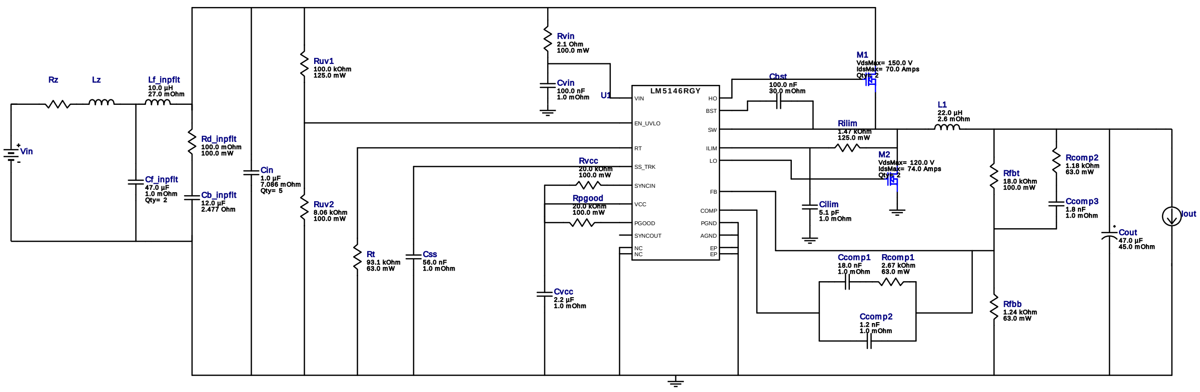
VinMin = 20.0V	Device = LM5146RGYR
VinMax = 90.0V	Topology = Buck
Vout = 12.5V	Created = 2023-01-31 07:47:10.068
Iout = 10.0A	BOM Cost = NA
	BOM Count = 36
	Total Pd = 6.62W

WEBENCH ® Design Report

Design : 141 LM5146RGYR
LM5146RGYR 20V-90V to 12.50V @ 10A



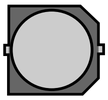
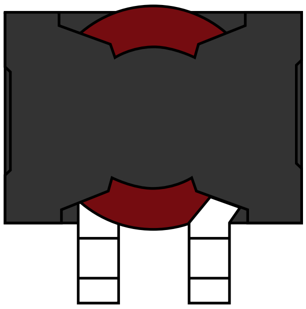
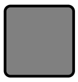
Design Alerts

Component Selection Information

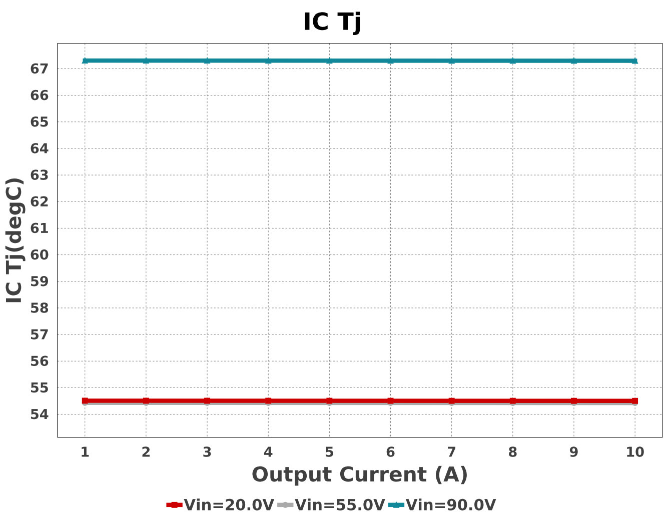
Please note that since parallel FETs have been chosen in this design, schematic and PCB export features will not work

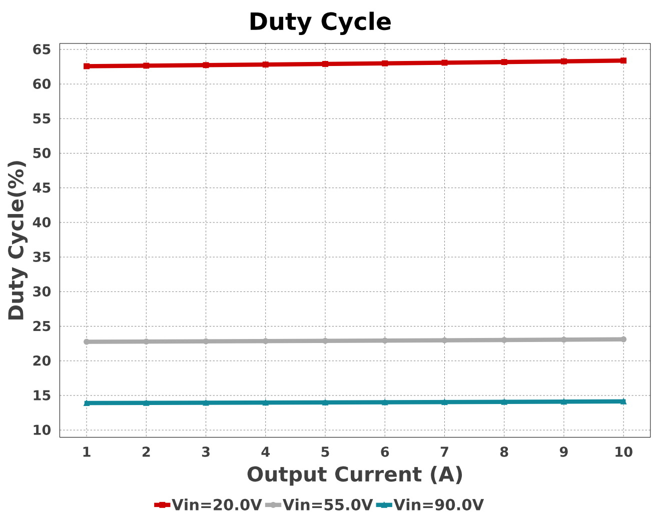
Electrical BOM

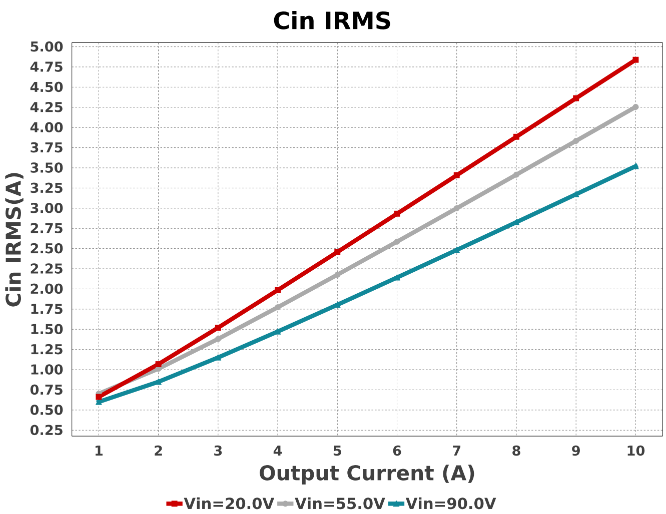
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cb_inpflt	CUSTOM	CUSTOM Series= ?	Cap= 12.0 uF ESR= 2.47664 Ohm VDC= 108.0 V IRMS= 657.85 mA	1	NA	CUSTOM 0 mm²
Cbst	MuRata	GRM188R61E104KA01D Series= X5R	Cap= 100.0 nF ESR= 30.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Ccomp1	MuRata	GRM155R71C183KA01D Series= X7R	Cap= 18.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Ccomp2	MuRata	GRM155R71H122KA01D Series= X7R	Cap= 1.2 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Ccomp3	MuRata	GRM155R71H182KA01D Series= X7R	Cap= 1.8 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cf_inpflt	AVX	FFWE6N0356K7X Series= 2237	Cap= 47.0 uF ESR= 1.0 mOhm VDC= 900.0 V IRMS= 67.0 A	2	$67.61	FFWE_8450X6400 0 mm²
Cilim	MuRata	GQM2195C2A5R1CB01D Series= C0G/NP0	Cap= 5.1 pF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 0.0 A	1	$0.15	0805 7 mm²
Cin	MuRata	GRM55DR72E105KW01L Series= X7R	Cap= 1.0 uF ESR= 7.086 mOhm VDC= 250.0 V IRMS= 2.0605 A	5	$0.35	2220_200 54 mm²

