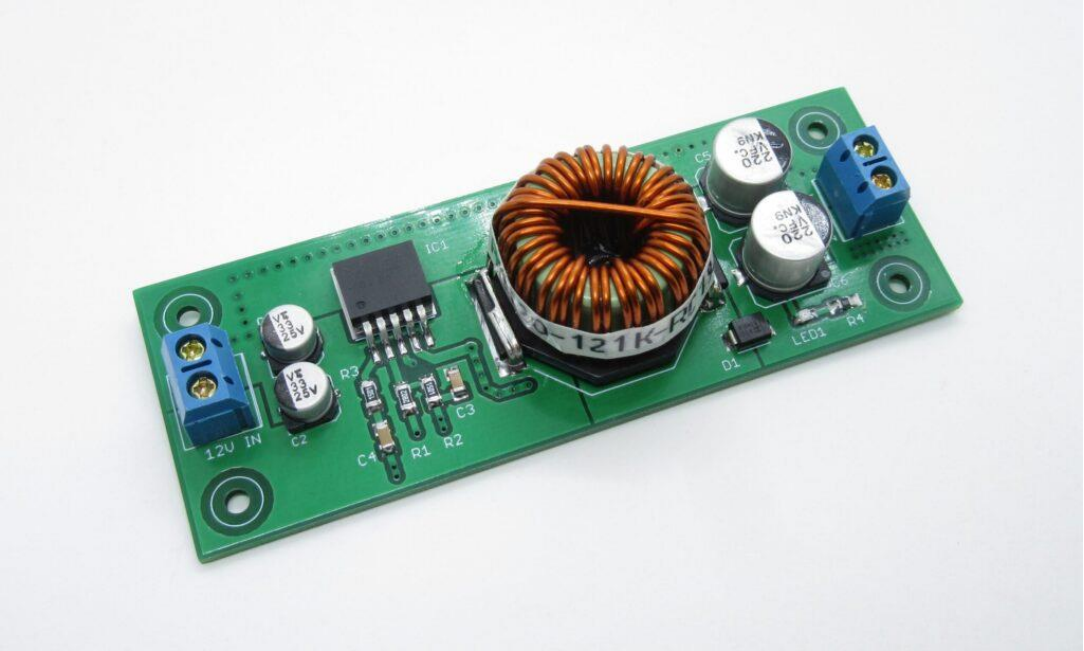
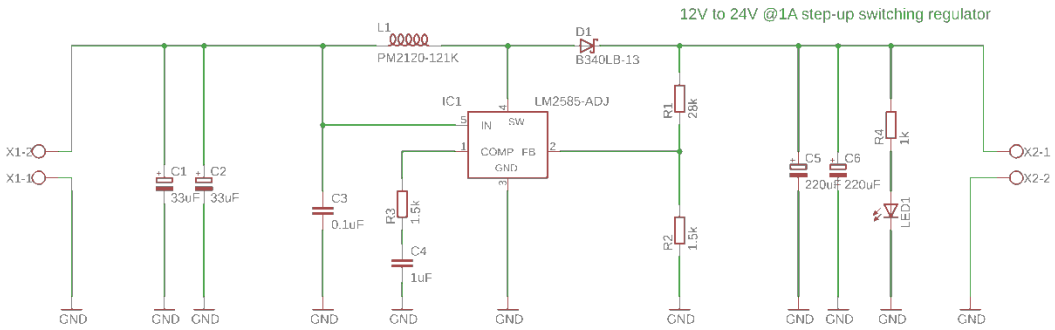
12V TO 24V @ 1A STEP-UP SWITCHING REGULATOR USING LM2585

- Tested

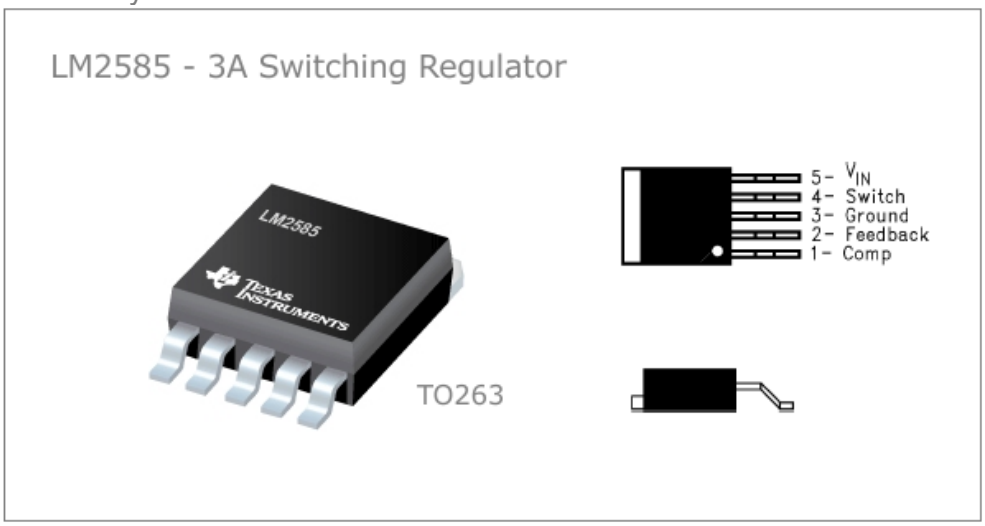


SCHEMATIC



DESCRIPTION

This is a DC-DC step-up converter based on **LM2585-ADJ** regulator manufactured by Texas Instruments. This IC was chosen for its simplicity of use, requiring minimal external components and for its ability to control the output voltage by defining the feedback resistors (R1,R2). NPN switching/power transistor is integrated inside the regulator and is able to withstand 3A maximum current and 65V maximum voltage. Switching frequency is defined by internal oscillator and it's fixed at 100KHz.



The power switch is a 3-A NPN device that can standoff 65 V. Protecting the power switch are current and thermal limiting circuits and an under-voltage lockout circuit. This IC contains a 100-kHz fixed-frequency internal oscillator that permits the use of small magnetics. Other features include soft start mode to reduce in-rush current during start-up, current mode control for improved rejection of input voltage, and output load transients and cycle-by-cycle current limiting. An output voltage tolerance of ±4%, within specified input voltages and output load conditions, is specified for the power supply system.

