Smart Industries in Industry4.0: An Iot and Cloud Based Real Time Energy Meter Monitoring System

Prateek Agrawal, Himmat Khatik, Yogendra Singh Solanki, Aditya Maheshwari, Vivek Jain

Abstract: - With increase in low cost internet and with advent of 4G technologies increase in internet speed, IoT-based applications are getting more popular day by day and it provides effective solution of many real time monitoring problems. In this research, a cloud based real-time monitoring system for industrial energy meter has been proposed. The prototype system provides continuous and ubiquitous access to energy consumption of the equipment under monitoring to the consumer using IoT technology. To implement the system in any industry it requires a simple and low-cost upgrade to the existing meters rather than complete replacement. Based on the experimental analysis, it is found that from the collected data, it is possible to obtain the pattern of consumption as well as faultiness present in the existing system. In terms of future scope of work, the presented work can also be extended to grid distribution level from which load distributed in the area can be estimated so that the system can be strengthened to enhance performance.

Keywords: - CRC: Cyclical Redundancy Check, LRC: Longitudinal Redundancy Check, THD: Total Harmonic Distortions: Universal Serial Bus, Smart Energy meter, IoT, Cloud, and Load optimization.

I. INTRODUCTION

Energy management is becoming crucial day by day. Today, energy costs have become one of the major factors in industrial as well as domestic budgeting, wherefore machine power consumption monitoring is important for most of modern industries.

Most of the production plants, organizations, and factories face several challenges in their day to day plant operation and the biggest one is the energy consumption monitoring, due to their massive scale and diversified infrastructure, lack of readings or actionable data related to their energy consumption.

For industries real time insights of machine's availability, its power consumption and performance is a very crucial part to run the business smoothly, with real time cloud based monitoring of equipment's downtimes, it empowers the owner or the manager to reduce undesired and sudden equipment breakdowns, to get the maximum output by utilizing the available machinery in optimized manner.

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The proposed System fetches the real-time energy consumption readings from the meter installed on the equipment and provides the machine on-time, off-time, efficiency, and power consumption details on smart phone or Personal Computer. Unlike traditional energy management systems, the proposed real time energy consumption monitoring system provides a convenient way to accumulate and analyse power quality.

Benefits of Power Monitoring Solutions:

- Abnormality detection & Reduction in Energy Consumption
- Cost Optimization
- Real-time Energy Insights
- Increased Performance of the available Facility
- Upcoming Energy Needs prediction
- Reduced Unnecessary Equipment running

Our Low-cost monitoring system collects the following parameters from panel meter mounted on all the machineries and send to the microprocessor/ microcontroller which upload all the data to the cloud dashboard which helps to monitor the data anywhere in the world.

The objective of this research project is to develop an IoT-based energy monitoring system for the industrial sector. The proposed system is integration of the advanced low cost SoC (system on Chip) based single board computers and cloud services. The rest of the paper is organized as follows. Section II provides an overview of the system. Section III describes the working of the proposed system. Section IV discusses the results and Section V concludes the paper with future work.

II. SYSTEM OVERVIEW

The System block diagram as shown in the figure. It consists of different part as Raspberry Pi-3 Model B+, USB to RS485 Converter and Meter (elite-440).

A. Raspberry Pi

In this System Raspberry Pi is Main part of the system. The Raspberry Pi is a very low-cost pocket size, single board computer that can plugs into monitor and also Connect with the Mouse and Keyboard through USB port. The Raspberry Pi has 4×ARM Cortex-A53 of 1.2GHz CPU and 1 GB LPDDR2 RAM @ 900MHz and It has 2.4GHz 802.11n wireless Wi-Fi or 4× USB 2.0, Ethernet port.

B. Elite 440 Panel meter

The Elite 440 is a three-phase digital panel meter for accurate and reliable measurement of electrical parameters such as voltage, current, power, frequency so on for industrial and home applications. The elite 440 can easily interface with external device as it is Modus [Rs-485] enable. It can be used for both star or delta connections and low or high voltage applications measurement. It has high accuracy of Class 0.2s, 0.5s, 0.1. It also provides Average THD measurement for voltage, current and power.

USB to RS-485 converter Module

The RS-485 was developed for High speed and max data rate in minimum time's to RS-485 converter is used to perform USB to two wire RS-485 (Half Duplex) and vice versa conversion. Module can power up by the USB bus. RS-485 has maximum transfer data rate of 10Mbps at maximum distance of about 50 feet**.**

III. SYSTEM OPERATION

Elite 440 panel meter is used to measure several electrical parameters and supported Rs-485 Modbus Protocol, which is mounted on the 3-phase Motor. A Raspberry Pi is used to continuously capture the value of parameter via Modbus protocol from the elite 440 and upload it to cloud. Basic Block Diagram of Low-Cost Monitoring System is shown in figure 2. The Raspberry pi is act as a master and elite 440 as a slave device for Modbus protocol, which is connected through a USB-RS485 converter.

