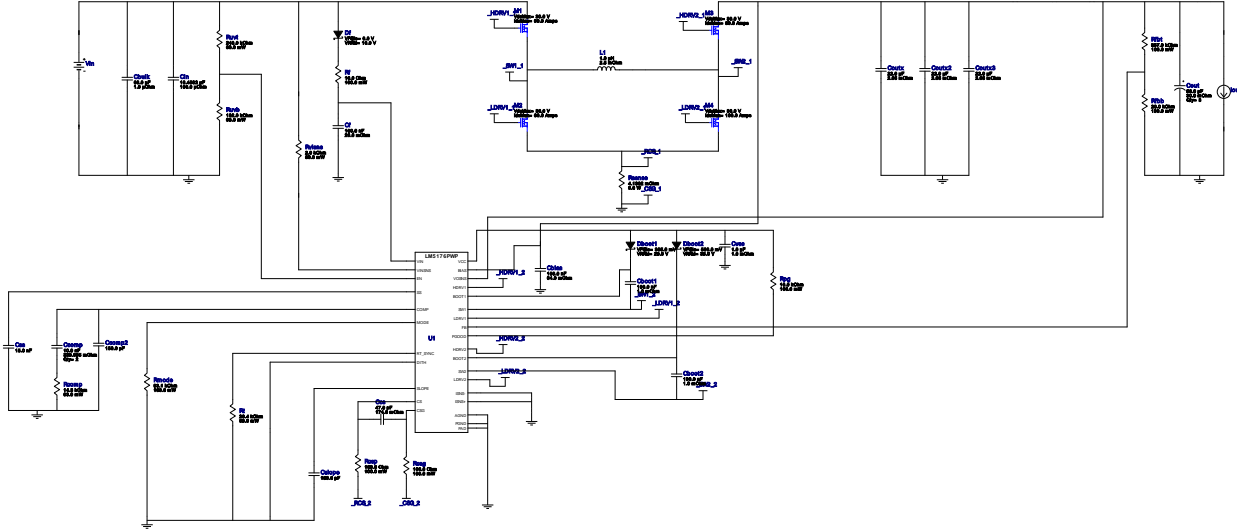


WEBENCH® Design Report

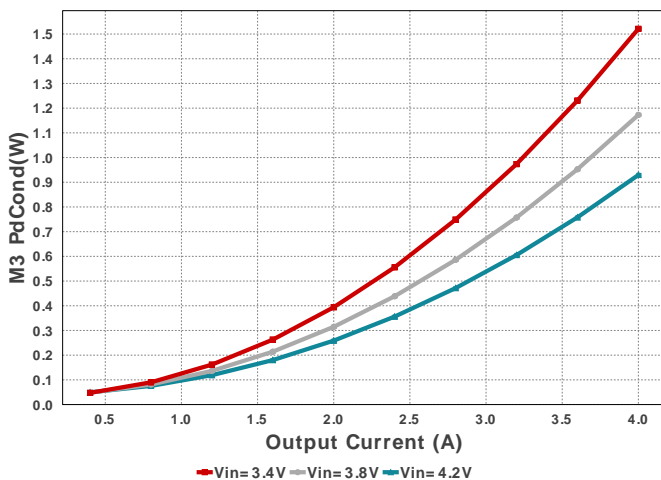
 Design : 270 LM5176PWPR
 LM5176PWPR 3.4V-4.2V to 15.00V @ 3.5A

Electrical BOM

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbias	Kemet	C0805C104M5RACTU Series= X7R	Cap= 100.0 nF ESR= 64.0 mOhm VDC= 50.0 V IRMS= 1.64 A	1	\$0.01	0805 7 mm ²
Cboot1	Kemet	C0603C104Z3VACTU Series= Y5V	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	\$0.01	0603 5 mm ²
Cboot2	Kemet	C0603C104Z3VACTU Series= Y5V	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	\$0.01	0603 5 mm ²
Cbulk	CUSTOM	CUSTOM Series= ?	Cap= 68.0 uF ESR= 1.0 uOhm VDC= 6.0 V	1	NA	CUSTOM 0 mm ²
Ccomp	TDK	CGA2B3X7R1H103K050BB Series= X7R	Cap= 10.0 nF ESR= 333.065 mOhm VDC= 50.0 V IRMS= 323.37 mA	2	\$0.01	0402 3 mm ²
Ccomp2	Samsung Electro-Mechanics	CL21C151JBANNNC Series= C0G/NP0	Cap= 150.0 pF VDC= 50.0 V IRMS= 0.0 A	1	\$0.01	0805 7 mm ²
Ccs	AVX	06035A470JAT2A Series= C0G/NP0	Cap= 47.0 pF ESR= 174.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	\$0.01	0603 5 mm ²
Cf	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 mm ²
Cin	CUSTOM	CUSTOM Series= ?	Cap= 16.4582 uF ESR= 100.0 uOhm VDC= 5.586 V IRMS= 2.0 A	1	NA	CUSTOM 0 mm ²

