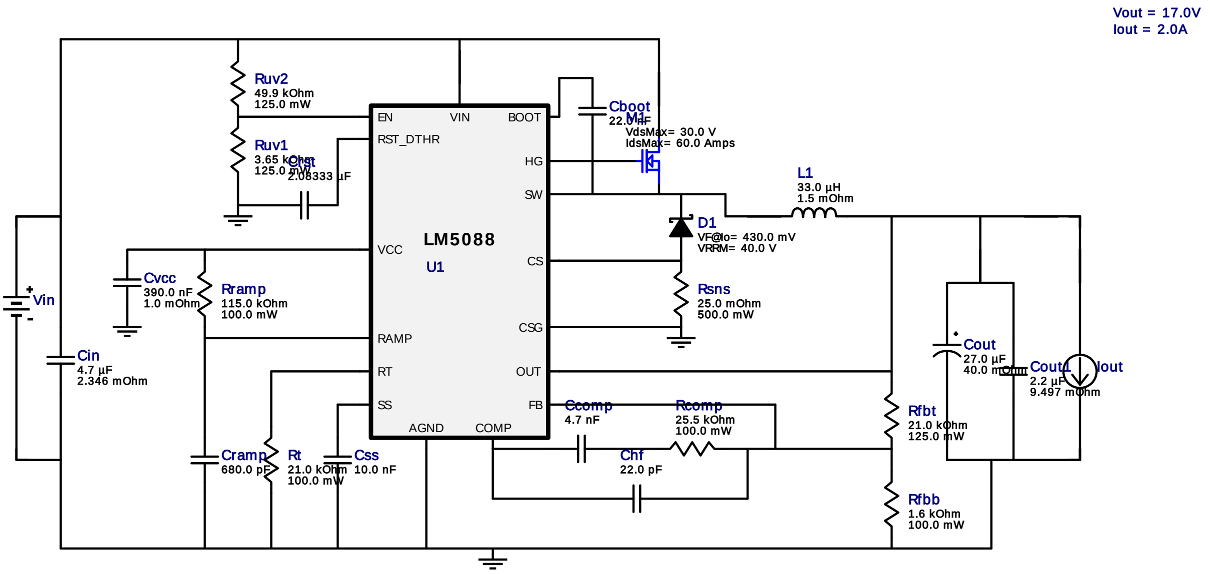
Texas Instruments

WEBENCH® Design Report

VinMin = 22.0V
VinMax = 24.0V
Vout = 17.0V
Iout = 2.0A

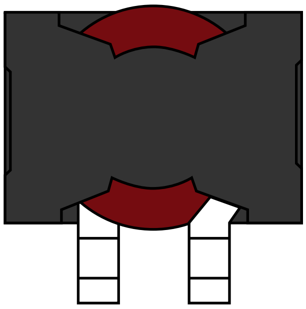
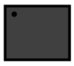
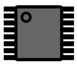
Device = LM5088MH-2/NOPB
Topology = Buck
Created = 2019-03-20 10:05:29.223
BOM Cost = NA
BOM Count = 22
Total Pd = 0.67W

