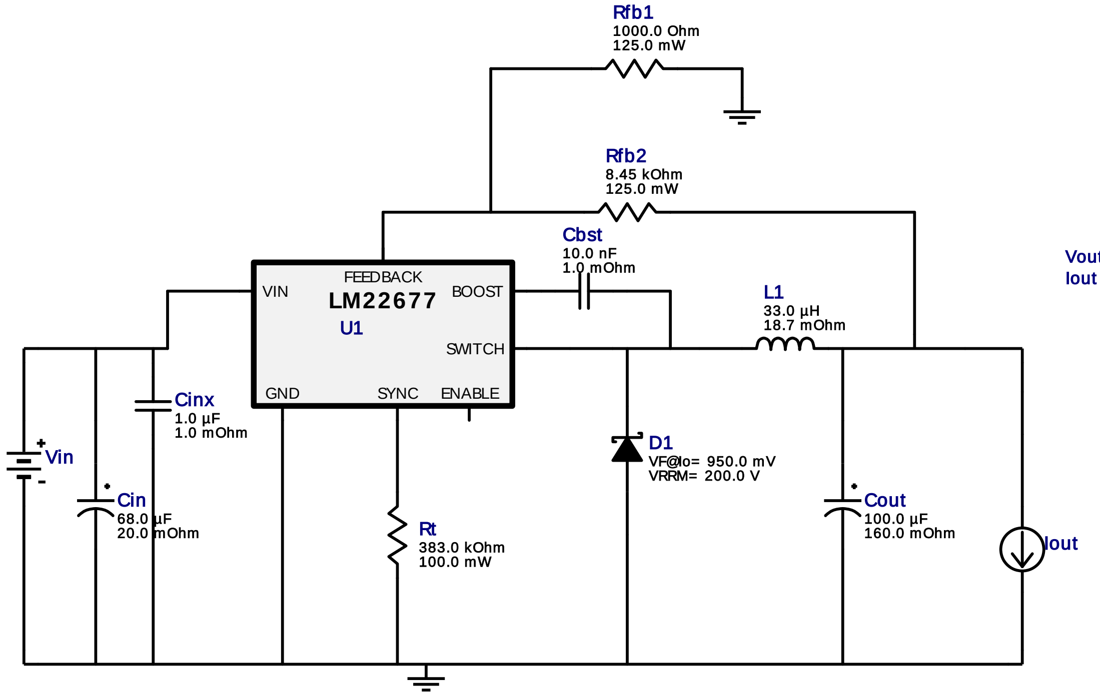
Texas Instruments

WEBENCH® Design Report

VinMin = 14.0V
VinMax = 28.0V
Vout = 12.0V
Iout = 5.0A

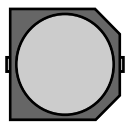
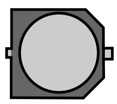
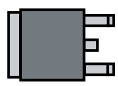
Device = LM22677TJE-ADJ/NOPB
Topology = Buck
Created = 2021-08-26 20:18:34.748
BOM Cost = $6.41
BOM Count = 10
Total Pd = 4.99W

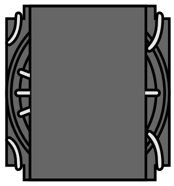
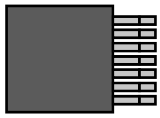
Design : 1 LM22677TJE-ADJ/NOPB
LM22677TJE-ADJ/NOPB 14V-28V to 12.00V @ 5A



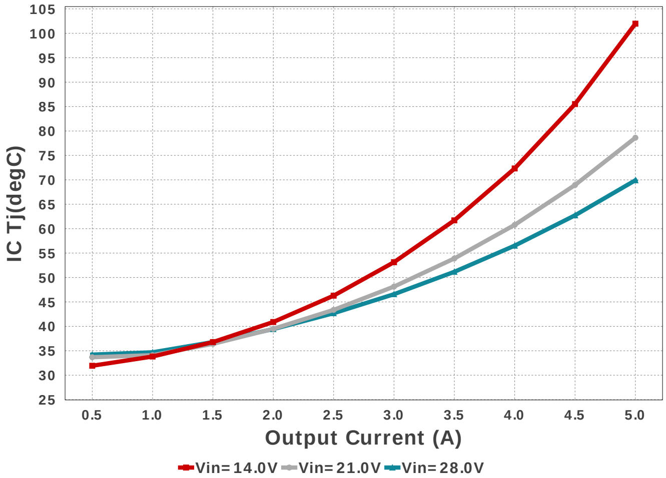
1. This regulator device is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application.View WEBENCH(R) Disclaimer.

Electrical BOM

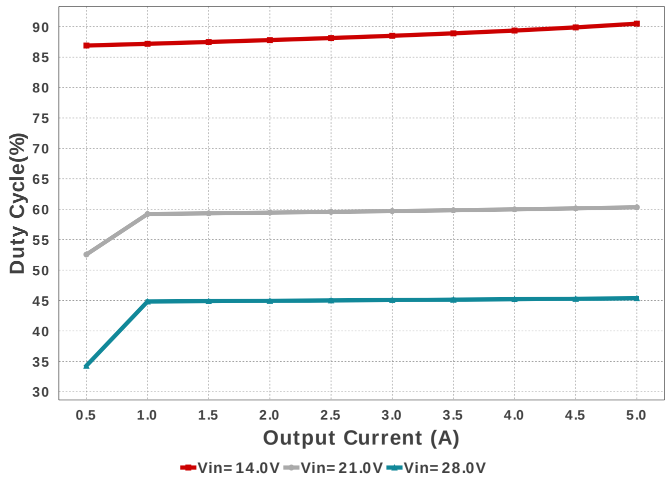
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbst	Yageo	CC0805KRX7R9BB103 Series= X7R	Cap= 10.0 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²
Cin	Panasonic	50SVPF68M Series= SVPF	Cap= 68.0 uF ESR= 20.0 mOhm VDC= 50.0 V IRMS= 4.3 A	1	$0.95	 CAPSMT_62_F12 151 mm²
Cinx	Taiyo Yuden	GMK212B7105KG-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 35.0 V IRMS= 0.0 A	1	$0.03	0805 7 mm²
Cout	Panasonic	EEE-FK1V101P Series= FK	Cap= 100.0 uF ESR= 160.0 mOhm VDC= 35.0 V IRMS= 600.0 mA	1	$0.21	 SM_RADIAL_F 124 mm²
D1	SMC Diode Solutions	SBRD10200TR	VF@Io= 950.0 mV VRRM= 200.0 V	1	$0.12	 DPAK 102 mm²

