International Journal of Education, Science, Technology and Engineering
p-ISSN: 2685-1458, e-ISSN: 2684-9844

Original Research Paper

A Critical Assessment of Data Loggers for Farm Monitoring: Addressing Limitations and Advancing Towards Enhanced Weather Monitoring Systems

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Article History
Received:
03.08.2023

Revised:
29.08.2023

Accepted:
05.09.2023

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Abstract: This comprehensive review examines thirty-nine data loggers and their associated literature, systematically critiquing their design and implementation. The integration of data loggers in farm monitoring proves cost-effective, enabling the simultaneous monitoring of multiple parameters without human intervention. The accrued data, when logged over time, contributes to more accurate weather predictions, empowering farmers to strategically plan for upcoming seasons. However, the review reveals a prevalent issue among existing data loggers: many cannot read and record various weather parameters concurrently, coupled with insufficient storage capacity. This limitation hinders their suitability for prolonged, unattended data storage. Additionally, a significant number of the reviewed data loggers lack long-range wireless data transmission capabilities, restricting effective weather monitoring from a distance. The findings underscore the need for researchers to focus on developing advanced long-range data logger systems with enhanced memory storage capacities to address these identified shortcomings.

Keywords: Data Longgers, Farm Monitoring, Long Range Data Transmission, Memory Storage Capacities, Weather Predictions.

1. Introduction

Data logging and recording are common measurement applications. Data is information, knowledge, and conceptions, related to people, or things, obtained by observation, investigation, interpretation, visualization, and mental creation [1]. In its most basic form, data logging is the measuring and recording of physical or electrical parameters over some time. The data can be temperature, strain, displacement, flow, pressure, voltage, current, resistance, power, and many others. A wide range of products can be categorized as data loggers, ranging from basic devices that perform a single measurement to more complex devices that offer analysis functions and integrated displays are more involved than just acquiring and recording signals, sometimes involving a combination of online analysis, offline analysis, display, report generation, and data sharing. Moreover, applications are beginning to require the acquisition and storage of other types of data, such as recording sound and video in conjunction with the other parameters. Data logging is used in a broad spectrum of applications [2]. Chemists record data such as temperature, pH, and pressure when performing experiments in the laboratories. Design engineers log performance parameters such as vibration, temperature, and battery level to evaluate product designs. Civil engineers record strain and load on bridges over time to evaluate safety [1]. Geologists use data logging to determine mineral formations when drilling for oil. Breweries log the conditions of their storage and brewing facilities to maintain quality. The list of applications for data logging goes on and on, but all of these applications have similar common requirements. Data loggers typically have slower sample rates than data acquisition systems. Data loggers imply stand-alone operation, while the typical data acquisition system must remain tethered to a computer to acquire data. This standalone aspect of data loggers implies onboard memory that is used to store acquired data. Sometimes this memory is too large to accommodate many days or even months of unattended recording.

Data loggers used physical forms of memory such as paper tape or paper disks - these were usually known as "chart recorders". Given the extended recording times of data loggers; they typically feature a time-and-date stamping mechanism to ensure that each recorded data value is associated with a date and time of acquisition. As such, data loggers typically employ built-in real-time clocks. The unattended nature of data logger applications implies the need to operate from a DC power source, such as a battery or solar power which may be used to supplement these power sources [3][4][5]. Solar Photovoltaic (PV) can be used as an alternative source of energy to power data loggers in the farm for effective and efficient records. The authors in [6][7][8], reviewed the different Maximum Power Point Tracking (MPPT) techniques that can be adopted for power efficiency enhancement. The author in [9][10] also developed maximum power point tracking techniques for power efficiency enhancement and recommends such as a good alternative for an alternative method of supplying power to standalone PVs. The standalone solar PV with good fabrication and Maximum power point tracking (MPPT) technique embedded into the charge controller will help to ensure a steady power supply to the data logger at a very low cost [10][11][12]. Before now, weather monitoring systems were generally based on mechanical or electromechanical instruments which suffered from drawbacks like poor rigidity, lack of power supply, need for human intervention, associated parallax errors, portability and durability. With the inclusion of electronics, the instruments were made compact cheaper and more reliable. The combination of sensors with a data acquisition system has proved to be a better approach for physical parameter monitoring and recording. This demands the development of a microcontroller-based embedded system for weather monitoring. Such a system should monitor and provide data for remote storage and analysis. The collected data by the weather monitoring system can easily be exported to a PC via a serial port to make subsequent data analysis or graphic and digital storage easy thus automatic data collection is possible without giving up PC resources.

