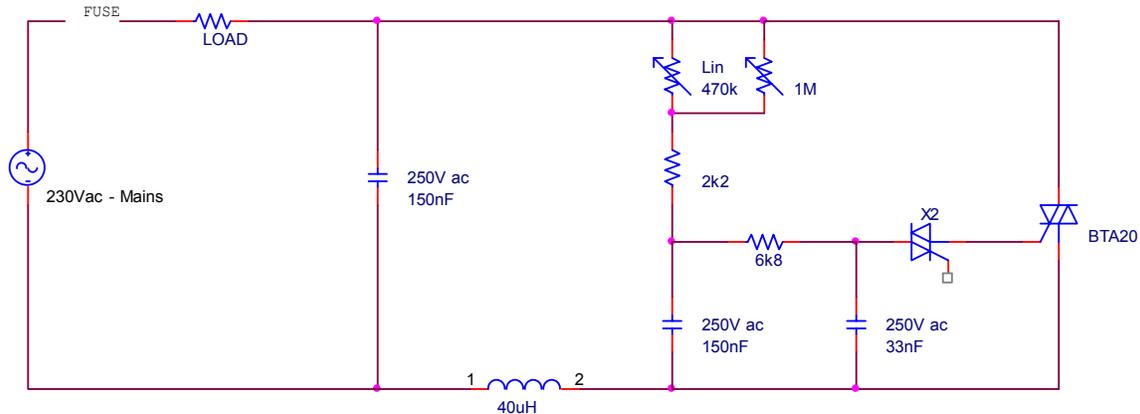


# Immersion Heater Controller

## By Matthew Stevens

For production of Biodiesel, it is desirable to have a controllable heat source to minimize energy waste, protect the element from potentially burning out and also to avoid the 'kettling' effect which can scorch the Veg oil used in the process.

Below is the circuit that can be used to do this...



Notes: -

Capacitors should ideally be X Type, must NOT be electrolytic or polarized and must be suitable for mains applications. This means either 400V rated or 250V AC rated.

Component X2 is a Diac (32V), although shown as a Triac on the diagram (look very similar schematically)

### **Circuit description –**

Ok, the Triac (ST's BTA20) is the power device which will switch on and off at different intervals synchronized to the mains. It is this which will let current flow through the load, which in our case, is the immersion heater (approximately 18 Ohms).

By firing the triac for different lengths of time, we can control the current. Now, a Triac will turn itself off when the voltage approaches 0V across it and therefore will turn off when the AC mains crosses 0V to go negative, or positive depending on which half cycle of the mains we are on. What we must do is fire the Triac part way through the mains cycle on both the positive and negative sides. For this, the Triac must be fired either with a positive voltage or negative voltage, again depending on which half of the mains cycle we are on.

This is actually easily done with an adjustable RC time constant which is formed essentially with the control potentiometer (470K) and 150nF cap – a further 6k8, 33nF filter (I actually used a 22n and 10k – about the same time constant) is linked which then goes via a Diac and into the gate of the Triac. The Diac ensures the voltage reaches at least 32V (pos or neg) before conducting and turning on the gate.

So – by adjusting the 470K pot, we adjust the time constant and hence shorten or lengthen the delay before firing the Triac synchronized to the zero crossing point of the mains– which then stays on until the end of the half cycle where it turns off again. And the process then continues for the next half cycle.

