# IoT Based Systems

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# Contents

# Preface

The Internet of Things (IoT) ecosystem is made up of web-enabled smart devices that employ embedded systems, such as processors, sensors, and communication gear, to gather, communicate, and act on the data they get from their surroundings. By connecting to an IoT gateway or other edge device, which either sends data to the cloud for analysis or analyses it locally, IoT devices exchange the sensor data they gather. These gadgets converse with other similar devices on occasion, acting on the data they exchange. Although individuals may engage with the devices to set them up, give them instructions, or retrieve the data, the gadgets accomplish the majority of the job without their help. These web-enabled devices' connection, networking, and communication protocols are heavily influenced by the particular IoT applications that have been implemented.

IoT may also employ machine learning and artificial intelligence (AI) to help make data collection procedures simpler and more dynamic. People who use the internet of things can live and work more intelligently and have total control over their life. IoT is crucial to business in addition to providing smart home automation devices. With the help of IoT, organizations can see in real time how their systems really function, gaining insights into anything from equipment performance to supply chain and logistics activities. Businesses may automate procedures and save money on labour thanks to IoT. Additionally, it reduces waste, enhances service delivery, lowers the cost of manufacturing and delivering items, and provides transparency into consumer interactions. As a result, IoT is among the most significant technologies of modern life, and it will gain momentum as more companies realise how linked gadgets can help them stay competitive. Organizations may get a number of advantages from the internet of things. Some advantages are exclusive to certain businesses, while others apply to many other industries.

IoT provides organisations with the resources they need to enhance their business strategies and challenges them to reevaluate how they conduct their operations. However, it has also found use cases for organisations within the agriculture, infrastructure, and home automation industries, leading some organisations towards digital transformation. In general, IoT is most prevalent in manufacturing, transportation, and utility organizations, using sensors and other IoT devices. The use of IoT in agriculture may help farmers by simplifying their work. Sensors can gather information on soil composition, temperature, humidity, rainfall, and other variables that might aid in automating agricultural practises. IoT may also assist with the capacity to monitor infrastructure-related processes. For instance, sensors might be used to track developments or changes in the structural elements of buildings, bridges, and other infrastructure. Benefits associated with this include cost savings, time savings, improvements to the workflow's quality of life, and paperless workflow. IoT may be used by a home automation company to control and monitor a building's electrical and mechanical systems. On a larger scale, smart cities may assist residents in using less garbage and energy. Every sector, including those in healthcare, banking, retail, and manufacturing, is impacted by IoT.

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# CHAPTER 1

# AQUACULTURE FOR FISHERIES USING IoT

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Aquaculture is the practice of cultivating aquatic animals or plants for food under regulated circumstances, including breeding, rearing, and harvesting. Food and industrial items are made, better environments are created, and populations of vulnerable or endangered animals are rebuilt. Modern aquaculture is now able to check water quality, record fish behaviour, and handle facility logistics thanks to the rise of agri-tech. As IoT gains popularity, more people are using it to check the quality of their water and make modifications in real-time to keep their stock in the best possible circumstances. Fish, seaweed, algae, and many other creatures are bred, raised, and harvested via aquaculture, which is also known as aqua-farming [1]–[3].

It is also described as breeding species that grows in a controlled aquatic habitat. One of the most dependable and environmentally friendly methods for providing people with high-quality protein is aquaculture. Because there is more food convergence in this process, it is more effective than other types of agriculture. The practise of aquaculture has gained worldwide recognition. Asia is responsible for 40.1% of the world's total aquaculture fish output, or 88.5 percent of global aquaculture production. In South Asia, namely during the past 15 years, aquaculture performance has increased more quickly. Cambodia, with its successful inland fisheries, is in the top three of the seven Southeast Asian nations Indonesia, Malaysia, Myanmar, the Philippines, Cambodia, Malaysia, Thailand, and Viet Nam outside of aquaculture production [4]–[6].

Comparing commercial aquaculture in India to other industries like agriculture, there is a technical gap. Numerous issues, such as water rescores, manual water testing, abrupt climatic change, lack of government attention, etc., affect farmers. Contrary to daily aquaculture monitoring, manually assessing thousands of people's behaviour and health is quite challenging. Other issues include inadequate site selection, poor record keeping, low water quality, and incorrect management techniques. The dynamics of aquaculture water quality monitoring cannot be changed by traditional water quality monitoring, which likewise did not accomplish fixed point monitoring.

Currently, manual testing is how Indian aqua farmers determine the properties of their water. In addition to increasing fish mortality and slowing fish development, this has the main problem of requiring more time. Operators of fish ponds must constantly check the water and deal with its changing conditions, which might jeopardise its quality. The project's primary goal is to monitor the fish farming system using a variety of sensors to lower the hazards. We employ sensors like pH, temperature, water level, and turbidity sensors in this procedure. All of the labour is automated by the use of these sensors, making it simple to remotely monitor fish farming from another place.

Fish farming has been practised for over 30 years. Aquaculture research is a factor in raising and stabilizing productivity. Fish farming is the practice of raising a variety of marine species for harvest in ponds, rivers, lakes, and oceans. It also includes raising shellfish, sport fish, bait fish, and decorative fish. Fish are cold-blooded creatures that directly depend on the aquatic environment to control their body temperature. The quantity of dissolved oxygen (DO) in the water and fish oxygen intake are both impacted by changes in water temperature. Despite being able to survive a wide variety of water temperatures, fish physiology will be significantly impacted by any abrupt, dramatic changes in water temperature. Fish will perish at pH levels below 4.5.

- Aquaculture, which accounts for roughly 1.07% of India's GDP, is one of the country's thriving industries.
- The country's expected 2025 fish consumption would be over 16 million tonnes, however owing to overfishing, natural fisheries have been depleted, leading to the development of commercial aquaculture.
- Currently, aqua farmers must do manual tests to determine the water's properties.
- This will take time and be erroneous since the criteria determining water quality may change over time.
- To solve this issue, aquaculture should use technology that boosts productivity and reduces losses via ongoing monitoring of water quality factors development of current water areas and construction of new water areas for extensive fish farming.

Advocate for improved standards of fisheries management and effective fisheries management. Offer the general and technical knowledge required for effective fisheries management. Enhance the reputation of the field of fisheries management.

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# CHAPTER 2

# SYSTEM FUNCTIONS

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The three main topics addressed in the piece are Effective parameters for measuring water quality, monitoring, control, and accessibility. The aqua pond may be managed based on sensor inputs and threshold values.

**Effective criteria for measuring water quality:**

The project's sensor module has several sensors, including those for turbidity, pH, temperature, salt, and others. These sensors are permanently mounted on the Raspberry Pi and constantly monitor the water's characteristics. Sensor module: The sensor module includes several sensors, such as those that measure temperature, pH, turbidity, and water level. These sensors are linked to a Raspberry Pi and are periodically used to measure the water parameters.

- A distinctive aspect of the planned work is the usage of an Arduino with a built-in Wi-Fi module.
- A solar panel, which is more dependable and wireless, is used to power it.
- Several sensors are attached to collect the data, and the aquafarmer receives the data through IoT. Aqua farmers will be alerted with a workable remedy if certain water quality measurements exceed the threshold range.
- Aqua farmers are provided with a workable solution when various sensors are used to measure characteristics like as temperature, pH, and turbidity.
- Because the data is kept in a cloud database, data analytics may be used to analyse it, enabling aqua aquaculture farmers to take preventative action before water quality metrics alter.
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- A solar panel, which is more dependable and wireless, is used to power it.
- Several sensors are attached to collect the data, and the aqua farmer receives the data through IoT. Aqua farmers will be alerted with a workable remedy if certain water quality measurements exceed the threshold range [1]–[3].
- Multiple sensors are used to measure characteristics like as temperature, pH, and turbidity, and aqua farmers are provided with a workable solution.
- Because the data is saved in a cloud database, data analytics may be used to analyse it, enabling aqua aquaculture farmers to take preventative action before the factors governing water quality alter.

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The ATmega328/P achieves throughputs near 1MIPS per MHz by processing strong programs in a single clock cycle. This gives system designers the ability to balance the device's power use and processing performance.

In general, a temperature sensor is a tool created especially to gauge how hot or cold an item is. The output of the precise IC temperature sensor LM35 is proportional to the measured temperature (in °C). The temperature can be monitored more precisely with the LM35 than it can with a thermistor. Additionally, it doesn't raise the temperature in still air by more than 0.1 °C and has minimal self-heating. The temperature gradient for operation is between -55°C and 150°C. Because of the LM35's low output amplitude, a linear output, and exact intrinsic calibration, it is particularly simple to interface with readout or control circuitry. Applications for it include battery management, appliances, power supply, etc [4]–[6].