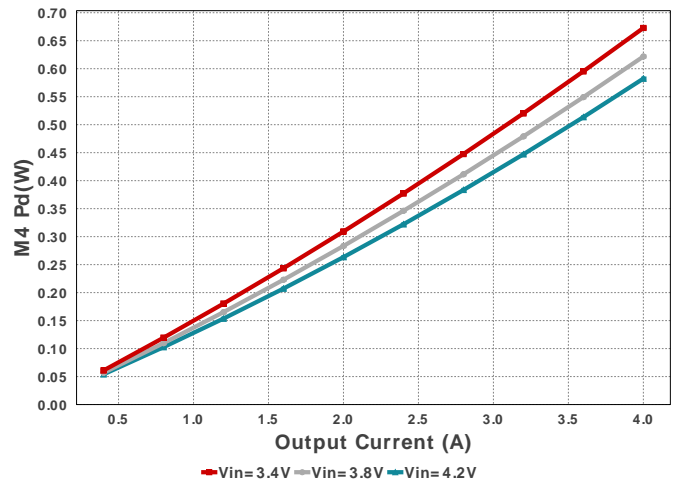
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cout	Panasonic	20SVPF56MX Series= SVPF	Cap= 56.0 uF ESR= 30.0 mOhm VDC= 20.0 V IRMS= 2.8 A	3	\$0.36	 CAPSMT_62_E61 53 mm ²
Coutx	TDK	C2012X5R1V226M125AC Series= X5R	Cap= 22.0 uF ESR= 2.05 mOhm VDC= 35.0 V IRMS= 4.5559 A	1	\$0.37	 0805 7 mm ²
Coutx2	TDK	C2012X5R1V226M125AC Series= X5R	Cap= 22.0 uF ESR= 2.05 mOhm VDC= 35.0 V IRMS= 4.5559 A	1	\$0.37	 0805 7 mm ²
Coutx3	TDK	C2012X5R1V226M125AC Series= X5R	Cap= 22.0 uF ESR= 2.05 mOhm VDC= 35.0 V IRMS= 4.5559 A	1	\$0.37	 0805 7 mm ²
Cslope	Samsung Electro-Mechanics	CL10C151JB8NNNC Series= C0G/NP0	Cap= 150.0 pF VDC= 50.0 V IRMS= 0.0 A	1	\$0.01	 0603 5 mm ²
Css	Kemet	C0603C153J3GACTU Series= C0G/NP0	Cap= 15.0 nF VDC= 25.0 V IRMS= 0.0 A	1	\$0.11	 0603 5 mm ²
Cvcc	Taiyo Yuden	EMK107B7105KA-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	\$0.02	 0603 5 mm ²
Dboot1	Comchip Technology	CDBK0520L-HF	VF@Io= 385.0 mV VRRM= 20.0 V	1	\$0.07	 SOD-123F 12 mm ²
Dboot2	Vishay-Semiconductor	BYS10-35-E3/TR	VF@Io= 500.0 mV VRRM= 35.0 V	1	\$0.07	 SMA 37 mm ²
Df	Diodes Inc.	ZLLS410TA	VF@Io= 0.0 V VRRM= 10.0 V	1	\$0.16	 SOD-323 9 mm ²
L1	Bourns	SRP1250-1R0M	L= 1.0 uH 2.5 mOhm	1	\$0.77	 SRP1250 253 mm ²
M1	Texas Instruments	CSD17577Q5A	VdsMax= 30.0 V IdsMax= 60.0 Amps	1	\$0.23	 TRANS_NexFET_Q5A 55 mm ²
M2	Texas Instruments	CSD17577Q5A	VdsMax= 30.0 V IdsMax= 60.0 Amps	1	\$0.23	 TRANS_NexFET_Q5A 55 mm ²
M3	Texas Instruments	CSD17577Q5A	VdsMax= 30.0 V IdsMax= 60.0 Amps	1	\$0.23	 TRANS_NexFET_Q5A 55 mm ²
M4	Texas Instruments	CSD17573Q5B	VdsMax= 30.0 V IdsMax= 100.0 Amps	1	\$0.60	 DNK0008A 56 mm ²
Rcomp	Vishay-Dale	CRCW040214K3FKED Series= CRCW..e3	Res= 14.3 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
