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DESIGN AND DEVELOPMENT OF IOT BASED WEATHER AND AIR QUALITY MONITORING STATION

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ABSTRACT:

This paper presents the Design and Development of IoT Based Weather and Air Quality Monitoring stations that provide weather-related information for agriculture, and aviation climate forecasting purposes. The prototype is made up of an outdoor unit that consistently monitors numerous climatic variables such as temperature, humidity, rainfall, and air quality using sensors with high accuracy. The air quality index (AQI) is also calculated using the sensors values which tell us whether the atmosphere is safe or polluted. Microcontroller which has a WiFi module is used to gather and send the sensor data through the Internet of things (IoT) to a ThingSpeak channel (IoT cloud), an internet platform where the data is saved, analyzed and read the data remotely. The weather station makes use of photovoltaic power and a rechargeable lead-acid battery to sustain the system. This paper also discusses the obvious strengths and shortcomings of the system and suggests plausible upgrades to assist the system in obtaining higher and long-term performance.

INTRODUCTION:

With all the talk around climate change and rising pollution levels, keeping an eye on our environment has never been more important. Thanks to the Internet of Things (IoT), we now have the tools to do this in a smarter and more efficient way. An IoT-based weather and air quality monitoring station is a great example—it allows us to track things like temperature, humidity, and air pollution in real time, giving us the data we need to better understand and respond to the world around us.

The system works by using a set of sensors that measure environmental factors such as CO₂ levels, fine dust particles (PM_{2.5} and PM₁₀), and basic weather conditions. These sensors send the data to the cloud through a microcontroller, and from there, it can be accessed through apps or online dashboards. This makes it easy to monitor trends over time, get alerts when air quality drops, or simply stay updated on current conditions—whether you're a researcher, a city planner, or just someone who cares about clean air.

Building this kind of station involves putting together both the hardware and software, using affordable components and open-source tech. It's designed to be simple, low-cost, and customizable so it can be used in different places—from cities to remote areas. At its core, this project is about making environmental monitoring more accessible and helping people stay more connected to the health of their surroundings.

LITERATURE REVIEW :

Kang. J. and Park S. “Integrated comfort sensing system on indoor climate” Sensors and Actuators. 2000. 302- 307.

Kang and Park (2000) created a system that goes beyond just measuring things like temperature or humidity on their own—it's designed to understand how people actually *feel* in an indoor space. By using sensors to gather data on temperature, humidity, and air movement, the system calculates comfort levels using models like PMV and PPD, which are basically ways to predict how comfortable or uncomfortable a room might feel to most people. What makes their project stand out is how it brings all this information together to give a more complete picture of indoor comfort, instead of just showing numbers. It's a thoughtful approach that helps create environments where people can feel genuinely comfortable, whether at home, at work, or in any indoor space.

Moghavvemi M. and Tan. S. “A reliable and economically feasible remote sensing system for temperature and relative humidity measurement”. Sensors and Actuators. 2005. 181-185.

Moghavvemi and Tan (2005) developed a remote sensing system that offers an affordable and reliable solution for measuring temperature and relative humidity. The paper addresses the limitations of traditional measurement techniques and proposes a more practical alternative for monitoring these environmental factors remotely. The system combines sensors with communication technology to provide accurate, real-time data over distances, making it an efficient and cost-effective option. This system is well-suited for various applications, such as agriculture, environmental monitoring, and industrial settings, and offers a practical alternative to conventional methods by focusing on both reliability and economic feasibility.

Hettiarachchi H.A.P.K. & Fernando I.M.K., “USB Based High Speed Data Acquisition System for an Unmanned Weather Station”, 2nd Int. Conf. on e-governance, 2004.

Hettiarachchi and Fernando (2004) introduce a USB-based high-speed data acquisition system designed for an unmanned weather station. The paper focuses on creating an efficient and cost-effective method to collect and transfer weather data, such as temperature, humidity, and pressure, from remote locations. By utilizing a USB interface, the system offers fast data transfer and easy integration with computers, making it accessible for real-time monitoring and analysis. This design is particularly useful for unmanned weather stations where reliable, continuous data collection is required without the need for manual intervention, making it an effective solution for automated environmental monitoring.

PROPOSED SYSTEM :

The proposed IoT-based weather and air quality monitoring station is designed to provide real-time data on environmental conditions such as temperature, humidity, air pressure, and air quality indicators like CO₂ levels and particulate matter (PM_{2.5} and PM₁₀). By using a network of sensors, the system continuously collects data and sends it over the internet to a cloud platform or server, where it can be accessed remotely. This allows users to monitor weather and air quality conditions from anywhere, at any time, through an intuitive web dashboard or mobile app, making it easy to track environmental changes in real time.