2. Literature Review

The importance of accurate data recording in virtually all spheres of engineering has given rise to a constant demand for improved, cheaper, and more reliable standalone data loggers [13]. Data logger is an electronic device that automatically records, scans and retrieves the data with high speed and greater efficiency during measurement, at any time. The type of information to be logged and monitored depends on the user’s specifications. Data logging and recording is a common measurement application. In its most basic form, data logging is the measuring and recording of physical or electrical parameters over some time. The data can be temperature, strain, displacement, flow, pressure, voltage, current, resistance, power, and many other parameters. A wide range of products can be categorized as data loggers, from basic devices that perform a single measurement to more complex devices that offer analysis functions and integrated displays [14].

The data logger is a stand-alone device which is portable, small in size, powered by a battery and able to collect data on a 24-hour operation. The basic requirement for a data logging system is acquisition, online analysis, logging, offline analysis, display and data sharing. Most data loggers collect data which may be directly transferred to a computer. It is a very common measurement application which can be programmed and record electrical parameters over a while with a built-in sensor. Conversion of electrical impulses from process instruments into digital data can be performed by using a microcontroller in order to record and store on the storage device for further analysis [15].

The monitoring of environmental variables such as temperature, pressure and humidity has a long history of development and the variables have shown significant impact on the productivity of plant growth, the quality of the food industry and the efficiency of many temperatures and humidity-sensitive equipment. The monitoring of temperature and humidity of laboratories, storages, halls, schools and hospitals is important with respect to health and hygiene. Reliable measurement and monitoring are crucial in this competitive era of technology [16].

2.1. Basic Data Logger Components and its Uses

The general components on which all data logger depends are the sensor, Global System for Mobile Communication (GSM) module, peripheral interface controller (PIC Microcontroller), pH sensing electrode, liquid crystal display (LCD), Multi Media Memory Card (MMC), Personal Computer (PC) and keypad matrix.

a) Sensors for Data Logger
   A sensor is an electronic transducer that detects and responds to some type of input from the physical environment [17]. There are many types of sensors to be reviewed in this research work such as temperature sensor, pH sensor, light intensity sensor, dissolved oxygen sensor, pressure sensor, infrared (IR) sensor, ultraviolent sensor and humidity sensor.

b) Temperature Sensor (Lm 35-Dz)
   A temperature sensor is a device that gathers data concerning temperature from a source and converts it to a form that can be understood either by an observer or another device. Temperature sensors can be used in many ways to detect the temperature of a particular device at a given point in time [18]. The LM35 series are precision integrated-circuit temperature sensors. Their output voltage is linearly proportional to the Celsius temperature. The LM35 thus has a benefit over linear temperature sensors calibrated in degree, as there is no need to subtract a large constant voltage from its output to obtain a Centigrade reading. It does not require any external calibration or trimming to provide typical accuracies of ±1/4°C at room temperature and ±3/4°C over a full -55 to +150°C temperature range. The low cost is due to trimming and calibration at the water level. The LM35's linear output and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. It draws only 60 µA from its supply, so it has very low self-heating, less than 0.1°C in still air. It is rated to operate over a -55° to +150°C temperature range, while the LM35C is rated for a -40° to +110°C range (-10°with improved accuracy) [9]. Figure 1 shows a typical LM 35 temperature sensor.

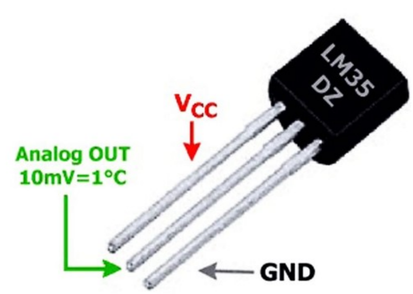

Figure 1. LM 35 Temperature Sensor [18]

The +Vs can be from 4V to 20V as specified by the pin configuration. To use the sensor Vs is connected to +5V, GND to ground and the OUT to one of the ADC (analog to digital converter channel). The output varies linearly with temperature. The output is 10 mill volts per degree centigrade.

Thermocouples are voltage devices that indicate temperature by measuring a change in voltage. As the temperature goes up, the output voltage of the thermocouple rises but is not necessarily linear. Often the thermocouple is located inside a metal or ceramic shield that protects it from exposure to a variety of environments. Metal-sheathed thermocouples also are available with many types of outer coatings, such as Teflon, for trouble-free use in acids and strong caustic solutions.

c) pH Sensor

pH is the measure of the acidity (or alkalinity) of water, soil or any other medium of interest. Production of aquatic animals depends largely on the pH level of the hosting water. Unpolluted deposition (or rain), in balance with atmospheric carbon dioxide, has a pH of 5.6. Almost everywhere in the world the pH of rain is lower than 5.6. The main pollutants responsible for acid deposition (or acid rain) are sulfur dioxide (SO_2) and nitrogen oxides (NO_x) [19][20][21]. Nitrogen and sulfuric emissions come from natural and anthropogenic sources. Natural emissions include e.g. volcano emissions, lightning, and microbial processes. Power stations and industrial plants, like the mining and smelting of high-sulfur ores and the combustion of fossil fuels, emit the largest quantities of sulfur and nitrogen oxides and other acidic compounds. These compounds mix with water vapour at unusual proportions to cause acid deposition with a pH of 4.2 to 4.7. That is 10 or more times the acidity of natural deposition. The acidification of freshwater in an area is dependent on the quantity of calcium carbonate (limestone) in the soil.

