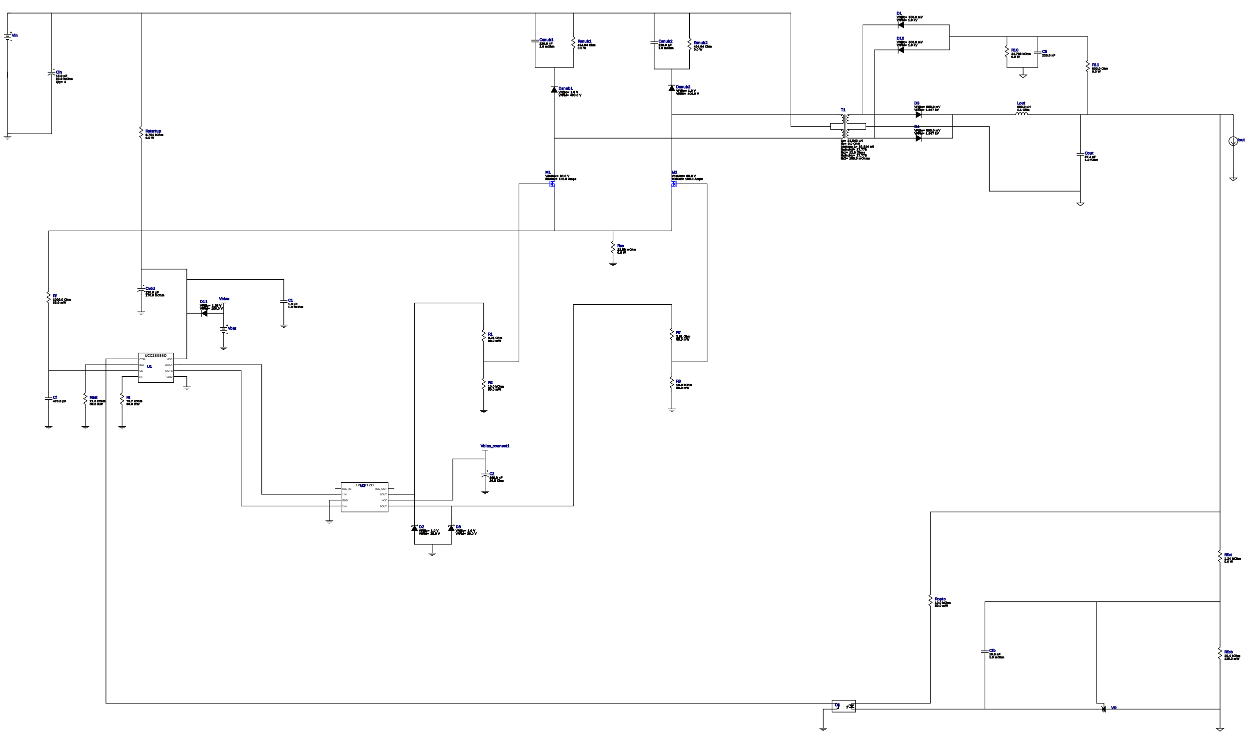
TEXAS INSTRUMENTS

VinMin = 12.0V
VinMax = 12.0V
Vout = 300.0V
Iout = 0.5A

Device = UCC28086D
Topology = Push Pull
Created = 2020-06-24 03:16:48.098
BOM Cost = NA
BOM Count = 46
Total Pd = 10.64W

WEBENCH ® Design Report

Design : 34 UCC28086D
UCC28086D 12V-12V to 300.00V @ 0.5A



Electrical BOM

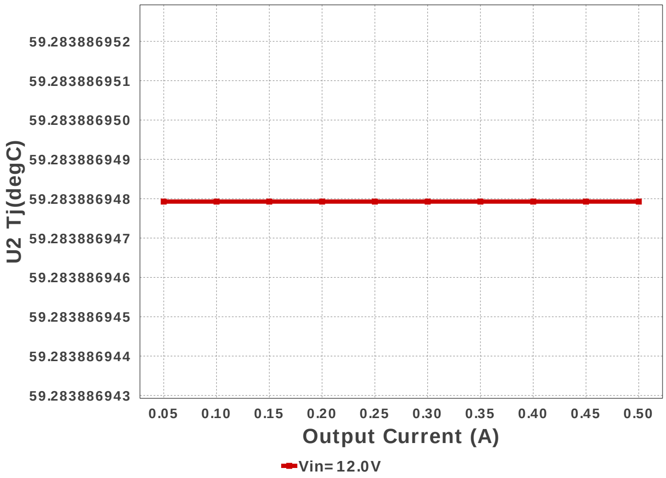
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
C1	Taiyo Yuden	GMK212B7105KG-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 35.0 V IRMS= 0.0 A	1	$0.03	0805 7 mm^2
C2	Vishay-Sprague	293D104X9035A2TE3 Series= 293D	Cap= 100.0 nF ESR= 20.0 Ohm VDC= 35.0 V IRMS= 60.0 mA	1	$0.09	3216-18 11 mm^2
C5	CUSTOM	CUSTOM Series= ?	Cap= 220.0 nF VDC= 1.6 kV IRMS= 0.0 A	1	NA	CUSTOM 0 mm^2
Cf	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
Cfb	MuRata	GRM033R70J103KA01D Series= X7R	Cap= 10.0 nF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 0.0 A	1	$0.01	0201 2 mm²
Cin	Panasonic	25SVPG15M Series= SVPG	Cap= 15.0 uF ESR= 30.0 mOhm VDC= 25.0 V IRMS= 2.8 A	4	$0.40	CAPSMT_62_B45 53 mm²
Cout	CUSTOM	CUSTOM Series= ?	Cap= 37.4 nF ESR= 1.0 fOhm VDC= 750.0 V IRMS= 93.939 mA	1	NA	CUSTOM 0 mm²
Csnub1	MuRata	GRM21AR72A224KAC5L Series= X7R	Cap= 220.0 nF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 0.0 A	1	$0.09	0805 7 mm²
Csnub2	MuRata	GRM21AR72A224KAC5L Series= X7R	Cap= 220.0 nF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 0.0 A	1	$0.09	0805 7 mm²
Cvdd	Nichicon	UUD1E221MNL1GS Series= uD	Cap= 220.0 uF ESR= 170.0 mOhm VDC= 25.0 V IRMS= 450.0 mA	1	$0.17	SM_RADIAL_8MM 113 mm²
D1	CUSTOM	CUSTOM	VF@Io= 500.0 mV VRRM= 1.6 kV	1	NA	CUSTOM 0 mm²
D10	CUSTOM	CUSTOM	VF@Io= 500.0 mV VRRM= 1.6 kV	1	NA	CUSTOM 0 mm²
D11	Diodes Inc.	1N4148W-7-F	VF@Io= 1.25 V VRRM= 100.0 V	1	$0.03	SOD-123 13 mm²
D2	SMC Diode Solutions	BAT54WSTR	VF@Io= 1.0 V VRRM= 30.0 V	1	$0.02	SOD-323 9 mm²
D3	CUSTOM	CUSTOM	VF@Io= 500.0 mV VRRM= 1.667 kV	1	NA	CUSTOM 0 mm²
D4	CUSTOM	CUSTOM	VF@Io= 500.0 mV VRRM= 1.667 kV	1	NA	CUSTOM 0 mm²
D8	SMC Diode Solutions	BAT54WSTR	VF@Io= 1.0 V VRRM= 30.0 V	1	$0.02	SOD-323 9 mm²
Dsnub1	SMC Diode Solutions	UF4004TA	VF@Io= 1.0 V VRRM= 400.0 V	1	$0.22	DO-41 43 mm²
Dsnub2	SMC Diode Solutions	UF4004TA	VF@Io= 1.0 V VRRM= 400.0 V	1	$0.22	DO-41 43 mm²
Lout	NIC Components	NPI52W681MTRF	L= 680.0 µH 1.1 Ohm	1	$0.35	IND_NPI52W 358 mm²
M1	Texas Instruments	CSD19502Q5B	VdsMax= 80.0 V IdsMax= 100.0 Amps	1	$0.85	DQK0006C 9 mm²
M2	Texas Instruments	CSD19502Q5B	VdsMax= 80.0 V IdsMax= 100.0 Amps	1	$0.85	DQK0006C 9 mm²
O1	Fairchild Semiconductor	FOD817A	Optocoupler	1	$0.11	DIP-4 71 mm²