The system is built on a flexible and scalable architecture, making it suitable for deployment in various environments, including urban areas, industrial sites, and rural locations. The sensors are selected for their accuracy and reliability, while the connectivity between the sensors and the cloud is facilitated by lowpower communication technologies like Wi-Fi or LoRa, depending on the range and power requirements. The system is designed to be energy-efficient, ensuring that it can operate for long periods with minimal maintenance, which is particularly important for outdoor or unmanned installations.

One of the key features of this system is its ability to provide real-time alerts and historical data analysis. Users can set thresholds for specific air quality or weather conditions, and the system will send notifications when these limits are exceeded, enabling timely interventions. This functionality makes it an invaluable tool for ensuring the health and safety of communities, as well as for supporting decisionmaking in areas like environmental monitoring, agriculture, and urban planning. Overall, the proposed system aims to offer a cost-effective, accessible, and reliable solution for monitoring air quality and weather conditions.

Block Diagram :

BLOCK DIAGRAM:

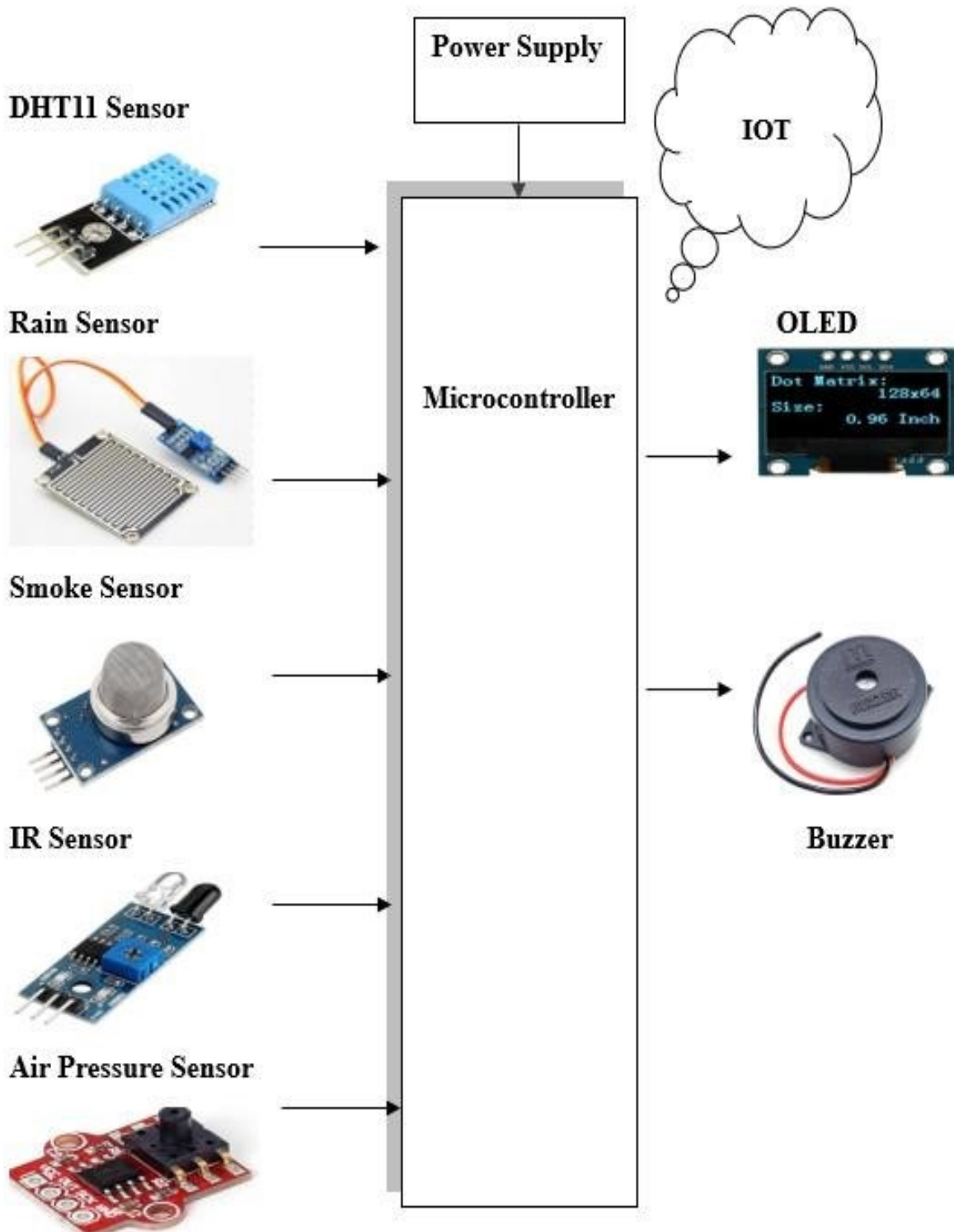
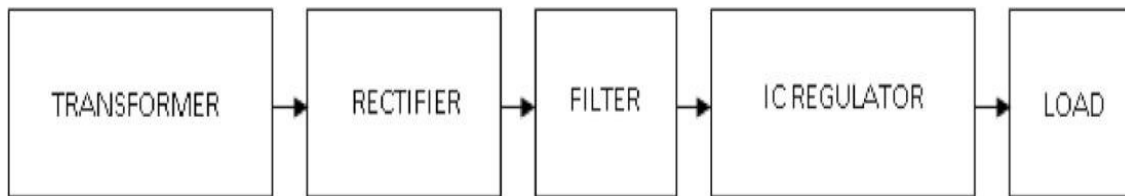


