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COMPONENT SUPPLIES

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We advise readers to check that all parts are still available before commencing any project.

PIC CONTROLLED INTRUDER ALARM

JOHN BECKER

A sophisticated multi-zone intruder detection system that offers deluxe monitoring facilities.

WHEN Editor Mike suggested that the author might be interested in designing a PIC controlled intruder alarm, the suggestion was accepted in the knowledge that to do the job properly would make a worthwhile challenge.

The author has designed alarms before but none having the sophistication that appeared possible through using a PIC microcontroller. It seemed that an ideal system should have the features itemised in Panel 1.

It is believed that all the requirements listed in the Panel have been met in this design. How they are implemented will be discussed as we progress.

CONCEPTUAL LOGIC

Designing an intruder alarm system is based on the simple Boolean logic concept that a sensor's switch contacts can be either open or closed. If the contacts are found to be in the opposite condition to that in which they should be (e.g. open when they should be closed), then an alarm condition exists and appropriate action should be taken.

Everything else follows on from this logical argument but, as is illustrated through Panel 1, there are many factors that make a considerable difference between a 1-gate circuit that simply detects an open-closed condition and a *system* that provides a great many other security aiding facilities as well (there are around 1900 program commands in the controlling software for this design).

CIRCUIT DIAGRAM

The main circuit diagram for the PIC Controlled Intruder Alarm is shown in Fig.1. The principal functions are as follows:

Main Zones

PIC16F877 microcontroller IC1 is in charge of the entire system. Via port pins RD0-RD3 and RC0-RC3, which are used in input mode, the PIC can monitor between one and eight sensor zones, plus an extra "Panic" zone via RB4. The quantity is selected by the user and can be changed at any time. Zone detection will be discussed shortly.

Alarm Outputs

Four audio/visual alarm control outputs are provided, three via pins RE0-RE2, and one via RB5. When activated, these pins go high and are specifically intended for driving an internal buzzer (RE0), external strobe (RE1), external bell (RE2) and any device of the user's choice (RB5). As will be discussed in relation to Fig.3, the outputs can activate these devices (depending on their type) either directly, or via power transistors TR1 to TR4.

In any alarm condition, the bell, strobe (if fitted) and buzzer are all activated. The bell remains active for a period preset (and automatically stored) by the user through the software, with a maximum duration of 20 minutes. The software prevents the bell from restarting again, irrespective of further unauthorised zone entries (but see Panic Switches later).

Once activated, the alarm system can (normally – also see later) only be reset by keying in the correct PIN code.

Display

A liquid crystal display (l.c.d.) module, X2, is controlled via pins RA0-RA5 operated in output mode. Pin RA4 is an open-collector output and is biased high to the +5V power line via resistor R2. The l.c.d. displays a variety of messages in respect of the several control and status modes that can be selected via the pushbutton keypad(s). It is used in conventional 4-bit control mode and its contrast is adjustable via preset VR1.

Keypad(s)

The main control of the system is accessed via a standard 16-key alphanumeric "data entry" keypad, S1, through which a unique 4-digit alphanumeric personal identity (PIN) code has to be keyed. There are 28560 permutations ($13^4 - 1$). The status of the keypad's pushbutton keys is monitored via port pins RC4-RC7 used in output mode, and RB0-RB3 used in input mode. Port B's internal "light pull-ups" are activated in the software and additional biasing resistors for RB0-RB3 are not needed.

Facilities for the use of an optional second 16-key keypad, S2, are provided, for reasons discussed later. Four of its pins share pins RC4-RC7 with keypad S1. The others are monitored by pins RD4-RD7 used in input mode, with logic-high biasing provided by resistors R3 to R6.

Prototype PIC Controlled Intruder Alarm showing control board, main function selecting keypad and l.c.d. display, but excluding entry sensors and alarm sounders etc.

PANEL 1: PIC Controlled Intruder Alarm Features

- Monitors between one and eight entry/exit points (zones) of a building or room
- Allows monitoring to be totally or partially suspended when required by the legitimate guardians (users) of the premises
- Indicates audibly (e.g. bell) and/or visibly (e.g. strobe) when one or more zones have been entered without authority
- Turns off activated bell after a preset period to prevent annoyance to neighbours
- Allows timed zone entry/exit (time-out) for users without triggering the full alarm
- Allows full monitoring of required zones once time-out has ended
- Allows users to terminate time-out procedure
- Allows users to control the monitoring system by means of a unique alphanumeric personal identity code (PIN) entered via a keypad
- Allows users to change the PIN code
- Allows users to access the control system without using a PIN code in the event of system failure or servicing
- Normally powered from a mains power source
- Instantaneously switches over to being powered by a heavy duty back-up battery if mains power fails
- Keeps the battery fully charged when mains power is present (the battery should be capable of keeping the monitoring system and any activated alarms operational for a reasonable period)
- Allows the system to resume active monitoring should power totally fail but subsequently resume
- Indicates that there has been a total power failure even after power has been resumed
- Prevents the bell from being activated when power is resumed
- Indicates for later viewing whether zones have been entered, even though there may also have been a power failure and resumption

