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Portable Diagnostic Station for Remote Health Camps

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IOT, Health Monitoring, Embedded System, Raspberry Pi, Sensors

ABSTRACT

The increasing demand for accessible and reliable healthcare in remote, rural, and underserved regions has highlighted the need for portable diagnostic solutions capable of providing essential medical assessments outside traditional hospital environments. The Portable Diagnostic Station is designed as a compact, low-cost, and efficient health monitoring system that integrates multiple biomedical sensors to measure vital parameters such as body temperature, heart rate, oxygen saturation (SpO_2), Weight and Force Sensor, and other critical physiological indicators. These sensors are interfaced with a microcontroller-based processing unit, such as Arduino and Raspberry Pi , which acquires real-time data, performs signal conditioning, and displays the processed information on a local screen for immediate assessment. To further enhance healthcare outreach, the system incorporates IoT-based communication through Wi-Fi, and cloud platforms, enabling the transmission of patient data to remote doctors or healthcare centers for timely diagnostics, teleconsultation, and medical decision-making. This feature is particularly valuable in regions with limited medical infrastructure, where expert guidance is not readily available. The portability of the system allows it to be used in mobile health camps, disaster relief operations, home-care environments, and community healthcare programs. By reducing the need for bulky medical equipment and minimizing the dependency on specialized healthcare professionals, the Portable Diagnostic Station serves as a practical and scalable solution for strengthening public health systems. Its ability to deliver fast, accurate, and continuous monitoring supports early disease detection, improves patient outcomes, and enhances the efficiency of telemedicine services. Overall, the proposed system contributes significantly to bridging the gap between urban medical facilities and remote populations, offering a promising approach for future smart healthcare applications.

INTRODUCTION

Access to quality healthcare remains a major challenge in rural, tribal, and geographically isolated regions, where hospitals and trained medical professionals are often limited. People living in these areas typically travel long distances to reach the nearest clinic or diagnostic center, resulting in delays in diagnosis and treatment. These challenges highlight the growing need for portable, reliable, and low-cost healthcare solutions that can bring essential diagnostic capabilities directly to the patient.

The evolution of Mobile Health (m-Health) technology has opened new opportunities to address these challenges by enabling remote medical monitoring using compact electronic devices. M-health refers to the use of mobile or wireless technologies to support medical care, disease diagnosis, and patient monitoring. It offers real-time data communication between patients and medical professionals, making it ideal for remote healthcare delivery. With the help of modern biomedical sensors and microcontrollers, vital signs like temperature, heart rate, blood pressure, oxygen saturation, and respiratory medical data to experts, leaving field workers without proper medical guidance.

Additionally, existing diagnostic devices are generally bulky, expensive, and require trained operators. There is minimal use of IoT or telemedicine in many remote areas, limiting communication between local health workers and specialist doctors. As a result, early detection of diseases becomes difficult, and many patients remain undiagnosed until symptoms worsen. Overall, the conventional system is slow, resource-dependent, and does not support efficient remote patient monitoring rate can now be measured accurately even outside hospital environments.

The Portable Diagnostic Station for Remote Health Camps is designed with this vision in mind. It integrates multiple biomedical sensors into a lightweight and easy-to-carry platform, providing critical patient information instantly. The data measured from the sensors is processed and displayed locally while being simultaneously transmitted to a remote doctor through IoT or mobile communication technologies. This enables health workers at remote camps to perform basic screenings while allowing specialists to make informed decisions despite being physically distant. Such systems reduce dependency on large medical equipment and improve the efficiency of health camps, emergency services, and public health initiatives.

In short, the Portable Diagnostic Station bridges the gap between healthcare providers and underserved populations. By delivering essential diagnostics at the point of need, the system helps improve early detection of diseases, enhances telemedicine efficiency, and promotes better health outcomes in areas lacking medical infrastructure.

LITERATURE SURVEY

The development of portable and intelligent healthcare monitoring systems has gained significant attention in recent years, particularly to address the challenges faced in rural and remote medical services. Various researchers and organizations have contributed to the advancement of mobile health (m-Health), Internet of Things (IoT)–based monitoring, and low-cost diagnostic solutions to improve accessibility, accuracy, and efficiency in healthcare delivery.

Several researchers have explored IoT-based remote health monitoring systems. Patel et al. (2020) proposed a real-time monitoring system capable of collecting and transmitting vital parameters using connected sensors, enabling doctors to monitor patients remotely. Similarly, Zhao et al. (2021) introduced a telemedicine model using IoT technologies that strengthened doctor–patient connectivity, especially in geographically isolated regions. Bashir et al. (2020) expanded this concept by designing wearable IoT-based devices capable of measuring multiple physiological parameters simultaneously.

