

INTELLIGENT MATTRESS FOR MONITORING AND THERAPEUTIC RELIEF FROM BEDSORE

Submitted in partial fulfillment of the requirements for the award of Bachelor of
Technology in B.Tech Biomedical Engineering

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**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **SHERYL ROBINSON (39240037)** and **AISHWARYA MOHAN KUMAR (39240004)** who carried out the final year project entitled "**INTELLIGENT MATTRESS FOR MONITORING AND THERAPEUTIC RELIEF FROM BEDSORE**" under our supervision from Oct to Apr 2023.

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DECLARATION

We, **SHERYL ROBINSON (39240037)** and **AISHWARYA MOHAN KUMAR (39240004)**, hereby declare that the Project Report entitled "**INTELLIGENT MATTRESS FOR MONITORING AND THERAPEUTIC RELIEF FROM BEDSORE**" done by us under the guidance of **Dr. J. BETHANNEY JANNEY** is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology degree in B.Tech Biomedical Engineering.



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ABSTRACT

One of the most common risks for individuals who are bedridden is the development of bedsores (Pressure Ulcers). The number of senior persons who are permanently disabled and semi-impaired is growing as the population ages. A pressure ulcer or bedsores is a damage to tissue that has been disturbed or lacks blood flow as a result of prolonged pressure and shear forces, and it can give the patient pain and discomfort. The conventional methods used to relieve bed sores tend to focus on the pressure distribution and very minimal focus is provided for therapy. Our proposed methodology the pressure and temperature of the patient will be monitored continuously and after a certain amount of time has passed, a message will be sent to an app installed on the caretaker's phone which informs them to change the current position of the patient. In addition to this we will be installing a cooling system to bring down the temperature as well as to prevent the further worsening of the ulcer. This system will be automatically triggered when the two parameters exceed a certain threshold value. Finally we will be incorporating a vibration massage system to increase the blood circulation at the localized region which would be turned ON and OFF by the caretaker with the help of the app.

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LIST OF ABBREVIATIONS

S.NO	ABBREVIATION	FULL FORM
1	PU	Pressure Ulcer
2	PI	Pressure Injury
3	ICU	Intensive care units
4	ML	Machine Learning
5	IoT	Internet Of Things
6	PUMP	Pressure Ulcer Monitoring Platform Devices
7	SMS	Short Message Service
8	ECS	Elder Care System
9	CNN	Convolutional Neural Network
10	HC	Human-centric Computing
11	SVM	Support Vector Machines
12	RF	Random Forest
13	HBLP	Human Body Lying Posture
14	EHR	Electronic Health Record
15	J48	Decision Tree
16	k-NN	k-Nearest Neighbor
17	MLP	Multilayer Perceptron
18	BMI	Body Mass Index

19	AI	Artificial Intelligence
20	FSR	Force sensitive resistor
21	DIY	Do it Yourself
22	LCD	Liquid Crystal Display
23	NodeMCU	Node MicroController Unit
24	ESP32	Espressif32
25	MQTT	Message Queuing Telemetry Transport
26	DC	Direct Current
27	USB	Universal Serial Bus
28	LED	Light Emitting Diode
29	PWM	Pulse-width modulation
30	AVR	Alf and Vegard's RISC processor
31	I/O	Input/Output
32	ADC	Analog to Digital Converter
33	UART	Universal Asynchronous Receiver/Transmitter
34	GPIO	General Purpose Input/Output
35	SMPS	Switched – Mode Power Supply
35	CPU	Central Processing Unit

CHAPTER 1

INTRODUCTION

Pressure Ulcers (PU) or Pressure Injury (PI) are referred to as decubitus ulcer and is also commonly known as bedsores. These are lesion or an injury that occurs on the skin or the underlying tissues which is caused by continuous exposure to pressure, friction, shear or a combination of all of these parameters. This type of injury occurs when the skin which covers a weight bearing region is pressed between the bones, a rigid surface and these injuries can also be brought on by medical equipment such as catheter, cervical collars and many more. PU/PI typically occurs in an aged population, individuals suffering from a nutrients deficiency or those suffering from neurological disorders. (Qazi M et al 2022). Pressure ulcers appear as open wounds and can be highly serious and painful. Moreover impaired sensory perception can lead to impaired mobility as these individuals do not move as they are unable to feel any discomfort. (Amit Gefen et al 2021).

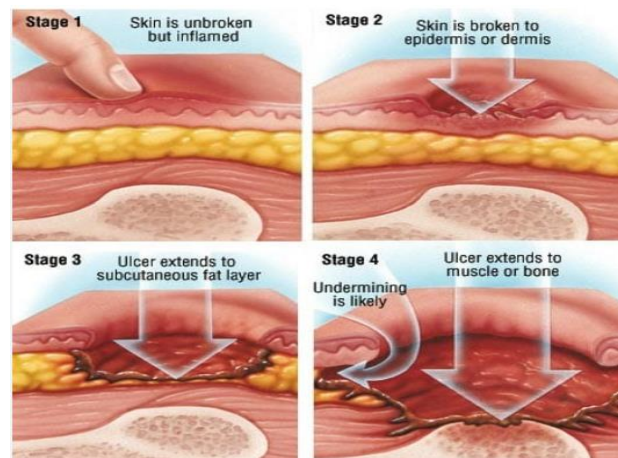


Fig. 1.1: Stages of Pressure Ulcers

According to reports, the intensive care units (ICU) PI incidence and prevalence ranged from 10.0% to 25.9% and 16.9% to 23.8%, respectively. Acute care settings saw a prevalence of PI ranging from 6% to 18.5% and hospital-acquired PI prevalence was 8.5% (Jiang M et al 2021). A patient suffering from PU has a higher risk of dying which

is 2 to 6 times more than a patient with no lesions or PU on their skin. Although it brings about terrifying effects, 95 % of these PU can be prevented. Furthermore the treatment of PU is highly expensive as it leads to prolonged hospital stay, delays rehabilitation and affects the individual social, psychological, physiological physical and economic aspects of their life. If a patient happens to develop pressure ulcers this is an indication of poor quality of health care service and also indicates prolonged exposure to pressure due to lack of movement which thus results in these types of injury. In hospitals it may be due to prolonged use of medical technologies, inadequacy of nurses due to improper nurse to patient ratio, lack of knowledge on PU handling, patient's uncooperativeness and increase workload of nurses. (Tesfa Mengist S et al 2022).

In addition to this studies have revealed that nurses in hospital lack the knowledge regarding the pressure ulcers prevention guidelines as well the skills required for it. At hospitals, nurses are responsible for the patients who are at risk of suffering from PU. So it is ideal that these nurses are to be equipped with the required knowledge to perform that task. However they tend to not be aware of the significance of being up to date with the latest technologies for the prevention of PUs as well as in using the up to date PU prevention proctors. So adequate training has to be done for the nurses who are to handle these type of patient to update their knowledge and skills (Wu Jing et al 2022). In order to reduce the burden and workload on the healthcare practitioners like doctors, nurses innovations have been done to aid them in monitoring patients inflicted with PU. This has been done by creating devices that produces signs and alerts that are able to indicate if the PU are getting better or is it worsening, if it's time to change the position of the patient to reduce the pressure being applied in the same region or if it's time to apply their medication and many more. Now in order to enhance the devices and make it easy to use, researchers have recently begun investigating ways to integrate machine learning (ML) and the internet of things (IoT) into healthcare systems (Ribeiro et al 2021).