Rated for entire -55°C to a 150°C range; Suitable for distant applications; Low cost owing to wafer-level trimming; Operates from 4 to 30 volts; I: Less than 60 mA current drain; Non-linearity only 0.25°C typical; Low impedance output, 0.1 for 1 mA load The glass electrode is the pH sensor used most often. It is used in a broad range of sectors and many industrial applications. The glass-electrode technique can test the pH of a variety of solutions and has great repeatability.

- A pH cathode is an electrochemical or potentiometric sensor with a voltage output.
- Two capacitors as well as electrodes make up a potentiometric sensor: the glass electrode, also known as the sensing battery or energetic electrode.
- Include the reference electrode. The pH level of the measured solution affects the electric potential that is produced between the working electrode and the reference electrode.

**Float Switch**

A sort of level sensor used to determine the liquid level in a tank is a float switch. The float shuts the reed switch by raising the magnet to it. One component may accommodate several reeds installed in the canal for various level indicators. A float switch's function is to open or stop a circuit in response to changes in a liquid's level. Most float switches are "usually closed," which means that when the float is at its lowest position and resting on its bottom clip, the two wires leading from the switch's top complete a circuit for example when a tank is dry.

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# CHAPTER 3

# SENSOR FOR TURBIDITY

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The translucent plastic can's two extensions are filled with water. The photo semiconductor and photodiode are respectively housed by these projections. Light beams from the phototransistor are sent toward the photodiode. These light beams cross the water pressure and get deflected when they come into contact with any suspended water particle. As a consequence, when compared to when it was emitting, the light acquired at the photodiode has a lower amplitude. The sensor's microcontroller receives information about this difference in light transmission and reception, and choices are made in response to it [1]–[3].

**Wi-Fi Module Introduction**

- A cheap standalone wireless emitter that may be utilised for end-point IoT advancements is the ESP8266 Wi-Fi module.
- ESP8266 Wi-Fi module allows embedded programmes to connect to the internet. It connects to the server or client using the TCP/UDP communication protocol.
- Wired technology, which is often used to link devices in wireless mode, is a competitor to wireless technology.
- The name Wi-Fi (Wireless Fidelity), which refers to the IEEE 802.11 standards for Wireless Local Area Networks, is a general one (WLANs).
- Wi-Fi networks link computers to the internet, the wired network, and each other.

**WiFi Network Elements**

- Access Point (AP) - An AP is a wireless LAN transceiver, often known as a "base station," that may link several wireless devices to the Internet at once.
- Wi-Fi cards: These devices take wireless signals and transmit data. Both internal and exterior ones are possible.
- Security measures- Firewalls and antivirus software make networks safe from unauthorised users and maintain the confidentiality of data.

Topology based on AP (Infrastructure Mode), Peer-to-peer network topology

- AP is not necessary.
- Client devices within a cell are capable of direct communication.
- It helps with rapid and simple wireless network setup.
- Infrastructure Network: Clients connect to access points to communicate.
- All correspondence must go via AP.

- When a Mobile Station (MS), such as a laptop, PDA, or phone, wishes to interact with another MS, it must transmit the data to the AP first, and the AP then delivers it to the target MS.
- By adding an access point to an internet connection, a Wi-Fi hotspot is established.
- A base station is an access point.
- A Wi-Fi-enabled device may wirelessly connect to a network when it comes across a hotspot.
- A single access point may work within a range of 100 to 150 feet inside and up to 300 feet outdoors, supporting up to 30 users.
- Ethernet cables may be used to link a lot of access points together to form one big network.

**Benefits**

Mobility, ease of installation, flexibility, cost, dependability, security, use of unlicensed wireless spectrum, roaming, and speed are among the criteria. Data processing sensor status in aquaculture maintenance of when sensor data changes, energy management, communication security, and dependability [4]–[6].

**Installation**

Hardware and software implementations of the overall system are divided into categories. After the sensor nodes with Raspberry Pi are constructed as the hardware component, the software component follows. The end user device, cloud, and sensor hub all enter the picture while acknowledging sequentially. Most crucially, data gathered by the sensor hub is sent to the cloud and the end user.

The web association will start reading the parameters of numerous sensors once it is set up. The relevant sensors' edge levels have been established. Just like the end client, the sensor data is forwarded to the distributed storage. The data may be looked through at anytime, anywhere. In the unlikely event that the sensor parameters exceed the limit level, the specific warning will then be generated, and the end user is informed through an alert. Values from the sensor node are visible to the user.

**Implementation Of Hardware**

If the water level is between 25°C and 30°C, the Arduino verifies this. The heater turns on because the water is too cold for the fish at less than 25°C. The fan turns on because the water is too warm if the temperature rises beyond 30°C. Similarly to this, the tank's water level is programmed to be checked every 10 to 20 cm to maintain it and prevent it from dropping too low. The pump turns on if there is less than 200mm of water in the tank and turns off when there is 200mm. When the pH of the water changes from 6.5 to 8, which is acceptable for fish, the pump will automatically turn on and start pumping water into a separate tank.

After that, water was poured into the tank to fill it. Turbidity is measured in ntu, and if it is under 2000 ntu, the water is still considered to be OK. If it is over, however, the water is considered to be too murky, and the pump is turned on to pump out the murky water while filling the tank with clear water from the storage tank. The Arduino is linked to the ESP 8266 to transfer data to the cloud, and the Thingspeak is connected to the Wi-Fi. With the help of the API key, the Arduino transmits data to the ESP 8266, which then sends it to the Thingspeak channel to be stored in the cloud. Every 16 seconds, the devices speak an update.

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# CHAPTER 4

# ESTIMATION OF pH VALUE

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PH measurement the 4250c analogue pH gauge must first be calibrated before it can be used. Accurately converting a 10-bit analogue value to a 0–5 voltage (V) is the goal of calibration. Since pH ranges from 0 to 14, the pH is mapping with 5 volts, making pH 7 equal to 2.5 V, pH 14 to 5, and pH 0 to 0V. Because pH 7 may not provide a precise value of 2.5V in real conversion, the calibration will reveal the measurements' level of uncertainty. Given that the short circuit indicates a pH of 7, the outcome should be 2.5.

**Measuring Turbidity**

Similar to the pH sensor, the measurement is a 10-bit analogue signal sensor that must be calibrated and its 10-bit value translated to voltage. To convert a 10-bit analogue reading, 0-1023, into an output power able to read between 0 and 5 volts Turbidity and voltage are inversely correlated, therefore when the voltage is lower, the turbidity is greater, and vice versa.

**Temperature Measurement**

The Smu Thermometer library is used to read sensor readings and convert them to degrees, like Celsius. Using the begin (), request Temperatures (), and even get TempoC by Index () functions, this library obtains temperature readings that are expressed in degrees Celsius.

The farmers monitor the parameters of the water quality using both conventional methods and practices and forecasting models. Because of World Wide Web use, our model cannot utilize a cloud database, although other studies do. In our model, we limit internet consumption while still developing a cost-effective model. Even if some models are cost-effective, they cannot satisfy the need for water quality since the system uses insufficient sensors. This system's primary goal is to offer real-time monitoring utilising an Arduino and a Wi-Fi module. The benefit of utilising sensors in this system is that data is frequently delivered with little delay and without errors.

- Increasing the ability of farmers to identify obstacles to the execution of rural aquaculture projects and find solutions using their observations and logic, increasing the productivity of home farm units.
- Safeguarding water supplies.
- Establishing a solid database on production and the expenses associated with various production methods.
- Enabling farmers to sell their agricultural goods, especially those with aquaculture origins, help them generate money [1]–[3].

Shortly, we anticipate the use of improved sensors, the gathering of additional data for big data and analytics, or the creation of artificial intelligence (AI) algorithms for process optimization.

**Total Suspended Solids vs. Turbidity (TSS)**

Talking about turbidity is impossible without bringing up total suspended solids (TSS). Particles floating in water affect both, but the measurements themselves are fundamentally different.

The term "turbidity" refers directly to the water's transparency. The quantity of scattering of light by microorganisms suspended in water may often be measured to put this into numerical form. How a particle scatters light depends on its size, shape, constitution, and surface properties. However, the fundamental tenet of measurement is that, typically, rising turbidity denotes a rise in precipitated particles for every unit volume of water.TSS sensors, in contrast, measure suspended particle concentration in milligrammes per litre (mg/L) measurements. In applications like wastewater, where it is crucial to comprehend the levels of biological activity in the treatment system, TSS is favoured over turbidity (i.e., biomass) [4]–[6].

