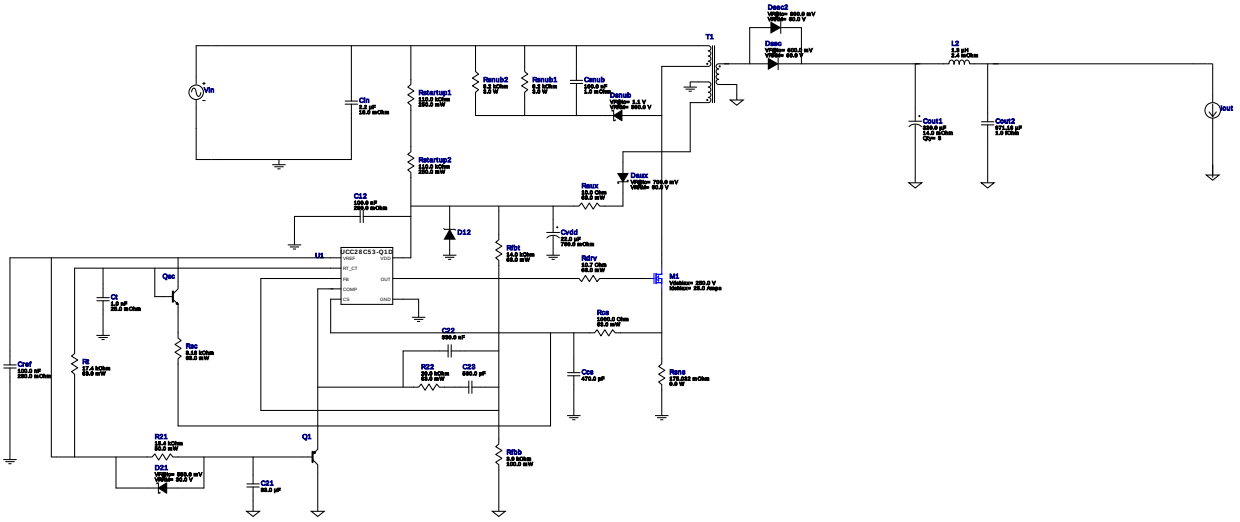
VinMin = 50.0V
VinMax = 85.0V
Vout = 12.0V
Iout = 5.0A

Device = UCC28C53QDRQ1
Topology = Flyback
Created = 2023-08-04 07:34:18.956
BOM Cost = NA
BOM Count = 40
Total Pd = 5.5W

WEBENCH® Design Report

Design : 14 UCC28C53QDRQ1
UCC28C53QDRQ1 50V-85V to 12.00V @ 5A



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.

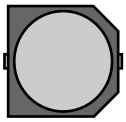
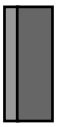
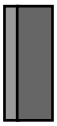
Design Alerts

Component Selection Information

The UCC28C53-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

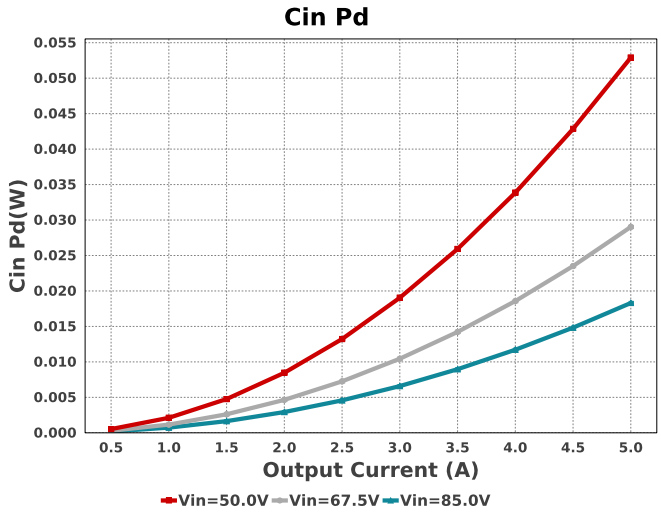
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
C12	AVX	08053C104KAT2A Series= X7R	Cap= 100.0 nF ESR= 280.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
C21	MuRata	KCM55WR7YA336MH01K Series= X7R	Cap= 33.0 uF VDC= 35.0 V IRMS= 0.0 A	1	$2.81	KCM55W 59 mm^2
C22	Panasonic	ECPU1C334MA5 Series= ECPU(A)	Cap= 330.0 nF VDC= 16.0 V IRMS= 0.0 A	1	$0.23	1206 11 mm^2
C23	MuRata	GRM1555C1H561JA01J Series= C0G/NP0	Cap= 560.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ccs	Samsung Electro-Mechanics	CL21C471JBANNNC Series= C0G/NP0	Cap= 470.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2

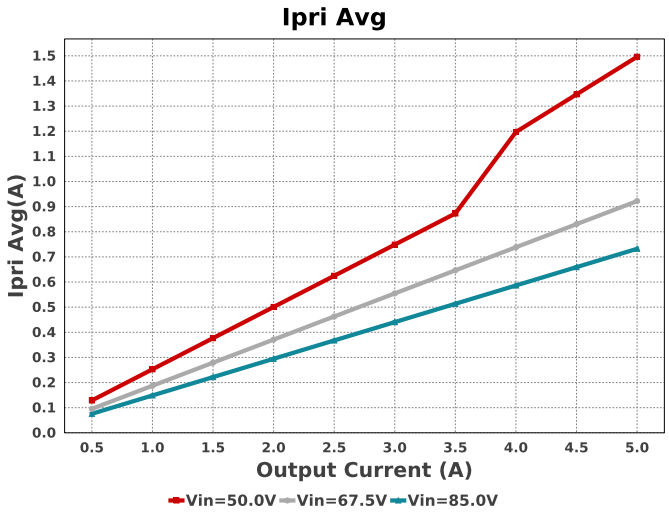
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cin	TDK	B32674D3225K Series= B32674	Cap= 2.2 uF ESR= 18.0 mOhm VDC= 300.0 V IRMS= 5.0 A	1	$0.92	 B32674_3150x1900x1100 436 mm²
Cout1	Panasonic	25SVPF330M Series= SVPF	Cap= 330.0 uF ESR= 14.0 mOhm VDC= 25.0 V IRMS= 5.0 A	3	$1.33	 CAPSMT_62_F12 151 mm²
Cout2	CUSTOM	CUSTOM Series= ?	Cap= 971.16 uF ESR= 1.0 fOhm VDC= 30.0 V IRMS= 9.3402 A	1	NA	CUSTOM 0 mm²
Cref	AVX	08053C104KAT2A Series= X7R	Cap= 100.0 nF ESR= 280.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	 0805 7 mm²
Csnub	TDK	C2012X7T2E104K125AA Series= X7T	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 250.0 V IRMS= 0.0 A	1	$0.09	 0805 7 mm²
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 mm²
Cvdd	Nichicon	UUD1V220MCL1GS Series= uD	Cap= 22.0 uF ESR= 760.0 mOhm VDC= 35.0 V IRMS= 150.0 mA	1	$0.14	 SM_RADIAL_5MM 58 mm²
D12	Diodes Inc.	MMSZ5248B-7-F	Zener	1	$0.04	 SOD-123 13 mm²
D21	Panasonic	DB2S31600L	VF@Io= 550.0 mV VRRM= 30.0 V	1	$0.03	 SOD-523 5 mm²
Daux	Fairchild Semiconductor	SS26FL	VF@Io= 700.0 mV VRRM= 60.0 V	1	$0.11	 SOD-123F 12 mm²
Dsec	Diodes Inc.	STPS30M60	VF@Io= 600.0 mV VRRM= 60.0 V	1	$0.79	 TO-220AB 79 mm²
Dsec2	Diodes Inc.	STPS30M60	VF@Io= 600.0 mV VRRM= 60.0 V	1	$0.79	 TO-220AB 79 mm²
Dsnub	SMC Diode Solutions	ST1300ATR	VF@Io= 1.1 V VRRM= 300.0 V	1	$0.12	 SMA 37 mm²
L2	Coilcraft	MLC1250-132MLB	L= 1.3 µH 2.4 mOhm	1	$0.79	 MLC1250 165 mm²
M1	Infineon Technologies	BSC600N25NS3GATMA1	VdsMax= 250.0 V IdsMax= 25.0 Amps	1	$2.26	 PG-TDSON-8 55 mm²

