# Circuit Chaos: Using Circuits and Boolean Algebra for Early Home Covid-19 Monitoring and Detection in Vulnerable Populations

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***Abstract* — The objective was to create a processing unit that allows for early home detection and monitoring of Covid-19 in vulnerable populations. The detector must be able to identify the presence of three symptoms in the subject: i) dry cough, ii) increase in body temperature, and iii) decrease in oxygen levels. Using colored LED lights and an alarm to indicate the number of detectable symptoms, the device must be able to warn the subject of potential infection by Covid-19 at regular time intervals. Using said systems, it allows for an easy, cost-effective and portable early warning device. Overall, the product was able to meet and exceed all available criteria, ensuring future usage and market success when implemented.**

***Keywords*— Circuit, Digital Logic, Boolean Algebra, Breadboard, COVID-19 detector, Multimeter**

## I. Introduction

Covid 19, the most prolific virus in recent years, has had a prolific effect within the social, political and economic climate. The World Health Organization reported up to 775.5 million cases since the pandemic's inception in 2020. Initially, the death rate for seniors was 1,645/100,000 cases in 2020[1]. In 2022, the senior death rate decreased, with 1,224/100,000 cases, but still proving to be the most vulnerable in comparison to healthy adolescents[2]. This alarming statistic highlighted the urgent need for protective measures, particularly for at-risk populations. Consequently, the task was undertaken to build an early home warning monitoring device for Covid-19 in vulnerable populations. The project utilized circuits, LEDs, logic gate chips, D-flip flops, timers, and a speaker. Given the complexity and importance of this endeavor, the design and planning process of creating a circuit board was crucial. During the building process, structured philosophies, such as the Design for Six Sigma, were implemented to quickly overcome flaws and analyze feedback swiftly in order to continuously improve our product, allowing for objectives to be accomplished efficiently while still finishing with a quality build.

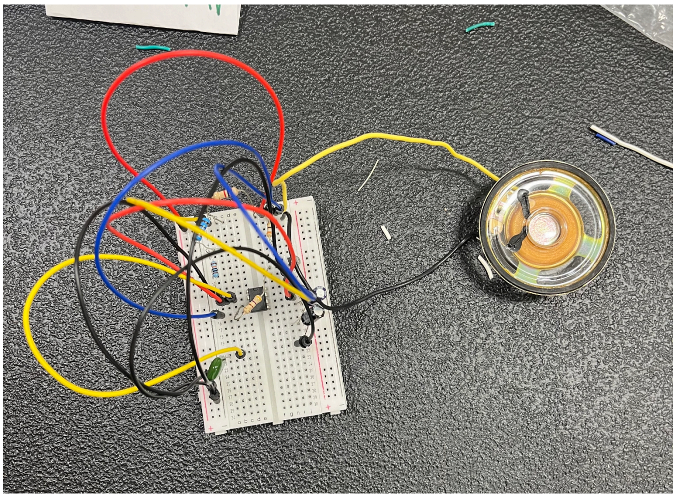

*Fig. 1.*

*Completed Alarm Circuit to notify user and admin of patients status. Worked together with the logic circuit to complete the Covid-19 detector.*

## II. MATERIALS AND METHODS

During the process, multiple tools were used to ensure that the product was functioning. General components that were used in every build included the breadboard, wires, batteries and resistors. Circuit function-specific items included 555 timing chips, AND and OR gates, speakers, and LEDs. In terms of functionality, each LED was assigned a degree of Covid-19 severity, with Green representing the presence of no symptoms, yellow representing 1 symptom, red representing 2 symptoms, and an alarm sound and EMTs notified when all 3 symptoms were present within the patient [Fig 1]. To support the main circuit, 2 others circuits were created, including a switch circuit to allow user input and a logic circuit [Fig 2] to process the input and control the alarms as well [Fig 3]. Before the assembly of each circuit, initial plans were drafted to ensure consistency and efficiency [Fig 4].

The majority of the steps were solely building towards the final process. The first step taken in the building process was the construction of the 555 timer connected to the electronic piezo that would serve as the alarm. Next up was the logic module constructed from AND, XOR, and NOT gates. To connect to said gates, the output module containing 4 LEDs, green, yellow, red, and blue, was built and tested with the logic module. Finally, the D-flip flops and the accompanying 555 timer were constructed and connected and following further trouble shooting, the circuit was complete.

The process of troubleshooting and fixing known issues was more complex. After building the alarm circuit, it was immediately tested and discovered to be malfunctioning. Before taking the alarm circuit apart, the speaker was replaced with a blue LED for testing. After testing, the blue LED was working adequately and it was determined that the speaker was the problem, and replacing it solved the issue. The logic units required extensive testing with a Multimeter to uncover the root cause of the problem, which was overdrawing from an AND chip. With that completed, only the D-flip flops and the timing circuit still needed testing. The D-flip flops went off without a hitch, but the timer required more effort to fix. The end product was ready for another round of troubleshooting. When fabricating and fixing these circuits, we relied heavily on the Design for Six Sigma steps, as imagination, planning and creating were crucial steps within the research and development process. Overall, these relatively simple steps are time-efficient while also being user friendly, allowing for seniors to readily access care and notify EMTs when needed.

