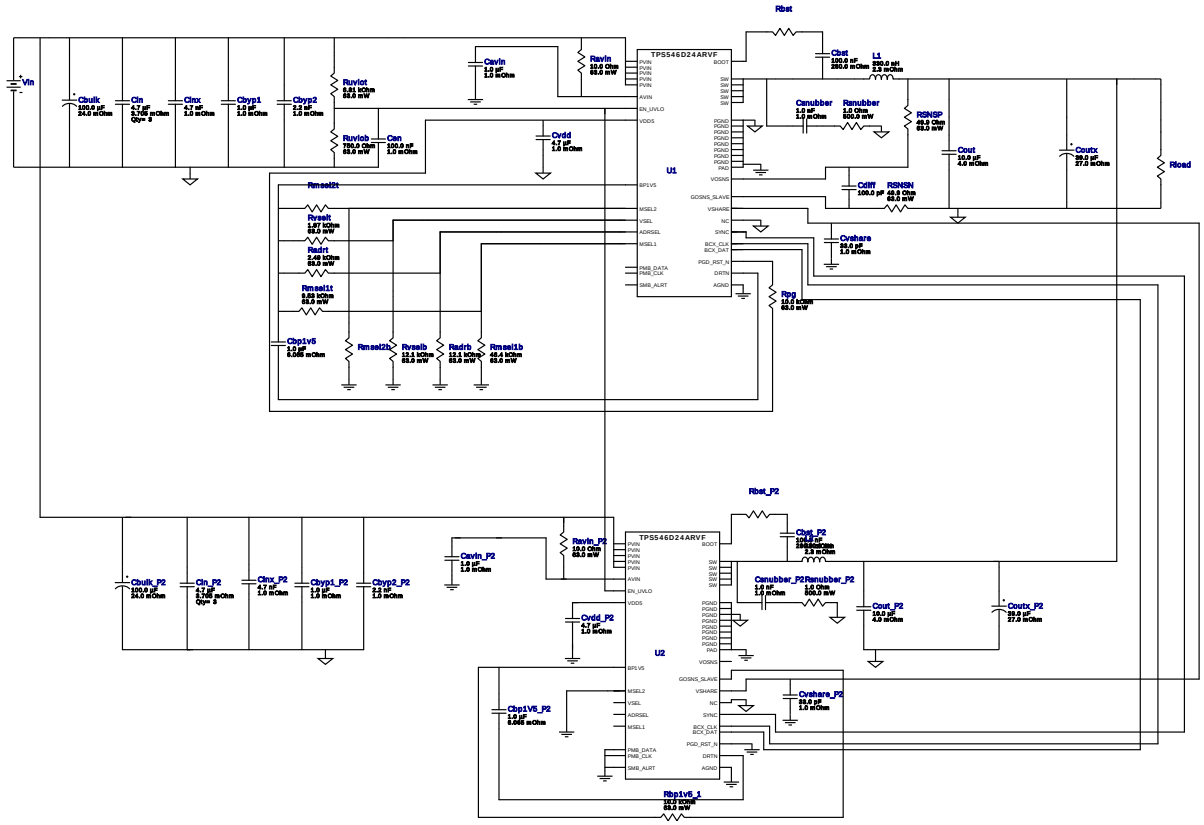
WEBENCH® Design Report

VinMin = 11.0V
VinMax = 15.0V
Vout = 5.0V
Vout Sch = 5.0V
Iout = 35.0A

Device = TPS546D24ARVFR
Topology = Buck
Created = 2025-02-28 10:33:54.251
BOM Cost = $19.63
BOM Count = 62
Total Pd = 11.71W

Design : 87 TPS546D24ARVFR
TPS546D24ARVFR 11V-15V to 5.00V @ 20A



1. Do not place Rmsel2b, Rmsel2t resistors. Place 0 Ohm resistor for Rbst.

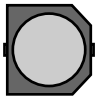
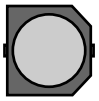
Design Alerts

TPS546D24A Design

DESIGN ERROR MESSAGE: Compensation setting does not give the required VLOOP; try changing the VLOOP gain, GMV*Rvv, to match the recommended VLOOP in the OPERATING VALUES Compensation tab. 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. Switching Frequency higher than 1100kHz are disabled on Webench for this input condition, as the junction temperature of the device is exceeding the limit. 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

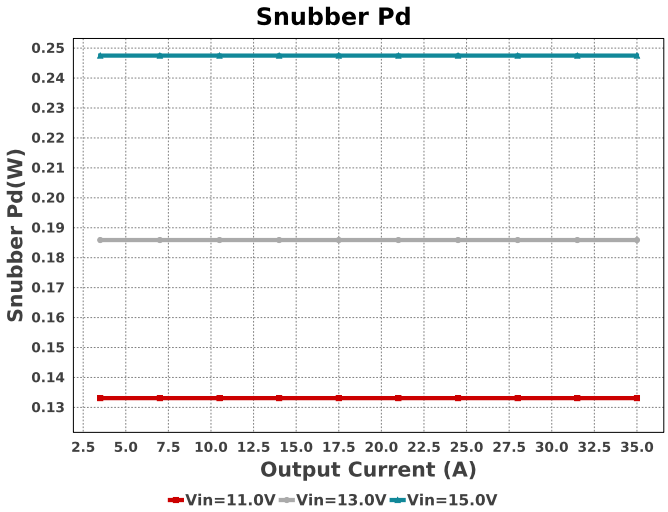
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cavin	Taiyo Yuden	TMK212BJ105KG-T Series= X5R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.03	0805 7 mm^2
Cavin_P2	Taiyo Yuden	TMK212BJ105KG-T Series= X5R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.03	0805 7 mm^2
Cbp1V5_P2	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