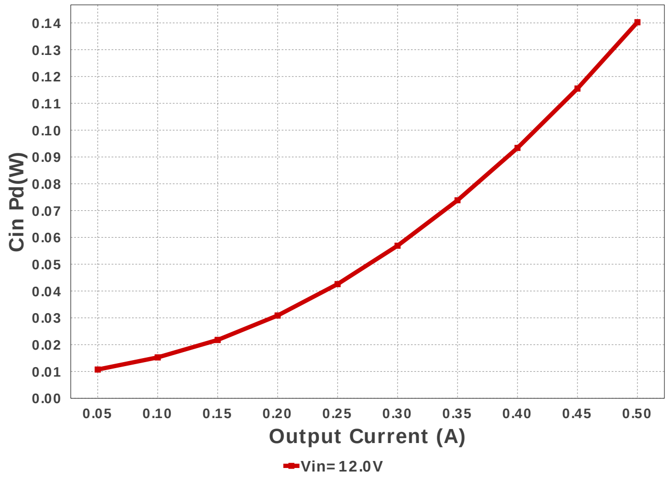
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
R1	Vishay-Dale	CRCW04023R01FKED Series= CRCW..e3	Res= 3.01 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
R10	CUSTOM	CUSTOM Series= ?	Res= 44.703 kOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm^2
R11	CUSTOM	CUSTOM Series= ?	Res= 800.0 Ohm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm^2
R2	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
R7	Vishay-Dale	CRCW04023R01FKED Series= CRCW..e3	Res= 3.01 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
R8	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rcs	CUSTOM	CUSTOM Series= ?	Res= 22.58 mOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm^2
Rf	Vishay-Dale	CRCW04021K00FKED Series= CRCW..e3	Res= 1000.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb	Yageo	RT0805BRD0710K4L Series= RT0805	Res= 10.4 kOhm Power= 125.0 mW Tolerance= 0.1%	1	$0.05	0805 7 mm^2
Rfbt	CUSTOM	CUSTOM Series= ?	Res= 1.24 MOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm^2
Ropto	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rset	Vishay-Dale	CRCW040221K0FKED Series= CRCW..e3	Res= 21.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rsnub1	CUSTOM	CUSTOM Series= ?	Res= 494.04 Ohm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm^2
Rsnub2	CUSTOM	CUSTOM Series= ?	Res= 494.04 Ohm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm^2
Rstartup	CUSTOM	CUSTOM Series= ?	Res= 8.704 kOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm^2
Rt	Vishay-Dale	CRCW040278K7FKED Series= CRCW..e3	Res= 78.7 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
T1	CUSTOM	CUSTOM	Lp= 21.542 µH Rp= 0.0 Ohm Leakage_L= 32.314 nH Ns1toNp= 27.778 Rs1= 12.0 Ohms Ns2toNp= 27.778 Rs2= 100.0 mOhms	1	NA	CUSTOM 0 mm^2
U1	Texas Instruments	UCC28086D	Switcher	1	$1.24	0 mm^2
U2	unknown		unknown		NA	

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
VR	Texas Instruments	TL431IDBVR	Voltage References	1	$0.06	R-PDSO-G3 16 mm²