Rcsg	Vishay-Dale	CRCW0603100RFKEA Series= CRCW..e3	Res= 100.0 Ohm Power= 100.0 mW Tolerance= 1.0%	1	\$0.01	 0603 5 mm ²

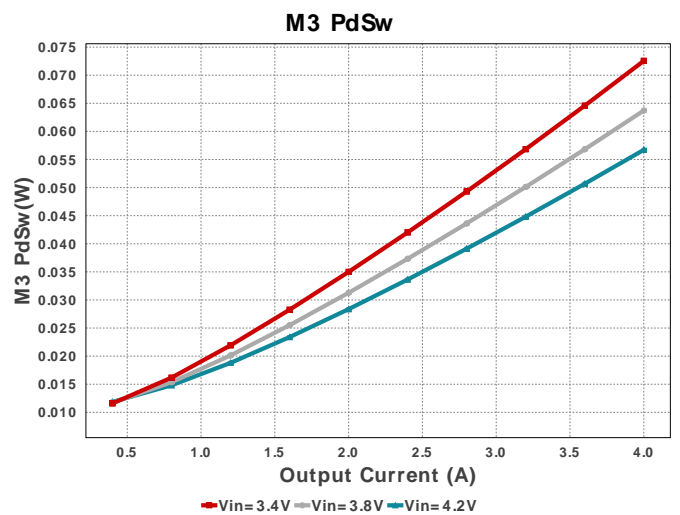
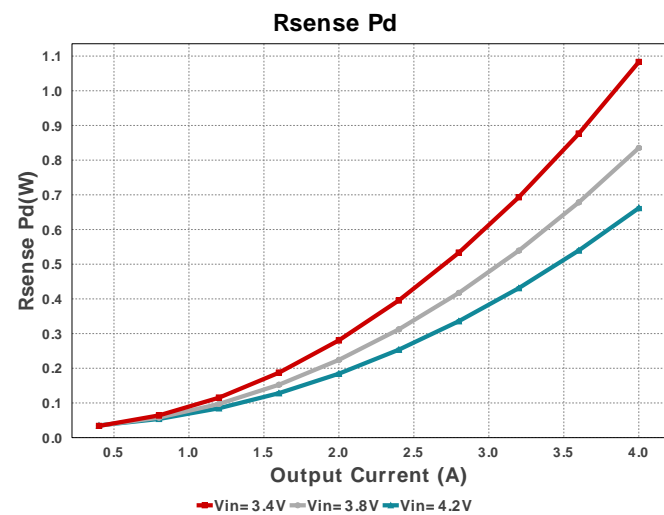
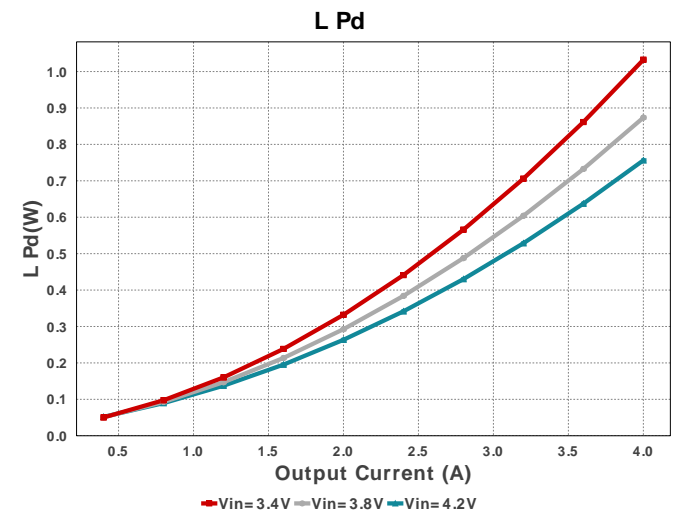
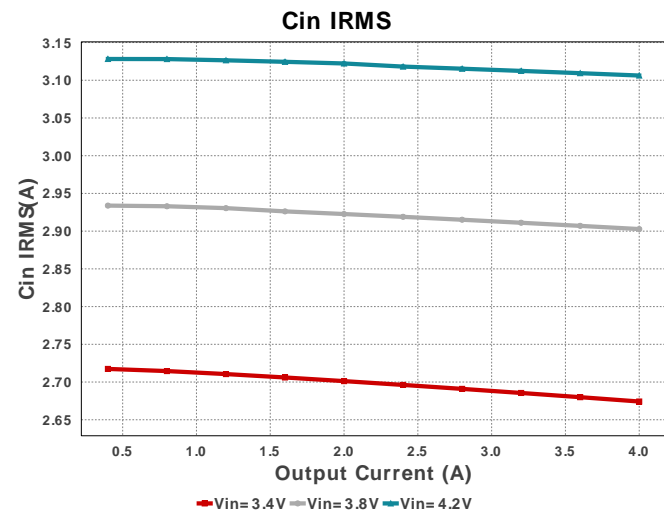
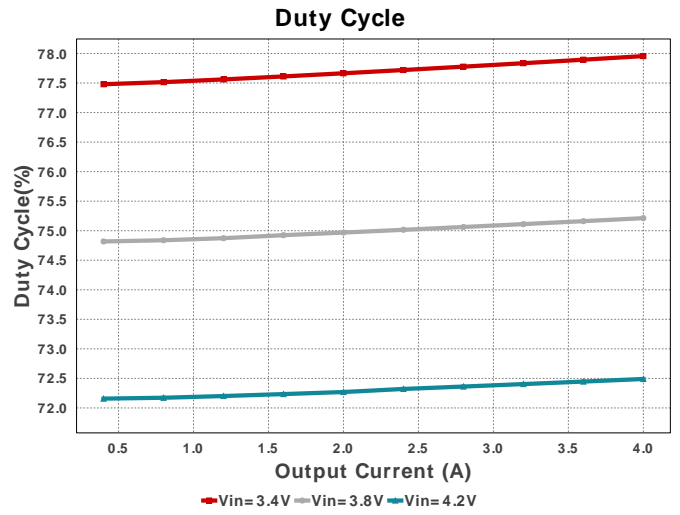
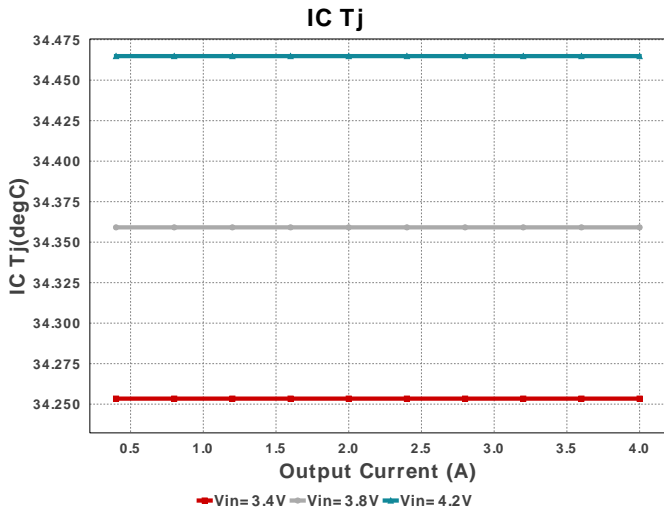
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rcsp	Vishay-Dale	CRCW0603100RFKEA Series= CRCW..e3	Res= 100.0 Ohm Power= 100.0 mW Tolerance= 1.0%	1	\$0.01	0603 5 mm ²
Rf	Vishay-Dale	CRCW060310R0FKEA Series= CRCW..e3	Res= 10.0 Ohm Power= 100.0 mW Tolerance= 1.0%	1	\$0.01	0603 5 mm ²
Rfbb	Vishay-Dale	CRCW060320K0FKEA Series= CRCW..e3	Res= 20.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	\$0.01	0603 5 mm ²
Rfbt	Yageo	RC0603FR-07357KL Series= ?	Res= 357.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	\$0.01	0603 5 mm ²
Rmode	Vishay-Dale	CRCW060393K1FKEA Series= CRCW..e3	Res= 93.1 kOhm Power= 100.0 mW Tolerance= 1.0%	1	\$0.01	0603 5 mm ²
Rpg	Yageo	RC0603FR-0710KL Series= ?	Res= 10.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	\$0.01	0603 5 mm ²
Rsense	CUSTOM	CUSTOM Series= ?	Res= 4.1302 mOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm ²
Rt	Vishay-Dale	CRCW040229K4FKED Series= CRCW..e3	Res= 29.4 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	0402 3 mm ²
Ruvb	Vishay-Dale	CRCW0402182KFKED Series= CRCW..e3	Res= 182.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	0402 3 mm ²
Ruvt	Yageo	RC0402FR-07249KL Series= ?	Res= 249.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	0402 3 mm ²
Rvisns	Vishay-Dale	CRCW04022K00FKED Series= CRCW..e3	Res= 2.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	0402 3 mm ²
U1	Texas Instruments	LM5176PWPR	Switcher	1	\$3.00	PWP0028C_N 98 mm ²