- Allows monitoring of fewer zones than are available
- Automatically recognises whether a sensor should be monitored for an open circuit or a closed circuit
- Allows open circuit or closed circuit sensors to be used without system modification
- Recognises that a sensor is incorrectly open or closed prior to monitoring being activated and indicates which sensor is incorrect (i.e. door open when it should be closed)
- Allows users to preview zone sensor status
- Allows the bell-on time to be set for a shorter period than the 20 minutes permitted in the UK
- Prevents the bell-on time exceeding the UK limit
- Allows users to check the system by means of indicator lights without activating the bell (etc.)
- Allows indicator lights to display the status of the power supply and bell (etc.)
- Provides anti-tamper warning of interference with the system
- Provides a "Panic" button that immediately activates the bell (etc.) even if the system is not set for full zone monitoring
- Provides "passive" advice (e.g. buzzer) that a zone has been entered even if the system is not set for full monitoring, and for the advice to be terminated once the zone has been vacated (e.g. to monitor shop-door opening/closing)
- Accepts all conventional types of switched-output commercial sensor, including magnetic catches, pressure pads, passive infra-red (PIR) devices, vibration detectors, etc., and for any mixture of these to be used
- Provides an optional slave keypad with separate PIN for additional access to a selected zone
- Inherently stable and most unlikely to be triggered except via the installed sensors
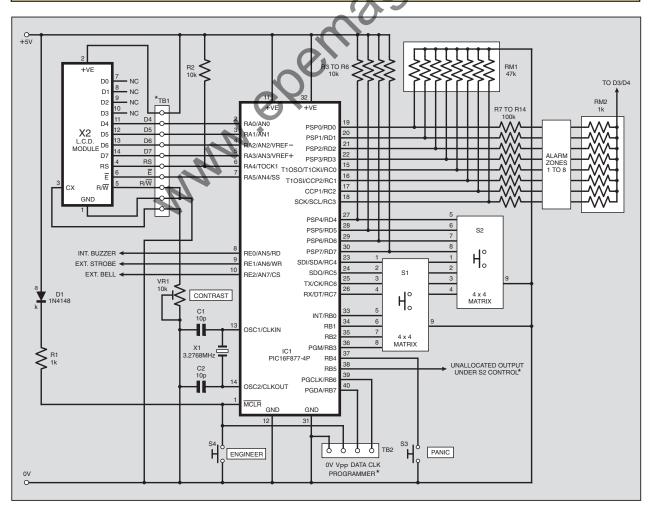- Inexpensive to construct

Fig.1. Main control unit for the PIC Controlled Intruder Alarm.

Immediate Panic

Port pin RB4 can be used as an alternative to using one of the eight main zones for "Panic" switch monitoring. The pin is used in input mode (internal pull-up activated) and when "Panic" switch S3 is pressed to short this pin to the 0V line, an "interrupt" is generated in the PIC and a flag is set.

In response to this flag, the software triggers the full alarm system, bell, strobe and buzzer (see Unauthorised Entry later). This occurs whether or not the rest of the alarm is in active or passive mode. The flag is then reset. The bell-on time is subject to the normal bell-on time-out, but also see later.

Timing

The PIC is operated at 3·2768MHz, as set by crystal X1. It is this rate which determines the accuracy of the software clock that controls the bell-on duration and entry/exit timing. In order to comply with the allocated timings, a different frequency *must not* be used with this design.

PIC Programming

During development, the author programmed the PIC via his *Toolkit TK3* system (Oct/Nov '01) and terminal block TB2. Resistor R1 and diode D1 allow correct operation of the MCLR pin during and after programming.

This facility may be used by those who wish to program their own PIC *in situ*. Pre-programmed PICs are available as stated later.

POWER SUPPLY

The design is intended to be mains powered with battery back-up. Referring to Fig.2, mains transformer T1 provides a 12V a.c. secondary output at about 1A. This is rectified by REC1 and smoothed by capacitors C3 and C4.

Light emitting diode (l.e.d.) D2, buffered by resistor R15, provides a power-on indication when a voltage of about 18V d.c. is present across C3. A mains input fuse is not used but could be included if preferred.

The raw d.c. voltage is fed to regulator IC2 whose nominal 12V d.c. output can be adjusted upwards by preset VR2. The intention is to set IC2's output voltage to the level that best suits the charging of the external 12V back-up battery, typically about 13·5V.

Current at the required voltage is fed to the back-up battery via diode D3, which prevents the battery from discharging back into IC2 during a mains power failure.

The voltage at the D3/battery junction is fed via diode D4 to provide approximately 12V d.c. to power external sensor and alarm warning devices, up to a total current of about 900mA (allowing a reasonable "headroom" for battery charging currents and that required by the control board).

Fuses FS1 and FS2 prevent transformer overload and battery discharging in the event of a short circuit between the 12V and 0V lines. It is recommended that panel mounting fuseholders are used.

The voltage at the D3/D4 junction is regulated down to +5V by IC3. This provides power for the PIC microcontroller IC1 and l.c.d. X2, neither of which must be powered at a higher voltage. The presence of an output voltage from IC3 is displayed by l.e.d. D5.