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
L1	Coilcraft	XAL1510-333MEB	L= 33.0 µH 18.7 mOhm	1	$2.27	 XAL1510 320 mm²
Rfb1	Panasonic	ERJ-6ENF1001V Series= ERJ-6E	Res= 1000.0 Ohm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²
Rfb2	Panasonic	ERJ-6ENF8451V Series= ERJ-6E	Res= 8.45 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²
Rt	Yageo	RC0603FR-07383KL Series= ?	Res= 383.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
U1	Texas Instruments	LM22677TJE-ADJ/NOPB	Switcher	1	$2.79	 TJ7A 199 mm²

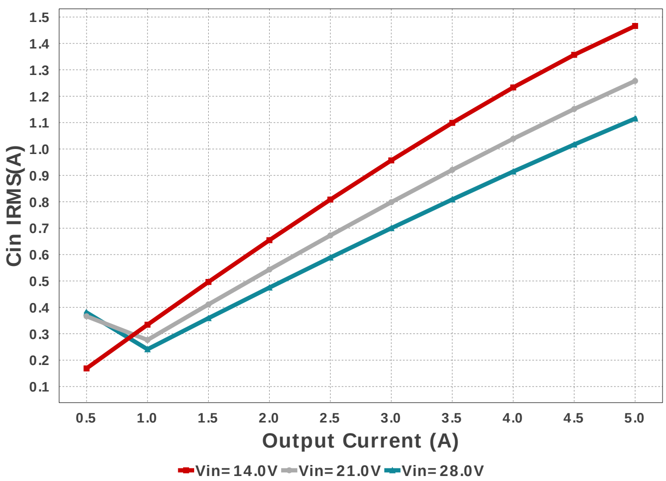
IC Tj



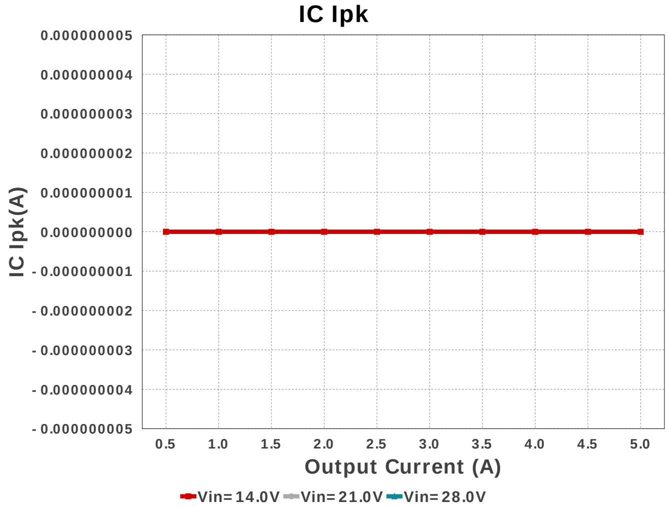
Duty Cycle

