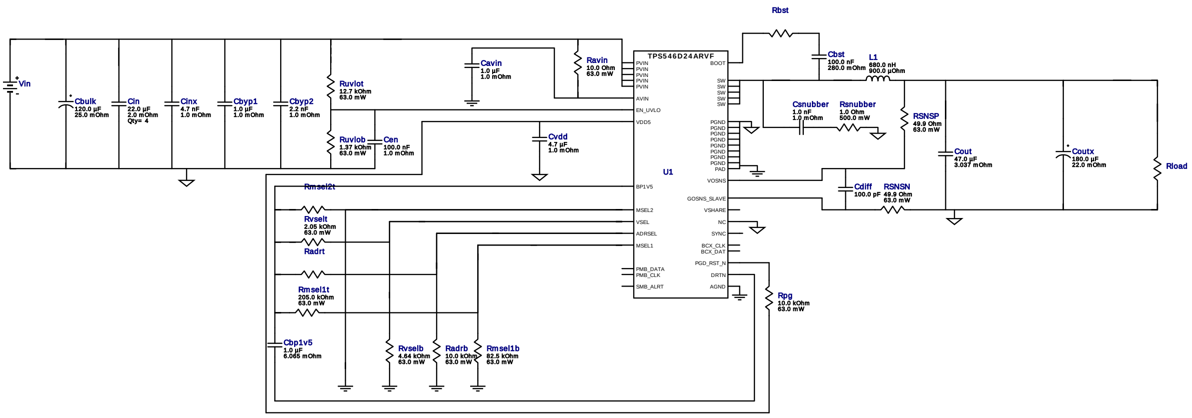
VinMin = 11.0V
VinMax = 13.0V
Vout = 3.6V
Vout Sch = 3.6V
Iout = 30.0A

Device = TPS546D24ARVFR
Topology = Buck
Created = 2023-12-27 22:49:32.824
BOM Cost = $8.46
BOM Count = 31
Total Pd = 6.55W

WEBENCH ® Design Report

Design : 15 TPS546D24ARVFR
TPS546D24ARVFR 11V-13V to 3.60V @ 30A

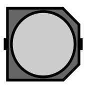


Design Alerts

Component Selection Information

The TPS546D24A is a PMBus(TM) device with key features listed below: PMBus(TM) features marked with * are included in WEBENCH(R) Power Designer. - Adaptive Voltage Scaling (AVS) through VOUT_COMMAND*, - Output voltage and current monitoring, - Thermal Shutdown, - Programmable over current protection, - OCP,OV, UV, OT Levels, - Selectable Internal Compensation*, - Selectable Switching Frequency*, - Turn-On and Turn-Off Delays, - UVLO*, Soft-Start*,OCP* and Soft-Stop. Use the Advanced Options on the left side to set the PMBus(TM) commands. Please refer to the TPS546D24A datasheet and visit http://www.ti.com/pmbus for more information.

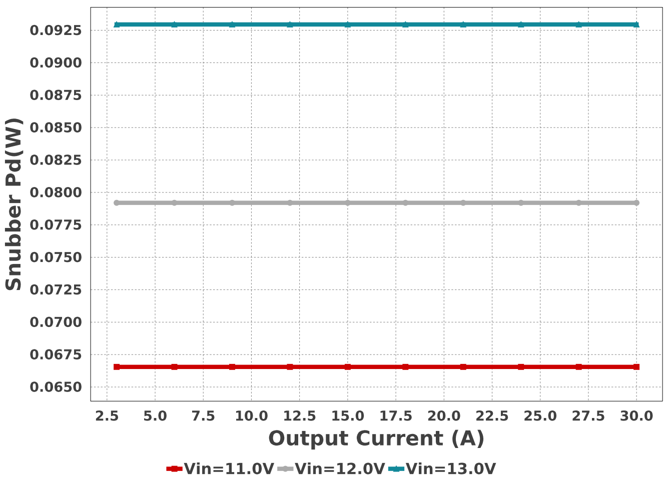
Electrical BOM

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cavin	Taiyo Yuden	TMK212BJ105KG-T Series= X5R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.03	0805 7 mm²
Cbp1v5	MuRata	GRM188R60J105KA01D Series= X5R	Cap= 1.0 uF ESR= 6.065 mOhm VDC= 6.3 V IRMS= 1.36934 A	1	$0.01	0603 5 mm²
Cbst	AVX	08053C104KAT2A Series= X7R	Cap= 100.0 nF ESR= 280.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²
Cbulk	Panasonic	20SVPF120M Series= SVPF	Cap= 120.0 uF ESR= 25.0 mOhm VDC= 20.0 V IRMS= 3.2 A	1	$0.57	 CAPSMT_62_F61 74 mm²