ALARM DEVICES

As previously said, there are four outputs through which the PIC can activate external alarm devices, either directly or indirectly, depending on their type.

Fig.3. Circuit diagram for alarm output device drivers.

The PIC is capable of supply 25mA from each output pin, but it has a maximum *total* output current capability of 200mA (which must not be exceeded).

The 25mA current is capable of directly driving a warning buzzer, of the type that has its own in-built oscillator. It could also trigger alarm devices such as bells or strobes that have their own control circuit built in to them.

Most external devices, though, are likely to require driving at voltages and currents greater than the PIC can supply. For this reason, each of the RE0-RE2/RB5 outputs are connected to power-Darlington transistors, TR1 to TR4, as illustrated in

Fig.3. Each transistor is capable of sinking 1A sourced from the 12V d.c. power line, but remember that this line can only supply about 900mA, as said earlier.

Because of the way in which the software is written, external audio/visual alarm devices should only be connected in the order shown. The buzzer is frequently used to indicate a variety of functions, such as keypad presses, to indicate that entry/exit timing is in progress, and that an entry has been made if the "passive" mode is in operation.

The buzzer is also activated, along with the strobe and bell, in the event of an unauthorised intrusion being detected when the system is in full monitoring mode. The bell is automatically turned off after a preset delay via line RE2 and transistor TR3. The strobe and buzzer, though, remain active until an authorised user resets the alarm.

The auxiliary output option controlled via line RB5 is only activated for the maximum period that has been set for it, more later.
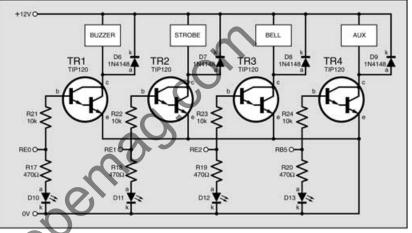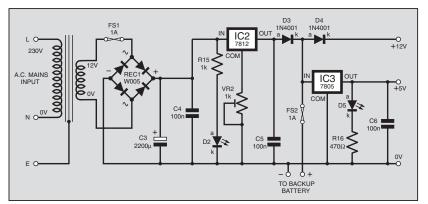
In addition to controlling their respective transistors (if installed), the four output lines each have an l.e.d./resistor pair. The l.e.d.s are turned on whenever the respective PIC line is high, regardless of whether a transistor is also connected to that output.

Each transistor has a diode connected between its collector and the 12V line. This is to inhibit back-e.m.f. pulses in the event that an inductive load is being driven via the transistor. It is permissible to control solenoids or relays.

INTRUSION DEFINITIONS

Returning to zone intrusion sensing via pins RD0-RD3 and RC0-RC3, refer to Fig.4.

This shows the equivalent circuits for the zone components when used with sensors that are normally-open or normally-closed. To clarify a possible source of confusion, the following definitions are used in this text:

Normally-open means any sensor which when in its normal required active state when monitoring an entry/exit point has its contacts in an *open* condition (see Fig.4a). Devices that work in this context of normally-open include pressure pads which require, for example, someone to tread on them in order to trigger the alarm system.
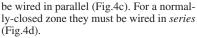
Normally-closed means any sensor which when in its normal required active state when monitoring an entry/exit point has its contacts in a *closed* condition (see Fig.4b).

Fig.2. Power supply circuit diagram.

Devices that work in this context of normally-closed include magnetically-operated switches secured either side of two adjacent sections on a door and its frame. The proximity of the magnet when the door is closed keeps the switch contacts closed. When the door is opened, the contacts open and so the alarm is triggered.

When ordering components for your alarm system it is important to understand these descriptions in relation to this design. Such terms have been known to create considerable confusion in the past. Hence our defining them now!

ZONE CIRCUIT LOGIC

In Fig.4, sensors are inserted into resistor networks as shown. In Fig.4a, with the sensor in a normally-open condition, the voltage at the junction of the 100k and 47k resistors is 0V, and monitored as such by the PIC.
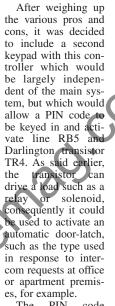

Fig.4. Zone intrusion sensor logic options.

If a zone is intruded, the sensor's contacts close and the voltage across the component series becomes the voltage at the output of diode D4, about 0·7V below that present at the battery, nominally 12V. The voltage actually fed to the PIC is that set by the potential divider values and will vary depending on the voltage across the divider.

Providing the input voltage is above $0·7V_{DD}$ ($5V \times 0.7 = 3·5V$), the PIC will recognise it as logic 1. The battery voltage can probably drop to as low as 10V and the PIC should still receive an input voltage recognisable as logic 1.

In Fig.4b, with the sensor in a normally-closed condition, the voltage at the junction of the 100k and 47k resistors is recognisable as logic 1 (see previous paragraph). If a zone is intruded, the sensor's contacts open and the voltage fed to the PIC falls to 0V.

The 1k resistor in the chain protects the 12V power line in the event of the sensor's cable being cut and shorted to 0V. It was felt to be unreasonable to attempt to protect the system against very high voltages being maliciously applied across sensor cables.

