PROJECT RATING 1

Kit Available
Order as 95210
Price £12.99

FEATURES

- 3-LED liquid level indicator
- Switched relay output with LED indicator
- AC or DC operation
- Remote sensor

APPLICATIONS

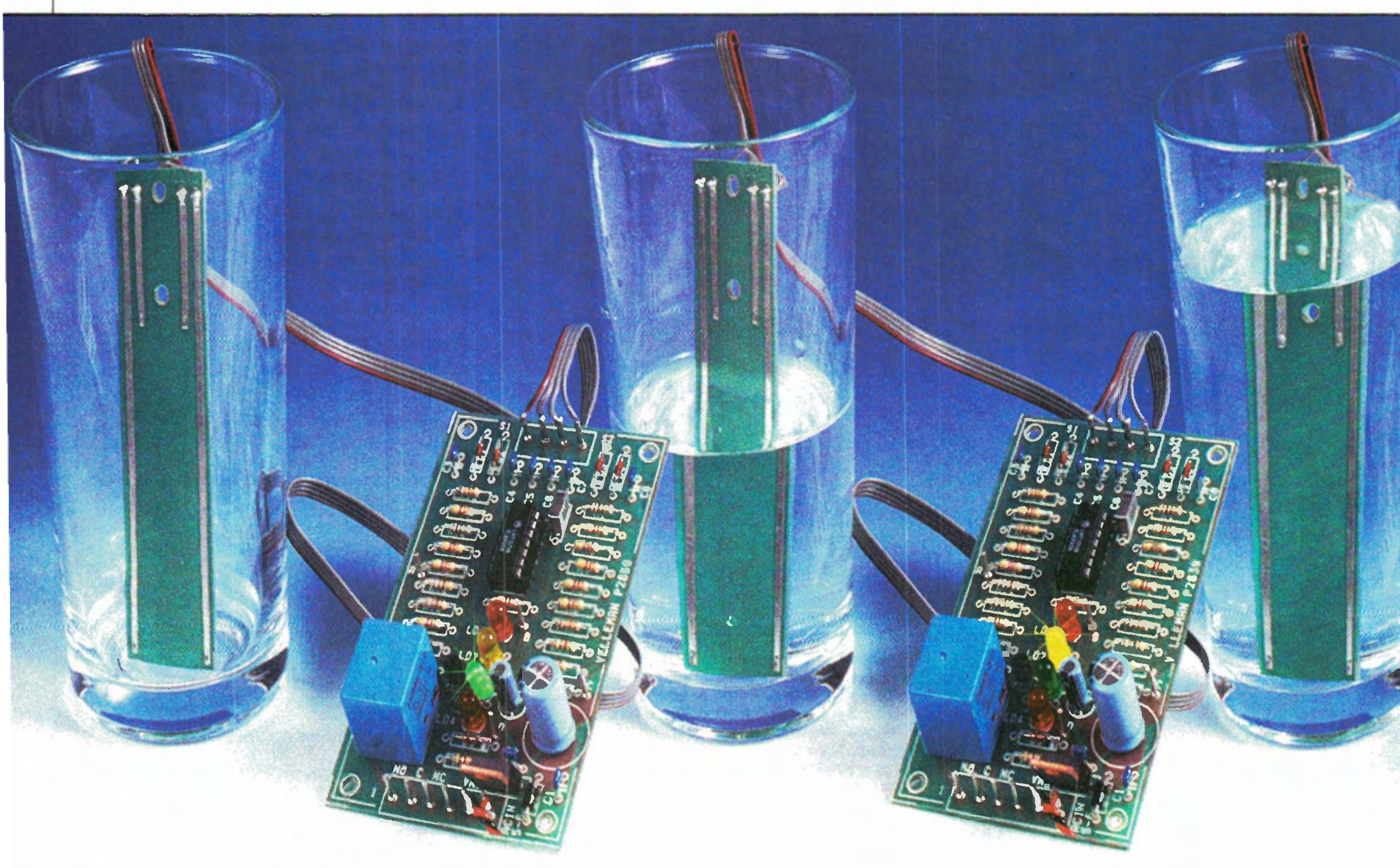
- Domestic sinks and baths
- Aquariums
- Rainwater butts/garden irrigation tanks
- Animal drinking troughs
- Water tanks

