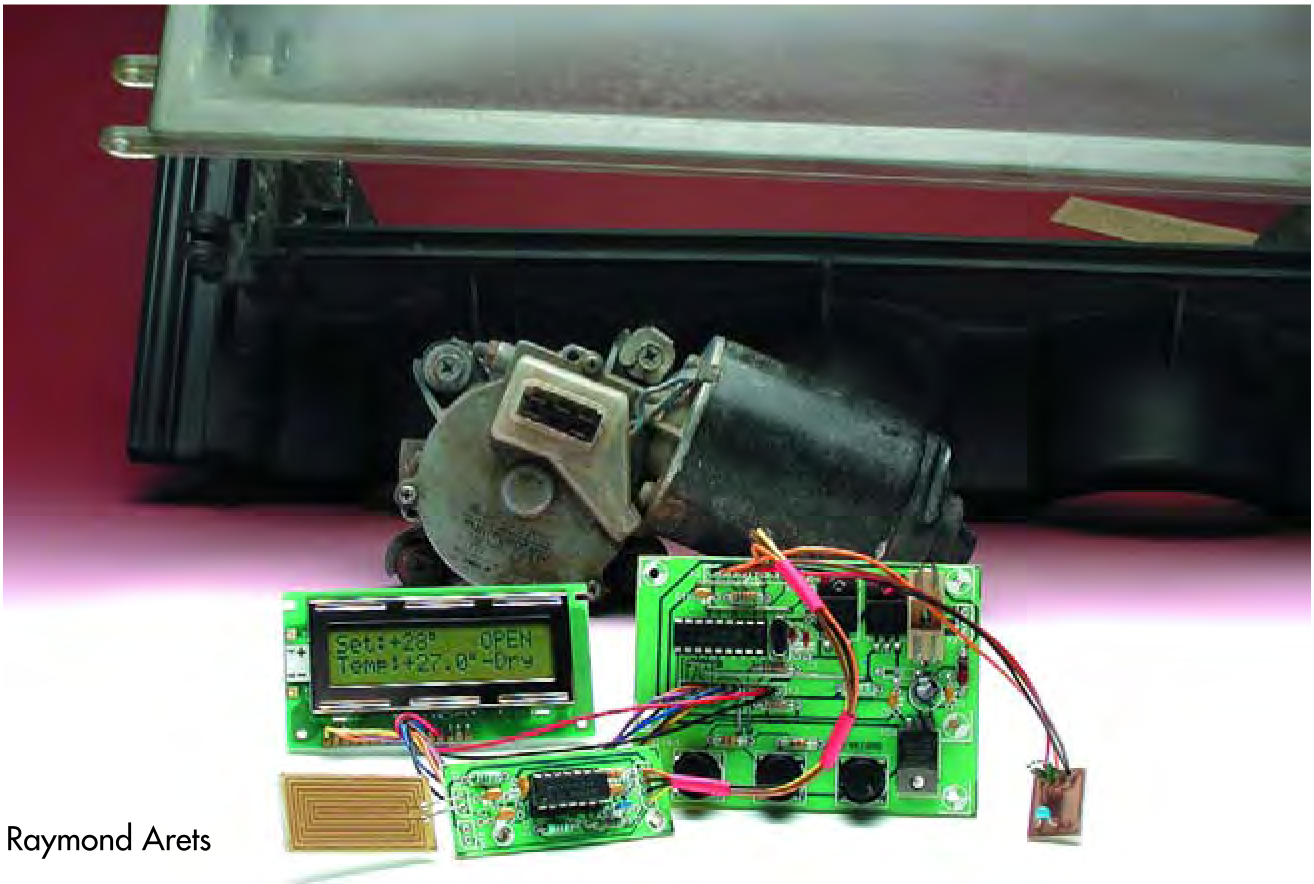
Automatic Attic Window Controller

With a weather dependent control



Raymond Arets

Electronic engineers are often ardent collectors. "Throwing these old parts away would be a waste", is an often-heard phrase. This results in attics and garages that are overflowing with boxes full of the things, much to the dismay of the other occupants of the house. A fair number of these items can be used in this design, reducing the size of your spare parts mountain.

The design for the attic window controller is based around the well-known PIC16F84. This versatile, and inexpensive, microcontroller has almost become a standard workhorse for projects like these. The program is written in a language called 'JAL', which we'll cover later on. An old windscreen wiper motor is used to open and close the window.

Description

Figure 1 shows all the electronic modules used in this design. With the help of the circuit diagrams in Figure 1 we'll explain how the circuit works and describe the part played by the different modules.