Some technology innovation proposed includes using smart mattress or cushions during the stay of the patient at the hospital. These devices increased the patient's tolerance to the pressure and all ensured that pressure was applied uniformly to the

body (G.S. Walia et al 2016). Wellsense a company situated in the United States introduced a technology for the continuous monitoring of the patients afflicted with bedsores which also supplies information, feedback and also provides visual and audible alerts. But till date this technology hasn't been implemented in the hospitals. Patients who have undergone surgery have to be managed properly and carefully so as to prevent the chance of getting afflicted with PU. It was found that patients with a high chance of PU related to surgery, when placed on a surface of redistribution of pressure during their post-operative period reduces the incidence of PI (Orta et al 2021). Studies have also revealed the potential use of self-management support interventions for individuals at risk of PU in order to prevent its occurrence (Marscha Engelen et al 2021). Other preventive measures have also been introduced some of them include accurate, and early pressure point mapping. This enable the caregiver or doctors to know which region of the body is experiencing an increase stress, strain or pressure which is of paramount importance as this one of the parameters that results in PI. This information would also be useful to study the cause of incidence of PI. Due to the recent advancements in modern technology, medical devices with high-level built-in functionality and interaction capabilities are now accessible. Now in order to help with this cause hospital beds come in different forms and perform new functions, but they still serve their primary objective which involves improving the patients stay at the hospital and also relieves the burden on the caretaker. As such, they offer many unique features like movable side rails and adjustable height, it also provides many electronic controls for controlling the bed and other neighboring electric appliances. Recent advancements in this field have had a significant effect on patient care as well in the design and manufacture standards of the final product (E. Karvounis et al 2021).

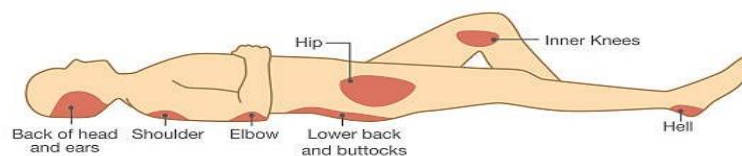


Fig 1.2: Regions commonly affected by Pressure ulcer

CHAPTER – 2

LITERATURE SURVEY

Kommey, Benjamin et al 2021 implemented a device that used an architecture known as Bedsore easing system. It comprised of 3 parts Bed device unit, Pocket device unit and a database information logging. The bed device unit comprises of a microcontroller which gathers data from a temperature or load sensors. The processed data is then used to trigger the alerts as well as the inflation and deflation system. The heat produced is monitored and can be used to diagnose the possible occurrence of bedsores. The pocket device unit will be with the caretakers/nurses who will receive signals from the bed device unit in a situation when an alarm occurs. The buzzer will sound and the LCD will display which bed number is in need of attention. The database information logging is where the information is stored here. The main function of it is to store the alert trigger and disable times

C.Ma et al 2020 designed a smart cushion to prompt users to main good sitting posture and to also remind them to take a break from prolonged siting as it tends to lead to reduced blood flow in the afflicted areas and thus a higher chance of getting pressure related injuries. It is highly promising as it is noninvasive and it can also be used on the seats of chairs, wheelchairs, as backrest on sofas and many more

Saleh et al 2021 designed a wirelessly controlled device that can predict the pressure ulcers before they could occur and also it tries to avert it by providing therapeutic feedback. This device comprises of a pad that is flexible with numerous sensors are used and that could be used to non-invasively and continuously monitor the vital signs related to ulcer especially in the vulnerable regions and this data is then used to predict the pressure ulcers using a decision making algorithm. Once this is detected an electrical stimulation is then activated to increase the blood flow to the region and thus

reduce the risk of obtaining pressure ulcer. The results also comprised readings of the force, humidity, blood oxygenation and temperature which were then recorded on a graph for viewing purpose

A. Abdelmoghith et al 2020 proposed an IoT-based system that keeps track of the patient's health based on body temperature, skin humidity, and the length of time the body is immobile—all of which are major contributors to the development of bedsores. By delivering soft air at the appropriate temperature through vents from the patient's bed's mattress, the device also acts on the patients' measured indicators. Additionally, the system incorporates a mobile application so that concerned parties may continue to remotely watch the patients.

Duvall J et al 2019. In order to reduce the risk of pressure injuries a device called E-scale was proposed which would continuously monitor the prevention protocols. The E-scale is a bed with load cells placed under its leg which monitors the weight of the patient. It can also detect and classify movements in bed which have the potential of causing pressure injuries. Four types of movements can be detected and the device accuracy is >94%.

Minteer DM et al 2020 developed two prototype pressure ulcer monitoring platform devices (PUMP1 and PUMP2), were evaluated in a clinical trial in order to encourage hospitalized patients to reposition themselves in their beds as effectively as possible to avoid developing pressure ulcers (PUs). The PUMP1, a portable electronic gadget was affixed to the patients clothing without coming into contact with the skin. Four identical electronic gadgets known as PUMP2 were positioned under the wheels patient's bed. While reading from PUMP devices were linked with actual repositioning movement of the patient, a video camera captured what happened in the patient room. Both engineers and physicians assessed and compared the effectiveness of various PUMP devices created by a team of researchers. Ten individuals with limited mobility were included in the trial. Both PUMP devices captured repositioning movement for 10 ± 2 hours, which was verified by video recording. Over 105 hours of capture, PUMP1 and

PUMP2 together identified a total of 137 motions. The sensors missed 11 motions and falsely recorded two further movements. Never did PUMP1 and PUMP2 collide while collecting data. The clinical trial showed that both PUMP1 and PUMP2 devices successfully captured patient repositioning movements with 11 missed movements, 85% reliability, and 2 false positives. To enhance caregiver repositioning behavior, future trials will pair PUMP devices with an SMS-based mobile phone alarm system

Zhang Y et al 2021 developed an adjustable pneumatic mattress that can turn over and thus lessen risk of getting pressure related injuries have been developed. A turnover airbag is connected to a support airbag in order to enhance patient's comfort. The mattress is divided into three portions, the middle portions is the turning area whereas the left and right sides serve as support. The air bags are placed underneath the mattress and these airbags enable the turnover. Gas can be pushed into these air bags with the help of an air pump. The airbags will be inflated, this is controlled by valves which are energized or de energized based on which side the patient has turned over present. A temperature sensor is also used to keep track of the condition of bedridden patients to monitor their turning over process, real time temperature, and the time when they get out of bed

Sen et al 2018 A wireless wearable device was developed with the aim of preventing pressure ulcers. It is a rectangular patch which comprises of a force sensor which measures the pressure, a control circuitry which does the wireless communication via Bluetooth, and a humidity and temperature sensor. This entire system is powered by a polymer battery. These sensor patches were tested in rats. It was carried out by surgically implanting a steel disc below its latissimus dorsi muscle. Ten days later a magnet was applied to the subcutaneous tissue. A sensor was then placed between the skin and the magnet to gather information about the pressure and duration. All rats which were subjected to magnet application for more than 2 hours developed pressure injury. The pressure measured was also higher than the intended pressure. By incorporating ML algorithm, these systems can highly ease the work burden on the caretakers. Furthermore this system can send an alert to indicate that a high pressure

is being applied at a specific region which can thus result in pressure ulcers.

