The SOLAR CONTROLLER

The Centre for Alternative Technology (CAT) is based in Machynlleth in mid-Wales and has been at the forefront of the alternative technology movement since its inception in 1975. Originally intended to be a statement in environmentally friendly living by a group of like-minded individuals looking to practice what they preached, CAT has grown into an internationally renowned centre for research into renewable energy systems, organic horticulture, alternative building methods and waste and water treatment systems. The centre offers consultancy in all its main areas of interest, runs a visitor's centre open to school and university groups and the general public, runs educational and leisure courses, has developed a travelling exhibition and collaborates with two universities on higher degrees. CAT also has its own list of publications to support the services offered by its free information service. The extract featured here is taken from one such title.

ELECTRONICS & BEYOND'S GREEN PAGES FOR SEPTEMBER FOLLOW UP ON THE JULY ISSUE'S SOLAR WATER HEATING ARTICLE WITH PLANS FOR A CONTROLLER YOU CAN BUILD AND FIT YOURSELF, DESIGNED TO SUIT SOLAR POWERED DOMESTIC HOT WATER SYSTEMS.

A solar water heating controller is a gadget used in conjunction with a solar water heating panel array to supply hot water to your taps. In the simplest systems, water circulates by itself. However, if you install a pump it means greater choice over where you position the panel, plus improved thermal efficiency. The controller is a simple thermostat that only switches on your pump to carry water from the heater when it's hot enough to be of use.

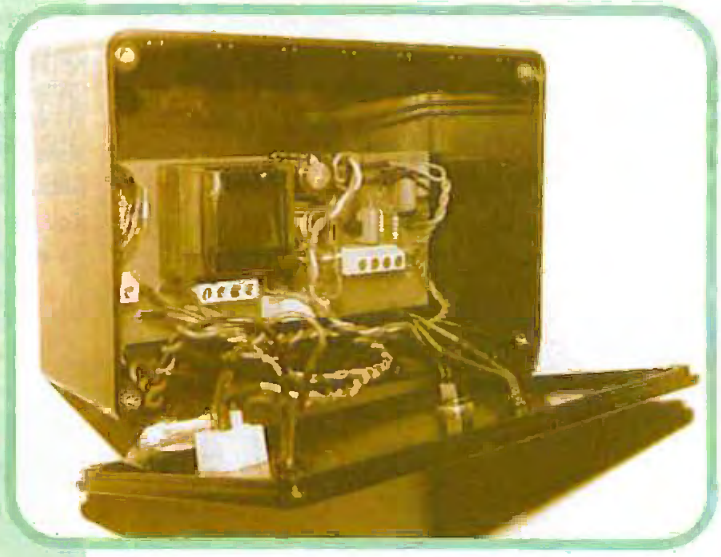


Figure 1. The completed box with the lid open demonstrating the circuit board and components

How to make and install a solar controller from standard electrical components.

This controller can be used for most solar heated water systems. Let's look first at how it works and then at making the control box, fitting the sensors, choosing the temperature difference, testing procedure, installation, and some additional technical detail.

How it works

Two sensors are mounted one on the hot water tank and one on the solar panel. They measure the difference in temperature between the two. When the panel is sufficiently hotter, they tell the controller automatically to switch on the pump. When the tank has heated up it will switch the pump off. There is also a manual override switch.

Building the control box

Most of the components are fitted on to a printed circuit board. This is shown in Figures 3 and 4. Figure 2 shows the circuit diagram. The board was designed to fit inside a plastic case measuring 150mm by 80mm by 50mm, although any reasonable size may be used; you could adapt something or build it out of wood. It should be possible to solder together and construct the controller, and put it in the case, with careful reference to the diagrams and photograph. However the following points are offered to avoid some of the mistakes that might occur.

Three rubber grommets are fitted to cable holes in the lid of the case, and the LEDs and switches are fitted in the lid. Take care to position these lid-mounted parts so that there's enough clearance space when the case is put together. When fitting the diodes and the capacitor C4, make sure that their polarity is correct and that the integrated circuit IC1 is the right way round. Similarly, when completing the interwiring between the components, pay careful attention to the polarity of the LEDs, to make sure they are connected the right way round.

