Homework #5 – Detailed Design

ECE 411 - Industry Design Processes

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V1.02

<u>Device</u>: Social Distancing Device

Level 0

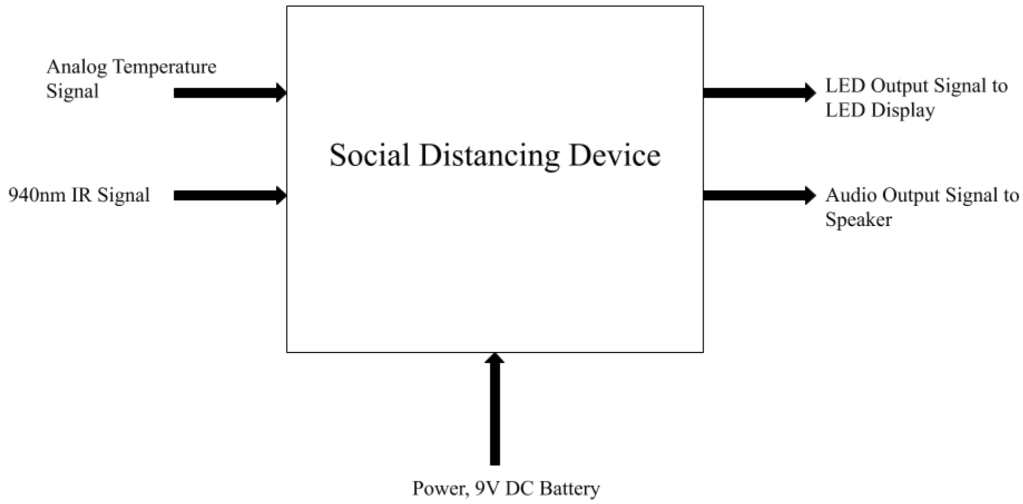
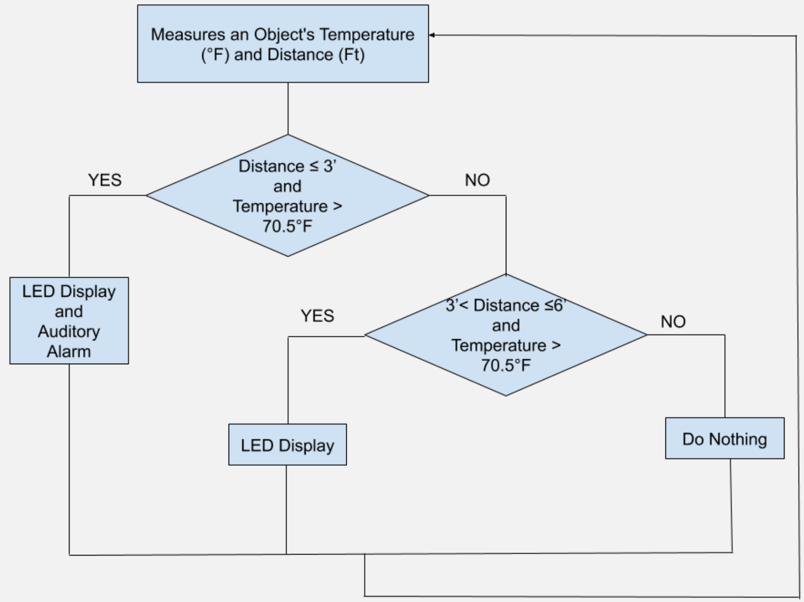


Figure 1: Level 0 – Social Distancing Device Block Diagram

Module	Social Distancing Device
Inputs	- Power Supply: 9V DC - Analog Temperature Signal (Contactless Temperature Sensor) - 940nm IR Signal (Time of Flight Sensor)
Outputs	- LED Display (Visual Alert) - Low Power Audio Amplifier (Auditory Alert)
Functionality	The Social Distancing Device takes the power supplied by a 9V battery and converts that into a 5V fixed DC output signal. This 5V DC signal will then drive the two sensors to measure the distance and temperature if another person is within the user. Based on these measurements if certain conditions are met then it will alert the user either through a visual indicator (LED display) or an auditory indicator (Low Power Audio Amplifier).