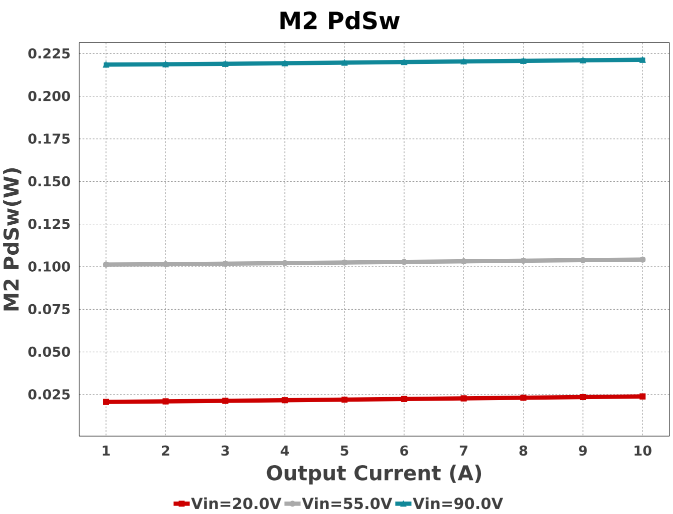
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cout	Panasonic	20SVP47M Series= SVP	Cap= 47.0 uF ESR= 45.0 mOhm VDC= 20.0 V IRMS= 1.89 A	1	$0.65	 SM_RADIAL_8MM 113 mm²
Css	MuRata	GRM155R71C563KA88D Series= X7R	Cap= 56.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cvcc	TDK	C1005X5R1V225K050BC Series= X5R	Cap= 2.2 uF ESR= 1.0 mOhm VDC= 35.0 V IRMS= 0.0 A	1	$0.06	0402_065 3 mm²
Cvin	CUSTOM	CUSTOM Series= ?	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 120.0 V IRMS= 1.0 mA	1	NA	CUSTOM 0 mm²
L1	Coilcraft	SER2918H-223KL	L= 22.0 µH 2.6 mOhm	1	$2.65	 SER2918H 652 mm²
Lf_inpflt	Coilcraft	XAL6060-103MEB	L= 10.0 µH 27.0 mOhm	1	$0.82	 XAL6060 72 mm²
M1	Fairchild Semiconductor	FDMS86200	VdsMax= 150.0 V IdsMax= 70.0 Amps	2	$2.70	 TRANS_Fairchild_PQFN08A 56 mm²
M2	Infineon Technologies	BSC240N12NS3 G	VdsMax= 120.0 V IdsMax= 74.0 Amps	2	NA	 PG-TDSON-8 55 mm²
Rcomp1	Vishay-Dale	CRCW04022K67FKED Series= CRCW..e3	Res= 2.67 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rcomp2	Vishay-Dale	CRCW04021K18FKED Series= CRCW..e3	Res= 1.18 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rd_inpflt	Panasonic	ERJ-3RSFR10V Series= ERJ-3R	Res= 100.0 mOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.03	0603 5 mm²
Rfbb	Vishay-Dale	CRCW04021K24FKED Series= CRCW..e3	Res= 1.24 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbt	Yageo	RC0603FR-0718KL Series= ?	Res= 18.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rilim	Panasonic	ERJ-6ENF1471V Series= ERJ-6E	Res= 1.47 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²
Rpgood	Yageo	RC0603FR-0720KL Series= ?	Res= 20.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²

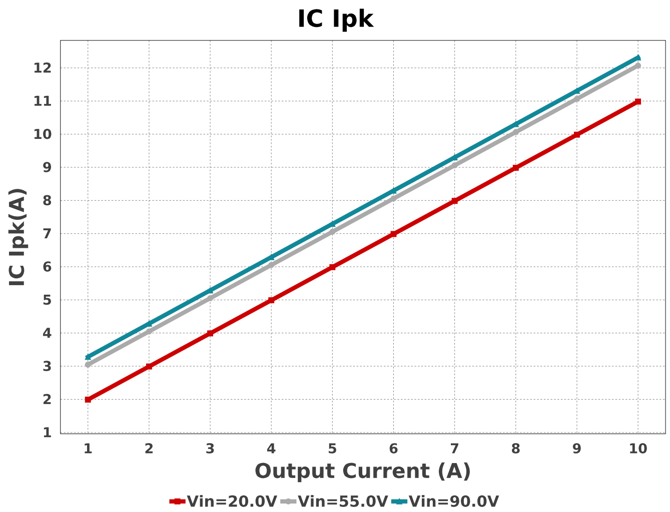
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rt	Vishay-Dale	CRCW040293K1FKED Series= CRCW..e3	Res= 93.1 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ruv1	Vishay-Dale	CRCW0805100KFKEA Series= CRCW..e3	Res= 100.0 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Ruv2	Vishay-Dale	CRCW06038K06FKEA Series= CRCW..e3	Res= 8.06 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rvcc	Yageo	RC0603FR-0720KL Series= ?	Res= 20.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rvin	Vishay-Dale	CRCW06032R10FKEA Series= CRCW..e3	Res= 2.1 Ohm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
U1	Texas Instruments	LM5146RGYR	Switcher	1	$1.29	RGY0020B 25 mm^2