A turbidity sensor may be used to infer TSS indirectly. If correlation coefficients are established, devices like the YSI ProDSS can compute TSS from a turbidity measurement. Turbidity information and related samples must be gathered at a sampling location to establish a link between turbidity and TSS. A lab analysis of the samples is required to get a precise TSS value (mg/L). The turbidity and TSS data pairs may then be used to compute coefficients. This is accomplished using YSI's Kor Software for the ProDSS.It is important to emphasise that because this connection is site-specific, data on correlation must be gathered for every individual sample site. In our blog post Understanding Turbidity, TDS, and TSS, you can find out more about turbidity, TSS, and a related metric called total dissolved solids (TDS).

**Colour vs. turbidity**

Although coloured particles may absorb the light employed in certain measuring technologies1, this can have an impact on turbidity measurements, which are independent of the colour of the water. Because of dissolved substances or suspended particles, water may seem coloured. For instance, dissolved organic acids called tannins may give water a tea-coloured hue. These are released into the water as plant matter, such as pine needles and tree roots, slowly decomposes into tiny particles that dissolve in the liquid.

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# CHAPTER 5

# TURBIDITY OF SURFACE WATER

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A great gauge of ecosystem health is turbidity. While eutrophication is often the source of low dissolved oxygen (DO) levels, excessive turbidity levels may also lead to the development of hypoxic conditions because Oxygen is replaced by extraneous particles in the water. Additionally capable of absorbing heat, these particles raise the water's temperature, which in turn lowers the amount of dissolved oxygen. High turbidity also hinders sunlight's ability to penetrate, which slows photosynthesis. Gaseous, atomic oxygen is a result of photosynthesis that may dissolve in water. When paired with low DO, turbidity-increasing particles may block fish gills and cause fish deaths. Lower reproduction rates may result from animals being unable to locate one another or their routes to spawning locations in severely murky circumstances. These species may not survive if a significant sediment load is placed into normally clean water where fish deposit their eggs and even where shellfish reside [1]–[3].

**Stream Turbidity Measurements**

Red salmon, often known as sockeye salmon, go to the Copper River in Alaska to breed. Fish may find it challenging to locate reproductive locations in waters with high turbidity levels. Whether you want to know if there will be any major environmental effects from construction or dredging, you may monitor the turbidity upstream and downstream of the work zone. Occasionally, this kind of monitoring is necessary, depending on the project. As was indicated in the sections on the causes of turbidity, building site debris that is loose may readily wash into streams and raise turbidity levels [4]–[6].

The pollutant(s) causing the water body's impairment might come from several different places. In this situation, the state may divide the available loading capacity between point sources and non-point sources. Since it is assumed that particles transmit other contaminants of relevance, turbidity is often employed as a stand-in measurement of pollutant transport in a system.

Turbidity is therefore a criterion of importance in TMDL development, NPDES licencing, and the listing of impaired waters. For a practical illustration, visit our blog post on how salinity monitoring keeps Lake Oconee clean. Stormwater Best Management Practices (BMPs), such as retention ponds, are one technique to reduce pollutant concentrations and loads in stormwater management (TMDLs apply to both stormwater and wastewater. One approach to assess if BMPs have improved water quality is by monitoring turbidity.

**Turbidity Measurement**

A stormwater BMP is something like a stormwater retention pond. They are often built in populated areas to catch and even filter pollutants that run off the terrain. Turbid waters may have a detrimental effect on how rivers are used for leisure since many people don't want to swim, boat, or fish in what they perceive to be "filthy" water. As a consequence, certain recreational places keep an eye on the turbidity levels since this information may show how the water's look impacts the general public's usage.

**Turbidity Clear Water Level**

People like swimming in water with lower turbidity levels because it is cleaner. Lake Tahoe, which is situated on the border of California and Nevada, is widely recognized for its crystal-clear water. Nearly all drinking water treatment systems monitor turbidity. High levels are linked to disease-causing microbes, therefore it not only gives a general indicator of water quality, but it also shows how well the filters employed in the treatment process are working.

The three sources listed below are normally where drinking water treatment plants acquire their water from. Surface water directly influences groundwater. Groundwater with abrupt changes in water quality characteristics that relate to climatological or surface water conditions is what is meant by this. The presence of large-diameter diseases, algae, or microorganisms may also make a source meet this criterion.

Water that is found underground in cracks and pores is known as groundwater. Facilities that treat surface water or drinking water that is directly impacted by surface water in the United States are obliged to assess turbidity. It is necessary to conduct measurements throughout the plant, including in the combined filter effluent.

**Measuring Turbidity in Drinking Water**

The Ohio EPA views the good fields in Dayton, Ohio as groundwater that is directly impacted by surface water. Surface water is directed into channels and retention basins, where it seeps into an aquifer from the Great Miami River. To continually monitor every step of their treatment process, some towns may choose to measure turbidity when it is not necessary. The personnel at the water treatment facility do their utmost to avoid complaints since customers notice when the turbidity levels in their drinking water soar.

Facilities with traditional filtration cannot handle turbidity levels over NTU, thus modifications to the treatment methods and/or pump systems may be necessary, which may be expensive. The World Health Organization states that greater disinfection dosages or contact durations are necessary at turbidities exceeding NTU to achieve effective treatment. Turbidity may reveal possible problems in the distribution system outside of the treatment plant and shows how well the filtration within the facility is working. Outside of a drinking water treatment plant, turbidity is significant. Turbidity in the distribution system may be a sign of hydraulic disturbances, such as a water main break, or the entry of pollutants because of pipe damage.

In the US, municipalities are normally obligated to collect distribution system samples and test them for turbidity in a lab. Although online monitoring is not required by law, some people opt to

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instal online turbidity analyzers in their distribution systems since the real-time data they gather might reveal system problems (such as a broken water main).

Before utilising the water they get from a well or the neighbourhood municipality in the manufacturing process, industrial facilities that utilise water often purify the water they acquire from such sources. Consumers won't drink a beverage with an odd tint or "cloudiness" to it, hence turbidity is an aesthetic problem in the food and beverage manufacturing industry.

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# CHAPTER 6

# FLOATING SENSORS

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It is preferable to take turbidity readings on-site. Although there are ways to help preserve samples, collecting samples and evaluating them later in a lab may lead to problems with the degradation process, growth, settling, crystallization of mineral deposits, and more.

**The mechanism for measuring turbidity**

A submersible turbidity probe, in contrast to tabletop metres, allows the sample to be put right where it is being measured. Turbidity sensors are available from YSI for our EXO, ProDSS, and ProSwap platforms. Portable submersible sensors may be lowered into the water (e.g., a stream, or an aeration basin in a wastewater treatment facility). Spot sampling is the purpose of instrumentation like the YSI ProDSS, while continuous, unmanaged monitoring in a variety of situations is the purpose of the YSI EXO. The YSI IQ SeniorNet VisoTurb, a turbidity sensor specially designed for use in a drunk water or wastewater treatment plant, is another product we provide.

**Components for Turbidity Sensors**

The windows on each side of the YSI field turbidity sensor allow light from an infrared LED to pass through. After the light strikes the water's particles, some of it is partially reflected by the sensor. The photodetector, which is positioned 90 degrees away from the light source, collects the dispersed light that the LED emits.

Compliance with Regulations: If reporting turbidity measurements are required by law, you'll probably need to utilise a device that complies with ISO7027 or EPA Method 180.1. The location of the measurement will dictate whether a tabletop metre or a submersible sensor should be used. Comparing Measurements: The same turbidity measuring technique should be utilised when comparing current readings to those that have already been obtained [1]–[4].

**Adherence to Regulations**

An EPA Method 180.1-compliant turbidity benchtop metre like the YSI Turb750 is required. It is almost impossible to utilise tungsten lamps on submersible sensors since they use a lot of power and have a shorter lifetime than infrared LEDs, the kind of light source that conforms with the EPA Method. Benchtop meters that adhere to ISO7027 are also available. Even if YSI does not, another Xylem brand does; have a look at the WTW Turb750 IR.

**Measurement Site Laboratory**

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When assessing samples that have been collected and returned to the lab, benchtop metres like the Turb750 work well. Additionally, since tabletop metres are more precise than subterranean instruments in the lower range, they are the best kind of equipment when the water possesses low turbidity levels. Facilities for the manufacturing of beverages and drinking water are two prominent applications for benchtop metres.