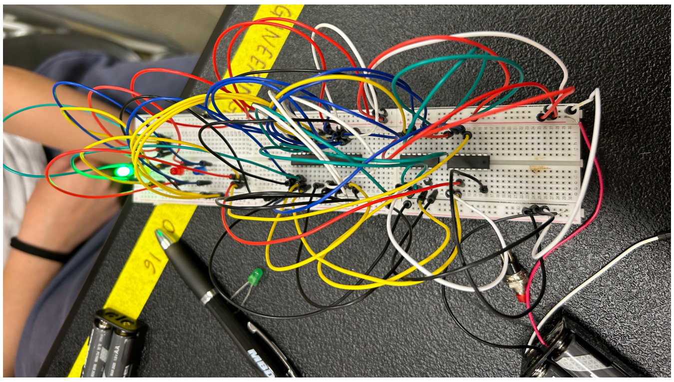

*Fig. 2 Completed Logic Board to ensure the other circuits worked together. This was crucial as it connected all the components together.*

## III. RESULTS

Measures taken during this process included modeling the future prototypes to be built in subsequent steps, drawing truth tables illustrating requirements for each LED and the alarm to be activated, and starting the building process for prototypes. An alternative option was denoted towards the use of a push-type switch, but another type of switch was utilized as it was more suitable for logic gates. After a few rounds of troubleshooting and reconfiguration of the product, it was able to fully function. With all of the circuits being completed and operating normally, the Covid-19 symptom detection circuits were ready to use.

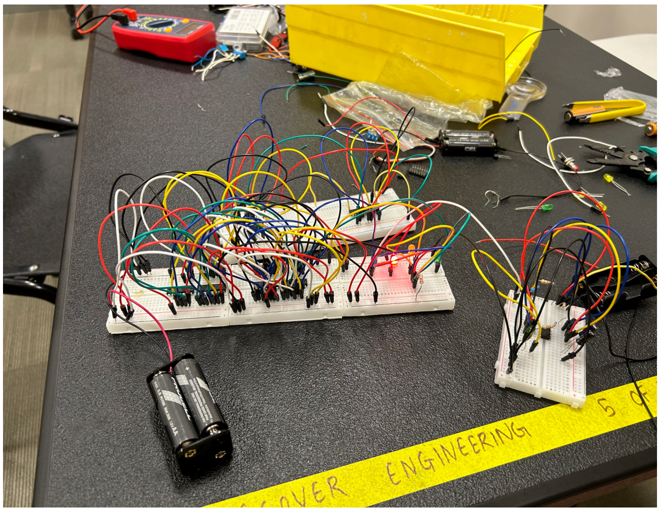


*Fig. 3 Final Iteration of the project. All parts seen in previous figures were assembled and can be seen functioning when 2 symptoms are present.*

## IV. CONCLUSION

Covid-19 has left a profound mark on society with high and staggering infection rates. The virus has disproportionately affected vulnerable populations such as seniors. The project focused on developing an early home warning monitoring device for Covid-19, utilizing wires, LEDs, and alarm, and logic gate chips. Despite the many troubleshooting issues encountered during this project, it was still successful and met all requirements, the circuits were able to detect early Covid-19 symptoms and execute actions such as activating an LED according to the number of symptoms detected and sounding an alarm when all early symptoms for Covid-19 were found. The next steps to take on to improve for future projects is to practice wire management skills to make circuits easier to follow and troubleshoot. If ever implemented, this device can alert its users about the virus they potentially have and can prevent Covid-19 from spreading at rapid rates.

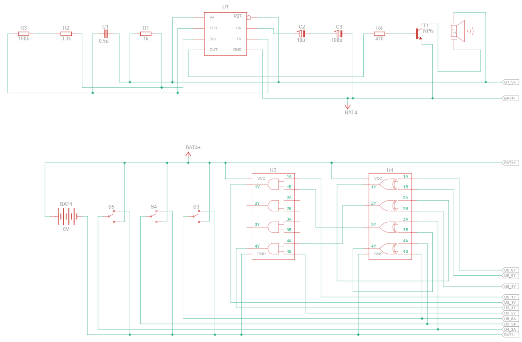

*Fig. 4 FLogic Schematic Layout that was used during the creation of the logic board circuit in fig 1. Saved time and resources during creation of the Logic Circuit.*

## References


[1] *Covid-19 Mortality in Adults Aged 65 and over - Cdc, www.cdc.gov/nchs/data/databriefs/db446.pdf. Accessed 24 June 2024.*

[2] *"Covid-19 Mortality Update - United States, 2022." Centers for Disease Control and Prevention, Centers for Disease Control and Prevention, 4 May 2023, www.cdc.gov/mmwr/volumes/72/wr/mm7218a4.htm.*