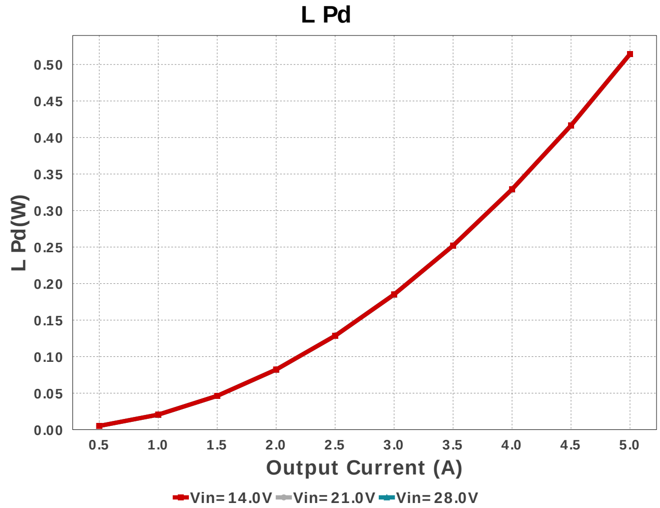


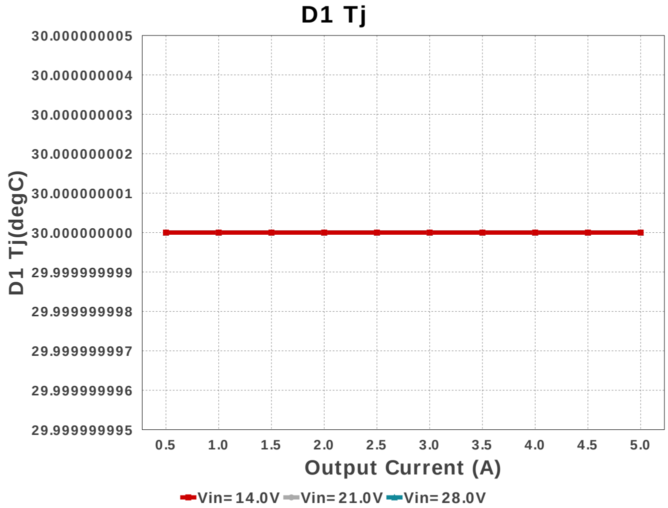
Cin IRMS

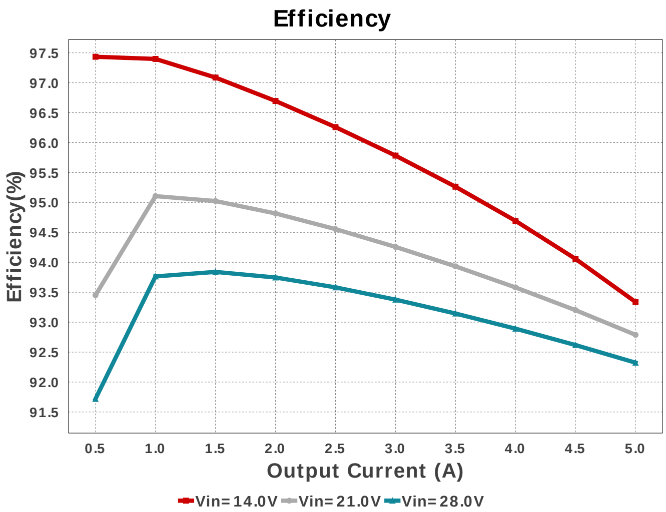


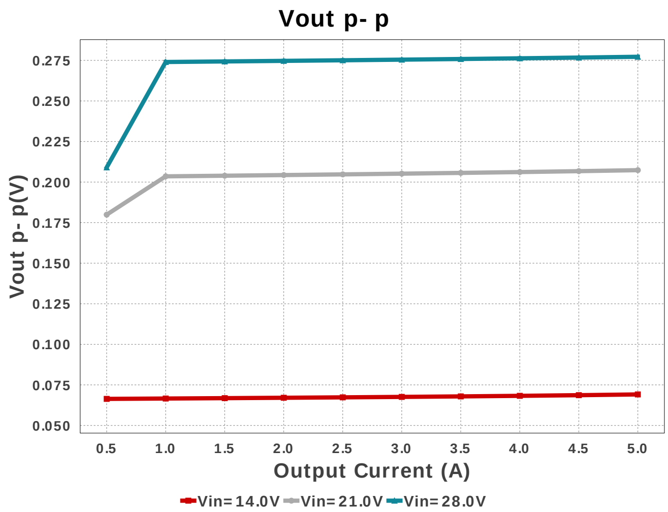
IC Ipk

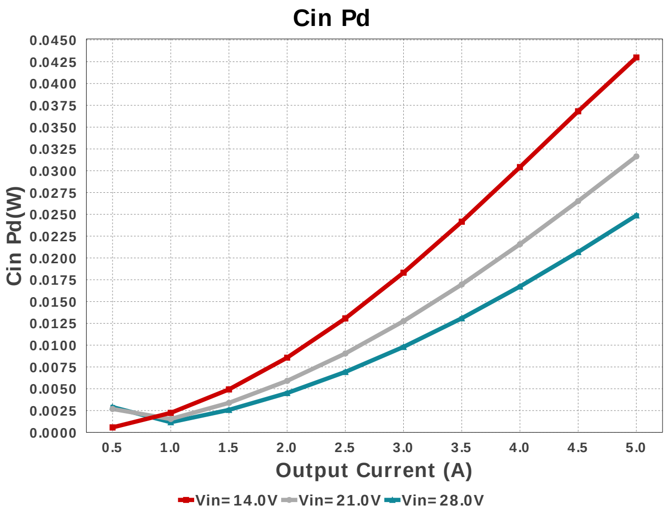


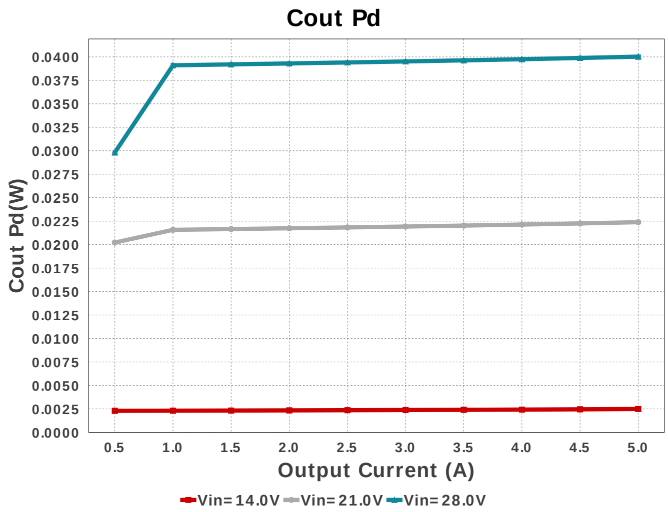

L Pd
L Pd(W)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin= 14.0V Vin= 21.0V Vin= 28.0V

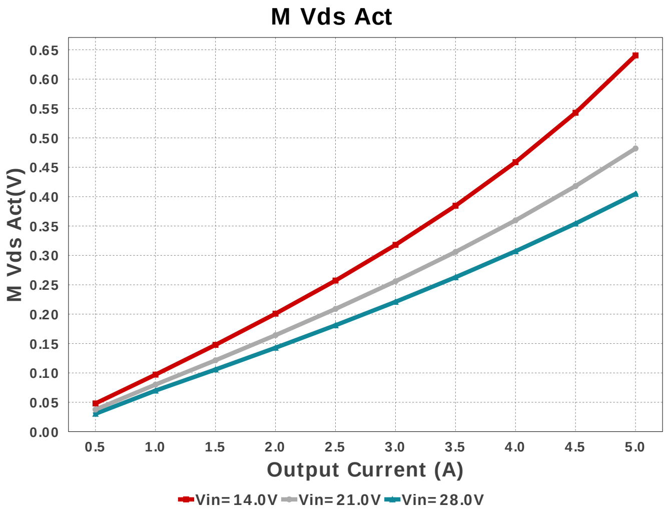

D1 Tj
D1 Tj(degC)
30.000000005
30.000000004
30.000000003
30.000000002
30.000000001
30.000000000
29.999999999
29.999999998
29.999999997
29.999999996
29.999999995
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin= 14.0V Vin= 21.0V Vin= 28.0V