SPECIFICATIONS

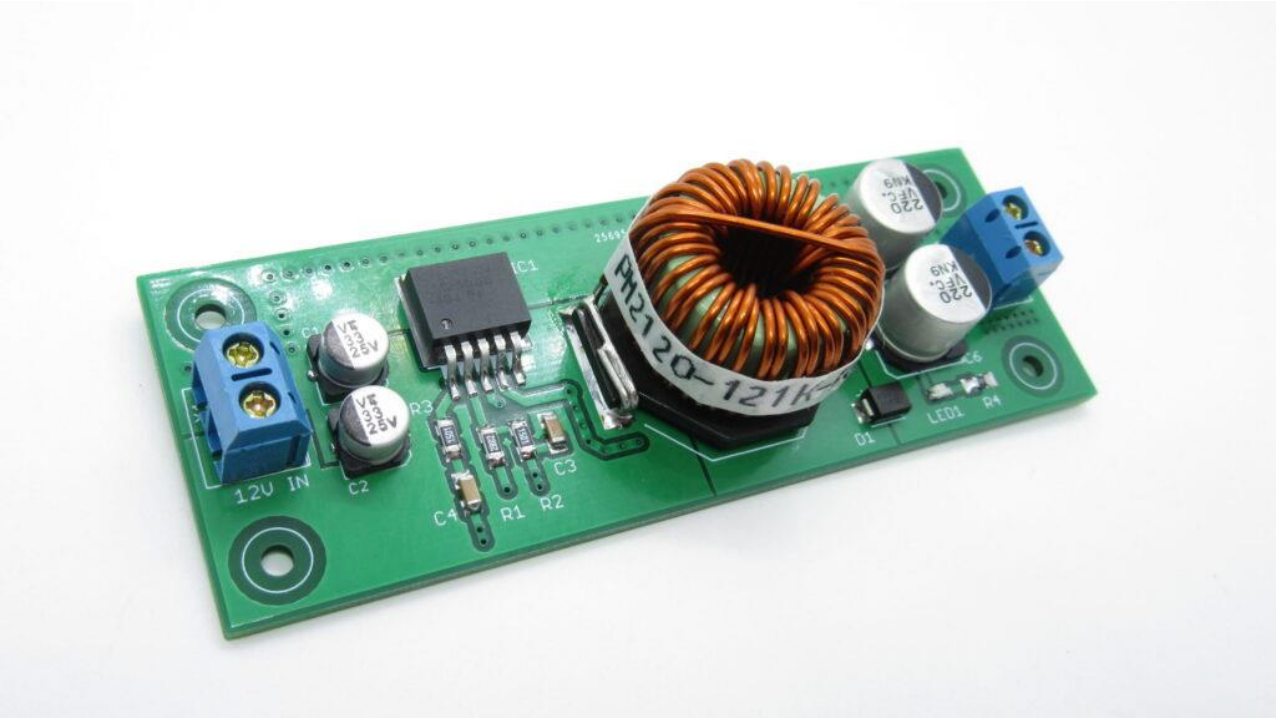
V_{in}: 10-15V DC V_{out}: 24V DC I_{out}: 1A Frequency: 100KHz

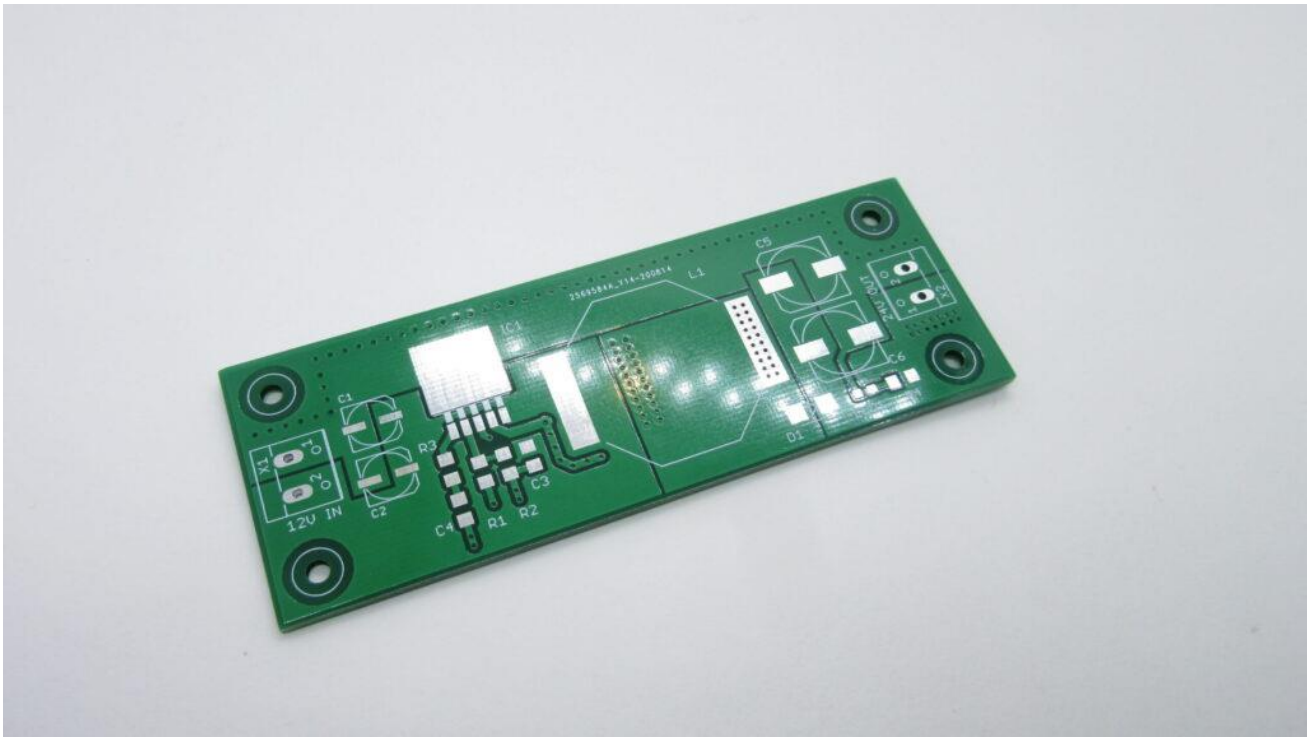
Schematic is a simple boost topology arrangement based on datasheet. Input capacitors and diode should be placed close enough to the regulator to minimize the inductance effects of PCB traces. IC1, L1, D1, C1,C2 and C5,C6 are the main parts used in voltage conversion. Capacitor C3 is a high-frequency bypass capacitor and should be placed as close to IC1 as possible.