Check the wiring of switch S1 since this will carry mains voltage. When the components of the board are all securely soldered in place, lower the board into the case you have made and connect a three core mains cable to the three way terminal block. The cable should be fitted with a 3 amp fused plug.

Installing the sensors.

First, make up the two sensor leads, one for the solar panel and one for the hot water tank. Use twin core 7/0.25mm cable. The type with one side marked with a coloured stripe or ribbing is ideal. At this stage each lead may be about 2 metres long. If necessary, extend

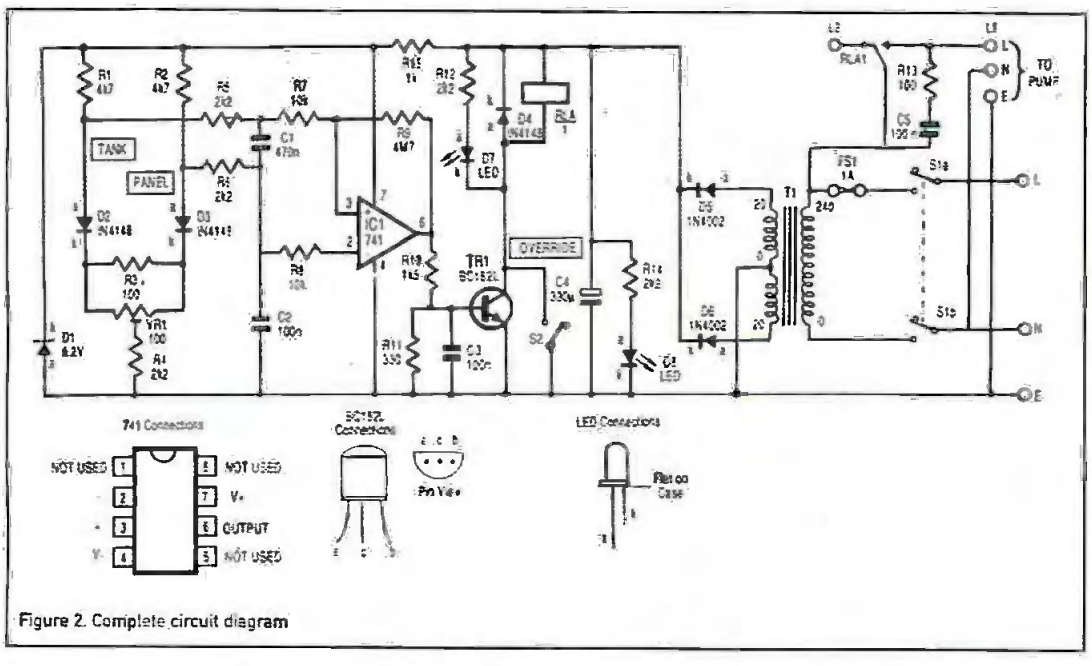


Figure 2. Complete circuit diagram

few minutes the relay should turn off. If it does all this you've succeeded so far. Now disconnect the unit from the mains. You may now install it.

Installation

In a typical solar heated system the solar energy collected by the panels is pumped to the pre-heat cylinder (see Figure 7). The pump is switched on by the solar panel controller. This pre-heated water is then drawn through the existing hot water tank.

The pump should be connected to your controller on the terminals marked L1, N and E on the controller's four way terminal block. Take note of the fact that terminal L2 is live when the green LED is off.

Now you can position the controller box. It should be in a visible and accessible position so the switching of the pump can be monitored. It should also be somewhere where the temperature won't vary widely. Don't put it in the attic.

them with more cable later; or calculate first the distance you want to position the controller from the panel and tank.

The sensors themselves are 1N4148 diodes. Simply solder them to the end of each lead as shown in Figure 5. Seal the bare wire and joints with epoxy putty against water. This will harden in a few minutes.

Thread the two sensor leads through the grommet on the end of your box and connect them into the terminal block as shown in Figure 3.