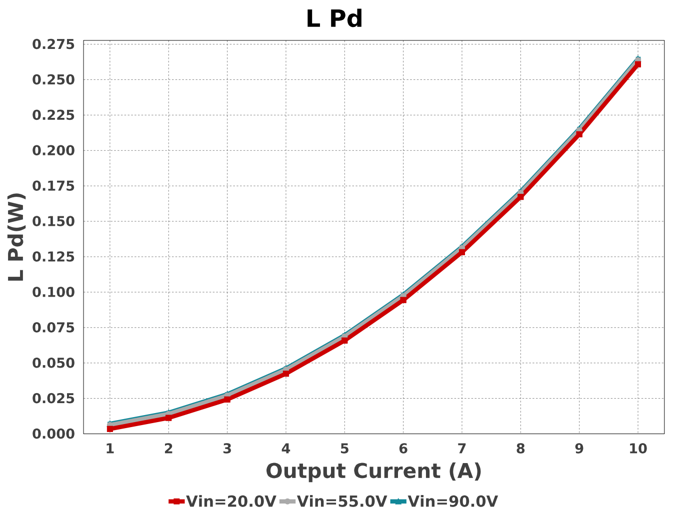


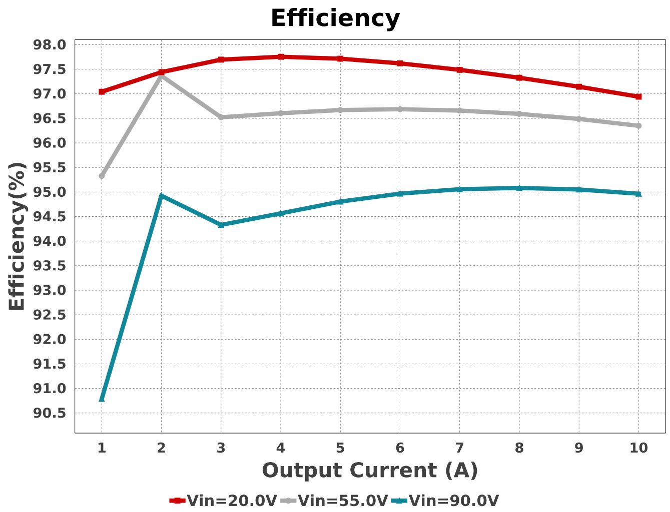


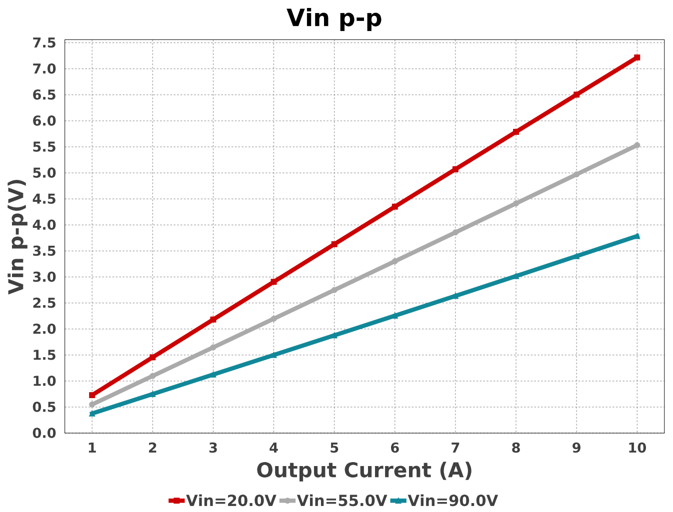


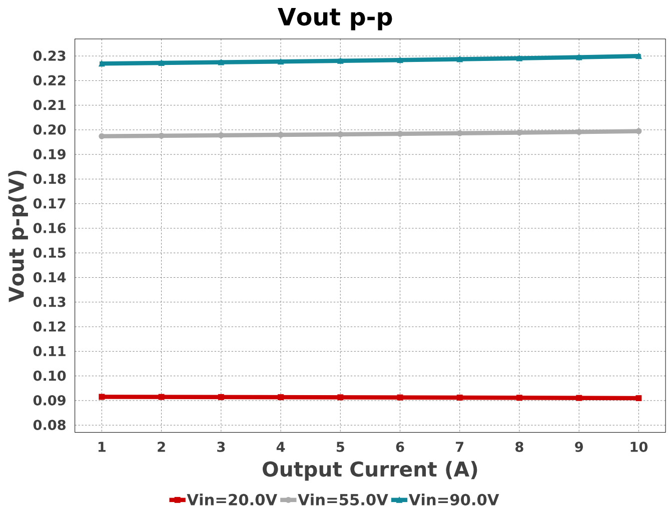


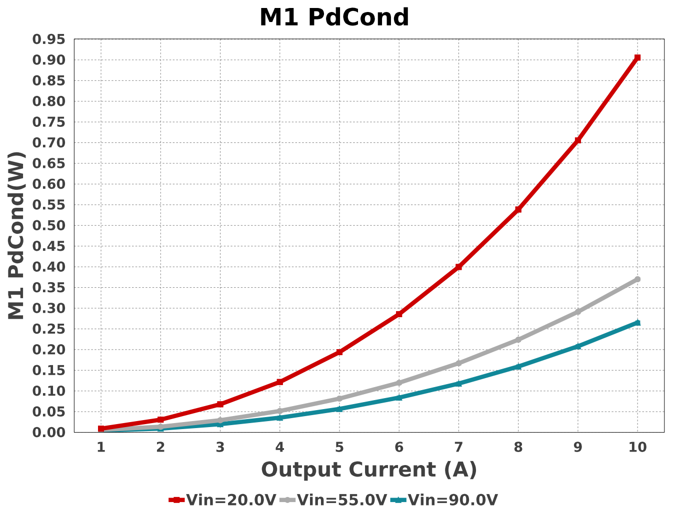

IC Ipk
IC Ipk(A)
Output Current (A)
Vin=20.0V Vin=55.0V Vin=90.0V


L Pd
L Pd(W)
Output Current (A)
Vin=20.0V Vin=55.0V Vin=90.0V

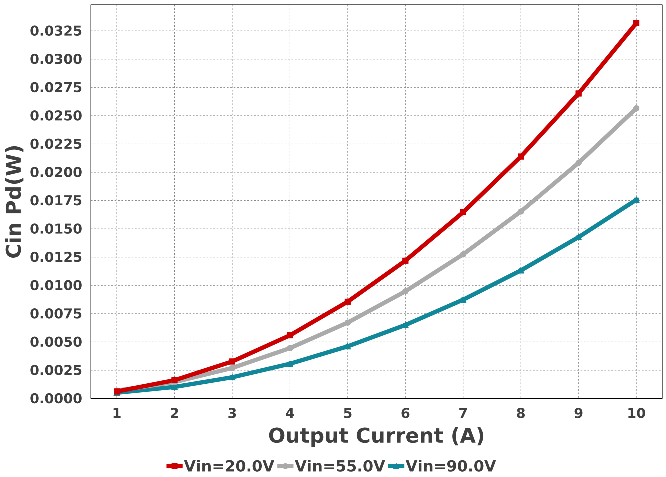

Efficiency
Efficiency(%)
Output Current (A)
Vin=20.0V Vin=55.0V Vin=90.0V


Vin p-p
Vin p-p(V)
Output Current (A)
Vin=20.0V Vin=55.0V Vin=90.0V

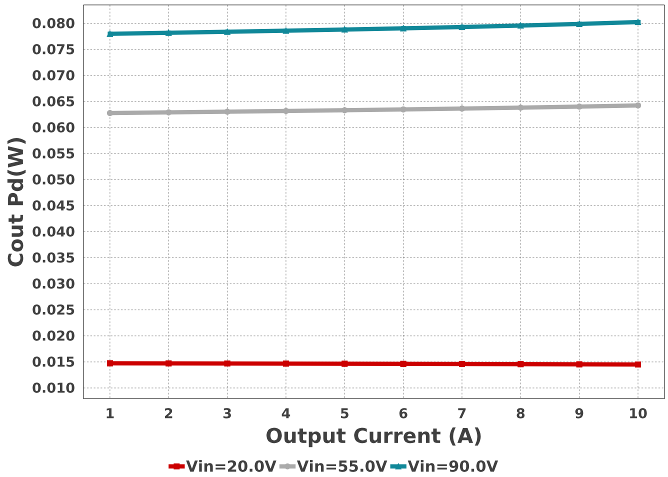

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=20.0V Vin=55.0V Vin=90.0V


M1 PdCond
M1 PdCond(W)
Output Current (A)
Vin=20.0V Vin=55.0V Vin=90.0V

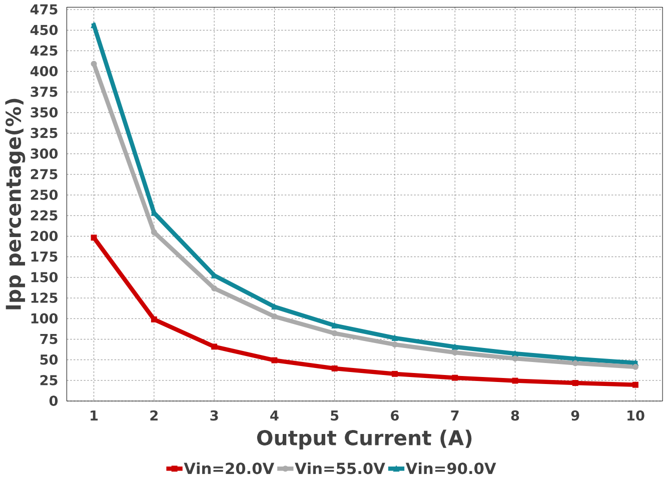
Cin Pd



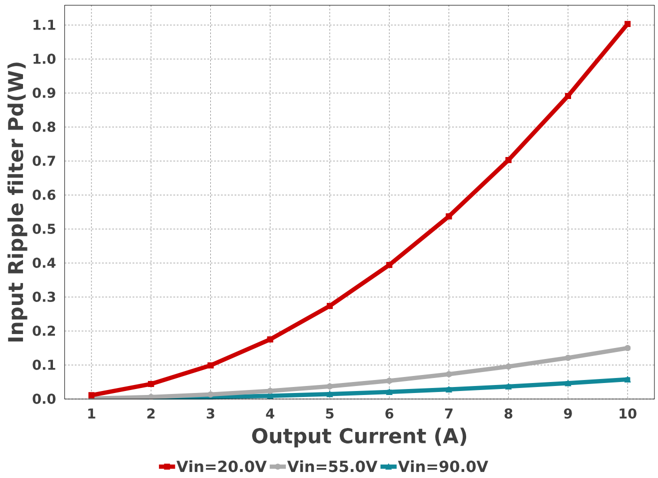
Cout Pd



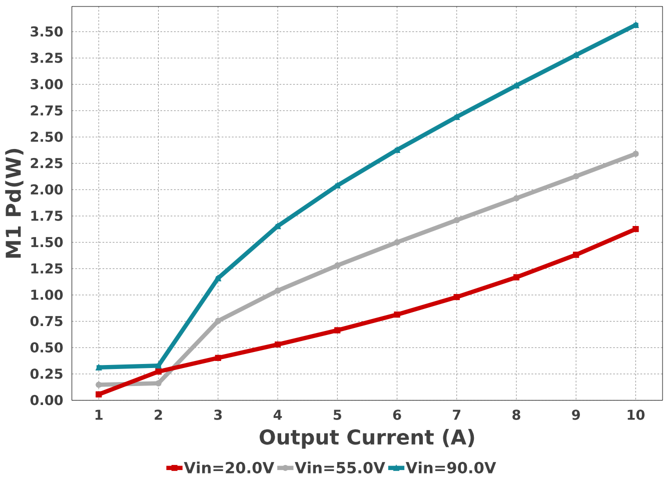
Ipp percentage



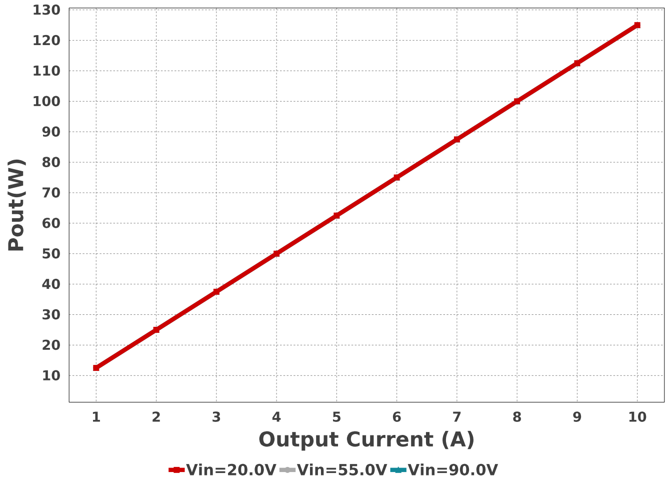
Input Ripple filter Pd

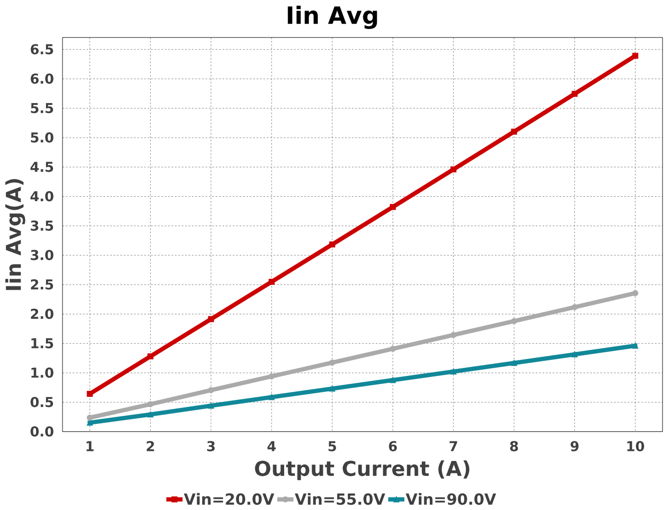


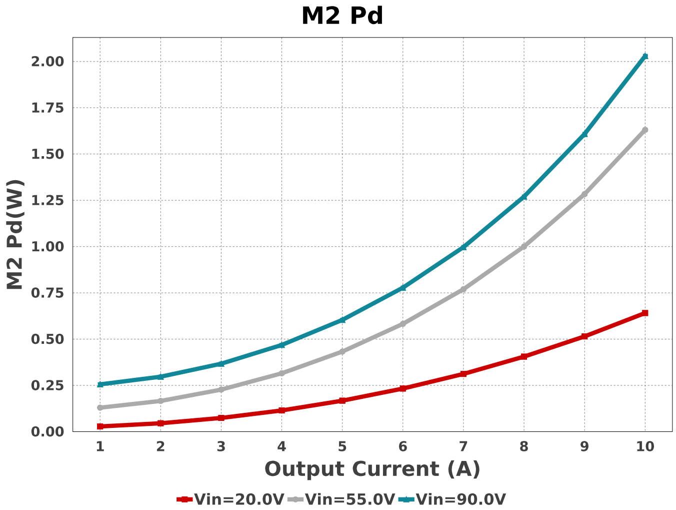
M1 Pd

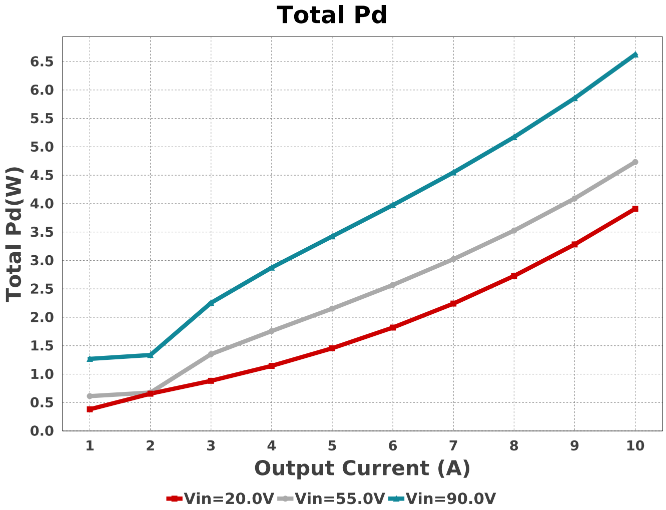


