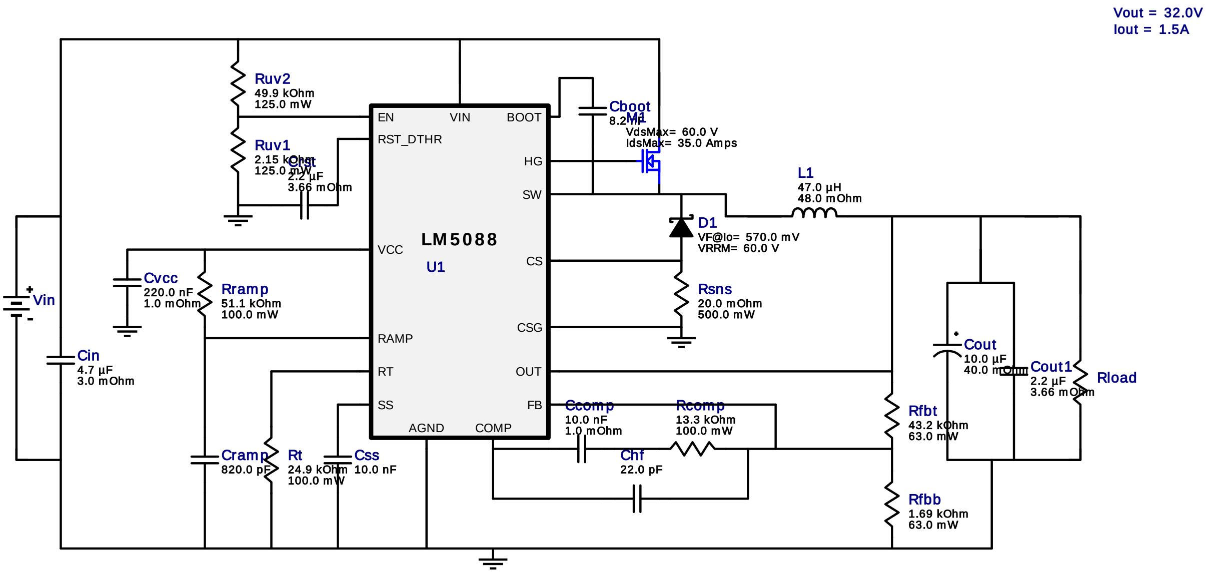
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 36.0V
VinMax = 36.0V
Vout = 32.0V
Iout = 1.5A

Device = LM5088MH-2/NOPB
Topology = Buck
Created = 2024-07-02 06:02:20.029
BOM Cost = $4.03
BOM Count = 22
Total Pd = 0.51W

Design : 190 LM5088MH-2/NOPB
LM5088MH-2/NOPB modified_adc_36V-36V to 32.00V @ 1.5A