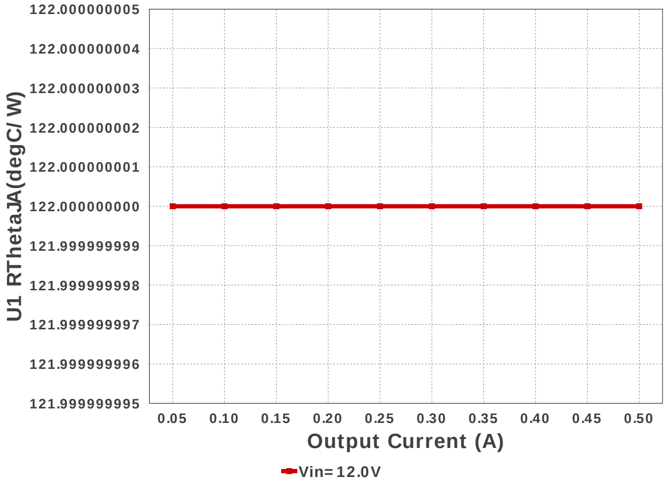
U2 Tj



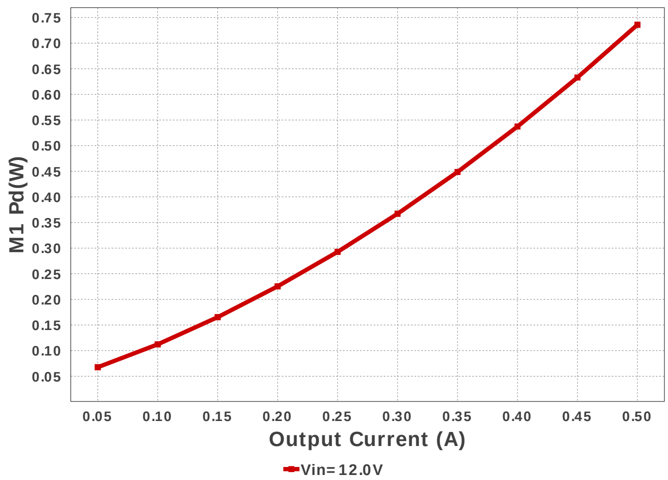
Cin Pd



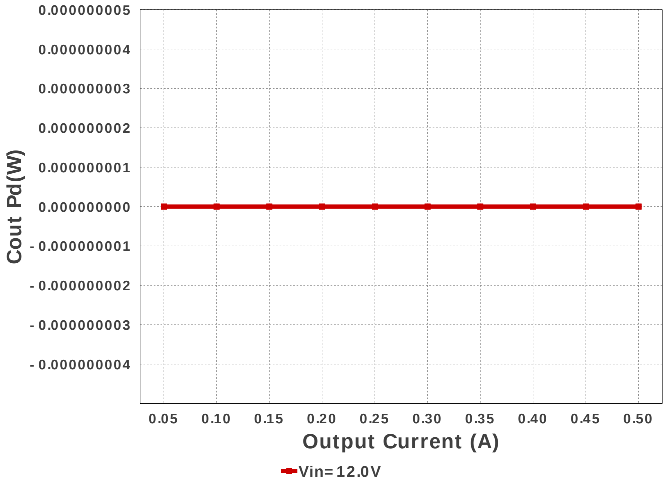
U1 RThetaJA



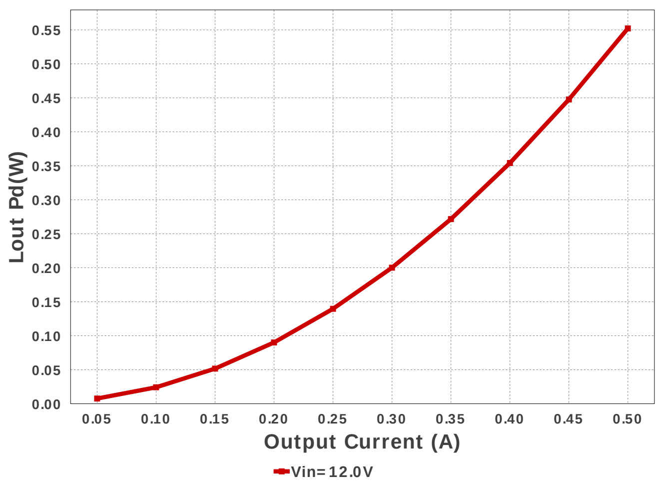
M1 Pd



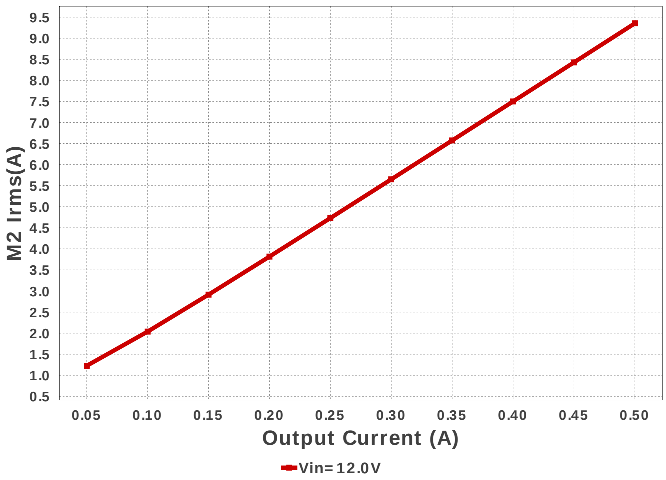
Cout Pd



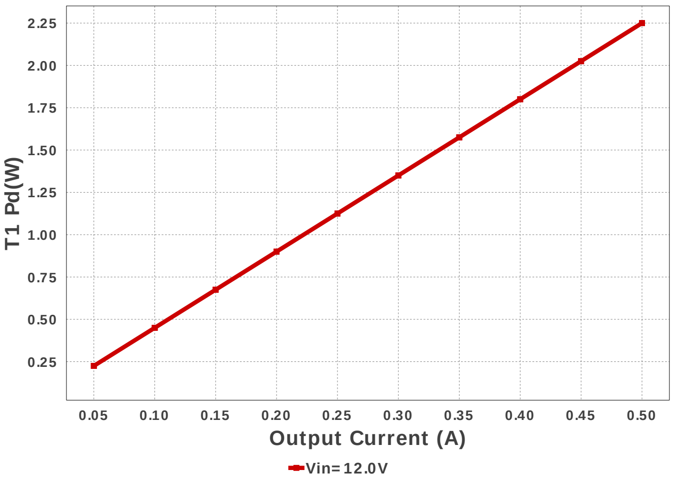
Lout Pd



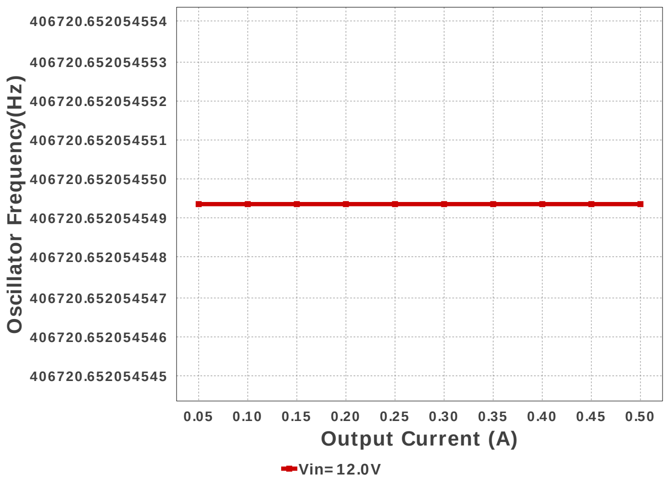
M2 Irms



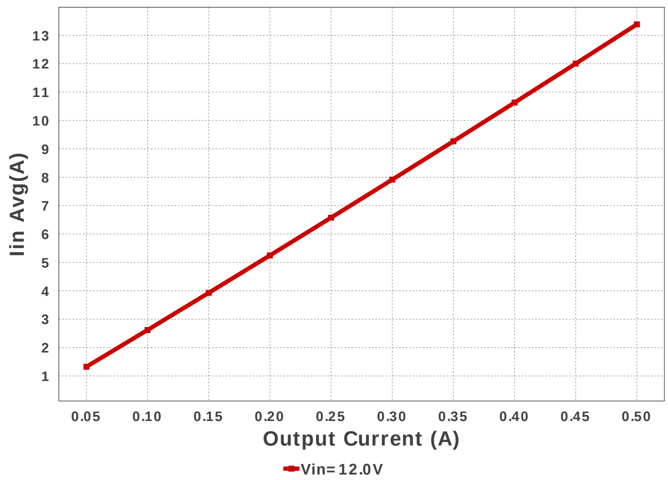
T1 Pd



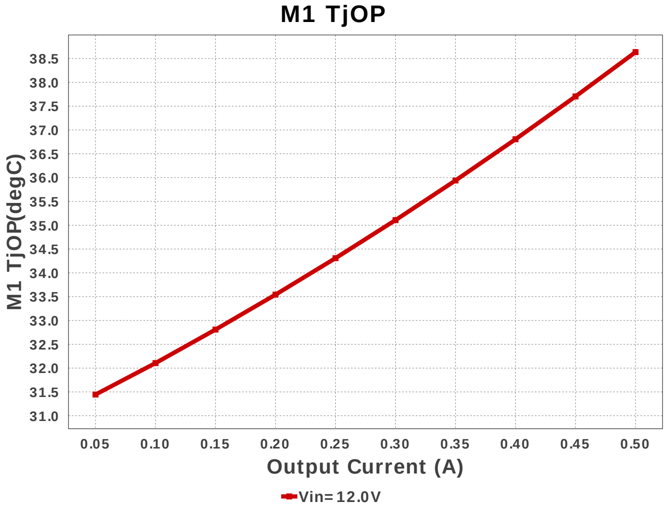
Oscillator Frequency



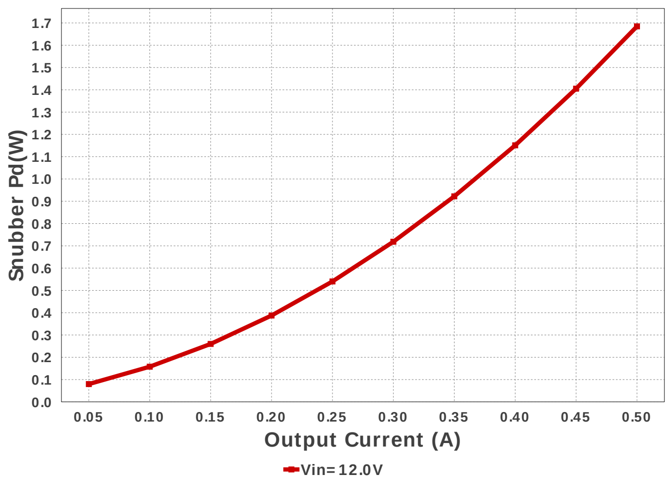
Iin Avg

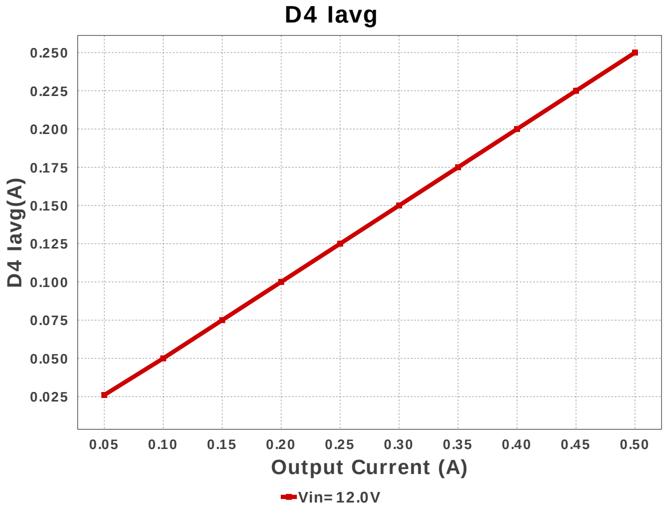