- Effects of pH on Aquatic Life

  Most freshwater lakes, streams, and ponds have a natural pH in the range of 6 to 8. Acid deposition has many harmful ecological effects when the pH of most aquatic environments falls below 6, especially below 5. Here are some effects of increased acidity on aquatic systems:

  As the pH approaches 5, non-desirable species of plankton and mosses may begin to invade, and populations of fish such as smallmouth bass disappear. Below a pH of 5, fish populations begin to disappear, the bottom is covered with un-decayed material, and mosses may dominate near-shore areas [22]. Below a pH of 4.5, the water is essentially devoid of fish. Aluminium ions (Al^{3+}) attached to minerals in nearby soil can be released into lakes, where they can kill many kinds of fish by stimulating excessive mucus formation. This asphyxiates the fish by clogging their gills. It can also cause chronic stress that may not kill individual fish, but leads to lower body weight and smaller size and makes fish less able to compete for food and habitat. The most serious chronic effect of increased acidity in surface waters appears to be interference with the fish' reproductive cycle. Calcium levels in the female fish may be lowered to the point where she cannot produce eggs or the eggs fail to pass from the ovaries or if fertilized, the eggs and/or larvae develop abnormally [23].

  Extreme pH can kill adult fish and invertebrate life directly and can also damage be developing juvenile fish. It will strip a fish of its slime coat and a high pH level 'chaps' the skin of fish because of its alkalinity. When the pH of freshwater becomes highly alkaline (9.6), the effects on fish may include death, damage to outer surfaces like gills, eyes, and skin and an inability to dispose of metabolic wastes. High pH may also increase the toxicity of other substances. It is directly toxic to aquatic life when it appears in alkaline conditions. Low concentrations of ammonia are generally permitted for discharge. The pH range positions are as shown in Figure 2.

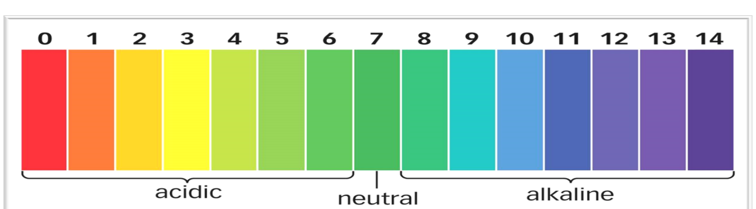

Figure 2. pH Scale and Colour Chart pH Sensors

- pH Measurement

  pH is an abbreviation of “Pondus Hydrogenii and was proposed by S.P.L. Sorensen, a Danish scientist, in 1909 in his quest to express the concentration of hydrogen ion (H+) of an aqueous solution [24]. The measurement of pH requires a pH meter, which includes a measuring electrode and a reference electrode. The pH sensor components are usually combined into one device, which is called combination pH electrodes. A successful pH measurement can only be achieved by choosing the correct system to meet the demands of the sample under examination. For a precise and continuous measurement of pH in a solution [25], a pH meter is always recommended. For the optimal pH measurement, criteria like, chemical composition, homogeneity, temperature, pH range and container size must be considered.

  Depending on the continued maintenance of the pH electrode, experimental conditions and the state of the sample will provide the accuracy of pH measured in a particular medium. A pH meter has a battery in which the positive terminal is the measuring electrode (pH electrode), and the negative terminal is the reference electrode. The pH electrode develops a voltage directly related to the hydrogen ion concentration of the solution, which is highly sensitive to hydrogen ions. A stable potential (voltage) is generated by the reference electrode against the measuring electrode. The measurement of pH in an aqueous solution can be made by immersing the pH meter in that solution. The potential of the reference electrode does not change with the changing hydrogen ion concentration. But the measuring electrode potential changes with the temperature and therefore a temperature sensor is necessary to correct this change in the output. The measuring electrode is usually a glass electrode but nowadays it is replaced with solid-state sensors.