In the domain of portable diagnostic devices, Sharma and Asthana (2019) developed a remote diagnostic system capable of measuring blood pressure and SpO_2 levels, demonstrating how compact solutions can replace bulky hospital equipment in field environments. Mendes et al. (2022) reviewed portable vital monitoring systems and concluded that such solutions significantly improve healthcare outreach during mobile health camps and emergency situations. Ahmed et al. (2018) also highlighted the effectiveness of emergency mobile health kits during disaster management scenarios.

Cost-effective healthcare technology is another major focus area. Gupta et al. (2020) introduced affordable diagnostic tools designed specifically for rural populations, ensuring accessibility without compromising essential medical functionality. Kaur and Yadav (2022) conducted a study on rural medical infrastructure and identified the urgent need for portable, easy-to-use diagnostic systems to overcome shortages of medical facilities and professionals.

Microcontroller-based health monitoring systems have also been widely studied. Prakash et al. (2021) developed an Arduino-based health station capable of acquiring and displaying patient parameters in real time. Kumar and Reddy (2018) demonstrated GSM-based health monitoring, where patient data could be transmitted through wireless communication modules, enabling remote supervision. Jadhav et al. (2019) further improved this approach by integrating multiple sensors into a unified system for simultaneous monitoring of various health indicators.

Advancements in wearable and sensor technologies have enhanced monitoring accuracy and efficiency. Lee et al. (2022) evaluated biomedical wearable sensors and analyzed their performance in continuous health tracking applications. Chaitanya et al. (2019) designed an energy-efficient pulse monitoring system suitable for long-term use in portable devices. Patel and Desai (2021) implemented Bluetooth Low Energy (BLE) technology for secure and low-power medical data transmission between devices.

Data management and storage have also evolved alongside sensing technologies. Rahman et al. (2023) proposed cloud-based health data storage systems that enable secure access, long-term record maintenance, and remote consultation. Tan et al. (2023) introduced a smart portable medical kit integrating sensing, processing, and communication modules into a single compact unit, demonstrating the future direction of mobile diagnostics. Niranjan et al. (2020) focused on field health monitoring systems designed specifically for use during rural health camps, ensuring quick screening and diagnosis.

Additionally, Singh et al. (2019) studied rural healthcare challenges and highlighted issues such as lack of diagnostic infrastructure, delayed treatment, and absence of continuous monitoring facilities. Their findings reinforced the importance of developing integrated, portable diagnostic stations capable of delivering real-time healthcare services outside traditional hospitals.

From the above studies, it is evident that significant progress has been made in IoT-enabled healthcare, wearable sensors, portable diagnostic devices, and wireless communication technologies. However, there remains a need for an integrated, low-cost, and user-friendly system that can combine multiple health parameter measurements, real-time monitoring, and data communication into a single portable unit. This research gap forms the foundation for the proposed Portable Diagnostic Station for Remote Health Camps, which aims to provide efficient, accurate, and accessible healthcare solutions in underserved regions.

OBEJECTIVE

The primary objective of this project is to design and develop a compact, low-cost, and portable diagnostic station capable of measuring essential health parameters in remote and underserved regions. The system aims to integrate multiple biomedical sensors to monitor vital signs such as temperature, heart rate, Stress Sensor, Weight, and oxygen saturation with high accuracy. Furthermore, the objective includes enabling real-time data processing, local display of results, and remote transmission of patient information using IoT or mobile health technologies, allowing doctors to provide timely diagnosis without requiring physical presence. By offering an easy-to-use, reliable, and scalable solution, the project seeks to strengthen rural healthcare delivery, support telemedicine services, enable early disease detection, and minimize the dependency on large medical equipment or specialized personnel.

METHODOLOGY

The Portable Diagnostic Station for Remote Health Camps is a compact and low-cost medical system designed to provide basic health checkups in rural or remote areas where hospitals are not easily available. Patient monitoring systems are considered as a part of M-health technology. These can also be named as m-health or mobile health. These systems are used for practice of medical and public health with the help of mobile devices. These monitoring systems can be used onsite or remotely.

The project is designed and developed for monitoring patients remotely using a IoT based wireless communication system. The main aim of this project is to monitor the HEART Beat, Blood Oxygen content, Stress /

Force Sensor, Weight Sensor (Load Sensor), Body Temperature of the patient and display the same to the doctor through Internet based server using Blynk cloud Server.

