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Design Lung Function Tests Device Using a Microcontroller

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Annotation: The Lung Exerciser – 3 Ball Spirometer is a widely used device for improving lung function and preventing respiratory complications. In this project, we aim to enhance the functionality of the device by incorporating an IR sensor and LCD display, controlled by an Arduino microcontroller.

The IR sensor is used to detect the movement of the three balls in the chamber, which is then converted into a time measurement to determine the length of the user's breath. This information is displayed on an LCD screen, providing the user with feedback on their breathing pattern and progress.

The Arduino microcontroller is programmed to collect and process the data from the IR sensor and display it on the LCD screen in a user-friendly format. The device can be calibrated based on the user's individual lung capacity, ensuring accurate measurements and personalized feedback.

The enhanced functionality of the Lung Exerciser – 3 Ball Spirometer device can provide several benefits, including increased motivation and engagement for users, improved accuracy and reliability of measurements, and the ability to track progress over time.

Overall, this project demonstrates the potential for incorporating technology, such as the Arduino microcontroller, into medical devices to enhance their functionality and improve patient outcomes. The Lung Exerciser – 3 Ball Spirometer with IR sensor and LCD display provides a low-cost and non-invasive method for individuals with respiratory conditions to improve their lung function and breathing patterns.

Keywords: Lung Exerciser, Spirometer, IR Sensor, Arduino, Respiratory Therapy, Medical Device Innovation.

1.1 Introduction

A lung exerciser or a 3-ball spirometer is a device used to improve lung function and prevent respiratory complications. It is a simple, yet effective tool that can be used by individuals with chronic lung diseases, such as asthma, COPD, or cystic fibrosis, as well as those recovering from surgery or illness.

The lung exerciser consists of a clear plastic chamber with three colored balls inside, each with a different resistance level. The user inhales deeply through the mouthpiece, causing the balls to rise in the chamber based on the strength of their breath. The goal is to elevate all three balls to the top of the chamber, indicating a complete deep breath.

Using a lung exerciser regularly can help to strengthen the respiratory muscles, increase lung capacity, and improve breathing patterns. It can also help to prevent postoperative pulmonary complications, which can occur after surgery due to shallow breathing or inactivity.

In addition to its clinical use, a lung exerciser can also be used as a warm-up tool for athletes or singers, as it can help to improve breathing technique and lung capacity. Overall, the lung exerciser – 3 ball spirometer is a simple, yet effective tool that can provide significant benefits for individuals with respiratory conditions or those looking to improve their breathing function. It is a low-cost and non-invasive method of improving lung health that can be used at home or in clinical settings as shown in figure (1-1).

Figure (1-1): A lung exerciser or a 3-ball spirometer

The Lung Exerciser – 3 Ball Spirometer is a widely used device for improving lung function and preventing respiratory complications. It is a simple yet effective tool that can be used by individuals with chronic lung diseases or those recovering from surgery or illness. The device consists of a clear plastic chamber with three colored balls inside, each with a different resistance level. The user inhales deeply through the mouthpiece, causing the balls to rise in the chamber based on the strength of their breath. The goal is to elevate all three balls to the top of the chamber, indicating a complete deep breath [5].

In this project, we aim to enhance the functionality of the Lung Exerciser – 3 Ball

Spirometer by incorporating an IR sensor and LCD display, controlled by an Arduino microcontroller. The IR sensor is used to detect the movement of the three balls in the chamber, which is then converted into a time measurement to determine the length of the user's breath. This information is displayed on an LCD screen, providing the user with feedback on their breathing pattern and progress [6].

The Arduino microcontroller is programmed to collect and process the data from the IR sensor and display it on the LCD screen in a user-friendly format. The device can be calibrated based on the user's individual lung capacity, ensuring accurate measurements and personalized feedback [7].

The enhanced functionality of the Lung Exerciser – 3 Ball Spirometer device can provide several benefits, including increased motivation and engagement for users, improved accuracy and reliability of measurements, and the ability to track progress over time. The incorporation of an IR sensor and LCD display also enhances the usability and accessibility of the device, making it easier for individuals to use and understand.