PROJECT

Liquid Level CONTROLLER

Text by Maurice Hunt

Avoid the potentially disastrous situation of water overflowing or leaking when filling up containers in the home (such as when running the bath), workplace or outdoors, by using this handy project to remotely indicate the current liquid level by means of coloured LEDs. The circuit also includes an on-board relay, which triggers when the highest liquid level indicator lights, and turns off again when the liquid level falls beyond a set level. The project can hence be used to activate an alarm, shut-off valve or pump when the container is full, or indeed, when it is almost empty. The project is capable, therefore, of being used as part of an automatic liquid level maintaining system.



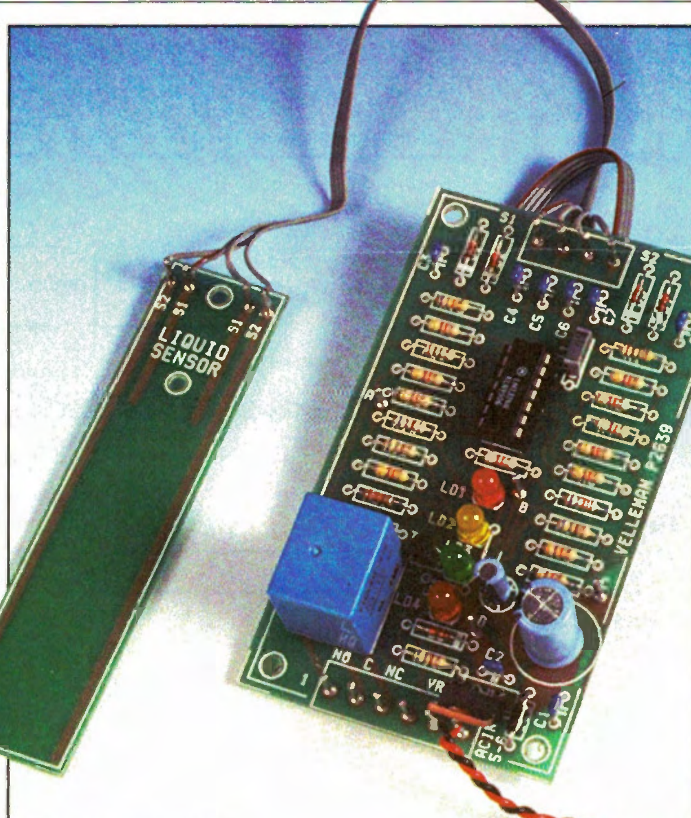
The Liquid Level Controller has many applications around the home, garden or in the workplace. Popular examples include monitoring the running of a bath while you concentrate on more important matters, an automatic aquarium topping-up system, plant irrigation, flood detection, rainfall monitoring, checking the level of water in a vehicle's windscreen washer bottle/header tank, in fact, almost anywhere that water is being contained and where the level needs to be kept in check. The circuit may also be interfaced to a computer if required, by means of the optional K2611 input card (Order Code 95207).

The kit contains all parts needed to build the Liquid Level Controller, including high quality glassfibre main board and liquid level sensor PCBs, on-board relay (with single pole, double throw – SPDT – mains rated contacts) and connection terminal pins. However, a suitable power supply will be required (see Specification table), in addition to connection cables of the required length and current rating for the chosen application.

Circuit Description

Refer to the block and circuit diagrams, shown in Figures 1 and 2, respectively. The power supply to the circuit may be DC or AC as stated in the Specification table, and D6 acts as both a half-wave rectifier (for AC supplies) or as a reverse polarity safeguard for DC supplies. C10 smoothens the half-wave rectified voltage, and acts as low-frequency decoupling if a DC supply is applied. VR1 regulates the input to give a stable 12V DC level to supply the rest of the circuit, while C1 and C2 provide high-frequency supply decoupling.