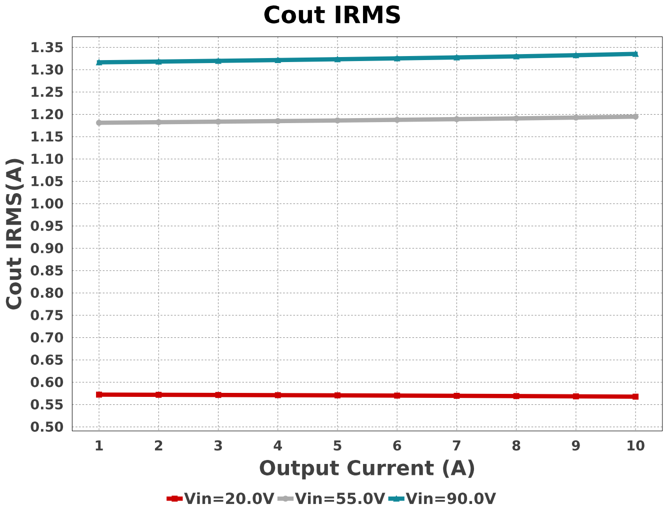
Pout

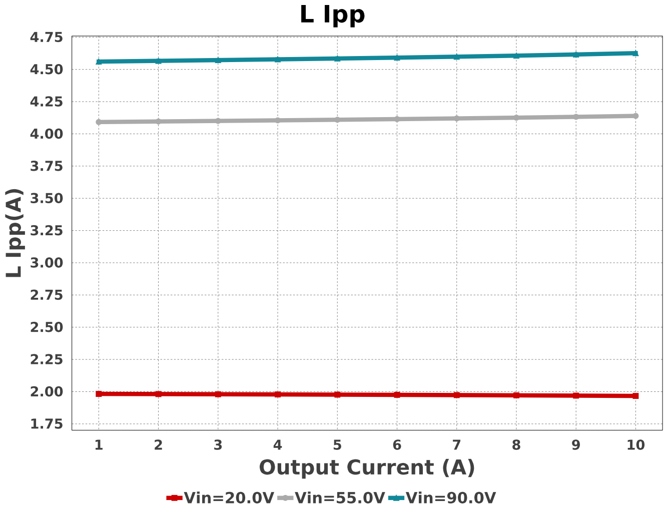


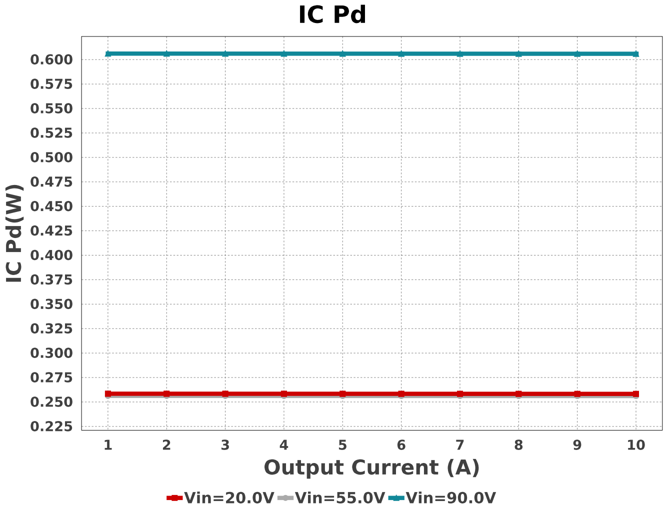

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=20.0V Vin=55.0V Vin=90.0V

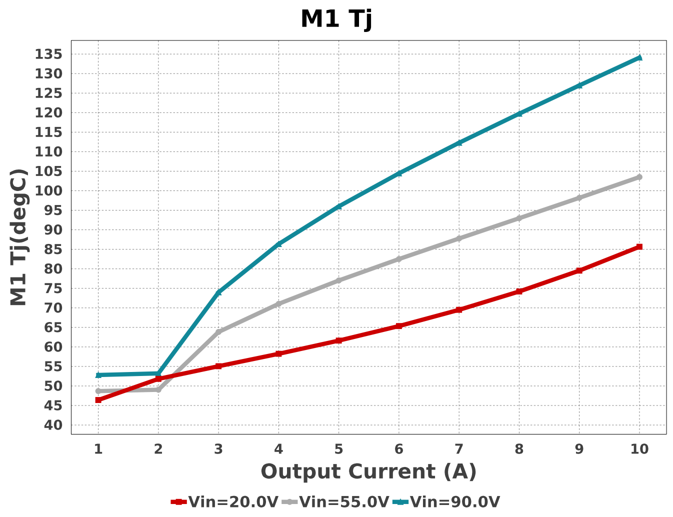

M2 Pd
M2 Pd(W)
Output Current (A)
Vin=20.0V Vin=55.0V Vin=90.0V

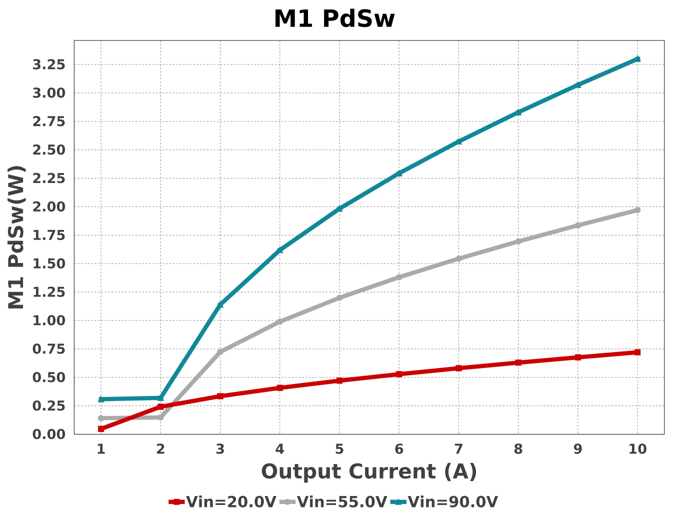

Total Pd
Total Pd(W)
Output Current (A)
Vin=20.0V Vin=55.0V Vin=90.0V

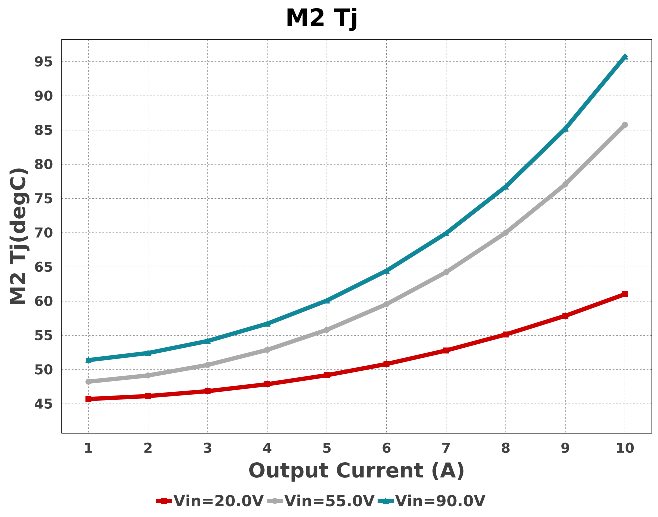

Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=20.0V Vin=55.0V Vin=90.0V

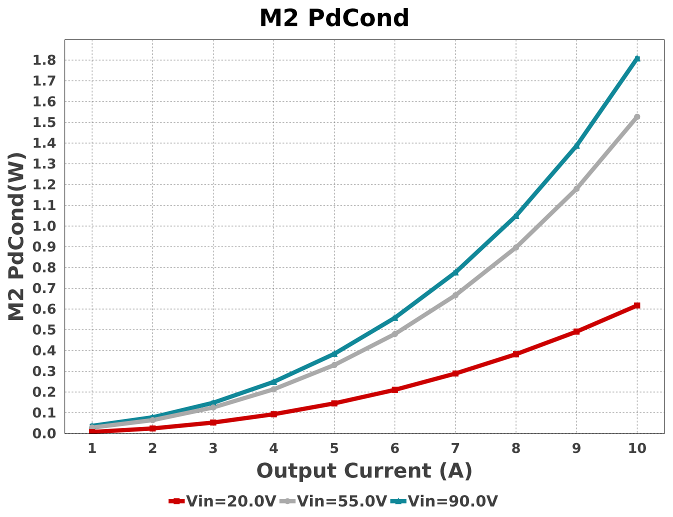

L Ipp
L Ipp(A)
Output Current (A)
Vin=20.0V Vin=55.0V Vin=90.0V

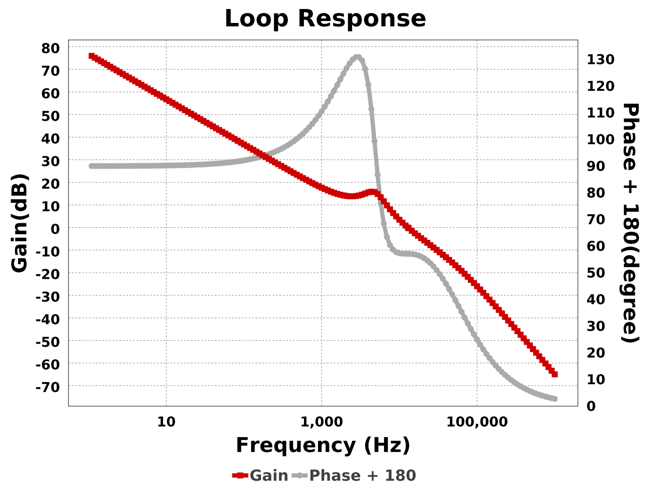

IC Pd
IC Pd(W)
Output Current (A)
Vin=20.0V Vin=55.0V Vin=90.0V

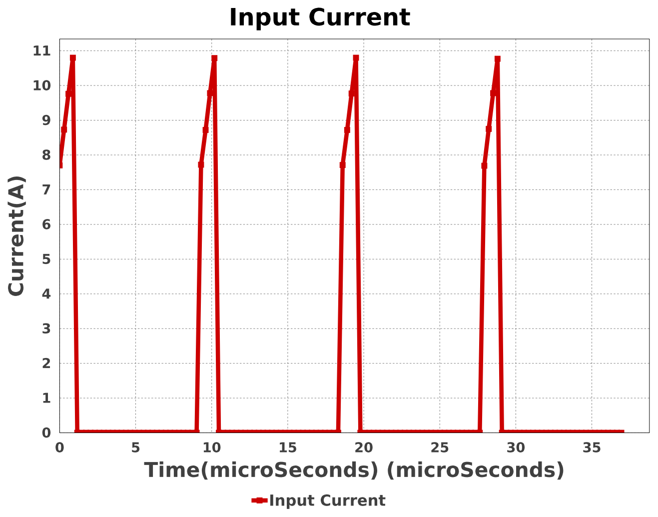

M1 Tj
M1 Tj(degC)
Output Current (A)
Vin=20.0V Vin=55.0V Vin=90.0V

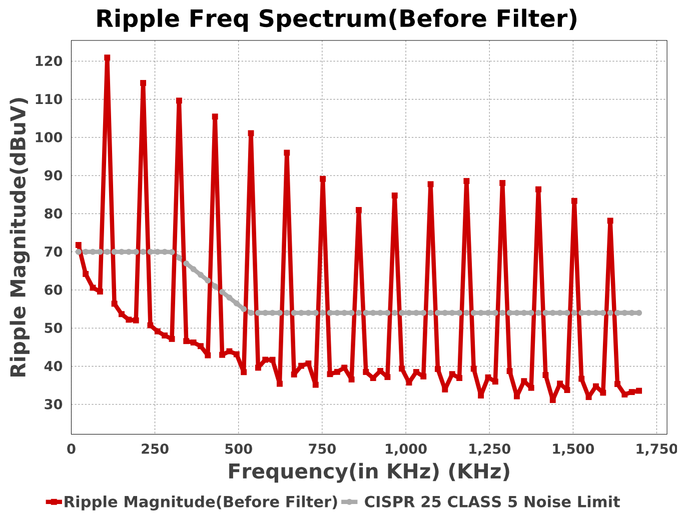

M1 PdSw
M1 PdSw(W)
Output Current (A)
Vin=20.0V Vin=55.0V Vin=90.0V

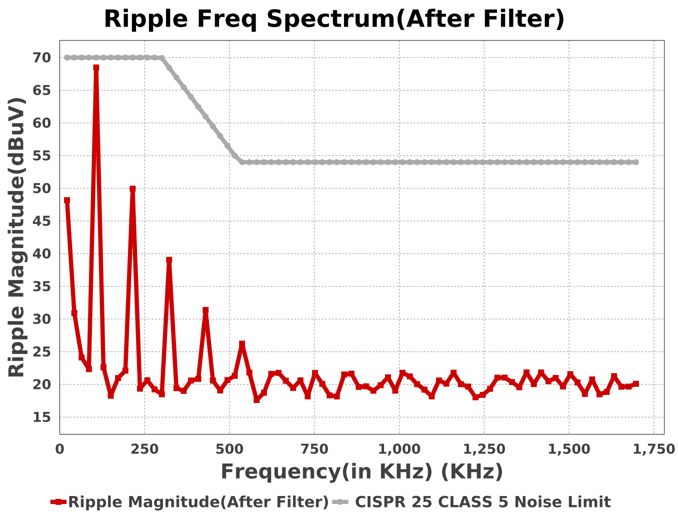

M2 Tj
M2 Tj(degC)
Output Current (A)
Vin=20.0V Vin=55.0V Vin=90.0V

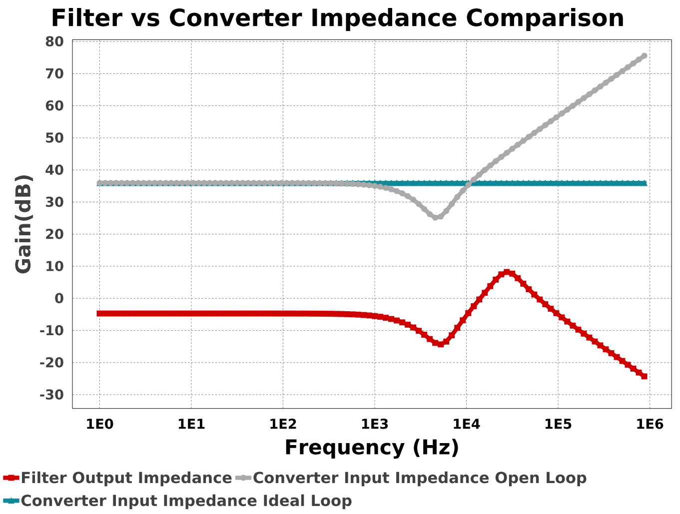

