Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 167 (2020) 1148–1160

Procedia Computer Science

www.elsevier.com/locate/procedia

International Conference on Computational Intelligence and Data Science (ICCIDS 2019)

IoT Based Wireless Sensor Network for Power Quality Control in Smart Grid

Amam Hossain Bagdadee[1]*, Md Zahirul Hoque[2], Li Zhang[1]

College of Energy and Electrical Engineering, Hohai University, Nanjing, 210098, China [1]
College of Computer and Information, Hohai University. Nanjing, 210098, China[2]

Abstract

The IoT based Power management system requires data from the feeder in the grid. Sufficient power supply with demand is a significant challenge for several countries around the world. Rapid growing demand for power supply requires power quality enhancement to get higher reliability in the smart grid. This smart power system sensor equipped that measures grid power capacity and update to the organization on a consistent schedule. Energy supplies to the specific region indicated by power install capacity in the grid; use a global system for mobile communications (GSM) messaging service to notify customers of power generation and power supply time. The IoT based wireless Sensor network (WSN) is a revolutionary system for smart monitoring. In this article propose a system demonstrate for the progress and implementation of WSN-based communication systems for smart monitoring and automated control in the electric grid. This work allows for the improvement of grid sharing for maintaining power quality. The dynamic controller has controlled the event of Power quality problem and voltage rise. Appropriate systems and controllers have been demonstrated and analyzed for control performance of a monitoring system in the smart grid.

Keywords: Internet of Things (IoT), WSN, GSM, Active Power Control, Communication System, Smart meter, Smart Grid

* Corresponding author. Tel.: +8615951723758;
E-mail address: a.bagdadee@hhu .edu.cn

1877-0509 © 2020 The Authors. Published by Elsevier B.V.

10.1016/j.procs.2020.03.417

1. Introduction

IoT is a significant regional arrangement that is related to the typical features of a conventional system that can communicate and trade data with one another. The system method can include any equipment, programming or sensors. IoT provides data management and security management. IoT connects individuals and objects from anywhere [1]. IoT can use in a combination of uses such as vehicle response to vehicles, smart buildings, acute stress, quick medical services, smart cities [2]. The internet is currently a series of system associations where the number of related devices is overgrowing. At present, the internet is being used to access process and order ongoing parameters from remote locations. A large number of sensors are used to control electrical machines for a long time in the past few days for domestic automation. However, it is not appropriately implemented, then cost-effectiveness and efficiency will not improve [3]. For home automation, a large number of sensors have been used for a long time to control electrical equipment. This is not cost effective because of the many sensors used. Each device requires its sensor, so the cost and power consumed will increase as the number of devices increases. In modern IoT systems, a large number of sensors can replace by a small number of sensors, IoT can be placed on one platform and thus consume power and energy. The context recognition system is designed to operate IoT effectively. Even in the most potent scenarios, wireless sensor networks that play an essential role in various monitoring applications are ideal application [4]. The emergence of a smarter grid increases the reliability of the system by taking pro-active steps when the power crisis and natural disasters occur. Increased emissions make it easier for consumers to reduce their dependence on the grid which involves greenhouse gas emissions from burning fossil fuels. Distributed generation using electronic converters and inverters, it is possible to overcome distributed problems by activating grid and island mode failures to cause power plants to turn off [5]. Detecting and control framework has three primary stages in particular: sensing stage, data response stage, and control stage. The sensing unit must generally operate by using a wireless sensor node (WSN) [6]. It is estimated that the WSN is exceptional and not suitable for a variety of topologies, is a versatile and promising innovation, allowing proper inspection and enhancement of power system [7]. Data correspondence can realize with the ultra-low power RF (radio frequency) signal used by the WSN receiver module. The control framework can appreciate with an electronic power converter that used as a substitute to send the generated control to the network.

