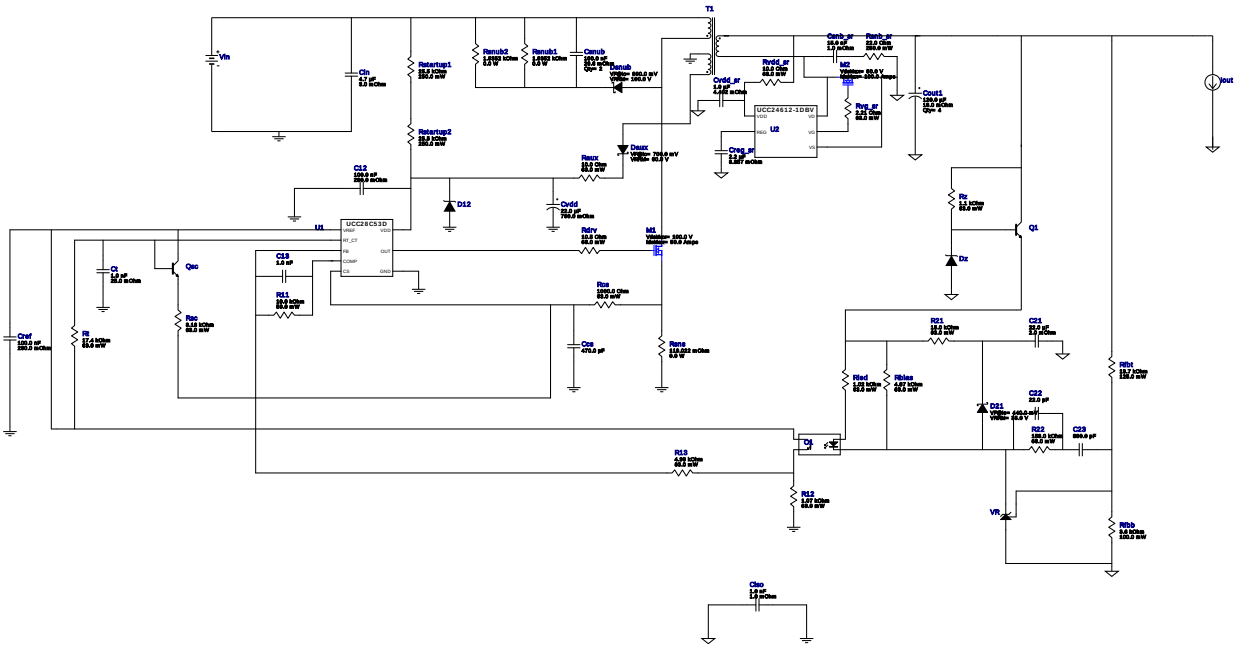
WEBENCH® Design Report

VinMin = 17.0V
VinMax = 32.5V
Vout = 12.0V
Iout = 2.5A

Device = UCC28C53DR
Topology = Flyback
Created = 2024-03-29 00:27:24.260
BOM Cost = NA
BOM Count = 60
Total Pd = 3.36W

Design : 41 UCC28C53DR
UCC28C53DR HEDS - 40W Final



Design Alerts

Component Selection Information
Use design suggestions or click on the transformer symbol in the schematic to explore the transformer core/ bobbin selection

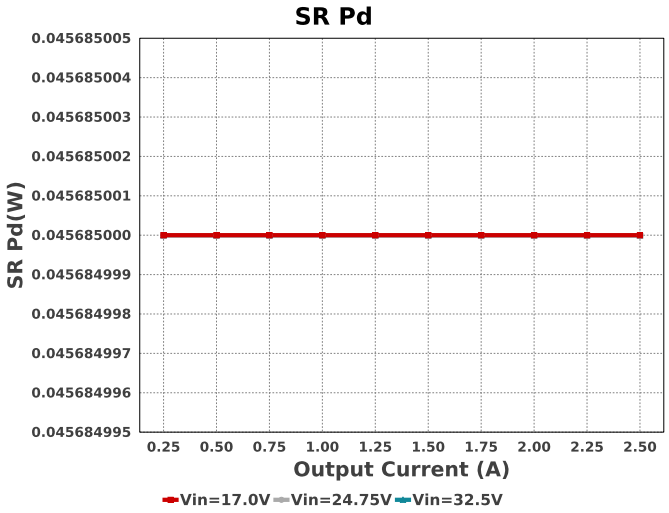
Electrical BOM

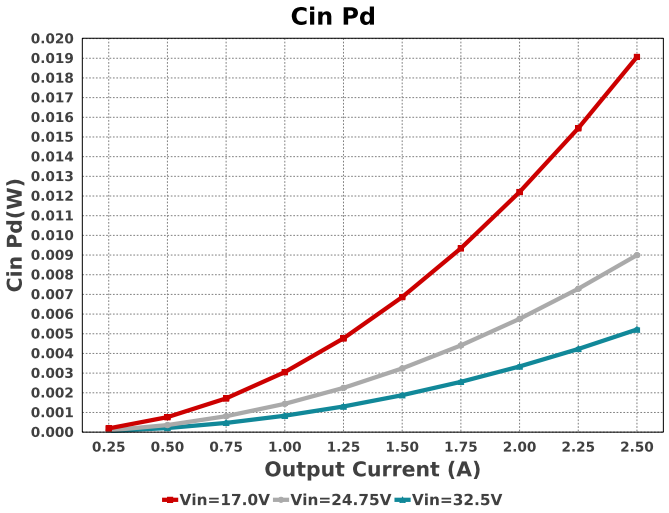
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
C12	AVX	08053C104KAT2A Series= X7R	Cap= 100.0 nF ESR= 280.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²
C13	MuRata	GRM1555C1H102JA01J Series= C0G/NP0	Cap= 1.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
C21	MuRata	GRM32ER61E226KE15L Series= X5R	Cap= 22.0 uF ESR= 2.0 mOhm VDC= 25.0 V IRMS= 3.67 A	1	$0.23	1210 15 mm²
C22	Samsung Electro-Mechanics	CL21C220JBANNNC Series= C0G/NP0	Cap= 22.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²
C23	MuRata	GRM1555C1H391JA01J Series= C0G/NP0	Cap= 390.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
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 mm²
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 mm²

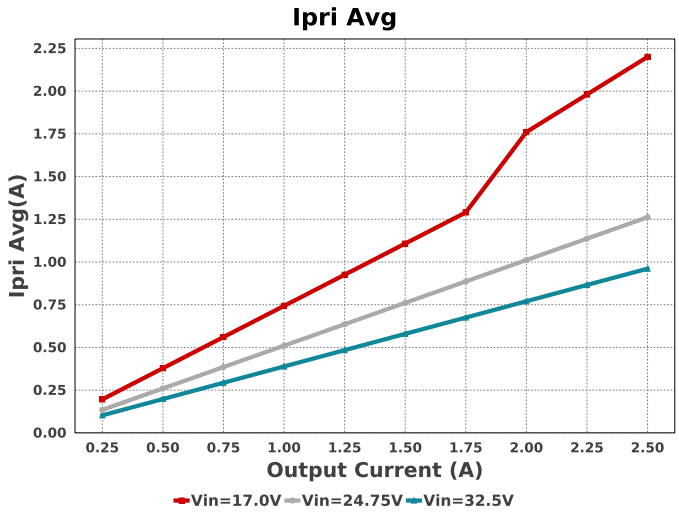
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Ciso	Johanson Technology	202R18W102KV4E Series= X7R	Cap= 1.0 nF ESR= 1.0 mOhm VDC= 2.0 kV IRMS= 0.0 A	1	$0.06	 1206_190 11 mm²
Cout1	Panasonic	35SEPF120M Series= SEPF	Cap= 120.0 uF ESR= 18.0 mOhm VDC= 35.0 V IRMS= 4.4 A	4	$0.96	 SEPF_F13 144 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
Creg_sr	MuRata	GRM21BR61E225KA12L Series= X5R	Cap= 2.2 uF ESR= 8.857 mOhm VDC= 25.0 V IRMS= 1.3111 A	1	$0.09	 0805 7 mm²
Csnb_sr	TDK	C3216C0G2E153J160AA Series= C0G/NP0	Cap= 15.0 nF ESR= 1.0 mOhm VDC= 250.0 V IRMS= 0.0 A	1	$0.19	 1206_190 11 mm²
Csnub	TDK	CGA3E2X7R1H104K080AA Series= X7R	Cap= 100.0 nF ESR= 29.6 mOhm VDC= 50.0 V IRMS= 971.99 mA	2	$0.01	 0603 5 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
Cvdd_sr	MuRata	GRM21BR71H105KA12L Series= X7R	Cap= 1.0 uF ESR= 4.402 mOhm VDC= 50.0 V IRMS= 1.677 A	1	$0.11	 0805 7 mm²
D12	Diodes Inc.	MMSZ5248B-7-F	Zener	1	$0.04	 SOD-123 13 mm²
D21	Bourns	CD0603-B0130L	VF@Io= 440.0 mV VRRM= 35.0 V	1	$0.09	 Diode_0603 5 mm²
Daux	Fairchild Semiconductor	SS26FL	VF@Io= 700.0 mV VRRM= 60.0 V	1	$0.11	 SOD-123F 12 mm²
Dsnub	Fairchild Semiconductor	SSA210	VF@Io= 800.0 mV VRRM= 100.0 V	1	$0.19	 SMA 37 mm²
Dz	ON Semiconductor	BZX84C9V1LT1G	Zener	1	$0.03	 SOT-23 14 mm²
M1	Texas Instruments	CSD19537Q3	VdsMax= 100.0 V IdsMax= 50.0 Amps	1	$0.35	 DQG0008A 18 mm²
M2	Texas Instruments	CSD19502Q5B	VdsMax= 80.0 V IdsMax= 100.0 Amps	1	$0.74	DQK0006C 9 mm²
O1	Vishay-Semiconductor	TCMT1107	Optocoupler	1	$0.19	 SOP-4 44 mm²
Q1	Diodes Inc.	MMBT3904-7-F	Bipolar Transistor	1	$0.02	 SOT-23 14 mm²
Qsc	STMicroelectronics	2N2222A	Bipolar Transistor	1	$1.19	 TO-18 57 mm²