M2 PdCond
M2 PdCond(W)
Output Current (A)
Vin=20.0V Vin=55.0V Vin=90.0V

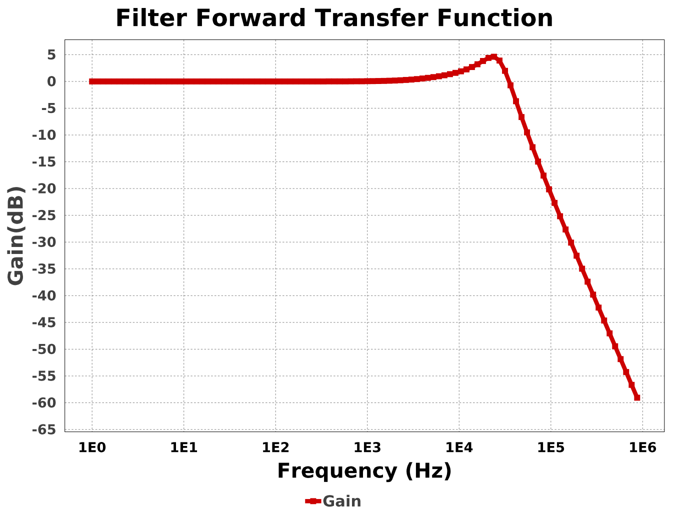

Loop Response
Gain(dB)
Phase + 180(degree)
Frequency (Hz)
Gain Phase + 180

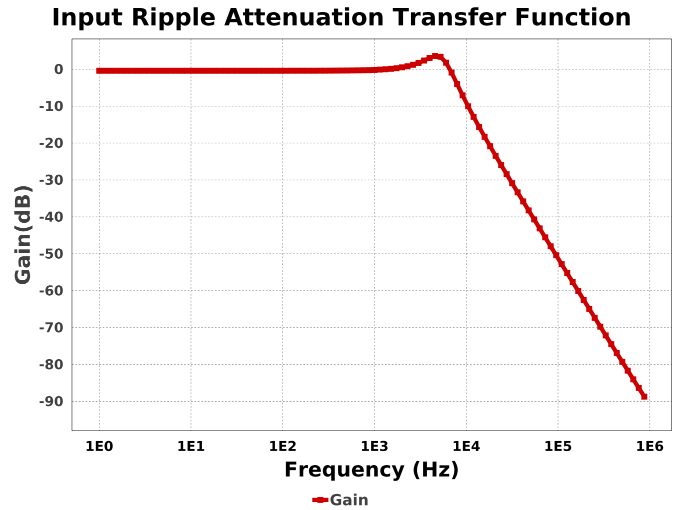

Input Current
Current(A)
Time(microSeconds) (microSeconds)
Input Current











Operating Values

#	Name	Value	Category	Description
1.	BOM Count	36		Total Design BOM count
2.	Total BOM	NA		Total BOM Cost
3.	Cin IRMS	3.521 A	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	17.567 mW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	1.335 A	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	80.257 mW	Capacitor	Output capacitor power dissipation
7.	Input Ripple Noise After input filter	68.49 dBuV	EMI Noise	Input Ripple Noise after filter at switching frequency
8.	Input Ripple Noise before input filter	120.94 dBuV	EMI Noise	Input Ripple Noise before filter at switching frequency
9.	Input Ripple filter Pd	57.703 mW	EMI Noise	Input Ripple Filter Power Dissipation

#	Name	Value	Category	Description
10.	Noise limits defined by CISPR Standards	70.0 dBuV	EMI Noise	Noise limits for CLASS 5 of CISPR 25 standard