At the hart of the circuit is IC2, a PIC16F84. This microcontroller uses a rain sensor and a temperature sensor to keep in touch with the outside world. The signals from these sensors affect what the controller shows on the display and what the motor does. The temperature is read every 30 seconds, whereas the rain sensor is monitored continuously.

For the display a standard 2×16 character LCD is used (also available from Elektor Electronics, order code 030451-73; see Figure 5).

T1 and T2 have to deal with the relatively large current of the motor. They may of course be different types than those specified in the parts list, as long as they can withstand the current (minimum 3 A, and preferably more because of the large peak currents of the motor). The driving voltage (12 V) probably won't be a problem. RB6 and RB7 on the microcontroller are used to drive the gates. T1 and T2 are connected to the ground side of the motor, since in this configuration there is no need to use a level-shifter.

Figure 2 shows how the windscreen wiper motor is set up. In **Figure 3** you can see the mechanical construction made by the author. It isn't overly difficult, but it helps if you don't have two left hands.

The function of switches S1 and S2 depends on the mode. During automatic mode the temperature at which the window is opened is increased by S1 and decreased by S2. When manual mode is selected and S1 is pressed the motor will turn on for a certain time, which has been defined in the software. This causes the skylight to open. How far the window opens depends on how long the motor is turned on. When S2 is pressed during manual mode the window will be closed. This is because the motor will stay on until the slider stops making contact with the slip-ring. At that instant the motor is in its original position and the window will therefore be shut. S3 is used to switch between manual and automatic operation.