Several sensors may be used in each zone. For a normally-open zone they must

be wired in parallel (Fig.4c). For a normally-closed zone they must be wired in *series* (Fig.4d).

Do not mix normally-open and normally-closed sensors in the same zone.

KEYPADS

The first of the keypads, S1, is for keyed control of the total alarm system, including responding to a unique PIN code when keyed-in, rejecting any code that is not recognised.

Facilities for a second *optional* keypad, S2, have been included following a reader's request. During development of this alarm system, David Mynatt of Manchaca, Texas, emailed us to say that he wished to instal a system that would allow his (presumably responsible) children to let themselves into the house by use of a coded keypad or similar technique, and could we help.

After weighing up the various pros and cons, it was decided to include a second keypad with this controller which would be largely independent of the main system, but which would allow a PIN code to be keyed in and activate line RB5 and Darlington transistor TR4. As said earlier, the transistor can drive a load such as a relay or solenoid, consequently it could be used to activate an automatic door-latch, such as the type used in response to intercom requests at office or apartment premises, for example.

The PIN code required for keypad S2 is initially set via keypad S1 as part of the main system. In operation though, keying the correct PIN into S2 directly activates TR4. A countdown is started at that instant and TR4 remains on for a period which can be previously set as required via the main system. During this time the buzzer on line RE0/TR1 is also activated.

At the end of the preset period, the buzzer and TR4 are turned off again.

This secondary control is not tied into the main zone sensing system. If the secondary entry time-out period is not met, for example, the main alarm system is not triggered.

However, secondary entry could be made to tie in with the main system as well, by treating this entry zone as an alarm zone with its own separate sensor.

This would require, therefore, David Mynatt's children to enter their own PIN on keypad S2 (installed in a porch outside the main entry door, for example). This could cause the main latch to open, but once the door itself were open, would activate the countdown timing of the main system's "authorised entry" mode. The children would thus need to use the household's main PIN to deactivate the alarm within its allocated entry time.

It would be permissible, but perhaps unwise from a security point of view, to give the same PIN code to both keypads.

PANIC SWITCHES

As referred earlier, two options for "Panic" switches have been included. The first can be made using Zone 8, which is never allowed to be turned off through the software. A normally-open or normally-closed pushbutton switch can be used, mounted at a strategic location. When the switch is pressed, changing the status of its contacts, an alarm condition is sensed and the full bell, strobe, buzzer system is activated, as with other zones, with the bell still subject to time-out and non-retriggering.

The other option is via pin RB4. This is normally held high via its internal pull-up resistor. When normally-open pushswitch S3 is pressed, the pin is shorted to 0V. Again an alarm condition is sensed and acted upon. In this mode the bell is still subject to the preset time-out period, but can be reactivated if the Panic button is pressed again.

It seems reasonable that if someone really is in a "Panic" situation that they should be allowed to reactivate the bell at will.

Unlike the first option, this Panic mode is triggered whether or not the main alarm is in monitoring mode. The condition once triggered needs to be reset in the usual way.

Be aware, however, that this interrupt-driven option is potentially a weak link in the system's stability. All other alarm zone monitoring is done via software polling of the zones. Interrupts via RB4, though, are automatically generated by the PIC in response to *any 0V-going* change of logic status at this pin.

Whereas it is believed that the power supply and other zones are likely to be largely immune to external electrical interference (such as caused by electrical storms), an RB4 interrupt might conceivably be triggered under such conditions. Reader feedback on this would be welcomed.

If this Panic interrupt is not required, connect a link between the pins of the S3 connector, so holding RB4 permanently low.
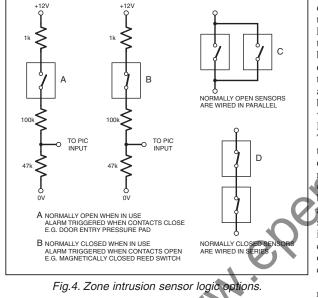
CONSTRUCTION

This design is mains powered and its construction should only be undertaken by those who are suitably experienced or supervised.

Printed circuit board component and track layout details are shown in Fig.5. This board is available from the *EPE PCB Service*, code 339.

Assemble the components in order of size and use a socket for the PIC. Do not insert the PIC, or connect the l.c.d., until the correctness of the power supply has been confirmed.

It is not necessary to instal all the zone terminals shown. Just solder in those that are actually required. The system can be configured later in software (via keypad S1) to suit the entry zones you've decided to use.

Nor do you have to instal all output controlling transistors if their higher power capability or control functions are not needed (e.g. omission of the strobe or second keypad facility) – similarly with their terminal connectors. Note that the output

Fig.5. Printed circuit board component layout and full-size track master pattern.
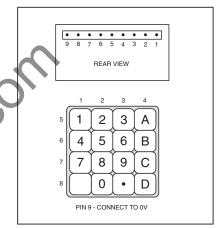
control logic is inverted if the transistors are not used. If the buzzer is to be used, TR1 must be installed.
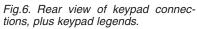
The l.e.d.s and their ballast resistors can also be omitted as you see fit, although they do offer a useful monitoring facility if you need to troubleshoot the circuit at any time.