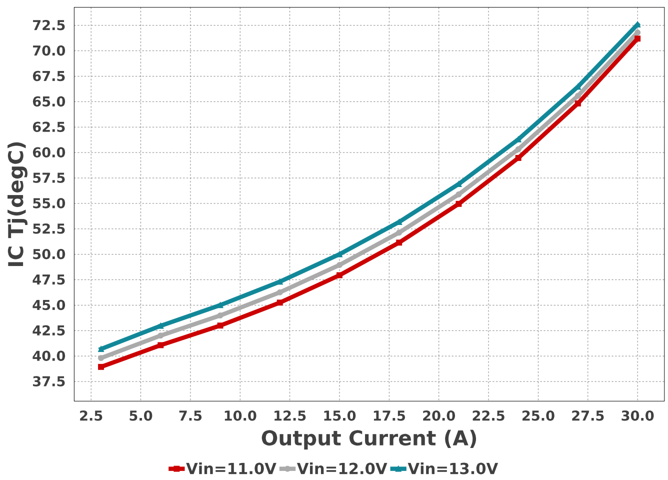
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbyp1	Taiyo Yuden	TMK212BJ105KG-T Series= X5R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.03	0805 7 mm^2
Cbyp2	MuRata	GRM155R61E222KA01D Series= X5R	Cap= 2.2 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cdiff	Kemet	C0201C101K3GACTU Series= C0G/NP0	Cap= 100.0 pF VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0201 2 mm^2
Cen	MuRata	GRM155R71A104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cin	MuRata	GRM32ER61E226KE15L Series= X5R	Cap= 22.0 uF ESR= 2.0 mOhm VDC= 25.0 V IRMS= 3.67 A	4	$0.23	1210 15 mm^2
Cinx	MuRata	GRM155R71E472KA01D Series= X7R	Cap= 4.7 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cout	MuRata	GRM32ER61C476KE15L Series= X5R	Cap= 47.0 uF ESR= 3.037 mOhm VDC= 16.0 V IRMS= 4.59346 A	1	$0.17	1210_280 15 mm^2
Coutx	Panasonic	16SVPF180M Series= SVPF	Cap= 180.0 uF ESR= 22.0 mOhm VDC= 16.0 V IRMS= 3.3 A	1	$0.57	CAPSMT_62_F61 74 mm^2
Csnubber	Yageo	CC0805KRX7R9BB102 Series= X7R	Cap= 1.0 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Cvdd	MuRata	GRM155R61A475MEAAD Series= X5R	Cap= 4.7 uF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.02	0402_065 3 mm^2
L1	Coilcraft	XAL1010-681MEB	L= 680.0 nH 900.0 µOhm	1	$1.71	XAL1010 160 mm^2
RSNSN	Vishay-Dale	CRCW040249R9FKED Series= CRCW..e3	Res= 49.9 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
RSNSP	Vishay-Dale	CRCW040249R9FKED Series= CRCW..e3	Res= 49.9 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Radrb	Vishay-Dale	CRCW040210K0FKED Series= CRCW..e3	Res= 10.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ravin	Vishay-Dale	CRCW040210R0FKED Series= CRCW..e3	Res= 10.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rmsel1b	Vishay-Dale	CRCW040282K5FKED Series= CRCW..e3	Res= 82.5 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rmsel1t	Yageo	AC0402FR-07205KL Series= ?	Res= 205.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rpg	Vishay-Dale	CRCW040210K0FKED Series= CRCW..e3	Res= 10.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rsnubber	Stackpole Electronics Inc	CSR1206FT1R00 Series= ?	Res= 1.0 Ohm Power= 500.0 mW Tolerance= 1.0%	1	$0.04	1206 11 mm^2
Ruvlob	Vishay-Dale	CRCW04021K37FKED Series= CRCW..e3	Res= 1.37 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ruvlot	Vishay-Dale	CRCW040212K7FKED Series= CRCW..e3	Res= 12.7 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rvselb	Vishay-Dale	CRCW04024K64FKED Series= CRCW..e3	Res= 4.64 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rvselt	Vishay-Dale	CRCW04022K05FKED Series= CRCW..e3	Res= 2.05 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
U1	Texas Instruments	TPS546D24ARVFR	Switcher	1	$4.22	RVF0040A 63 mm^2