It is worth mentioning that a little trick

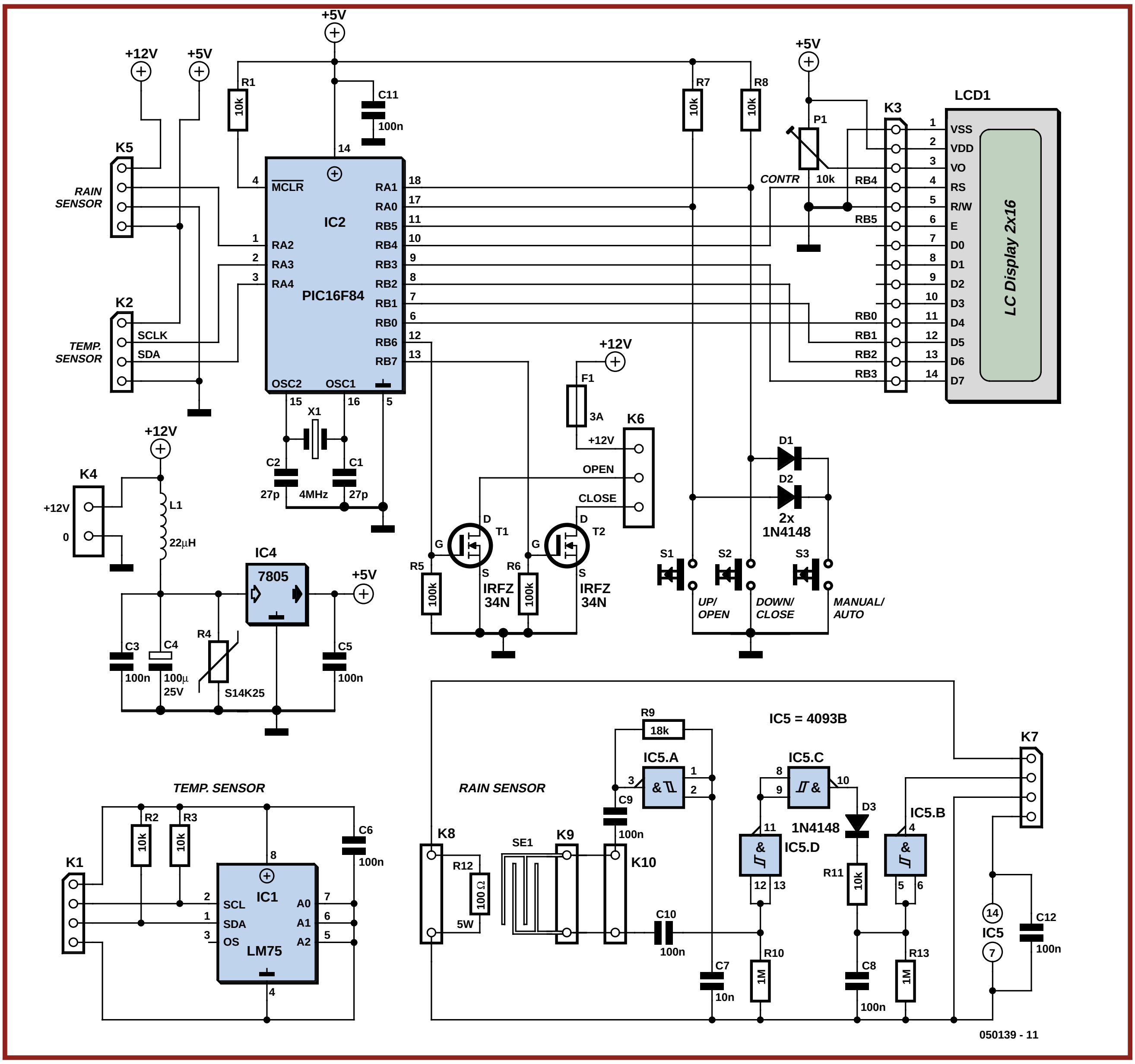


Figure 1. The circuit may appear elaborate at first sight, but if you look closer you'll find that it consists of just a few simple modules. There is even room for an I²C bus.

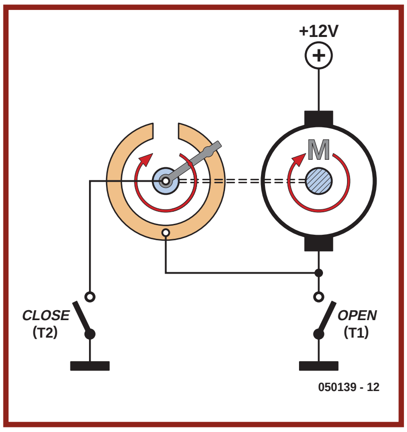


Figure 2. Connections to the windscreen wiper motor.

was used when S3 was added. There weren't any more pins available on the PIC16F84 to add a switch for changing between manual and automatic mode. The author used the following trick to get round this: he added S3 in such a way that it appears to the PIC that S1 and S2 are pressed simultaneously. D1 and D2 prevent S1 and S2 from interfering with each other.

An LM75 is used for the temperature sensor. This digital temperature sensor has an I^2C interface and can be read at any time. The temperature range runs from -55 to 125 °C, with an accuracy of ±3 degrees. Address lines A0 to A2 can be used to connect up to eight LM75s to one I^2C bus, but in this case that is obviously not necessary. More information about I^2C can be found previous issues of *Elektor Electronics*; simply use the Search box on our website to locate the articles).

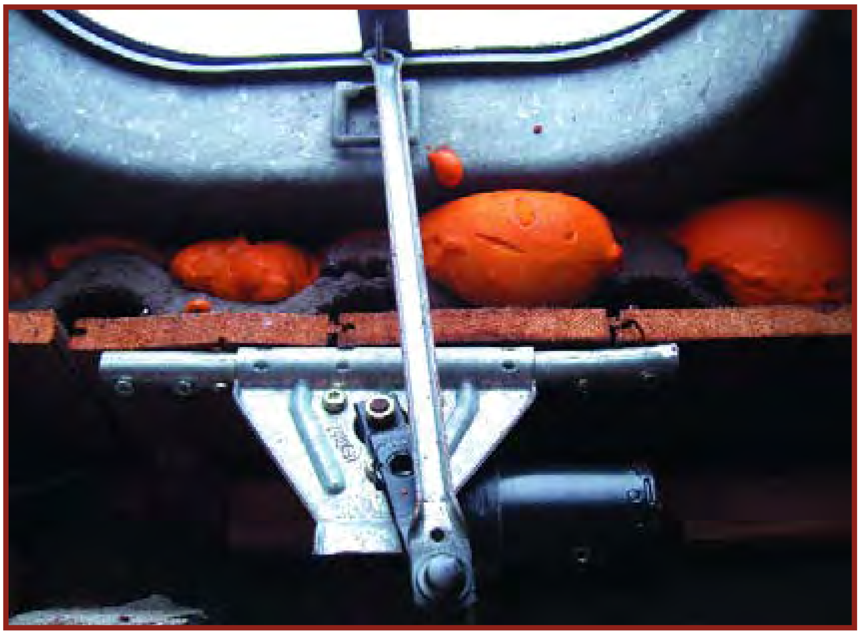


Figure 3. Apart from the electrical work, some mechanical construction is also needed.

