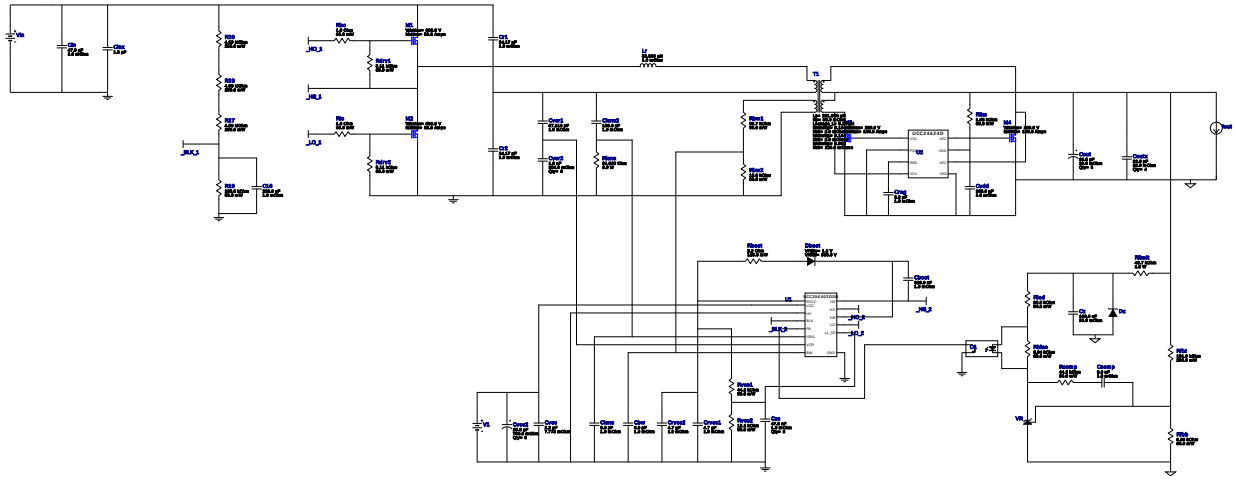
VinMin = 380.0V
VinMax = 400.0V
Vout = 32.0V
Iout = 12.5A

Device = UCC256403DDBR
Topology = LLC
Created = 2023-04-28 05:48:58.556
BOM Cost = NA
BOM Count = 74
Total Pd = 7.57W

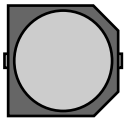
WEBENCH® Design Report

Design : 51 UCC256403DDBR
UCC256403DDBR 380V-400V to 32.00V @ 12.5A



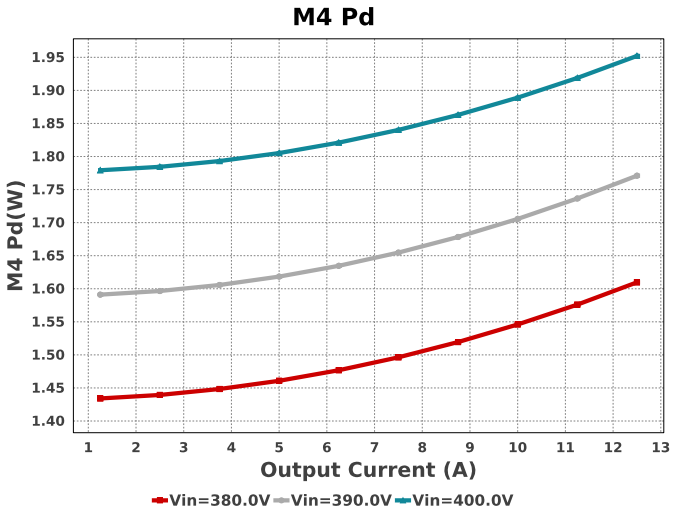
Electrical BOM

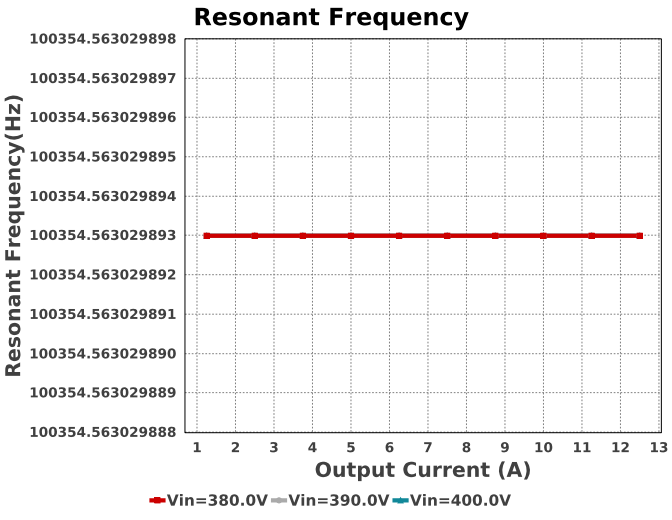
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
C16	MuRata	GRM155R72A221KA01D Series= X7R	Cap= 220.0 pF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cboot	MuRata	GRM219R71E824KA88D Series= X7R	Cap= 820.0 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.09	0805 7 mm^2
Cbw	MuRata	GRM1555C1H3R9CA01D Series= C0G/NP0	Cap= 3.9 pF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ccomp	MuRata	GRM155R72A332KA01D Series= X7R	Cap= 3.3 nF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cin	CUSTOM	CUSTOM Series= ?	Cap= 47.0 uF ESR= 1.0 mOhm VDC= 480.0 V IRMS= 510.0 mA	1	NA	CUSTOM 0 mm^2
Cinx	CUSTOM	CUSTOM Series= ?	Cap= 1.5 uF VDC= 440.0 V IRMS= 510.0 mA	1	NA	CUSTOM 0 mm^2
Cisns	MuRata	GRM1555C1H3R3CA01D Series= C0G/NP0	Cap= 3.3 pF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cisns2	CUSTOM	CUSTOM Series= ?	Cap= 150.0 pF ESR= 1.0 mOhm VDC= 528.91 V IRMS= 7.9563 mA	1	NA	CUSTOM 0 mm^2

