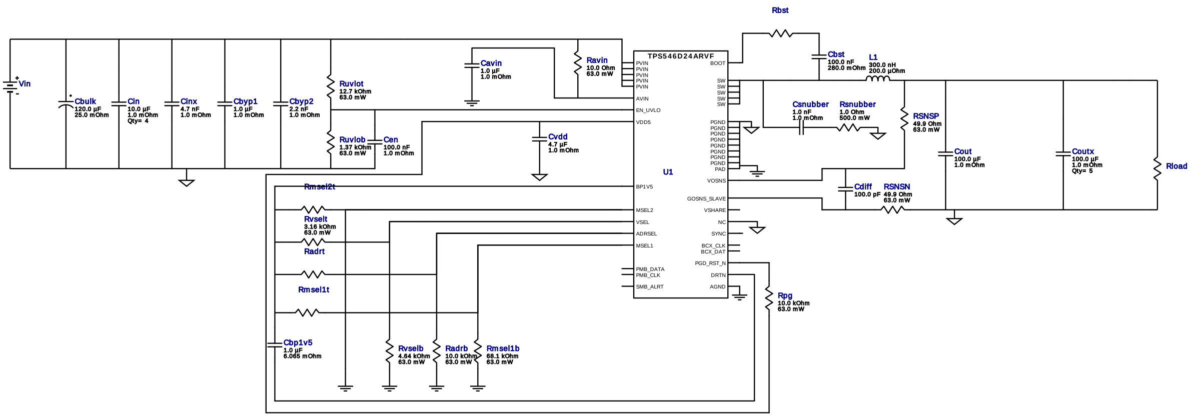
WEBENCH® Design Report

VinMin = 11.0V
VinMax = 13.0V
Vout = 2.4V
Vout Sch = 2.4V
Iout = 40.0A

Device = TPS546D24ARVFR
Topology = Buck
Created = 2025-09-15 13:40:46.376
BOM Cost = $8.60
BOM Count = 34
Total Pd = 8.11W

Design : 110 TPS546D24ARVFR
TPS546D24ARVFR 11V-13V to 2.40V @ 40A



1. Do not place Rmsel2t, Radrt, Rmsel1t resistors. Place 0 Ohm resistor for Rbst.

Design Alerts

TPS546D24A Design

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 mm^2
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 mm^2
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 mm^2

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
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 mm^2
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	Yageo	CC0201JRNPO8BN101 Series= C0G/NP0	Cap= 100.0 pF VDC= 5.0 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	TDK	C3225X7R1H106M250AC Series= X7R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 5.0 A	4	$0.27	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	GRM32EC80J107ME20L Series= X6S	Cap= 100.0 uF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 6.0 A	1	$0.17	1210_270 15 mm^2
Coutx	MuRata	GRM32EC80J107ME20L Series= X6S	Cap= 100.0 uF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 6.0 A	5	$0.17	1210_270 15 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	SLC1480-301MLB	L= 300.0 nH 200.0 µOhm	1	$0.78	SLC1480 231 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	Yageo	RC0402FR-0768K1L Series= ?	Res= 68.1 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2

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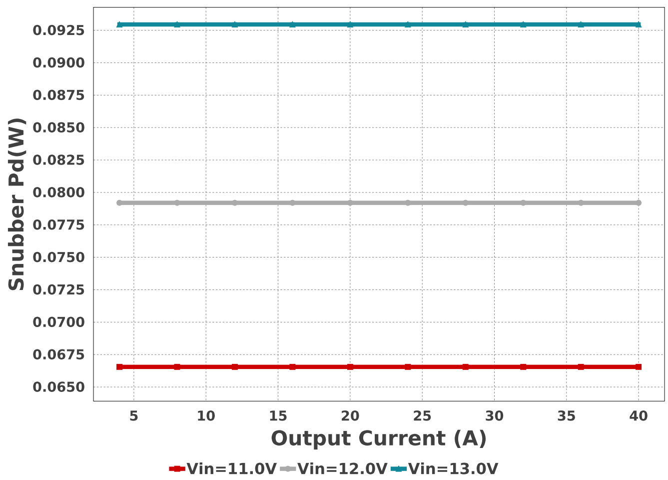
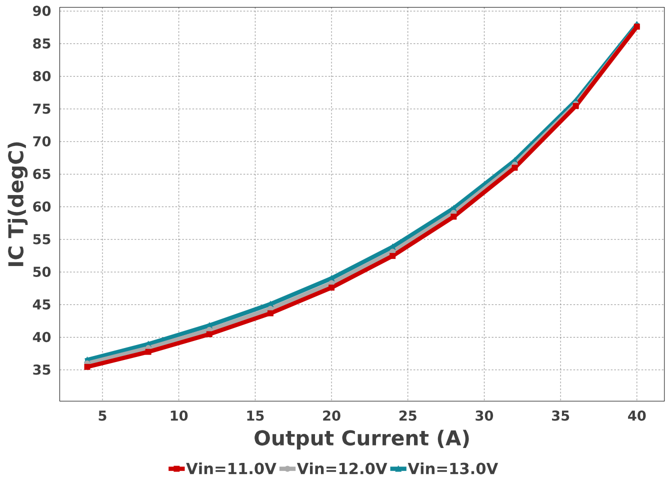
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rpg	Vishay-Dale	CRCW040210K0FKED Series= CRCW..e3	Res= 10.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rsnubber	Stackpole Electronics Inc	CSR1206FT1R00 Series= ?	Res= 1.0 Ohm Power= 500.0 mW Tolerance= 1.0%	1	$0.04	1206 11 mm^2
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	CRCW04023K16FKED Series= CRCW..e3	Res= 3.16 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
U1	Texas Instruments	TPS546D24ARVFR	Switcher	1	$4.86	RVF0040A 63 mm^2