Design : 86 LM5088MH-2/NOPB
LM5088MH-2/NOPB 22V-24V to 17.00V @ 2A

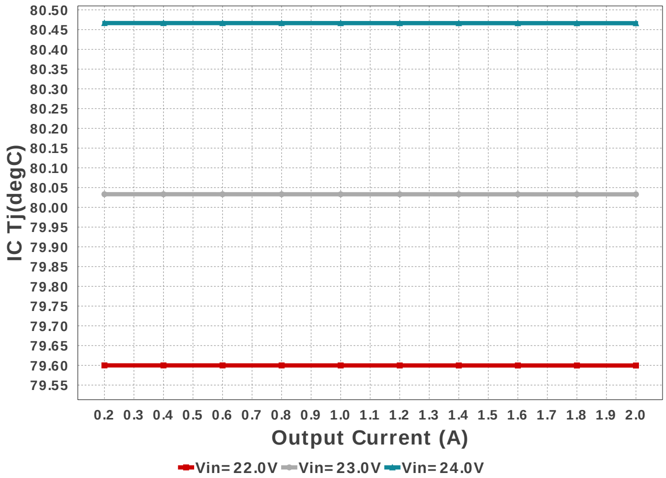


Electrical BOM

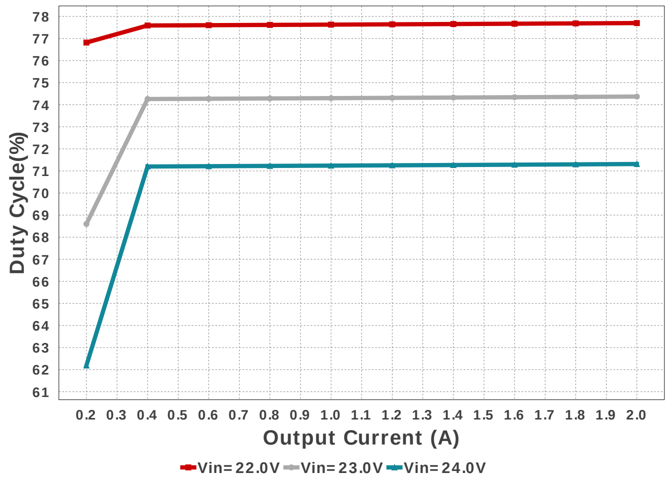
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	TDK	CGA4J2C0G1H223J125AA Series= C0G/NP0	Cap= 22.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.08	0805 7 mm²
Ccomp	TDK	CGA3E2C0G1H472J080AA Series= C0G/NP0	Cap= 4.7 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.05	0603 5 mm²
Chf	Samsung Electro-Mechanics	CL10C220JB8NNWC Series= C0G/NP0	Cap= 22.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Cin	TDK	C2012X6S1H475K125AC Series= X6S	Cap= 4.7 uF ESR= 2.346 mOhm VDC= 50.0 V IRMS= 4.2602 A	1	$0.19	0805 7 mm²
Cout	Panasonic	25SVPF27MX Series= SVPF	Cap= 27.0 uF ESR= 40.0 mOhm VDC= 25.0 V IRMS= 2.45 A	1	$0.36	CAPSMT_62_E61 53 mm²
Cout1	MuRata	GRM219R61E225KA12D Series= X5R	Cap= 2.2 uF ESR= 9.497 mOhm VDC= 25.0 V IRMS= 1.40815 A	1	$0.11	0805 7 mm²
Cramp	Samsung Electro-Mechanics	CL10C681JB8NFNC Series= C0G/NP0	Cap= 680.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Crst	CUSTOM	CUSTOM Series= ?	Cap= 2.08333 uF VDC= 0.0 V IRMS= 0.0 A	1	NA	CUSTOM 0 mm²
Css	Samsung Electro-Mechanics	CL10C103JA8NNNC Series= C0G/NP0	Cap= 10.0 nF VDC= 25.0 V IRMS= 0.0 A	1	$0.06	0603 5 mm²

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cvcc	MuRata	GRM188R61A394KA61D Series= X5R	Cap= 390.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.03	0603 5 mm^2
D1	ON Semiconductor	MBRS2040LT3G	VF@Io= 430.0 mV VRRM= 40.0 V	1	$0.10	 SMB 44 mm^2
L1	Coilcraft	SER2915L-333KL	L= 33.0 µH 1.5 mOhm	1	$1.88	 SER2915L 652 mm^2
M1	Texas Instruments	CSD17577Q5A	VdsMax= 30.0 V IdsMax= 60.0 Amps	1	$0.23	 TRANS_NexFET_Q5A 55 mm^2
Rcomp	Vishay-Dale	CRCW060325K5FKEA Series= CRCW..e3	Res= 25.5 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rfbb	Yageo	RC0603FR-071K6L Series= ?	Res= 1.6 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rfbt	Vishay-Dale	CRCW080521K0FKEA Series= CRCW..e3	Res= 21.0 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Rramp	Yageo	RC0603FR-07115KL Series= ?	Res= 115.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rsns	Stackpole Electronics Inc	CSR1206FK25L0 Series= ?	Res= 25.0 mOhm Power= 500.0 mW Tolerance= 1.0%	1	$0.10	 1206 11 mm^2
Rt	Vishay-Dale	CRCW060321K0FKEA Series= CRCW..e3	Res= 21.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rt	Vishay-Dale	CRCW060321K0FKEA Series= CRCW..e3	Res= 21.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Ruv1	Panasonic	ERJ-6ENF3651V Series= ERJ-6E	Res= 3.65 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Ruv2	Vishay-Dale	CRCW080549K9FKEA Series= CRCW..e3	Res= 49.9 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
U1	Texas Instruments	LM5088MH-2/NOPB	Switcher	1	$1.76	 MXA16A 59 mm^2