Denys J.C et al 2021 designed a DIY bed sensor mat which detected five postures sitting on the bed, prone, supine, lateral left, and lateral right positions. Furthermore they trained a machine learning model which showed a precision of 85.02% for a consumer. It comprised of a red wool base was used as the bottom layer which was then sewn to a mattress protector which acted as a top layer. 12 pressure tiles and 8 electrodes were placed in between the layers for capacitive sensing. Load cells were also placed under each leg of the bed to better infer the users posture. More work can be done by measuring vital signs of patients, a sensor network that could provide more details regarding the user's activity.

Francesco Orciuoli et al 2020 proposed an app that implemented a system for supporting clinical decisions to help its user to assess, trace its evolution and classify the status of bedsores. This would potentially help them to make the right decision regarding the actions to be taken to treat it. This app uses augmented reality technology along with deep learning. The results of the system are promising and the authors are working on more significant validation for this work regarding the result of classifiers based on deep neural network.

Rajesh Pandey et al 2018 designed a smart bed to improve patient turning. This cuts down the number of people needed to turn the patients and time spent on taking care of their needs. This still requires supervision and care of a nurse. It comprises of AI, computer control, morphable tiled floor and sensor network. The bed consists of a tiled surface where each tile works independently or in tandem with the other. This bed can redistribute the forces on a patient by repositioning and inflation or deflation. Air bladders whose pressure can be changed via an air pumps are provided to distribute the forces away from the high risk regions to the less pressure regions. By measuring and balancing the force on the tiles, this pneumatic actuation along with the an array of pressure sensor placed on the top of these air bladders gives rise to a force based servo system. SVM which is a learning algorithm is used to train the risk assessor which helps

to assess the risk of developing pressure ulcers. (Rajesh Pandey et al 2018).

Lorenz Grunerbel et al 2022 proposed a Bed head elevation system which was used to avert the concentration of pressure which causes the blood supply to the skin to reduce and thus increases the chance of pressure ulcer injury. But the issue with this system was that the air cells used tend to lag behind the change in pressure during its operation. So as to avoid this a system was proposed to predict the pressure distribution. The pressure distribution pattern was obtained as image and the prediction in change in pressure was done by applying a deep neural network.

G. Pongthanisor et al 2020 proposed an Elder Care System (ECS) for observing elderly patients behaviours on the bed. The system consists of a real-time monitoring system, in-bed position prediction system and notification system

Amelia Wong Azman et al 2019 implemented a device using electrical stimulation to act as therapeutic relief for chair bound and bedridden patients. Electrodes were embedded into a fabric mat to give tactile characteristics for persistent pressure mapping as well as stimulation terminals for external stimulator signals. When the measured pressure exceeds a predefined threshold, electrical stimulator is switched on and then sends stimuli to the specific area. This can be used as a method to prevent pressure ulcer, decreases atrophy, increases blood flow etc.

CHAPTER – 3

AIM AND SCOPE

3.1. AIM

The aim of our project is to monitor and treat the patients affected by bedsores. Firstly, we would like to detect the presence of patient on bed as well as to monitor the temperature of the bedsore region and to alert the caretaker to change the position of the patient. Furthermore, a vibration massage system will be incorporated into this prototype to enhance the blood circulation. A peltier module is included so as to provide relief to the patient by reducing the temperature of the affected area. Lastly, a push button (emergency) will be incorporated in order to help the patients.

3.2. SCOPE

In order to detect patterns of warning signs or pathogens that can be treated early to reduce morbidity and mortality as well as length and expense of hospitalization, it is crucial to continuously monitor the patient's health while they are in the hospital. Healthcare workers continuously monitor the patient's vital signs, making it simple and safe to shield the patient from unforeseen threats and to reduce harmful health issues. On the other hand, a major side effect of hospitalization is the impact of pressure ulcers on the bedridden patient as a result of strong shear forces. So we came up with this method of monitoring and treatment of patients with bedsores. The unique features of our project is that we will be using vibration instead of electrical stimulation as it tends to cause irritation of the skin underneath the electrode. The other feature is that we will be incorporating a cooling mechanism with the help of peltier modules to provide relief to the areas affected by bedsores. In future with necessary financial aid and technical assistance, further development of diagnosis can be provided. A proper heat sink for

peltier module can be created and further improvement in app features can be made.

CHAPTER – 4

MATERIALS AND METHODS

4.1. HARDWARE COMPONENTS

4.1.1. Power board

A power board is used to provide electric power to the system and typically can be a battery, USB cable, A adapter, or a regulated power source device. It can be used with any power adapter that gives 7 to 20 volts and will regulate the voltage down to a very clean 5 volts. The adapter must be DC (Direct current).

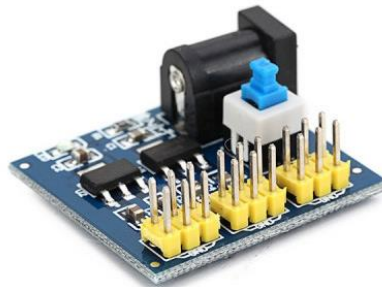


Fig. 4.1: Power Board

4.1.2. Arduino Uno

Arduino UNO is a low-cost, flexible, and easy-to-use programmable open-source microcontroller board that can be integrated into a variety of electronic projects. This board can be interfaced with other Arduino boards, Arduino shields, Raspberry Pi boards and can control relays, LEDs, servos, and motors as an output. Arduino UNO

features AVR microcontroller Atmega328, 6 analogue input pins, and 14 digital I/O pins out of which 6 are used as PWM output.



Fig. 4.2: Arduino UNO

4.1.3. NODE MCU 32S – ESP32

NodeMCU-32S is a Lua WiFi IOT development board based on ESP-32S module. Some of its features are:

- Onboard ESP32-S module
- Onboard CH340, USB to UART converter
- USB port for power input, firmware programming, or UART debugging
- 2x19pin extension headers, breakout all the I/O pins of the module
- 2x keys, used as reset or user-defined



Fig. 4.3: Node MCU 32S – ESP32

4.1.4. 16 x 2 LCD MODULE

It is a particular type of electronic display module used in a wide array of circuits and devices, including mobile phones, calculators, computers, and other electronics. These displays are mostly preferred for seven segments and multi-segment light-emitting diodes. The primary advantages of adopting this module are its low cost, ease of programming, animations, and lack of any restrictions on the display of customised characters, unique and even animations, etc.