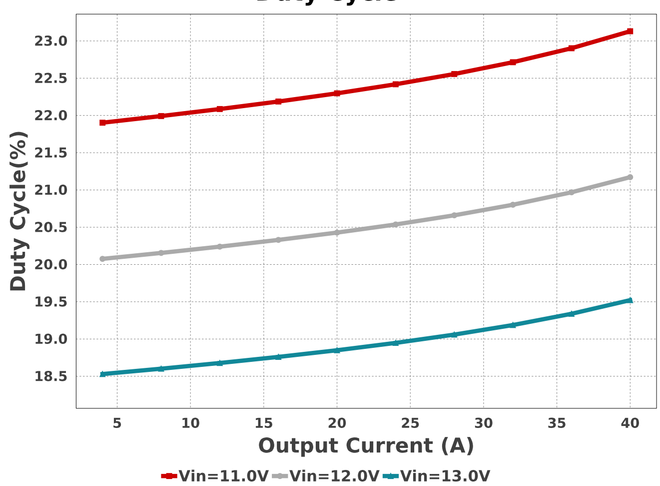
Snubber Pd



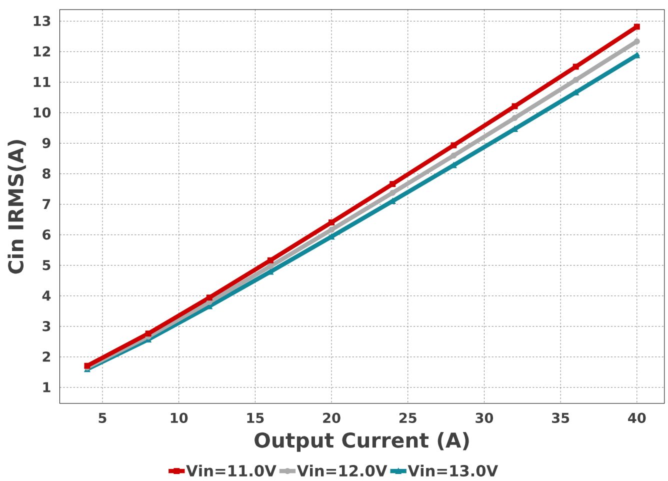
IC Tj

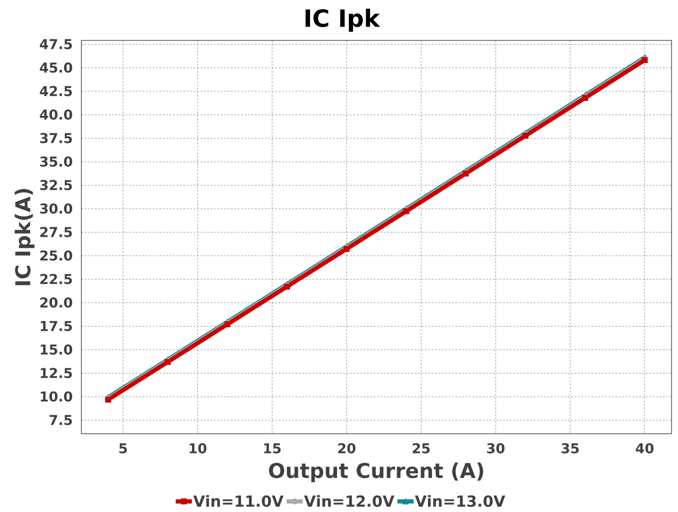


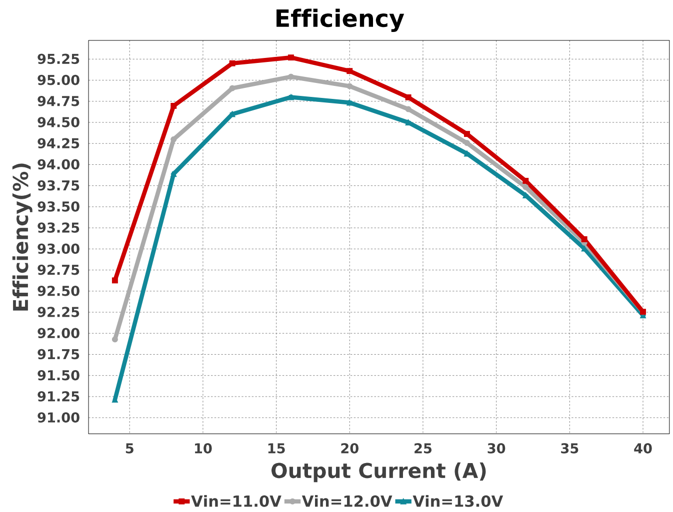
Duty Cycle

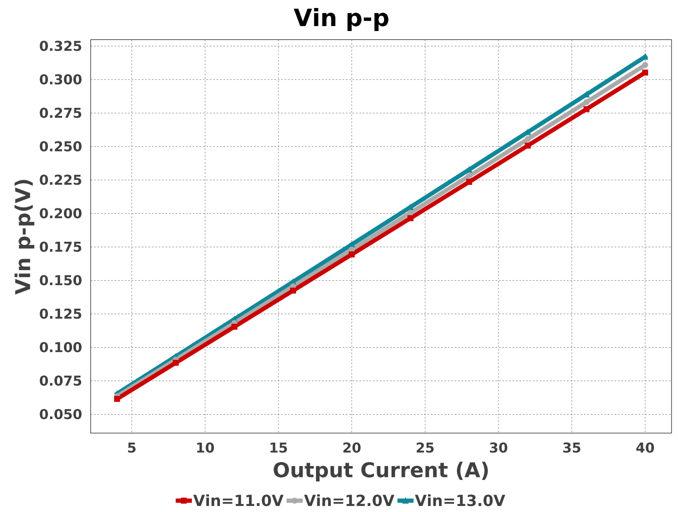


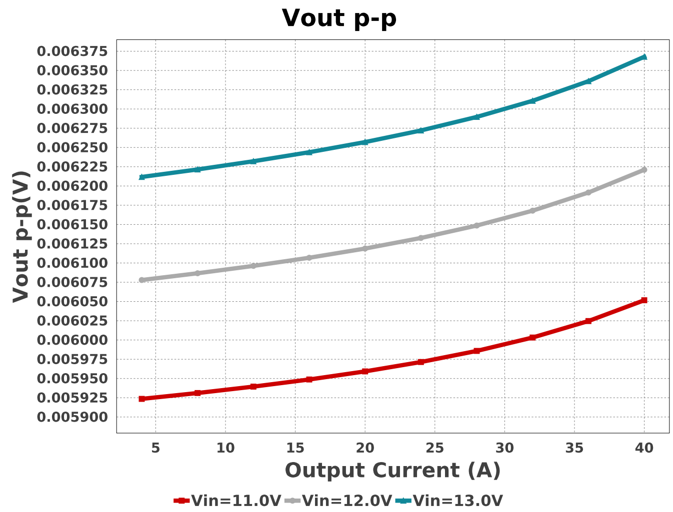
Cin IRMS

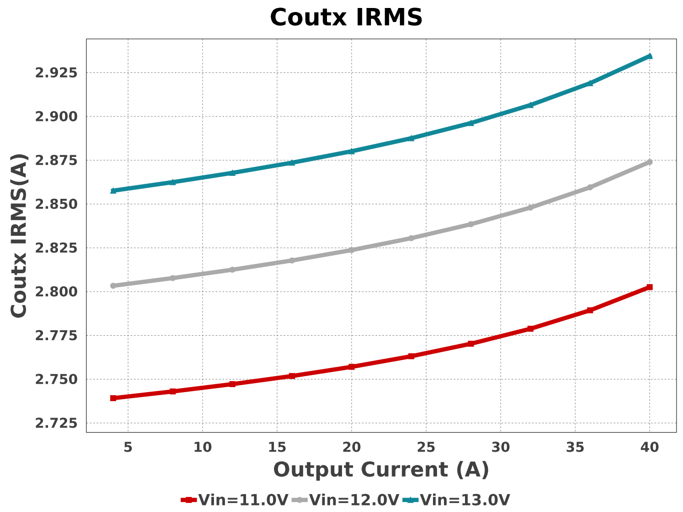