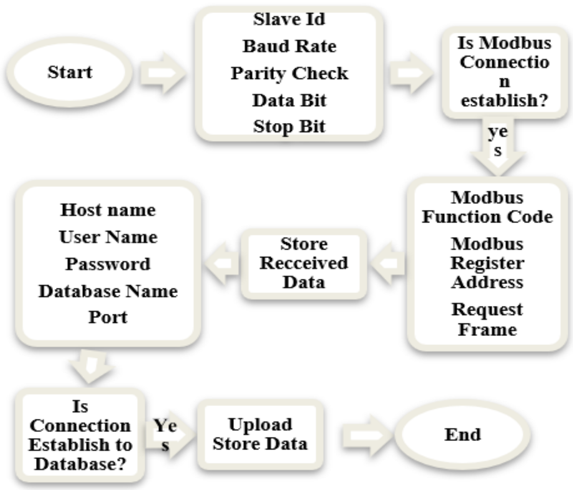


Fig. 1: Flow Chart

Modbus is a serial communication protocol works as master/slave communication. It enables communication among many devices connected to the same network. In one network there is one master and 246 slave devices communicate to each other. Each device communicating on a Modbus is given unique address. Each slave has different register to store several values in it, which can be access through Modbus communication by using Modbus function codes the value at registers can be read/write depends on type of register. Every communication has been checked by CRC/LRC. Flowchart of Low-Cost Monitoring System is shown in figure 1.

Fig. 2. Block Diagram

During Initialization, serial communication between raspberry pi and elite 440 is establish by providing the correct slave information such as slave id, baud rate, parity check, data bit, stop bit. After the successful connection raspberry pi send read register request to elite 440 with Modbus register address given is table 1 elite 440 calculate CRC of receive message frame then compare it to the received CRC if CRC matches then elite 440 respond back to master request elite 440 sends the store data of register to raspberry pi and then raspberry pi upload the data to the cloud.

Start 3.5 char	Slave Id 8-bit	Function Code 8-bit	Modbus Register Address 16-bit	CRC 16-bit	End 3.5 char

Fig.3. Modbus Request Message Frame

Table 1: elite 440 Modbus register address

Sr. No.	MODBUS Register	Parameter	Unit	In Hex
1	40100	R Phase to Neutral Voltage	Volt	0x63
2	40102	Y Phase to Neutral Voltage	Volt	0x65
3	40104	B Phase to Neutral Voltage	Volt	0x67
4	40106	Average Voltage	Volt	0x69
5	40108	RY Voltage	Volt	0x6B
6	40110	YB Voltage	Volt	0X6D
7	40112	BR Voltage	Volt	0X6F
8	40114	R Phase Line current	Ampere	0X71
9	40116	Y Phase Line current	Ampere	0X73
10	40118	B Phase Line current	Ampere	0X75
11	40120	Neutral Line current	Ampere	0X77
12	40122	R Phase Active Current	Ampere	0X79
13	40124	Y Phase Active Current	Ampere	0X7B
14	40126	B Phase Active Current	Ampere	0X7D
15	40128	R Phase Reactive Current	Ampere	0X7F
16	40130	Y Phase Reactive Current	Ampere	0X81
17	40132	B Phase Reactive Current	Ampere	0X83
18	40134	Power factor		0X85
19	40136	Power factor		0X87
20	40138	Power factor		0X89
21	40140	Average power factor		0X8B
22	40142	R- Phase Active Power	kW	0x8D
23	40144	Y- Phase Active Power	kW	0x8F
24	40146	B- Phase Active Power	kW	0x91
25	40148	3 Phase Active Power	KW	0x93
26	40150	R- Phase Reactive Power	kVAr	0x95
27	40152	Y- Phase Reactive Power	kVAr	0x97
28	40154	B- Phase Reactive Power	kVAr	0x99
29	40156	3 Phase Reactive Power	kVAr	0x9B
30	40158	R- Phase Apparent Power	kVA	0x9D
31	40160	Y- Phase Apparent Power	kVA	0x9F
32	40162	B- Phase Apparent Power	kVA	0xA1
33	40164	3 Phase Apparent Power	kVA	0xA3
34	40172	Frequency Hz	Hz	0xAB
35	40174	Meter real Time	Seconds	0xAD
36	40178	R-Phase Voltage Total Harmonic Distortion	%	0XB1
37	40180	Y-Phase Voltage Total Harmonic Distortion	%	0XB3
38	40182	B-Phase Voltage Total Harmonic Distortion	%	0xB5
39	40184	R-Phase Current Total Harmonic Distortion	%	0xB7
40	40186	Y-Phase Current Total Harmonic Distortion	%	0xB9
41	40188	B-Phase Current Total Harmonic Distortion	%	0xBB
42	40190	R-Phase Power Total Harmonic Distortion	%	0XBD

43	40192	Y-Phase Power Total Harmonic Distortion	%	0xBF
44	40194	B-Phase Power Total Harmonic Distortion	%	0xC1
45	40200	Active Total - Import	kWh	0xC9

IV. RESULT

The prototype of system is constructed as shown in fig.4 the prototype is presently installed in our college premises to monitor the real time power consumption. The system is connected to a three-phase water pump and on interval of 30 minutes the system fetches the meter readings and uploads the data to the cloud database.