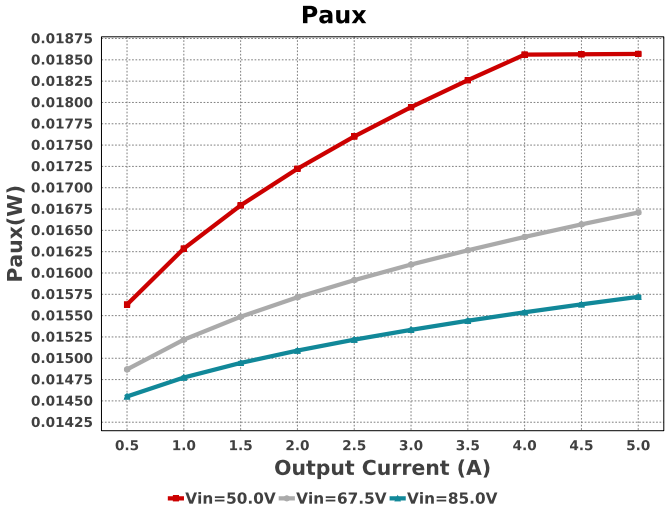
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Q1	Diodes Inc.	MMBT3906-7-F	Bipolar Transistor	1	$0.02	 SOT-23 14 mm²
Qsc	STMicroelectronics	2N2222A	Bipolar Transistor	1	$1.19	 TO-18 57 mm²
R21	Yageo	RC0201FR-0715K4L Series= ?	Res= 15.4 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
R22	Vishay-Dale	CRCW040220K0FKED Series= CRCW..e3	Res= 20.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Raux	Vishay-Dale	CRCW040210R0FKED Series= CRCW..e3	Res= 10.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rcs	Vishay-Dale	CRCW04021K00FKED Series= CRCW..e3	Res= 1000.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rdrv	Vishay-Dale	CRCW040210R7FKED Series= CRCW..e3	Res= 10.7 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbb	Yageo	RC0603FR-073K9L Series= ?	Res= 3.9 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rfbt	Vishay-Dale	CRCW040214K0FKED Series= CRCW..e3	Res= 14.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rsc	Vishay-Dale	CRCW04023K16FKED Series= CRCW..e3	Res= 3.16 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rsns	CUSTOM	CUSTOM Series= ?	Res= 175.032 mOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm²
Rsnub1	Vishay-Bccomponents	PR03000208201JAC00 Series= ?	Res= 8.2 kOhm Power= 3.0 W Tolerance= 5.0%	1	$0.18	 PR03 197 mm²
Rsnub2	Vishay-Bccomponents	PR03000208201JAC00 Series= ?	Res= 8.2 kOhm Power= 3.0 W Tolerance= 5.0%	1	$0.18	 PR03 197 mm²
Rstartup1	Vishay-Dale	CRCW1206110KFKEA Series= CRCW..e3	Res= 110.0 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	 1206 11 mm²
Rstartup2	Vishay-Dale	CRCW1206110KFKEA Series= CRCW..e3	Res= 110.0 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	 1206 11 mm²
Rt	Vishay-Dale	CRCW040217K4FKED Series= CRCW..e3	Res= 17.4 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
T1	Core=TDK , CoilFormer=TDK	Core=B66421G0000X197 , CoilFormer=B66422W1010D001	Lp= 87.0 µH Turns Ratio(Nas)= 6:5 Turns Ratio(Nps)= 27:5 Npri= 27.0 Naux= 6.0 Nsec= 5.0	1	$0.49	 TDK_B66305 756 mm²

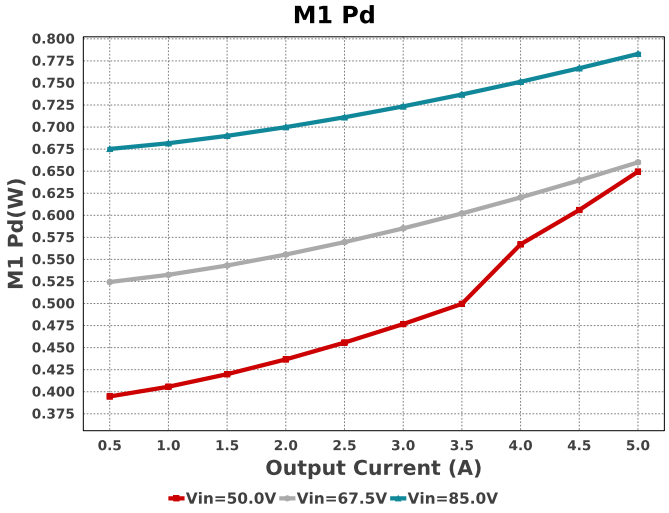
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
U1	Texas Instruments	UCC28C53QDRQ1	Switcher	1	$0.67	

