El Dictator

Design By Erik Vincent

For those who need a small form factor power supply for their pedal boards. Take a noisy wall supply that outputs 12V to 25V and clean it up for your pedals!

This simple power supply solution also features a voltage sag control so you can simulate the effect of a dying battery. This works well for fuzz pedals.

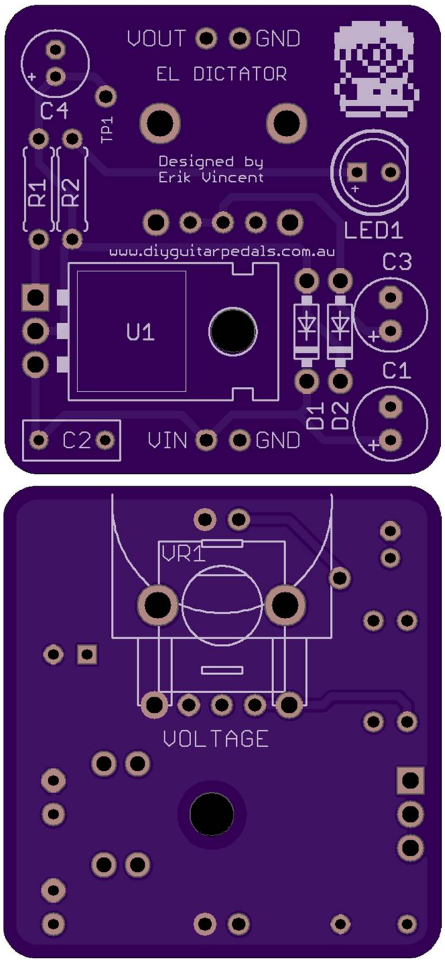
Build yours today! As soon as possible. El Dictator demands it.

This project is small enough to fit in a 1590A enclosure.

Bill of Materials, El Dictator

Capacitor		Resistor	
C1	47µF (Electrolytic)	**R1**	160 *
C2	100nF (film)	**R2**	1K
C3	10µF (Electrolytic)		
C4	1µF (Electrolytic)		
Diode		**LED**	
D1	1N4001	**LED1**	Any T1-3/4 LED
D2	1N4001		
ICs		**Potentiometer**	
U1	LM317 (TO-220)	**Voltage**	1kb (16mm or 9mm) *

*** These values can be changed for different desired voltage outputs**



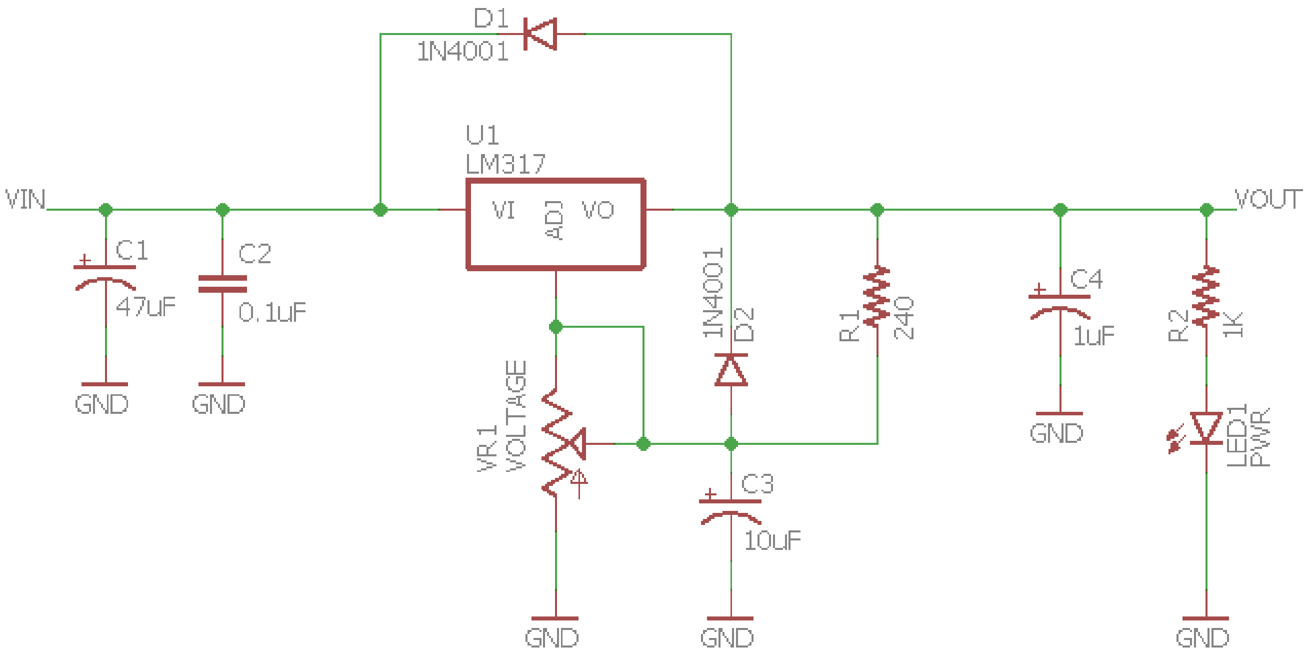
PCB Spacing
The El Dictator PCB is spaced for 1590A sized enclosures or larger

