PROJECT

Possession Loop Alarm

Guard your possessions with this inexpensive loop alarm.

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This circuit is designed to operate in the same way as the alarms you will find in stores, where valuable items are linked together by a wire which is passed through the items and which causes an alarm to go off if the continuity of the loop is broken. Although this circuit is not as invincible as the more sophisticated systems found in the stores, it should provide sufficient security to prevent casual removal of items by the opportunist.

Theory

The heart of the circuit is a latch made up of two 2-input NAND gates in a "cross coupled" configuration. Logic circuits are so called because they have built into them a "logic" which decides what state the output of the device will be for all of the possible combinations of input conditions. Unlike other types of circuit, logic circuits operate with only two input/output voltage conditions. These are the logic "1" state which is the same as whatever the battery voltage happens to be, in other words an "On" state, or the logic "0" state which is 0 volts or an "Off" state.

The input and output states of logic circuits are usually shown in a format known as a Truth Table. For a two input NAND gate such as the ones we are using this is:

Two Input NAND Gate

In	Out
0 0	1
0 1	1
1 0	1
1 1	0

This may look slightly complicated but what is really shown is that the output of the NAND gate is in the logic 1 (on) state except for the one combination when both of the inputs are in the logic 0 (off) state.

In this circuit two 2-input NAND gates are connected into a cross coupled arrangement which makes the circuit operate so that when the available input to one gate is made to go briefly to the logic 0 state (0 volts) then the latch is triggered, going to the logic 1 state, and will remain in that state until the spare input to the other latch is made to go to the logic 0 state. The characteristic of this cross coupled gate circuit is that the two gates operate so that when the output of one of the gates is at logic 0 the output of the other gate is at the logic 1 state.

In the circuit used for this project the spare input to one of the cross coupled gates is held in the logic 1 state by being connected to the battery positive supply rail through the alarm linking wire. If this connection is broken the spare input is pulled down to the logic 0 state, by a "pull down" resistor connected to the 0 volt rail. Thus breaking this connection by attempting to remove a protected article causes the input to the gate to fall to the logic 0 state which immediately triggers the alarm.

The other input to the cross coupled gates is a circuit which provides a very short, negative pulse. This circuit automatically sets the latch to the correct state, as soon as power is applied to the circuit.

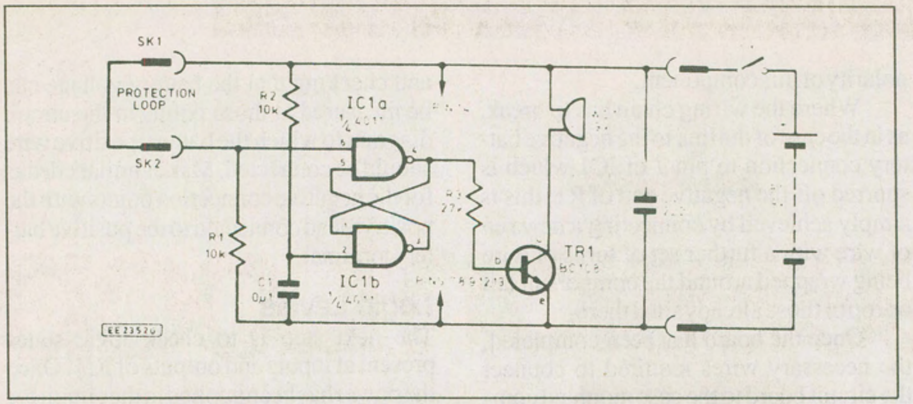

Fig. 1. Circuit diagram of the Possession Loop Alarm.

The output from the latch circuit is of a relatively low current handling capacity so the alarm is actually switched off and on by a simple transistor switch.

Circuit Description

The circuit diagram for the project is shown in Fig. 1. The latch circuit is made up of the two NAND gates IC1a, IC1b, which are each one quarter of a 4011, quad, 2-input, NAND gate. The other two NAND gates available in the 4011 integrated circuit are not used and, in order to prevent them from interfering with the operation of the circuit, their inputs are connected to 0 volts.

