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IoT Innovations in Power System Monitoring: Reviewing Transmission Line Multiple Fault Detection Systems

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Abstract

In this review, it is possible to highlight a new project idea called Transmission Line Multiple Fault Detection System with Internet of Things (IoT). It is a IoT based research that helps in identifying multiple failures on transmission lines leading to fast and correct response. It consist of installing many senors of different types like temperature sensors, current sensors, and vibration sensors on the lines in order to carry out uninterrupted monitoring of all line's parameters. These sensors collect data which is communicated to a control center through a wireless communication network for real time calculation and decision making.

Keywords: Arduino-based transmission line fault detection, Voltage Sensor, Voltage divider, Current Sensor, ESP8266, Transformer ac to dc, Android/web application

INTRODUCTION

When a fault occurs in an overhead transmission line system, there are abrupt changes in voltage and current at the fault site that produce a high frequency signal. These signals, also known as travelling waves because they are electromagnetic impulses, travel along the transmission line in both directions away from the fault site. The electrical power system is irritated by a wide range of natural and man-made events, which can negatively affect the general stability and performance of the grid.

The defect has a very low impedance. During the fault, the fault current is comparatively high. The supply to the reduced area is impacted as the power flow is redirected through the fault. Finding the error as soon as feasible is crucial.

Currently, when a fault arises in India, we are not notified in real time by the system. The lack of a real-time system is concerning since it may harm the underlying connected devices and endanger the nearby living things. Frequent maintenance or checking of the transmission cables is typically done in order to minimize the likelihood of such accidents. The Internet of Things (IoT) plays a key role in enabling real-time data gathering, analysis, and communication by allowing devices and sensors embedded in physical infrastructure to be networked. IoT-enabled sensors can be positioned strategically along transmission lines to monitor a variety of factors, including vibration, temperature, voltage, and amperage. These sensors collect data continually and use networks of wireless communications to send it to a central management system. The electrical grid is the foundation of any contemporary society, and it must function reliably to support daily living. However, the stability and resilience of the grid are severely hampered by the fault-proneness of transmission lines. Blackouts and

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disturbances can be avoided and reduced by quickly identifying and fixing errors. Within this framework, integrating Internet of Things (IoT) technology shows promise to improve transmission line problem detection capabilities. This article examines the idea of an Internet of Things-based Transmission Line Multiple Fault Detection System and how it affects grid resilience.

Recognising the Challenge

Short circuits, line breaks, and insulation failures are just a few of the many fault types that can affect transmission lines, which are exposed to extreme weather over long distances. It is imperative to rapidly identify these errors in order to avoid cascading failures that may result in extensive disruptions. Conventional fault detection techniques frequently rely on labor-intensive, time-consuming manual inspections or periodic assessments, which may not be able to identify flaws in real-time. Automated, effective fault detection systems are desperately needed as grid complexity and electricity consumption both rise.

METHODOLOGY

Using sensors to monitor voltage, current, temperature, vibration, and other characteristics along the transmission line is a key component of the Internet of Things technology for problem detection in transmission lines. These sensors gather data in real time and wirelessly send it to a central monitoring station. This data is analyzed by the central system to find any anomalies or transmission line problems. Below is a general process outline as shown in Figure 1.

Sensor Deployment

Position sensors along the transmission line at key points. It should be possible for these sensors to measure pertinent variables including vibration, temperature, voltage, and current. Although wired and wireless sensors are both possible, wireless sensors are recommended due to their ease of deployment and maintenance [7].

Data Acquisition

The sensors gather information about the transmission line's working characteristics continually.

Data Analysis and Processing

Real-time data processing is done by the central monitoring system once it receives it from the sensors. The data is analyzed using sophisticated analytics algorithms to find any anomalies or patterns that might point to transmission line failures. By learning from past data and seeing minute patterns connected to various defect kinds, machine learning algorithms can be used to increase the accuracy of fault detection.

Localization and Detection

Following the discovery of a problem, the system needs to pinpoint its location along the transmission line. This can be done by comparing the readings from several sensors and analyzing the data to determine which part of the line the irregularity happened on. methods like impedance-based techniques or time-domain reflectometry (TDR).

