GSJ: Volume 9, Issue 8, August 2021, Online: ISSN 2320-9186
www.globalscientificjournal.com

DESIGN OF ROBUST POWER SYSTEM FOR FREQUENCY CONTROL IN INDUSTRIAL SECTORS FOR ENHANCING SCIENCE EDUCATION

[1]Oladayo Abraham Oladele, [2]Irionye James and [3]Akanbi Olawale

[1]Department of Electrical and Electronic Engineering, Transmission Company of Nigeria, Osogbo, Osun State

[2]Department of Curriculum and Instruction, Adeyemi College of Education, Ondo State, Nigeria

[3]Department of Machine Learning and Algorithm Development, Embeddedkits Technologies, Osogbo, Osun State, Nigeria

ABSTRACT

The technique of remote monitoring of different gadgets and machinery in process plants businesses is catching on in the decades to come. Constant progress has been made in industrial automation development thanks to remote monitoring and diagnosis, which is done almost entirely through computers and the Internet. - A conventionally used SCADA system in the electricity system uses voltage and frequency as their primary system monitoring parameters, which are checked consecutively at regular intervals. It is feasible to reduce the observed voltage and frequency data to a single string that is then sent to monitoring/control room, where it may be compressed using appropriate data compression methods. To extract the required data from the sent string, use the appropriate decompression method at the receiving end. In order to allow a compressed string to be decoded into the input voltage and frequency, a MATLAB-based system was created that can generate this compressed string and output the voltage and frequency corresponding to the input. Aspects that have emerged as critical design issues in the development of a supervisory control system that is internet-based include latency (delays on the internet), the security of the system, and the design of the interface. In this project, the designers of supervisory control systems, namely, internet latency and security, faced all of the many design problems found on the Internet. The key objective of this system is to provide automated real-time XML report creation for the online and offline processes. Programmable Logic Controllers (PLCs), Supervisory control and data acquisition (SCADA), and virtual private networks (VPN) all play a part in making automation Internet-based. The software was built utilizing SCADA (Supervisory Control and Data Acquisition) software, PLC (Programmable Logic Controller) applications for controlling the real-time process, and VBA/front page scripts for managing information systems. Utilizing XML encoding and solely using VPN through GSM

connection for communication between the server and client, the individual monitoring device may further enhance the system's security.

Keywords: Frequency Control, Industrial sectors, Power System, Robust and Science Education

1.0 Introduction

People who are not scientists should be taught about science. For example, they may be schoolchildren, college students, or the general public. Teaching science involves addressing all of the many aspects of science instruction, from topic to procedure, to include social science, and even some pedagogy. It is all about increasing a person's knowledge of science, and encouraging scientific literacy and responsible citizenship.[1-2] Communicating about science will enable folks to improve their science-related knowledge. Network Control Systems that utilize the Internet as the common communications network are sometimes referred to as Internet-based Control Systems. The Internet forms a critical component in Internet-based control systems. These systems rely on a control point where instructions are given and data is monitored, a point where those orders are carried out and data is gathered, which may include sensors and actuators, and the Internet. A window of opportunity has opened up for control engineers as a result of the Internet-based control systems that enable customers to see production conditions in real time. Manufacturing can help businesses gain more flexibility by providing them with the ability to consolidate all control and expertise into one location, thus reducing the amount of time and money spent on sending out expert teams. [3] With a huge number of access points, the Internet enables experienced and competent plant managers in one place to provide remote help to plant managers in other locations and cooperate as if they were all at the real site, even though one may be situated far away from the other. It enables sales and marketing teams to dynamically alter production rates in response to fluctuating demand and market conditions. An added benefit is that it may help improve openness, so government watchdogs and consumer organizations can conduct inspections of facilities to make sure they follow best practices. [1] A virtual laboratory utilizing SCADA (Supervisory Control and Data Acquisition) has been described in this system. In this example, the remote laboratory (a two-level inverter, measuring equipment, a magnetic Power brake, and an AC/DC converter) is utilized to show the efficacy of an Induction Motor control. An integrated control system was built, consisting of a programmable logic controller (PLC) and a SCADA system, to monitor and control the functioning of the system. Control of induction Motor Remotely through SCADA is described in detail here. This Laboratory environment for many users provides an affordable option with the Remote Laboratory. Students that use this system will be able to use the actual laboratory instruments while at home, thanks to the Internet. The proposed design also empowers students to assist better their fellow classmates. SCADA skills used in industrial environments [2], [6].