This Sensor signal are fed to Arduino Microcontroller board for further processing. Further this data is send to Nodemcu Wifi Module to upload it to Blynk cloud server for Realtime Monitoring. Paramedical staff is provided with a Blynk Android Application to view each patient's Real-time Heart Beat, Blood Oxygen Body and Body Temperature data. Load Cell is used to measure the Weight. For demonstration purpose we will be using some dummy weights. Two LCD Module is interfaced with the system Raspi Pi Pico is interfaced with this system to display the Alert Message on First LCD if sensor data crosses any threshold range. Another LCD is interfaced with the Arduino controller to display the Live Sensor data. Force / Stress sensor is mounted over a Ball to measure the force applied by the user while pressing it and if the sensor data crosses threshold value then buzzer will be generated. To measure the Weight user to press start switch and apply weight on Load cell, if the weight crosses threshold limit than Buzzer will be generated.

This Health Monitoring device automatically connects with Local Internet Wi-Fi Router at Initial Startup using Nodemcu and, its updates the data to Blynk Channel. Panic Button / Switch is interfaced with this system. This will help to call the Paramedic Staff or Nurse immediately in any Emergency Condition by generating a Buzzer Alert. If Temperature, Stress or Load Cell / Weight is increased than the threshold range than Buzzer sound will be generated.

Embedded C based programming languages is used to write the logical part of this system. Arduino IDE Compiler is used to write the program code and upload in Raspi and Arudino controller. Sensors are interfaced to the Analog Pin of Arduino controller, LCD is connect to LCD and Nodemcu is connected to TX pin of Microcontroller Unit.

The power supply setup of the system contains a step-down transformer of 230/12V, used to step down the voltage to 12VAC. To convert it to DC, a bridge rectifier is used. 7805 voltage regulator is used regulate 12V Dc to +5V that will be needed for microcontroller and other components operation. Filter Capacitor are used to remove ripple from DC Voltages.

HARDWARE COMPONENTS DESCRIPTION

ARDUINO UNO

Arduino is common term for a software company, project, and user community that designs and manufactures computer open-source hardware, open-source software, and microcontroller-based kits for building digital devices and interactive objects that can sense and control physical devices.[1]

The project is based on microcontroller board designs, produced by several vendors, using various microcontrollers. These systems provide sets of digital and analog I/O pins that can interface to various expansion boards (termed *shields*) and other circuits. The boards feature serial communication interfaces, including Universal Serial Bus (USB) on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides an integrated development environment (IDE) based on a programming language named Processing, which also supports the languages C and C++.

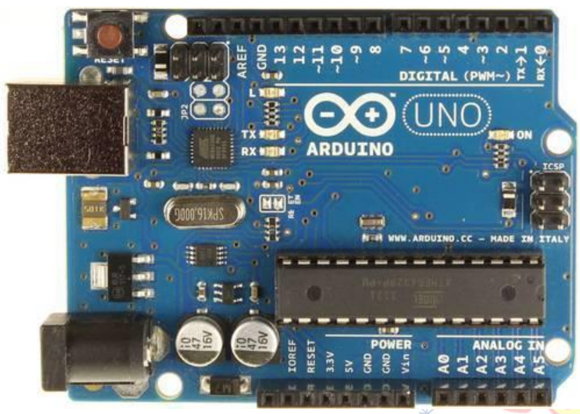
The first Arduino was introduced in 2005, aiming to provide a low cost, easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors.

Arduino programs may be written in any programming language with a compiler that produces binary machine code. Atmel provides a development environment for their microcontrollers, AVR Studio and the newer Atmel Studio.[19][20]

The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in the programming language Java. It originated from the IDE for the languages *Processing* and *Wiring*. It is designed to introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and provides simple one-click mechanism to compile and load programs to an Arduino board. A program written with the IDE for Arduino is called a "sketch".[21]

Arduino Uno - Details

The Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, 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.. You can tinker with your UNO without worrying too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.

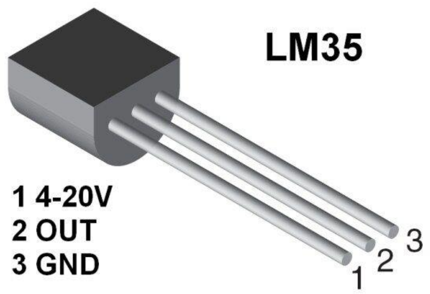


"Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

Technical specs

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

B. LM35 – TEMPERATURE SENSOR

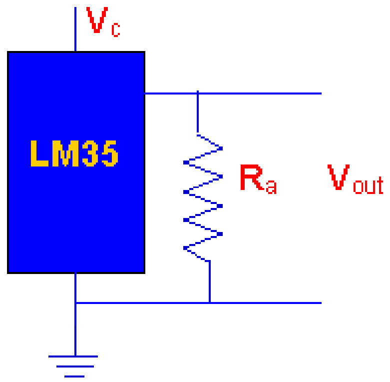


LM35 is a precision IC **temperature sensor** with its output proportional to the temperature (in ºC). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than with a Thermistor. It also possess low self heating and does not cause more than 0.1 ºC temperature rise in still air. The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every ºC rise/fall in ambient temperature, *i.e.*, its scale factor is 0.01V/ºC.