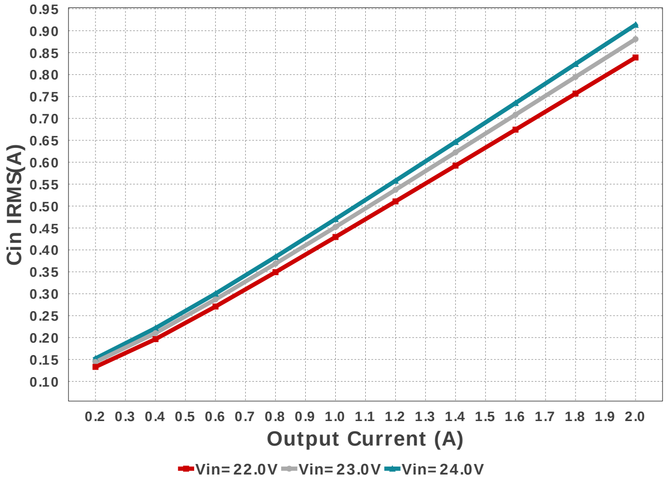
IC Tj



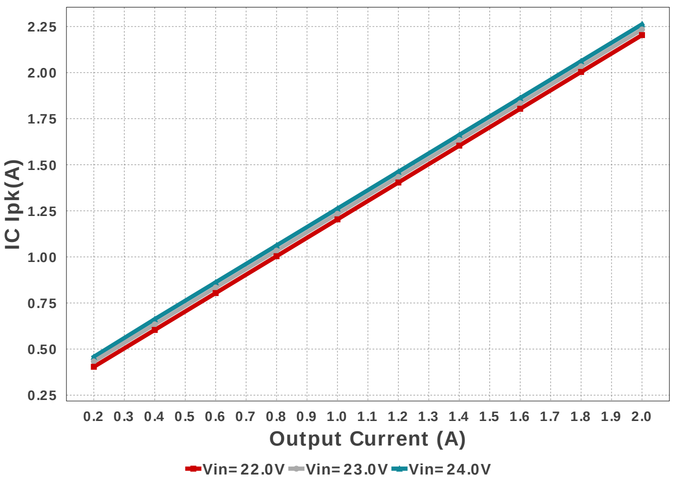
Duty Cycle



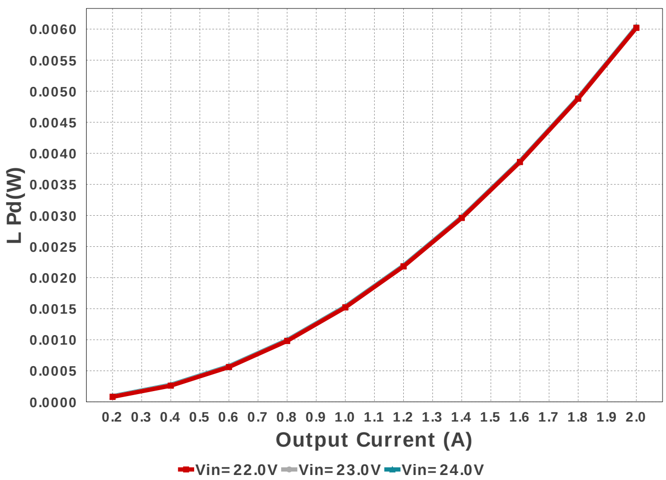
Cin IRMS



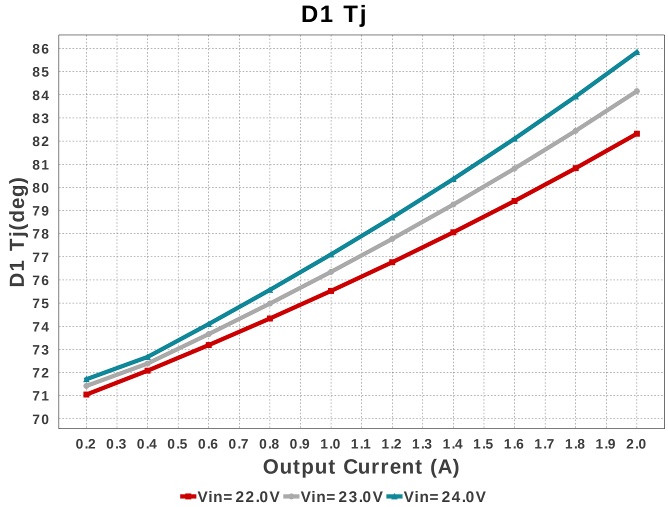
IC Ipk

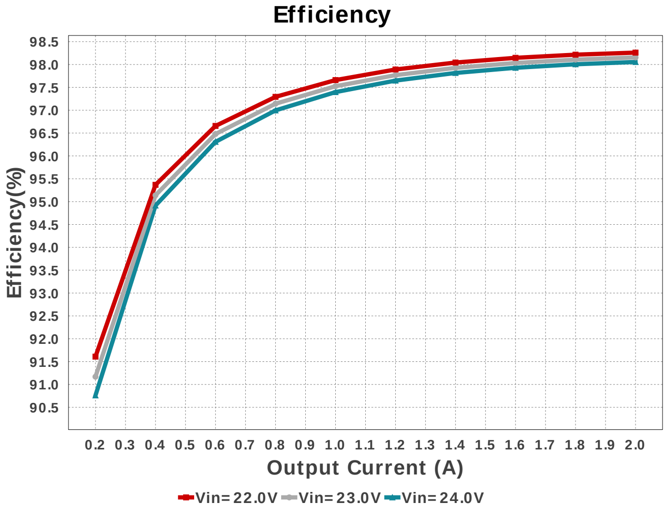


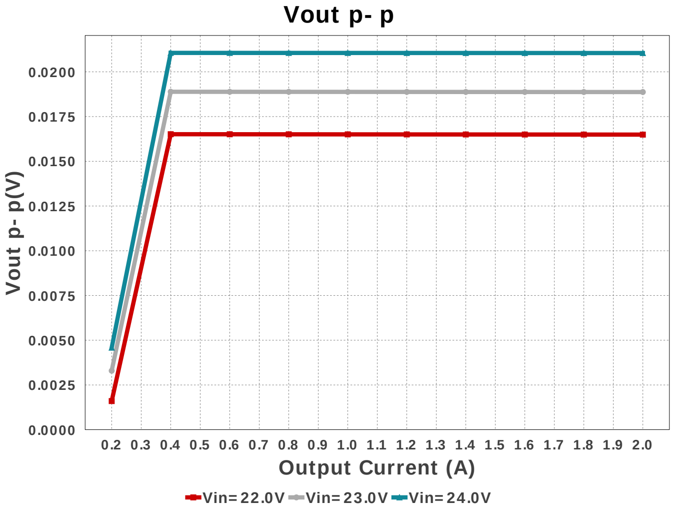
L Pd

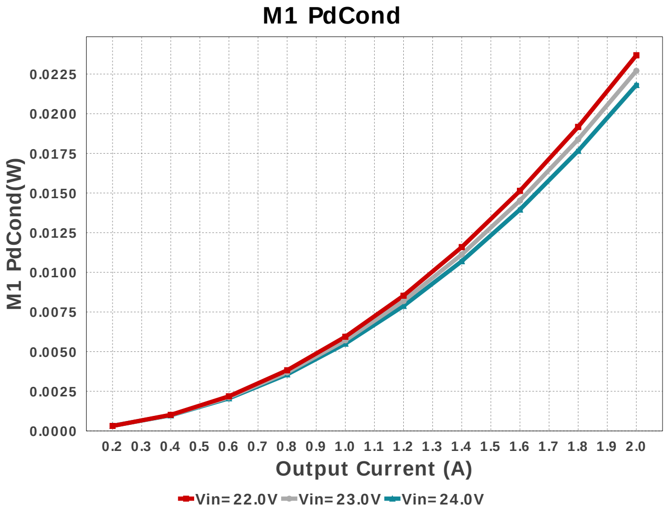