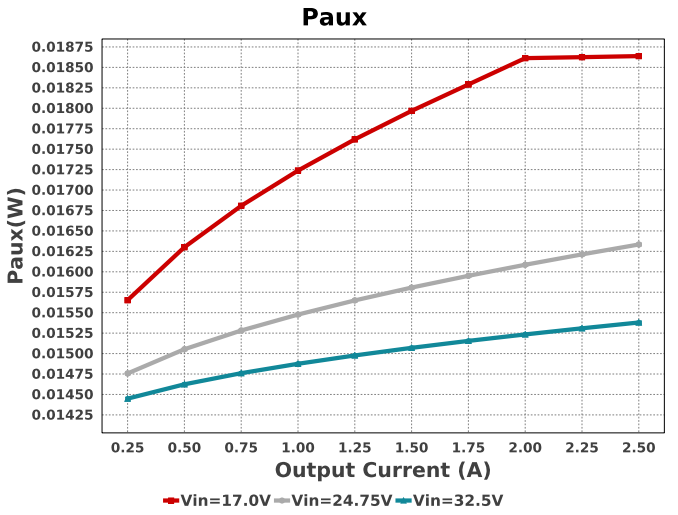
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
R11	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
R12	Vishay-Dale	CRCW04021K07FKED Series= CRCW..e3	Res= 1.07 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
R13	Vishay-Dale	CRCW04024K99FKED Series= CRCW..e3	Res= 4.99 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
R21	Vishay-Dale	CRCW040215K0FKED Series= CRCW..e3	Res= 15.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
R22	Vishay-Dale	CRCW0402158KFKED Series= CRCW..e3	Res= 158.0 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
Rbias	Vishay-Dale	CRCW04024K87FKED Series= CRCW..e3	Res= 4.87 kOhm 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	CRCW040210R5FKED Series= CRCW..e3	Res= 10.5 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbb	Yageo	RC0603FR-073K6L Series= ?	Res= 3.6 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rfbt	Vishay-Dale	CRCW080513K7FKEA Series= CRCW..e3	Res= 13.7 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²
Rled	Vishay-Dale	CRCW04021K02FKED Series= CRCW..e3	Res= 1.02 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
Rsnb_sr	Yageo	RC1206FR-0722RL Series= ?	Res= 22.0 Ohm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm²
Rsnb_sr	Yageo	RC1206FR-0722RL Series= ?	Res= 22.0 Ohm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm²
Rsns	CUSTOM	CUSTOM Series= ?	Res= 119.022 mOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm²
Rsnub1	CUSTOM	CUSTOM Series= ?	Res= 1.9352 kOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm²
Rsnub2	CUSTOM	CUSTOM Series= ?	Res= 1.9352 kOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm²
Rstartup1	Vishay-Dale	CRCW120625K5FKEA Series= CRCW..e3	Res= 25.5 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm²
Rstartup2	Vishay-Dale	CRCW120625K5FKEA Series= CRCW..e3	Res= 25.5 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

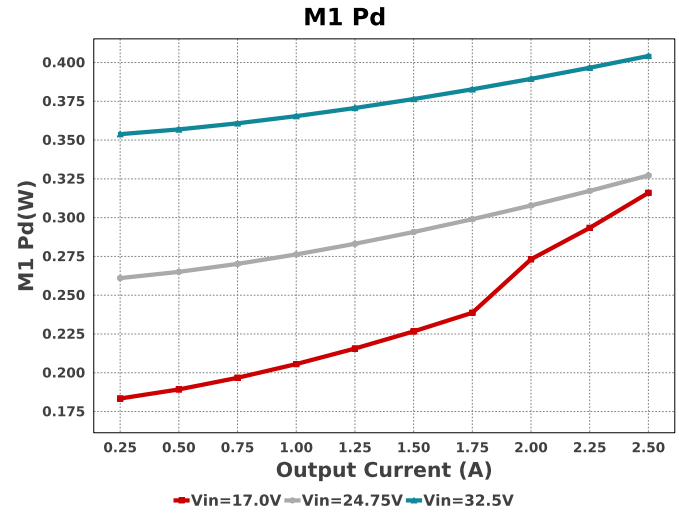
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rvdd_sr	Vishay-Dale	CRCW040210R0FKED Series= CRCW..e3	Res= 10.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm²
Rvdd_sr	Vishay-Dale	CRCW040210R0FKED Series= CRCW..e3	Res= 10.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm²
Rvg_sr	Vishay-Dale	CRCW04022R21FKED Series= CRCW..e3	Res= 2.21 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm²
Rvg_sr	Vishay-Dale	CRCW04022R21FKED Series= CRCW..e3	Res= 2.21 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm²
Rz	Vishay-Dale	CRCW04021K10FKED Series= CRCW..e3	Res= 1.1 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm²
T1	Core=Wurth Elektronik , CoilFormer=Wurth Elektronik	Core=150-2623 , CoilFormer=070-2255	Lp= 20.0 µH Turns Ratio(Nas)= 7:6 Turns Ratio(Nps)= 11:6 Npri= 11.0 Naux= 7.0 Nsec= 6.0	1	NA	 TDK_B65803 556 mm²
U1	Texas Instruments	UCC28C53DR	Switcher	1	$0.26	 D0008A 57 mm²
U2	Texas Instruments	UCC24612-1DBVR	Switcher	1	$0.24	 DBV0005A 15 mm²
VR	Texas Instruments	TL431IDBVR	Voltage References	1	$0.05	 R-PDSO-G3 16 mm²

