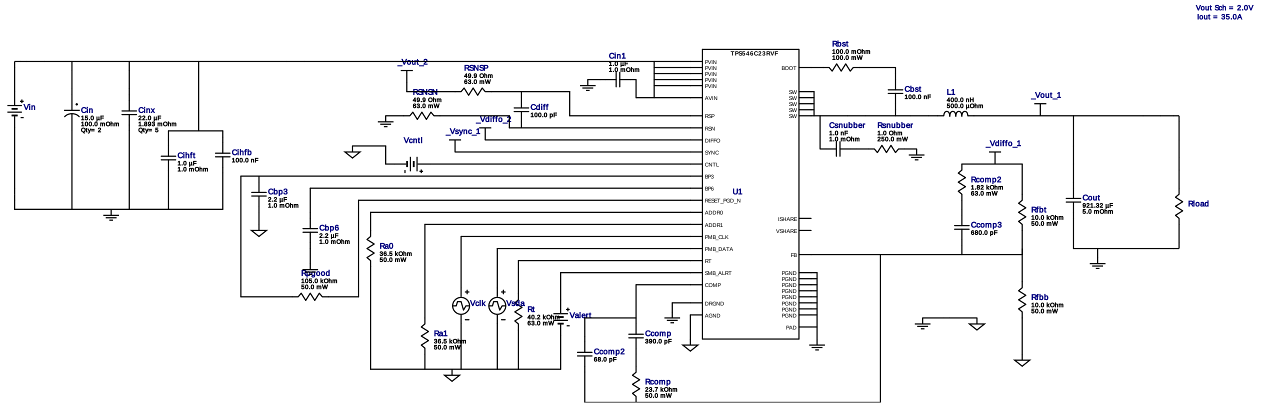
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 11.4V
VinMax = 12.6V
Vout = 2.0V
Vout Sch = 2.0V
Iout = 35.0A

Device = TPS546C23RVFR
Topology = Buck
Created = 2020-12-02 14:57:35.033
BOM Cost = NA
BOM Count = 33
Total Pd = 15.06W

Design : 5 TPS546C23RVFR
TPS546C23RVFR 11.4V-12.6V to 2.00V @ 35A



Design Alerts

TPS546C23 Design

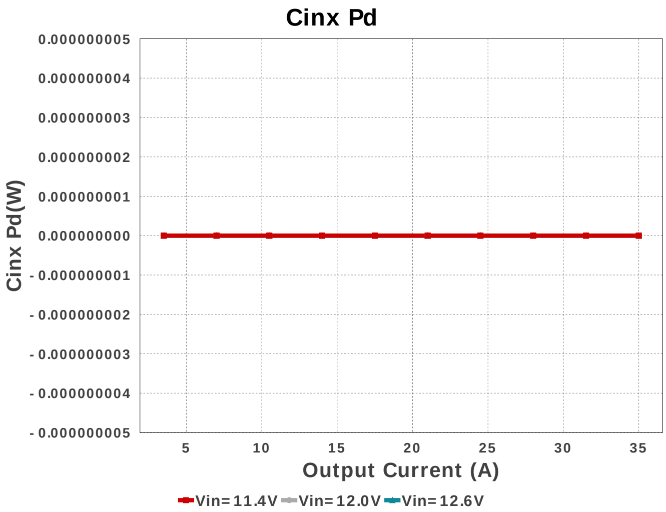
The TPS546C23 is a PMBus(TM) device with key features listed below. PMBus(TM) features marked with * are included in WEBENCH(R) Power Designer. - Adaptive Voltage Scaling (AVS) through VOUT_COMMAND * - Programmable output transition rate* - Output voltage and current monitoring - External temperature sensing and reporting - Programmable over current protection with Thermal Compensation - OV, UV, OT Levels - Turn-On and Turn-Off Delays - UVLO*, Soft-Start*, and Soft-StopUse the Advanced Options on the left side to set the PMBus(TM) commands.Please refer to the TPS546C23 datasheet and visit http://www.ti.com/pmbus for more information.

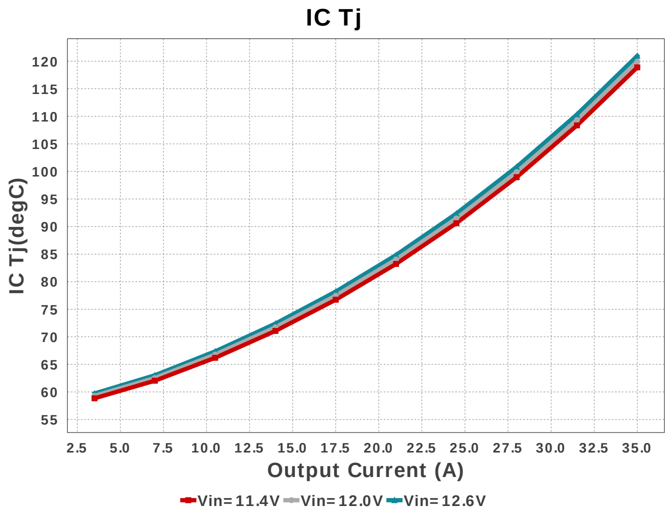
Electrical BOM

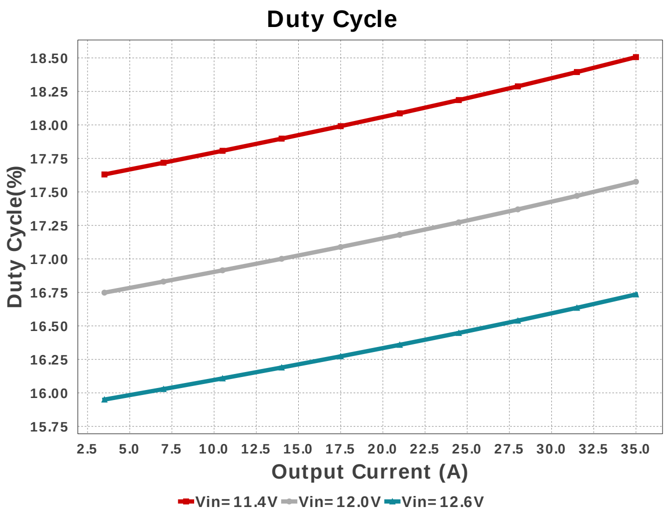
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbp3	Taiyo Yuden	EMK212BJ225KG-T Series= X5R	Cap= 2.2 uF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2
Cbp6	Taiyo Yuden	EMK212BJ225KG-T Series= X5R	Cap= 2.2 uF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2
Cbst	AVX	08053C104JAZ2A Series= X7R	Cap= 100.0 nF VDC= 25.0 V IRMS= 0.0 A	1	$0.06	0805 7 mm^2
Ccomp	Samsung Electro-Mechanics	CL10C391JB8NNNC Series= C0G/NP0	Cap= 390.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2
Ccomp2	Samsung Electro-Mechanics	CL10C680JB8NNNC Series= C0G/NP0	Cap= 68.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2
Ccomp3	Samsung Electro-Mechanics	CL05C681JB5NNNC Series= C0G/NP0	Cap= 680.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cdiff	Samsung Electro-Mechanics	CL21C101JBANNNC Series= C0G/NP0	Cap= 100.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Cihfb	AVX	08053C104JAZ2A Series= X7R	Cap= 100.0 nF VDC= 25.0 V IRMS= 0.0 A	1	$0.06	0805 7 mm^2
Cihft	Taiyo Yuden	TMK212B7105KG-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2

