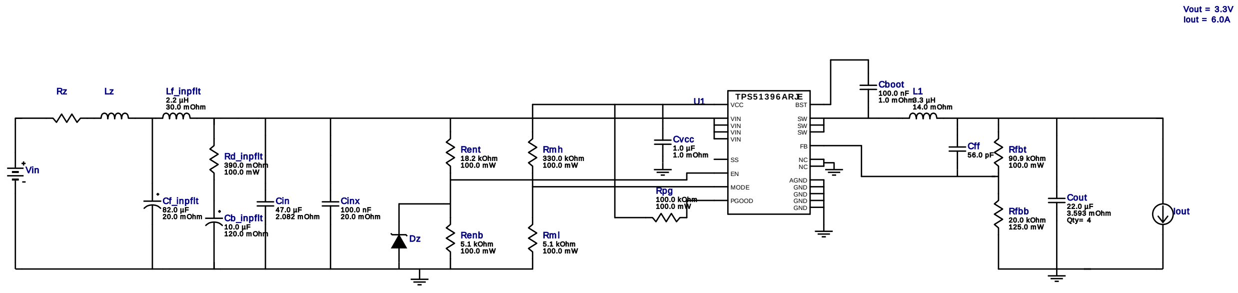
VinMin = 8.0V VinMax = 22.0V Vout = 3.3V Iout = 6.0A	Device = TPS51396ARJER Topology = Buck Created = 2023-10-27 09:40:59.041 BOM Cost = $3.44 BOM Count = 23 Total Pd = 2.06W

WEBENCH ® Design Report

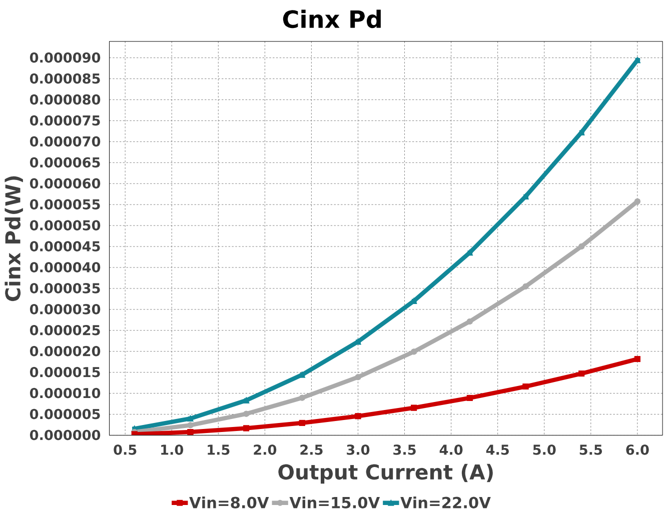
Design : 5 TPS51396ARJER
TPS51396ARJER 8V-22V to 3.30V @ 6A

