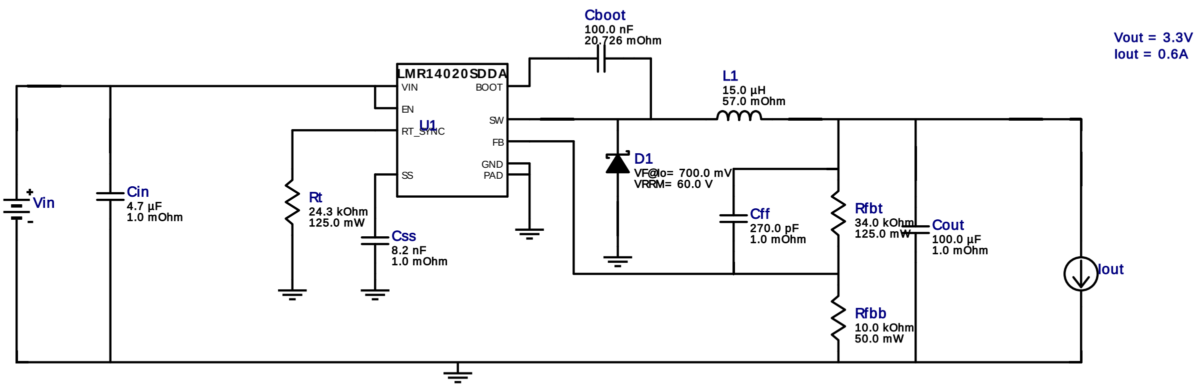
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 7.0V
VinMax = 36.0V
Vout = 3.3V
Iout = 0.6A

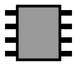
Device = LMR14020SDDAR
Topology = Buck
Created = 2019-04-17 06:00:57.032
BOM Cost = $2.83
BOM Count = 11
Total Pd = 0.71W