Fig 1-Block diagram of air&weather monitoring system**Hardware Components :****Power Supply :**

The power supply section is the section which provides +5V for the components to work. IC LM7805 is used for providing a constant power of +5V. The ac voltage, typically 220V, is connected to a transformer, which steps down the ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation. A regulator circuit removes the ripples and also retains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units .

**Fig 2-Block diagram of power supply Transformer**

:

Transformers convert AC electricity from one voltage to another with little loss of power. Transformers work only with AC and this is one of the reasons why mains electricity is AC. Step-up transformers increase voltage, step-down transformers reduce voltage. Most power supplies use a step-down transformer to reduce the dangerously high mains voltage (230V in India) to a safer low voltage.

Rectifier :

There are several ways of connecting diodes to make a rectifier to convert AC to DC. The bridge rectifier is the most important and it produces full-wave varying DC. A full-wave rectifier can also be made from just two diodes if a centre-tap transformer is used, but this method is rarely used now that diodes are cheaper. A single diode can be used as a rectifier but it only uses the positive (+) parts of the AC wave to produce half-wave varying DC.

Voltage Regulators :

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustable set voltage. The regulators can be selected for operation with load currents from hundreds of milli amperes to tens of amperes, corresponding to power ratings from milli watts to tens of watts.

RASPBERRY PI PICO W

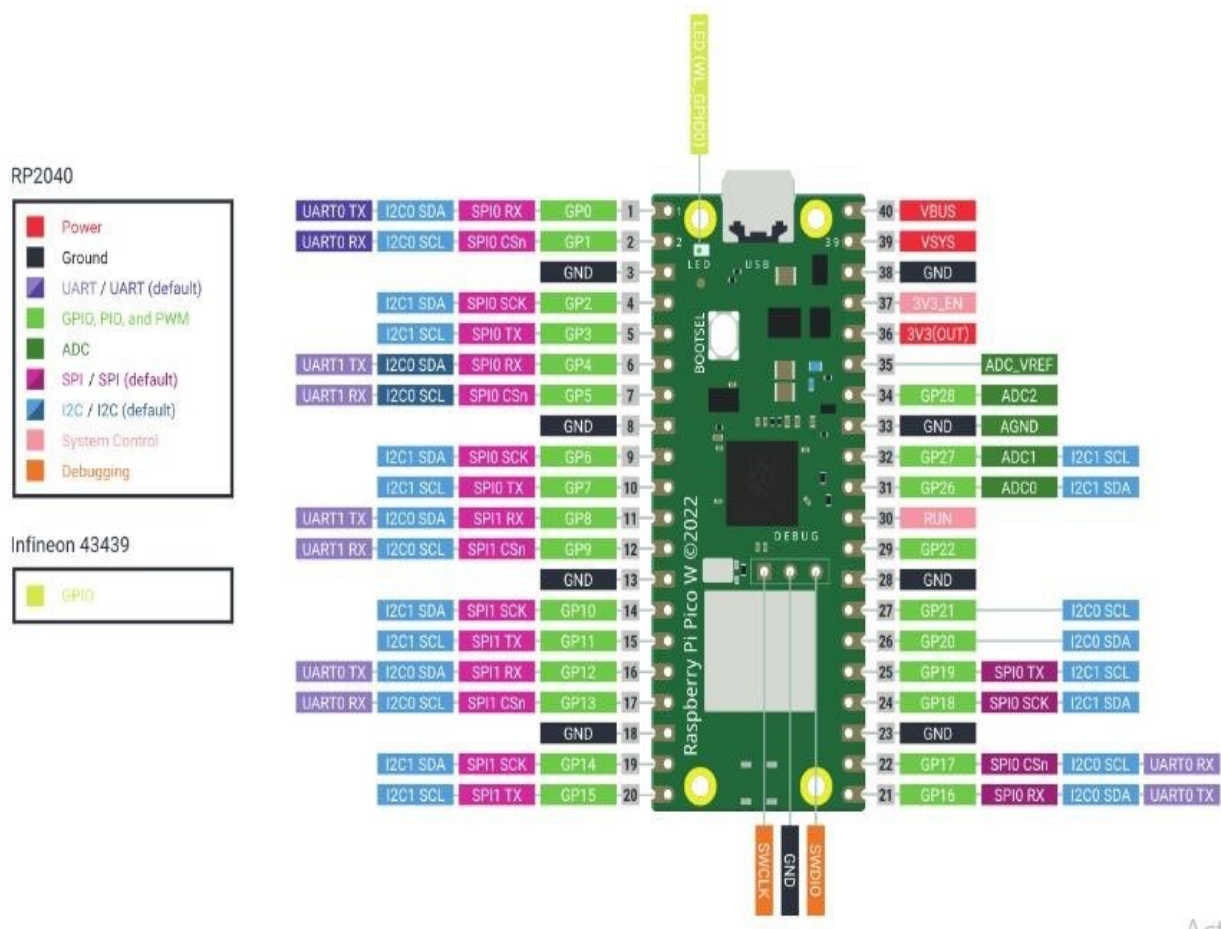