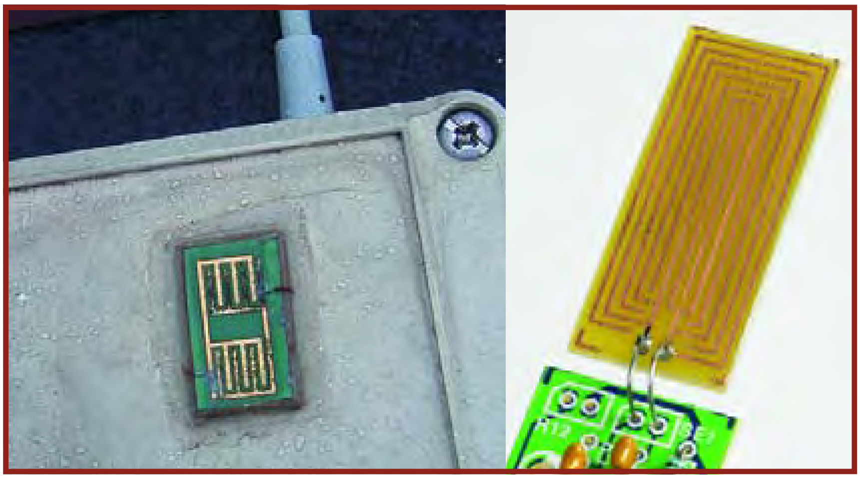


Figure 4. The rain sensor can be made from the board out of an old keyboard (left), or you can etch your own (right). The corrosion on the author's sensor was caused by the DC voltage that was applied in the first prototype version.

It is of course possible to use an expensive rain sensor, but it is easier to use a piece of PCB from an old keyboard (see **Figure 4**). A gold-plated sensor is obviously most resistant to corrosion, but this is difficult to implement if you etch the sensor yourself. To keep the sensor from conducting too long it is heated and dried by R12, which is mounted directly underneath the sensor.

To avoid corrosion as much as possible you have to make sure that there is no DC voltage across the sensor. If this should happen the tracks would quickly corrode due to electrolysis. For this reason an oscillator has been built around IC5a. The exact frequency doesn't matter here; the only function of the oscillator is to provide an AC voltage to the sensor. In our case the frequency was about 10 kHz, but this is not critical.

The circuit round IC5c and IC5d functions as a buffer. R10 keeps the input of IC5d low when it is dry, but when the sensor becomes wet it starts to conduct and a pulsing signal will appear at the input to IC5d via C10. This pulsing signal charges C8 via IC5c, D3 and R11. D3 stops C8 from discharging via IC5c, leaving R13 as the only discharge path. In this way the signal from the sensor is averaged out. The output of IC5b therefore goes low when rain is detected. This is fed to the PIC, which then closes the attic window.

The power for IC2 and IC5 is regulated by a simple circuit around IC4. L1 acts as a choke and varistor R4 suppresses voltage spikes. R4 isn't really necessary when a lead-acid battery is used.

The construction is fairly straightforward (see **Figure 5**). No components have been used that are difficult to solder. The soldering of the SMD packaged LM75 may require some more attention (this is mounted on the underside of the temperature sensor board), but it shouldn't cause any problems. The layout of this board is shown in **Figure 6**.

Software

As we mentioned earlier, the software was written in JAL (Just Another Language, [1]). JAL is a simple programming language, which even beginners should find easy to follow. Because of this the software can also be adapted easily to your own requirements.