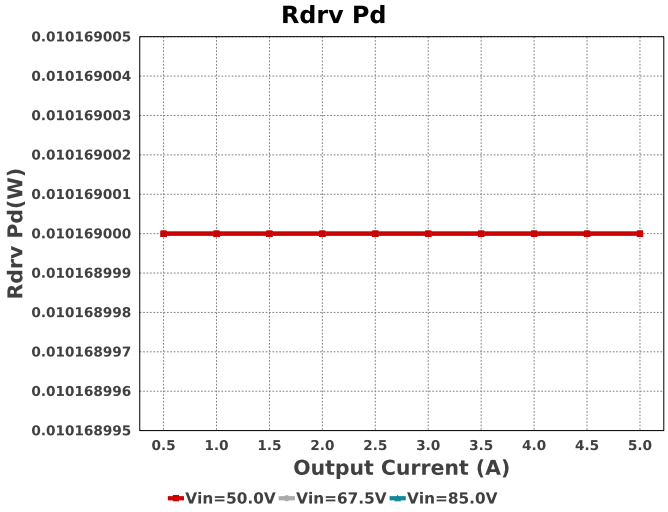
D0008A 57 mm^2

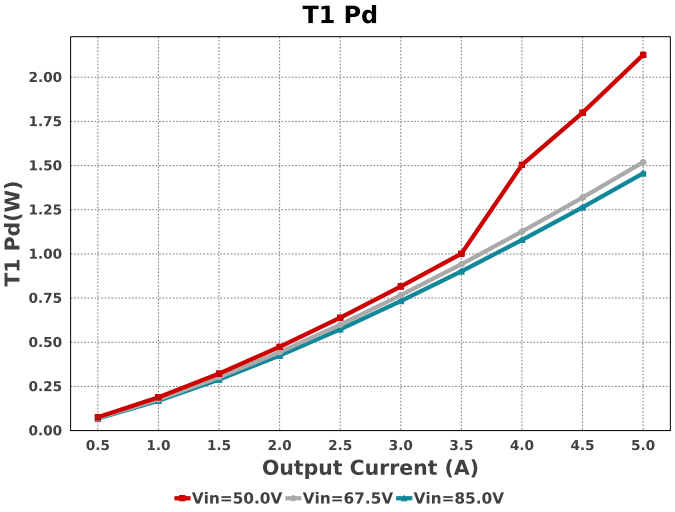


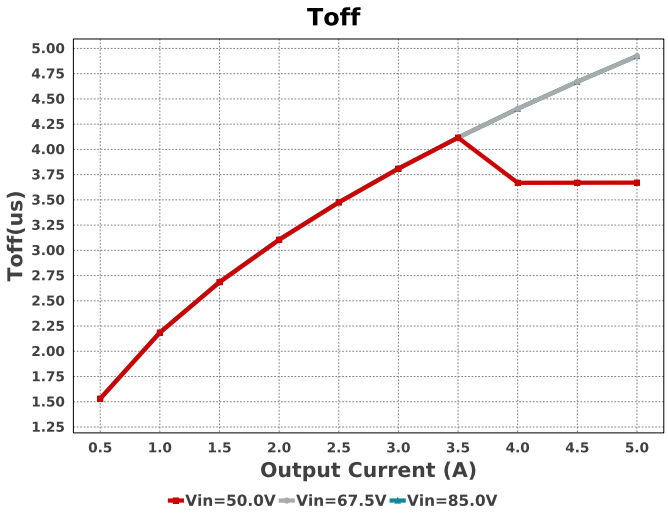


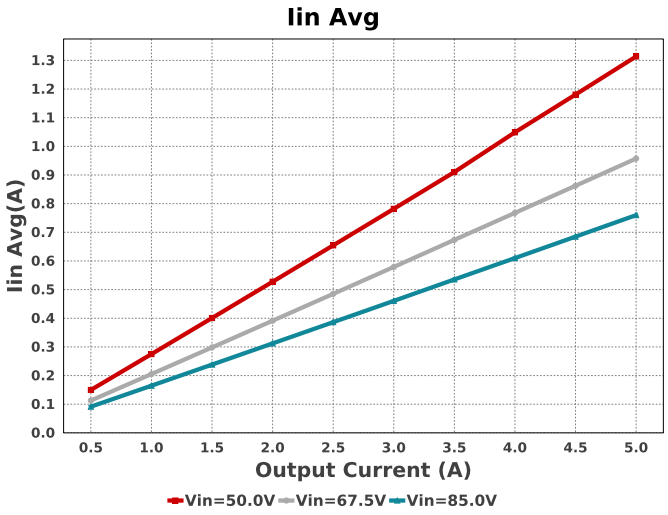


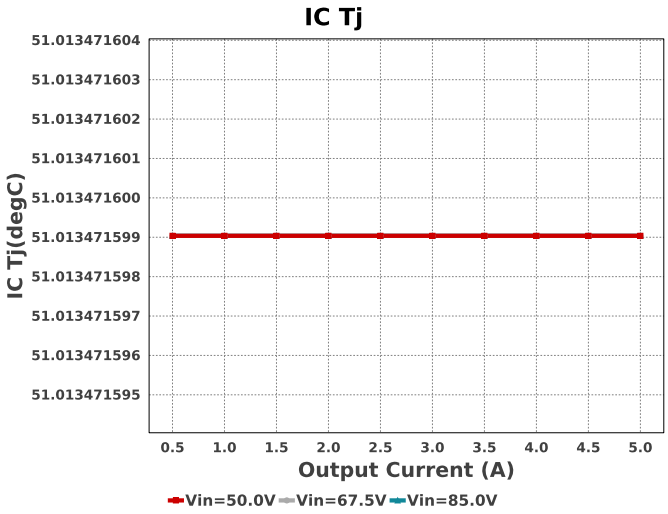


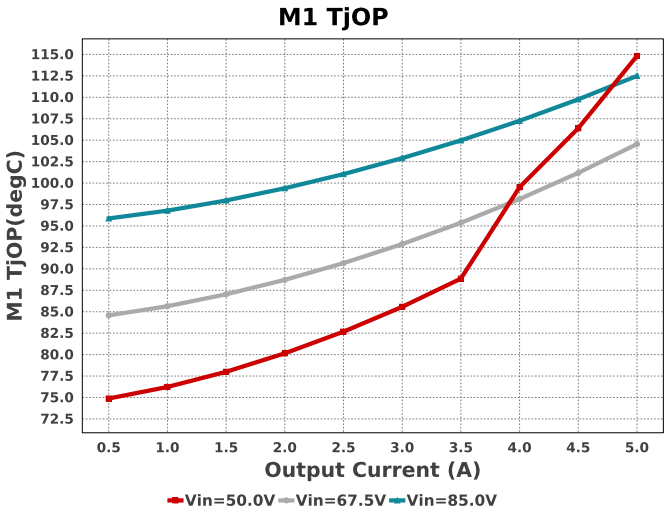


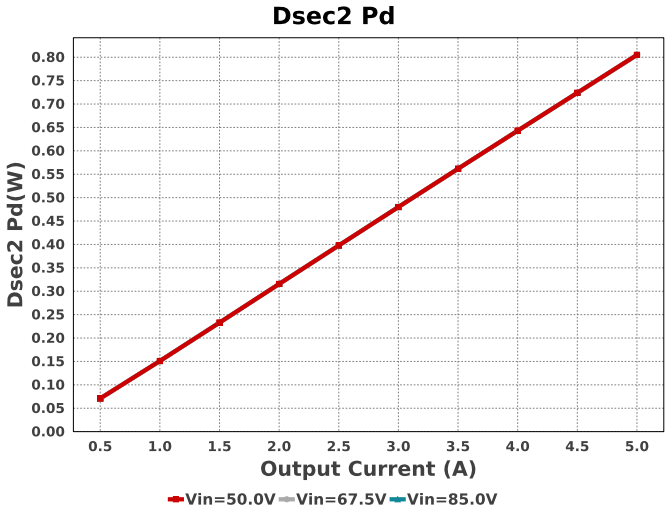


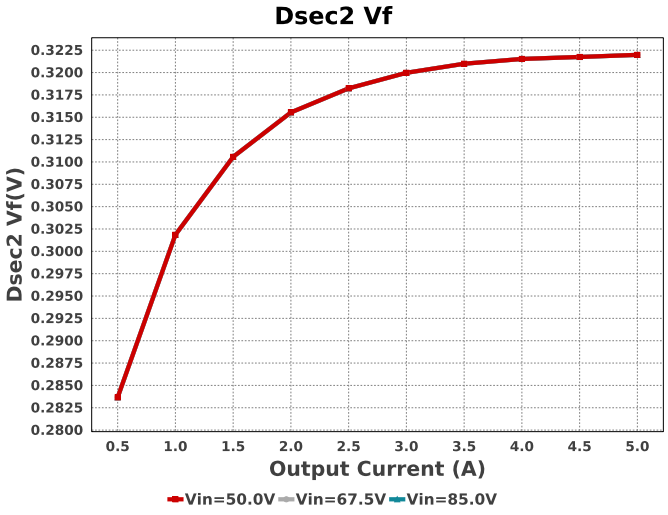


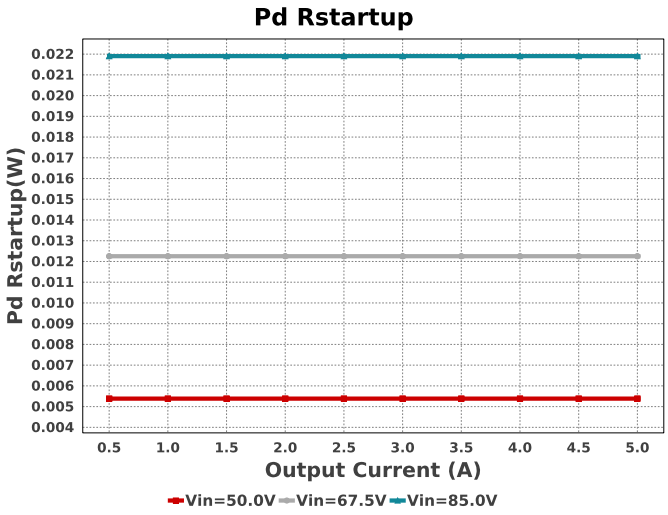


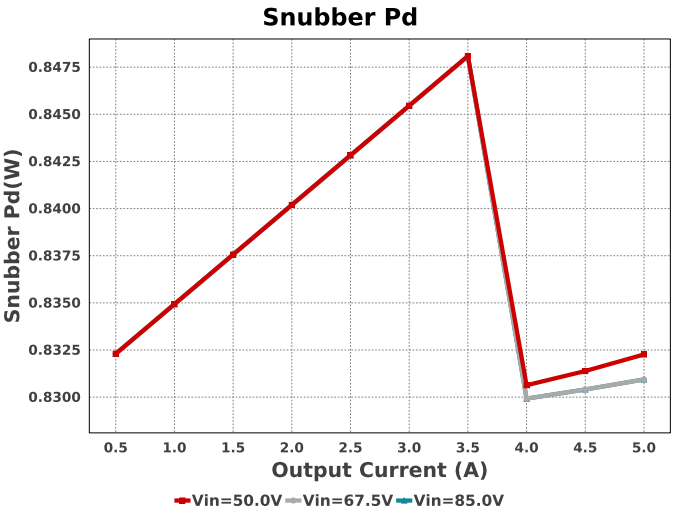


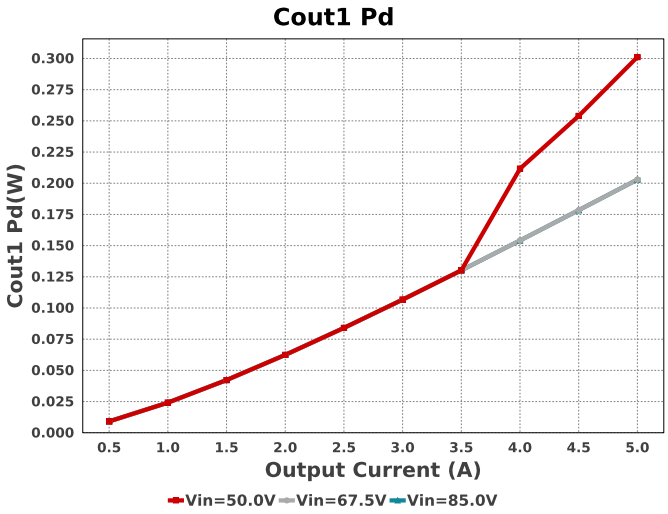


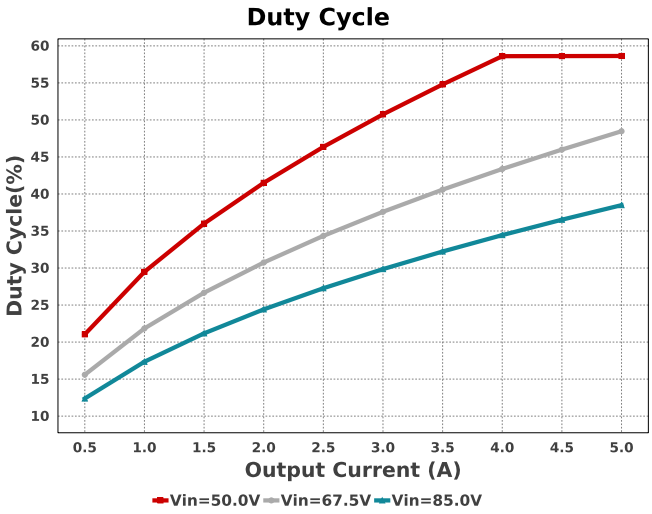


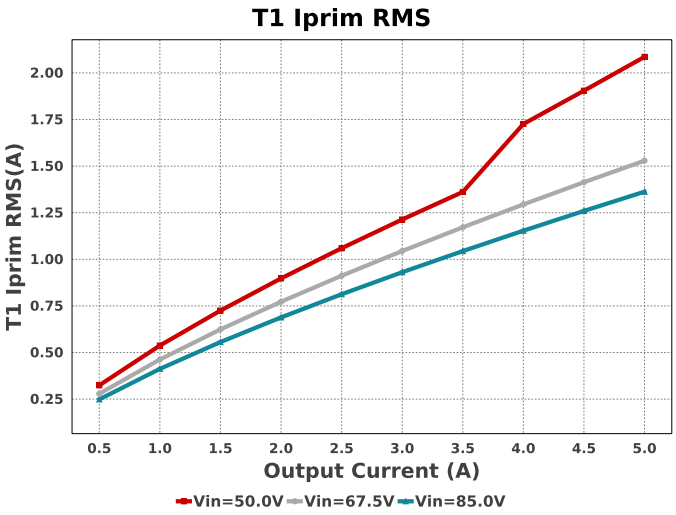


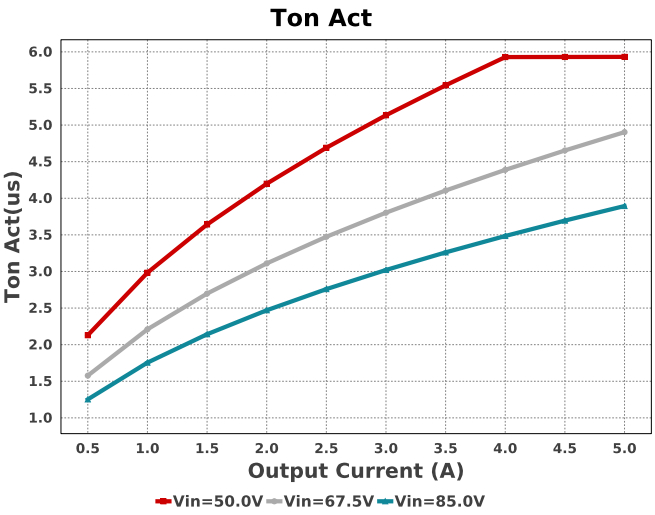


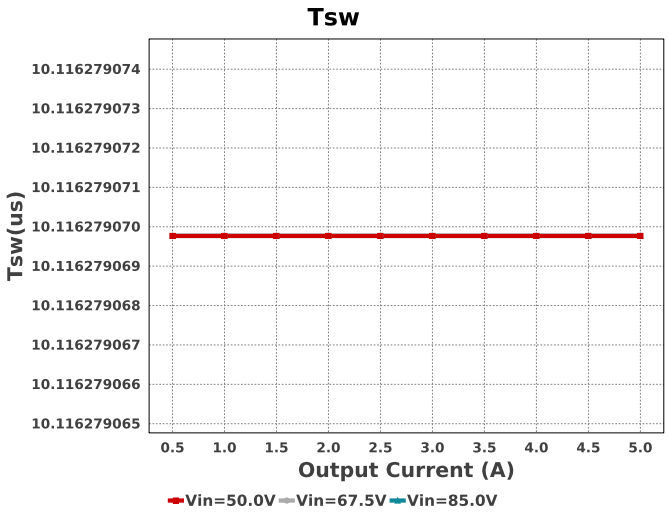


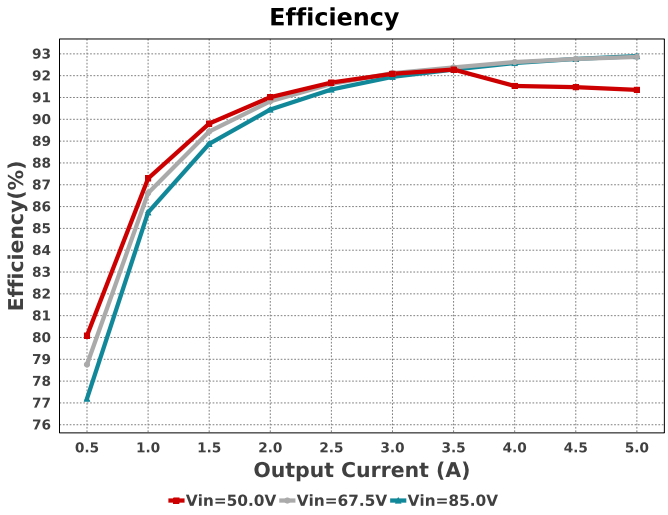


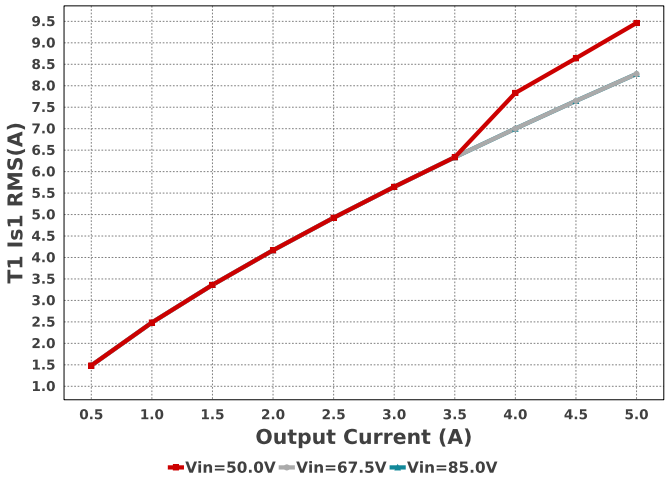


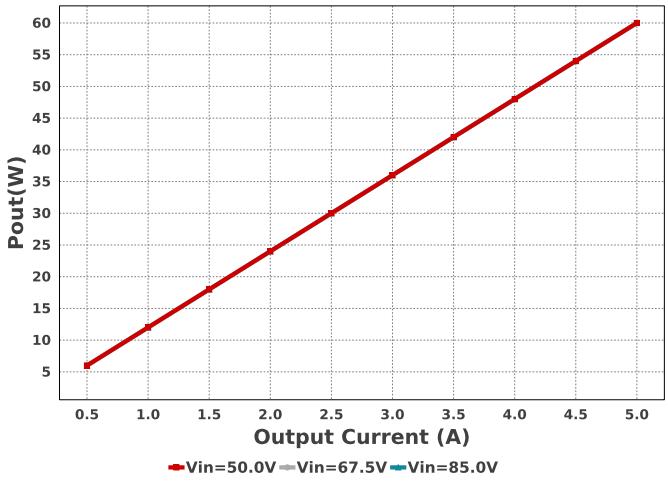


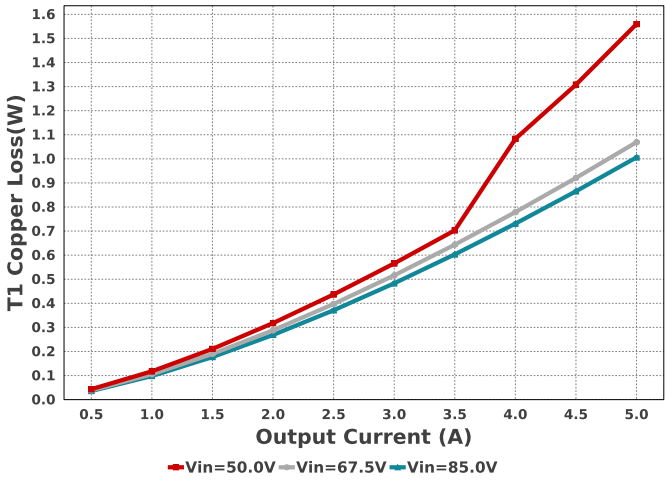


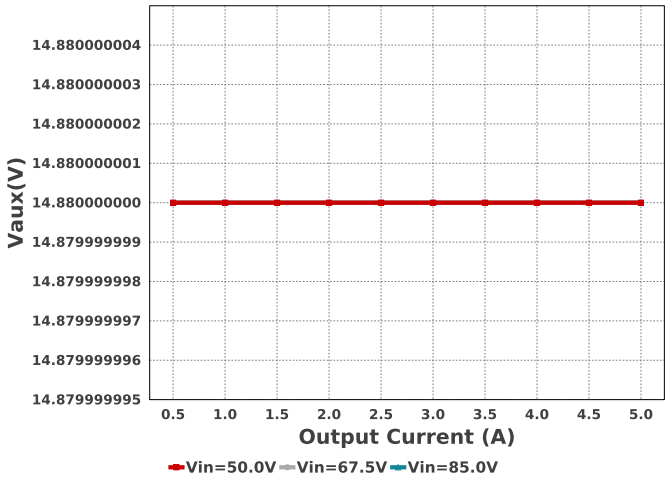


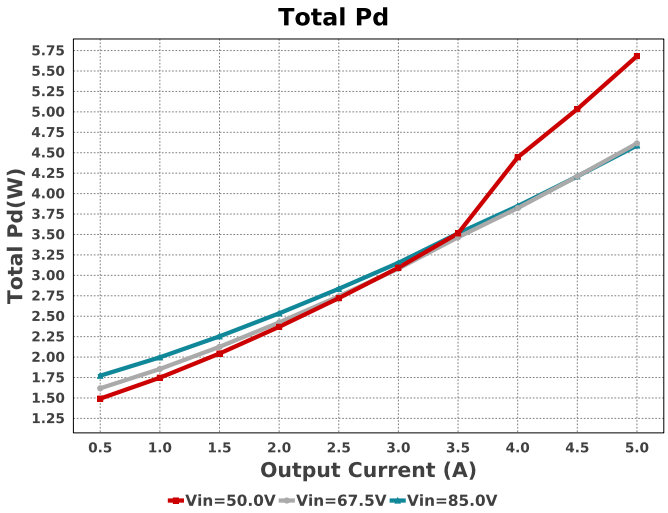


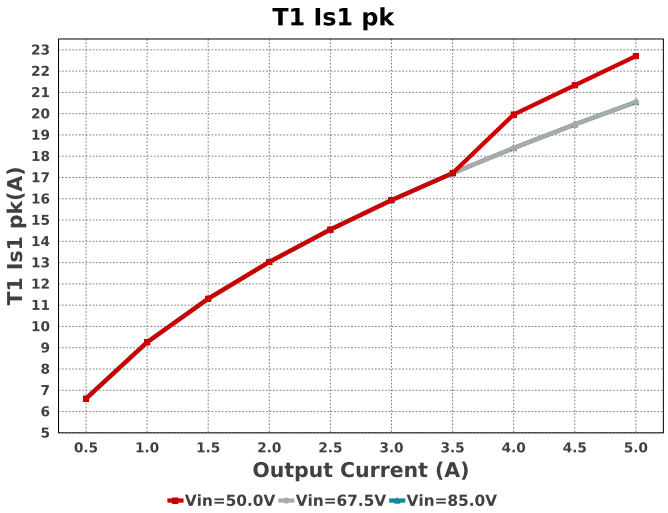


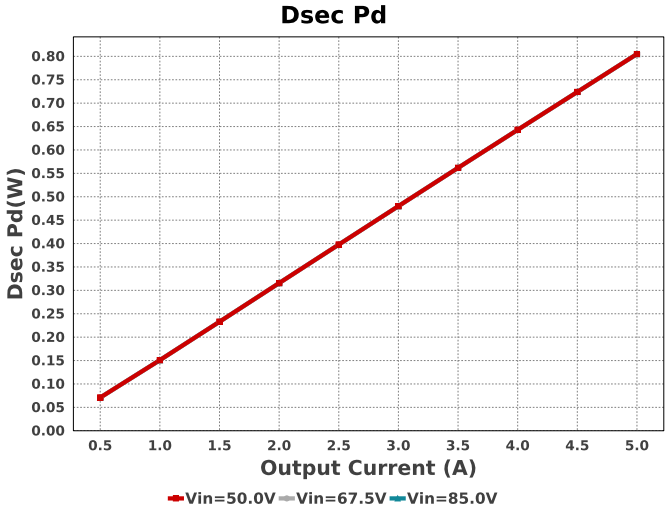


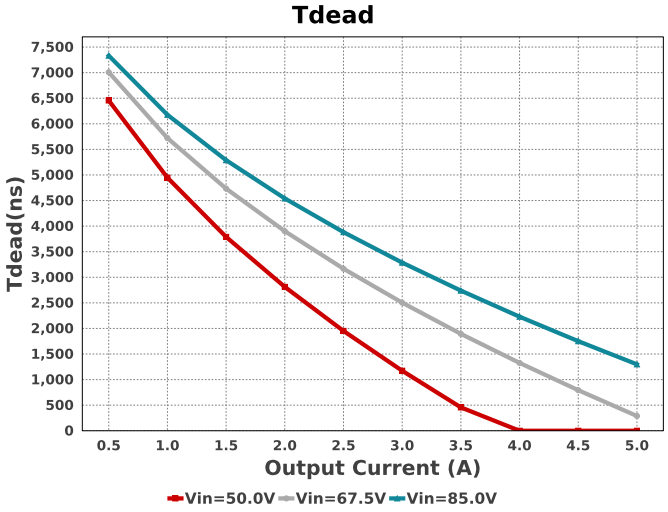


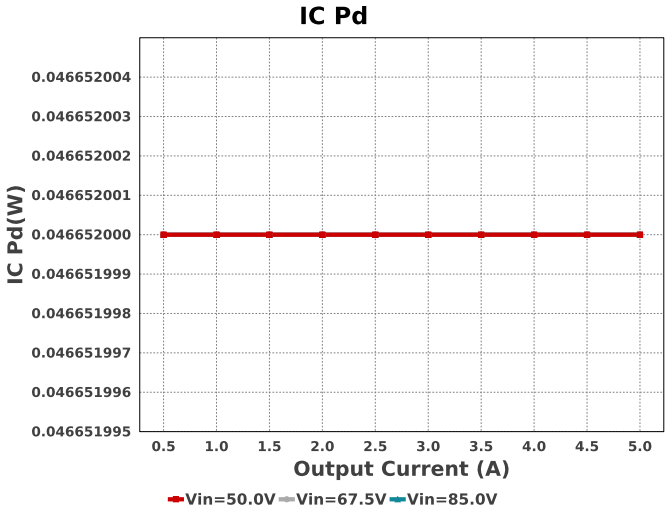


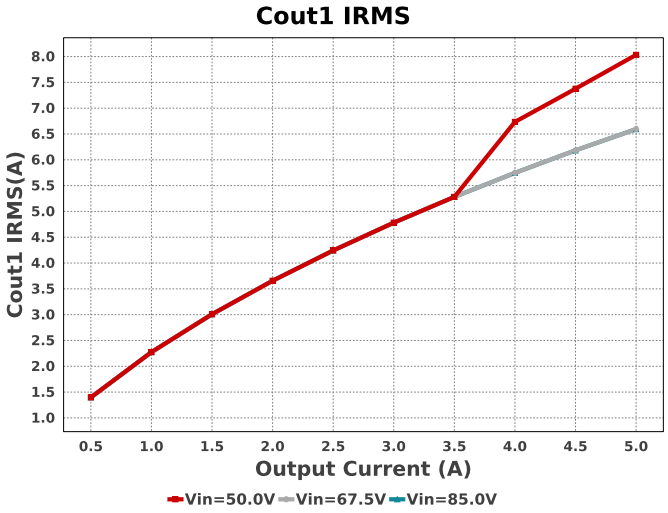


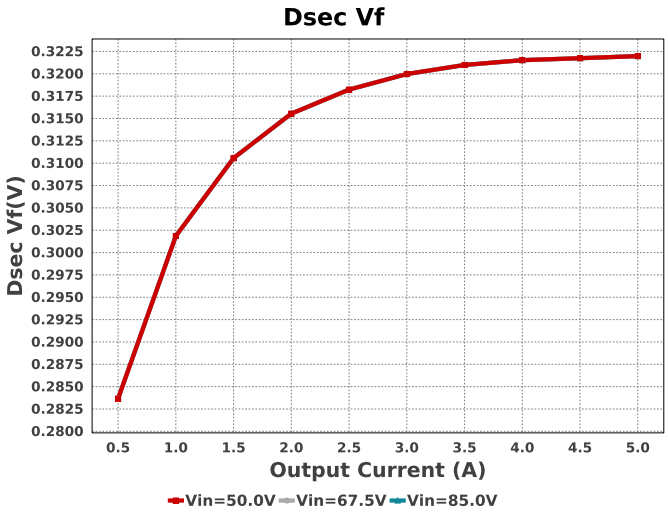


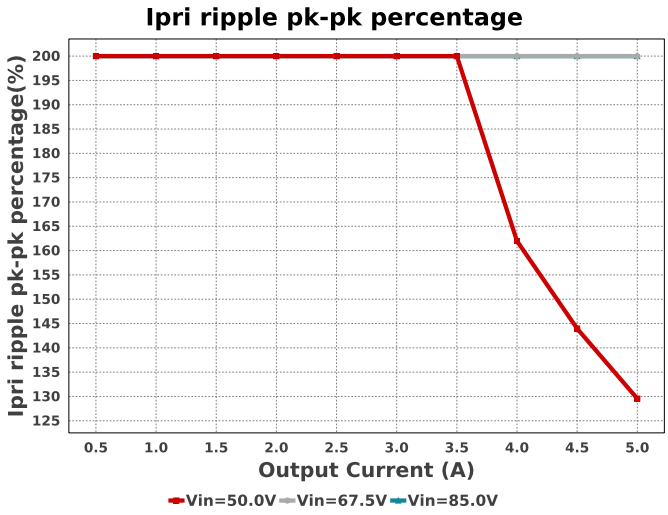


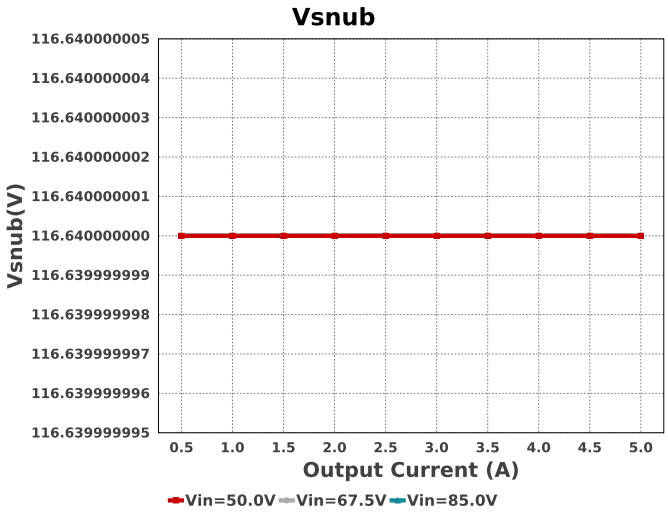


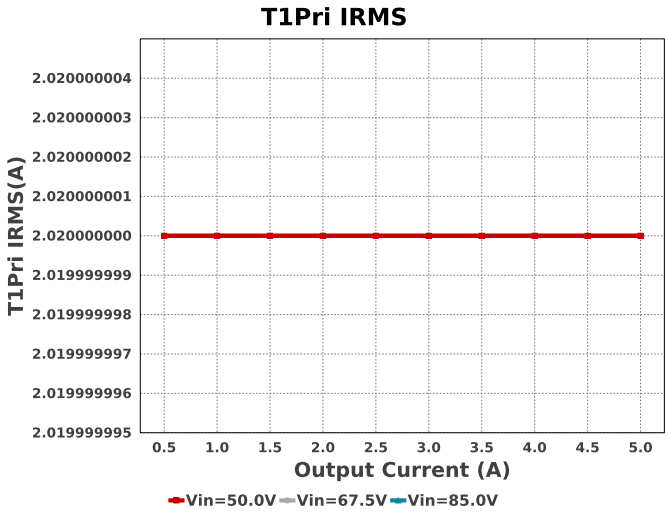


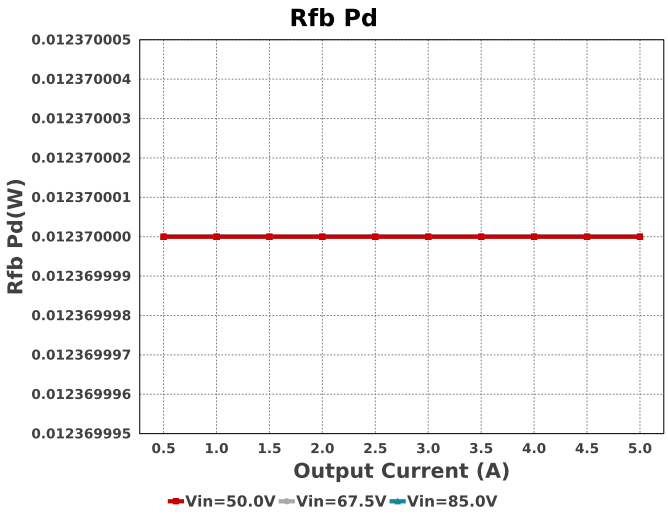