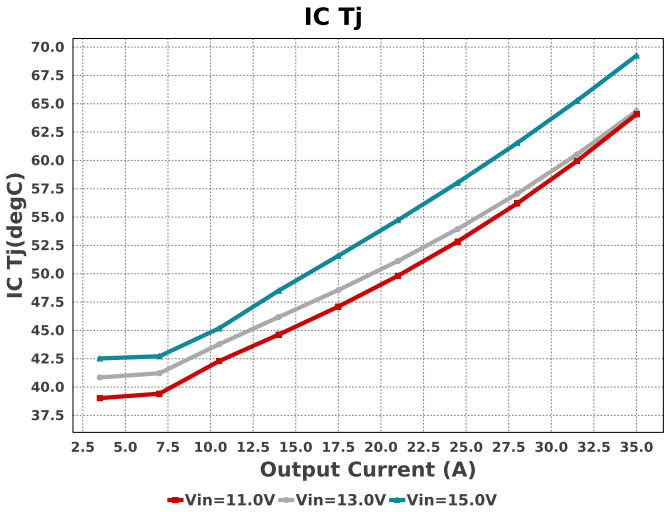
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbp1v5	MuRata	GRM188R60J105KA01D Series= X5R	Cap= 1.0 uF ESR= 6.065 mOhm VDC= 6.3 V IRMS= 1.36934 A	1	$0.01	0603 5 mm²
Cbst	AVX	08053C104KAT2A Series= X7R	Cap= 100.0 nF ESR= 280.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²
Cbst_P2	AVX	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	25SVPF100M Series= SVPF	Cap= 100.0 uF ESR= 24.0 mOhm VDC= 25.0 V IRMS= 3.2 A	1	$0.66	 CAPSMT_62_E7 106 mm²
Cbulk_P2	Panasonic	25SVPF100M Series= SVPF	Cap= 100.0 uF ESR= 24.0 mOhm VDC= 25.0 V IRMS= 3.2 A	1	$0.66	 CAPSMT_62_E7 106 mm²
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 mm²
Cbyp1_P2	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
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 mm²
Cbyp2_P2	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 mm²
Cdiff	Kemet	C0201C101K3GACTU Series= C0G/NP0	Cap= 100.0 pF VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0201 2 mm²
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 mm²
Cin	MuRata	GRM31CR71E475KA88L Series= X7R	Cap= 4.7 uF ESR= 3.705 mOhm VDC= 25.0 V IRMS= 2.8649 A	3	$0.09	1206_190 11 mm²
Cin_P2	MuRata	GRM31CR71E475KA88L Series= X7R	Cap= 4.7 uF ESR= 3.705 mOhm VDC= 25.0 V IRMS= 2.8649 A	3	$0.09	1206_190 11 mm²
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 mm²
Cinx_P2	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 mm²
Cout	MuRata	GRM31CR71E106KA12L Series= X7R	Cap= 10.0 uF ESR= 4.0 mOhm VDC= 25.0 V IRMS= 6.0 A	1	$0.06	1206_180 11 mm²

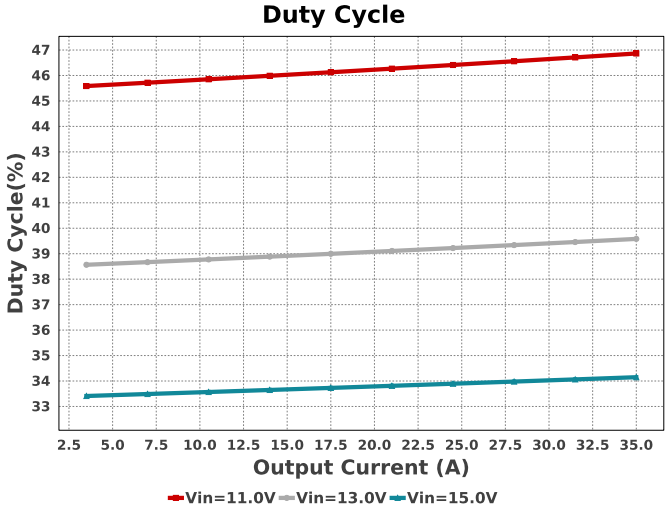
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cout_P2	MuRata	GRM31CR71E106KA12L Series= X7R	Cap= 10.0 uF ESR= 4.0 mOhm VDC= 25.0 V IRMS= 6.0 A	1	$0.06	1206_180 11 mm^2
Coutx	Panasonic	16SVPC39MV Series= SVPC	Cap= 39.0 uF ESR= 27.0 mOhm VDC= 16.0 V IRMS= 2.35 A	1	$0.44	SM_RADIAL_5MM 58 mm^2
Coutx_P2	Panasonic	16SVPC39MV Series= SVPC	Cap= 39.0 uF ESR= 27.0 mOhm VDC= 16.0 V IRMS= 2.35 A	1	$0.44	SM_RADIAL_5MM 58 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
Csnubber_P2	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
Cvdd_P2	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
Cvshare	MuRata	GRM1555C1E330JA01D Series= C0G/NP0	Cap= 33.0 pF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cvshare_P2	MuRata	GRM1555C1E330JA01D Series= C0G/NP0	Cap= 33.0 pF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
L1	Coilcraft	XAL6030-331MEB	L= 330.0 nH 2.3 mOhm	1	$0.65	XAL6030 72 mm^2
L2	Coilcraft	XAL6030-331MEB	L= 330.0 nH 2.3 mOhm	1	$0.65	XAL6030 72 mm^2
L2	Coilcraft	XAL6030-331MEB	L= 330.0 nH 2.3 mOhm	1	$0.65	XAL6030 72 mm^2
L2	Coilcraft	XAL6030-331MEB	L= 330.0 nH 2.3 mOhm	1	$0.65	XAL6030 72 mm^2
L2	Coilcraft	XAL6030-331MEB	L= 330.0 nH 2.3 mOhm	1	$0.65	XAL6030 72 mm^2
L2	Coilcraft	XAL6030-331MEB	L= 330.0 nH 2.3 mOhm	1	$0.65	XAL6030 72 mm^2