Alert Generation and Notification

When a fault is identified, the system sends out alerts and notifications to the appropriate staff, like operators or maintenance teams, to let them know about it. Alerts can be distributed by email, SMS, or a specific dashboard interface [8-11]. The message ought to contain information on the kind and location of the error as well as suggestions for fixing it.

Remote Maintenance and Monitoring

The Internet of Things (IoT)-based monitoring system makes it possible to remotely monitor the transmission line, giving operators access to diagnostic data and real-time data from any location. As a result, there is less downtime and quicker reaction times for preventative maintenance and troubleshooting.

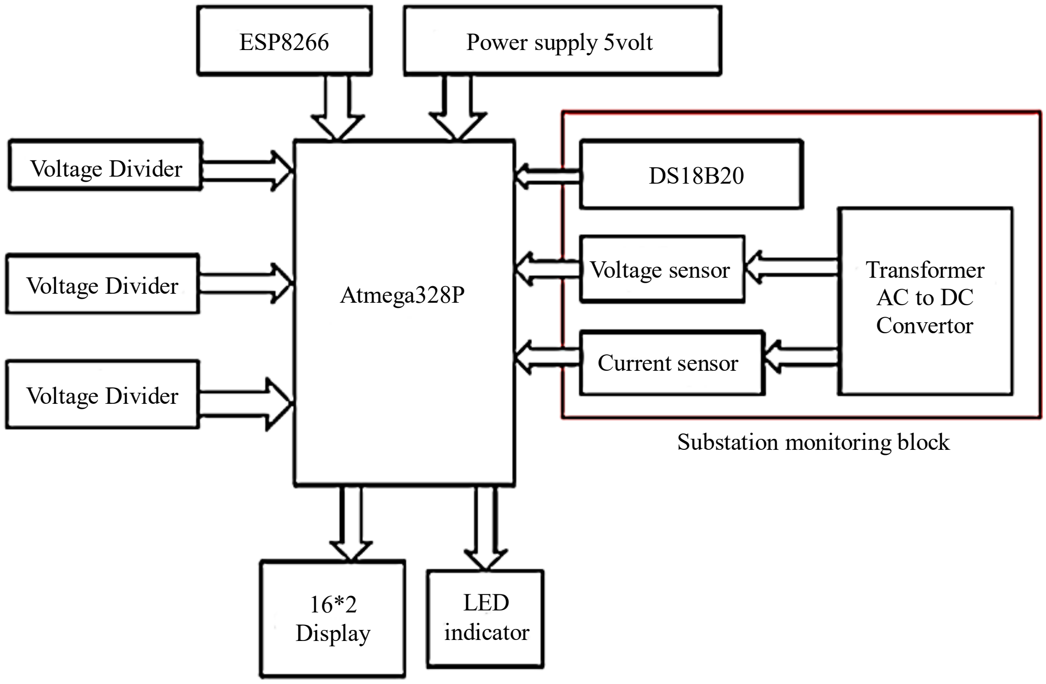

Figure 1. Block diagram of system.

LITERATURE REVIEW

Here are few articles referred and studied for better understanding of the concept as shown in tabular form in Table 1.

COMPONENTS USED FOR THE CONSTRUCTION OF PROTOTYPE

Hardware

ESP32 Board

In this paper, we shall talk about NuiVend's utilization of a range of technologies in this essay. For example, Microsoft Kinect, other Microsoft Cognitive API services, relay and sensor boards, and the control software's general logic. Lastly, we talk about future directions for NuiVend and Microsoft Language Understanding Intelligent Service (LUIS) approaches that can be used for a variety of additional NUI based projects in the future.

The ESP32 is a low-cost, low-power system-on-a-chip (SoC) microcontroller as shown in Figure 2 that has Bluetooth and Wi-Fi built right in. Because of its advantages and versatility, it is frequently used in many different IoT (Internet of Things) applications.

ATmega328P Microcontroller

- This is the primary part that manages the board's functionality. Fourteen digital pins are available for usage as outputs or inputs. The Arduino IDE's digitalWrite() and digitalRead() routines can be used to control them as shown in Figure 3.
- Pins for pulse-width modulation (PWM): Six digital pins (3, 5, 6, 9, 10, and 11) can be uses as PWM outputs.