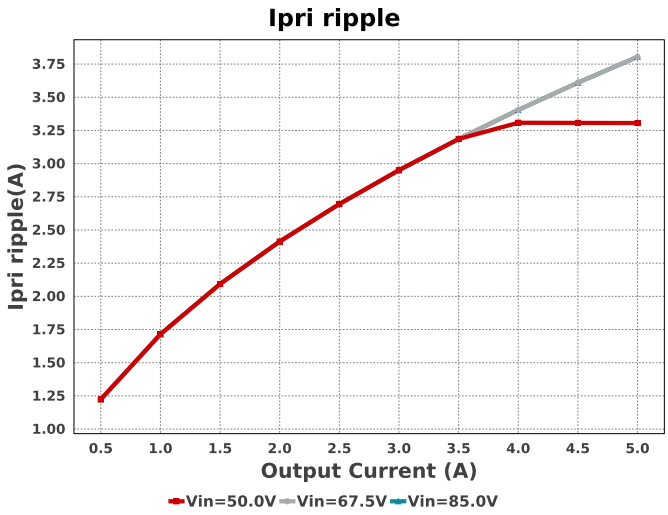


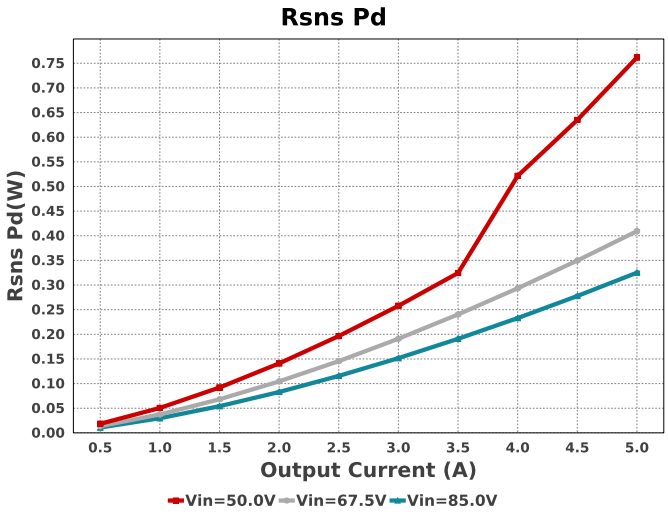


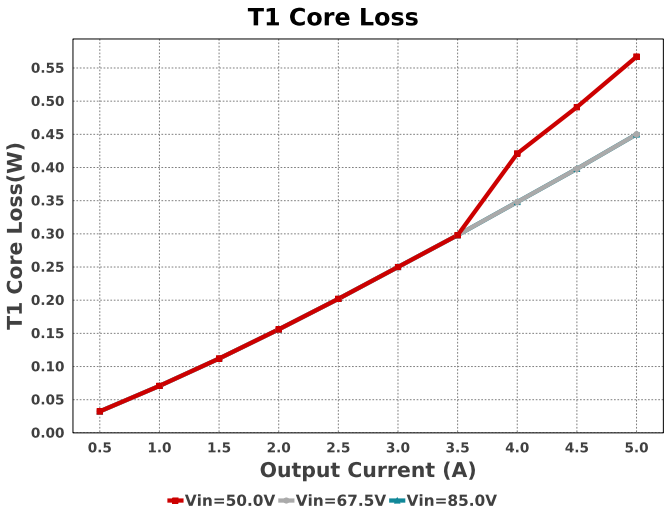


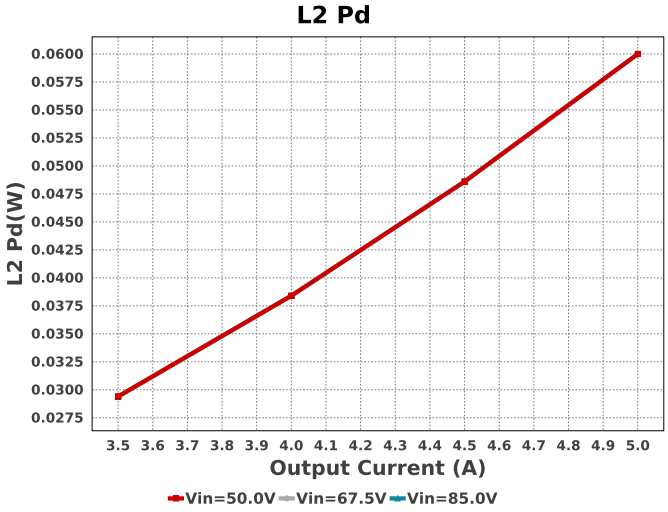


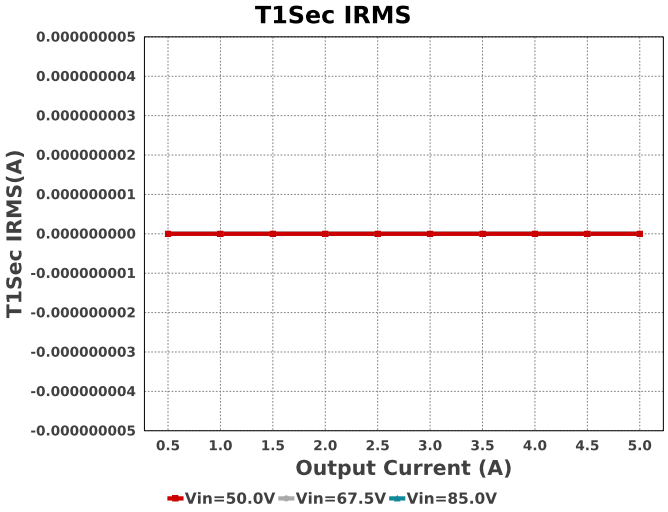


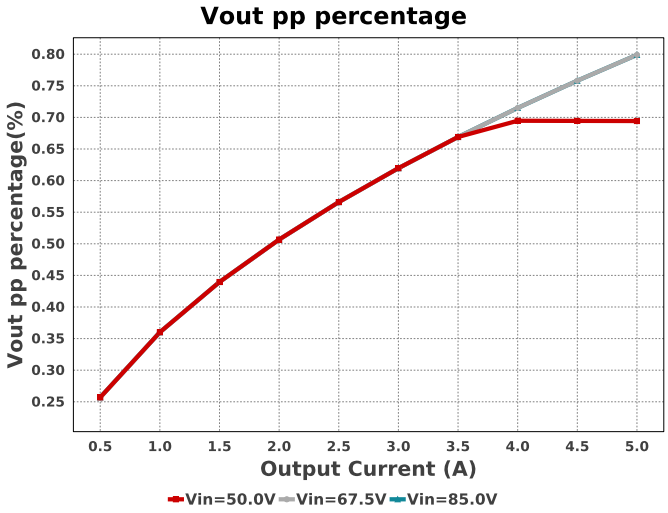


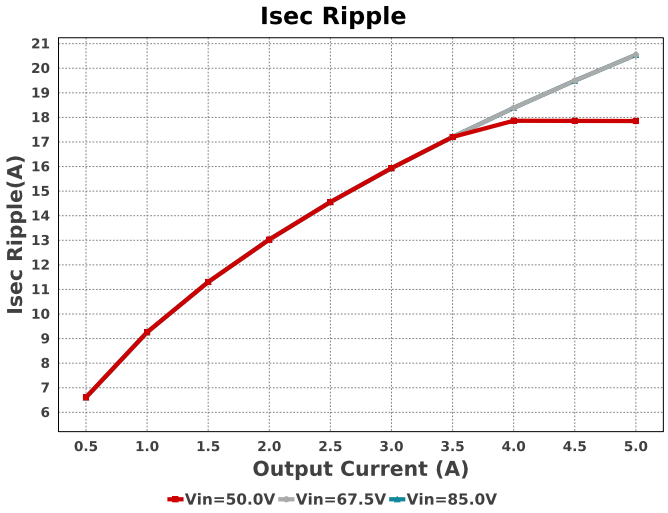


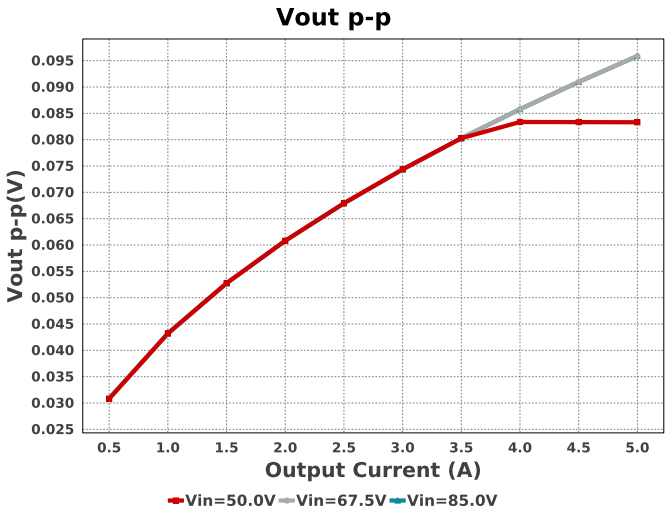


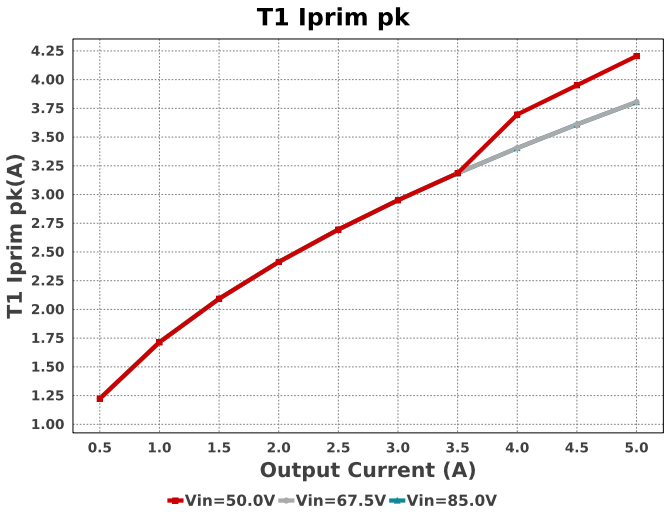












Operating Values

#	Name	Value	Category	Description
1.	Cin Pd	52.898 mW	Capacitor	Input capacitor power dissipation
2.	Cout1 IRMS	8.014 A	Capacitor	Output capacitor1 RMS ripple current
3.	Cout1 Pd	299.72 mW	Capacitor	Output capacitor1 power dissipation
4.	Daux trr	8.26 ns	Diode	Auxiliary Diode Reverse Recovery Time
5.	Dsec Pd	804.95 mW	Diode	Secondary Diode Power Dissipation
6.	Dsec Vf	321.979 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	804.95 mW	Diode	Secondary Diode Power Dissipation
9.	Dsec2 Vf	321.979 mV	Diode	Effective Forward Voltage Drop at the Operating Current
10.	Dsnub trr	35.0 ns	Diode	Snubber Diode Reverse Recovery Time
11.	IC Pd	46.652 mW	IC	IC power dissipation
12.	IC Tj	51.013 degC	IC	IC junction temperature
13.	ICThetaJA	128.9 degC/W	IC	IC junction-to-ambient thermal resistance
14.	Iin Avg	1.31 A	IC	Average input current
15.	L2 Pd	60.0 mW	Inductor	Average Power Dissipation in the Inductor Over the AC Line Period
16.	M1 Pd	644.03 mW	Mosfet	M1 MOSFET total power dissipation