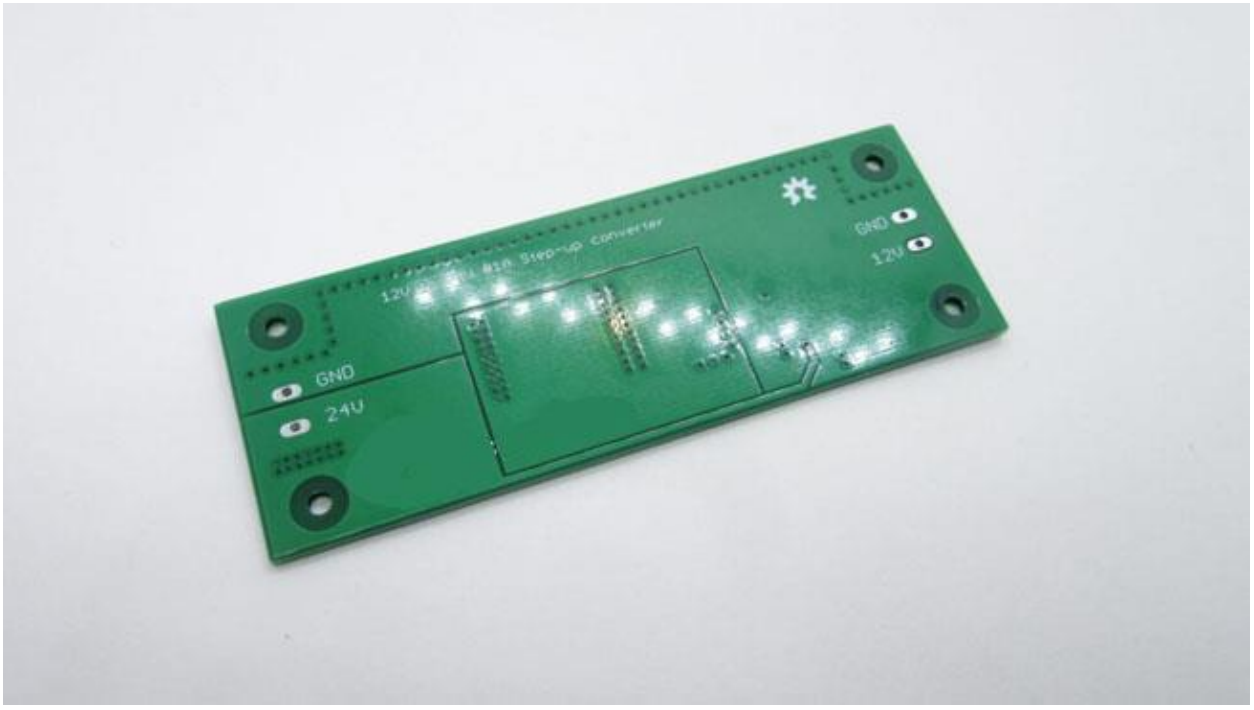
All components are selected for their low loss characteristics. So capacitors selected have low ESR and inductor selected has low DC resistance.

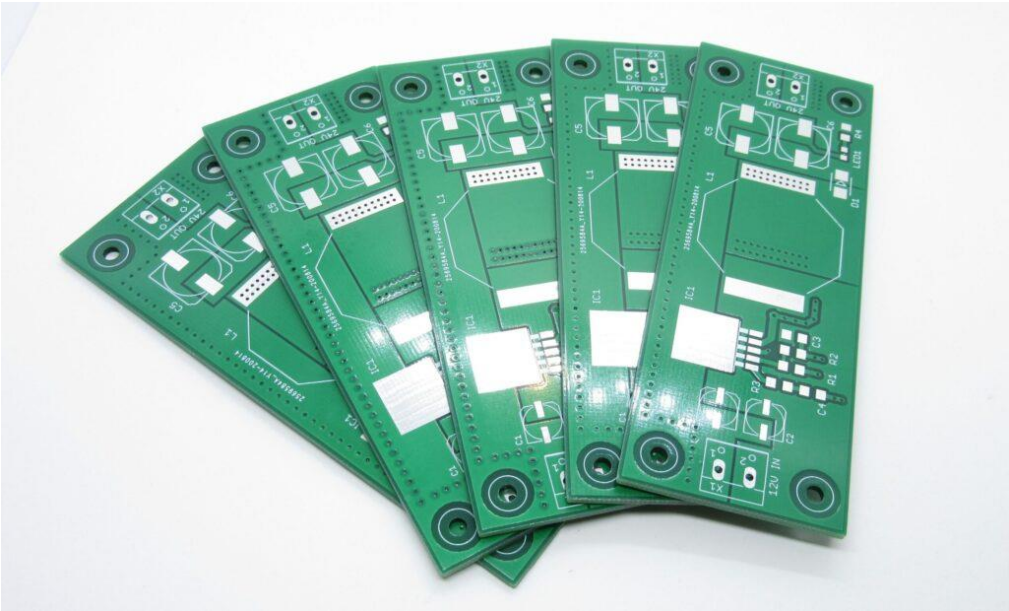
At maximum output power, there is significant heat produced by IC1 and for that reason, we mounted it directly on the ground plane to achieve maximum heat dissipation.