Raspberry Pi Pico W is **Raspberry Pi**'s first wireless microcontroller board, designed especially for physical computing. It is the successor of the popular **Raspberry Pi Pico** board. Similar to the Pico board, which we discussed earlier, the **Pico W** board is also built around the **Raspberry Foundation** in-house ARM chip RP2040. The main improvement is the addition .of Wi-Fi and Bluetooth functionality. **Raspberry Pi Pico W** incorporates an Infineon **CYW43439** wireless chip that supports IEEE 802.11 b/g/n wireless LAN, and Bluetooth 5.2.

Raspberry Pi Pico Vs Raspberry Pi Pico W

The main difference between the **Pico** and **Pico W** is the inclusion of Infineon's CYW43439 2.4-GHz WiFi chip, which is responsible for WiFi and Bluetooth. Another major change is with the power section. The new Pico W uses the **RT6154A** from **Richtek** as the power regulator instead of the **RT6150B** in the original Pico design. The debug port also moved near the SoC to make space for the Wi-Fi antenna.

2.4.3 RASPBERRY PI PICO W PINOUT



Raspberry Pi Pico W is pin-to-pin compatible with the older Pico board and has a total of 40 Pins out of which 26 are multipurpose GPIOs. These 26 digital input and output pins are labeled as GP0, GP1, and so on up to GP28. Out of these 30 pins, GP23, GP24, GP25, and GP29 are not exposed on the header, hence we only get a total of 26 GPIO pins. All GPIOs are operating at a 3.3V logic level. Apart from these pins, Pico w also offers a 3-Pin header for debug interface which is located near the **RP2040 Chip**.

The following table shows the GPIOs and the corresponding ADC channels we can access through the pinout.

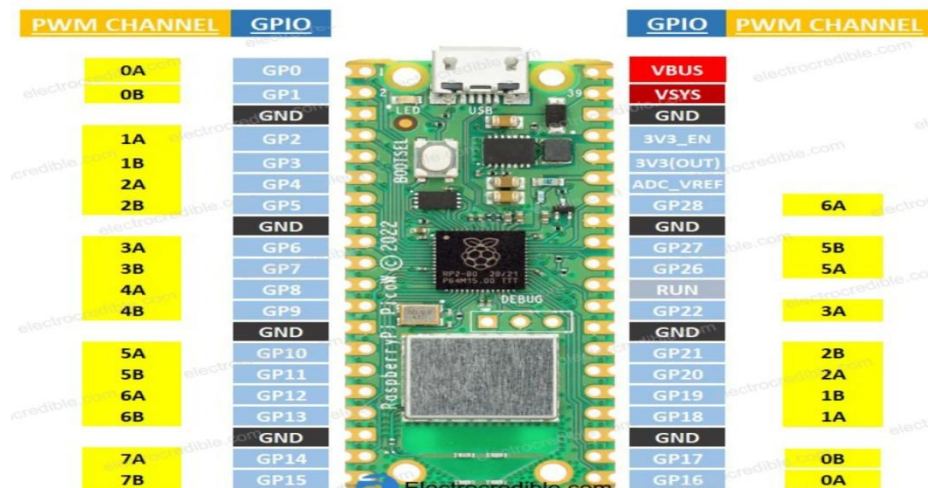
ADC Channel	GPIO
ADC 0	GPIO 26

ADC 1	GPIO 27
ADC 2	GPIO 28

RPi Pico & Pico W PWM Pinout:

The RP2040 in Raspberry Pi Pico has 8 identical slices of PWM block. Each slice can monitor the frequency or duty cycle of an input signal as well as produce two PWM output signals. So, there are 16 controllable PWM outputs. The PWM block may operate each of the 26 available GPIO pins onboard the Raspberry Pi Pico.