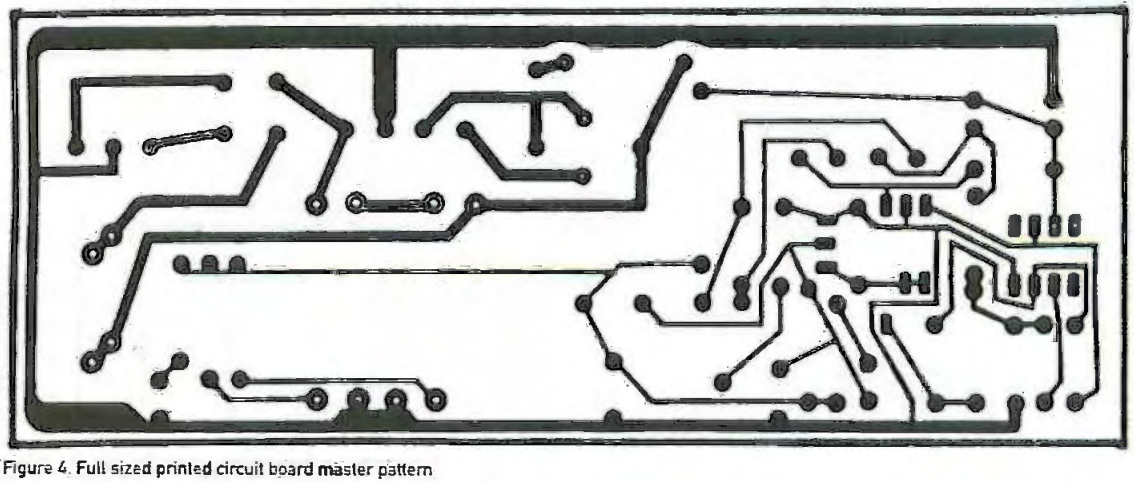


Figure 4. Full sized printed circuit board master pattern

Choosing the temperature difference

The size of the temperature difference between the tank and the panel that switches the pump on or off is controlled by the component called R9. This is a feedback resistor of the 741 amplifier. You can choose its specification to give a temperature difference as shown below:

SPECIFICATION	TEMPERATURE DIFFERENCE
3M3	10°C
4M7	7°C
10M	3.5°C

You may wish to experiment with installing different resistors at different values to find the one that works best for your conditions. Alternatively you could fit a variable resistor, and having found the optimum position, leave it there.

Test procedure

You're ready to try it out. Plug in the unit and turn switch S1 on. If it's all connected properly, the red LEDs should light up. Now switch S2 into the auto position. Take care. The fuse clips and components near the 3-way terminal block are now live, as is the back of switch S1.

Next, ensure that the two sensors are near to each other, and therefore at the same temperature. Turning the preset dial VR1 should cause the relay and the green LED to turn on and off. If it does, the next step is to find the correct point at which to set VR1. This is done by turning it until the relay just comes on. Then turn it back until it is just past the point at which the relay turns off. Five degrees of rotation past the turn off point is about right. Leave it there.

You're now ready to see if a temperature difference between the sensors turns on the switch. Find something hot like a soldering iron and hold it near or against the panel sensor. The relay should click on after a few seconds. If you then leave the sensor to cool down for a

It's now time to fix the sensors. If you don't get this right, the whole system won't work. Firstly, don't run the leads near mains leads, because they cause interferance. Fit the sensors in place with epoxy putty or silicone sealant and cover them with insulation, such as polystyrene. Figure 6 shows this arrangement. The tank sensor should be mounted on the pipe running from the pre-heat cylinder to the solar panels, and as near as possible to the tank. The actual connection flange is an ideal place.

The panel sensor goes on the outlet pipe inside the box of the last solar panel in the sequence. After the putty has dried, you're now ready to switch on, and the whole system should work.

Insert pic and caption Figure 7. A typical system design employing solar collectors to pre-heat water before the immersion heater or boiler finishes the job. This system is pumped and uses a solar controller.

For those looking for further information on this and related subjects, CAT is offering a number of books, products and courses to Electronics & Beyond readers. For further details and to order contact CAT Mail Order Department, CAT, Machynlleth, Powys, SY20 9AZ. Tel. 01654 705959 or visit the website at cat.org.uk and quote the reference E&B003.

