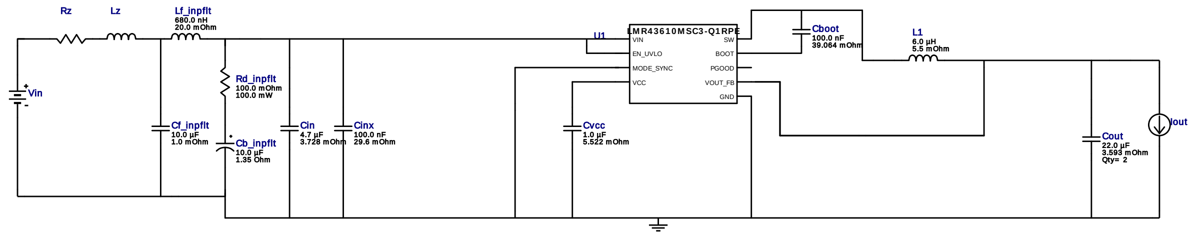
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 5.0V
VinMax = 22.0V
Vout = 3.3V
Iout = 0.5A

Device = LMR43610MSC3RPERQ1
Topology = Buck
Created = 2024-06-05 10:22:43.054
BOM Cost = $3.51
BOM Count = 12
Total Pd = 0.09W

Design : 1 LMR43610MSC3RPERQ1
LMR43610MSC3RPERQ1 5V-22V to 3.30V @ 0.5A



Design Alerts

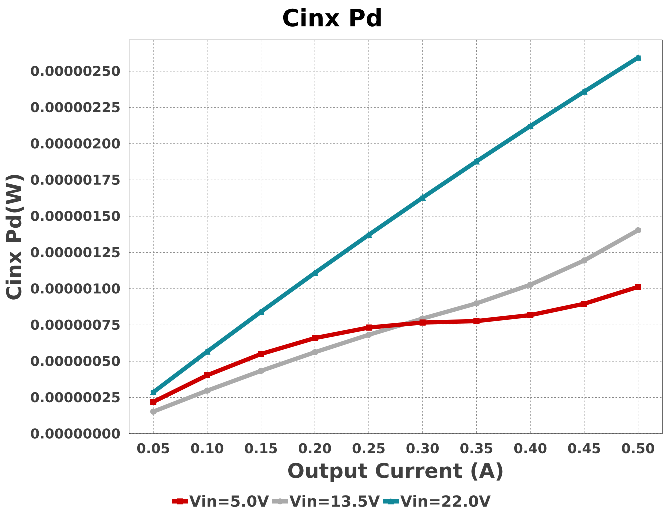
Component Selection Information

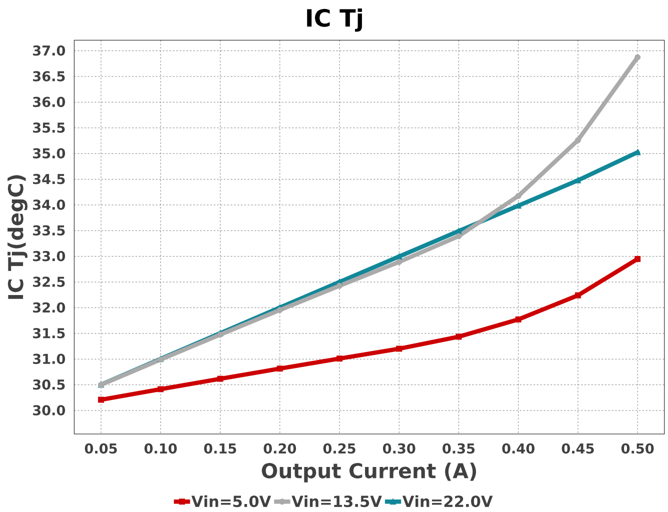
The LMR43610MSC3-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application.This device is recommended for maximum Vin of 36V