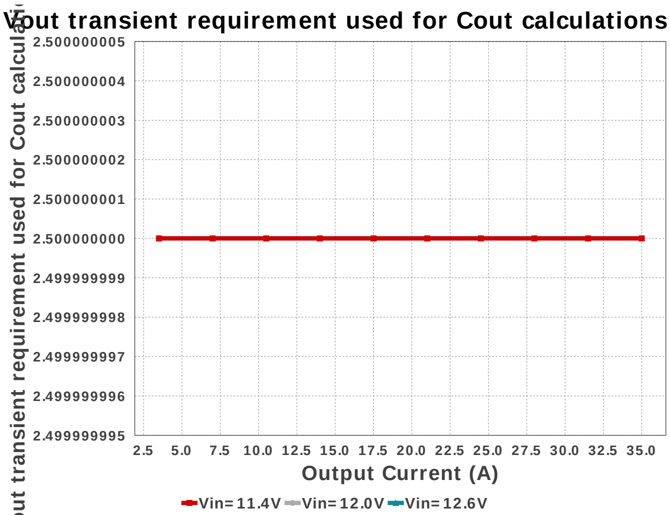
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cin	Panasonic	25TQC15MYFB Series= TQC	Cap= 15.0 uF ESR= 100.0 mOhm VDC= 25.0 V IRMS= 900.0 mA	2	$0.42	3528-21 17 mm^2
Cin1	Taiyo Yuden	TMK212B7105KG-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2
Cinx	TDK	CGA9P2X7R1E226M250KA Series= X7R	Cap= 22.0 uF ESR= 1.893 mOhm VDC= 25.0 V IRMS= 6.635 A	5	$0.92	2220_280 54 mm^2
Cout	CUSTOM	CUSTOM Series= ?	Cap= 921.32 uF ESR= 5.0 mOhm VDC= 3.2 V IRMS= 3.661 A	1	NA	CUSTOM 0 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
L1	Coilcraft	XAL1580-401MEB	L= 400.0 nH 500.0 µOhm	1	$2.40	XAL1580 313 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
Ra0	Yageo	RC0201FR-0736K5L Series= ?	Res= 36.5 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Ra1	Yageo	RC0201FR-0736K5L Series= ?	Res= 36.5 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rbst	Panasonic	ERJ-3RSFR10V Series= ERJ-3R	Res= 100.0 mOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.03	0603 5 mm^2
Rcomp	Yageo	RC0201FR-0723K7L Series= ?	Res= 23.7 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rcomp2	Vishay-Dale	CRCW04021K82FKED Series= CRCW..e3	Res= 1.82 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rfbt	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rpgood	Yageo	RC0201FR-07105KL Series= ?	Res= 105.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rsnubber	Vishay-Dale	CRCW12061R00FKEA Series= CRCW..e3	Res= 1.0 Ohm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm^2
Rt	Vishay-Dale	CRCW040240K2FKED Series= CRCW..e3	Res= 40.2 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2

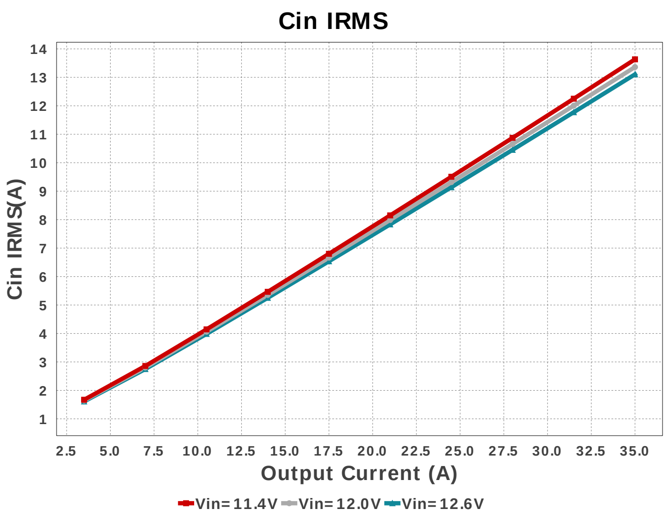
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
U1	Texas Instruments	TPS546C23RVFR	Switcher	1	$4.10	RVF0040A 63 mm²