Many alternators, linked to one another and to the system load, are operated in parallel in contemporary power systems. The alternators must be synced with each other and with the bus bar or the National Grid in order to service these linked loads. The entire network of linked power stations is often referred to as a grid. A more precise way of saying this is that grid is the interconnected system of power plants that are linked together by connecting their alternators in

© GSJ

parallel (which may be accomplished after synchronizing them with one another or with the busbar). For changing load, the parallel operation ensures service continuity maintenance, even when the load fluctuates according to the generation and maximum efficiency is required. Only after the alternator has been synchronized can it be connected in parallel. Receiving alternator and bus bar voltage, frequency, phase angle, and phase sequence should be same [1, 2, 4].

Regardless of the rapid change in load or the unexpected outage of one or more alternators linked to it, the entire interconnected system voltage and frequency stays constant because of the inertia of the system. [As a consequence of a glitch or malfunction, the system becomes unstable and the voltage and frequency deviate from their usual values [3]. Throughout order to avoid loss of synchronism, the system voltage and frequency must be monitored constantly in the whole network. This process of continuously monitoring synchronization parameters for sending data to monitoring stations at the state, regional, and national levels uses SCADA (Supervisory Control and Data Acquisition) systems [5].

The information, usually sent individually in two cycles, is used to monitor voltage and frequency. You might combine the voltage and frequency data into a single string before sending it to the computer, resulting in a bigger string that may have no noticeable impact on the system's performance. The data being sent may be compressed to decrease the length of the actual data string using appropriate data compression methods. If it's possible to condense the transmission of voltage and frequency data, the amount of time needed for transmission will be greatly reduced. [7-8] Another approach that makes use of the mathematical operation known as "Basic Arithmetic Coding" (a lossless data compression technique) is described in this article. This method compresses voltage and frequency values to a single character array, reducing the number of characters. Received voltage and frequency are obtained on the receiving end by decompressing the array of sent voltage and frequency values. It's explained in the following diagram: the suggested voltage and frequency monitoring system using SCADA compression technology is shown below. When using the data compression method, it is shown below.

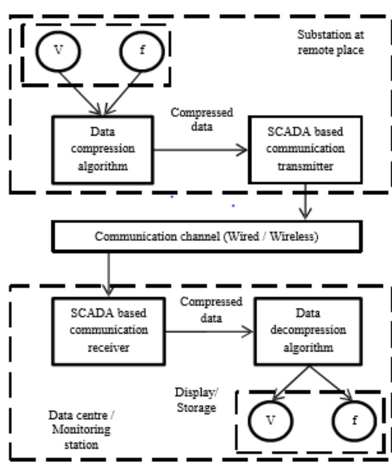

Figure 1: An electric and frequency monitoring system utilizing data compression is being proposed.

GSJ© 2021
www.globalscientificjournal.com

Source[9-11]

Power generation and load demand should be equal so that system stability may be maintained in the actual world. SCADA system is used for both monitoring and control of distant field equipment through an appropriate communication connection. Measuring and transmitting the data to the control center whenever it is required is achieved using meters, sensors, and other measurement devices located at the distant end. Supervisory information may be transmitted by automated or operator-driven control centers to field devices according to that information. When this is done, the circuit breakers or valves will be opened and closed, data from sensors will be collected, and the local environment will be monitored. SCADA offers a broad range of industrial applications. Due to its widespread use in the energy industry, substations and producing stations may be remotely controlled and operated. The basic SCADA architecture is shown below, with five, six, and seven on the left.

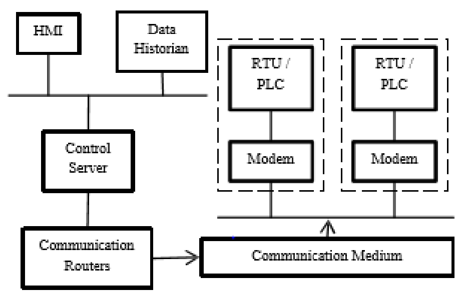

Figure 2: Scanning Control and Data Acquisition Structure

Source [10]

Sensors in the system are connected to RTUs, which send their data to the supervisory system. It may also receive orders from a supervisory system. In addition to sensors, programmable logic controllers (PLCs) do not come equipped with any telemetry hardware. Due to their economics, adaptability, flexibility, and configurability, PLCs may replace RTUs. For signal transmission between field equipment and the control center, a wired or wireless communication system is needed. Data Historian, Control/Data Acquisition Server, Communication Router and HMI make up the control center. Human-Machine Interface (HMI) is used to provide the processed data to the human operator for monitoring and interaction (HMI). There are many different types of data in Data Historian's database that may be accessed through HMI. They may access data from field devices via an appropriate protocol [6] since both HMI and Historian are clients of data acquisition server.