It's crucial to be aware of the differences between benchtop metres that adhere to EPA Technique 180.1 (such as the YSI Turb750) and ISO7027 (such as the WTW Turb 750 IR) if you are NOT compelled to employ a certain turbidity measuring method. Turbidity measurements are influenced by particle size, particle density, and watercolour, as was indicated in the section on the light source. A light source that adheres to ISO7027 reduces the impacts of stray light and removes the influence of colour on the measurement. White light, in contrast, can detect tiny particles because of its shorter wavelength [5]–[7].

When measuring in situ, such as in a stream, lake, or ocean, field submersible sensors are the best turbidity monitoring equipment. They offer a larger measurement range and are easier to use than desktop metres; all you have to do is stick the sensor in the water to get a reading! However, they are less accurate in low turbidity samples than in benchtop metres. Turbidity sensors are available from YSI for the ProDSS and EXO portals. The ProDSS is portable equipment with a single cable that is held in the hand and a bulkhead that houses the sensors. This is a genuine field instrument with titanium sensors, a metal, military-spec (MS) cable connection, and a tough, waterproof housing (IP-67 certified). This tool is not intended for unattended monitoring; rather, it is designed for spot sampling.

**Samples of Turbidity in Water**

Turbidity is measured using the ProDSS, a field device with many parameters that is portable. It is perfect for a variety of spot-sampling applications for outdoor water quality. Similar to the ProDSS, the EXO sonde has additional sensors (such as the NitraLED) and is intended for uninterrupted, uncontrolled monitoring in a variety of situations. Its inbuilt data recording, batteries, and wiper enable deployments in challenging areas for months at a time. The platform we provide for monitoring the quality of outdoor water is the most sophisticated. Not persuaded? See our blog entry on Bayou Sorrell | An Unexpected Bonus with EXO Sondes for more information.

**Continual Unattended Water Turbidity Monitoring**

Turbidity and several other water quality parameters are measured using the multiparameter sonde known as the EXO. Our top-of-the-line outdoor water quality platform, The EXO, has capabilities that make it perfect for ongoing, unattended monitoring. The YSI IQ SensorNet VisoTurb, a turbidity sensor specially designed for use in a drinking greywater plant, is another product we provide. This nephelometric sensor, which is normally placed directly in process water, detects dispersed light at a 90-degree angle. The VisoTurb is toughly built with an aluminium body and sapphire measuring glass to handle high particles since many production waters may be severely contaminated, particularly in wastewater treatment. This sensor also has ultrasonic cleaning, which shakes the measuring window continuously to prevent particle accumulation. Postintervention in drinking water facilities, as well as effluent monitoring in wastewater facilities, are common uses.

A Secchi disc is an additional tool for in-situ turbidity measurements. Despite the disadvantages of visual sensors (learn more about Visual Tools here; insert jump link), they are substantially less expensive than nephelometers (i.e., turbidity meters). A Secchi disc, like the ProDSS, is designed for spot sampling rather than long-term unattended monitoring.

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# CHAPTER 7

# INTRODUCTION TO STREETLIGHTS

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Streetlights are a crucial component of every growing community. They may be found in the suburbs as well as on all main thoroughfares. Even when nobody is nearby, streetlights are always on from dusk until daybreak at full power. To provide the necessary electrical energy, these streetlights cost millions of dollars per day on a worldwide scale. The greatest remedy for electrical power waste is provided in this paper. Additionally, the lighting system's manual control is entirely gone. Due to population expansion and economic development across the globe, energy demand is rising at the quickest rates possible, while the world's access to energy sources is still gravely limited. We use the term "smart" because the technology not only powers the street lights but also assists in identifying the pedestrian's direction of travel and provides illumination for that route up until the next street light is nearby. Dimming the lights during off-peak hours would be a straightforward and efficient solution to this. The lights in its immediate vicinity will illuminate in regular (bright) mode whenever presence is sensed. This would result in significant energy savings and lower streetlight operating expenses. Using the Internet of Things (IoT), we can instantly and from any location monitor the status of street lights online and address any processing-related problems [1]–[4].

- To increase the visibility of the road's traffic and barriers for convenience and safety.
- A smart embedded system is used to accomplish the project, and it regulates the street light depending on the sensing of sunshine.
- The street light turns on automatically at night and turns off automatically during the day. Through the internet, The ON/OFF may be accessed from any location at any time.
- To monitor activity on the road, a camera is mounted on top of the street light. The video is then saved on a server.

Based on the real-time system, the street light (ON/OFF Status) will be accessible over the internet at any time and from any location. The NodeMCU ESP826 street controller has to be put on the pole light. The Internet of Things (IoT) is a sophisticated automation and analytics system that uses big data, artificial intelligence, networking, sensing, and sensing technologies to give comprehensive systems for a product or service. Any industry or system may use these solutions to achieve improved transparency, control, and performance. IoT systems have been used in a variety of sectors because of their exceptional flexibility and capacity to be adaptable in any setting. With the help of intelligent devices and potent supporting technologies, they improve data collecting, automation, operations, and much more. Users may gain greater automation, analysis, and integration inside a system using IoT solutions. They increase the precision and range of these regions. IoT makes use of both established and new technologies for sensing, networking, and robotics. IoT takes use of current software developments, declining hardware costs, and contemporary attitudes about technology. Major changes in the distribution of commodities, services, and products, as well as the social, economic, and political effects of those changes, are brought about by its novel and cutting-edge components [5]–[7].

**IoT FEATURES**

Artificial intelligence, connection, sensors, active involvement, and the usage of tiny devices are the IoT's key characteristics. Below is a quick summary of these characteristics. AI IoT transforms everything into a "smart" object by using data collecting, artificial intelligence algorithms, and networks to improve every area of life. This may be as basic as improving your refrigerator and cabinets to know when milk and your favourite cereal are running low and to order more from your favourite grocer when necessary.

- **Connectivity:** Thanks to emerging IoT networking technologies, networks are no longer only dependent on large service providers. Networks are still useful even when they are considerably smaller and less expensive. These little networks are built by IoT between their system components.
- **Sensors:** The Internet of Things would be nothing without them. They serve as defining tools that turn the Internet of Things from a typical passive network of devices into an active system that can be integrated into the actual world. Active Engagement Passive engagement accounts for a large portion of modern interactions with linked technologies. A new paradigm for active content, product, or service interaction is introduced by IoT.
- **Small Devices:** As expected, devices have become smaller, less expensive, and more potent over time. To achieve its accuracy, scalability, and adaptability, IoT makes use of specially designed tiny devices.

**IoT Benefits:**

Every sphere of business and leisure benefits from IoT. The following is a list of some of the benefits that IoT may provide:

- **Greater Customer Interaction:** As said, engagement is still passive, and current analytics have substantial blind spots and accuracy issues. This is radically transformed by IoT to enable deeper and more successful audience interaction.
- **Technology Optimization:** The same data and technologies that enhance consumer experience also enable better device use and more significant technological advancements. Critical functional and field data are unlocked via IoT.
- **Less Waste:** IoT highlights development opportunities. Current analytics only provide us with surface-level understanding, whereas IoT offers real-world data that improve resource management.

Improved Data Gathering Modern data collection is constrained by its software uses platforms, embedded systems, partner systems, and middleware to handle its main networking and action domains. Within the IoT network, these particular and master apps are in charge of data gathering, device integration, real-time analytics, and application and process expansion. When carrying out

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related duties, they take use of integration with important business systems such as ordering systems, robots, scheduling, and more.

Data Gathering this programme controls data aggregation, light data security, light data filtering, and sensing. It helps sensors connect to machine-to-machine networks in real-time by using certain protocols. After then, it gathers information from various devices and disperses it in line with parameters. Additionally, it operates backwards by dispersing data between devices. Eventually, the system sends all of the data it has gathered to a centralized server.

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# CHAPTER 8

# ESP 32- SLAVE DEVICE TO A HOST MCU

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Espressif Systems' ESP32 is a dual-core MCU with built-in Wi-Fi and Bluetooth. If you have experience with the ESP8266, the ESP32 is a vast improvement with many additional functions. With or without any knowledge of the Internet of Things or the ESP8266, this getting originated with ESP32 instruction and is intended for total novices. For those new when it comes to microcontrollers and embedded systems, Arduino is a fantastic platform. You may create several projects that are either for fun or are even for sale using a lot of inexpensive sensors and modules. New project concepts and implementations emerged as technology developed, and the Internet of Things, or IoT, is one such notion. It is a platform that is linked to several "things" or gadgets over the internet to share information [1]–[3].

