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Analog Data Logger for Remote Monitoring of Control Systems

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Abstract: An analogue data logger (also known as a data recorder or logger) is an electrical device that captures data over time or in relation to location using either internal instruments and sensors or external instruments and sensors. They partially (but not entirely) depend on a digital processor or computer. They are generally small, battery-powered, portable devices with a microprocessor, internal memory for data storage, and sensors. Some devices can function independently and have a local interface (keypad, LCD). Some data recorders employ software to activate the device, view, and analyse the recorded data when connected to a computer. There are many various types of data loggers, from general-purpose devices used for a wide range of measurement applications to highly specialist devices used for only one kind of environment or application. Although programmability is often found in general-purpose types, many still operate as static machines with few or no customizable options. Electronic data loggers have replaced chart recorders in many applications. The ability of data loggers to automatically and continually collect data is one of its key benefits. In order to measure and record data, data loggers are typically turned on, deployed, and left alone for the length of the monitoring period. This makes it possible to monitor environmental factors like air temperature and relative humidity in order to provide a full and accurate picture.

Keywords: Data Logger, Microprocessor, Instrumentation, Measurement, Signal Processing, Programmability, Sensors.

I. INTRODUCTION

A data logger is a device that monitors and logs circumstances as they change over time. It may consist of many channels or be a single standalone device. The majority of standalone devices run on batteries, enabling them to record continuously and for long periods of time. When a system is driven by inputs, output data from the system must be used to evaluate its performance. It is necessary to record and store the output data for analysis and performance review. A sufficient pace of data must exist for accurate analysis. A data logger connects to the system to record the data and collect the data. It contains several channels for recording the important system parameters. In the current work, battery voltage and current are recorded using a data logger. It records and saves data for further analysis on a memory storage device, such as a secure digital (SD) card. Additionally, a data logger may be connected to a wireless fidelity (Wi-Fi) system so that it can be sent to cloud storage and retrieved from a distance for additional analysis. A data logger's primary purpose is to use sensors to continually capture and store environmental parameters. This standalone device measures, collects, and saves data online or on an SD card. A micro-controller is used by this system to carry out the job.

Data capture and recording measurement applications are quite common. Data logging is basically the long-term observation and recording of the electrical or physical characteristics of sensors. The data may also contain information about power, voltage, current, resistance, temperature, strain, displacement, flow, pressure, and a wide variety of other variables. Beyond merely collecting and recording signals, real-world data logging systems often need to produce reports, share data, and display the data. Engineers and developers constantly utilise the data collected to build or improve system performance. Data collecting and analysis are common practises in most firms. A periodic collection and recording of analogue data is required for certain measurements, such as those of meteorological parameters. This system can also capture both real-time information and historical data. A control system can identify problems with the air, temperature, and humidity within the building or outdoors. Sensors and data recorders are used in this process.

A data logger is a freestanding, battery-operated device that is small, portable, and capable of collecting data constantly. A data logging system must include the following basic components: data acquisition, online analysis, logging, off-line analysis, display, and data sharing. The majority of data loggers capture data that can be directly transferred to a computer. This increases the company's cost burden since it regularly requires a large amount of staff. An automated system is required to allow for sensitive parameter changes in the data logger and independence from human inputs. A person measuring a parameter in a high-risk situation must thus be replaced.

The primary goals of the proposed work are:

- To build a standalone, microcontroller-based remote data logger that can measure, monitor, and store current parameters including temperature, light intensity, humidity, and air pollutants on a Secure Digital (SD) card.

- Preserve data for future analysis: To enable rapid analysis by the user, the measured data will be recorded on a memory card similar to an SD card in an actual format and at user-defined intervals.

- Present the data: A liquid crystal display (LCD) will concurrently show the sensor-generated parameter measurements.

II. RECENT WORKS

An automatic data logger system is required since technology is evolving quickly and drastically. This aids in information collection and data capturing for later analysis.

[2] outlines a straightforward method for fusing the concepts of analogue and digital circuits with programming techniques. It employs hardware for remote temperature and relative humidity detection. Relative humidity and temperature are converted by the sensor circuit into an analogue signal that is transferred to a microcontroller-based data logger for storage. The data is then sent from the RS232 standard serial connection to the computer. The data transmission between the data logger and the computer will be handled by the user interface programme. allows the user to provide some more crucial parameters, such as the sample interval and the time and date at which the logging procedure will begin. The system has real-time and offline capabilities.

In particular, the need for indoor environment monitoring systems is rising in medical wards, agriculture incubators, and research labs. Presented in [3] is a low-cost indoor environment monitoring system with secure digital (SD) card storage. The designed system measures temperature, humidity, and brightness using an on-chip 10-bit analog-to-digital converter (ADC) on an 8-bit microcontroller as the system core.

To track solar energy, a data recording and monitoring system was created as in [4]. The system is validated by comparing its results with those from the previous work in the same field, and it is discovered that the system performs marginally better. This suggests that the data logger and monitoring system is effective and that it may be used to track solar energy factors even at individual dwellings. The system is able to collect data in such a way that, during the rainy seasons, the climatic variables taken into account accounted for 99.88% of the power production, while 0.12% of the variance was not explained by other factors. The most efficient solar panels are those facing the South Pole and tilted at a 50-degree inclination.

Data loggers and web transmission are both required to gather the sensor data for monitoring the performance of an isolated photovoltaic (PV) system. The data comprises measurements of the PV system's voltage and current as well as local weather. In practise, weather sensors are located between 25 and 50 metres from PV installations. Because long connections may greatly decrease the number of cables in a big PV system with long distances, it is recommended to implement sensor communications through wireless transmission rather than long cables [5]. All sensor data is received by the PC, which then sends it to a web server (Thingspeak).