Transformer AC to DC Convertor (Figure 4)

- Input Voltage: AC 85~265V 50/60Hz or DC100~370V
- Output Voltage: DC5V (+/- 0.2 V)
- Output Current: 700mA
- Power: 3.5W

Table 1. Related articles and their analysis.

Title	Author	Publication Year	Methodology	Constituents
IOT based transmission line multiple fault detection and indication to EB	Mr. S. Surendiran, D. Naveen Kumar, S. Palraj, S. Sankar, K. Vignesh	2021 [1]	In order to monitor the transmission lines and rapidly alert the Electric Board about any faults, an Electric Board (EB) can implement an Internet of Things - based transmission line multiple fault detection and indication system.	GSM Communication Pic 16F877A, Microcontroller, Node MCU.
Three phase transmission line fault detection & protection	Abhijeet Lad, Ajaykumar Khopkar, Sahil Lad ,Vaishnavi Kalaskar, AS Yadav	2022 [2]	Three-phase transmission lines require a complete technique that includes both fault detection and protection methods to detect and prevent failures.	Microcontroller 89C51, Transformer.
Design, analysis And Fabrication of A Transmission Fault Detector	M. K. Das1, K. Rout and J. K. Moharana	2013 [3]	To guarantee a transmission fault detector's efficacy, dependability, and safety, several procedures must be taken during the design, analysis, and fabrication processes.	GSM Modem, RF, transmitter/receiver, LED, Atmega16.
Monitoring and fault detection system for power transmission using gsm technology	Okokpujie Kennedy, Amuta Elizabeth, Okonigene Robert, Samuel John	2017 [4]	To guarantee effective operation and prompt fault detectionand a GSM (Global System for Mobile Communications)-based monitoring and fault identification system for electricity transmission technology must be designed in several processes.	Pic microcontroller, GSM technology.
Fault detection and monitoring systems for photovoltaic installations: A review	Triki-Lahiani A, Abdelghani AB, Slama-Belkhodja I	2018 [5]	Major solar system failures are discussed in this work. After that, solar monitoring methods that have been suggested in recent literature are reviewed and examined to highlight their benefits, drawbacks, and distinctions.	
Real-time sensing and fault diagnosis for transmission lines.	Shakiba FM, Shojaee M, Azizi SM, Zhou M.	[6]	Through the use of convolutional neural networks, it demonstrated a reliable detection and identification method.	CNN, time-based voltage and current data

Figure 2. ESP32 Board.

Figure 3. ATmega328P Microcontroller.

Figure 4. Transformer AC to DC convertor.

Voltage Sensor

- This module can reduce the input terminal connection's voltage five times and is based on resistive voltage divider design principles.
- The maximum voltage that can be used on the module's adc side is 5 volts, allowing for a maximum input voltage of 25 volts as shown in Figure 5.

SOFTWARE COMPONENTS

Arduino IDE

- One well-liked open-source tool for programming microcontrollers is the Arduino IDE. It offers an easy-to-use interface for uploading and creating code. Numerous boards and microcontrollers that are Arduino-compatible are supported by the Arduino ID. It uses the Wiring language, based on C/C++, making it accessible to beginners.
- The IDE includes a built-in code editor with features like syntax highlighting and auto completion. Users can easily manage libraries and board configurations within the IDE.
- Arduino IDE offers a straightforward process for verifying and uploading code to connected devices. It works with multiple operating systems, such as Linux, macOS, and Windows as shown in Figure 6. Arduino IDE is actively maintained by a community of developers and enthusiasts.
- It is still a well-liked option for academics, professionals working in embedded systems and electronics, and enthusiasts.

Figure 5. Voltage sensor.