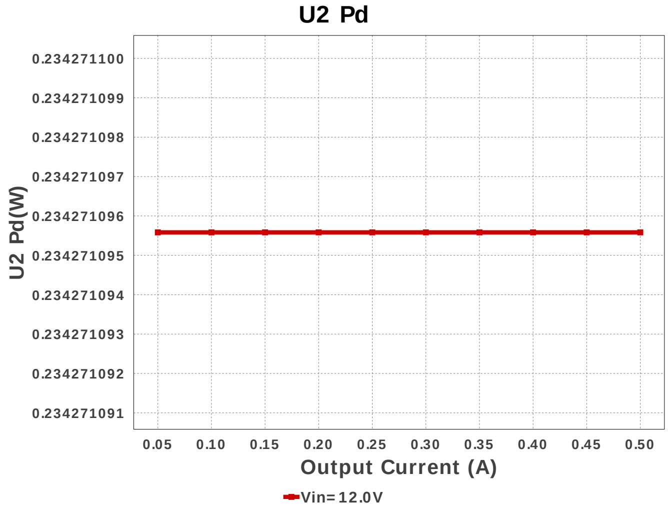
M1 TjOP

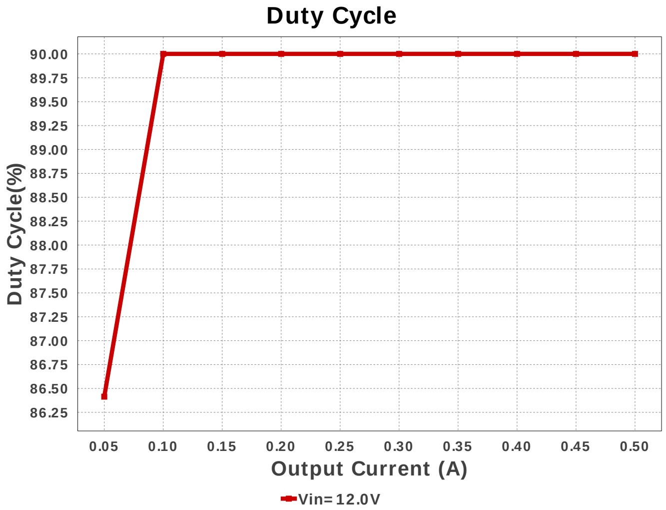


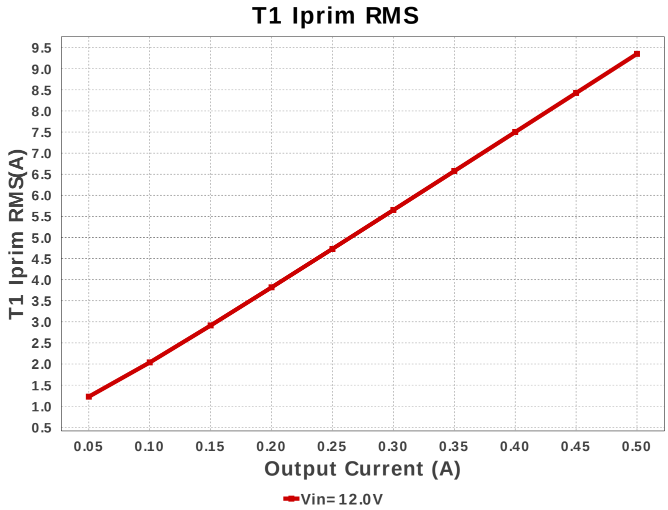
Snubber Pd

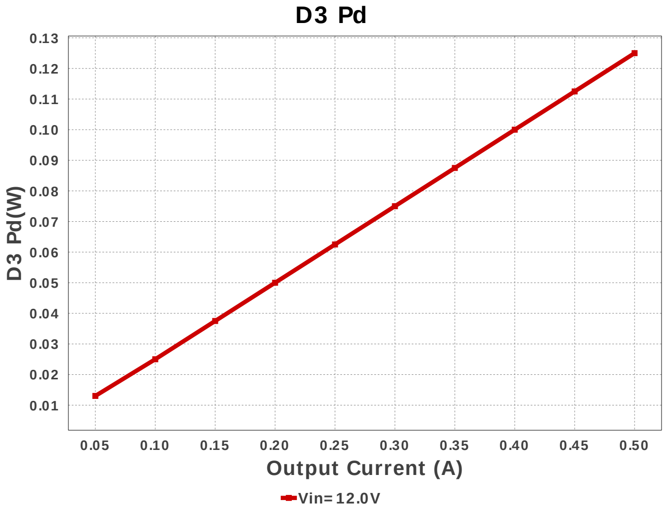


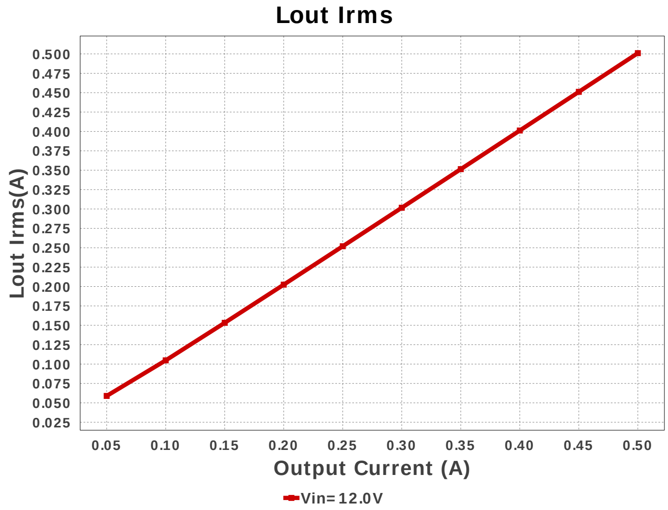

D4 Iavg
D4 Iavg(A)
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

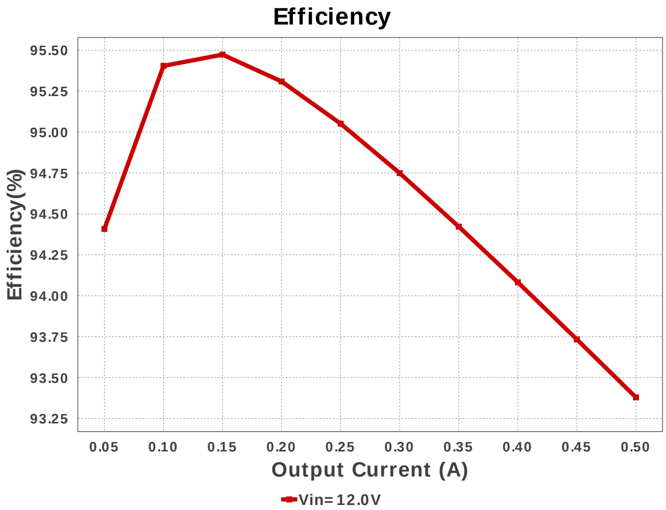

U2 Pd
U2 Pd(W)
0.234271100
0.234271099
0.234271098
0.234271097
0.234271096
0.234271095
0.234271094
0.234271093
0.234271092
0.234271091
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

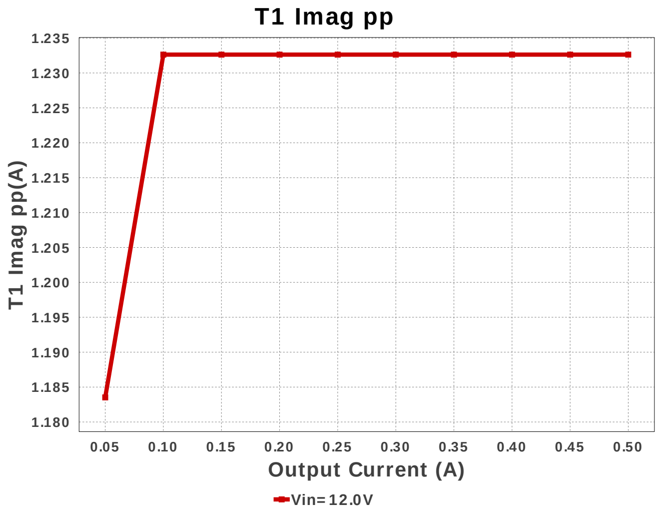