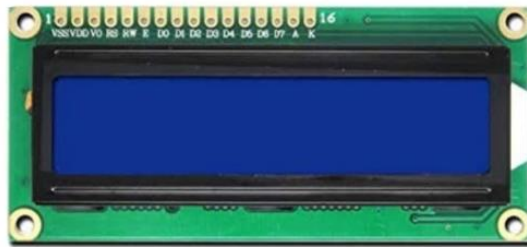


Fig. 4.4: 16 x 2 LCD module

4.1.5. Load cell

A load cell is a transducer that generates an electrical signal whose value is directly proportionate to the force being measured. Pneumatic load cells, strain gauge load cells and hydraulic load cells, are some of the several kinds of load cells. This is a typical load cell for measuring weight up to 5 kg. A microcontroller cannot directly measure the milli-volt output of the load cell. To make the load cell output accessible by a microcontroller, an ADC with high resolution or an instrumentation amplifier is needed.

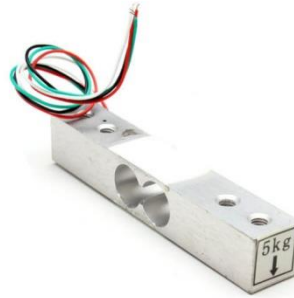


Fig. 4.5: 5 kg load cell

4.1.6. HX711 Load cell amplifier module

The HX711 electronic scale module operates on the premise of converting observed changes in resistance value changes into electrical output through a conversion circuit. Any load cell can be used with the board, which is an ADC convertor. A two-wire interface (Clock and Data) is used by the HX711 sensor module for communication. The GPIO pins of any microcontroller should function, and many libraries have been created to make it simple to read data from the HX711.

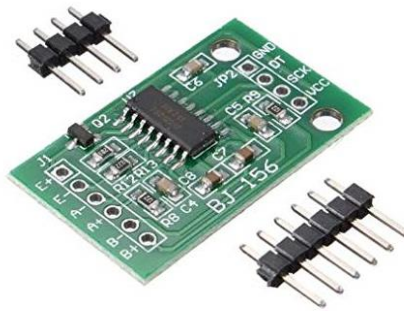


Fig. 4.6: HX711 load cell amplifier module

4.1.7. DS18B20 Temperature sensor

Dallas Semiconductor produces the DS18B20 1-Wire® temperature sensor (acquired by Maxim Integrated). It can interface with the microcontroller using just one digital pin because it is a 1-wire device. The DS18B20 temperature sensor works without any extra components and is fairly accurate. It is accurate to within 0.5°C throughout a

temperature range of -55 to $+125^{\circ}\text{C}$. There are three resolution options for the temperature sensor: 9, 10, and 11. However, 12-bit resolution (i.e., 0.0625°C precision) is the default setting at initialization.



Fig. 4.7: DS18B20 temperature sensor

4.1.8. Peltier module

A thermal control module called a Peltier module (thermoelectric module) has both warming and cooling effects. The surface temperature can be changed and maintained at the desired temperature by running an electric current through the module. They are frequently utilized in industries, medical instruments, refrigerators, computer CPUs, etc.



Fig. 4.8: Peltier module

4.1.9. Vibration motor

Electric or pneumatic (air) energy can be used to power vibration motors, which produce vibration. All industrial devices that require vibration energy employ vibration motors. They produce vibration energy by the energised motor's rotor rotating.



Fig. 4.9: Vibration motor

4.1.10. Tactile push button

In electronic projects, tactile push-button switches are frequently utilised as standard input "buttons." These are most effective when mounted on a PCB, but they can also be used for prototype temporary connections on a solderless breadboard. When the button is pressed, the pins—which are ordinarily open and disconnected—are briefly closed, completing the circuit. With a variety of working strengths available, this tactile switch also has powerful tactile feedback and dependable dome contact technology. The following are some examples of applications: consumer electronics, audio/visual, telecommunications, medical devices, and computer/peripherals.



Fig. 4.10: Tactile push button

4.1.11. Buzzer

An audio signaling device like a beeper or buzzer may be electromechanical or piezoelectric or mechanical type. The main function of this is to convert the signal from audio to sound. Generally, it is powered through DC voltage and used in timers, alarm devices, printers, alarms, computers, etc. Based on the various designs, it can generate different sounds like alarm, music, bell & siren. This type of buzzer is made with a magnet, solenoid coil, oscillator, housing, vibration diaphragm, and magnet. Once the power supply is given, the oscillator which produces the audio signal current will supply throughout the solenoid coil to generate a magnetic field. Sometimes, the vibration diaphragm will vibrate & generates sound under the magnet & solenoid coil interaction. The frequency range of this buzzer ranges from 2 kHz to 4 kHz.



Fig. 4.11: Buzzer

4.1.12. Water sensor

Water sensor brick is designed for water detection, which can be widely used in sensing rainfall, water level, and even liquid leakage. Connecting a water sensor to an Arduino is a great way to detect a leak, spill, flood, rain, etc. It can be used to detect the presence, the level, the volume and/or the absence of water. These have a series of exposed traces which is connected to ground which is interlaced with sensor traces that are placed in between it. These have a weak pull up resistor of 1 M Ω . In this project it is used to detect the sweat level.



Fig. 4.12: Water sensor

4.1.13. 12 V SMPS Power supply

This is the switched – mode power supply (SMPS) which converts 100-250V AC to 12 V DC. It can provide up to 10A maximum current. All types of protections like overload, over voltage and short circuit are provided in the circuit.



Fig. 4.13: 12 V SMPS Power supply

4.2. SOFTWARE COMPONENTS

4.2.1. ARDUINO IDE

The Arduino IDE is an open-source software, which is used to write and upload code to the Arduino boards. The IDE application is suitable for different operating systems such as Windows, Mac OS X, and Linux. It supports the programming languages C and

C++. IDE stands for Integrated Development Environment. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub `main()` into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program `avrdude` to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

4.2.2. THINGSPEAK

ThingSpeak is a cloud-based IoT analytics application that allows you to compile, visualize and analyse live data streams. ThingSpeak provides instant visualizations of information posted by your devices to ThingSpeak. With the power to execute MATLAB® code in ThingSpeak you'll perform online analysis and processing of the information because it comes in. ThingSpeak is usually used for prototyping and proof of concept IoT systems that need analytics. ThingSpeak is a cloud-based tool for aggregating, visualising and analysing live data streams. A number of the key capabilities of ThingSpeak include the flexibility to:

- Configure common IoT protocols to send data to ThingSpeak with ease.
- Visualize your sensor data in real-time.
- Aggregate data on-demand from third-party sources.
- Use the ability of MATLAB to create sense of your IoT data.
- Run your IoT analytics automatically supported schedules or events.
- Prototype and build IoT systems without fitting servers or developing web software.
- Use third-party applications like Twilio® or Twitter® to automatically action your data and connect.

4.2.3. MQTT Software

Message Queuing Telemetry Transport is a lightweight message protocol. It is designed to establish connections to remote locations that contain devices with low network bandwidth or resource availability.