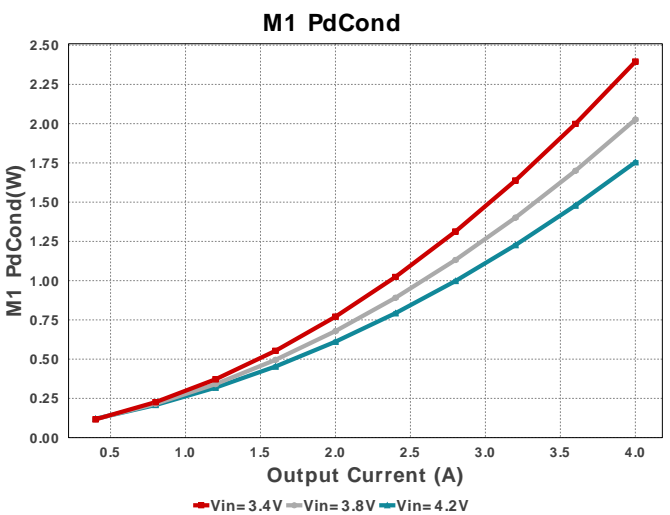
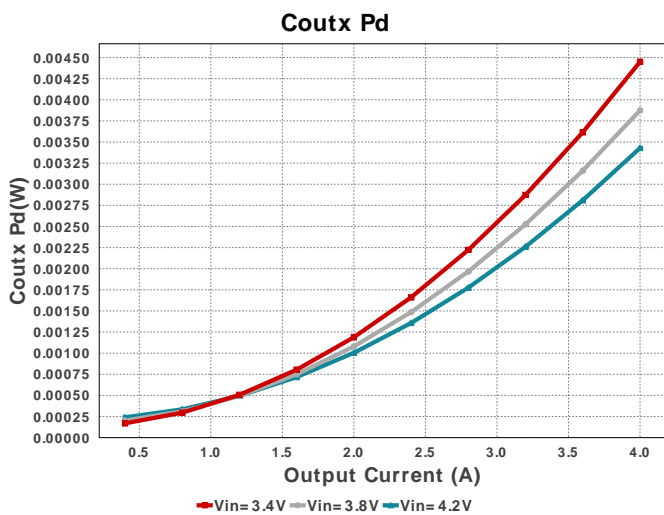
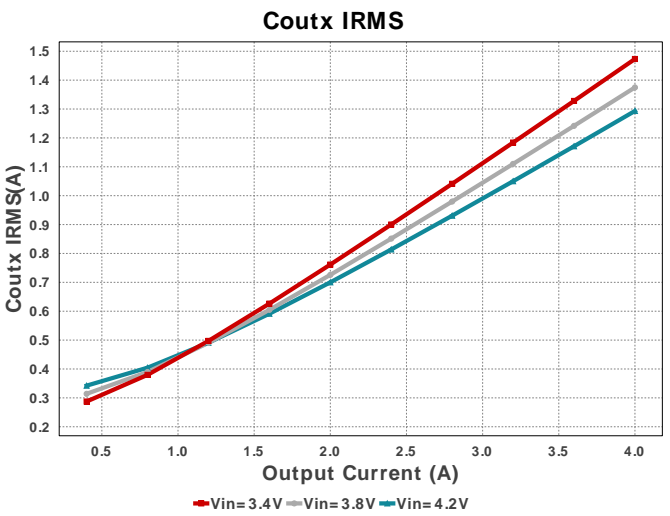
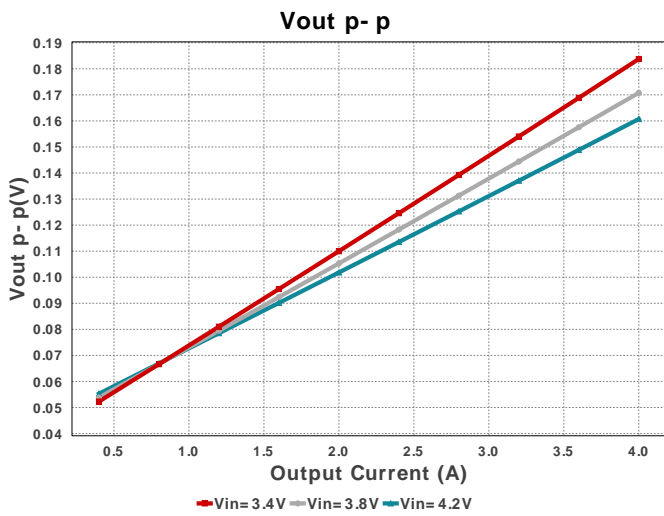
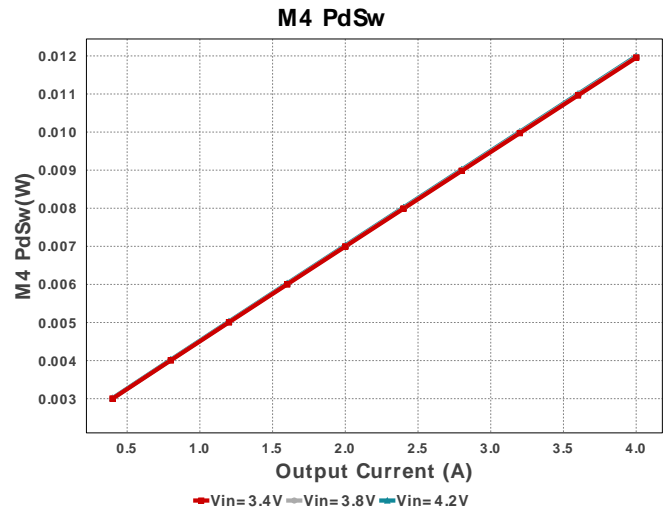
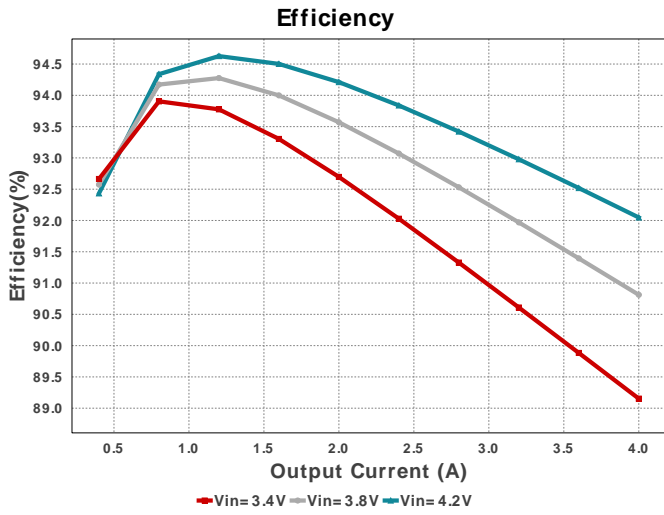
M3 PdCond