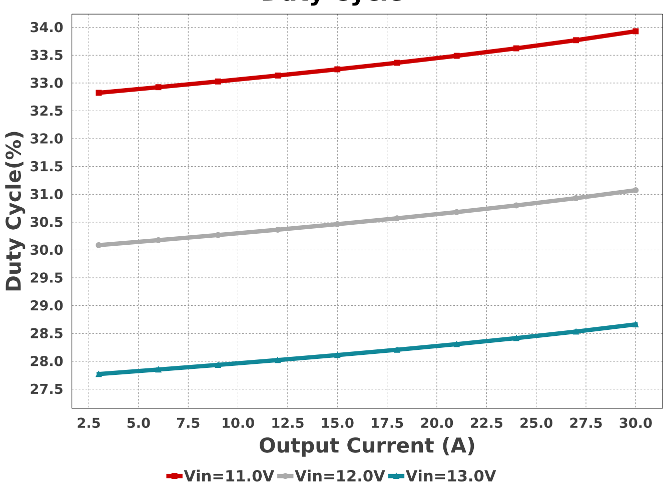
Snubber Pd



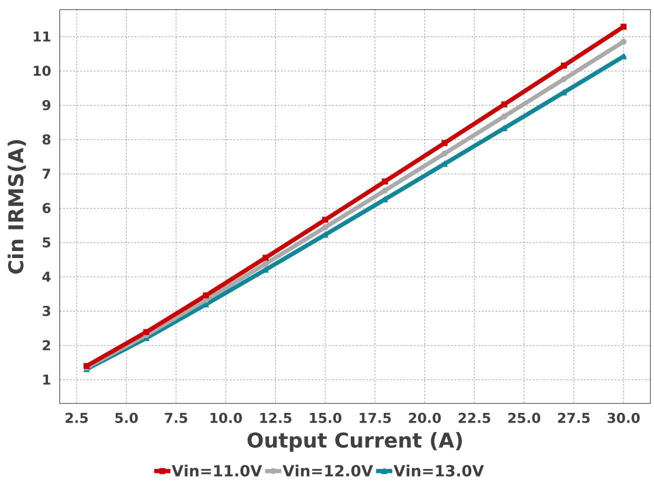
IC Tj

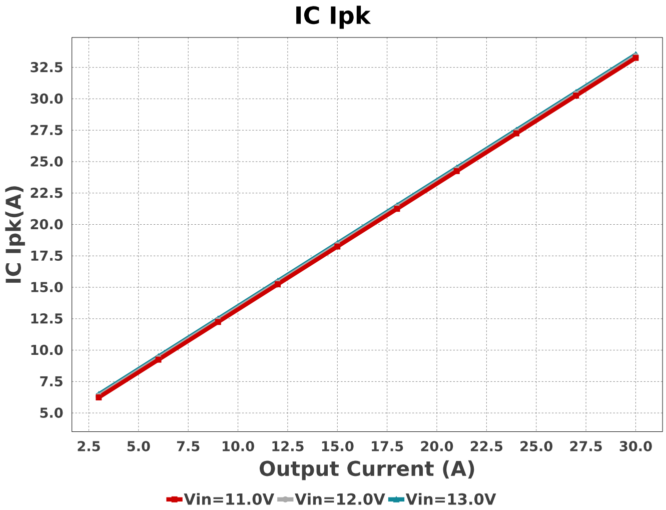


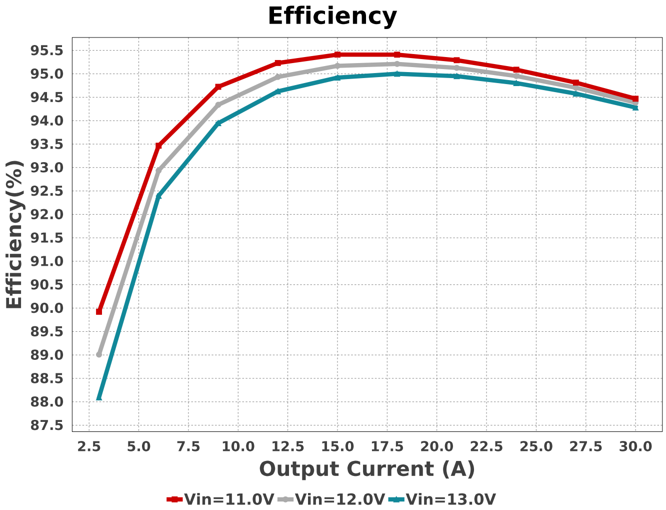
Duty Cycle

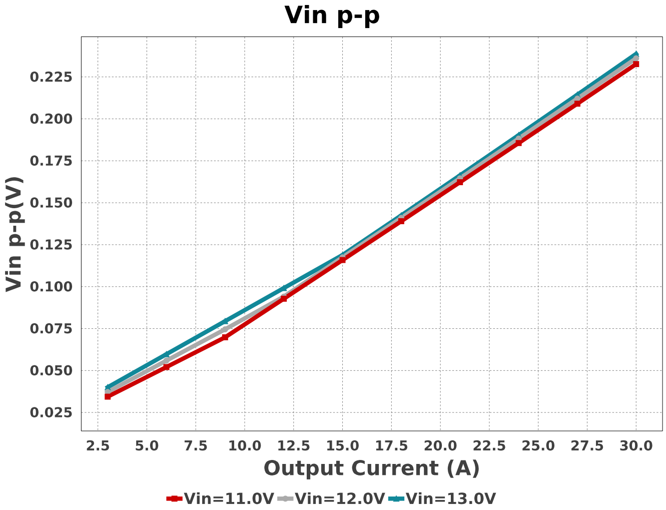


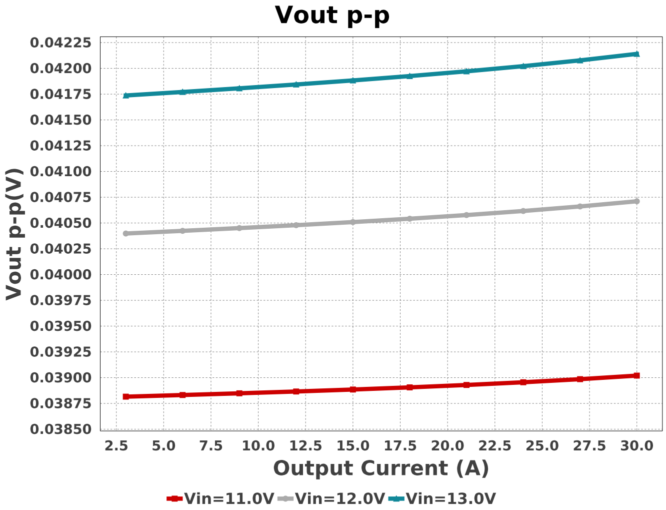
Cin IRMS

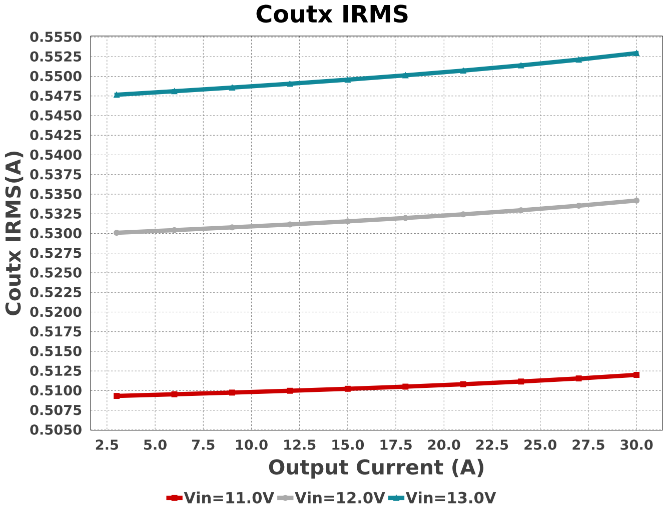


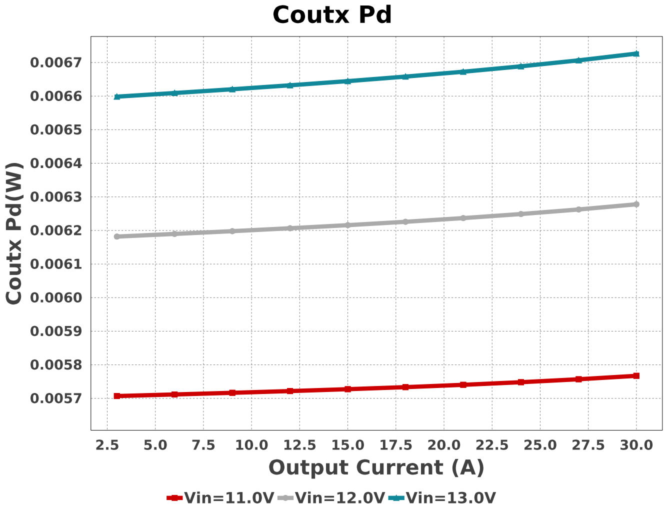

IC Ipk