4.3. BLOCK DIAGRAM

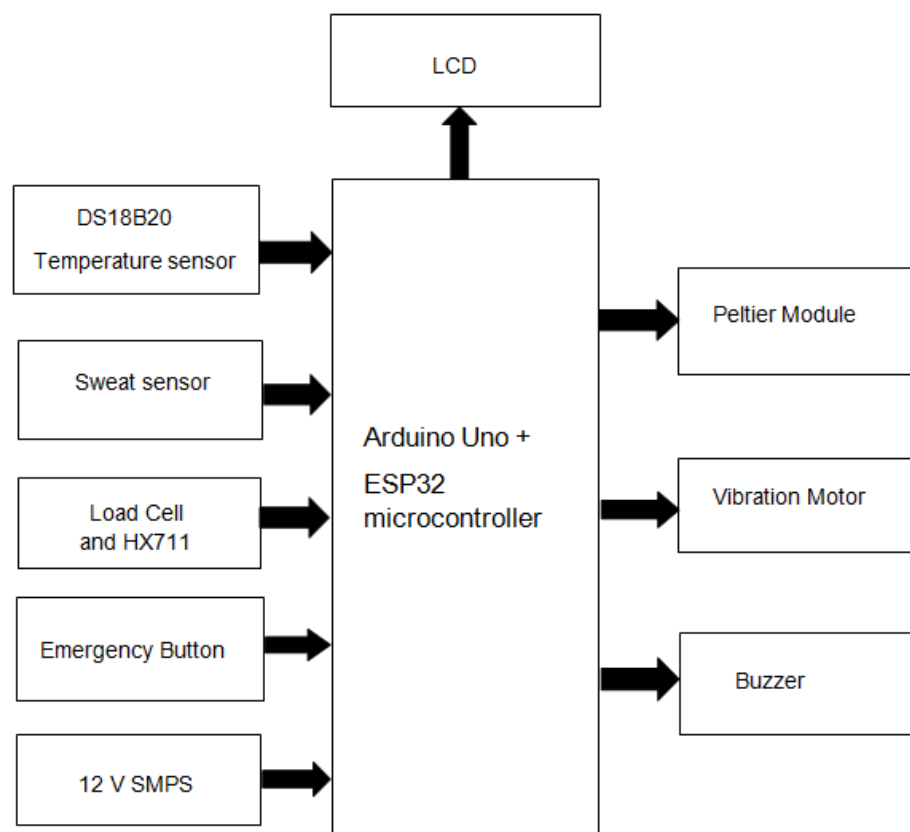


Fig. 4.14: Block diagram of prototype

4.4. WORKING

The proposed prototype consists of two microcontrollers namely the arduino UNO and ESP32. To the arduino UNO the rest of the components including the ESP32 is connected. The entire system is powered by a 12V SMPS which passes through a 5v buck converter before reaching the arduino UNO. The vibration motors are driven by a separate power source of 9V so as to increase the speed of the motor and thus provide better result. The load cell along with HX711 which is connected to the Arduino UNO helps in detecting the presence of the patient. The DS18B20 temperature sensor and water sensor incorporated detects the temperature and sweat level of the patient respectively. The Peltier module gets switched on when the measured temperature exceeds the set threshold value. The ESP32 is used to send these measured data to an IOT platform called ThingSpeak which would display the presence of patient on bed, temperature and the sweat levels of the patient. It also sends notifications to the caretaker reminding them to change the current position of the patient. The vibration motor present will be triggered by means of an app created by MQTT software. The emergency button can be used by patient with minimal movement to alert their caretaker through means of the buzzer as well via the app. The LCD will display the parameters in situations where the app fails to work.