Resistor R1 is a pull down resistor which is attached to the input of IC1a which is not cross coupled with the output of IC1b. This input is held in the logic 1 state by being connected, through the protection link, to the positive battery voltage via the two sockets SK1 and SK2. As long as a sound connection exists between SK1 and SK2 then this input is held at the logic 1 state and the latch remains in the untriggered state.

As soon as the link through the protected possessions is broken then the state of this input falls to the logic 0 state, by virtue of it being connected to 0 volts via R1. This causes the circuit to trigger, with the outputs of IC1a and IC1b switching states so that the output of IC1a goes to the logic 1 state.

Resistor R2 and capacitor C1 form a negative pulse trigger circuit which is connected to the input of IC1b so as to reset the latch as soon as power is supplied to the circuit. Initially, with the power supply to the circuit switched off, C1 is discharged. This causes the input to IC1b to be in the logic 0 state immediately the circuit is switched on. However, as soon as power is supplied to the circuit, C1 starts to charge rapidly through R2. This causes the input to IC1b to rise to the logic 1 state. The effect of this is to cause the output of IC1a to go to the logic 0 state immediately the circuit is switched on and to remain in that state until triggered by the breaking of the circuit between SK1 and SK2.

The output from the logic circuit is capable of handling only a relatively small output current and, in order to ensure reliable operation of a loud alarm buzzer, a simple transistor switching circuit comprising TR1 and R3 is used. When a cur-

Parts List

Resistors

R1,2 ....10k
R3 ....27k
All 1/4 watt 5%.

Capacitors

C1 ....0.1u
C2 ....2u2 tantalum 10V

Semiconductors

TR1 ....2N3904, BC108, etc
IC1 4011 ....2-input NAND gate

Miscellaneous

S1 SPST key operated switch
SK1, SK2 single connection sockets (see text)
B1 9V battery plus connector
WD1 audible warning device, 9V operation

Perfboard, wire, case to suit.

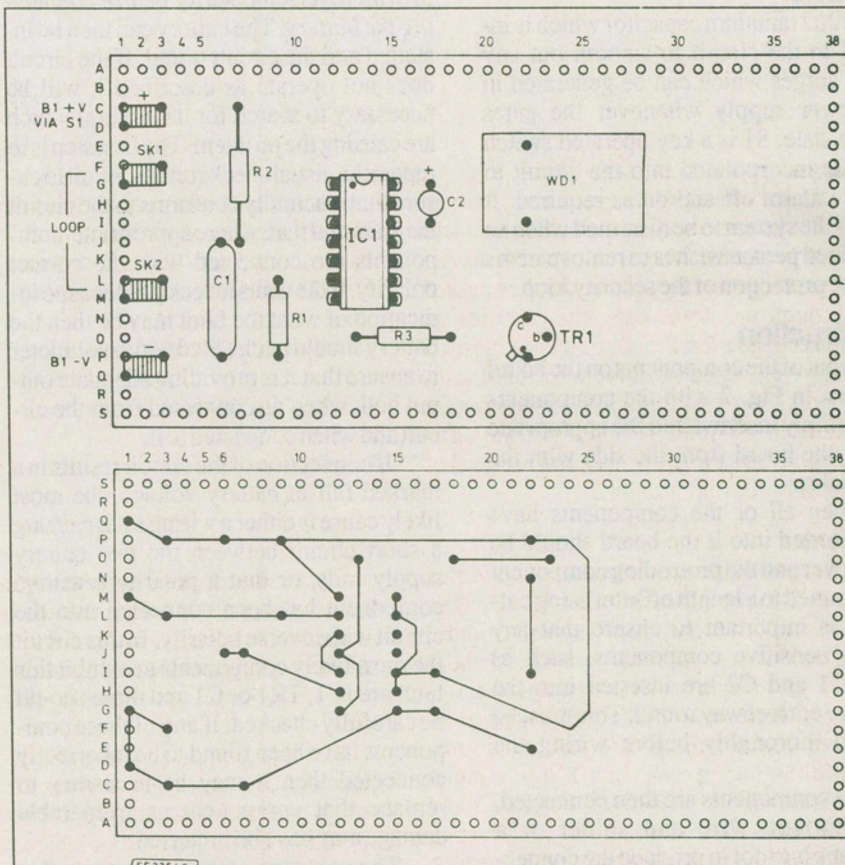

Fig. 2. Parts location and underside wiring for the Loop Alarm.

rent is allowed to flow through the base/emitter connection of a transistor it allows a much larger current to be drawn through the emitter/collector circuit. In the case of the transistor chosen the current which may be drawn through the collector/emitter circuit is approximately 150 to 200 times the current which is required to flow through the base/emitter junction in order to switch the transistor on.