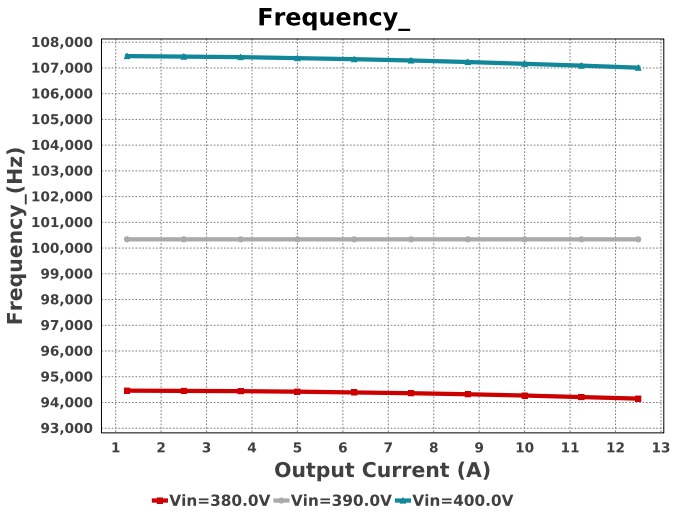
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cout	Panasonic	50SVPF68M Series= SVPF	Cap= 68.0 uF ESR= 20.0 mOhm VDC= 50.0 V IRMS= 4.3 A	3	$1.57	 CAPSMT_62_F12 151 mm²
Coutx	TDK	CKG57NX5R1H226M500JH Series= X5R	Cap= 22.0 uF ESR= 10.0 mOhm VDC= 50.0 V IRMS= 4.6 A	4	$1.77	 CKG57N 56 mm²
Cr1	CUSTOM	CUSTOM Series= ?	Cap= 24.17 nF ESR= 1.0 mOhm VDC= 392.78 V IRMS= 3.6901 A	1	NA	CUSTOM 0 mm²
Cr2	CUSTOM	CUSTOM Series= ?	Cap= 24.17 nF ESR= 1.0 mOhm VDC= 392.78 V IRMS= 3.6901 A	1	NA	CUSTOM 0 mm²
Creg	TDK	C1005X5R1V225K050BC Series= X5R	Cap= 2.2 uF ESR= 1.0 mOhm VDC= 35.0 V IRMS= 0.0 A	1	$0.06	 0402_065 3 mm²
Crvcc1	Taiyo Yuden	TMK212BJ475KG-T Series= X5R	Cap= 4.7 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.06	 0805 7 mm²
Crvcc2	Taiyo Yuden	TMK212BJ475KG-T Series= X5R	Cap= 4.7 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.06	 0805 7 mm²
Css	MuRata	GRM155R71E473KA88D Series= X7R	Cap= 47.0 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	3	$0.01	 0402 3 mm²
Cvcc	MuRata	GRM21BR71E225KA73L Series= X7R	Cap= 2.2 uF ESR= 7.773 mOhm VDC= 25.0 V IRMS= 1.35654 A	1	$0.14	 0805 7 mm²
Cvcc2	Nichicon	UUD1V150MCL1GS Series= uD	Cap= 15.0 uF ESR= 760.0 mOhm VDC= 35.0 V IRMS= 150.0 mA	8	$0.14	 SM_RADIAL_5MM 58 mm²
Cvcr1	CUSTOM	CUSTOM Series= ?	Cap= 67.216 pF ESR= 1.0 mOhm VDC= 528.91 V IRMS= 8.9552 mA	1	NA	CUSTOM 0 mm²
Cvcr2	Kemet	C0805C102J5RACTU Series= X7R	Cap= 1.0 nF ESR= 384.0 mOhm VDC= 50.0 V IRMS= 214.0 mA	6	$0.02	 0805 7 mm²
Cvdd	Yageo	CC0805KRX7R9BB104 Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.02	 0805 7 mm²
Cz	TDK	CGA3E2X7R1H104K080AA Series= X7R	Cap= 100.0 nF ESR= 29.6 mOhm VDC= 50.0 V IRMS= 971.99 mA	1	$0.01	 0603 5 mm²
Dboot	Microsemi	UFS180JE3/TR13	VF@Io= 1.2 V VRRM= 800.0 V	1	$0.95	 DO-214BA 42 mm²
Dz	ON Semiconductor	BZX84C11LT1G	Zener	1	$0.03	 SOT-23 14 mm²

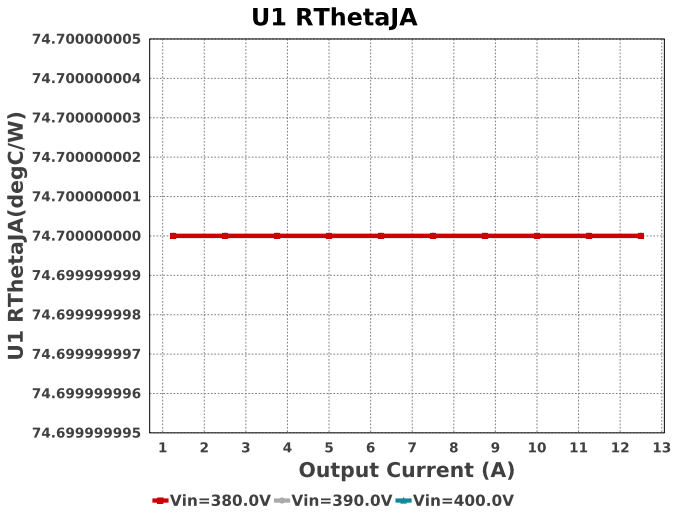
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Lr	CUSTOM	CUSTOM	L= 52.399 µH 1.0 mOhm	1	NA	CUSTOM 0 mm^2
M1	Fairchild Semiconductor	FCH070N60E	VdsMax= 600.0 V IdsMax= 52.0 Amps	1	$4.40	 TO-247 123 mm^2
M2	Fairchild Semiconductor	FCH070N60E	VdsMax= 600.0 V IdsMax= 52.0 Amps	1	$4.40	 TO-247 123 mm^2
M3	Texas Instruments	CSD19533Q5A	VdsMax= 100.0 V IdsMax= 100.0 Amps	1	$0.45	 TRANS_NexFET_Q5A 55 mm^2
M4	Texas Instruments	CSD19533Q5A	VdsMax= 100.0 V IdsMax= 100.0 Amps	1	$0.45	 TRANS_NexFET_Q5A 55 mm^2
O1	California Eastern Laboratories	PS2501L-1-A	Optocoupler	1	$0.32	 PS2501L 77 mm^2
R19	Yageo	RC0201FR-07133KL Series= ?	Res= 133.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	 0201 2 mm^2
R20	Vishay-Dale	CRCW12064M99FKEA Series= CRCW..e3	Res= 4.99 MOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	 1206 11 mm^2
R27	Vishay-Dale	CRCW12064M99FKEA Series= CRCW..e3	Res= 4.99 MOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	 1206 11 mm^2
R28	Vishay-Dale	CRCW12064M99FKEA Series= CRCW..e3	Res= 4.99 MOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	 1206 11 mm^2
Rbias	Vishay-Dale	CRCW04026K04FKED Series= CRCW..e3	Res= 6.04 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm^2
Rboot	Yageo	RC0805FR-072R2L Series= ?	Res= 2.2 Ohm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	 0805 7 mm^2
Rbw1	Vishay-Dale	CRCW040235K7FKED Series= CRCW..e3	Res= 35.7 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm^2
Rbw2	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	 0201 2 mm^2
Rcomp	Vishay-Dale	CRCW020144K2FNED Series= ?	Res= 44.2 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	 0201 2 mm^2
Rdrv1	Vishay-Dale	CRCW04025K11FKED Series= CRCW..e3	Res= 5.11 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm^2
Rdrv2	Vishay-Dale	CRCW04025K11FKED Series= CRCW..e3	Res= 5.11 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm^2
Rfbb	Vishay-Dale	CRCW04028K06FKED Series= CRCW..e3	Res= 8.06 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm^2
Rfbt	Yageo	RC1206FR-07191KL Series= ?	Res= 191.0 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	 1206 11 mm^2