Design : 36 LMR14020SDDAR
LMR14020SDDAR 7V-36V to 3.30V @ 0.6A

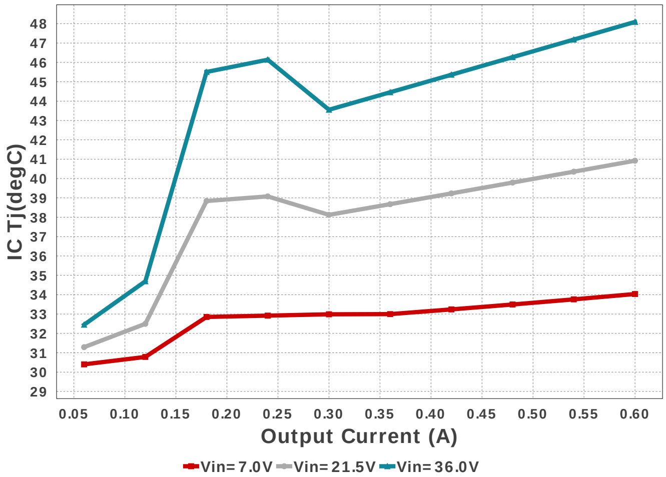


Electrical BOM

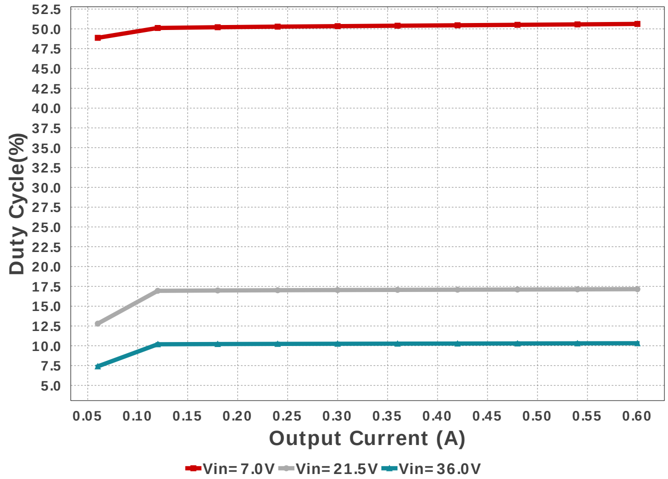
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	TDK	CGA4J2X7R2A104K125AA Series= X7R	Cap= 100.0 nF ESR= 20.726 mOhm VDC= 100.0 V IRMS= 1.456 A	1	$0.04	0805 7 mm²
Cff	MuRata	GRM033R71C271KA01D Series= X7R	Cap= 270.0 pF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0201 2 mm²
Cin	MuRata	GRM32ER71H475KA88L Series= X7R	Cap= 4.7 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 6.0 A	1	$0.55	1210 15 mm²
Cout	MuRata	GRM32ER60J107ME20L Series= X5R	Cap= 100.0 uF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 6.0 A	1	$0.52	1210_270 15 mm²
Css	MuRata	GRM155R71C822KA01D Series= X7R	Cap= 8.2 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
D1	Diodes Inc.	B160-13-F	VF@Io= 700.0 mV VRRM= 60.0 V	1	$0.05	SMA 37 mm²
L1	Bourns	SRR6038-150Y	L= 15.0 µH 57.0 mOhm	1	$0.32	SRR6038 77 mm²
Rfbb	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
Rfbt	Vishay-Dale	CRCW080534K0FKEA Series= CRCW..e3	Res= 34.0 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²
Rt	Panasonic	ERJ-6ENF2432V Series= ERJ-6E	Res= 24.3 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
U1	Texas Instruments	LMR14020SDDAR	Switcher	1	$1.30	 DDA0008E_N 55 mm²