Whilst it is not necessary to fit link wires between unrequired zone terminal/track pairs, it is preferable to retain all zone 0V biassing via resistor module RM1. This will help to provide electrical stability to the PIC's unused inputs.

If "Panic" mode detection via RB4 is not needed, wire this pin to the 0V line to keep it stable.

It is suggested that the keypad(s) should be connected via ribbon cable and suitable 9-pin connectors to match their terminal pins and those on the board. A rear view of the keypad pinouts is shown in Fig.6.

Fig.6. Rear view of keypad connections, plus keypad legends.

It is recognised that if the second keypad is also used, the cost of running 9-way ribbon cable from the unit across several metres to a door could be considerable. An alternative is to use two lengths of standard 4-way alarm system cable to make the connections for pins 1 to 8.

Pin 9 is simply for grounding the keypad's metal frame to earth and can possibly be ignored (but consider any possible mains electrical safety aspects first – any metal item that could potentially come into undesirable electrical contact with a mains supply *must* be earthed).

It would also be reasonable to use just four connections so that only four keys are active. The same degree of code security would remain since all 16 keys would still *appear* to be available.

TESTING

To assist bench testing, temporarily connect one or more switches to various zones to simulate sensors.

Fully check your p.c.b. assembly for errors and poor soldering before applying power. Do not connect mains power to the system until you have checked the rest of the system using a 12V battery (or bench power supply).

Connect the battery to the allocated terminals and check that +5V is present at the output of regulator IC3, and that around +11·4V is present at the cathode (k) of

COMPONENTS

Approx. Cost Guidance Only excluding case and alarm hardware

£35

Resistors

R1, R15,	1k (2 off)
R2 to R6, R21 to R24	10k (9 off)
R7 to R14	100k (8 off)
R16, R17 to R20	470Ω (5 off)
RM1	8 x 47k common 9-pin s.i.l. resistor module
RM2	8 x 1k common 9-pin s.i.l. resistor module

(R1 to R24 0·25W 5% carbon film or better)

See SHOP TALK page

Potentiometers

VR1	10k min. preset, round
VR2	1k min. preset, round

Capacitors

C1, C2	10p ceramic, 5mm pitch (2 off)
C3	2200µ radial elect, 25V
C4 to C6	100n ceramic, 5mm pitch (3 off)

Semiconductors

D1, D6 to D9	1N4148 signal diode (5 off)
D2, D5, D10 to D13	red l.e.d. (6 off) (see text)
D3, D4	1N4001 rectifier diode (2 off)
REC1	W005 50V 1A bridge rectifier
TR1 to TR4	TIP120 *npn* Darlington transistor (4 off) (see text)
IC1	PIC16F877 microcontroller, pre-programmed (see text)
IC2	7812 +12V 1A voltage regulator
IC3	7805 +5V 1A voltage regulator

Miscellaneous

S1, S2	16-key (4 x 4) data entry keypad (2 off, see text)
S3	push-to-make "Panic" switch, extra large, palm-activated, wall-mounting
S4	push-to-make switch, p.c.b. mounting, 0·2in pitch
FS1, FS2	1A fuse, slow-blow, with panel mounting holder (2 off)
T1	mains transformer, 12V secondary, 1A rating or higher
TB1	10-way pin-header strip, 0·1in pitch, 1mm dia.
TB2	4-way pin-header strip, 0·1in pitch, 1mm dia. (see text)
X1	3·2768MHz crystal
X2	2-line 16-character (per line) alphanumeric l.c.d. module

Printed circuit board, available from the *EPE PCB Service*, code 339; 40-pin d.i.l. socket; 2-way terminal blocks, p.c.b. mounting, side-by-side stacking, 0·2in pitch, screw connections (quantity to suit application, see text); metal or plastic case to suit application; 12V heavy-duty sealed lead-acid back-up battery; ribbon cable (9-way) for keypad(s) (see text); 9-pin pin-header strips and connectors, 0·1in pitch, 1mm dia. (2-off, optional, see text); p.c.b. supports (4 off); connecting wire; solder; etc.

Alarm fittings

Intruder sensors, bell, strobe, buzzer, types as required to suit application, 2-way or 4-way alarm cable (see text)

diode D4 (i.e. about 0·6V below the battery's actual output voltage). L.E.D. D5 should be on.

If all is well, disconnect the battery. Connect the secondary winding of transformer T1 to the terminals provided. Set preset VR2 for minimum resistance between the common pin of regulator IC2 and the 0V line.

Ensuring satisfactory safety precautions are observed, connect mains power to the transformer. There should about +18V d.c. across the terminals of capacitor C3 and +12V at the output of IC2. Adjust VR2 until a voltage of about 13.5V (or the recharging voltage specified by the back-up battery manufacturer) is present across the battery terminal block pins.

Disconnect the mains power, insert the PIC, and reconnect the battery (which should be in a reasonably fully-charged state when first put into use). If the PIC has not been programmed yet, you can do this *in situ* now, using *Toolkit Mk2* or *Mk3* via connector TB2.