Overall, this project demonstrates the potential for incorporating technology, such as the Arduino microcontroller, into medical devices to enhance their functionality and improve patient outcomes. The Lung Exerciser – 3 Ball Spirometer with IR sensor and LCD display provides a low-cost and non-invasive method for individuals with respiratory conditions to improve their lung function and breathing patterns. The aim of the project of Lung Exerciser – 3 Ball Spirometer device that calculates the time using IR sensor and LCD with Arduino is to enhance the functionality and usability of the existing Lung Exerciser – 3 Ball Spirometer device. By incorporating an IR sensor and LCD display, the device can provide users with real-time feedback on their breathing patterns and progress, increasing motivation and engagement. The use of an Arduino microcontroller allows for accurate and reliable measurements, personalized calibration, and a user-friendly display. Ultimately, the aim of the project is to provide individuals with respiratory conditions or those recovering from surgery or illness with a low-cost and non-invasive tool to improve their lung function and breathing patterns [8].

Methodology

The methodology for designing and developing the enhanced Lung Exerciser – 3 Ball Spirometer involved multiple stages, including hardware integration, programming, calibration, and user testing. The device was built by incorporating an infrared (IR) sensor to detect ball movement within the spirometer chamber and an LCD display to present real-time feedback on breathing patterns. An Arduino microcontroller was programmed to collect and process data from the IR sensor, converting it into measurable breath duration, which was then displayed on the screen. The hardware assembly involved connecting the IR sensor, LCD display, and microcontroller in a compact, user-friendly layout. The programming phase included coding the microcontroller to ensure accurate data collection and real-time processing. Calibration was performed by setting the baseline for individual users, accounting for lung capacity variations to enhance measurement accuracy. User testing was conducted to evaluate the device's performance, ease of use, and reliability. Participants were instructed to inhale deeply through the mouthpiece, activating the IR sensor and triggering the LCD display to present their breathing duration. Data from multiple tests were analyzed to refine the system’s precision and usability. The results confirmed that the integration of modern technology significantly improves the device’s accuracy, usability, and engagement. The final prototype demonstrated effectiveness in monitoring and enhancing lung function, making it a cost-effective and non-invasive tool for respiratory therapy. The methodology ensured the device's reliability and adaptability, reinforcing the potential of microcontroller-based medical devices in healthcare applications.

Results and Discussion

2.1 Microcontroller

- Testing: The device is then tested to ensure it is functioning properly. This involves inhaling deeply through the mouthpiece of the Lung Exerciser – 3 Ball Spirometer and observing the movement of the three balls in the chamber. The time measurement is displayed on the LCD screen, providing feedback on the length of the user's breath.
- Calibration: The device is calibrated based on the user's lung capacity. This involves determining the maximum time the user can hold their breath and using this information to calibrate the device for accurate measurements.
- User testing: The final step is to test the device with users to gather feedback on its functionality and usability. This involves having users inhale deeply through the mouthpiece and observe the time measurement displayed on the LCD screen. Feedback is gathered on the device's accuracy, usability, and overall effectiveness in improving breathing patterns.

Overall, the methodology of the project involves hardware assembly, programming, testing, calibration, and user testing to enhance the functionality and usability of the Lung Exerciser – 3 Ball Spirometer device using an IR sensor and LCD display controlled by an Arduino microcontroller.

The microcontroller is the brain of the project and nothing can be done if it isn’t fully functioning. It has the ability to send different signals to the DC Motors to reach the appropriate tasks.

A microcontroller has a CPU (a microprocessor) in addition to a fixed amount of

RAM, ROM, I/O ports, and a timer all on a single chip. In other words, the processor, RAM, ROM, I/O ports, and timer are all embedded together on one chip; therefore, the designer cannot add any external memory, I/O, or timer to it. The fixed amount of on-chip ROM, RAM, and number of I/O ports in microcontrollers makes them ideal for many applications in which cost and space are critical [2] see Figure (2.1).