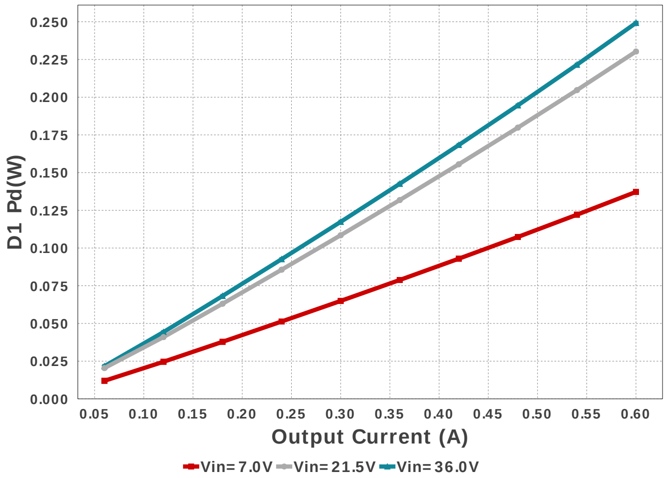
IC Tj



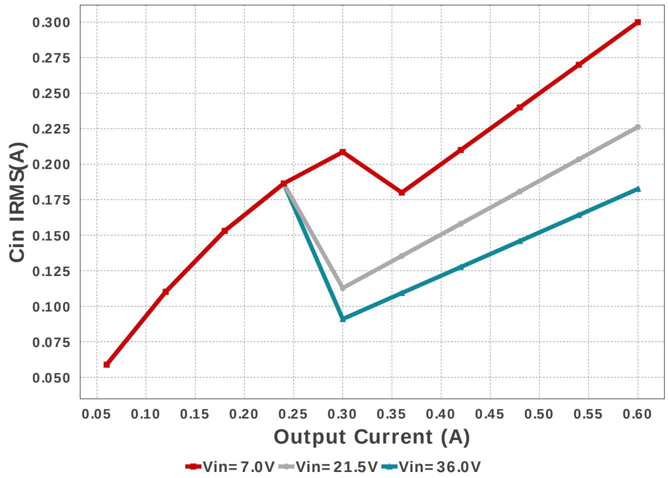
Duty Cycle



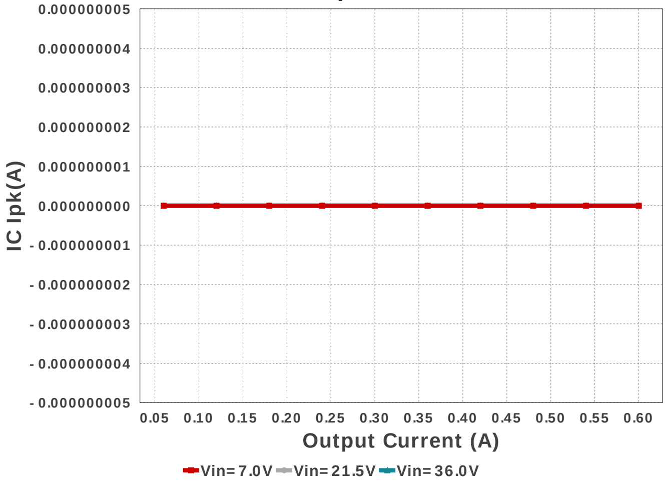
D1 Pd



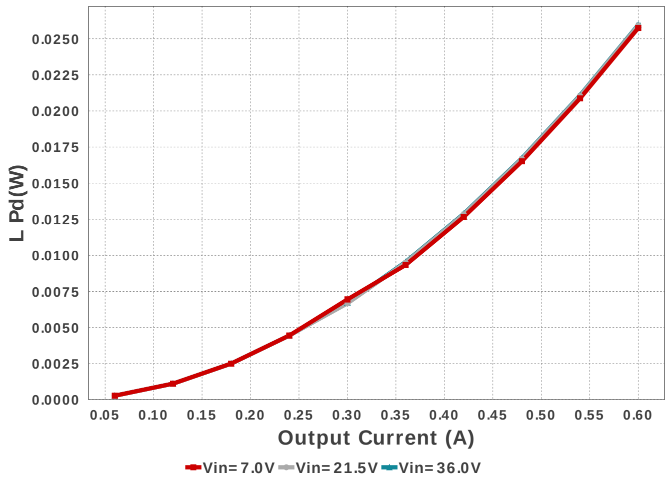
Cin IRMS

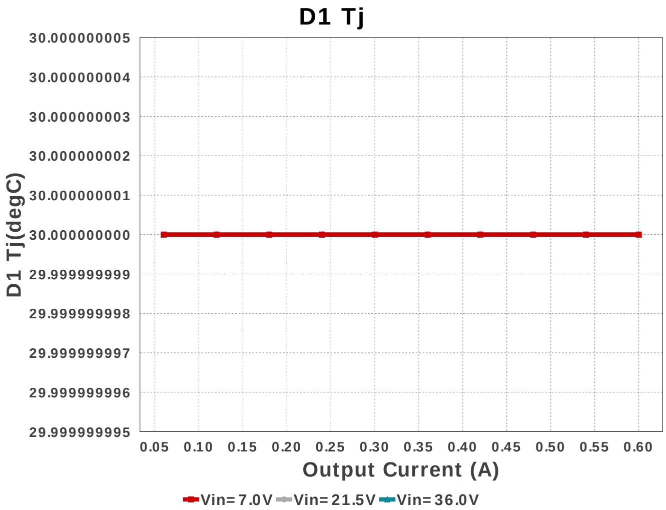


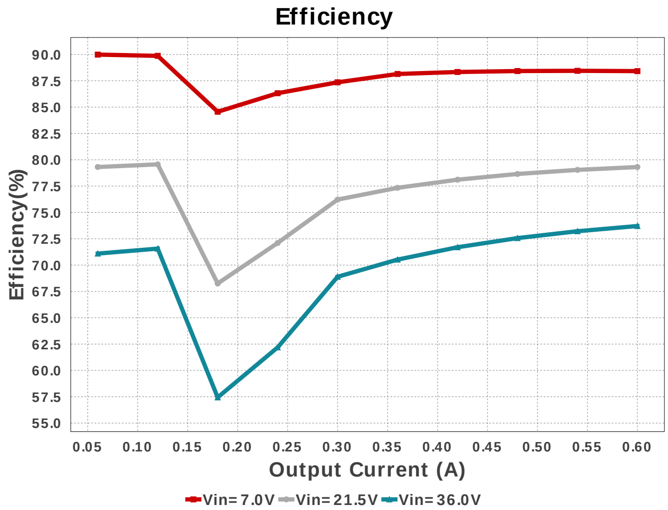
IC Ipk

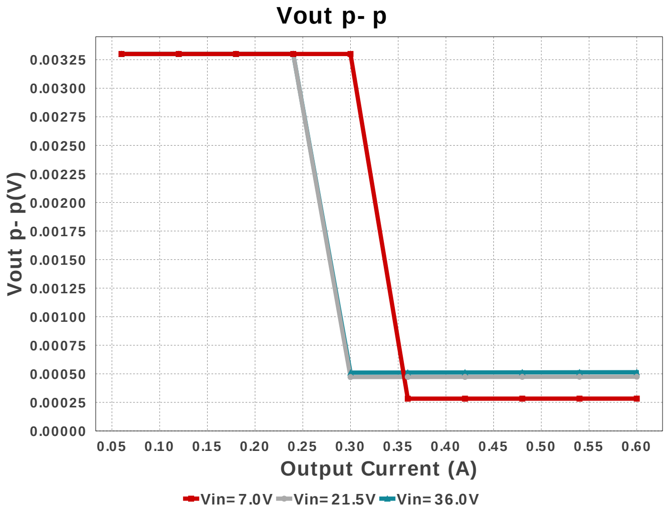