The data logger shown in [6] was created to assess prospective solar panel energy sources. On the data logger board, a current sensor and a voltage sensor were incorporated to monitor the parameters that influenced the PV system's efficiency. During data gathering, the gained power will be used for evaluation and assessment. However, the Maximum Power Point Tracking (MPPT) approach will effectively provide peak power statistics. Data loggers provide the advantage of automatically collecting data across a number of periods. For analysis, the data may be plotted as V-I graphs

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and P-V graphs. According to the test bench results, the maximum power is 35W. This portable recorder with MPPT functionality may be used to compare the power in various locations.

It is described in [7] how a standalone data recorder device may be used to measure the power characteristics of solar panels. The energy generated by the solar panel is measured using the RTC and SD Card mounted on the device, and the data is then saved in CSV format, which is compatible with MS Excel. It is useful for monitoring solar panel systems put in distant areas because to its independent functionality. The findings of the study show that every component of the gadget is operating flawlessly. Voltage sensors convert the solar panel's output voltage range of 0 to 24 volts to an appropriate value of 0 to 5 volts. A 16 x 2 LCD display real time measurement is also utilised with real Time clock (RTC), despite data being saved on an SD Card.

Using open source hardware and software, a low-cost data logger created for standalone photovoltaic (PV) systems was developed as in [8]. In accordance with the International Electro-technical Commission (IEC) standard for PV monitoring systems, it may measure electrical and meteorological factors. The new datalogger stores data on SD cards and requires no maintenance, allowing the installation of the monitoring system in locations without telephone networks. For testing and verifying the new low-cost datalogger in actual settings, a stand-alone PV (SAPV) system that really operates was installed. These systems are comparable to those used in underdeveloped nations. The results showed adherence to the IEC standard, monitoring all necessary parameters with great precision and little power usage.

It is suggested in [9] to use a computer-based data collecting system to monitor and manage solar power producing systems. It makes use of a graphical programming environment called PC 400 and a Campbell scientific data collection board (CR3000). A small-scale PV power generating system comprising a 6.4kw solar panel, a charge controller, and a DC to AC converter was constructed before the data gathering system was designed. This method has broad applications in the field of renewable energy sources (RES). The suggested system comprises of a number of sensors that can measure electrical characteristics like photovoltaic voltage and current as well as climatic factors like temperature and humidity. [9]

Presented in [11] is the design and creation of a data acquisition system (DAQ) for a hybrid photovoltaic-thermoelectric generator (PV-TEG). It keeps track of system parameters gathered from the PV-TEG source and maintains them in big memory storage. Real-Time Clock (RTC) on-chip technology is included in a time-based microcontroller (DS1307).

Direct current (DC) energy data logger built using a microcontroller, as in [12]. Based on the ATmega328, it measures the DC and voltage characteristics of the PV system while also continuously recording the observed value over time to calculate the energy output in Watt-hours (Wh). The prototype logger has been put through its paces on a working 1 kW standalone PV system. Using a voltage divider sensing circuit, the voltage sensor monitors output voltages from PV series arrays that range from 0 to 50 VDC. The current sensor, a 50A ACS756 hall effect IC, was incorporated to accurately measure the current output from the PV array. The data was collected and stored on an SD card in text format with comma-separated values (CSV), which is a *.csv file.

[13] proposes an off-grid photovoltaic (PV) energy system with an open-source, ultra-low powered data-logger. Voltage, current, and light sensors are utilised in conjunction with the deep-sleep mode of the ESP32-S2 micro-controller to record PV energy system data to an external micro SD card. The operating modes of the data-logger may be switched between deep sleep and web-server modes using a toggle switch. A local web site that has been built in the micro-controller may be used to monitor real-time PV data. The historical data of a PV energy system may also be checked and downloaded using the same web site. The system as it is built uses 7.33mWh of energy while in deep sleep mode and 425mWh when in web server mode.

In order to save energy costs, photovoltaic (PV) systems have been extensively used in residential settings. However, in many instances, it is not carefully followed up on or handled. Each PV module must be carefully monitored by a low-cost PV monitoring system, and the monitored data must be easily accessible. In order to be extensively used, the PV monitoring system must also be inexpensive. This study suggests a user-friendly PV monitoring system based on a low-cost power line communication (PLC) to meet these demands. Without a communication modem, the PLC module is designed as in [14] to save costs. Each PV module has a PLC module fitted for thorough monitoring; the data logger compiles the monitored data from each PV module and the PV inverter. Smart apps are used to provide the graphical representation of the aggregated data for easy user access. The PV monitoring system is placed at a genuine 16 400 W PV module PV system for outdoor testing. Users may use a smart device to determine the condition of the whole PV system.

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A data logger device that can record voltage and current measurements in real time while operating under fluctuating load resistance is shown in [15]. Under partial shadowing circumstances (PSCs), it employs a 3x3 photovoltaic (PV) system. In addition, compared to conventional methods, the device is cost-effective and reduces the testing time for PV system characterization. The open-source Arduino platform (Atmega-328 micro-controller) is merged with analogue voltage and current sensors to measure and save real-time performance data in the SD card assembly. In fact, the power-voltage (P-V) and current-voltage (I-V) curves of the 20W PV system are also verified by the MATLAB/Simulink research. For three separate instances, including global maximum power point (GMPP), minimised power loss (PL), and enhanced fill factor (FF), performance metrics including voltage and power are measured. The efficacy of the proposed system under the PSCs is shown in the system validation. Three separate examples are used to compute and assess real-time 3x3 size PV performance data. Short circuit current and open circuit voltage are calculated for each of the three scenarios while considering power losses. According to the simulation's findings, the percentage errors in each of the three situations are as low as 0.48%, 1.95%, and 1.37%, respectively.

Data loggers put in rural areas of poor nations must be independent, durable, and have a large storage capacity since they may be subjected to extreme environmental conditions like those described in [16]. A climate that is very hot, dry, and dusty may indicate increased equipment wear and tear. To test the data logger under controlled environmental circumstances, a test process was created and carried out in a small area. The results showed that it was durable and able to withstand severe weather. A new version with a redundant system based on an SD card was created and tested in real-world settings in order to prevent the loss of data.

