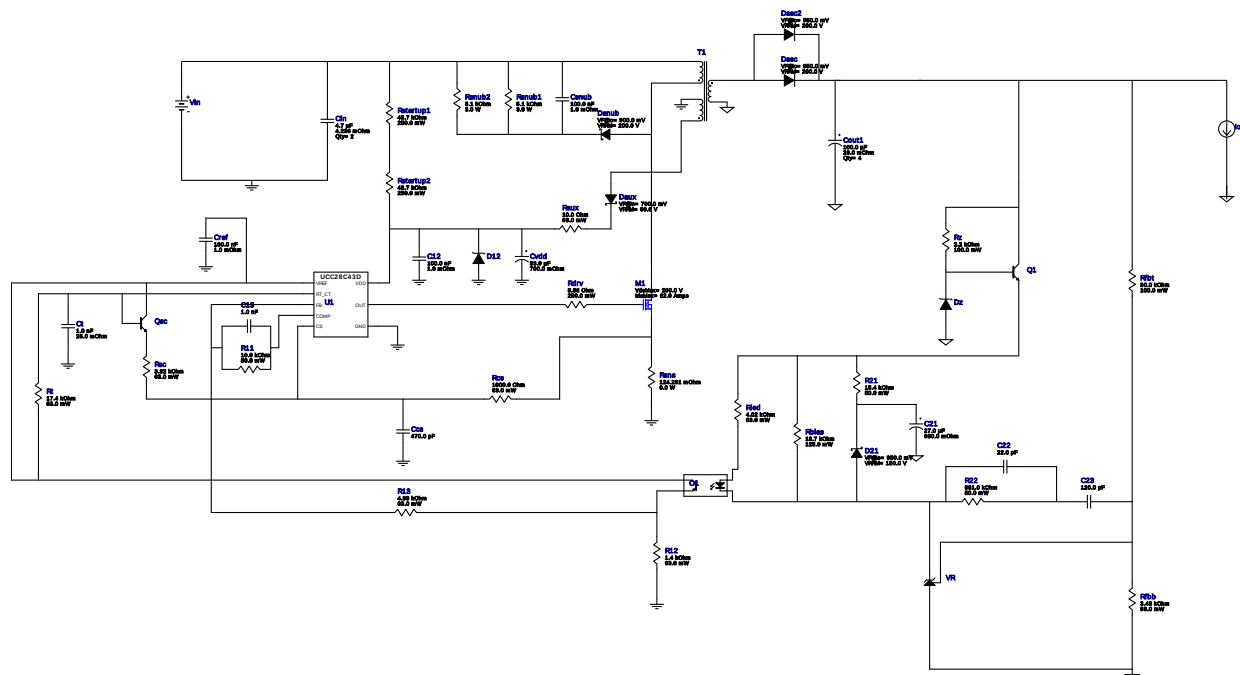


WEBENCH® Design Report

Design : 17147 UCC28C43D
UCC28C43D 37V-57V to 24.00V @ 2.5A



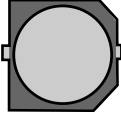
Design Alerts

Component Selection Information

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

Electrical BOM

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
C12	MuRata	GRM155R71C104KA88D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	\$0.01	0402 3 mm ²
C13	MuRata	GRM1555C1H102JA01J Series= C0G/NP0	Cap= 1.0 nF VDC= 50.0 V IRMS= 0.0 A	1	\$0.01	0402 3 mm ²
C21	Nichicon	UUD1H270MCL1GS Series= uD	Cap= 27.0 uF ESR= 680.0 mOhm VDC= 50.0 V IRMS= 185.0 mA	1	\$0.13	 SM_RADIAL_6.3BMM 80 mm ²
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 mm ²
C23	Samsung Electro-Mechanics	CL21C121JBANNNC Series= C0G/NP0	Cap= 120.0 pF VDC= 50.0 V IRMS= 0.0 A	1	\$0.01	0805 7 mm ²
Ccs	AVX	04025A471JAT2A Series= C0G/NP0	Cap= 470.0 pF VDC= 50.0 V IRMS= 0.0 A	1	\$0.01	0402 3 mm ²

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cin	TDK	CGA6M3X7S2A475K200AB Series= X7S	Cap= 4.7 uF ESR= 4.236 mOhm VDC= 100.0 V IRMS= 3.57337 A	2	\$0.47	 1210_220 15 mm ²
Cout1	Panasonic	EEHZA1H101P Series= ZA	Cap= 100.0 uF ESR= 28.0 mOhm VDC= 50.0 V IRMS= 2.0 A	4	\$1.00	 SM_RADIAL_10BMM 160 mm ²
Cref	MuRata	GRM155R71C104KA88D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	\$0.01	 0402 3 mm ²
Csnub	TDK	C2012X7T2E104K125AA Series= X7T	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 250.0 V IRMS= 0.0 A	1	\$0.07	 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	Panasonic	EEE-FK1E330UR Series= FK	Cap= 33.0 uF ESR= 700.0 mOhm VDC= 25.0 V IRMS= 160.0 mA	1	\$0.09	 SM_RADIAL_C 62 mm ²
D12	ON Semiconductor	MMSZ4705T1G	Zener	1	\$0.04	 SOD-123 13 mm ²
D21	SMC Diode Solutions	SK215ATR	VF@Io= 950.0 mV VRRM= 150.0 V	1	\$0.04	 SMA 37 mm ²
Daux	Fairchild Semiconductor	SS26FL	VF@Io= 700.0 mV VRRM= 60.0 V	1	\$0.07	 SOD-123F 12 mm ²
Dsec	SMC Diode Solutions	SBRD10200TR	VF@Io= 950.0 mV VRRM= 200.0 V	1	\$0.12	 DPAK 102 mm ²
Dsec2	SMC Diode Solutions	SBRD10200TR	VF@Io= 950.0 mV VRRM= 200.0 V	1	\$0.12	 DPAK 102 mm ²
Dsnub	Fairchild Semiconductor	S320	VF@Io= 900.0 mV VRRM= 200.0 V	1	\$0.13	 SMB 44 mm ²
Dz	Diodes Inc.	MMSZ5250B-7-F	Zener	1	\$0.03	 SOD-123 13 mm ²
M1	Fairchild Semiconductor	FDB2614	VdsMax= 200.0 V IdsMax= 62.0 Amps	1	\$1.97	 DDPAK 210 mm ²
O1	Fairchild Semiconductor	FOD817A	Optocoupler	1	\$0.11	 DIP-4 71 mm ²
Q1	Diodes Inc.	MMBT4401-7-F	Bipolar Transistor	1	\$0.02	 SOT-23 14 mm ²
Qsc	STMicroelectronics	2N2222A	Bipolar Transistor	1	\$1.11	 TO-18 57 mm ²

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 mm ²
R12	Vishay-Dale	CRCW04021K40FKED Series= CRCW..e3	Res= 1.4 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
R13	Vishay-Dale	CRCW04024K99FKED Series= CRCW..e3	Res= 4.99 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 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	Yageo	RC0201FR-07681KL Series= ?	Res= 681.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	\$0.01	 0201 2 mm ²
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
Rbias	Vishay-Dale	CRCW080513K7FKEA Series= CRCW..e3	Res= 13.7 kOhm Power= 125.0 mW Tolerance= 1.0%	1	\$0.01	 0805 7 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	CRCW12068R66FKEA Series= CRCW..e3	Res= 8.66 Ohm Power= 250.0 mW Tolerance= 1.0%	1	\$0.01	 1206 11 mm ²
Rfbb	Vishay-Dale	CRCW04023K48FKED Series= CRCW..e3	Res= 3.48 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
Rfbt	Yageo	RC0603FR-0730KL Series= ?	Res= 30.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	\$0.01	 0603 5 mm ²
Rled	Vishay-Dale	CRCW04024K02FKED Series= CRCW..e3	Res= 4.02 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
Rsc	Vishay-Dale	CRCW04023K32FKED Series= CRCW..e3	Res= 3.32 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
Rsns	CUSTOM	CUSTOM Series= ?	Res= 124.231 mOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm ²
Rsub1	Vishay-Bccomponents	PR03000205101JAC00 Series= ?	Res= 5.1 kOhm Power= 3.0 W Tolerance= 5.0%	1	\$0.09	 PR03 197 mm ²
Rsub2	Vishay-Bccomponents	PR03000205101JAC00 Series= ?	Res= 5.1 kOhm Power= 3.0 W Tolerance= 5.0%	1	\$0.09	 PR03 197 mm ²
Rstartup1	Panasonic	ERJ-8ENF4872V Series= ERJ-8E	Res= 48.7 kOhm Power= 250.0 mW Tolerance= 1.0%	1	\$0.01	 1206 11 mm ²
Rstartup2	Panasonic	ERJ-8ENF4872V Series= ERJ-8E	Res= 48.7 kOhm Power= 250.0 mW Tolerance= 1.0%	1	\$0.01	 1206 11 mm ²
Rt	Vishay-Dale	CRCW040217K4FKED Series= CRCW..e3	Res= 17.4 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
Rz	Yageo	RC0603FR-072K2L Series= ?	Res= 2.2 kOhm Power= 100.0 mW Tolerance= 1.0%	1	\$0.01	 0603 5 mm ²