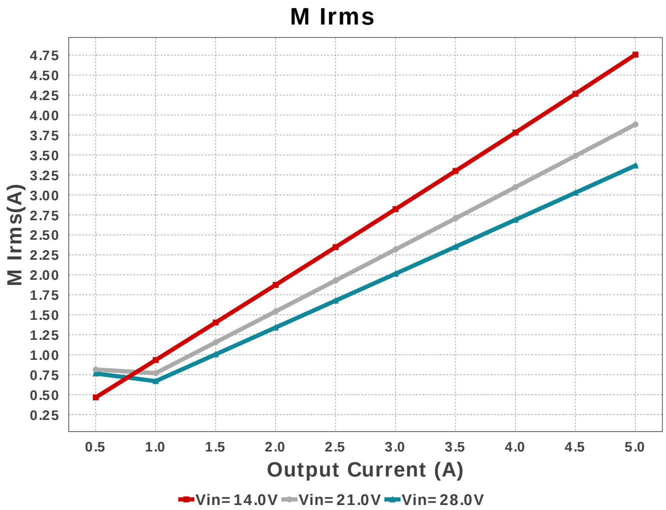

Efficiency
Efficiency(%)
97.5
97.0
96.5
96.0
95.5
95.0
94.5
94.0
93.5
93.0
92.5
92.0
91.5
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin= 14.0V Vin= 21.0V Vin= 28.0V

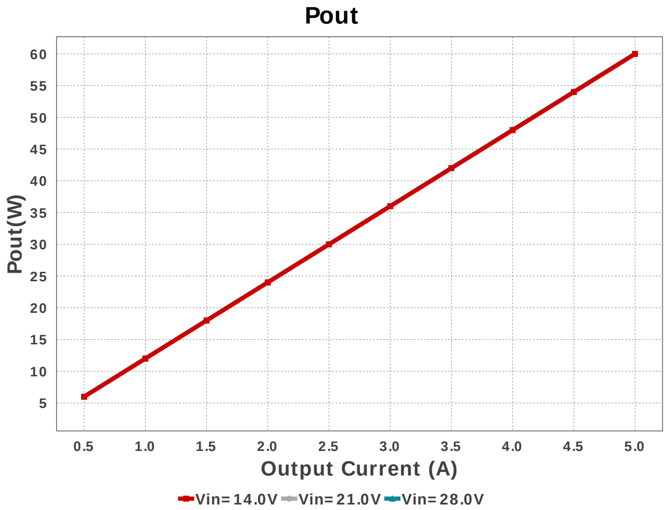

Vout p- p
Vout p- p(V)
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin= 14.0V Vin= 21.0V Vin= 28.0V

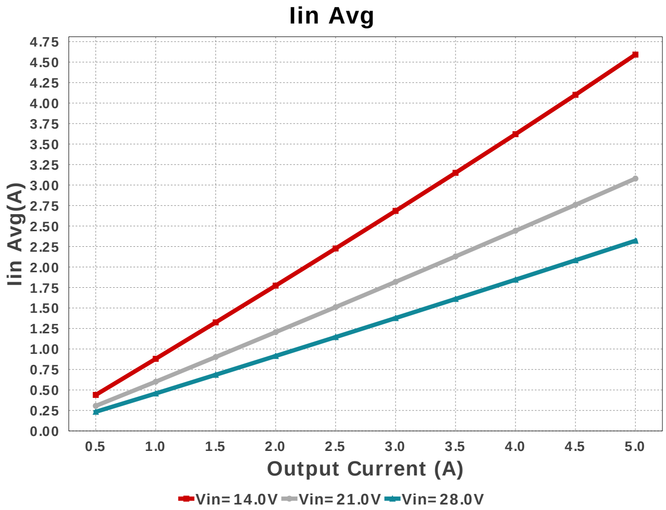

Cin Pd
Cin Pd(W)
0.0450
0.0425
0.0400
0.0375
0.0350
0.0325
0.0300
0.0275
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin= 14.0V Vin= 21.0V Vin= 28.0V

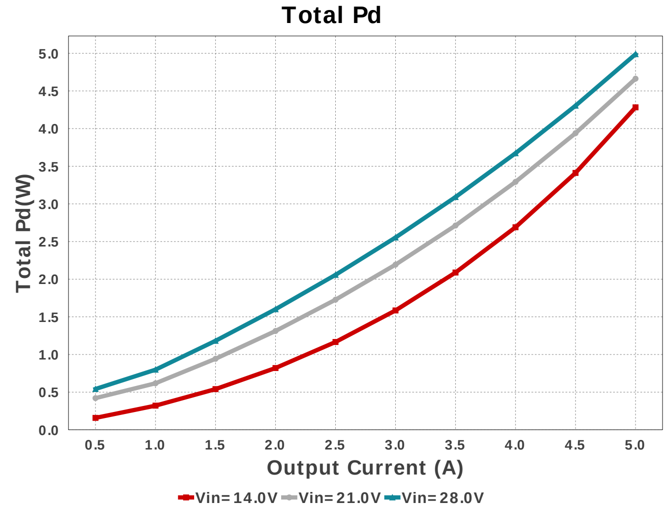

Cout Pd
Cout Pd(W)
0.0400
0.0375
0.0350
0.0325
0.0300
0.0275
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin= 14.0V Vin= 21.0V Vin= 28.0V

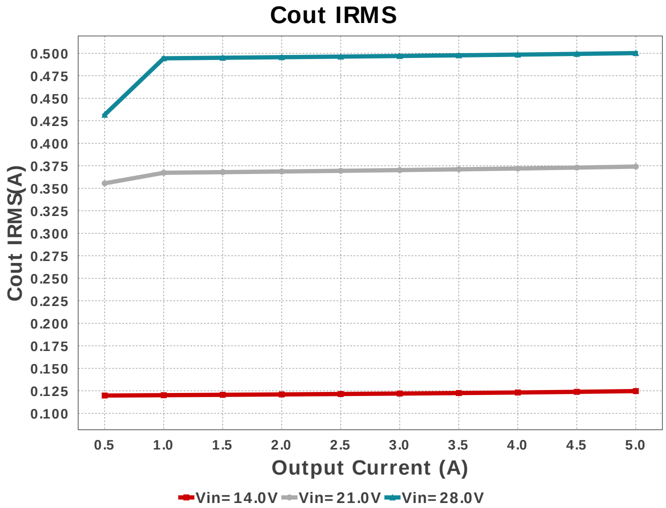

M Vds Act
M Vds Act(V)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.55
0.60
0.65
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V

