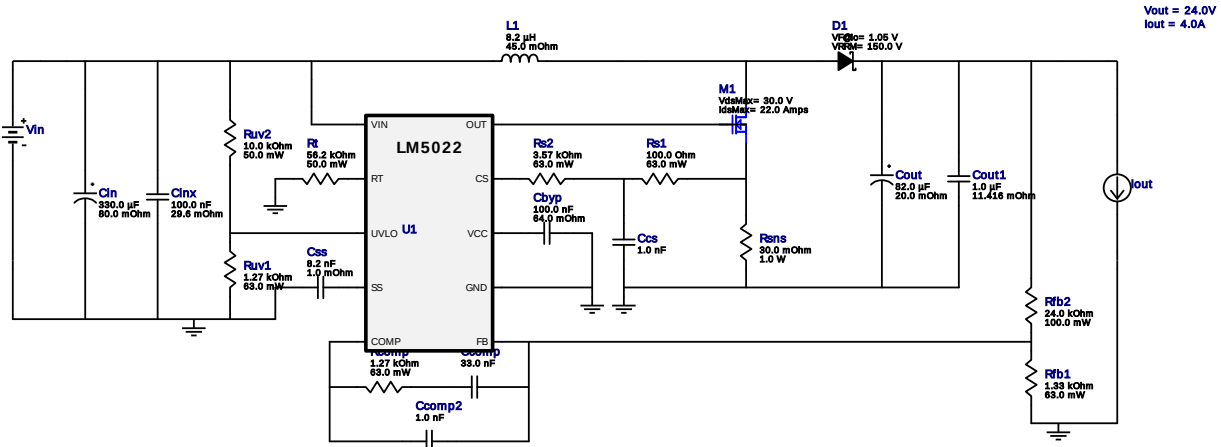


WEBENCH® Design Report

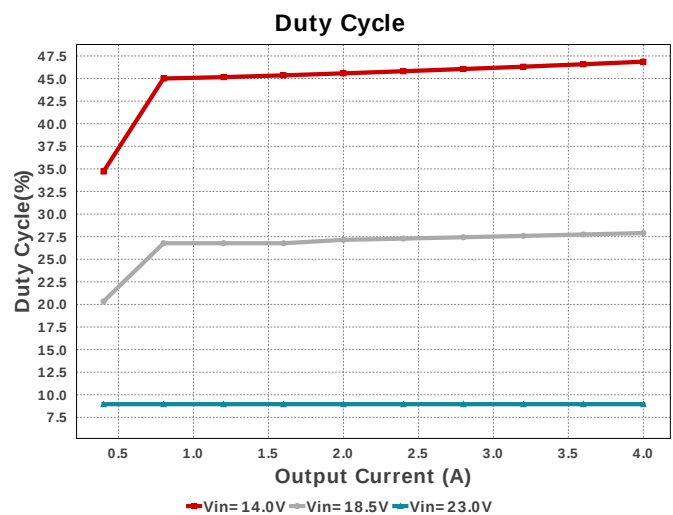
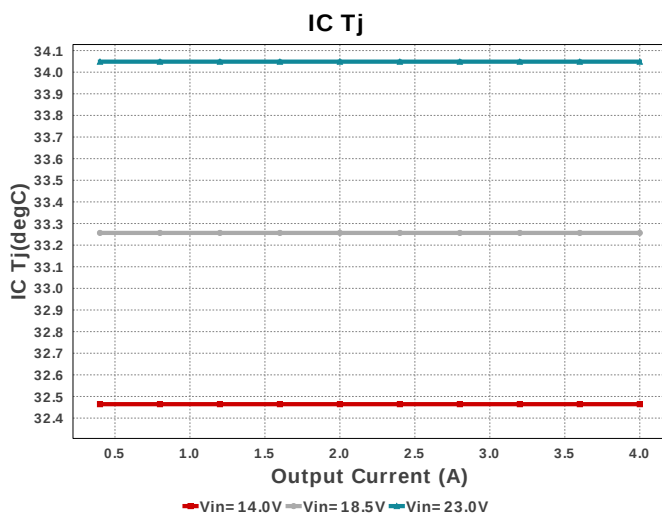
Design : 4 LM5022MM/NOPB
LM5022MM/NOPB 14V-23V to 24.00V @ 4A