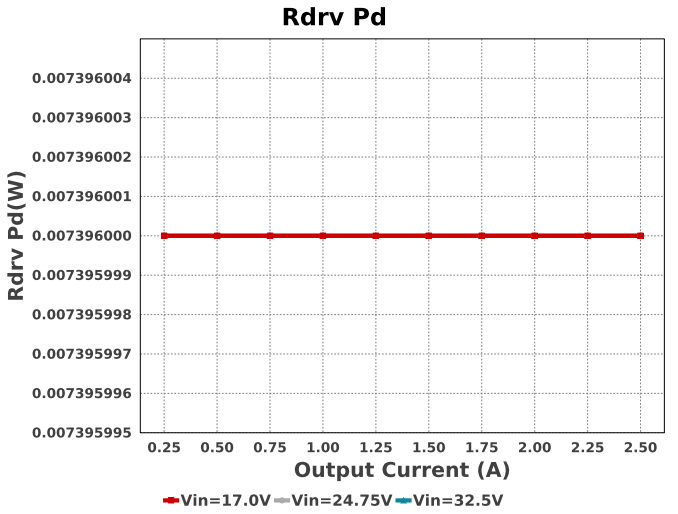


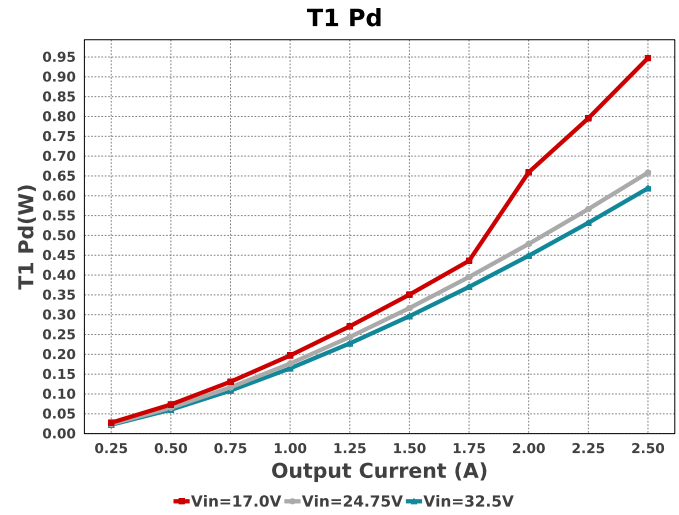


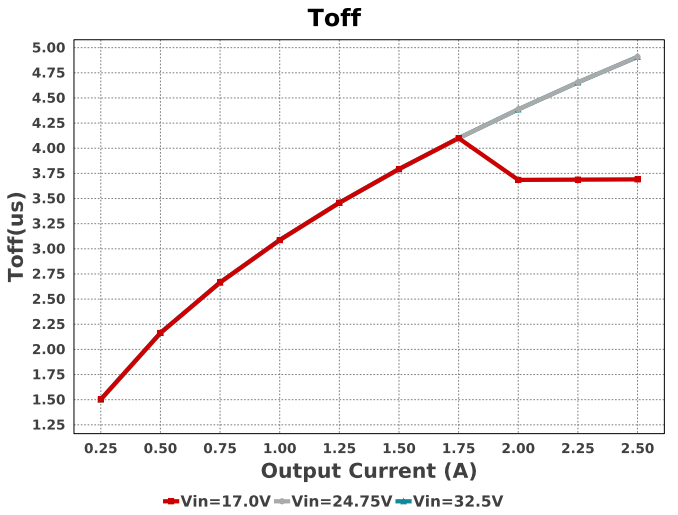


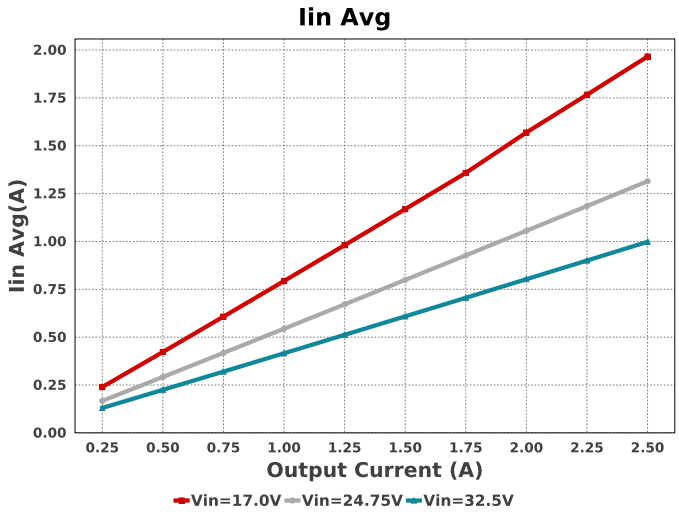


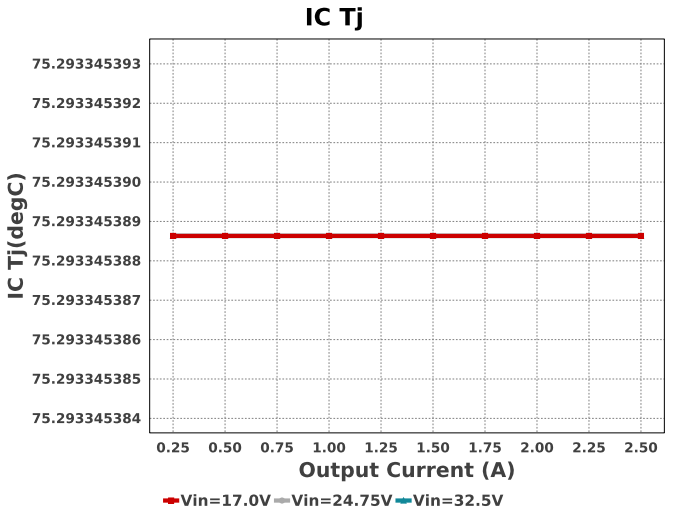


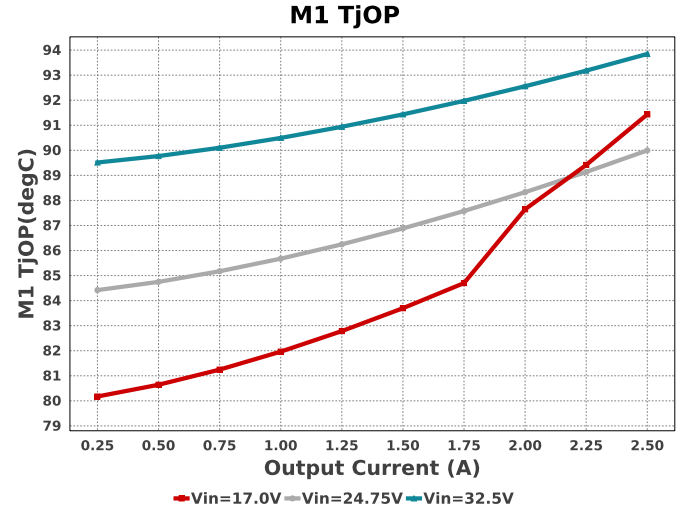


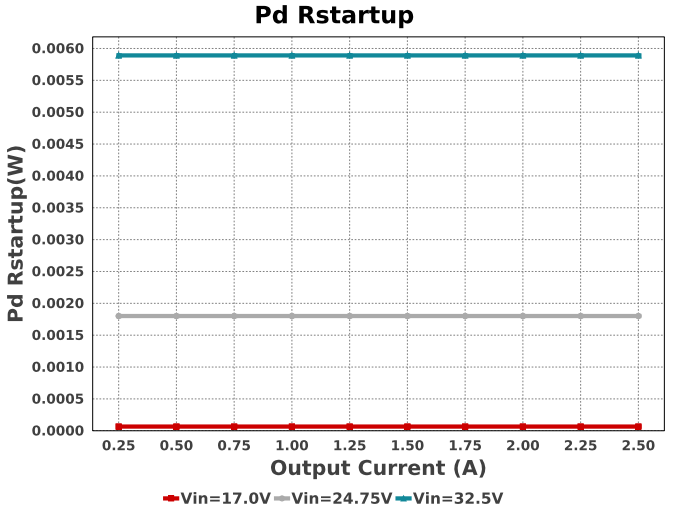


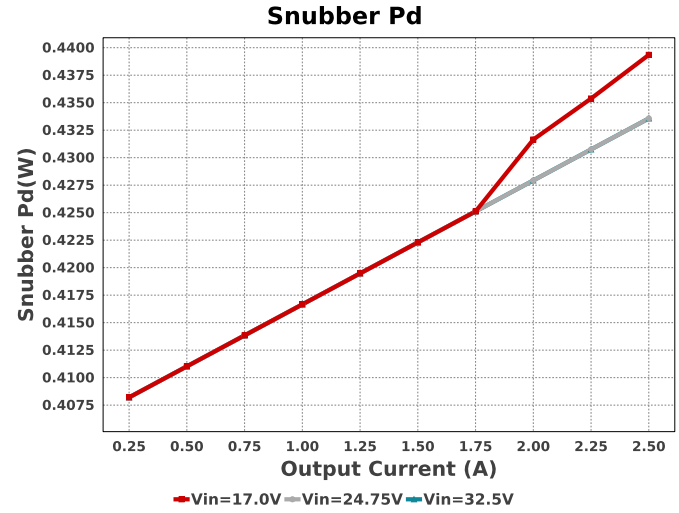


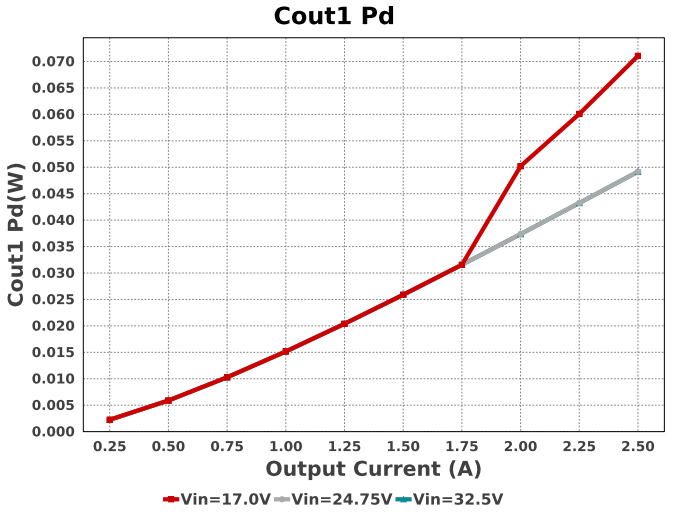


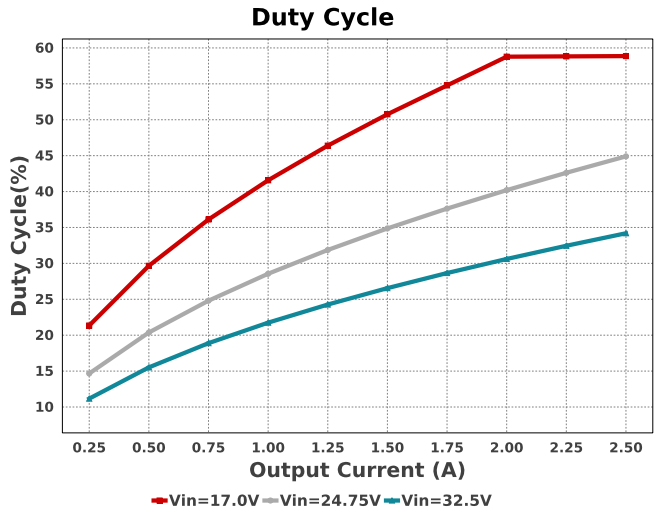


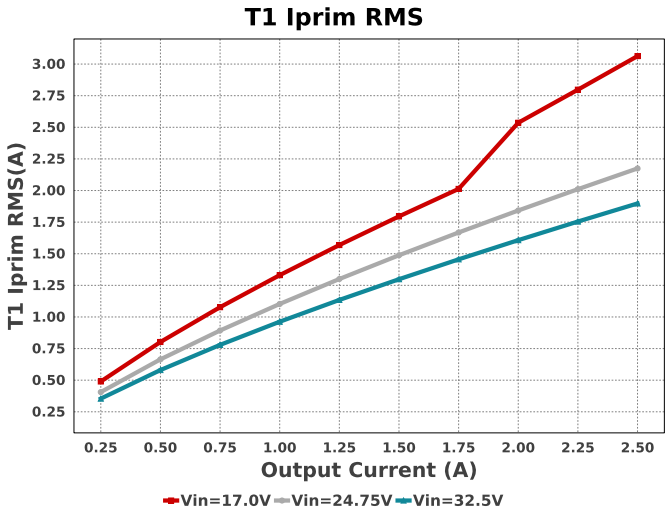


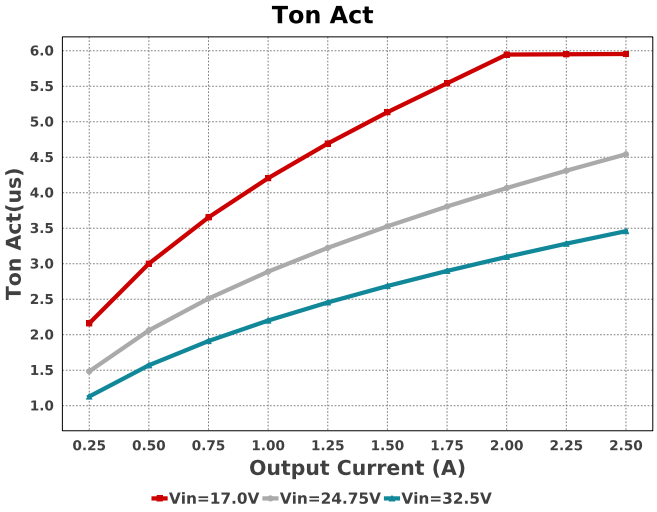


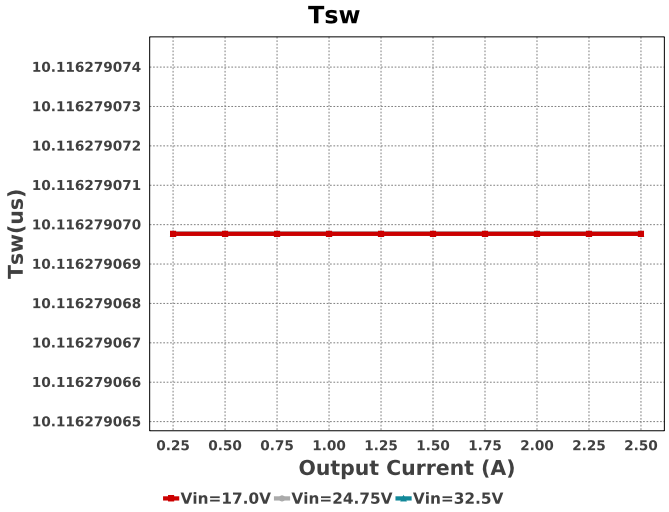


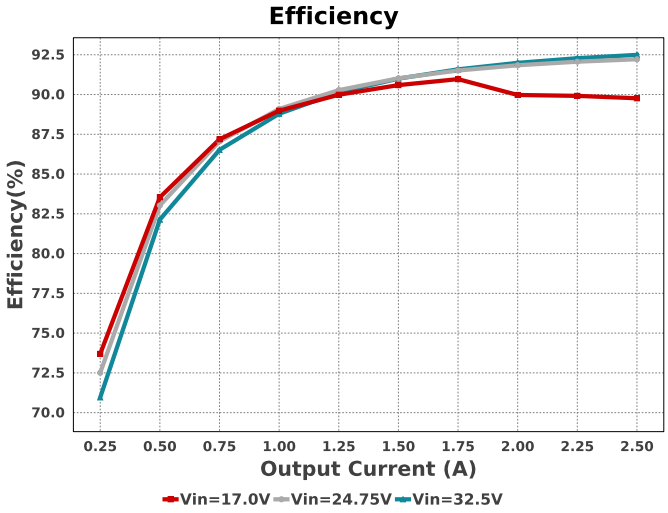


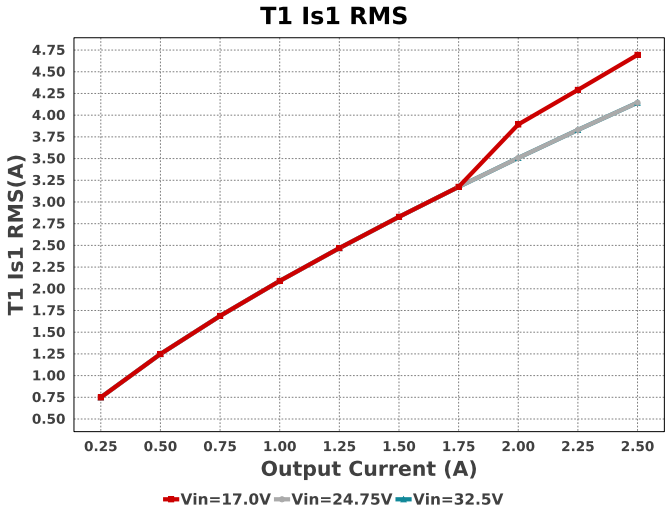


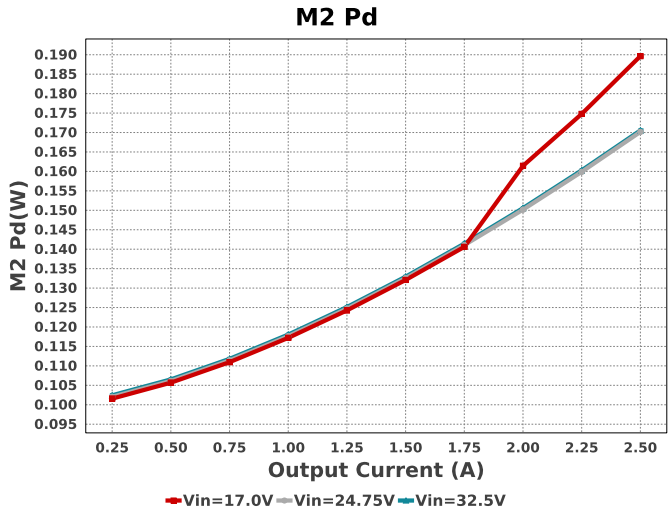


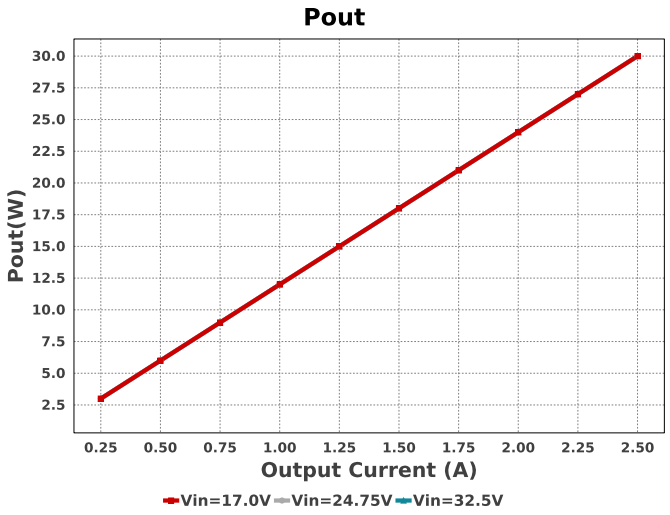