POWERING UP

When powering up with the programmed PIC in place, your first need is to adjust preset VR1. Ignore any information which then becomes apparent – it depends on the existing contents of the PIC's data EEPROM.

Having set the contrast, put the program into "Engineer's Mode" by holding down keypad D (bottom right), then pressing and releasing Reset switch S4 (mounted separately on the p.c.b.), and then releasing key D. This action allows an "authorised engineer" (i.e. *you*!) to change the main PIN code without previously knowing the correct one. On other occasions, it also resets the alarm if it has been activated, turning off the bell, etc.

Additionally, it resets various default factors:

Zones to be monitored	1 and 8
Entry/exit zone	1
Entry/exit time	30 seconds
Bell-on time	15 minutes
Keypad 2 entry time-out	30 seconds

Normally, the PIN code and other factors can be amended from within the running system, but only after the correct PIN has been keyed in.

On entry to Engineer's mode, you will be greeted by the 1-line message:

Enter your chosen 4-character PIN code using any of keys 0 to 9 and A to C, for example: 123A. The other three keys (blank, decimal point and D cannot be used for the PIN code. Each keypress is accompanied by a beep of the buzzer and its associated l.e.d. being briefly turned on.

Each accepted keypress digit will be shown on line 2. If you make a mistake, press the blank key to clear line 2, allowing you to start again. Pressing "blank" when no digits are shown exits this mode.

When all four digits have been entered, press D. The word STORED will now appear briefly, telling you that the code has been stored in the PIC's data EEPROM for future recall. All data EEPROM values are retained even after power has been disconnected.

The screen then displays ALL OFF on line 1, with line 2 clear. From here on, access to all modes must be prefixed by your PIN code being keyed in.

Key it in now. If you enter a wrong digit, nothing will happen. There is no screen confirmation of which key is pressed, for obvious security reasons.

When the correct PIN has been entered, line 1 displays the message SELECT MODE.

You now have a choice of eleven modes, selected by pressing one of the following keys:

0 Activate alarm and start exit-delay count-down

1 Change main PIN code

2 Change entry/exit time (time-out)

3 Set zone to be regarded as the sole main entry/exit point

4 Set zones required to be monitored when the alarm is active

5 Set bell-on time, between 1 and 20 minutes

6 Automatically assess zones for sensor status (normally-open or normally-closed)

7 Display normal zone logic (sensors n.o. or n.c.) – for information only

8 Select second PIN code, as required for second (optional) keypad

9 Set entry time for zone covered by second keypad

● (decimal point) Set "passive" mode in which any zone entry is displayed and a buzzer sounded, terminated when zone entry ceases

When new data has been keyed-in, press D to store it in the data EEPROM, confirmed by STORED appearing and a return to SELECT MODE.

All modes except "Passive" (see later) may be exited by pressing the "blank" key, but any changed data is NOT stored if you do so.

Having "escaped" from a mode, or having completed any changes permitted by it and stored them by pressing D, the screen returns to displaying SELECT MODE, and another mode selection can be made.

Pressing the "blank" key when SELECT MODE is shown, fully exits the mode selection facility, followed by ALL OFF again being displayed. It is necessary to key-in your main PIN code (keypad 1) to re-enter the mode selection facility.

Next time a "data" mode is entered the data displayed is that previously keyed in and stored.

Each mode will now be discussed in detail.

MODE 0 – activate alarm system

When Mode 0 is entered, the software first checks that all zones have the open or closed status as set in Mode 6 (assess zone logic). If they do not, a 2-line message is displayed, of which the following is an example:

in which zone 6 is not in the required condition (e.g. a door open when it should be closed). The allocated entry/exit zone may remain open at this time, since that is the route that will be taken by the user once the alarm has been set on.

This message will continue to be displayed until the zone has been returned to its required condition, or the "blank" key pressed to exit this mode and return to a display of ALL OFF.

If the "blank" key is not used, when the incorrect zone status has been remedied, the alarm-on procedure will resume, and a 2-line message shown, such as:

where the countdown starts at the seconds value previously set for the entry/exit delay and proceeds to count down to zero. The buzzer sounds during this period.

The countdown may be terminated and a return made to ALL OFF if the "blank" key is pressed. Otherwise when zero is reached the system will be placed into the full alarm monitoring condition, "watching" those zones set through Mode 4:

An exit from and closure of the allocated entry/exit zone must be made within the allotted entry/exit time. Failure to do so will cause an alarm condition to exist.

MODE 1 – Change main PIN code

Discussed previously.

MODE 2 – Change entry/exit time

On selection of Mode 2, the screen displays a 2-line message such as:

where the value following PREV is the previously set time-out period in seconds.

Any value between 01 and 99 may be selected (note the prefix 0 for values below 10). Each digit entered is displayed at the bottom left of line 2. If you make a mistake, press the "blank" key to clear the value just entered, allowing you to start again. Note that you are returned to the SELECT MODE display if "blank" is pressed when only one digit has been entered.

If more than two digits are keyed in succession, the others will be ignored.