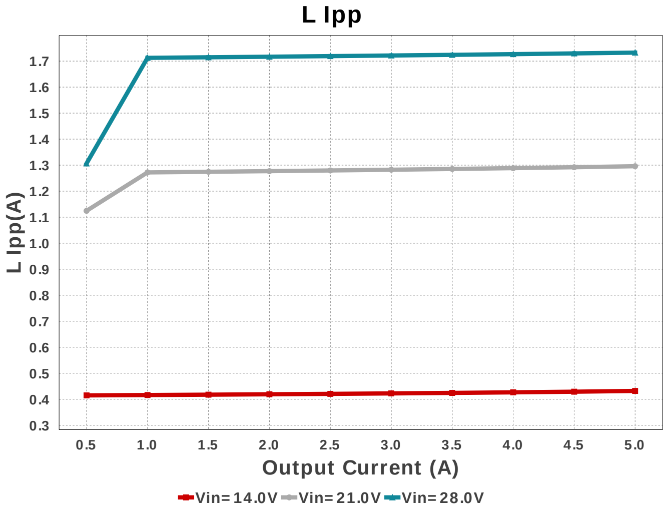

M Irms
M Irms(A)
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
3.75
4.00
4.25
4.50
4.75
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V

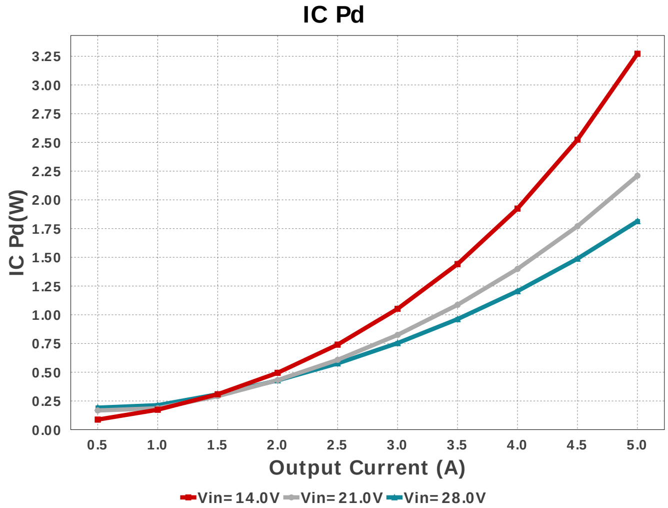

Pout
Pout(W)
5
10
15
20
25
30
35
40
45
50
55
60
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V

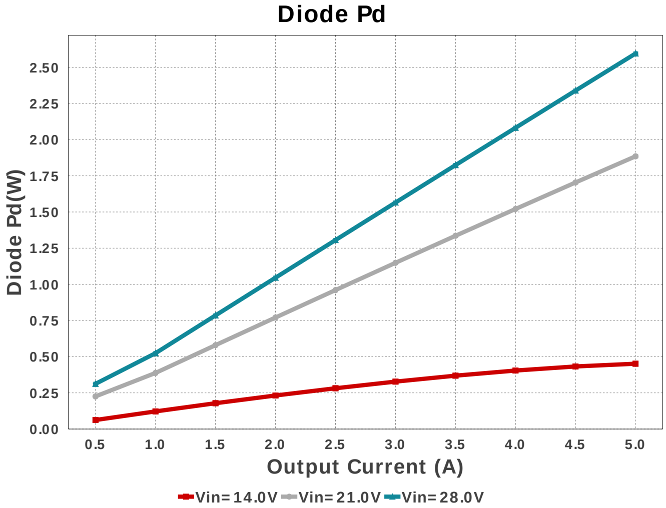

Iin Avg
Iin Avg(A)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
3.75
4.00
4.25
4.50
4.75
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V


Total Pd
Total Pd(W)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V


Cout IRMS
Cout IRMS(A)
0.100
0.125
0.150
0.175
0.200
0.225
0.250
0.275
0.300
0.325
0.350
0.375
0.400
0.425
0.450
0.475
0.500
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin=14.0V Vin=21.0V Vin=28.0V







Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	1.115 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	24.877 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	500.165 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	40.026 mW	Capacitor	Output capacitor power dissipation
5.	D1 Tj	30.0 degC	Diode	D1 junction temperature
6.	Diode Pd	2.595 W	Diode	Diode power dissipation
7.	IC Ipk	0.0 A	IC	Peak switch current in IC
8.	IC Pd	1.814 W	IC	IC power dissipation
9.	IC Tj	69.909 degC	IC	IC junction temperature
10.	IC Tolerance	19.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA	22.0 degC/W	IC	IC junction-to-ambient thermal resistance
12.	Iin Avg	2.321 A	IC	Average input current
13.	L Ipp	1.733 A	Inductor	Peak-to-peak inductor ripple current
14.	L Pd	514.25 mW	Inductor	Inductor power dissipation
15.	M Irms	3.368 A	Mosfet	MOSFET RMS ripple current
16.	M Vds Act	404.831 mV	Mosfet	Voltage drop across the MosFET
17.	Cin Pd	24.877 mW	Power	Input capacitor power dissipation
18.	Cout Pd	40.026 mW	Power	Output capacitor power dissipation
19.	Diode Pd	2.595 W	Power	Diode power dissipation
20.	IC Pd	1.814 W	Power	IC power dissipation
21.	L Pd	514.25 mW	Power	Inductor power dissipation
22.	Total Pd	4.988 W	Power	Total Power Dissipation
23.	BOM Count	10	System Information	Total Design BOM count
24.	Cross Freq	7.759 kHz	System Information	Bode plot crossover frequency
25.	Duty Cycle	45.367 %	System Information	Duty cycle
26.	Efficiency	92.324 %	System Information	Steady state efficiency
27.	FootPrint	927.0 mm^2	System Information	Total Foot Print Area of BOM components