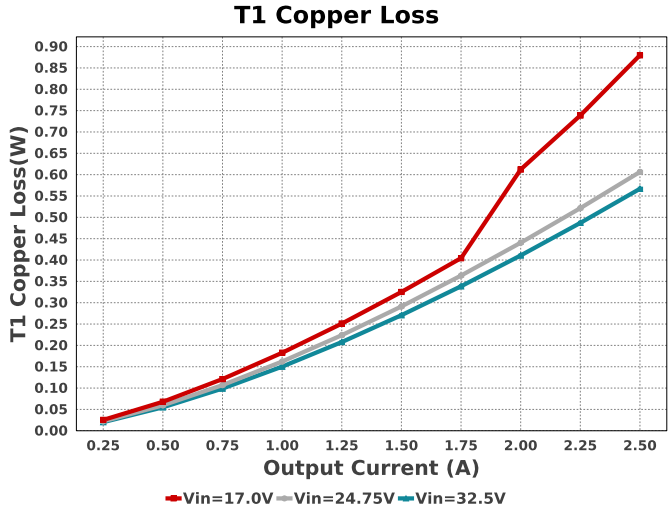


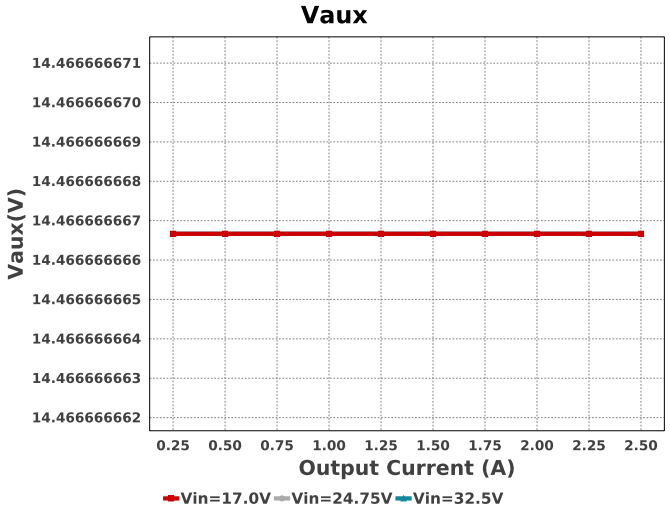


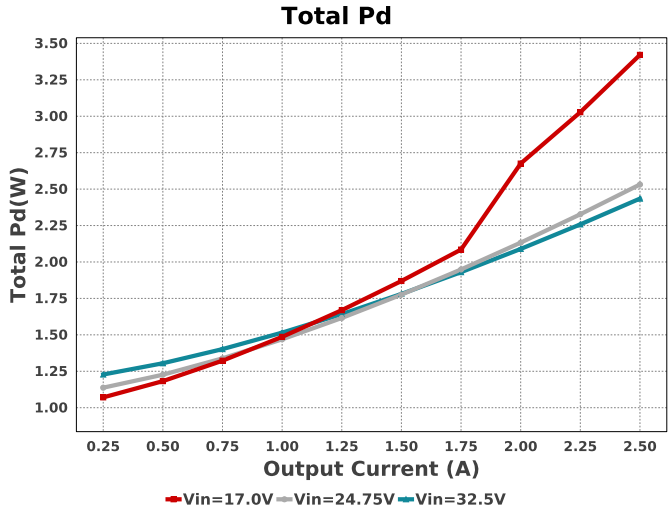


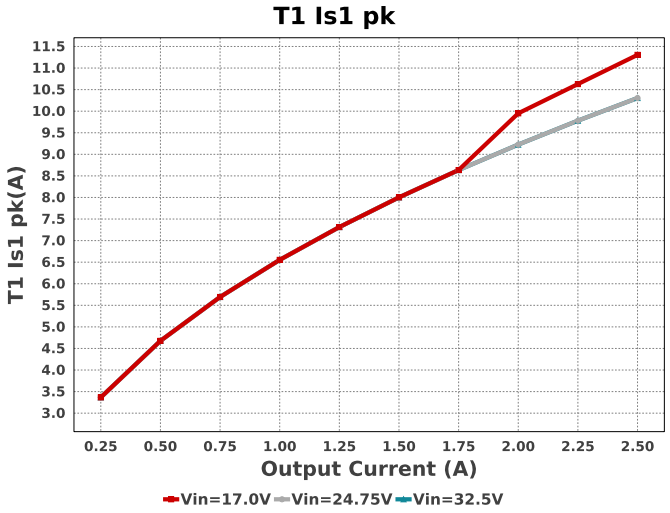


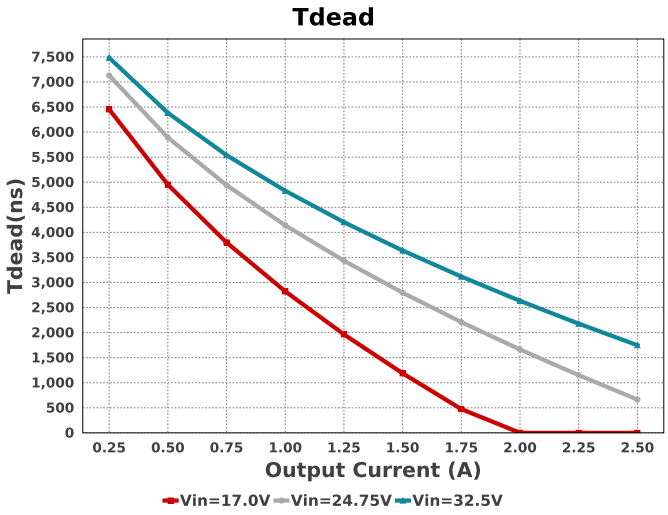


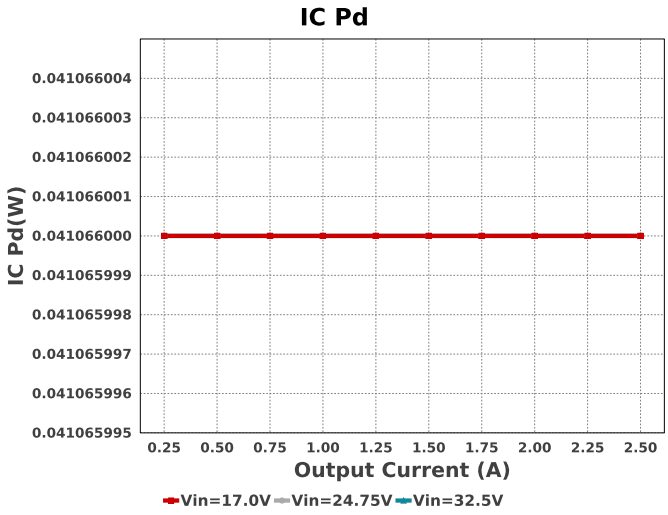


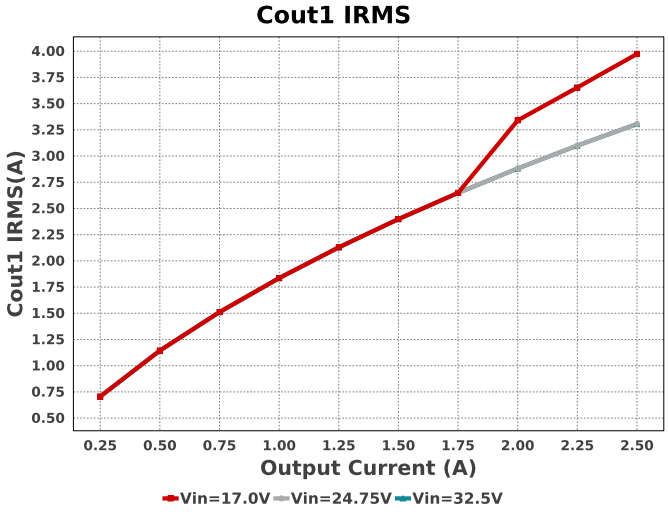


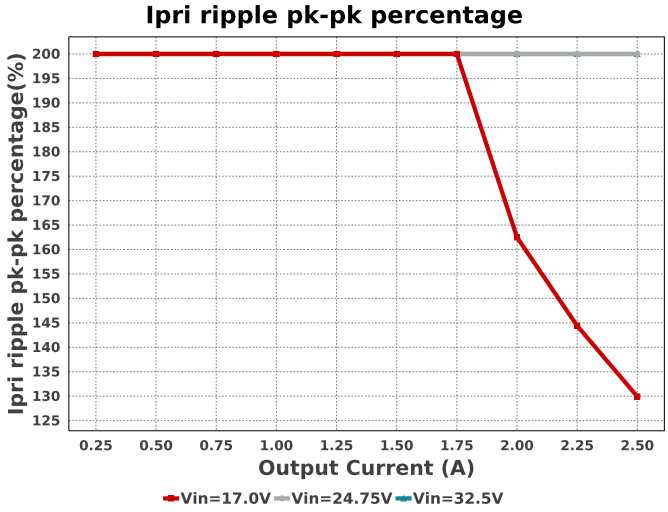


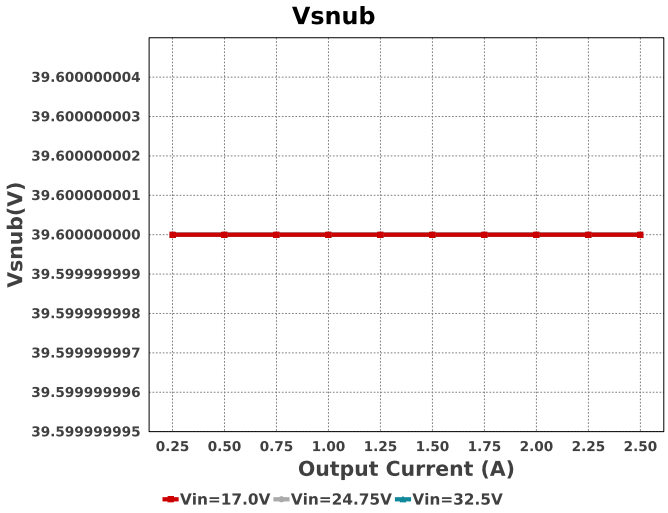


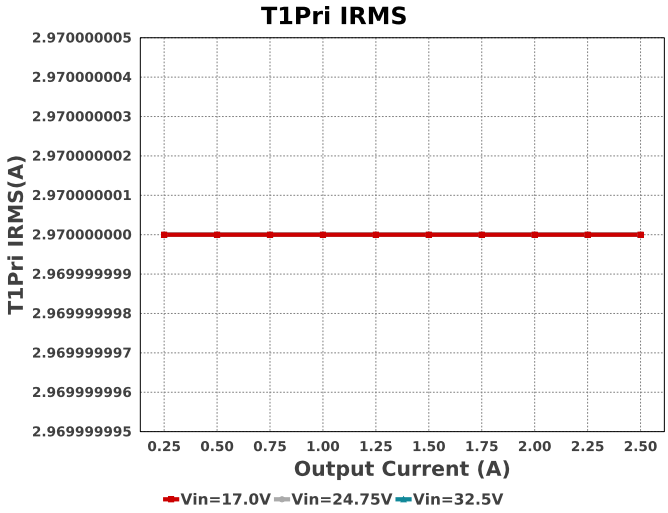


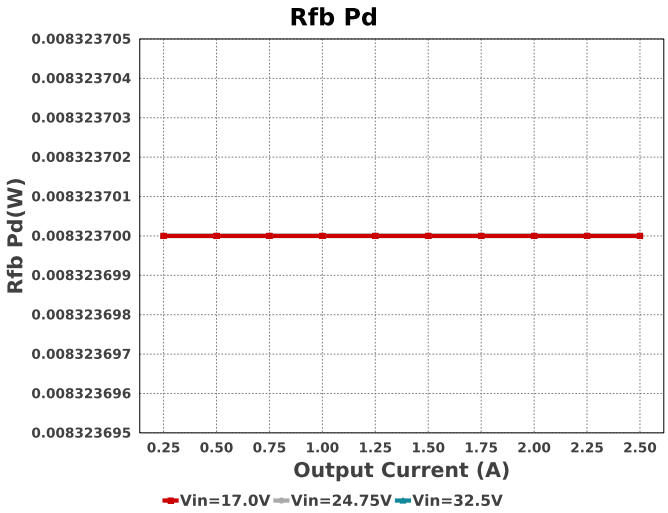


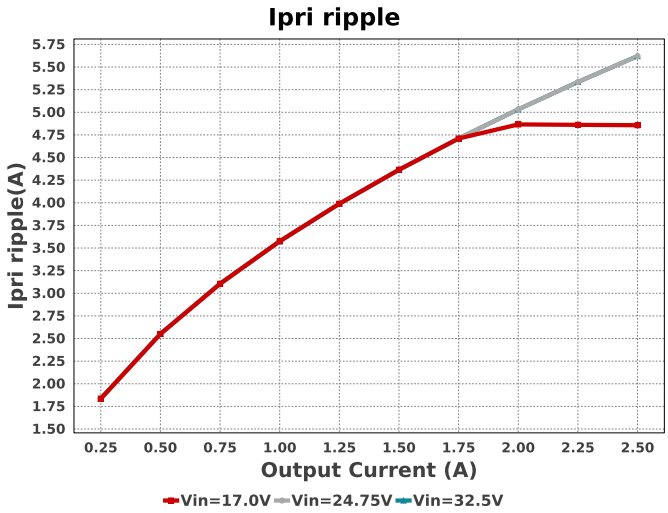


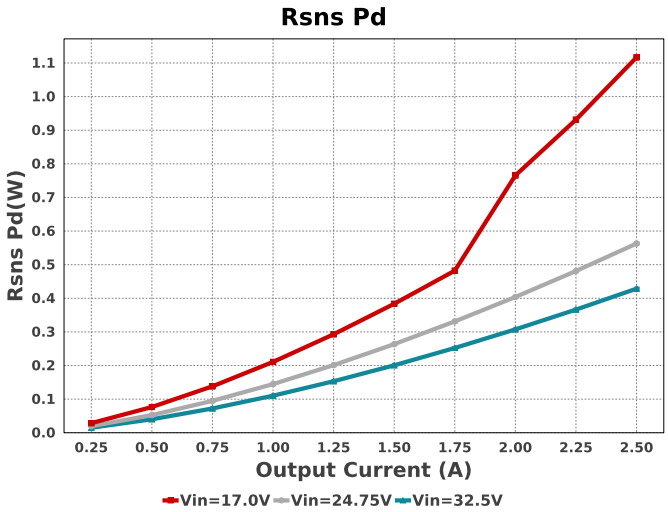


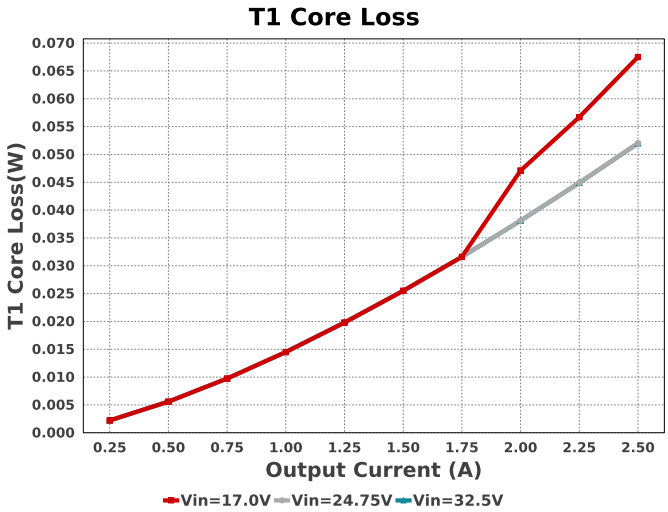


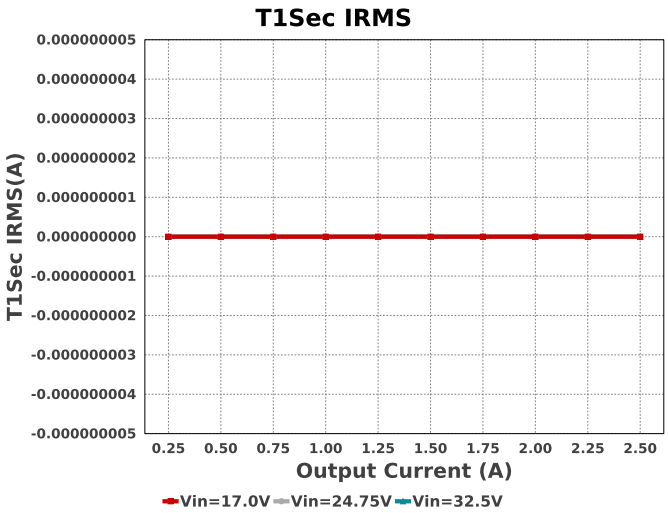


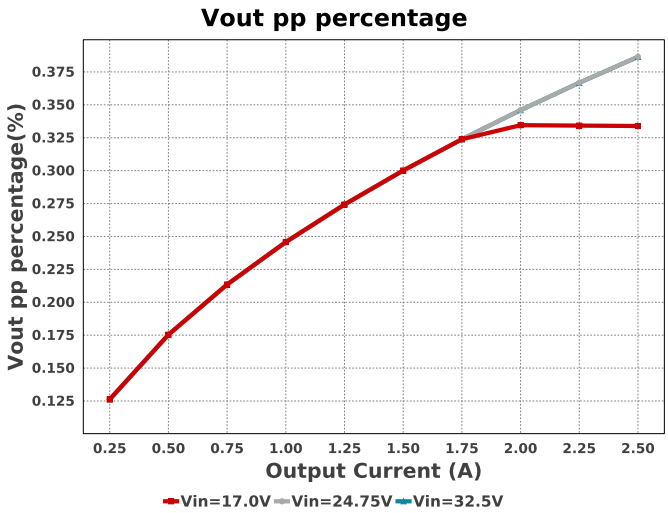


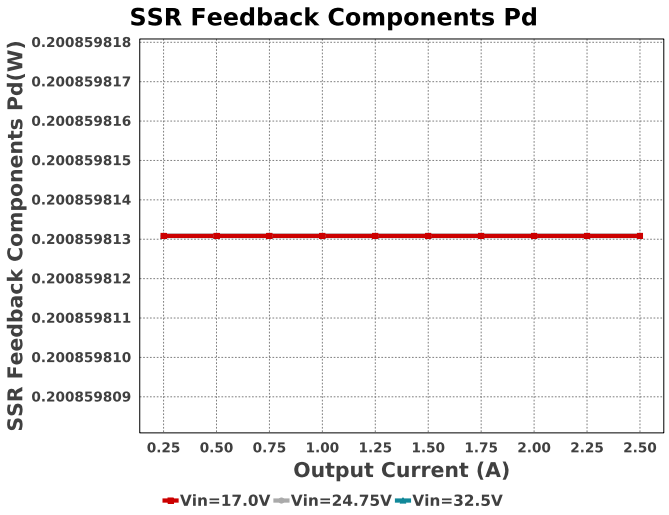