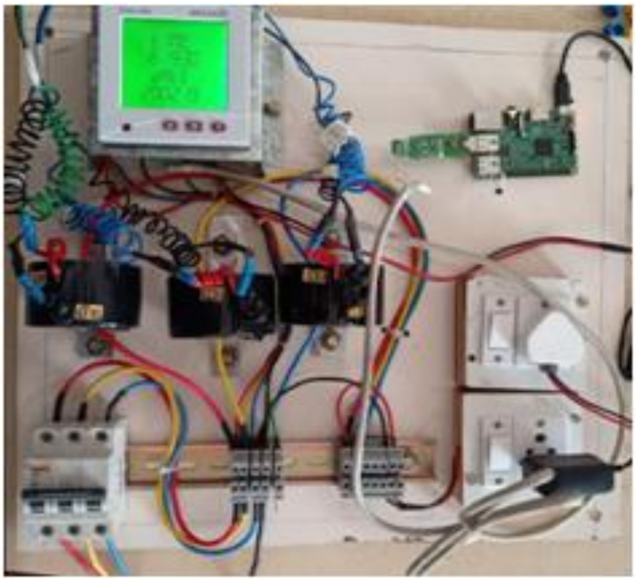
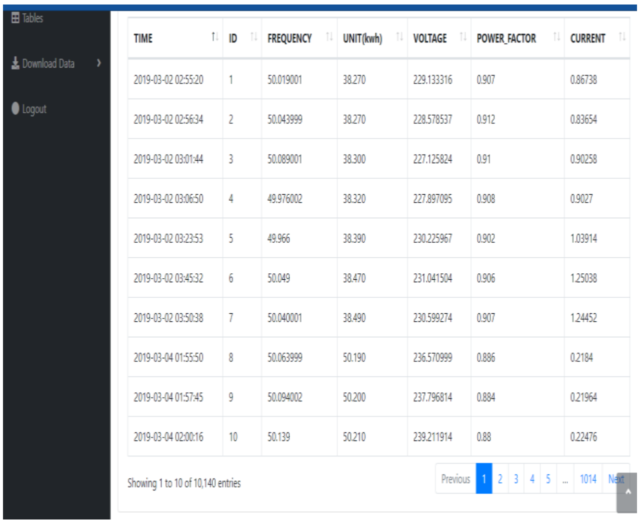


Fig.4. System Setup

The meter readings of all the parameters which are shown in the table 1 are stored in the cloud database along with the time stamp. The consolidated data can be visualized on the cloud as chart, dashboard, graph and tablefig.5, fig.7, fig.8. Also, the dashboard shows the current running status of the machine as shown in the fig. 6.



TIME	ID	FREQUENCY	UNIT(kwh)	VOLTAGE	POWER_FACTOR	CURRENT
2019-03-02 02:55:20	1	50.019001	38.270	229.133316	0.907	0.86738
2019-03-02 02:56:34	2	50.043999	38.270	228.578537	0.912	0.83654
2019-03-02 03:01:44	3	50.089001	38.300	227.125824	0.91	0.90258
2019-03-02 03:06:50	4	49.976002	38.320	227.897095	0.908	0.9027
2019-03-02 03:23:53	5	49.966	38.390	230.225967	0.902	1.03914
2019-03-02 03:45:32	6	50.049	38.470	231.041504	0.906	1.25038
2019-03-02 03:50:38	7	50.040001	38.490	230.599274	0.907	1.24452
2019-03-04 01:55:50	8	50.063999	50.190	236.570999	0.886	0.2184
2019-03-04 01:57:45	9	50.094002	50.200	237.796814	0.884	0.21964
2019-03-04 02:00:16	10	50.139	50.210	239.211914	0.88	0.22476