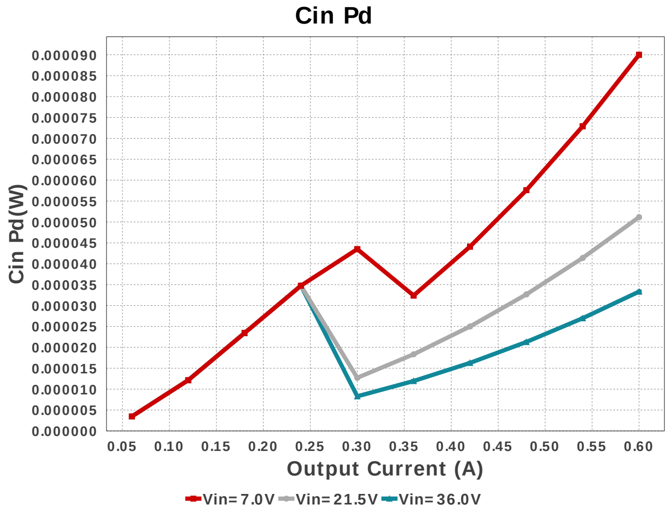
L Pd

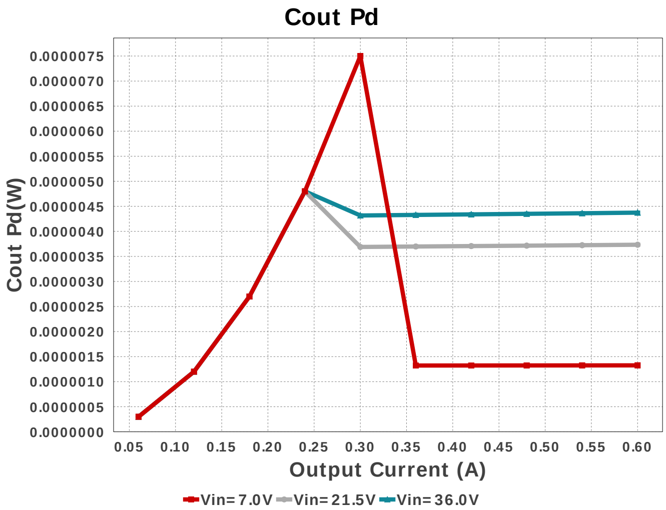


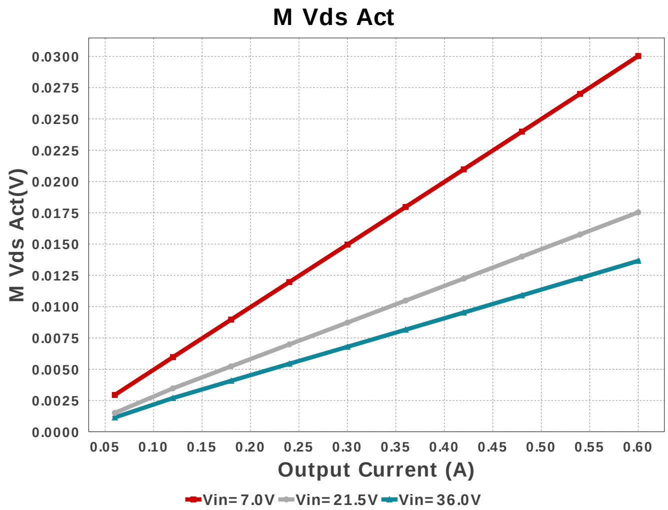

D1 Tj
D1 Tj(degC)
Output Current (A)
Vin=7.0V Vin=21.5V Vin=36.0V

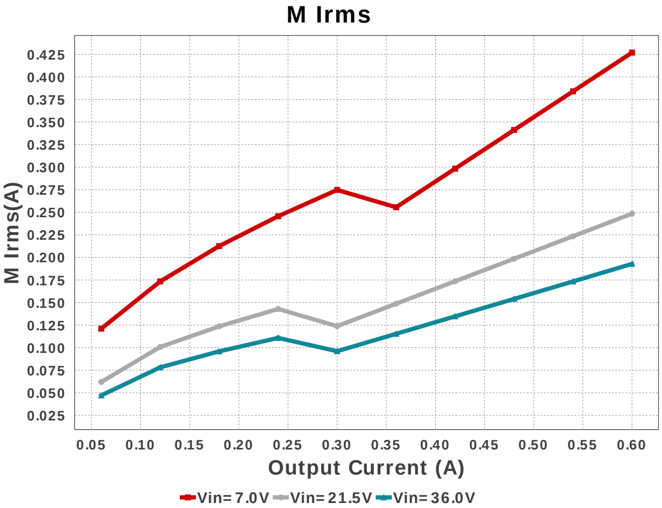

Efficiency
Efficiency(%)
Output Current (A)
Vin=7.0V Vin=21.5V Vin=36.0V