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
T1	Core=TDK , CoilFormer=TDK	Core=B66421G0000X197 , CoilFormer=B66422W1010D001	Lp= 47.0 μ H Turns Ratio(Nas)= 6:10 Turns Ratio(Nps)= 20:10 Npri= 20.0 Naux= 6.0 Nsec= 10.0	1	\$0.35	 TDK_B66305 756 mm ²

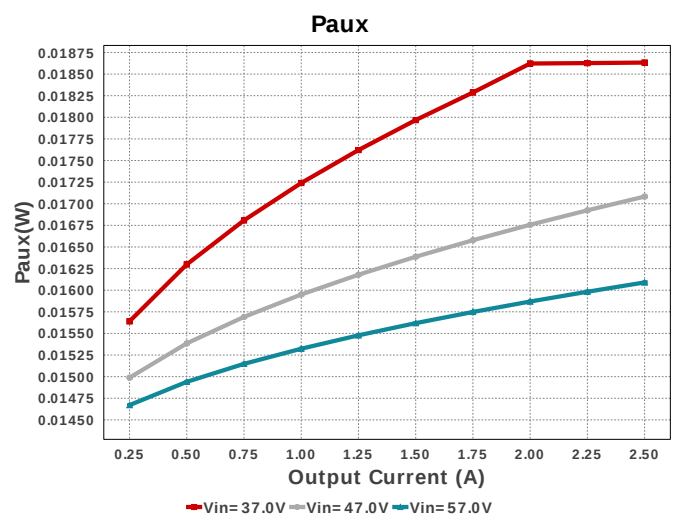
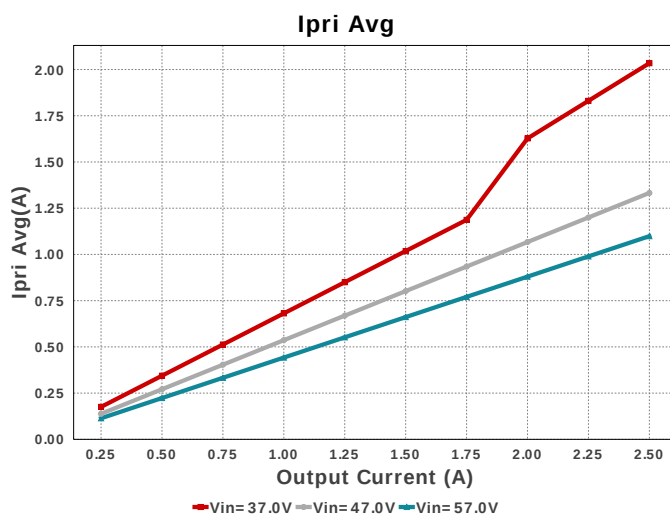
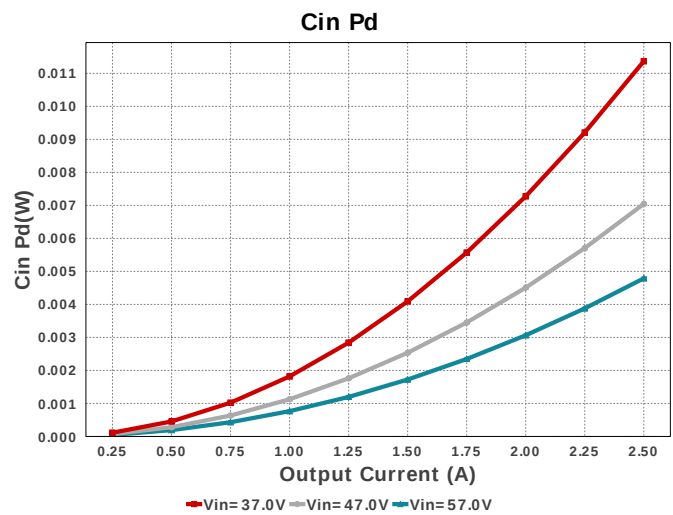
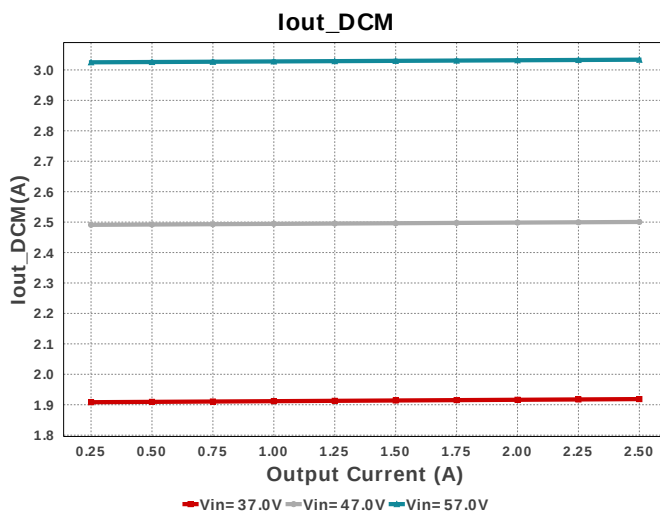
U1	Texas Instruments	UCC28C43D
----	-------------------	-----------

Switcher	1	\$0.70
----------	---	--------

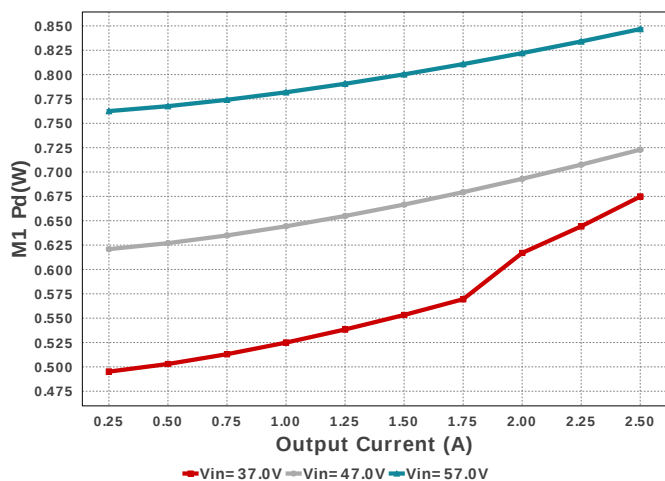
D0008A 57 mm²

VR	Texas Instruments	TL431IDBVR
----	-------------------	------------

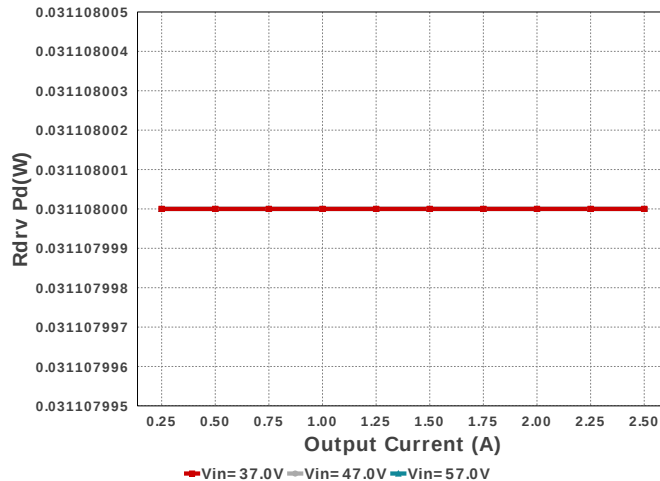
Voltage References	1	\$0.07
--------------------	---	--------

