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# IoT based Eye Movement Guided Wheelchair driving control using AD8232 ECG Sensor

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***Abstract: Each and every muscular movement in the body is induced by electrical signals. These electrical signals are in mV and they are very sensitive to noise factors like electrical gadgets placed nearby, different movements, earthing, etc. If such signals are traced carefully, they can be used to accomplish multiple tasks. Such signals are called Myographs. This paper proposes a new method for eye-movement tracking, using Arduino Nano along with AD8232, i.e. the ECG Sensor. Most of the devices for Eye Tracking need to be placed right on the eye which sometimes use Infrared Radiations which may be harmful to eyes. This proposed method captures the gaze direction by muscular contraction, also called Myography. This is done by placing the electrode pads on the forehead and the ECG line graphs demonstrate the direction of gaze which can be understood using the convolution method. After the movement direction is decided based on convolution method, the values are sent and received from the IoT cloud. Thus, the wheelchair movement can be controlled by online and offline modes, making it more opportune to the patient. The goal of the system is to avail low-cost solutions to the needer.***

***Keywords : AD8232, Arduino Nano, Convolution, ECG, Eye Tracking, Myography, Saccades***

## I. INTRODUCTION

A person's morale is proportional to his ability to be independent. According to the 2011 census, 2.21% people in India are disabled, out of which 20% people have a disability in movement, i.e. 45 lakh people in the country [4]. This count has increased in the last decade. A survey also indicated that many such people find it impossible to maneuver the conventional wheelchairs by themselves which makes them dependent on other people.

In today's world, many types of robotic and electric wheelchairs have been designed. However, it needs to be steered manually and is also very expensive. Also, since the disability can vary from person to person, a model that is universal and also cost-effective cannot be designed. After all, many differently-abled people see their supportive equipment as an augmentation of themselves, it has been a topic of absolute requisite to build types of equipment that the people who use it can coalesce into their lives well [7]. Hence, we propose a wheelchair that can be steered by the eyeball motion.

In this paper, different types of Myography signals like write, pressure, accelerometer and electrical Myographs are explained. Different types of sensors like pulse sensor, heartbeat signal, ECG signal, and temperature signals are discussed as well. The AD8232 sensor is described in detail with its specifications. The small computation device "Arduino" is also mentioned and certain programming details to use it are also given.

The tracking of eye movement is a technique using which an individual's eye movements are captured to know the direction in which the person is gazing. On the basis of the direction of the eye motion, commands are given to the wheelchair electrically. The eye motion is tracked using the ECG sensor i.e. AD8232. This is done by placing the electrode pads on the forehead which can detect ECG Anomalies [19] and the Myograph signal and capture the direction in which the individual is gazing. When the left or right motion of the eye is detected, the wheelchair is given the command to move in the same direction.

Further, the signals are fed to the convolution matrix where, based on the signal nature, the value is calculated. This value is used to decide the direction of the wheelchair movement. The proposed system is also deployed on ThingSpeak cloud to make it IoT enabled. It is thus making the wheelchair movement available in online as well as offline mode to help the patients and their well-wishers.

## II. BACKGROUND KNOWLEDGE

### A. Eye Movement

In simple words, eye movement is the intentional or unintentional movement of the eyes, assists in obtaining, fixating and apprehending visual impetus. The voluntary eye movements in humans are triggered by a small cortical region in the brain's frontal lobe. They are of three types: vergence shifts, saccades, and smooth pursuit.

The eye movements are controlled by six muscles: superior oblique, inferior oblique, medial rectus, lateral rectus, superior rectus, and inferior rectus.

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The rotation of the eye with about a millimeter translation is caused due to the torque applied to the sphere when the muscles employ different forces. So, the eye undergoes rotations about a single point that is the eye kernel. The eyes follow an object moving at constant speed quite quickly, though to match the pace they may have saccadic jerks many a time.