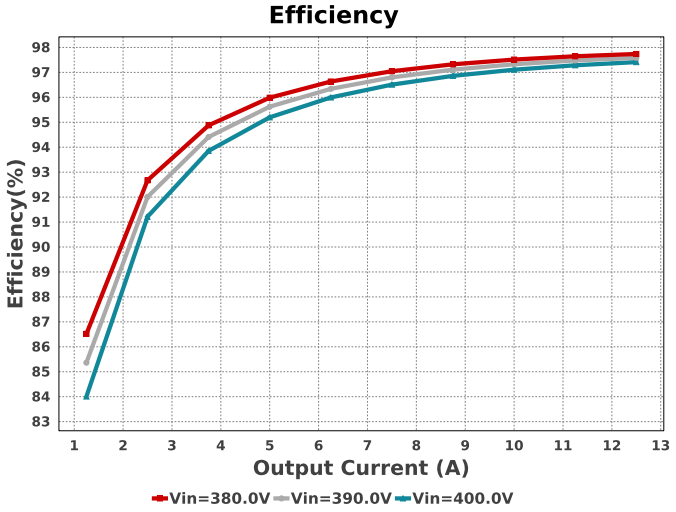
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rho	Vishay-Dale	CRCW04021R00FKED Series= CRCW..e3	Res= 1.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Risns	CUSTOM	CUSTOM Series= ?	Res= 81.068 Ohm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm²
Rled	Yageo	RC0201FR-0736K5L Series= ?	Res= 36.5 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
Rlim	Vishay-Dale	CRCW04021K65FKED Series= CRCW..e3	Res= 1.65 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rlimit	Vishay-Dale	CRCW251248K7FKEG Series= CRCW..e3	Res= 48.7 kOhm Power= 1.0 W Tolerance= 1.0%	1	$0.05	2512 43 mm²
Rlo	Vishay-Dale	CRCW04021R00FKED Series= CRCW..e3	Res= 1.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rvcc1	Vishay-Dale	CRCW020144K2FNED Series= ?	Res= 44.2 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
Rvcc2	Yageo	RC0201FR-0712K1L Series= ?	Res= 12.1 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
T1	CUSTOM	CUSTOM	Lp= 261.996 µH Rp= 50.0 mOhm Leakage_L= 5.24 µH Ns1toNp= 164.103 m Rs1= 5.0 mOhms Ns2toNp= 0.164 Rs2= 5.0 mOhms Ns3toNp= 0.082 Rs3= 125.0 mOhms	1	NA	CUSTOM 0 mm²
U1	Texas Instruments	UCC256403DDBR	Switcher	1	$0.74	DDB0014A 95 mm²
U2	Texas Instruments	UCC24624DR	Switcher	1	$0.69	DBV0005A 15 mm²
VR	Texas Instruments	TLV431AIDBVT	Voltage References	1	$0.33	DBV0005A 15 mm²