Pin Description:

Pin No	Function	Name
1	Supply voltage; 5V (+35V to -2V)	Vcc
2	Output voltage (+6V to -1V)	Output
3	Ground (0V)	Ground

How Do You Use An LM35? (Electrical Connections)



- Here is a commonly used circuit. For connections refer to the picture above.
- In this circuit, parameter values commonly used are:
- V_c = 4 to 30v
- 5v or 12 v are typical values used.
- $R_a = V_c / 10^{-6}$
- Actually, it can range from 80 KW to 600 KW , but most just use 80 KW.

C.MAX30100 – SP02 / HEART BEAT SENSOR

Max30100 Sensor module

Maxim's MAX30100 integrated pulse oximetry and a heart-rate sensor. It's an optical sensor that derives its readings from emitting two wavelengths of light from two LEDs – a red and an infrared one – then measuring the absorbance of pulsing blood through a photodetector. This particular LED color combination is optimized for reading the data through the tip of one's finger.

The signal is processed by a low-noise analog signal processing unit and communicated to the target MCU

through the mikroBUS I2C interface. Developers of end-user applications should note that the readings can be negatively impacted by excess motion and changes in temperature. Also, too much pressure can constrict capillary blood flow and therefore diminish the reliability of the data. A programmable INT pin is also available. The operates at the 3.3V power supply.

D.NODE MCU

NodeMCU is an open source LUA based firmware developed for ESP8266 wifi chip. By exploring functionality with ESP8266 chip, NodeMCU firmware comes with ESP8266 Development board/kit i.e. NodeMCU Development board. Since NodeMCU is open source platform, their hardware design is open for edit/modify/build.

NodeMCU Dev Kit/board consist of ESP8266 wifi enabled chip. The **ESP8266** is a low-cost Wi-Fi chip developed by Espressif Systems with TCP/IP protocol. For more information about ESP8266, you can refer ESP8266 WiFi Module.

There is Version2 (V2) available for NodeMCU Dev Kit i.e. NodeMCU Development Board v1.0 (Version2), which usually comes in black colored PCB.

NodeMCU Dev Kit has Arduino like Analog (i.e. A0) and Digital (D0-D8) pins on its board.

It supports serial communication protocols i.e. UART, SPI, I2C etc.

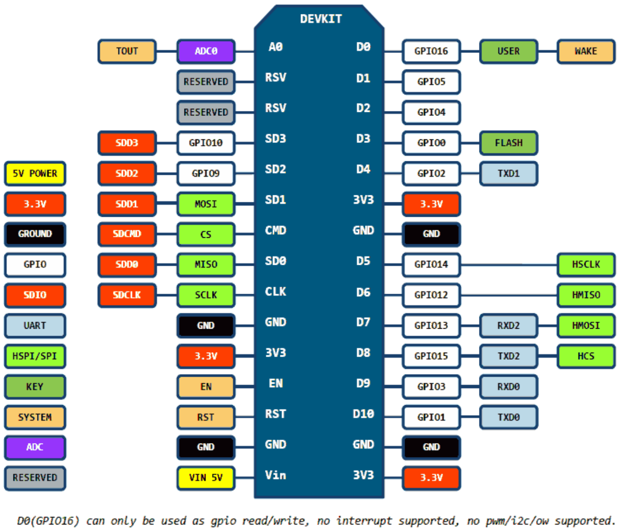
Using such serial protocols we can connect it with serial devices like I2C enabled LCD display, Magnetometer HMC5883, MPU-6050 Gyro meter + Accelerometer, RTC chips, GPS modules, touch screen displays, SD cards etc.

NodeMCU Development board is featured with wifi capability, analog pin, digital pins and serial communication protocols.

To get start with using NodeMCU for IoT applications first we need to know about how to write/download NodeMCU firmware in NodeMCU Development Boards. And before that where this NodeMCU firmware will get as per our requirement.

There is online NodeMCU custom builds available using which we can easily get our custom NodeMCU firmware as per our requirement.