The quick and simultaneous movements of both eyes in the same direction is called Saccades. The frontal lobe of the brain regulates these voluntary eye movements. They are particularly crucial for our research. [16]

### B. Myograph signal

A Myograph is an equipment that is used to quantify the intensity exerted by a muscle under contraction. The study of the velocity and intensity of a muscular contraction is called Myography. The Myograph signal is a biomedical signal that measures, analyzes and detects medical abnormalities, activation level or recruitment order or analyzes the biomechanics of a human or animal movement [1]. A Myograph can take several forms such as [2] :

**1. Pressure Myograph:** It is used to quantify the physiological action and attributes of artery ducts, veins, and other tubes. Pressure Myographs enable the study of the pharmacological effects of pharmaceutical pills, drugs and other endogenous agents that causes either increase or decrease in blood pressure on small isolated vessels under near-physiological circumstances. In this type of Myography, a whole part of an artery duct or some other vessel is fitted on two small glass cylinders and coerced to an appropriate transmutable pressure. This is a near-physiological circumstance which grants access to the inspection of natural (myogenic) reflexes that can be grossed up to the behavior of the whole vascular bed (autoregulation). [11]

**2. Wire Myograph:** It is a mechanism that enables us to inspect functional reflexes and vascular reactivity of separated small resistant ducts. Vessels from various species, involving transient systems, and vascular beds can be studied in many ways of pathological disease phases. Tubes/Ducts are dichotomized, cleansed, and then fitted on a four-channel myograph with isometric techniques. Every duct is then regularized to derive maximal progressive force development. It enables the systematization of the start probationary conditions, a necessary contemplation when scrutinizing pharmacological differences between ducts.

**3. Acceleromyograph:** An accelero-myograph is a piezoelectric myograph. It is used to quantify the force exerted by a muscle after undergoing nerve inducement. They are used during unconsciousness when muscle intoxicants are administrated to calibrate the depth of neuromuscular hindrance and to ensure capacity of rehabilitation from these representatives at the end of the operation. Acceleromyography is classified as quantitative neuromuscular monitoring. It is for skeletal muscles and other devices

**4. Electromyograph:** It is an electrodiagnostic medical strategy for estimating and taping the electric potential composed by scrawny muscles. It is implemented using a device known as an electromyograph to compose a report which is known as an electromyogram. This device detects the electric activity produced by muscle cells when the cells are neurologically or electrically activated. These wave motions can be investigated to notice therapeutic deviations, recruitment order or activation level, or to study the biomechanics of animal or human movement.

Equipment used for measuring the intensity of a Myographic signal is called a Myographic sensor, for example, a myo-ware muscle sensor [3]. This Sensor uses EMG (Electromyography) to sense the electrical activity of the muscles. It then converts the activity into varying voltage that can be read on the analog input pin of any micro-controller.

## III. SENSORS AND INTERFACING

Different available and suitable sensors are studies and the AD8232 with Arduino interfacing is shown below.

1. **MAX30102: Pulse Oximetry and Heart Rate Monitor**

MAX30102, pulse oximetry, and heart-rate monitor biosensor encompass photo detectors, internal LEDs, low-noise electronics and optical elements. It simplifies the planning process for wearable devices and mobiles by providing an elaborate system solution. This sensor works on one power supply of 1.8 V and the internal LEDs operate on a disjoint power supply of 3.3 V. I2C-compatible interface is used for intercommunication. The power rails stay connected all the time as the module is switched off through program with no backup current. [10]

2. **MAX30100: Heart Rate Sensor**

MAX30100, an integrated heart rate monitor sensor, and pulse oximetry encompass a photo detector, optimized optics, low-noise analog signal processing, and two LEDs. This sensor operates with power supplies from 1.8V and 3.3V and can be switched off through program with no backup current, thus allowing the power supply to remain powered all the time. It can be used as a wearable fitness assistant or a medical monitoring device. [12]

3. **DS18B20: Temperature Sensor**

The DS18B20 is an excellent choice for calibrating temperature at many points as it does not require the using of many digital pins, instead it uses only one digital pin in order to transmit data. It is a 1-wire programmable Temperature sensor and is mostly used to calibrate temperature in environments such as soil, mines, chemical compounds, etc. The stricture of the sensor is jagged. It also has a waterproof variant. It can calibrate temperature within the range of -55°C to +125° with veracity of 5°C. [13]

4. **AD8232: ECG Sensor**

AD8232 is a small chip used to calibrate the electrical activity of the heart and can be used to diagnose heart conditions if any. It is architectured to extort, boost and refine biopotential signals if some noisy conditions exist. The architecture of this sensor permits for an embedded microcontroller or an extremely low power ADC to get the output signal easily. It is available in a 4 mm × 4 mm, 20-lead LFCSP package. The specified performance says 0°C to 70°C however; it is viable from −40°C to +85°C. [14]