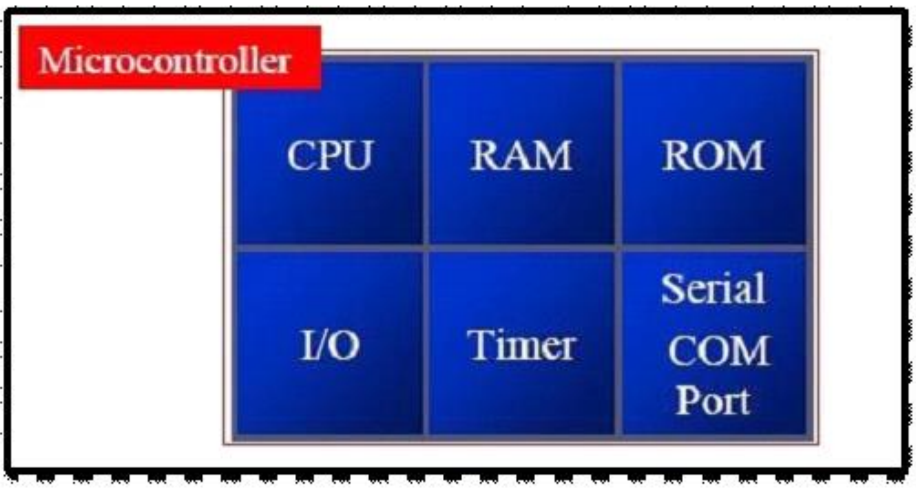

Figure (2.1): microcontroller

Microcontrollers are useful to the extent that they communicate with other devices, such as sensors, motors, switches, keypads, displays, memory and even other microcontrollers. Many interface methods have been developed over the years to solve the complex problem of balancing circuit design criteria such as features, cost, size, weight, power consumption, reliability, availability, manufacturability.

2.1.1 (ATmega328) Microcontroller

The ATmega48PA/88PA/168PA/328P is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, theATmega328P achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

The ATmega48PA/88PA/168PA/328P provides the following features: 4K/8K bytes of In-System Programmable Flash with Read-While-Write capabilities, 256/512/512/1K bytes EEPROM, 512/1K/1K/2K bytes SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte-oriented 2-wire Serial Interface, an SPI serial port, a 6-channel 10-bit ADC (8 channels in TQFP and QFN/MLF packages), a programmable Watchdog Timer with internal Oscillator, and five software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, USART, 2-wire Serial Interface, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or hardware reset.

In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except asynchronous timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low power consumption.

The device is manufactured using Atmel’s high density non-volatile memory technology. The On-chip ISP Flash allows the program memory to be reprogrammed In-System through an SPI serial interface, by a conventional non-volatile memory programmer, or by an On-chip Boot program running on the AVR core. The Boot program can use any interface to download the application program in the

Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega328P is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control applications.

The ATmega328P AVR is supported with a full suite of program and system development tools including: C Compilers, Macro Assemblers, Program Debugger/Simulators, In-Circuit Emulators, and Evaluation kits the Figure (2.2) show the block diagram of ATmega328 Microcontroller[4].