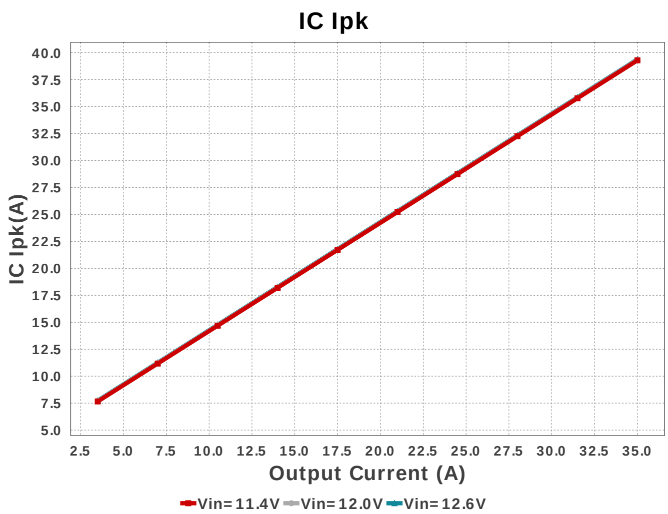


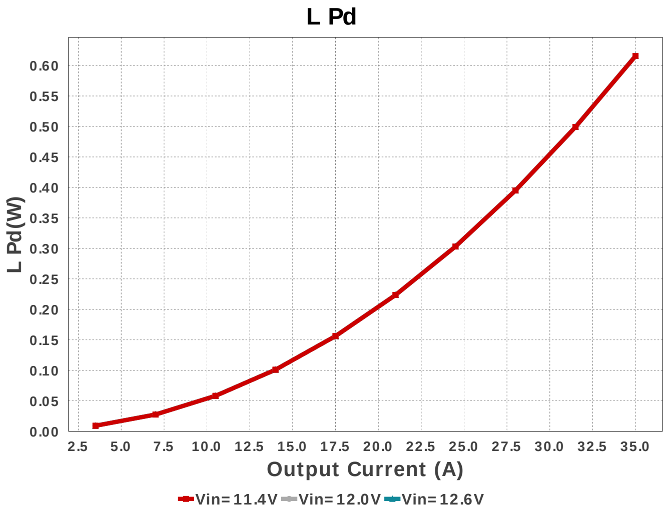


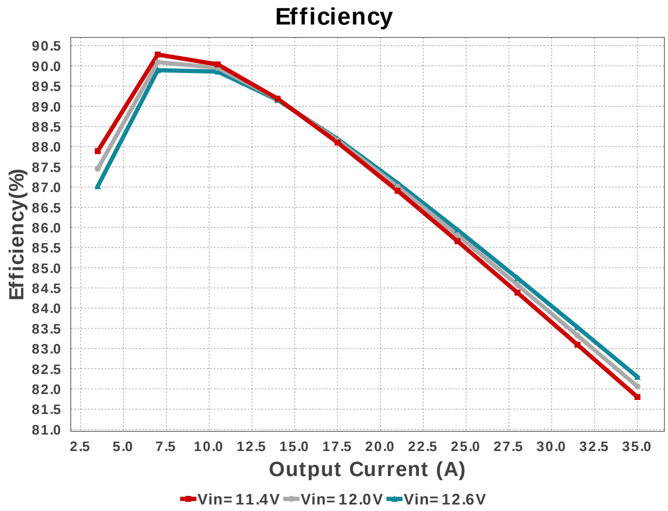


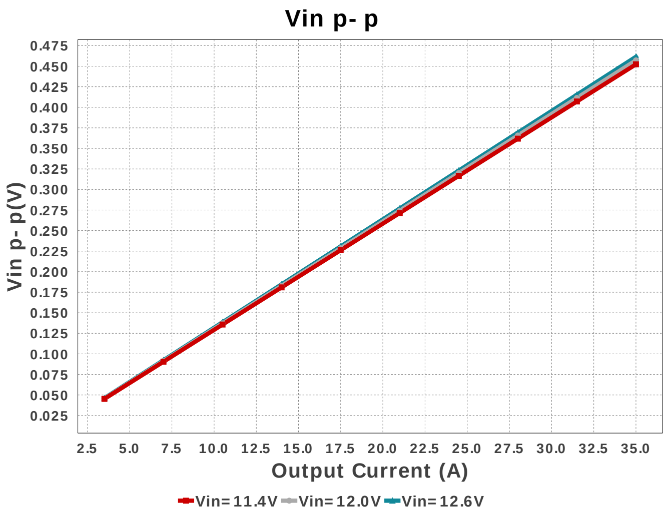


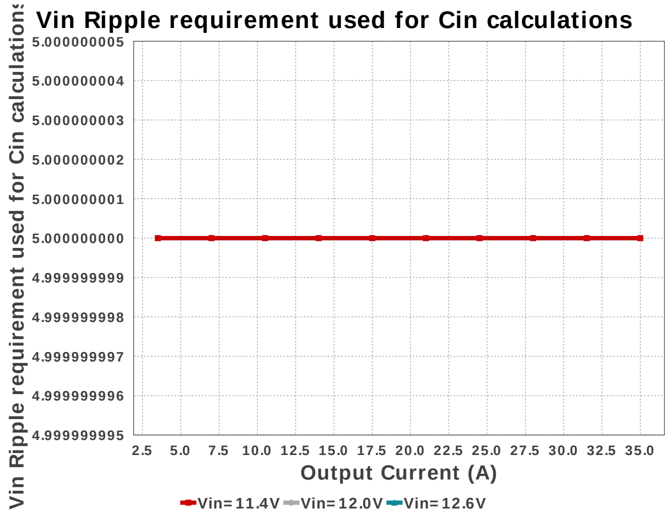


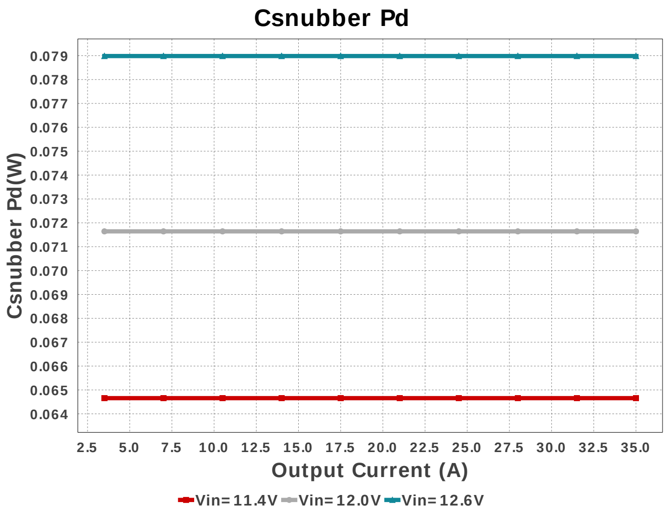


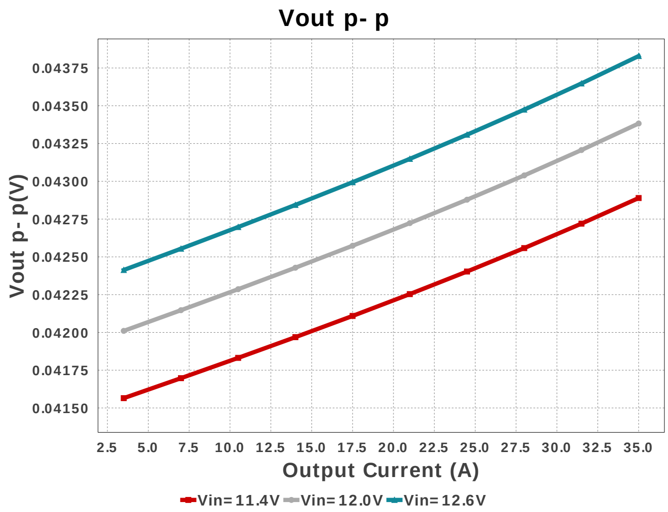

L Pd
L Pd(W)
Output Current (A)
Vin=11.4V Vin=12.0V Vin=12.6V

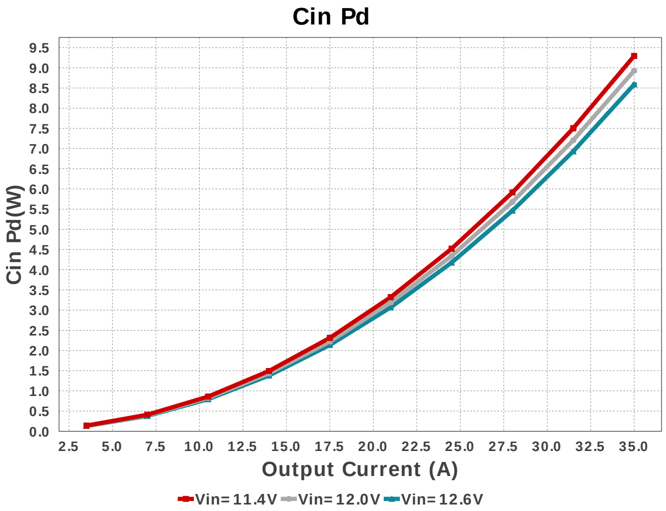

Efficiency
Efficiency(%)
Output Current (A)
Vin=11.4V Vin=12.0V Vin=12.6V

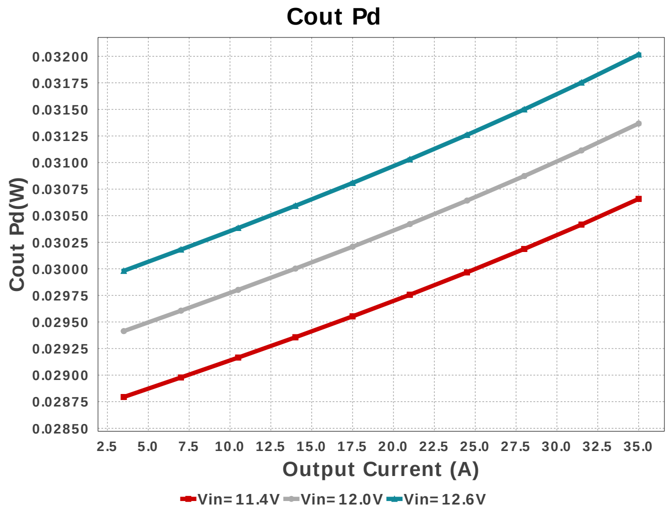

Vin p- p
Vin p- p(V)
Output Current (A)
Vin=11.4V Vin=12.0V Vin=12.6V

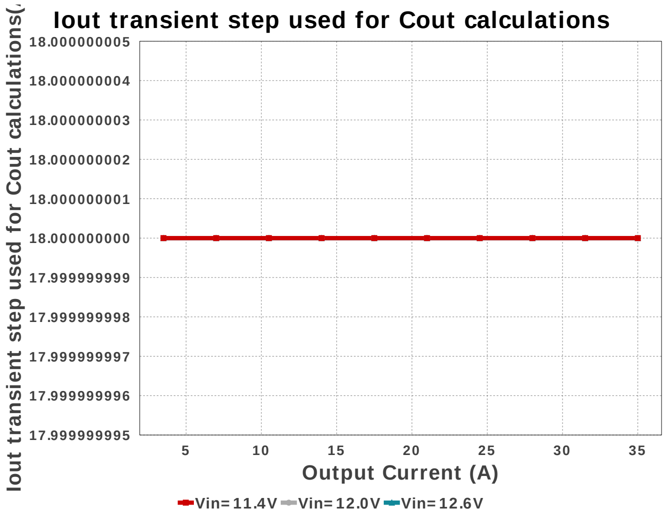

Vin Ripple requirement used for Cin calculations
Vin Ripple requirement used for Cin calculations
Output Current (A)
Vin=11.4V Vin=12.0V Vin=12.6V