This framework provides data to headquarters using a web server for database support. The database protected by ensuring that the secret key is password. The consumer is notified to pay every level of utilization of the control. Input power measured in number fractions such as units per minute. The power unit estimated with a power flow sensor related to Arduino [8]. The remainder of this paper as followed: the central segment can solve the problems that distinguished by clarifying indigenous techniques.

2. Literature

In literature, Smart sensors can be considered the essential IoT devices for smart grids. The smart sensor is the device that informs control systems about specific parameters and what happens to actual substance monitored. Smart sensors provide rough information to handle information, detailed analysis [9]. Nowadays, innovations in several advanced sensors are connected in various fields. Principal objectives are to make technical arrangements to achieve the accuracy of unusual situations and improve system quality and reliability. IoT shows intelligent devices in a power system that are intelligently related to information collected from installed sensors, actuators, and other physical documents [10]. In future IoT needs to increase customer satisfaction and business efficiency and immediately distribute other administrative elements that open opportunities [11]. Another vital part of the IoT framework is the adjustment of various seasons [14]. The IoT-based framework must have the ability to handle and change in response to these changes that can always apply the IoT framework right at that time. In this way, an essential part of the IoT-based framework, care for conventional varieties ends. Also, physical parameters from various locales are also perfect[15]. This system consists of two units such as director of resources and autonomy [16]. The resources monitored are essential substances, and it consists of sensors and effectors. The sensor detects nature and collects information. Sensor detectors are an interface that is used by the intelligent devices to control the earth [17]. Autonomous heads are also more complicated to provide embedded controls and conduct information investigations. Controls collected combine observation and disclosure of information [18]. Observed domains and information collected. Information is separated, monitored, and then revealed. The inspection department models the environment and learns about the earth. This will help to predict future situations. In transmission and distribution monitoring systems, smart sensors can be used in various places that can be distributed to networks such as electricity networks, distribution lines, distribution transformers, substations. They are two types of smart sensors that can be used [19]. The main types are used to measure climate conditions around advantages such as wind direction sensors, temperature sensors, wind speed sensors, sticky sensors, rain sensors, and so on. These sensors are responsible for assistance and mitigation for violent incidents that cannot be accessed with the current network. In this way, it becomes a structure of autonomous learning. This framework will be more capable and reliable for improving power system.

3. Problem Formulation

This problem selects the optimal location of the capability and the most constructive bulk of the distributed generation unit. The initial stage of this technique is to characterize the objective. It reveals multi-objective operation based on the power quality problem and a voltage stability indices:

The power quality indices = $$EPI = \frac{|E_L| - |E_{LDG}|}{|E_L|} \tag{1}$$

E_L is actual power loss with no compensation; the E_{LDG} is a not actual power loss after the expansion of DG. The voltage stability indices that effectively combine the effects of actual and apparent reactive power growth scientifically details as follows.

$$Vs1 = \frac{2\frac{M}{N}\sqrt{P_X^2 + Q_X^2}}{\frac{V_K^2}{N} - 2\frac{M}{N}P_X \operatorname{Cos}(\alpha_1 - \beta_1) - 2\frac{M}{N}Q_X \operatorname{Sin}(\alpha_1 - \beta_1)} \leq 1 \tag{2}$$

When VS1 is called the voltage stability index of the value P_x and Q_x are the real power and reactive power at the receiving end. V_K is the amount of voltage on the transmitter side. M< α_1 and N < β_1 are limits on the transmission line. As long as the high index is less than 1, the system is stable. However, it will be put together at the system. Objective functions are regulated considering power quality problem and voltage stability, respectively.

$$\min F_1 = \sum_{i=1}^{s} I^2 S$$
$$i \in 2, \ldots\ldots\ldots\ldots, s \tag{3}$$

$$\max F_2 = \frac{1}{VS1} \tag{4}$$
$$i \in 2, \ldots\ldots\ldots\ldots, s$$

Where, F1 and F2 are aspects that should consider. The actual operation is responsible for standard output power regulated for impartiality criteria and the other imbalance requirements. The magnitude of the transport voltage, the actual and apparent output power limits are flowing:

$$V_I \min \leq V_I \leq V_I \max \tag{5}$$

$$P_I \min \leq P_I \leq P_I \max \tag{6}$$

$$Q_I \min \leq Q_I \leq Q_I \max \tag{7}$$

4. System Design

Major equipment:

This system was based on Arduino, remote sensors, ultrasonic sensors, GSM modules. This system can measure power capacity and provide measured data to local offices.