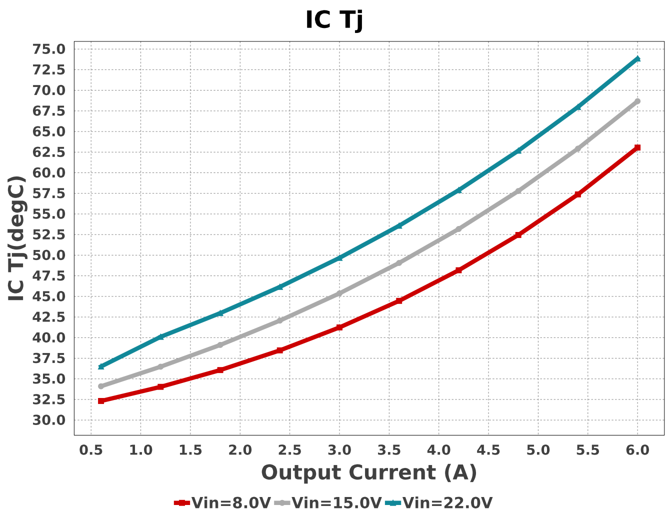


Electrical BOM

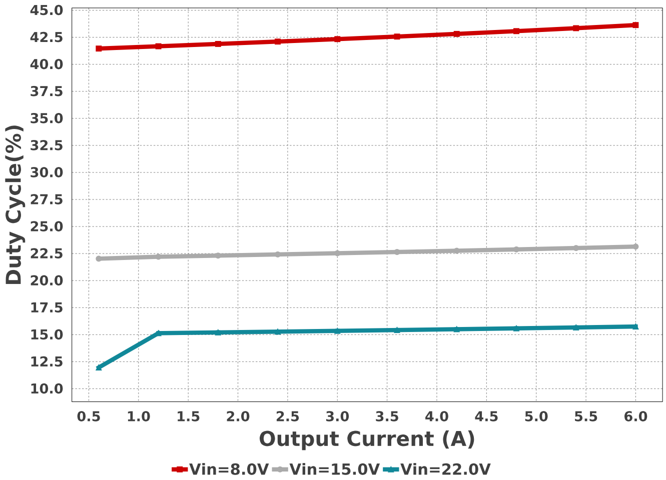
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cb_inpflt	Panasonic	EEHZA1H100R Series= ZA	Cap= 10.0 uF ESR= 120.0 mOhm VDC= 50.0 V IRMS= 750.0 mA	1	$0.46	SM_RADIAL_5MM 58 mm^2
Cboot	Taiyo Yuden	EMK107B7104KA-T Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2
Cf_inpflt	Panasonic	35SVPF82M Series= SVPF	Cap= 82.0 uF ESR= 20.0 mOhm VDC= 35.0 V IRMS= 4.0 A	1	$1.17	CAPSMT_62_E12 106 mm^2
Cff	Taiyo Yuden	UMK105CG560JV-F Series= C0G/NP0	Cap= 56.0 pF VDC= 5.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cin	TDK	C3216X5R1E476M160AC Series= X5R	Cap= 47.0 uF ESR= 2.082 mOhm VDC= 25.0 V IRMS= 5.0279 A	1	$0.35	1206 11 mm^2
Cinx	MuRata	GRM188R71H104KA93D Series= X7R	Cap= 100.0 nF ESR= 20.0 mOhm VDC= 50.0 V IRMS= 3.8 A	1	$0.02	0603 5 mm^2
Cout	MuRata	GRM31CR71A226KE15L Series= X7R	Cap= 22.0 uF ESR= 3.593 mOhm VDC= 10.0 V IRMS= 3.5332 A	4	$0.12	1206_190 11 mm^2
Cvcc	Taiyo Yuden	EMK107B7105KA-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2
Dz	ON Semiconductor	BZX84C3V6LT1G	Zener	1	$0.03	SOT-23 14 mm^2
L1	NIC Components	NPI52P3R3MTRF	L= 3.3 µH 14.0 mOhm	1	$0.36	IND_NPI52P 445 mm^2

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Lf_inpflt	NIC Components	NPI54C2R2MTRF	L= 2.2 µH 30.0 mOhm	1	$0.09	IND_NPI54C 61 mm^2
Rd_inpflt	Panasonic	ERJ-3RQFR39V Series= ERJ-3R	Res= 390.0 mOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.02	0603 5 mm^2
Renb	Yageo	RC0603FR-075K1L Series= ?	Res= 5.1 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rent	Vishay-Dale	CRCW060318K2FKEA Series= CRCW..e3	Res= 18.2 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rfbb	Vishay-Dale	CRCW080520K0FKEA Series= CRCW..e3	Res= 20.0 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Rfbt	Yageo	RC0603FR-0790K9L Series= ?	Res= 90.9 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rmh	Yageo	RC0603FR-07330KL Series= ?	Res= 330.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rml	Yageo	RC0603FR-075K1L Series= ?	Res= 5.1 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rpg	Vishay-Dale	CRCW0603100KFKEA Series= CRCW..e3	Res= 100.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
U1	Texas Instruments	TPS51396ARJER	Switcher	1	$0.37	RJE0020A 16 mm^2