2.0 MATERIALS AND METHOD

They were intended to provide near real-time information on the present status of the remote process, as well as to manipulate/control it remotely via the use of a human operator. In a typical SCADA system, there are four subsystems:

1. The central computer (host system responsible for all data processing).

2. Remote terminal unit is a field-based remote measurement and control device (RTU).

3. All of these pieces of equipment must be connected through a wide-area communication system (telephone, Internet, or intranet). For the most reliable data transmission, a fiber-optic communication network is often utilized to connect various pipelines and their associated equipment.

4. An operator's interface enables the users to have an access to a computer system.

Despite advances in technology and topology, the SCADA system's basic architecture and four key subsystems have remained virtually unchanged throughout the years (Figure 3).

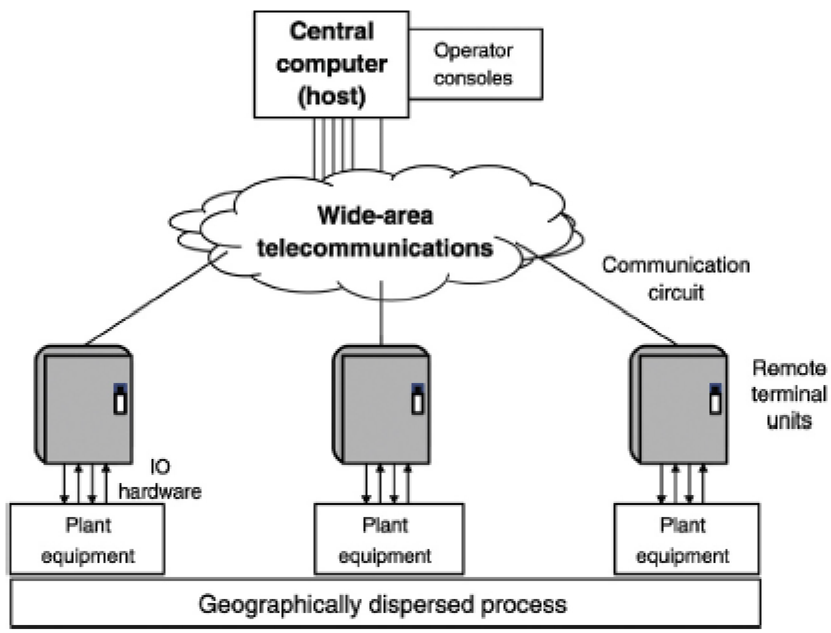

Figure 3: .Simplified diagram of a SCADA

The following are the core functions of a SCADA system:

1. RTU-based data collection from field instrument devices.

2. In order to detect alarms and other important process changes, field data is processed to identify them.

3. Providing an uniform database of pipeline and facility process information.

4. Visual user interface, alerts, trends, and reports for simple understanding of the data.

5. Controlling field equipment remotely.

6. Monitoring and diagnosing the system, and taking necessary measures, if needed.

7. Recent and long-term preservation of data.

8. Modeling systems, such as pipeline application systems, may receive and provide real-time engineering data directly.

9. Assisting supply chain management and management information systems (MIS) with system data.

10. Assisting in the integration of GIS facilities.

Figure 4 depicts the overall system architecture of the proposed system. Data may be sent and received between various analog devices via the network using an M2M server, which is outlined in this system's design. In order to establish a remote monitoring system in this system, a real-time process station is being explored for implementation.

For real-time monitoring and control, a PLC ladder program is utilized to create a process monitoring setup utilizing Allen Bradley PLC (1400 series).