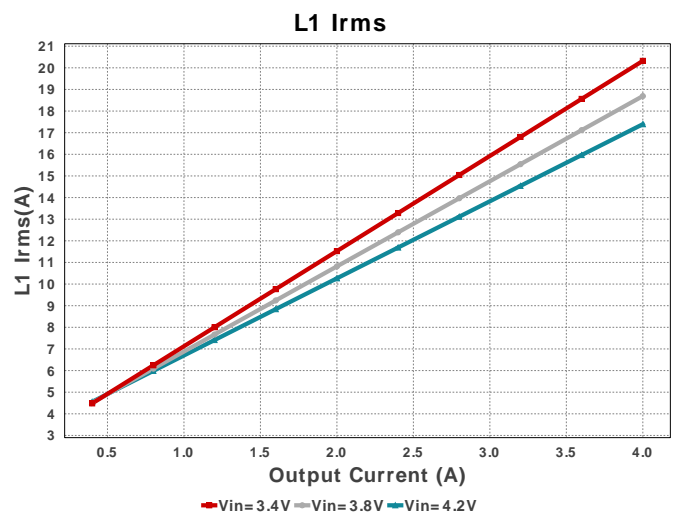
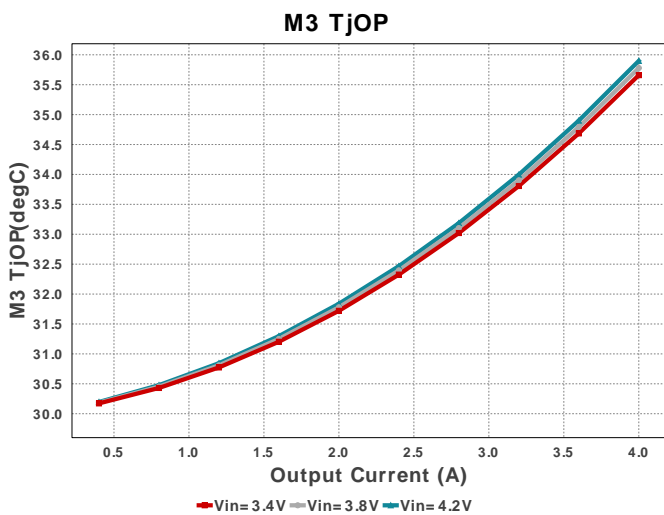
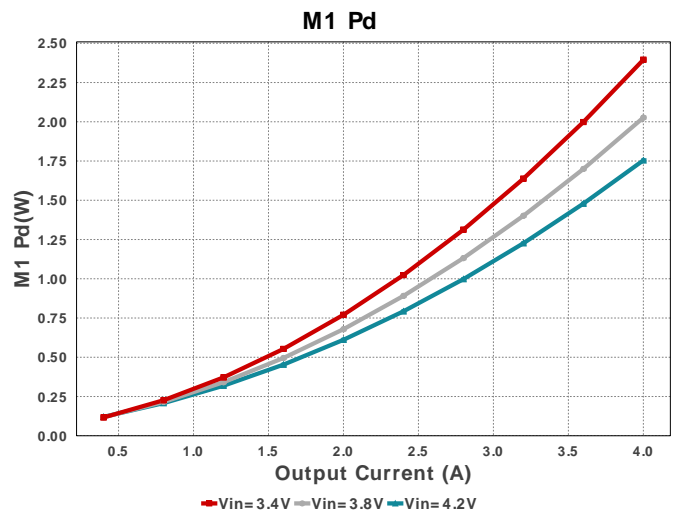
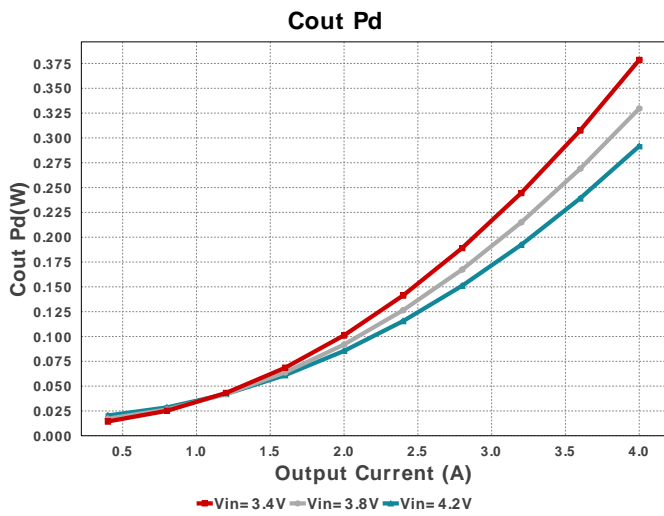
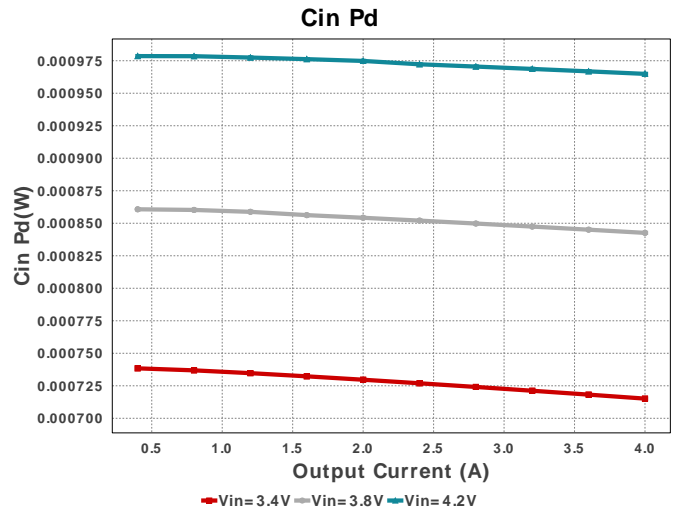
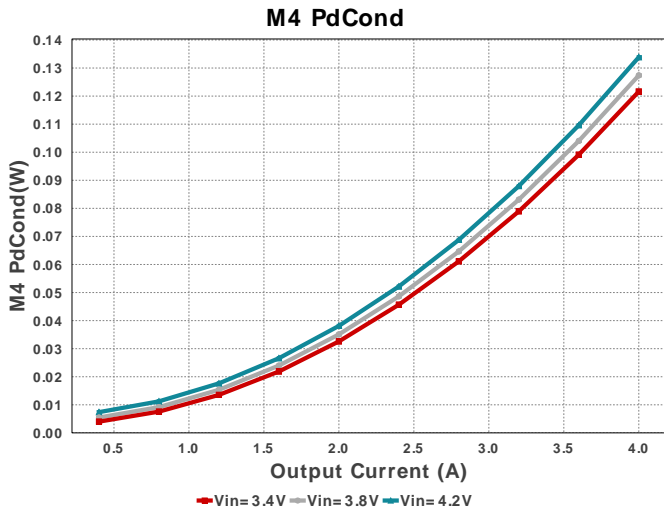