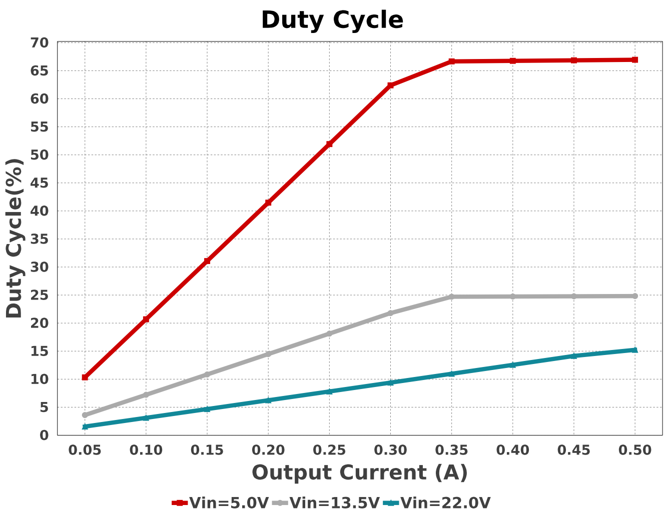
Electrical BOM

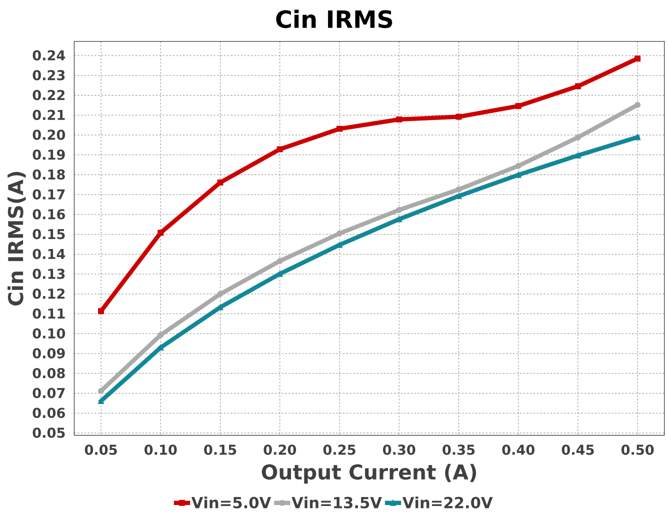
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cb_inpflt	Panasonic	EEE-FK1V100UR Series= FK	Cap= 10.0 uF ESR= 1.35 Ohm VDC= 35.0 V IRMS= 90.0 mA	1	$0.11	SM_RADIAL_B 47 mm^2
Cboot	TDK	CGA2B3X7R1H104K050BB Series= X7R	Cap= 100.0 nF ESR= 39.064 mOhm VDC= 50.0 V IRMS= 814.67 mA	1	$0.02	0402 3 mm^2
Cf_inpflt	TDK	C3225X7R1H106M250AC Series= X7R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 5.0 A	1	$0.27	1210 15 mm^2
Cin	TDK	C1608X5R1V475K080AC Series= X5R	Cap= 4.7 uF ESR= 3.728 mOhm VDC= 35.0 V IRMS= 2.69359 A	1	$0.10	0603 5 mm^2
Cinx	TDK	CGA3E2X7R1H104K080AA Series= X7R	Cap= 100.0 nF ESR= 29.6 mOhm VDC= 50.0 V IRMS= 971.99 mA	1	$0.01	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	2	$0.12	1206_190 11 mm^2
Cvcc	TDK	CGA3E1X7R1V105K080AC Series= X7R	Cap= 1.0 uF ESR= 5.522 mOhm VDC= 35.0 V IRMS= 2.2162 A	1	$0.05	0603 5 mm^2
L1	Coilcraft	MLC1565-602MLB	L= 6.0 µH 5.5 mOhm	1	$1.05	MLC1565 243 mm^2

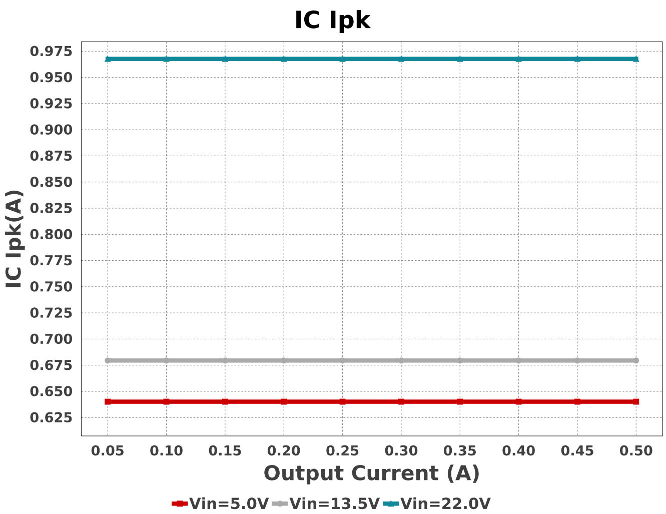
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Lf_inpflt	TDK	VLF252015MT-R68N	L= 680.0 nH 20.0 mOhm	1	$0.45	VLF252015MT 12 mm^2
Rd_inpflt	Panasonic	ERJ-3RSFR10V Series= ERJ-3R	Res= 100.0 mOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.03	0603 5 mm^2
U1	Texas Instruments	LMR43610MSC3RPERQ1	Switcher	1	$1.18	RPE0009A 9 mm^2