SCADA is used to create a high-level monitoring and control system for process parameters, which allows for the visualization of process parameters and control actions. For the Management Information System, a SCADA system is built, which incorporates XML reporting that fetches process information and real-time parameters (MIS). By using this report, it is possible to analyze real-time data via the Internet, and then diagnose process parameters as a result. This system has been presented with a completely new network architecture .[4]

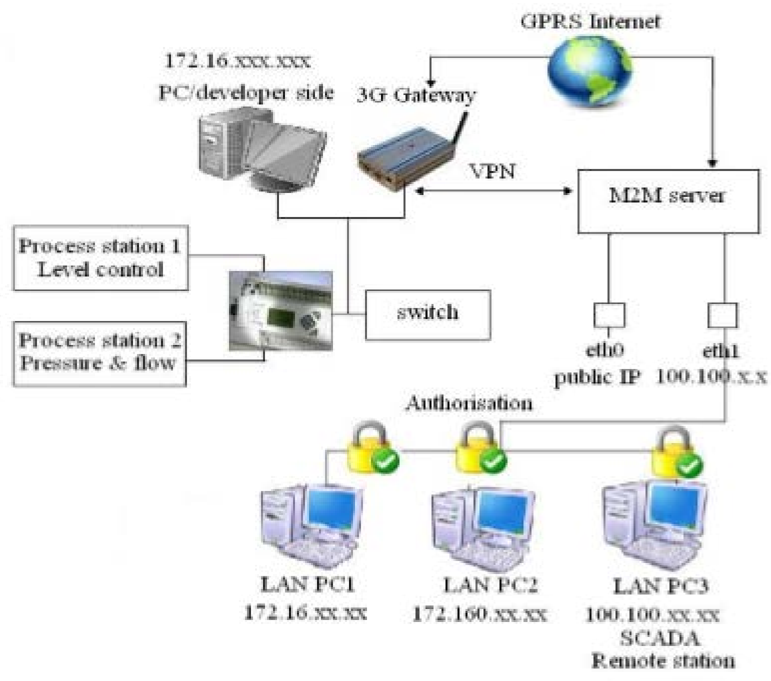

Figure 4: Architecture of the system

Client/Server architecture is used to create the real model of the system. The distant plant is referred to as the customer. 3G Arctic gateway device is used for wireless Internet connection through GPRS to link the process monitoring system to the gateway device for wireless Internet communication. A MOVICON SCADA software must be created on the client side in order to link distant PLCs through M2M devices. M2M gateway device is linked to one of the server nodes through public IP address and the other server node is connected to the local area network by a number of data channels. [10],[9]

Virtual Private Networks (VPNs) link the M2M and Arctic gateway (VPN).

SCADA applications need various degrees of user authentication in order to prevent unwanted access and to allow authorized users to view real-time data. Whenever a problem occurs, the plant engineers use the Internet to perform a remote diagnostic. An Information Management System (IMS) for real-time process parameters is also proposed for the next phase of this project. Web-based Remote Monitoring Industrial Automation System is a novel approach.

Input:

volt - Voltage (kilovolt) round up to the nearest 2 decimal place,

freq - Frequency (Hetz) round up to the nearest 2 decimal place

Output:

rem - Number of zeros added,

ce - Length of Compressed string,

comarr - Combined string character string

© GSJ

STEP 1: Enter the voltage and the frequency.

STEP 2: Multiply voltage and frequency by 100 to convert them to string of decimal numbers.

STEP 3: vf is formed by concatenating voltage and frequency.

STEP 4: Calculate vf's string length (lac).

STEP 5: Calculate vf's value in the range nmin - nmax.

STEP 6: Between nmin and nmax, find bin, the binary array with the lowest bits.

STEP 7: To get na, concatenate the array elements bin and zero.

STEP 8: Split up na into 7 X ce arrays..

STEP 9: A null array asci (1 X ce) is initialized with the value i := 1.

STEP 10: Then, repeat steps 11 through 13 until i ! = ce+1

STEP 11: : Calculate the decimal number that relates to division (7 X i).

STEP 12: : Calculate the ascii value of deci and insert it in the ascii (i).

STEP 13: : Counter i will be increased by 1.

STEP 14: The loop is complete.

STEP 15: In this case, the SCADA system transmits a reduced array asci.

STEP 16: Stop.

Algorithm's result is as follows.

Input

Voltage of the System = 220.32 KV

Frequency of the System = 50.15 Hz

Steps that are intermediate

vf is ‘220325015’

lac is 9.0

nmin is 0.220325015

nmax is 0.220325016

© GSJ

Output

rem is 1.0

ce is 4.0

comarr is ‘   sC’ corresponds to ASCII values ‘14 12   115 67’

In order to retrieve the actual sent value, the compressed string must be decompressed at the receiving end. In order to decompress, however, the system needs to know the compressed string length and the number of zeros appended to the binary string. This system's reception algorithm will be as follows.