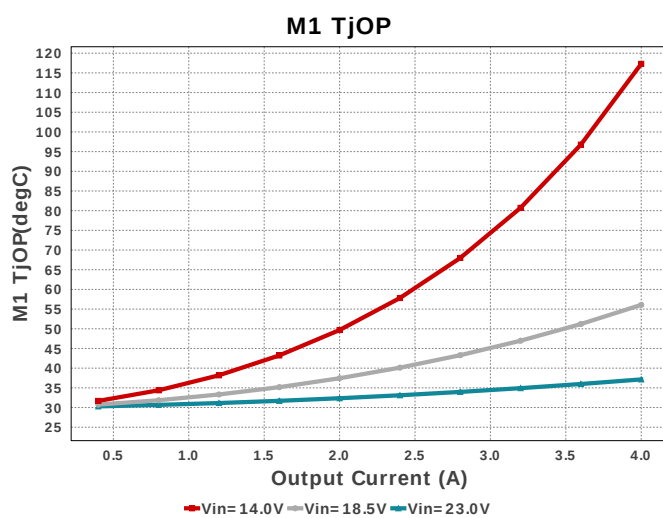
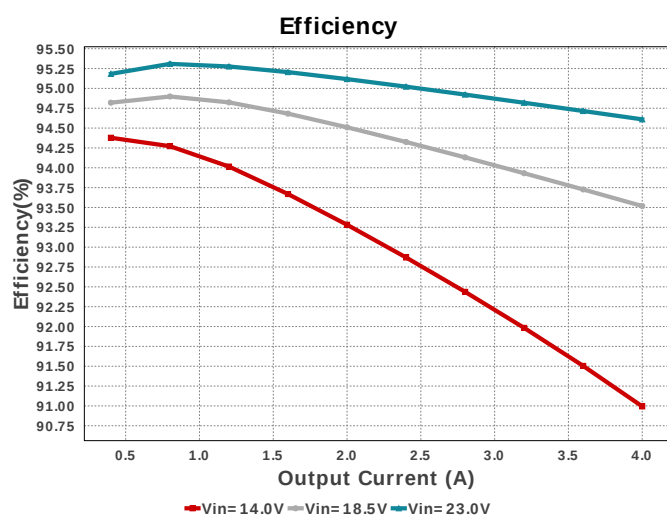
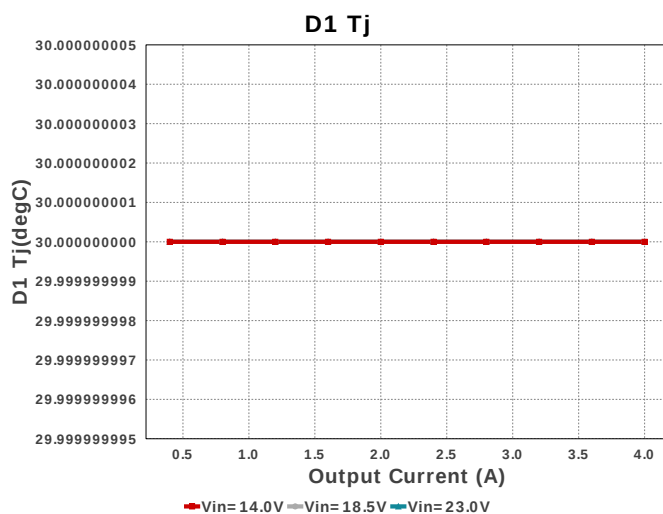
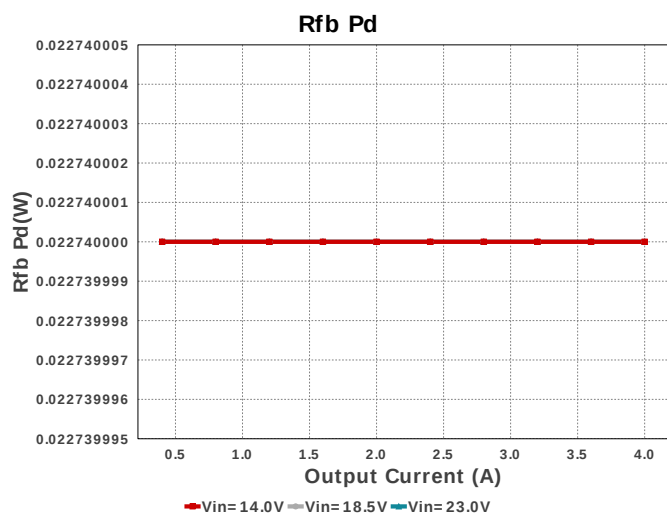
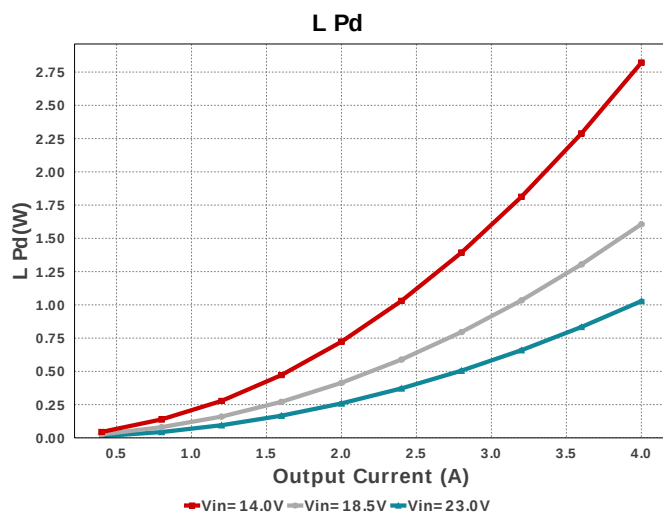
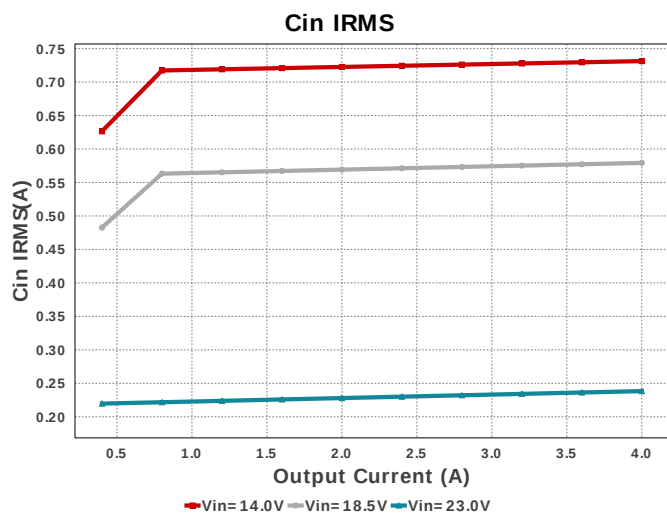