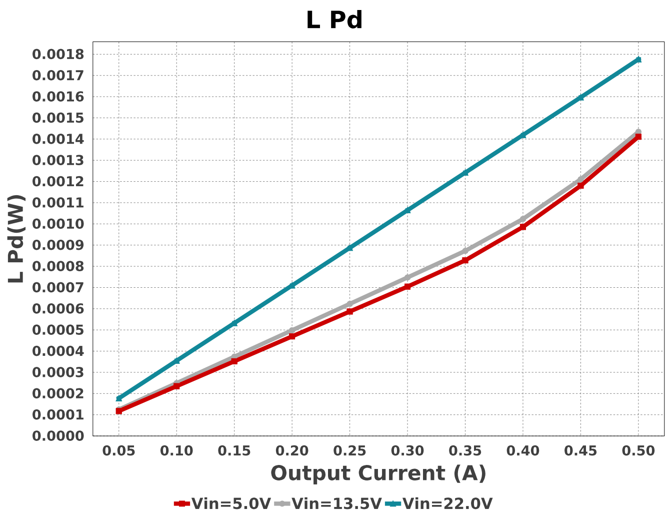


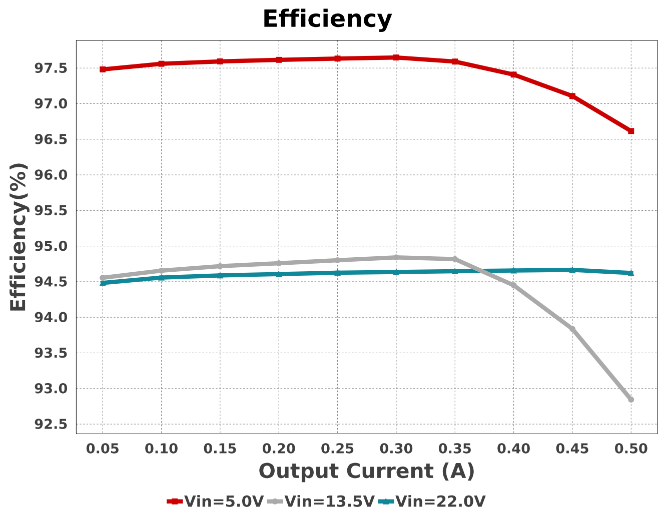


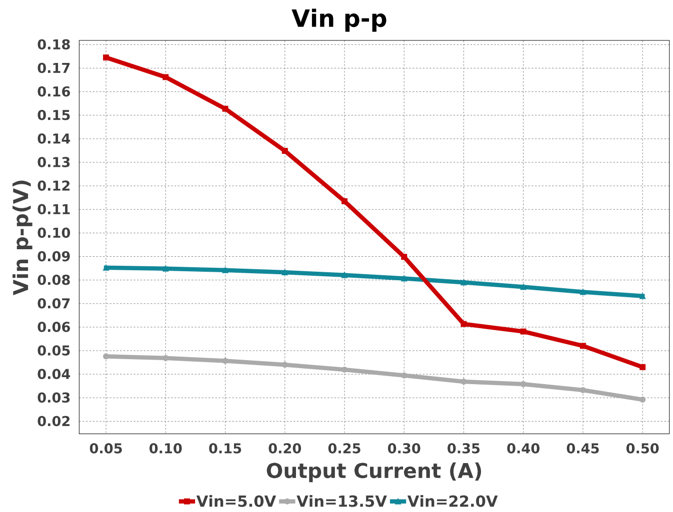


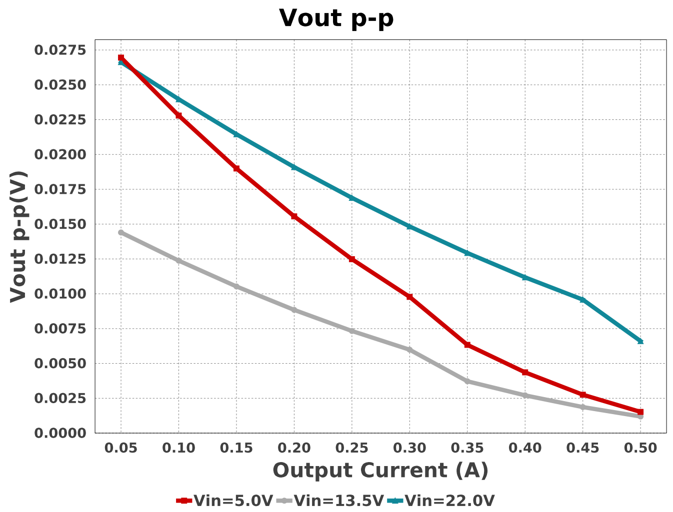


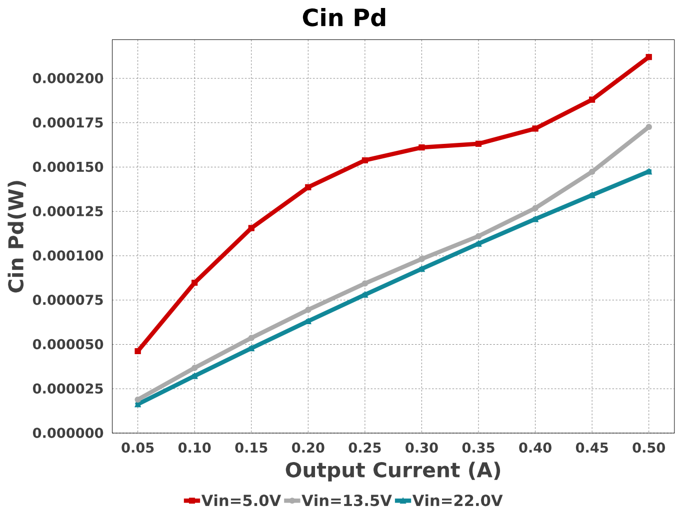


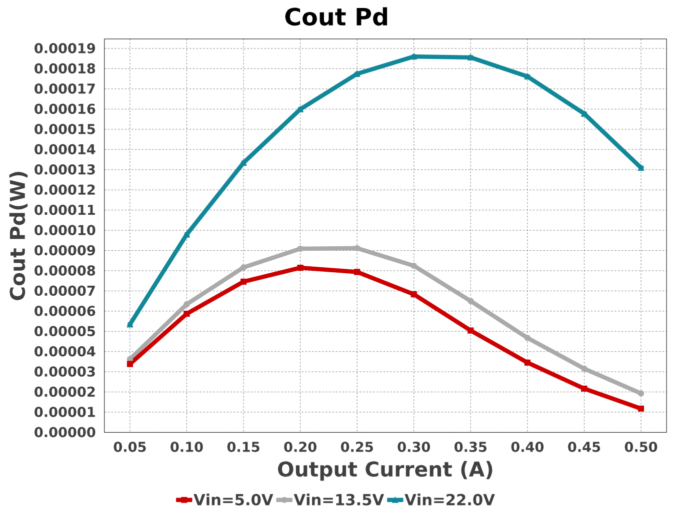


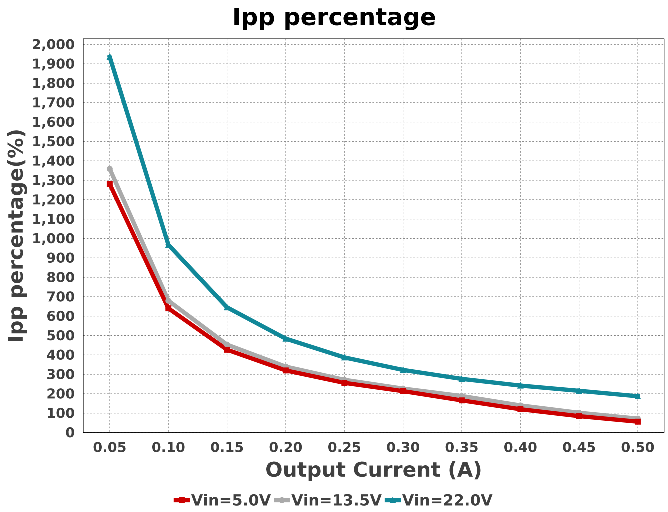

Efficiency
Efficiency(%)
Output Current (A)
Vin=5.0V Vin=13.5V Vin=22.0V

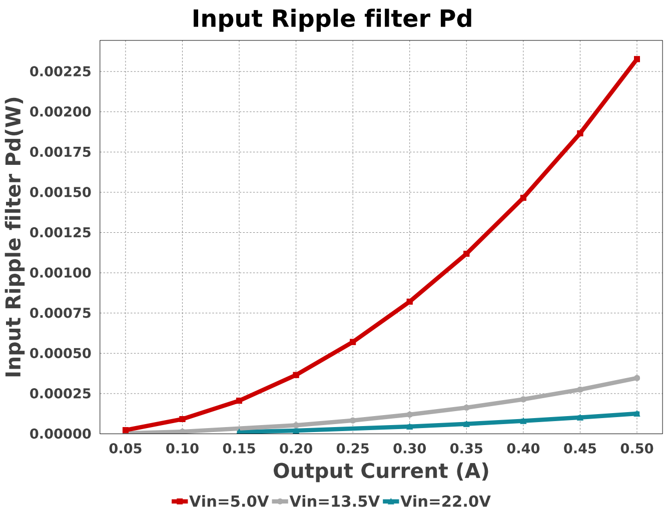

Vin p-p
Vin p-p(V)
Output Current (A)