Fig .5 Dashboard Table

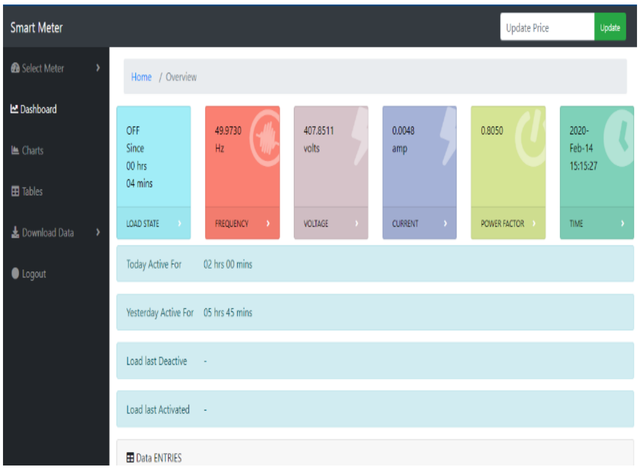


Fig. 6. Dashboard

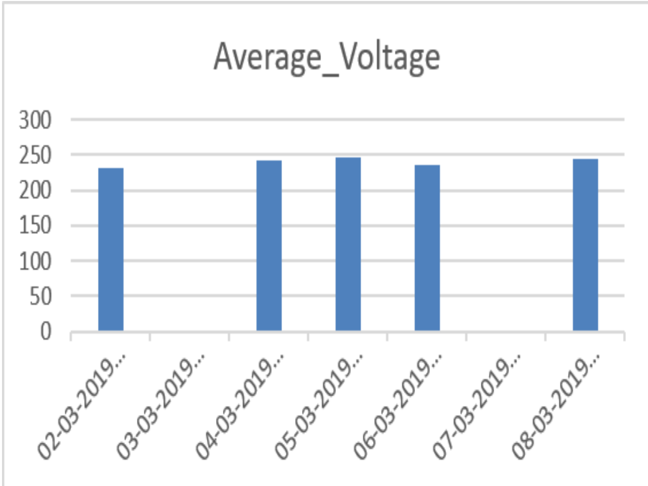


Fig. 7. Voltage consumption pattern

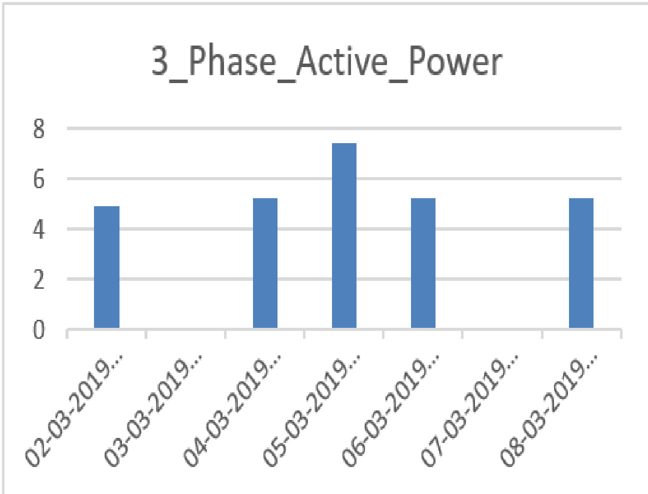


Fig.8. Energy Consumption pattern

V. CONCLUSION& FUTURE WORK

The proposed system is based on the emerging technologies like IOT and cloud for real-time industrial energy meter monitoring and it provides the continuous meter data.

The importance of the proposed solution is to minimize man power requirement in monitoring the run time and down time and the quality of the power. An affordable prototype is designed to fetch, compute the real time meter data to an easy to use cloud dashboard.

Further, the developed work can be extended to apply the machine learning and data analytics on the collected data set to predict the future energy requirements of the plant and the predictive maintenance requirement. Also, the compressive sensing techniques and the advantage AI enabled hardware can be utilized to perform the edge analytics.

REFERENCES

1. https://kupdf.net/download/elite-440-modbus-mapping_59faf59ee2b6f5bf6dec254e_pdf
2. https://www.raspberrypi.org/products/raspberry-pi-3-model-b-plus/
3. https://en.wikipedia.org/wiki/Modbus
4. http://www.securemeters.com/files/5714/7832/5529/Elite_440.pdf
5. https://www.electronics-notes.com/articles/connectivity/serial-data-communications/rs485-introduction-basics.php
6. M. Jagadesh ; M. Saravanan ; V. Narayanan ; M. Priya Vadhana ; K. Logeshwaran"Monitoring system in industrial iot"
7. https://www.researchgate.net/publication/330467093_Design_of_an_IoT_Energy_Monitoring_System
8. https://ieeexplore.ieee.org/document/5752958
9. https://www.researchgate.net/publication/277141436_Automatic_Energy_Meter_Reading_using_Smart_Energy_Meter
10. https://www.ijariit.com/manuscripts/v4i2/V4I2-1978.pdf
11. http://www.ijcea.com/wp-content/uploads/2018/04/80_CRC.pdf
12. https://irjet.net/archives/V5/i3/IRJET-V5I3612.pdf

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