Duty Cycle
Duty Cycle(%)
90.00
89.75
89.50
89.25
89.00
88.75
88.50
88.25
88.00
87.75
87.50
87.25
87.00
86.75
86.50
86.25
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

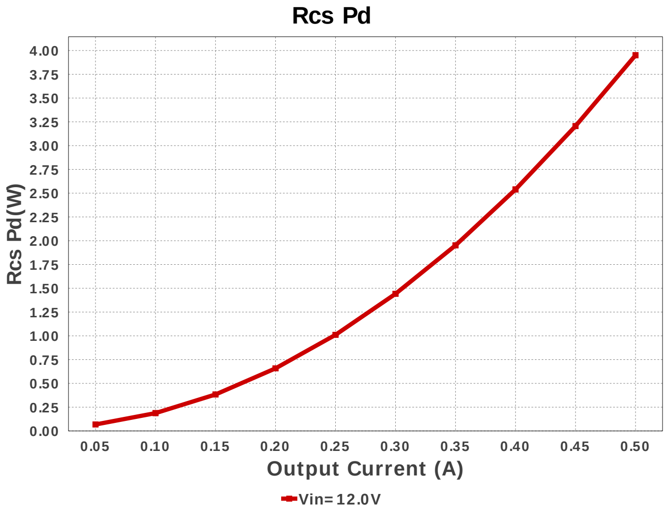

T1 Iprim RMS
T1 Iprim RMS(A)
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

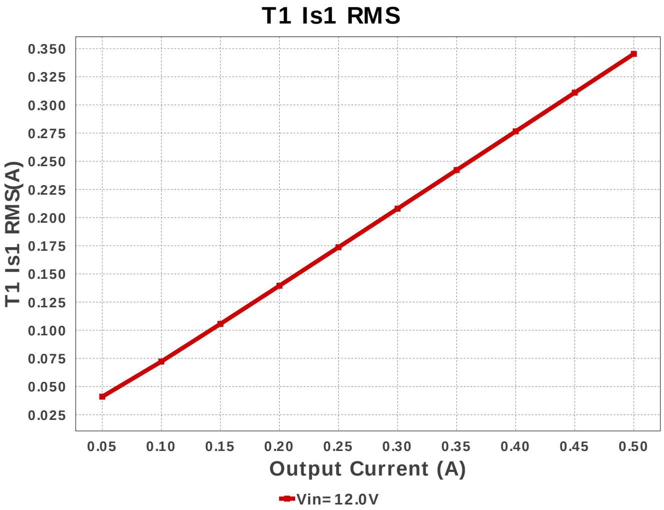

D3 Pd
D3 Pd(W)
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

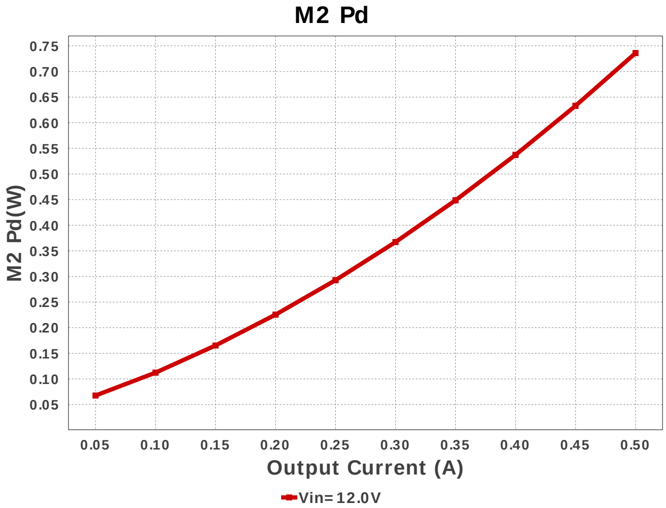

Lout Irms
Lout Irms(A)
0.500
0.475
0.450
0.425
0.400
0.375
0.350
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