11.	IC Ipk	12.313 A	IC	Peak switch current in IC
12.	IC Pd	605.94 mW	IC	IC power dissipation
13.	IC Tj	67.299 degC	IC	IC junction temperature
14.	IC Tolerance	8.0 mV	IC	IC Feedback Tolerance
15.	ICThetaJA	36.8 degC/W	IC	IC junction-to-ambient thermal resistance
16.	Iin Avg	1.462 A	IC	Average input current
17.	Ipp percentage	46.262 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
18.	L Ipp	4.626 A	Inductor	Peak-to-peak inductor ripple current
19.	L Pd	264.64 mW	Inductor	Inductor power dissipation
20.	M1 Pd	3.564 W	Mosfet	M1 MOSFET total power dissipation
21.	M1 PdCond	265.28 mW	Mosfet	M1 MOSFET conduction losses
22.	M1 PdSw	3.299 W	Mosfet	M1 MOSFET switching losses
23.	M1 Tj	134.105 degC	Mosfet	M1 MOSFET junction temperature
24.	M2 Pd	2.03 W	Mosfet	M2 MOSFET total power dissipation
25.	M2 PdCond	1.808 W	Mosfet	M2 MOSFET conduction losses
26.	M2 PdSw	221.4 mW	Mosfet	M2 MOSFET switching losses
27.	M2 Tj	95.74 degC	Mosfet	M2 MOSFET junction temperature
28.	Cin Pd	17.567 mW	Power	Input capacitor power dissipation
