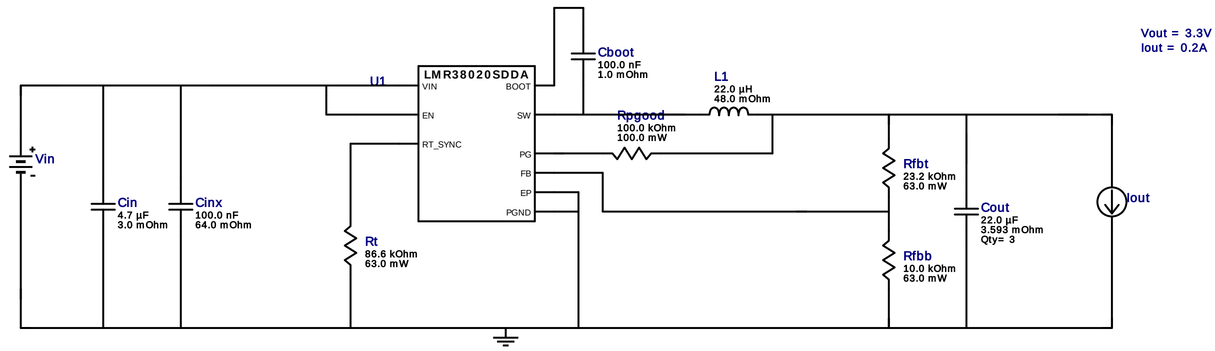
VinMin = 9.0V
VinMax = 36.0V
Vout = 3.3V
Iout = 0.2A

Device = LMR38020SDDAR
Topology = Buck
Created = 2023-11-28 10:35:36.151
BOM Cost = $2.18
BOM Count = 12
Total Pd = 0.1W

WEBENCH ® Design Report

Design : 72 LMR38020SDDAR
LMR38020SDDAR 9V-75V to 3.30V @ 0.3A



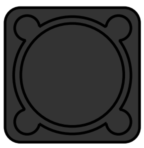
Design Alerts

Component Selection Information

This device support spread spectrum feature which is not modeled on WEBENCH. This device can work in steady state at Vin = 4.2V. However, needs a minimum of 4.5V during start up. See datasheet for details.

Electrical BOM

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM155R71C104KA88D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
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 mm^2
Cinx	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
Cout	MuRata	GRM31CR71A226KE15L Series= X7R	Cap= 22.0 uF ESR= 3.593 mOhm VDC= 10.0 V IRMS= 3.5332 A	3	$0.12	1206_190 11 mm^2
L1	Bourns	SRR1208-220ML	L= 22.0 µH 48.0 mOhm	1	$0.56	SRR1208 216 mm^2



Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rfbb	Vishay-Dale	CRCW040210K0FKED Series= CRCW..e3	Res= 10.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt	Vishay-Dale	CRCW040223K2FKED Series= CRCW..e3	Res= 23.2 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rpgood	Vishay-Dale	CRCW0603100KFKEA Series= CRCW..e3	Res= 100.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2

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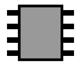
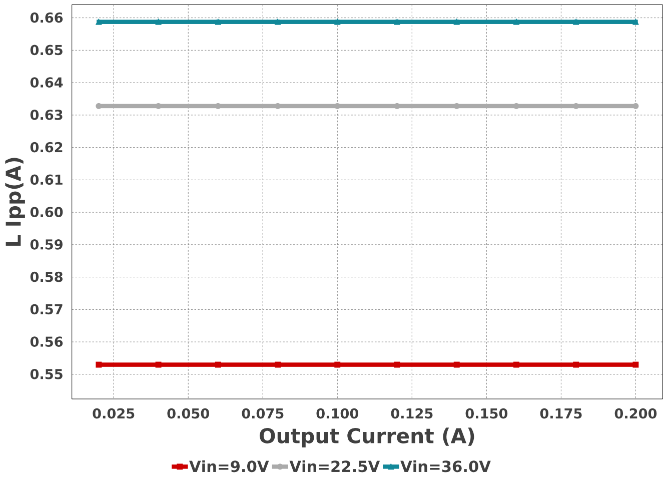
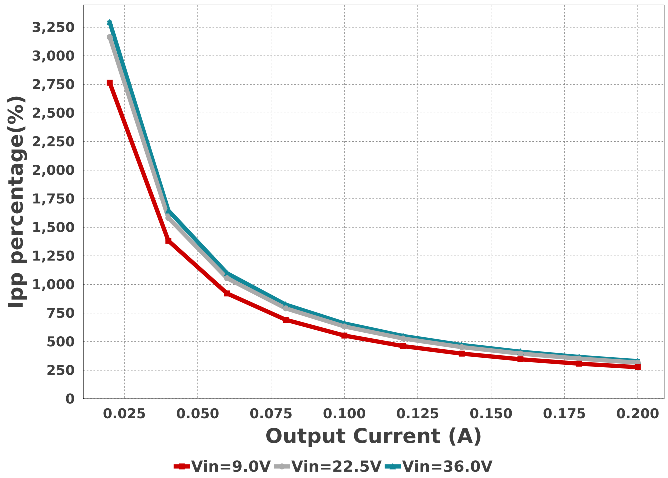
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rt	Yageo	AC0402FR-0786K6L Series= ?	Res= 86.6 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
U1	Texas Instruments	LMR38020SDDAR	Switcher	1	$1.10	DDA0008E_N 55 mm^2