The development, construction, programming, and installation of an experimental prototype of a revolutionary data logger based on free hardware and software may be shown in [17]. The data logger's efficacy is increased by remote monitoring in regions without an electrical grid or conventional wired telephone networks. Small stand-alone photovoltaic (PV) systems may be remotely monitored thanks to the Internet of Things (IoT) integration in solar measuring systems, which improves the system's performance and maintenance. The data recorder measured electrical and environmental characteristics with the requisite precision outlined by the IEC61724 standard (up to 14 parameters, extendable). By using 3G technology, it was possible to monitor standalone PV systems remotely through the web or a mobile application, all at a reasonable price. The new data logger was tested outside for more than a year in a variety of locales under challenging environmental circumstances, confirming the system's durability and resilience in a variety of situations.

One of the most well-known sustainable energy sources, solar photovoltaic (PV) energy accounts for a bigger portion of the production of renewable energy. In terms of performance advancement, monitoring systems have drawn a lot of attention since solar energy consumption has grown significantly over the last several decades. The battery of the solar monitoring system has been linked to a wireless platform, enabling wireless data collection from different nodes and sensors. The utility of solar PV monitoring may be constrained by a number of issues, including huge data management, long distance data transmission, signal interference, and security. As a result, a contemporary method for monitoring solar system battery activity was created and put in place [18]. This will make use of contemporary communication technology to send data across vast distances for the cheapest price and with the most battery life.

Searches for alternative energy sources have intensified due to the depletion of fossil fuel resources and the rising demand for energy. Solar energy is one alternative energy source that works well in the tropical area. Photovoltaic (PV) energy is one of the solar energy technologies that has started to be extensively employed. The output of a PV system is strongly influenced by the surrounding environment, particularly the sun's strength and temperature. The PV production is further impacted by soiling (dust) and shadowing (shadows), in addition to these two variables. A data logger-based instrumentation framework for PV panels is created to examine voltage and current [19]. Real-time data on the PV output in the form of voltage and current as well as environmental factors like the surrounding temperature and sun intensity were gathered. An avometer will be used to compare the data logger's measurement findings to manual measurements. Thermocouple observations will be compared to temperature data.

With the aid of the MATLAB tool, a model for a Battery management unit for a Solar PV-based off-grid standalone system is implemented in [20]. Any autonomous system needs a secondary storage component, such as a battery, to offer an energy backup. Since a lithium ion (Li Ion) battery has a favourable charge and discharge profile, a high power density, takes up less space, and requires less maintenance, it has been taken into consideration for modelling. By regularly observing and managing their State of Charge (SOC), such batteries must be operated safely. The battery's remaining energy is guaranteed by the SOC calculation, which also makes it easier to discharge it in accordance with system demands. The main parts include of representing the PV source, using MPPT, managing the DC output using a boost converter and an inverter, and regulating the energy flow from the source to the battery, load, and vice versa. [20]

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One of the well-known renewable energy sources that contributes a larger portion of the energy produced from renewable resources is solar photovoltaic (PV). Monitoring systems have drawn a lot of interest in regard to performance improvement since the demand for solar energy has increased significantly over the last several decades. The monitoring system for solar PV recently got integrated with a wireless platform that includes wireless data transfer and data collecting from different sensors and nodes. However, a number of challenges, including huge data management, signal interference, long-range data transmission, and security, might impair the efficacy of solar PV monitoring. It is suggested in [21] to use PV-based monitoring solutions that concentrate on different data processing modules and data transmission methods. The kind, design, implementations, requirements, and limits of each module- and transmission protocol-based monitoring technology are examined.

A contemporary measuring and instrumentation system must include data logging. The majority of industrial processes call for data logging. A proprietary data logger makes it difficult to find an affordable and practical solution for data recording in industrial and scientific processes today. [22] presents the design and development of a two-channel data logger, which offers a practical and affordable way to monitor and record the voltage, current, power, and energy of two PV solar panels. The developed prototype data logger is based on the Arduino UNO and allowed data recording on an SD card or on the memory of an Android smartphone using Bluetooth.

III. DESIGN AND IMPLEMENTATION

An analogue data logger's architectural layout is seen in Fig 1. The I2C communication protocol, which is supported by the Arduino Mega 2560 micro-controller, is used to link the sensors to it. Both the ACS758 and the ADS1115 are 16-bit, 150 kHz analog-to-digital converters. The ACS758 is a 100A Hall-Effect current sensor. The Dallas D180B20 is a digital thermometer. The I2C interface connects all three of these sensors to the controller. An XL7015 1005V buck-converter is used to monitor the battery system, which powers the Arduino.

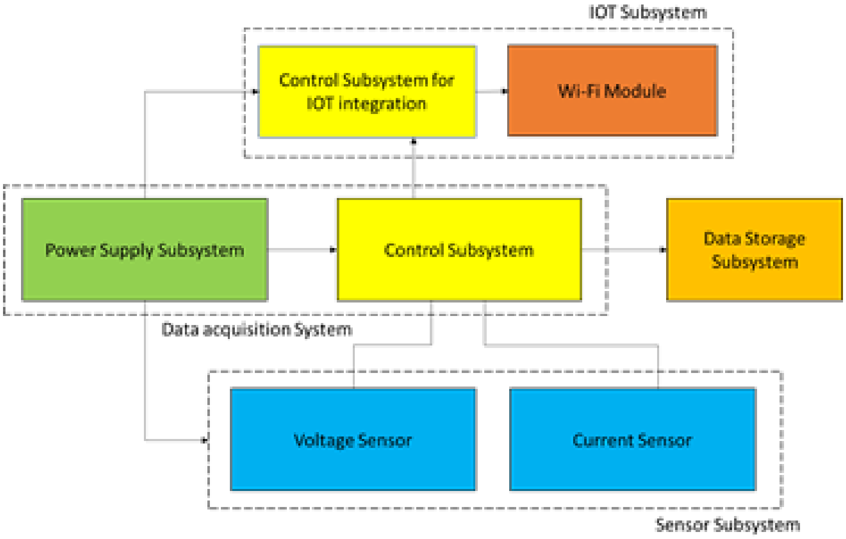

Fig. 1 Block Diagram of the Analog Data Logger

The data logger's components are installed on the printed circuit board (PCB) as indicated in Fig. 2. A four-cell battery is used to power this. Eight channels on the data logger allow you to record any eight parameters coming from the sensor subsystem or the system it communicates with. These are the subsystems that make up a data logger:

a) A power supply system,

b) A control system, and

c) A data storage system

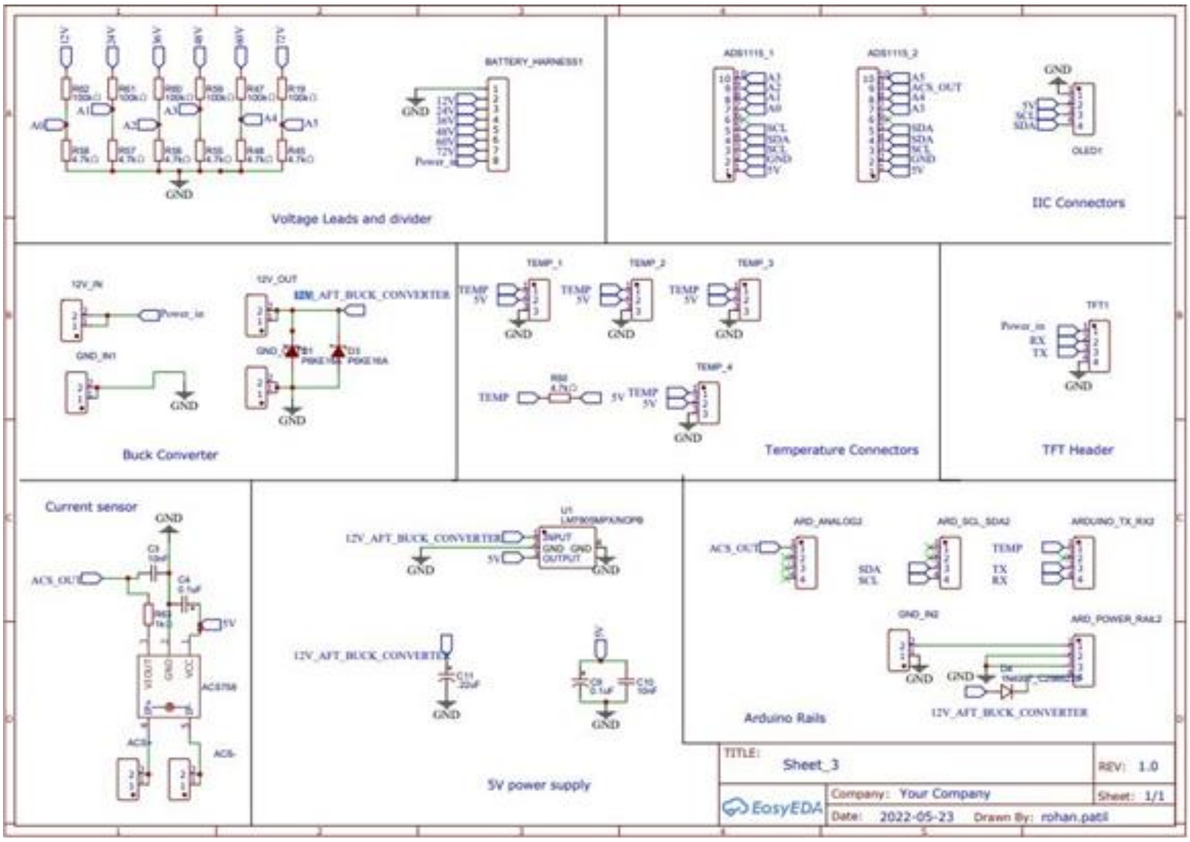

Fig. 2 Schematic Diagram of the Analog Data Logger

Data may be logged using the Control Subsystem. Eight data input channels make up the control subsystem, which reads data from the system with which it interacts. These data channels need an input that falls between 0 and 5 volts. Through eight Analogue to Digital Converter (ADC) connections, these analogue signals are sent to a microcontroller in the data logger. Using scale factors suitable for each channel, the micro-controller transforms the voltage to floating point integers.

The storage media and microcontroller work together to save the data on the storage medium for analysis. The integers received in the control subsystem must be multiplied with the appropriate scale factors to get the actual input values. The sensor readings may be saved in the data storage subsystem after they have been acquired and calibrated in the control subsystem. Through the Internet of Things (IoT) and Wi-Fi module, data may also be transferred to cloud storage (Google Sheets) for remote access.

A current data recorder is designed to record data on battery currents and voltages. The sensors in the reading voltage range of 0 -5V are used to acquire these data. The micro-controller's internal software handles these conversions. The programme allows users to alter scale factors.

