 mA	Capacitor	Output capacitor1 RMS ripple current
3.	Cout1 Pd	9.188 mW	Capacitor	Output capacitor1 power dissipation
4.	Daux trr	30.0 ns	Diode	Auxiliary Diode Reverse Recovery Time
5.	Dsec Pd	175.0 mW	Diode	Secondary Diode Power Dissipation
6.	Dsec Vf	500.0 mV	Diode	Effective Forward Voltage Drop at the Operating Current
7.	Dsec trr	0.0 ns	Diode	Output Diode Reverse Recovery Time
8.	Dsec2 Pd	175.0 mW	Diode	Secondary Diode Power Dissipation
9.	Dsec2 Vf	500.0 mV	Diode	Effective Forward Voltage Drop at the Operating Current
10.	Dsnub trr	8.02 ns	Diode	Snubber Diode Reverse Recovery Time
11.	IC Pd	41.704 mW	IC	IC power dissipation
12.	IC Tj	40.376 degC	IC	IC junction temperature
13.	ICThetaJA	128.9 degC/W	IC	IC junction-to-ambient thermal resistance
14.	Iin Avg	1.407 A	IC	Average input current
15.	M1 Pd	72.239 mW	Mosfet	M1 MOSFET total power dissipation
16.	M1 TjOP	37.89 degC	Mosfet	M1 MOSFET junction temperature
17.	Cin Pd	9.188 mW	Power	Input capacitor power dissipation
18.	Cout1 Pd	9.188 mW	Power	Output capacitor1 power dissipation
19.	Dsec Pd	175.0 mW	Power	Secondary Diode Power Dissipation
20.	Dsec2 Pd	175.0 mW	Power	Secondary Diode Power Dissipation
21.	IC Pd	41.704 mW	Power	IC power dissipation
22.	M1 Pd	72.239 mW	Power	M1 MOSFET total power dissipation
23.	Paux	19.111 mW	Power	Power Dissipation in Raux and Daux
24.	Pd Rstartup	419.36 µW	Power	Power Dissipation in Rstartup1 and Rstartup2
25.	Rdrv Pd	7.146 mW	Power	Power Dissipation in Gate Drive Resistor
26.	Rfb Pd	11.376 mW	Power	Rfb Power Dissipation
27.	Rsns Pd	870.09 mW	Power	Current Limit Sense Resistor Power Dissipation
28.	Snubber Pd	782.324 mW	Power	Snubber Power Dissipation
29.	T1 Copper Loss	735.0 mW	Power	Transformer Copper Loss Power Dissipation
30.	T1 Core Loss	735.0 mW	Power	Transformer Core Loss Power Dissipation
31.	T1 Pd	1.47 W	Power	Estimated Losses in Transformer
32.	Total Pd	3.643 W	Power	Total Power Dissipation
33.	Pd Rstartup	419.36 µW	Resistor	Power Dissipation in Rstartup1 and Rstartup2
34.	Rdrv Pd	7.146 mW	Resistor	Power Dissipation in Gate Drive Resistor
35.	Rfb Pd	11.376 mW	Resistor	Rfb Power Dissipation
36.	Rsns Pd	870.09 mW	Resistor	Current Limit Sense Resistor Power Dissipation
37.	BOM Count	38	System Information	Total Design BOM count
38.	Duty Cycle	35.096 %	System Information	Duty cycle
39.	Efficiency	87.056 %	System Information	Steady state efficiency
40.	FootPrint	933.0 mm^2	System Information	Total Foot Print Area of BOM components
41.	Frequency	99.307 kHz	System Information	Switching frequency
42.	Iout	700.0 mA	System Information	Iout operating point
43.	Mode	CCM	System Information	Conduction Mode
44.	Pout	24.5 W	System Information	Total output power