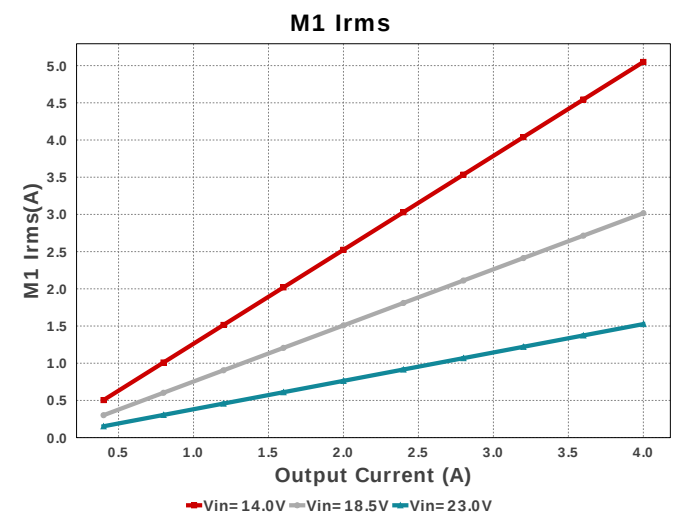
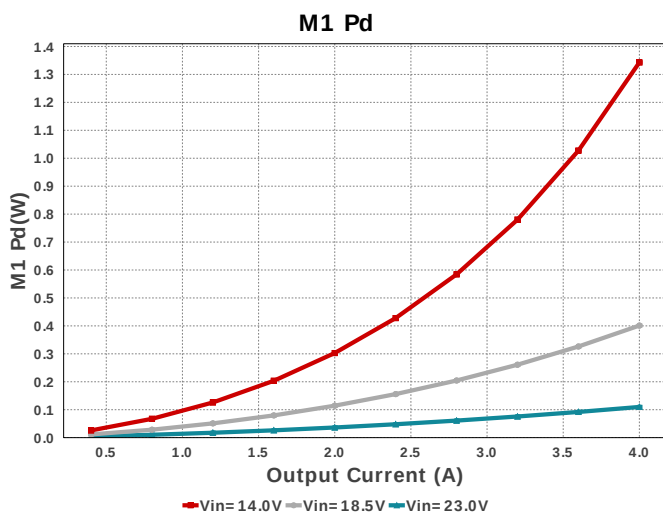
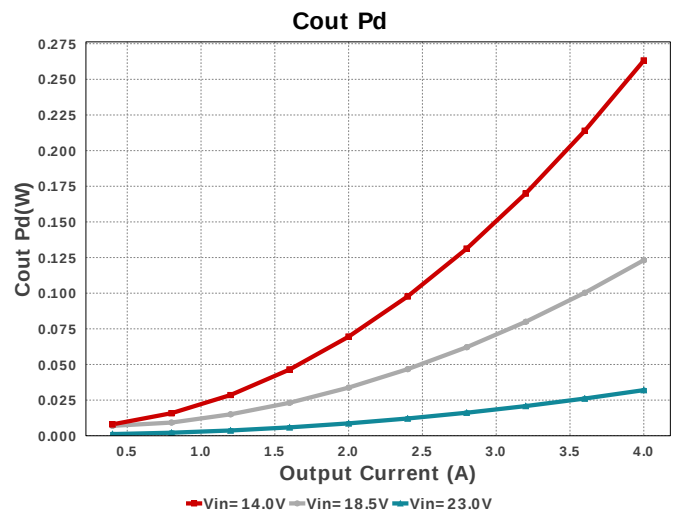
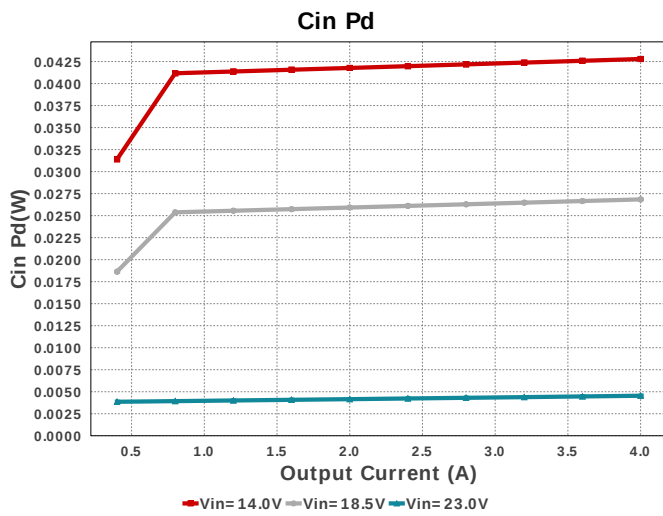
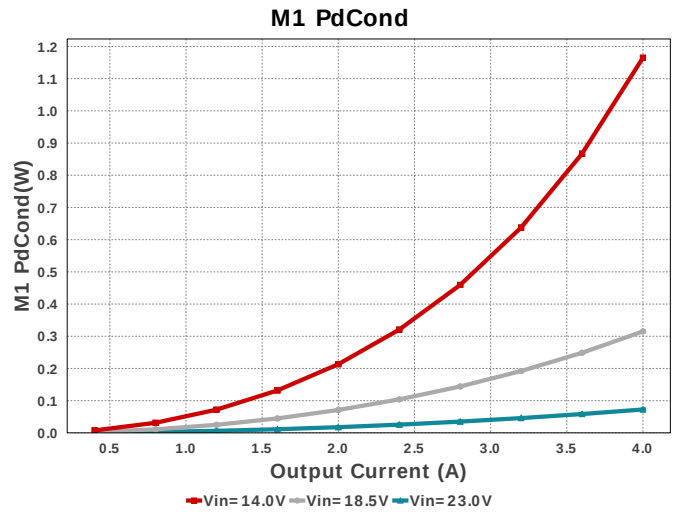
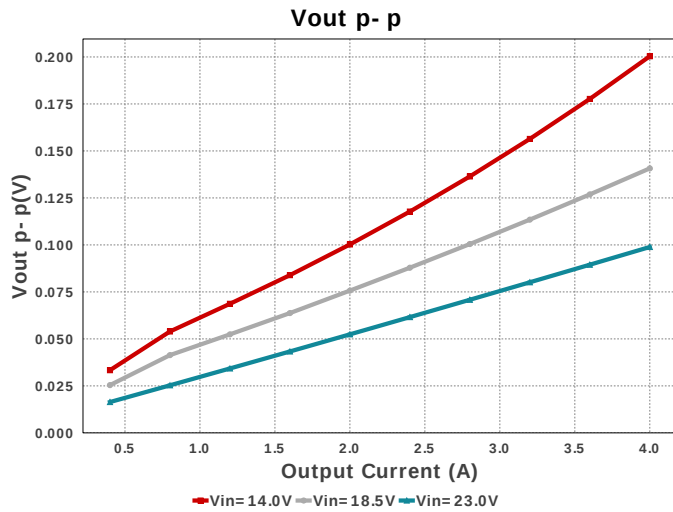
Electrical BOM