Parts List

Resistors		
R1,R2	4K7	
R3,R13	100R	
R4,R5,R6	2K2	
R7,R8	10K	
R9	4M7	(see note)
R10	1K5	
R11	330R	
R12,R14	2K2, 0.5Watt	
R15	1K 1Watt	
VR1	100R cermet preset	
Capacitors		
C1	470nF capacitor polyester 100V	
C2,C3	100nF capacitor polyester 100V	2
C4	330uF capacitor radial electrolytic 40V	
C5	100nF suppression capacitor	
Diodes		
D1	8V2 zener diode	
D2,D3,D4	1N4148	3
D5,D6	1N4002 or 1N4007	2
D7	green LED (with clip)	
D8	red LED (with clip)	
Miscellaneous		
TR1	BC182L transistor	
IC1	LM741 opamp	
RLA	10A single pole changeover relay, 24V coil	
T1	3 VA transformer, 240V primary, 20-0-20V secondary	
S1	d.p.s.t. rocker switch, 240V AC 4A	
S2	s.p.s.t. toggle switch, 30V DC1A	
FS1	1 amp fuse	
3 way terminal block		
4 way terminal block		2
p.c.b. terminal pins		10
fuse clips		2
plastic case		
rubber grommets		3
printed circuit board		
twin 7/0.25mm cable		
epoxy putty and (maybe) silicone sealant		

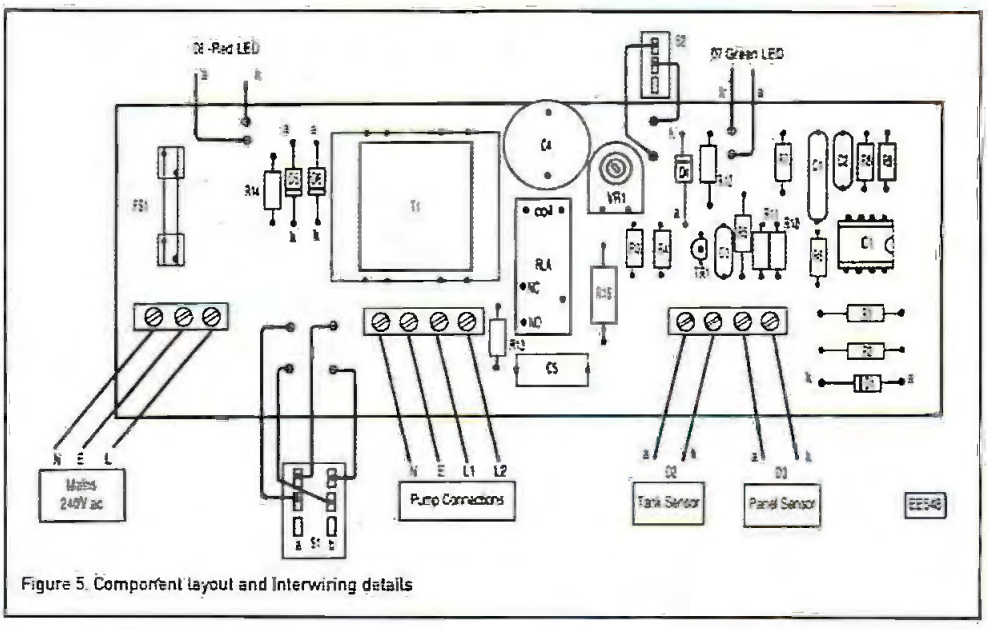
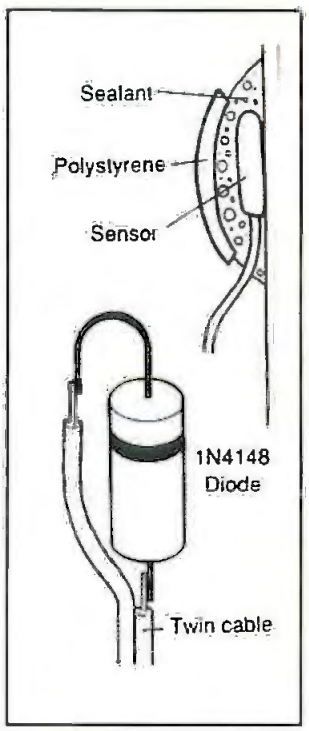