17.	M1 TjOP	114.02 degC	Mosfet	M1 MOSFET junction temperature
18.	Cin Pd	52.898 mW	Power	Input capacitor power dissipation
19.	Cout1 Pd	299.72 mW	Power	Output capacitor1 power dissipation
20.	Dsec Pd	804.95 mW	Power	Secondary Diode Power Dissipation
21.	Dsec2 Pd	804.95 mW	Power	Secondary Diode Power Dissipation
22.	IC Pd	46.652 mW	Power	IC power dissipation
23.	L2 Pd	60.0 mW	Power	Average Power Dissipation in the Inductor Over the AC Line Period
24.	M1 Pd	644.03 mW	Power	M1 MOSFET total power dissipation
25.	Paux	18.523 mW	Power	Power Dissipation in Raux and Daux
26.	Pd Rstartup	5.385 mW	Power	Power Dissipation in Rstartup1 and Rstartup2
27.	Rdrv Pd	10.169 mW	Power	Power Dissipation in Gate Drive Resistor
28.	Rfb Pd	12.37 mW	Power	Rfb Power Dissipation
29.	Rsns Pd	754.38 mW	Power	Current Limit Sense Resistor Power Dissipation
30.	Snubber Pd	832.213 mW	Power	Snubber Power Dissipation
31.	T1 Copper Loss	1.418 W	Power	Transformer Copper Loss Power Dissipation
32.	T1 Core Loss	540.0 mW	Power	Transformer Core Loss Power Dissipation
33.	T1 Pd	1.958 W	Power	Estimated Losses in Transformer
34.	Total Pd	5.499 W	Power	Total Power Dissipation
35.	Pd Rstartup	5.385 mW	Resistor	Power Dissipation in Rstartup1 and Rstartup2
36.	Rdrv Pd	10.169 mW	Resistor	Power Dissipation in Gate Drive Resistor
37.	Rfb Pd	12.37 mW	Resistor	Rfb Power Dissipation