Pot Spacing
The El Dictator PCB mounted potentiometers are spaced for Alpha 16mm or 9mm potentiometers.

El Dictator Circuit Analysis for modifying purposes.

1. Adjustable Linear Regulator Circuit

The El Dictator is a pedal friendly example of an LM317 adjustable linear regulator circuit.



The C1 Capacitor is used as a bulk capacitor to smooth out low frequency ripple coming from the input DC wall power. C2 is a faster film capacitor used to clean up higher frequency noise coming from the input DC wall power. C3 improves the ripple rejection of the regulator by referring the regulator AC reference to GND rather than Vout. A typical value is 10 µF which will improve the ripple rejection by 10 dB to 20 db depending on the output voltage and current.
In addition to increased ripple rejection, C3 can reduce the regulator's output noise. Increasing C2 beyond 10 µF does very little for ripple rejection or output noise, but can be used to reduce the regulators low-frequency output impedance. C4 is a decoupling output capacitor to further reject noise. It is advised that when selecting a capacitor for C4 (2.5mm leads), to select one with the least equivalent series resistance, or ESR, as possible.

D1 is used to stop any possibility that Vout can go above Vin, such as a reverse polarity situation. D2 is to prevent C3 from discharging through the regulator's ADJ pin.

LED1 is an output power indicator LED. Any T1-3/4 5mm LED can be used here.

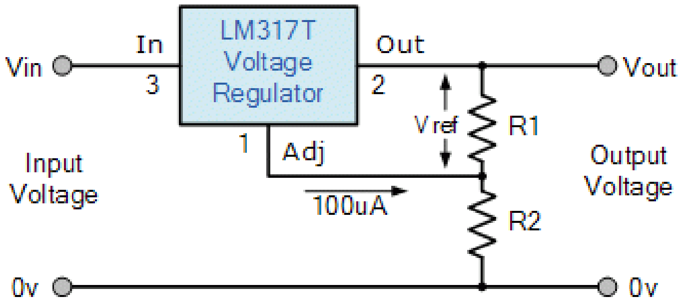
R1 and VR1 (5K) are used as a voltage reference for the LM317 to determine its output voltage. R2 is the current limiting resistor LED1.

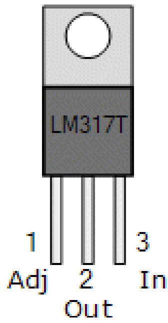
U1 is the LM317T, a fully adjustable 3-terminal positive voltage regulator capable of supplying 1.5 amps with an output voltage ranging from around 1.25 volts to just over 30 volts. By using the ratio of two resistances, one of a fixed value and the other variable (or both fixed), we can set the output voltage to the desired level with a corresponding input voltage being anywhere between 3 and 40 volts. However, it is to note that the LM317 has a voltage drop of 3V, so make sure the input voltage is at least 3 volts higher than the desired output voltage.

The LM317T variable voltage regulator also has built in current limiting and thermal shut down capabilities which makes it short-circuit proof and ideal for any low voltage or home-made bench power supply.

2. How to Adjust the Output Voltage

The output voltage of the LM317T is determined by ratio of the two feedback resistors R1 and R2 which form a potential divider network across the output terminal as shown below.