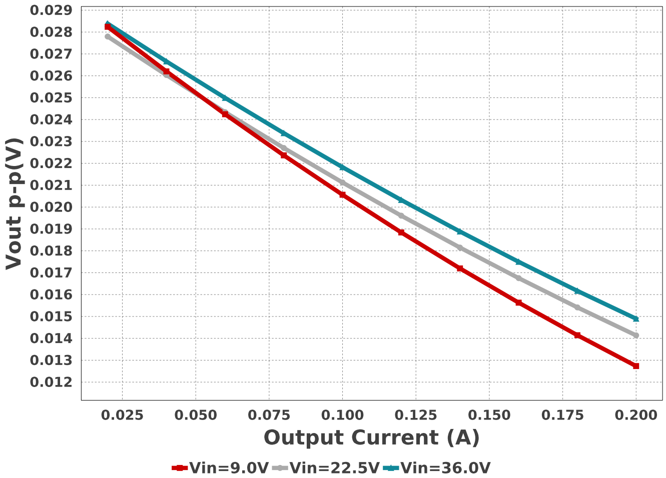
L Ipp



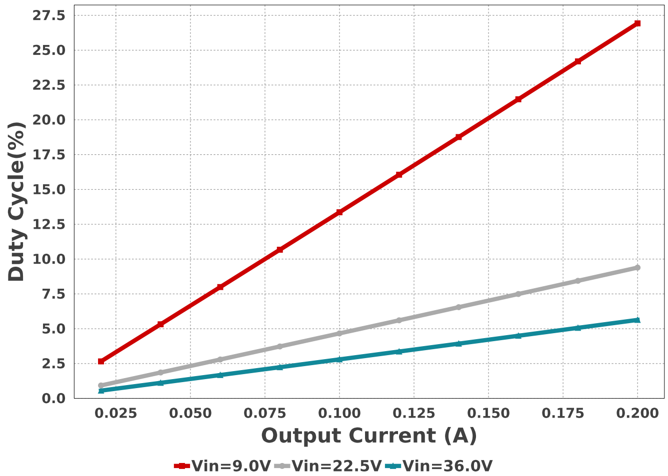
Ipp percentage



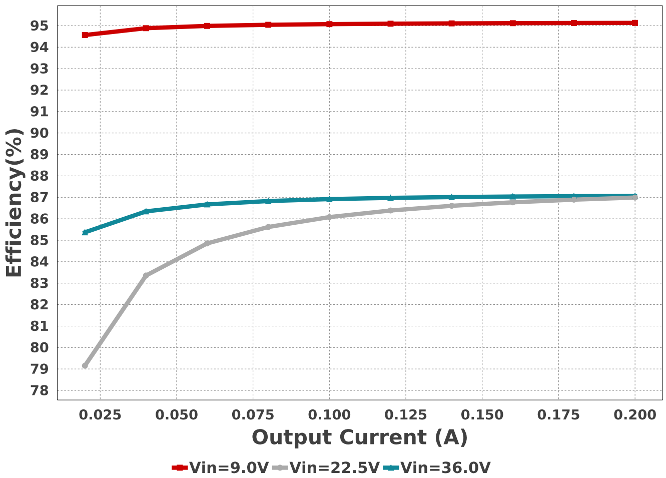
Vout p-p



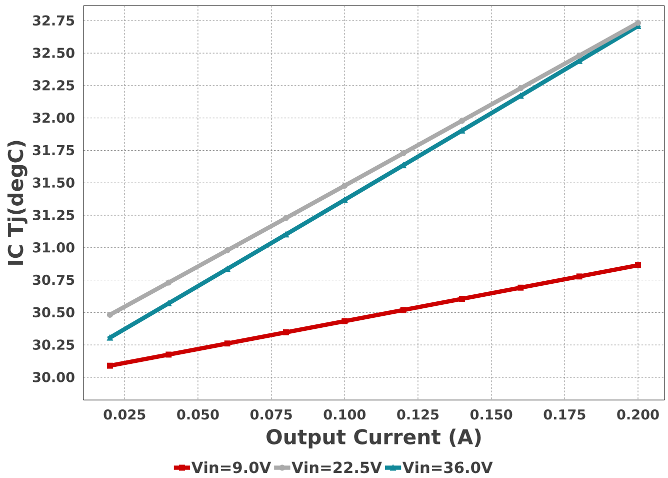
Duty Cycle



Efficiency



IC Tj