A. Arduino

Arduino is a PC device and programming organization, business entity, consumer network that builds and creates microcontroller units to create sophisticated devices and smart substance that can detect and control substance in the system [20]. This framework provides a digital and comfortable set of information/results (I/O) sticks that can interact with different extension panel ("shields") and circuits.

B. Power measurement theory

The apparent power is the voltage of an alternating current (AC) framework multiplied with each current that streams into it. It registered as the result of (Root Mean Square)RMS voltage value and RMS current, as appeared in Eq. (1) Moreover, it is communicated in units of voltage/volt-amperes(V/A). Current RMS value and Voltage RMS value esteems are computed utilizing Eq.(2) and (3) where N is the number of analysis and i(s), and u(s) are the examples of the electrical current and voltage signals.
Where,

$$ApparantPower = Current_{RMS} \times Voltage_{RMS} \tag{8}$$

$$Current_{RMS} = \sqrt{\sum_{s=0}^{S-1} i\left(S\right)^2} \tag{9}$$

$$Voltage_{RMS} = \sqrt{\sum_{s=0}^{S-1} u\left(S\right)^2} \tag{10}$$

Furthermore, the actual power supply is the circuit operating at once. This must be confirmed simultaneously by estimating voltage and current, parallel and averaging for a while:

$$ActualPower = \sqrt{\sum_{s=0}^{S-!} i(S) \times u(S)} \tag{11}$$

The fraction of real power to apparent power is called the power factor (equation (12) and refers to the capability of the electrical system in a facility to convert the current workload to useful such as heat or light.

$$PowerFactor = ActualPower \,/\, ApperentPower \tag{12}$$

The actual power estimated by calculating the apparent power, because of the non-linear load that breaks the wave, or because the energy is put back into the load. There is always a current that can draw from the source. In such cases, the power factor is not 100%. As a general rule, apparent power can consider as a limit on actual power.

C. Power Sensor

Structurally, its use is SCT - 013 - 030 current sensors which can recognize the importance of IAC from 0 to 30 A. The current level of induction sensor is N = 1800, and the result is relative V. As shown in equation (6), I work from 1V to 62O when checking obstacles. This sensor selected for extended work, accuracy, and comfort that can be accessed by Open Energy Monitor. The sensor output signal is prepared with a time window of 10 AC signal cycles to ensure the correct Current RMS usual incentive. Given European standards, all electricity companies have a recurrence of 50 Hz, and an inspection window of around 200 ms is taken to maintain a strategic distance with nominal plume based on the Nyquist Shannon hypothesis test. However, based on 250 milliseconds or less window use trials, especially, comparing product results with industrially accessible products, or estimating devices, that is entirely accurate. Regardless of the device sensor, use a low-passing programming channel from the flag that is checked to issue a stable balance that present, test the negative estimate of the flag, and confirm the respect of the Current RMS.

The Voltage RMS is stable from specific electrical systems (around 230V an in the EU). There is no doubt that this frustrates the general accuracy of estimates. In this method, that will improve procedures to build a framework and reduce the cost of the establishment of these lines. Even more critical is to critically limit all possible problems caused by gadget activity (such as device disappointments) and not affect the security of the general framework.