In our case, R2 is a variable resistor, our 5K potentiometer VR1. The voltage across the feedback resistor R1 is a constant 1.25V reference voltage, Vref produced between the “output” and “adjustment” terminal. The adjustment terminal current is a constant current of 100uA. Since the reference voltage across resistor R1 is constant, a constant current will flow through the other resistor R2 (our VR1), resulting in an output voltage of:

$$V_{OUT} = 1.25\left(1+\frac{R_2}{R_1}\right)$$

However, let’s assume we know what we want our output voltage to be with the potentiometer at its max (so we don’t accidentally fry a pedal by going over its voltage limit). Then we will need to find either the value of R1 or R2 (our VR1 potentiometer), assuming we know what one of them will be. In that case, these formulas will be used:

$$R_1 = \frac{R_2}{\left(\frac{V_{OUT}}{1.25}-1\right)}$$

Or

$$R_2 = R_1\left(\frac{V_{OUT}}{1.25}-1\right)$$

One the next page are some examples.

Example 1: 12-18V wall power to 9V maximum output

This is probably going to be the most commonly used circuit for guitar pedals, as most pedals are rated for 9V max. With a 12V input DC power supply, the 3V voltage drop on the LM317 should by default bring the maximum output down to 9V, but due to load requirements, it may not drop the full 3 volts, not to mention the wall supply might push a few more millivolts than the 12V is has listed on the supply when under a small load. Obviously, input supplies greater than 12V will be a larger problem. To resolve this possibility, we can use the value of R1 and VR1 to stop the LM317 from outputting more than 9V.

If we assume the potentiometer has a maximum resistance of 5K, or 5,000 ohms, R1 can be determined with this formula:

R1 = 5000 / ((9 / 1.25) – 1)

R1 = 5000 / (7.2 – 1)

R1 = 5000 / 6.2

R1 = 806 ohms.

As 806 ohms isn't a common resistor value, you may want to go with next common values. If we use an 820 ohm resistor, this will top out the voltage at 8.87 volts. If we use a 750 ohm resistor, this puts the top voltage at 9.58 volts.

Another approach would be to change the value of the potentiometer to 1K, or 1,000 ohms. Now let's see what the value of R1 will be:

R1 = 1000 / ((9 / 1.25) – 1)

R1 = 1000 / (7.2 – 1)

R1 = 1000 / 6.2

R1 = 161 ohms.

160 ohm resistors are a common value, which tops out the maximum voltage at 9.06V.

Example 2: 24V wall power to 18V maximum output

This is probably going to be the most commonly used circuit for guitar pedals, as most are rated for 9V max. With a 12V input DC power supply, the 3V voltage drop on the LM317 should by default bring the maximum output down to 9V, but due to load requirements, it may not drop the full 3 volts, not to mention the wall supply might push a few more millivolts than the 12V is has listed on the supply when under a small load. To resolve this possibility, we can use the value of R1 and VR1 to stop this from being a problem.

If we assume the potentiometer has a maximum resistance of 2K, or 2,000 ohms, R1 can be determined with this formula:

R1 = 2000 / ((18 / 1.25) – 1)

R1 = 2000 / (14.4 – 1)

R1 = 2000 / 13.4

R1 = 149 ohms.

As 149 ohms isn't a common resistor value, you may want to go with next common value, 150 ohm which will top out the voltage at 17.92 volts.

3. Heatsinks: Do We Need Them or Not?

Because the LM317 is a linear regulator, it removes the excess incoming voltage as heat to get the output voltage to where it has been set. If the current draw on the output device is low, such as for a single guitar pedal (or even a couple), no heatsink is required. However, if the input/output voltage difference is large, or a large amount of current draw is on the output, a heatsink will be required. How do we know if we need a heatsink, and what size of one would we need?

So, using an LM317T with a TO-220 package to regulate a 9V guitar pedal.

RthJC (θJC) = 5 Degrees C/W (Found in the datasheet)
RthJA (θJA) = 50 Degrees C/W (Found in the datasheet)
TOP Range = 0 - 125 degrees C (Found in the datasheet)

Example 1: 12V Wall Power to a 9V, 20mA Guitar Pedal

To calculate Power Dissipation, we take the source voltage and subtract by the regulated voltage and multiply by the current.

So, 12V - 9V = 3V * 0.020A = 0.060W or 60mW.