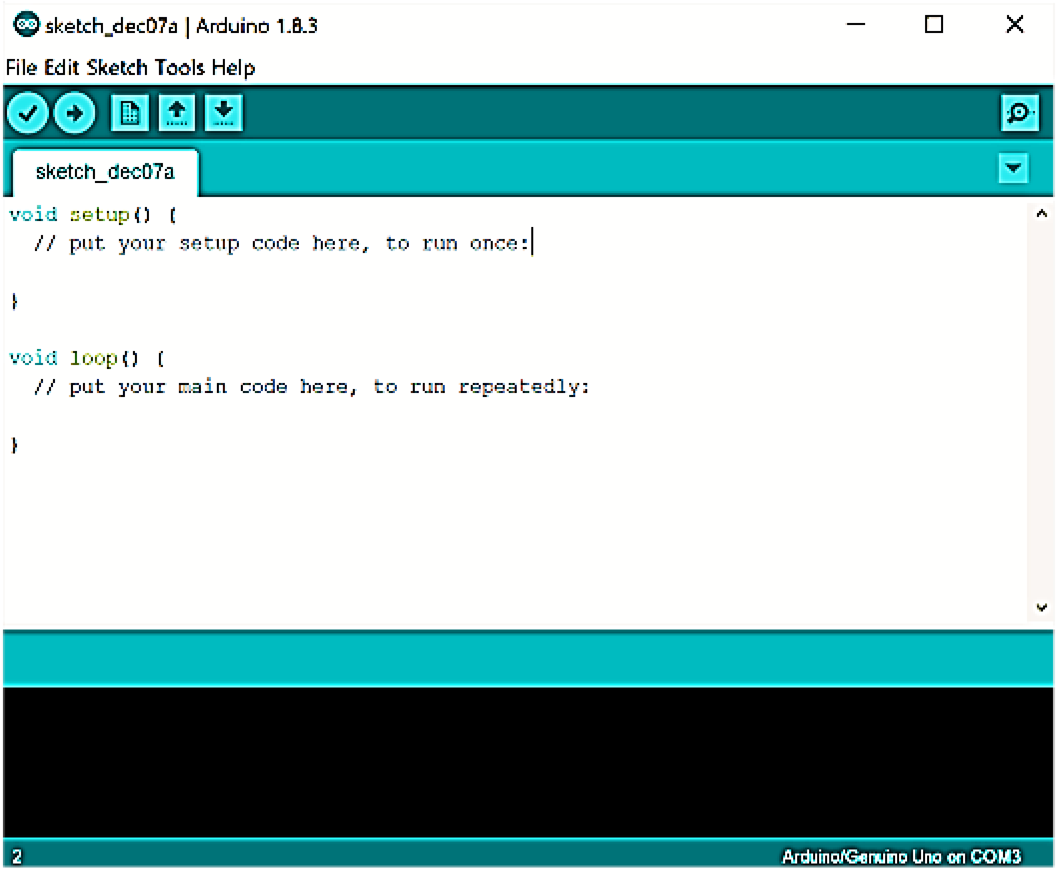

Figure 6. Arduino IDE.

PROTEUS SOFTWARE

Proteus is a popular electronic design automation (EDA) software tool used for schematic capture, simulation, and printed circuit board (PCB) design as shown in Figure 7. It's commonly used by engineers and electronics enthusiasts to design and test electronic circuits and PCB layouts. Proteus allows users to create schematics, simulate circuit behaviour, and design PCBs within a single integrated environment. It's a valuable tool for prototyping and testing electronic projects before physical implementation. Please let me know if you have specific questions or if you'd like more information about using Proteus.

SYSTEM FLOW CHART

The final working algorithm presented in Figure 8.

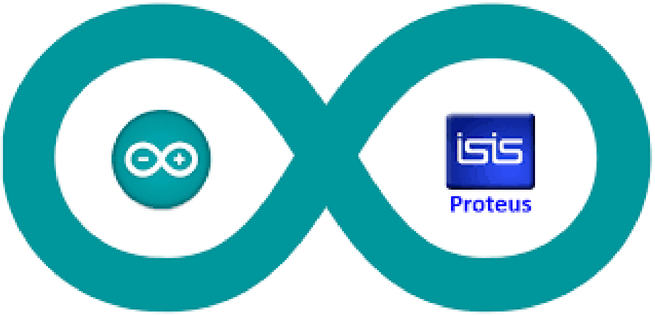

Figure 7. Proteus software.