PHOTOS




IC1
L1
C5
C6
D1
C1
C2
C3
C4
R1
R2
R3
12V IN
GND
24V

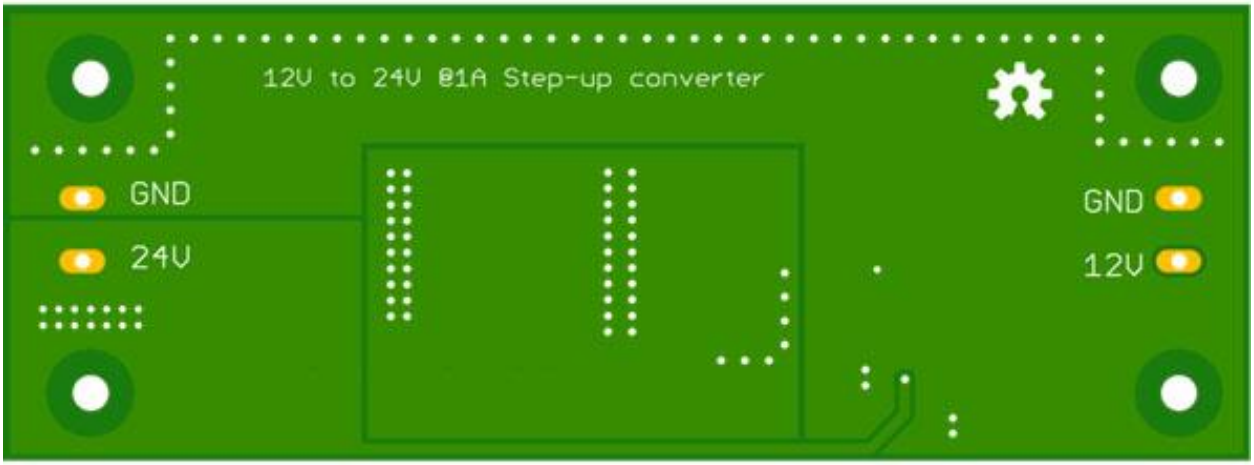

GND
12V
GND
24V

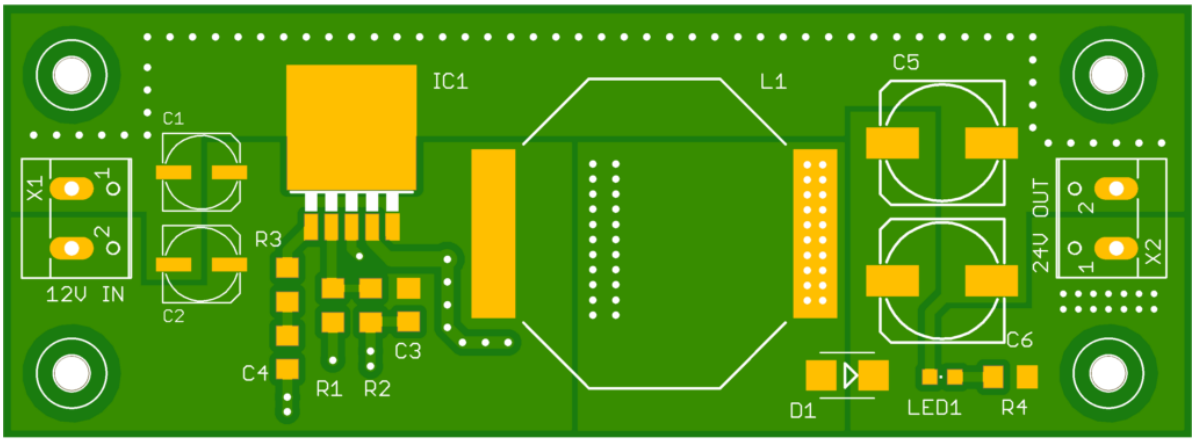


PARTS LIST

Part	Value	Package	MPN	Mouser No
C1 C2	33uF 25V 1Ω	6.3 x 5.4mm	UWX1E330MCL1GB	647-UWX1E330MCL1
C3	0.1uF 50V 0Ω	1206	C1206C104J5RACTU	80-C1206C104J5R
C4	1uF 25V	1206	C1206C105K3RACTU	80-C1206C105K3R
C5 C6	220uF 35V 0.15Ω	10 x 10.2mm	EEE-FC1V221P	667-EEE-FC1V221P
D1	0.45 V 3A 40V Schottky	SMB	B340LB-13-F	621-B340LB-F
IC1	LM2585S-ADJ	TO-263	LM2585S-ADJ/NOPB	926-LM2585S-ADJ/NOPB
L1	120 uH 0.04Ω	30.5 x 25.4 x 22.1 mm	PM2120-121K-RC	542-PM2120-121K-RC
R1	28 KΩ	1206	ERJ-8ENF2802V	667-ERJ-8ENF2802V
R2 R3	1.5 KΩ	1206	ERJ-8ENF1501V	667-ERJ-8ENF1501V
R4	1 KΩ	1206	RT1206FRE07931KL	603-RT1206FRE07931KL
LED1	RED LED 20mA 2.1V	0805	599-0120-007F	645-599-0120-007F