So, let’s assume the ambient air temp is 27 degrees C, or 80 degrees F.

θJA (TOTAL) = Temperature of Junction (Max of TOP) - Temperature of Ambience and then divide that by the Power Dissipation.

So, 125C - 27C = 98C / 0.06W = 1,633 Degrees C/W

If θJA (TOTAL) < θJC. If the junction-to-ambient (total) thermal resistance is less than junction-to-case thermal resistance, then you need to look for a higher wattage regulator. 1633 is not lesser than 5, so the regulator is good to use.

If θJA (TOTAL) > θJA. If the junction-to-ambient (total) thermal resistance is greater than junction-to-ambient thermal resistance, then a heat sink is not required. 1633 is greater than 50, so in this case, a heatsink isn't required. As a matter of fact, you could connect two dozen 20mA pedals to this single supply in this case and still not need a heatsink, so long as the wall voltage remains 12V

Example 2: 18V Wall Power to a 9V, 10x 20mA Guitar Pedals

To calculate Power Dissipation, we take the source voltage and subtract by the regulated voltage and multiply by the current.

So, 18V - 9V = 9V * 0.200A = 1.8W

Let's say the enclosure of the LM317 will be enclosed, so it has poor air circulation, and it's outside in the summer, in the sun. Ambient temperature can get up to 60 C.

So, 125C - 60C = 65C / 1.8W = 36.1 Degrees C/W. 36.1 is not lesser than 5, so the regulator is good to use.

If θJC < θJA (TOTAL) < θJA. If the junction-to-ambient (total) thermal resistance is less than junction-to-ambient, but more than junction-to-case thermal resistance, then a heat sink is required.

5 < 36.1 < 50, so yes, a heatsink is required.

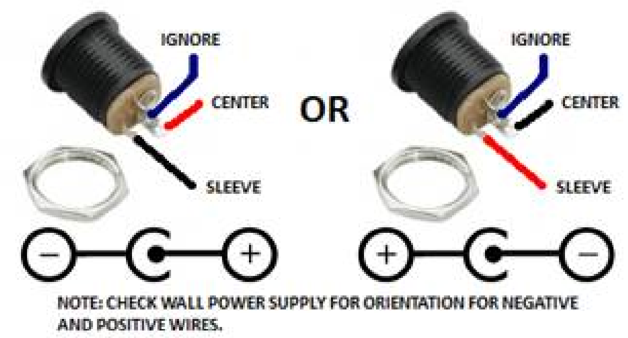
So, if we look at a heatsink online, the value we want is θSA (sink-to-ambient thermal resistance). To calculate what we need, θSA = θJA (TOTAL) - θJC.