2.2. Global System for Mobile Communication Module

Global System for Mobile (GSM)/General Packet Radio Service (GPRS) TTL-Modem is a SIM900 Quad-band GSM / GPRS device, that works on frequencies 850 MHZ, 900 MHZ, 1800 MHZ and 1900 MHZ [26]. It is very compact in size and easy to use as a plug-in GSM Modem. The Modem is designed with 3.3V and 5VDC TTL interfacing circuitry, which allows the User to directly interface with 5V Microcontrollers (PICMICRO and other Microcontroller) as well as 3V3 Microcontrollers (ARM, ARM Cortex XX, etc.). The baud rate can be configurable from 9600-115200 bps through Attention (AT) commands. This GSM/GPRS TTL Modem has an internal TCP/IP stack to enable Users to connect with the internet through the GPRS feature [27] [28]. It is suitable for SMS as well as data transfer applications in mobile phone-to-mobile phone interfaces. The modem can be interfaced with a Microcontroller using the USART (Universal Synchronous Asynchronous Receiver and Transmitter) feature (serial communication).

Table 1. Summary of AT Commands of the GSM Module

Command	Description	Return	Result
AT+CPIN ?	check the SIM card status	*+CPIN:READY*	A SIM card is found
AT+CSQ	check signal quality	*+CSQ:30,0*	30 is the quality of the signal, max of 31
AT+COPS?	check card service provider	*+COPS:0,0, "CHINAMOBILE" or empty*	CHINA MOBILE is the service provider
AT+CGMI	Check the module maker	*SIMCOM_Ltd*	Made by Simon
AT+CGMM	Check the module model type	*SIMCOM_SIM900A*	SIM900A
AT+CGSN	Check the module IMEI, a worldwide unique	*869988012018905*	869988012018905
AT+CNUM	Check the number of current SIM cards, not all kinds of cards support this function	*+CNUM:"","08033671533",129, 7,4*	phone number 08033671533
AT+ATE1	on/off AT commands return info	*send either ATE0 or ATE1*	

International Journal of Education, Science, Technology and Engineering, vol. 6, no. 2, pp. 55-67, December 2023. **DOI: 10.36079/lamintang.ijeste-0602.593**

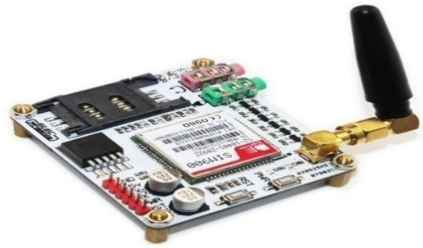

Figure 3. Typical GSM Module [28][27]

Figure 3 is a typical GSM module whereas Table 1 is the summary of AT commands of the GSM module. Table 2 shows the SMS command codes that are used to disseminate signals from one point to the other.

Table 2. SMS Command

Command	Description	Return	Result
AT+CPMS	Inquiry or set message storage settings	AT+CPMS? to check how many messages can be stored maximally and how many messages stored	: +CPMS: "SM",1,50, means support 50 sms max and 1 sms are stored now
AT+CNMI	Set the new message reminder, for example, AT+CNMI=2,1,	+CMTI: "SM",2	when the set is on and the message box is NOT full, the message is stored at position 2
AT+CMGS	send a message, send 180 bytes at GSM mode, or 70 Chinese characters at UCS2 mode, AT+CMGS="18576608994"	will return ">" and then type message, then end up with hex value 1A(0X1A, "CTRL+Z"), send 1B to cancel "ESC"	and finally return +CMGS:156, in which 156 has meaning.
AT+CMGF	Set the module message mode, set either at PDU(0) or text mode(1)	OK	-
AT+CSCS	Set TE character set, set AT+CSCS="GSM" for English-only messages, or set AT+CSCS="UCS2" for another language	OK	-
AT+CMGR	read the message, for example, AT+CMGR=1 to read the message at position 1	-	-
AT+CMGS (e.g. Chinese SMS)	set AT+CMGR=1; AT+CSMP=17,167,2,25; AT+CSCS="UCS2" now the message can be by Unicode, AT+CMGS="003100350031 00320034003500330032003600370032" (number 15124532672)	will return ">" and then type message 00530049004D003900300 03000414E2D82F1658777 ED4FE153D190016D4B8 BD5, end with 1A	-
AT+CMGD	delete a message, to delete the message at position 1: AT+CMGD=1	OK	-

Features of the Global System for Mobile Communication (GSM) Module:

- Quad Band GSM/GPRS: 850 / 900 / 1800 / 1900 MHz· Built in RS232 to TTL or vice versa Logic Converter (MAX232)
- Configurable Baud Rate · SMA (SubMiniature version A) connector with GSM L Type Antenna