MODE 3 – select entry/exit zone

On entry to Mode 3, a 2-line message will be displayed, such as:

where in this instance the numeral 1 indicates that Zone 1 is currently the selected entry/exit zone. As MAX 6 states, one of six zones can be nominated as the entry/exit zone. Pressing any key between 1 and 6 selects that zone and the chosen digit appears, replacing the appropriate "dash", and with a "dash" now replacing the previous digit.

Zones 7 and 8 cannot be selected for entry/exit as these are regarded by the software as being for anti-tamper and Panic zone use.

MODE 4 – select zones to be monitored

On entry to Mode 4, a 2-line message will be displayed of which the following is an example:

This example shows that zones 1 and 8 have been selected for unauthorised access monitoring. If any of these zones are entered when zone monitoring is active, an alarm condition will exist, accompanied by the bell and buzzer sounding, and the strobe flashing (if installed).

The exception is when the zone entered is that allocated as the entry/exit zone. If this zone is entered during active monitoring, the entry/exit countdown timer will start, with the buzzer sounding. If the correct PIN code is keyed-in within the allotted time (see Mode 2) the system will be deactivated and the buzzer silenced. If the entry/exit delay is exceeded, then the bell and strobe will be activated.

When in Mode 4, pressing any key between 1 and 7 will toggle that zone between "active" (watched) and ignored. When selected, the zone number will be displayed, otherwise a "dash" will be shown. Note the following, however:

● Zone 8 cannot be deselected as the software regards this as being a "Panic" zone.
● Zone 7, nominally allocated as an anti-tamper zone, *can* be selected/deselected.
● Any zone nominated as the entry/exit zone cannot be deselected.

● When in Mode 2 (set entry/exit zone) the selected zone automatically causes the same "Watch" zone to be activated.

MODE 5 – Set bell-on time

On entry to Mode 5, a 2-line message will be displayed of which the following is an example:

Through this mode you can set the time for which the bell is turned on if unauthorised entry to a zone occurs. There is a legal limit in the UK of 20 minutes maximum. You may set a time between 1 and 20 minutes.

In the above example, the previously set bell-on time is shown as 12 minutes, with the MAX20 reminding that 20 minutes is the maximum. On line 2, "??" is where your newly selected time is displayed when you press the permitted numeric keys.

The first digit (the "tens" of minutes) can only have a value between 0 and 2. A value between 0 and 9 can be keyed for digit 2 (the "units"). The following conditions apply, though:

If digit 1 has a value of 2, only 0 can be entered for digit 2. If digit 1 has a value of 0, a value of 0 cannot be keyed in for digit 2. This ensures that only a time between 1 and 20 minutes can be selected.

MODE 6 – Auto zone assess

On entry to Mode 6, a 2-line message will be displayed of which the following is an example:

This mode allows the system to assess whether it should be monitoring individual zones as normally-open or normally-closed. The letter "C" in any of the eight positions on line 2 indicates that a zone sensor is currently closed, letter "o" shows that it is currently open.

In this example, zones 1, 4 and 6 are shown as having normally-closed logic. Zones 2, 3, 5, 7 and 8 have normally-open logic.

The settings shown in line 2 can be stored to the data EEPROM by pressing D, they will then be the settings that the system checks are correct when in active monitoring mode. Should any sensor be found to be in a different condition, and that zone is one of those selected to be monitored (see Mode 4), then an alarm condition exists. The system then behaves as described under Mode 4 (bells etc.).

Before pressing D to store the data, physically visit all zones and ensure that the sensors are in the required condition, i.e. doors and windows closed, the cat not sitting on the pressure mat, wife not moving around in front of the PIR sensor, etc.

Except for "blank", all other keys are ignored in this mode.

MODE 7 – View normal zone logic

On entry to Mode 7, a 2-line message will be displayed of which the following is an example:

This mode is for information only. It simply shows the normally-open and normally-closed logic for each sensor as stored in the data EEPROM – in this case they are all shown as normally-open.

MODE 8 – Set second keypad PIN

On entry to Mode 8, the following line 1 message will be displayed (but with line 2 blank):

Mode 8 is used in the same way as Mode 1, but allowing you to enter the required 4-digit PIN for use with the optional keypad 2. It may be the same PIN as used with keypad 1, but it does not provide access to the main system.

Note that if you have chosen to use just a 4-wire connection to keypad 2 (as discussed earlier) you can only use those keys for which wiring exists. All others will be ignored.

MODE 9 – Set keypad 2 entry time

On entry to Mode 9, a 2-line message will be displayed of which the following is an example (after the new entry time, 15 secs, has been keyed-in):

This mode sets the time during which the auxiliary output (transistor TR4) and the buzzer are activated when the correct PIN code has been keyed-in via keypad 2. At the end of the time-out, TR4 and the buzzer are turned off.

This mode is used identically to Mode 2.

MODE " ● " – Activate "passive" monitor mode

An eleventh mode is available, entered by pressing the "●" (decimal point) key. On entry to this mode, a 2-line message will be displayed of which the following is an example:

When in this mode, all zones are monitored and if any are found to have their

sensors in the opposite logic to that expected (e.g. open instead of closed), the buzzer sounds until all sensors return to their normal expected status. The appropriate zone numbers are displayed on line 2, with the number being replaced by a "dash" when no longer triggered. In the example, zone 6 has been entered.