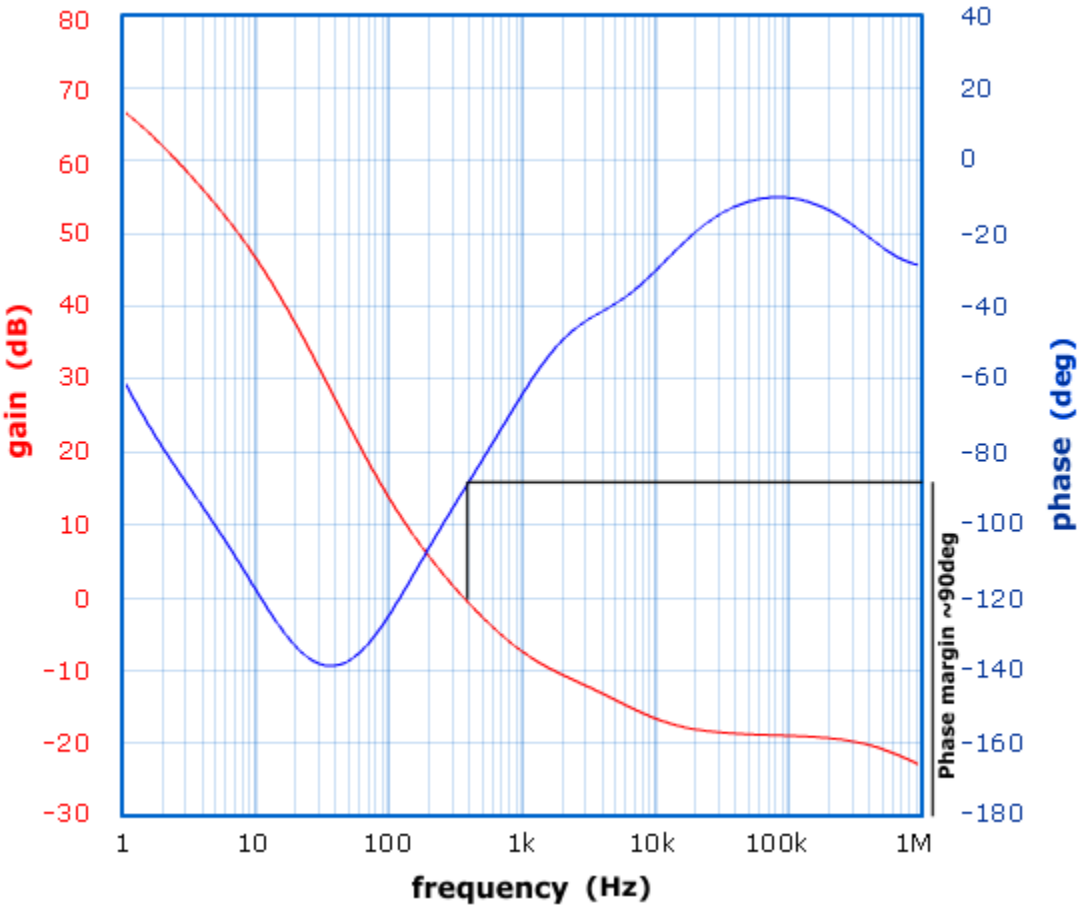
GERBER VIEW





SIMULATION

We've done a simulation of the LM2585 step-up DC-DC converter using the TI's WEBENCH online software tools and some of the results are presented here.
The first graph is the open-loop BODE graph. In this graph, we see a plot of GAIN vs FREQUENCY in the range 1Hz – 1M and PHASE vs FREQUENCY in the same range. This plot is useful as it gives us a detailed view of the stability of the loop and thus the stability and performance of our DC-DC converter.

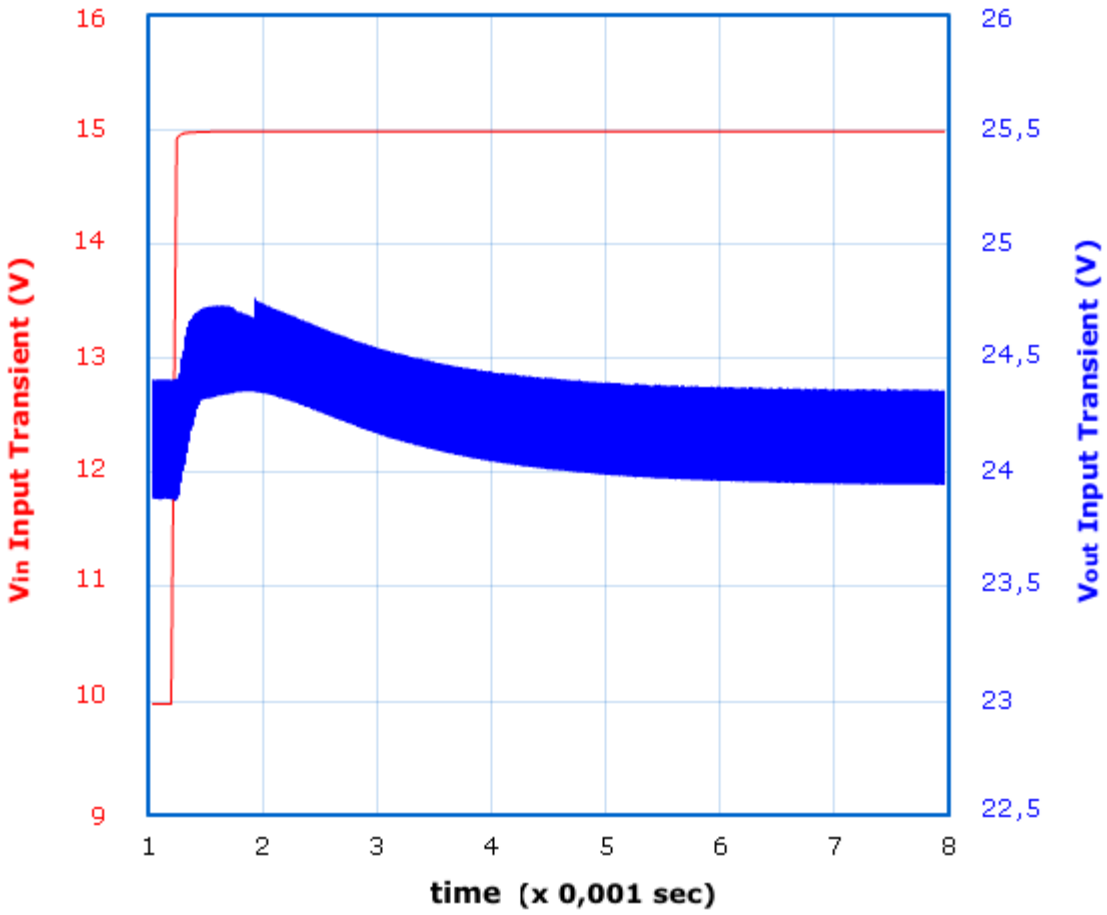


Bode plot of open control loop

What's interesting on this plot is the "**phase margin**" and "**gain margin**". The gain margin is the gain for **-180deg phase shift** and phase margin is the phase difference from 180deg for **0db gain** as shown in the plot above. For the system to be considered stable there should be enough phase margin (>30deg) for 0db gain or when phase is -180deg the gain should be less than 0db.

On the plot above we see that the phase margin is ~90deg and that ensures that the DC-DC converter will be stable over the measured range.