#	Name	Value	Category	Description
28.	Frequency	126.952 kHz	System Information	Switching frequency
29.	Iout	5.0 A	System Information	Iout operating point
30.	Mode	CCM	System Information	Conduction Mode
31.	Phase Marg	64.368 deg	System Information	Bode Plot Phase Margin
32.	Pout	60.0 W	System Information	Total output power
33.	Total BOM	$6.41	System Information	Total BOM Cost
34.	Vin	28.0 V	System Information	Vin operating point
35.	Vout	12.0 V	System Information	Operational Output Voltage
36.	Vout Actual	12.143 V	System Information	Achieved Vout with feedback resistor pair
37.	Vout Tolerance	3.312 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
38.	Vout p-p	277.22 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	5.0	Maximum Output Current
VinMax	28.0	Maximum input voltage
VinMin	14.0	Minimum input voltage
Vout	12.0	Output Voltage
base_pn	LM22677	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

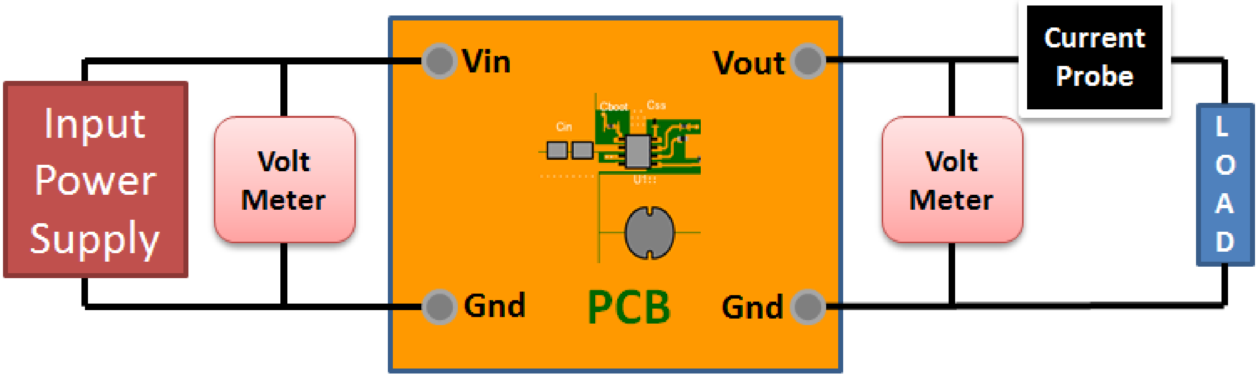
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 14.0V 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.