Input:

comarr - Character string that has been compressed.,

rem - The number of zero added,

lac - Length of combined string,

ce - Length compressed string

Output:

Vrx - Voltage received from the system,

Frx - Frequency received from the system

STEP 1: reveive rem, comarr, lac & ce.

STEP 2: Declare array deci as null, then initialize i:=1 (1 X ce).

STEP 3: Repete step 4 and 5 until i ! = ce + 1

STEP 4: : Calculate the decimal equivalent of comarr(i), then you can store it in deci (1, i).

STEP 5: : Counter i increase by 1.
STEP 6: The loop is complete.

STEP 7: Initialize j := 1 & a null array bin(ce X 7).

STEP 8: Repeat steps 9 & 10 until j != ce+1.

STEP 9: : Determine the binary array corresponds to deci(1, j) & store the 7-bit result in bin (j X 7).

STEP 10: : Increment counter j by 1.

STEP 11: End of the loop.

STEP 12: Bin1 will be arranged in the (1 X 7 * ce) array.

STEP 13: with len, find bin1 array size

STEP 14: Remove the first len bits from bin1 to obtain the actual binary array actb.

STEP 15: The float value, fl, that corresponds to actb is computed from it.

STEP 16: Using fl & lac, the arithmetic decompression method yields the number string nmst.

STEP 17: Two strings (v1 & f1) are created by splitting nmst (voltage & frequency respectively).

STEP 18: The voltage and frequency are converted to transmitted system voltage and frequency by converting v1 and f1 to decimal and multiplying them by 0.01.

STEP 19: Stop.

Although SQL is not an API in and of itself, it is often used in SCADA systems to exchange data with other systems or between complex application applications (Figure 5).

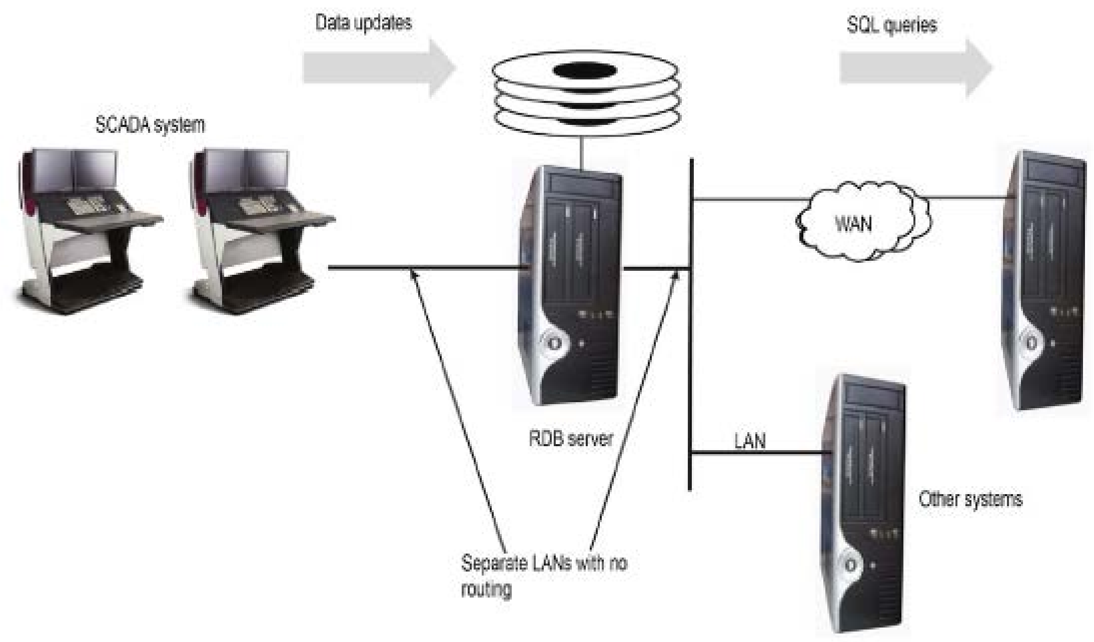

Figure 5: Use of SQL-compliant relational database server for SCADA communication.

Data and config information may be overwhelming in certain kinds of systems, such as pipeline models, which rely on their own relational databases. GIS applications also often store their data in relational database tables. Database query language SQL and migration of major relational database packages to Wintel and Linux/Unix systems have made this possible.