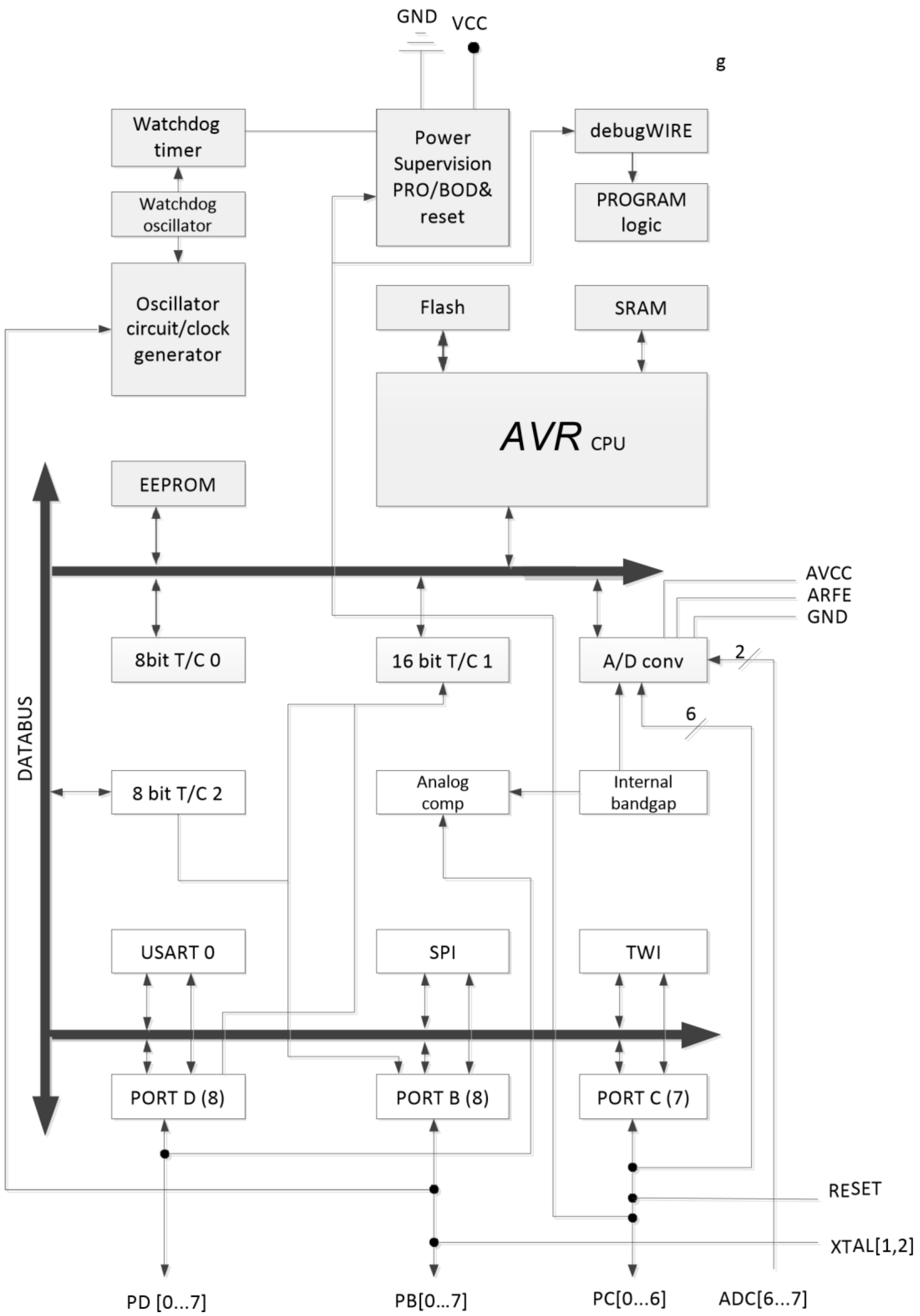

Figure (2.2) Block Diagram of ATmega328 Microcontroller

2.1.2 Arduino Uno microcontroller board

The Arduino Uno is a microcontroller board,as shown in figure(2.3) based on the ATmega328.It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.[3]