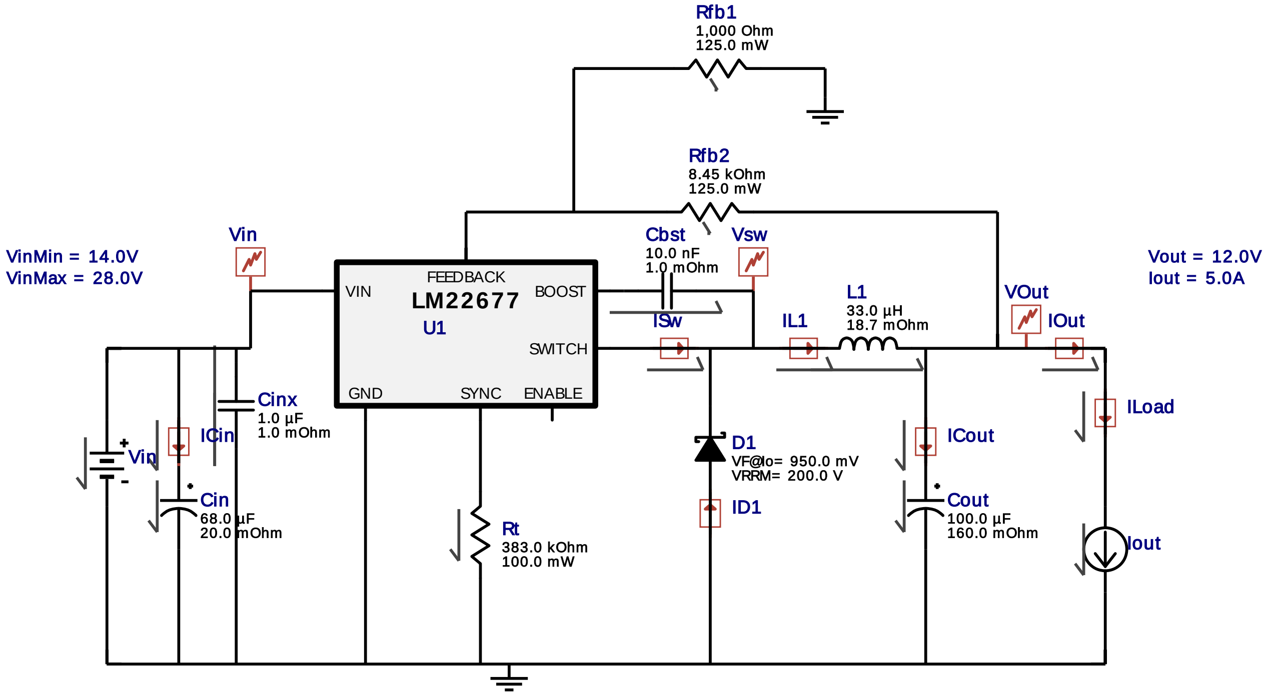


WEBENCH® Electrical Simulation Report

Design Id = 1

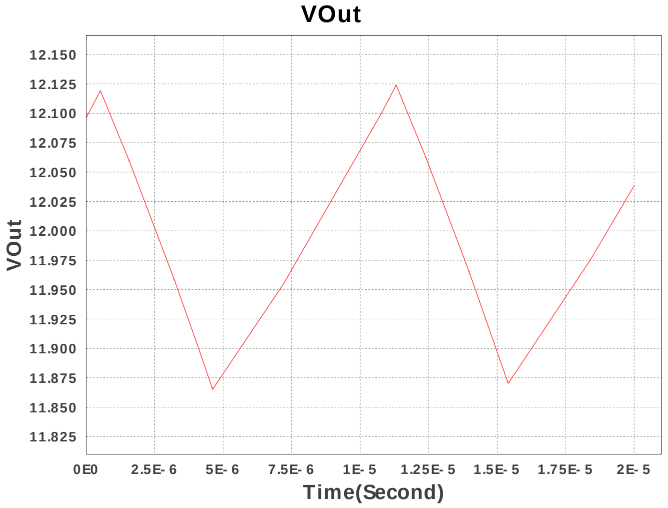
sim_id = 1

Simulation Type = Steady State



Simulation Parameters

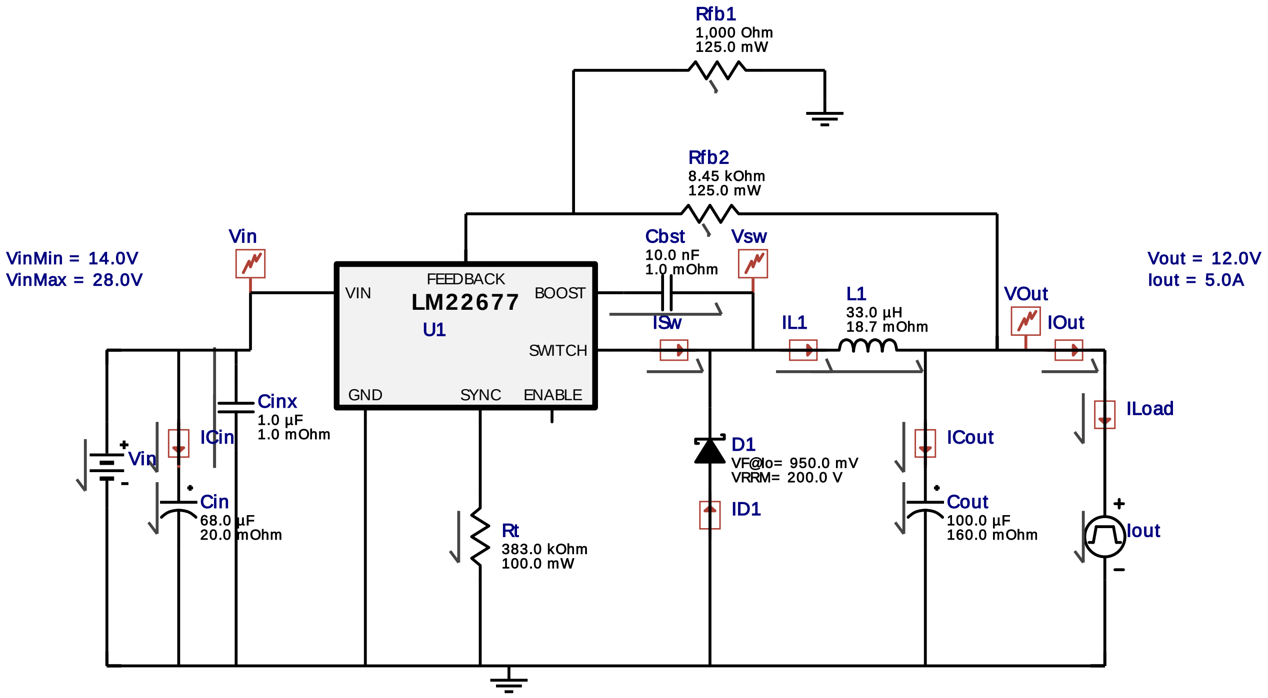
#	Name	Parameter Name	Description	Values
1.	Cout	IC	Initial Condition Across Cout	12.0 V
2.	Iout	I	Load Current	5.0 A



Design Id = 1

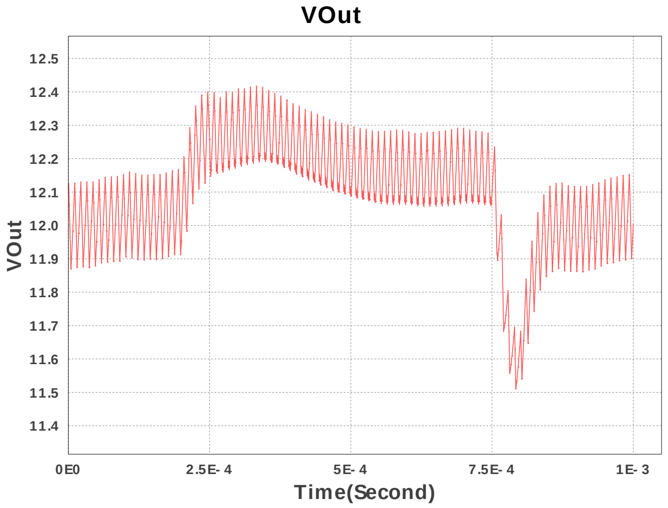
sim_id = 2

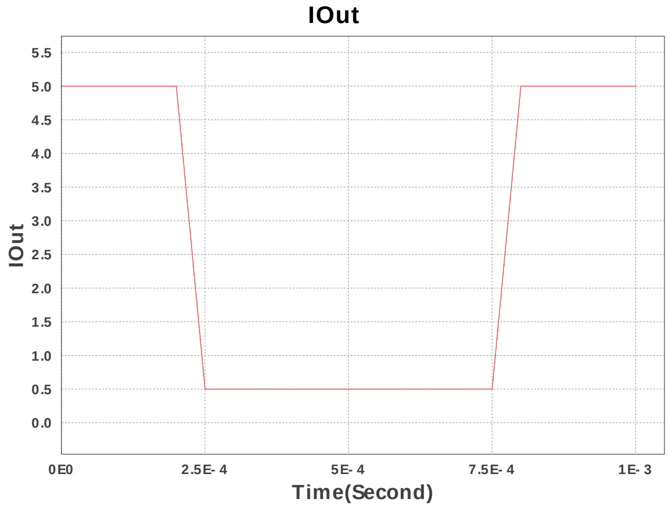
Simulation Type = Load Transient



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Cout	IC	Initial Condition Across Cout	12.0 V
2.	Iout	signal_type	Signal Type	PULSE
		I1	Initial Current	5.0 A
		I2	Peak Current	0.5 A
		Td	Initial Delay Time	200u Sec
		Tr	Rise Time	50u Sec
		Tf	Fall Time	50u Sec
		Pw	Pulse Width	500u Sec