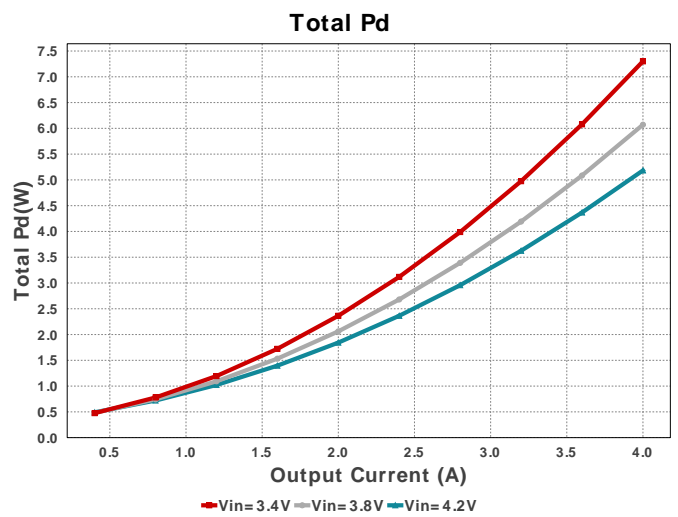
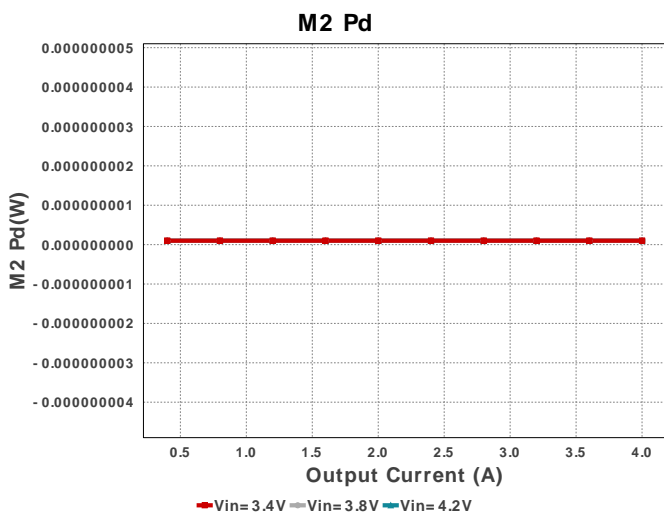
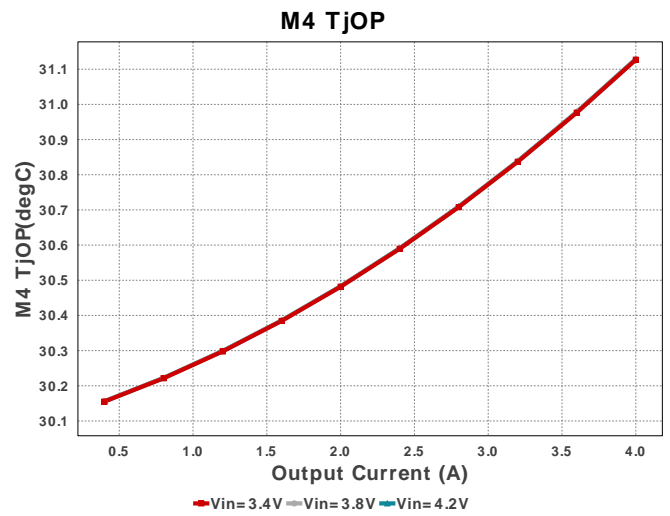
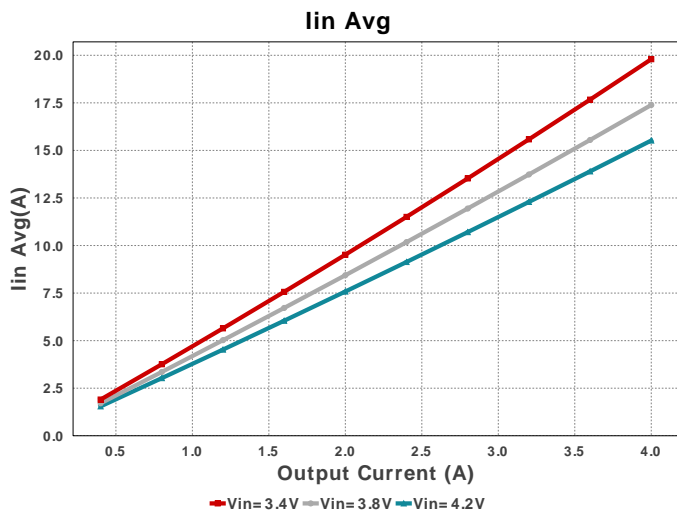
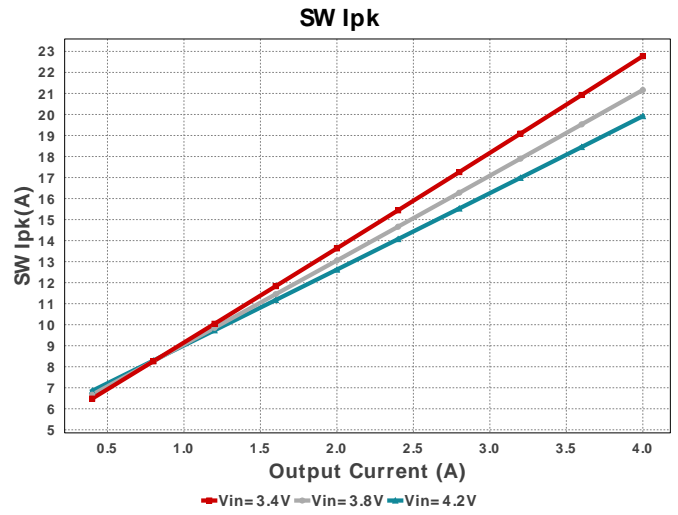
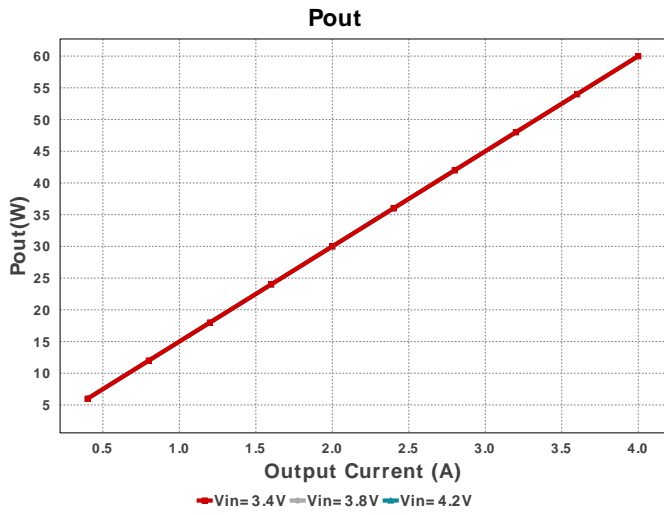
M4 Pd