- Built-in SIM (Subscriber Identity Module) Cardholder ·
- Built in Network Status LED·
- Inbuilt Powerful TCP / IP (Transfer Control Protocol / Internet Protocol) stack for internet data transfer through GPRS (General Packet Radio Service).
- Audio Interface Connectors (Audio in and Audio out).
- Most Status and Controlling pins are available
- Normal Operation Temperature: -20 °C to +55 °C
- Input Voltage: 5V to 12V DC · LDB9 connector (Serial Port) provided for easy interfacing

2.3. Microcontroller

PIC is a family of modified Harvard architecture microcontrollers made by Microchip Technology. In this research PIC microcontroller (peripheral interface controller) will be used. A most notable feature of this controller is the possession of an in-built ADC (Analog-to-Digital converter) that reduces the complexity of the circuit board and component count, USART (universal synchronous asynchronous receiver transmitter) for interface with the computer, USB (universal serial bus), IIC or I2C capability (inter-integrated circuit) for communication with other memory chips [29][30][31][32].

- The PIC architecture is characterized by its multiple attributes:
- Separate code and data spaces (Harvard architecture).
- A small number of fixed-length instructions
- Most instructions are single-cycle (2 clock cycles, or 4 clock cycles in 8-bit models), with one delay cycle on branches and skips
- One accumulator (W0), the use of which (as source operand) is implied (not encoded in the opcode)
- All RAM locations function as registers as both the source and/or destination of math and other functions.
- A hardware stack for storing return addresses
- A small amount of addressable data space (32, 128, or 256 bytes, depending on the family), extended through banking
- Data-space mapped CPU, port, and peripheral registers
- ALU status flags are mapped into the data space
- The program counter is also mapped into the data space and writable (this is used to implement indirect jumps) [33][34][35]

The researcher in [36] researched on Data Logger and Remote Monitoring System for Multiple Parameter Measurement Applications using a microcontroller for monitoring temperature and humidity which data is logged into a personal computer. The main task of monitoring parameters viz. temperature (T) and humidity (H) along with the transmission of this information in the form of short message service (SMS) to the user’s mobile phone is done by the system. The data logger block diagram is shown in Figure 4.

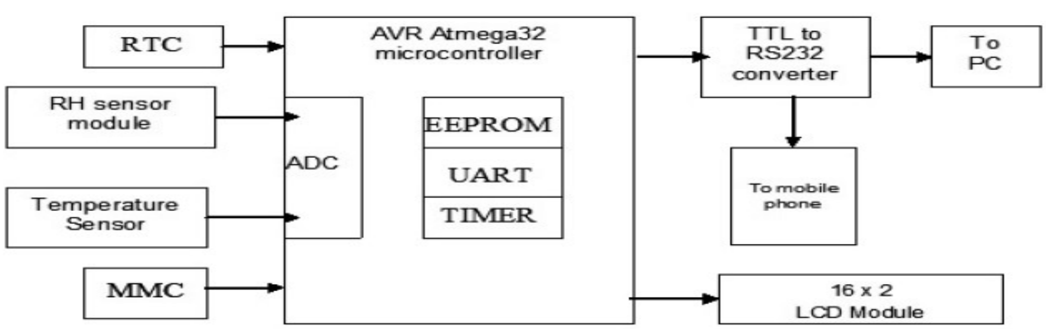

Figure 4. Block Diagram of Weather Remote Monitoring Device [36]

The researchers used LM35-DZ as the temperature sensor, and SY-HS-220 as the humidity sensor while the Atmega32 microcontroller was used for the central processing unit (CPU). The storage facility for the system was micro-SD, a real-time clock (RTC) chip-DS1307 is used for Time-Base purposes. Communication between the RTC and the microcontroller is achieved via a simple serial interface bus protocol. A separate battery source supplies the power required by the chip, hence enabling RTC operation kept without interruption in the event of main power source failure. Data stored in MMC can be accessed directly with the personal computer (PC) through a serial port connection.

The researcher in [18] designed and developed a data logger based on IEEE 802.15.4/ZigBee and GSM. The PIC32, JN5148 and GSM modules are the main components in the designed DL, PIC32 microcontroller acts as a control unit of the DL. Data from wireless sensor nodes is received by JN5148, and PIC32 takes data from the JN5148 through UART2, after the data is successfully received, if GSM services are not available data is then saved on EEPROM and if GSM services are available the data is transmitted on a TCP/IP. The PIC32MX250f128b is chosen as a centralized control unit for the DL. To communicate with wireless sensor nodes in the designed DL the IEEE802.15.4 based Zigbee JN5148 M003 wireless microcontroller is used. The ZigBee is a wireless data communication and networking protocol which is based on IEEE 802.15.4 standard. The SIM900 GSM module is used to connect the data logger with a remote database through TCP/IP. The function flow diagram is shown in Figure 5.