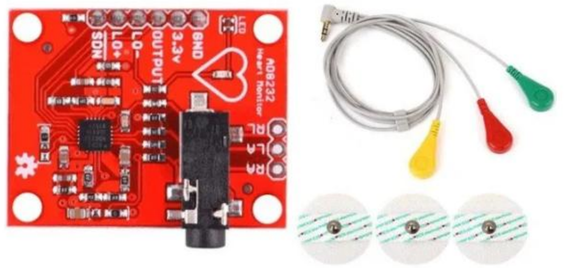

**Fig. 1. AD8232 ECG Sensor [18]**

**4.1AD8232 interfacing with Hardware Arduino Nano**

The digital output of the heartbeat is obtained when we place the finger on the heartbeat sensor. The heartbeat sensor has a glowing LED which flashes in harmony with each pulse when the sensor is working. The output obtained from the sensor is sent directly to the microcontroller to quantify the heart beats per minute (BPM) rate [5]. For measuring the electrical activity of the heart, i.e. the Electrocardiogram or the ECG, we use a little chip called AD8232. [8] It is an agglomerated

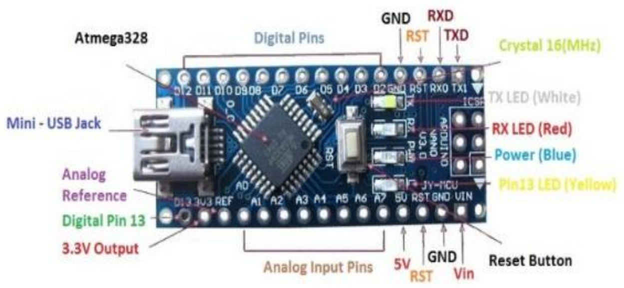


**Fig. 2. Arduino Nano [20]**

signal preparation device for measuring heart activity and also used for other measurement applications. It is constructed to obtain, exaggerate, and clean small radiations at the time of disordered environment, for example, such as those generated by motion or remote electrode placement. The hardware that we use in our proposed system is Arduino Nano [9]. It is a Micro-controller chipboard developed by Arduino.cc and based on Atmega328p / Atmega168. Arduino boards are widely used in robotics, embedded systems, and electronic projects where automation is an essential part of the system.

## IV. EYE MOVEMENT TRACKING APPLICATION

The tracking of eye movement can have several day-to-day applications in various fields such as Psychology, Education, Clinical Research, Marketing, Consumer Research, etc. Some of them are:

**1. Automotive Industry:** The study of data of the driver's eye movements can be very productive for sleepiness and attention measurements while a person is driving. Since the eye movements and the part of the brain cortex related to attention are the same, they are quite related to each other. Analyzing the amplitude of gaze activity and the blink duration can be used to detect the drowsiness of the driver. [15]

**2. Virtual Environment:** In a virtual environment experiment, eye motions were noted and then re-created with the help of virtual eyes. Knowing the gaze point of another user's avatar is an important interactional enhancement. [15]

**3. Desktop Navigation:** Eyeball motion can also be used to scroll the computer pages up and down, and control several other screen activities. The speed of scrolling can also be controlled by using the gaze intensification method. [15] Similarly, eyeball motion can also be used to control the cursor.

**4. Steering a Wheelchair**: The eye motion can be used to control the movement of a wheelchair. As the left or right movement of the eyeball is noted, the wheelchair moves in that particular direction. These commands are recognized by the wheelchair-using electric wave motions that are used to direct the motion of the wheelchair. It has two generators attached to the wheels of the chair. These signals are directed to the generators with the use of hardware ports. This port has some pins which are predefined that accept the directions given to the wheelchair in the form of electrical signal movements. To demonstrate this movement using eyeball movement, a model is made in this project, that uses batteries. [17]

## V. IMPLEMENTATION AND RESULTS

The Electrodes of AD8232 Sensors are places on forehead as shown in figure 3.The red electrode pad is placed in the center, the yellow electrode pad is placed on patient's right forehead and the green is placed on patient's left (optional).