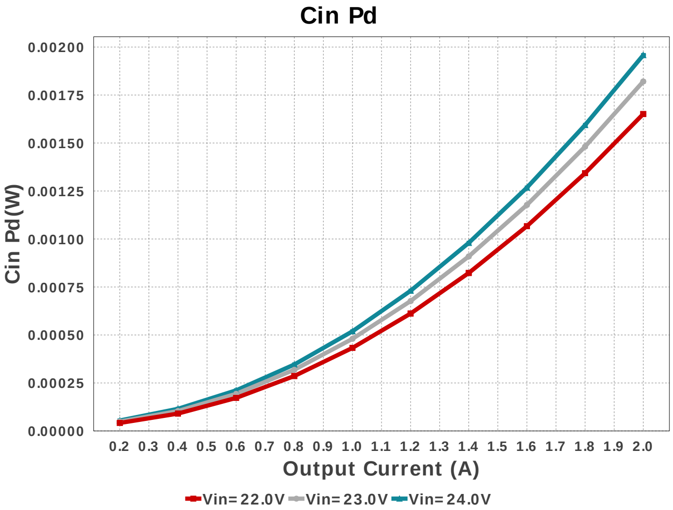
D1 Tj

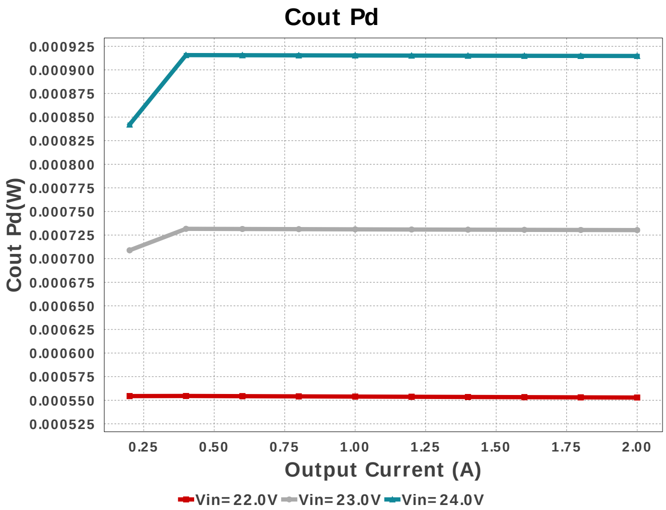


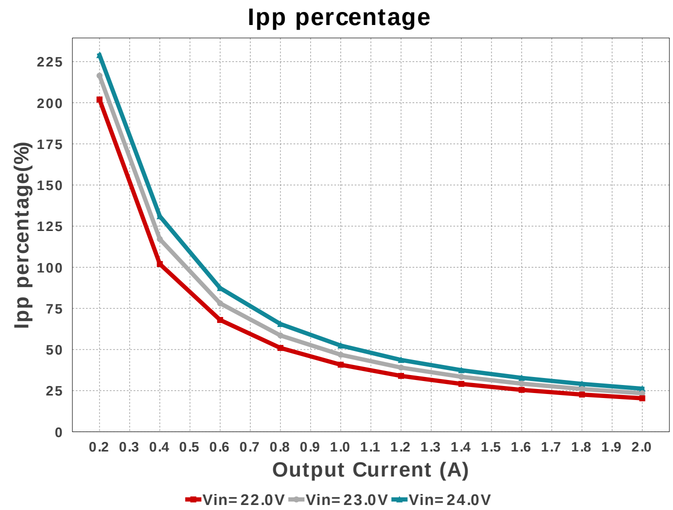

Efficiency
Efficiency(%)
Output Current (A)
Vin=22.0V Vin=23.0V Vin=24.0V


Vout p-p
Vout p-p(V)
Output Current (A)
Vin=22.0V Vin=23.0V Vin=24.0V

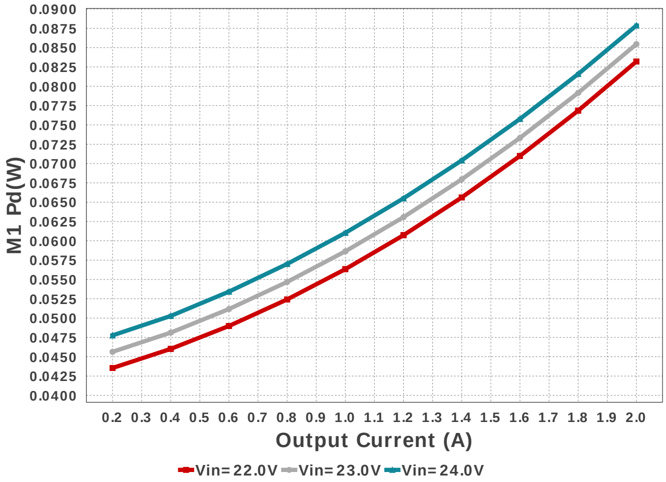

M1 PdCond