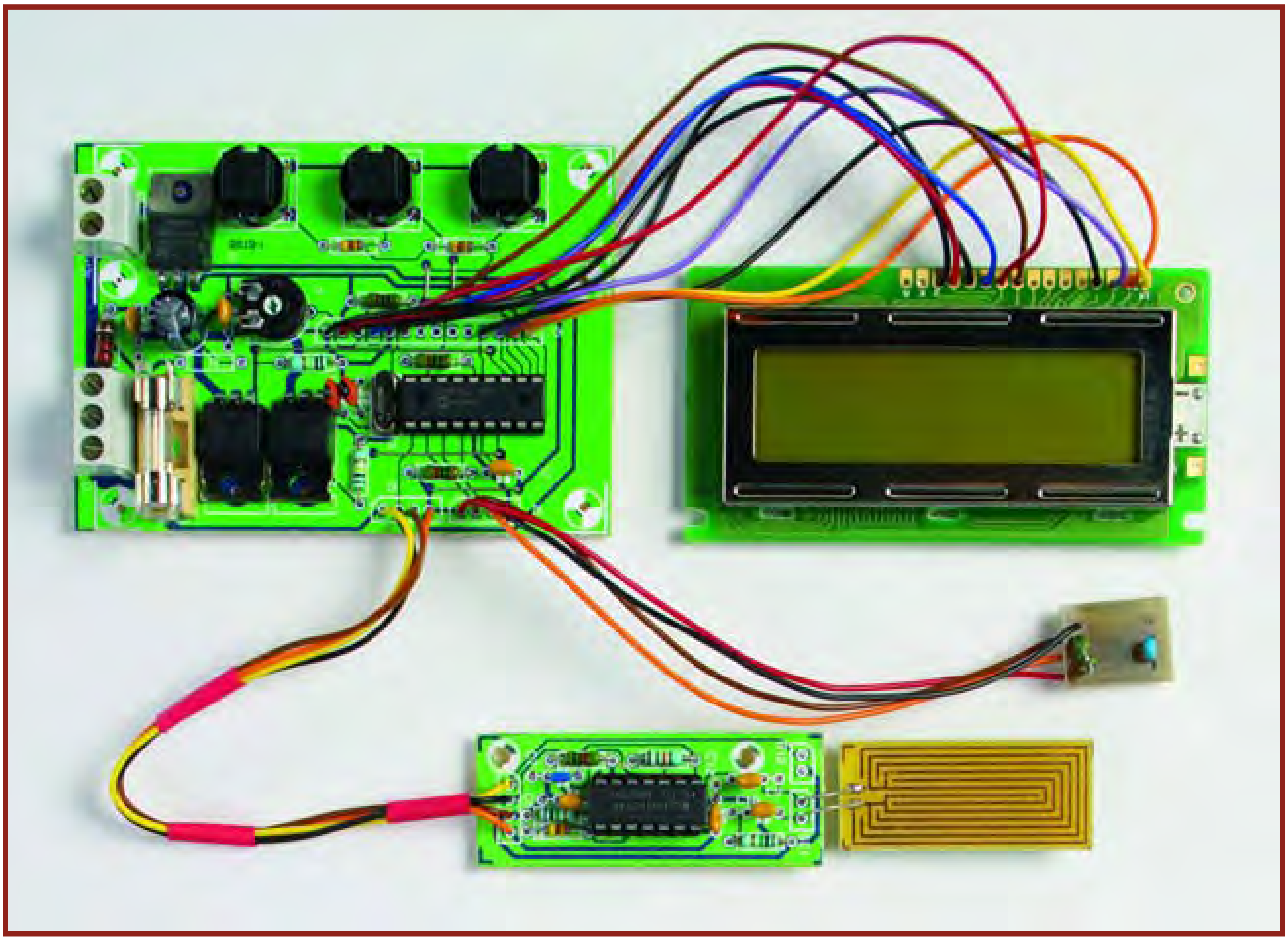


Figure 5. The construction is fairly straightforward. Remember to solder the wire-links first.

As usual we start by defining the inputs, outputs and variables. For the clock speed we've used 4 MHz. When you use the 10 MHz version you should use the *16f84_10* library instead of *16f84_4*. At switch-on the temperature setting (address 0), the last position of the window (address 1) and the bit for the operating mode (address 2) are retrieved from the EEPROM. If a temperature is read that is less than 5 or higher than 35 degrees (centigrade), it will be changed into 15 degrees. These minimum and maximum temperatures can be changed in the procedures 'readbutton_up' and 'readbutton_down'.

The procedure 'readtemp' read the temperature from the LM75 and displays it on the LC display. A counter is included in this procedure ('flash'), which is used when the word 'dry' has to be flashing on the display. There is a refresh procedure that restricts the measurement of the temperature to about twice a

COMPONENTS LIST

Resistors:
R1,R2,R3,R7,R8,R11 = 10kΩ
R4 = varistor type S14K25
R5,R6 = 100kΩ
R9 = 18kΩ
R10,R13 = 1MΩ
R12 = 100Ω 5W
P1 = 10kΩ preset

Capacitors:
C1,C2 = 27pF
C3,C5,C6,C8-C12 = 100nF
C4 = 100µF 25V radial
C7 = 10nF

Semiconductors:
D1,D2,D3 = 1N4148
T1,T2 = IRFZ34N
IC1 = LM75
IC2 = PIC16F84A-20I/P, programmed, order code **050139-41**
IC3 = not fitted
IC4 = 7805
IC5 = 4093

Miscellaneous:
L1 = 22µH miniature choke
X1 = 4MHz quartz crystal
F1 = fuse, 3AT (slow) with PCB mount holder
K1,K2,K5,K7 = 4-way SIL connector
K3 = 14-way SIL connector
K4 = 2-way PCB terminal block, lead pitch 5mm
K6 = 3-way PCB terminal block, lead pitch 5mm
K8,K9,K10 = 2-way SIL connector
S1,S2,S3 = pushbutton, 1 make contact
LCD module, 2x16 characters, e.g. order code **030451-73** (P-LED) or **030451-72**

PCB, ref. 050139-1 from The PCBShop (see www.elektor-electronics.co.uk)

Disk, PIC source- and hex code, order code **050139-11** or Free Download.