D. Power quality with DMR meters

The DMR meters introduced at the consumer association focus that can track the power quality of the low voltage system. The structure of DMR metering can measure power quality circumstance, for instance, measurements of power consumption, common conductor defects, excessive phase sequences, over current, isolated, termination of the power supply and grid inversion that can measure the supply of the distributed network. During PV generation determines voltage deviations that especially unapproved microgeneration and over and under voltages is essential. Because of the nature of the measurement and implementation of communication technologies, the estimated quality of the power achieved should not be continuous. Evaluation of power quality can reflect in initial estimates. This is because the measurement data is updated to the Caruana's data framework every day at midnight. The general process structure for DMR meter data collection demonstrated in Fig. Individual DMR meters assemble utilization and power quality information into the internal memory in the packets including the 4-hour estimate. When the packets of a particular meter end, the meter focus the information concentrator and the concentrator restores the packet from the meter. Information concentrators usually located in optional substances from the LV settings. The communication between the DMR meter and concentrator uses power lines communication (PLC), which means that this signal transmitted through the current LV allocation settings. In this way, because the signal cannot transmit through a current transformer, the information collection device must be associated with the LV setting that is equivalent to the DMR meter. Relevant information will synchronize with the distributed system meter management framework such as working hours of information gathering equipment within hour's afternoon. The connection between the information concentrator and the meter management framework is terminated using a conventional 2G or 3G portable system from the measurement management framework, quality control and utilization of information circulated to the desired client application framework. The 24-hour synchronization cycle means that opportunity information that can be accessed by the system operator must reflect from the previous time. However, several opportunities can distinguish as opportunities with high needs. If there is such an opportunity, the DMR meter will send a quick sign to the concentrator, restore it instantly and communicate information to the meter management framework. Under the situation of the Caruana's conductor and deficiencies in the performing arts named opportunities with high needs power Line Connection in general that can consider as particular strategies where moods have changed, and after a while, it cannot configure the clutch interface between the central unit and the instrument. As a result, DMR meters are ready to store various packets in internal memory too.