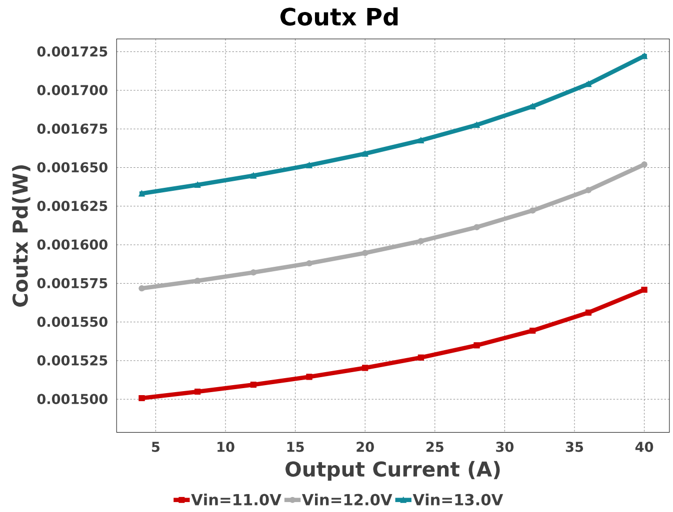

IC Ipk
IC Ipk(A)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

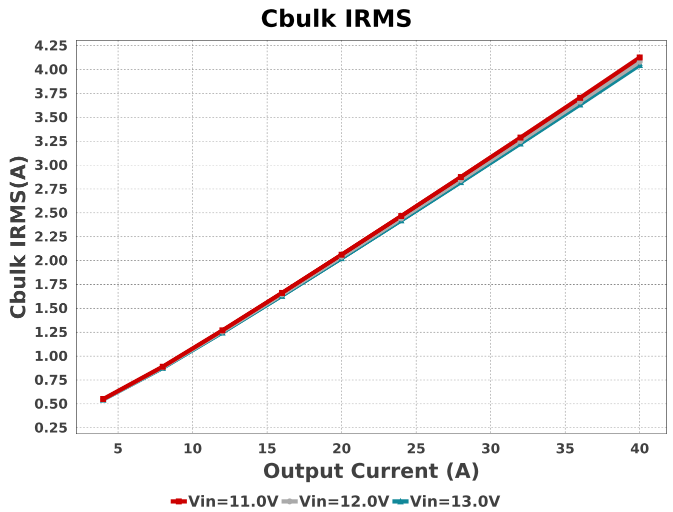

Efficiency
Efficiency(%)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

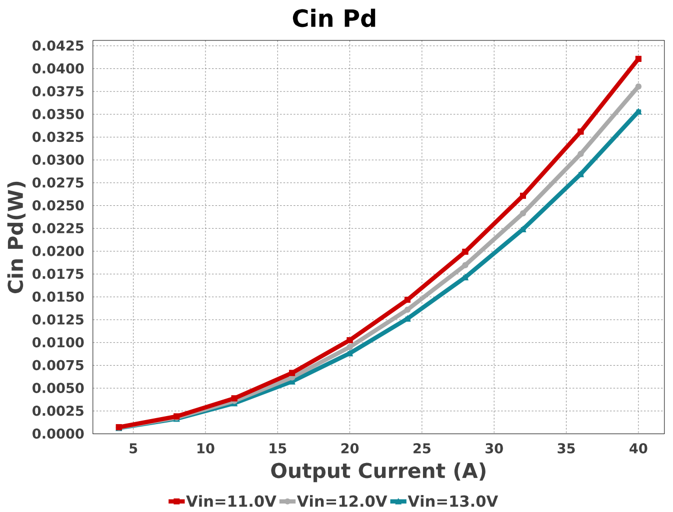

Vin p-p