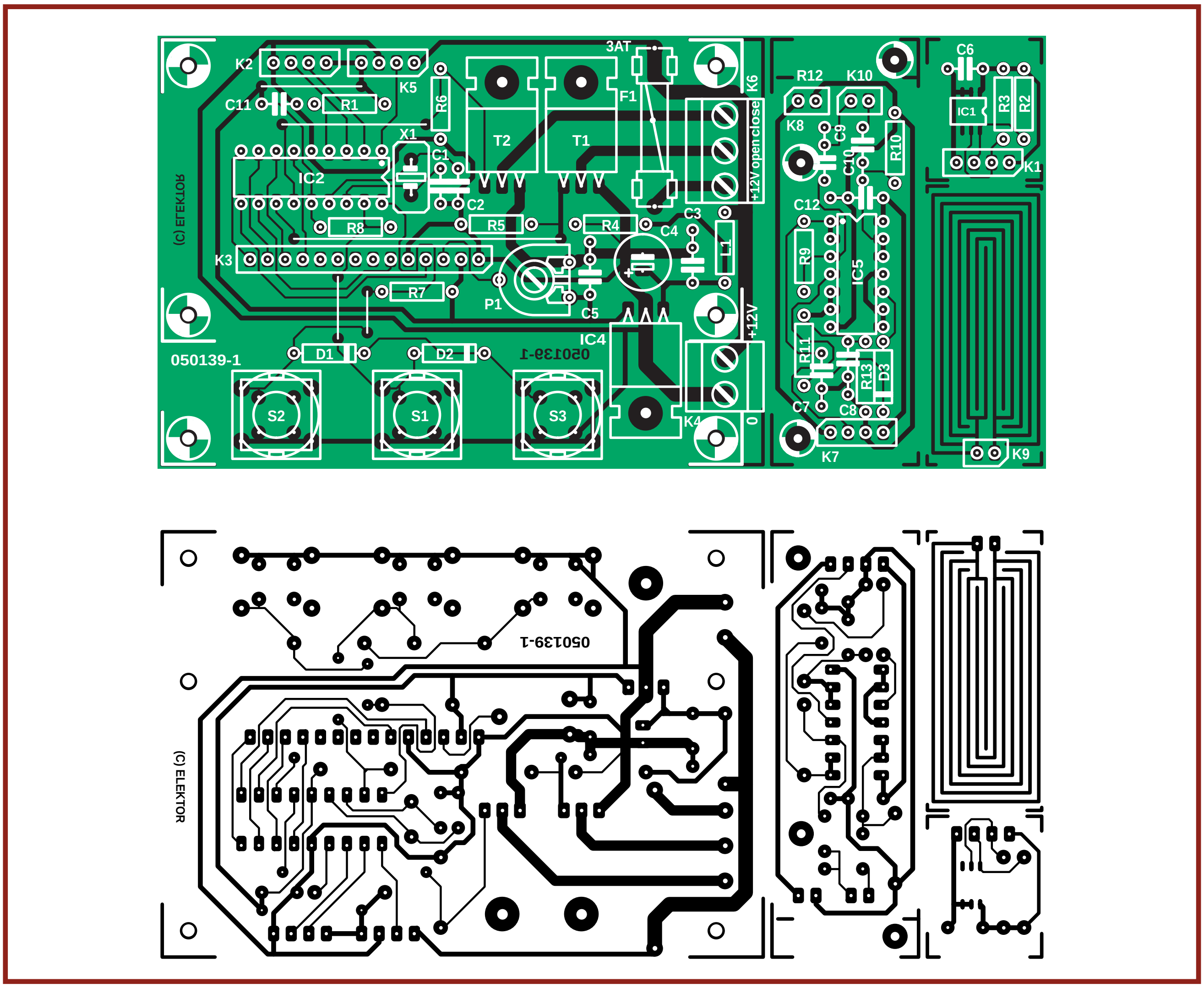


Figure 6. PCB and component layout of the attic window controller.

minute, so that the display of the temperature doesn't change so often.
The line 'd = d + 3' is to correct the temperature reported by the LM75, which in our case was 3 degrees too low. With the help of this line you can therefore calibrate your own sensor, making the temperature shown on the display the real temperature.