PIN DEFINITION



NODEMCU DEV KIT V1.0 PIN DESCRIPTIONS

GPIO (General Purpose Input Output) Pins:

NodeMCU has general purpose input output pins on its board as shown in above pinout diagram. We can make it digital high/low and control things like LED or switch on it. Also, we can generate PWM signal on these GPIO pins.

ADC (Analog to Digital Converter) channel (A0):

NodeMCU has one ADC channel/pin on its board.

SPI (Serial Peripheral Interface) Pins:

NodeMCU based ESP8266 has Hardware SPI (HSPI) with four pins available for SPI communication. It also has SPI pins for Quad-SPI communication. With this SPI interface, we can connect any SPI enabled device with NodeMCU and make communication possible with it.

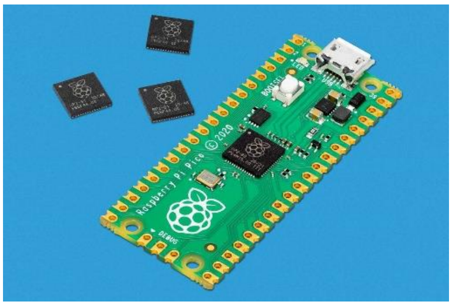
I2C (Inter-Integrated Circuit) Pins:

NodeMCU has I2C functionality support on ESP8266 GPIO pins. Due to internal functionality on ESP-12E we cannot use all its GPIOs for I2C functionality. So, do tests before using any GPIO for I2C applications.

UART (Universal Asynchronous Receiver Transmitter) Pins:

NodeMCU based ESP8266 has two UART interfaces, UART0 and UART1. Since UART0 (RXD0 & TXD0) is used to upload firmware/codes to board, we can't use them in applications while uploading firmware/codes.

E. Raspberry Pi Pico



The **Raspberry Pi Pico** is a high-performance microcontroller board designed by Raspberry Pi Foundation. It is built around the **RP2040** microcontroller chip and is known for its efficiency, versatile GPIO pins, low power consumption, and excellent performance for embedded projects. Its compact design makes it ideal for portable diagnostic devices, sensor-based projects, and real-time monitoring systems.

Key Features

- RP2040 Dual-Core ARM Cortex-M0+ Processor (up to 133 MHz)
- 264 KB SRAM, 2 MB Flash Memory
- 26 multi-function GPIO pins
- 3× ADC channels, PWM support, UART, I2C, SPI
- USB 1.1 controller with device and host support
- Support for C/C++, MicroPython, CircuitPython
- Low power consumption suitable for battery-powered devices
- Compact 40-pin DIP style form factor

F. Force / Stress Sensor

A force sensor is a device used to measure pressure, force, Stress or strain applied to a surface. In electronics and embedded systems, the most common force sensors include FSR (Force Sensitive Resistor). These sensors convert applied force into measurable electrical signals, enabling real-time monitoring and control.

Types of Force Sensors

1. FSR (Force Sensitive Resistor)

- Resistance decreases as force increases
- Ideal for light to moderate pressure measurement
- Thin, flexible, low-cost

2. Load Cell (Strain Gauge Based)

- High accuracy
- Measures weight/force in industrial and medical systems
- Outputs very small changes—requires an amplifier (HX711)

3. Piezoelectric Force Sensor

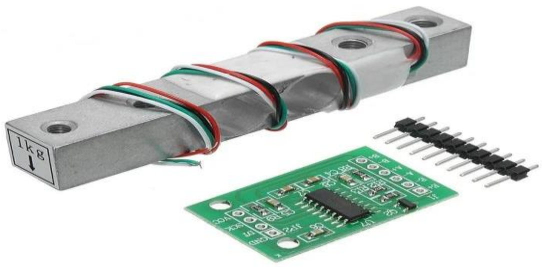
- Generates voltage when force/vibration is applied
- Suitable for dynamic force measurements
- Very sensitive and fast response

Working Principle (FSR Example)

- Composed of conductive polymer that changes resistance when pressure is applied
- **High resistance → low force**
- **Low resistance → high force**
- Measured using a voltage divider with an ADC input of microcontroller (like Raspberry Pi Pico)

G. HX711 (LOAD CELL)

The load cell works on the principle of strain gauge technology.Inside the load cell, there are strain gauges attached to a metal beam.When weight is applied, the metal slightly deforms (compresses or stretches).This deformation causes a small change in the electrical resistance of the strain gauges.The change in resistance is proportional to the applied weight.This small analog signal (in millivolts) is sent to an amplifier module (HX711).The amplifier converts it into a digital signal that the Arduino can read.The Arduino processes this data and calculates the actual weight using calibration.