38.	Rsns Pd	754.38 mW	Resistor	Current Limit Sense Resistor Power Dissipation
39.	BOM Count	40	System Information	Total Design BOM count
40.	Duty Cycle	58.481 %	System Information	Duty cycle
41.	Efficiency	91.604 %	System Information	Steady state efficiency
42.	FootPrint	2.874 k mm^2	System Information	Total Foot Print Area of BOM components
43.	Frequency	98.851 kHz	System Information	Switching frequency
44.	Iout	5.0 A	System Information	Iout operating point
45.	Mode	CCM	System Information	Conduction Mode

#	Name	Value	Category	Description
46.	Pout	60.0 W	System Information	Total output power
47.	Tdead	0.0 ns	System Information	Approximate Dead Time of the Regulator
48.	Toff	3.684 us	System Information	Approximate Converter Off Time
49.	Ton Act	5.916 us	System Information	Approximate Converter On Time
50.	Total BOM	NA	System Information	Total BOM Cost
51.	Tsw	10.116 us	System Information	Switching Time Period
52.	Vin	50.0 V	System Information	Vin operating point
53.	Vout	12.0 V	System Information	Operational Output Voltage
54.	Vout p-p	83.093 mV	System Information	Peak-to-peak output ripple voltage
55.	Vout pp percentage	692.445 m%	System Information	Output Voltage ripple percentage
56.	Vsnub	116.64 V	System Information	Voltage Across the Snubber
57.	Ipri Avg	1.487 A	Transformer	Average Current in Primary Winding over the complete Switching Period