The controller can be in one of three states:

- 'Rain' indicates that it is raining,
- 'dry' (flashing) means that it is dry now, but it has rained in the last 20 minutes,
- 'dry' (constant) means that it has been dry for at least 20 minutes.

The variable 'dry' in the software determines the delay after the last detected raindrop. This stops the window being opened in between two showers. It is only when the set amount of time has passed ('80' corresponds to about 20 minutes), that the window is opened again (as long as the temperature isn't too low, of course).
The procedure 'keys_both' checks if the up and down buttons are pressed simultaneously (or S3). If this is the case then the mode will switch between automatic and manual. In the manual mode the window can be opened or closed at any time. The rain sensor is then ignored and the display shows 'manual' to reflect the new operating mode.
In the procedures 'open' and 'close' you can set the length of time required to open and close the window.

And finally...

Because we've used a windscreen wiper motor it doesn't matter if the programmed closing period is too long. The motor always stops at its end position due to the slip-ring, which in this case means that the skylight is closed. The 'open' time can be varied to control how far the window opens.
When the attic window controller is set to automatic the skylight will open when it is dry and the temperature is above the set value. The window closes again when the temperature drops more than three degrees below the set temperature or when it starts raining.
A lead-acid battery from a car can be used to supply the windscreen wiper motor, but it is also possible to use a PC power supply for this. The current through the motor can rise up to about 3 A, but this shouldn't be a problem for most PC power supplies.
The rain sensor should naturally be left fully exposed to the outside elements.

(050139-1)

[1] JAL: http://jal.sourceforge.net

In all mains-operated equipment certain important safety requirements must be met. The relevant standard for most sound equipment is Safety of Information Technology Equipment, including Electrical Business Equipment (European Harmonized British Standard BS EN 60950:1992). Electrical safety under this standard relates to protection from

- a hazardous voltage, that is, a voltage greater than 42.4 V peak or 60 V d.c.;
- a hazardous energy level, which is defined as a stored energy level of 20 Joules or more or an available continuous power level of 240 VA or more at a potential of 2 V or more;
- a single insulation fault which would cause a conductive part to become hazardous;
- the source of a hazardous voltage or energy level from primary power;
- secondary power (derived from internal circuitry which is supplied and isolated from any power source, including d.c.)

Protection against electric shock is achieved by two classes of equipment.

Class I equipment uses basic insulation ; its conductive parts, which may become hazardous if this insulation fails, must be connected to the supply protective earth.

Class II equipment uses double or reinforced insulation for use where there is no provision for supply protective earth (rare in electronics – mainly applicable to power tools).

The use of a a Class II insulated transformer is preferred, but note that when this is fitted in a Class I equipment, this does not, by itself, confer Class II status on the equipment.

Electrically conductive enclosures that are used to isolate and protect a hazardous supply voltage or energy level from user access must be protectively earthed regardless of whether the mains transformer is Class I or Class II.

Always keep the distance between mains-carrying parts and other parts as large as possible, but never less than required.

If at all possible, use an approved mains entry with integrated fuse holder and on/off switch. If this is not available, use a strain relief (Figure, note 2) on the mains cable at the point of entry. In this case, the mains fuse should be placed after the double-pole on/off switch unless it is a Touchproof® type or similar. Close to each and every fuse must be affixed a label stating the fuse rating and type.

The separate on/off switch (Figure, note 4), which is really a 'disconnect device', should be an approved double-pole type (to switch the phase and neutral conductors of a single-phase mains supply). In case of a three-phase supply, all phases and neutral (where used) must be switched simultaneously. A pluggable mains cable may be considered as a disconnect device. In an approved switch, the contact gap in the off position is not smaller than 3 mm.

The on/off switch must be fitted by as short a cable as possible to the mains entry point. All components in the primary transformer circuit, including a separate mains fuse and separate mains filtering components, must be placed in the switched section of the primary circuit. Placing them before the on/off switch will leave them at a hazardous voltage level when the equipment is switched off.

If the equipment uses an open-construction power supply which is not separately protected by an earthed metal screen or insulated enclosure or otherwise guarded, all the conductive parts of the enclosure must be protectively earthed using green/yellow wire (green with a narrow yellow stripe – do not use yellow wire with a green stripe). The earth wire must not be daisy-chained from one part of the enclosure to another. Each conductive part must be protectively earthed by direct and separate wiring to the primary earth point which should be as close as possible to the mains connector or mains cable entry. This ensures that removal of the protective earth from a conductive part does not also remove the protective earth from other conductive parts.