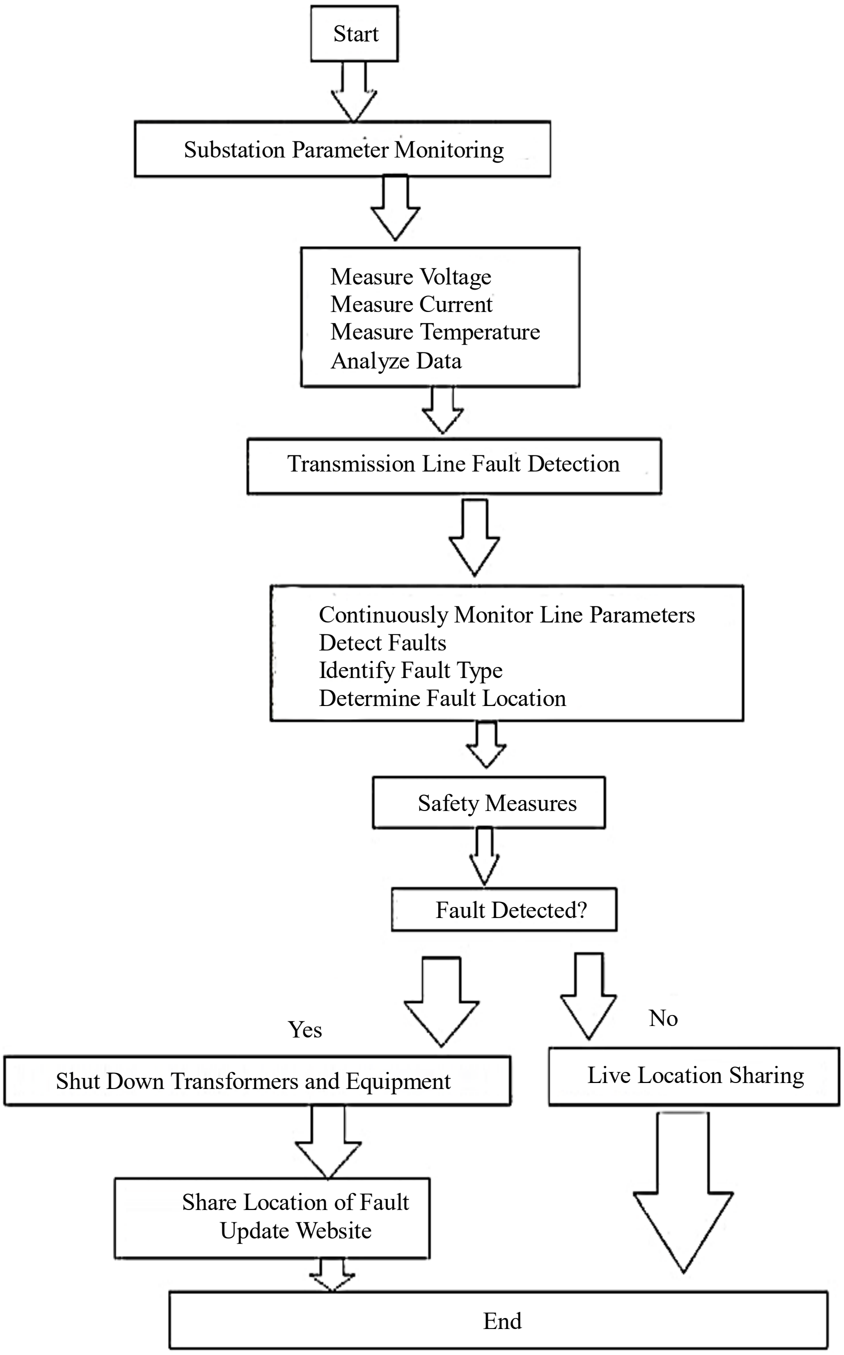

Figure 8. Flowchart of proposed algorithm.