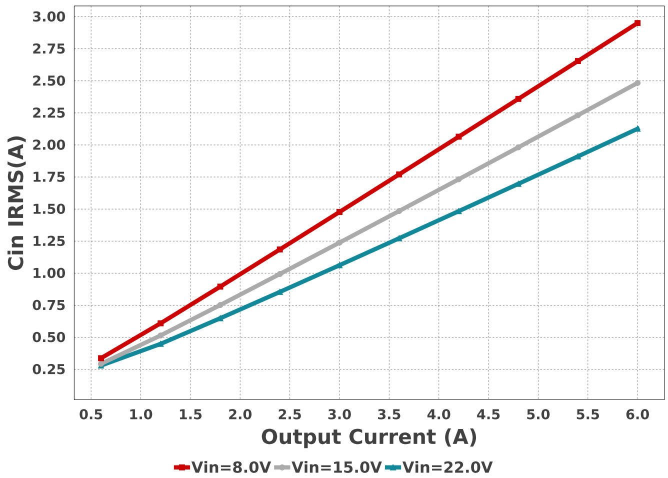




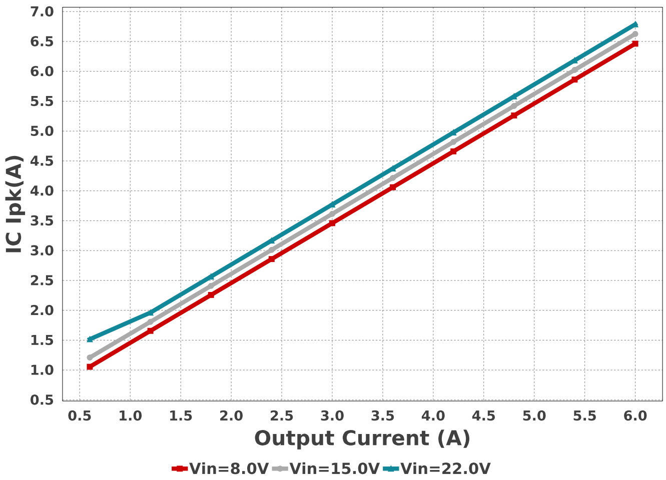
Duty Cycle



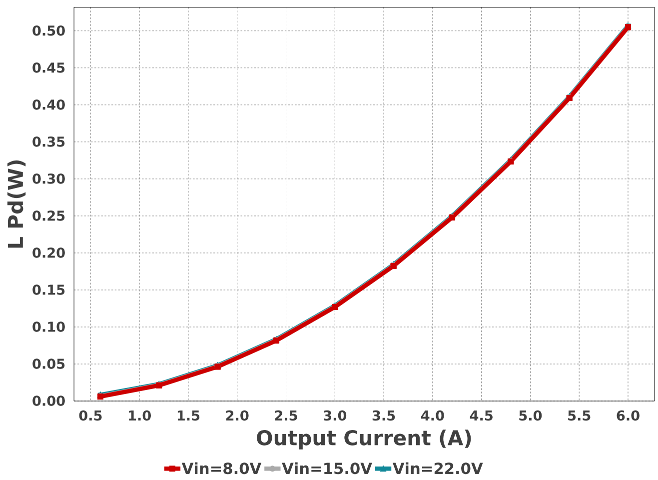
Cin IRMS



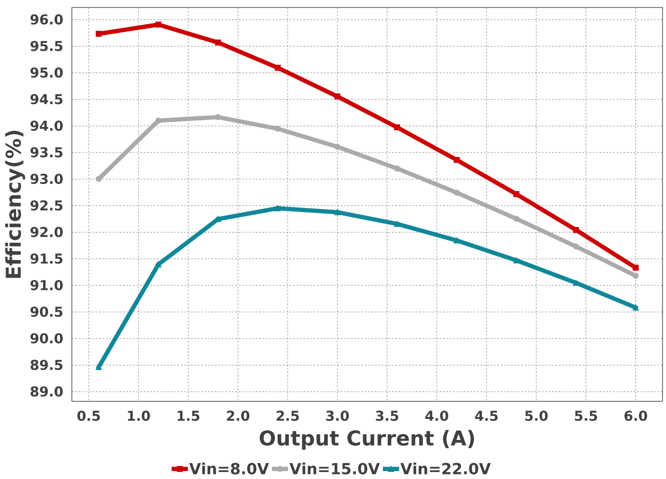
IC Ipk



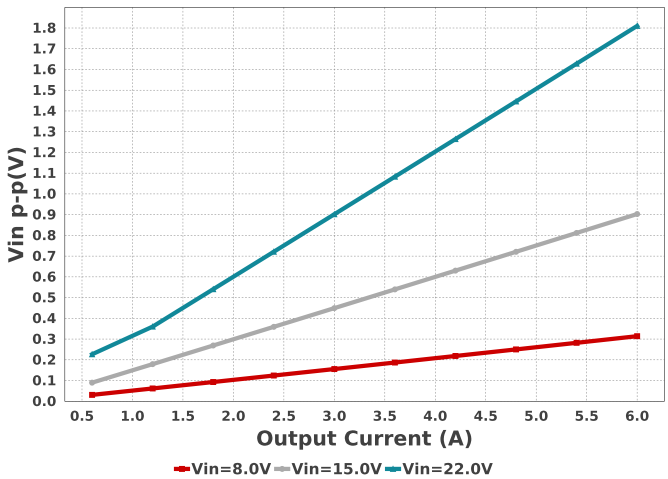
L Pd

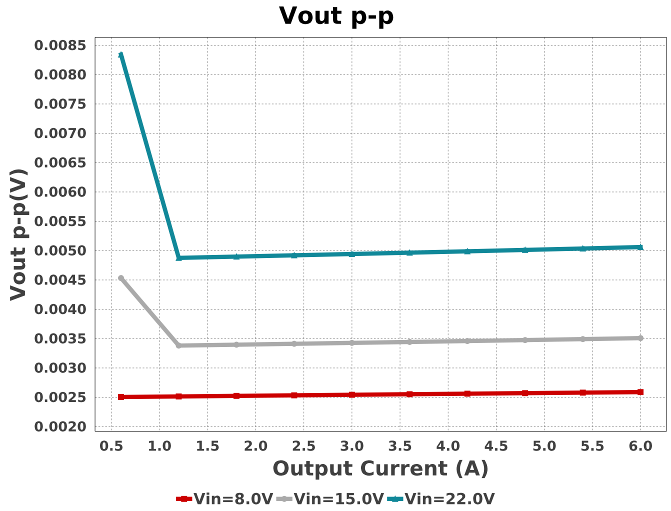


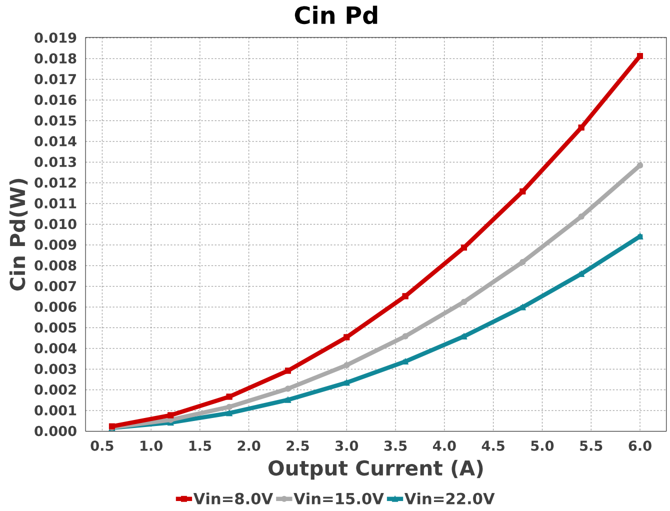