Home automation and smart home applications are the core IoT projects in the DIY community, whereas commercial and industrial IoT projects employ considerably more sophisticated implementations, such as machine learning, artificial intelligence, wireless sensor networks, etc. This succinct introduction highlights the need for an Internet connection for every Internet of Things project, regardless of size, whether it be a simple DIY effort by a hobbyist or a sophisticated industrial operation. The likes of ESP8266 and ESP32 enter the picture in this situation. ESP8266 is a fantastic solution if you want to provide your project's Wi-Fi connection. However, ESP32 is the best option if you want to develop a comprehensive system with Wi-Fi connection, Bluetooth connectivity, resolution ADCs, DAC, serial connectivity, and many other capabilities [4]–[6].

**ESP32**

Espressif Systems, the same company that created the well-known ESP8266 SoC, offers the inexpensive ESP32 System on Chip (SoC) Microcontroller. The 32-bit Xtensa LX6 Microprocessor by Tensilica is a replacement for the ESP8266 SoC and has built-in Wi-Fi and Bluetooth. It is available in single-core and dual-core versions.

Including ESP8266, ESP32 has integrated RF parts like a power amplifier, low-noise receiver amplifier, antenna switch, filters, and RF balun, which is a nice feature. As a result, it is relatively simple to construct hardware around the ESP32 as minimal external components are needed.

The fact that ESP32 is produced utilising TSMC's ultra-low-power 40 nm technology is another crucial piece of information to be aware of. Therefore, employing ESP32 should make it extremely simple to create battery-operated applications like wearables, audio equipment, baby monitors, smart watches, etc.

**ESP32 specifications**

It is challenging to incorporate all the specs in this Getting Started with ESP32 tutorial since ESP32 has many more functions than ESP8266. So, I've compiled a summary of some of the key ESP32 specs below. The Datasheet, however, has a comprehensive list of specifications, thus I highly advise you to go there.

- A 32-bit LX6 microprocessor with a single or dual core with a clock speed of up to 240 MHz.
- 448 KB of ROM, 16 KB of RTC SRAM, and 520 KB of SRAM.
- Supports up to 150 Mbps 802.11 b/g/n Wi-Fi networking.
- Assistance with BLE and Classic Bluetooth v4.2 standards.
- 34 programmable GPIOs.
- Two channels of 8-bit DAC and up to 18 channels of 12-bit SAR ADC.
- There are 4 SPI, 2 I2C, 2 I2S, and 3 UART serial ports.
- Physical LAN communication with Ethernet MAC (requires external PHY). 15
- One SD/SDIO/MMC host controller and one SDIO/SPI slave controller.
- PWM for motors and up to 16 LED channels.
- Flash Encryption and Secure Boot.
- Hardware acceleration for AES, Hash (SHA-2), RSA, ECC, and RNG cryptographic operations.

If there are several ways to programme (write code for) good hardware like the ESP32, the device will be more user-friendly. The ESP32 offers a variety of programming environments, which is not unexpected. Several of the frequently used programming environments include:

MicroPython, PlatformIO IDE (VS Code), and Arduino IDE. We will utilise the Arduino IDE, which is currently a comfortable setting, to programme the ESP32 in our next projects. But you may also give other options a go.

**The ESP32 Development Board's ESP32 DevKit**

i. The ESP-WROOM-32 16 Module is one of the numerous ESP32-based modules that Espressif Systems has produced. A 40 MHz crystal oscillator, a 4 MB Flash IC, plus a few passive parts make up the ESP32 SoC.

ii. The PCB of the ESP-WROOM-32 Module contains edge castellations, which is advantageous. As a result, third-party manufacturers create a break-out board for the ESP-WROOM-32 Module.

iii. The ESP32 DevKit Board is one such board. It includes the ESP-WROOM-32 as the primary module along with some extra hardware for quick ESP32 programming and GPIO Pin connectivity.

**LAYOUT**

By examining the design of the ESP32 DevKit Board, one of the well-known low-cost ESP Boards on the market, we can discover what makes up a standard ESP32 Development Board. The ESP32 Development Board that I own is laid out as seen in the accompanying picture.

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Market-available ESP32 Boards based on the ESP-WROOM-32 Module are many. From board to board, the layout, pinout, and functionality differ have a board with 30 pins (15 pins on each side). Some of the boards have 36 pins, while others have a few fewer. So, before establishing connections or even powering up the board, double-check the pins.

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# CHAPTER 9

# LDR SENSOR

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A piece of exposed semiconductor material, such as cadmium sulfideide, is used to make a Light Dependent Resistor (LDR), which reduces its electrical resistance from several thousand Ohms in the dark to only a few hundredth Ohms when exposed to light. The overall result is an increase in conductivity with less resistance and more light. Additionally, it takes a lot of seconds for photoresistive cells to react to a change in light intensity. Lead sulphide (PbS), lead selenide (PbSe), and indium antimonide (InSb) are materials used as semiconductor substrates that detect light in the infrared spectrum, with cadmium sulphide being the most widely used of the photoresistive light sensors (Cds). Since its spectral response curve closely resembles that of the human eye and can even be adjusted using a basic torch as a light source, cadmium sulphide is employed in the production of photoconductive cells. Therefore, it typically has a peak sensitivity wavelength (p) in the visible spectral region between 560 and 600 nm [1]–[3].

## LED LUMINARS

A two-terminal semiconductor device is an LED (Light Emitting Diode). While LEDs work similarly to regular diodes, they produce light when current flows through them. Most electrical circuits utilise it as a signal or visual cue to let the average person know the circuit is in good operating order. LEDs are used in several applications nowadays. They are used in hoardings for advertisements, electronic gadgets, displays, nightlights, etc.

Below are some of the top DIY LED projects and circuits that are available from Electronics Hub. All of these circuits have undergone theoretical testing, and for each one, thorough circuit descriptions, applications, advantages, and limitations have been published. These, in our opinion, will be extremely helpful to many electronics engineering students in helping them choose LED-based projects and circuits quickly.

## Camera ESP32

The ESP32-CAM is an ESP32-based, compact camera module with minimal power requirements. It has an inbuilt TF card slot and an OV2640 camera. Numerous clever IoT applications, including WiFi image upload, QR recognition, wireless video monitoring, and others, may make use of the ESP32-CAM.

## Control Button

An electrical gadget called a panic alarm is made to help inform people in emergency circumstances when there is a risk to people or propert the phrase "Internet of Things" refers to new opportunities for engaging with electronic equipment via digital interfaces, such as the possibility of giving information to a smart device linked to the same network as the rest of the system in a very straightforward, user-friendly style. Every device in this system must function using IoT and be linked to the same network. LDR sensors, NODEMCU ESP8266, and LED make up the adaptive system architecture. The NODEMCU microcontroller serves as the system's central processing unit in this setup. The microcontroller is connected to every sensor that is used in this system. A light-dependent resistor is an LDR. Its resistance drops when the afternoon sun shines on it, causing the light to turn off. Since the sensor is not illuminated throughout the night, its resistance rises, which causes the light to turn on [4]–[6].

Comparatively speaking to the already in place system, the suggested solution is simpler to instal and maintain. By adding logic to the code, it is possible to further improve the system by automating the process of turning on the street light at sunset and turning it off at dawn by retrieving information about the time of sunrise and sunset from a trustworthy weather reporting source. This further reduces the need for human involvement since only in the event of a fault would a manual visit to the position of the street lights be necessary. Compared to manual procedures, automated systems are more efficient. This gadget may also be reprogrammed to suit our requirements.

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# CHAPTER 10

# READ ONLY MEMORY AND RANDOM ACCESS MEMORY

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A computer is a microcontroller. All computers have several characteristics, whether we're talking about a small microcontroller, a massive mainframe computer, or a personal desktop computer. A CPU, or central processing unit, is a component of any computer that runs programmers. If you are reading this article while seated at a desktop computer, the CPU in that device is now running software that incorporates the Web browser that is showing this page. The application is downloaded to the CPU. The browser application is retrieved from the hard drive on your desktop computer. The computer may store "variables" in some random-access memory (RAM) the computer also contains certain input and output gadgets so that it can communicate with humans. The television and printer are output devices on a desktop computer, whereas the keys and mouse are input devices. An I/O device, such as a hard drive, manages both output and input [1]–[3].

Your desktop computer is a general-purpose computer, meaning it can execute any of the countless applications. They are special-purpose computers and microcontrollers. Microcontrollers excel at only one thing. Microcontrollers are characterized by a variety of other traits. A computer may be referred to as a microcontroller if it has the majority of these features. Microcontrollers are "embedded" into some other device typically a consumer product so that they may control the functionality or actions of the product. Consequently, "embedded controller" is another term for a microcontroller.