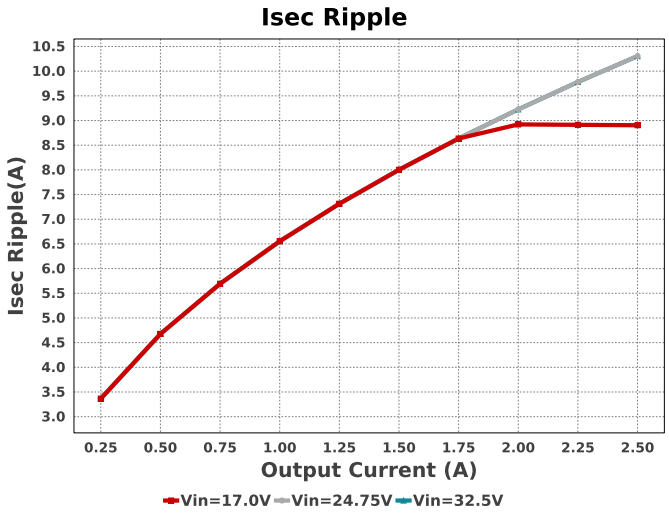


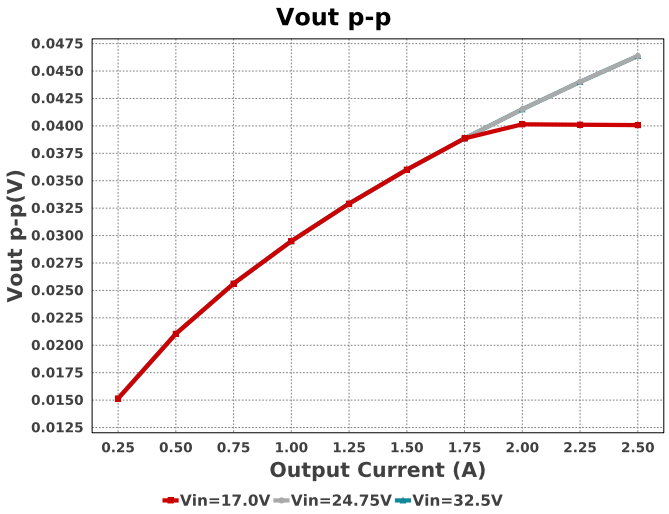


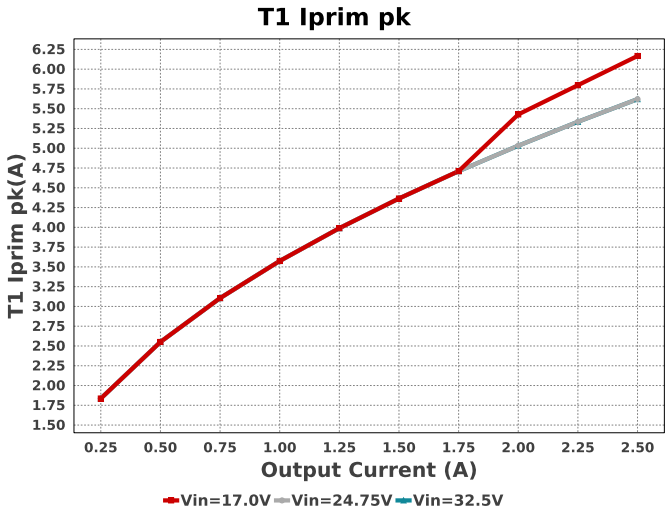












Operating Values

#	Name	Value	Category	Description
1.	Cin Pd	19.066 mW	Capacitor	Input capacitor power dissipation
2.	Cout1 IRMS	3.974 A	Capacitor	Output capacitor1 RMS ripple current
3.	Cout1 Pd	71.052 mW	Capacitor	Output capacitor1 power dissipation
4.	Daux trr	8.26 ns	Diode	Auxiliary Diode Reverse Recovery Time
5.	Dsnub trr	8.02 ns	Diode	Snubber Diode Reverse Recovery Time
6.	IC Pd	41.066 mW	IC	IC power dissipation
7.	IC Tj	75.293 degC	IC	IC junction temperature
8.	ICThetaJA	128.9 degC/W	IC	IC junction-to-ambient thermal resistance
9.	Iin Avg	1.962 A	IC	Average input current