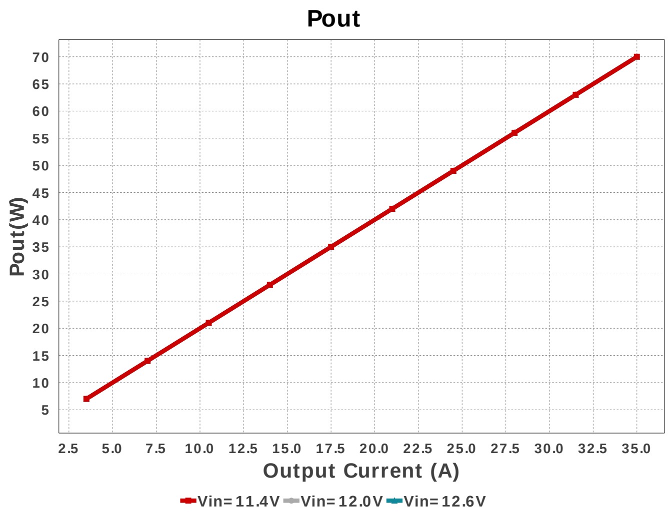

Csnubber Pd
Csnubber Pd(W)
Output Current (A)
Vin=11.4V Vin=12.0V Vin=12.6V

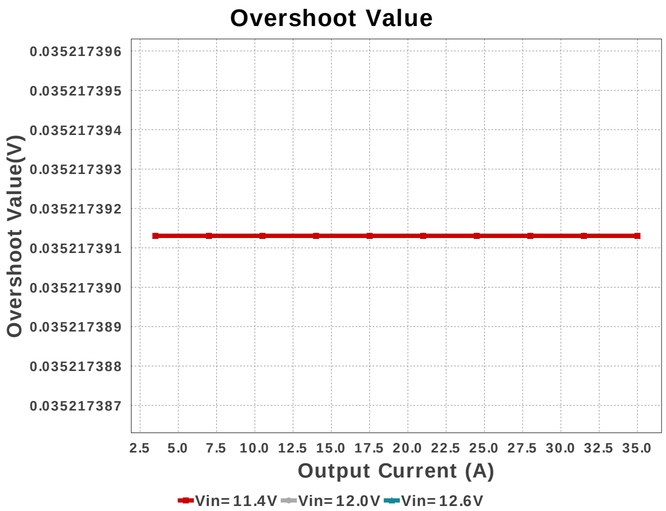

Vout p- p
Vout p- p(V)
Output Current (A)
Vin=11.4V Vin=12.0V Vin=12.6V

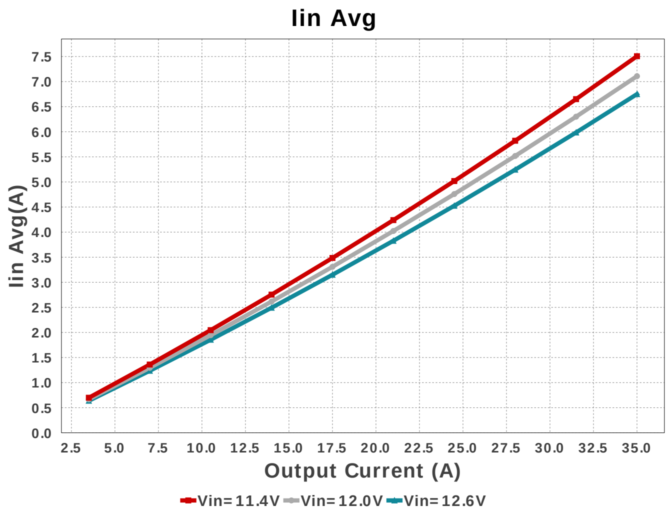

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=11.4V
Vin=12.0V
Vin=12.6V

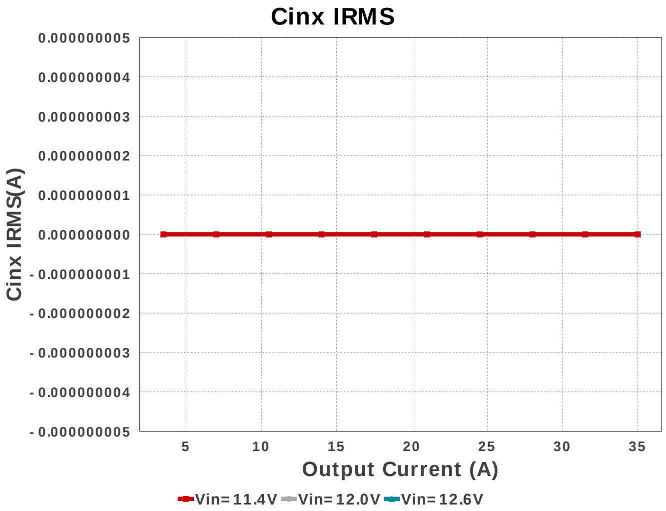

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=11.4V
Vin=12.0V
Vin=12.6V

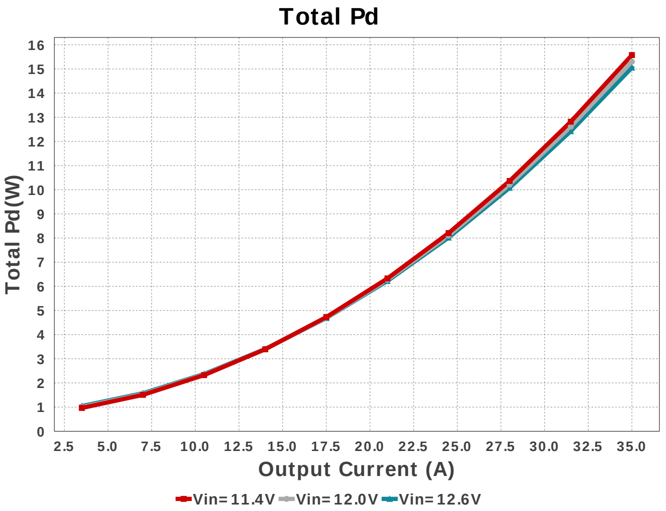

Iout transient step used for Cout calculations
Iout transient step used for Cout calculations(
Output Current (A)
Vin=11.4V
Vin=12.0V
Vin=12.6V

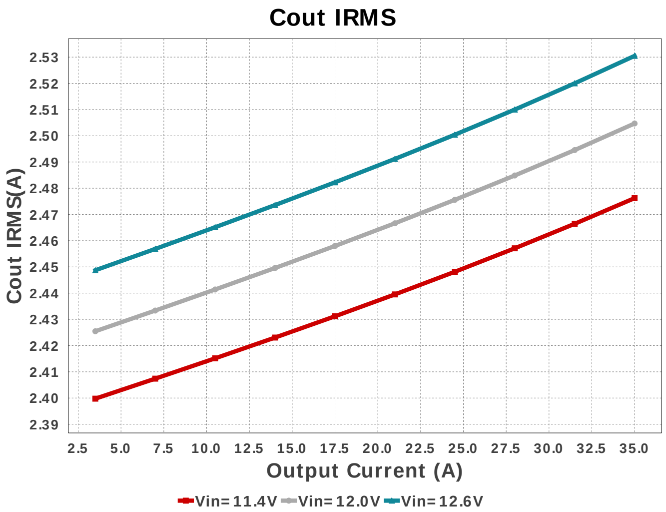

Pout
Pout(W)
Output Current (A)
Vin=11.4V
Vin=12.0V
Vin=12.6V

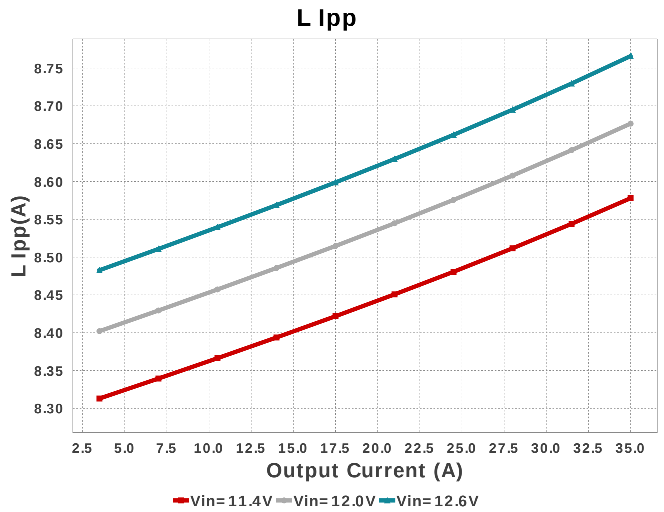

Overshoot Value
Overshoot Value(V)
Output Current (A)
Vin=11.4V
Vin=12.0V
Vin=12.6V