29.	Cout Pd	80.257 mW	Power	Output capacitor power dissipation
30.	IC Pd	605.94 mW	Power	IC power dissipation
31.	Input Ripple filter Pd	57.703 mW	Power	Input Ripple Filter Power Dissipation
32.	L Pd	264.64 mW	Power	Inductor power dissipation
33.	M1 Pd	3.564 W	Power	M1 MOSFET total power dissipation
34.	M1 PdCond	265.28 mW	Power	M1 MOSFET conduction losses
35.	M1 PdSw	3.299 W	Power	M1 MOSFET switching losses
36.	M2 Pd	2.03 W	Power	M2 MOSFET total power dissipation
37.	M2 PdCond	1.808 W	Power	M2 MOSFET conduction losses
38.	M2 PdSw	221.4 mW	Power	M2 MOSFET switching losses
39.	Total Pd	6.625 W	Power	Total Power Dissipation
40.	Duty Cycle	14.144 %	System Information	Duty cycle
41.	Efficiency	94.965 %	System Information	Steady state efficiency
42.	FootPrint	1.443 k mm^2	System Information	Total Foot Print Area of BOM components
43.	Frequency	107.411 kHz	System Information	Switching frequency
44.	Iout	10.0 A	System Information	Iout operating point
45.	Mode	FCCM	System Information	Conduction Mode
46.	Pout	125.0 W	System Information	Total output power
47.	Vin	90.0 V	System Information	Vin operating point