R-PDSO-G3 16 mm²

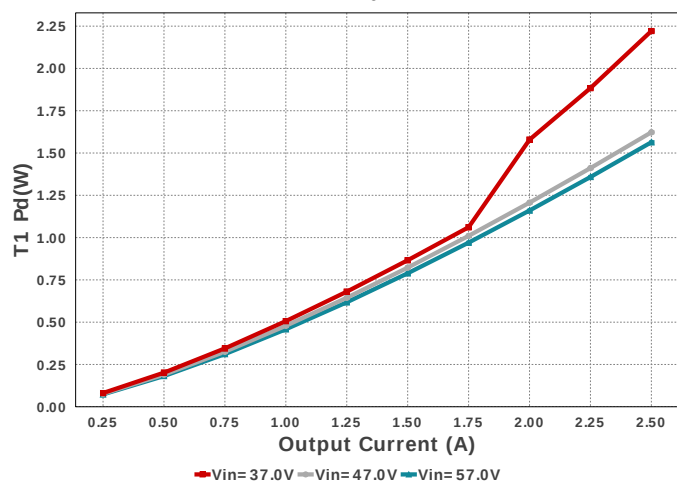
M1 Pd



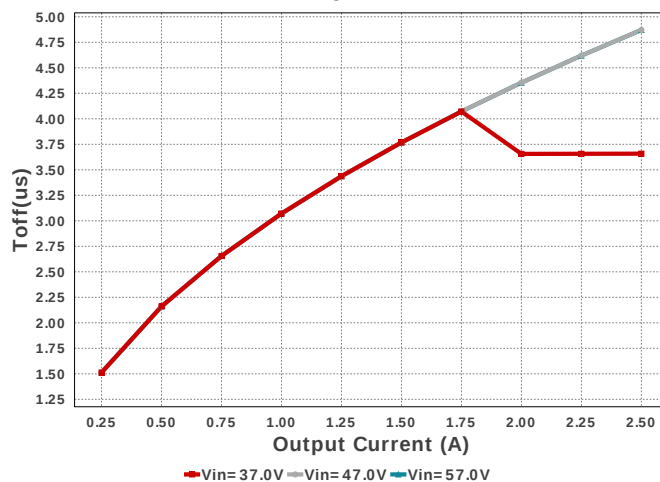
Rdrv Pd



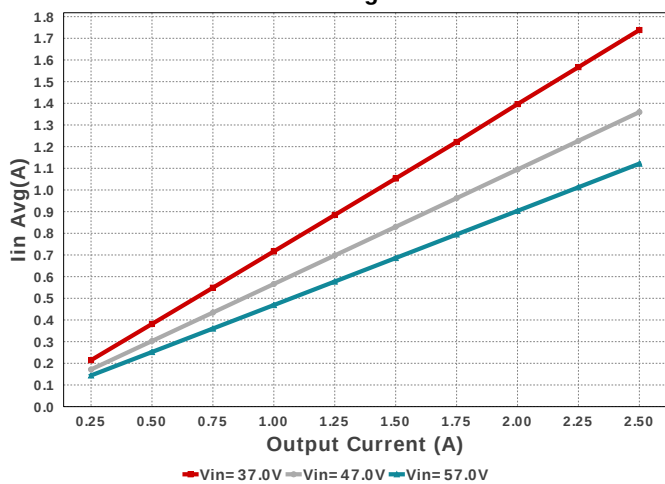
T1 Pd



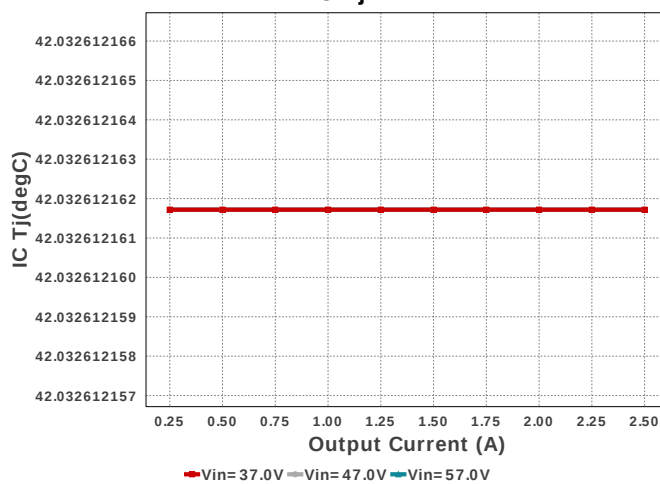
Toff

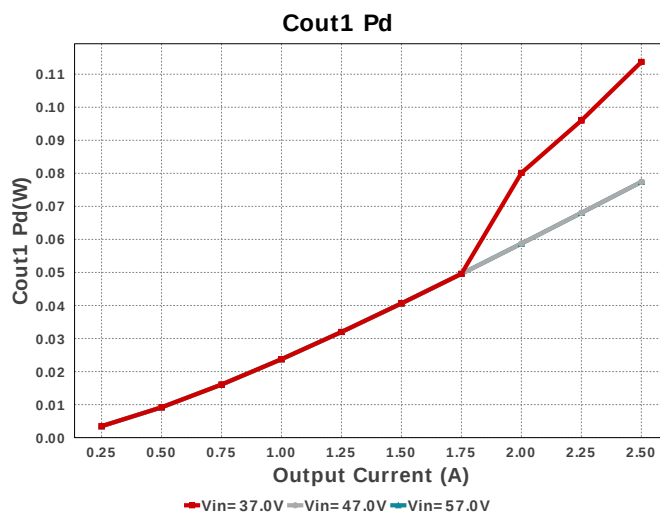
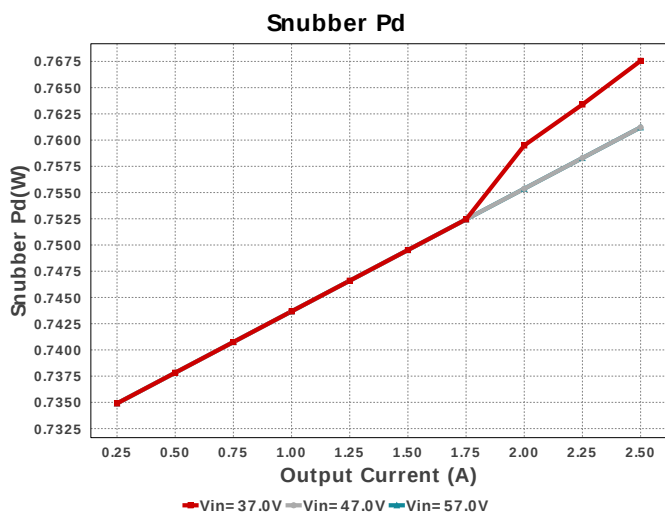
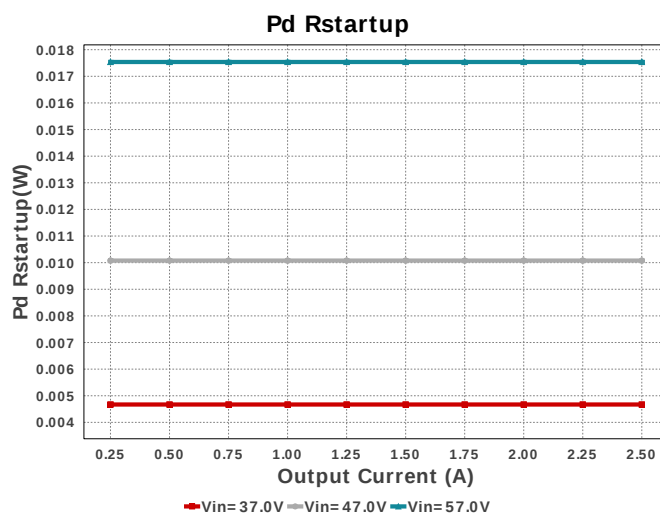
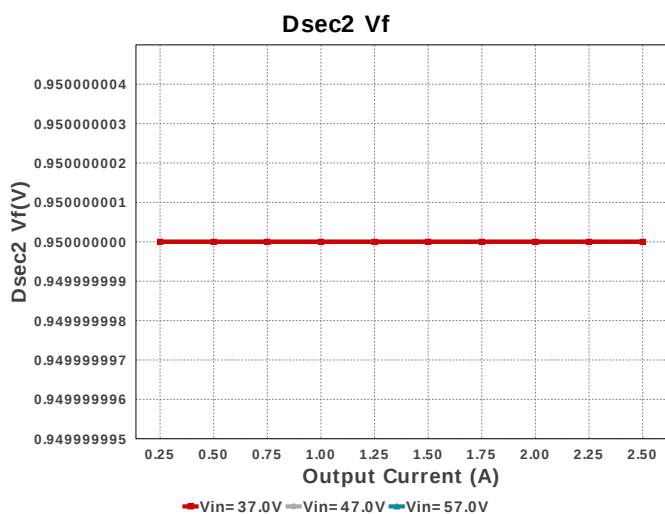
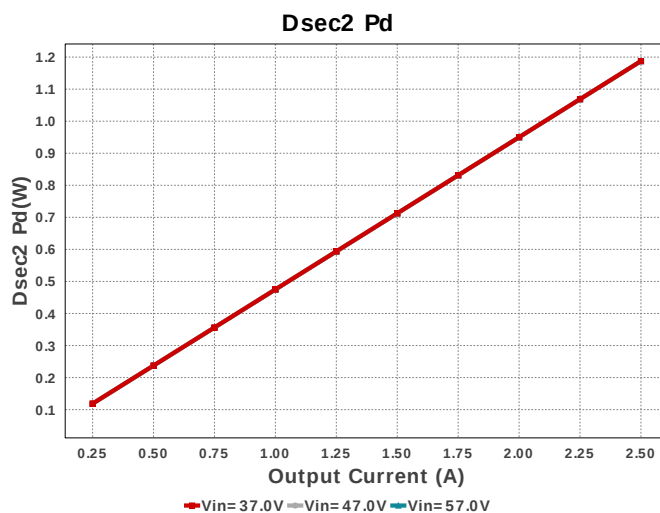
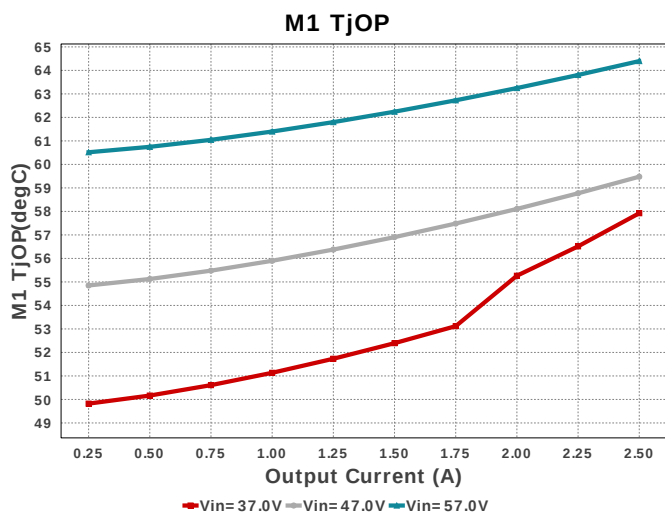