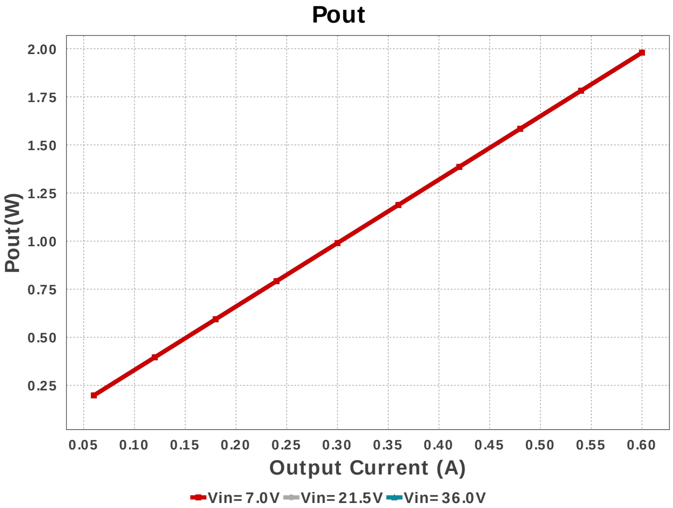

Vout p- p
Vout p- p(V)
Output Current (A)
Vin=7.0V Vin=21.5V Vin=36.0V

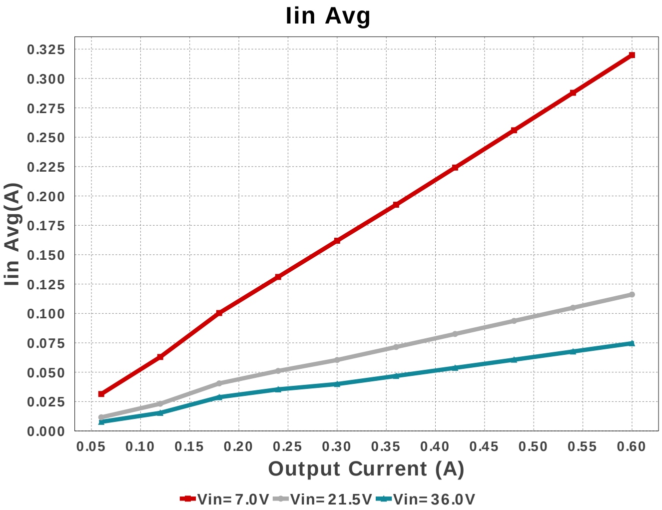

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=7.0V Vin=21.5V Vin=36.0V

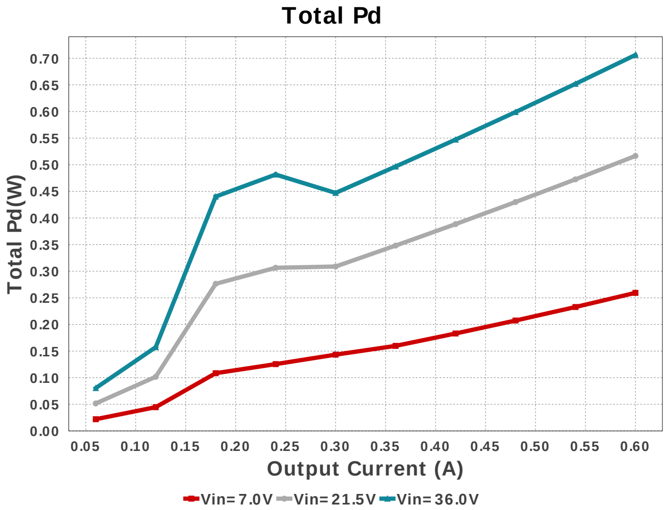

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=7.0V Vin=21.5V Vin=36.0V