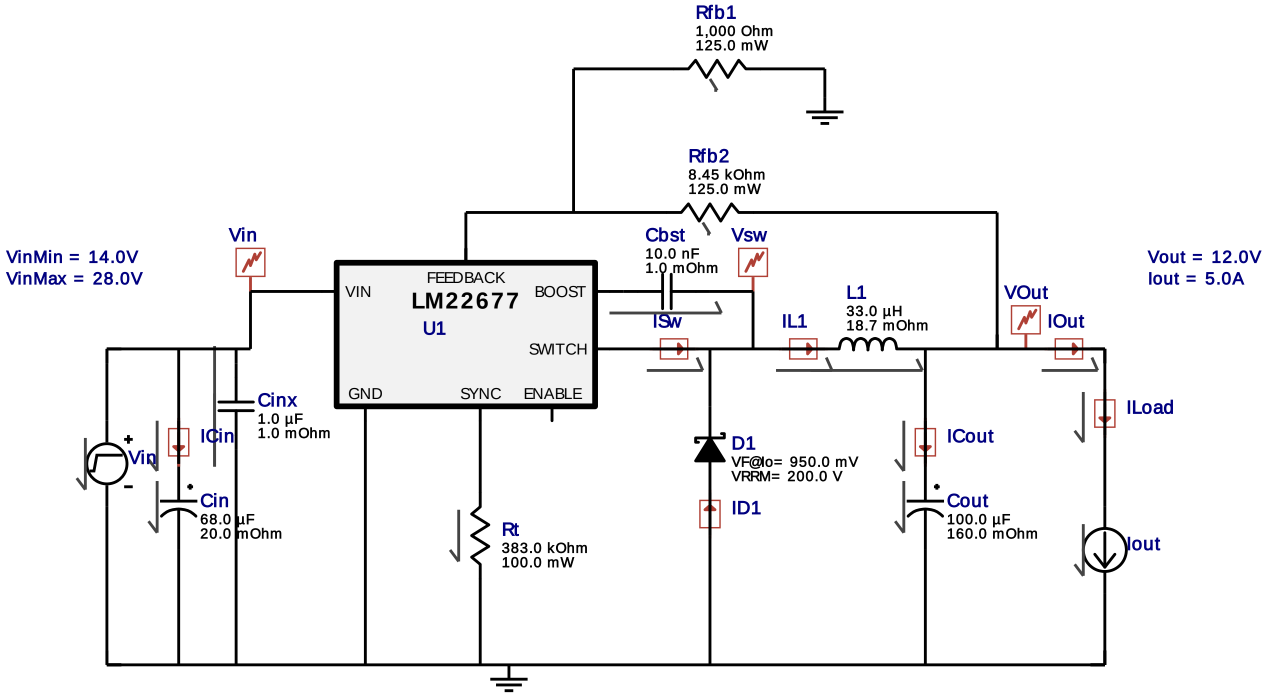




Design Id = 1

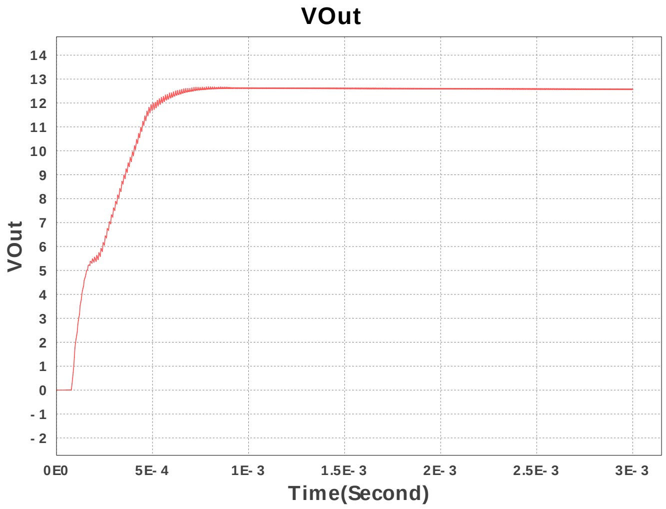
sim_id = 3

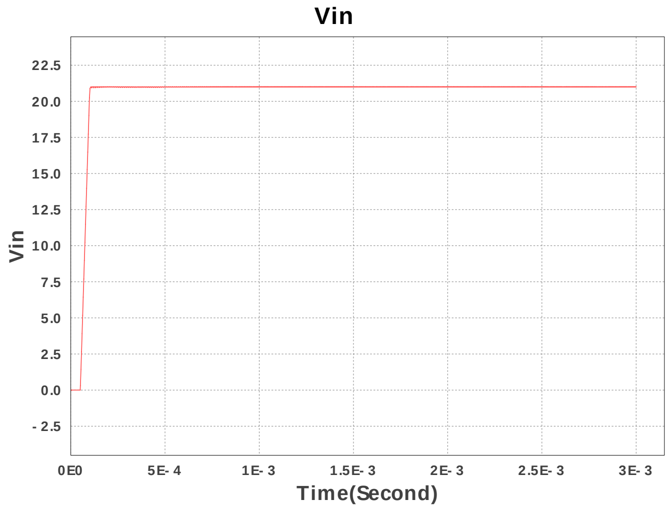
Simulation Type = Startup



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Cout	IC	Initial Condition Across Cout	0 V





Design Assistance

1. Why WEBENCH recomends the 5.0 option for your 12.0V output: The internal compensation for the ADJ version of the LM22677 is optimized for output voltages below 5V. Therefore it is recommended that for outputs greater than 5V, the 5.0 option be used with an additional external resitive feedback divider. Part Description The LM22677 is a monolithic integrated circuit that provides all of the active functions for a step-down (buck) switching regulator capable of driving up to 5.0A loads with excellent line and load regulation characteristics. High efficiency (>90%) is obtained through the use of a low ON-resistance N-channel MOSFET.

2. Master key : F665DCF9D2842CC4[v1]

3. **LM22677** Product Folder : http://www.ti.com/product/LM22677 : contains the data sheet and other resources.

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