Iin Avg

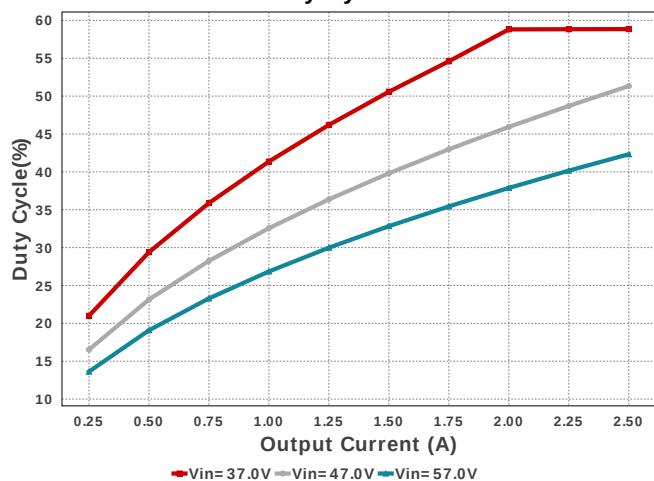


IC Tj

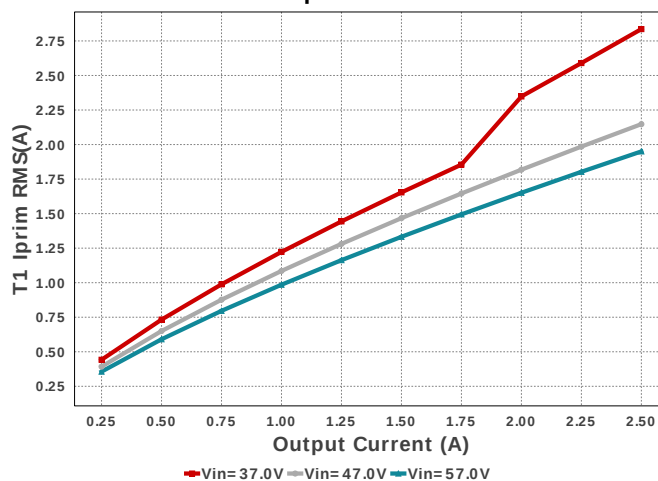




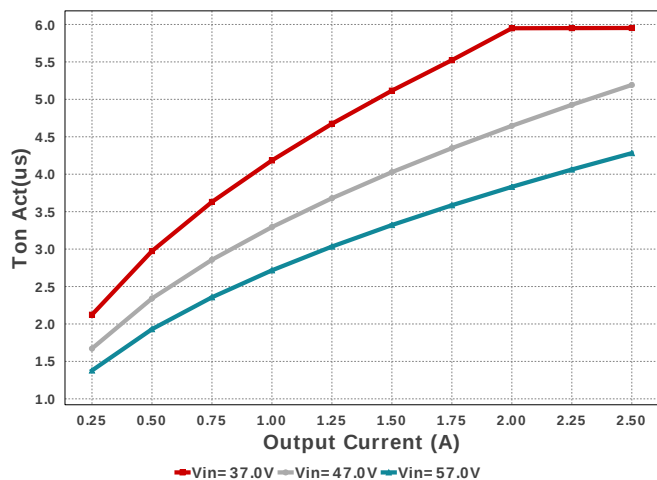
Duty Cycle



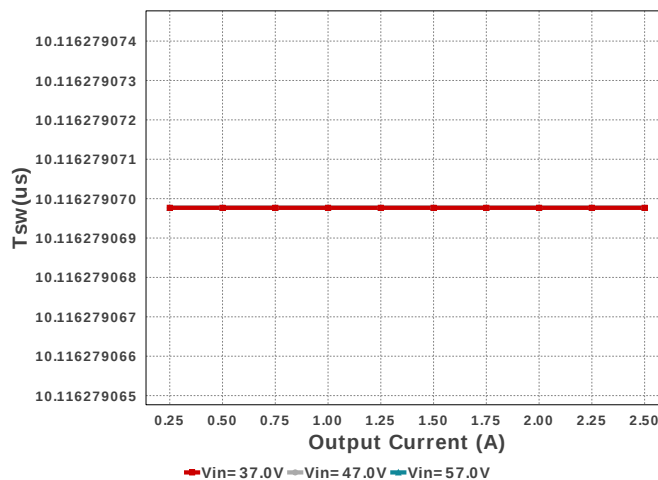
T1 Iprim RMS



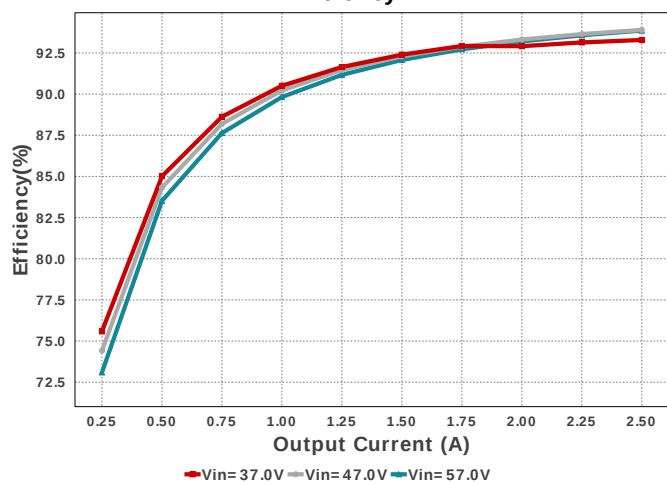
Ton Act



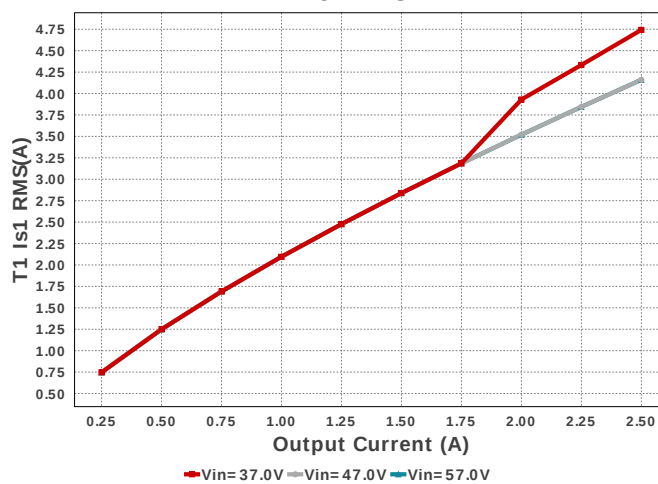
Tsw

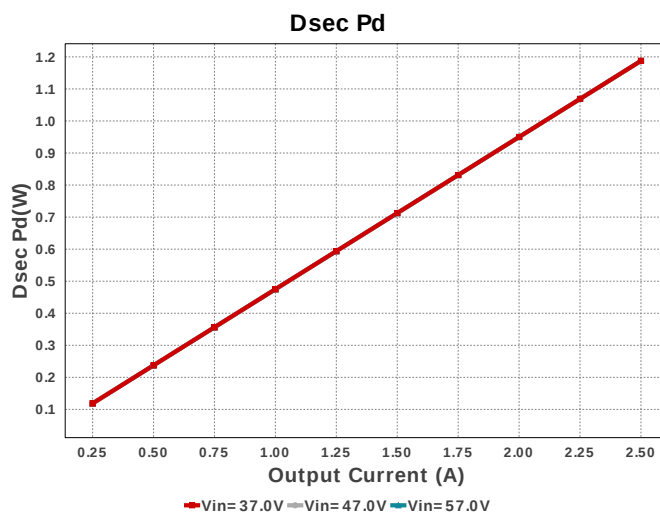
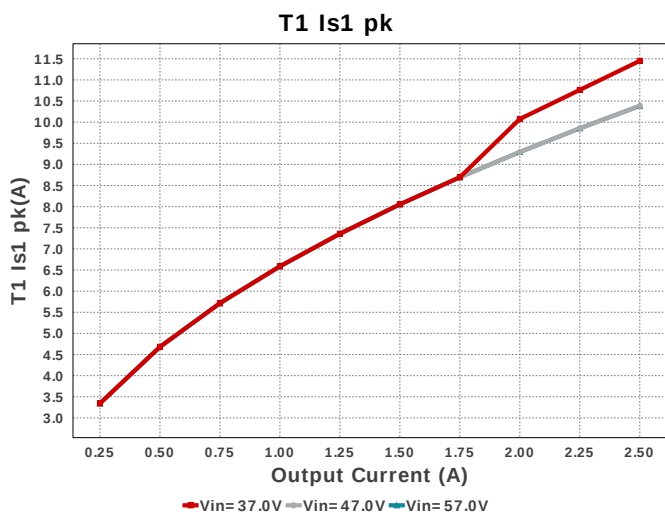
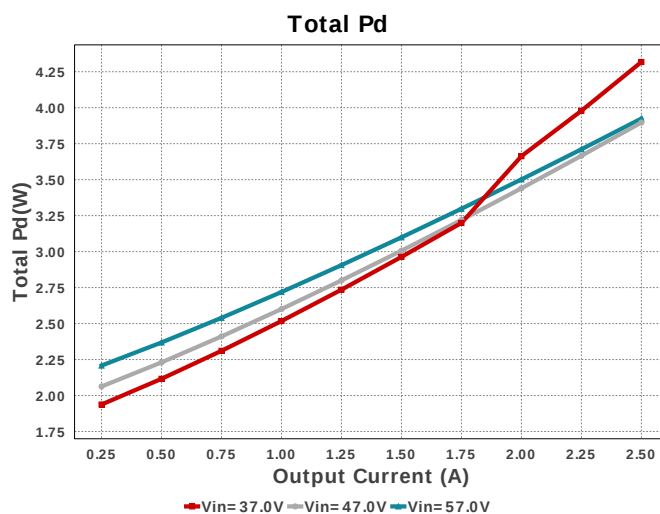
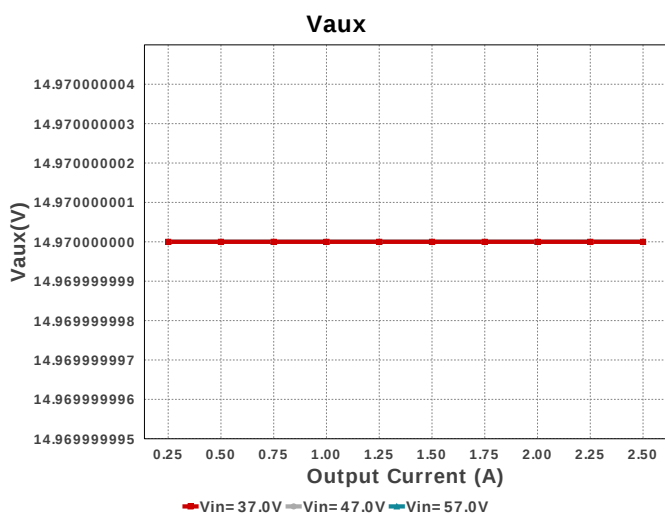
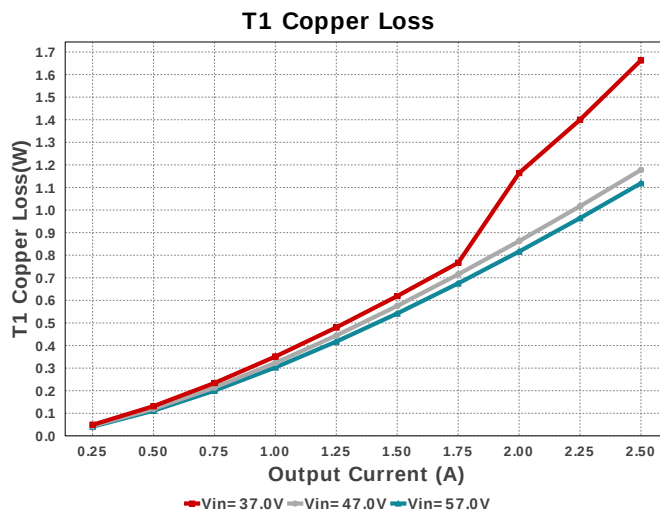
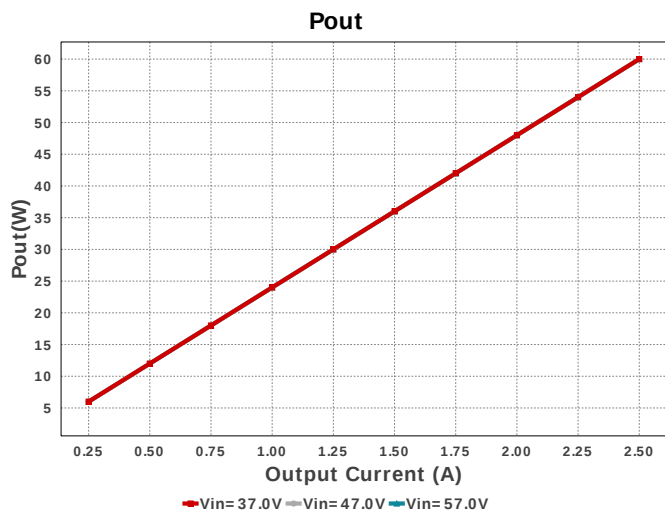