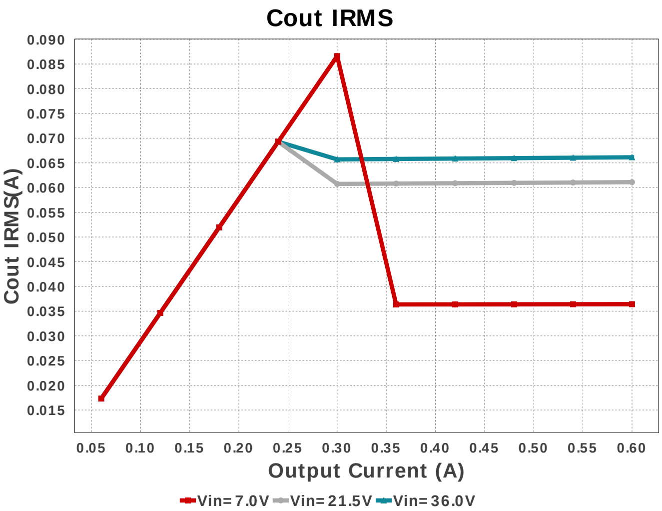

M Vds Act
M Vds Act(V)
Output Current (A)
Vin=7.0V Vin=21.5V Vin=36.0V

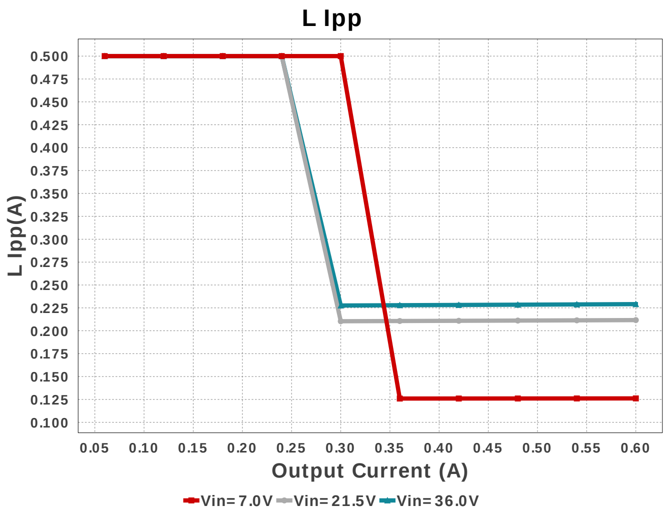

M Irms
M Irms(A)
0.425
0.400
0.375
0.350
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60
Output Current (A)
Vin=7.0V Vin=21.5V Vin=36.0V