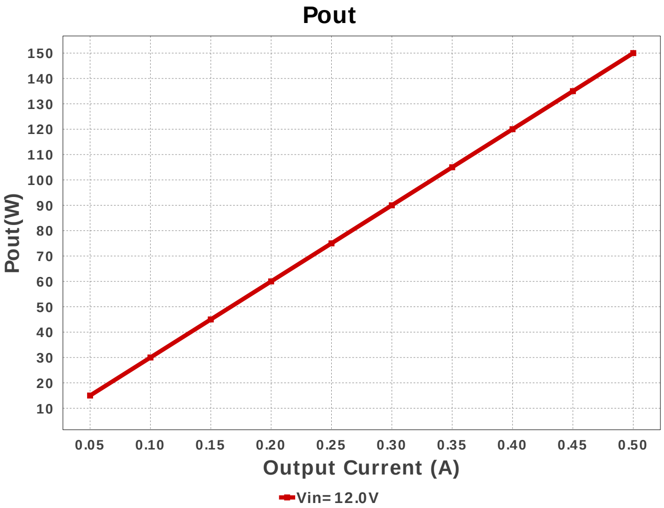

Efficiency
Efficiency(%)
95.50
95.25
95.00
94.75
94.50
94.25
94.00
93.75
93.50
93.25
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

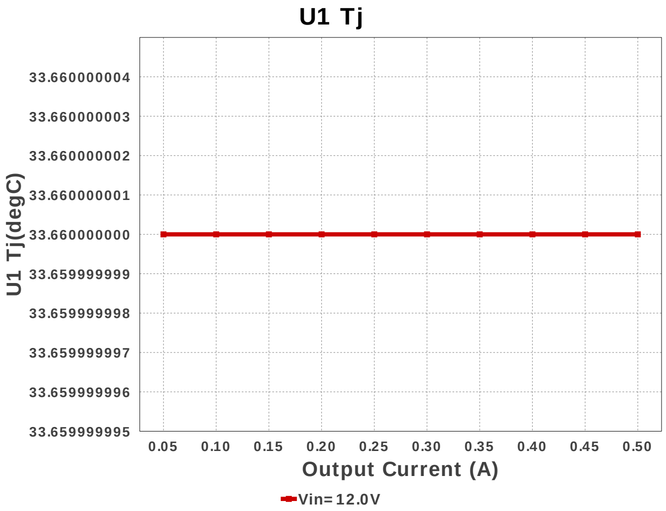

T1 Imag pp
T1 Imag pp(A)
1.235
1.230
1.225
1.220
1.215
1.210
1.205
1.200
1.195
1.190
1.185
1.180
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

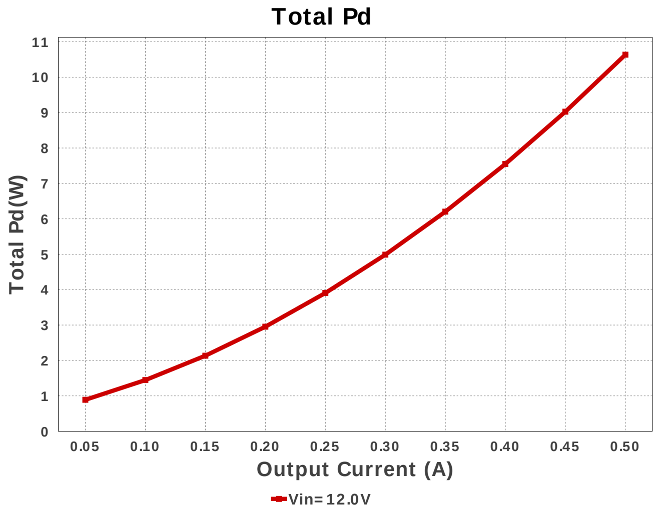

Rcs Pd
Rcs Pd(W)
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

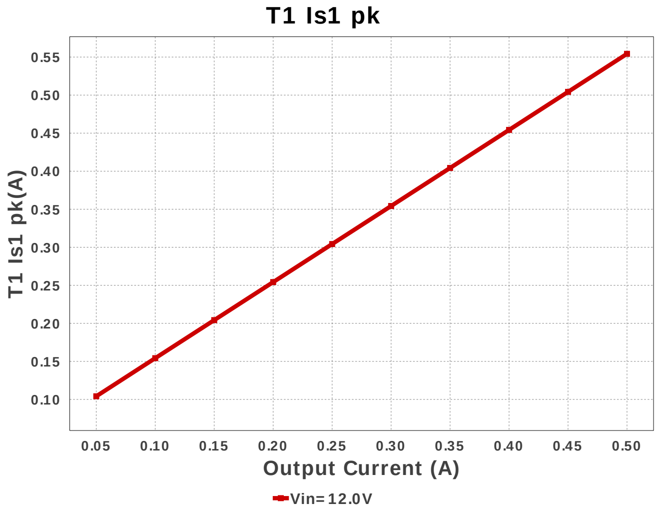

T1 Is1 RMS
T1 Is1 RMS(A)
0.350
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

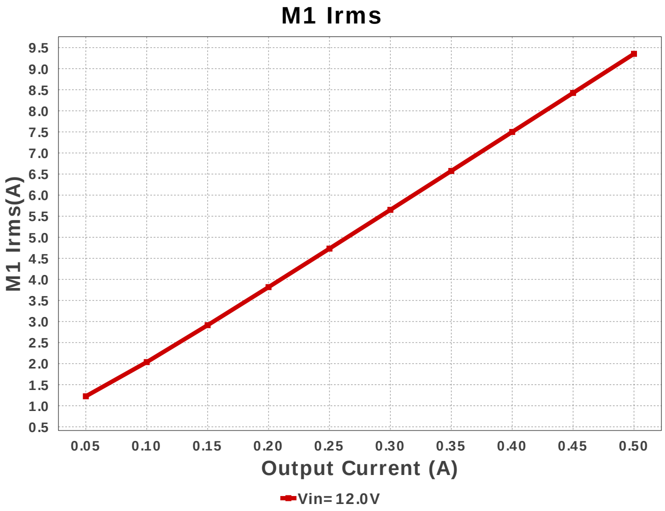

M2 Pd
M2 Pd(W)
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

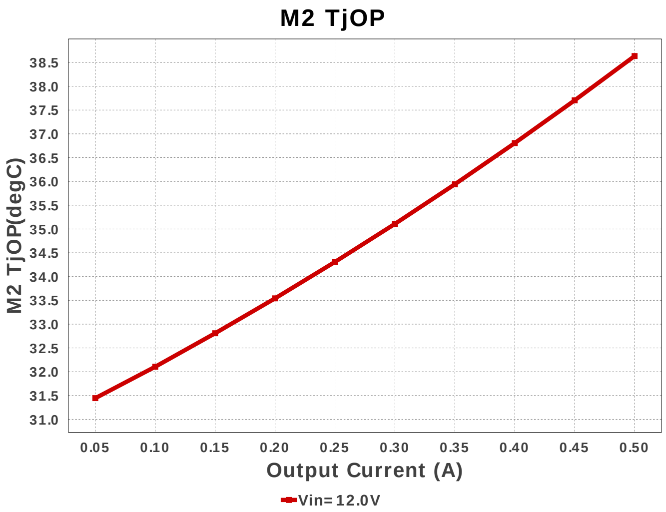

Pout
Pout(W)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

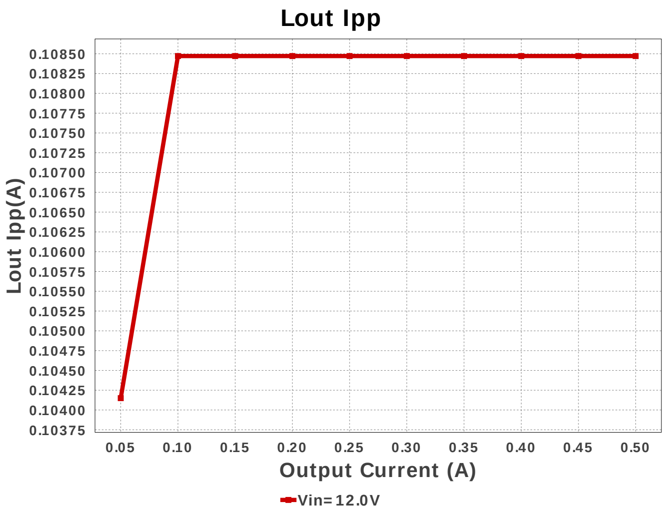

U1 Tj
U1 Tj(degC)
33.660000004
33.660000003
33.660000002
33.660000001
33.660000000
33.659999999
33.659999998
33.659999997
33.659999996
33.659999995
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