Vin=5.0V Vin=13.5V Vin=22.0V

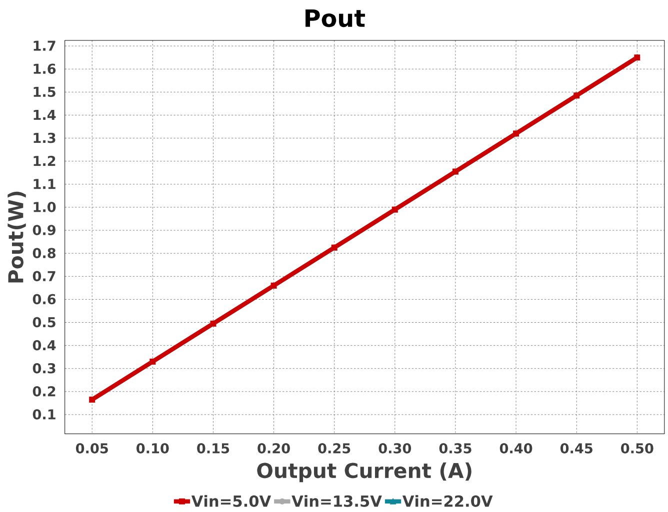

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=5.0V Vin=13.5V Vin=22.0V

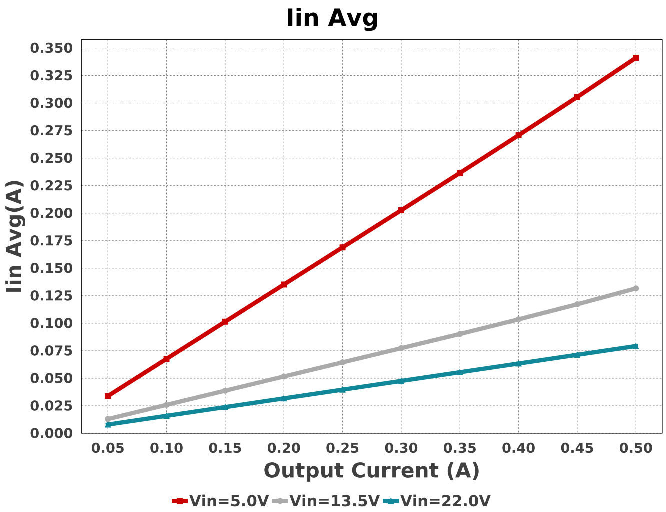

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=5.0V Vin=13.5V Vin=22.0V

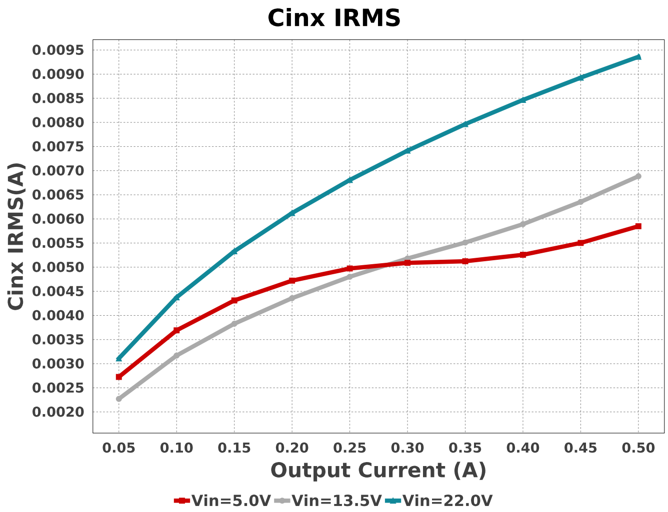

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=5.0V Vin=13.5V Vin=22.0V

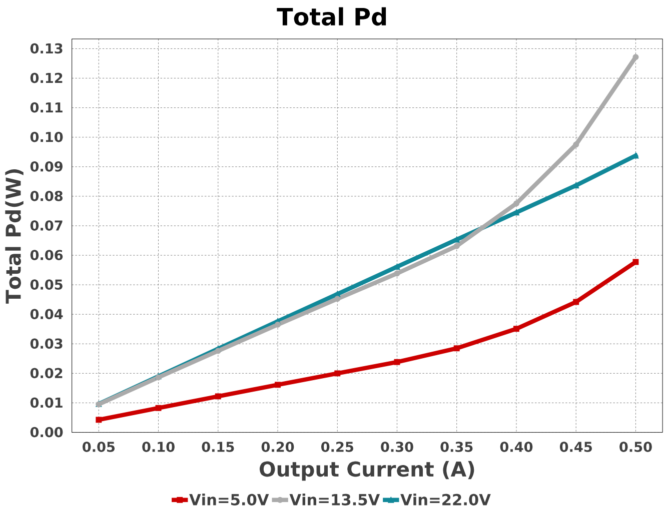

Ipp percentage