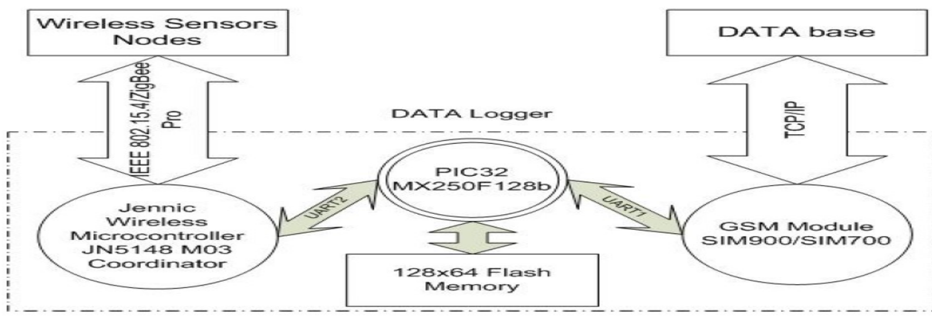

Figure 5. Working Flow Diagram of Data Logger [18]

The results obtained indicated that the voltage and current data of the three-phase transformer which the device is designed to monitor were obtained as specified in the design.

Researcher [17] Designed and Implemented a Digital Temperature and Humidity Data Logger and its Comparative Analysis with the conventional one used microcontroller and SD card for the data logging function. The hardware was designed and constructed using five functional parts that comprising of ATMega328P microcontroller, real-time clock, liquid crystal display unit, SD card and a low-cost DHT22 temperature and humidity sensor to capture the temperature and relative humidity. The hardware is powered by an AC source through a regulated power supply comprising a shunt-regulated IC, LM7805. The block diagram of the system designed by [17] is shown in Figure 6.

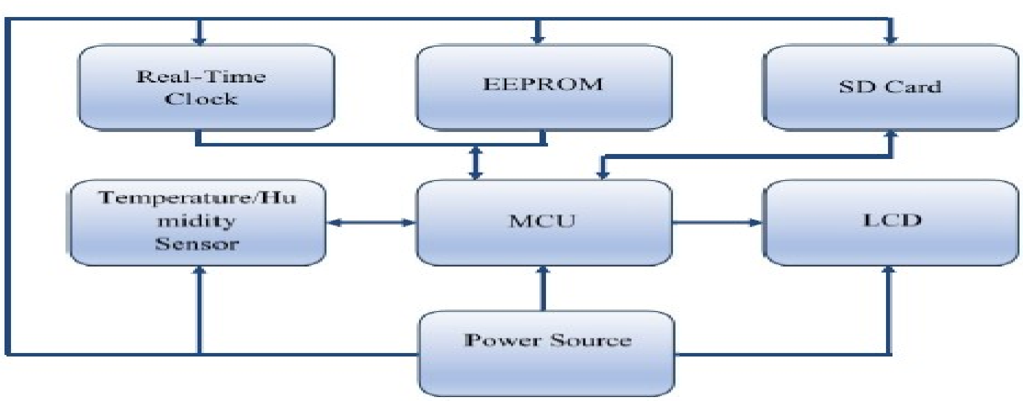

Figure 6. Functional Block Diagram of Temperature and Humidity Data Logger [17]

The captured data is processed and stored on a memory chip (SD card) which can be retrieved at any time and displayed in a Microsoft Excel format by inserting the SD card into a computer system. Data captured is displayed and managed with the aid of a visual interface display unit of a 16 x 2 alphanumeric LCD. The results obtained showed that the parameters measured (temperature and humidity) are less than the reference parameter showing that the device has an accuracy error.

The author in [13] carried out the design and implementation of a standalone general-purpose data logger. The standalone general-purpose data logger is centered on a single microcontroller unit (MCU) the PIC18F4520. The circuit takes an input range of 15 – 30V DC in addition; an in-built 9V rechargeable battery provides backup power in the absence of an external source. The block diagram of the system is shown in Figure 7.