Pay particular attention to the metal spindles of switches and potentiometers: if touchable, these must be protectively earthed. Note, however, that such components fitted with metal spindles and/or levers constructed to the relevant British Standard fully meet all insulation requirements.

The temperature of touchable parts must not be so high as to cause injury or to create a fire risk.

Most risks can be eliminated by the use of correct fuses, a sufficiently firm construction, correct choice and use of insulating materials and adequate cooling through heat sinks and by extractor fans.

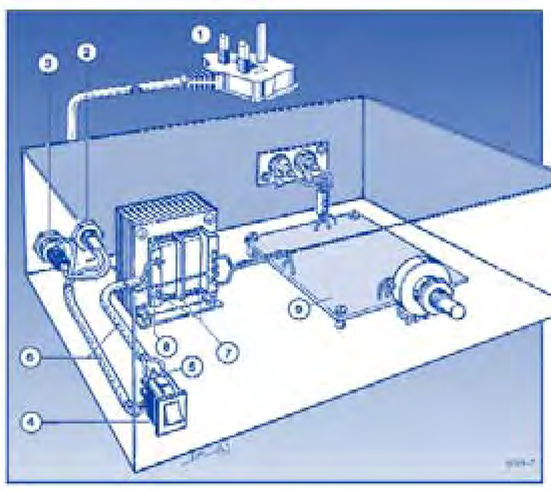
The equipment must be sturdy: repeatedly dropping it on to a hard surface from a height of 50 mm must not cause damage. Greater impacts must not loosen the mains transformer, electrolytic capacitors and other important components.

Do not use dubious or flammable materials that emit poisonous gases.

Shorten screws that come too close to other components.

Keep mains-carrying parts and wires well away from ventilation holes, so that an intruding screwdriver or inward falling metal object cannot touch such parts.

As soon as you open an equipment, there are many potential dangers. Most of these can be eliminated by disconnecting the equipment from the mains before the unit is opened. But, since testing requires that it is plugged in again, it is good practice (and safe) to fit a residual current device (RCD)*, rated at not more than 30 mA to the mains system (sometimes it is possible to fit this inside the mains outlet box or multiple socket).



1. Use a mains cable with moulded-on plug.
2. Use a strain relief on the mains cable.
3. Affix a label at the outside of the enclosure near the mains entry stating the equipment type, the mains voltage or voltage range, the frequency or frequency range, and the current drain or curent drain range.
4. Use an approved double-pole on/off switch, which is effectively the 'disconnect device'.
5. Push wires through eyelets before soldering them in place.
6. Use insulating sleeves for extra protection.
7. The distance between transformer terminals and core and other parts must be ≥ 6 mm.
8. Use the correct type, size and current-carrying capacity of cables and wires – see shaded table below.
9. A printed-circuit board like all other parts should be well secured. All joints and connections should be well made and soldered neatly so that they are mechanically and electrically sound. Never solder mains-carrying wires directly to the board: use solder tags. The use of crimp-on tags is also good practice.
10. Even when a Class II transformer is used, it remains the on/off switch whose function it is to isolate a hazardous voltage (i.e., mains input) from the primary circuit in the equipment. The primary-to-secondary isolation of the transformer does not and can not perform this function.

* Sometimes called residual current breaker – RCB – or residual circuit current breaker –RCCB.

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3-core mains cable to BS6500 1990 with three stranded conductors in thick PVC sheath

Max current	**3 A**	**6 A**	**13 A**
conductor size	**16/0.2 mm**	**24/0.2 mm**	**40/0.2 mm**
Nom cond area	**0.5 mm^2**	**0.75 mm^2**	**1.25 mm^2**
overall cable dia.	**5.6 mm**	**6.9 mm**	**7.5 mm**

Insulated hook-up wire to DEF61-12

Max current	**1.4 A**	**3 A**	**6 A**
Max working voltage	**1000 V rms**	**1000 V rms**	**1000 V rms**
PVC sheath thickness	**0.3 mm**	**0.3 mm**	**0.45 mm**
conductor size	**7/0.2 mm**	**16/0.2 mm**	**24/0.2 mm**
Nom cond area	**0.22 mm^2**	**0.5 mm^2**	**0.95 mm^2**
overall wire dia	**1.2 mm**	**1.6 mm**	**2.05 mm**

3-flat-pin mains plug to BS 1363A