Ipp percentage(%)
Output Current (A)
Vin=5.0V Vin=13.5V Vin=22.0V

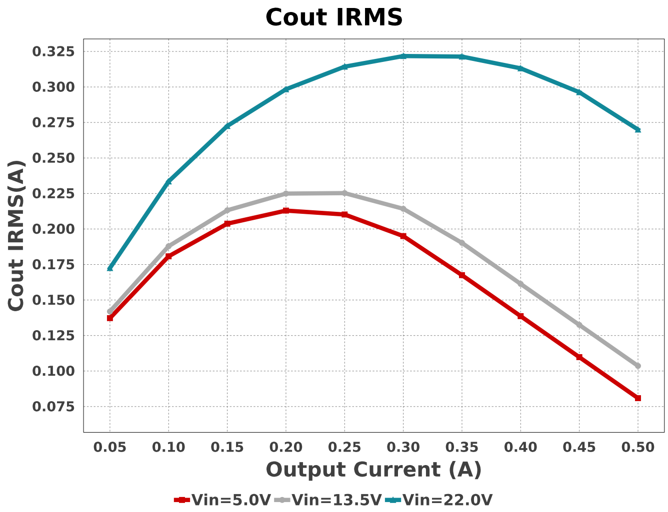

Input Ripple filter Pd
Input Ripple filter Pd(W)
0.00225
0.00200
0.00175
0.00150
0.00125
0.00100
0.00075
0.00050
0.00025
0.00000
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=5.0V Vin=13.5V Vin=22.0V

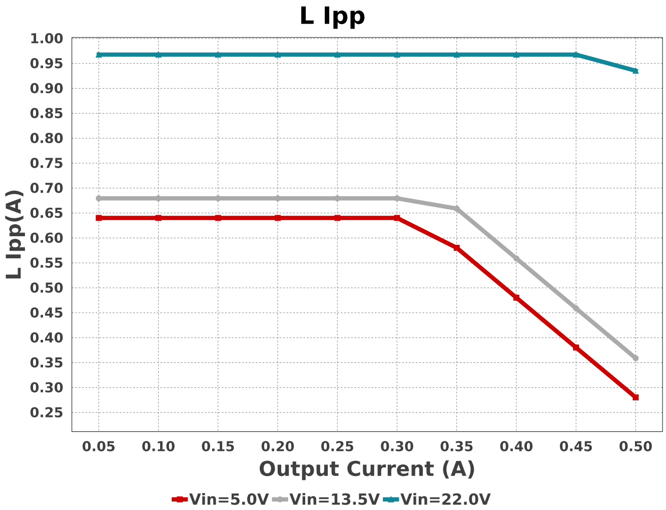

Pout
Pout(W)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=5.0V Vin=13.5V Vin=22.0V