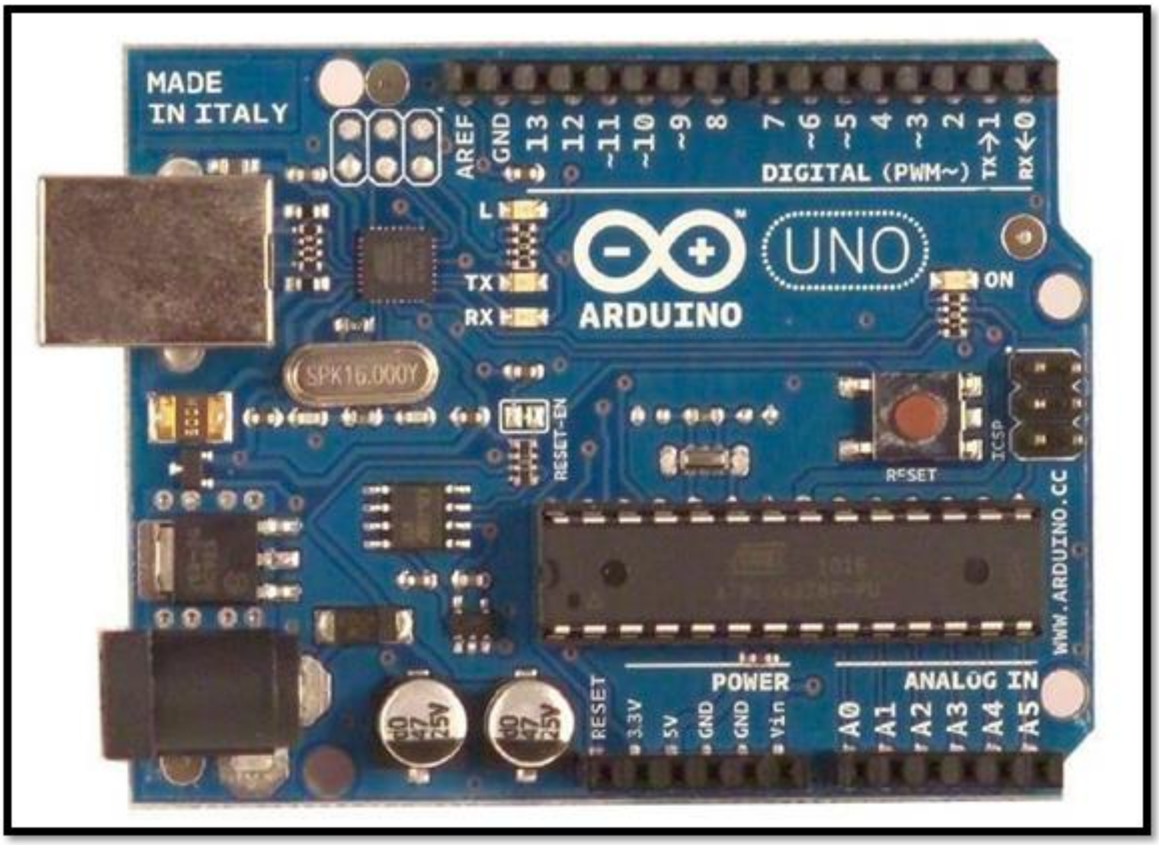

Figure (2.3): Arduino Uno microcontroller board

The Uno differs from all preceding boards in that it does not use the FTDI USB-toserial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

- 1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible with both the board that uses the AVR, which operates with 5V and with the Arduino Due that operates with 3.3V. The second one is a not connected pin, that is reserved for future purposes.
- Stronger RESET circuit. • Atmega 16U2 replace the 8U2.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

schematic for reference. The pin configuration is identical on all three processors.

The Power of Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V.This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.
- 3V3. A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- GND. Ground pins.
- IOREF. This pin on the Arduino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs for working with the 5V or 3.3V.
- The ATmega328 has 32 KB (with 0.5 KB used for the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), anddigitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data.

These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

- External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.
- PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.
- SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. Additionally, some pins have specialized functionality:

- TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.

There are a couple of other pins on the board:

- AREF. Reference voltage for the analog inputs. Used with analogReference().
- Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

See also the mapping between Arduino pins and ATmega328 ports. The mapping for the Atmega8, 168, and 328 is identical.

2.2 IR sensor

An infrared proximity sensor or IR Sensor is an electronic device that emits infrared lights to sense some aspect of the surroundings and can be employed to detect the motion of an object. As this is a passive sensor, it can only measure infrared radiation. This sensor is very common in the electronic industry and if you've ever tried to design an obstacle avoidance robot or any other proximity detection-based system, chances are you already know about this module, and if you don't, then follow this article as here we will discuss everything about it.