A current flows through the base emitter junction as soon as the voltage between the base and emitter exceeds 0.7 volts. As the logic 1 state of the output from IC1a is equivalent to a voltage of 9 volts, R3 is included in series with the base TR1 so as to prevent a voltage in excess of 0.7 volts appearing across the base/emitter junction. If R3 were not included in the base circuit of TR1 then the action of the transistor would be to attempt to reduce the battery voltage to 0.7 volts, by dissipating the excess voltage as heat. This would cause failure of the transistor.

Capacitor

C2 is a 2u2 tantalum capacitor which is included in the circuit to smooth out any power surges which can be generated in the power supply whenever the gates change state. S1 is a key operated switch which is incorporated into the circuit to turn the alarm off and on as required. It enables the system to be disarmed when an authorized person wishes to remove items from the protection of the security loop.

Construction

The layout of the components on the board is shown in Fig. 2 with the components being simply inserted into the appropriate hole in the board from the side with the wider holes.

When all of the components have been inserted into it the board should be turned over and the protruding component tails trimmed to a length of 3mm using cutters. It is important to ensure that any polarity sensitive components, such as TR1, IC1 and C2 are inserted into the board the correct way round. This must be checked thoroughly before wiring the board up.

The components are then connected, using hookup wire and solder or a wirewrapping tool to produce the connections as shown in Fig. 3. The wiring layout has been designed on the basis that the buzzer is not polarized; if the buzzer is polarized then the wiring layout may have to be redesigned to accommodate the polarity of this component.

Where the wiring chain has to break, as in the case of the link to the negative battery connection to pin 7 of IC1 which is spurred off the negative end of R1, this is simply achieved by connecting a new run of wire with a further set of turns of wire being wrapped around the component tail on top of those already sited there.

Once the board has been completed, the necessary wires required to connect the circuit board to the case mounted components (S1, SK1 and SK2) can be prepared with the correct terminations to mate up with the on-board connectors. In the case of the end of the wire which is connected to the board this is a simple matter of crimping on the connectors with pliers to the bared end of the wire. The other ends of the wire will, however, need to be soldered onto the components.

Testing and Fault Finding

Before proceeding any further it is necessary to visually check for short circuits or components installed in the wrong places or with reversed polarity *before connecting the battery*. The battery can then be installed and the circuit tested. If the circuit does not operate as described it will be necessary to search for the fault(s) which are causing the problem. The first step is to repeat the visual checks on the circuit to ensure that it actually conforms to the circuit diagram and that, where appropriate, components are connected with the correct polarity. If the visual check produces no indication of what the fault may be then the battery should be checked with a voltmeter to ensure that it is providing adequate output both when disconnected from the circuit and when connected to it.

If connection of the circuit results in a marked fall in battery voltage, the most likely cause is either a wiring fault causing a short circuit between the two battery supply rails, or that a polarity sensitive component has been connected into the circuit with reverse polarity. In this circuit the most likely components to exhibit this fault are IC1, TR1 or C1 and these should be carefully checked. If any of these components have been found to be incorrectly connected then it may be necessary to replace that component as irreparable damage may have been caused.

The next step in fault finding on this circuit is to check that the battery voltage is measured across all of the correct points in the circuit. This is most easily checked by connecting the negative lead of the voltmeter to the negative input connection and checking that the battery voltage can be measured at those points in the circuit diagram to which the battery positive wire should be connected. Make similar checks for the negative connection points with the positive lead connected to the positive battery terminal.

Logic Levels

The next step is to check logic states present at inputs and outputs of IC1. Once the power has been applied to the circuit for long enough for C1 to charge then pin 2 of IC1 should be a the logic 1 (9V) state. If this point is found to be at the logic 0 (0V) state then the most likely causes are: a short circuit in or across C1; a poor connection between the positive power supply rail and the positive end of R2; a poor or missing connection between the negative end of R2 and the positive end of C1; or a poor or missing connection between the junction of R2 and C1 with pin 2 of IC1.