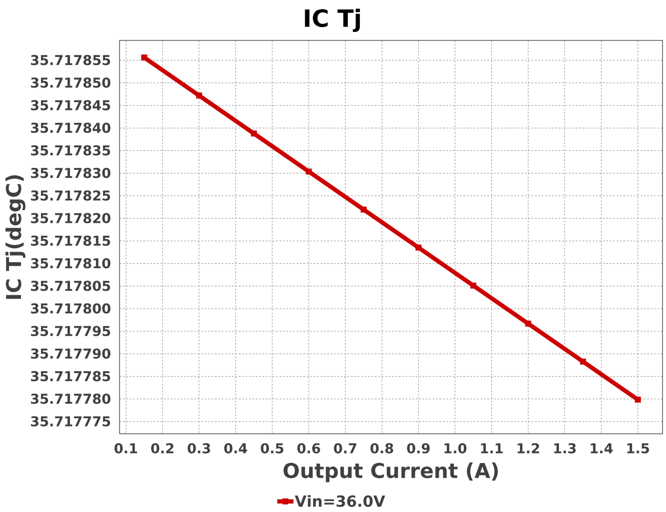
Electrical BOM

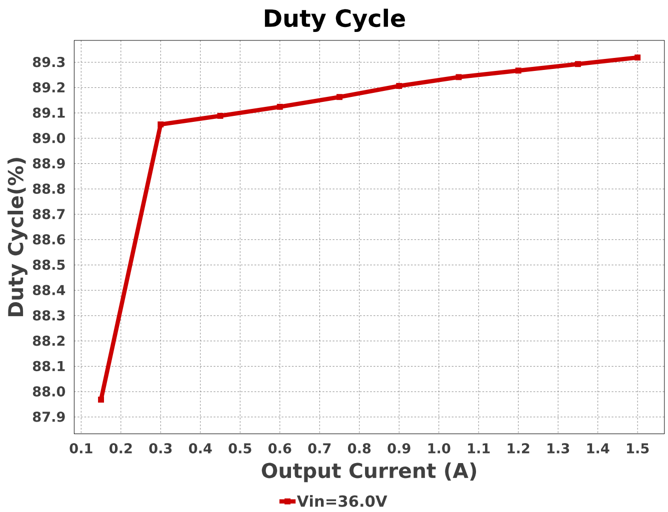
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	TDK	CGA3E2C0G1H822J080AA Series= C0G/NP0	Cap= 8.2 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.05	0603 5 mm²
Ccomp	Kemet	C0603C103K5RACTU Series= X7R	Cap= 10.0 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Chf	Samsung Electro-Mechanics	CL10C220JB8NNNC Series= C0G/NP0	Cap= 22.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Cin	MuRata	GRM31CR71H475KA12L Series= X7R	Cap= 4.7 uF ESR= 3.0 mOhm VDC= 50.0 V IRMS= 4.98 A	1	$0.10	1206 11 mm²
Cout	Panasonic	50SVPF10M Series= SVPF	Cap= 10.0 uF ESR= 40.0 mOhm VDC= 50.0 V IRMS= 2.5 A	1	$0.59	CAPSMT_62_F61 74 mm²
Cout1	TDK	C2012X5R1H225K125AB Series= X5R	Cap= 2.2 uF ESR= 3.66 mOhm VDC= 50.0 V IRMS= 3.4121 A	1	$0.13	0805 7 mm²
Cramp	Samsung Electro-Mechanics	CL10C821JB8NNNC Series= C0G/NP0	Cap= 820.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.02	0603 5 mm²
Crst	TDK	C2012X5R1H225K125AB Series= X5R	Cap= 2.2 uF ESR= 3.66 mOhm VDC= 50.0 V IRMS= 3.4121 A	1	$0.13	0805 7 mm²

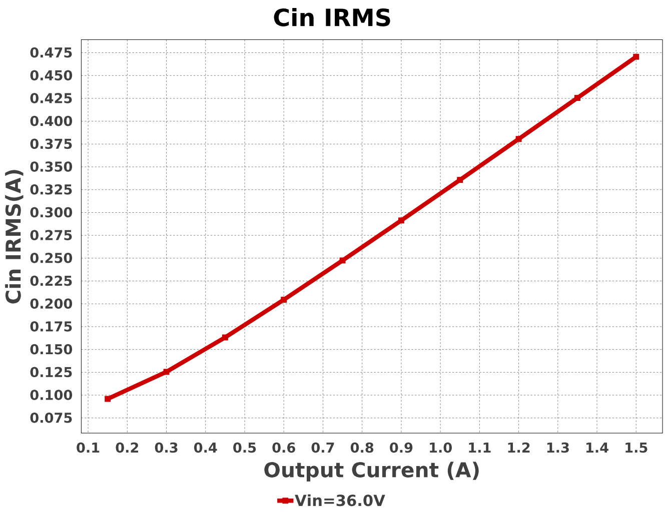
Copyright © 2024, Texas Instruments Incorporated

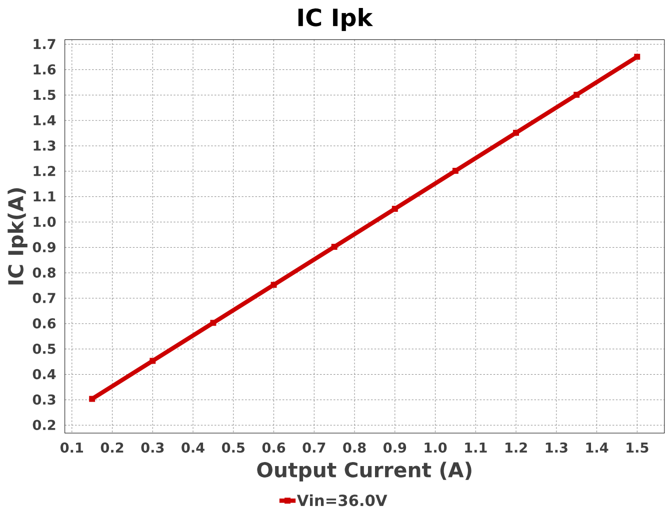
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Css	Samsung Electro-Mechanics	CL10C103JA8NNNC Series= C0G/NP0	Cap= 10.0 nF VDC= 25.0 V IRMS= 0.0 A	1	$0.04	0603 5 mm^2
Cvcc	Kemet	C0603C224Z4VACTU Series= Y5V	Cap= 220.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2
D1	Nexperia	PMEG6010CEH,115	VF@Io= 570.0 mV VRRM= 60.0 V	1	$0.04	SOD-123F 12 mm^2
L1	Coilcraft	MSS1210-473MEB	L= 47.0 µH 48.0 mOhm	1	$0.81	MSS1210 204 mm^2
M1	Texas Instruments	CSD18543Q3A	VdsMax= 60.0 V IdsMax= 35.0 Amps	1	$0.21	DNH0008A 18 mm^2
Rcomp	Vishay-Dale	CRCW060313K3FKEA Series= CRCW..e3	Res= 13.3 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rfbb	Vishay-Dale	CRCW04021K69FKED Series= CRCW..e3	Res= 1.69 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt	Vishay-Dale	CRCW040243K2FKED Series= CRCW..e3	Res= 43.2 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rramp	Vishay-Dale	CRCW060351K1FKEA Series= CRCW..e3	Res= 51.1 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rsns	Stackpole Electronics Inc	CSR1206FK20L0 Series= ?	Res= 20.0 mOhm Power= 500.0 mW Tolerance= 1.0%	1	$0.10	1206 11 mm^2
Rt	Vishay-Dale	CRCW060324K9FKEA Series= CRCW..e3	Res= 24.9 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rt	Vishay-Dale	CRCW060324K9FKEA Series= CRCW..e3	Res= 24.9 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Ruv1	Vishay-Dale	CRCW08052K15FKEA Series= CRCW..e3	Res= 2.15 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	$1.71	MXA16A 59 mm^2