#	Name	Value	Category	Description
45.	Tdead	774.012 ns	System Information	Approximate Dead Time of the Regulator
46.	Toff	5.762 us	System Information	Approximate Converter Off Time
47.	Ton Act	3.534 us	System Information	Approximate Converter On Time
48.	Total BOM	NA	System Information	Total BOM Cost
49.	Tsw	10.07 us	System Information	Switching Time Period
50.	Vin	20.0 V	System Information	Vin operating point
51.	Vout	35.0 V	System Information	Operational Output Voltage
52.	Vout p-p	13.183 mV	System Information	Peak-to-peak output ripple voltage
53.	Vout pp percentage	37.667 m%	System Information	Output Voltage ripple percentage
54.	Vsnub	22.114 V	System Information	Voltage Across the Snubber
55.	Ipri Avg	1.495 A	Transformer	Average Current in Primary Winding over the complete Switching Period
56.	Ipri ripple	2.55 A	Transformer	Ripple Current in the Primary Winding
57.	Ipri ripple pk-pk percentage	59.866 %	Transformer	Primary Current pk-pk ripple percentage(of Ipri avg during ton only)
58.	Isec Ripple	732.41 mA	Transformer	Ripple Current in the Secondary Winding
59.	Paux	19.111 mW	Transformer	Power Dissipation in Raux and Daux
60.	T1 Copper Loss	735.0 mW	Transformer	Transformer Copper Loss Power Dissipation
61.	T1 Core Loss	735.0 mW	Transformer	Transformer Core Loss Power Dissipation
62.	T1 Iprim RMS	2.561 A	Transformer	Transformer Primary RMS Current
63.	T1 Iprim pk	5.535 A	Transformer	Transformer Primary Peak Current
64.	T1 Is1 RMS	1.0 A	Transformer	Transformer Secondary1 RMS Current
65.	T1 Is1 pk	1.59 A	Transformer	Transformer Secondary1 Peak Current
66.	T1 Pd	1.47 W	Transformer	Estimated Losses in Transformer
67.	T1Pri IRMS	2.506 A	Transformer	Transformer Primary RMS Current
68.	T1Sec IRMS	959.522 mA	Transformer	Transformer Secondary RMS Current
69.	Vaux	15.928 V	Transformer	Auxiliary Voltage

Design Inputs

Name	Value	Description
Iout	700.0 m	Maximum Output Current
VinMax	28.0	Maximum input voltage
VinMin	20.0	Minimum input voltage
Vout	35.0	Output Voltage
base_pn	UCC28C59-Q1	Base Product Number
source	DC	Input Source Type
Ta	35.0	Ambient temperature
UserFsw	99.0 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

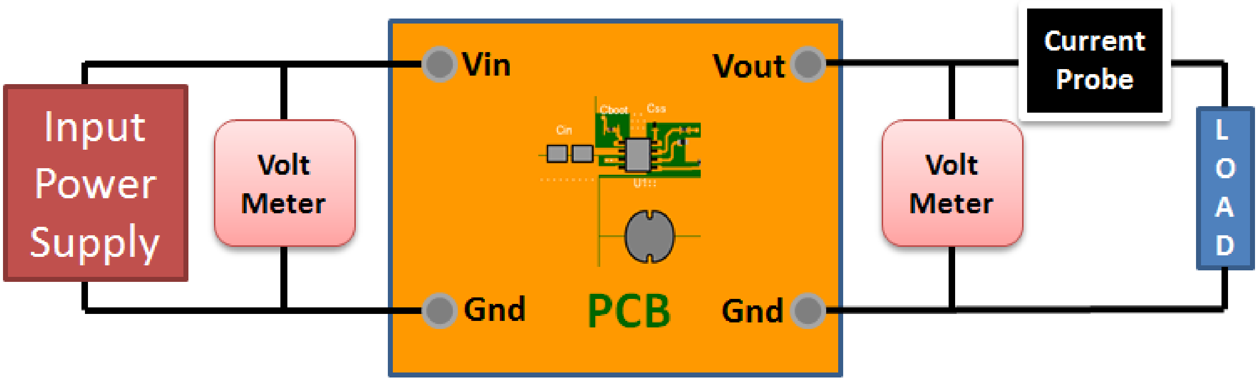
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 20.0V and set the input supply's current limit to zero. With the input supply off connect up the input supply to Vin and GND. Connect a digital volt meter and a load if needed to set the minimum Iout of the design from Vout and GND. Turn on the input supply and slowly turn up the current limit on the input supply. If the voltage starts to rise on the input supply continue increasing the input supply current limit while watching the output voltage. If the current increases on the input supply, but the voltage remains near zero, then there may be a short or a component misplaced on the board. Power down the board and visually inspect for solder bridges and recheck the diode and capacitor polarities. Once the power supply circuit is operational then more extensive testing may include full load testing, transient load and line tests to compare with simulation results.

Load Testing

The setup is the same as the initial startup, except that an additional digital voltmeter is connected between Vin and GND, a load is connected between Vout and GND and a current meter is connected in series between Vout and the load. The load must be able to handle at least rated output power + 50% (7.5 watts for this design). Ideally the load is supplied in the form of a variable load test unit. It can also be done in the form of suitably large power resistors. When using an oscilloscope to measure waveforms on the prototype board, the ground leads of the oscilloscope probes should be as short as possible and the area of the loop formed by the ground lead should be kept to a minimum. This will help reduce ground lead inductance and eliminate EMI noise that is not actually present in the circuit.



Design Assistance

1. Feature Highlights: This device provides the features that are necessary to implement off-line or dc-to-dc fixed-frequency current-mode control schemes, with a minimum number of external components.

2. The UCC28C59-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

3. Master key : FFB87DF0A64C39D259A4EAC78DAAC85C[v1]

4. **UCC28C59-Q1** Product Folder : https://www.ti.com/product/UCC28C59%2DQ1 : contains the data sheet and other resources.

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