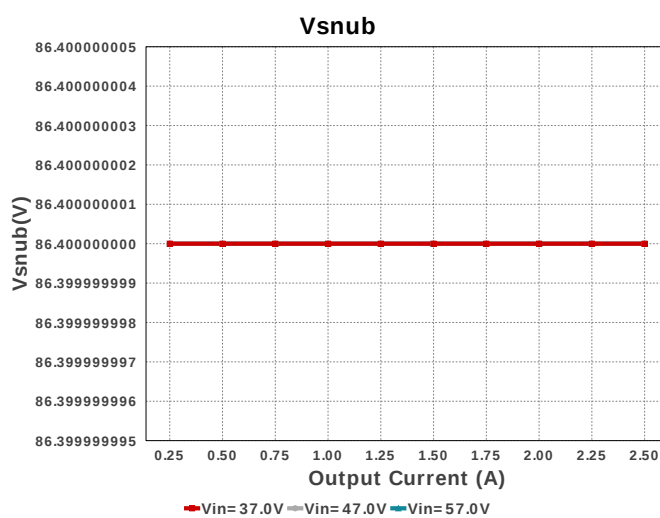
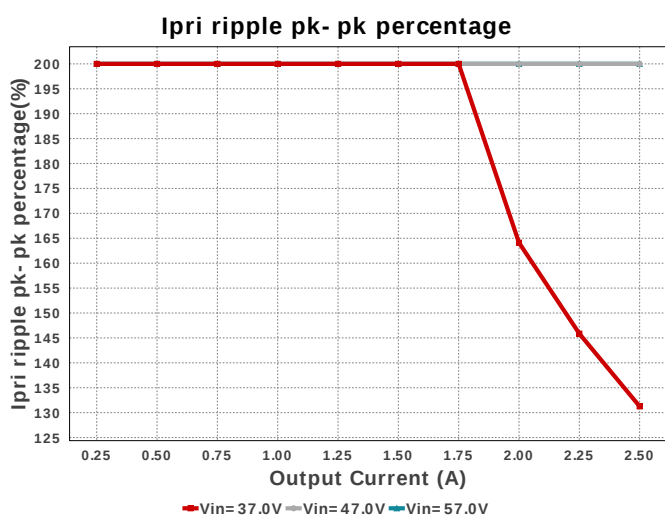
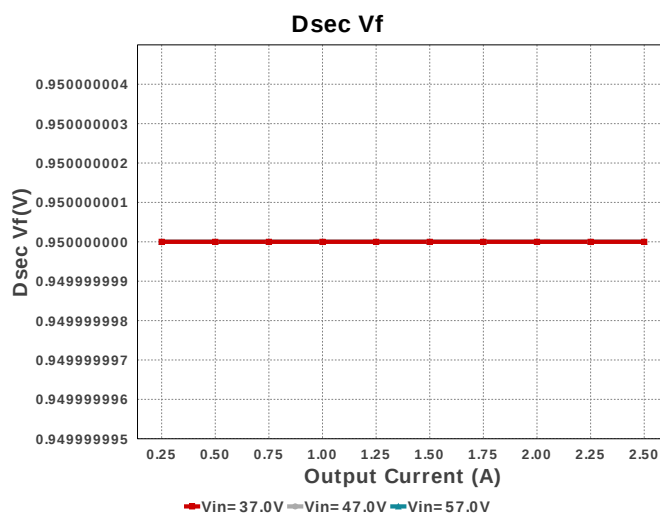
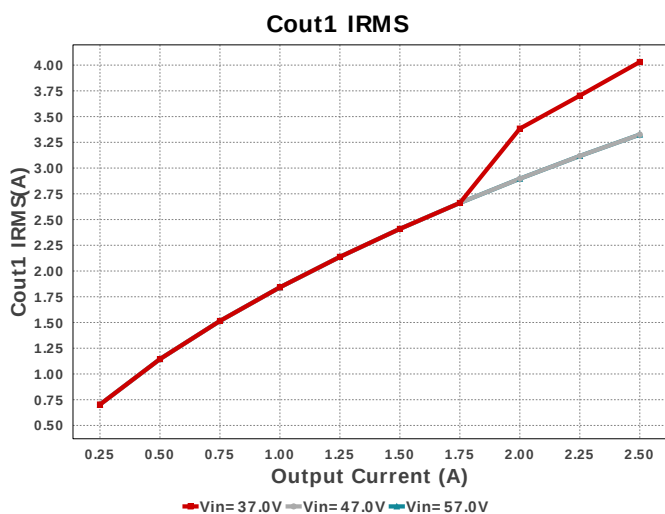
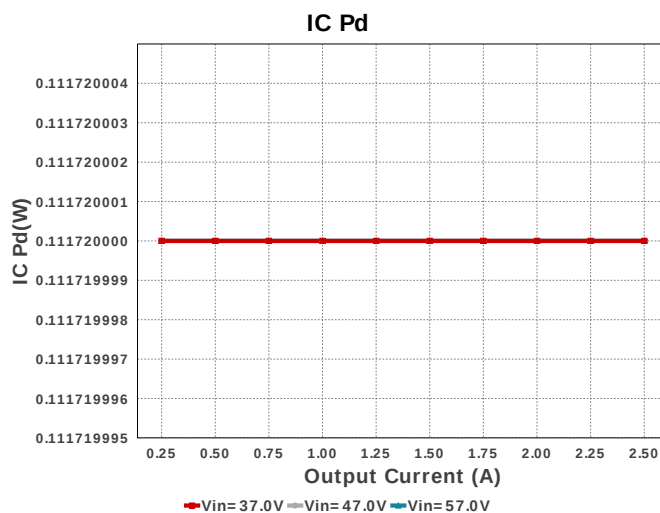
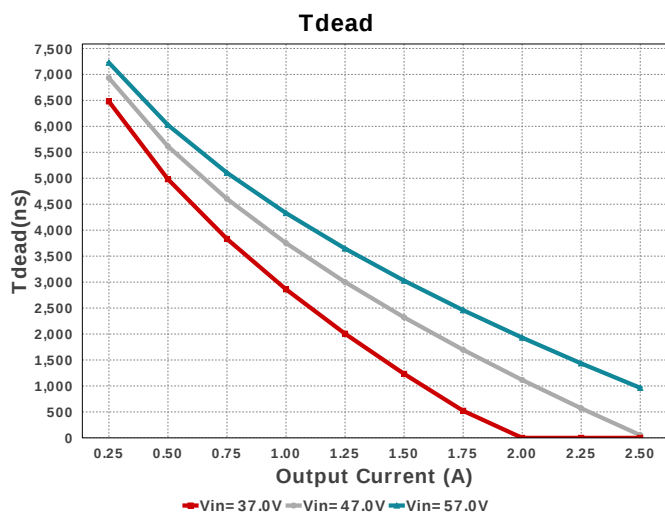
Efficiency