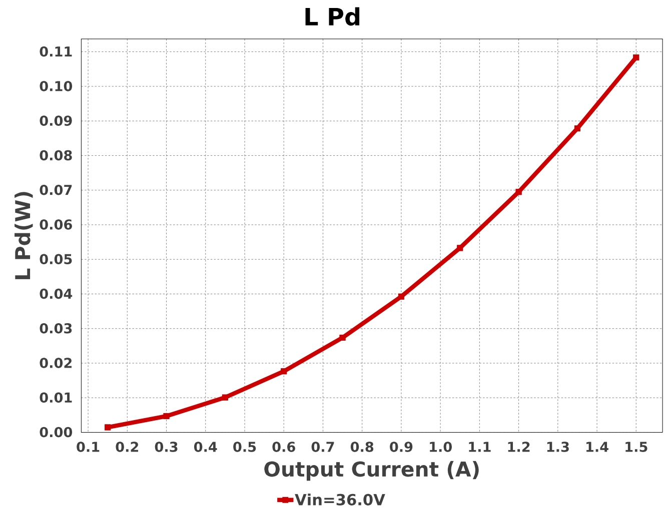
Copyright © 2024, Texas Instruments Incorporated

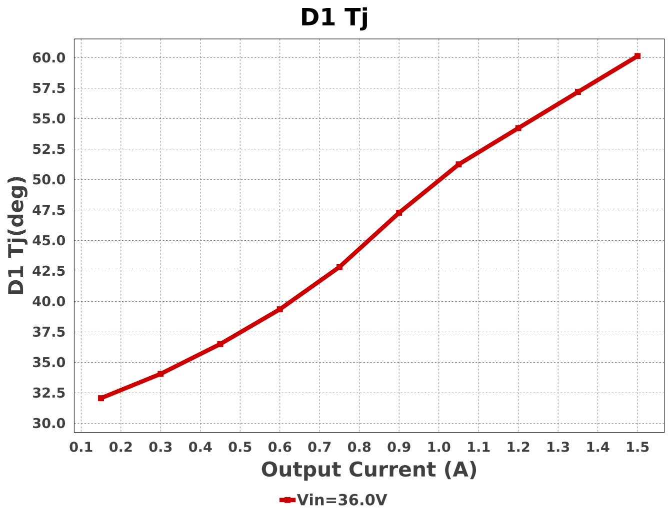

IC Tj
IC Tj(degC)
Output Current (A)
Vin=36.0V

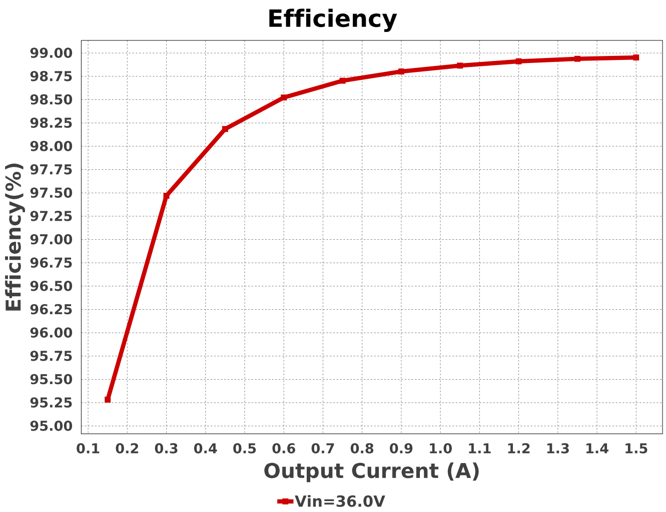

Duty Cycle
Duty Cycle(%)
Output Current (A)
Vin=36.0V

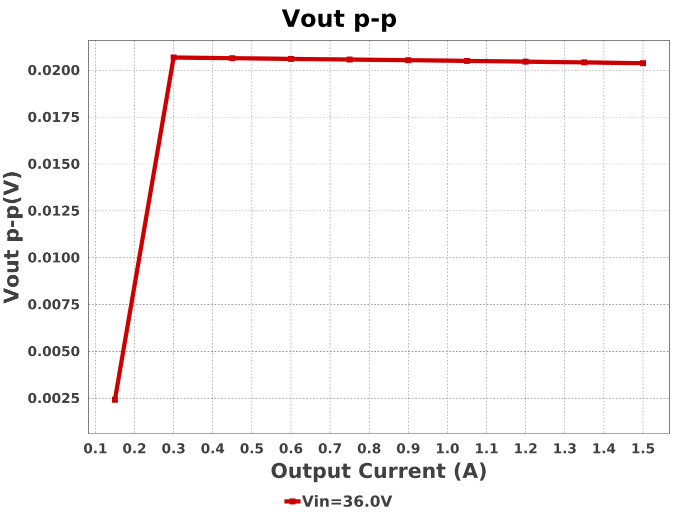

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=36.0V

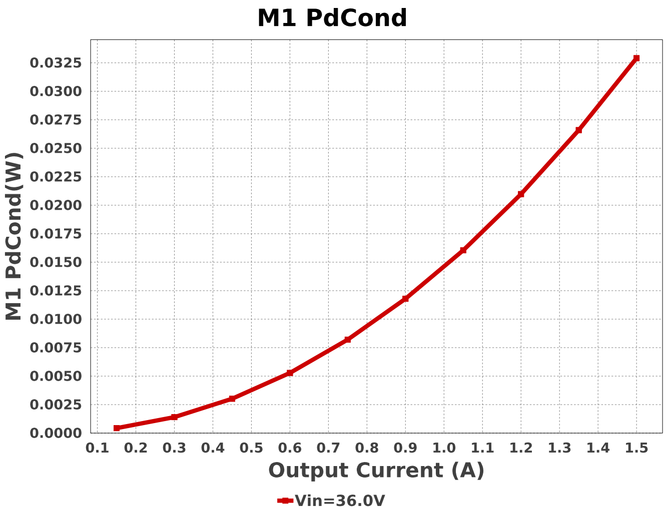

IC Ipk
IC Ipk(A)
Output Current (A)
Vin=36.0V

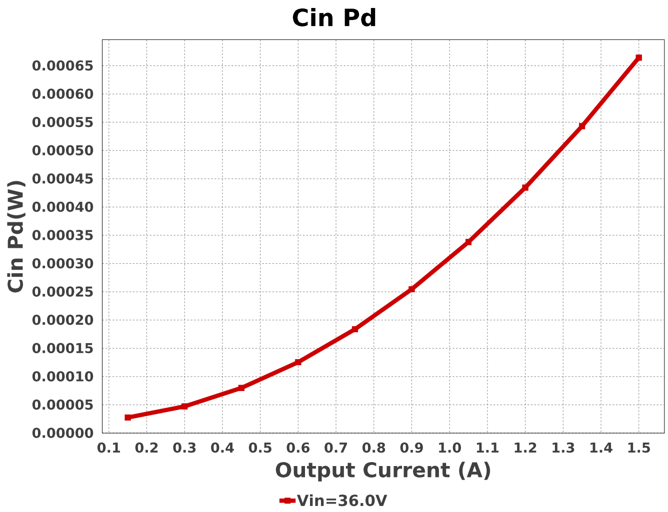

L Pd
L Pd(W)
Output Current (A)
Vin=36.0V

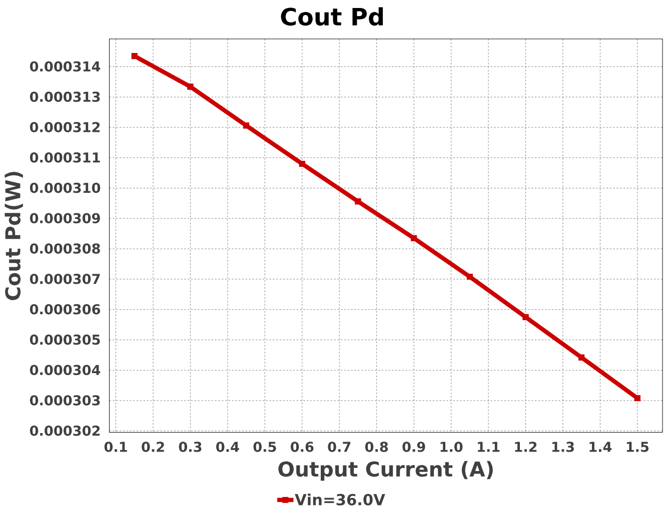

D1 Tj
D1 Tj(deg)
Output Current (A)
Vin=36.0V

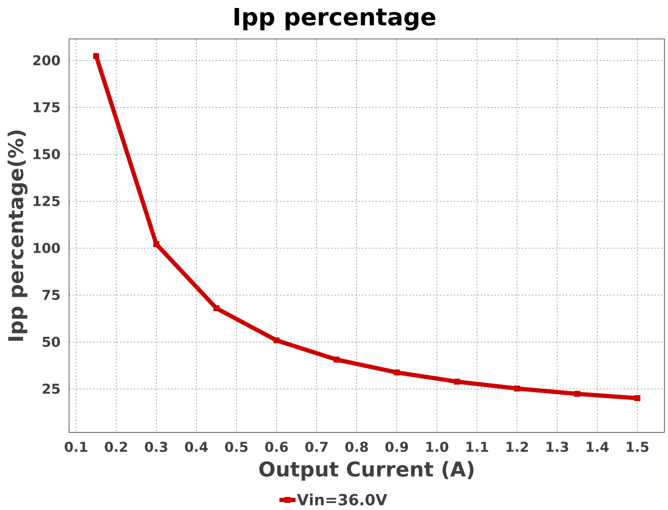

Efficiency
Efficiency(%)
Output Current (A)
Vin=36.0V


Vout p-p
Vout p-p(V)
Output Current (A)
Vin=36.0V

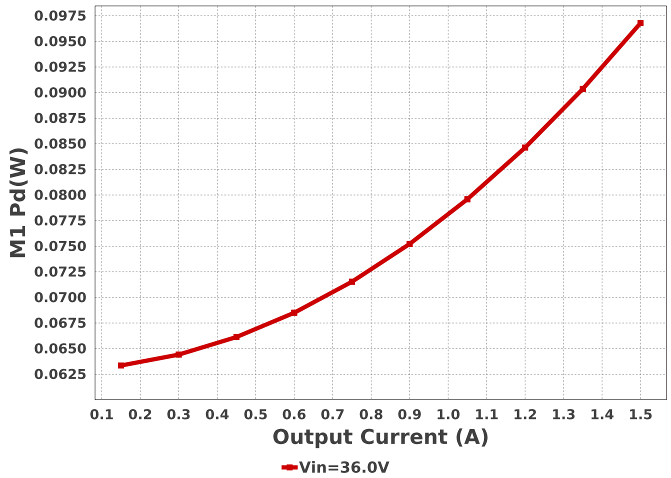

M1 PdCond
M1 PdCond(W)
Output Current (A)
Vin=36.0V