M1 PdCond(W)
Output Current (A)
Vin=22.0V Vin=23.0V Vin=24.0V


Cin Pd
Cin Pd(W)
Output Current (A)
Vin=22.0V Vin=23.0V Vin=24.0V

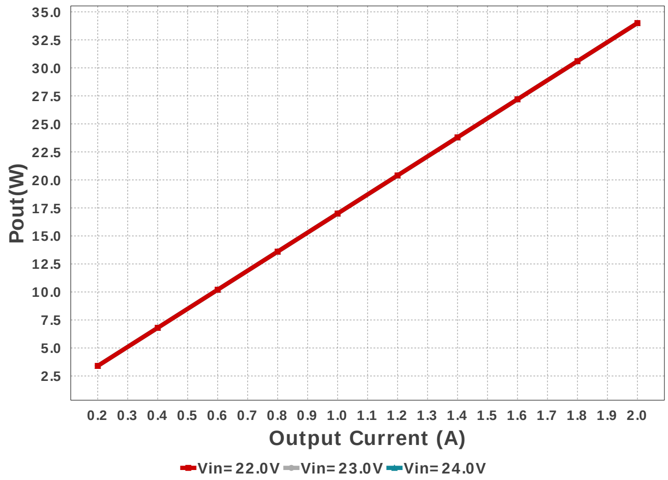

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=22.0V Vin=23.0V Vin=24.0V


Ipp percentage
Ipp percentage(%)
Output Current (A)
Vin=22.0V Vin=23.0V Vin=24.0V