Efficiency

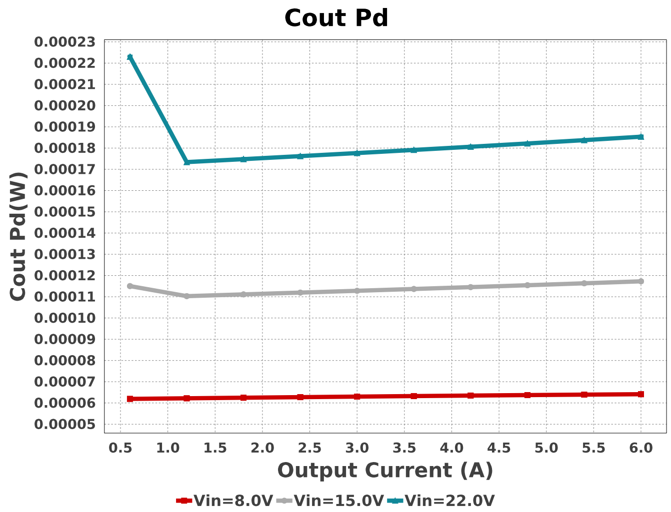


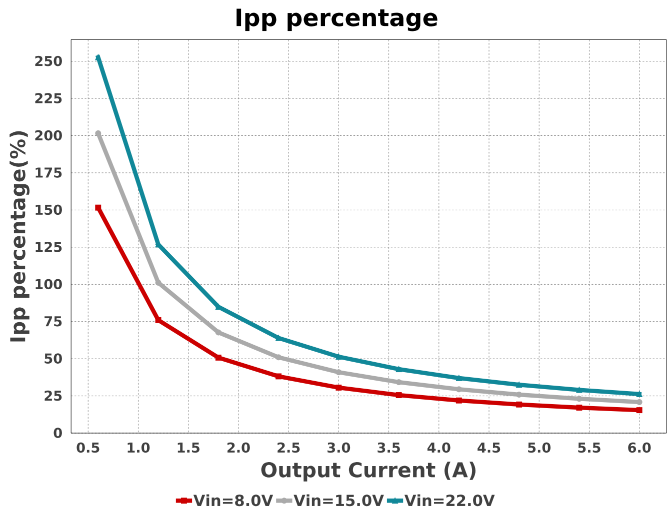
Vin p-p

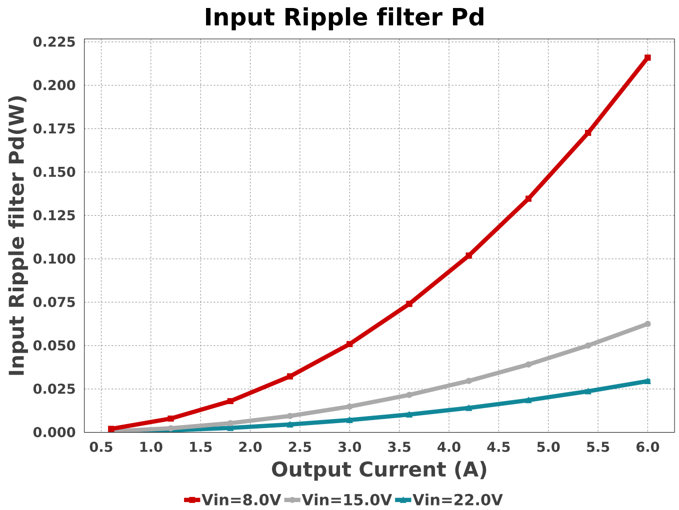


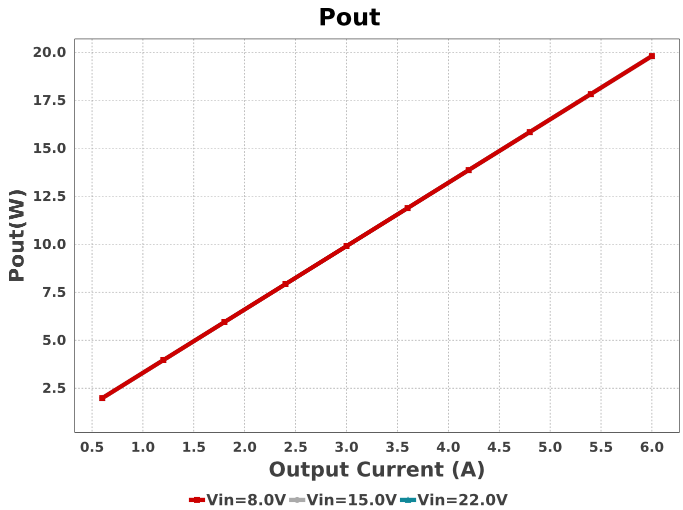

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=8.0V Vin=15.0V Vin=22.0V


Cin Pd
Cin Pd(W)
Output Current (A)
Vin=8.0V Vin=15.0V Vin=22.0V