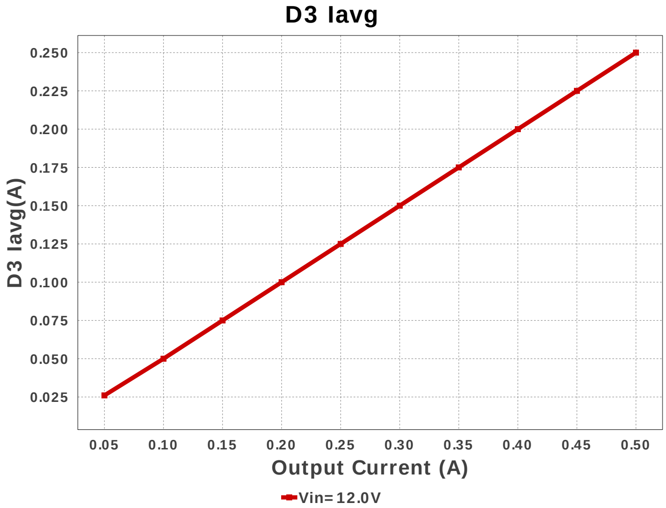

Total Pd
Total Pd(W)
11
10
9
8
7
6
5
4
3
2
1
0
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

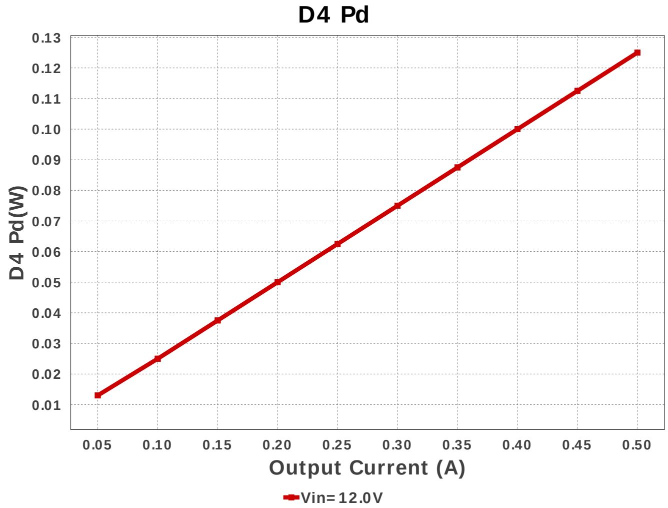

T1 Is1 pk
T1 Is1 pk(A)
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

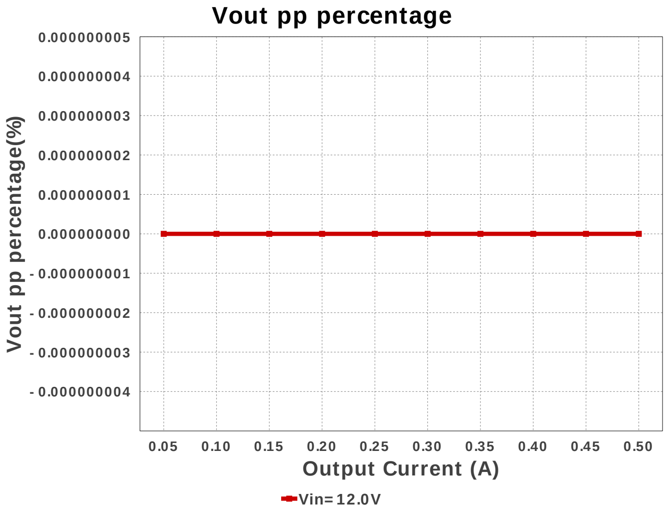

M1 Irms
M1 Irms(A)
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

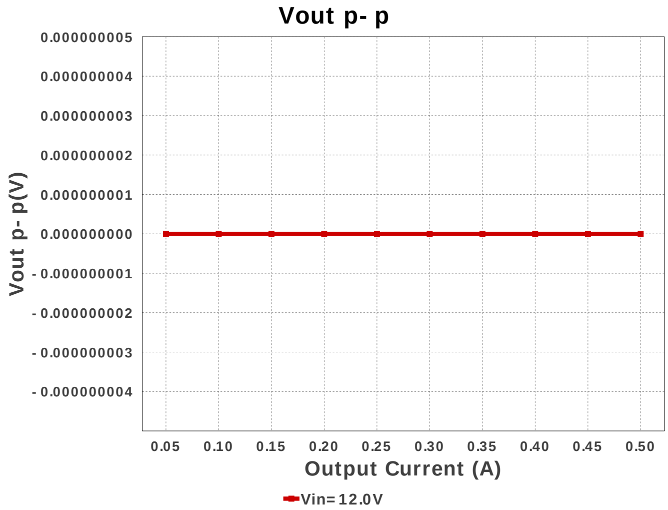

M2 TjOP
M2 TjOP(degC)
38.5
38.0
37.5
37.0
36.5
36.0
35.5
35.0
34.5
34.0
33.5
33.0
32.5
32.0
31.5
31.0
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

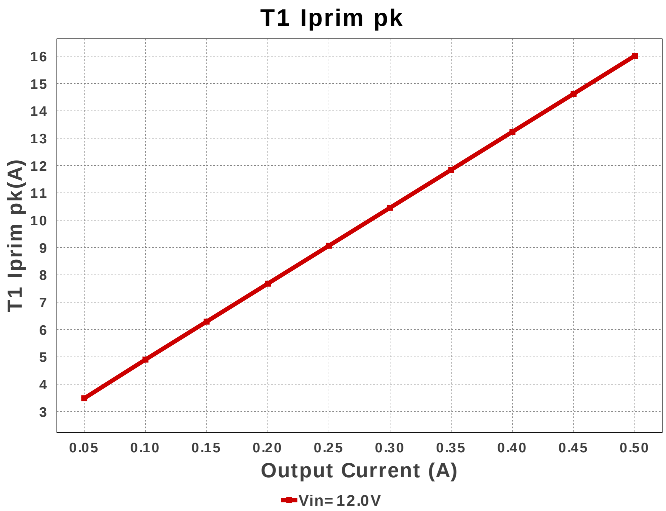

Lout Ipp
Lout Ipp(A)
0.10850
0.10825
0.10800
0.10775
0.10750
0.10725
0.10700
0.10675
0.10650
0.10625
0.10600
0.10575
0.10550
0.10525
0.10500
0.10475
0.10450
0.10425
0.10400
0.10375
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=12.0V