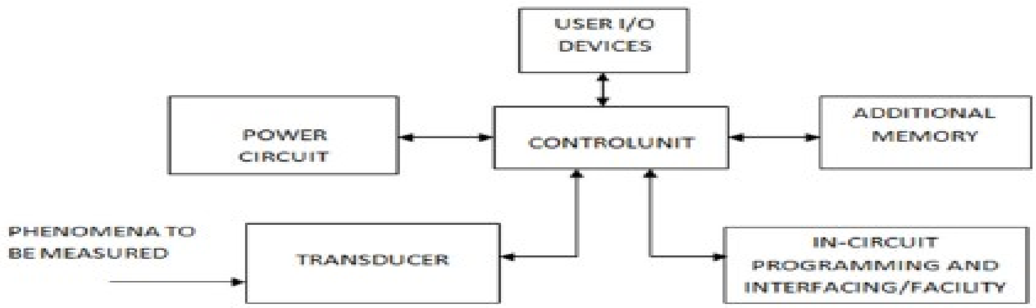

Figure 7. Block diagram of Data Logger [13]

Although the PIC18F4520 features 256 bytes of nonvolatile EEPROM data memory, four AT24C256 2-wire serial EEPROM chips were used for data storage. The four chips were cascaded to form a memory bank that connects to the MCU via a common single 2-wire bus. The hardware employed to achieve the RS-232 serial interface was a 9-pin D-shell serial connector and a voltage-level translator chip (Maxim's MAX232). The connector simply allows the device to be coupled to a serial port of a PC using a standard serial cable. The results obtained showed that the system met the technical specifications set out in the design problem while meeting the objectives set out in the design.

In [37] the researcher designed and developed a smart real-time embedded Arduino-based data logger for indoor and outdoor environments in a Smart Real-Time Embedded Arduino Based Data Acquisition System. The researcher used Arduino Uno based on Atmega328 as its control unit with sensors to determine temperature, humidity and solar insolation parameters. The system block diagram is shown in Figure 8.

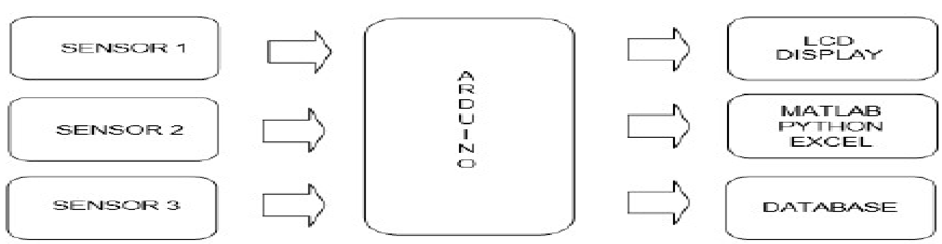

Figure 8. Block diagram of Data Acquisition System [37]

The researchers used DHT-11 humidity and temperature sensors to obtain the appropriate parameters and a solar cell was used to determine solar insolation of the environment. The data from the sensors are stored by the Arduino microcontroller used in the design and then exported to a personal computer for analysis.

The researcher in [38] designed and developed a data logger for measuring atmospheric temperature, pressure and relative humanity in "A Low-Cost Microcontroller-based Weather Monitoring System". The system was divided into four main parts, namely, the sensor circuit, the data-logging circuit, the time-keeping circuit and the USB interfacing circuit. The sensor circuit contains the IC temperature sensor, resistive humidity sensor and barometric pressure sensor. The analogue outputs from these sensors are converted into digital signals by an ADC before being fed into the data-logging circuit which encompasses a microcontrollerPIC16F877A.The block diagram of the overall system is depicted in Figure 9.

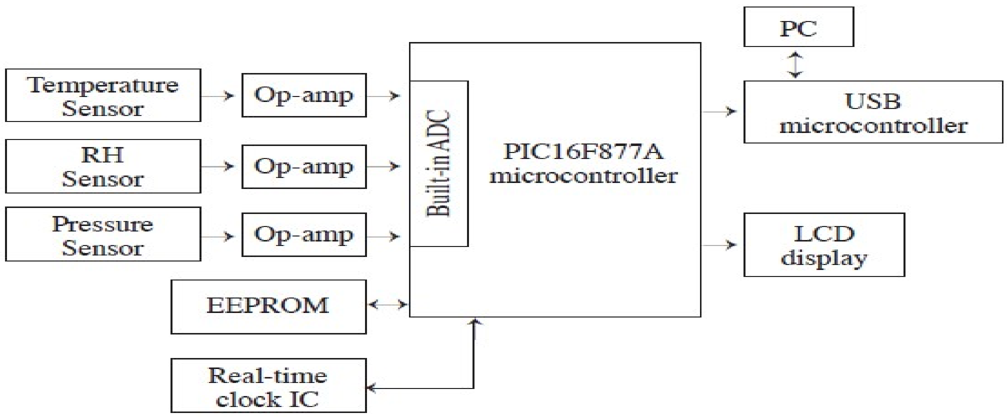

Figure 9. Block Diagram of Low-Cost Microcontroller-Based Weather Monitoring System [38]

For temperature sensing, an integrated circuit temperature sensor LM35 was used. Relative humidity measurement is performed by the resistive-based humidity sensor, HSP15A from GE and MPX4115A was employed for pressure measurement. The current time for data-logging purposes is provided by the time-keeping circuit while the USB interfacing circuit facilitates the data transfer between the data logger and a PC. Data stored in the EEPROM can be accessed directly with a personal computer (PC) through a USB connection. This connection is established via a USB interface microcontroller named 16C745, manufactured by Microchip.