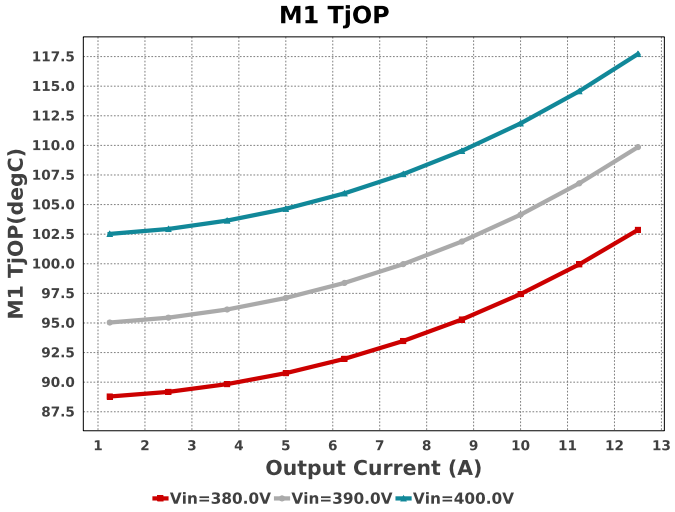


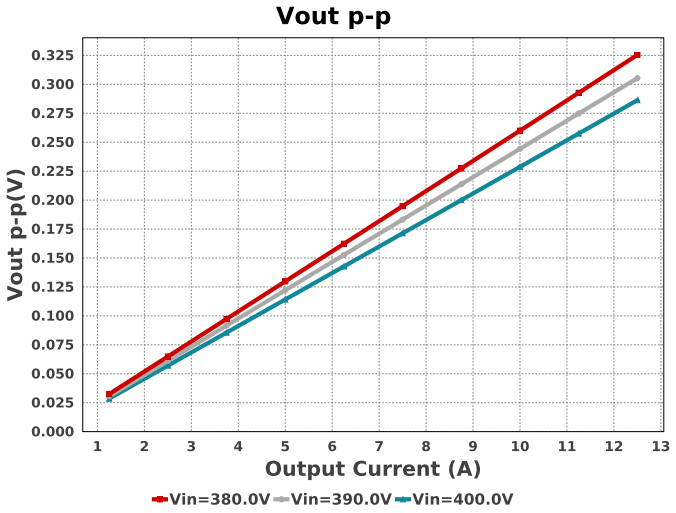


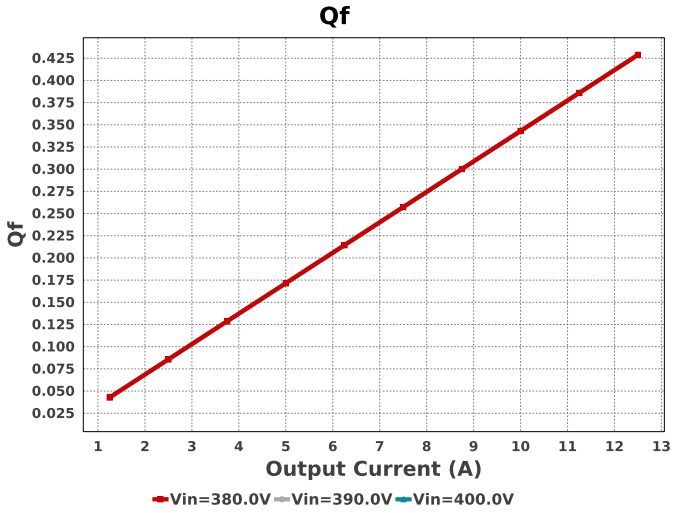


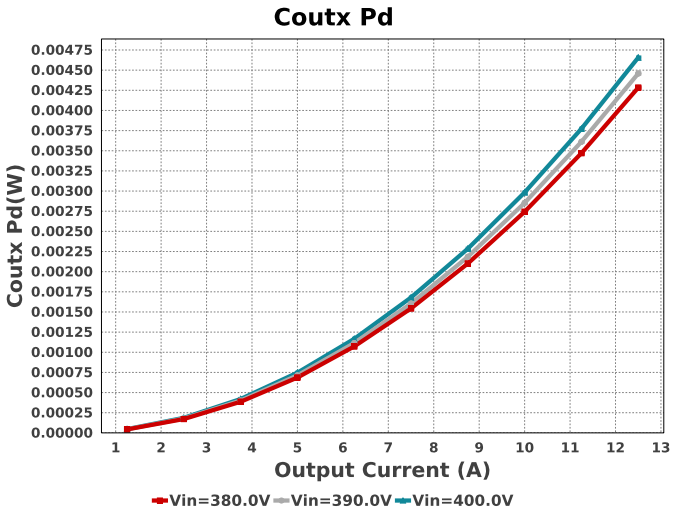


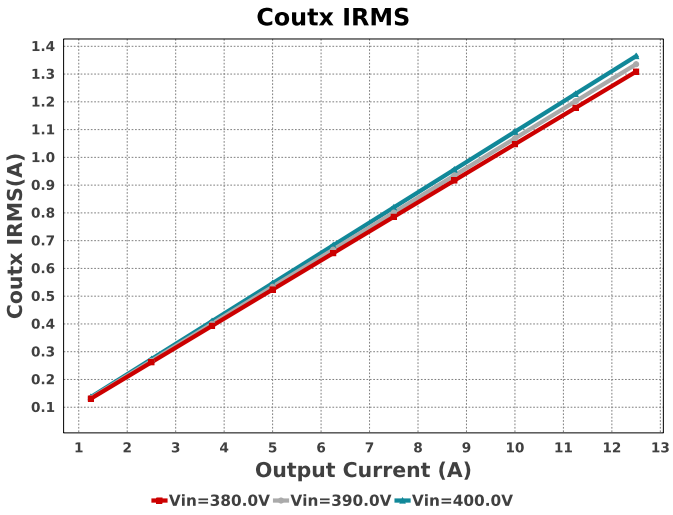


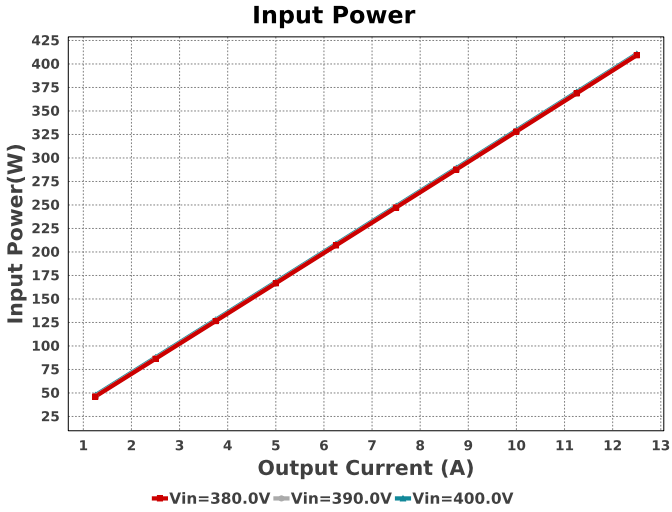


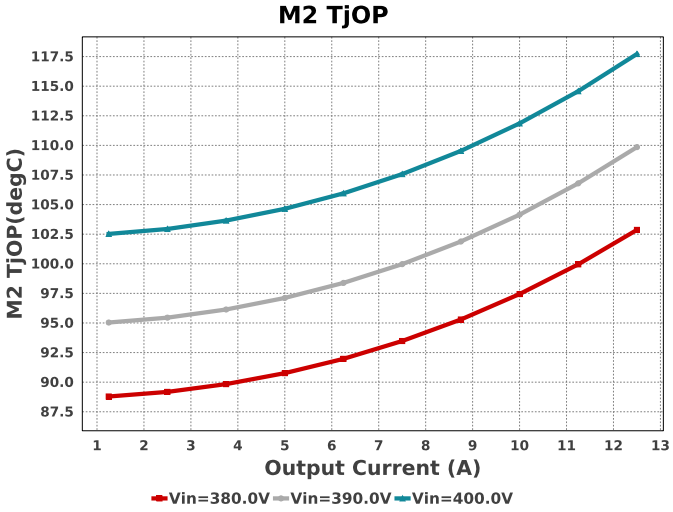


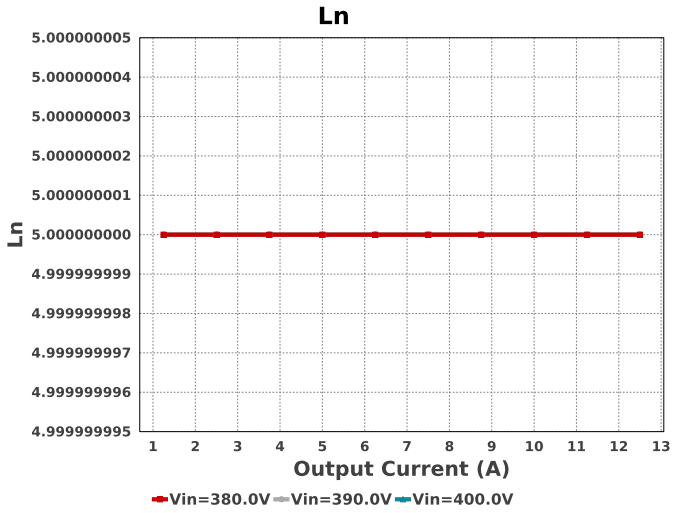


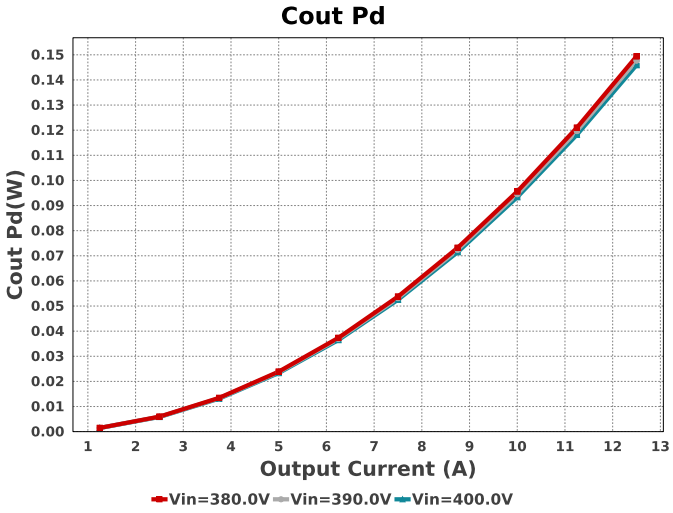


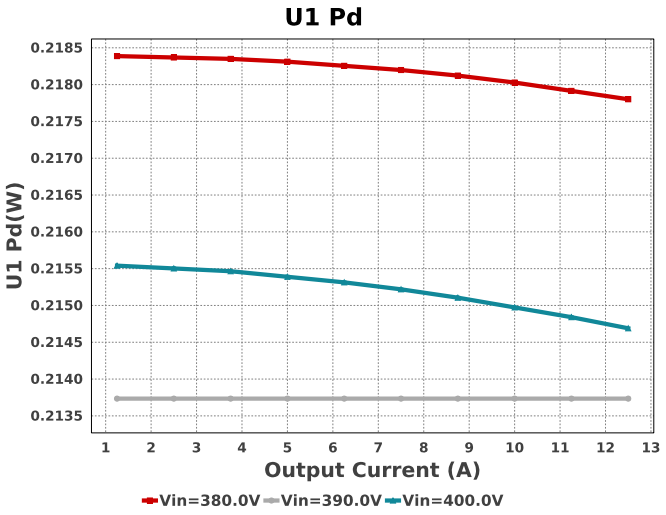


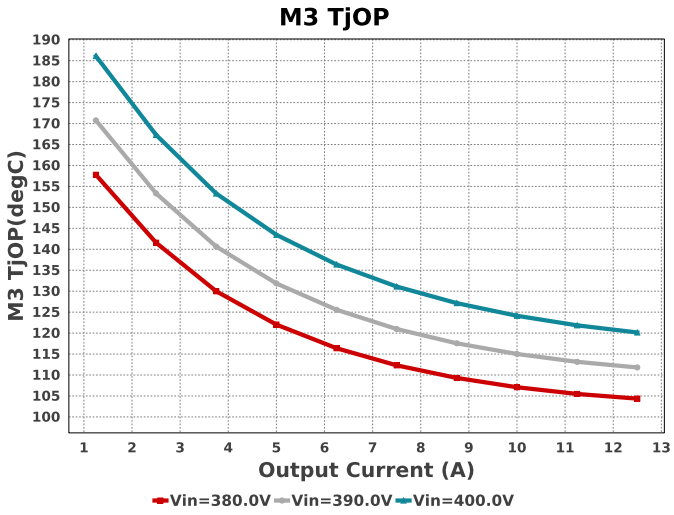


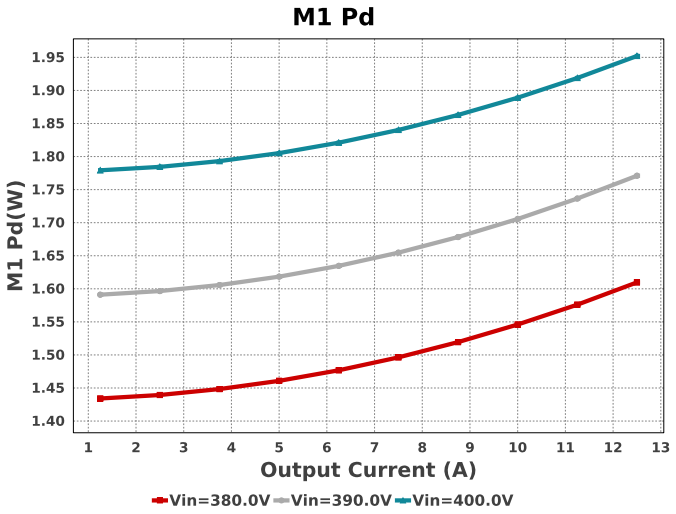


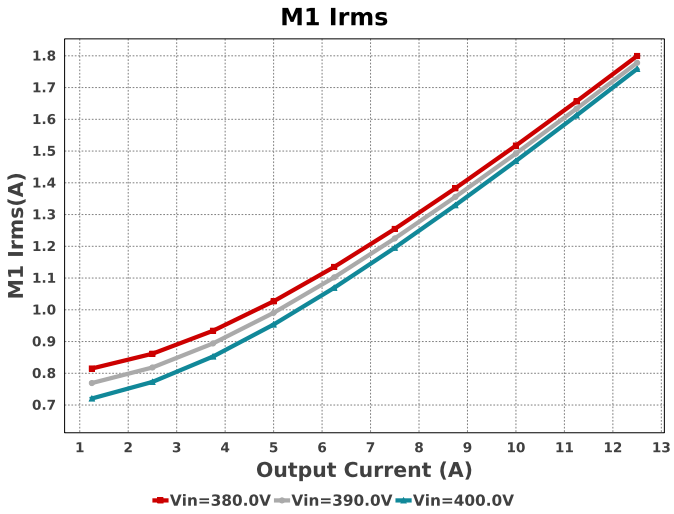


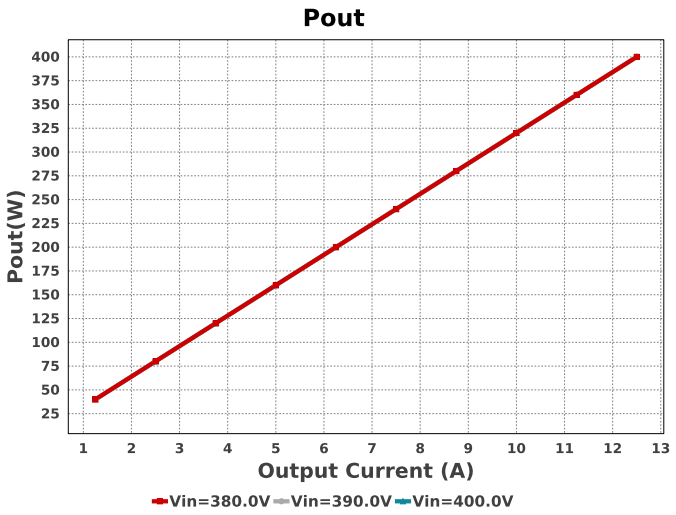


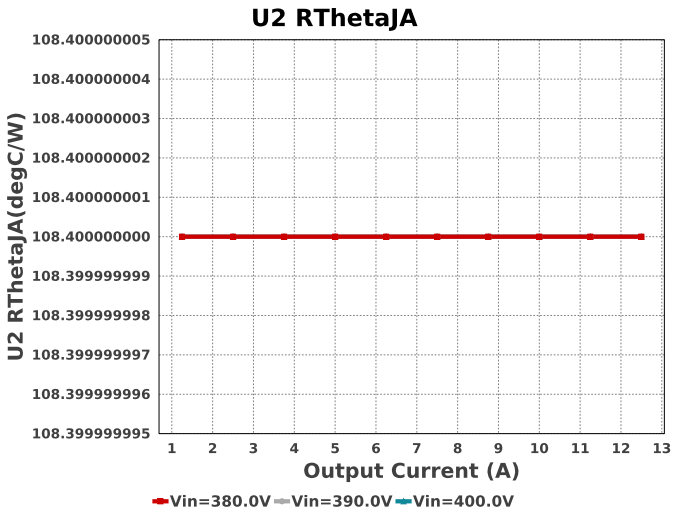


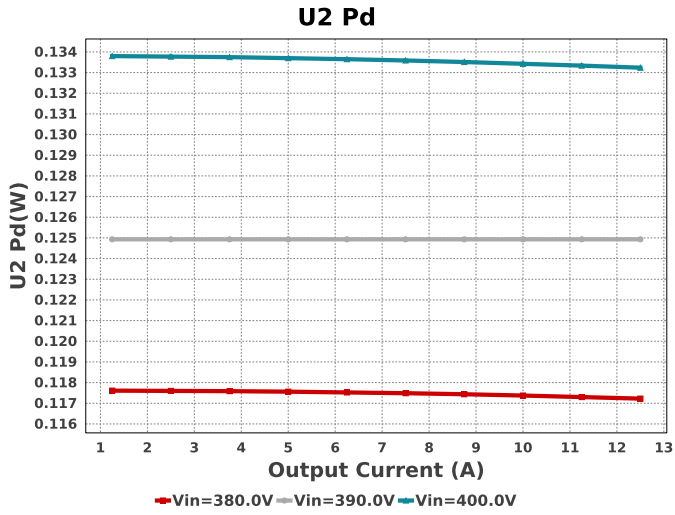


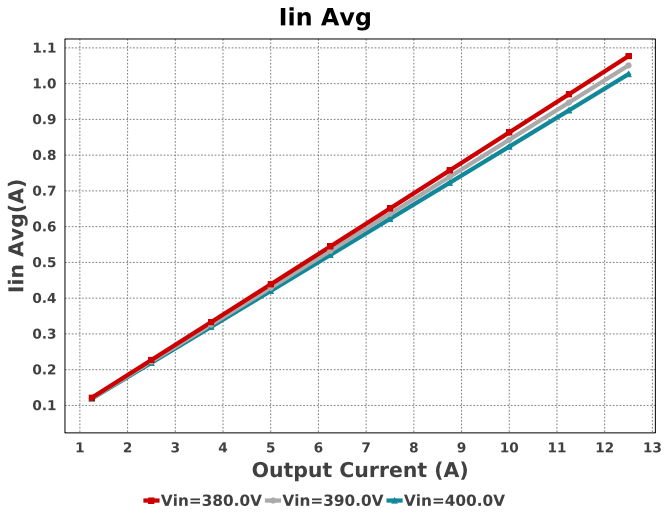


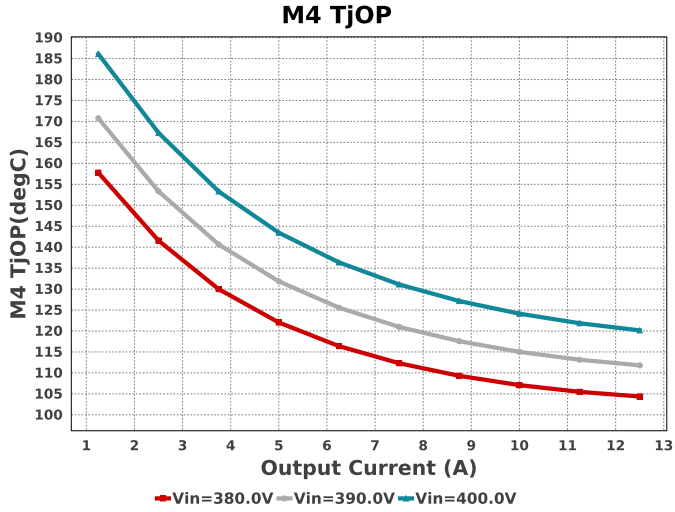


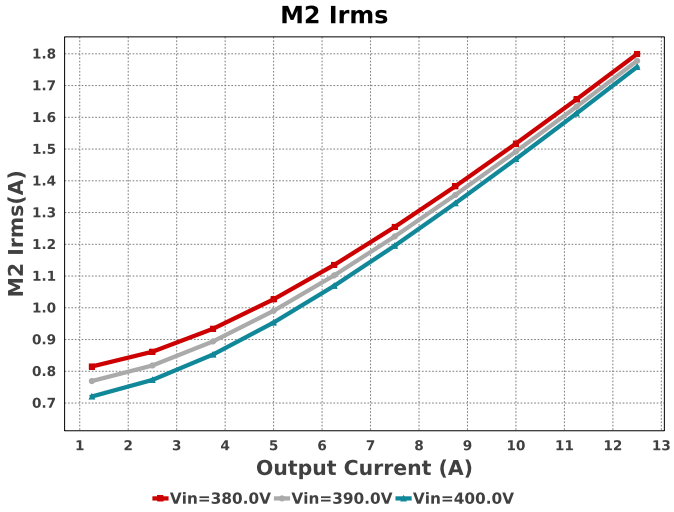


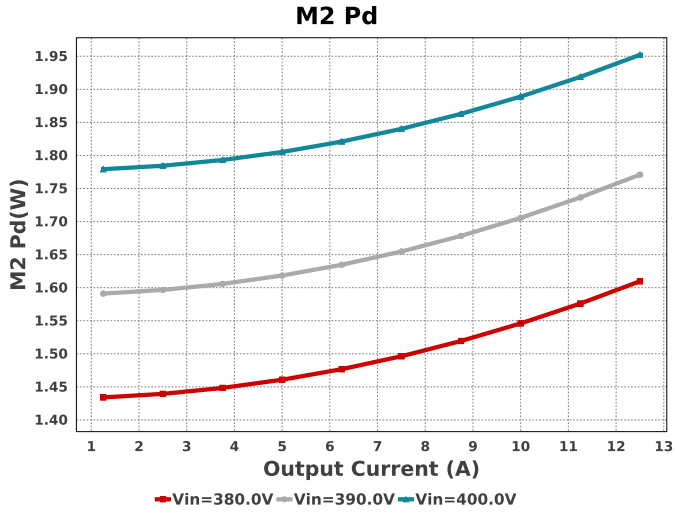


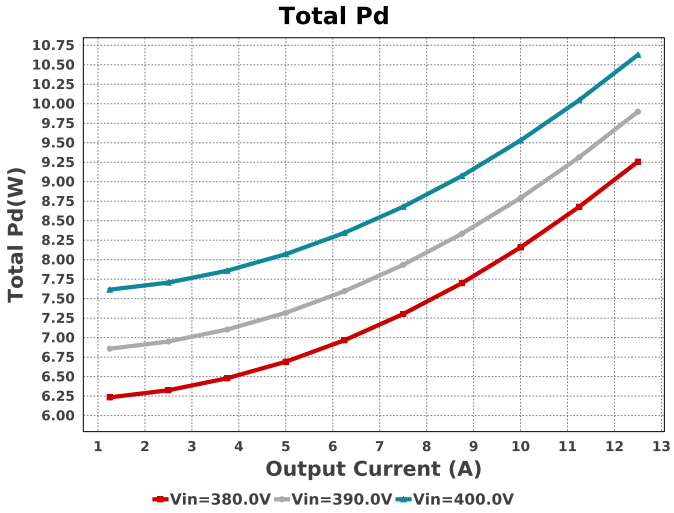


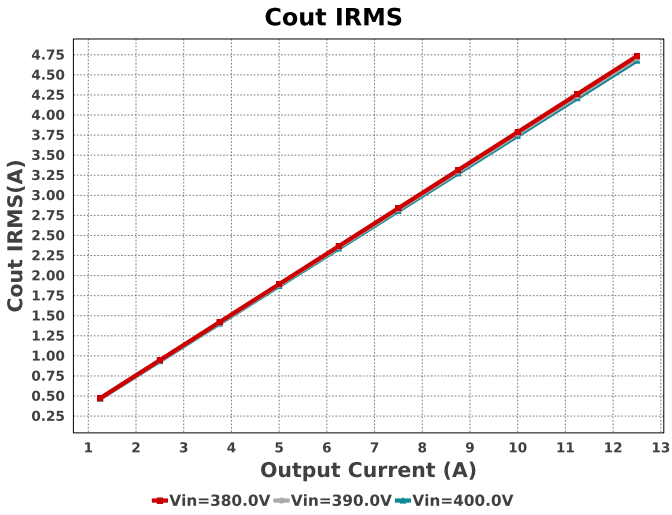


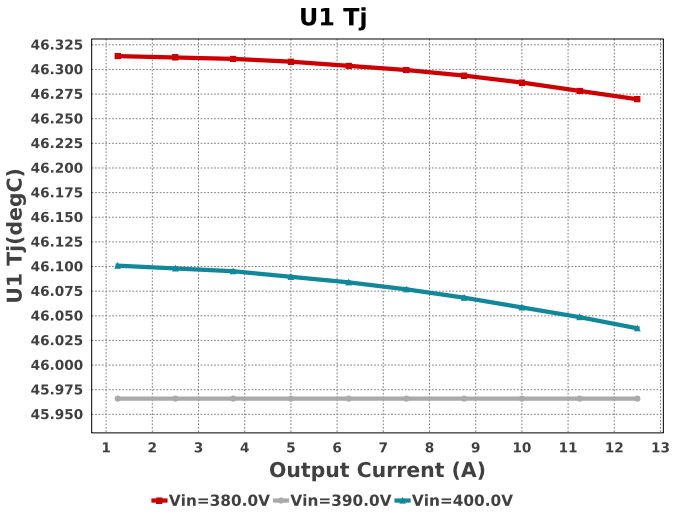