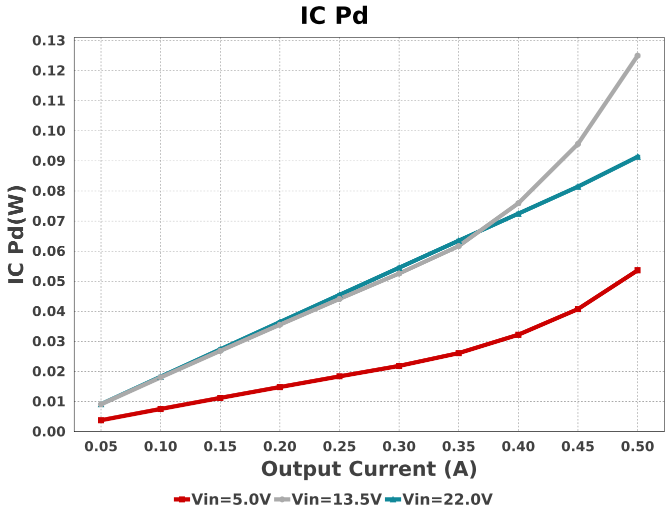

Iin Avg
Iin Avg(A)
0.350
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=5.0V Vin=13.5V Vin=22.0V

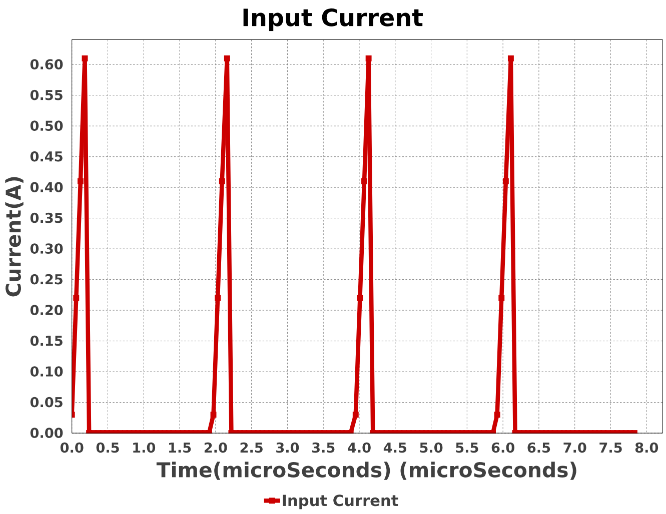

Cinx IRMS
Cinx IRMS(A)
0.0095
0.0090
0.0085
0.0080
0.0075
0.0070
0.0065
0.0060
0.0055
0.0050
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=5.0V Vin=13.5V Vin=22.0V

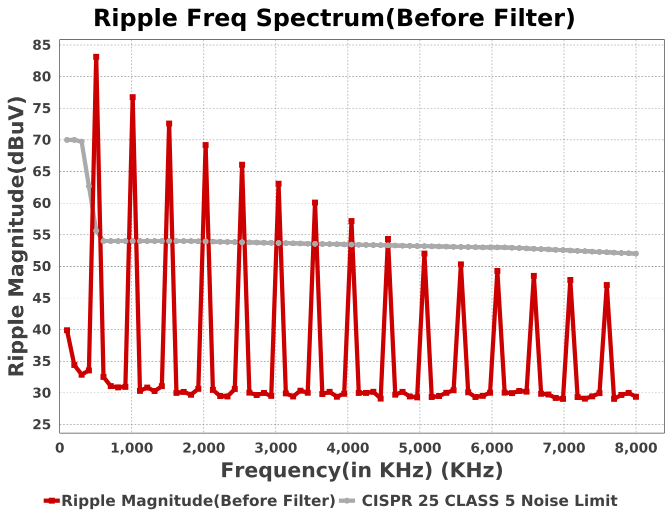

Total Pd
Total Pd(W)
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=5.0V Vin=13.5V Vin=22.0V

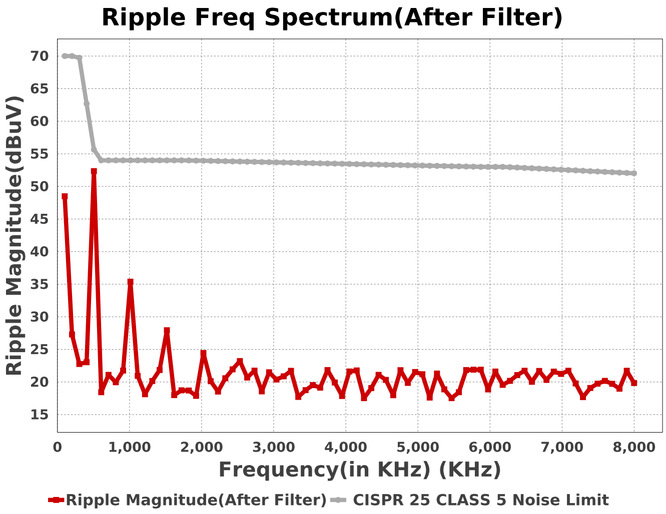

Cout IRMS
Cout IRMS(A)
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=5.0V Vin=13.5V Vin=22.0V