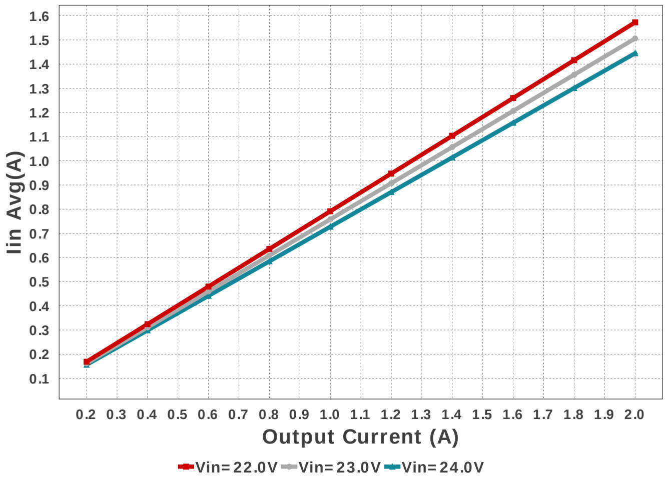
M1 Pd



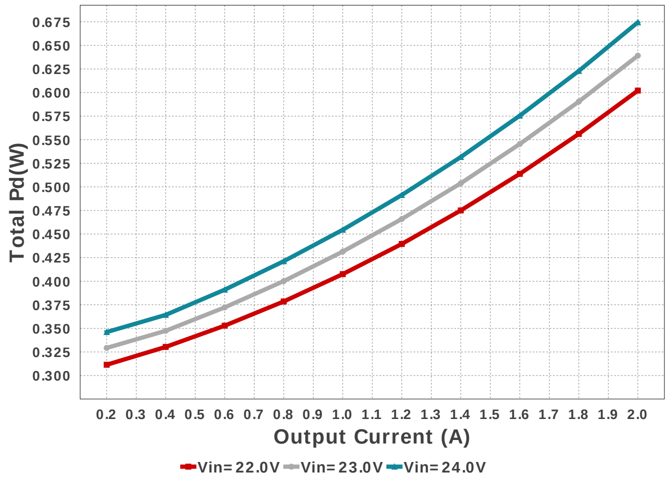
Pout



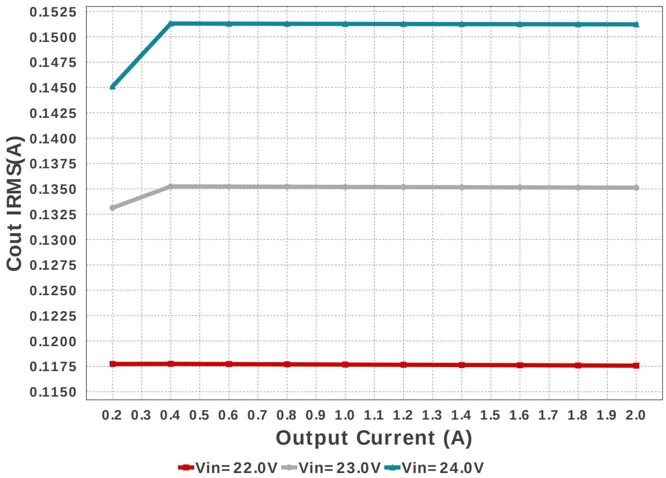
Iin Avg



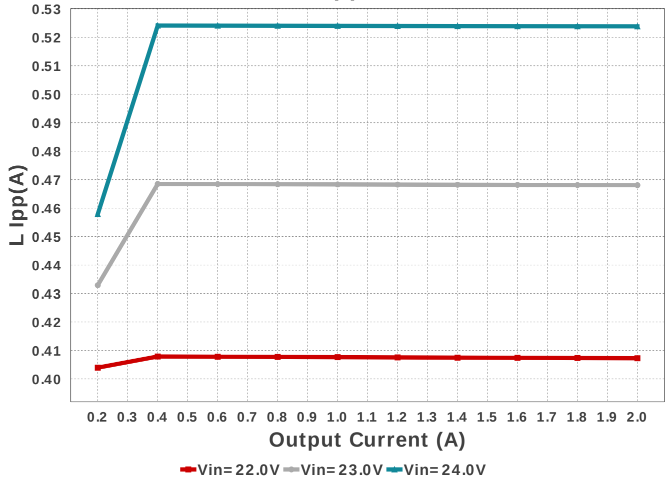
Total Pd

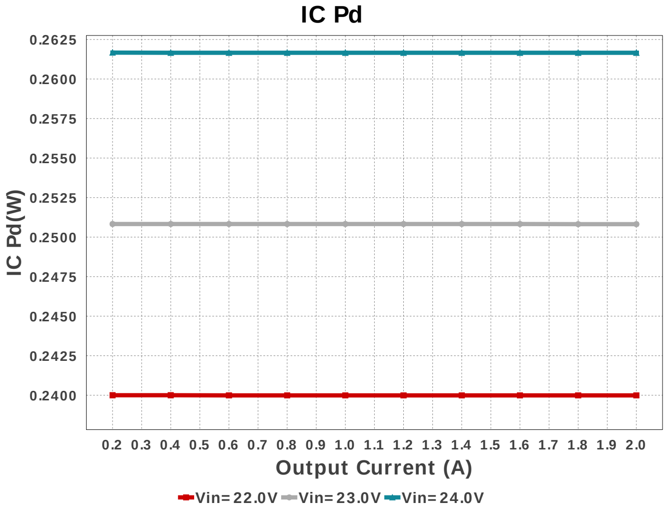


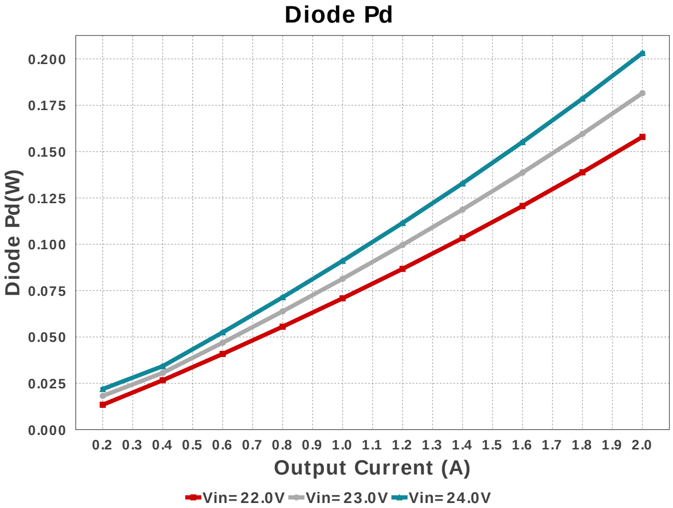
Cout IRMS

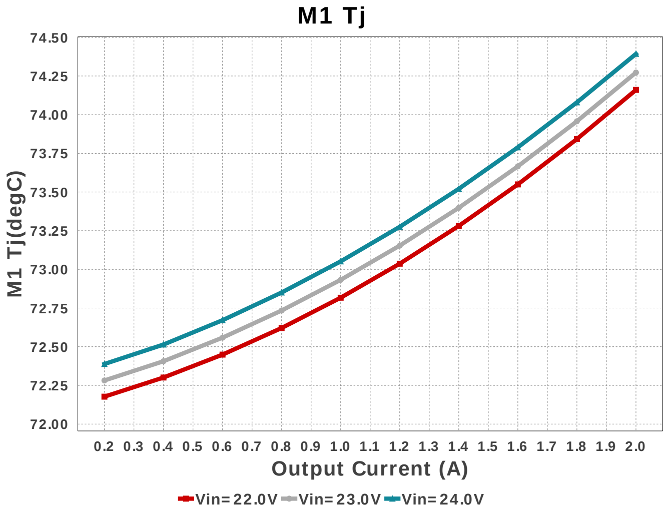


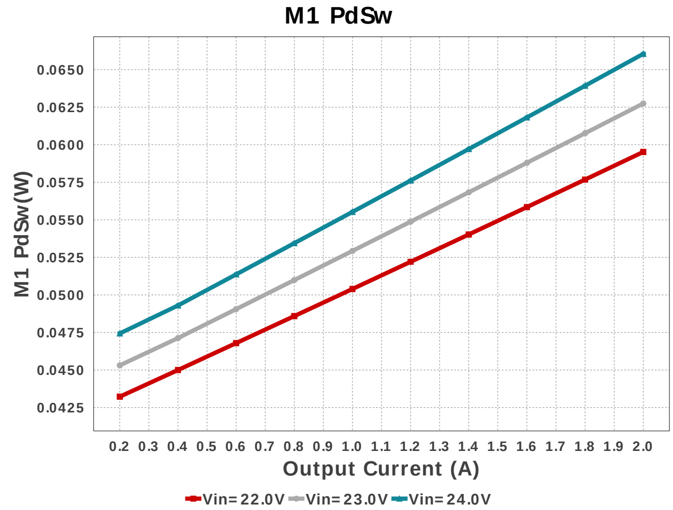
L Ipp











Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	913.559 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	1.958 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	151.223 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	914.73 µW	Capacitor	Output capacitor power dissipation
5.	D1 Tj	85.845 deg	Diode	D1 junction temperature
6.	Diode Pd	203.14 mW	Diode	Diode power dissipation
7.	IC Ipk	2.262 A	IC	Peak switch current in IC
8.	IC Pd	261.66 mW	IC	IC power dissipation
9.	IC Tj	80.466 degC	IC	IC junction temperature
10.	IC Tolerance	18.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA	40.0 degC/W	IC	IC junction-to-ambient thermal resistance
12.	Iin Avg	1.445 A	IC	Average input current
13.	Ipp percentage	26.193 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