Parameter	Specification
Capacity	5 kg / 10 kg / 20 kg (depending on model)
Output Sensitivity	~1.0 mV/V
Operating Voltage	5 V (via HX711)
Accuracy	±0.05% Full Scale
Material	Aluminum Alloy
Operating Temperature	0°C to 60°C
Protection Class	IP54 (dust protection)
Response Time	< 1 second
Signal Type	Analog (requires HX711 amplifier)
Size	Compact, suitable for portable systems

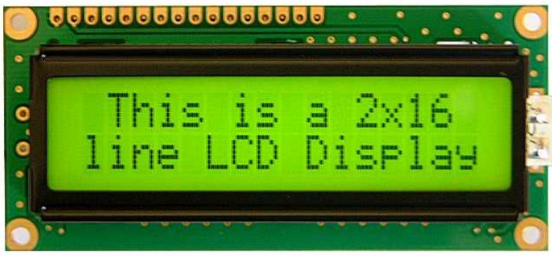
A load cell is a sensor used to measure weight or force by converting mechanical load into an electrical signal. In this project, the load cell is used to measure the patient's body weight as part of the Portable Diagnostic Station. It is highly accurate, compact, and suitable for portable medical applications.

H. LCD 2 X 16 Modules

A liquid-crystal display (LCD) is a flat-panel display or other electronic visual display that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are used in a wide range of applications including computer monitors, televisions, instrument panels, aircraft cockpit displays, and signage. They are common in consumer devices such as DVD players, gaming devices, clocks, watches, calculators, and telephones, and have replaced cathode ray tube (CRT) displays in nearly all applications. They are available in a wider range of screen sizes than CRT and plasma displays, and since they do not use phosphors, they do not suffer image burn-in. LCDs are, however, susceptible to image persistence.

The LCD screen is more energy-efficient and can be disposed of more safely than a CRT. Its low electrical power consumption enables it to be used in battery-powered electronic equipment more efficiently than CRTs. It is an electronically modulated optical device made up of any number of segments controlling a layer of liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in color or monochrome.

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of



displaying special & even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

Pin Description:

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	VEE
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	Backlight Vcc (5V)	Led+
8	Backlight Ground (0V)	Led-

VEE pin is meant for adjusting the contrast of the LCD display and the contrast can be adjusted by varying the voltage at this pin. This is done by connecting one end of a POT to the Vcc (5V), other end to the Ground and connecting the center terminal (wiper) of of the POT to the VEE pin.

The JHD162A has two built in registers namely data register and command register. Data register is for placing the data
to be displayed , and the command register is to place the commands. The 16×2 LCD module has a set of commands each meant for doing a particular job with the display.

High logic at the RS pin will select the data register and Low logic at the RS pin will select the command register. If we make the RS pin high and the put a data in the 8 bit data line (DB0 to DB7) , the LCD module will recognize it as a data to be displayed . If we make RS pin low and put a data on the data line, the module will recognize it as a command.

R/W pin is meant for selecting between read and write modes. High level at this pin enables read mode and low level at this pin enables write mode.

E pin is for enabling the module. A high to low transition at this pin will enable the module.

DB0 to DB7 are the data pins. The data to be displayed and the command instructions are placed on these pins.

LED+ is the anode of the back light LED and this pin must be connected to Vcc through a suitable series current limiting resistor. LED- is the cathode of the back light LED and this pin must be connected to ground.

a) 16×2 LCD module commands.

16×2 LCD module has a set of preset command instructions. Each command will make the module to do a particular task. The commonly used commands and their function are given in the table below.

b) LCD initialization.

The steps that has to be done for initializing the LCD display is given below and these steps are common for almost all applications.

Send 38H to the 8 bit data line for initialization

- Send 0FH for making LCD ON, cursor ON and cursor blinking ON.
- Send 06H for incrementing cursor position.

- Send 01H for clearing the display and return the cursor.

c) Sending data to the LCD.

The steps for sending data to the LCD module is given below. I have already said that the LCD module has pins namely RS, R/W and E. It is the logic state of these pins that make the module to determine whether a given data input is a command or data to be displayed.

- Make R/W low.
- Make RS=0 if data byte is a command and make RS=1 if the data byte is a data to be displayed.
- Place data byte on the data register.
- Pulse E from high to low.
- Repeat above steps for sending another data.

A key advantage of every film capacitor's internal construction is direct contact to the electrodes on both ends of the winding. This contact keeps all current paths very short. The design behaves like a large number of individual capacitors connected in parallel, thus reducing the internal ohmic losses (ESR) and ESL. The inherent geometry of film capacitor structure results in low ohmic losses and a low parasitic inductance, which makes them suitable for applications with high surge currents (snubbers) and for AC power applications, or for applications at higher frequencies.