Figure 5. Component layout and interwiring details

Publications

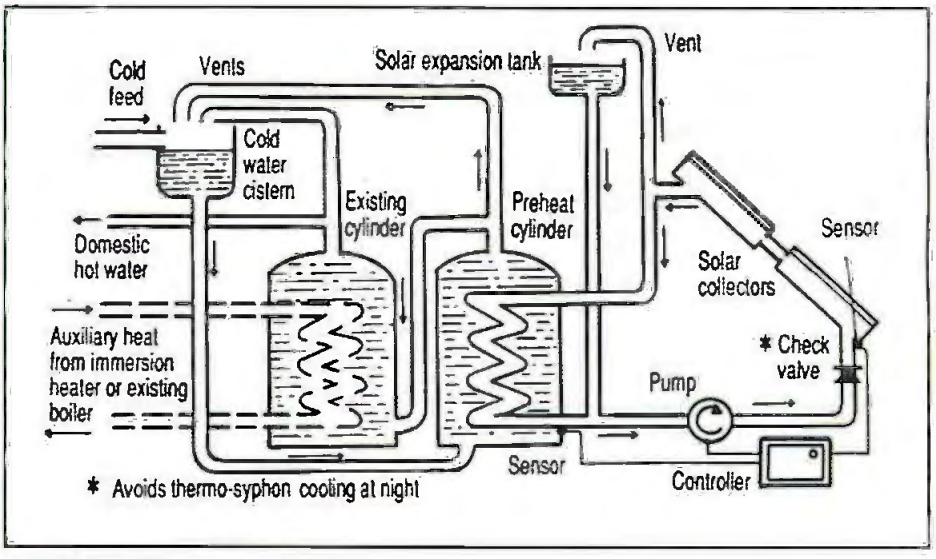
Tapping the Sun: *A guide to solar water heating, B. Horne, P. Geddes.*
Offer price £3.15 (£3.50 rrp)
All you need to know before buying or installing a solar water heating system. How it works...Types of panel...Costs and benefits...How to fit a panel into your plumbing system.



Solar Water Heating: *A DIY guide, Paul Trimby, 28pp*
Offer price £5.40 (£5.99 rrp)
This practical DIY guide is packed with photographs and diagrams designed to help you through the process from design to construction and installation. The panels described in the book can be made by anyone with basic woodworking and plumbing skills and also make ideal practical projects for schools and science courses.

Solar Energy: *a factsheet, CAT, 8pp, A4*
Offer price £2.70 (£3.00 rrp)
An introduction to solar power: covering passive solar building design; the collection of solar heat for storage and use as a low temperature heat for water and space heating.

Hot Water from the Sun: *How to construct your own solar panel, Jurgen Streib, 134pp*
Offer price £13.50 (£15.00 rrp)
The central idea of this book is that solar panels ought to be constructed in the respective countries where they are being used. Covers everything from building panels to testing their efficiency.



Solar Water Heating Resource Guide,
CAT, 14pp
Offer price £1.80 (£2.00 rrp)
Complete listing of consultants, manufacturers and suppliers, sources of information, products and courses...names, addresses, telephone numbers and websites.

Products

Clip Fin Solar Collectors
Offer price £4.19 each or £45.00 for 12 (£4.65/£50.00 rrp)
High conductivity aluminium sheet, designed to clip on to standard 15mm copper water pipe as part of a solar flat plate collector. This provides efficient transfer of heat to the water in the pipe, and makes DIY solar collectors easy to construct. Each fin measures 380 x 200mm.

Courses

(When requestion information or booking details please quote E&B003.)

Solar Water Heating Systems
October 5–7 2001
Fees: High waged: £230; waged: £170; non-waged/student: £120
This course is ideal for those who want to design or install a solar water heating system. Sessions will cover types of collector, energy storgage, plumbing and controls. There will be practical tuition on the construction of a collector and in-depth instruction on the design of solar heating systems.

Introduction to Renewable Energy Systems
September 24–27 2001
Fees: High waged: £230; waged: £170; non-waged/student: £120
This course will look at the potential for generating your own electricity from wind, water and solar power and also at the possibilities for reducing energy consumption. It will be led by CAT engineers and based in CAT's unique Eco Cabins, which have their own renewable electricity supply.

For £16.00 per year you can join the Alternative Technology Association, CAT's member organisation, which entitles you to quarterly copies of the journal, Clean Slate, a 10% discount on all CAT publications and other members' benefits. Contact ATA on 01654 705988, quoting the reference E&B003.