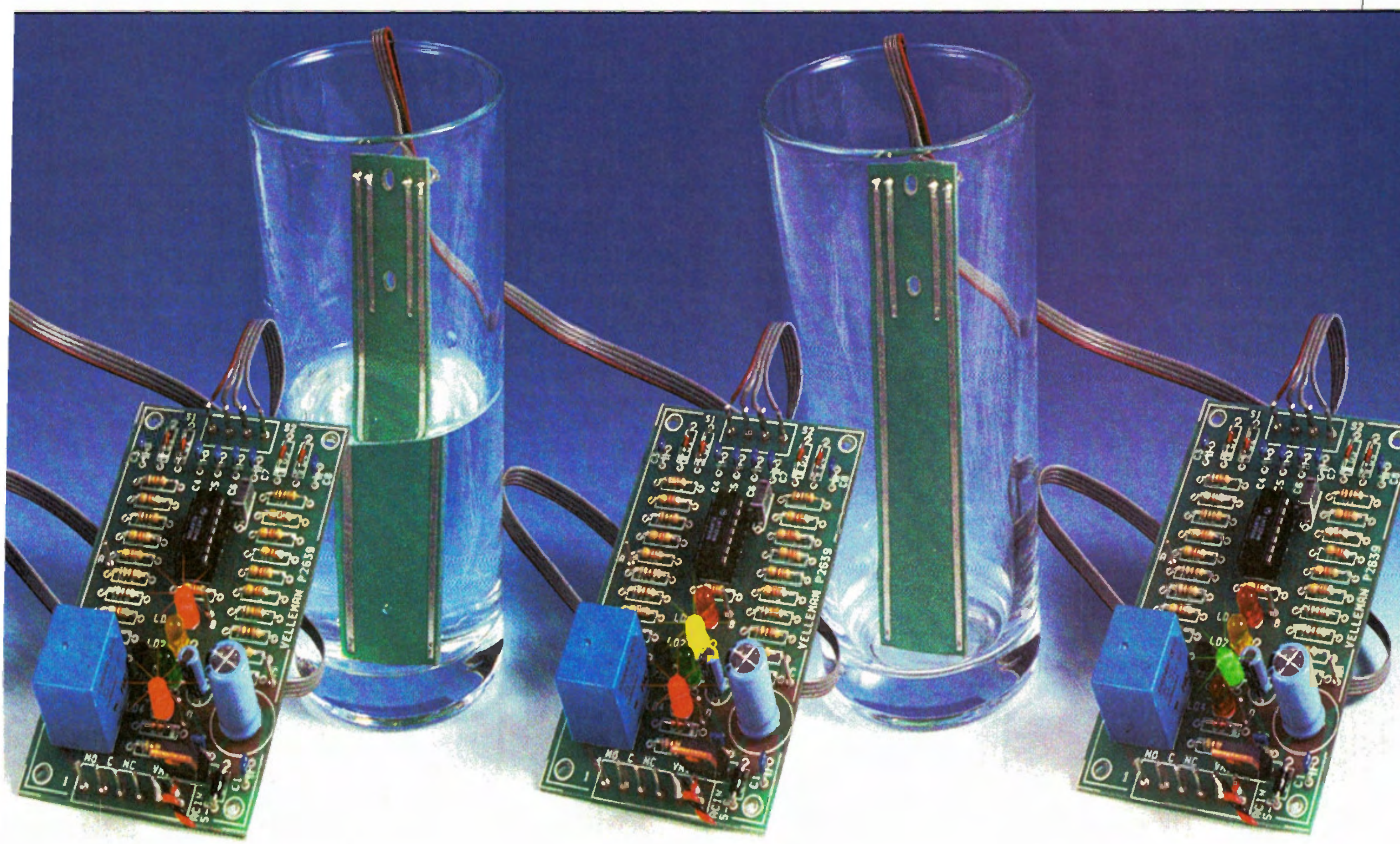
IC1 is a quad operational amplifier, all four of its amplifiers being employed in this circuit. The first amplifier is configured as an oscillator, generating a square wave signal of approximately 1kHz. This is passed via coupling capacitors C5 & C6 to the liquid level sensors. The reason behind applying an alternating signal to the sensors is to prevent the electrolysis effect that would otherwise occur if a DC voltage was present between the sensor terminals; this would lead to the build up of `gunk' on the strips on one side of the sensor, and possible erosion of the strips on the other side, with resulting unreliability of operation!