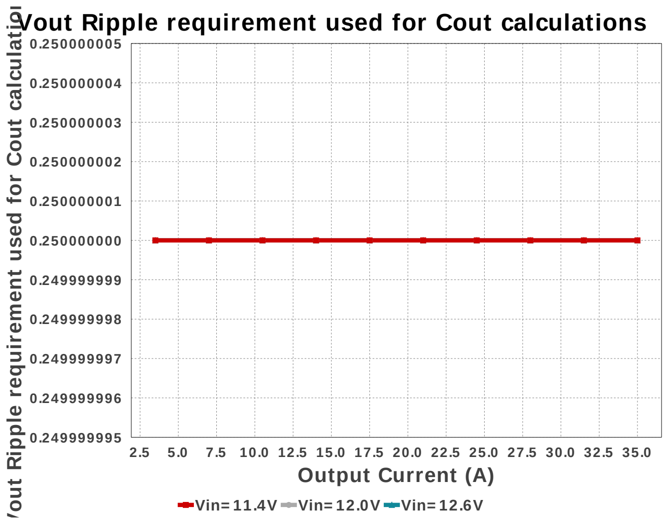

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=11.4V
Vin=12.0V
Vin=12.6V

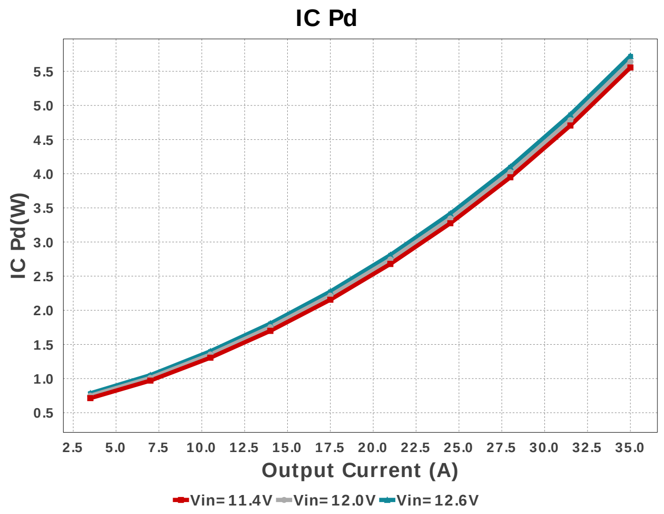

Cinx IRMS
Cinx IRMS(A)
0.000000005
0.000000004
0.000000003
0.000000002
0.000000001
0.000000000
- 0.000000001
- 0.000000002
- 0.000000003
- 0.000000004
- 0.000000005
5 10 15 20 25 30 35
Output Current (A)
Vin=11.4V Vin=12.0V Vin=12.6V

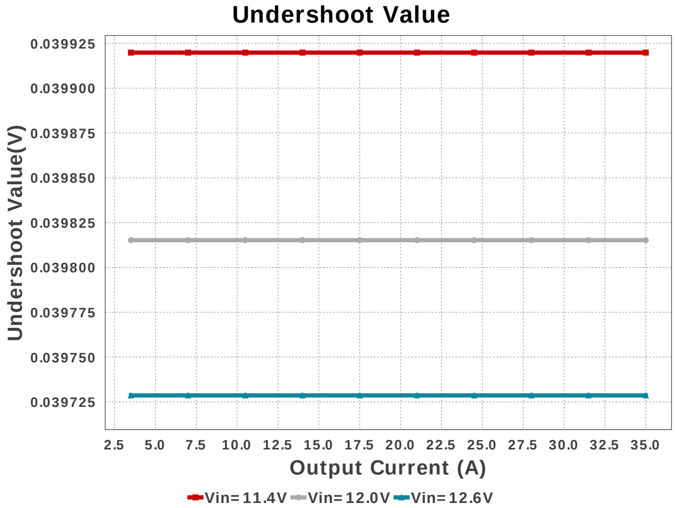

Total Pd
Total Pd(W)
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0 22.5 25.0 27.5 30.0 32.5 35.0
Output Current (A)
Vin=11.4V Vin=12.0V Vin=12.6V

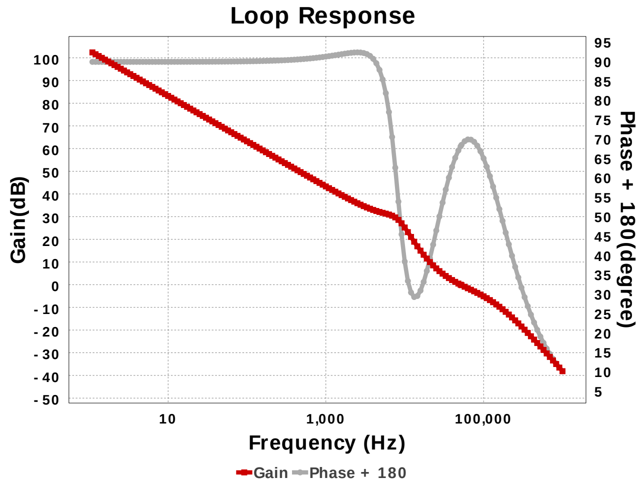

Cout IRMS
Cout IRMS(A)
2.53 2.52 2.51 2.50 2.49 2.48 2.47 2.46 2.45 2.44 2.43 2.42 2.41 2.40 2.39
2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0 22.5 25.0 27.5 30.0 32.5 35.0
Output Current (A)
Vin=11.4V Vin=12.0V Vin=12.6V


L Ipp
L Ipp(A)
8.75 8.70 8.65 8.60 8.55 8.50 8.45 8.40 8.35 8.30
2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0 22.5 25.0 27.5 30.0 32.5 35.0
Output Current (A)
Vin=11.4V Vin=12.0V Vin=12.6V


Vout Ripple requirement used for Cout calculations
Vout Ripple requirement used for Cout calculati
0.250000005
0.250000004
0.250000003
0.250000002
0.250000001
0.250000000
0.249999999
0.249999998
0.249999997
0.249999996
0.249999995
2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0 22.5 25.0 27.5 30.0 32.5 35.0
Output Current (A)
Vin=11.4V Vin=12.0V Vin=12.6V


IC Pd
IC Pd(W)
5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0 22.5 25.0 27.5 30.0 32.5 35.0
Output Current (A)
Vin=11.4V Vin=12.0V Vin=12.6V





Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	13.106 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	8.588 W	Capacitor	Input capacitor power dissipation
3.	Cinx IRMS	33.175 A	Capacitor	Bulk capacitor RMS ripple current
4.	Cinx Pd	0.0 W	Capacitor	Bulk capacitor power dissipation
5.	Cout IRMS	2.53 A	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	32.016 mW	Capacitor	Output capacitor power dissipation
7.	Csnubber Pd	78.985 mW	Capacitor	Snubber Power Dissipation
8.	IC Ipk	39.383 A	IC	Peak switch current in IC
9.	IC Pd	5.724 W	IC	IC power dissipation
10.	IC Tj	120.971 degC	IC	IC junction temperature
11.	ICThetaJA Effective	12.4 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
12.	Iin Avg	6.75 A	IC	Average input current
13.	L Ipp	8.766 A	Inductor	Peak-to-peak inductor ripple current
14.	L Pd	615.7 mW	Inductor	Inductor power dissipation
15.	PMBus Vout Command	1.024 k	PMBus	PMBus Vout Command
16.	PMBus Vout Scale Loop	500.0 m	PMBus	PMBus Vout Scale Loop
17.	Cin Pd	8.588 W	Power	Input capacitor power dissipation
18.	Cinx Pd	0.0 W	Power	Bulk capacitor power dissipation
19.	Cout Pd	32.016 mW	Power	Output capacitor power dissipation
20.	Csnubber Pd	78.985 mW	Power	Snubber Power Dissipation
21.	IC Pd	5.724 W	Power	IC power dissipation
22.	L Pd	615.7 mW	Power	Inductor power dissipation
23.	Total Pd	15.056 W	Power	Total Power Dissipation
24.	BOM Count	33	System Information	Total Design BOM count
25.	Cross Freq	51.038 kHz	System Information	Bode plot crossover frequency
26.	Duty Cycle	16.735 %	System Information	Duty cycle
27.	Efficiency	82.299 %	System Information	Steady state efficiency
28.	FootPrint	826.0 mm^2	System Information	Total Foot Print Area of BOM components
29.	Frequency	497.512 kHz	System Information	Switching frequency
30.	Gain Marg	-49.426 dB	System Information	Bode Plot Gain Margin
31.	Iout	35.0 A	System Information	Iout operating point
32.	Iout transient step used for Cout calculations	18.0 A	System Information	Custom Transient current step requirement that was used for Cout selection (A).
33.	Low Freq Gain	102.397 dB	System Information	Gain at 1Hz
34.	Mode	CCM	System Information	Conduction Mode
35.	Overshoot Value	35.167 mV	System Information	Theoretical Vout Overshoot Value
36.	Phase Marg	68.235 deg	System Information	Bode Plot Phase Margin
37.	Pout	70.0 W	System Information	Total output power

#	Name	Value	Category	Description
38.	Total BOM	NA	System Information	Total BOM Cost
39.	Undershoot Value	39.672 mV	System Information	Theoretical Vout Undershoot Value
40.	Vin	12.6 V	System Information	Vin operating point
41.	Vin Ripple requirement used for Cin calculations	5.0 %	System Information	Custom maximum input ripple requirement that was used for Cin selection(% of Minimum Vin).
42.	Vin p-p	461.468 mV	System Information	Peak-to-peak input voltage
43.	Vout	2.0 V	System Information	Operational Output Voltage
44.	Vout Actual	2.0 V	System Information	Vout Actual calculated based on selected voltage divider resistors
45.	Vout Ripple requirement used for Cout calculations	250.0 m%	System Information	Custom maximum output ripple requirement that was used for Cout selection(% of Vout).
46.	Vout Tolerance	1.515 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
47.	Vout p-p	43.829 mV	System Information	Peak-to-peak output ripple voltage
48.	Vout transient requirement used for Cout calculations	2.5 %	System Information	Custom Transient voltage change requirement that was used for Cout selection (% of Vout).

Design Inputs

	Name	Value	Description
	Iout	35.0	Maximum Output Current
	VinMax	12.6	Maximum input voltage
	VinMin	11.4	Minimum input voltage
	Vout	2.0	Output Voltage
	base_pn	TPS546C23	Base Product Number
	source	DC	Input Source Type
	Ta	50.0	Ambient temperature
	UserFsw	500.0 k	Customer Selected Frequency
1.	Vout Sch	2.0	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

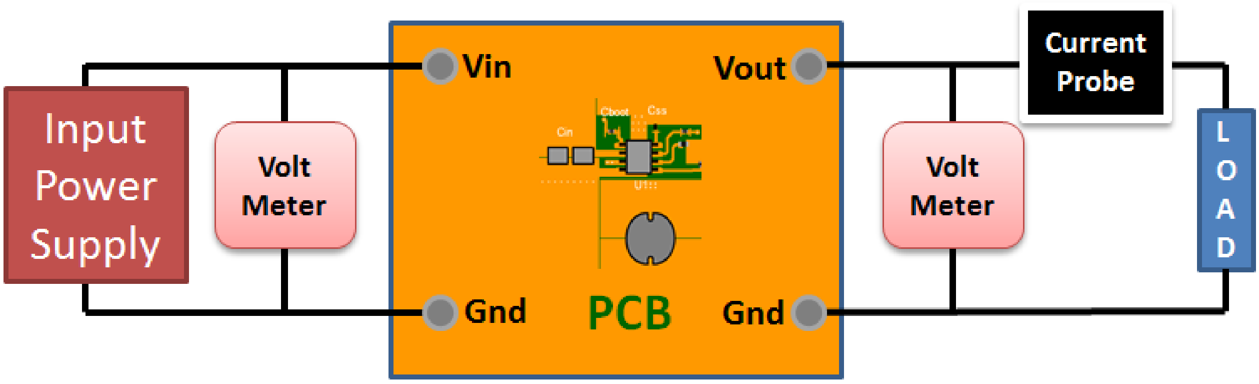
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 11.4V 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.