IC Ipk(A)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

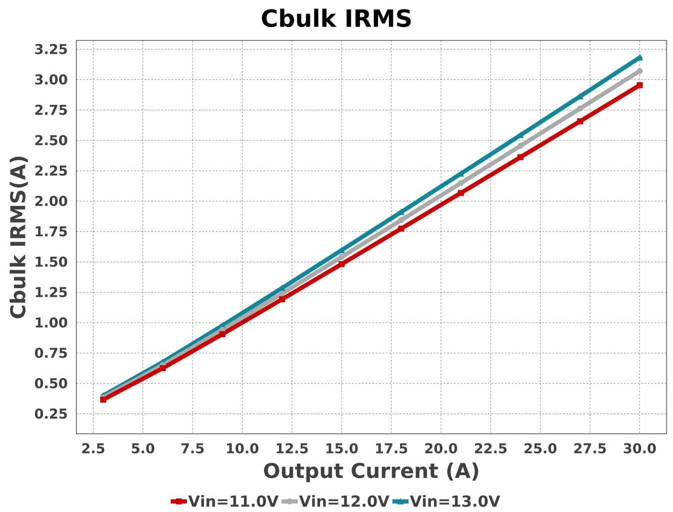

Efficiency
Efficiency(%)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

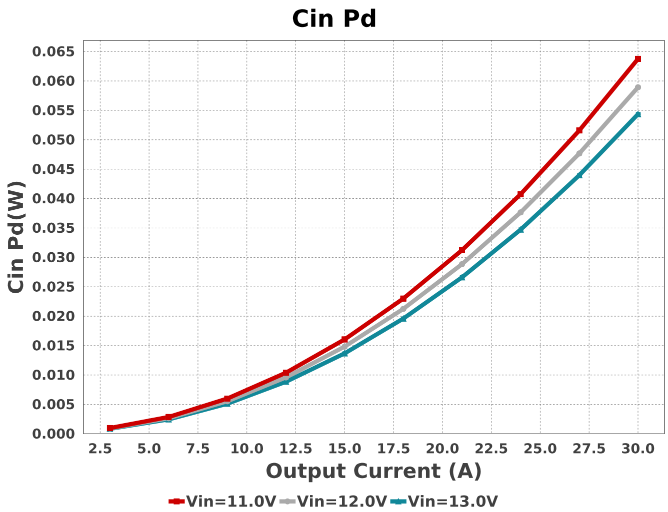

Vin p-p
Vin p-p(V)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

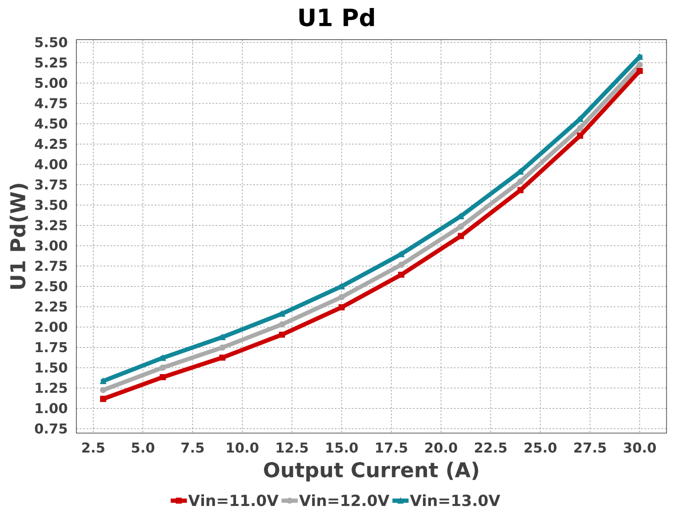

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