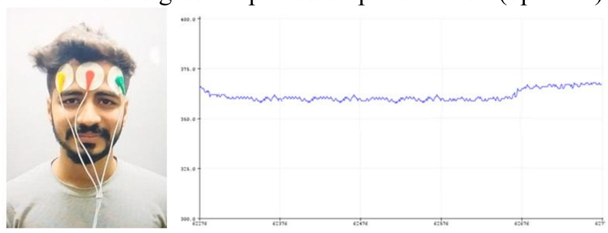

**Fig. 3. Position of Electrodes and the signal generation when gazing straight**

When both the eyes gaze towards the right, ECG translated the eyeball motion into the line tracing given below.

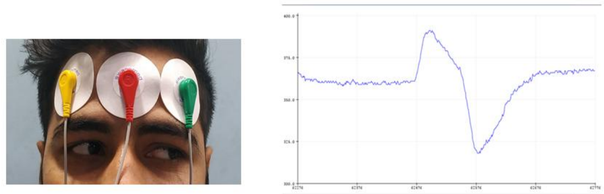

**Fig. 4. Signal formation when gazing towards the left**

Under similar conditions, when the patient gazes towards the right, we get the following line tracing:

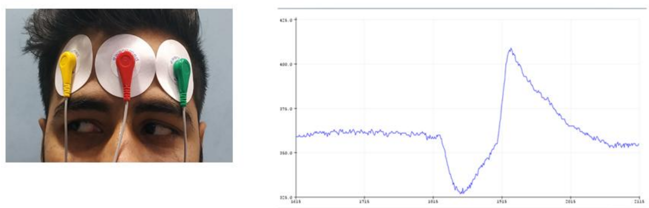

**Fig. 5. Signal formation when gazing towards the right**

### A. Detecting Movement direction from the signal

There multiple ways to detect the signal nature, its slope, and shapes, but many of them are computationally intensive.

To make it less complex, here the convolution approach is used. The matrices are designed in such a way that it will return positive, zero and negative values. This method is less in terms of time and space complexity. Also, it can be performed on the same Arduino, which is reading the signals.

| | | | | | |
|---|---|---|---|---|---|
| +3 | +3 | +2 | +2 | +1 | +1 |
| +3 | +3 | +2 | +2 | +1 | +1 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| -3 | -3 | -2 | -2 | -1 | -1 |
| -3 | -3 | -2 | -2 | -1 | -1 |

Convolution value = +5

| | | | | | |
|---|---|---|---|---|---|
| +3 | +3 | +2 | +2 | +1 | +1 |
| +3 | +3 | +2 | +2 | +1 | +1 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| -3 | -3 | -2 | -2 | -1 | -1 |
| -3 | -3 | -2 | -2 | -1 | -1 |

Convolution value = 0

| | | | | | |
|---|---|---|---|---|---|
| +3 | +3 | +2 | +2 | +1 | +1 |
| +3 | +3 | +2 | +2 | +1 | +1 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| -3 | -3 | -2 | -2 | -1 | -1 |
| -3 | -3 | -2 | -2 | -1 | -1 |

Convolution value = -6

**Fig. 6. Waveform and convolution matrix to detect the signal nature**

From the values obtained by convolution matrices, that is the nature of the value, if it is positive then the signal is to turn left when it is zero then go straight and for negative values, it should turn right.

### B. Deployment on ThingSpeak Cloud and using IoT to control the wheelchair movement

IoT makes the device control possible over the internet. The wheelchair can work in online and offline mode. The offline mode is very effective and quick as it does not have the networking delays. But the online mode is very vital to reach and control the wheelchair remotely. For example, if the patient is away from the wheelchair then by using the IoT based service, he can command the wheelchair to come closer. Any other person and doctor supporting staff can also guide the wheelchair to reach in a particular ward. To make it IoT enabled, the Arduino is connected to wifi, and it is reading the signal, finding the convolution matrix value and sending those values to the ThingSpeak Cloud. While sending and receiving the value over the ThingSpeak cloud, developer has to use, read and write API keys.