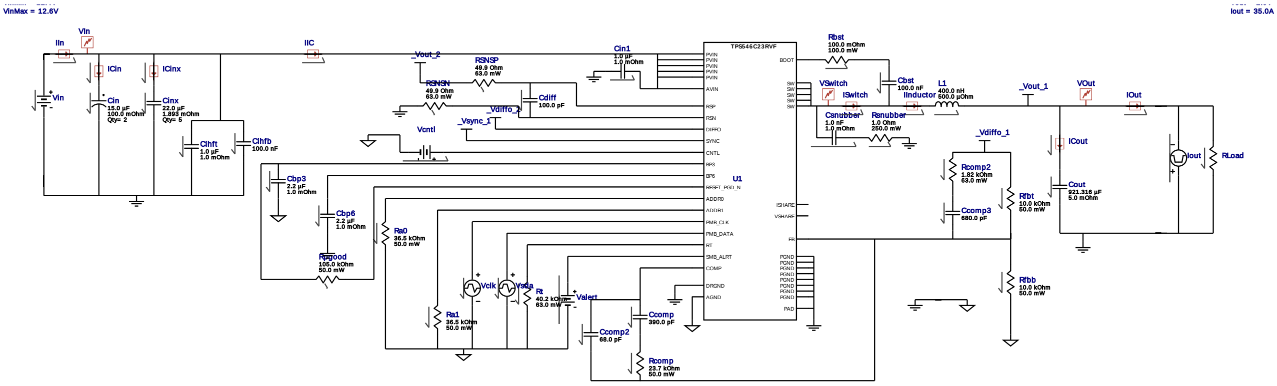


WEBENCH® Electrical Simulation Report

Design Id = 5

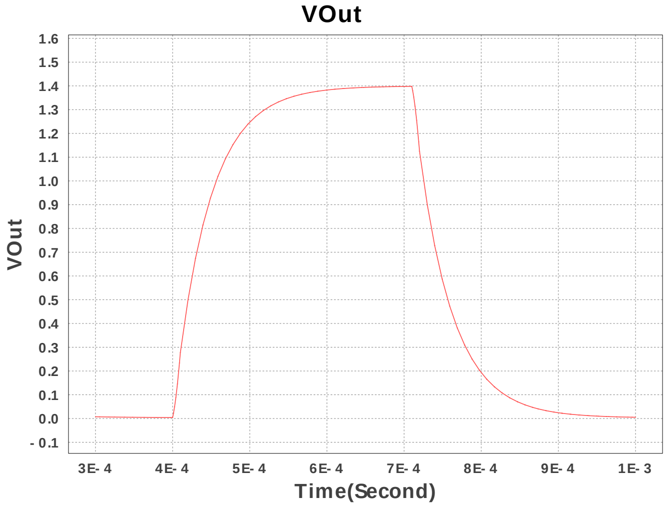
sim_id = 2

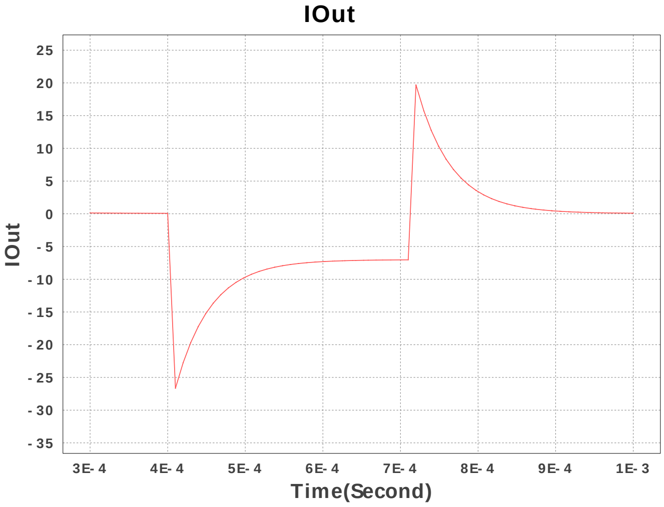
Simulation Type = Load Transient



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Cbp6	IC	Initial Voltage	6.6 V
2.	Cihft	IC	Initial Voltage	12.0 V
3.	Cbp3	IC	Initial Voltage	3.3 V
4.	Vcntl	V	Control Voltage	1.5 Volts
5.	Cin	IC	Initial Voltage	12.0 V
6.	Cout	IC	Initial Voltage	2.0 V
7.	Cbst	IC	Initial Voltage	12.0 V
8.	L1	IC	Initial Current	35.0 V
9.	Cihfb	IC	Initial Voltage	12.0 V
10.	Iout	signal_type	Signal Type	PULSE
		I1	Initial Load Current	0 A
		I2	Minimum Load Current	31.5 A
		Td	Initial Time Delay	400u s
		Tf	Fall Time	10u s
		Tr	Rise Time	10u s
		Pw	Pulse Width	300u s
11.	RLoad	R	Load Resistance	0.05714285714285714 Ohm

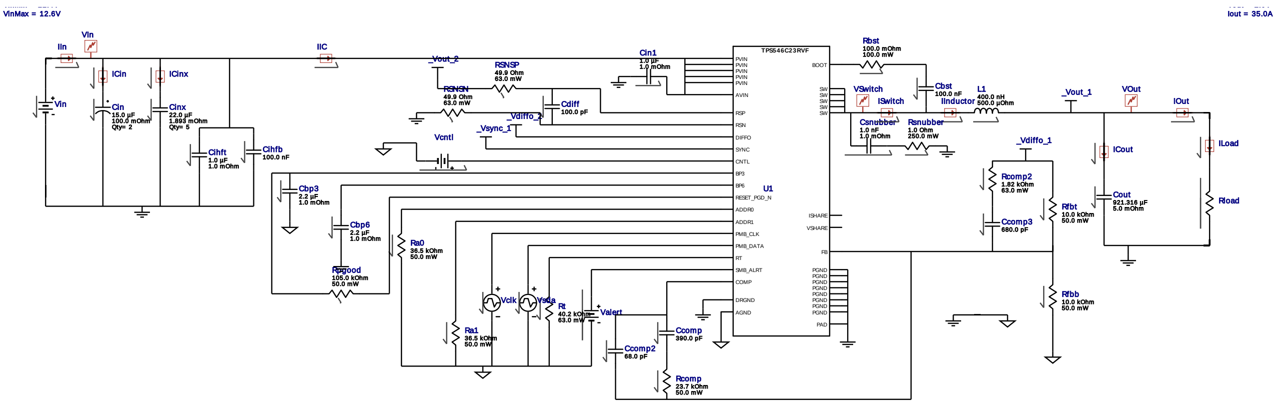




Design Id = 5

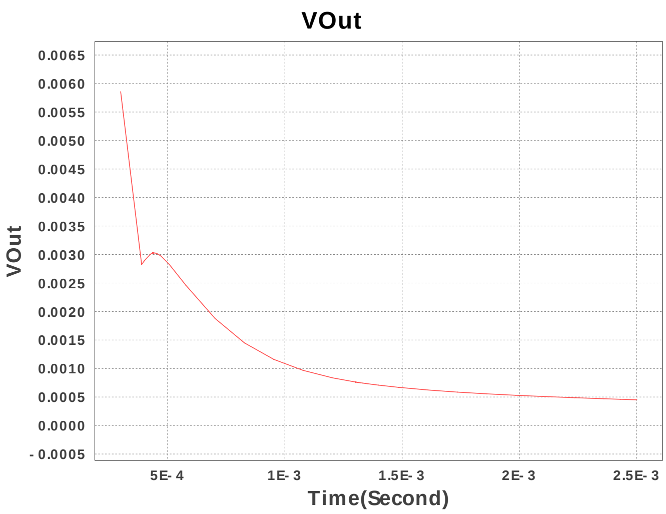
sim_id = 3

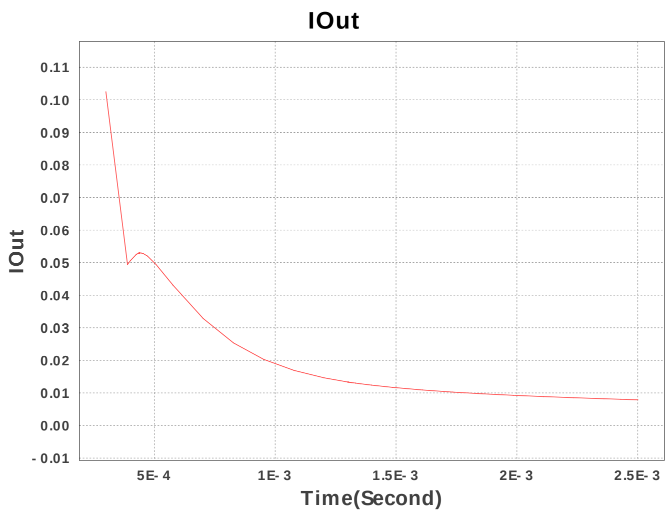
Simulation Type = Vout Transition



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Cbp6	IC	Initial Voltage	6.6 V
2.	Cihft	IC	Initial Voltage	11.4 V
3.	Cbp3	IC	Initial Voltage	3.3 V
4.	Vcntl	V	Control Voltage	1.5 Volts
5.	Cin	IC	Initial Voltage	11.4 V
6.	Cout	IC	Initial Voltage	2.0 V
7.	Cbst	IC	Initial Voltage	11.4 V
8.	L1	IC	Initial Current	35.0 V
9.	Cihfb	IC	Initial Voltage	11.4 V
10.	Rload	R	Load Resistance	0.05714285714285714 Ohm

