Project Lab Sheet A: Reversing Alarm

Two projects must be submitted, one no later than week 11; the other no later than week 12.

1 Aims

The aim of this lab is to implement a simple reversing alarm:

- An IR emitter and IR detector are used to detect light reflected from an object.
- An audible tone is generated when an object is detected.

1.1 Example Projects

The following example projects are available. You may adapt code from these projects to complete the requirements described here.

1. **Analogue to digital**: A project demonstrating the use of the ADC converter. You need this to measure the input from the IR detector.
2. **Tone Generator**: Two projects that demonstrate techniques to generate tone. The simpler one – allowing the volume to vary with a fixed frequency – should be sufficient.

2 Project Requirements

The system functional requirements are:

1. A button should be used to arm the system and then disarm it. In a car, this is done when the reverse gear is engaged.
2. When it is engaged, the system should give an audible confirmation that it is working.
3. When an object is detected, an audible tone is generated and becomes increasingly noticeable, as the object gets closer.

You need to clarify these requirements to make the behaviour precise. You can do so in any way you choose[1].

3 Using the IR Emitter and Detector

The proximity sensor uses an IR emitter (LED) and an IR detector (phototransistor) pointing in the same direction to determine if any object is reflecting IR energy from the LED.

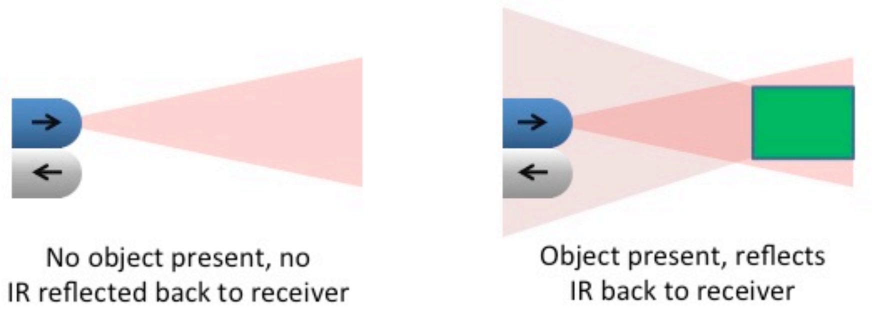


Figure 1. Proximity sensor method of operation.

[1] You are demonstrating your ability as a developer: do not overelaborate the system but very simple solutions may gain slightly fewer marks.

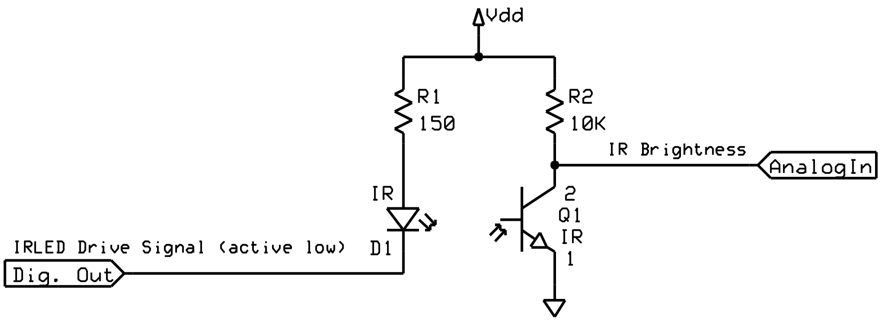
Sensing occurs in two steps:

1. First, the software measures the IR light level (using IR-sensitive phototransistor Q1 and the analog to digital converter) when the IR-emitting LED is **turned off**.
2. Second, the software measures the IR light level when the IR LED is **turned on**.

If there is an object nearby reflecting the IR from D1 back to Q1 the second measured voltage will be lower. You can verify that the IR LED is turned on by viewing it with a digital camera (e.g. in a mobile phone), as these are sensitive to IR energy[2].

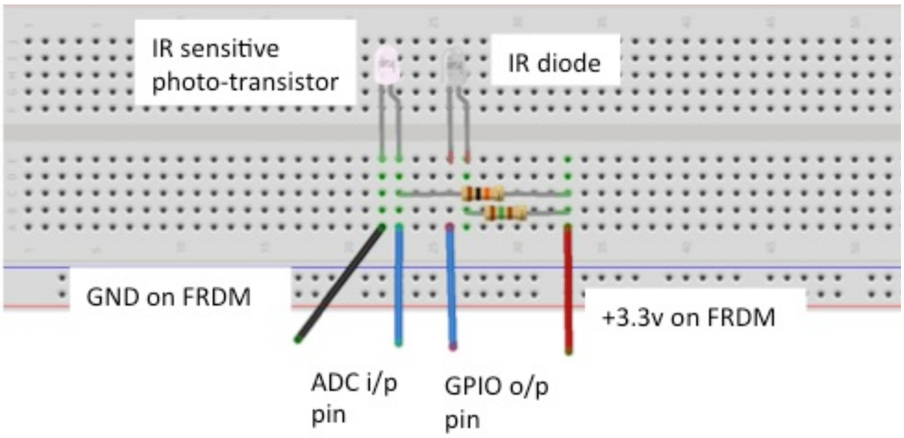
3.1 Circuit and Operation

Build the circuit on the breadboard as shown below. **You need to get the components from the lab cabinet.**