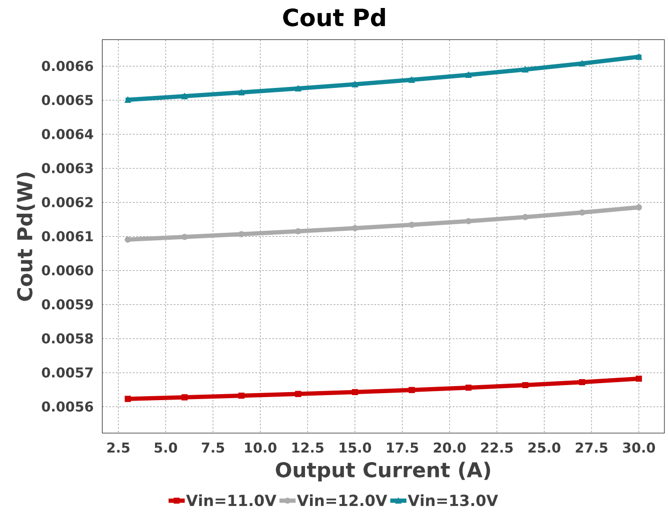

Coutx IRMS
Coutx IRMS(A)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

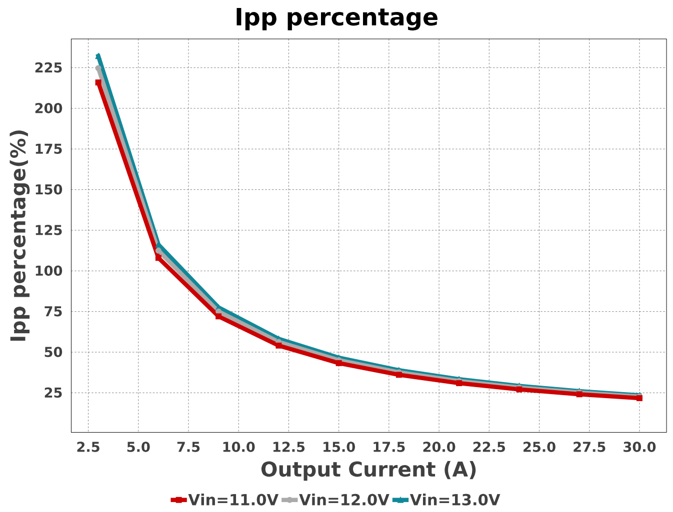

Coutx Pd
Coutx Pd(W)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

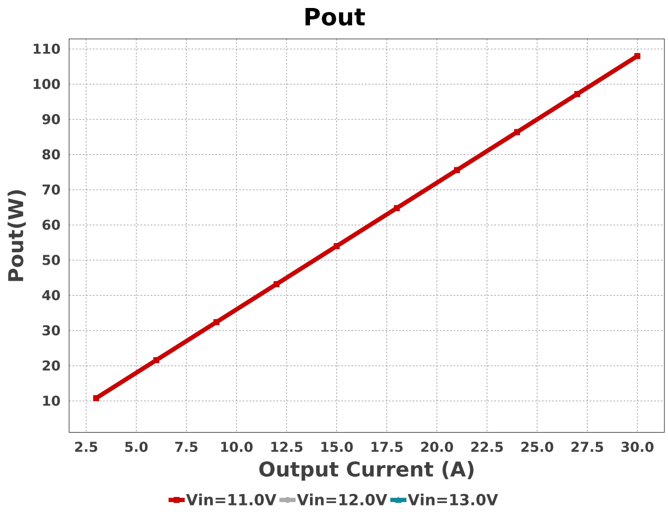

Cbulk IRMS
Cbulk IRMS(A)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

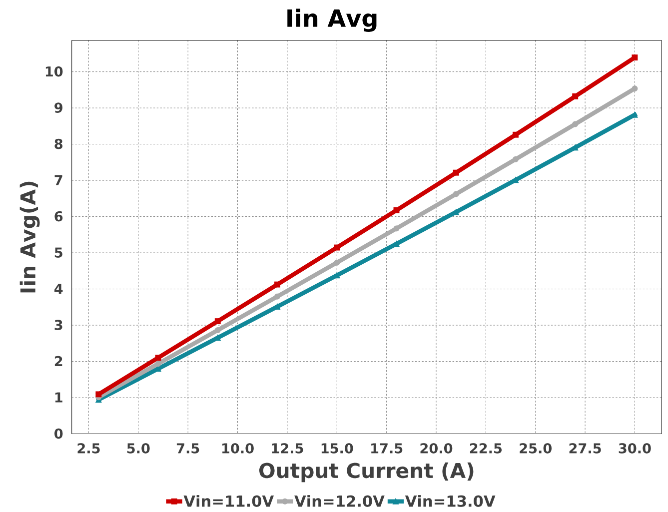