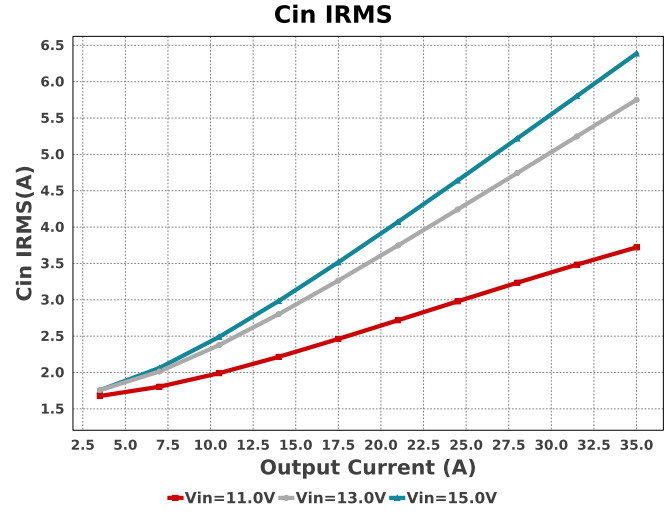
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
L2	Coilcraft	XAL6030-331MEB	L= 330.0 nH 2.3 mOhm	1	$0.65	XAL6030 72 mm^2
L2	Coilcraft	XAL6030-331MEB	L= 330.0 nH 2.3 mOhm	1	$0.65	XAL6030 72 mm^2
L2	Coilcraft	XAL6030-331MEB	L= 330.0 nH 2.3 mOhm	1	$0.65	XAL6030 72 mm^2
L2	Coilcraft	XAL6030-331MEB	L= 330.0 nH 2.3 mOhm	1	$0.65	XAL6030 72 mm^2
L2	Coilcraft	XAL6030-331MEB	L= 330.0 nH 2.3 mOhm	1	$0.65	XAL6030 72 mm^2
L2	Coilcraft	XAL6030-331MEB	L= 330.0 nH 2.3 mOhm	1	$0.65	XAL6030 72 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	Yageo	AC0402FR-0712K1L Series= ?	Res= 12.1 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Radrt	Vishay-Dale	CRCW04022K49FKED Series= CRCW..e3	Res= 2.49 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
Ravin_P2	Vishay-Dale	CRCW040210R0FKED Series= CRCW..e3	Res= 10.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rbp1v5_1	Vishay-Dale	CRCW040210K0FKED Series= CRCW..e3	Res= 10.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rmsel1b	Vishay-Dale	CRCW040246K4FKED Series= CRCW..e3	Res= 46.4 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rmsel1t	Vishay-Dale	CRCW04029K53FKED Series= CRCW..e3	Res= 9.53 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
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
Rsnubber_P2	Stackpole Electronics Inc	CSR1206FT1R00 Series= ?	Res= 1.0 Ohm Power= 500.0 mW Tolerance= 1.0%	1	$0.04	1206 11 mm^2

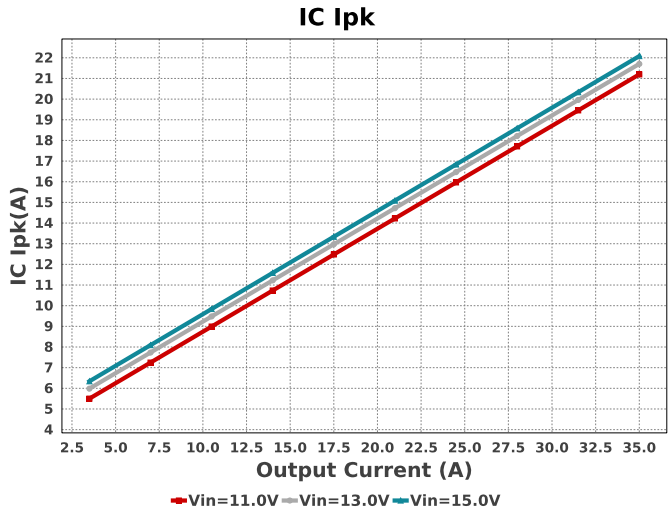
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Ruvlob	Vishay-Dale	CRCW0402750RFKED Series= CRCW..e3	Res= 750.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Ruvlot	Vishay-Dale	CRCW04026K81FKED Series= CRCW..e3	Res= 6.81 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rvselb	Yageo	AC0402FR-0712K1L Series= ?	Res= 12.1 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rvselt	Vishay-Dale	CRCW04021K87FKED Series= CRCW..e3	Res= 1.87 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
U1	Texas Instruments	TPS546D24ARVFR	Switcher	1	$4.22	RVF0040A 63 mm²
U2	Texas Instruments	TPS546D24ARVFR	Switcher	1	$4.22	LQFN-CLIP 0 mm²