Microcontrollers carry out a single job and execute a single programme. The software is often not changed and is kept in read-only memory (ROM). Devices with minimal power consumption include microcontrollers. A desktop computer may use up to 50 watts of power and is often hooked into a wall socket. A microcontroller powered by batteries could need 50 milliwatts [4]–[6].

In addition to having a specific input device, microcontrollers often though not always include a tiny LED or LCD display as an output. A microcontroller not only sends signals to various parts of the device it is managing but also receives input from the instrument it is controlling. As an example, the microcontroller in a television receives input from the motion sensor and outputs it on the screen. The controller regulates the sound system, the channel selection, and a few image tube electrical settings like tint and brightness. A car's engine controller receives data from sensors like oxygen and knock sensors and uses that data to regulate factors like fuel mix as well as spark plug timing. A convection oven controller accepts keyboard input, outputs it on an LCD display, and manages a relay to switch on and off the microwave generator.

A microcontroller is often inexpensive and compact. The components are selected to be as small and affordable as feasible. Although not usually, a microcontroller is ruggedized in some fashion.

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For instance, the microcontroller in charge of a car's engine must operate under conditions of severe heat that a typical computer often cannot tolerate. The microprocessor in a vehicle must function well at temperatures as low as -30 degrees Fahrenheit (-34 degrees Celsius), yet it may be functioning at 120 degrees Fahrenheit in Nevada (49 C). The temperature in the engine compartment may reach as high as 150 or 180 degrees F (65 or 80 C) when the heat naturally produced by the engine is added. On the other hand, a VCR's embedded microprocessor hasn't been at all ruggedized.

A microcontroller may be implemented using a variety of different processors. For instance, a Z-80 CPU is included in the mobile phone seen in Inside a Digital Cell Phone. An 8-bit microprocessor called the Z-80 was created in the 1970s and was first used in desktops of the era. According to what I've been informed, the Intel 80386 low-power variant is found in the Garmin GPS shown in How GPS Receivers Work. The original applications for the 80386 were desktop PCs.

The demand for the CPU is quite modest in many goods, such as microwave ovens, therefore cost is a key factor. In these circumstances, manufacturers use specialized microcontroller chips, which were initially intended to be inexpensive, compact, low-power embedded CPUs. These chips include the Intel 8051 and the Motorola 6811. A firm named Microchip also produces a range of well-liked controllers referred to as "PIC microcontrollers." These CPUs are exceedingly basic by today's standards, but when acquired in bulk, they are incredibly cheap and often able to satisfy the demands of a device's creator with only one chip.

A typical low-end microcontroller chip may feature eight I/0 pins, 1,000 bytes of ROM, and 20 bytes of RAM. These chips may sometimes be had for only cents when purchased in big numbers. Microsoft Word needs about 30 megabytes of RAM and a CPU that can carry out millions of instructions per second, thus you will never be able to operate it on such a device. However, you can use a microwave oven without using Microsoft Word as well. With a microcontroller, you are aiming to do a single job, and low-cost performance and low power are what matter.

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# CHAPTER 11

# INTRODUCTION TO DIGITAL CLOCK

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If you want to experiment with a BASIC Stamp, getting started is fairly simple. A personal computer and a startup kit for the BASIC Stamp are required. The Stamp, a computer program cable, and an application you use on your desktop or laptop to download BASIC programmes into the Stamp are all included in the basic set. You may get a starting kit from the manufacturer, Parallax, or through a vendor like Jameco (who should be familiar to you from the electronic gates and digital clock articles). You may get the BASIC Stamp D Starter Kit from Parallax (part number 27202), or you can order part number 140089 from Jameco. Both providers are charging $79 for the equipment. Connecting the Stamp is simple. It is connected to your computer's parallel port. After that, you modify your BASIC programme using DOS software before downloading it to the Stamp [1]–[3].

You press ALT-R to launch the application in this editor. The BASIC programme is reviewed by the editor application before being sent over the wire to the Stamp's EEPROM. The software is then run by the Stamp [4]–[6]. On I/O pin 3 in this instance, the application generates a square wave. A logic probe or LED connected to pin 3 will flash on and off twice per second (for more information, read the page on electronic gates) (it changes state every 250 milliseconds because of the PAUSE commands). A 9-volt battery would be able to power this software for several weeks. By utilising the NAP command instead of PAUSE, you may reduce the amount of time the LED is on.

**Making a Very Pricey Digital Clock**

You may think it's expensive to pay $79 for an LED to flash. You presumably want to utilise your BASIC stamp to make something helpful. You can make a pretty good digital clock for approximately $100 extra! Until you learn that the components may be used in several other projects that you might wish to make in the future, this may seem quite pricey.

Let's imagine we want to show numerical values on the BASIC Stamp's I/O pins. We learned how to use a 7447 chip to connect to a 7-segment LED display in the digital clock article. The BASIC Stamp would function just as well with 7447s. Four of the I/O pins may be directly connected to a 7447, allowing you to quickly display a number between 0 and 9. It is simple to drive two 7447s directly using this method since the BS-1 Stamp has eight I/O pins. We need to get a minimum of four digits for a clock. We need to be a little more inventive to drive four 7447s with just eight I/O pins. The illustration below demonstrates one method:

The eight I/O wires from the Stamp enter from the left in this figure. This method employs four wires that connect to each of the four 7447s. Then the last four lines from the Stamp sequentially

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activate the 7447s. The BASIC software in the Stamp would output the first number on the four data lines to make this setup work, and the first 7447 would be turned on by tripping its E pin with the first control line. After then, it would continually sequence through all four of the 7447s, activating the second 7447 with the value for the second digit. You could do this with a single 7447 by slightly altering the wiring. This method allows you to drive up to 16 digits utilising a 74154 demultiplexer chip and some drivers.

In reality, this is a common approach to operating LED screens. For instance, jiggle an ancient LED calculator while monitoring the display when turning it on. The fact that just one digit is ever lit at a time will be visible to you. The method is referred to as multiplexing the display. Although this method works well for clocks and calculators, it has two significant flaws.

**LEDs use a lot of energy:**

Only numerical values may be shown on 7-segment LEDs.Utilizing an LCD panel is an alternate strategy. It turns out that LCDs are commonly accessible and are simple to connect to a Stamp. For instance, the two-line by 16-character alphanumeric display seen below is offered by both Jameco and Parallax. Here, a common display installed on a breadboard for the simpler interface is shown:

**This kind of LCD provides several benefits:**

One I/O pin may be used to drive the display. There is just one I/O pin required since the display has circuitry that enables serial communication with a Stamp. Additionally, Stamp BASIC's SEROUT command handles the serial connection with ease, making it easy to communicate with the display.

- Alphanumeric text, including letters, numbers, and even special characters, may be shown on the LCD.
- The LCD uses just 3 milliamps of electricity, which is very minimal.

The only issue is the $59 price tag for one of these screens. A toaster oven is not where you would insert one of these. However, if you were constructing a toaster oven, you would probably use one of these screens for the prototype before developing your circuits and software to power far less expensive LCDs in the finished product.

This display may be driven by simply connecting one of the Stamp's I/O pins to the input line of the display and providing it with +5 volts and ground the Stamp provides both from the 9-volt battery. I've discovered that using a wire-wrap tool and 30-gauge wire-wrap wire is the simplest method to connect the Stamp's I/O pins to a device like an LCD. In this manner, connections are reliable and small without the need for soldering.

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# CHAPTER 12

# INTRODUCTION TO SMART FARMING

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Significant advances have been developed throughout human history to increase agricultural productivity with fewer resources and labor demands. However, despite all of these attempts, the high population rate prevented supply and demand from matching. The population of the globe is projected to reach 9.8 billion people in 2050, an increase of around 25% from the present number. It is anticipated that emerging nations would account for almost the entire population growth stated. On the other hand, the trend toward urbanization is expected to intensify, with nearly 70% of the world's population expected to live in cities by 2050 (compared to 49% now). Additionally, income levels will be several times higher than they are today, which will increase the need for food, particularly in emerging nations. As a consequence, people in these countries will be more conscious of their diets and the quality of their food; as a result, consumer tastes may shift from wheat and grains to legumes and then, eventually, to meat. By 2050, food production needs quadruple to feed this bigger, more urbanized, and wealthier population. In particular, the yearly supply of beef must rise by more than 200 million tons to meet the need of 470 million tons, and the present number of 2.1 billion tons of grain should reach almost 3 billion tons. Crop production is increasingly essential not just for food but also for industry; in fact, many countries' economies depend heavily on crops like cotton, rubber, and gum [1], [2].