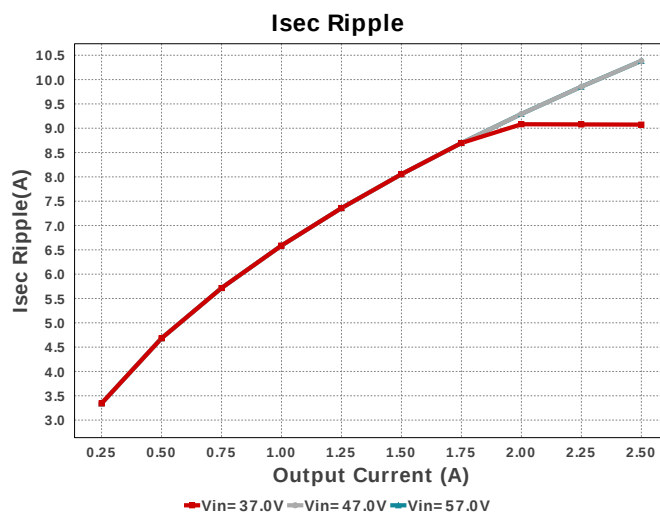
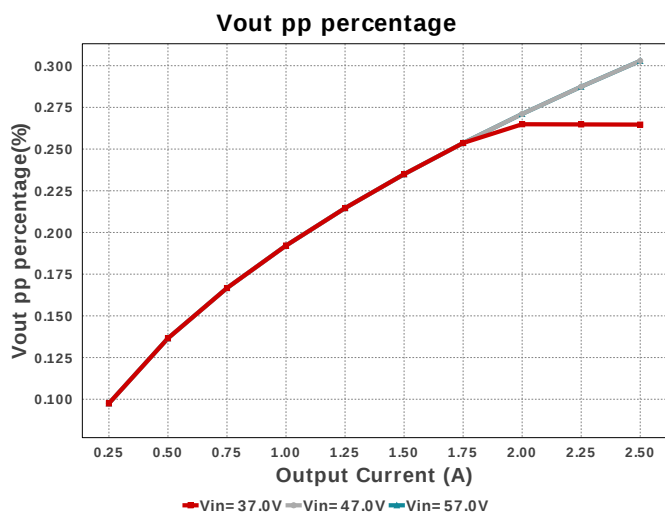
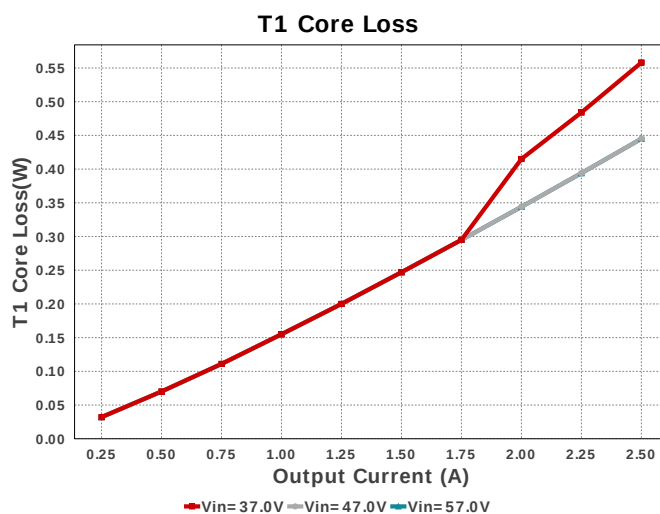
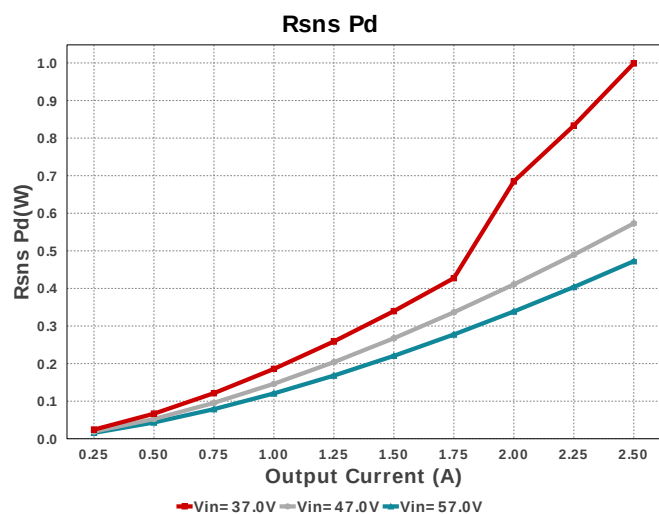
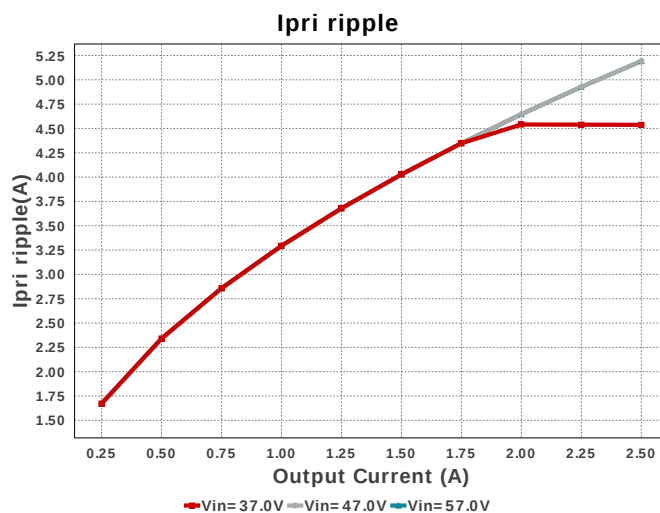
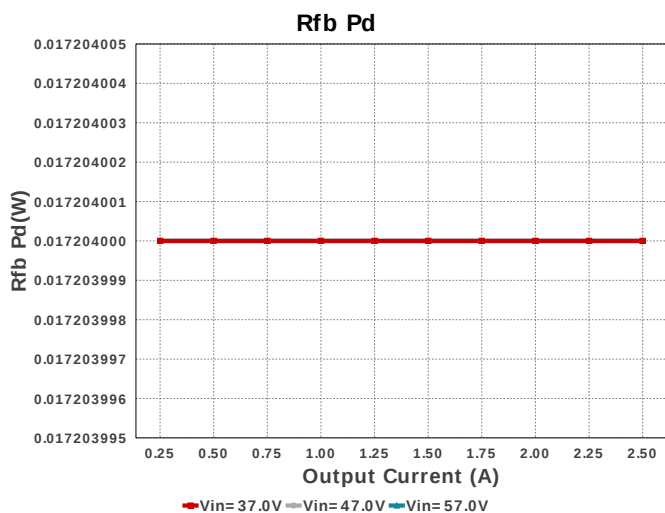