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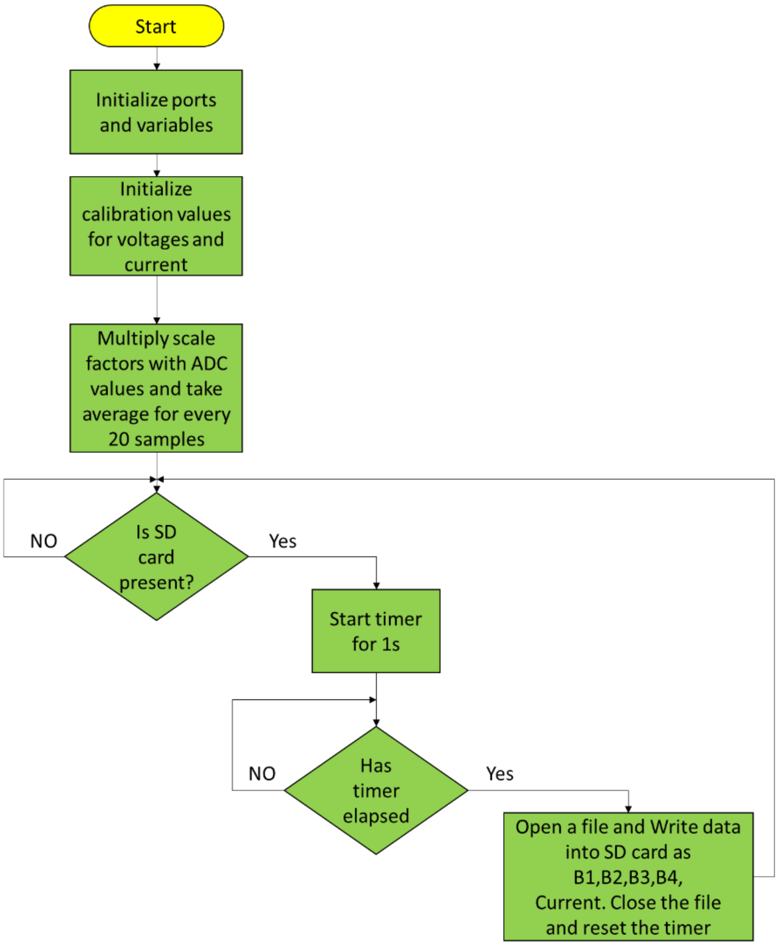

Fig. 3 Flow Diagram of the data logger – Primary

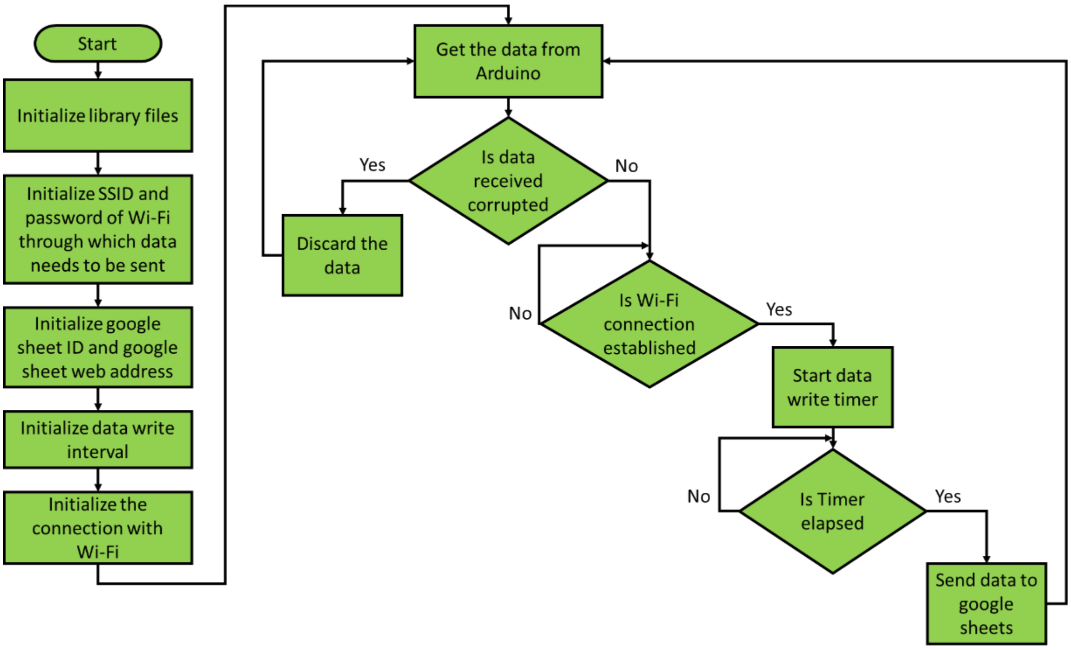

Fig 4. Flow Diagram of the data logger – Secondary

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Figures 3 and 4 depict the software flow for the main and secondary data loggers, respectively. These are the procedures to be followed:

1. Using the scale factors for the individual channel voltages and currents, initialise all the calibration-related variables.
2. Setup library files and the Baud rate.
3. To get the real input data to the sensor, read the sensor values and multiply them by scaling factors.
4. Calculate the average across all 20 samples and save it as a variable.
5. Verify if an SD card is present. You may do this by using the command SD.open(). If an SD card is inserted, SD.open() returns a TRUE result.
6. If an SD card is provided, open a file and enter the following numbers every 1 second: the voltages of Batteries 1, 2, 3, and 4, as well as the charging and discharging currents. The programme allows to alter the data recording time.
7. Close the file.
8. Repeat the process from Step 3.

IV. RESULTS AND DISCUSSIONS

This section focuses on the outcomes of the suggested work's execution and discusses their consequences. The data from an analogue data logger installed in an electric bicycle with NDS motors is shown in Fig. 5. The logger was developed using an ADS1115 ADC. For the purpose of calculating speed, variables such as recording battery voltage across the battery, battery in the motor, DS18B20 temperature sensor for battery temperature, and TU with GSM support (TFT100) are recorded. The information shows how an analogue data logger has changed over time.