IoT is used in agriculture via precision farming by using robots, sensors, drones, or computer imagery along with analytical tools to get insights or monitor the crops. Farms using physical equipment monitor and collect data, which is subsequently utilized to get insightful information. Every item that can be controlled via the Internet is considered an IoT device. Wearable IoT (Internet of Wearable Things) goods, like smartwatches, and home management products, like Google Home, have made IoT devices widely available in consumer markets. By 2020, it is predicted that more than 30 billion gadgets will be linked to the Internet of Things.

To fulfill rising demand and reduce output losses, Internet of Things applications in agriculture focus on traditional agricultural activities. Robots, remote sensors, drones, computer imagery, and ever-evolving machine learning or analytical tools are used in IoT in agriculture to monitor crops, survey and map fields, or provide farmers the information they may use to make time- and money-saving farm management decisions [3], [4].

Additionally, the bioenergy market based on food crops has lately begun to expand. Before a decade, just the ethanol industry used 110 million tons of coarse grains or around 10% of total global output. Food security is in jeopardy as food crops are being used for the production of biofuels, bioenergy, and other industrial purposes. The burden on already limited agricultural

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resources is rising as a consequence of these demands. Due to several restrictions, including temperature, climate, topography, and soil quality, only a small fraction of the earth's surface is appropriate for agricultural usage. Even the majority of the favorable regions are not uniform. When increasing the variety of landscapes and plant species, several new distinctions begin to appear that might be challenging to define. Furthermore, political and economic variables like population density, climatic patterns, and land use influence the amount of agricultural land that is accessible, and growing urbanization is a persistent threat to the supply of arable land. The overall amount of agricultural land used for food production has decreased during the last several decades [5].

The ability to monitor greenhouse environments has increased steadily, and a healthy greenhouse environment may boost crop quality, shorten the growth cycle, and increase productivity, all of which have significant theoretical implications and are worthwhile for further investigation. In this study, the environment in the greenhouse is monitored using a cell phone as a monitoring device. Design of a Wireless ZigBee Sensor Network-Based Greenhouse Humidity Monitoring System. A total of 18.6 million square miles (or 37.73% of the world's land area) of arable land was used for food production in 2013, down from 19.5 million square miles (or 39.47% of the world's land area) in 1991. As a result, the disparity between the availability and demand for food is growing, which is concerning.

In a greenhouse, temperature and humidity play key roles in crop development and product quality. The distribution of humidity in greenhouses across distance and time has to be studied. The ideal option is a greenhouse humidity monitoring system based on ZigBee wireless sensor networks (ZWSN). To save energy, the study's goals are to construct ZWSN nodes for sensing temperature and humidity in greenhouses, design appropriate software to put the nodes to sleep when idle, and establish a time delay for each node to enhance network performance. The intended system had been used to monitor the humidity levels in a greenhouse. The results of experiments demonstrated that this system runs steadily, with energy consumption of 22.4mA when working and 4.7mA while sleeping. With a delay, it had a 97.1% success rate in receiving data packets. The necessity for greenhouse humidity monitoring may be satisfied by the ZWSN system.

In the current research, a greenhouse dryer's performance in the force convection method of heat transmission is examined along with its design and fabrication. In both the forced convection greenhouse drier and the natural convection open sun drying modes, a thermal model of the system is built. At a latitude of 25°N, experiments were carried out on the grounds of SHIATS-DU Allahabad. The amount of sunlight, the relative humidity inside and outside the greenhouse dryer, the pace at which moisture is removed, the air velocity, and the temperatures at various locations were all measured. It is discovered that the forced convection greenhouse drying mode's average convective heat transfer coefficient is greater than the open sun drying.

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# CHAPTER 13

# WORKING PRINCIPLE OF SMART FARMING

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The project's whole operational strategy will be shown in the block diagram. To help us monitor the health of the green plant, we utilize a variety of sensors. The sensor data is delivered to a microcontroller board that is directly linked to the PC [1]–[3]. After that, information on the state of green plants will be continuously updated in the cloud through WiFi. Data may be accessed at any time and from any location via Web services or mobile applications, as shown in Figure 1.

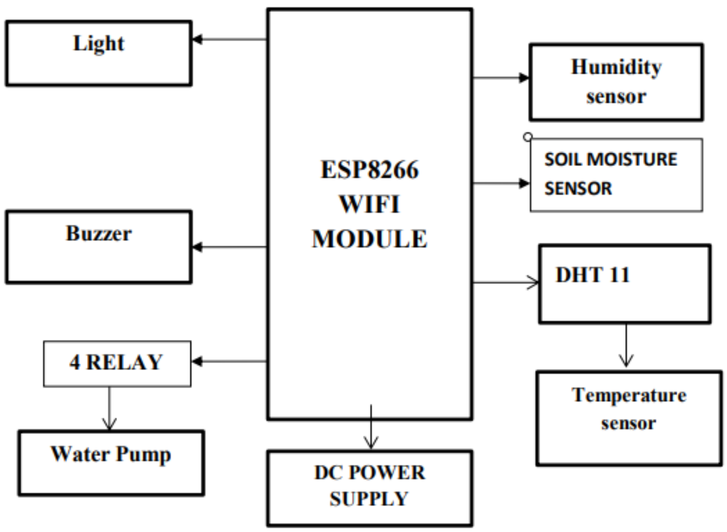


**Figure 1: Illustrate the block diagram of Smart Farming Using IoT.**

## COMPONENTS REQUIRED:

Hardware:

- Soil moisture sensor
- Temperature sensor
- Water Pump
- Micro-controller(ESP8266)
- Light
- Pump
- Buzzer
- Blynk app
- Humidity sensor.

**WIFI MODULE FOR ESP8266:**

The ESP8266 WiFi Module, a self-contained SOC with an integrated TCP/IP protocol stack, enables any microcontroller to connect to your WiFi network. The ESP8266 is capable of hosting an application or delegating all Wi-Fi networking duties to another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, so all you have to do is connect it to your Arduino device to get almost as much WiFi capabilities as a WiFi Shield (and that's right out of the box). A particularly cost-effective board with a large and growing community is the ESP8266 module. This module can connect to sensors or other application-specific devices through its GPIOs with little prior programming or runtime loading because to its rich internal processing and storage capabilities. Due to the high level of on-chip integration, it only requires a minimal amount of external circuitry, and even the front-end module is designed to take up little space on the PCB. Due to the ESP8266's self-calibrated RF, it can operate in any environment without the need of any additional RF components. For VoIP applications, it also supports Bluetooth coexistence across faces and APSD. Because of the ESP8266's significant community support, it is possible for it to access almost infinite amounts of information. You may find a variety of tools to help you use the ESP8266 in the Documents section below, including instructions on how to use this module as part of an IoT (Internet of Things) solution [4]–[6].

**FEATURES:**

- 802.11 b/g/n
- Integrated TCP/IP protocol stack
- Integrated TR switch, power amplifier, balun, LNA, or matching network
- Wi-Fi Direct (P2P), soft-AP
- Integrated PLLs, DCXO, regulators, and power management units
- Power down leakage current of < 2ms
- +19.5dBm output power in 802.11b mode
- Standby power consumption of < 1.0mW (DTIM3)

**WI-FI MODULE**

- Wired technology, which is often used to connect devices in wireless mode, is an alternative to wireless technology.
- A general name for the IEEE 802.11 standard for Wireless Local Area Networks, is Wi-Fi (Wireless Fidelity) (WLANs).
- Wi-Fi networks link computers to the internet, other computers on the network, and wired networks.

Wi-Fi Networks use Radio Technologies to transmit and receive data at high speed:

- IEEE 802.11b
- IEEE 802.11g
- IEEE 802.11a

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# CHAPTER 14

# SENSOR FOR TEMPERATURE

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Precision integrated-circuit temperature sensors of the LM35 series provide an output voltage that is exactly proportional to the temperature in Celsius (Centigrade). The LM35 sensor has a benefit over linear temperature sensors calibrated in degrees Kelvin because the user does not need to subtract a sizable constant voltage from its output to get appropriate Centigrade scaling. Without any further calibration or trimming, the LM35 sensor can give typical accuracies of 14°C at room temperature and 34°Cover the whole temperature range of -55 to +150°C. Low cost is ensured through trimming and calibrating at the wafer level. The LM35 is very easy to interface with reading or control circuitry because of its low output impedance, linear output, and precise internal calibration. It may be utilized with both positive and negative power sources in addition to just one. It only utilizes around 60 of its supply, thus it warms up by itself very slowly less than 0.1°C in calm air. The operational temperature range of the LM35 sensor is between -55° and +150°C, whereas that of the LM35C sensor is between -40° and +110°C (-10° with higher precision). The LM35 series is also available in hermetic TO-46 transistor packages, in addition to the plastic TO-92 transistor packaging that is available for the LM35C, LM35CA, and LM35D. Additionally, a plastic TO-220 package as well as an 8-lead surface mount small outline package are available for the LM35D sensor.