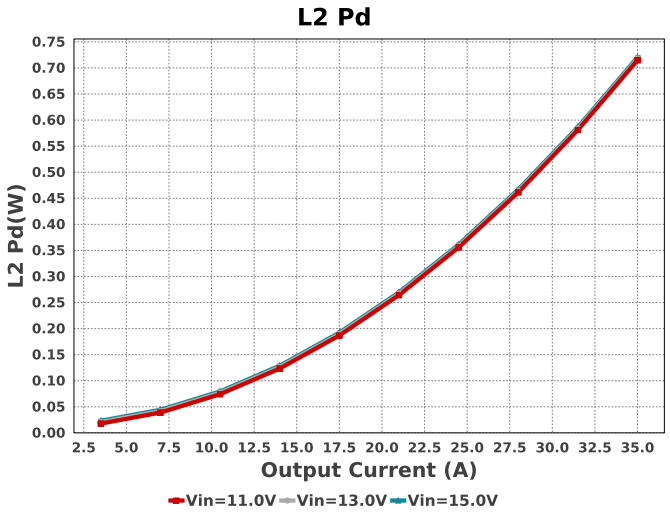


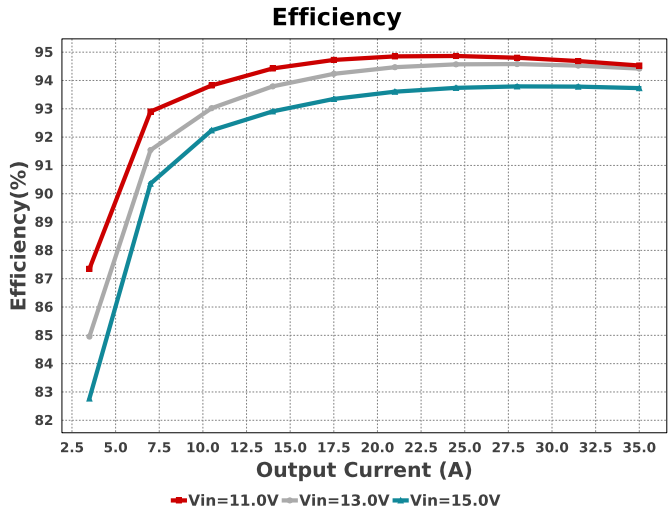


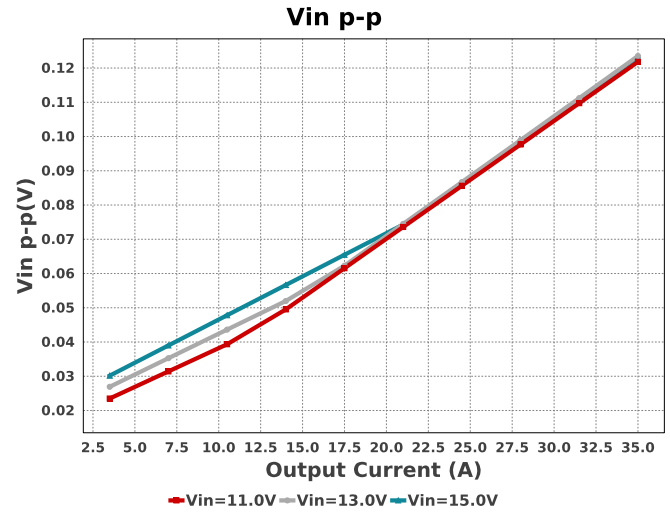


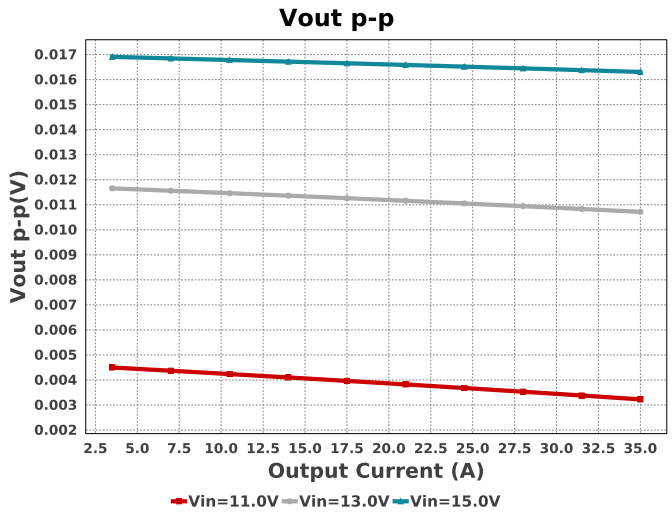


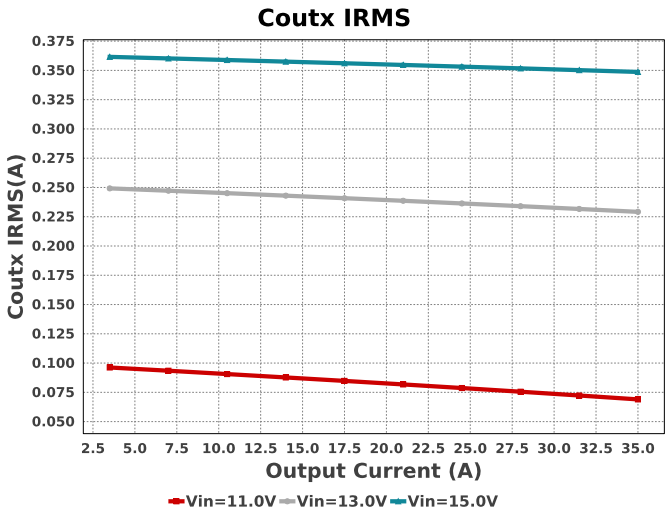


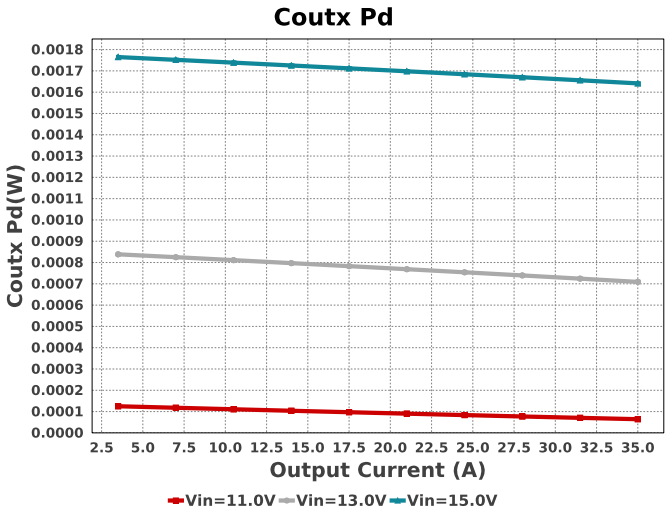


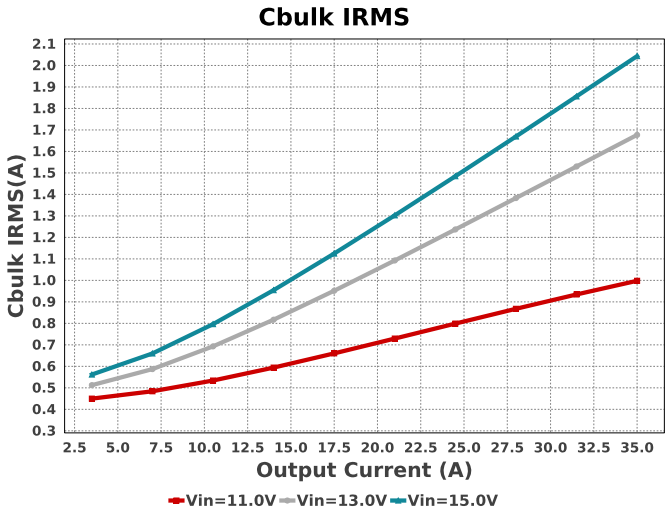


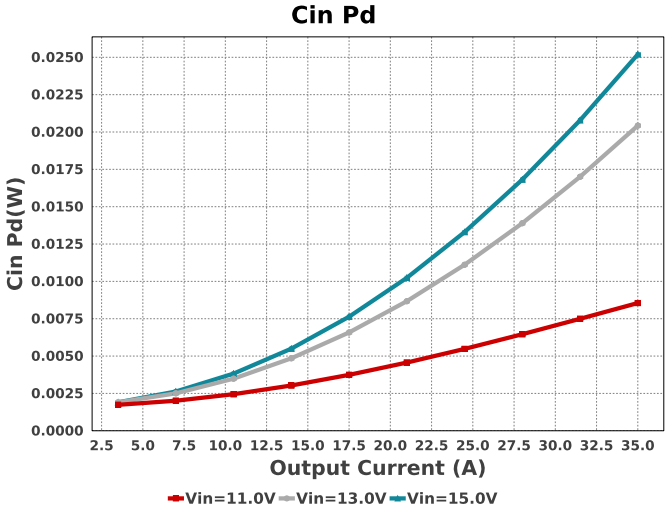


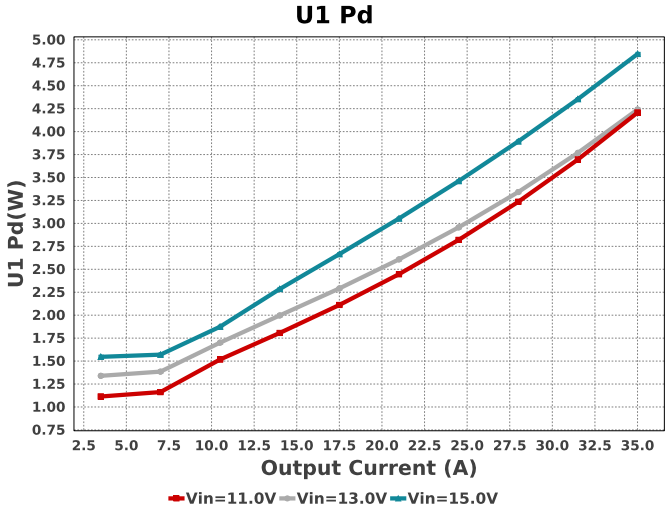


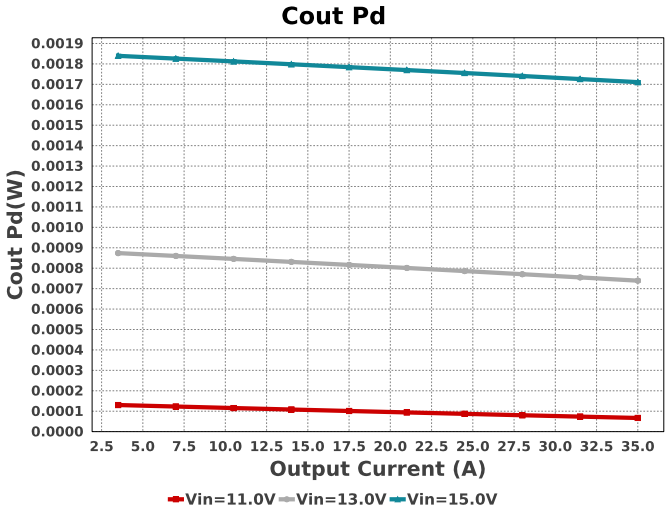


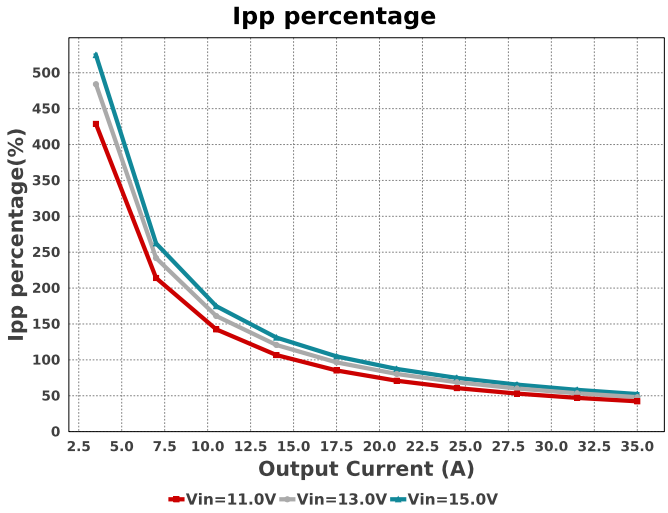


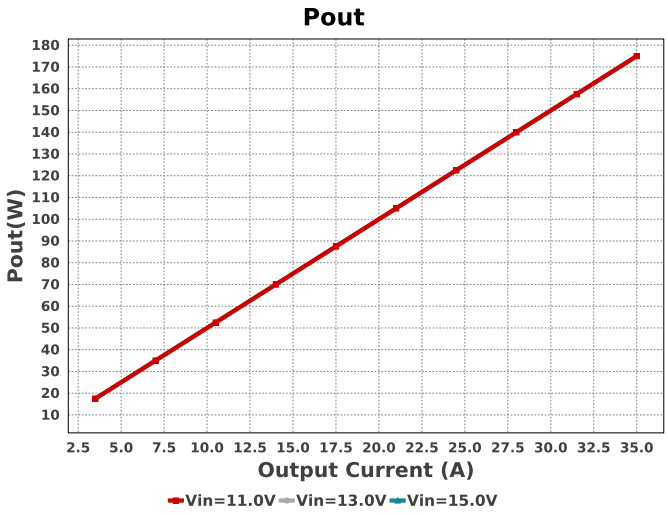


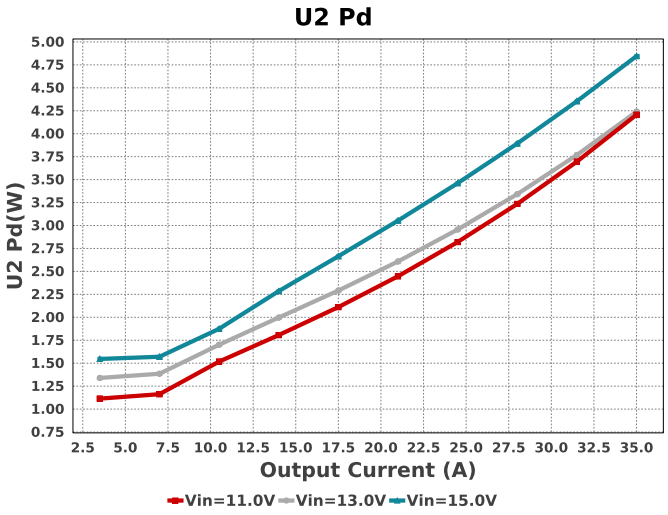


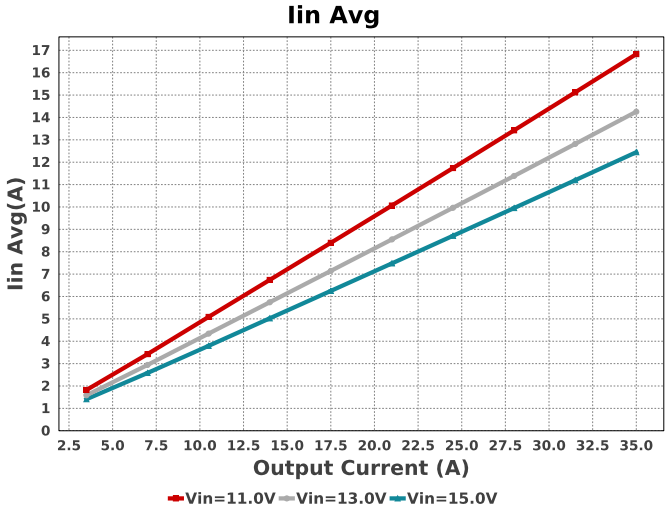


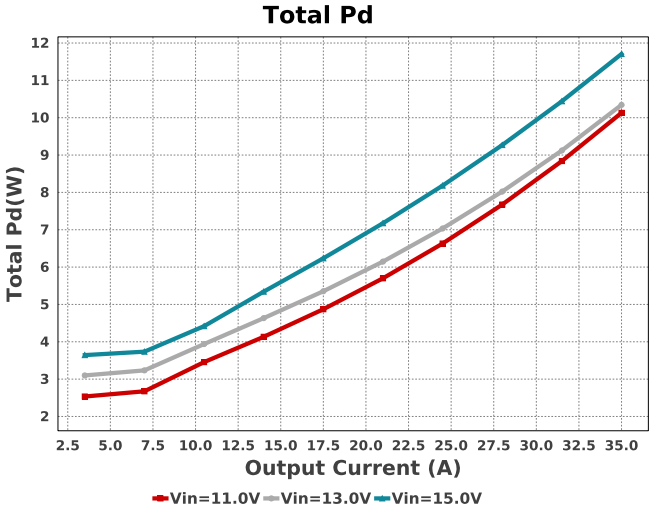


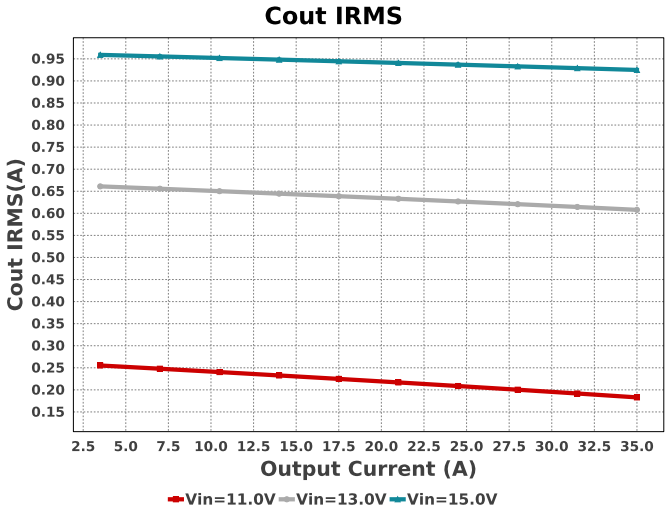


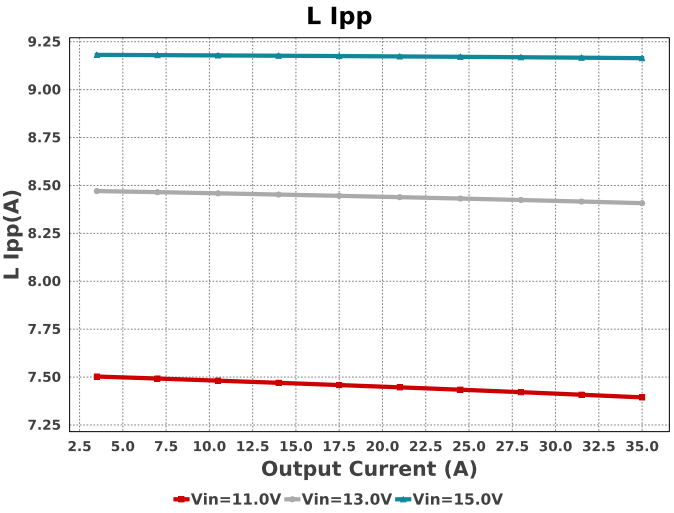