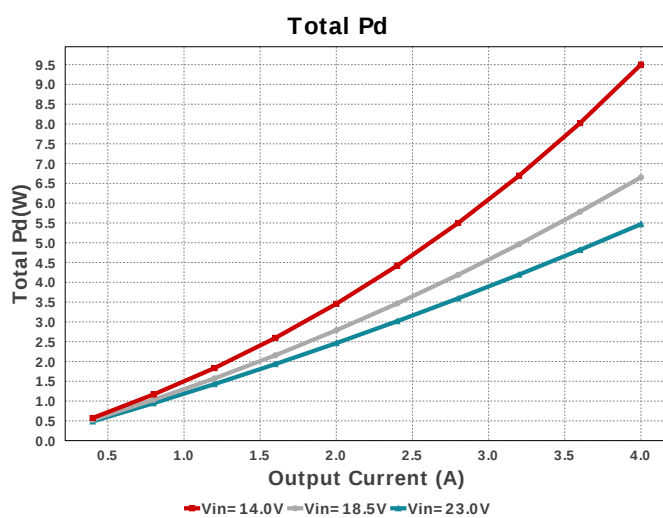
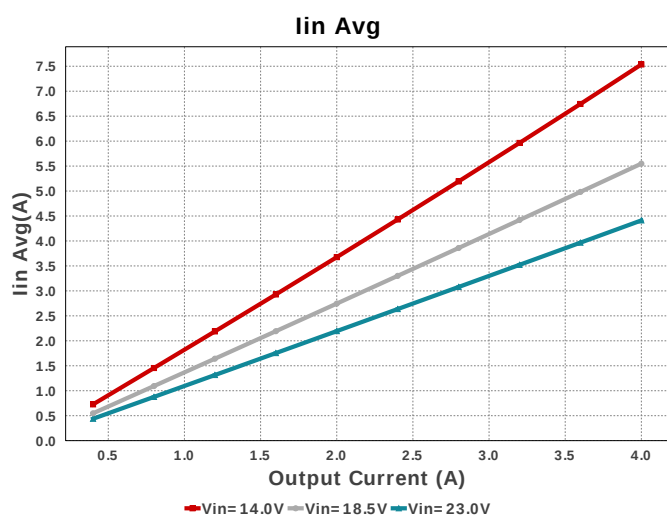
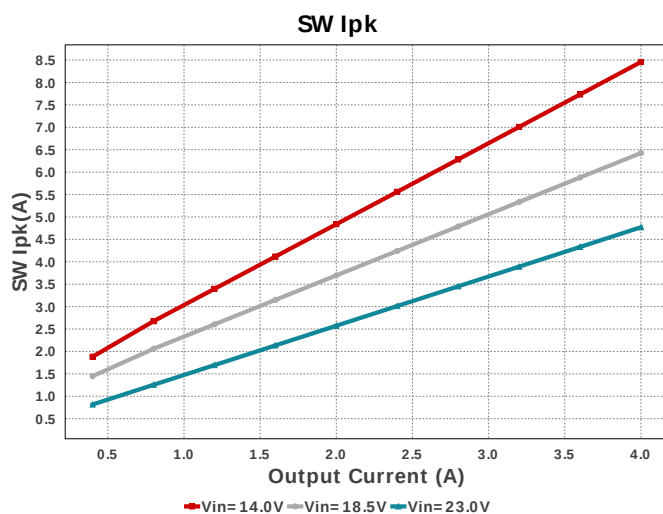
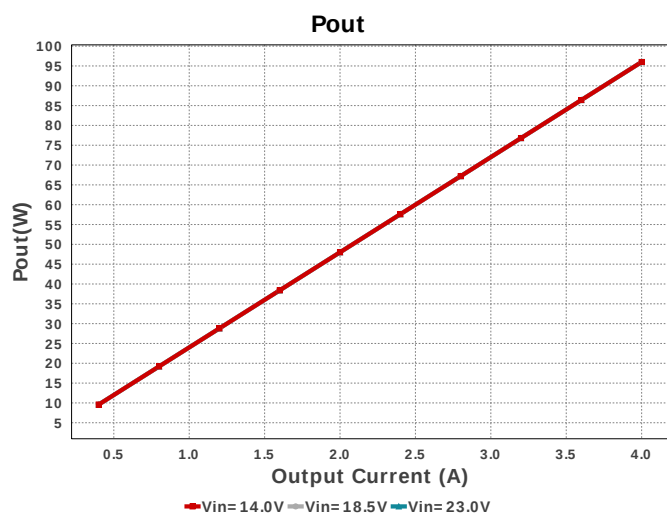
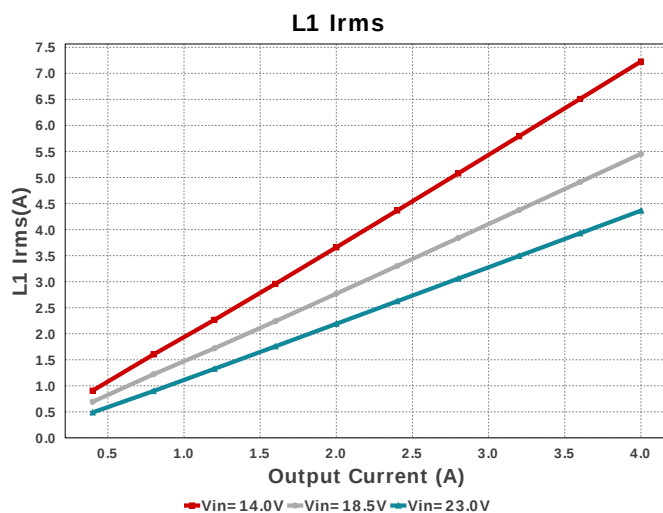
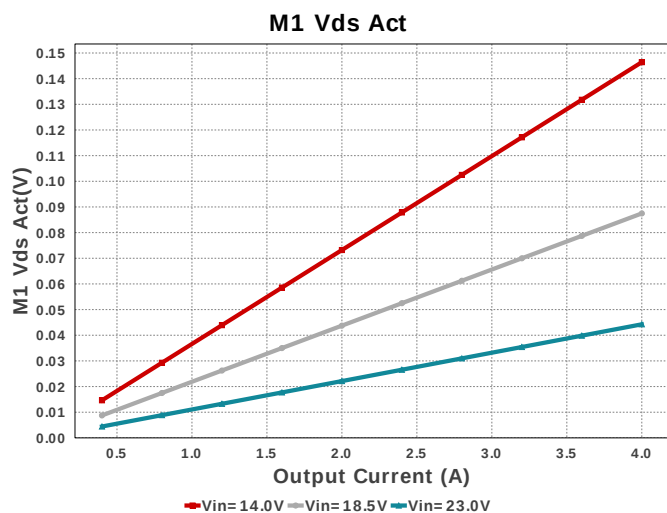
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbyp	Kemet	C0805C104M5RACTU Series= X7R	Cap= 100.0 nF ESR= 64.0 mOhm VDC= 50.0 V IRMS= 1.64 A	1	\$0.01	0805 7 mm ²
Ccomp	TDK	CGA4J2C0G1H333J125AA Series= C0G/NP0	Cap= 33.0 nF VDC= 50.0 V IRMS= 0.0 A	1	\$0.09	0805 7 mm ²
Ccomp2	MuRata	GRM1555C1H102JA01J Series= C0G/NP0	Cap= 1.0 nF VDC= 50.0 V IRMS= 0.0 A	1	\$0.01	0402 3 mm ²
Ccs	MuRata	GRM1555C1H102JA01J Series= C0G/NP0	Cap= 1.0 nF VDC= 50.0 V IRMS= 0.0 A	1	\$0.01	0402 3 mm ²
Cin	Panasonic	EEE-FK1V331P Series= FK	Cap= 330.0 uF ESR= 80.0 mOhm VDC= 35.0 V IRMS= 850.0 mA	1	\$0.23	SM_RADIAL_G 172 mm ²
Cinx	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
Cout	Panasonic	35SVPF82M Series= SVPF	Cap= 82.0 uF ESR= 20.0 mOhm VDC= 35.0 V IRMS= 4.0 A	1	\$0.63	CAPSMT_62_E12 106 mm ²
Cout1	TDK	C1005X5R1V105K050BC Series= X5R	Cap= 1.0 uF ESR= 11.416 mOhm VDC= 35.0 V IRMS= 1.483 A	1	\$0.03	0402 3 mm ²
Css	MuRata	GRM155R71E822KA01D Series= X7R	Cap= 8.2 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	\$0.01	0402 3 mm ²