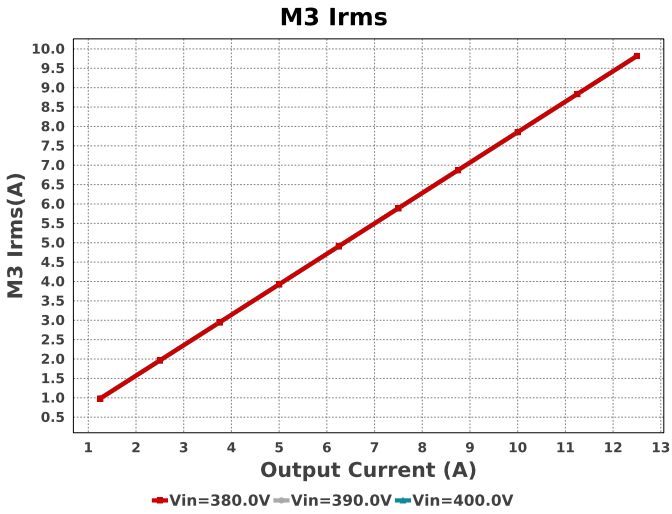


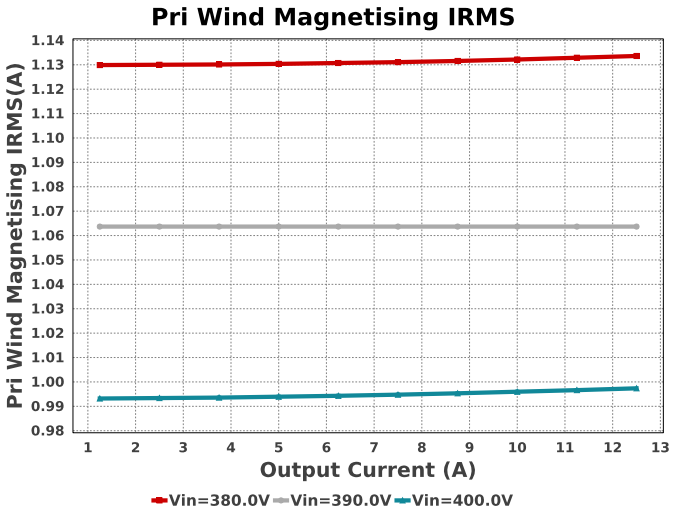


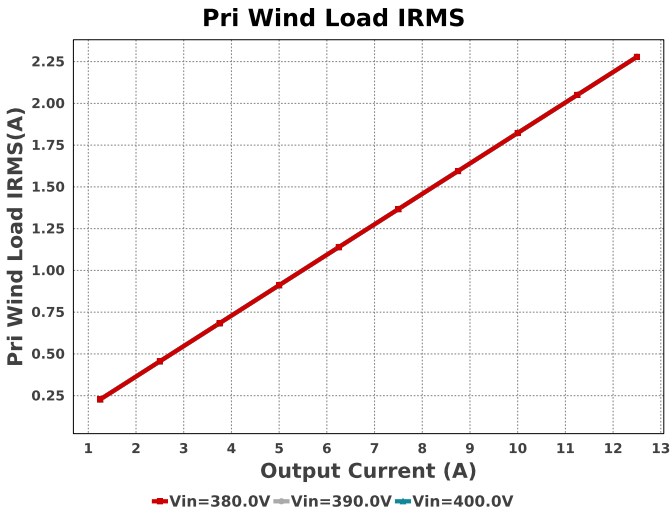


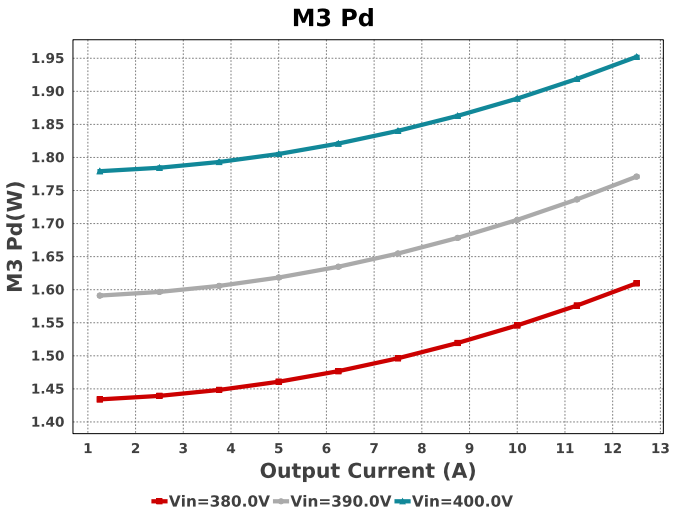


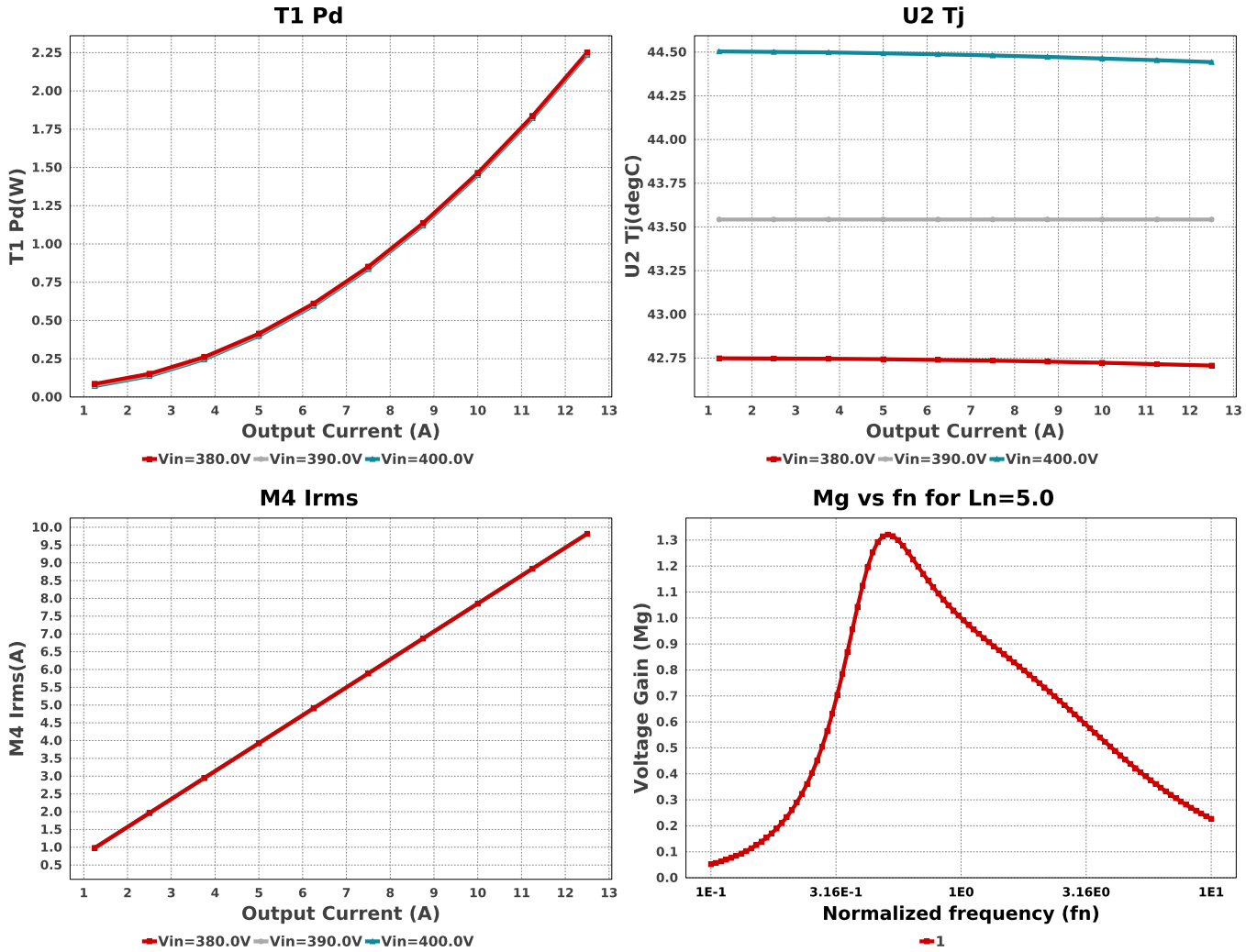












Operating Values

#	Name	Value	Category	Description
1.	Cout IRMS	4.735 A	Capacitor	Output capacitor RMS ripple current
2.	Cout Pd	149.49 mW	Capacitor	Output capacitor power dissipation
3.	Coutx IRMS	1.307 A	Capacitor	Output capacitor RMS ripple current
4.	Coutx Pd	4.274 mW	Capacitor	Output capacitor_x power loss
5.	Iin Avg	1.073 A	IC	Average input current
6.	M1 Irms	1.801 A	Mosfet	M1 MOSFET Irms
7.	M1 Pd	1.605 W	Mosfet	MOSFET power dissipation
8.	M2 Irms	1.801 A	Mosfet	M2 MOSFET Irms
9.	M2 Pd	1.605 W	Mosfet	MOSFET power dissipation
10.	M3 Irms	9.817 A	Mosfet	M3 MOSFET Irms
11.	M3 Pd	764.31 mW	Mosfet	MOSFET power dissipation
12.	M4 Irms	9.817 A	Mosfet	M4 MOSFET Irms
13.	M4 Pd	764.31 mW	Mosfet	MOSFET power dissipation
14.	Cout Pd	149.49 mW	Power	Output capacitor power dissipation