If-Then-Else Functional Device Design



Level 1

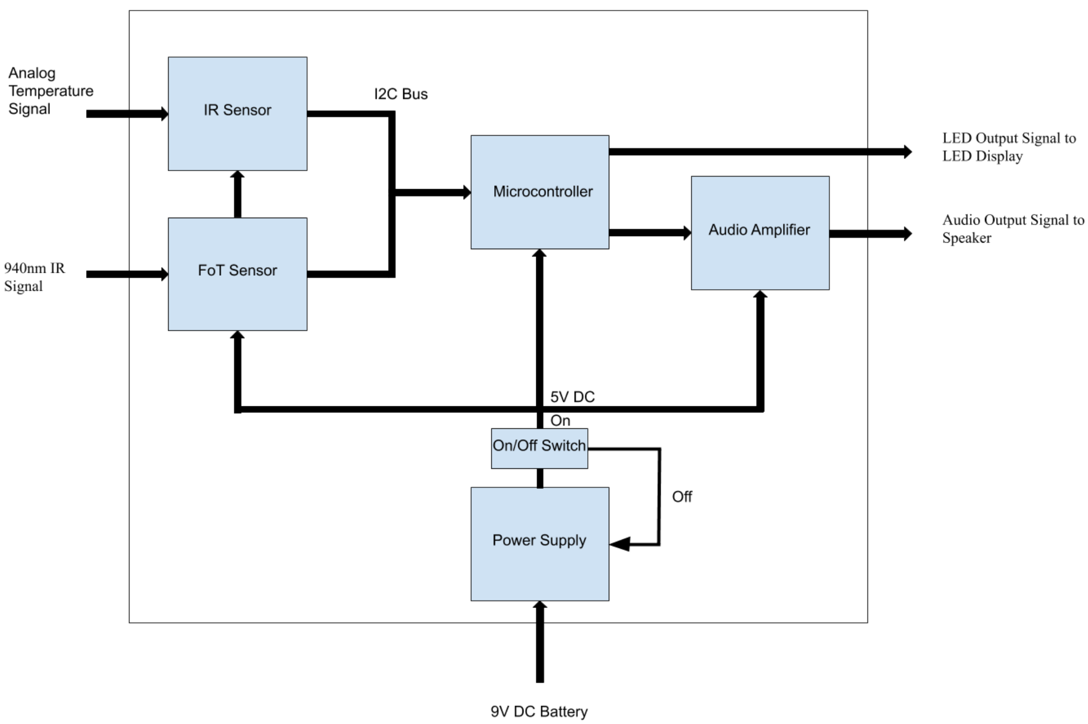


Figure 2: Level 1 – Social Distancing Device Block Diagram

Power Supply Module

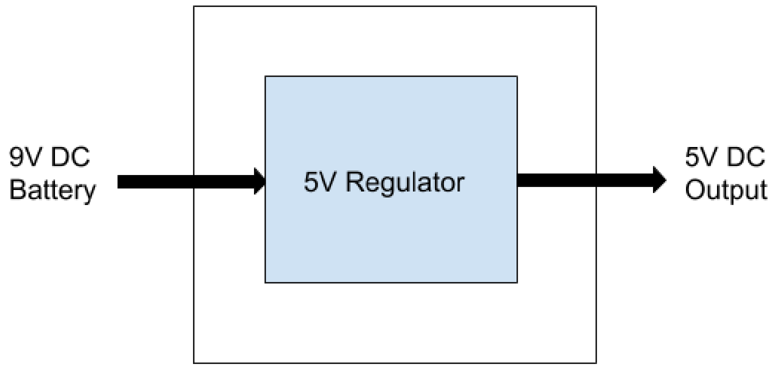


Figure 3: Level 2 – Power Supply Module Block Diagram

Module	Power Supply (Fixed-Output Voltage Regulator)
Inputs	- 9V DC Battery
Outputs	- 5V DC Output Signal
Functionality	The 9V battery signal enters an Integrated Circuit of Transistors (LM7805) that regulates the linear voltage to 5V. This IC maintains noise reduction on the linear 5V signal. Input Voltage Range: 7V – 35V Current Rating: I_C = 1A Output Voltage Range: V_{MAX} = 5.2V and V_{MIN} = 4.8V