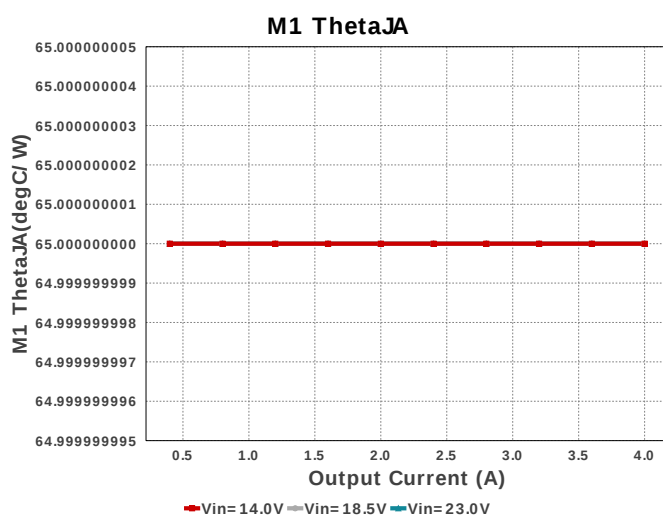
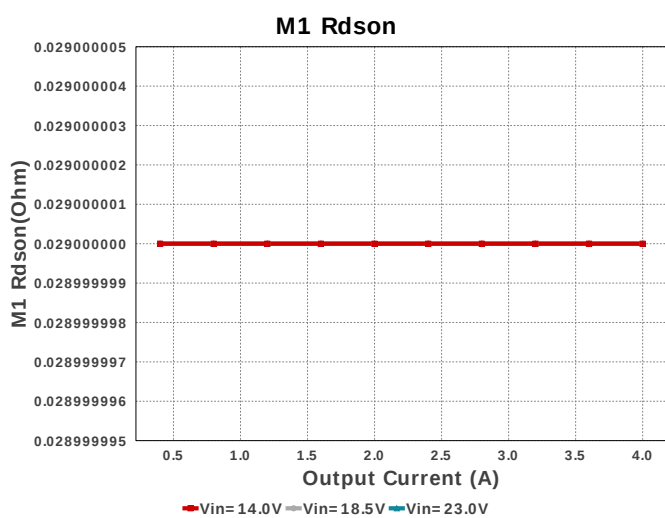
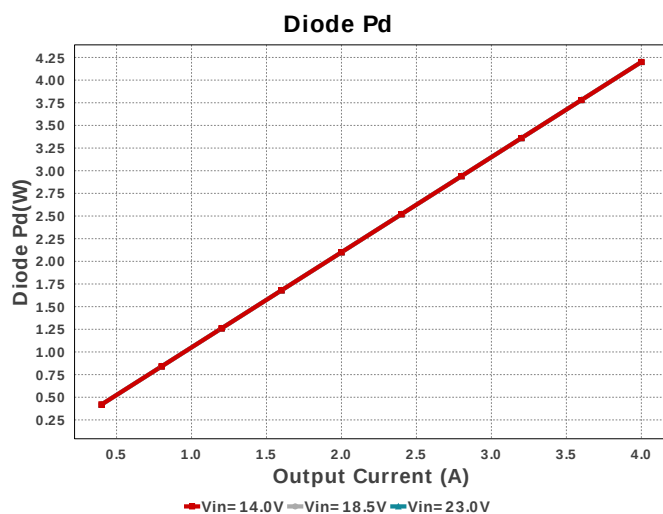
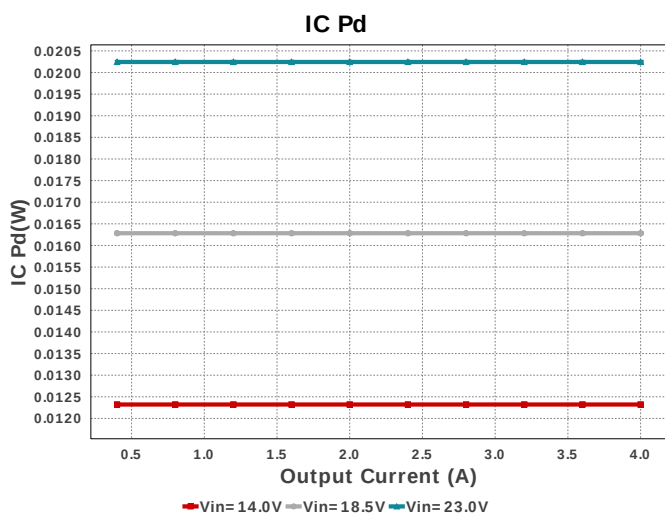
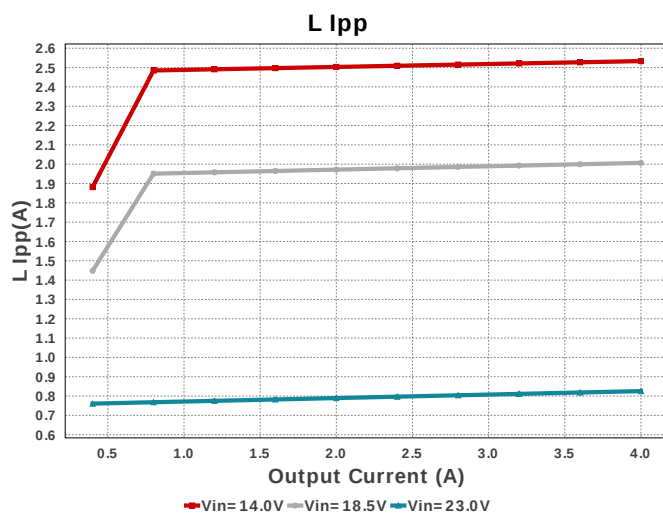
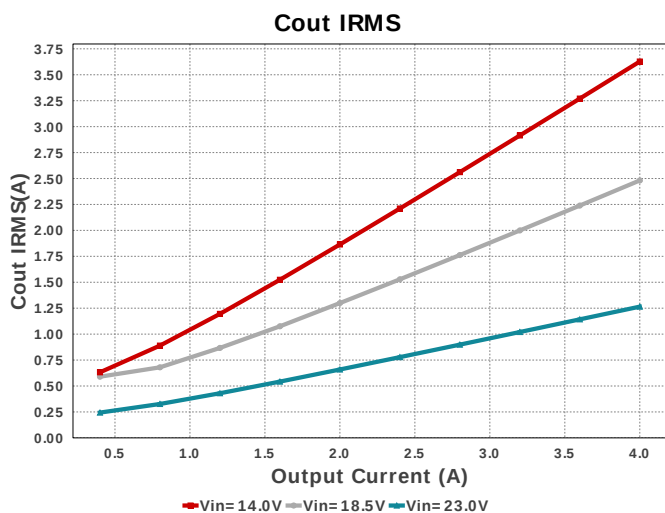
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
D1	SMC Diode Solutions	SB20150TR	VF@Io= 1.05 V VRRM= 150.0 V	1	\$0.20	 DO-201AD 166 mm ²
L1	Würth Elektronik	74437358082	L= 8.2 µH 45.0 mOhm	1	\$1.32	 WE-LHMI_8040 123 mm ²
M1	Texas Instruments	CSD17571Q2	VdsMax= 30.0 V IdsMax= 22.0 Amps	1	\$0.10	 DQK0006C 9 mm ²
Rcomp	Vishay-Dale	CRCW04021K27FKED Series= CRCW..e3	Res= 1.27 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
Rfb1	Vishay-Dale	CRCW04021K33FKED Series= CRCW..e3	Res= 1.33 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
Rfb2	Yageo	RC0603FR-0724KL Series= ?	Res= 24.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	\$0.01	 0603 5 mm ²
Rs1	Vishay-Dale	CRCW0402100RFKED Series= CRCW..e3	Res= 100.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
Rs2	Vishay-Dale	CRCW04023K57FKED Series= CRCW..e3	Res= 3.57 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
Rsns	Stackpole Electronics Inc	CSRN2010FK30L0 Series= ?	Res= 30.0 mOhm Power= 1.0 W Tolerance= 1.0%	1	\$0.16	 2010 32 mm ²
Rt	Yageo	RC0201FR-0756K2L Series= ?	Res= 56.2 kOhm Power= 50.0 mW Tolerance= 1.0%	1	\$0.01	 0201 2 mm ²
Ruv1	Vishay-Dale	CRCW04021K27FKED Series= CRCW..e3	Res= 1.27 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
Ruv2	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	\$0.01	 0201 2 mm ²
U1	Texas Instruments	LM5022MM/NOPB	Switcher	1	\$0.87	 MUB10A 24 mm ²