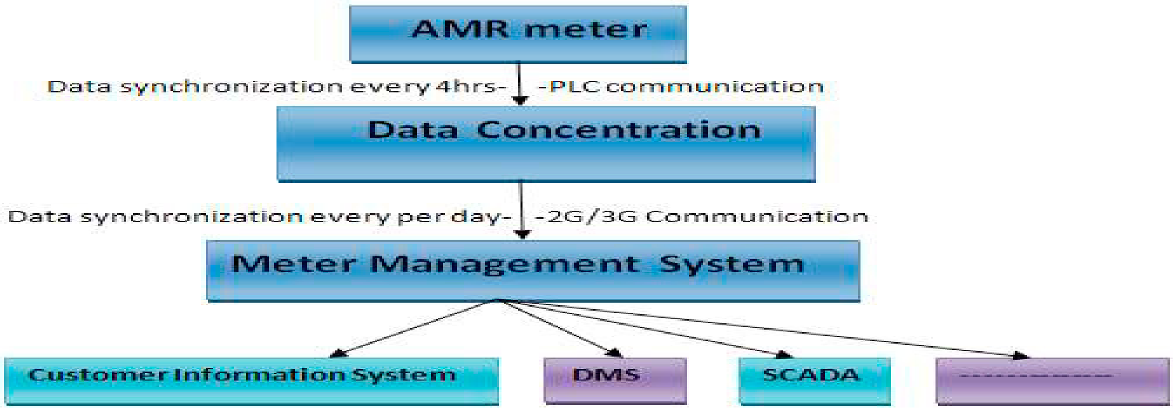

Fig.1.Digital metering infrastructure

The length of the package that can store in the memory meter changes from different weeks to different months depending on the purpose of the estimate and the estimated number of channels used. In this way, it can imagine that the delay in high requirements for the warning framework will extend. In this case, the adequacy of the estimated DMR meter data in the first grid operational management, which reaction time must be fast in principle, can be compromised. Even though the situation is high, that can physically investigate the estimated data from each DMR meter. An application can send from the measurement management framework or various frameworks set for it. The useful association results to the DMR meter send the current estimated data to the framework. In both cases, because of the vulnerability of tasks that meet power line connection requirements, the relationship with the condition of the meter can be framed, and the information concentrator can stop the request. In this situation, that cannot obtain current continuous data from the instrument, and the last 4 hours estimated package that can be accessed by the concentrator collected.DMR meters offer broad prospects for LV power quality opportunities and reflect a 24-hour delay. Because the entrance to the meter foundation is high, it is possible to form detailed images of past events in the grid effectively. Also, opportunities in the sample zone, in particular, can be checked by the time of the inspection, using manual survey usability from the meter management framework. For example, DMS programming used through Caruana is built into the meter management framework and makes it possible to survey opportunity data on the quality intensity of the desired area. Also, the current opportunity level data is sufficient to achieve a general view of power quality issues, presenting tighter opportunities requiring the handling and separation of information obtained within the framework of meter management. The Generation of DMR meters is currently best used for reflecting different power quality problems, thus identifying LV systems with, for example, apparent and intermittent power quality problems. Due to the lack of continuing information, DMR meter inventory is difficult to use with primary control or voltage control applications in progress and operation.

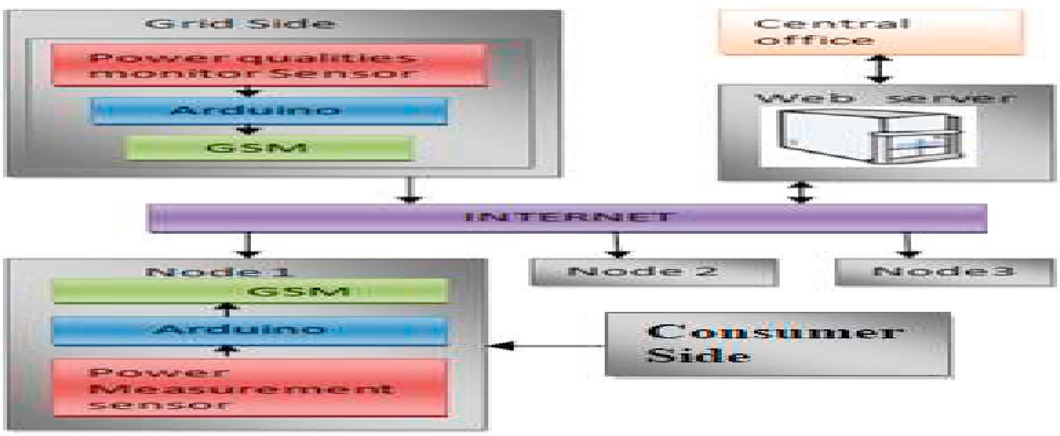

Fig.2. System architecture Diagram

E. GSM module

SIM 800 GSM/GPRS is the USB SIM 800 modem highlights the industry standard interface and provides execution of GSM 900/1800 MHz for SMS, information, and voice with low image frequency and low power consumption.

F. Ultrasonic sensor

Ultrasonic sensors have transmitters and receivers. This distinguishes the separation from the problem by sending ultrasound after 200 µs, then recognizing the reflected wave. The time is taken from the transmission to the wave and used by the wave until the recipient accepts it is a way to decide the separation of the object.

5. Functional Description

A. Consumer module

When the customer-side module has turned on, all peripherals installed. After Arduino confirmed the power quality, a re-check carried out if Arduino paid the customer with a month-end invoice, Arduino operated the power supply and began recording power unit, after 30 days the information was stored in the data center.