The pinout diagram below shows how the PWM pins are arranged.



2.5 OLED (Organic Light Emitting Diodes)

OLED (Organic Light Emitting Diodes) is a flat light emitting technology, made by placing a series of organic thin films between two conductors. When electrical current is applied, a bright light is emitted. OLEDs are emissive displays that do not require a backlight and so are thinner and more efficient than LCD displays (which do require a white backlight).

OLED displays are not just thin and efficient - they provide the best image quality ever and they can also be made transparent, flexible, foldable and even rollable and stretchable in the future. OLEDs represent the future of display technology!

OLED vs LCD

An OLED display have the following advantages over an LCD display:

- Improved image quality - better contrast, higher brightness, fuller viewing angle, a wider color range and much faster refresh rates.
- Lower power consumption.
- Simpler design that enables ultra-thin, flexible, foldable and transparent displays
- Better durability - OLEDs are very durable and can operate in a broader temperature range



The future - flexible and transparent OLED displays

As we said, OLEDs can be used to create flexible and transparent displays. This is pretty exciting as it opens up a whole world of possibilities:

- Curved OLED displays, placed on non-flat surfaces
- Wearable OLEDs
- Foldable OLEDs and rollable OLEDs which can be used to create new mobile devices
- Transparent OLEDs embedded in windows or car windshields □ And many more we cannot even imagine today...

Flexible OLEDs are already on the market for many years (in smartphones, wearables and other devices) and since 2019, with the introduction of the Samsung Galaxy Fold, foldable devices are increasing in popularity. In 2019 LG also announced the world's first rollable OLED - its 65" OLED R TV that can roll into its base! An OLED is made by placing a series of organic thin films between two conductors. When electrical current is applied, a bright light is emitted. [Click here for a more detailed view of the OLED technology.](#) OLEDs are

organic because they are made from carbon and hydrogen. There's no connection to organic food or farming - although OLEDs are very efficient and do not contain any bad metals - so it's a real green technology. OLED is the best display technology - and indeed OLED panels are used today to create the most stunning TVs ever - with the best image quality combined with the thinnest sets ever. And this is only the beginning, as in the future OLED will enable large rollable and transparent TVs!

Currently the only company that produces OLED TV panels is LG Display. The Korean display maker is producing a wide range of OLED TV panels, offering these to LG Electronics, Panasonic, Sony, Philips and others.

Specifications

- ✓ Use CHIP No.SH1106
- ✓ Use 3.3V-5V POWER SUPPLY
- ✓ Graphic LCD 1.3” in width with 128x64 Dot Resolution
- ✓ White Display is used for the model OLED 1.3 I2C WHITE and blue Display is used for the model OLED 1.3 I2C BLUE
- ✓ Use I2C Interface
- ✓ Directly connect signal to Microcontroller 3.3V and 5V without connecting through Voltage Regulator Circuit
- ✓ Total Current when running together is 8 mA - PCB Size: 33.7 mm x 35.5 mm

Internet of things (IoT)

Internet of things (IoT), is another advance technology in IT sector, provides internetworking for numerous of devices such as sensors, actuators, PLCs and other electronic embedded smart devices and controls, and various software's' and provides systems network configuration and connectivity, which enables communication between these numerous devices for information exchanging.

In 1995, "thing to thing" was coined by BILL GATES. In 1999, IoT (Internet of Things) was come up by EPC global. IOT interconnects human to thing, thing to thing and human to human. The goal of IoT is bring out a huge network by combining different types connected devices. IoT targets three aspects Communication, automation, cost saving in a system. IOT empowers people to carry out routine activities using internet and thus saves time and cost making them more productive. IOT enables the objects to be sensed and/or controlled remotely across existing network model. IOT in environmental monitoring helps to know about the air and water quality, temperature and conditions of the soil, and also monitor the intrusion of animals in to the field. IOT can also play a significant role in precision farming to enhance the productivity of the farm.

Recent advancements, such as the vision of the Internet of Things (IoT), the cloud computing model, and cyber-physical systems, provide support for the transmission and management of huge amounts of data regarding the trends observed in environmental parameters. In this context, the current work presents three different IoT-based wireless sensors for environmental and ambient monitoring: one employing User Datagram Protocol (UDP)-based Wi-Fi communication, one communicating through Wi-Fi and Hypertext Transfer Protocol (HTTP), and a third one using Bluetooth Smart. All of the presented systems provide the possibility of recording data at remote locations and of visualizing them from every device with an Internet connection, enabling the monitoring of geographically large areas. The development details of these systems are described, along with the major differences and similarities between them. The feasibility of the three developed systems for implementing monitoring applications, taking into account their energy autonomy, ease of use, solution complexity, and Internet connectivity facility, was analysed, and revealed that they make good candidates for IoT-based solutions.