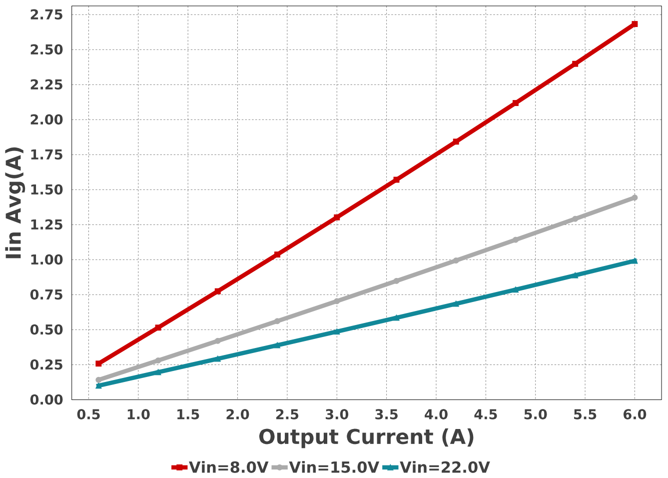

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=8.0V Vin=15.0V Vin=22.0V


Ipp percentage
Ipp percentage(%)
Output Current (A)
Vin=8.0V Vin=15.0V Vin=22.0V

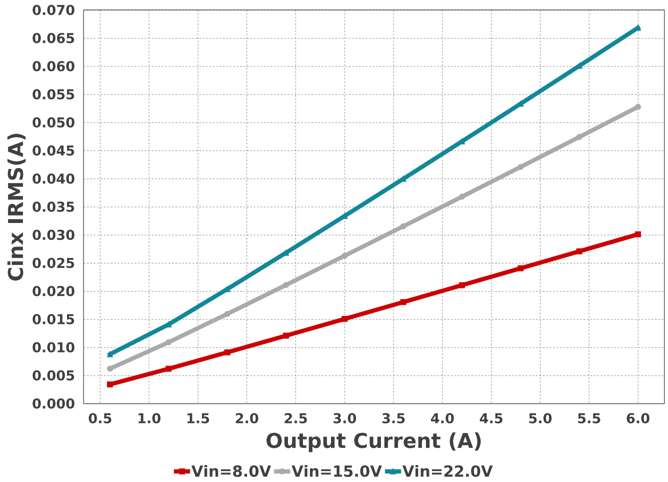

Input Ripple filter Pd
Input Ripple filter Pd(W)
Output Current (A)
Vin=8.0V Vin=15.0V Vin=22.0V