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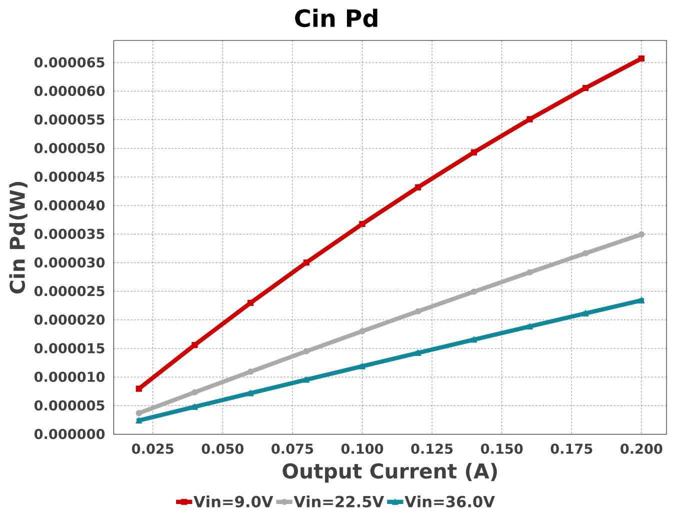
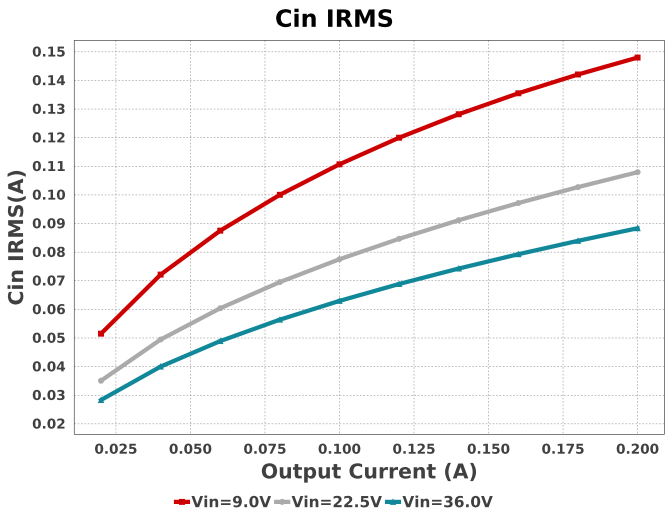
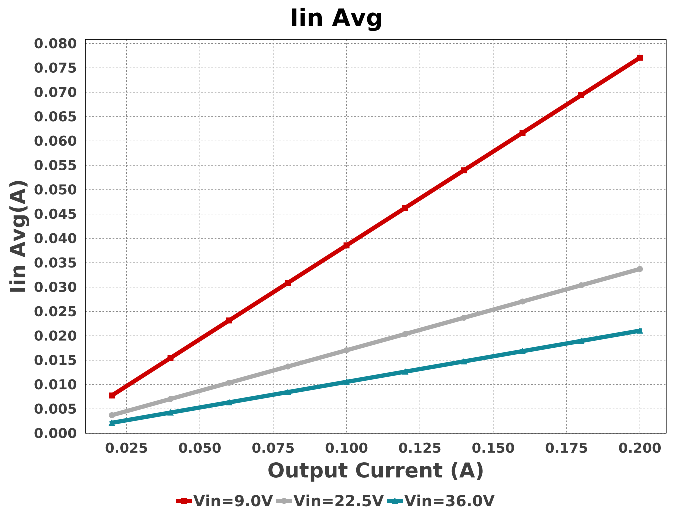
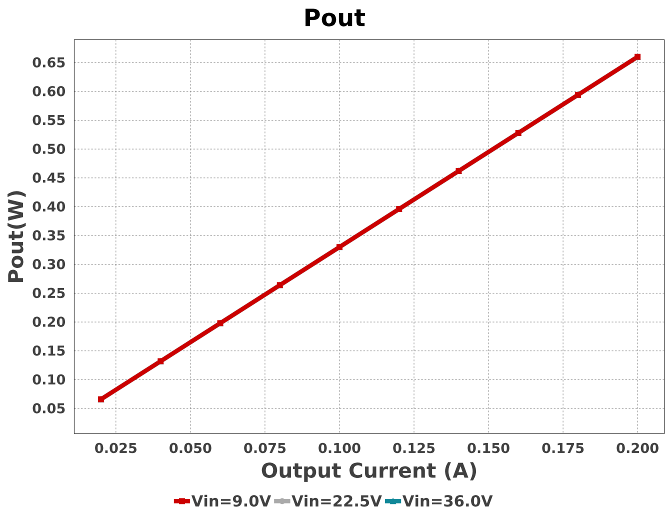
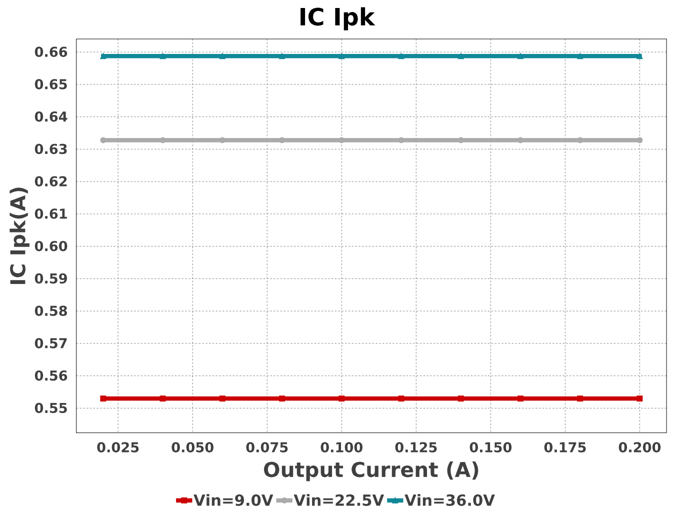
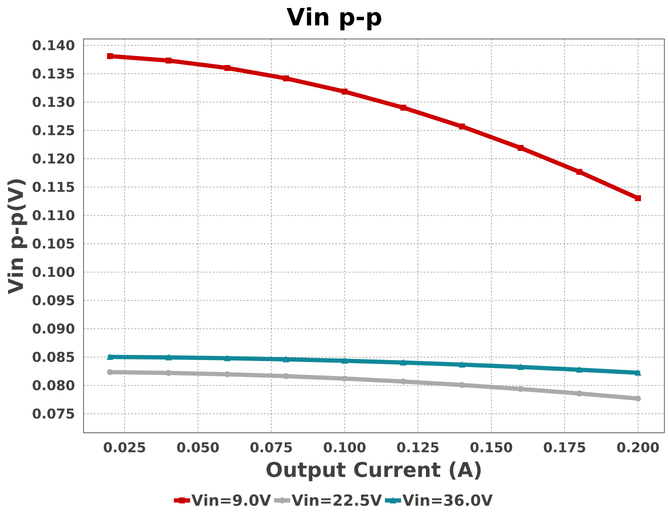

Cin Pd
Cin Pd(W)
0.000065
0.000060
0.000055
0.000050
0.000045
0.000040
0.000035
0.000030
0.000025
0.000020
0.000015
0.000010
0.000005
0.000000
0.025 0.050 0.075 0.100 0.125 0.150 0.175 0.200
Output Current (A)
Vin=9.0V Vin=22.5V Vin=36.0V