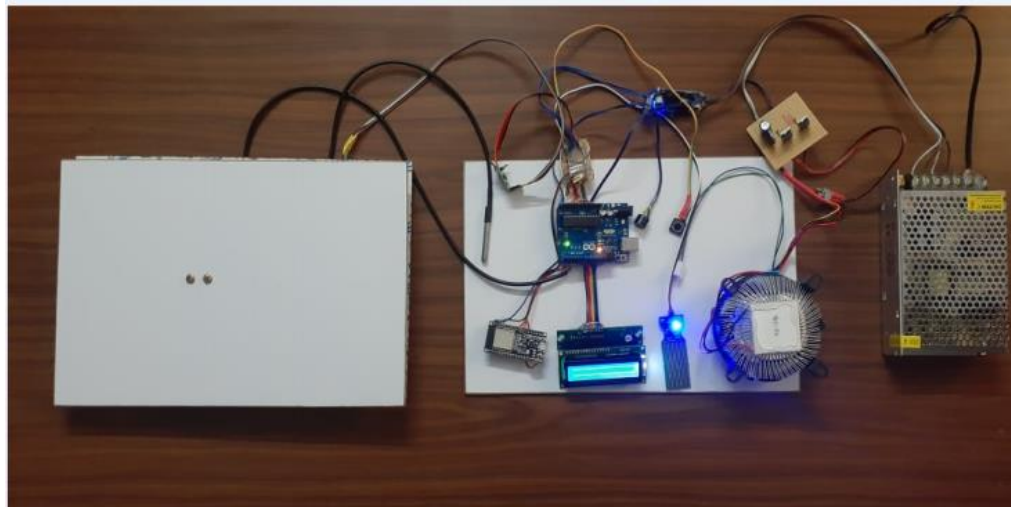


Fig. 4.15: Picture depicting all the connections

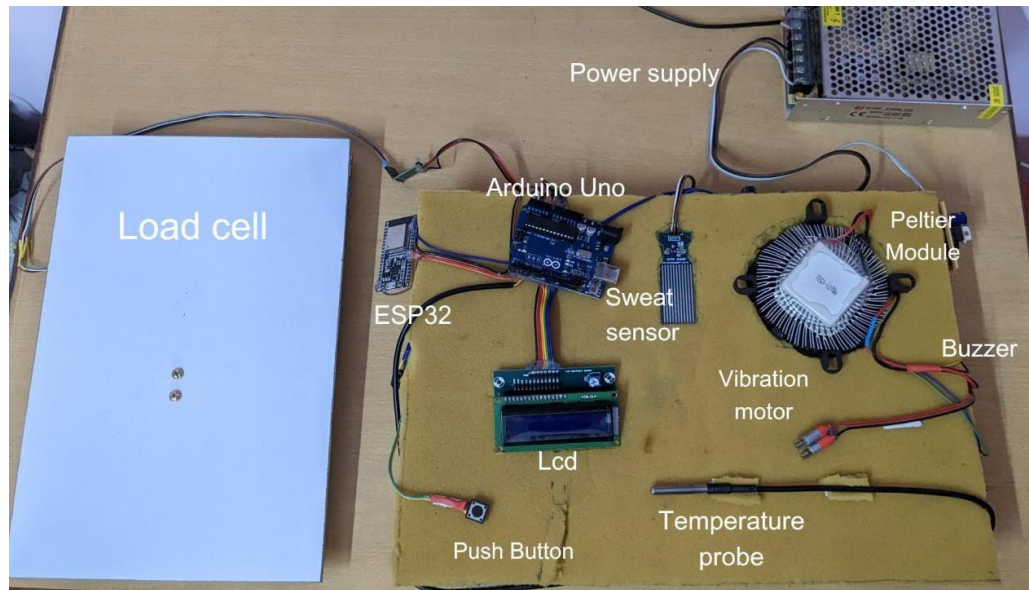


Fig. 4.16: Prototype of Intelligent Mattress



Fig.4.17: LCD displaying the temperature and sweat level

CHAPTER – 5

RESULTS AND DISCUSSION

The entire system is powered by the 12 V SMPS. When the system is powered on the LCD first displays the title of the project followed by a blank display. The reason for this is because nothing is placed on the platform as such the sensors aren't triggered and the values aren't displayed on the LCD. When a weight is applied on these platforms, the sensors are activated and start measuring the patient's parameters. The LCD displays the temperature and sweat level values. An LCD screen is used here so that the caretaker can view the parameters at real time and it is also beneficial in situations where there happens to be a failure in transmitting the data of the sensors (load cell, temperature and sweat level) to the cloud platform.

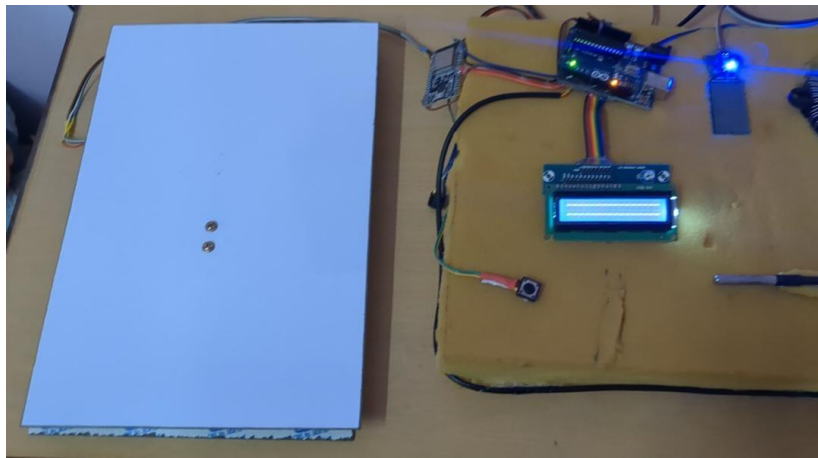


Fig.5.1: LCD displays a blank screen when no weight is present

The presence of the patient on the bed can be detected by the load cell placed in between the boards. In this project we have used a 5kg load cell. The output of these sensors can be seen in the ThingSpeak platform. It displays the weight as well as the date and time as to when the patient's presence is detected on the load cell platform as seen in figure 5.2

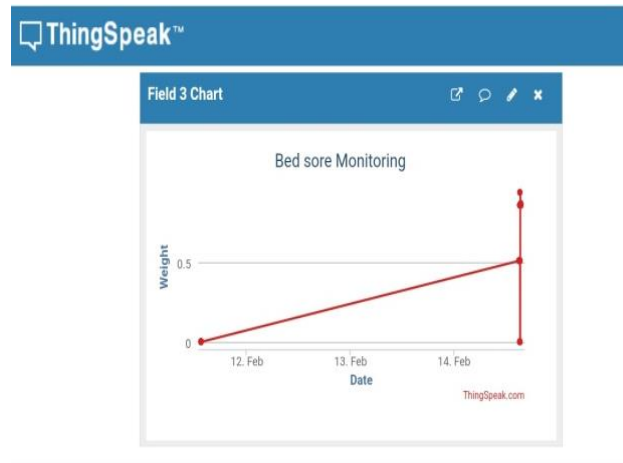


Fig.5.2: Output of load cell

Furthermore the temperature and sweat level can also be seen on thingspeak which would continuously display these values as seen in figures 5.3 and 5.4. This is extremely useful as doctors will be able to study the reasons as to why the wounds are worsening or showing improvement. They can use this data to develop better treatment plans so that the patients can recover. Furthermore this data can also be used to

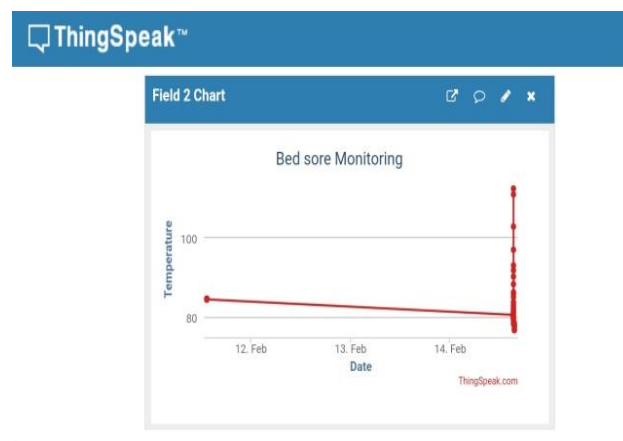


Fig.5.3: Output of DS18B20 temperature sensor

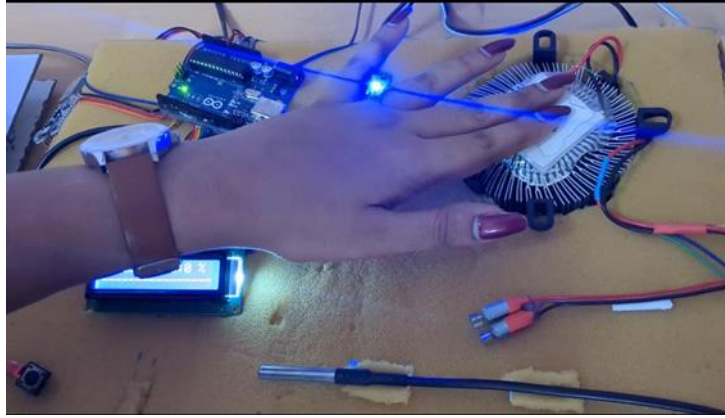


Fig.5.4: Peltier module is triggered and a cooling sensation is delivered

When the temperature exceeds the threshold value which has been set to 100 F, the peltier module is automatically triggered which starts to produce a cooling sensation. This automatically switches off once the temperature falls below the threshold value. Furthermore the buzzer also sounds to alert the caretakers about this.

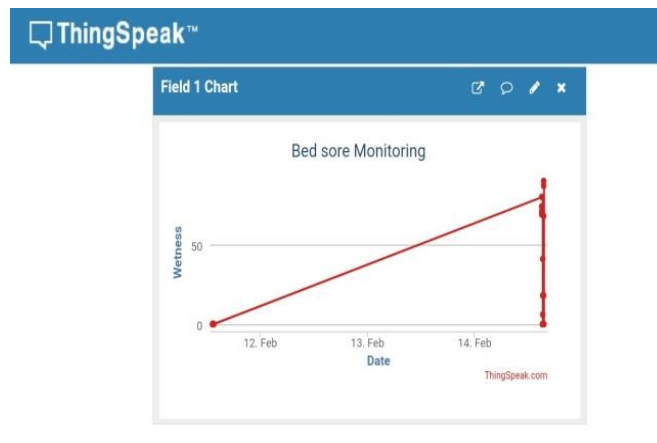


Fig.5.5: Output of sweat sensor

The water sensor employed here is used to monitor the sweat level of the patient. If the amount of sweat detected on this sensor exceeds the set value which is 60 to 90 % the buzzer gets triggered but at a different tone so that the caretaker is able to differentiate which parameter of the patient has exceeded the nominal value.