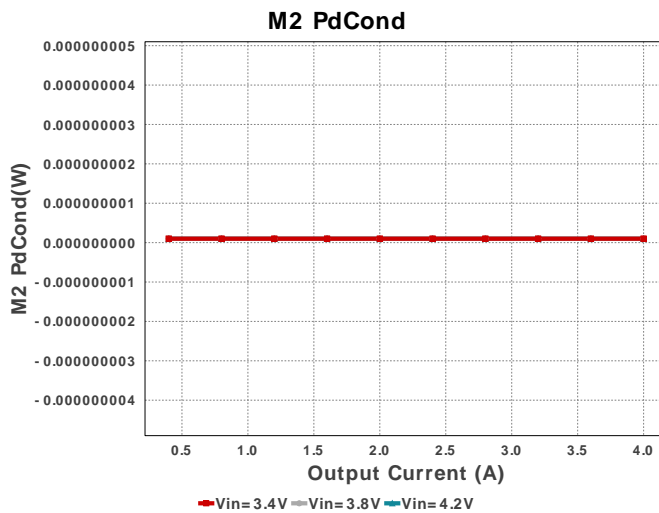
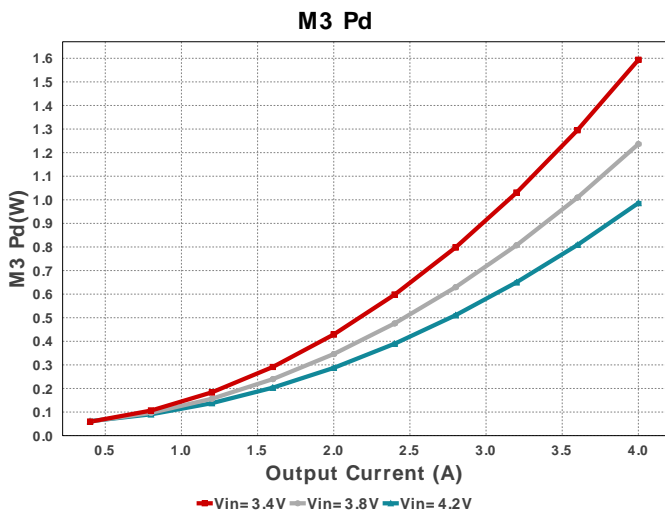
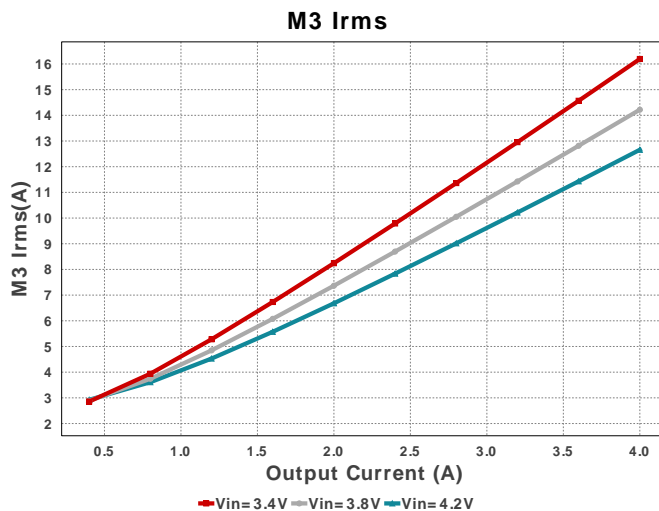
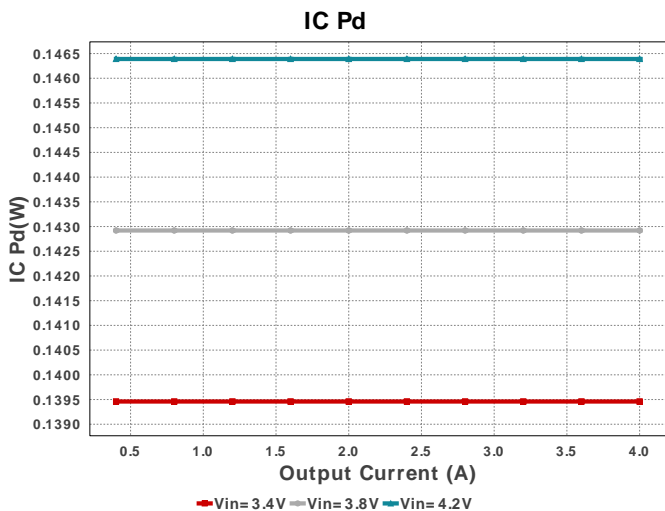
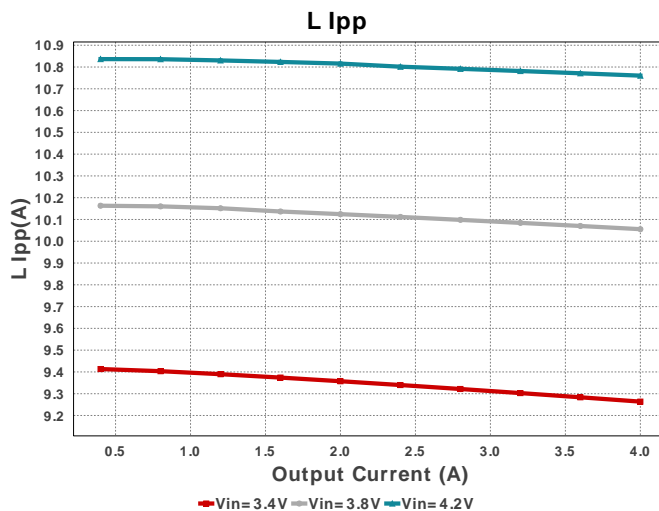
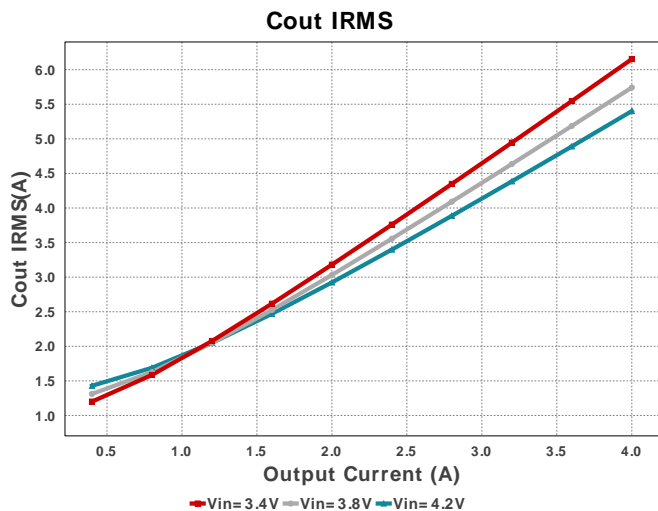