Cin IRMS
Cin IRMS(A)
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.025 0.050 0.075 0.100 0.125 0.150 0.175 0.200
Output Current (A)
Vin=9.0V Vin=22.5V Vin=36.0V

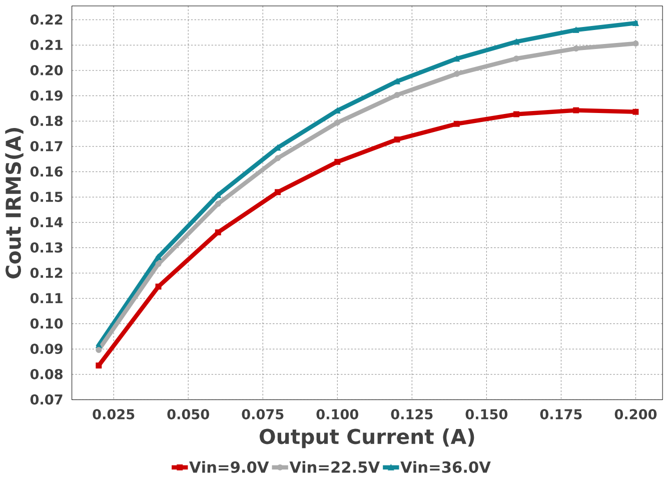

Iin Avg
Iin Avg(A)
0.080
0.075
0.070
0.065
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0.025 0.050 0.075 0.100 0.125 0.150 0.175 0.200
Output Current (A)
Vin=9.0V Vin=22.5V Vin=36.0V


Pout
Pout(W)
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.025 0.050 0.075 0.100 0.125 0.150 0.175 0.200
Output Current (A)
Vin=9.0V Vin=22.5V Vin=36.0V

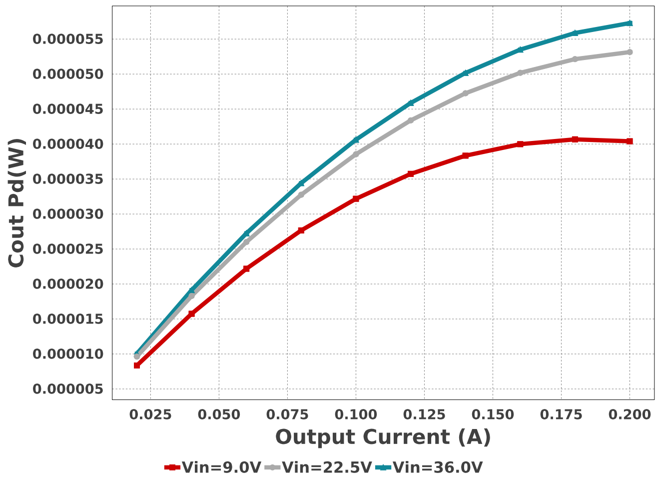

IC Ipk
IC Ipk(A)
0.66
0.65
0.64
0.63
0.62
0.61
0.60
0.59
0.58
0.57
0.56
0.55
0.025 0.050 0.075 0.100 0.125 0.150 0.175 0.200
Output Current (A)
Vin=9.0V Vin=22.5V Vin=36.0V


Vin p-p
Vin p-p(V)
0.140
0.135
0.130
0.125
0.120
0.115
0.110
0.105
0.100
0.095
0.090
0.085
0.080
0.075
0.025 0.050 0.075 0.100 0.125 0.150 0.175 0.200
Output Current (A)
Vin=9.0V Vin=22.5V Vin=36.0V