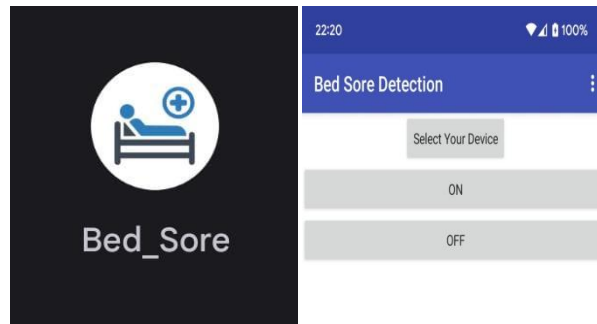


Fig.5.6: Bed_Sore app created using MQTT software

The MQTT software was used to create the app which sends a reminder message to the caretaker's phone every two hours to remind them to change the position of the patients. For this prototype we have set the limit as 30 mins and future work can be done to customize the app.

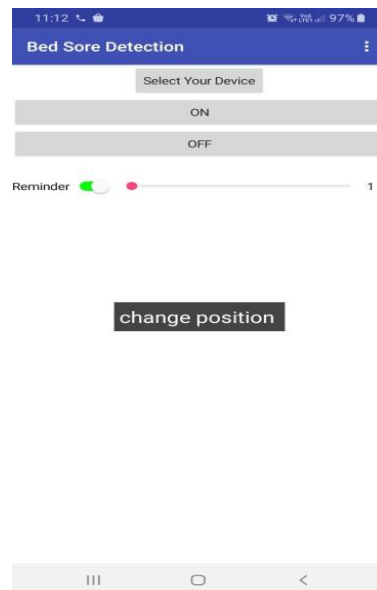


Fig.5.7: Bed_Sore app sends the notification to change the position

The vibration motors are also controlled via the app which is done by switching the on or off button present on the app. When the emergency button is pressed, it triggers the alarm to alert the caretaker.

CHAPTER – 6

SUMMARY AND CONCLUSION

6.1. SUMMARY

The prototype that we have developed focuses on not only monitoring but also on providing therapeutic relief to the patients as well as reducing the burden on the guardians and caretakers. Arduino UNO has been used to control the various sensors, motors and display present. While the ESP32 has been employed for the purpose of transmitting the data obtained by these sensors to a cloud platform and for also controlling the app. The sensor would be triggered only if a weight is present on the surface of the load cell platform. This feature thereby reduces the power usage of the system and thus can help increase battery life of the prototype. When the temperature at the probe is abnormal the peltier module was triggered which would provide a cooling sensation to the region of interest. This reduces a significant burden on the caretakers as they need not continuously check the accumulation of sweat or possibility of temperature rise due to friction as this system will alert them in such situation and also provide relief to the patient.

Moreover a vibration motor which is used to enhance blood flow to the affected region is also used. This has been successfully operated by means of the app and is triggered based on the physician's input. Not only that the app also can be used to set a reminder to the patient. This feature has been successfully tested and a reminder message was sent to the user phone via the app based on the time that was set by the user through the app. This further relieves the burden on the caretaker or guardian as the app reminds them to change the position of the patient so as to avoid the worsening of the wound

The data of all the sensors was uploaded to the cloud platform and the user was able to view the data in real time. Which is beneficial for the doctors in the long term to

develop better treatment plan for their patients. This system saves the time of the caretaker and also provides means by which immediate therapeutic relief can be given to the patient.

6.2. CONCLUSION

This smart mattress proves to be a feasible method for detecting as well as preventing bedsores in bedridden patients. Previous works focused mainly on the diagnosis part alone but we have given equal importance to the therapy part too in our project by incorporating methods like vibration therapy and cooling mechanism. The proposed system has adequate alert systems to warn the caretaker when any of the parameter exceeds by sending a buzzer or also through notifications via the app. The output can also be seen through the ThingSpeak application which is easy to use and can be used by caretakers or doctors for further prognosis. Future works can be done by improving the pressure detection of the bedridden patient and by incorporating therapeutic methods like Infrared Red light, Pulse magnetic therapy etc.

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APPENDIX

1)

```
#include <LiquidCrystal.h>
#include <OneWire.h>
#include "HX711.h"
#include <SoftwareSerial.h>

SoftwareSerial ard_node(2,3);

float node_update = 50;

#define splash splash1
#define buz A4
#define water A3
#define pelt 7
#define emer A2

OneWire ds(4);

HX711 scale1(A1, A0);
// LiquidCrystal lcd( 13, 12, 11, 10, 9, 8);
LiquidCrystal lcd(8, 9, 10, 11, 12, 13);

int alert_Status;
int emer_r;

float celsius, fahrenheit;
float calibration_factor = 557999;

void setup() {

    Serial.begin(115000);
```

```

ard_node.begin(115200);
pinMode(pelt, OUTPUT);
pinMode(buz, OUTPUT);
digitalWrite(buz, LOW);
pinMode(emer, INPUT_PULLUP);

LcdSet();
scale1.set_scale();
scale1.tare();
long zero_factor1 = scale1.read_average();

splash(0, "Initializing");
splash(1, "Sensors");
delay(2000);
lcd.clear();
}

void LcdSet() {

    lcd.begin(16, 2);
    splash(0, "Bed Sore");
    splash(1, "Monitoring");
    delay(3000);
    lcd.clear();
}

void loop() {
    getDSTemp();
    scale1.set_scale(calibration_factor);
    float kg = scale1.get_units();
    if (kg <= 0) {
        kg = 0;
    }
    node_update++;
}

```

```

int wat_r = analogRead(water);

if (wat_r > 730) {
    wat_r = 730;
}

wat_r = map(wat_r, 0, 730, 0, 100);
emer_r = digitalRead(emer);
if (!emer_r) {
    digitalWrite(buz, HIGH);
}

if (kg >= .5) {
    lcd.setCursor(0, 0);
    lcd.print("T:      ");
    lcd.setCursor(2, 0);
    lcd.print(fahrenheit, 1);
    lcd.print(char(223));
    lcd.print("F  ");

    lcd.setCursor(10, 0);
    lcd.print("W:      ");
    lcd.setCursor(12, 0);
    lcd.print(wat_r);
    lcd.print(" % ");

    if (fahrenheit >= 100) {
        digitalWrite(buz, HIGH);
        delay(50);
        digitalWrite(buz, LOW);
        digitalWrite(pelt, HIGH);

    } else {

        digitalWrite(pelt, LOW);
    }
}