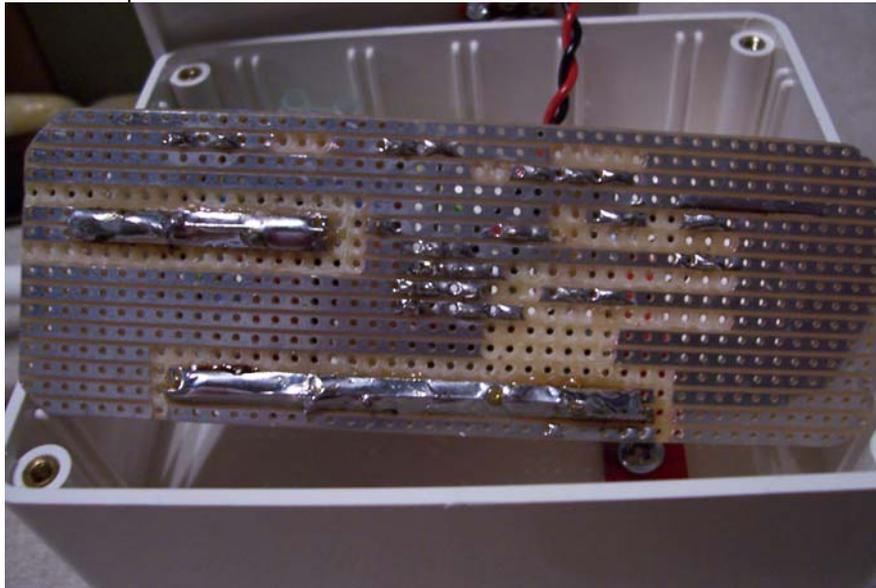
To the left hand side of the circuit is an inductor and capacitor across the incoming mains lines which helps to filter out the noise created by the Triac firing on and off.

### Component List –

- 1x Immersion Heater
- 1x 1M Ohm adjustable potentiometer (small screw adjustment type)
- 1x 470K Ohm Linear Potentiometer
- 1x 2k2 resistor ¼ W
- 1x 6k8 resistor ¼ W
- 2x 150nF 250Vac X type Capacitors
- 1x 33nF 250Vac capacitor
- 1x Veroboard
- 1x Plastic Project Box (approx 120mm x 46mm x 100mm)
- 1x 32V Diac
- 1x 20A ST BTA20 Triac
- 1x 40uH ferrite cored inductor – must be able to handle around 20A (I used 1mm insulated wire)
- Chockblock
- 3-core mains flexi wire
- Plug
- Dial for Potentiometer
- Heatsink
- Insulated heat transfer pad

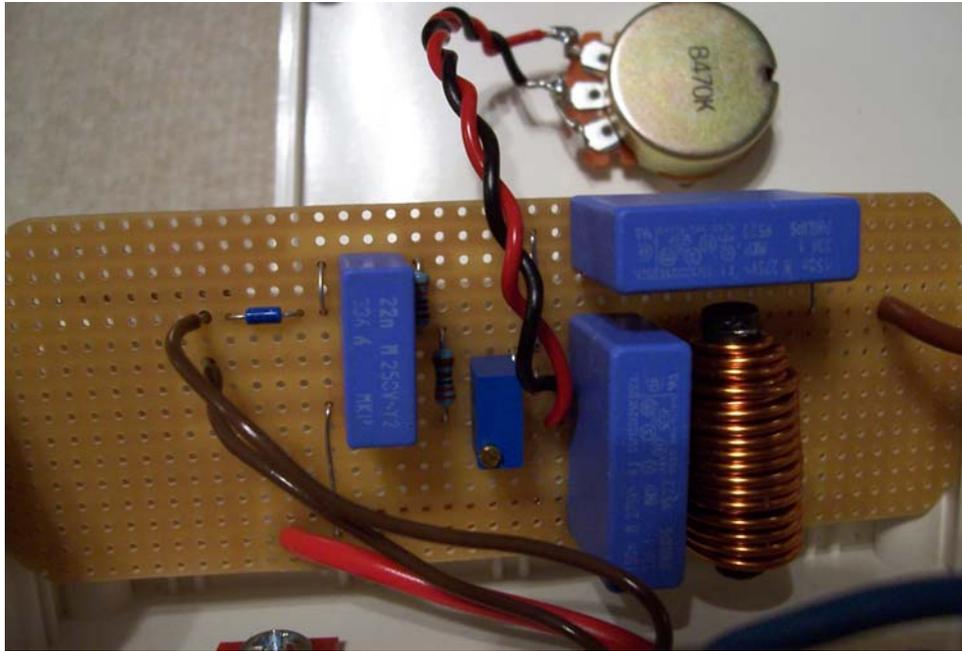
### Construction –

The below pictures show the construction of the controller...