2.2.1 IR Sensor Pinout

The IR sensor has a 3-pin connector that interfaces it to the outside world. The connections are as follows figure (2.4) IR sensor:

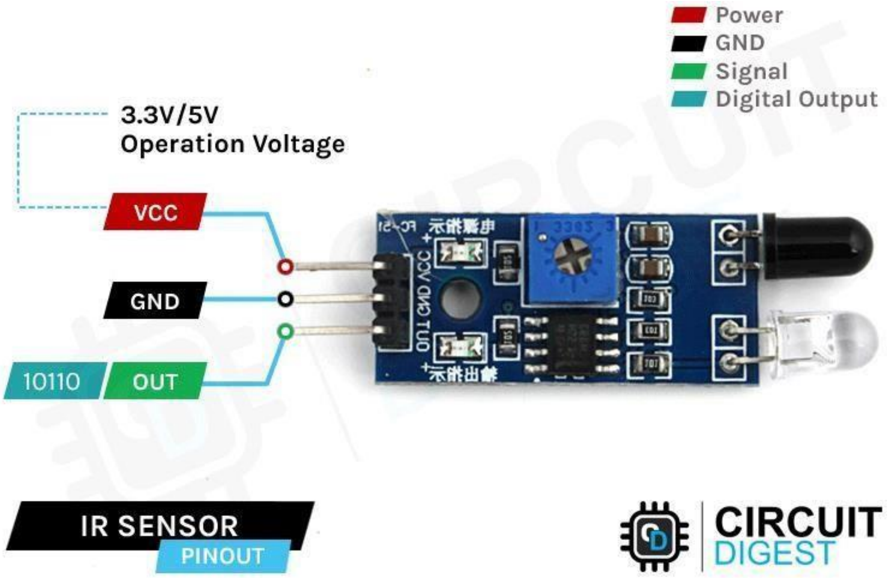

Figure (2.4): IR Sensor

VCC: is the power supply pin for the IR sensor which we connect to the 5V pin on the Arduino.

OUT: pin is a 5V TTL logic output. LOW indicates no motion is detected; HIGH means motion is detected.

GND: Should be connected to the ground of the Arduino. As shown in fgure(2.5) IR sensor.

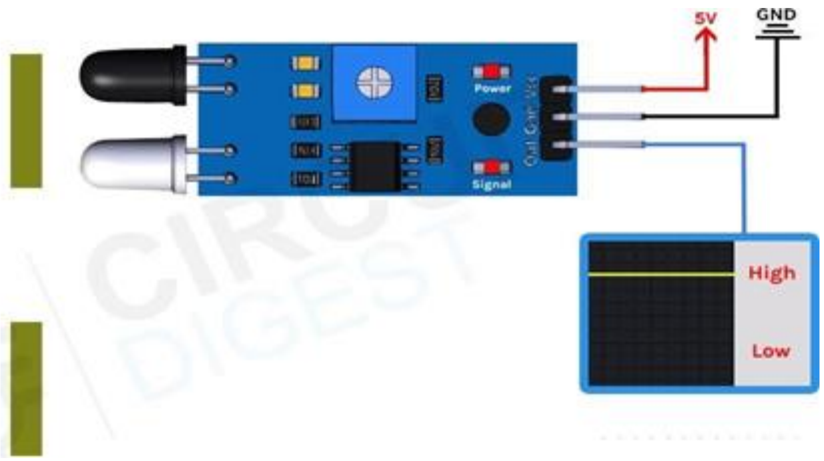

Figure (2.5): IR sensor response

An IR proximity sensor works by applying a voltage to the onboard Infrared Light Emitting Diode which in turn emits infrared light. This light propagates through the air and hits an object, after that the light gets reflected in the photodiode sensor. If the object is close, the reflected light will be stronger, if the object is far away, the reflected light will be weaker. If you look closely toward the module. When the sensor becomes active it sends a corresponding Low signal through the output pin that can be sensed by an Arduino or any kind of microcontroller to execute a particular task.