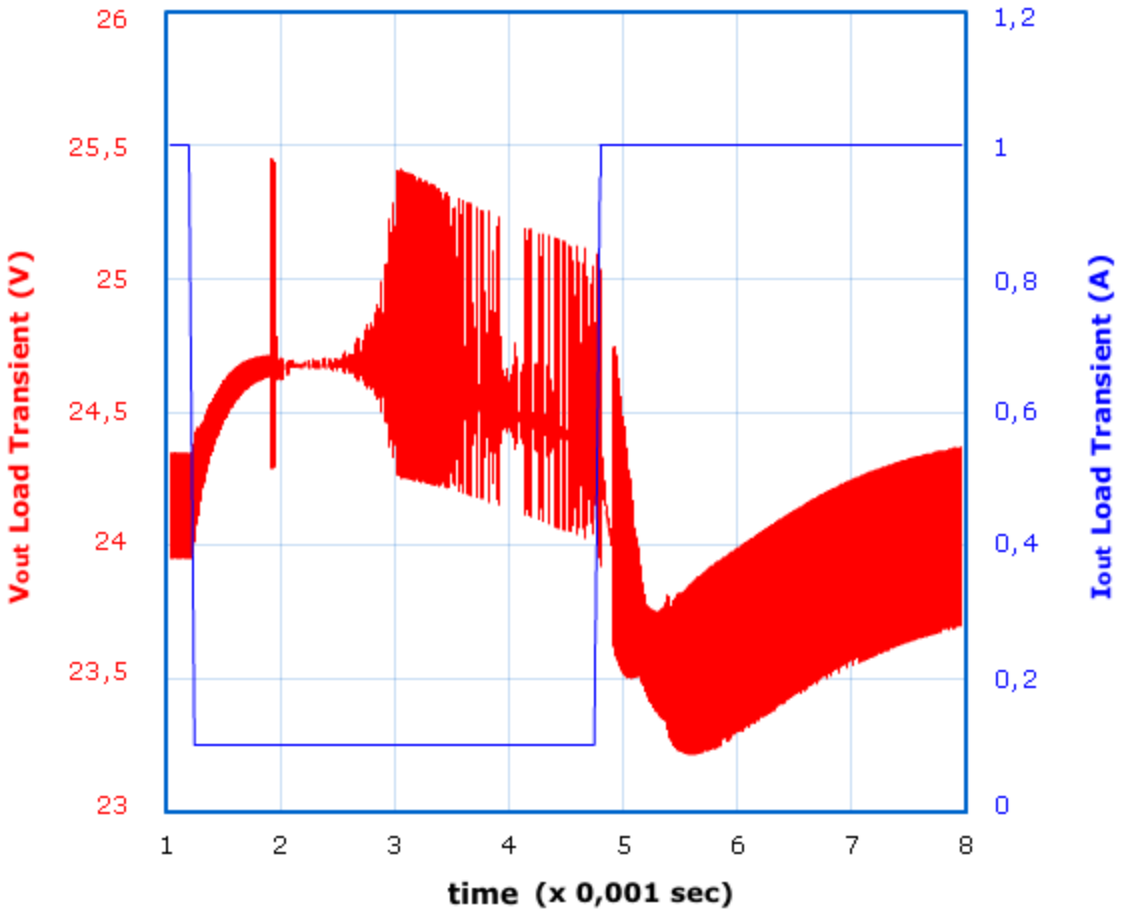
The next simulation graph is the **Input Transient** plot over time.



Input Transient simulation

In this plot, we see how the output voltage is recovering when the input voltage is stepped from 10V to 15V. We see that 4ms after the input voltage is stepped the output has recovered to the normal output voltage of 24V.

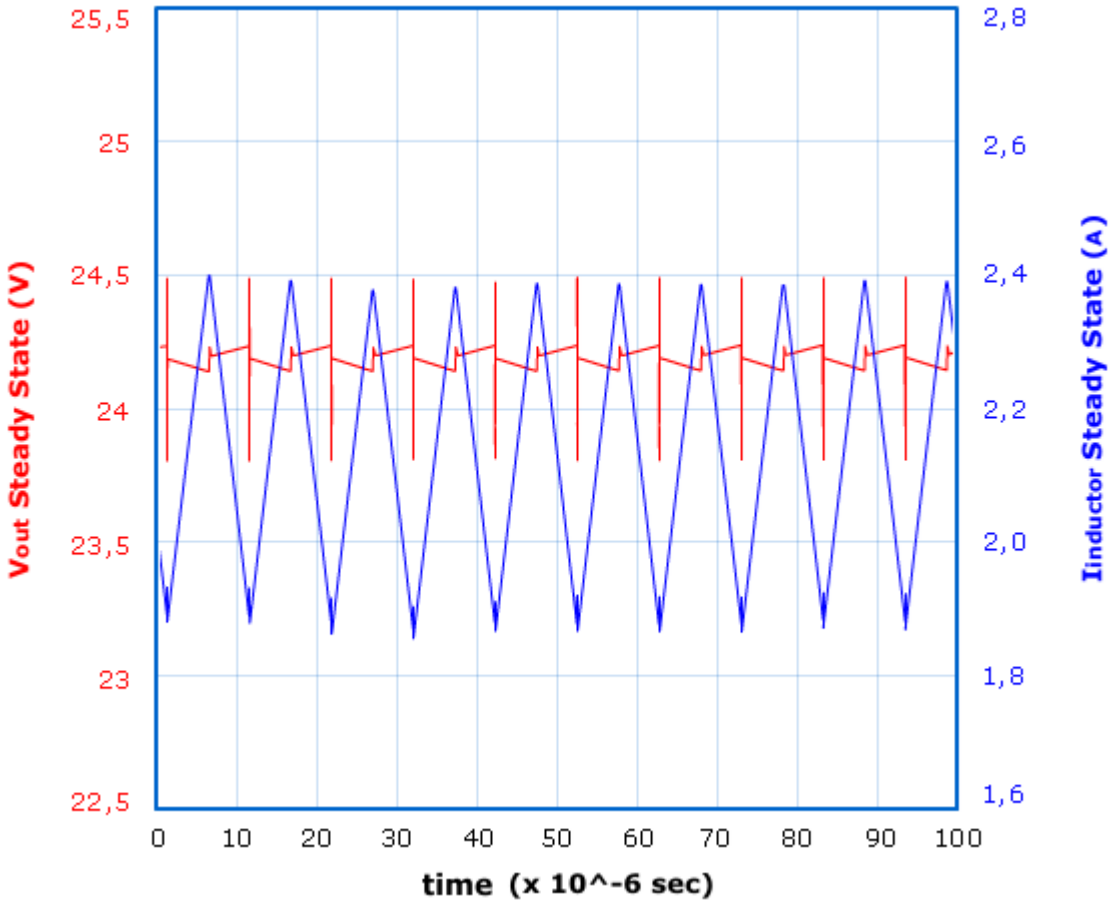
The next graph is the Load Transient.