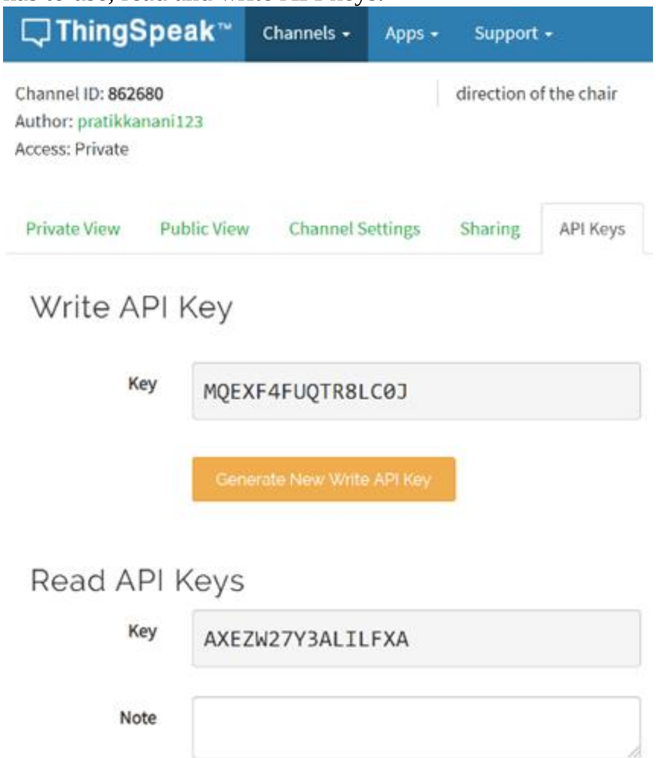


**Fig.7. Read and Write API keys on the ThingSpeak Cloud**

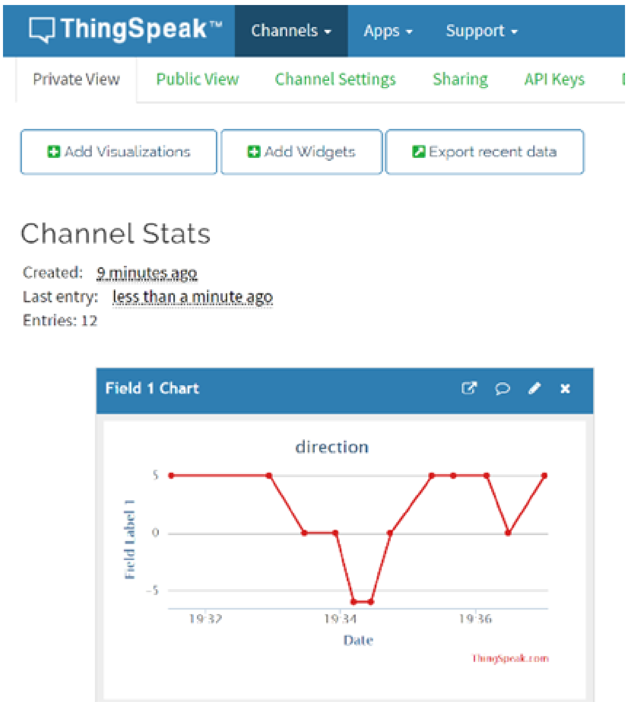


**Fig. 8. Direction values on the ThingSpeak Cloud**

To send and receive the direction values, the Arduino code used is given below.

https://api.thingspeak.com/update?api_key=MQEXF4FUQTR8LC0J&field1=val

https://api.thingspeak.com/channels/862680/fields/1/last.json?api_key=AXEZW27Y3ALILFXA

## VI. CONCLUSION

Myographic signals are helpful for controlling user movements. Such signals are shaped due to different muscle movements related to pressure, writing, actions, motions and muscle movements. Different sensors are used to detect such signals. Here, Arduino and AD8232 sensors are used to trace the signal generated due to the eyeball gazing direction. Further these signals are processed in the Arduino and they are sent on the ThingSpeak Cloud to make it IoT enabled. The wheelchair system developed is having remote location control over it. The proposed wheelchair system can be easily operated by the user. The user only needs to gaze left or right to move towards the desired direction. This method of eyeball motion tracking is easy and comfortable for the people who use it. The system uses a convolution matrix method to detect the direction which requires low computation and the simple Arduino is able to process the same. Hence, the system is time and space-efficient and it can be built at a low cost. In future, different signals from different parts of the patients body can be recorded and by using such signals patients can also convey the message for food, medicines, water and going to washroom.