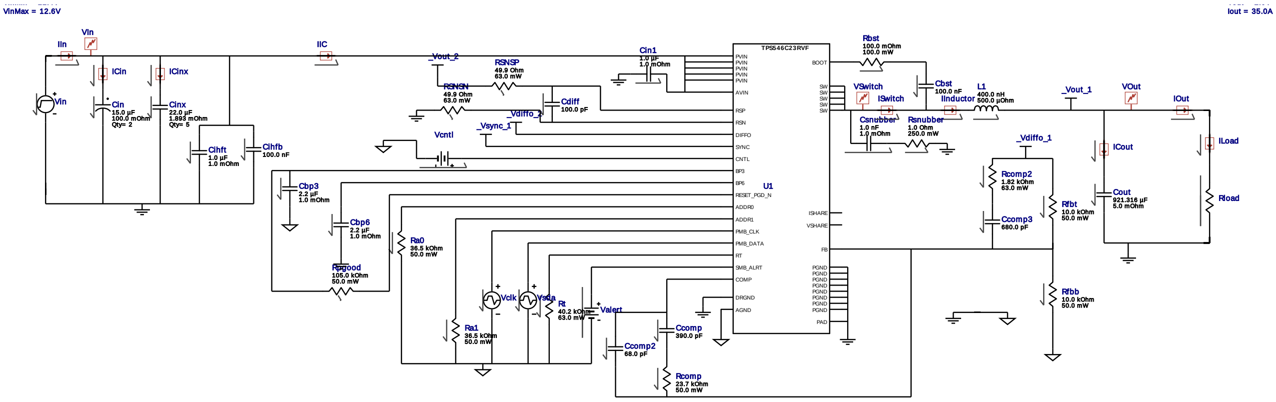




Design Id = 5

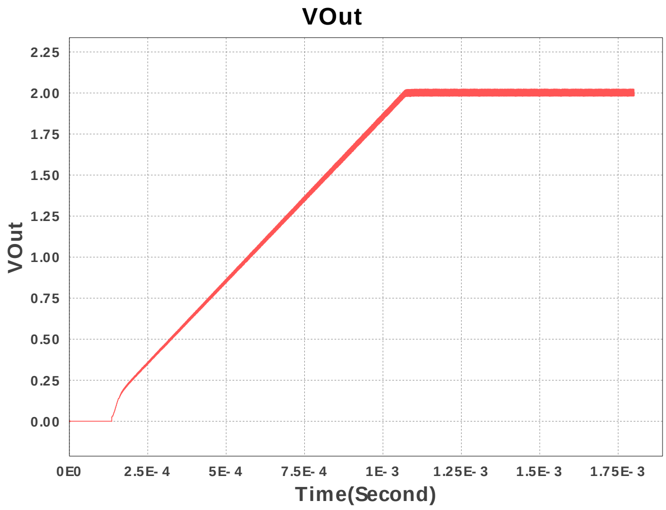
sim_id = 4

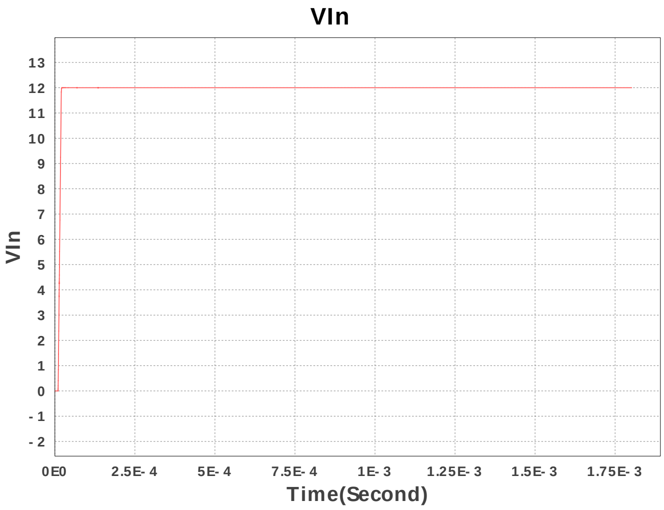
Simulation Type = Startup



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Cbp6	IC	Initial Voltage	0 V
2.	Cbp3	IC	Initial Voltage	0 V
3.	Vcntl	V	Control Voltage	1.5 Volts
4.	Rload	R	Load Resistance	0.05714285714285714 Ohm

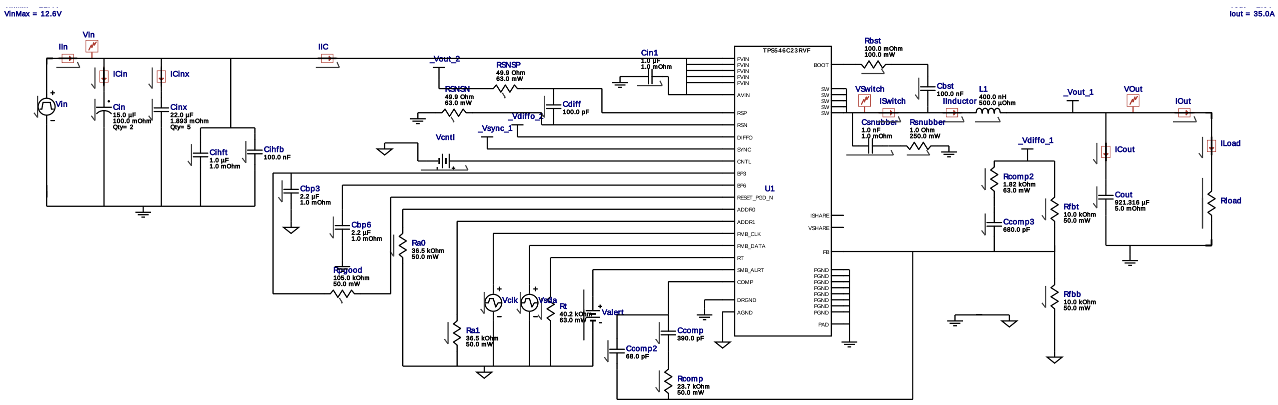




Design Id = 5

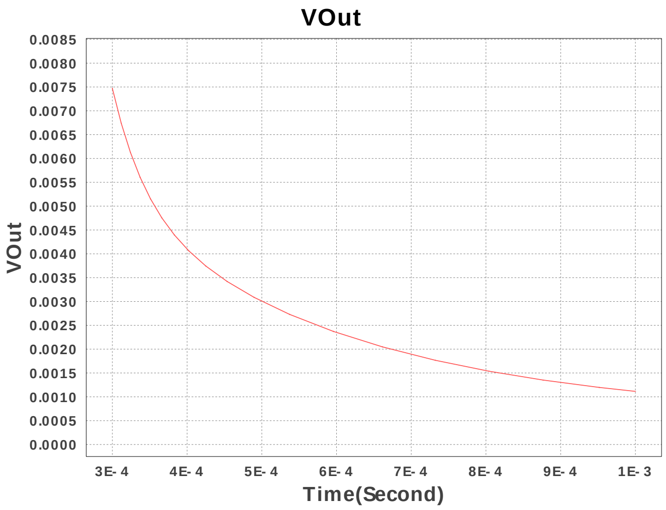
sim_id = 5

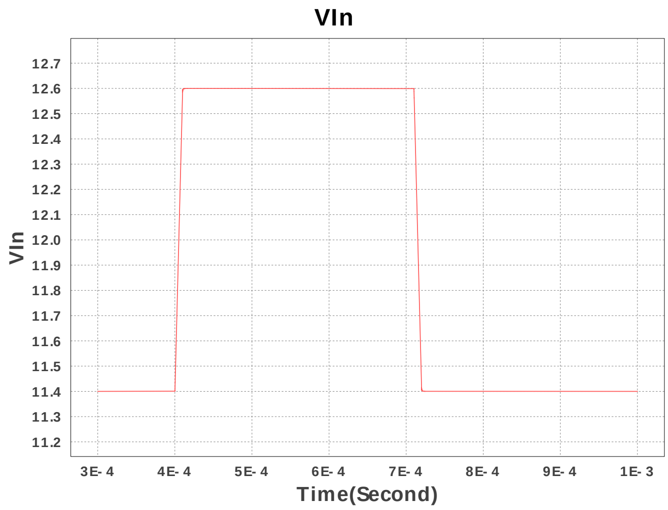
Simulation Type = Input Transient



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Cbp6	IC	Initial Voltage	6.6 V
2.	Cihft	IC	Initial Voltage	11.4 V
3.	Cbp3	IC	Initial Voltage	3.3 V
4.	Vcntl	V	Control Voltage	1.5 Volts
5.	Cin	IC	Initial Voltage	11.4 V
6.	Cout	IC	Initial Voltage	2.0 V
7.	Cbst	IC	Initial Voltage	VinMin V
8.	L1	IC	Initial Current	35.0 V
9.	Cihfb	IC	Initial Voltage	11.4 V
10.	Rload	R	Load Resistance	0.05714285714285714 Ohm





Design Assistance

1. Master key : 8C6B510EB8781533[v1]

2. **TPS546C23** Product Folder : http://www.ti.com/product/TPS546C23 : contains the data sheet and other resources.

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