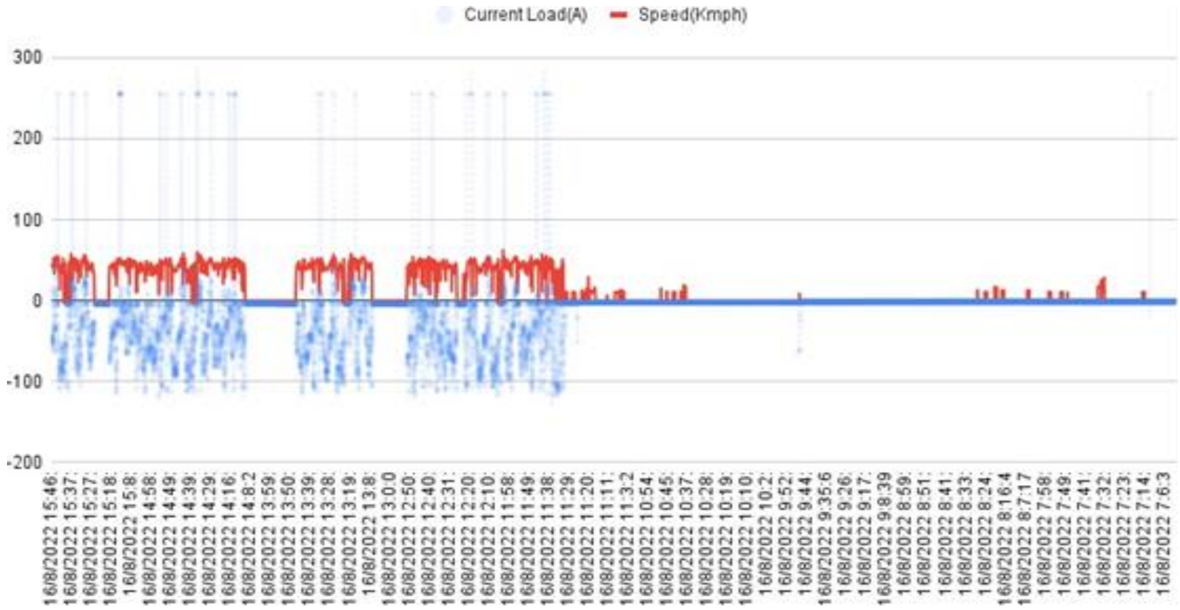

Fig. 5 Response of the Analog Data Logger

V. CASE STUDY OF THE ANALOG DATA LOGGER

The results from two electric bikes with NDS motors that were equipped with analogue data loggers are tabulated in Table 1 and Table 2.

The motor current and voltage across the bike's battery are measured by the data logger's ADS1115 ADC and ACS758 current sensor. The temperature of the battery is determined by the DS18B20 temperature sensor readout. Every two seconds, the data is refreshed, and the recording duration may be adjusted to meet specific needs.

Table 1: Analog Data Logger Data Sheet Electric bike 1

Time	**SOC [%]**	**Voltage [V]**	**Current Load[A]**	**Battery Temperature**	**Speed [Kmph]**	**Power [Watts]**
16/8/2022 15:46:47	56	47.07	-21.25	36.875	21	1000.2375
16/8/2022 15:46:45	55.1375	46.98375	-24.75	36.90625	21	1162.847813
16/8/2022 15:46:43	54.4625	46.91625	-23.25	36.921875	21	1090.802812
16/8/2022 15:46:41	54.3875	46.90875	-22.5	36.921875	21	1055.446875
16/8/2022 15:46:39	53.9375	46.86375	-31.25	36.90625	21	1464.492187
16/8/2022 15:46:37	55.85	47.055	-21.75	36.921875	21	1023.44625
16/8/2022 15:46:35	57.4625	47.21625	-23	36.9375	22	1085.97375
16/8/2022 15:46:33	56.675	47.1375	-19.5	36.9375	22	919.18125
16/8/2022 15:46:32	56.0375	47.07375	-26	36.9375	22	1223.9175
16/8/2022 15:46:30	55.8125	47.05125	-21.25	36.953125	22	999.8390625
16/8/2022 15:46:28	**55.2875**	**46.99875**	**-24**	**36.953125**	**22**	**1127.97**
16/8/2022 15:46:26	54.9125	46.96125	-26.75	36.984375	21	1256.213438
16/8/2022 15:46:24	53.7875	46.84875	-28.25	37	21	1323.477188
16/8/2022 15:46:22	53.4875	46.81875	-25.5	37	21	1193.878125
16/8/2022 15:46:20	54.5	46.92	-25	37.03125	21	1173
16/8/2022 15:46:18	54.6125	46.93125	-26.5	37.03125	21	1243.678125
16/8/2022 15:46:16	55.0625	46.97625	-25.25	37.015625	21	1186.150313
16/8/2022 15:46:14	54.65	46.935	-25.75	37.015625	21	1208.57625
16/8/2022 15:46:12	**55.2875**	**46.99875**	**-24.25**	**37.015625**	**21**	**1139.719688**
16/8/2022 15:46:10	56.1125	47.08125	-24	37.03125	22	1129.95
16/8/2022 15:46:8	56.525	47.1225	-23.75	37.03125	22	1119.159375
16/8/2022 15:46:6	56.8625	47.15625	-23	37.078125	22	1084.59375
16/8/2022 15:46:4	56.9375	47.16375	-23.25	37.078125	22	1096.557187
16/8/2022 15:46:2	56.375	47.1075	-23.75	37.078125	22	1118.803125
16/8/2022 15:46:0	56.3	47.1	-25.25	37.078125	21	1189.275
16/8/2022 15:45:58	56.825	47.1525	-24	37.09375	21	1131.66
16/8/2022 15:45:56	57.3875	47.20875	-22	37.109375	21	1038.5925
16/8/2022 15:45:54	55.7	47.04	-26.75	37.125	22	1258.32
16/8/2022 15:45:52	55.3625	47.00625	-28.75	37.15625	22	1351.429688
16/8/2022 15:45:50	59.525	47.4225	-29	37.171875	21	1375.2525
16/8/2022 15:45:48	77.4875	49.21875	7.25	37.203125	21	356.8359375
16/8/2022 15:45:46	60.5	47.52	-19.25	37.234375	21	914.76
16/8/2022 15:45:44	60.35	47.505	-21.5	37.265625	23	1021.3575
16/8/2022 15:45:42	63.2	47.79	-24	37.265625	23	1146.96
16/8/2022 15:45:40	74.45	48.915	-2	37.296875	26	97.83
16/8/2022 15:45:38	74.9375	48.96375	-1.75	37.296875	26	85.6865625

When visualising the response, data from Table 1 are utilised. It is anticipated that the response will be constant (flat) throughout the application for a certain period of time.