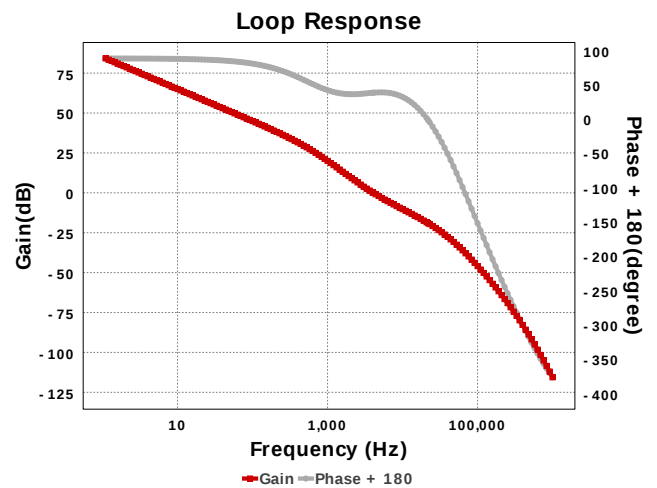
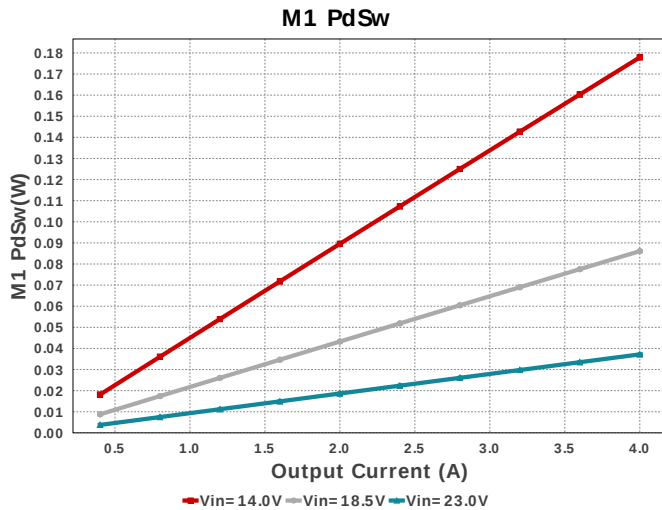












Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	809.961 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	52.483 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	3.636 A	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	264.48 mW	Capacitor	Output capacitor power dissipation
5.	D1 Tj	30.0 degC	Diode	D1 junction temperature
6.	Diode Pd	4.2 W	Diode	Diode power dissipation
7.	IC Pd	14.154 mW	IC	IC power dissipation
8.	IC Tj	32.831 degC	IC	IC junction temperature
9.	IC Tolerance	25.0 mV	IC	IC Feedback Tolerance
10.	ICThetaJA	200.0 degC/W	IC	IC junction-to-ambient thermal resistance
11.	Iin Avg	7.539 A	IC	Average input current
12.	L Ipp	2.806 A	Inductor	Peak-to-peak inductor ripple current
13.	L Pd	2.827 W	Inductor	Inductor power dissipation
14.	L1 Irms	7.236 A	Inductor	Inductor ripple current
15.	M1 Irms	5.038 A	Mosfet	M1 MOSFET Irms
16.	M1 Pd	1.371 W	Mosfet	M1 MOSFET total power dissipation
17.	M1 PdCond	1.169 W	Mosfet	M1 MOSFET conduction losses
18.	M1 PdSw	202.49 mW	Mosfet	M1 MOSFET switching losses
19.	M1 Rdson	29.0 mOhm	Mosfet	Drain-Source On-resistance
20.	M1 ThetaJA	65.0 degC/W	Mosfet	MOSFET junction-to-ambient thermal resistance
21.	M1 TJOP	119.12 degC	Mosfet	M1 MOSFET junction temperature
22.	Cin Pd	52.483 mW	Power	Input capacitor power dissipation
23.	Cout Pd	264.48 mW	Power	Output capacitor power dissipation
24.	Diode Pd	4.2 W	Power	Diode power dissipation
25.	IC Pd	14.154 mW	Power	IC power dissipation
26.	L Pd	2.827 W	Power	Inductor power dissipation
27.	M1 Pd	1.371 W	Power	M1 MOSFET total power dissipation
28.	M1 PdCond	1.169 W	Power	M1 MOSFET conduction losses
29.	M1 PdSw	202.49 mW	Power	M1 MOSFET switching losses
30.	Rfb Pd	22.74 mW	Power	Rfb Power Dissipation
31.	Total Pd	9.55 W	Power	Total Power Dissipation
32.	Rfb Pd	22.74 mW	Resistor	Rfb Power Dissipation
33.	BOM Count	22	System	Total Design BOM count
34.	Cross Freq	2.868 kHz	System	Bode plot crossover frequency
35.	Duty Cycle	46.893 %	System	Duty cycle
36.	Efficiency	90.952 %	System	Steady state efficiency
37.	FootPrint	686.0 mm ²	System	Total Foot Print Area of BOM components
38.	Frequency	275.0 kHz	System	Switching frequency
39.	Gain Marg	-21.11 dB	System	Bode Plot Gain Margin
40.	Iout	4.0 A	System	Iout operating point
41.	Low Freq Gain	79.506 dB	System	Gain at 1Hz
42.	Mode	CCM	System	Conduction Mode