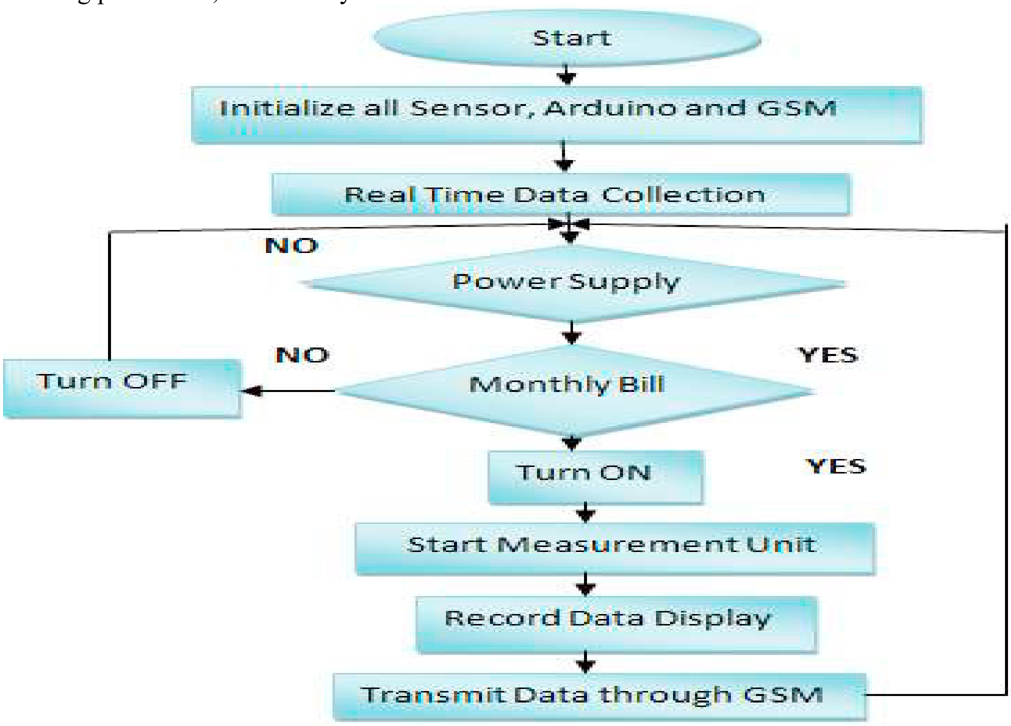

Fig.3. A functional diagram of a consumer module

B. Grid module

The grid-side module confirms the presence of power in the network and transmits the information on inventory controls in the office focusing on a consistent schedule. This module contains one ultrasonic sensor to detect power quality, interact with Arduino, communicate about processing activities such as calculating the power supply capacity in the grid and then using unit information send it to the head office by the GSM.

Fig.4. A functional diagram of the grid module

6. Proposed System

The general system design has shown in Fig 5. This framework has planned for 2 generation plants of consumer, and customer of distributed generation. A wireless sensor system to obtain information from these units, the overall framework has been demonstrated. For solar-based power plants, the power conditioning unit (PCU) promotes autonomous mode by providing power to input information from the grid for synchronization. Isolation mode for generation consumer is popular with photovoltaic devices because converters use critical data to send the power generated to the grid. In the lack of critical data from the detection module, it shows distress or shutdown of the grid. In such cases, the power supply is turned off in the generating unit, and the connection with the network terminated until the input collected. In island mode only, it is not an extreme point but can harmonize the respect of the power produced such as voltage or frequency. The consumer use in the same direction, the sensor only handles communication; the controller is not like that harmonics. The power quality affected by the customer loads and sent to the communication controller because there are reasonable concerns to extend the transmission that is a reliable power supply by maintaining power quality. The association ends with the maintaining the power quality of the global grid when there are too many assessment levels dropped. The wind power has a controller for synchronizing the framework at the converter level, and the communication devices collect that information. Wireless sensor nodes with voltage sensors and power sensors integrated with the transceiver module arrows referred to as the mechanical sensors shown in Figure 5. These nodes are equipped to form a system through the associated collection nodes without the need for other communication such as stations base. The adjacent node will act as like as relay and multi-bounce communication in the system.