14.	L Ipp	523.853 mA	Inductor	Peak-to-peak inductor ripple current
15.	L Pd	6.034 mW	Inductor	Inductor power dissipation
16.	M1 Pd	97.179 mW	Mosfet	M1 MOSFET total power dissipation
17.	M1 PdCond	21.859 mW	Mosfet	M1 MOSFET conduction losses
18.	M1 PdSw	75.32 mW	Mosfet	M1 MOSFET switching losses
19.	M1 Tj	74.393 degC	Mosfet	M1 MOSFET junction temperature
20.	Cin Pd	1.958 mW	Power	Input capacitor power dissipation
21.	Cout Pd	914.74 µW	Power	Output capacitor power dissipation
22.	Diode Pd	203.15 mW	Power	Diode power dissipation
23.	IC Pd	261.66 mW	Power	IC power dissipation
24.	L Pd	6.034 mW	Power	Inductor power dissipation
25.	M1 Pd	87.858 mW	Power	M1 MOSFET total power dissipation
26.	M1 PdCond	21.811 mW	Power	M1 MOSFET conduction losses
27.	M1 PdSw	66.047 mW	Power	M1 MOSFET switching losses
28.	Total Pd	674.433 mW	Power	Total Power Dissipation
29.	BOM Count	22	System Information	Total Design BOM count

#	Name	Value	Category	Description
30.	Duty Cycle	71.314 %	System Information	Duty cycle
31.	Efficiency	98.055 %	System Information	Steady state efficiency
32.	FootPrint	962.0 mm^2	System Information	Total Foot Print Area of BOM components
33.	Frequency	288.018 kHz	System Information	Switching frequency