A similar check should be carried out on the logic state at pin 6 of IC1. With a sound connection between SK1 and SK2 the state of pin 6 should be at logic 1 but this should fall to the logic 0 state when the link between SK1 and SK2 is removed. If this does not happen then the connections between SK1 and the positive power supply rail and those between SK2, R1 and pin 6 of IC1 should be checked, as should the voltage present at the negative end of R1, which should remain at 0 volts in all circumstances.

The output states of the two gates at pins 3 and 4 of IC1 should also be checked. These two pins should always be at opposite logic states with pin 4 being at logic 0 if the circuit is switched on with the protective link intact and going to the logic 1 state as soon as the connection between SK1 and SK2 is broken. If this does not occur then the connections between pins 3 and 5 and between pins 1 and 4 of IC1 should be checked. Pins 7, 8, 9, 12 and 13 of IC1 should also be checked to ensure that they are at the logic 0 state.

If the logic states of the inputs are correct but the logic states of the output are not then a check for short circuits across or between pins 3 and 4 and their neighbours should be made. If no problem is found with these connections then it is most probable that the IC is faulty and it should be replaced.

Buzzer

If the output states of IC1 check out correctly but the buzzer does not sound when pin 6 of IC1 is in the logic 1 state then the transistor output circuit should be checked. To test the buzzer it is necessary to briefly short out the emitter and collector of TR1 which should cause the buzzer to sound. If this does not occur then the connections from the positive power supply rail through the buzzer to the collector of TR1 and between the emitter of TR1 and the negative power supply rail should be checked. If these connections are sound and the polarity of the buzzer (if any) is correct but the buzzer does not sound then the buzzer should be removed from the circuit and tested independently across the disconnected battery.

If the buzzer sounds when the emitter and collector of TR1 are shorted out but does not sound when the output of IC1a goes to the logic 1 state, then the connections between pin 4 of IC1 and the base of TR1 through R3 should be checked to ensure that they are sound. When the output of IC1a is in the logic 1 state, the battery voltage (measured with respect to the negative power supply connection) should be measurable at the top of R3 and approximately 0.7 volts should be measurable both at the negative end of R3 and at the base of TR1.

If no voltage is measurable at the base of TR1, but the battery voltage is measured at the end of R3 which is connected to pin 4 of IC1, then the resistance of R3 should be measured to make sure that it is correct. If all is correct but either no voltage is measurable between the base and emitter, or a voltage of 0.7 volts or more is measurable between the base and emitter of TR1, but the buzzer does not sound then it may be assumed that TR1 is faulty and should be replaced.

Housing

This circuit must be enclosed in a case in order to prevent unauthorized tampering which might destroy its effectiveness. Ideally the switch S1 should be mounted in an easily accessible position with the sockets SK1 and SK2 similarly mounted where the wire protection loop may be easily disconnected or connected by an authorized person. It is, however, important when selecting SK1 and SK2 to ensure that it is not possible for SK1 and SK2 to be shorted out without the unit being turned off.

Once a suitable case has been obtained then the necessary holes must be made to mount SK1, SK2 and S1. It will also be necessary to consider how the case can be securely attached to a suitable surface so that it may not be removed along with the possession it is intended to protect. If necessary drill suitable mounting holes in the case.

Once the enclosure has been prepared then the case mounted components can be installed along with the circuit board and the case mounted components connected to the board. The circuit should be tested once more to ensure correct operation before the lid is screwed shut and the alarm used in earnest.

In Use

To use the Possession Alarm it is necessary to securely fix the device to a suitably immovable part of the building or a heavy piece of furniture close to the articles you wish to protect. A single conductor wire is then connected between SK1 and SK2, threaded through holes in the devices or equipment that you wish to protect.

Once the loop of wire is in place, the key switch can be turned on. As long as the connection between SK1 and SK2 remains intact the alarm will not sound. As soon as the circuit is broken then the buzzer will sound and remain on until either the battery wears out or the alarm is switched off by turning the key switch. ■