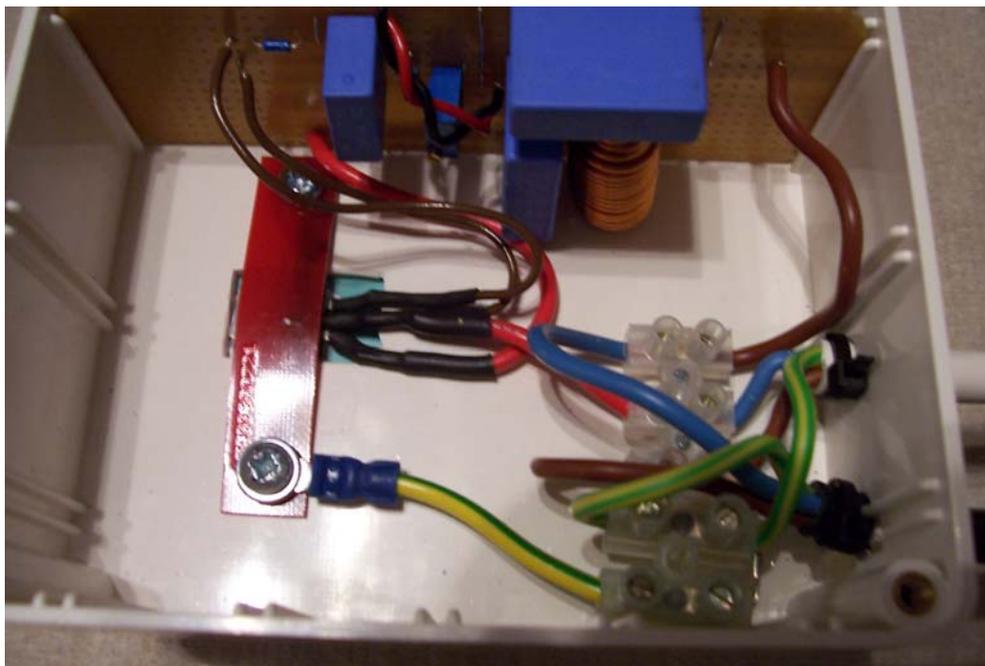


Notice that the tracks carrying the current have been thickened up using two veroboard tracks and a lot of solder!. This is the path from the mains in – through the inductor – and then to the Triac. The main current then goes through the Triac and to the load and this is handled in the wiring. Only this path carries high current, so these are the only tracks which need to be thick – the Triac gate for example does not.

Also notice that I have tried to give plenty of isolation by removing the copper tracks around the high voltage differential areas.



This picture shows the majority of the components – the wires to the left go to the Triac, the one on the right is mains into the inductor. With reference to the back picture above, it is like turning the board 180 degrees on a vertical axis (Thick solder track is still at the bottom).



On this picture you can see the PCB in the box with the Triac mounted through a hole and onto the heatsink at the back. I strapped the Triac down with a piece of FR4 (The stuff PCB's are made from), but you could use a piece of aluminium for example.

Note – the Triac body is NOT isolated from the mains. This means you must insert an **insulating heat exchanger** pad between the device and the heatsink (in the diagram you can see the green colour of this). Also I have earthed the heatsink via the screw clamping it to the box – if anything goes wrong, it should blow the 13A fuse in the plug.

The wires on the right entering the box – White is heater, Black is mains.



A picture from the bottom showing the heatsink. It may be a little overkill – but it is what was available in the lab at work! Having said that, the Triac does drop a few volts and with 13A going through it, the fact its encapsulated in a box, it will get hot. Adequate cooling is necessary. Even with this heatsink, I saw temperatures of 65 degrees C on the Triac body after 10-15mins. (The Triac is good for upto 120 degrees).

I suppose you could engineer this so that you use the body of the reactor if it's a copper cylinder...a perfect heatsink! Just make sure its isolated.



Heres the finished box. I used a current clamp and oscilloscope to work out the positions of  $\frac{1}{4}$  and  $\frac{1}{2}$  setpoints etc. I also trimmed the setpoint with the internal 1M pot. Using this you can ensure that when the main control pot is turned fully to the left – that it is actually OFF and to the right it is actually fully ON etc.

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