Pout
Pout(W)
Output Current (A)
Vin=8.0V Vin=15.0V Vin=22.0V

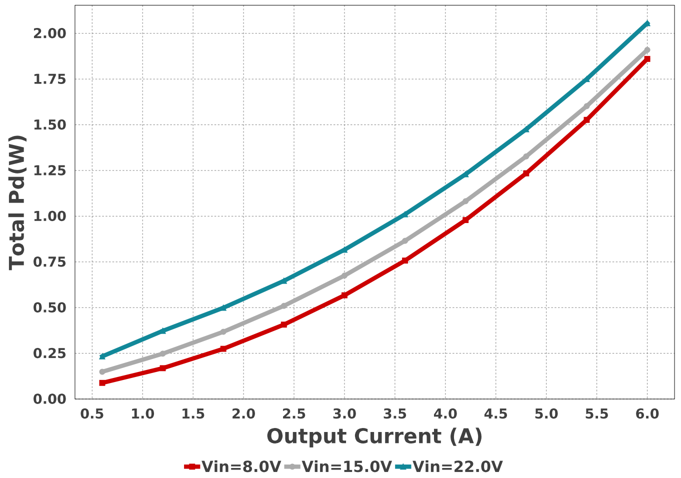
Iin Avg



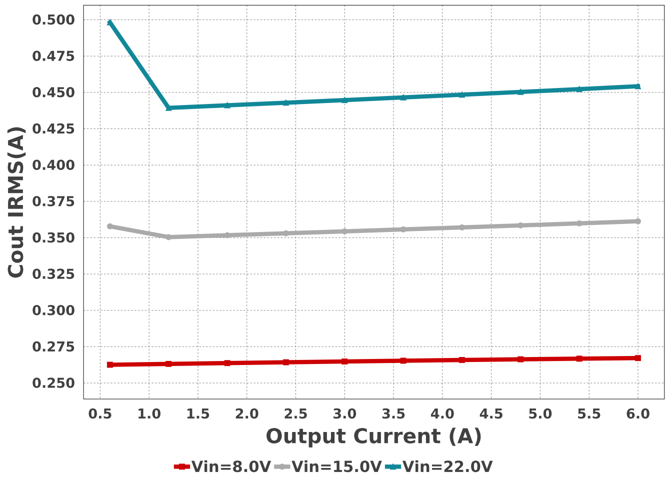
Cinx IRMS



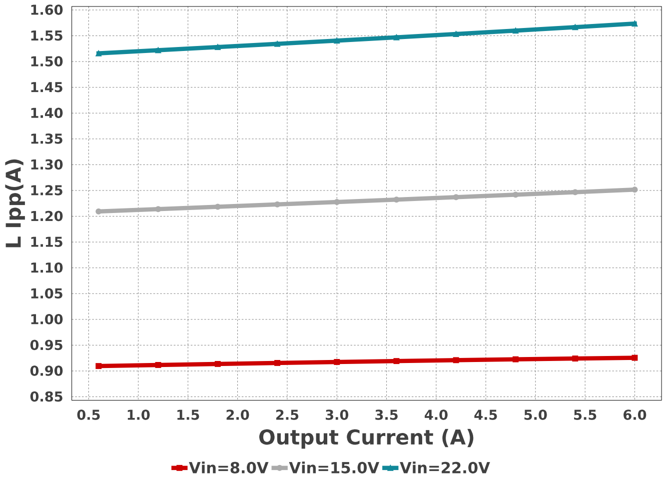
Total Pd



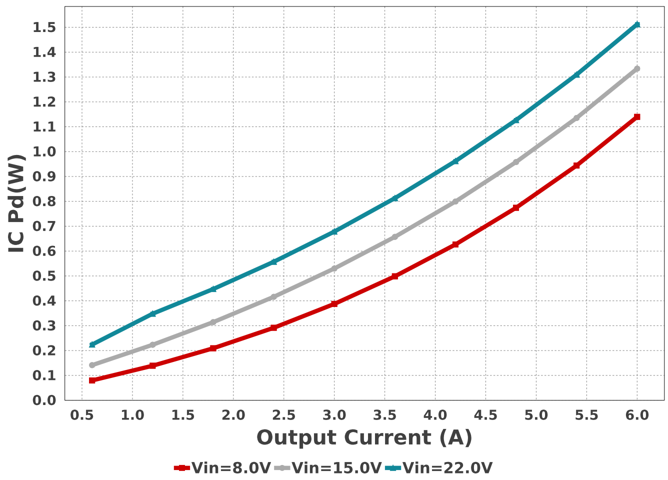
Cout IRMS



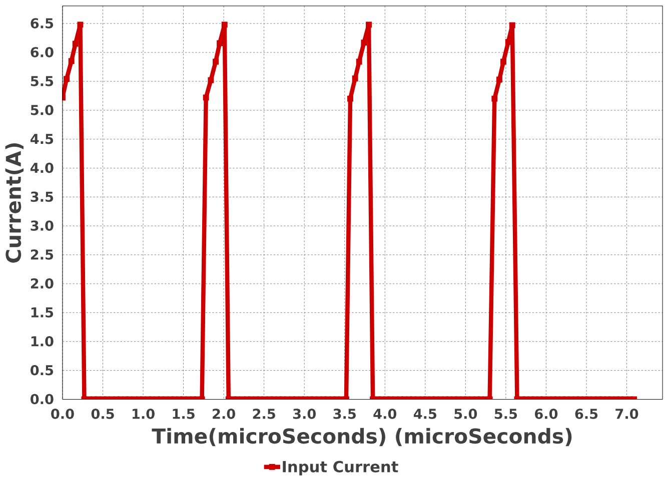
L Ipp