Cin Pd
Cin Pd(W)
Output Current (A)
Vin=36.0V

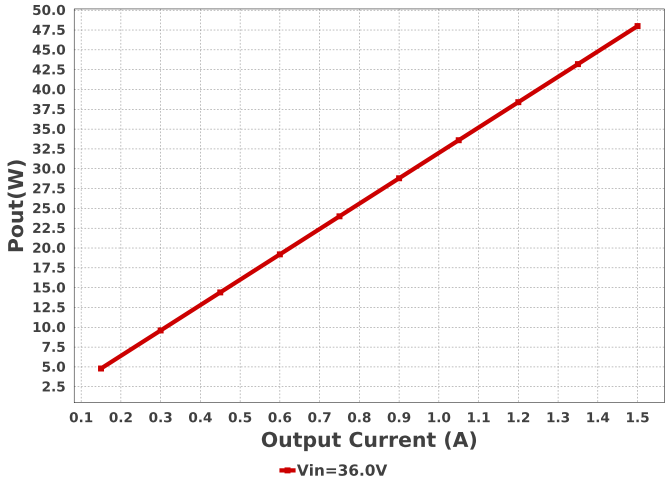

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=36.0V


Ipp percentage
Ipp percentage(%)
Output Current (A)
Vin=36.0V

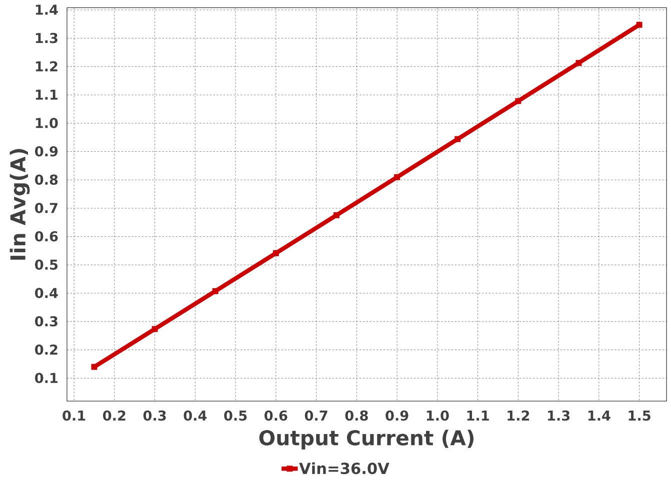
M1 Pd



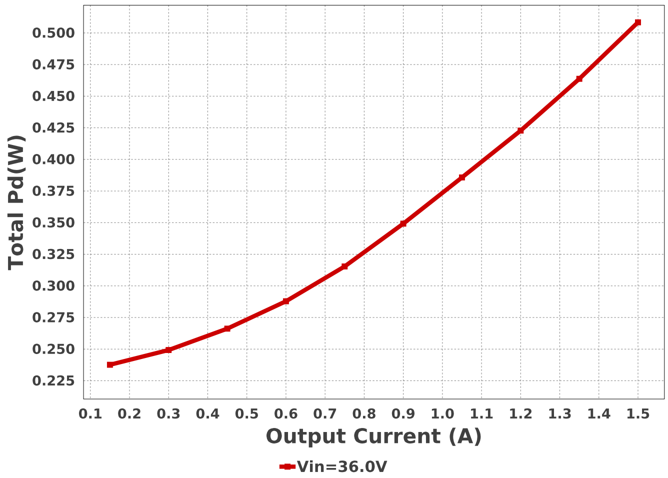
Pout



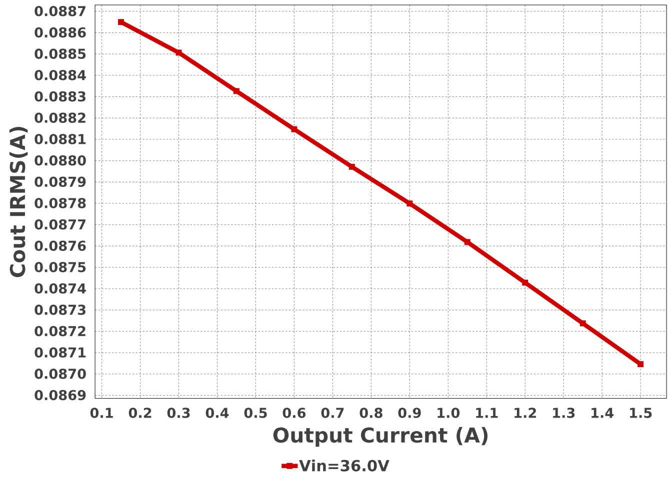
Iin Avg



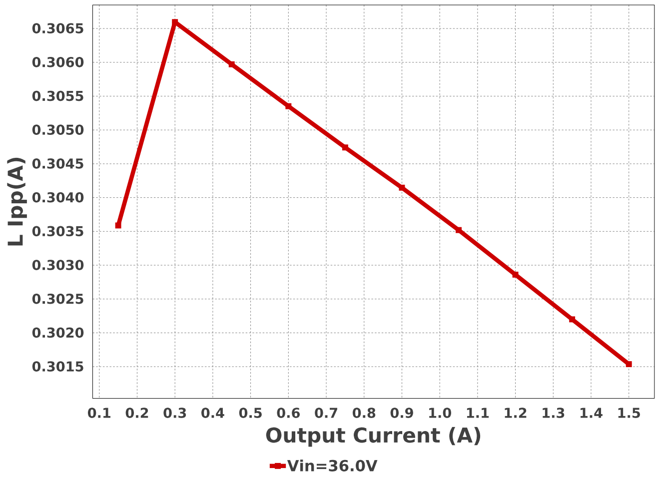
Total Pd



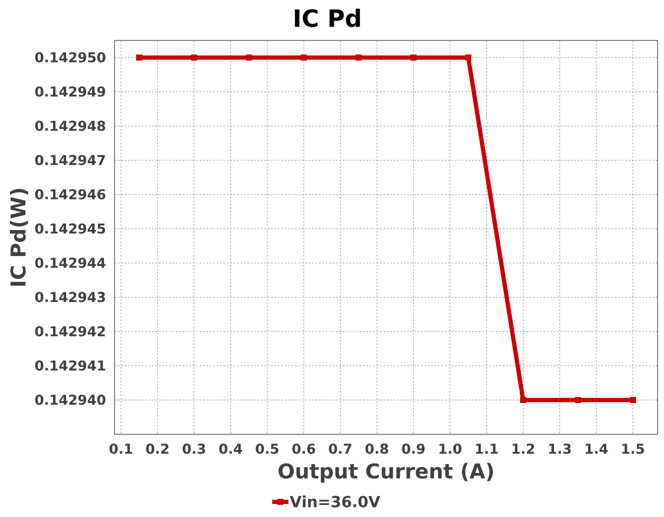
Cout IRMS

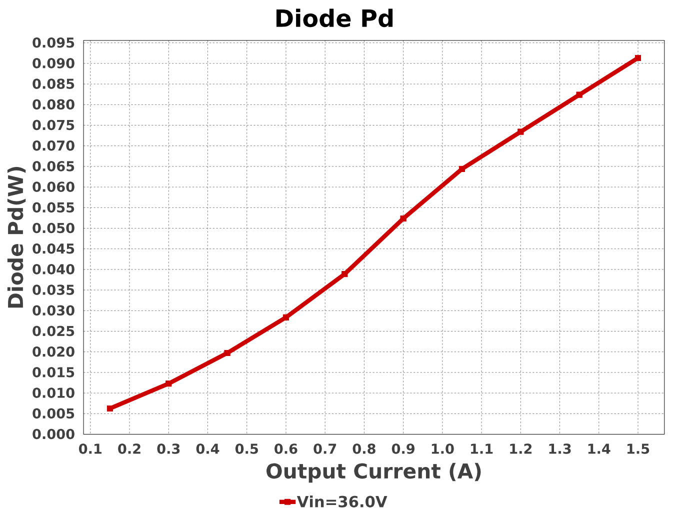


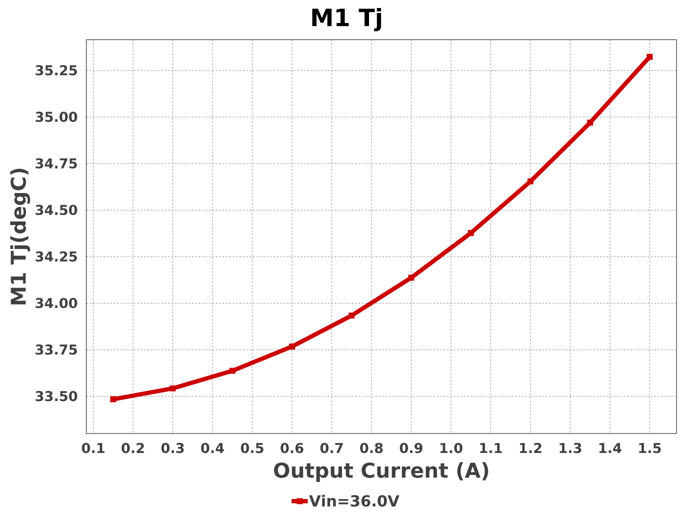
L Ipp

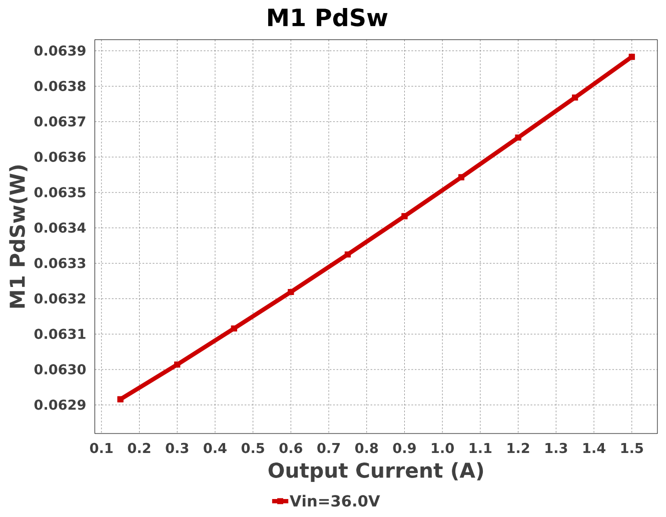


Copyright © 2024, Texas Instruments Incorporated









Operating Values

#	Name	Value	Category	Description
1.	BOM Count	22		Total Design BOM count
2.	Total BOM	$4.03		Total BOM Cost