## HUMIDITY SENSOR:

Using humidity sensors, the moisture content of the soil and other materials of a similar kind is determined. The sensor has two large exposed pads that function as the sensor's probes as well as a variable resistor when combined. The moisture content of the soil is measured by this sensor. When the conductivity between the electrodes in the soil changes, the analog voltage will start to grow when the level in the soil is low. Any plant, even flower plants, may have its irrigation automated with the use of this sensor [1]–[3].

## INTERNET OF THING (IoT)

The Internet of Thing (IoT) is a contemporary robotization and investigation framework that makes use of big data, artificial intelligence, planning, and constantly detecting technologies to provide comprehensive frameworks for a good or service. These solutions may be applied to any industry or framework to achieve improved clarity, control, and execution. IoT systems have been used in many fields because of their exceptional flexibility and capacity to be adaptable in any environment. They increase information collection, computerization, duties, and much more with the use of clever devices and potent enabling innovations [4]–[6].

By using IoT solutions, customers may get more robotization, research, or joining inside a system. They expand these regions' breadth and precision. IoT makes use of established and cutting-edge

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developments in detecting, system administration, and mechanical technology. IoT makes use of recent advancements in programming, dropping equipment costs, and cutting-edge viewpoints on innovation. Its innovative and cutting-edge components result in significant changes in how things are distributed, how things are administered, and how things are used, as well as the social, economic, and political effects of those changes.

**IOT CHARACTERISTICS:**

- Artificial intelligence, connection, sensors, active involvement, and the usage of tiny devices are some of the most crucial IoT features. Below is a quick summary of these characteristics.
- Anything may become "smart" thanks to the Internet of Things (IoT) and artificial intelligence (AI), which enhance all aspects of life. This might be as simple as adjusting your refrigerator or cabinets to be more aware of when milk and your preferred cereal are becoming low so you can purchase more from your preferred grocer as needed.
- Connectivity: Networks are no longer only reliant on big service providers thanks to developing IoT networking technology. Even when they are far smaller and less costly, networks are still helpful. IoT creates these little networks connecting the parts of their systems.
- Without sensors, IoT would be less unique. They operate as defining instruments that transform the Internet of Things from an ordinary passive network of gadgets into an active system that can be incorporated into the real world.
- Active Participation The bulk of interactions with connected gadgets nowadays are passive. IoT introduces a new paradigm for interactive information, products, or services.
- Tiny Devices Devices have become smaller, more accessible, and more powerful over time as was to be anticipated. IoT uses specifically crafted small devices to accomplish its precision, scalability, and flexibility.

**IOT BENEFITS:**

Every sphere of business and leisure benefits from IoT. Some of the benefits that IoT has to offer are listed below:

- Enhanced Client Engagement As previously said, interaction is still mostly passive, and existing analytics have serious accuracy problems. IoT completely transforms this to allow for richer and more fruitful audience involvement.
- Data and technology optimization that improves user experience also improves device usage and facilitates more substantial technological developments. IoT provides a large array of essential features and field data.
- Waste minimization IoT identifies areas in need of improvement. IoT gives real-world data that allows more effective resource management, while current analytics only give us high-level insight.
- Improved Data The flaws and passive architecture of current data collecting are problematic. IoT lifts information away from these locations and places it exactly where people want to go to learn about the world. It facilitates the viewing of the whole picture.

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# CHAPTER 15

# BLYNK APP

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Blynk is a collection of tools for all makers, badass creators, designers, educators, nerds, and geeks who want to use their cell phones to control Arduino, Raspberry Pi, and other comparable devices. We've already put in the effort to create an app, connect to the internet, and write hardware code. With Blynk, you can quickly put up a stunning user interface using the many widgets we provide, upload the sample code to your hardware, and take pleasure in the first results in under 5 minutes [1]–[3].

- It works flawlessly for novice creators and saves wicked geniuses a ton of time. All widely used boards and shields are compatible with Blynk. When determining how to integrate Blynk into an existing or brand-new project, we wanted to allow you complete choice.
- Blynk Cloud's convenience is something else you'll appreciate. Which is, incidentally, open-source and free. Think of your smartphone as a prototype board where you can drag and drop buttons, sliders, displays, graphs, and other useful widgets. These widgets can also access Arduino and operate it in a couple of minutes.
- Blynk is not a limited-use app for a certain shield. Instead, the boards and shields you are now using will be supported by it. It also works on iOS and Android.
- Blynk now supports USB as well. This implies that while you wait for some internet protection to come, you may experiment with the software by connecting it to your laptop or desktop.
- Using the Internet, Blynk operates. Therefore, the only need is that your gear can communicate with the Internet.

Blynk libraries and sample sketches will get you online, connect to Blynk Server, or pair with your smartphone regardless of the connection method you choose, such as Ethernet, Wi-Fi, or maybe this new ESP8266 everyone is talking about. The use of Arduino or cloud computing has been suggested for an Internet of Things-based smart farming system for real-time temperature and soil moisture monitoring. The system is very accurate and efficient in retrieving real-time data on soil moisture and temperature. The IoT-based smart farming system that is suggested in this report will help farmers increase agricultural yield and effectively manage food production because it will constantly lend a helping hand to them to obtain accurate live feeds of environmental temperature and humidity with results that are more than 99% accurate [4]–[6]. This research proposes the design and implementation of a greenhouse parameter control and measurement system. This system is capable of gathering data on the primary environmental factors affecting the greenhouse, including temperature, humidity, light, and soil moisture. Using sensors and an Android app, it is

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also possible to maintain these characteristics below those of the surrounding environment. Using microcontrollers, various sensors' analog signals are transformed into digital values.

**FUTURE PROSPECT**

Future development will concentrate further on expanding the system's sensors to collect additional data, particularly concerning pest control, and incorporating a GPS module to further develop this agriculture IoT technology into a fully-fledged, agriculture precision-ready device.

**AGRICULTURE AND IOT IN THE FUTURE**

- By lowering environmental risks like harsh weather and climate shifts, IoT helps us satisfy our food demands.
- Tractors and harvesters are two mechanical innovations that have been used in agriculture since the 20th century. Due to the rising need for food, the agricultural sector is very reliant on innovations.
- Smart solutions based on IoT will become increasingly prevalent in agricultural operations over the next years since the Industrial IoT has helped boost agricultural production at a reduced cost.
- According to a recent prediction, the installation of IoT systems would cause the agriculture business to develop at a 20% compound annual growth rate (CAGR).
- In addition, there will be 225 million connected agricultural devices by 2024, up from 13 million in 2014.

**SENSORS FOR IOT IN AGRICULTURE**

- For over ten years, farmers have used sensors in their operations. Traditional sensor technology does not, however, provide real-time data, which is a drawback. We were able to utilize the data since the sensors had it recorded in their associated memory.
- Future IoT in agriculture will make considerably more advanced sensors accessible. These gadgets may now be connected to the cloud through a cellular or satellite connection. By doing so, we can access the sensors' real-time data and make smarter decisions.
- The use of IoT sensors in agriculture has made it simpler for farmers to keep an eye on water tanks and improve irrigation. IoT technology makes it possible to include sensors in various facets of agricultural operations, including the time it takes for a seed or crop to grow and the associated expenses.
- The Internet of Things in Agriculture is a second wave of the green movement. Implementing IoT may assist farmers in two different ways.
- By using trustworthy data to guide their decisions, farmers have been able to lower expenses and boost yields.

**AGRICULTURE AND IOT APPLICATIONS**

- Smart farming is a high-tech, effective, and ecologically responsible way to cultivate the land and produce food. This is a method of incorporating intelligent electronics and cutting-edge technology into farming.

- The Internet of Things is crucial to smart farming. This decreases the need for human effort on the part of farmers and producers and maximizes output.
- Agriculture benefits greatly from the Internet of Things because it relies on it. Along with other advantages, it has improved input efficiency and water efficiency. The Internet of Things' enormous benefits has significantly altered agriculture.
- The IoT-based Smart Farming technology boosts the whole agricultural system by monitoring the field in real time. To make the Internet of Things work for farmers, they may save time by using IoT sensors in agriculture and connectivity.
- Water and electricity waste have both decreased as a result. It offers a clear, in-the-moment image of some different factors, including humidity, temperature, and soil.
- The following are some advantages of contemporary technology in agriculture.

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