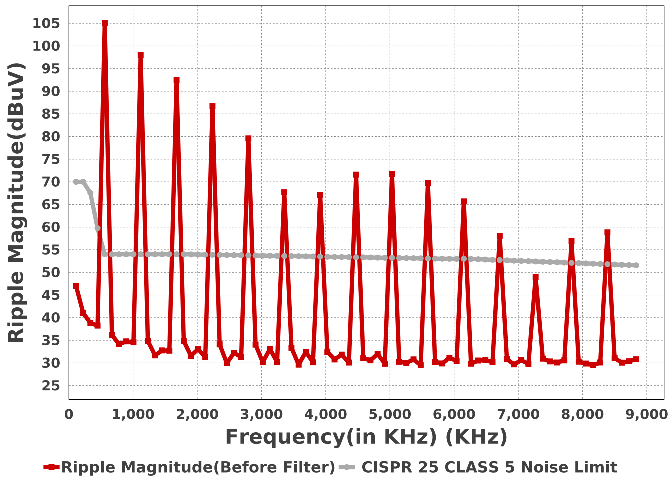
IC Pd



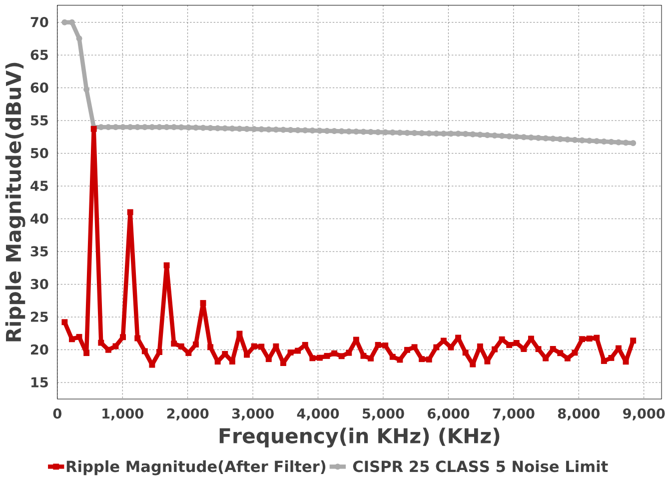
Input Current



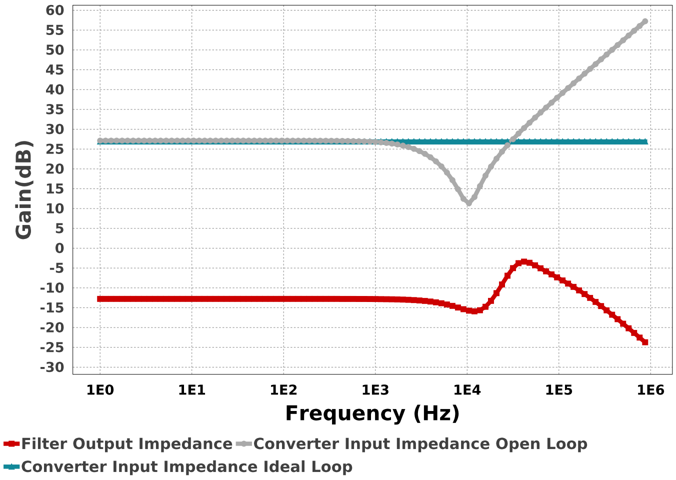
Ripple Freq Spectrum(Before Filter)



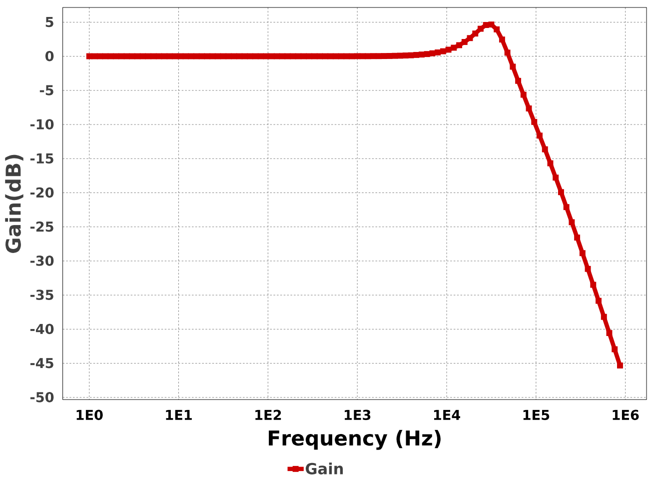
Ripple Freq Spectrum(After Filter)



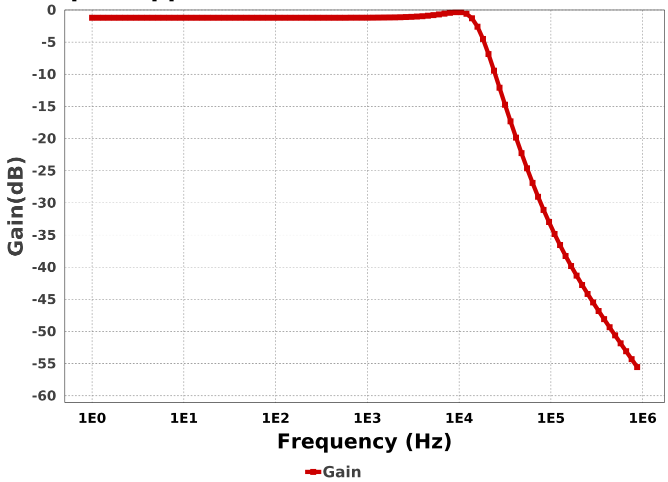
Filter vs Converter Impedance Comparison