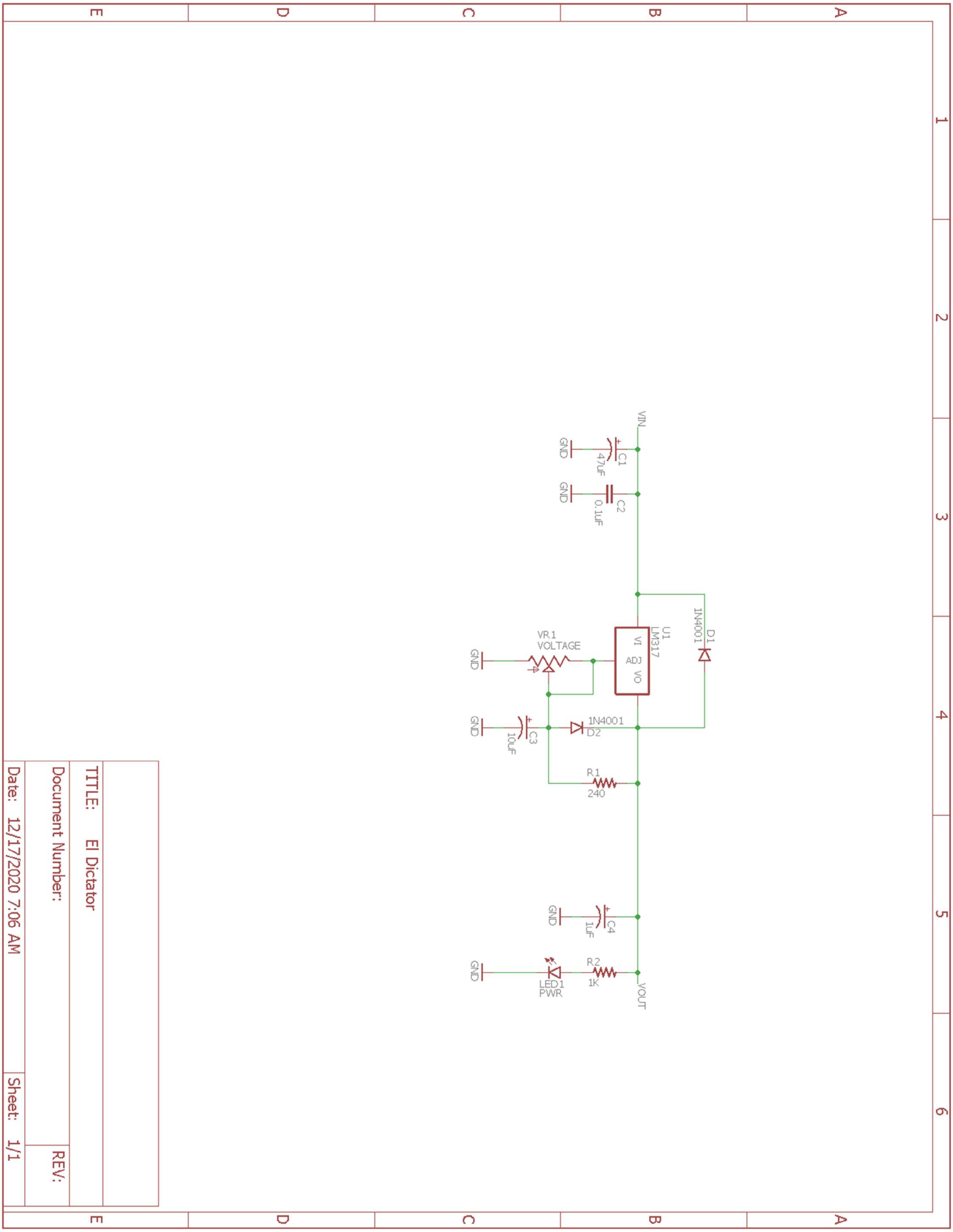
So 36.1 - 5 = 31.1 C/W

So, any heatsink that naturally handle 31.1 C/W or lower will be sufficient in cooling this LM317. A good example would be the Aavid 577102B00000G heatsink for TO-220 ICs.

Off Board Wiring Diagram

Make sure to check the wall power supply for voltages, current delivery and polarity.





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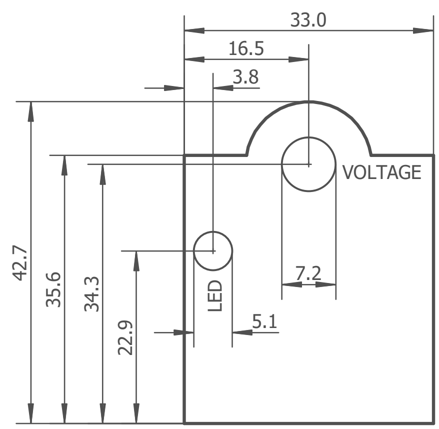
Sheet: 1/1
VIN
C1 47uF
C2 0.1uF
GND
D1 1N4001
U1 LM317
VI
ADJ
VO
VR1 VOLTAGE
D2 1N4001
C3 10uF
R1 240
C4 1uF
R2 1K
LED1 PWR
VOUT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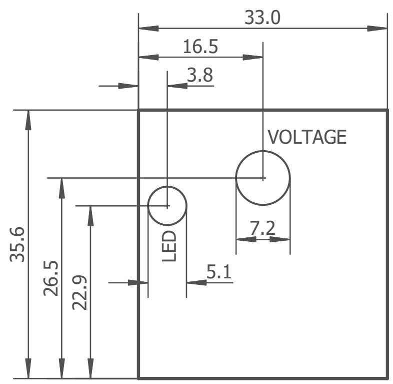
16.5
3.8
42.7
35.6
34.3
22.9
VOLTAGE
LED
7.2
5.1


33.0
16.5
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VOLTAGE
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26.5
22.9
LED
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5.1