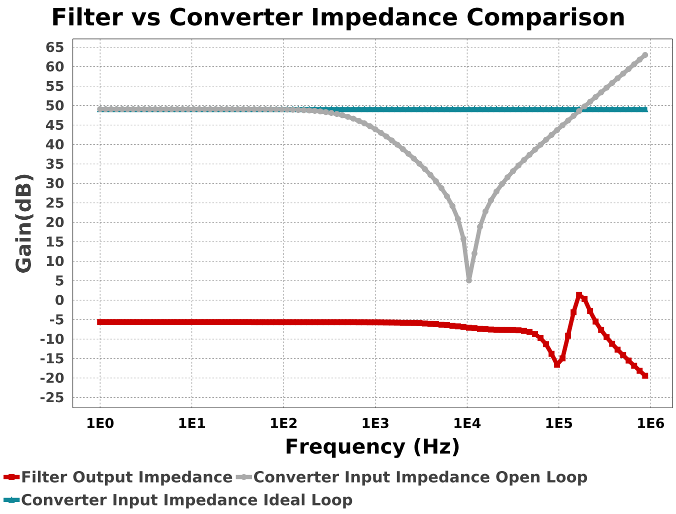

L Ipp
L Ipp(A)
Output Current (A)
Vin=5.0V
Vin=13.5V
Vin=22.0V

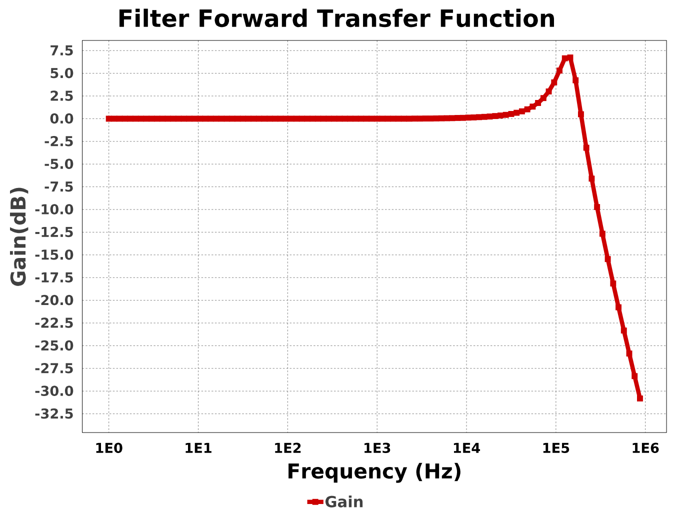

IC Pd
IC Pd(W)
Output Current (A)
Vin=5.0V
Vin=13.5V
Vin=22.0V

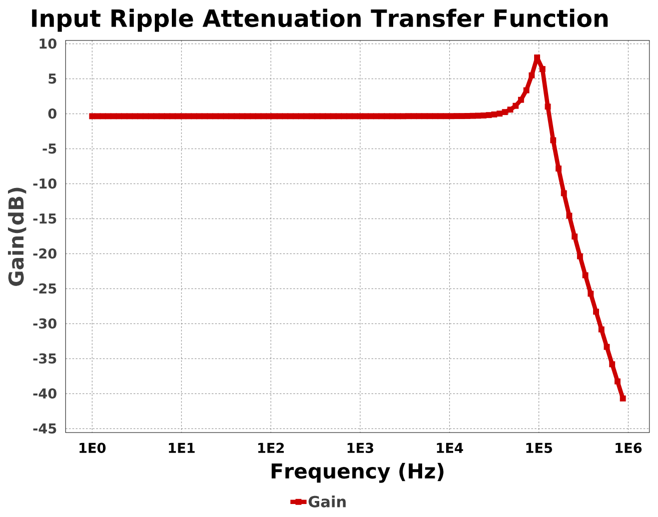

Input Current
Current(A)
Time(microSeconds) (microSeconds)
Input Current

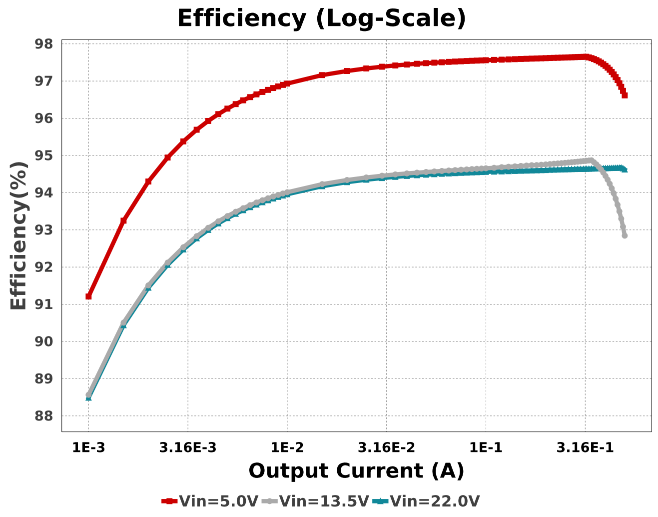

Ripple Freq Spectrum(Before Filter)
Ripple Magnitude(dBuV)
Frequency(in KHz) (KHz)
Ripple Magnitude(Before Filter)
CISPR 25 CLASS 5 Noise Limit


Ripple Freq Spectrum(After Filter)
Ripple Magnitude(dBuV)
Frequency(in KHz) (KHz)
Ripple Magnitude(After Filter)
CISPR 25 CLASS 5 Noise Limit