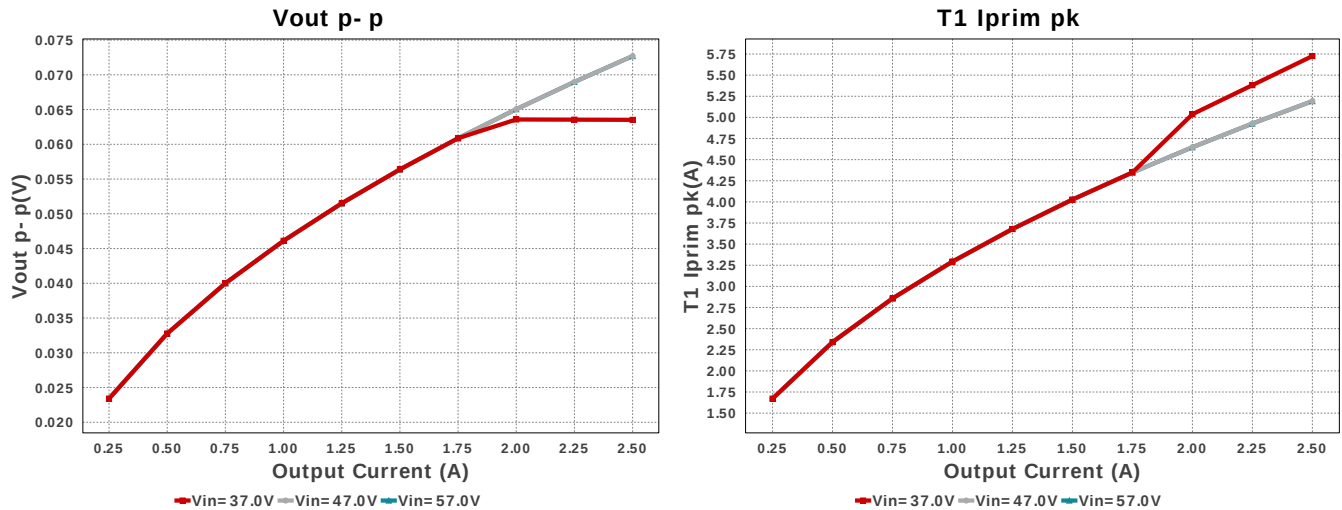
T1 Is1 RMS











Operating Values

#	Name	Value	Category	Description
1.	Cin Pd	22.733 mW	Capacitor	Input capacitor power dissipation
2.	Cout1 IRMS	4.03 A	Capacitor	Output capacitor1 RMS ripple current
3.	Cout1 Pd	113.71 mW	Capacitor	Output capacitor1 power dissipation
4.	Daux trr	8.26 ns	Diode	Auxiliary Diode Reverse Recovery Time
5.	Dsec Pd	1.188 W	Diode	Secondary Diode Power Dissipation
6.	Dsec Vf	950.0 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	1.188 W	Diode	Secondary Diode Power Dissipation
9.	Dsec2 Vf	950.0 mV	Diode	Effective Forward Voltage Drop at the Operating Current
10.	Dsnub trr	30.0 ns	Diode	Snubber Diode Reverse Recovery Time
11.	IC Pd	111.72 mW	IC	IC power dissipation
12.	IC Tj	42.033 degC	IC	IC junction temperature
13.	ICThetaJA	107.7 degC/W	IC	IC junction-to-ambient thermal resistance
14.	Iin Avg	1.739 A	IC	Average input current
15.	M1 Pd	674.8 mW	Mosfet	M1 MOSFET total power dissipation
16.	M1 TjOP	57.923 degC	Mosfet	M1 MOSFET junction temperature
17.	Cin Pd	22.733 mW	Power	Input capacitor power dissipation
18.	Cout1 Pd	113.71 mW	Power	Output capacitor1 power dissipation
19.	Dsec Pd	1.188 W	Power	Secondary Diode Power Dissipation
20.	Dsec2 Pd	1.188 W	Power	Secondary Diode Power Dissipation
21.	IC Pd	111.72 mW	Power	IC power dissipation
22.	M1 Pd	674.8 mW	Power	M1 MOSFET total power dissipation
23.	Paux	18.633 mW	Power	Power Dissipation in Raux and Daux
24.	Pd Rstartup	4.671 mW	Power	Power Dissipation in Rstartup1 and Rstartup2
25.	Rdrv Pd	31.108 mW	Power	Power Dissipation in Gate Drive Resistor
26.	Rfb Pd	17.204 mW	Power	Rfb Power Dissipation
27.	Rsns Pd	998.96 mW	Power	Current Limit Sense Resistor Power Dissipation
28.	Snubber Pd	767.553 mW	Power	Snubber Power Dissipation
29.	T1 Copper Loss	1.513 W	Power	Transformer Copper Loss Power Dissipation
30.	T1 Core Loss	534.0 mW	Power	Transformer Core Loss Power Dissipation
31.	T1 Pd	2.047 W	Power	Estimated Losses in Transformer
32.	Total Pd	4.329 W	Power	Total Power Dissipation
33.	Pd Rstartup	4.671 mW	Resistor	Power Dissipation in Rstartup1 and Rstartup2
34.	Rdrv Pd	31.108 mW	Resistor	Power Dissipation in Gate Drive Resistor
35.	Rfb Pd	17.204 mW	Resistor	Rfb Power Dissipation
36.	Rsns Pd	998.96 mW	Resistor	Current Limit Sense Resistor Power Dissipation
37.	BOM Count	50	System	Total Design BOM count
38.	Duty Cycle	58.846 %	System	Duty cycle
39.	Efficiency	93.27 %	System	Steady state efficiency
40.	FootPrint	2.818 k mm ²	System	Total Foot Print Area of BOM components
41.	Frequency	98.851 kHz	System	Switching frequency
42.	Iout	2.5 A	System	Iout operating point
43.	Iout_DCM	1.919 A	System	Approximate Current below which DCM mode of operation will begin
44.	Mode	CCM	System	Conduction Mode