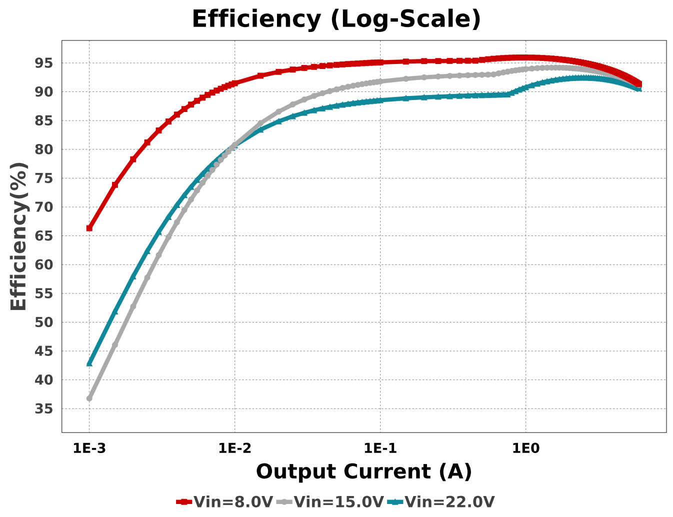


Filter Forward Transfer Function



Input Ripple Attenuation Transfer Function





Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	2.126 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	9.413 mW	Capacitor	Input capacitor power dissipation
3.	Cinx IRMS	66.875 mA	Capacitor	Bulk capacitor RMS ripple current
4.	Cinx Pd	89.444 µW	Capacitor	Bulk capacitor power dissipation
5.	Cout IRMS	454.255 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	185.35 µW	Capacitor	Output capacitor power dissipation
7.	Input Ripple Noise After input filter	53.71 dBuV	EMI Noise	Input Ripple Noise after filter at switching frequency
8.	Input Ripple Noise before input filter	105.11 dBuV	EMI Noise	Input Ripple Noise before filter at switching frequency
9.	Input Ripple filter Pd	29.535 mW	EMI Noise	Input Ripple Filter Power Dissipation
10.	Noise limits defined by CISPR Standards	54.0 dBuV	EMI Noise	Noise limits for CLASS 5 of CISPR 25 standard
11.	IC Ipk	6.787 A	IC	Peak switch current in IC
12.	IC Pd	1.512 W	IC	IC power dissipation
13.	IC Tj	73.852 degC	IC	IC junction temperature
14.	IC Tolerance	6.0 mV	IC	IC Feedback Tolerance
15.	ICThetaJA Effective	29.0 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
16.	Iin Avg	992.22 mA	IC	Average input current
17.	Ipp percentage	26.226 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
18.	L Ipp	1.574 A	Inductor	Peak-to-peak inductor ripple current
19.	L Pd	506.89 mW	Inductor	Inductor power dissipation
20.	Cin Pd	9.413 mW	Power	Input capacitor power dissipation
21.	Cinx Pd	89.444 µW	Power	Bulk capacitor power dissipation
22.	Cout Pd	185.35 µW	Power	Output capacitor power dissipation
23.	IC Pd	1.512 W	Power	IC power dissipation
24.	Input Ripple filter Pd	29.535 mW	Power	Input Ripple Filter Power Dissipation
25.	L Pd	506.89 mW	Power	Inductor power dissipation
26.	Total Pd	2.056 W	Power	Total Power Dissipation
27.	BOM Count	23	System Information	Total Design BOM count
28.	Duty Cycle	15.751 %	System Information	Duty cycle
29.	Efficiency	90.583 %	System Information	Steady state efficiency
30.	FootPrint	811.0 mm^2	System Information	Total Foot Print Area of BOM components
31.	Frequency	559.175 kHz	System Information	Switching frequency
32.	Iout	6.0 A	System Information	Iout operating point
33.	Iout transient step used for Cout calculations	3.0 A	System Information	Custom Transient current step requirement that was used for Cout selection (A).
34.	Mode	CCM	System Information	Conduction Mode
35.	Overshoot Value	62.267 mV	System Information	Theoretical Vout Overshoot Value
36.	Pout	19.8 W	System Information	Total output power
37.	Total BOM	$3.44	System Information	Total BOM Cost

#	Name	Value	Category	Description
38.	Undershoot Value	49.326 mV	System Information	Theoretical Vout Undershoot Value
39.	Vin	22.0 V	System Information	Vin operating point
40.	Vin p-p	1.81 V	System Information	Peak-to-peak input voltage
41.	Vout	3.3 V	System Information	Operational Output Voltage
42.	Vout Actual	3.327 V	System Information	Vout Actual calculated based on selected voltage divider resistors
43.	Vout Ripple requirement used for Cout calculations	1.0 %	System Information	Custom maximum output ripple requirement that was used for Cout selection(% of Vout).
44.	Vout Tolerance	2.672 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
45.	Vout p-p	5.061 mV	System Information	Peak-to-peak output ripple voltage
46.	Vout transient requirement used for Cout calculations	5.0 %	System Information	Custom Transient voltage change requirement that was used for Cout selection (% of Vout).

Design Inputs

Name	Value	Description
Iout	6.0	Maximum Output Current
VinMax	22.0	Maximum input voltage
VinMin	8.0	Minimum input voltage
Vout	3.3	Output Voltage
base_pn	TPS51396A	Base Product Number
source	DC	Input Source Type
Ta	30.0	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

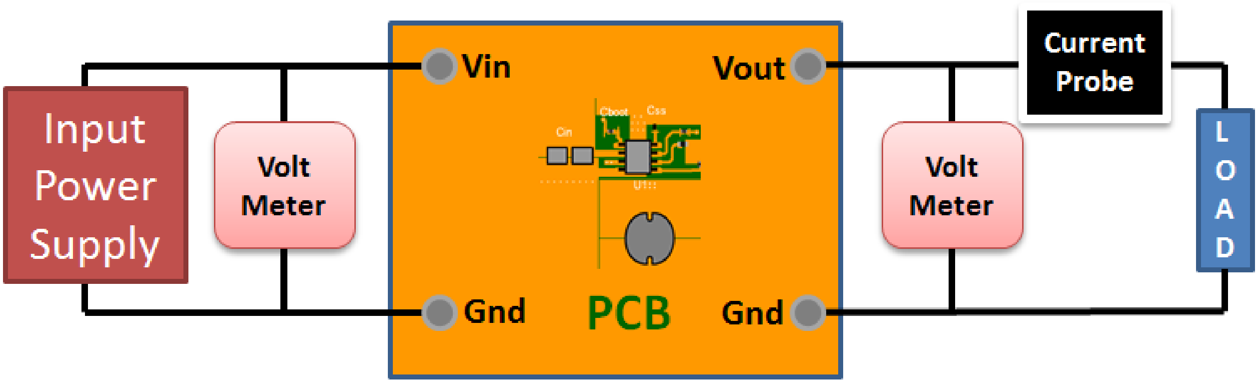
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 8.0V 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 : F4491D82BBC561DD[v1]

2. **TPS51396A** Product Folder : http://www.ti.com/product/TPS51396A : contains the data sheet and other resources.