48.	Vin p-p	3.786 V	System Information	Peak-to-peak input voltage
49.	Vout	12.5 V	System Information	Operational Output Voltage
50.	Vout Actual	12.413 V	System Information	Vout Actual calculated based on selected voltage divider resistors
51.	Vout Tolerance	2.909 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
52.	Vout p-p	229.978 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	10.0	Maximum Output Current
VinMax	90.0	Maximum input voltage
VinMin	20.0	Minimum input voltage
Vout	12.5	Output Voltage
base_pn	LM5146	Base Product Number
source	DC	Input Source Type
Ta	45.0	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

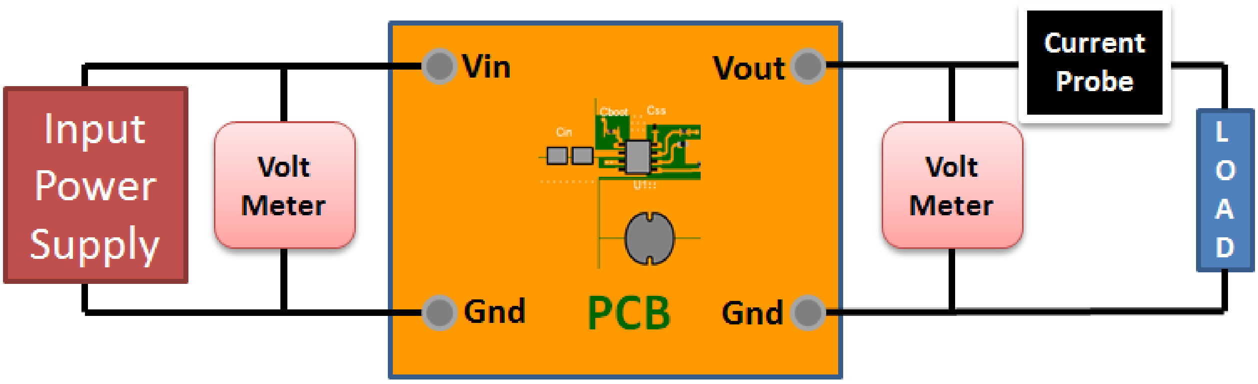
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 20.0V 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. Please note that since parallel FETs have been chosen in this design, schematic and PCB export features will not work

2. Master key : 1AEB83024E0A56E3[v1]

3. **LM5146** Product Folder : http://www.ti.com/product/lm5146 : contains the data sheet and other resources.

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