Vin p-p(V)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

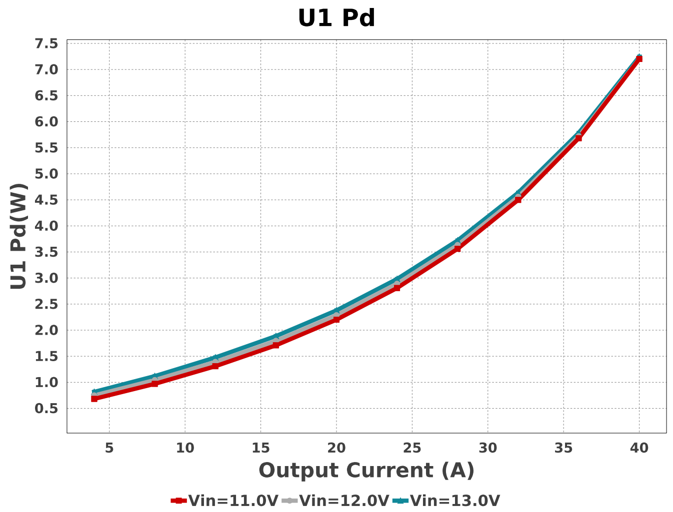

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

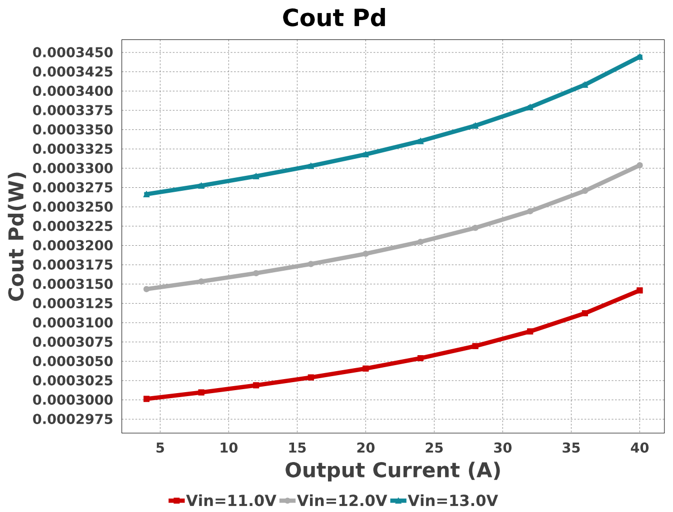

Coutx IRMS
Coutx IRMS(A)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

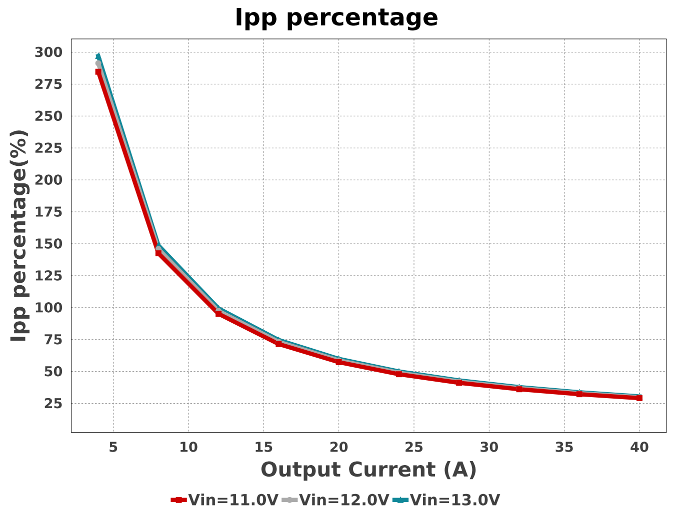