```

```

    if (wat_r > 80) {
        digitalWrite(buz, HIGH);
        delay(100);
        digitalWrite(buz, LOW);
    }

    Serial.print(" Temperature = ");
    Serial.print(celsius);
    Serial.print(" Celsius, ");
    Serial.print(fahrenheit);
    Serial.println(" Fahrenheit");
} else {
    splash(0, "");
    splash(1, "");
}

if (node_update >= 3) {

    node_update = 0;
    String out = String(wat_r);
    out += ",";
    out += String(fahrenheit);
    out += ",";
    out += String(kg);
    out += ",";

    ard_node.print(out);
    Serial.println(out);
}

delay(20);
}

```

```

void getDSTemp() {
    byte i;
    byte present = 0;
    byte type_s;
    byte data[12];
    byte addr[8];

    if (!ds.search(addr)) {
        //    Serial.println("No more addresses.");
        //    Serial.println();
        ds.reset_search();
        delay(250);
        return;
    }

    //    Serial.print("ROM =");
    for (i = 0; i < 8; i++) {
        //    Serial.write(' ');
        //    Serial.print(addr[i], HEX);
    }

    if (OneWire::crc8(addr, 7) != addr[7]) {
        //    Serial.println("CRC is not valid!");
        return;
    }
    //    Serial.println();

    // the first ROM byte indicates which chip
    switch (addr[0]) {
        case 0x10:
            //    Serial.println("  Chip = DS18S20"); // or old DS1820
            type_s = 1;
            break;

```

```

    case 0x28:
        //      Serial.println("  Chip = DS18B20");
        type_s = 0;
        break;
    case 0x22:
        //      Serial.println("  Chip = DS1822");
        type_s = 0;
        break;
    default:
        Serial.println("Device is not a DS18x20 family device.");
        return;
}

ds.reset();
ds.select(addr);
ds.write(0x44, 1); // start conversion, with parasite power on at the
end

delay(500); // maybe 750ms is enough, maybe not
// we might do a ds.depower() here, but the reset will take care of
it.

present = ds.reset();
ds.select(addr);
ds.write(0xBE); // Read Scratchpad

//  Serial.print("  Data = ");
//  Serial.print(present, HEX);
//  Serial.print(" ");
for (i = 0; i < 9; i++) { // we need 9 bytes
    data[i] = ds.read();
    //      Serial.print(data[i], HEX);
    //      Serial.print(" ");
}
//  Serial.print(" CRC=");
//  Serial.print(OneWire::crc8(data, 8), HEX);

```

```

// Serial.println();

// Convert the data to actual temperature
// because the result is a 16 bit signed integer, it should
// be stored to an "int16_t" type, which is always 16 bits
// even when compiled on a 32 bit processor.
int16_t raw = (data[1] << 8) | data[0];
if (type_s) {
    raw = raw << 3; // 9 bit resolution default
    if (data[7] == 0x10) {
        // "count remain" gives full 12 bit resolution
        raw = (raw & 0xFFF0) + 12 - data[6];
    }
} else {
    byte cfg = (data[4] & 0x60);
    // at lower res, the low bits are undefined, so let's zero them
    if (cfg == 0x00) raw = raw & ~7; // 9 bit resolution, 93.75 ms
    else if (cfg == 0x20) raw = raw & ~3; // 10 bit res, 187.5 ms
    else if (cfg == 0x40) raw = raw & ~1; // 11 bit res, 375 ms
    //// default is 12 bit resolution, 750 ms conversion time
}
celsius = (float)raw / 16.0;
fahrenheit = celsius * 1.8 + 32.0;
// Serial.print(" Temperature = ");
// Serial.print(celsius);
// Serial.print(" Celsius, ");
// Serial.print(fahrenheit);
// Serial.println(" Fahrenheit");
}

```

2)

```

#include <WiFi.h>
#include <ESPmDNS.h>
#include <WiFiUdp.h>

```

```

#include <ArduinoOTA.h>
#include <Wire.h>
#include "ThingSpeak.h"
#include "BluetoothSerial.h"

#if !defined(CONFIG_BT_ENABLED) || !defined(CONFIG_BLUEDROID_ENABLED)
#error Bluetooth is not enabled! Please run `make menuconfig` to and
enable it
#endif

BluetoothSerial SerialBT;

char ssid[] = "Project";
char password[] = "1234567890";
#define ard_node Serial2

//Bedsore12@
#define vib 23

unsigned long channelID = 2030418;
const char* writeAPIKey = "8GZNPLICJSPS79QQ"; // write API key for your
ThingSpeak Channel
const char* server = "api.thingspeak.com";
String th;

float bt_update = 9;
int bt_t;

String data_print_out = "";

int rst = 0;
int tup = 15000;

float temp, wet, weig;

```

```

WiFiClient client;

void setup() {
  Serial.begin(115200);
  pinMode(vib, OUTPUT);
  SerialBT.begin("Bed-Sore");
  WiFi.mode(WIFI_STA);
  WiFi.begin(ssid, password);
  setupWifi();
  ArduinoOTA.setHostname("Bed_sore_IOT");
  OTA();
  ard_node.begin(115200);
  // ard_node.begin (115200, SWSERIAL_8N1, RX, TX, false, 256);
  ard_node.println("");
  ThingSpeak.begin(client);
}

void setupWifi() {

  if (WiFi.status() == WL_CONNECTED) {
    delay(800);
    Serial.print(".");
    Serial.println("");
    Serial.println("WiFi connected");
    Serial.println("IP address: ");
    Serial.println(WiFi.localIP());
    delay(1000);
  }
}

void loop() {

  getArd();

  if (SerialBT.available()) {

```

```

    char k = SerialBT.read();
    Serial.write(k);
    if (k == '1') {
        digitalWrite(vib, HIGH);
    }
    if (k == '2') {
        digitalWrite(vib, LOW);
    }
}

UpdateServer();
delay(10);
}

void getArd() {

    String SS = "";
    String SSs = "";
    while (ard_node.available() > 0) {

        char S = ard_node.read();
        SS += S;

        delay(10);
    }
    if (SS.length() > 0) {
        Serial.println(SS);

        String a = getSplitValue(SS, ',', 0);
        String b = getSplitValue(SS, ',', 1);
        String c = getSplitValue(SS, ',', 2);

        wet = a.toFloat();

```

```

    temp = b.toFloat();
    weig = c.toFloat();

    // dis_per = a.toInt();

    ard_node.flush();
}
}
// 9150958399
// kings
// bme
// karthana

void UpdateServer() {

    tup++;
    if (tup >= 1500) {
        if (client.connect(server, 80)) {

            ThingSpeak.setField(1, String(wet));
            ThingSpeak.setField(2, String(temp));

            ThingSpeak.setField(3, String(weig));

            int xx = ThingSpeak.writeFields(channelID, writeAPIKey);
            if (xx == 200) {
                Serial.println("Channel update successful.");
            } else {
                Serial.println("Problem updating channel. HTTP error code " +
String(xx));
            }
        }
    }
}

```

```
        tup = 0;  
    }  
}
```