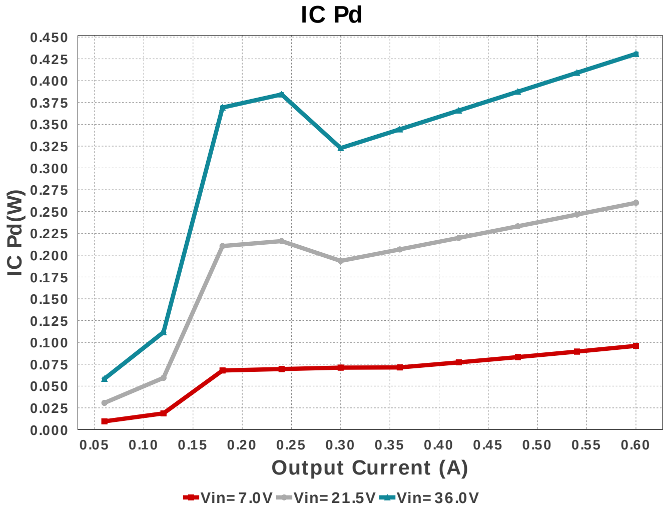

Pout
Pout(W)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60
Output Current (A)
Vin=7.0V Vin=21.5V Vin=36.0V

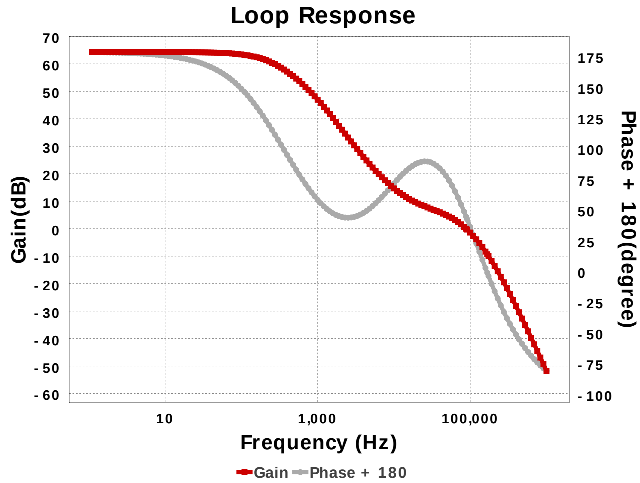

Iin Avg
Iin Avg(A)
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60
Output Current (A)
Vin=7.0V Vin=21.5V Vin=36.0V


Total Pd
Total Pd(W)
0.70
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
0.00
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60
Output Current (A)
Vin=7.0V Vin=21.5V Vin=36.0V


Cout IRMS
Cout IRMS(A)
0.090
0.085
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
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60
Output Current (A)
Vin=7.0V Vin=21.5V Vin=36.0V


L Ipp
L Ipp(A)
0.500
0.475
0.450
0.425
0.400
0.375
0.350
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60
Output Current (A)
Vin=7.0V Vin=21.5V Vin=36.0V