The assembled PCBs.

SPECIFICATION

Operating voltage:	12-14V AC (300mA minimum) or 16-18V DC (100mA minimum)
Operating current:	80mA mazimum
Relay output:	240V/3A AC or 125V/15A AC maximum
PCB dimensions:	104 × 60 × 23mm (assembled main board) 104 × 25 × 1·5mm (sensor board)



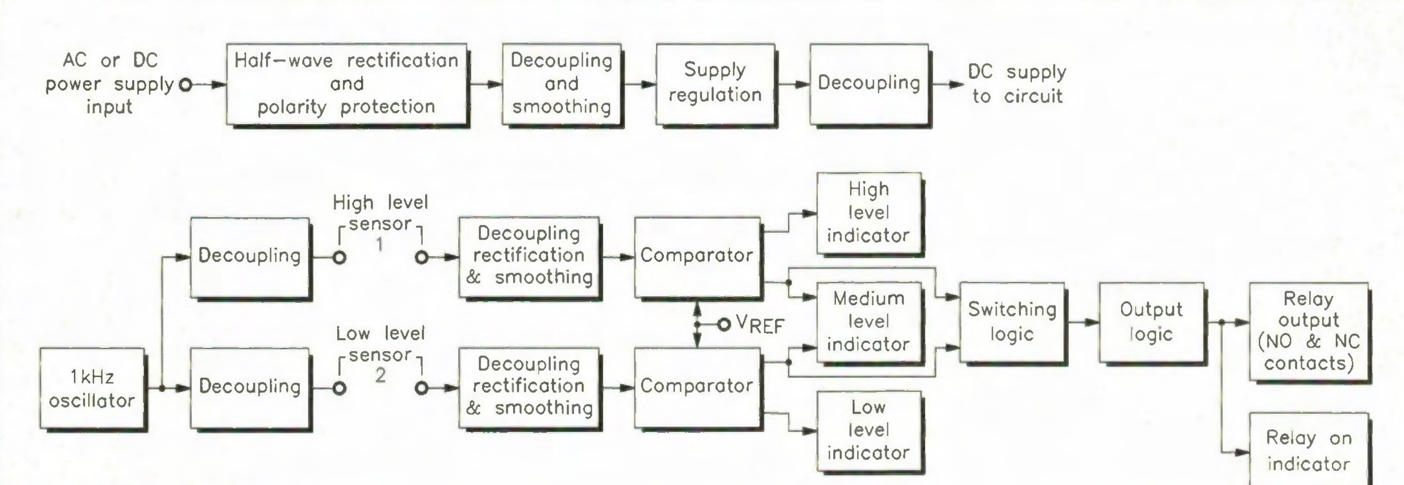
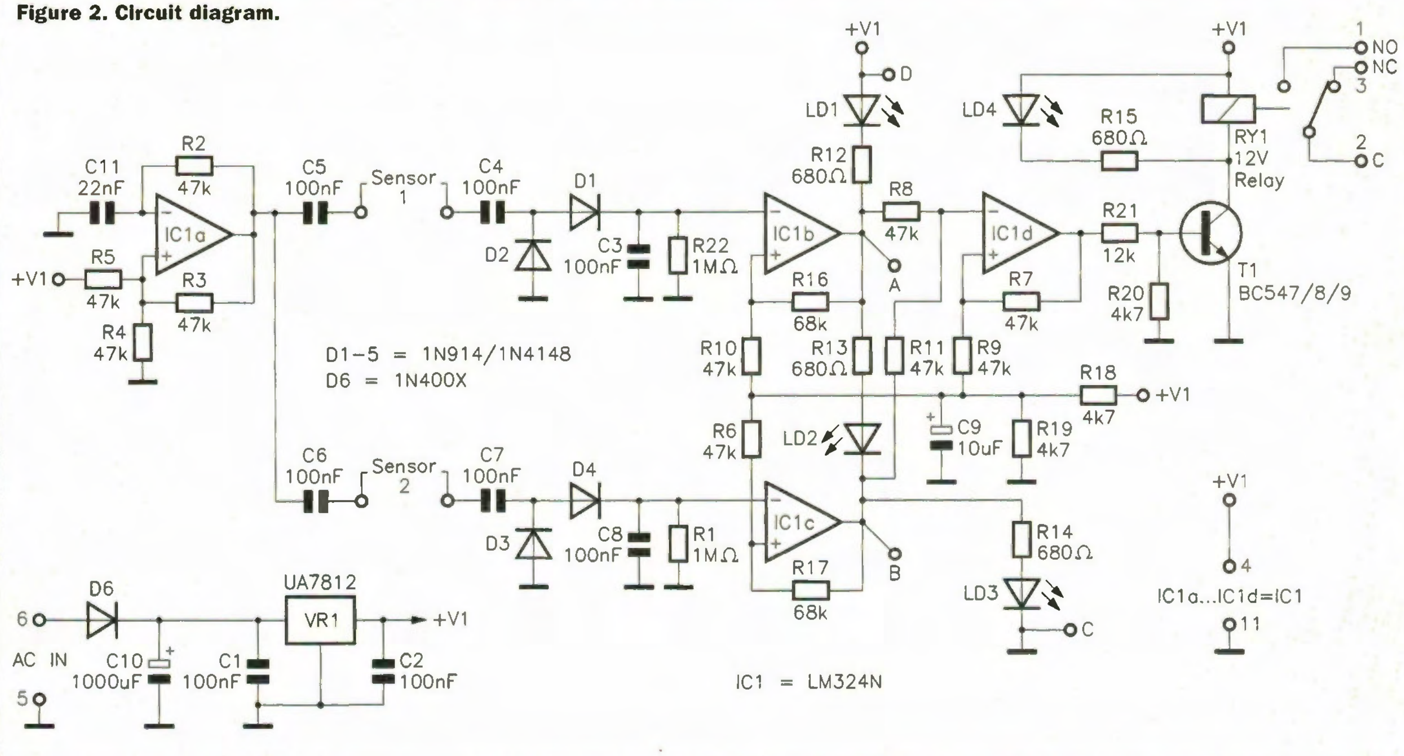