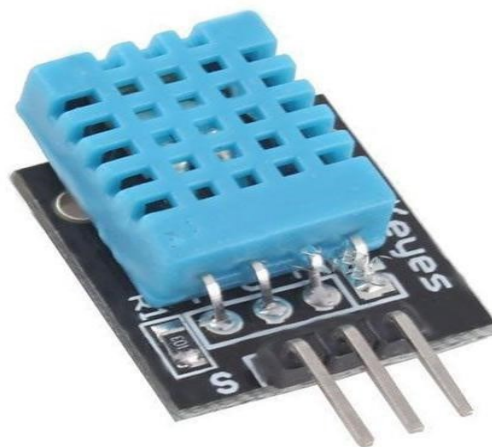
Nowadays, IoT is one of the most advanced, efficient, and cost less technological solution which encompasses various hardware and software resources; and allows remotely connected sensing devices to sense with more capabilities, provides efficiency and can be monitored and controlled through deployed of

existing systems or infrastructures, resulting the physical World integration with computer controllers (or systems).

DHT11 – TEMPERATURE AND HUMIDITY SENSOR

Pin Identification and Configuration:

No:	Pin Name	Description
For DHT11 Sensor		
1	Vcc	Power supply 3.5V to 5.5V
2	Data	Outputs both Temperature and Humidity through serial Data
3	NC	No Connection and hence not used
4	Ground	Connected to the ground of the circuit
For DHT11 Sensor module		
1	Vcc	Power supply 3.5V to 5.5V
2	Data	Outputs both Temperature and Humidity through serial Data
3	Ground	Connected to the ground of the circuit



DHT11 Specifications:

- Operating Voltage: 3.5V to 5.5V
- Operating current: 0.3mA (measuring) 60uA (standby)
- Output: Serial data
- Temperature Range: 0°C to 50°C

- Humidity Range: 20% to 90%
- Resolution: Temperature and Humidity both are 16-bit
- Accuracy: $\pm 1^{\circ}\text{C}$ and $\pm 1\%$

The **DHT11 sensor** can either be purchased as a sensor or as a module. Either way, the performance of the sensor is same. The sensor will come as a 4-pin package out of which only three pins will be used whereas the module will come with three pins as shown above.

RAIN SENSOR MODULE

Description

The rain sensor module is an easy tool for rain detection. It can be used as a switch when raindrop falls through the raining board and also for measuring rainfall intensity. The module features, a rain board and the control board that is separate for more convenience, power indicator LED and an adjustable sensitivity through a potentiometer.

The analog output is used in detection of drops in the amount of rainfall. Connected to 5V power supply, the LED will turn on when induction board has no rain drop, and DO output is high. When dropping a little amount water, DO output is low, the switch indicator will turn on. Brush off the water droplets, and when restored to the initial state, outputs high level.

Specifications

Adopts high quality of RF-04 double sided material.

Area: 5cm x 4cm nickel plate on side,

Anti-oxidation, anti-conductivity, with long use time;

Comparator output signal clean waveform is good, driving ability, over 15mA;

Potentiometer adjust the sensitivity;

Working voltage 5V;

Output format: Digital switching output (0 and 1) and analog voltage output AO;

With bolt holes for easy installation;

Small board PCB size: 3.2cm x 1.4cm;

Uses a wide voltage LM393 comparator

SMOKE SENSOR

A gas detector is a device which detects the presence of various [gases](#) within an area, usually as part of a safety system. This type of equipment is used to detect a gas leak and interface with a control system so a

process can be automatically shut down. A gas detector can also sound an alarm to operators in the area where the leak is occurring, giving them the opportunity to leave the area. This type of device is important because there are many gases that can be harmful to organic life, such as humans or animals.



In current technology scenario, monitoring of gases produced is very important. From home appliances such as air conditioners to electric chimneys and safety systems at industries monitoring of gases is very crucial. Gas sensors are very important part of such systems. Small like a nose, gas sensors spontaneously react to the gas present, thus keeping the system updated about any alterations that occur in the concentration of molecules at gaseous state.

Gas sensors are available in wide specifications depending on the sensitivity levels, type of gas to be sensed, physical dimensions and numerous other factors. This Insight covers a methane gas sensor that can sense gases such as ammonia which might get produced from methane. When a gas interacts with this sensor, it is first ionized into its constituents and is then adsorbed by the sensing element. This adsorption creates a potential difference on the element which is conveyed to the processor unit through output pins in form of current.

FEATURES

- * High sensitivity to LPG, natural gas , town gas .
- * Small sensitivity to alcohol, smoke.
- * Fast response .
- * Stable and long life.
- * Simple drive circuit.