IR Contactless Temperature Sensor

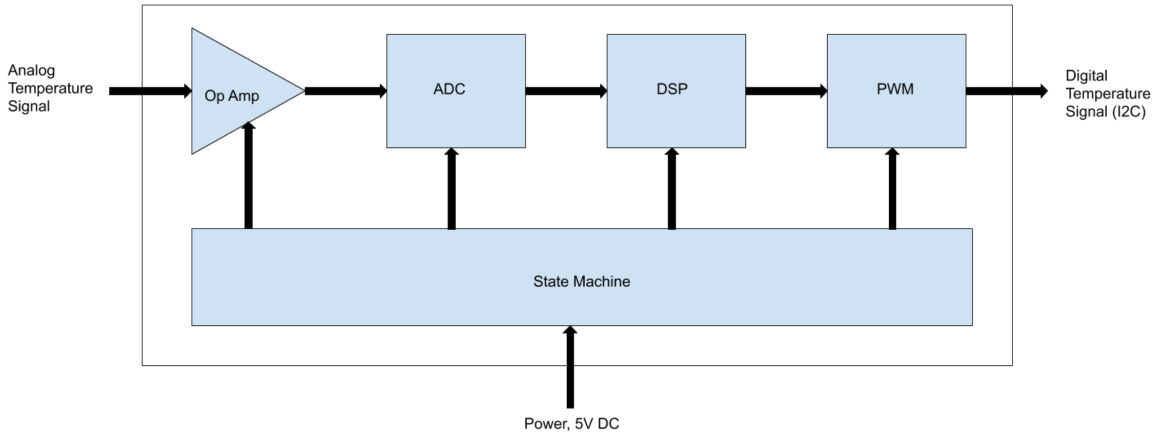


Figure 4: Level 2 – IR Contactless Temperature Sensor Block Diagram

Module	IR Contactless Temperature Sensor
Inputs	- Power: 5V DC - Analog Temperature Signal (IR)
Outputs	- Digital Temperature Signal (Sends data to ATmega328p's I2C bus)
Functionality	The IR contactless temperature sensor focuses the IR energy (Radiation of the energy/ unit area (flux) emitted by the governing body) that converts the energy into an electrical signal. After stages of signal amplification, linearization, and temperature stabilization, the electrical signal is converted into an average value of the measured temperature contained within the sensor's Field of Vision (FOV). This sensor utilizes the Stefan-Boltzmann Law $P_{rad} = \sigma \varepsilon T_{obj}^4$ Where, $P_{rad} = \frac{Energy}{Unit\ Area}\ (flux\ emitted\ by\ the\ body\ of\ the\ object)$ $\sigma = constant\ of\ proportionality = 5.67 * 10^{-8} W m^{-2}$ $\epsilon = The\ Emissitivity\ of\ the\ Body$ $T = Surface\ Temperature\ of\ the\ body\ (in\ °K)$ Note: This sensor design is used by the Melexis MLX90614 BCC Contactless Sensor used in this project