© GSJ

3.0 RESULT AND DISCUSSION

This method allows for the compression of power system stability parameters. Data storage requirements are reduced since the number of characters is reduced significantly. This decreased string size also reduces transmission time if this data has to be sent to others. Transmission voltage levels (132 kV & above) and normal frequency are suitable for this method. For voltage levels below this threshold, the algorithm must be changed. Through the use of this method, it is also feasible to implement any appropriate communication scheme's arithmetic coding-based data compression. The algorithm's output for a variety of inputs is shown in the table below.

Output

Table 3.1

Different input values result in compressed data and matching output.

Sl. No	Input		Compressed data	Output	
	Voltage (kV)	Frequency (Hz)		Voltage (kV)	Frequency(Hz)

1	132.21	50.02	‘ !l5u’	132.21	50.02
2	220.12	50.14	‘ pZ ;’	220.12	50.14
3	400.15	49.98	‘ f8#[’	400.15	49.98
4	765.23	50.01	‘ Cs ’	765.23	50.01

As shown in table 3.1, the algorithm produces accurate answers for a variety of transmission voltage and frequency input values. The length of compressed data may, however, vary depending on the input. arithmetic-based data compression produces a length binary array that is dependent on the number string. As a consequence, the compressed string may have a different length. The disadvantage of this algorithm is that to decode the compressed string, the length of the combined voltage and frequency string, the length of the binary string, and the length of the array of zeros added before the binary string must be known, which is extremely difficult in a real-world scenario. By integrating all of this data with the compressed string, which can subsequently be retrieved at the decoding stage, this problem may be avoided. Despite the fact that the compressed string's length rises, it still contains less characters than the transmitted combined array.

To solve this issue, some SCADA systems compute the hourly value (rather simply retrieving it at hour demarcation) using minute data gathered in the previous hour, as an example. If you use this method, you may get a more typical result instead of only recording immediate data. Hourly recorded values may be calculated from the previous hour's data using the average/mean, maximum or lowest value (or all of them) (s). There is an alternative to simply overwriting (and losing) the oldest historical data when new information is recorded in SCADA systems. The oldest data values are transferred onto a removable storage medium before being overwritten (and lost) (Figure 6).