Filter vs Converter Impedance Comparison
Gain(dB)
Frequency (Hz)
Filter Output Impedance
Converter Input Impedance Open Loop
Converter Input Impedance Ideal Loop







Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	198.918 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	147.51 µW	Capacitor	Input capacitor power dissipation
3.	Cinx IRMS	9.36 mA	Capacitor	Bulk capacitor RMS ripple current
4.	Cinx Pd	2.593 µW	Capacitor	Bulk capacitor power dissipation
5.	Cout IRMS	270.004 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	130.97 µW	Capacitor	Output capacitor power dissipation
7.	Input Ripple Noise After input filter	52.41 dBuV	EMI Noise	Input Ripple Noise after filter at switching frequency
8.	Input Ripple Noise before input filter	83.11 dBuV	EMI Noise	Input Ripple Noise before filter at switching frequency
9.	Input Ripple filter Pd	125.63 µW	EMI Noise	Input Ripple Filter Power Dissipation
10.	Noise limits defined by CISPR Standards	55.65 dBuV	EMI Noise	Noise limits for CLASS 5 of CISPR 25 standard
11.	IC Ipk	967.66 mA	IC	Peak switch current in IC
12.	IC Pd	91.366 mW	IC	IC power dissipation
13.	IC Tj	35.025 degC	IC	IC junction temperature
14.	IC Tolerance	12.5 mV	IC	IC Feedback Tolerance
15.	ICThetaJA Effective	55.0 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
16.	Iin Avg	79.257 mA	IC	Average input current
17.	Ipp percentage	187.064 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
18.	L Ipp	935.32 mA	Inductor	Peak-to-peak inductor ripple current
19.	L Pd	1.776 mW	Inductor	Inductor power dissipation
20.	Cin Pd	147.51 µW	Power	Input capacitor power dissipation
21.	Cinx Pd	2.593 µW	Power	Bulk capacitor power dissipation
22.	Cout Pd	130.97 µW	Power	Output capacitor power dissipation
23.	IC Pd	91.366 mW	Power	IC power dissipation
24.	Input Ripple filter Pd	125.63 µW	Power	Input Ripple Filter Power Dissipation
25.	L Pd	1.776 mW	Power	Inductor power dissipation
26.	Total Pd	93.774 mW	Power	Total Power Dissipation
27.	BOM Count	12	System Information	Total Design BOM count

#	Name	Value	Category	Description
28.	Duty Cycle	15.23 %	System Information	Duty cycle
29.	Efficiency	94.622 %	System Information	Steady state efficiency
30.	FootPrint	370.0 mm^2	System Information	Total Foot Print Area of BOM components
31.	Frequency	506.252 kHz	System Information	Switching frequency
32.	Iout	500.0 mA	System Information	Iout operating point
33.	Mode	PFM	System Information	Conduction Mode
34.	Pout	1.65 W	System Information	Total output power
35.	Total BOM	$3.51	System Information	Total BOM Cost
36.	Vin	22.0 V	System Information	Vin operating point
37.	Vin p-p	73.206 mV	System Information	Peak-to-peak input voltage
38.	Vout	3.3 V	System Information	Operational Output Voltage
39.	Vout Tolerance	378.79 m%	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
40.	Vout p-p	6.605 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	500.0 m	Maximum Output Current
VinMax	22.0	Maximum input voltage
VinMin	5.0	Minimum input voltage
VinTyp	20.0	Typical input voltage
Vout	3.3	Output Voltage
base_pn	LMR43610MSC3-Q1	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

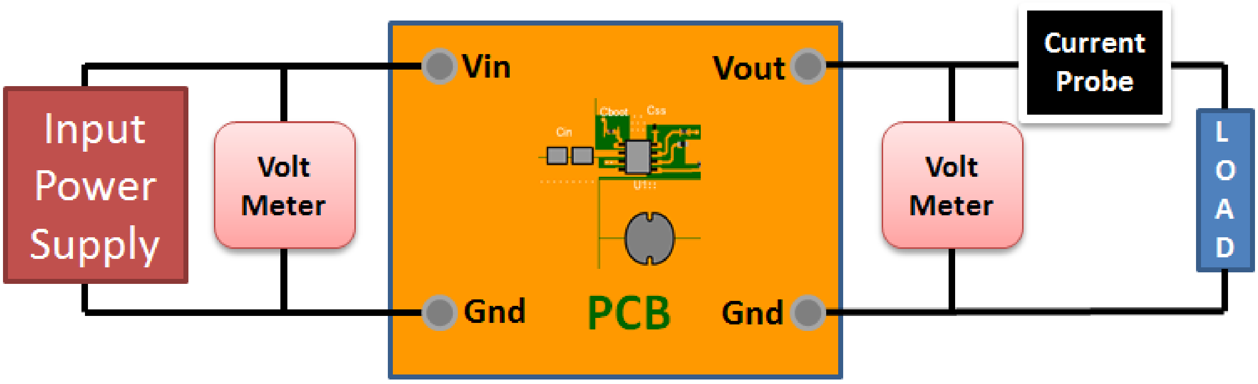
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 5.0V 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. The LMR43610MSC3-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application This device is recommended for maximum Vin of 36V

2. Master key : BCA55829A380142305AFEF36D33EA357[v1]

3. **LMR43610MSC3-Q1** Product Folder : http://www.ti.com/product/LMR43610%2DQ1 : contains the data sheet and other resources.

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