Time of Flight (ToF) Sensor

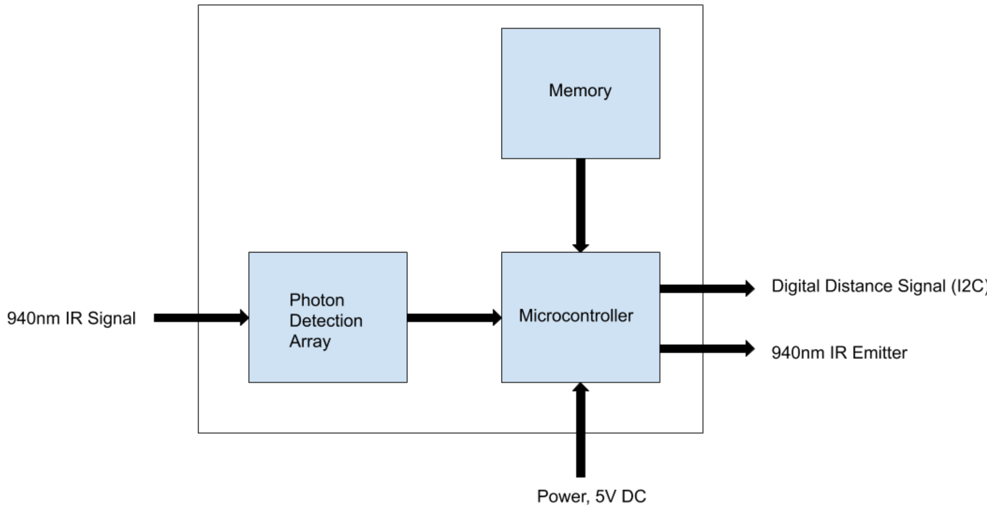


Figure 5: Level 2 – Time of Flight (ToF) Sensor Block Diagram

Module	Time of Flight (ToF) Sensor
Inputs	- Power: 5V DC Signal - 940nm IR Signal
Outputs	- Digital Distance Signal (Connected to ATmega328p's I2C bus)
Functionality	The Time of Flight (ToF) Sensor has a Photon Detection Array that emits an IR laser signal and measures the time that elapses till the incident IR signal is sent and the reflected IR signal returns. The difference in return time and the wavelength of the IR signal is used to calculate the respective distance that object is away from the sensor. Lastly the onboard microcontroller converts the measured distance into a digital signal that will be utilized for the conditional statement of the design. $$d = \frac{c * t_0}{2}\left(\frac{q_2}{q_1 + q_2}\right)$$ Where, $c = speed\ of\ light\ (\cong 3 * 10^8\ m/s)$ $t_0 = length\ of\ the\ pulse\ (940nm)$ $q_1 =$ Accumulated charge in the pixel when light is emitted $q_2 =$ Accumulated charge when it is not Note: This sensor design is used by the Vl53L1X Time of Flight Sensor (Max Range: 4m) used in this project.

Low Power Audio Amplifier

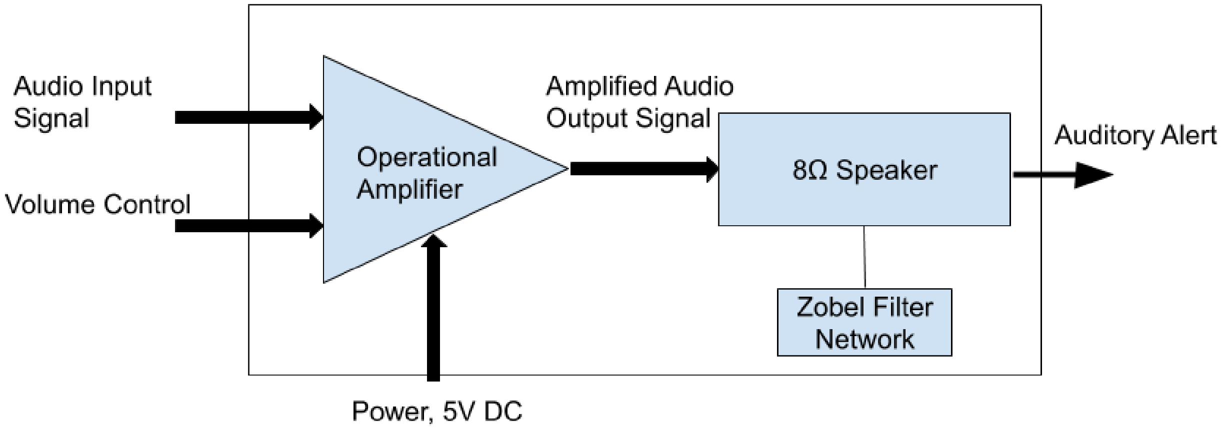


Figure 6: Level 2 – Low Power Audio Amplifier Block Diagram

Module	Low Power Audio Amplifier
Inputs	- Audio Input Signal - Power: 5V DC Signal - Volume Control
Outputs	- Auditory Alert
Functionality	Once certain conditions are met (Distance ≤3' and Temp > 70.5°F) then the ATmega328 will transmit audio frequencies to the Low Power Audio Amplifier. The user will have volume control provided by a 10kΩ rotary potentiometer. Based on the set volume from the user the signal will then go through an amplification (gain) stage set to a gain of 200. Then the decoupled and amplified audio signal will enter an 8Ω speaker in parallel to a Zobel Filter Network to neutralize the effects of the driver's inductance coil and alarm the user if they are too close to another person.