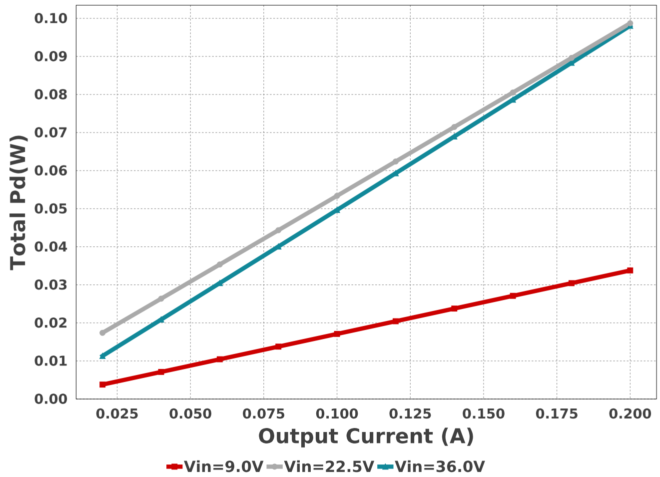
Cout IRMS



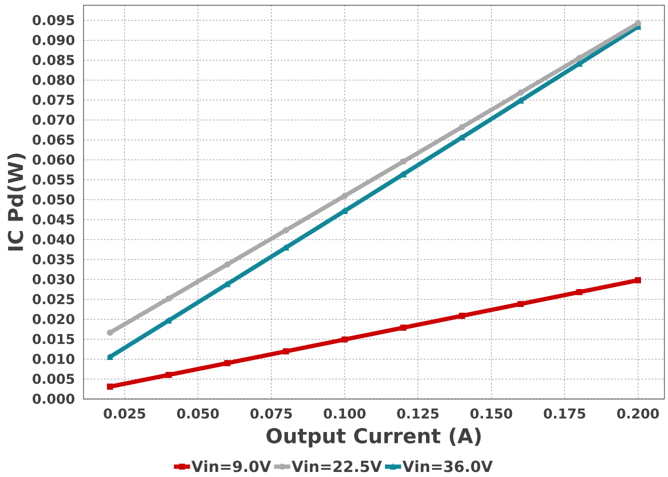
Cout Pd



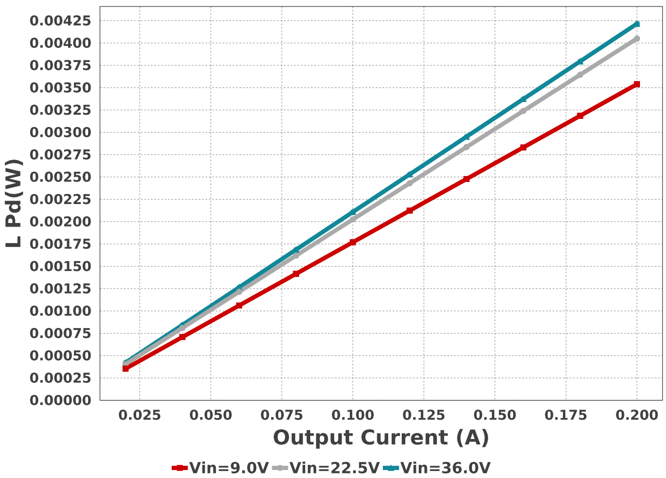
Total Pd



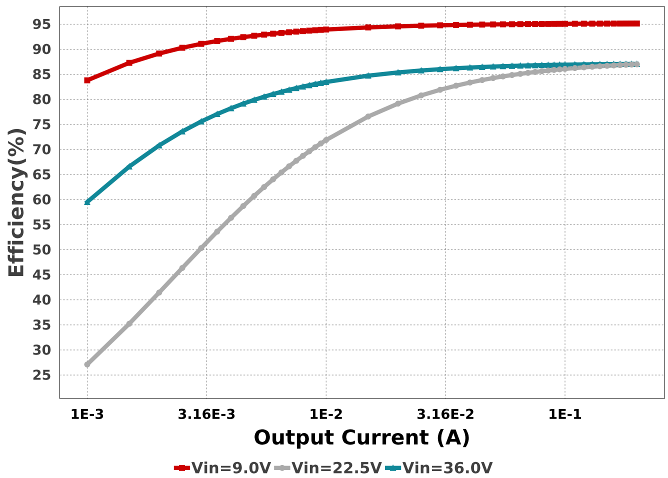
IC Pd



L Pd



Efficiency (Log-Scale)



Operating Values

#	Name	Value	Category	Description
1.	BOM Count	12		Total Design BOM count
2.	Total BOM	$2.182		Total BOM Cost
3.	Cin IRMS	88.349 mA	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	23.417 µW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	218.709 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	57.289 µW	Capacitor	Output capacitor power dissipation
7.	IC Ipk	658.752 mA	IC	Peak switch current in IC
8.	IC Pd	93.411 mW	IC	IC power dissipation
9.	IC Tj	32.709 degC	IC	IC junction temperature
10.	IC Tolerance	5.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA Effective	29.0 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance

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#	Name	Value	Category	Description
12.	Iin Avg	21.057 mA	IC	Average input current
13.	Ipp percentage	329.376 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
14.	L Ipp	658.752 mA	Inductor	Peak-to-peak inductor ripple current
15.	L Pd	4.216 mW	Inductor	Inductor power dissipation
16.	Cin Pd	23.417 µW	Power	Input capacitor power dissipation
17.	Cout Pd	57.289 µW	Power	Output capacitor power dissipation
18.	IC Pd	93.411 mW	Power	IC power dissipation
19.	L Pd	4.216 mW	Power	Inductor power dissipation
20.	Total Pd	98.039 mW	Power	Total Power Dissipation
21.	Duty Cycle	5.634 %	System Information	Duty cycle
22.	Efficiency	87.067 %	System Information	Steady state efficiency
23.	FootPrint	338.0 mm^2	System Information	Total Foot Print Area of BOM components
24.	Frequency	126.843 kHz	System Information	Switching frequency
25.	Inductor ripple current requirement used for Inductor selection	40.0 %	System Information	Custom Inductor ripple current (% of average inductor current) requirement used for Inductor selection
26.	Iout	200.0 mA	System Information	Iout operating point
27.	Iout transient step used for Cout calculations	100.0 mA	System Information	Custom Transient current step requirement that was used for Cout selection (A).
28.	Mode	PFM	System Information	Conduction Mode
29.	Overshoot Value	614.98 µV	System Information	Theoretical Vout Overshoot Value
30.	Pout	660.0 mW	System Information	Total output power
31.	Undershoot Value	13.274 mV	System Information	Theoretical Vout Undershoot Value
32.	Vin	36.0 V	System Information	Vin operating point
33.	Vin p-p	82.243 mV	System Information	Peak-to-peak input voltage
34.	Vout	3.3 V	System Information	Operational Output Voltage
35.	Vout Actual	3.32 V	System Information	Vout Actual calculated based on selected voltage divider resistors
36.	Vout Ripple requirement used for Cout calculations	1.0 %	System Information	Custom maximum output ripple requirement that was used for Cout selection(% of Vout).
37.	Vout Tolerance	1.919 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
38.	Vout p-p	14.897 mV	System Information	Peak-to-peak output ripple voltage
39.	Vout transient requirement used for Cout calculations	3.0 %	System Information	Custom Transient voltage change requirement that was used for Cout selection (% of Vout).

Design Inputs

Name	Value	Description
Iout	200.0 m	Maximum Output Current
VinMax	36.0	Maximum input voltage
VinMin	9.0	Minimum input voltage
Vout	3.3	Output Voltage
base_pn	LMR38020S	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature
UserFsw	300.0 k	Customer Selected Frequency

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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

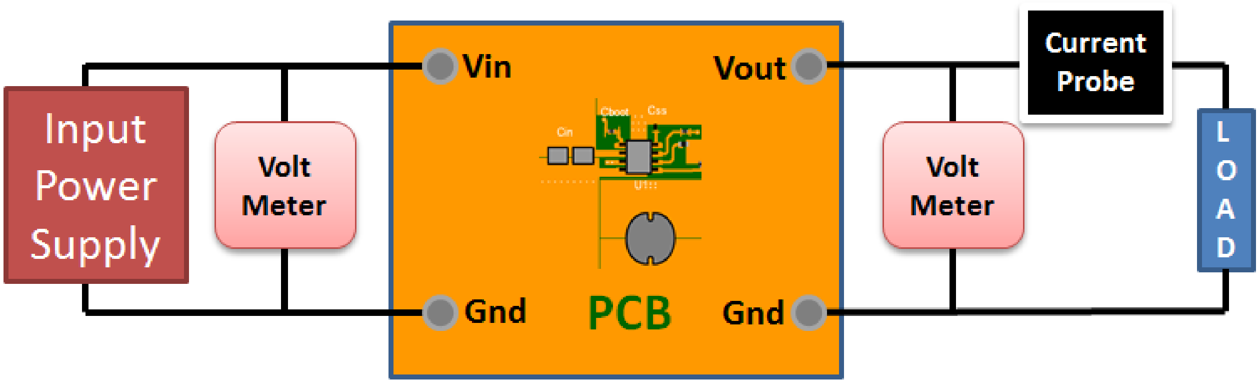
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 9.0V 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 : 2BDF0096E146A26C[v1]

2. **LMR38020S** Product Folder : http://www.ti.com/product/LMR38020 : contains the data sheet and other resources.

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