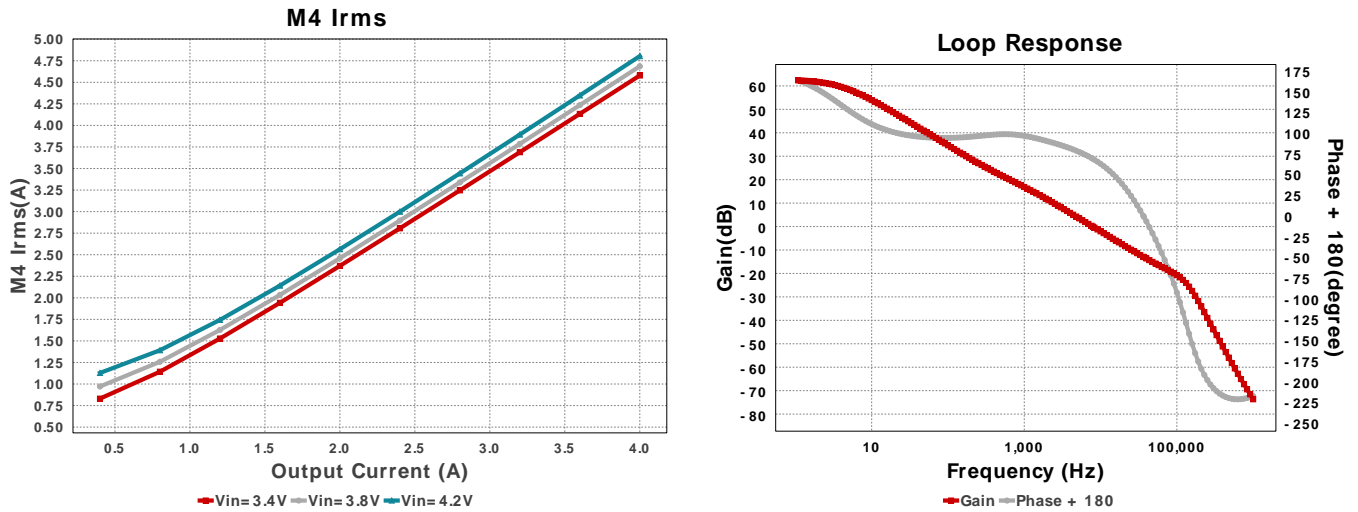












Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	2.672 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	713.87 μ W	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	5.408 A	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	292.51 mW	Capacitor	Output capacitor power dissipation
5.	Coutx IRMS	1.252 A	Capacitor	Output capacitor_x RMS ripple current
6.	Coutx Pd	3.216 mW	Capacitor	Output capacitor_x power loss
7.	IC Pd	146.39 mW	IC	IC power dissipation
8.	IC Tj	34.465 degC	IC	IC junction temperature
9.	IC Tolerance	0.0 V	IC	IC Feedback Tolerance
10.	ICThetaJA	30.5 degC/W	IC	IC junction-to-ambient thermal resistance
11.	Iin Avg	19.78 A	IC	Average input current
12.	L Ipp	9.256 A	Inductor	Peak-to-peak inductor ripple current
13.	L Pd	1.032 W	Inductor	Inductor power dissipation
14.	L1 Irms	20.319 A	Inductor	Inductor ripple current
15.	M1 Pd	2.395 W	Mosfet	M1 MOSFET total power dissipation
16.	M1 PdCond	2.395 W	Mosfet	M1 MOSFET conduction losses
17.	M2 Pd	100.0 μ W	Mosfet	M2 MOSFET total power dissipation
18.	M2 PdCond	100.0 μ W	Mosfet	M2 MOSFET conduction losses
19.	M3 Irms	16.289 A	Mosfet	MOSFET RMS ripple current
20.	M3 Pd	1.612 W	Mosfet	MOSFET power dissipation
21.	M3 PdCond	1.539 W	Mosfet	M1 MOSFET conduction losses
22.	M3 PdSw	72.98 mW	Mosfet	M1 MOSFET switching losses
23.	M3 ThetaJA	50.0 degC/W	Mosfet	MOSFET junction-to-ambient thermal resistance
24.	M3 TjOP	36.402 degC	Mosfet	MOSFET junction temperature
25.	M4 Irms	4.606 A	Mosfet	MOSFET RMS ripple current
26.	M4 Pd	674.17 mW	Mosfet	MOSFET power dissipation
27.	M4 PdCond	123.02 mW	Mosfet	M2 MOSFET conduction losses
28.	M4 PdSw	11.995 mW	Mosfet	M2 MOSFET switching losses
29.	M4 ThetaJA	50.0 degC/W	Mosfet	MOSFET junction-to-ambient thermal resistance
30.	M4 TjOP	31.613 degC	Mosfet	MOSFET junction temperature
31.	Cin Pd	713.87 μ W	Power	Input capacitor power dissipation
32.	Cout Pd	292.51 mW	Power	Output capacitor power dissipation
33.	Coutx Pd	3.216 mW	Power	Output capacitor_x power loss
34.	IC Pd	146.39 mW	Power	IC power dissipation
35.	L Pd	1.032 W	Power	Inductor power dissipation
36.	M1 Pd	2.395 W	Power	M1 MOSFET total power dissipation
37.	M1 PdCond	2.395 W	Power	M1 MOSFET conduction losses
38.	M2 Pd	100.0 μ W	Power	M2 MOSFET total power dissipation
39.	M2 PdCond	100.0 μ W	Power	M2 MOSFET conduction losses
40.	M3 Pd	1.612 W	Power	MOSFET power dissipation
41.	M3 PdCond	1.539 W	Power	M1 MOSFET conduction losses
42.	M3 PdSw	72.98 mW	Power	M1 MOSFET switching losses
43.	M3 Rdson	5.8 mOhm	Power	Drain-Source On-resistance
44.	M4 Pd	674.17 mW	Power	MOSFET power dissipation
45.	M4 PdCond	123.02 mW	Power	M2 MOSFET conduction losses
46.	M4 PdSw	11.995 mW	Power	M2 MOSFET switching losses
47.	M4 Rdson	5.8 mOhm	Power	Drain-Source On-resistance
48.	Rsense Pd	1.096 W	Power	LED Current Rsns Power Dissipation
49.	Total Pd	7.252 W	Power	Total Power Dissipation
50.	Rsense Pd	1.096 W	Resistor	LED Current Rsns Power Dissipation
51.	BOM Count	41	System Information	Total Design BOM count

#	Name	Value	Category	Description
52.	Cross Freq	7.949 kHz	System Information	Bode plot crossover frequency
53.	Duty Cycle	72.608 %	System Information	Duty cycle
54.	Efficiency	89.217 %	System Information	Steady state efficiency
55.	FootPrint	955.0 mm ²	System Information	Total Foot Print Area of BOM components
56.	Frequency	277.747 kHz	System Information	Switching frequency
57.	Gain Marg	-12.965 dB	System Information	Bode Plot Gain Margin
58.	Iout	4.0 A	System Information	Iout operating point
59.	Low Freq Gain	62.329 dB	System Information	Gain at 1Hz
60.	Mode	CCM	System Information	Conduction Mode
61.	Operating Topology	Boost	System Information	The current operating topology of the device
62.	Phase Marg	69.953 deg	System Information	Bode Plot Phase Margin
63.	Pout	60.0 W	System Information	Total output power
64.	SW Ipk	19.231 A	System Information	Peak switch current
65.	Total BOM	NA	System Information	Total BOM Cost
66.	Vin	3.4 V	System Information	Vin operating point
67.	Vout	15.0 V	System Information	Operational Output Voltage
68.	Vout Actual	15.08 V	System Information	Vout Actual calculated based on selected voltage divider resistors
69.	Vout Tolerance	1.913 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
70.	Vout p-p	160.242 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	4.0	Maximum Output Current
VinMax	4.2	Maximum input voltage
VinMin	3.4	Minimum input voltage
Vout	15.0	Output Voltage
base_pn	LM5176	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

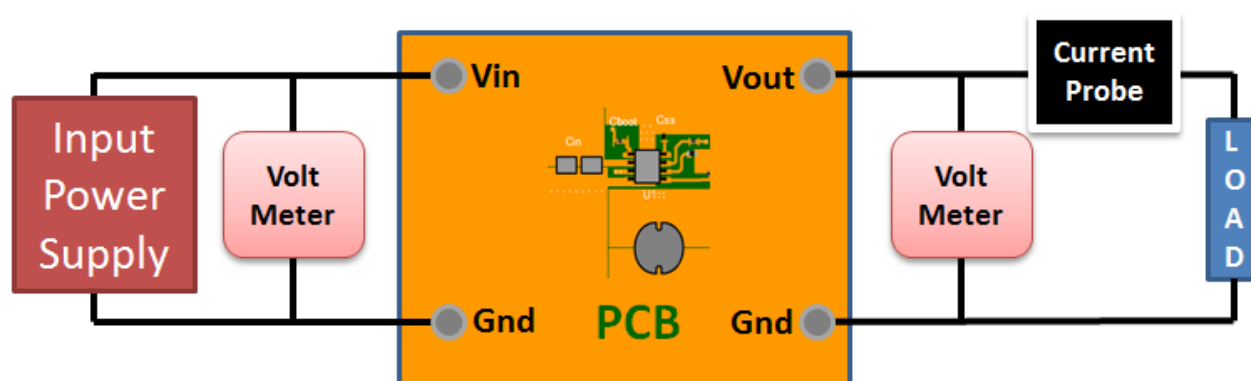
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 3.4V 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.



Design Assistance

1. Tip: Snubbers and/or gate resistors may be required to limit the SW1,2 node switching spikes below the IC and FET abs max ratings.
2. Tip: Slope Capacitor: smaller slope capacitors provide better transition region behavior.
3. Master key : 65FE43A04D06E42A[v1]
4. **LM5176** Product Folder : <http://www.ti.com/product/LM5176> : contains the data sheet and other resources.

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