APPLICATION

They are used in gas leakage detecting equipments in family and industry, are suitable for detecting of LPG, natural gas , town gas, avoid the noise of alcohol and cooking fumes and cigarette smoke.

2.10 IR SENSOR

IR sensor is very useful if you are trying to make a obstacle avoider robot or a line follower. In this project we are going to make a simple IR sensor which can detect a object around 6-7 cm. IR sensor is nothing but a diode, which is sensitive for infrared radiation. This infrared transmitter and receiver is called as IR TXRX pair.



Fig. IR Sensor

FEATURES

- Fast response time
- Because it have good range which is fulfill our requirements.
- It is very low cost and can be constructed on general purpose.
- It is of very small size.
- You can increase numbers of transmitter as you want for good result □ Good immunity to ambient light and waves are invisible to eyes.

WORKING OF IR

Working of IR sensor is very simple and working principle is totally based on change in resistance of IR receiver. Here in this sensor we connect IR receiver in reverse bias so it give very high resistance if it is not exposed to IR light. the resistance in this case is in range of Mega ohms, but when IR light reflected back and fall on IR receiver. The resistance of Rx it comes in range between Kilo ohms to hundred of ohms. We convert this change in resistance to change in voltage . Then this voltage is applied to a comparator IC which compare it with a threshold level.

2.11 BUZZER

A buzzer or beeper is a signaling device, usually electronic, typically used in automobiles, house hold appliances such as a microwave oven, or game shows.

It most commonly consists of a number of switches or sensors connected to a control unit that determines if and which button was pushed or a preset time has lapsed, and usually illuminates a light on the appropriate button or control panel, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound. Initially this device was based on an electromechanical system which was identical to an electric bell without the metal gong (which makes the ringing noise). Often these units were anchored to a wall or ceiling and used the ceiling or wall as a sounding board. Another implementation with some AC connected devices was to implement a circuit to make the AC current into a noise loud enough to drive a loudspeaker and hook this circuit up to a cheap 8-ohm speaker. Nowadays, it is more popular to use a ceramic-based piezoelectric sounder like a Sonalert which makes a high-pitched tone. Usually these were hooked up to “driver” circuits which varied the pitch of the sound or pulsed the sound on and off.

In game shows it is also known as a “lockout system,” because when one person signals (“buzzes in”), all others are locked out from signalling. Several game shows have large buzzer buttons which are identified as “plungers”.



Fig. Buzzer

RESULT:

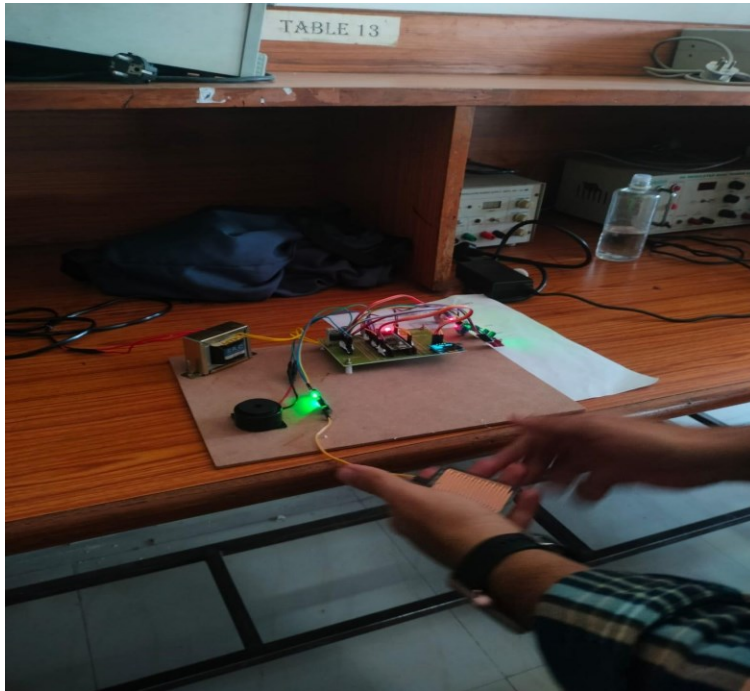
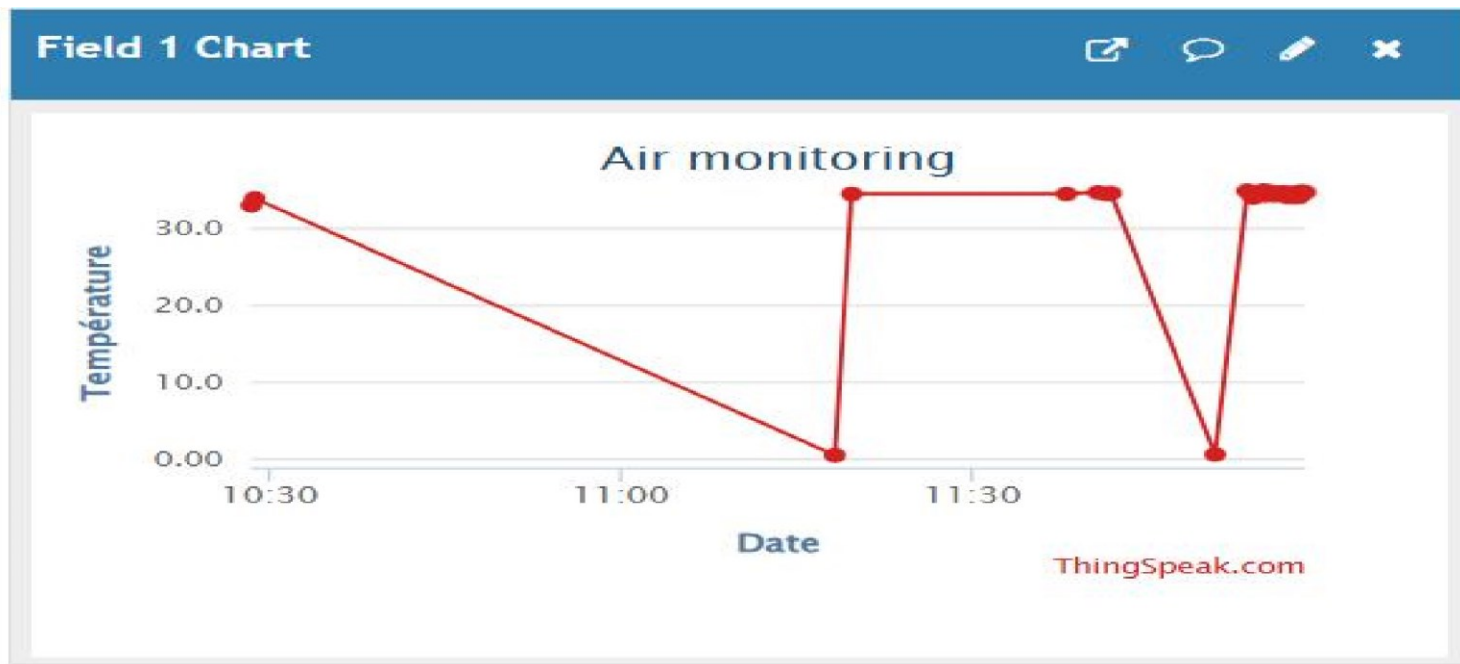


Fig 9-Hardware Kit

Fig 11-Output Displayed on



cloud(Thingspeak)

RESULT :

- **Real-time Environmental Awareness:** Provides immediate data on key environmental parameters (temperature, humidity, air pressure, and specific air quality indicators), enabling timely insights into local conditions in Hyderabad.
- **Comprehensive Environmental Monitoring:** Offers a holistic view by measuring multiple crucial environmental factors simultaneously.
- **Data-Driven Decision Making:** Enables informed decisions based on reliable, real-time data, potentially for research, urban planning, or public health initiatives in Hyderabad.
- **Trend Identification:** Historical data logging allows for the analysis of environmental trends and patterns over time in the Hyderabad region.
- **Remote Accessibility:** Data is readily available from anywhere with an internet connection via the online dashboard/app, facilitating convenient monitoring and analysis.
- **Automated Data Collection:** Reduces the need for manual data gathering, saving time and resources while ensuring consistent and frequent measurements in Hyderabad.
- **Early Anomaly Detection:** Continuous monitoring can help identify unusual environmental shifts or anomalies that may require further investigation in the local context.
- **Scalability Potential:** The successful end-to-end system demonstrates a working model that could potentially be scaled for broader environmental monitoring across Hyderabad or other regions.
- **Validation of System Design:** Confirms the effectiveness and functionality of the designed hardware and software architecture for environmental monitoring.
- **Foundation for Further Research & Development:** Provides a robust platform for conducting more indepth environmental studies and potentially integrating additional sensors or functionalities in the future for the Hyderabad context

CONCLUSION:

So, we successfully built this smart weather and air quality station using IoT technology. It basically gathers readings like temperature, humidity, and pollution levels [mention 1-2 key ones like CO2 or PM2.5 if you like] using its sensors and then sends that data over the internet [mention Wi-Fi/etc. if relevant] to a place where you can easily check it out online or through an app. The real benefit here is getting that super local, real-time environmental info without the massive cost of traditional stations, which is incredibly useful for everything from knowing the air quality for health reasons, to helping farmers, or even for smarter city planning. Of course, it's a prototype, so there are things to keep in mind, like making sure the sensors stay

accurate, needing a steady power source and internet connection, and ensuring the outside case is tough enough. But overall, it works well and proves this approach is solid.

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