Figure 1. Block diagram.

Figure 2. Circuit diagram.



The sensors themselves comprise of parallel tinned copper strips on a separate PCB, approximately 1in. (25·4mm) long for S1 (the high level sensor), and approximately 4in. (101·6mm) long for S2 (the low level sensor). The length of these strips is unimportant – the sensor PCB can be cut down to size, or a new, longer sensor PCB could be fabricated and used instead, if required. However, the strips must be reasonably close together for the sensor to be effective – no more than an inch (25·4mm) or so apart. Note that the sensor is really designed for monitoring normal (tap) water levels; de-ionised water or other less conductive liquids may require the sensor strips to be closer together. Non-conductive liquids will not activate the circuit at all. There again, if measuring the levels of highly conductive 'liquids', such as Mercury, the strips could be yards apart and still allow successful operation!

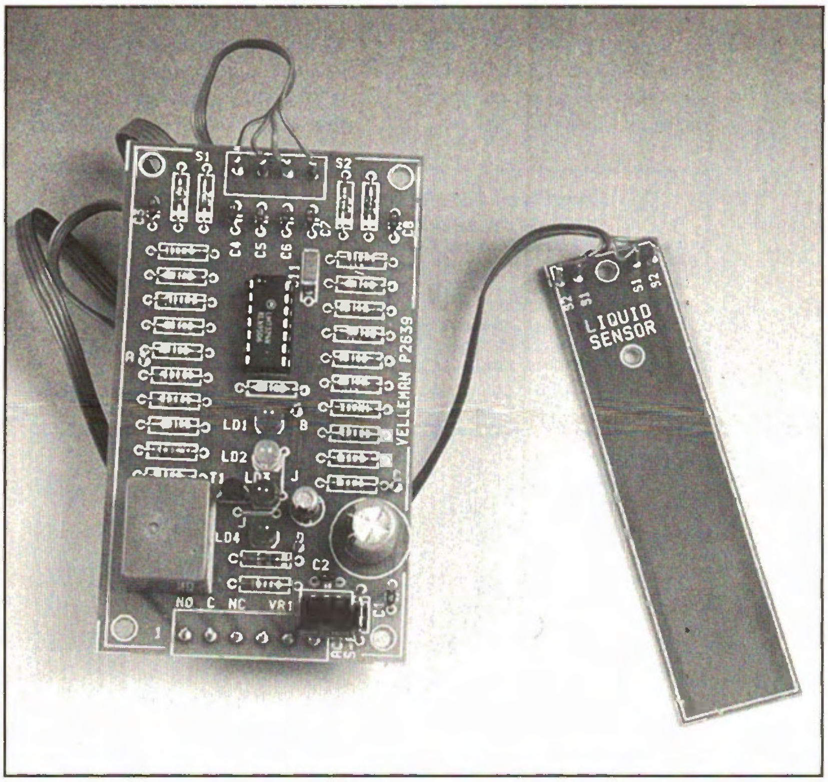
Capacitors C4 & C7 couple the signal passing across the sensor strips (in the presence of conducting liquid) to rectification and smoothing networks formed by D1, D2, C3 & R22 and D3, D4, C8 & R1. The outputs of these networks is in the form of two DC voltages, which are applied to two comparators, IC1b & IC1c. The reference voltage for the comparators is set by the resistors R6, R10 & R18. The operation of the comparators is such that their outputs are high until the DC input voltage exceeds the reference voltage (which occurs if the sensor strips are in contact with water, whereupon the outputs swing low. While the output of IC1c remains high, LED LD3 (the LOW level indicator) lights. When the output of comparator IC1c swings low, LD2 (the MEDIUM level indicator) lights, and LD3 is extinguished. When the output of comparator IC1b swings low, LED LD1 (the HIGH level indicator) lights, and LD2 is then extinguished.

The purpose of the fourth op-amp, IC1d, is to act as logic, so that when the HIGH level indicator (LD1) lights, the transistor T1 goes on, in turn switching on RELAY ON indicator LD4 and energising the relay coil, thus causing its contacts to change over.

If the liquid level then drops below the SENSOR 1 strips but still reaches the (lower down) SENSOR 2 strips, the logic causes LD4 (RELAY ON) and LD2 (MEDIUM) to remain lit and the relay energised. However, if the liquid level drops further, causing both sensors to become dry, only LD3 (LOW level) lights and the relay (and LD4) are switched off.

Diode D5 protects the transistor and LD4 from the high back e.m.f. generated in the relay coil when it de-energises. Points A-D (corresponding to the PCB pins A-D) are used if the optional K2611 Input Card is to be connected to the circuit; A is the output of comparator IC1b, B the output of comparator IC1c, C is the ground connection, and D the +V (regulated) DC connection.

The circuit operation is summarised in Table 1.