58.	Ipri ripple	3.297 A	Transformer	Ripple Current in the Primary Winding
59.	Ipri ripple pk-pk percentage	129.695 %	Transformer	Primary Current pk-pk ripple percentage(of Ipri avg during ton only)
60.	Isec Ripple	17.806 A	Transformer	Ripple Current in the Secondary Winding
61.	Paux	18.523 mW	Transformer	Power Dissipation in Raux and Daux
62.	T1 Copper Loss	1.418 W	Transformer	Transformer Copper Loss Power Dissipation
63.	T1 Core Loss	540.0 mW	Transformer	Transformer Core Loss Power Dissipation
64.	T1 Iprim RMS	2.076 A	Transformer	Transformer Primary RMS Current
65.	T1 Iprim pk	4.191 A	Transformer	Transformer Primary Peak Current
66.	T1 Is1 RMS	9.446 A	Transformer	Transformer Secondary1 RMS Current
67.	T1 Is1 pk	22.632 A	Transformer	Transformer Secondary1 Peak Current
68.	T1 Pd	1.958 W	Transformer	Estimated Losses in Transformer
69.	T1Pri IRMS	2.018 A	Transformer	Transformer Primary RMS Current
70.	T1Sec IRMS	9.251 A	Transformer	Transformer Secondary RMS Current
71.	Vaux	14.88 V	Transformer	Auxiliary Voltage

Design Inputs

Name	Value	Description
Iout	5.0	Maximum Output Current
VinMax	85.0	Maximum input voltage
VinMin	50.0	Minimum input voltage
VinTyp	72.0	Typical input voltage
Vout	12.0	Output Voltage
base_pn	UCC28C53-Q1	Base Product Number
source	DC	Input Source Type
Ta	45.0	Ambient temperature