The one cool thing about this module is that it has two onboard LEDs built-in, one of which lights on when power is available and another one turns on when the circuit gets triggered.

3. Design Implementation of DBCAN Algorithm

3.1 Introduction

To make this project it must Bring the component from the market and in figure (3.1) shown proposed system of this project

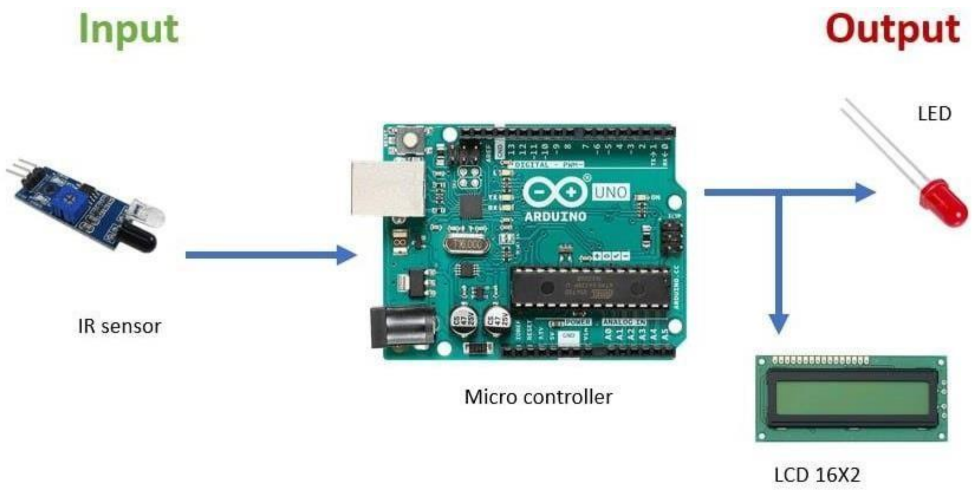

Figure (3.1) The Component Used

3.2 Arduino Installation

Then it must install arduino c program the steps used to install the software listed as follows:

1. Plug in your board and wait for Windows to begin it's driver installation process
2. After a few moments, the process will fail, despite its best efforts
3. Click on the Start Menu, and open up the Control Panel
4. While in the Control Panel, navigate to System and Security. Next, click on System
5. Once the System window is up, open the Device Manager
6. Look under Ports (COM & LPT). You should see an open port named

"Arduino UNO (COMxx)". If there is no COM & LPT section, look under 'Other Devices' for 'Unknown Device' as shown in figure (3-2).

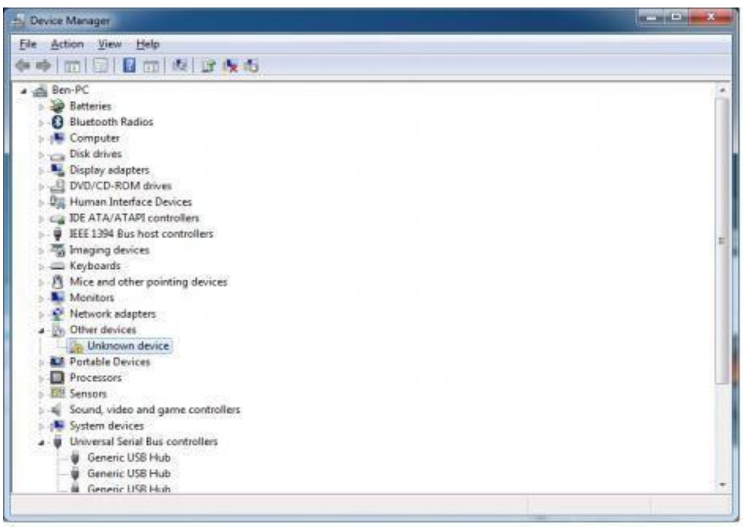

Figure (3.2): Step One to Install Sketch Software

Figure (3.3): Step to Upload the Program

8. After a second, you should see some LEDs flashing on your Arduino, followed by the message 'Done Uploading' in the status bar of the Blink sketc