## REFERENCES

1. Myograph (2019, July 3) [Online]. Available: https://en.wikipedia.org/wiki/Myograph
2. Electromyography (EMG) (2019, July 7) [Online]. Available: https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/electromyography-emg
3. Getting Started with Myoware Muscle Sensor (2019, July 10) [Online]. Available: https://learn.adafruit.com/getting-started-with-myoware-muscle-sensor
4. Disabled Persons in India, A statistical Profile 2016 (2019, July 13) [Online]. Available: http://mospi.nic.in/sites/default/files/publication_reports/Disabled_persons_in_India_2016.pdf
5. Heartbeat Sensor Circuit and Working Operation with 8051 (2019, July 15) [Online]. Available: https://www.elprocus.com/heartbeat-sensor
6. AD8232 Heart Rate Monitor Hookup Guide (2019, July 17) [Online]. Available: https://learn.sparkfun.com/tutorials/ad8232-heart-rate-monitor-hookup-guide/all
7. M. Jain, S. Puri, and S. Unishree, "Eyeball Motion Controlled Wheelchair Using IR Sensors",World Academy of Science, Engineering and Technology, International Journal of Computer and Information Engineering vol:9, No:4, 2015 (2019, July 25) [Online]. Available: https://waset.org/publications/10001895/eyeball-motion-controlled-wheelchair-using-ir-sensors
8. SUNROM, ECG Sensor Module - AD8232 (2019, August 3) [Online]. Available: https://www.sunrom.com/p/ecg-sensor-module-ad8232
9. Introduction to Arduino Nano, A complete step by step tutorial on the Introduction to Arduino Nano (2019, August 9) [Online]. Available: https://www.theengineeringprojects.com/2018/06/introduction-to-arduino-nano.html
10. MAX30102, High-Sensitivity Pulse Oximeter and Heart-Rate Sensor for Wearable Health (2019, August 15) [Online]. Available: https://www.maximintegrated.com/en/products/sensors/MAX30102.html
11. DMT, PRESSURE MYOGRAPH SYSTEMS (2019, August 17) [Online]. Available: http://www.navbo.org/images/dmt2.pdf
12. MAX30100, Pulse Oximeter and Heart-Rate Sensor IC for Wearable Health (2019, August 21) [Online]. Available: https://datasheets.maximintegrated.com/en/ds/MAX30100.pdf
13. DS18B20 Temperature Sensor (2019, August 23) [Online]. Available: https://components101.com/sensors/ds18b20-temperature-sensor
14. Analog Devices, Single-Lead, Heart Rate Monitor Front End, AD8232 (2019, August 25) [Online]. Available: https://www.analog.com/media/en/technical-documentation/data-sheets/AD8232.pdf
15. F. BARBUCEANU, C. ANTONYA1, EYE TRACKING APPLICATIONS (2019, August 28) [Online]. Available: https://pdfs.semanticscholar.org/0bf1/27a7d47da4624b5b85989b22854613a2d888.pdf
16. Sowmiya V, Dr.R.Jegannthan, "Cursor Movement Using Eyeball Motion", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, Issue 8, August 2015. (2019, September 7) [Online]. Available: http://www.ijirset.com/upload/2015/august/95A_BIOMEDICAL_014_Jegannthan.pdf
17. Eye motion tracking for wheelchair control (2019, September 9) [Online]. Available: https://www.researchgate.net/publication/228410088_Eye_motion_tracking_for_wheelchair_control
18. ECG Graph Monitoring With AD8232 ECG Sensor & Arduino (2019, September 17) [Online]. Available: AD8232 ECG Sensor, https://www.how2electronics.com/ecg-monitoring-with-ad8232-ecg-sensor-arduino/
19. Kanani P., Padole M. (2018) Recognizing Real Time ECG Anomalies Using Arduino, AD8232 and Java. In: Singh M., Gupta P., Tyagi V., Flusser J., Ören T. (eds) Advances in Computing and Data Sciences. ICACDS 2018. Communications in Computer and Information Science, vol 905. Springer, Singapore
20. Introduction to Arduino Nano (2019, September 29) [Online]. Available: Introduction to Arduino Nano, https://www.theengineeringprojects.com/2018/06/introduction-to-arduino-nano.html

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