Load Transient simulation

Load transient is the response of output voltage to sudden changes of load or I_{out}. We see that the output current suddenly changes from 0,1A to 1A and that the output voltage drops down to 23,2V until it recovers in about 3ms. We also see that when the load is reduced from 1A to 0,1A, output voltage spikes up to ~25,5V, then rings until it recovers to 24V in about 4ms.

The last graph shows the Steady State operation of DC-DC converter @ 1A output.



This graph shows the simulated output voltage ripple and inductor current. We see that output voltage ripple is ~0,6Vpp and the inductor current has a peak current of 2,4A. The inductor we used is rated at max 5,6A DC so it can easily withstand such operating current and without much heating of the coil.

Operating point data (Vin=13V, Iout=1A)

Operating Values

Pulse Width Modulation (PWM) frequency	Frequency	100 kHz
Continuous or Discontinuous Conduction mode	Mode	Cont
Total Output Power	Pout	24.0 W
Vin operating point	Vin Op	13.00 V
Iout operating point	Iout Op	1.00 A

Operating Point at Vin= 13.00 V,1.00 A

Bode Plot Crossover Frequency, indication of bandwidth of supply	Cross Freq	819 Hz
Steady State PWM Duty Cycle, range limits from 0 to 100	Duty Cycle	48.3 %
Steady State Efficiency	Efficiency	93.2 %

IC Junction Temperature	IC Tj	65.2 °C
IC Junction to Ambient Thermal Resistance	IC ThetaJA	34.9 °C/W
Current Analysis		
Input Capacitor RMS ripple current	Cin IRMS	0.14 A
Output Capacitor RMS ripple current	Cout IRMS	0.48 A
Peak Current in IC for Steady State Operating Point	IC Ipk	2.2 A
ICs Maximum rated peak current	IC Ipk Max	3.0 A
Average input current	Iin Avg	2.0 A
Inductor ripple current, peak-to-peak value	L Ipp	0.50 A
Power Dissipation Analysis		
Input Capacitor Power Dissipation	Cin Pd	0.01 W
Output Capacitor Power Dissipation	Cout Pd	0.035 W
Diode Power Dissipation	Diode Pd	0.45 W
IC Power Dissipation	IC Pd	1.0 W
Inductor Power Dissipation	L Pd	0.16 W

CONFIGURING OUTPUT VOLTAGE

The output voltage is configured by R1, R2 according to the following expression

(Vref=1,23V)

