Widget Lab 2 – Studio Report

1. For each sensor, was the output signal analogue, discrete, or digital?

Analogue – Continuous in both time and value  
Discrete – Discrete in time, value, or both

Digital – Discrete in both time and value – subcategory of discrete signals

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sensor | Thermistor | PIR | Digital temp/humidity | Photoresistor | Ultrasonic |
| Signal Type | Analogue | Discrete | Digital | Analogue | Digital |

1. For each actuator, was the actuated effect analogue, discrete, or digital?

|  |  |  |  |
| --- | --- | --- | --- |
| Actuator | LED | Buzzer | DC Motor |
| Effect Type | Digital | Digital | Analogue |

Buzzers and LEDs can only take on discrete values of frequencies or on/off, respectively. They, however, are continuous throughout time/these signals can change at any time.

Note that DC motors are designed to spin quickly without needing to stop at specific places; allowing them to take continuous positions of spin speed over continuous time.

1. For the thermistor:
   1. What circuit element does the thermistor behave like?

A thermistor behaves like a resistor.

* 1. How does its property change in response to changes in temperature?

Thermistors are resistors that depend on temperature of the surroundings. Resistance decreases with increase to temperature and increases with decrease to temperature.

1. For the PIR sensor:
   1. Does the sensor respond to change in input or constant input?

**change**

**constant**

* 1. In configuration A, does the sensor signal stop immediately when input stops?

**yes**

**no**

* 1. In configuration B, does the output stay on for more or less time after the input stops than it did in configuration A?

**more**

**less**

1. For the digital temperature/humidity sensor, what did the pull-up resistor do?

Diagram

Description automatically generatedAs the team used an AM2320 sensor, two pull-up resistors were connected to the digital temperature/humidity sensor. The purpose of a pull-up resistor is to differentiate the state of the input pin when the sensor is connected to the microcontroller unit (MCU). Known as *floating*, a connection to the program without pull-up resistors can confuse the MCU when the input pin attempts to recognize a logic high from a logic low. Notably, pull-up resistors also limit the amount of passing current – mitigating voltage overflow damages to the device.

Figure 7 – Simpler diagram depicting the functionality of a pull-up resistor in a circuit

A picture containing text, electronics

Description automatically generatedThe functionality of a pull-up resistor (R1) can be seen in *Figure 7*. There, a high state will be read if the button is unpressed, and low state, if the button is pressed. Additionally, if R1 was not there, pressing of the button can result in a short circuit.

Figure 8 – Lab set-up of the temperature/humidity sensor wirings with the raspberry pi

When applying this understanding to the lab, the pull-up resistor in question is labeled R1 and located on the right in *Figure 8*; of which provides the alternate, pull-up resistance. A high state will be read for certain temperatures/humidity moving to the pi, while a low state for the other values; allowing the pi to make sense of the incoming information.

1. For the photoresistor:
   1. What circuit element does the photoresistor behave like?

A photoresistor behaves like a resistor.

* 1. How does its property change in response to changes in light?

A picture containing text, electronics

Description automatically generatedPhotoresistors are sensors whose resistance changes when a light is shone on it. Higher intensities of light results in a decrease in their resistance, whereas a lower intensity will result in higher resistances.

1. For the ultrasonic sensor:
   1. How does the sensor work?

**Target:** By emitting ultrasonic sound that human ears cannot detect – the sensor is able to locate the distance from itself to a target. The target’s surface should optimally be smooth and flat, without inclination such that reflection of the sound in a direction that would not strike the sensor will be minimized.

Figure 9 – Diagram of the set-up that depicts the raspberry connection to the ultrasonic sensor

**Setup:** The setup of the sensor can be seen in *Figure 9* where external wire connections exiting the ultrasonic sensor are:

* Red: VCC (voltage supply)
* Orange: Trigger sound connection to GPIO2
* Blue: Echo sound connection to GPIO3
* Black: Ground (GND) connection

**Interaction:** When the observer wishes to measure the distance between an object and the sensor, the sensor is triggered (in the case of *Figure 9* – by a button press) to send out a pulse of ultrasonic sound. Upon reaching an object that the pulse is directed at, sound waves will bounce off the object and make it back to the sensor to be registered by the sensor again. The time for sound waves to make this journey is relayed by the sensor and encoded for interpretation and computing of next steps by the MCU.

**Encoding:** Knowing the speed of the ultrasonic sound and the time taken for a trip to the object and back, the distance of a one-way journey to the object can be computed by distance = time x speed. Encoded by the ultrasonic sensor as digital outputs, the pi’s job is to coordinate this effort and ensure that communication between the button and sensor is uninterrupted.

* 1. What happens when you change the distance between the object and the sensor?

When distance increases between the object and the sensor, the travel time of the sound will increase. However, chances of sonar-based interference, dispersion and faulty readings contributing to error will also increase. There is a certain range by which the sensor can effectively determine the distance. At shorter distances, there is no problem – as sound waves do not need to travel so far, and interference effects are minimized.

1. For the LED:
   1. How does the duty cycle relate to the brightness of the LED?

**As duty cycle increases,** brightness increases.

* 1. What happens when the frequency of the PWM becomes very low?

The LED will appear as discretely on or off for some time before switching to its opposite state (on🡪off or off🡪on). Brightness will also decrease, and flickering will occur.

1. For the buzzer:
   1. How does the duty cycle relate to the buzzer actuation?

**As duty cycle increases,** the volume of the buzzer will increase.

* 1. How does the PWM frequency relate to the buzzer actuation?

**As frequency increases,** each “buzz” of the buzzer will audibly appear more and more analogous. Pitch of the buzzer will thereby increase.

1. For the DC motor:
   1. How does the duty cycle relate to the speed of the motor?

**As duty cycle increases,** the longer the motor will run per cycle that the motor is programmed to run – and vice versa. With voltage supplied over a longer period as duty cycle increases, the motor will make more rotations per cycle of time as the duty cycle increases (spinning more or faster) and less rotations per cycle of time as duty cycle decreases (spinning less or slower).

* 1. What happens when the duty cycle of the PWM becomes very low?

A very low duty cycle of the PWM will translate to the motor being mostly immobile or turn very slowly.

* 1. What is the minimum duty cycle that you need for the DC motor to move?

According to the manual, the maximum voltage supply given is supplied by the 12V adapter. However, only 5V are needed to run the motor driver, and subsequently, the motor. Thus, the PWM’s duty cycle must be able to provide 5V. The relation is illustrated as follows, where signal amplitude is 12V. Thus:

Duty cycle x (signal amplitude) = 5V (minimum, to start motor movement)

Duty cycle x 12V = 5V

Duty cycle = 0.41666666… = 41.67%

This answer is supported by research references; of which suggests a roughly 40% duty cycle.