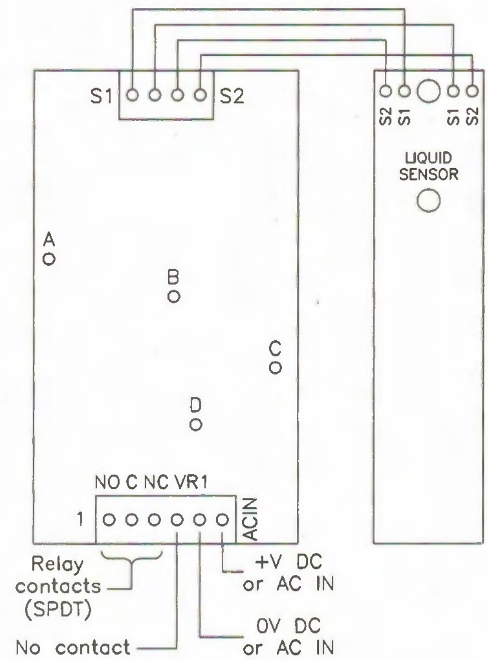


Figure 3. Wiring diagram.

Construction Details

The main board has a printed legend showing the position and orientation of the components. Assemble the board in order of ascending component height, starting with the resistors, diodes, and DIL holder (locating the end notch as per the legend). Progress through the smaller (non-polarised) capacitors, transistor, LEDs (using the colour order of your choice, noting that LD1 indicates the high level, LD2 medium, LD3 low and LD4 the relay on). Note also that the LEDs should be mounted at an appropriate height off the board, or could be mounted remotely if required, using hook-up wire to connect them to their contact points on the board.

Proceed to install the PCB pins (using the hot tip of a soldering iron to gently push them in if tight), then the taller electrolytic capacitors, voltage regulator and the relay. Install the IC into its holder last of all, with its end notch aligning with that of the holder/printed legend.

Additionally, there are four PCB pins to be fitted to the sensor PCB (if used). Having completed the board assembly, check your work for misplaced components, solder whiskers, bridges, or dry joints, then clean excess flux off the boards using a suitable solvent.

Testing and Use

Refer to the wiring diagram shown in Figure 3. Connect the sensor board to the corresponding S1/S2 terminals on the main board. The sensor board is fitted remotely from the main board, and is interconnected by ribbon cable or 4-way cable (e.g. telephone type cable), using suitable 4-way connectors if required. The length of this interconnecting cable is unimportant (within reason!).

Apply either an AC or DC supply of the correct voltage (see Specification table) to the main board; if DC, the '+' connection is to the pin nearest the legend 'AC IN', and the OV connection is to the pin next to it. If using an AC supply (such as a 300mA transformer), connect the secondary winding to the same pins as above – it does not matter which way round.

With power on (and both pairs of sensor strips dry), LD3 (the LOW level indicator) should be lit. Using either a wire link or by placing the sensor into a beaker and adding water, bridge the longer SENSOR 2 (S2) strips. LD3 (LOW level) should be extinguished, and LD2 (MEDIUM level) should now light. Now add another link, or top up the beaker with water, so that both sensor strips (S1 & S2) are bridged. LD1 (HIGH level) and LD4 (RELAY ON) should now be on, and the relay should be heard to click, confirmation that its contacts have changed over. A continuity tester could be used at this point, to check that the relay normally open (NO) contacts have now closed, to be doubly sure.

Now remove the link across S1 (the shorter sensor strips) or drain off the appropriate amount of water from the beaker using a syringe/syphon. LD2 (MEDIUM level) and LD4 (RELAY ON) indicators should be lit. Next, remove the link across the S2 strips/empty the beaker, and LD3 (LOW level) should light, and LD4 (RELAY ON) should be extinguished – the relay should also be heard to click off.

See Table 1 for clarification of the correct circuit operation. If the circuit operates as above, then it is ready for use in the chosen application. It is advisable to install the main board into a suitable sealed plastic housing to protect it – this is a MUST if an otherwise unhoused mains AC transformer is supplying the power to the circuit, or if the relay is being used to switch high voltages.

Sensor 1	Sensor 2	Output	Indication
DRY	DRY	LD3 lit	LOW liquid level
DRY	WET	LD2 lit	MEDIUM liquid level
WET	WET	LD1 & LD4 lit	HIGH liquid level; relay energised
DRY	WET	LD2 & LD4 lit	MEDIUM liquid level; relay remains energised
DRY	DRY	LD3 lit	LOW liquid level; relay de-energised

Table 1. Summary of circuit operation.