GSJ© 2021
www.globalscientificjournal.com

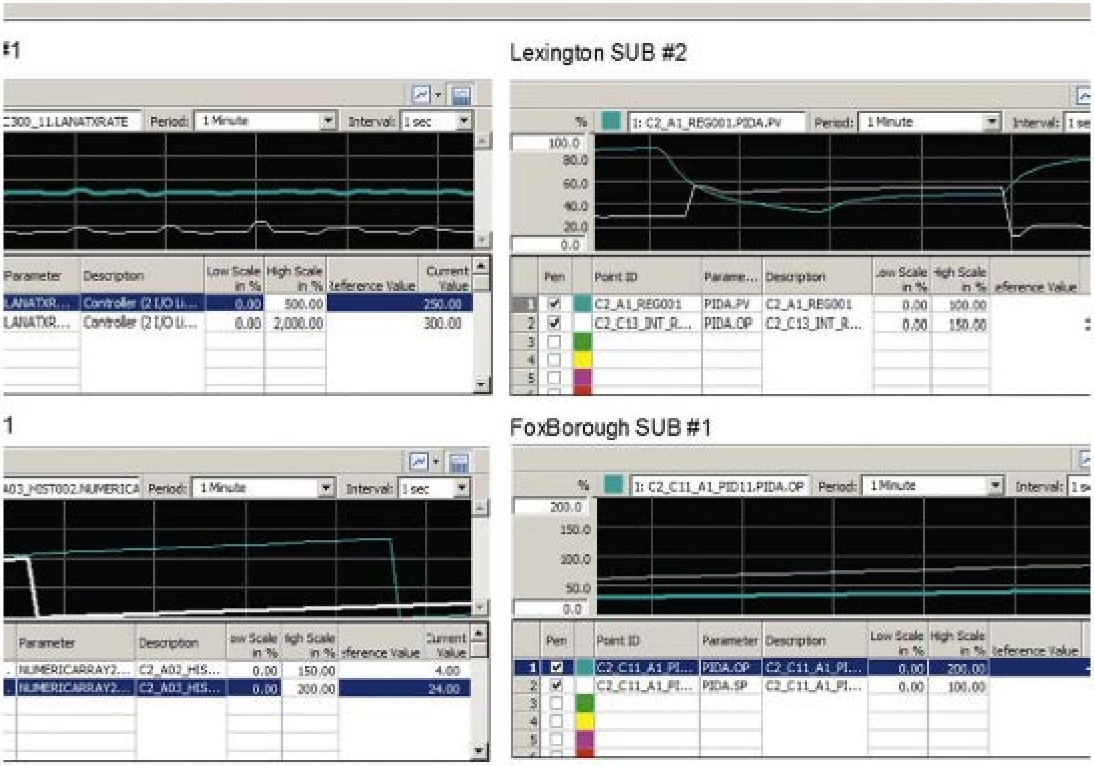

Figure 6: An example of a historical trending graph

However, if required at a later date, the data may be transferred (temporary) into the system disk or mounted in the appropriate portable media drive, and then made accessible for display on the SCADA system. Off-line storage refers to data that is not instantly accessible, but must be retrieved through human intervention (and potentially a data transfer procedure). Online storage refers to data that resides on the hard drive(s) and may be accessed instantly by application applications. Disks that can be removed and read directly, such as CDs and DVDs, have blurred this line a little. However, it is not necessary to transfer the data on a hard disk in order to access it. No time limit is set for the preservation of historical data records in certain businesses. In order to meet this requirement, off-line storage may be used as a permanent method of data preservation. As a result, its loss or modification may have a financial effect in certain instances.

4.0 CONCLUSION AND RECOMMENDATION

Because of its great security and little internet latency, this technology is unique in that an industrial process may be managed and monitored from any location in the globe. With the technology, online reports on real-time processes may be produced. It was explained that these are XML reports that may be accessed through the internet environment Therefore, we can adapt this remote monitoring system for industrial level monitoring. Virtual Private Networks (VPNs) link the M2M and Arctic gateway (VPN). SCADA applications need various degrees of user authentication in order to prevent unwanted access and to allow authorized users to view real-time data. As soon as a problem arises, the plant's engineers are notified via remote diagnostics over the Internet. It's easy to use and dependable. It's versatile and affordable. This framework may also be applied to many Real-time scenarios.

REFERENCE

[1] Wang, C., Lida, X., and Peng., W. (2007) ""Theoretical design of remote monitoring and problem diagnostic systems," Science Direct (Information Systems), vol. 32, pp.996-1004.

[2] Goel A. and Shankar R., (2018)" A Wireless SCADA System for Remote Data Acquisition", International Journal of Engineering (IJE), Volume (3): Issue (1), p.

[3] Raghavendra, D., Sowjanya, A. and TulasiRam, S., (2008) "The journal Engineering Education defines real-time decision support for energy management as: ", as presented in World Congress on Engineering Vol. I, pp. 16-22

[4] Ozdemir, E., and Karacor, M., (2008) "SCADA (Supervisory Control and Data Acquisition) systems based on mobile phones for industrial automation," ISA Transactions, Volume 45, Number 1, January 2006, pp. 67–75.

[5] Da'na, S., Sagahyroon, A., Elrayes, A., Al-Ali, A., and AlAydi, R., (2008) "Monitoring and controlling PLC-based applications: a new monitoring and control platform", Computer Standards & Interfaces 30 (2008): 157-161.

[6] Yang, S., (2011) "An Introduction to Internet-Based Control Systems Design and Applications, Industrial Press, p.1-199

[7] Kakanakov et al., (2006)" Web-based multitier model for distributed automation systems", IEEE (Information Technology and Control), Volume 2, pages 17-22.

[8] Chang, W.,Yu-Chi, W., and Chiu, C., (2006) "Department. of Electrical Engineering, National United University, No.1 Lian-Da Street Miao-Li 360, Taiwan, Taiwanese Republic, volume 1, pp. 401-7

[9] Zhao, X., and Liang, W., (2008) "Hunan University of Commerce, Department of Computer and Electronic Engineering, "Research on Remote Monitoring and Intelligent Fault Diagnosis System".

[10] Changsha, (2008) "Wireless Communications, Networking and Mobile Computing" (WiCOM'08),, pp.1-4.

[11] Aydogmus, Z., and Aydogmus, O., (2009) "Web-based remote access laboratory that uses SCADA. IEEE Transactions on Education, vol. 52, no. 1, pp. 126-132

GSJ© 2021
www.globalscientificjournal.com