This facility can be used, for example, in a shop when it desirable to know if a customer has opened a door, or removed an object from where it should be.

"Passive" monitoring is terminated by keying in the PIN code, to return to SELECT MODE.

MODE SUMMARY

The following is the summary of the modes and their keyed identities. It is suggested that you photocopy it and secure the details to the front panel of your enclosed alarm.

0. Set alarm on
1. Set main PIN code
2. Set access time-out
3. Set access zone
4. Set active zones
5. Set bell time
6. Set zone logic
7. Show zone logic
8. Set 2nd PIN code
9. Set 2nd time-out
● Set passive mode

CHOICE OF SENSORS

It is believed that this design can be used with any type of intruder sensor currently available. The choice is entirely yours as to which type you use for which zone. Many companies sell intruder alarm products and they or their catalogues should be consulted for advice on the sensors available.

The choice of case and back-up battery is also yours. For the latter a sealed lead-acid type rated at 12V and, say 5Ah, is suggested. If you are using the anti-tamper option, it recommended that a microswitch is installed in the case and the bell housing, causing an alarm condition if either enclosure is entered without authority.

The system can be used to monitor just one zone. Each zone used can be connected by using 2-core cable (available specifically for alarm use). If anti-tamper detection is required, 4-core alarm cable should be used, the entry sensor itself wired to one pair, the anti-tamper connections made by the other and connected separately to the system's allotted anti-tamper terminals (zone 7).

Anti-tamper wiring could be connected in series between all required zones. Alternatively the zones could be treated as separate anti-tamper connections, with each cable pair "commoned" into the zone 7 terminal block. The latter technique may make it easier to trace an open-circuit should one occur. Anti-tamper wiring should always be normally-closed.

It is debatable as to whether anti-tamper monitoring is required in a normal domestic security system.

UNAUTHORISED ENTRY

If one more zones are entered without authority, the bell, strobe and buzzer are all activated. A clock is started from zero

when the first zone is entered. The screen changes to display a message showing which zone has been triggered, plus the clock read-out, e.g.:

In this example, zone 1 is shown to have been entered and that it is 1 hour, 28 minutes and 15 seconds since that event. The clock continues counting until the alarm is reset via your PIN code. The elapsed time can reach 99:59:59 (just over four days – a long week-end, for example) and then restarts from zero.

The bell is automatically turned off after the preset delay period has elapsed, as discussed earlier. The strobe and buzzer remain on until reset by keying in your PIN code.

If a second unauthorised entry is made following the first, the bell is not reactivated, nor does this event affect the clock's current counting. It is the elapsed time since the *first* entry occurred that continues to be shown. The display, though, is updated to show the number of the second zone (or more) as well as the first.

When "Panic" mode is triggered via switch S3, the clock is always reset to zero.

If the bell time-out has not completed following zone triggering and a total power failure occurs, the bell is NOT reactivated when power is resumed, although the buzzer and strobe are re-triggered.

When entering the correct PIN code to stop an alarm condition and turn off the bell, strobe and buzzer as appropriate, all zone and timing information remains on screen until "blank" is pressed to cause a return to ALL OFF mode.

Be assured that even if the alarm is in active monitoring mode and use of the keypad is made, full system scanning continues, preventing unauthorised users from "fooling" the system by holding down a key indefinitely.

TOTAL POWER LOSS

If there is a total power loss through a mains failure and lack of battery power, and then one or the other is restored, the software restarts from a Reset condition. In doing so, it notes this fact and displays one of three messages.

If the system has not been set into active monitoring mode, the following 2-line message appears:

The second line is cleared when you enter your PIN code and enter SELECT MODE, from which you can immediately escape if you wish (press "blank" key).

If the alarm was previously in monitoring mode and there has been no unauthorised zone entry, a 2-line message similar to following is shown:

This indicates that no zones have been intruded and that it is 6 seconds (and counting!) since the power was restored.

If one or more zones have been intruded, the message might appear as:

indicating that zone1 has been entered and that "panic" has been pressed, again showing the elapsed time since power restoration. The message PSU ERR (or the earlier POWER ERROR) means that you should check the condition of your battery.

To clear either of the last two messages, you must reset the alarm by keying in your PIN code and pressing "blank" to return to ALL OFF.

AUTHOR'S EXIT

The PIC Monitored Intruder Alarm has not been tested "in active service". However, it has been extensively bench tested with a variety of switches and sensor-simulation devices. It is believed that it lives up the specifications outlined earlier, but this cannot be guaranteed and no legal responsibility can be accepted for it.

However, if you have any suggestions for how the system could be improved, please advise us at Editorial HQ (not via the *Chat Zone* since we do not visit this regularly).

May you live without intrusion!

RESOURCES

Software for this design is available on 3·5-inch disk (for which a nominal handling charge applies). It is also available for *free* download from out ftp site. (See *PCB Service* page.)

Read this month's *Shoptalk* page for additional details on obtaining the software, plus pre-programmed PICs, and general information on buying components for this PIC Controlled Intruder Alarm. □