In [39] the researcher embarked on a microcontroller-based Remote Weather Monitoring System. The system was based on an Arduino Uno Microcontroller that can monitor, measure and display the temperature, relative humidity and light intensity of the atmosphere, using analogue and digital components. The analogue outputs of the sensors are connected to a microcontroller through an ADC for digital signal conversion and data logging. An LCD is also connected to the microcontroller to display the measurement. The block diagram of the system is shown in Figure 10.

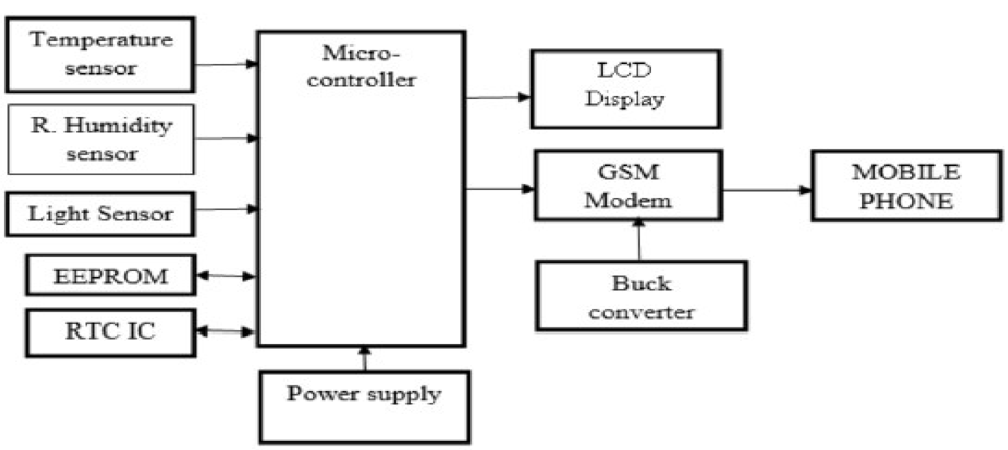

Figure 10. Block Diagram of Remote Weather Monitoring System [39]

The microcontroller employed was Arduino Uno based on ATmega328P, DHT11 was employed for measurement of temperature and humidity, light dependent resistor (LDR) was used to obtain light intensity while communication with the user was done using SIM800L GSM module.

3. Methodology

This research article reviewed thirty-nine articles in the agricultural, solar and environmental fields. From the thirty-nine reviewed articles an inference was drawn about data logger for agricultural purposes based on the existing data logger characteristics, memory capacity, transmission range, actual parameters used to measure and finally, the overall performance of the logger.

4. Finding and Discussion

It was observed from the reviewed work that there is a knowledge gap in the use of a data logger for determining dissolved oxygen in water and the pH level of water. These parameters are very important for the survival of aquatic animals and plants. Hence, the researcher in [18] used ZigBee for wireless transmission which limits the data logger to the data transmission length of ZigBee. The researchers in [13] [17] [37] [38] did not use any wireless communication to make the data logger remotely monitored, rather SD card was used to store the acquired data and then transferred the data to a personal computer for analysis. This made the systems require constant human attention, making them difficult to use. Due to the microcontroller employed by the researchers in the works reviewed, the systems designed are relatively lower in speed and operation, hence, the accuracy of the measured parameter has significant errors. Therefore, this review paper recommends an improvement in the area of measuring additional important parameters such as pH level and dissolved oxygen, remote monitoring of the parameter of interest using GSM technology for faster system response and operation using PIC18F4550 which has a higher speed of operation and accuracy of parameters obtained is guaranteed. This review therefore recommends researchers embark on designing and implementing a PIC18F4550 microcontroller coupled with a GSM technology-based data logger for effective and efficient results.

5. Conclusion

This research work successfully reviewed twenty-six works in data logger, ten papers in renewable energy (solar photovoltaics) as sources of power, three papers in water supply sources and excellent findings and recommendations were drawn. This review paper reviewed the articles based on the characteristics, means of power supply, memory, means of transmissions and performance of the techniques used for the data logger based on the parameters they measure. It was observed at the time of this review that the best-designed data logger used ZigBee for wireless transmission which had the limitation of long-range transmission and never considered the memory space that would enable so much data stored and archived for a long time.

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