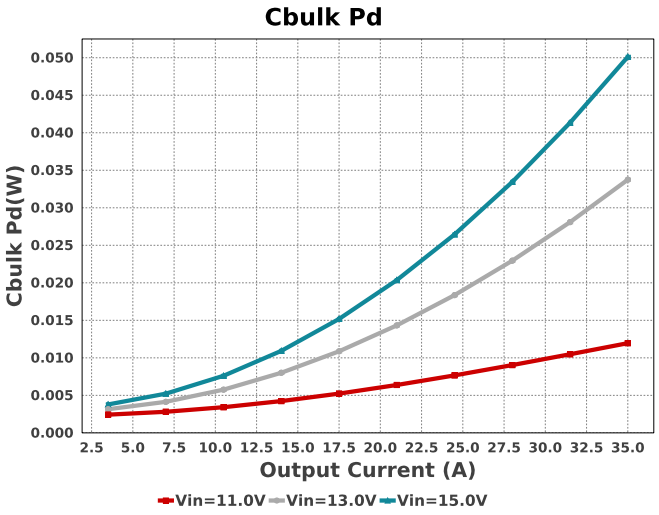


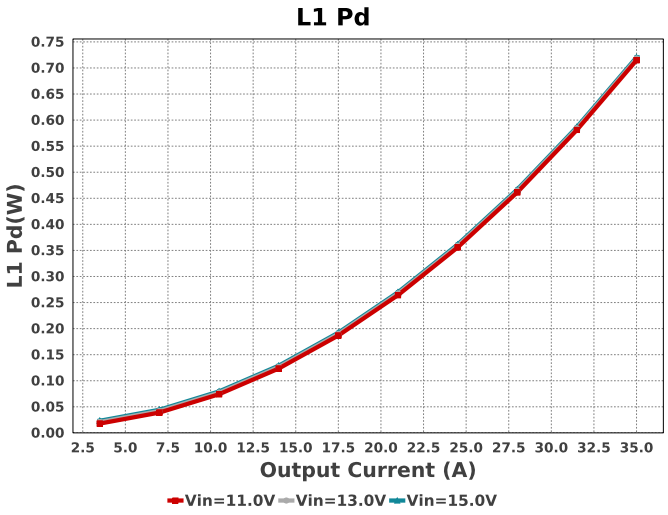


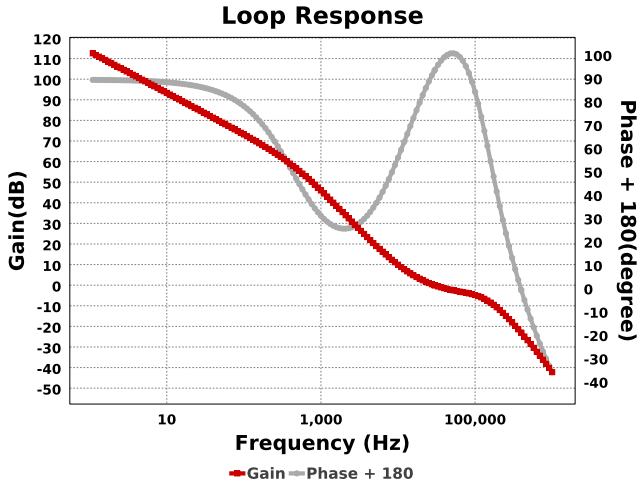












Operating Values

#	Name	Value	Category	Description
1.	Cbulk IRMS	2.044 A	Capacitor	Bulk capacitor RMS ripple current
2.	Cbulk Pd	50.115 mW	Capacitor	Bulk capacitor power dissipation
3.	Cin IRMS	6.388 A	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	25.196 mW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	924.873 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	1.711 mW	Capacitor	Output capacitor power dissipation
7.	Coutx IRMS	348.682 mA	Capacitor	Output capacitor_x RMS ripple current
8.	Coutx Pd	1.641 mW	Capacitor	Output capacitor_x power loss
9.	Fpi	1.421 MHz	Compensation	Current Loop Pole Frequency