The plastic films used as the dielectric for film capacitors are Polypropylene (PP), Polyester (PET), Polyphenylene sulfide (PPS), Polyethylene naphthalate (PEN), and Polytetrafluoroethylene or Teflon (PTFE). Polypropylene film material with a market share of something about 50% and Polyester film with something about 40% are the most used film materials. The rest of something about 10% will be used by all other materials including PPS and paper with roughly 3%, each.

value. The xx in 78xx indicates the fixed output voltage it is designed to provide. 7805 provides +5V regulated power supply. Capacitors of suitable values can be connected at input and output pins depending upon the respective voltage levels.

PROPOSED SYSTEM

The proposed Portable Diagnostic Station introduces a compact, digital, and IoT-integrated solution to address the shortcomings of existing healthcare systems. It combines multiple biomedical sensors—such as temperature, pulse, SpO_2, weight (Load Cell), Stress / Force Sensor—into a single unit capable of performing essential diagnostic tests in any environment. The embedded microcontroller processes sensor outputs and displays alert data on a local screen, allowing health workers to immediately assess the patient's condition.

To enhance remote medical support, the device transmits the collected parameters over IoT, mobile health platforms to a centralized medical database or directly to a doctor. This enables specialists to monitor patient conditions instantly, provide treatment recommendations, and detect

abnormalities even from distant locations. The system creates digital health records for future reference and supports continuous monitoring during emergencies or health camps.

The design emphasizes low cost, portability, reliability, and ease of use, making it suitable for rural healthcare volunteers with minimal technical training. By integrating sensor technology with mobile communication, the proposed system strengthens telemedicine, promotes timely diagnosis, and ensures healthcare accessibility in underserved regions. This modern approach transforms traditional health camps into smart, connected diagnostic units capable of saving time, cost, and human effort.

EXISTING SYSTEM

In most rural or remote regions, healthcare delivery is still heavily dependent on manual, traditional practices. Health workers typically carry limited diagnostic tools and rely on physical observation or patient-reported symptoms to assess health conditions. Standard medical equipment such as, blood analyzers, or multi-parameter monitors are usually available only in hospitals or district-level clinics, making it difficult to perform accurate diagnostics in remote field camps.

Patients often need to travel long distances to access diagnostic services, causing delays in treatment and increasing healthcare burden. Emergency situations become even more critical due to the absence of rapid monitoring tools. Current systems also lack the ability to send real-time medical data to experts, leaving field workers without proper medical guidance.

Additionally, existing diagnostic devices are generally bulky, expensive, and require trained operators. There is minimal use of IoT or telemedicine in many remote areas, limiting communication between local health workers and specialist doctors. As a result, early detection of diseases becomes difficult, and many patients remain undiagnosed until symptoms worsen. Overall, the conventional system is slow, resource-dependent, and does not support efficient remote patient monitoring.

Additionally, there is no integrated system to record, store, or share patient health data in real time, making it challenging for doctors to track patient conditions or provide timely medical assistance. This lack of portability, real-time analysis, and connectivity highlights the need for a compact and efficient diagnostic solution for remote health camps.

Furthermore, there is no portable system that allows healthcare providers to measure multiple health parameters at once in field conditions. Data is usually recorded manually on paper, which can lead to errors, data loss, and difficulty in maintaining patient history.

PROTOTYPE HARDWARE IMPLEMENTATION

Fig 1: Circuit Setup in OFF state

The figure illustrates the hardware configuration of a Raspberry Pi Pico–based force sensing and monitoring system. The controller processes input from the load cell sensor to measure applied force accurately, while the LCD display presents real-time values clearly. Alert components such as a buzzer notify the user when the force crosses a set threshold. A regulated power unit supplies stable voltage to ensure smooth and reliable system operation.

The absence of real-time monitoring and digital data transmission makes it challenging for doctors to provide immediate consultation or track patient health remotely.

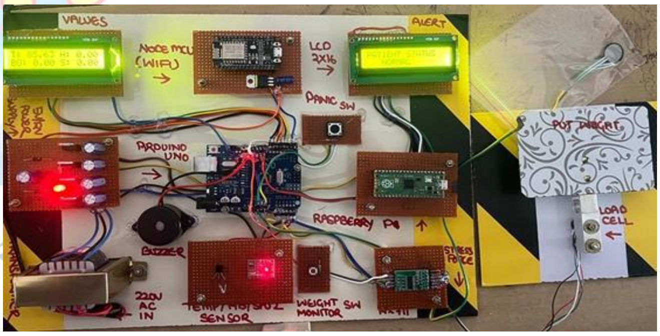


Fig 2 : Circuit setup in ON state

The figure shows the working prototype of the Portable Diagnostic Station developed for monitoring basic health parameters in remote and rural environments. The system is designed as a compact and portable unit in which all hardware components are mounted on a single platform for easy transportation and field deployment. The Arduino UNO acts as the main controller, collecting data from sensors that measure body temperature, heart rate, and oxygen saturation (SpO_2). These signals are processed in real time and converted into meaningful health information.