Coutx Pd
Coutx Pd(W)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

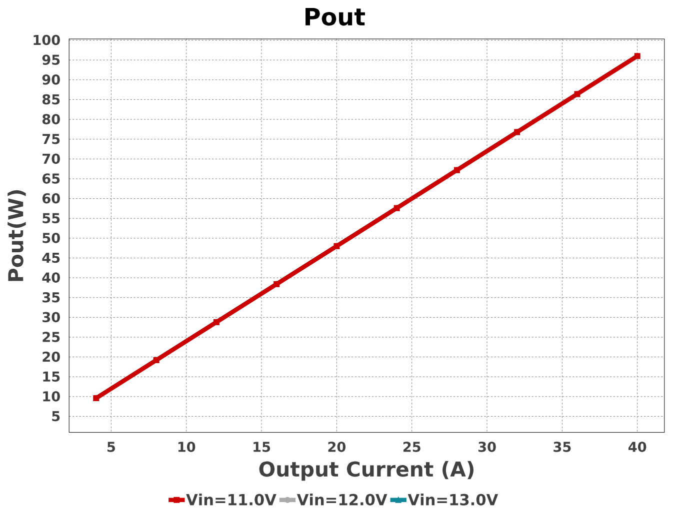

Cbulk IRMS
Cbulk IRMS(A)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

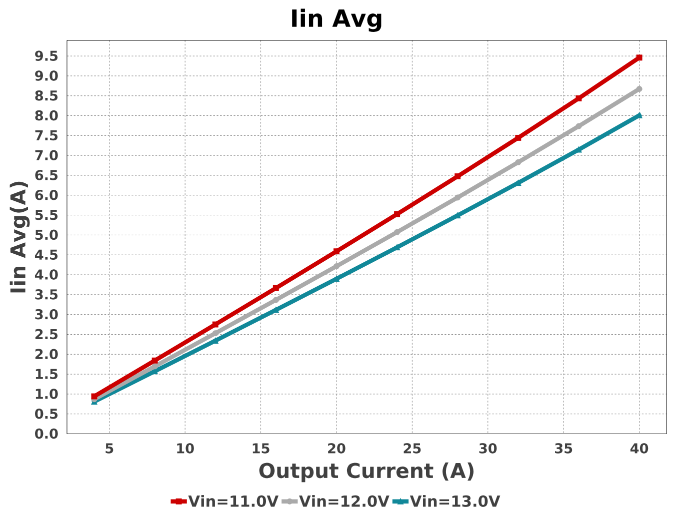

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

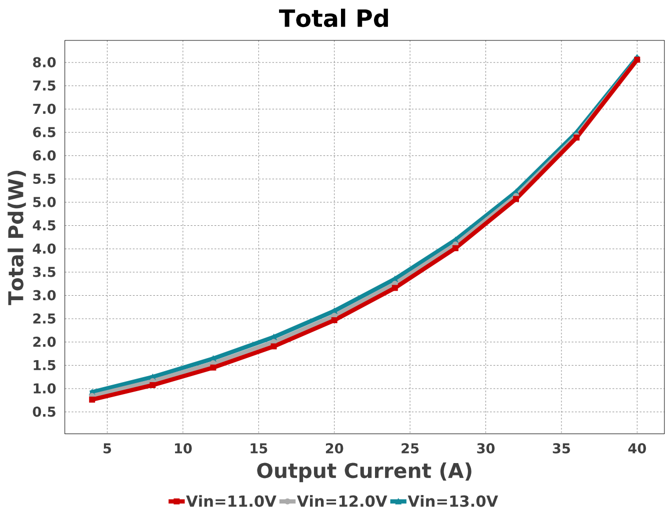