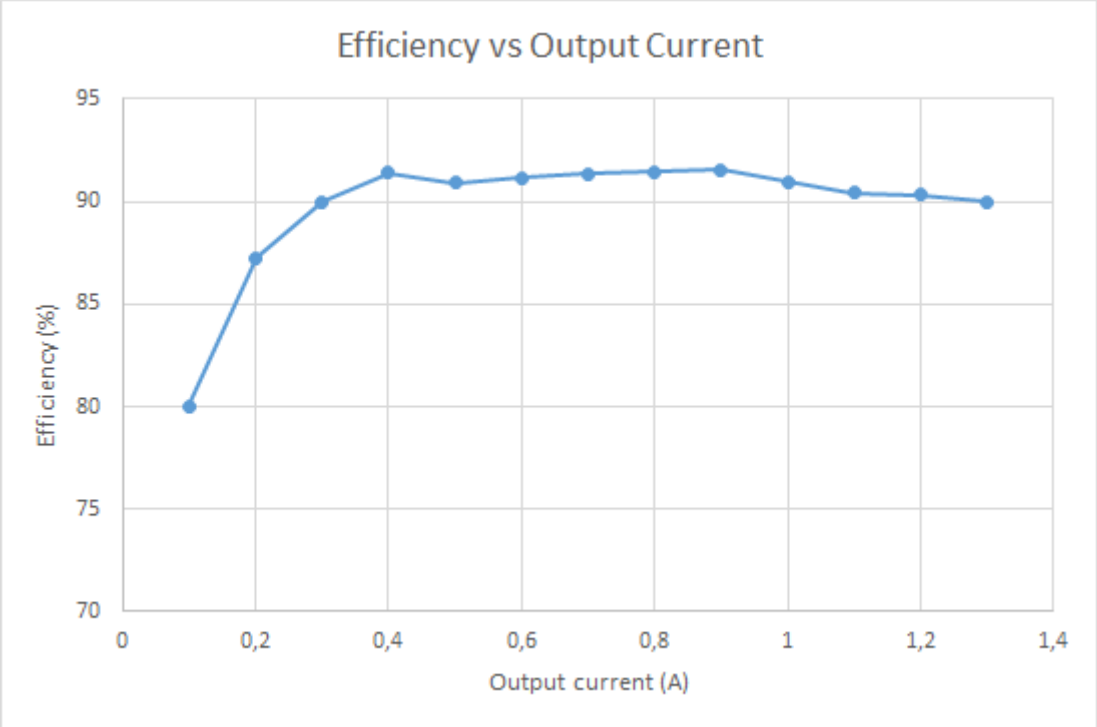
$$V_{OUT} = V_{REF} (1 + R1/R2)$$

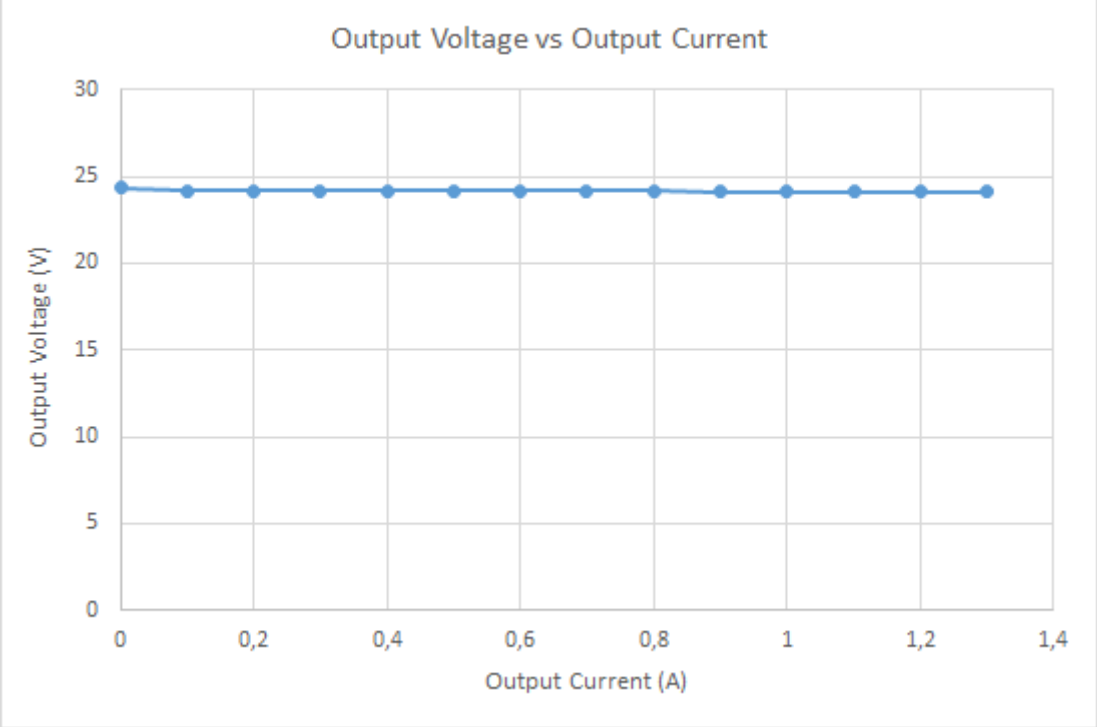
If R2 has a value between 1k and 5k we can use this expression to calculate R1:

$$R1 = R2 (V_{OUT}/V_{REF} - 1)$$

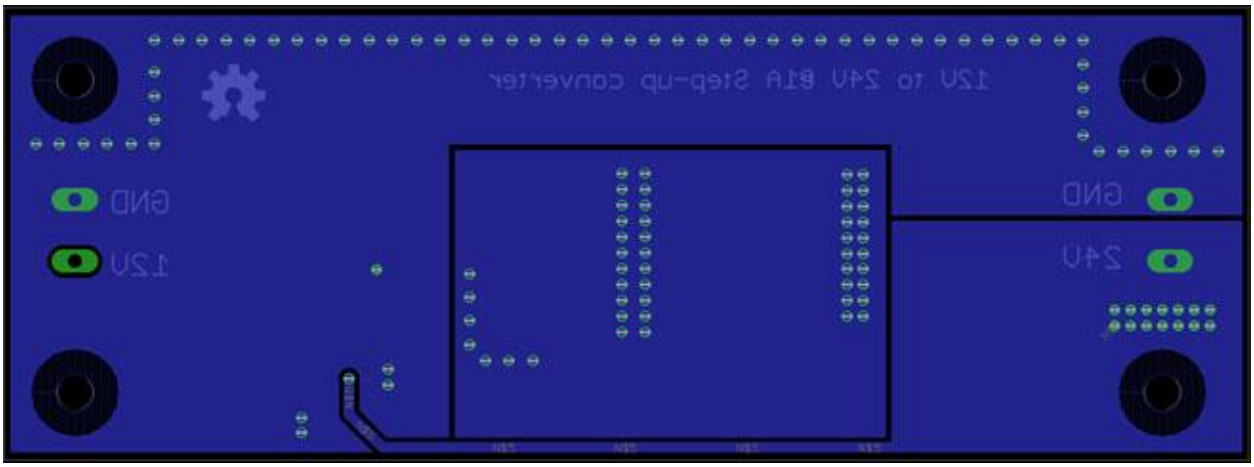
For better thermal response and stability it is suggested to use 1% metal film resistors.

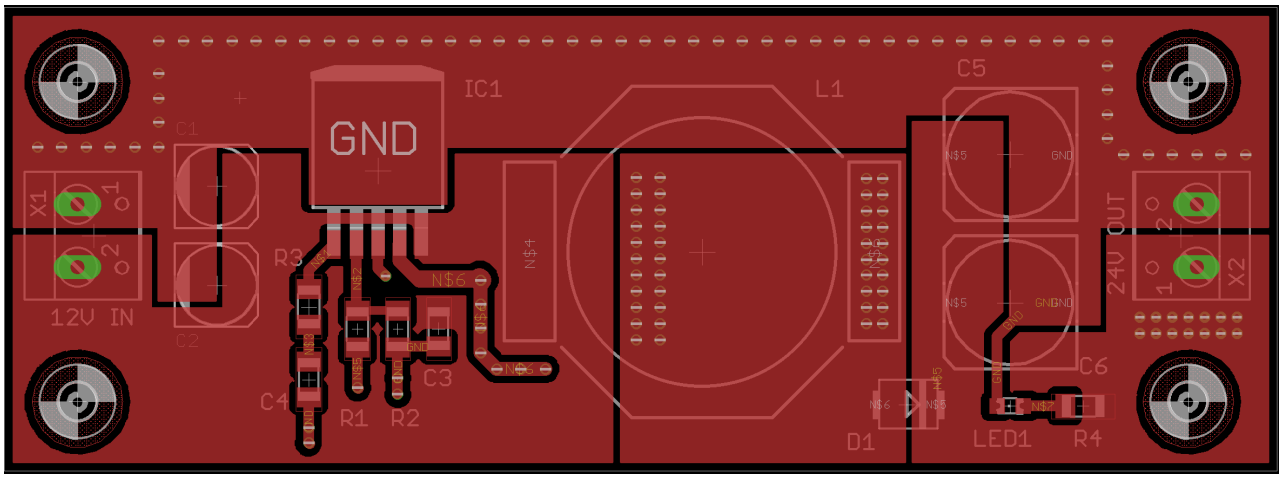
MEASUREMENTS





PCB


GND
12V
GND
24V


GND
IC1
L1
C5
C1
C2
C3
C4
C6
R1
R2
R3
R4
D1
LED1
X1
X2
12V IN
24V OUT
N$4
N$5
N$6
N$7