10.	SR Pd	45.685 mW	IC	Synchronous Rectification Controller (SR) Power Dissipation.
11.	M1 Pd	315.97 mW	Mosfet	M1 MOSFET total power dissipation
12.	M1 TjOP	91.434 degC	Mosfet	M1 MOSFET junction temperature
13.	M2 Pd	189.65 mW	Mosfet	M1 MOSFET total power dissipation
14.	Cin Pd	19.066 mW	Power	Input capacitor power dissipation
15.	Cout1 Pd	71.052 mW	Power	Output capacitor1 power dissipation
16.	IC Pd	41.066 mW	Power	IC power dissipation
17.	M1 Pd	315.97 mW	Power	M1 MOSFET total power dissipation
18.	M2 Pd	189.65 mW	Power	M1 MOSFET total power dissipation
19.	Paux	18.638 mW	Power	Power Dissipation in Raux and Daux
20.	Pd Rstartup	65.904 µW	Power	Power Dissipation in Rstartup1 and Rstartup2
21.	Rdrv Pd	7.396 mW	Power	Power Dissipation in Gate Drive Resistor
22.	Rfb Pd	8.324 mW	Power	Rfb Power Dissipation
23.	Rsns Pd	1.117 W	Power	Current Limit Sense Resistor Power Dissipation
24.	SR Pd	45.685 mW	Power	Synchronous Rectification Controller (SR) Power Dissipation.
25.	SSR Feedback Components Pd	200.86 mW	Power	SSR control Mode Feedback Components Power Dissipation.
26.	Snubber Pd	439.348 mW	Power	Snubber Power Dissipation
27.	T1 Copper Loss	817.02 mW	Power	Transformer Copper Loss Power Dissipation
28.	T1 Core Loss	65.1 mW	Power	Transformer Core Loss Power Dissipation
29.	T1 Pd	882.12 mW	Power	Estimated Losses in Transformer
30.	Total Pd	3.356 W	Power	Total Power Dissipation
31.	Pd Rstartup	65.904 µW	Resistor	Power Dissipation in Rstartup1 and Rstartup2