SYSTEM OUTPUT RESULTS

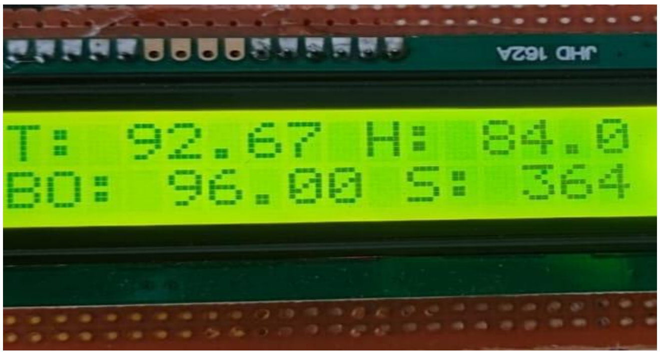


Fig 3: Display output of LCD 1 patient readimgs

As shown in the figure, the LCD display presents real-time readings from all connected sensors. The screen displays temperature, blood oxygen level (SpO_2), heart rate, and body stress values obtained from the respective sensors. The continuous update of these parameters confirms that the sensors are functioning correctly and that the system is accurately processing and displaying the measured health data.

Fig 4: Display output of LCD 2 Patient status

The figure shows the LCD display indicating the patient's health status based on the sensor readings. When all measured parameters remain within normal limits, the display shows the message "Patient Status: Normal." If the body temperature exceeds the preset threshold, the system detects the abnormal condition, displays a warning message, and activates the buzzer to alert the user. This feature helps in quick identification of health issues and ensures timely attention.

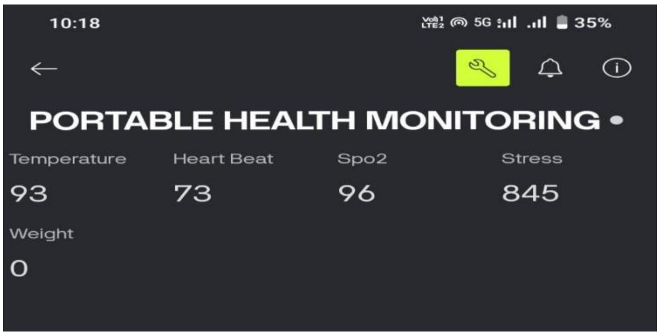


Fig 5: Patient Reading Displayed in Blynk App

The figure shows the Blynk mobile application displaying live health parameter readings from the system. The app presents real-time values of body temperature, heart rate, SpO_2, stress level, and weight, allowing continuous monitoring of the patient. Through the Blynk platform, the data can be accessed remotely from anywhere using a mobile phone. This feature improves convenience and enables timely observation of the patient's health condition.

CONCLUSION

The development of the Raspberry Pi Pico–based force sensing and monitoring system represents a significant step forward in creating compact, and highly adaptable embedded solutions for real-world applications. By integrating force sensors with the advanced processing capabilities of the RP2040 microcontroller, the system successfully demonstrates how accurate physical force measurement can be achieved using minimal hardware resources. Throughout the project, the Raspberry Pi served as a robust and efficient controller, offering high-speed data acquisition, flexible interfacing capabilities, and reliable processing performance for sensor calibration, data filtering, and decision-making tasks. The force sensors, when interfaced with appropriate signal conditioning circuits, provided real-time, consistent, and precise measurements, enabling continuous monitoring of applied pressures, loads, or mechanical stresses.

Overall, the project successfully meets its objectives by delivering a reliable, scalable, and energy-efficient force-sensing platform capable of real-time monitoring and analysis. The modular structure of the system allows future enhancements, such as wireless data transmission, integration with cloud platforms, machine-learning-based trend prediction, and compatibility with additional environmental sensors. The work completed through this project not only validates the effectiveness of Raspberry Pi as an embedded controller but also demonstrates the potential of sensor-driven automation for diverse applications. Hence, the system stands as a strong foundation for future research, innovation, and product development in the domain of intelligent sensing and embedded technology.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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