Identifier	Description
R1	150 Ω (brown-green-brown-gold)
R2	10 kΩ ohms (brown-black-orange-gold)
D1	This is the IR emitting diode: like an LED but you cannot see the light. Note that the flat side of the package marks the cathode (negative terminal, long lead)
Q1	This is the IR detector: the resistance falls when it is illuminated using IR light. Note that the flat side of the package marks the emitter (negative terminal, short lead) – **unfortunately, this may vary**.

As the IR energy increases, the conductivity of the phototransistor Q1 increases and lowers the output voltage. However, the phototransistor has a slow response i.e. the voltage does not change immediately the IR source changes. (You can try measuring the delay with an oscilloscope).



[2] This may only work with older phone cameras.

3.2 Software for Distance Measurement

The steps for the range measurement software are:

- Take distance measurements by (i) turning the IR LED on, waiting for a short delay and measuring the voltage then (ii) turning the IR LED off, waiting and then measuring again.
- The difference between the two voltage measurements indicates the presence of a reflecting object and the greater the difference the closer the object.
- It is best to repeat the measurement multiple (e.g. 5-10) times and take the average.
- The delay between switching the IR emitter on or off and measuring the voltage may need to be of the order of 1+ ms or more.

4 Suggestions

This section contains some additional information that may be useful. You do not have to read this section if you do not wish to.

4.1 Software Requirements

Work out the detailed software requirements. For example:

How will you indicate that the alarm is working when it is engaged? Can you avoid confusing this with the warning?

- How will you make the warning tone more noticeable?

It is best to work incrementally: start simply and then add more functionality. You may also wish to set the on-board LEDs as a simple way to confirm the operation is an expected.

4.2 Use of Pins

Create a table of the I/O pins by function, pin name and FRM-KL25Z header/pin number. You need this to wire the system correctly. In addition, it is possible that the pins used in the demonstration projects clash (*if so, it is not deliberate*).

4.3 Software Design

For a cyclic system[3] design:

- What tasks will you have?
- What states dos each task (or the system overall) have?
- How the tasks communicate?
- What ISRs are needed (SysTick at least). Will you poll buttons or use interrupts?

Then plan the functions you will need, for initialisation and for the cyclic tasks.

4.4 Calibration

You may need to adjust the physical layout or the software parameters of the system for it to work well. This section has some suggestions.

4.4.1 Ambient Light and Shielding

Does the ambient light make a difference?

- Disconnect the IR emitter. Is the phototransistor reading steady or variable?
- With the IR emitter connected, monitor the IR difference reading. Shield the phototransistor from IR energy emitted from the side of the LED. Does this change the difference signal strength?

[3] You can use the RTOS if you wish.

4.4.2 Delay

The sensitivity of the proximity sensor increases as you wait longer to sample the phototransistor's voltage after changing the IR LED. It should be sufficient to wait one cycle of the cyclic system but you may wish to look at the change of voltage on an oscilloscope.

4.4.3 Range Calibration

The detection of the object will depend on its reflectivity[4]. Choose an object to work with (such as a sheet of paper).

Calibrate your system to record the voltage difference against distance (for a particular object). You should complete a table like this and use this to control the audible warning.

Voltage Difference	Distance	Notes
95%		Max range (approx. 20cm)
	1cm	Max difference

[4] The IR sensor is not suitable for a real reversing system as you could reverse into black objects.

5 Answer Sheet

This sheet should be printed out and handed in during the lab session. It can be completed either electronically or by hand.

Surname		**First name**	
Student number			

5.1 Information About Your System

5.1.1 Requirements

Explain exactly what your proposed system does. Note any requirements that are not implemented.

5.1.2 Design

Detail the main elements of the design of your system, including the cycle time, the tasks, the communication between tasks and the states of tasks. You may wish to draw one or more state diagram.

5.2 Viva Record

You should demonstrate your system, at least once. You may choose to do more demonstrations if you are working incrementally.

Initials / Date	**Comments Describing Functionality Observed**

5.3 Overall Feedback

Marker	**Date**	**Grade**