U1 Pd
U1 Pd(W)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

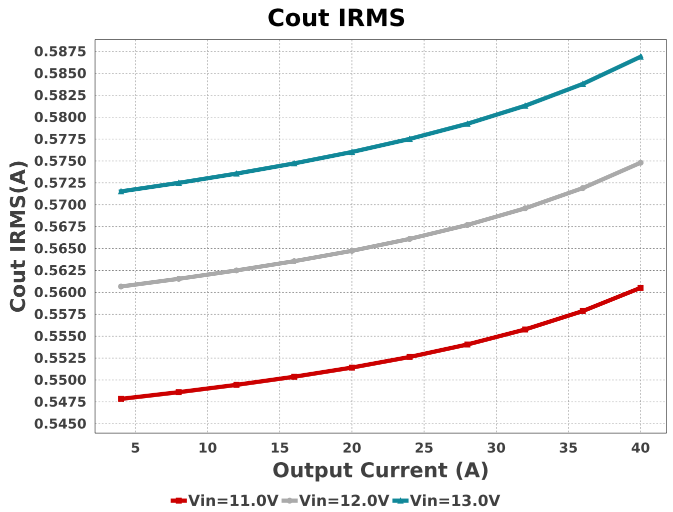

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

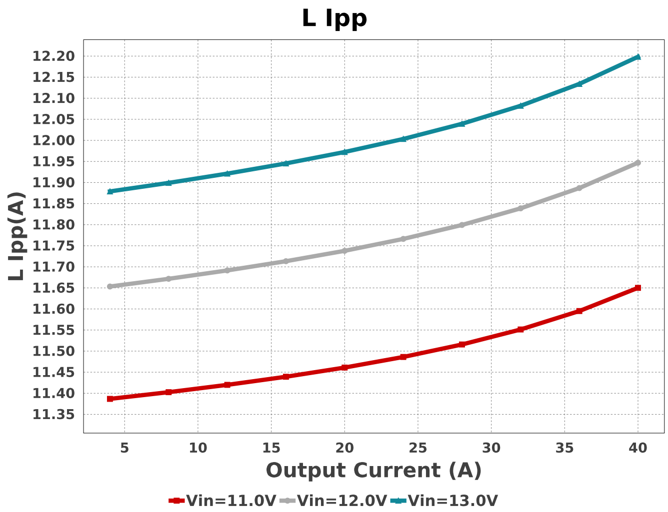

Ipp percentage
Ipp percentage(%)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