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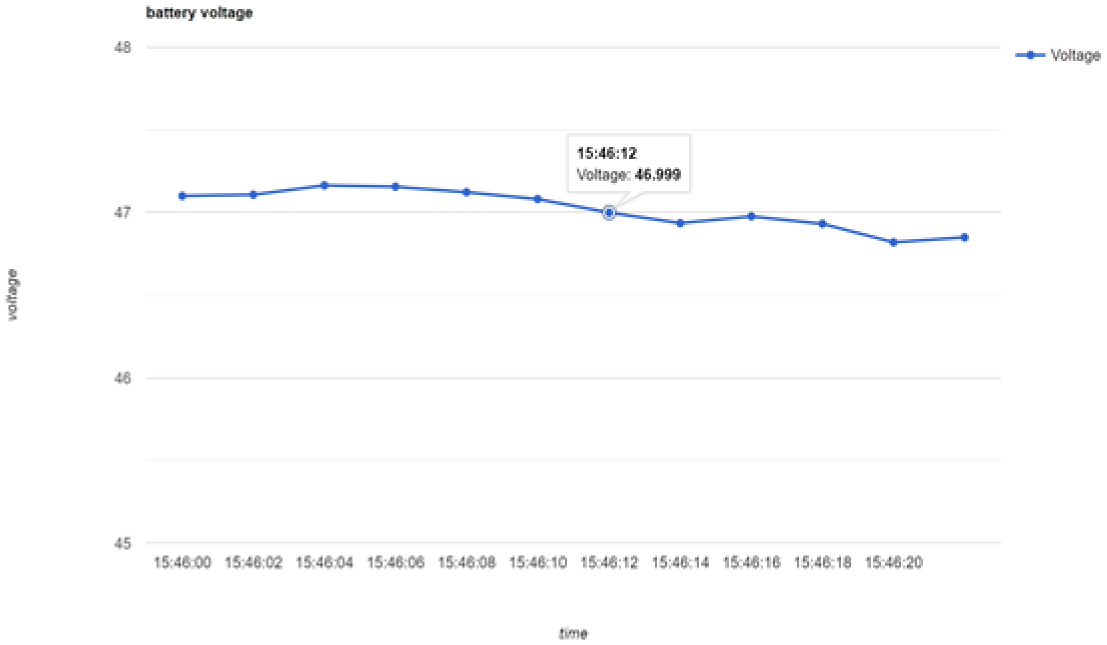

Fig. 6 Response of Battery Voltage Variations of Electric Bike 1

It is possible to determine the vehicle's speed from the GPS data using the data from the telemetry unit (TFT100). The information from the analogue data recorder, such as the battery voltage and motor current, may be utilised to calculate the vehicle's on-board speed in rotations per minute (RPM), wheel diameter, and other mechanical specifications. The vehicle's determined instantaneous speed is shown in Figure 7 as a depiction. In order to plot it, power fluctuation on voltage with regard to time is taken into account.

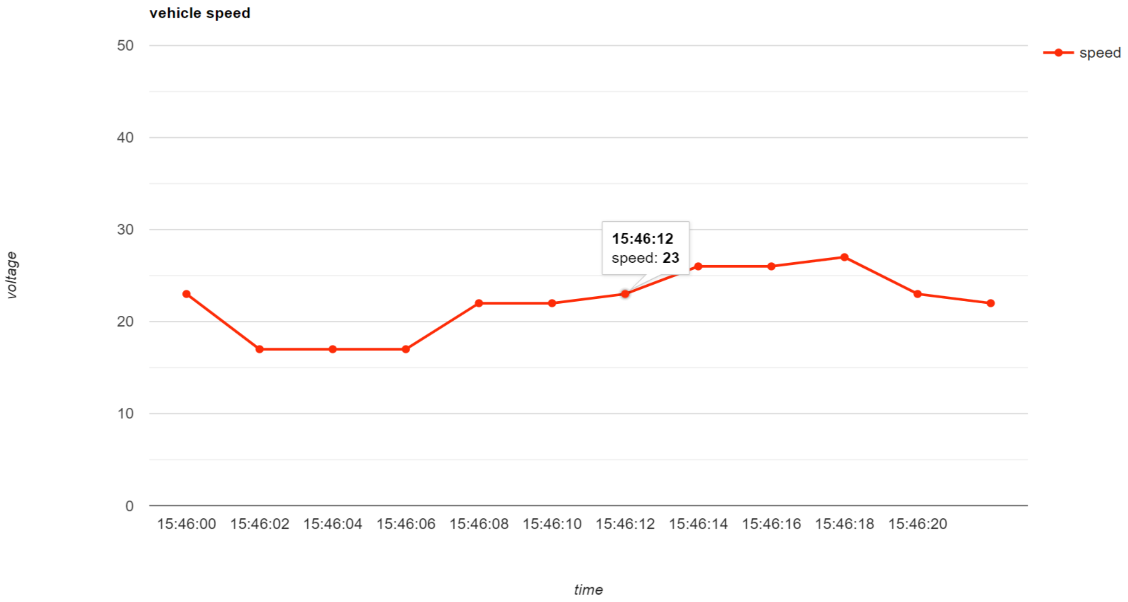

Fig. 7 Variations of Speed for Electric Bike 1

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Table 1: Analog Data Logger Data Sheet Electric bike 1