3.	Cin IRMS	470.559 mA	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	664.28 µW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	87.046 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	303.08 µW	Capacitor	Output capacitor power dissipation
7.	D1 Tj	60.137 deg	Diode	D1 junction temperature
8.	Diode Pd	91.325 mW	Diode	Diode power dissipation
9.	IC Ipk	1.651 A	IC	Peak switch current in IC
10.	IC Pd	142.94 mW	IC	IC power dissipation
11.	IC Tj	35.718 degC	IC	IC junction temperature
12.	IC Tolerance	18.0 mV	IC	IC Feedback Tolerance
13.	ICThetaJA	40.0 degC/W	IC	IC junction-to-ambient thermal resistance
14.	Iin Avg	1.348 A	IC	Average input current
15.	Ipp percentage	20.102 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
16.	L Ipp	301.537 mA	Inductor	Peak-to-peak inductor ripple current
17.	L Pd	108.36 mW	Inductor	Inductor power dissipation
18.	M1 Pd	96.791 mW	Mosfet	M1 MOSFET total power dissipation
19.	M1 PdCond	32.908 mW	Mosfet	M1 MOSFET conduction losses
20.	M1 PdSw	63.883 mW	Mosfet	M1 MOSFET switching losses
21.	M1 Tj	35.323 degC	Mosfet	M1 MOSFET junction temperature
22.	Cin Pd	664.28 µW	Power	Input capacitor power dissipation
23.	Cout Pd	303.08 µW	Power	Output capacitor power dissipation
24.	Diode Pd	91.325 mW	Power	Diode power dissipation
25.	IC Pd	142.94 mW	Power	IC power dissipation
26.	L Pd	108.36 mW	Power	Inductor power dissipation
27.	M1 Pd	96.791 mW	Power	M1 MOSFET total power dissipation
28.	M1 PdCond	32.908 mW	Power	M1 MOSFET conduction losses
29.	M1 PdSw	63.883 mW	Power	M1 MOSFET switching losses
30.	Total Pd	508.385 mW	Power	Total Power Dissipation

Copyright © 2024, Texas Instruments Incorporated

#	Name	Value	Category	Description
31.	Duty Cycle	89.319 %	System Information	Duty cycle
32.	Efficiency	98.952 %	System Information	Steady state efficiency
33.	FootPrint	464.0 mm^2	System Information	Total Foot Print Area of BOM components