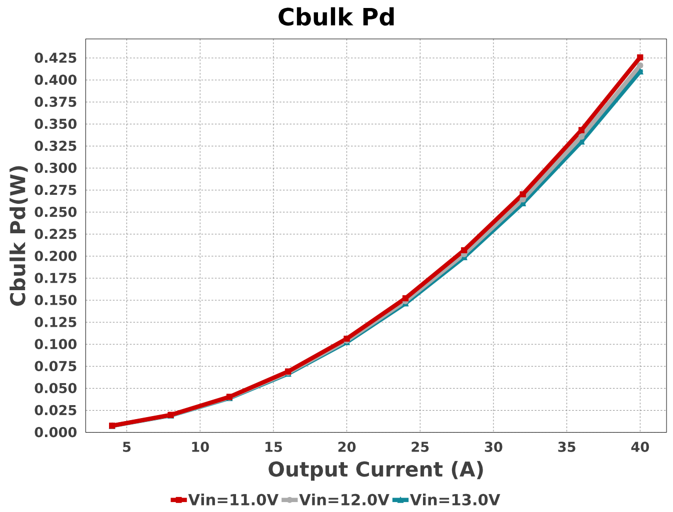

Pout
Pout(W)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

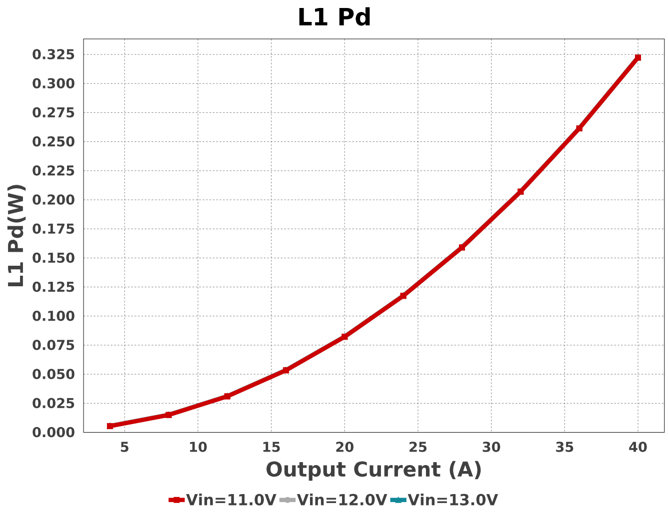

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V

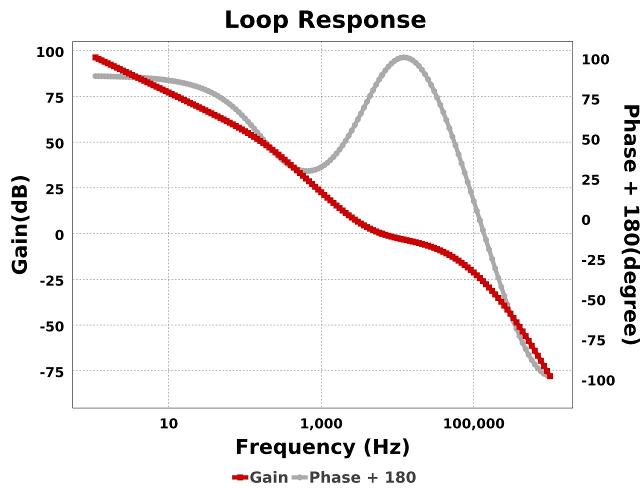

Total Pd
Total Pd(W)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V


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


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


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


L1 Pd
L1 Pd(W)
Output Current (A)
Vin=11.0V Vin=12.0V Vin=13.0V



Operating Values

#	Name	Value	Category	Description
1.	Cbulk IRMS	4.048 A	Capacitor	Bulk capacitor RMS ripple current
2.	Cbulk Pd	409.66 mW	Capacitor	Bulk capacitor power dissipation
3.	Cin IRMS	11.883 A	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	35.3 mW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	586.894 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	344.44 µW	Capacitor	Output capacitor power dissipation
7.	Coutx IRMS	2.934 A	Capacitor	Output capacitor_x RMS ripple current
8.	Coutx Pd	1.722 mW	Capacitor	Output capacitor_x power loss
9.	Fpi	552.621 kHz	Compensation	Current Loop Pole Frequency
10.	Fpv	212.207 kHz	Compensation	Voltage Loop Pole Frequency
11.	Fzi	14.224 kHz	Compensation	Current Loop Zero Frequency
12.	Fzv	5.305 kHz	Compensation	Voltage Loop Zero Frequency
13.	ILOOP Gain	6.501	Compensation	Recommended Current Loop Mid-band Gain
14.	VLOOP Gain	7.138	Compensation	Recommended Voltage Loop Mid-band Gain
15.	Zout (Fco)	56.539 mOhm	Compensation	Output Impedance at Crossover Frequency
16.	Zout (Fsw)	657.89 µOhm	Compensation	Output Impedance at Switching Frequency
17.	IC Ipk	46.099 A	IC	Peak switch current in IC
18.	IC Tj	87.953 degC	IC	IC junction temperature
19.	ICThetaJA Effective	8.0 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
20.	Iin Avg	8.008 A	IC	Average input current
21.	U1 Pd	7.244 W	IC	IC power dissipation
22.	Ipp percentage	30.496 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
23.	L Ipp	12.198 A	Inductor	Peak-to-peak inductor ripple current
24.	L1 Pd	322.48 mW	Inductor	Inductor power dissipation
25.	CPI	9.6 pF	PMBus	Selectable compensation parameter through pinstrapping
26.	CPV	18.75 pF	PMBus	Selectable compensation parameter through pinstrapping
27.	CZI	372.96 pF	PMBus	Selectable compensation parameter through pinstrapping
28.	CZV	750.0 pF	PMBus	Selectable compensation parameter through pinstrapping
29.	GMI	200.0 µS	PMBus	Selectable compensation parameter through pinstrapping
30.	GMV	50.0 µS	PMBus	Selectable compensation parameter through pinstrapping
31.	PMBus Vout Command	2.4	PMBus	PMBus Vout Command
32.	PMBus Vout Scale Loop	125.0 m	PMBus	PMBus Vout Scale Loop
33.	RVI	30.0 kOhm	PMBus	Selectable compensation parameter through pinstrapping
34.	RVV	40.0 kOhm	PMBus	Selectable compensation parameter through pinstrapping
35.	Cbulk Pd	409.66 mW	Power	Bulk capacitor power dissipation
36.	Cin Pd	35.3 mW	Power	Input capacitor power dissipation
37.	Cout Pd	344.44 µW	Power	Output capacitor power dissipation
38.	Coutx Pd	1.722 mW	Power	Output capacitor_x power loss
39.	L1 Pd	322.48 mW	Power	Inductor power dissipation
40.	Snubber Pd	92.95 mW	Power	Snubber Power Dissipation
41.	Total Pd	8.107 W	Power	Total Power Dissipation
42.	U1 Pd	7.244 W	Power	IC power dissipation
43.	BOM Count	34	System Information	Total Design BOM count
44.	Cross Freq	6.191 kHz	System Information	Bode plot crossover frequency
45.	Duty Cycle	19.522 %	System Information	Duty cycle
46.	Efficiency	92.213 %	System Information	Steady state efficiency