Operating Values

#	Name	Value	Category	Description
1.	BOM Count	11		Total Design BOM count
2.	Total BOM	$2.83		Total BOM Cost
3.	Cin IRMS	182.566 mA	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	33.33 µW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	66.134 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	4.374 µW	Capacitor	Output capacitor power dissipation
7.	D1 Pd	249.22 mW	Diode	Output Diode Power Dissipation
8.	D1 Tj	30.0 degC	Diode	D1 junction temperature
9.	IC Ipk	0.0 A	IC	Peak switch current in IC
10.	IC Pd	430.75 mW	IC	IC power dissipation
11.	IC Tj	48.092 degC	IC	IC junction temperature
12.	IC Tolerance	18.0 mV	IC	IC Feedback Tolerance
13.	ICThetaJA	42.0 degC/W	IC	IC junction-to-ambient thermal resistance
14.	Iin Avg	74.617 mA	IC	Average input current
15.	L Ipp	229.094 mA	Inductor	Peak-to-peak inductor ripple current
16.	L Pd	25.962 mW	Inductor	Inductor power dissipation
17.	M Irms	192.789 mA	Mosfet	MOSFET RMS ripple current
18.	M Vds Act	13.66 mV	Mosfet	Voltage drop across the MosFET
19.	Cin Pd	33.33 µW	Power	Input capacitor power dissipation
20.	Cout Pd	4.374 µW	Power	Output capacitor power dissipation
21.	D1 Pd	249.22 mW	Power	Output Diode Power Dissipation
22.	IC Pd	430.75 mW	Power	IC power dissipation
23.	L Pd	25.962 mW	Power	Inductor power dissipation
24.	Total Pd	706.205 mW	Power	Total Power Dissipation
25.	Cross Freq	88.63 kHz	System Information	Bode plot crossover frequency
26.	Duty Cycle	10.324 %	System Information	Duty cycle
27.	Efficiency	73.71 %	System Information	Steady state efficiency
28.	FootPrint	227.0 mm^2	System Information	Total Foot Print Area of BOM components
29.	Frequency	982.032 kHz	System Information	Switching frequency
30.	Gain Marg	-9.33 dB	System Information	Bode Plot Gain Margin
31.	Iout	600.0 mA	System Information	Iout operating point
32.	Low Freq Gain	64.272 dB	System Information	Gain at 1Hz
33.	Mode	CCM	System Information	Conduction Mode
34.	Phase Marg	45.549 deg	System Information	Bode Plot Phase Margin
35.	Pout	1.98 W	System Information	Total output power
36.	Vin	36.0 V	System Information	Vin operating point
37.	Vout	3.3 V	System Information	Operational Output Voltage

#	Name	Value	Category	Description
38.	Vout Actual	3.3 V	System Information	Vout Actual calculated based on selected voltage divider resistors
39.	Vout Tolerance	3.999 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
40.	Vout p-p	513.935 µV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	600.0 m	Maximum Output Current
SoftStart	2.0 ms	Soft Start Time (ms)
VinMax	36.0	Maximum input voltage
VinMin	7.0	Minimum input voltage
Vout	3.3	Output Voltage
base_pn	LMR14020S	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature
UserFsw	1000.0 k	Customer Selected Frequency

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

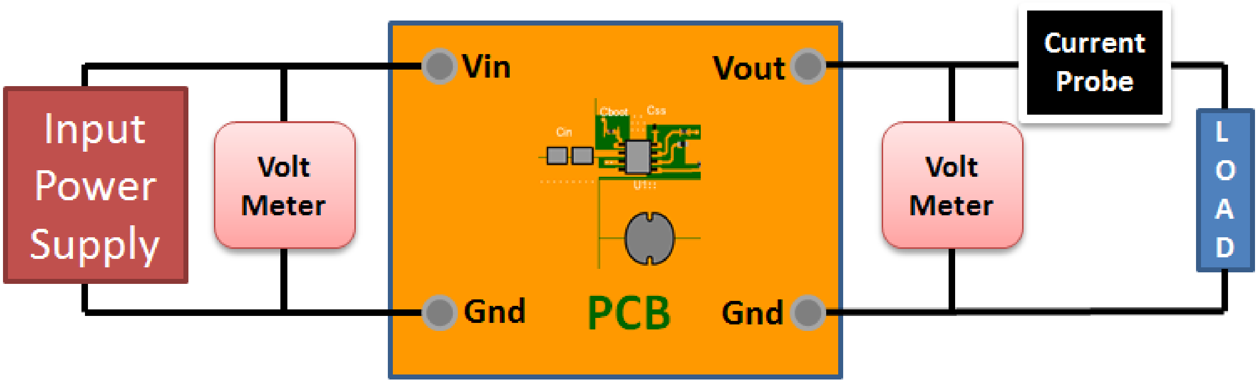
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 7.0V 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 : 53D3AAA5CEE23887[v1]

2. **LMR14020S** Product Folder : http://www.ti.com/product/LMR14020 : contains the data sheet and other resources.

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