15.	Coutx Pd	4.274 mW	Power	Output capacitor_x power loss
16.	M1 Pd	1.605 W	Power	MOSFET power dissipation
17.	M2 Pd	1.605 W	Power	MOSFET power dissipation
18.	M3 Pd	764.31 mW	Power	MOSFET power dissipation
19.	M4 Pd	764.31 mW	Power	MOSFET power dissipation
20.	T1 Pd	2.252 W	Power	Estimated Losses in Transformer
21.	Total Pd	7.569 W	Power	Total Power Dissipation
22.	U1 Pd	217.177 mW	Power	U1 Power Dissipation
23.	U2 Pd	116.814 mW	Power	U2 Power Dissipation
24.	BOM Count	74	System Information	Total Design BOM count
25.	Efficiency	98.143 %	System Information	Steady state efficiency
26.	FootPrint	2.095 k mm^2	System Information	Total Foot Print Area of BOM components
27.	Frequency	93.82 kHz	System Information	Switching frequency

#	Name	Value	Category	Description
28.	Frequency	93.82 kHz	System Information	Switching frequency
29.	Input Power	407.57 W	System Information	Total input power
30.	Iout	12.5 A	System Information	Iout operating point
31.	Ln	5.0	System Information	Inductor ratio (Lm/Lr)