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

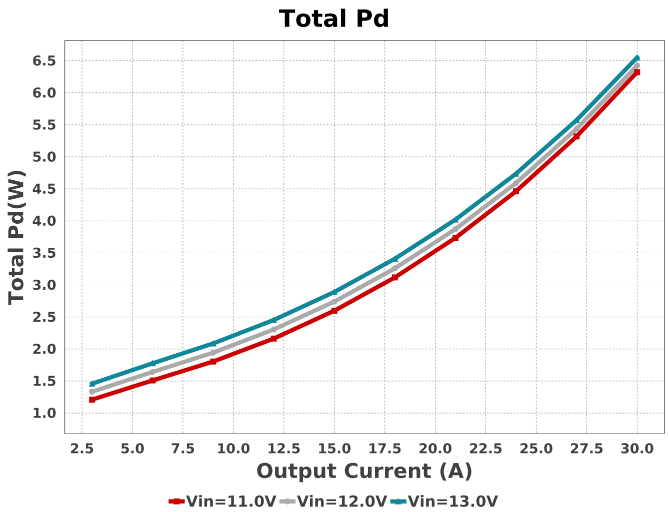

U1 Pd
U1 Pd(W)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

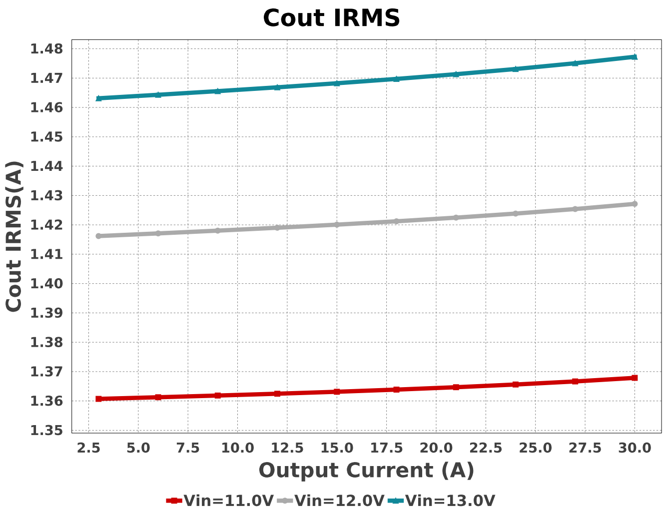

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

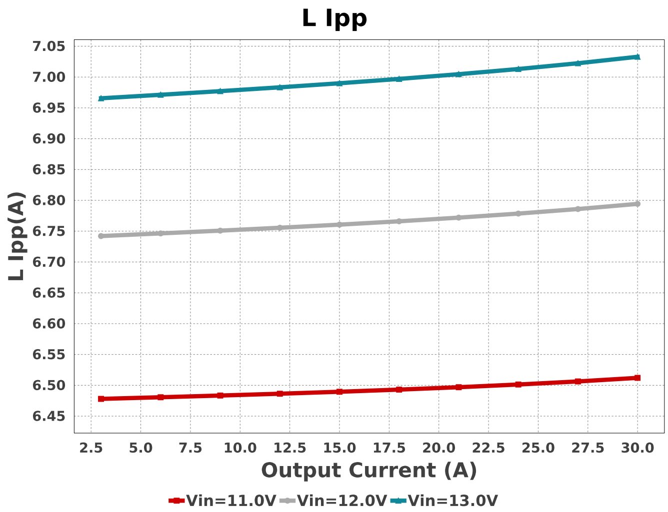

Ipp percentage
Ipp percentage(%)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