UserFsw	199.0 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

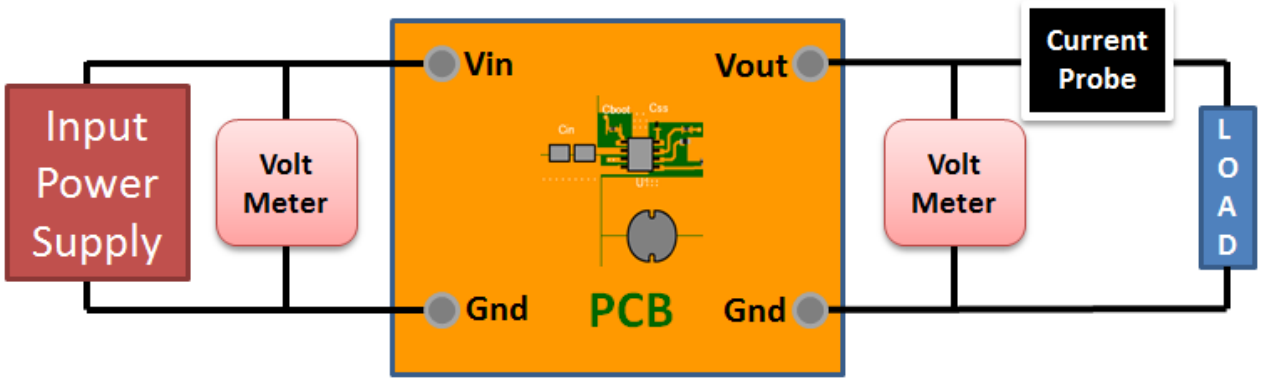
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 50.0V 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	B66421G0000X197
2.	Core Manufacturer	TDK
3.	Coil Former Part Number	B66422W1010D001
4.	Coil Former Manufacturer	TDK

Transformer Electrical Diagram

Primary

Turns	27.0
AWG	28.0
Layers	2.0
Strands	3.0
Insulation Type	Heavy Insulated Magnet Wire

Secondary

Turns	5.0
AWG	26.0
Layers	1.0
Strands	4.0
Insulation Type	Triple Insulated

Auxiliary

Turns	6.0
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 1/2.0	28.0	14	Clockwise
Triple Insulated Secondary	26.0	5.0	Counter Clockwise
Auxiliary	28.0	6.0	Counter Clockwise
Primary Second 1/2.0	28.0	13	Clockwise

Transformer Parameters

#	Name	Value
1.	Lpri	8.7E-5H
2.	Inductance Factor(Al)	120.0nH
3.	Npri	27.0
4.	Nsec	5.0
5.	Naux	6.0
6.	Core Type	EFD25/13/9
7.	Core Material	N97

#	Name	Value
8.	Bmax	0.23T
9.	Switching Frequency	98.85kHz
10.	DMax	0.6
11.	Ipk(Primary)	4.11A
12.	Irms(Primary)	2.02A
13.	Ipk(Secondary)	22.2A
14.	Irms(Secondary)	8.9A

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 UCC28C53-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 : FCC71AEA8B535B1B[v1]

4. **UCC28C53-Q1** Product Folder : https://www.ti.com/product/UCC28C53%2DQ1 : contains the data sheet and other resources.