Time	SOC [%]	Voltage [V]	Current Load[A]	Battery Temperature	Speed [Kmph]	Power [Watts]
16/8/2022 15:45:36	77.375	49.2075	1	37.296875	26	49.2075
16/8/2022 15:45:34	79.025	49.3725	5.75	37.28125	24	283.891875
16/8/2022 15:45:32	78.05	49.275	3.75	37.25	24	184.78125
16/8/2022 15:45:30	76.5875	49.12875	5.5	37.265625	23	270.208125
16/8/2022 15:45:28	72.725	48.7425	0.5	37.265625	23	24.37125
16/8/2022 15:45:27	69.2	48.39	-4.5	37.28125	23	217.755
16/8/2022 15:45:25	65.825	48.0525	-10.25	37.296875	17	492.538125
16/8/2022 15:45:23	60.425	47.5125	-16.5	37.296875	17	783.95625
16/8/2022 15:45:21	52.5125	46.72125	-31.75	37.3125	17	1483.399688
16/8/2022 15:45:19	75.2375	48.99375	7.75	37.328125	22	379.7015625
16/8/2022 15:45:17	71.075	48.5775	-2.25	37.328125	22	109.299375
16/8/2022 15:45:15	62.7125	47.74125	-15.75	37.328125	23	751.9246875
16/8/2022 15:45:13	62.075	47.6775	-17.75	37.34375	23	846.275625
16/8/2022 15:45:11	63.35	47.805	-13.5	37.34375	22	645.3675
16/8/2022 15:45:9	62.975	47.7675	-17	37.359375	22	812.0475
16/8/2022 15:45:7	62.45	47.715	-16.75	37.359375	22	799.22625
16/8/2022 15:45:5	62.375	47.7075	-17.25	37.359375	23	822.954375
16/8/2022 15:45:3	62.3	47.7	-17	37.34375	23	810.9
16/8/2022 15:45:1	62.7875	47.74875	-17	37.34375	23	811.72875
16/8/2022 15:44:59	62.5625	47.72625	-18.75	37.359375	22	894.8671875
16/8/2022 15:44:57	62.375	47.7075	-19	37.359375	22	906.4425
16/8/2022 15:44:55	64.5125	47.92125	-17.25	37.34375	23	826.6415625
16/8/2022 15:44:53	66.2	48.09	-17.5	37.34375	23	841.575
16/8/2022 15:44:51	66.875	48.1575	-18	37.34375	23	866.835
16/8/2022 15:44:49	68.675	48.3375	-15.75	37.34375	26	761.315625
16/8/2022 15:44:47	71.4875	48.61875	-13.75	37.3125	26	668.5078125
16/8/2022 15:44:45	72.725	48.7425	-9.5	37.328125	22	463.05375
16/8/2022 15:44:43	74.4125	48.91125	-8.5	37.328125	22	415.745625
16/8/2022 15:44:41	77.4125	49.21125	-4.25	37.328125	22	209.1478125
16/8/2022 15:44:39	84.7625	49.94625	11.5	37.3125	26	574.381875
16/8/2022 15:44:37	89.7125	50.44125	19.25	37.296875	26	970.9940625
16/8/2022 15:44:35	88.175	50.2875	15	37.28125	27	754.3125
16/8/2022 15:44:33	89.1125	50.38125	22	37.296875	27	1108.3875
16/8/2022 15:44:31	88.775	50.3475	21.25	37.25	27	1069.884375
16/8/2022 15:44:29	87.875	50.2575	21.5	37.265625	25	1080.53625
16/8/2022 15:44:27	87.35	50.205	19	37.265625	25	953.895
16/8/2022 15:44:25	85.475	50.0175	18.75	37.234375	23	937.828125
16/8/2022 15:44:23	81.7625	49.64625	14	37.234375	23	695.0475
16/8/2022 15:44:21	75.65	49.035	3	37.234375	23	147.105
16/8/2022 15:44:20	65.8625	48.05625	-9.25	37.234375	21	444.5203125
16/8/2022 15:44:18	59.0375	47.37375	-16.75	37.234375	21	793.5103125

The power flow in the battery may be computed using the observed voltage across the battery and the current going to and from the motor. The user may be alerted to the crucial values shown in Fig. 8 by having these data immediately checked for any odd levels. The power flow is shown in the following graph.

Fig. 8 Variations in Power Flow

When the accelerator is depressed, the power value progressively increases along with the increase in motor current, reaching a maximum of 789 watts. Regenerative power is generated in a very little quantity when the brakes are applied, as illustrated in the graph.

VI. CONCLUSIONS AND FUTURE SCOPE

Using data monitoring, scientists and engineers may evaluate a variety of factors, from weather patterns to industrial performance. The greatest customization, integration, and flexibility are offered by PC-based data recording systems. To create a data logging system, it is required to evaluate each need for data collection, processing, recording, display, and report output. As a result, data recording software and hardware may be updated to meet any needs depending on the requirements. Open source hardware and software are available on the Arduino platform for all purposes. The conversion, storage, measurement, and computation of numerous electrical characteristics in an electric car are comprehensively examined using an Arduino-based data logger. It is especially beneficial for data logger applications since it has an integrated Analogue to Digital Converter (ADC) module. The created data logger is discovered to be functionally equivalent to proprietary data loggers and to fulfil all the required requirements. The designed prototype data logger has been successfully converted to function as a proprietary data logger, and its operation and functioning are deemed to be acceptable.

Future opportunities for the inexpensive data recording and monitoring of electrical and physical parameters are abundant in the proposed approach. In the future, it may be feasible to integrate internet of things (IoT), wireless sensors, and wireless relays into a data logger design that can conduct remote monitoring, data recording, and measurement of an electric vehicle's electrical and physical properties.Future research might explore how protection circuit functions using wireless relays and analyse various physical aspects like temperature, wind speed, etc. Future study might explore wireless control for automatic process control. The operation of the data logger in various weather circumstances could be tested since the impact of weather conditions was not taken into account when it was designed and developed. The programming of the data logger that was built is solely connected to the data recording of the direct current (DC) amount of an electric vehicle battery, but it may be readily modified in the future to monitor other physical quantities.

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