#	Name	Value	Category	Description
32.	Rdrv Pd	7.396 mW	Resistor	Power Dissipation in Gate Drive Resistor
33.	Rfb Pd	8.324 mW	Resistor	Rfb Power Dissipation
34.	Rsns Pd	1.117 W	Resistor	Current Limit Sense Resistor Power Dissipation
35.	BOM Count	60	System Information	Total Design BOM count
36.	Duty Cycle	58.862 %	System Information	Duty cycle
37.	Efficiency	89.939 %	System Information	Steady state efficiency
38.	FootPrint	1.733 k mm^2	System Information	Total Foot Print Area of BOM components
39.	Frequency	98.851 kHz	System Information	Switching frequency
40.	Iout	2.5 A	System Information	Iout operating point
41.	Mode	CCM	System Information	Conduction Mode
42.	Pout	30.0 W	System Information	Total output power
43.	Tdead	0.0 ns	System Information	Approximate Dead Time of the Regulator
44.	Toff	3.69 us	System Information	Approximate Converter Off Time
45.	Ton Act	5.955 us	System Information	Approximate Converter On Time
46.	Total BOM	NA	System Information	Total BOM Cost
47.	Tsw	10.116 us	System Information	Switching Time Period
48.	Vin	17.0 V	System Information	Vin operating point
49.	Vout	12.0 V	System Information	Operational Output Voltage
50.	Vout Actual	11.7 V	System Information	Achieved Vout with feedback resistor pair
51.	Vout Tolerance	25.0 m%	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
52.	Vout p-p	40.07 mV	System Information	Peak-to-peak output ripple voltage
53.	Vout pp percentage	333.914 m%	System Information	Output Voltage ripple percentage
54.	Vsnub	39.6 V	System Information	Voltage Across the Snubber
55.	Ipri Avg	2.2 A	Transformer	Average Current in Primary Winding over the complete Switching Period
56.	Ipri ripple	4.857 A	Transformer	Ripple Current in the Primary Winding
57.	Ipri ripple pk-pk percentage	129.929 %	Transformer	Primary Current pk-pk ripple percentage(of Ipri avg during ton only)
58.	Isec Ripple	8.904 A	Transformer	Ripple Current in the Secondary Winding
59.	Paux	18.638 mW	Transformer	Power Dissipation in Raux and Daux
60.	T1 Copper Loss	817.02 mW	Transformer	Transformer Copper Loss Power Dissipation
61.	T1 Core Loss	65.1 mW	Transformer	Transformer Core Loss Power Dissipation
62.	T1 Iprim RMS	3.063 A	Transformer	Transformer Primary RMS Current
63.	T1 Iprim pk	6.167 A	Transformer	Transformer Primary Peak Current
64.	T1 Is1 RMS	4.695 A	Transformer	Transformer Secondary1 RMS Current
65.	T1 Is1 pk	11.305 A	Transformer	Transformer Secondary1 Peak Current
66.	T1 Pd	882.12 mW	Transformer	Estimated Losses in Transformer
67.	T1Pri IRMS	2.968 A	Transformer	Transformer Primary RMS Current
68.	T1Sec IRMS	4.452 A	Transformer	Transformer Secondary RMS Current
69.	Vaux	14.467 V	Transformer	Auxiliary Voltage

Design Inputs

Name	Value	Description
Iout	2.5	Maximum Output Current
VinMax	32.5	Maximum input voltage
VinMin	17.0	Minimum input voltage
Vout	12.0	Output Voltage
base_pn	UCC28C53	Base Product Number
source	DC	Input Source Type
Ta	70.0	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

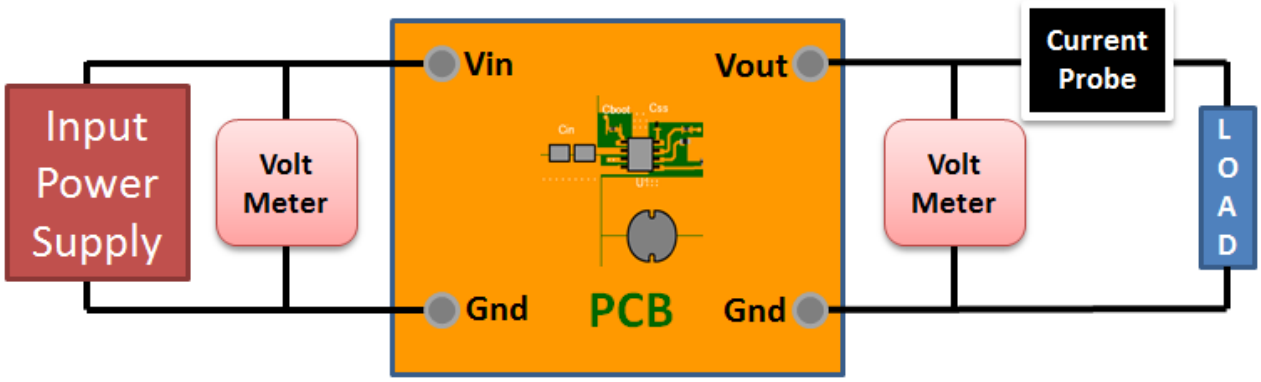
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 17.0V and set the input supply's current limit to zero. With the input supply off connect up the input supply to Vin and GND. Connect a digital volt meter and a load if needed to set the minimum Iout of the design from Vout and GND. Turn on the input supply and slowly turn up the current limit on the input supply. If the voltage starts to rise on the input supply continue increasing the input supply current limit while watching the output voltage. If the current increases on the input supply, but the voltage remains near zero, then there may be a short or a component misplaced on the board. Power down the board and visually inspect for solder bridges and recheck the diode and capacitor polarities. Once the power supply circuit is operational then more extensive testing may include full load testing, transient load and line tests to compare with simulation results.

Load Testing

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



WEBENCH® Transformer Report

#	Name	Value
1.	Core Part Number	150-2623
2.	Core Manufacturer	Wurth Elektronik
3.	Coil Former Part Number	070-2255
4.	Coil Former Manufacturer	Wurth Elektronik

Transformer Electrical Diagram

Primary

Turns	11.0
AWG	28.0
Layers	2.0
Strands	4.0
Insulation Type	Heavy Insulated Magnet Wire

Secondary

Turns	6.0
AWG	27.0
Layers	1.0
Strands	2.0
Insulation Type	Triple Insulated

Auxiliary

Turns	7.0
AWG	28.0
Layers	1.0
Strands	3.0
Insulation Type	Heavy Insulated Magnet Wire

Transformer Construction Diagram

Winding Instruction

Winding	AWG	Turns	Winding Orientation
Primary First 1/2.0	28.0	6	Clockwise
Auxiliary	28.0	7.0	Counter Clockwise
Triple Insulated Secondary	27.0	6.0	Counter Clockwise
Primary Second 1/2.0	28.0	5	Clockwise

Transformer Parameters

#	Name	Value
1.	Lpri	2.0E-5H
2.	Inductance Factor(Al)	167.0nH
3.	Npri	11.0
4.	Nsec	6.0
5.	Naux	7.0
6.	Core Type	RM8
7.	Core Material	TP4A

#	Name	Value
8.	Bmax	0.19T
9.	Switching Frequency	98.85kHz
10.	DMax	0.6
11.	Ipk(Primary)	6.05A
12.	Irms(Primary)	2.97A
13.	Ipk(Secondary)	11.1A
14.	Irms(Secondary)	4.44A

Design Assistance

1. Master key : B9890894CF415FA2B99C435FCF30401B[v1]
2. **UCC28C53** Product Folder : https://www.ti.com/product/UCC28C53 : contains the data sheet and other resources.