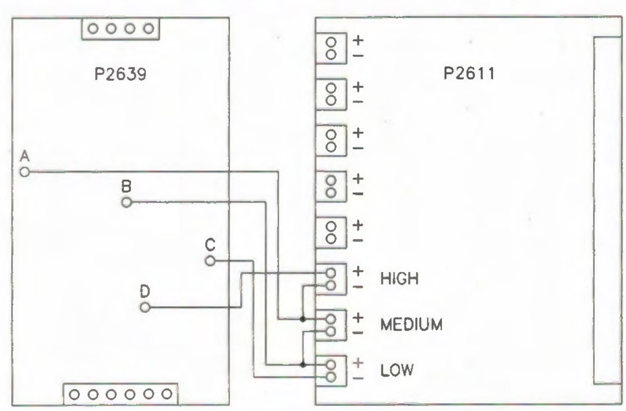


Figure 4. Wiring to K2611 Input Card.

Computer Aided Level Control

Figure 4 shows how the Liquid Level Controller can be connected to the optional K2611 Input Card (95207), to allow the unit to be interfaced to a computer. This enables the computer to be utilised to monitor liquid levels and control them efficiently. If the computer is supported by the Velleman Interface System (95208 & 95209), the K2611 Input Card can be connected via a motherboard.

Connections A-D on the main Liquid Level Controller board should be connected to the card as indicated in the diagram. Connect B with the '+' of optocoupler input 1 (LOW), and C with the '–' of input 1. Connect A and B with the '+' and '–' inputs, repectively, of input 2 (MID). Connect D with the '+' of input 3 (HIGH), and A with the '–' of input 3. If an optocoupler input appears to remain permanently high, a 3 to 6V Zener diode should be connected in series with the + of input 3. If higher resolution is required, additional Liquid Level Control units can be added to detect more than three levels. ELECTRONICS

Important Safety Note

NEVER use the sensor in an environment containing explosive gasses: when the sensor strips are dry, it is possible that very small sparks can occur on them, which could ignite pockets of combustible gas with a resultant explosion. In a chemical environment, the metal sensor electrodes can erode and/or corrode – in this case, the sensor electrodes should be formed from inert metal, e.g. inoxidable steel (inox). Take all the usual mains safety precautions if using a transformer to power the project or if the relay is being used to switch mains voltages. If in doubt, consult a qualified electrician.

PROJECT PARTS LIST

RESISTORS: All 0·5W ±5% Metal Film

R1,22	1MΩ	2	
R2-11	47k	10	
R16,17	68k	2	
R12-15	680Ω	4	
R18-20	4k7	3	
R21	12k	1	

CAPACITORS

C1-8	100nF Polyester	8	
C9	10μF 35V Radial Electrolytic	1	
C10	1,000μF 25V Radial Electrolytic	1	
C11	22nF Polyester Layer	1	

SEMICONDUCTORS

D1-5	1N914/1N4148	5	
D6	1N400X	1	
T1	BC547/8/9	1	
VR1	UA7812	1	
LD1-4	5mm LEDs (2 × Red, 1 × Yellow, 1 × Green)	4	
IC1	LM324N	1	

MISCELLANEOUS

12V DC SPDT Relay, 15A@125V AC Rated Contacts	1	
14-pin DIL Socket	1	
PCB Pins	18	
Main PCB	1	
Sensor PCB	1	
Instruction Leaflet	1	
Constructors' Guide	1	(XH79L)

OPTIONAL (Not in Kit)

K2611 8-channel Opto-coupler Input Card	1	(95207)
K2612 Intelligent Motherboard	1	(95208)
K2631 Extension Kit	1	(95209)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items are available in kit form only.

Order As 95210 (Liquid Level Controller) Price £12.99

Please Note: Some parts, which are specific to this project (e.g., PCB), are not available separately.