34.	Frequency	246.015 kHz	System Information	Switching frequency
35.	Iout	1.5 A	System Information	Iout operating point
36.	Mode	CCM	System Information	Conduction Mode
37.	Pout	48.0 W	System Information	Total output power
38.	Vin	36.0 V	System Information	Vin operating point
39.	Vout	32.0 V	System Information	Operational Output Voltage
40.	Vout Actual	32.539 V	System Information	Vout Actual calculated based on selected voltage divider resistors
41.	Vout Tolerance	3.442 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
42.	Vout p-p	20.38 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	1.5	Maximum Output Current
SoftStart	1.0 ms	Soft Start Time (ms)
VinMax	36.0	Maximum input voltage
VinMin	36.0	Minimum input voltage
Vout	32.0	Output Voltage
base_pn	LM5088	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature
UserFsw	250.0 k	Customer Selected Frequency

Copyright © 2024, Texas Instruments Incorporated

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

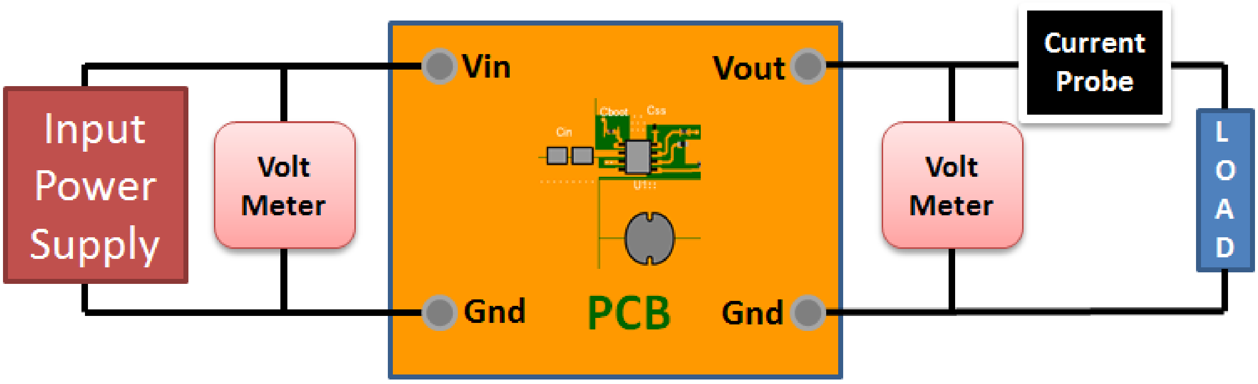
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 36.0V 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 : 9DDFEA0050C8FDF9[v1]

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

Important Notice and Disclaimer

TI provides technical and reliability data (including datasheets), design resources (including reference designs), application or other design advice, web tools, safety information, and other resources AS IS and with all faults, and disclaims all warranties. These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

Providing these resources does not expand or otherwise alter TI's applicable Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with TI products.

Copyright © 2024, Texas Instruments Incorporated