34.	Iout	2.0 A	System Information	Iout operating point
35.	Mode	CCM	System Information	Conduction Mode
36.	Pout	34.0 W	System Information	Total output power
37.	Total BOM	NA	System Information	Total BOM Cost
38.	Vin	24.0 V	System Information	Vin operating point
39.	Vout	17.0 V	System Information	Operational Output Voltage
40.	Vout Actual	17.303 V	System Information	Vout Actual calculated based on selected voltage divider resistors
41.	Vout Tolerance	3.374 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
42.	Vout p-p	21.052 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	2.0	Maximum Output Current
VinMax	24.0	Maximum input voltage
VinMin	22.0	Minimum input voltage
Vout	17.0	Output Voltage
base_pn	LM5088	Base Product Number
source	DC	Input Source Type
Ta	70.0	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

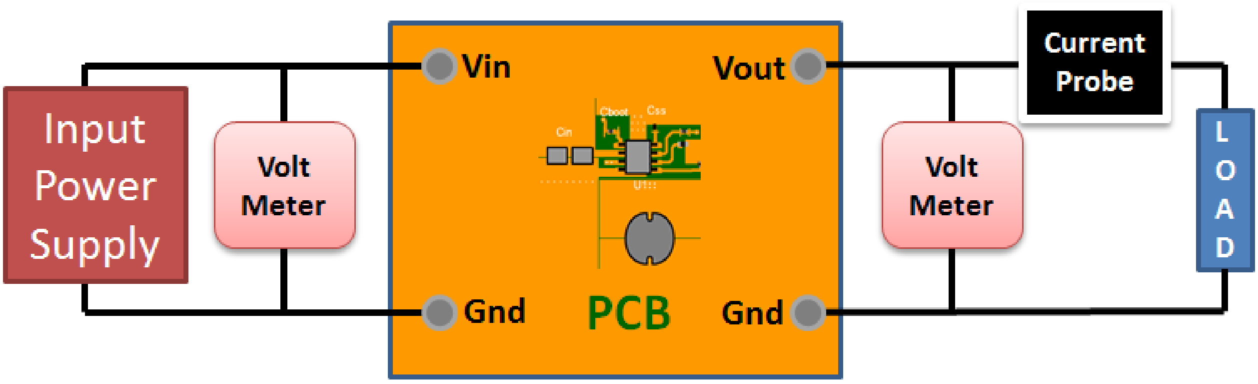
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 22.0V 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 : 12D4263C7BDF7440[v1]

2. **LM5088** Product Folder : http://www.ti.com/product/LM5088 : contains the data sheet and other resources.

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