\The system will already worked when the user send order from the remote control to the IR sensor the IR sensor will give the information received to the Arduino UNO the last device will treated this information and give order to the servo motor to open or close the door all this process will done on less than second in the same time there is ultrasonic that if the car will be near to the wall the door will closed automatically and if the car will be far about the wall the door will opened automatically. And the flowchart in figure (3.9) shown the architecture of the process

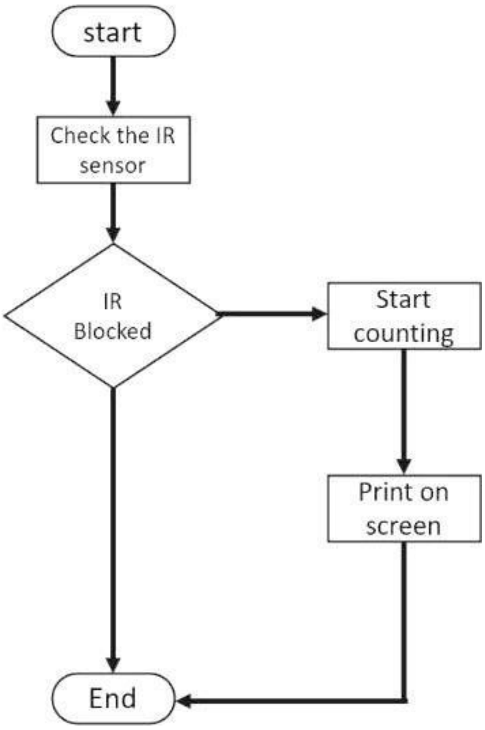

Figure (3.8): The Flowchart Of The System

4.1 Conclusion

1-In conclusion, the Lung Exerciser – 3 Ball Spirometer device that calculates the time using IR sensor and LCD with Arduino has been successfully designed and developed to provide real-time feedback on breathing patterns and progress. The incorporation of an IR sensor and LCD display has enhanced the functionality and usability of the Lung Exerciser – 3 Ball Spirometer device, allowing for accurate measurements and personalized feedback based on the user's individual lung capacity.

2-The device offers a low-cost and non-invasive tool for individuals with chronic lung diseases or those recovering from surgery or illness to improve their lung function and prevent respiratory complications. The use of an Arduino microcontroller has demonstrated the potential for incorporating technology into medical devices to enhance their functionality and usability.

3-User testing has provided positive feedback on the device's accuracy, usability, and effectiveness in improving breathing patterns. Overall, the Lung Exerciser – 3 Ball Spirometer device that calculates the time using IR sensor and LCD with Arduino has the potential to improve patient outcomes and provide a valuable tool in respiratory care.

4.2 Suggestions for Future Work

1-Future work for the Lung Exerciser – 3 Ball Spirometer device that calculates the time using IR sensor and LCD with Arduino could include:

2-Integration with mobile applications: The device could be integrated with a mobile application to allow for more personalized feedback, progress tracking, and reminders for consistent use.

3-Wireless connectivity: The addition of wireless connectivity could allow for remote monitoring by healthcare providers and real-time data analysis.

4-Integration with other health monitoring devices: The device could be integrated with other health monitoring devices to provide a comprehensive picture of an individual's overall health.

5-Improved design: Future iterations of the device could include a more ergonomic and user-friendly design to enhance usability and comfort during use.

6-Clinical studies: Clinical studies could be conducted to evaluate the effectiveness of the device in improving lung function and preventing respiratory complications in a larger patient population.

7-Overall, the Lung Exerciser – 3 Ball Spirometer device that calculates the time using IR sensor and LCD with Arduino has the potential for further development and expansion into respiratory care and health monitoring.

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