32.	M1 TjOP	102.67 degC	System Information	M1 MOSFET junction temperature
33.	M2 TjOP	102.67 degC	System Information	M2 MOSFET junction temperature
34.	M3 TjOp	86.272 degC	System Information	M3 MOSFET junction temperature
35.	M4 TjOp	86.272 degC	System Information	M4 MOSFET junction temperature
36.	Pout	400.0 W	System Information	Total output power
37.	Qf	427.273 m	System Information	Quality factor
38.	Resonant Frequency	100.0 kHz	System Information	Resonant Frequency
39.	Total BOM	NA	System Information	Total BOM Cost
40.	U1 RThetaJA	74.7 degC/W	System Information	U1 IC junction-to-ambient thermal resistance
41.	U1 Tj	46.223 degC	System Information	U1 junction temperature
42.	U2 RThetaJA	108.4 degC/W	System Information	U2 IC junction-to-ambient thermal resistance
43.	U2 Tj	42.663 degC	System Information	U2 junction temperature
44.	Vin	380.0 V	System Information	Vin operating point
45.	Vout	32.0 V	System Information	Operational Output Voltage
46.	Vout Actual	30.625 V	System Information	Vout Actual calculated based on selected voltage divider resistors
47.	Vout Tolerance	1.938 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
48.	Vout p-p	326.554 mV	System Information	Peak-to-peak output ripple voltage
49.	Pri Wind Load IRMS	2.278 A	Transformer	Primary winding Load RMS current
50.	Pri Wind Magnetising IRMS	1.138 A	Transformer	Primary winding Magnetising RMS current
51.	T1 Pd	2.252 W	Transformer	Estimated Losses in Transformer

Design Inputs

Name	Value	Description
Iout	12.5	Maximum Output Current
VinMax	400.0	Maximum input voltage
VinMin	380.0	Minimum input voltage
Vout	32.0	Output Voltage
base_pn	UCC256403	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

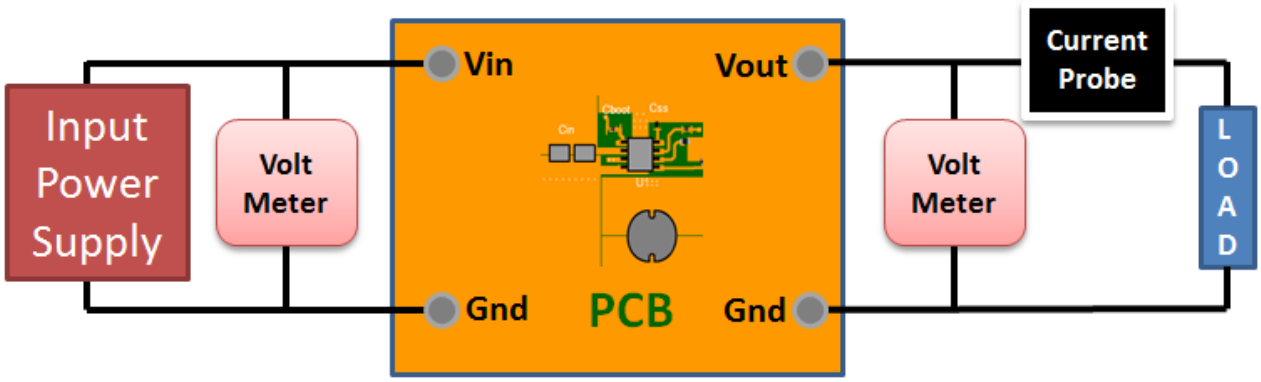
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 380.0V 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 : 8806C969D088DD38[v1]
2. **UCC256403** Product Folder : http://www.ti.com/product/UCC256403 : contains the data sheet and other resources.