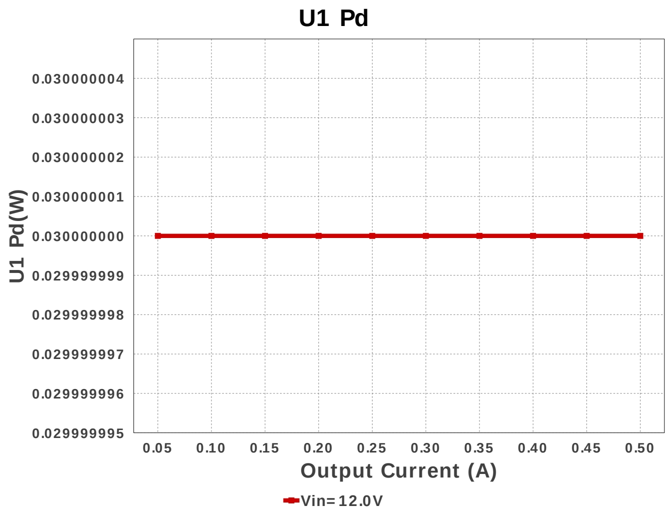












Operating Values

#	Name	Value	Category	Description
1.	Cin Pd	140.25 mW	Capacitor	Input capacitor power dissipation
2.	Cout Pd	0.004 fW	Capacitor	Output capacitor power dissipation
3.	D3 Iavg	250.0 mA	Current	Average current through D3
4.	D4 Iavg	250.0 mA	Current	Average current through D4
5.	Lout Irms	500.98 mA	Current	Lout ripple current
6.	D4 Pd	125.0 mW	Diode	Average Power Dissipation in the Diode over AC Line Period
7.	Iin Avg	13.386 A	IC	Average input current
8.	U1 RThetaJA	122.0 degC/W	IC	U1 IC junction-to-ambient thermal resistance
9.	Lout Ipp	108.472 mA	Inductor	Peak-to-peak output inductor ripple current
10.	M1 Irms	9.353 A	Mosfet	M1 MOSFET Irms
11.	M1 Pd	735.89 mW	Mosfet	M1 MOSFET total power dissipation

#	Name	Value	Category	Description
12.	M1 TjOP	66.795 degC	Mosfet	M1 MOSFET junction temperature
13.	M2 Irms	9.353 A	Mosfet	M2 MOSFET Irms
14.	M2 Pd	735.89 mW	Mosfet	M2 MOSFET total power dissipation
15.	M2 TjOP	66.795 degC	Mosfet	M2 MOSFET junction temperature
16.	Oscillator Frequency	406.721 kHz	Op Point	Oscillator Frequency
17.	Cin Pd	140.25 mW	Power	Input capacitor power dissipation
18.	Cout Pd	0.004 fW	Power	Output capacitor power dissipation
19.	D3 Pd	125.0 mW	Power	
20.	D4 Pd	125.0 mW	Power	Average Power Dissipation in the Diode over AC Line Period
21.	Lout Pd	552.157 mW	Power	Lout power dissipation
22.	M1 Pd	735.89 mW	Power	M1 MOSFET total power dissipation
23.	M2 Pd	735.89 mW	Power	M2 MOSFET total power dissipation
24.	Rcs Pd	3.951 W	Power	Power Dissipation in Current Sense Resistors
25.	Snubber Pd	1.685 W	Power	Snubber Power Dissipation
26.	T1 Pd	2.25 W	Power	Estimated Losses in Transformer
27.	Total Pd	10.635 W	Power	Total Power Dissipation
28.	U1 Pd	30.0 mW	Power	U1 Power Dissipation
29.	U2 Pd	234.271 mW	Power	U2 Power Dissipation
30.	Rcs Pd	3.951 W	Resistor	Power Dissipation in Current Sense Resistors
31.	BOM Count	46	System Information	Total Design BOM count
32.	Duty Cycle	90.0 %	System Information	Duty cycle
33.	Efficiency	93.379 %	System Information	Steady state efficiency
34.	FootPrint	1.387 k mm^2	System Information	Total Foot Print Area of BOM components
35.	Iout	500.0 mA	System Information	Iout operating point
36.	Mode	CCM	System Information	Conduction Mode
37.	Pout	150.0 W	System Information	Total output power
38.	Total BOM	NA	System Information	Total BOM Cost
39.	U1 Tj	33.66 degC	System Information	U1 junction temperature
40.	U2 Tj	59.284 degC	System Information	U2 junction temperature
41.	Vin	12.0 V	System Information	Vin operating point
42.	Vout Actual	300.0 V	System Information	Operational Output Voltage
43.	Vout Tolerance	99.268 m%	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
44.	Vout p-p	0.108 fV	System Information	Peak-to-peak output ripple voltage
45.	Vout pp percentage	0.036 f%	System Information	Output Voltage ripple percentage
46.	T1 Imag pp	1.233 A	Transformer	Transformer peak to peak magnetising current
47.	T1 Iprim RMS	9.353 A	Transformer	Transformer Primary RMS Current
48.	T1 Iprim pk	16.012 A	Transformer	Transformer Primary Peak Current
49.	T1 Is1 RMS	345.276 mA	Transformer	Transformer Secondary1 RMS Current
50.	T1 Is1 pk	554.236 mA	Transformer	Transformer Secondary1 Peak Current
51.	T1 Pd	2.25 W	Transformer	Estimated Losses in Transformer

Design Inputs

Name	Value	Description
Iout	500.0 m	Maximum Output Current
VinMax	12.0	Maximum input voltage
VinMin	12.0	Minimum input voltage
Vout	300.0	Output Voltage
base_pn	UCC28086	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 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

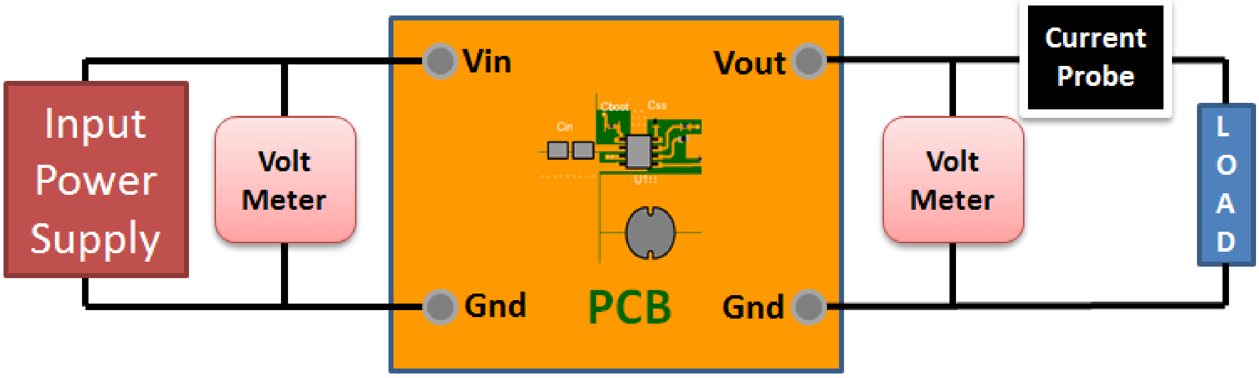
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 12.0V 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. Master key : 0434838523D1C46A[v1]

2. **UCC28086** Product Folder : http://www.ti.com/product/UCC28083 : contains the data sheet and other resources.

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