10.	Fpv	636.62 kHz	Compensation	Voltage Loop Pole Frequency
11.	Fzi	85.27 kHz	Compensation	Current Loop Zero Frequency
12.	Fzv	15.915 kHz	Compensation	Voltage Loop Zero Frequency
13.	ILOOP Gain	14.302	Compensation	Recommended Current Loop Mid-band Gain
14.	VLOOP Gain	653.642 m	Compensation	Recommended Voltage Loop Mid-band Gain
15.	Zout (Fco)	58.436 mOhm	Compensation	Output Impedance at Crossover Frequency
16.	Zout (Fsw)	5.631 mOhm	Compensation	Output Impedance at Switching Frequency
17.	IC Ipk	22.082 A	IC	Peak switch current in IC
18.	IC Tj	69.25 degC	IC	IC junction temperature
19.	ICThetaJA Effective	8.1 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
20.	Iin Avg	12.447 A	IC	Average input current
21.	U1 Pd	4.846 W	IC	IC power dissipation
22.	U2 Pd	4.846 W	IC	IC power dissipation
23.	Ipp percentage	52.367 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
24.	L Ipp	9.164 A	Inductor	Peak-to-peak inductor ripple current
25.	L1 Pd	720.47 mW	Inductor	Inductor power dissipation
26.	L2 Pd	720.47 mW	Inductor	Inductor power dissipation
27.	CPI	3.2 pF	PMBus	Selectable compensation parameter through pinstrapping
28.	CPV	6.25 pF	PMBus	Selectable compensation parameter through pinstrapping
29.	CZI	53.328 pF	PMBus	Selectable compensation parameter through pinstrapping
30.	CZV	250.0 pF	PMBus	Selectable compensation parameter through pinstrapping
31.	GMI	200.0 µS	PMBus	Selectable compensation parameter through pinstrapping

