SCC.369 Mini-Project: The Intruder Alarm

The intruder alarm we are looking for is inspired by a real-world implementation built by one of the teaching team for their rented apartment using an ATTiny84. Your task, if you chose to replicate it, is to build it using the PIC16F1507.

Alarm Specification

The design of the intruder alarm begins with a simple requirement. The flat has a short "private corridor" outside its main door. The corridor has a screen door at one end. Anyone wishing to reach the main door must open this screen door first and then walk down the corridor towards the main door. The aim is to alert the occupants that a potential intruder has opened the screen door. The fully functional alarm system will satisfy the following requirements.

R1: Triggering the alarm

The alarm is triggered when the screen door is opened and stays in alert mode even if the door is closed.

Hardware to achieve this: Your kit already has a piezo-buzzer and a magnetic door contact switch. The magnetic door contact switch consists of both a reed switch and magnet, both of which are housed in separate plastic enclosures. The switch is closed circuit when the magnet is present and open circuit when the magnet is removed (i.e., the door is opened). The piezo-buzzer can be supplied with a square-wave of varying frequencies to produce different audible notes (but limited by the PIC's ability to generate these frequencies). This piezo-buzzer should produce beeps continuously once the door is opened. You can also (in addition to, not in lieu of the piezo-buzzer) use an LED to visually indicate that the alarm has been triggered.

R2: Reset the alarm

The alarm, once triggered by a visitor or a late-night intruder, stays in alert mode till it is reset.

Hardware to achieve this: Your kit should contain a micro push-button switch. Once the push-button is pressed, the alarm should shut off, i.e., the piezo-buzzer should stop producing beeps. The alarm returns to armed mode.

R3: Program an alarm-trigger delay

When the occupants of the flat leave the flat, they will open the screen door to exit. This will trigger the alarm if only R1 is implemented. To allow the occupants to leave and keep the alarm armed for intruders, program an alarm-trigger delay of 30 seconds. The occupants are given an audible indication (different than R1's audio indication) that the alarm is in delayed trigger mode and once the delay is over, the alarm returns back to armed mode.

Hardware to achieve this: Use another micro push-button switch. If the alarm is in armed state (not triggered) and this push-button is pressed, the piezo-buzzer could emit beeps at ~1 second intervals for ~30 seconds, allowing the occupants to open and close the screen door without triggering the alarm. If the screen door is opened after 30s, the alarm should be triggered, but not before.

R4: Program a beep-ramp

When the occupants return, they will open the screen door and trigger the alarm. However, this won't give them an opportunity to know if the alarm was triggered by an intruder in their absence. To help them differentiate an intruder created alarm-trigger versus the alarm-trigger due to their return, the alarm once triggered needs to start with a slower rate of beeping and ramp up to a faster

rate after 30 seconds (e.g., 2 beeps per second for first 10 seconds, 3 beeps per second for next 10 seconds, 4 beeps per second for next 10 seconds, and then actual beep rate till reset).

Hardware to achieve this: Nothing extra is needed

R5: Energy-efficient alarm

Sustainability should be core to any embedded design. One aspect of sustainability is to minimize energy use. The PIC should operate in a power-saving sleep mode unless triggered. See Section 8 of the datasheet for details on how to operate the chip in sleep mode. *(NOTE: The real-world implementation worked on three unbranded AAAs for 8 months which included 200+ delays, 50+ postman triggered alerts, 10+ postman triggered alerts when not at home and 4 actual late-night intruder alerts. Contrast this with the initial prototype without sleep which lasted for only 10 hrs on Duracell AAAs)*

Hardware to achieve this: Nothing extra is needed

Hints and Tips:

For R1, contrast the choice of using the weak internal pull-up with a switch to ground (high when door opens) versus a switch to high (pulled low when door opens).

For R2, a piezo "beep" is created by delivering a square-wave of a fixed frequency for a fixed period of on-time and followed by off-time. Thus, the beep has two parameters: frequency and duration. One sample standard (**MIL-STD-1472G :** 5.3.1.3 Characteristics of audio warning signals) states that the frequency should be between 500Hz to 2000Hz. Beyond this, an on-time duration of 0.2-0.5 seconds is adequate for drawing attention, while an off-period of minimum of 0.1 seconds is enough to separate out individual beeps. Timer2 offers PWM capabilities (see Section 19 of datasheet). The PWM period is inverse of the PWM frequency (i.e., a period of 2ms produces a frequency of 500Hz). PWM duty cycle for a simple square wave is 50%.

For R3 and R4, consider using interrupt-based approach (so that R5 is achievable without re-write of code). When using interrupts, the interrupts can arrive in any order and ***the programmer must decide which interrupts to ignore*** based on the 'program state' they are in. Consider implementing a state-model approach which can include states like SLEEP, DELAY_TRIG, ALARM_TRIG etc.

Grading

On a 100-point scale, each requirement will contribute the following:

R#	Max Score	Evidence
R1	30 pt	Working demonstration, wiring diagram, basic tone function with frequency and beep duration, register config for timers/PWM
R2	10 pt	Working demonstration, register configuration, code
R3	15 pt	Working demonstration, wiring diagram, tone function for delay mode, interrupt config, code
R4	20 pt	Working demonstration, tone function for ramp, interrupt config, code
R5	10 pt	Working demonstration, code, (maybe: multimeter current reading?)
-	15 pt	Resilience and innovation. All Rs satisfied and operating without conflicting with each other. Innovative design decisions. Earn that A+