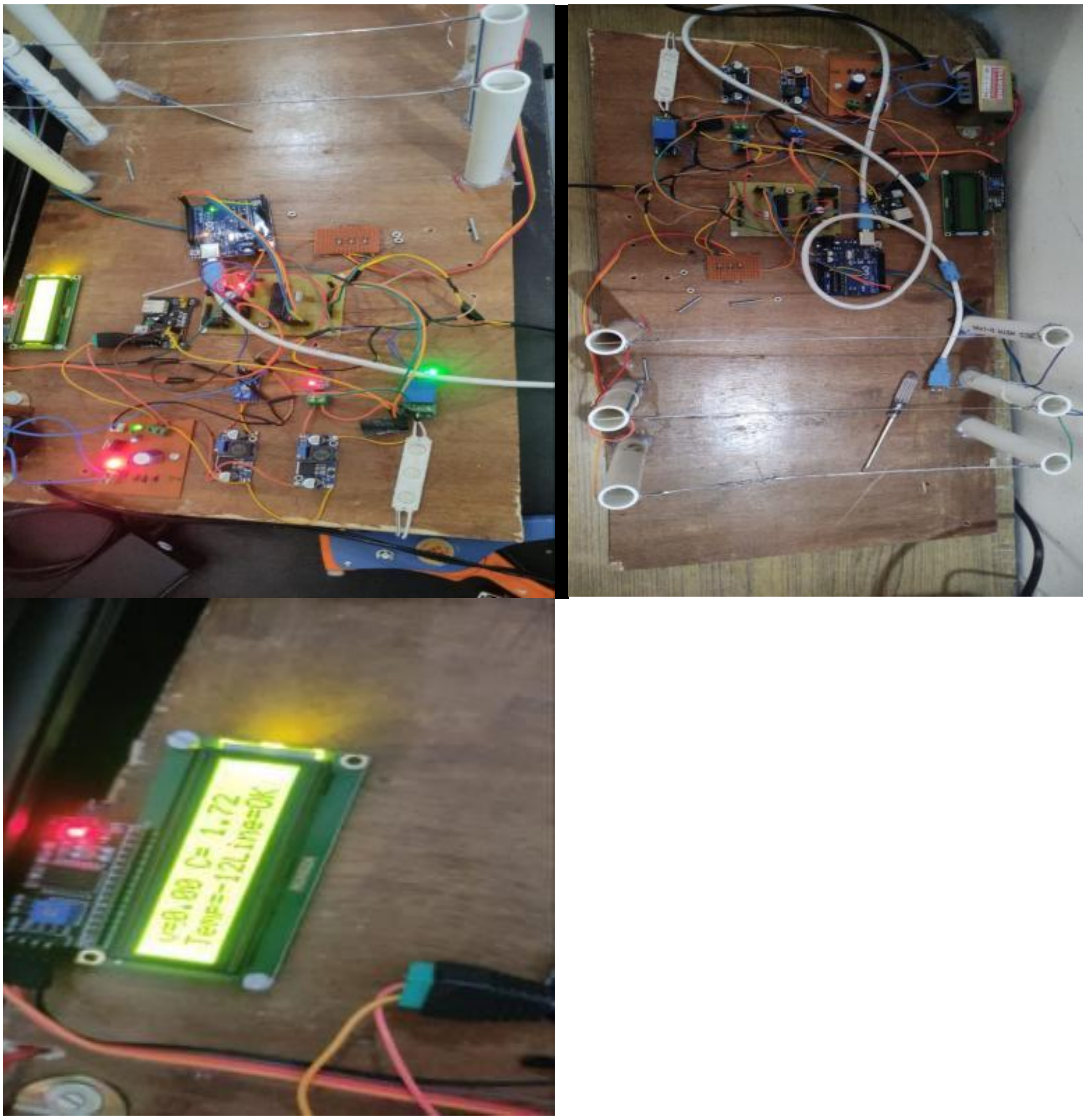

Figure 9. Display of the wired prototype.

RESULT

- In this we can compute the result of electric transmission line fault detection as shown in figure 9.
- We can compute the L-G fault, or we can observe the temperature of the line in this we can take the advantages of this to monitor the system.

FUTURE SCOPE

- 5G Connectivity: As 5G networks are deployed, data transfer speeds and dependability will increase, enabling even greater real-time control and monitoring capabilities.
- Artificial Intelligence (AI) and Machine Learning: Better defect detection, predictive maintenance, and data analytics will all be improved by more developments in AI and machine learning processes.

CONCLUSION

The model's purpose is to address the power system's issues. Such an approach makes it simple to identify and fix the problem. It finds the fault in a three-phase transmission line and is very dependable. It is also meant to store data.

It makes it possible to keep all real-time data sheets current and prevents transmission line issues in the future. The initiative has many benefits, but it also has drawbacks, such as the need for technical know-how, reliance on internet access, and possible environmental restrictions. Effective design, upkeep, and adaption, however, can mitigate these drawbacks.

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