#	Name	Value	Category	Description
43.	Phase Marg	38.432 deg	System Information	Bode Plot Phase Margin
44.	Pout	96.0 W	System Information	Total output power
45.	SW Ipk	8.593 A	System Information	Peak switch current
46.	Total BOM	\$3.76	System Information	Total BOM Cost
47.	Vin	14.0 V	System Information	Vin operating point
48.	Vout	24.0 V	System Information	Operational Output Voltage
49.	Vout Actual	23.997 V	System Information	Vout Actual calculated based on selected voltage divider resistors
50.	Vout Tolerance	3.936 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
51.	Vout p-p	206.032 mV	System Information	Peak-to-peak output ripple voltage
52.	M1 Vds Act	146.116 mV		M Vds

Design Inputs

Name	Value	Description
Iout	4.0	Maximum Output Current
VinMax	23.0	Maximum input voltage
VinMin	14.0	Minimum input voltage
Vout	24.0	Output Voltage
base_pn	LM5022	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

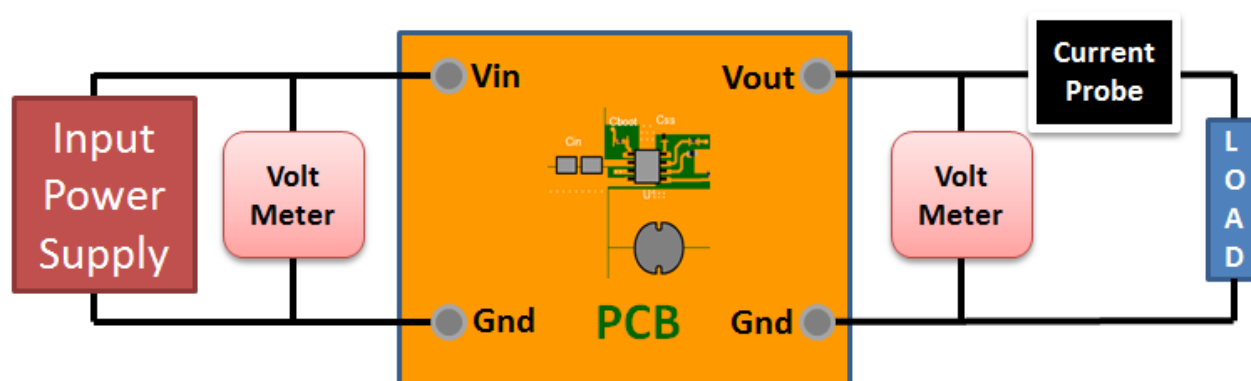
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 14.0V 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.



Design Assistance

1. Master key : 359A14B844FF66EF[v1]
2. **LM5022** Product Folder : <http://www.ti.com/product/LM5022> : contains the data sheet and other resources.

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