#	Name	Value	Category	Description
47.	FootPrint	602.0 mm^2	System Information	Total Foot Print Area of BOM components
48.	Frequency	550.0 kHz	System Information	Switching frequency
49.	Gain Marg	-24.304 dB	System Information	Bode Plot Gain Margin
50.	Iout	40.0 A	System Information	Iout operating point
51.	Low Freq Gain	96.308 dB	System Information	Gain at 1Hz
52.	Mode	CCM	System Information	Conduction Mode
53.	Phase Marg	89.973 deg	System Information	Bode Plot Phase Margin
54.	Pout	96.0 W	System Information	Total output power
55.	Total BOM	$8.6	System Information	Total BOM Cost
56.	Vin	13.0 V	System Information	Vin operating point
57.	Vin p-p	317.039 mV	System Information	Peak-to-peak input voltage
58.	Vout	2.4 V	System Information	Operational Output Voltage
59.	Vout Tolerance	333.33 m%	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
60.	Vout p-p	6.368 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

	Name	Value	Description
	Iout	40.0	Maximum Output Current
	VinMax	13.0	Maximum input voltage
	VinMin	11.0	Minimum input voltage
	Vout	2.4	Output Voltage
	base_pn	TPS546D24A	Base Product Number
	source	DC	Input Source Type
	Ta	30.0	Ambient temperature
1.	Vout Sch	2.4	Output voltage selected

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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

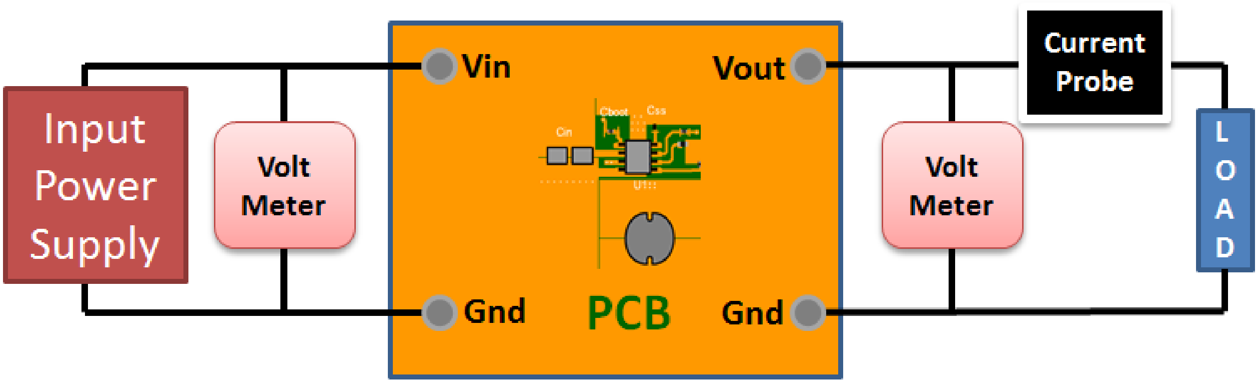
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 : 4403CD56E2ECE12A[v1]

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

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