#	Name	Value	Category	Description
32.	GMV	50.0 µS	PMBus	Selectable compensation parameter through pinstrapping
33.	PMBus Vout Command	5.0	PMBus	PMBus Vout Command
34.	PMBus Vout Scale Loop	125.0 m	PMBus	PMBus Vout Scale Loop
35.	RVI	35.0 kOhm	PMBus	Selectable compensation parameter through pinstrapping
36.	RVV	40.0 kOhm	PMBus	Selectable compensation parameter through pinstrapping
37.	Cbulk Pd	50.115 mW	Power	Bulk capacitor power dissipation
38.	Cin Pd	25.196 mW	Power	Input capacitor power dissipation
39.	Cout Pd	1.711 mW	Power	Output capacitor power dissipation
40.	Coutx Pd	1.641 mW	Power	Output capacitor_x power loss
41.	L1 Pd	720.47 mW	Power	Inductor power dissipation
42.	L2 Pd	720.47 mW	Power	Inductor power dissipation
43.	Snubber Pd	247.5 mW	Power	Snubber Power Dissipation
44.	Total Pd	11.706 W	Power	Total Power Dissipation
45.	U1 Pd	4.846 W	Power	IC power dissipation
46.	U2 Pd	4.846 W	Power	IC power dissipation
47.	BOM Count	62	System Information	Total Design BOM count
48.	Cross Freq	29.614 kHz	System Information	Bode plot crossover frequency
49.	Duty Cycle	34.149 %	System Information	Duty cycle
50.	Efficiency	93.73 %	System Information	Steady state efficiency
51.	FootPrint	1.499 k mm^2	System Information	Total Foot Print Area of BOM components
52.	Frequency	1.1 MHz	System Information	Switching frequency
53.	Gain Marg	-23.058 dB	System Information	Bode Plot Gain Margin
54.	Iout	35.0 A	System Information	Iout operating point
55.	Low Freq Gain	112.558 dB	System Information	Gain at 1Hz
56.	Mode	CCM	System Information	Conduction Mode
57.	Phase Marg	93.741 deg	System Information	Bode Plot Phase Margin
58.	Pout	175.0 W	System Information	Total output power
59.	Total BOM	$19.63	System Information	Total BOM Cost
60.	Vin	15.0 V	System Information	Vin operating point
61.	Vin p-p	123.169 mV	System Information	Peak-to-peak input voltage
62.	Vout	5.0 V	System Information	Operational Output Voltage
63.	Vout Tolerance	160.0 m%	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
64.	Vout p-p	16.306 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

	Name	Value	Description
	Iout	35.0	Maximum Output Current
	VinMax	15.0	Maximum input voltage
	VinMin	11.0	Minimum input voltage
	Vout	5.0	Output Voltage
	base_pn	TPS546D24A	Base Product Number
	source	DC	Input Source Type
	Ta	30.0	Ambient temperature
1.	Vout Sch	5.0	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

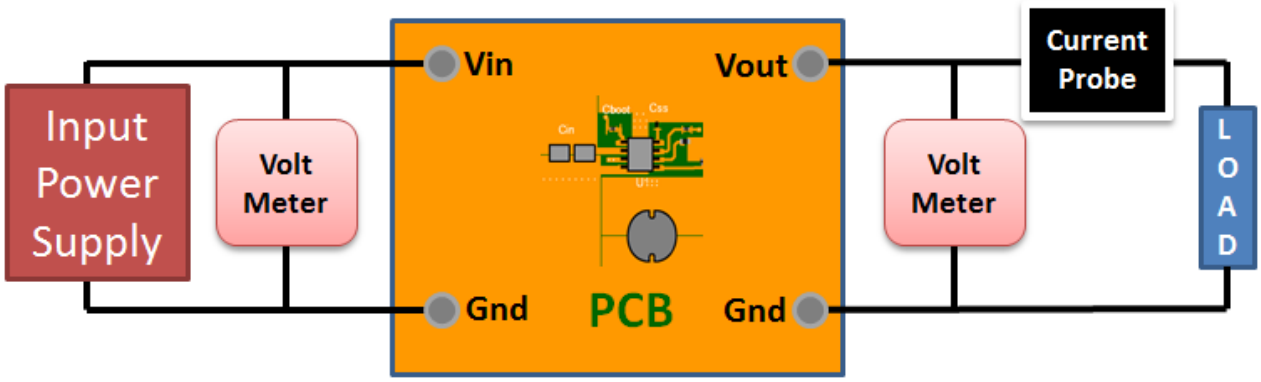
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 : 92FCE6B197623EBF[v1]
2. **TPS546D24A** Product Folder : http://www.ti.com/product/TPS546D24A : contains the data sheet and other resources.