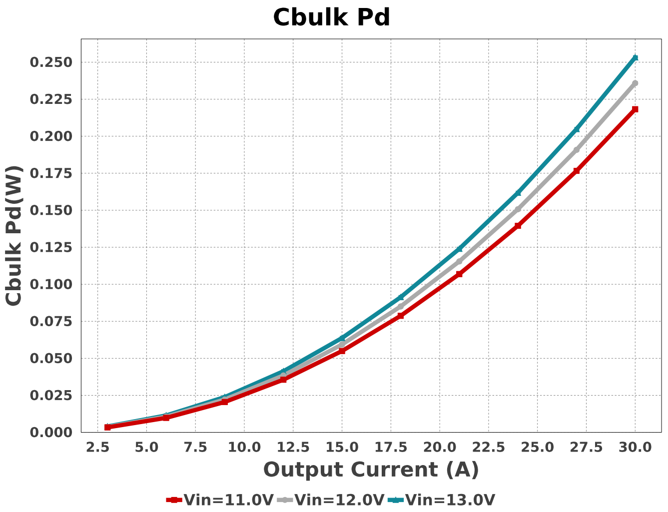

Pout
Pout(W)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

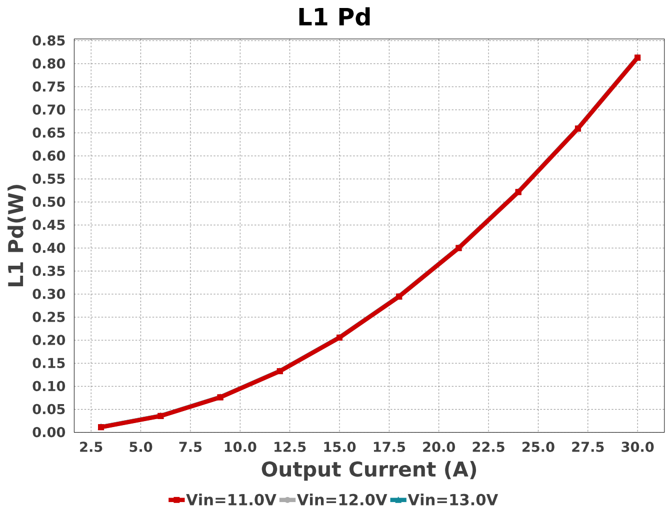

Iin Avg
Iin Avg(A)
0
1
2
3
4
5
6
7
8
9
10
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0
Output Current (A)
Vin=11.0V
Vin=12.0V
Vin=13.0V

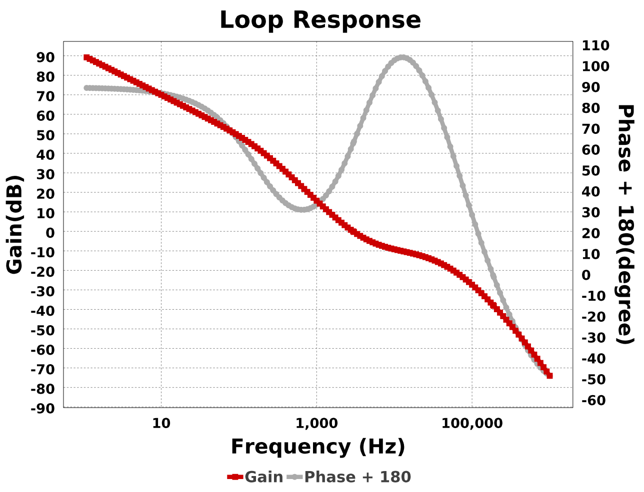

Total Pd
Total Pd(W)
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0
Output Current (A)
Vin=11.0V
Vin=12.0V
Vin=13.0V


Cout IRMS
Cout IRMS(A)
1.35
1.36
1.37
1.38
1.39
1.40
1.41
1.42
1.43
1.44
1.45
1.46
1.47
1.48
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0
Output Current (A)
Vin=11.0V
Vin=12.0V
Vin=13.0V


L Ipp
L Ipp(A)
6.45
6.50
6.55
6.60
6.65
6.70
6.75
6.80
6.85
6.90
6.95
7.00
7.05
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0
Output Current (A)
Vin=11.0V
Vin=12.0V
Vin=13.0V


Cbulk Pd
Cbulk Pd(W)
0.000
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
0.225
0.250
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0
Output Current (A)
Vin=11.0V
Vin=12.0V
Vin=13.0V


L1 Pd
L1 Pd(W)
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
0.65
0.70
0.75
0.80
0.85
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0
Output Current (A)
Vin=11.0V
Vin=12.0V
Vin=13.0V