#	Name	Value	Category	Description
45.	Pout	60.0 W	System Information	Total output power
46.	Tdead	0.0 ns	System Information	Approximate Dead Time of the Regulator
47.	Toff	3.658 us	System Information	Approximate Converter Off Time
48.	Ton Act	5.953 us	System Information	Approximate Converter On Time
49.	Total BOM	NA	System Information	Total BOM Cost
50.	Tsw	10.116 us	System Information	Switching Time Period
51.	Vin	37.0 V	System Information	Vin operating point
52.	Vout	24.0 V	System Information	Operational Output Voltage
53.	Vout Actual	24.004 V	System Information	Vout Actual calculated based on selected voltage divider resistors
54.	Vout Tolerance	2.137 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
55.	Vout p-p	63.522 mV	System Information	Peak-to-peak output ripple voltage
56.	Vout pp percentage	264.674 m%	System Information	Output Voltage ripple percentage
57.	Vsnub	86.4 V	System Information	Voltage Across the Snubber
58.	Ipri Avg	2.034 A	Transformer	Average Current in Primary Winding over the complete Switching Period
59.	Ipri ripple	4.537 A	Transformer	Ripple Current in the Primary Winding
60.	Ipri ripple pk-pk percentage	131.259 %	Transformer	Primary Current pk-pk ripple percentage(of Ipri avg during ton only)
61.	Isec Ripple	9.075 A	Transformer	Ripple Current in the Secondary Winding
62.	Paux	18.633 mW	Transformer	Power Dissipation in Raux and Daux
63.	T1 Copper Loss	1.513 W	Transformer	Transformer Copper Loss Power Dissipation
64.	T1 Core Loss	534.0 mW	Transformer	Transformer Core Loss Power Dissipation
65.	T1 Iprim RMS	2.836 A	Transformer	Transformer Primary RMS Current
66.	T1 Iprim pk	5.725 A	Transformer	Transformer Primary Peak Current
67.	T1 Is1 RMS	4.743 A	Transformer	Transformer Secondary1 RMS Current
68.	T1 Is1 pk	11.451 A	Transformer	Transformer Secondary1 Peak Current
69.	T1 Pd	2.047 W	Transformer	Estimated Losses in Transformer
70.	Vaux	14.97 V	Transformer	Auxiliary Voltage

Design Inputs

Name	Value	Description
Iout	2.5	Maximum Output Current
VinMax	57.0	Maximum input voltage
VinMin	37.0	Minimum input voltage
Vout	24.0	Output Voltage
base_pn	UCC28C43	Base Product Number
source	DC	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 C_{in} and C_{out} , 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

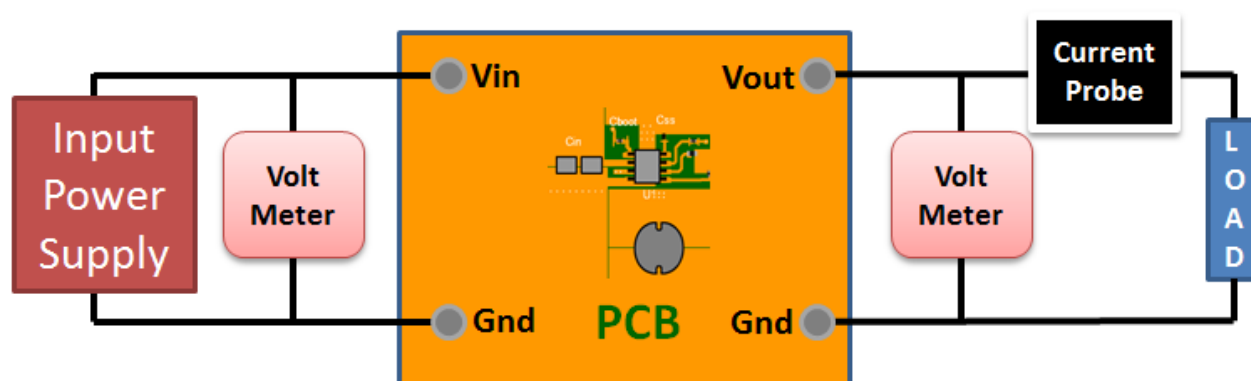
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. To solder the tab down 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 37.0V and set the input supply's current limit to zero. With the input supply off connect up the input supply to V_{in} and GND. Connect a digital volt meter and a load if needed to set the minimum load of the design from V_{out} 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 V_{in} and GND, a load is connected between V_{out} and GND and a current meter is connected in series between V_{out} 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

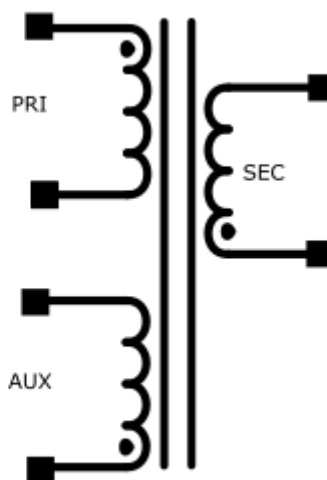
Turns	20.0
AWG	26.0
Layers	2.0
Strands	3.0
Insulation Type	Heavy Insulated Magnet Wire

Auxiliary

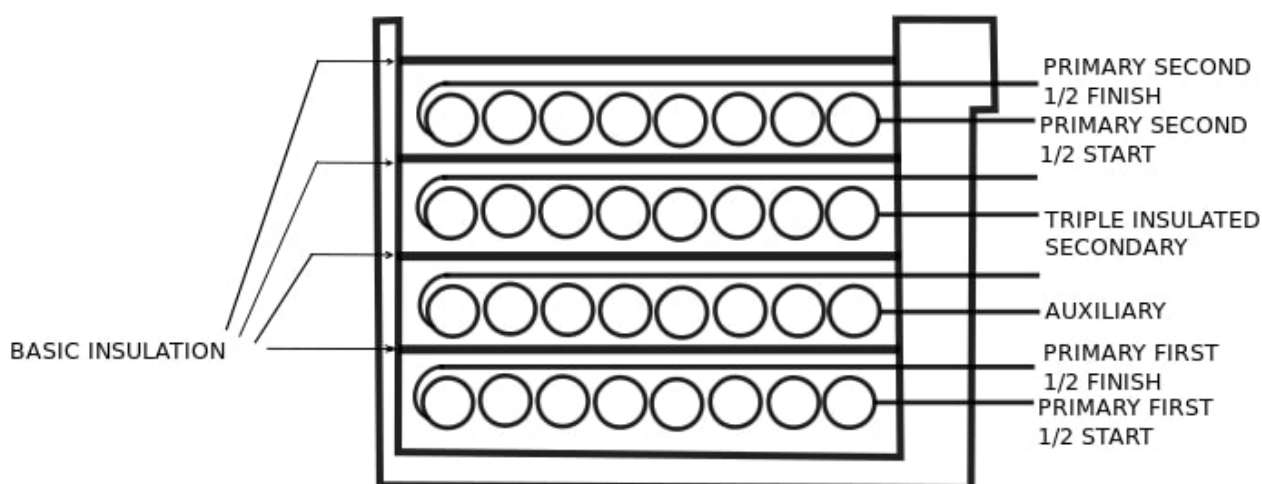
Turns	6.0
AWG	28.0
Layers	1.0
Strands	4.0
Insulation Type	Heavy Insulated Magnet Wire

Secondary

Turns	10.0
AWG	26.0
Layers	1.0
Strands	2.0
Insulation Type	Triple Insulated



Transformer Construction Diagram



Winding Instruction

Winding	AWG	Turns	Winding Orientation
Primary First 1/2.0	26.0	10	Clockwise

Winding	AWG	Turns	Winding Orientation
Auxiliary	28.0	6.0	Counter Clockwise
Triple Insulated Secondary	26.0	10.0	Counter Clockwise
Primary Second 1/2.0	26.0	10	Clockwise

Transformer Parameters

#	Name	Value
1.	Lpri	4.7E-5H
2.	Inductance Factor(Al)	119.0nH
3.	Npri	20.0
4.	Nsec	10.0
5.	Naux	6.0
6.	Core Type	EFD25/13/9
7.	Core Material	N97
8.	Bmax	0.23T
9.	Switching Frequency	98.85kHz
10.	DMax	0.6
11.	Ipk(Primary)	5.57A
12.	Irms(Primary)	2.73A
13.	Ipk(Secondary)	11.1A
14.	Irms(Secondary)	4.46A

Design Assistance

1. Master key : EA1A2FC478260EC3[v1]

2. **UCC28C43** Product Folder : <http://www.ti.com/product/UCC28C43> : contains the data sheet and other resources.

Important Notice and Disclaimer

TI provides technical and reliability data (including datasheets), design resources (including reference designs), application or other design advice, web tools, safety information, and other resources AS IS and with all faults, and disclaims all warranties. These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

Providing these resources does not expand or otherwise alter TI's applicable Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with TI products.