Operating Values

#	Name	Value	Category	Description
1.	BOM Count	31		Total Design BOM count
2.	Total BOM	$8.465		Total BOM Cost
3.	Cbulk IRMS	3.182 A	Capacitor	Bulk capacitor RMS ripple current
4.	Cbulk Pd	253.2 mW	Capacitor	Bulk capacitor power dissipation
5.	Cin IRMS	10.427 A	Capacitor	Input capacitor RMS ripple current
6.	Cin Pd	54.358 mW	Capacitor	Input capacitor power dissipation
7.	Cout IRMS	1.477 A	Capacitor	Output capacitor RMS ripple current
8.	Cout Pd	6.628 mW	Capacitor	Output capacitor power dissipation
9.	Coutx IRMS	552.95 mA	Capacitor	Output capacitor_x RMS ripple current
10.	Coutx Pd	6.727 mW	Capacitor	Output capacitor_x power loss
11.	Fpi	552.621 kHz	Compensation	Current Loop Pole Frequency
12.	Fpv	212.207 kHz	Compensation	Voltage Loop Pole Frequency
13.	Fzi	14.224 kHz	Compensation	Current Loop Zero Frequency
14.	Fzv	5.305 kHz	Compensation	Voltage Loop Zero Frequency
15.	ILOOP Gain	14.736	Compensation	Recommended Current Loop Mid-band Gain
16.	VLOOP Gain	996.81 m	Compensation	Recommended Voltage Loop Mid-band Gain
17.	Zout (Fco)	248.398 mOhm	Compensation	Output Impedance at Crossover Frequency
18.	Zout (Fsw)	6.007 mOhm	Compensation	Output Impedance at Switching Frequency
19.	IC Ipk	33.516 A	IC	Peak switch current in IC
20.	IC Tj	72.588 degC	IC	IC junction temperature
21.	ICThetaJA Effective	8.0 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
22.	Iin Avg	8.812 A	IC	Average input current
23.	U1 Pd	5.324 W	IC	IC power dissipation
24.	Ipp percentage	23.443 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
25.	L Ipp	7.033 A	Inductor	Peak-to-peak inductor ripple current
26.	L1 Pd	813.71 mW	Inductor	Inductor power dissipation
27.	CPI	9.6 pF	PMBus	Selectable compensation parameter through pinstrapping
28.	CPV	37.5 pF	PMBus	Selectable compensation parameter through pinstrapping
29.	CZI	372.96 pF	PMBus	Selectable compensation parameter through pinstrapping
30.	CZV	1.5 nF	PMBus	Selectable compensation parameter through pinstrapping
31.	GMI	200.0 µS	PMBus	Selectable compensation parameter through pinstrapping
32.	GMV	50.0 µS	PMBus	Selectable compensation parameter through pinstrapping
33.	PMBus Vout Command	3.6	PMBus	PMBus Vout Command
34.	PMBus Vout Scale Loop	125.0 m	PMBus	PMBus Vout Scale Loop
35.	RVI	30.0 kOhm	PMBus	Selectable compensation parameter through pinstrapping
36.	RVV	20.0 kOhm	PMBus	Selectable compensation parameter through pinstrapping
37.	Cbulk Pd	253.2 mW	Power	Bulk capacitor power dissipation
38.	Cin Pd	54.358 mW	Power	Input capacitor power dissipation
39.	Cout Pd	6.628 mW	Power	Output capacitor power dissipation
40.	Coutx Pd	6.727 mW	Power	Output capacitor_x power loss
41.	L1 Pd	813.71 mW	Power	Inductor power dissipation
42.	Snubber Pd	92.95 mW	Power	Snubber Power Dissipation
43.	Total Pd	6.551 W	Power	Total Power Dissipation
44.	U1 Pd	5.324 W	Power	IC power dissipation
45.	Cross Freq	2.949 kHz	System Information	Bode plot crossover frequency
46.	Duty Cycle	28.663 %	System Information	Duty cycle
47.	Efficiency	94.281 %	System Information	Steady state efficiency

#	Name	Value	Category	Description
48.	FootPrint	534.0 mm^2	System Information	Total Foot Print Area of BOM components
49.	Frequency	550.0 kHz	System Information	Switching frequency
50.	Gain Marg	-37.762 dB	System Information	Bode Plot Gain Margin
51.	Iout	30.0 A	System Information	Iout operating point
52.	Low Freq Gain	89.2 dB	System Information	Gain at 1Hz
53.	Mode	CCM	System Information	Conduction Mode
54.	Phase Marg	63.075 deg	System Information	Bode Plot Phase Margin
55.	Pout	108.0 W	System Information	Total output power
56.	Vin	13.0 V	System Information	Vin operating point
57.	Vin p-p	238.727 mV	System Information	Peak-to-peak input voltage
58.	Vout	3.6 V	System Information	Operational Output Voltage
59.	Vout Tolerance	222.222 m%	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
60.	Vout p-p	42.14 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

	Name	Value	Description
	Iout	30.0	Maximum Output Current
	VinMax	13.0	Maximum input voltage
	VinMin	11.0	Minimum input voltage
	Vout	3.6	Output Voltage
	base_pn	TPS546D24A	Base Product Number
	source	DC	Input Source Type
	Ta	30.0	Ambient temperature
1.	Vout Sch	3.6	Output voltage selected

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

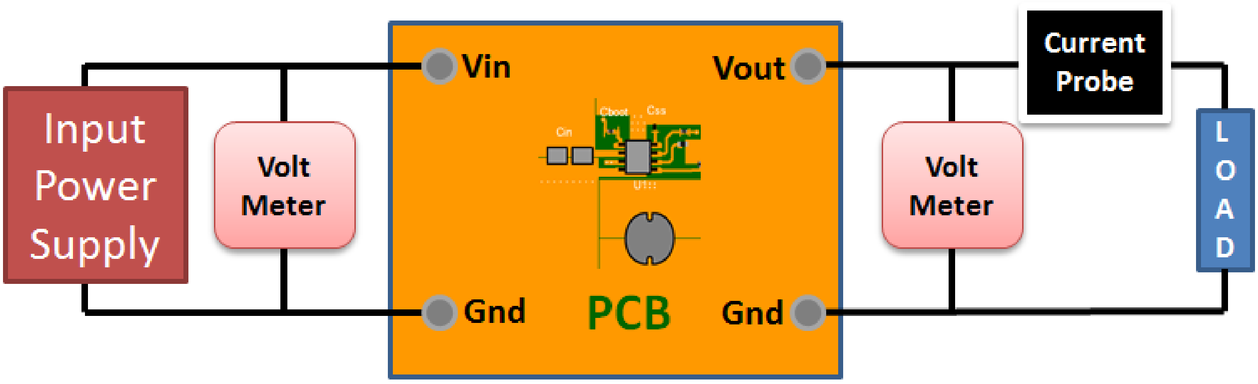
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 11.0V 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 : 330B248541F6394ED110965082F3CA95[v1]

2. **TPS546D24A** Product Folder : http://www.ti.com/product/TPS546D24A : contains the data sheet and other resources.

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