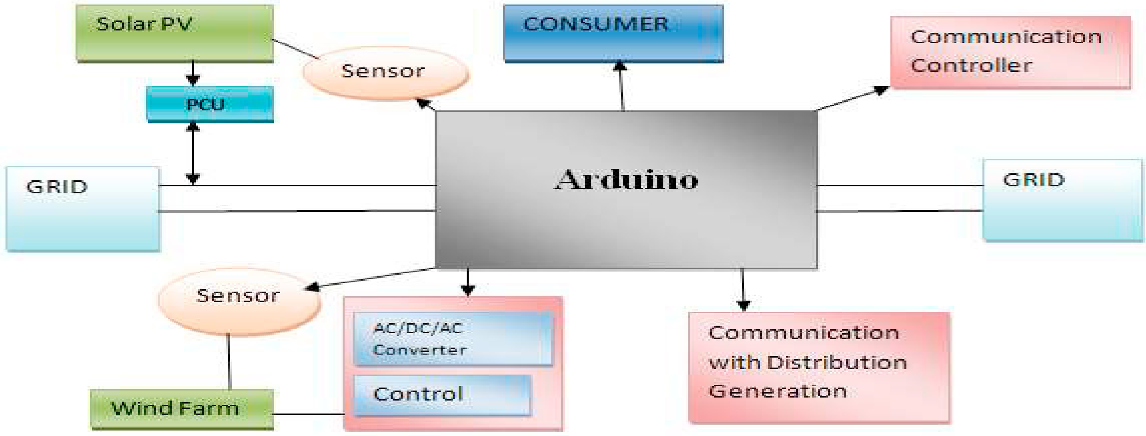

Fig.5. Monitoring and controlling system in a smart grid

A. System Operation

The parameters monitored by the atmosphere information from in the generation station when using voltage, control noise, power quality, consumer side, and infinite resources for substation monitoring. The implementation measurements that must consider for approval are the delay and timing of the power quality analysis. The exchange rate of data depends on each framework, depending on the frequency of standard and operates carried out by the system framework. The IoT based WSN operation is selected in the 3.45GHz ISM band, and the equivalent bit is '5' µs. The system of processing of the framework depends on the real-time data.

$$T_{dataPr} = T_{data} * T_{load} + T_{pr} \tag{13}$$

T_{data} and T_{Pr} is the time needed to handle the data specified in equation (13) and corresponds to the amount of data payload time, and data preparation time of the trailer bit. For example, describing the subtle elements and explaining the tendency to the field. Power consumed for similar applications can pursue:

$$E_{tot} = E_{tx} + E_{arx} + E_{pr} + E_L \tag{14}$$

(E_{tot}) Represents the total power considered in communication and is equivalent to all the transmitted power *(E_{tx})*, apparent power *(E_{arx})*, and processing capacity *(E_{pr})*, and WSN processing substations and there are three stages: detection, transmission, and preparation. Unobstructed views are considered a method in which two demonstrations of beam ground reflection and power unbalance calculated. The transmitted power is transmitted through the receiver to all the processing power and transmission power and transmitted to condition (15), and the power inside the prop is exponential back off, channel detection, packet transmission, buffering, ability to build inactive frameworks and devices from rest. The apparent Power gained is a condition (16).

$$E_{tx} = E_{pr} + (E_{backoff} + E_{ch\ sense} + E_{pkt\ tx} + E_{buff} + E_{sys\ idle} + E_{wakeup}) \tag{15}$$

$$E_R = \frac{E_{tx} G_{rx} G_{tx} h_{tx}^2 h_{rx}^2}{d^4 L} \tag{16}$$

B. Simulation Parameters

The system has intended in smart grid for simulation structured with 15kW solar power plants, 15kW wind power plants, 35kW variable loads, 4kW distributed generation, 5kW load. The IoT Based WSN framework has been operated with seven nodes for secure communication at the equipment level and tested at the simulation level to verify multi-hop communication delays and to determine the level of package delivery to make sure the 35 Nodes system performance has made.

C. Simulation Scenario

This system based on specific scenarios such as grid spread out, demand surpasses generation, satisfying the demand for production, reduced demand, production is overgrowing, and power quality affects the grid. In this case, an algorithm for solving such cases has improved and below the algorithm follows:

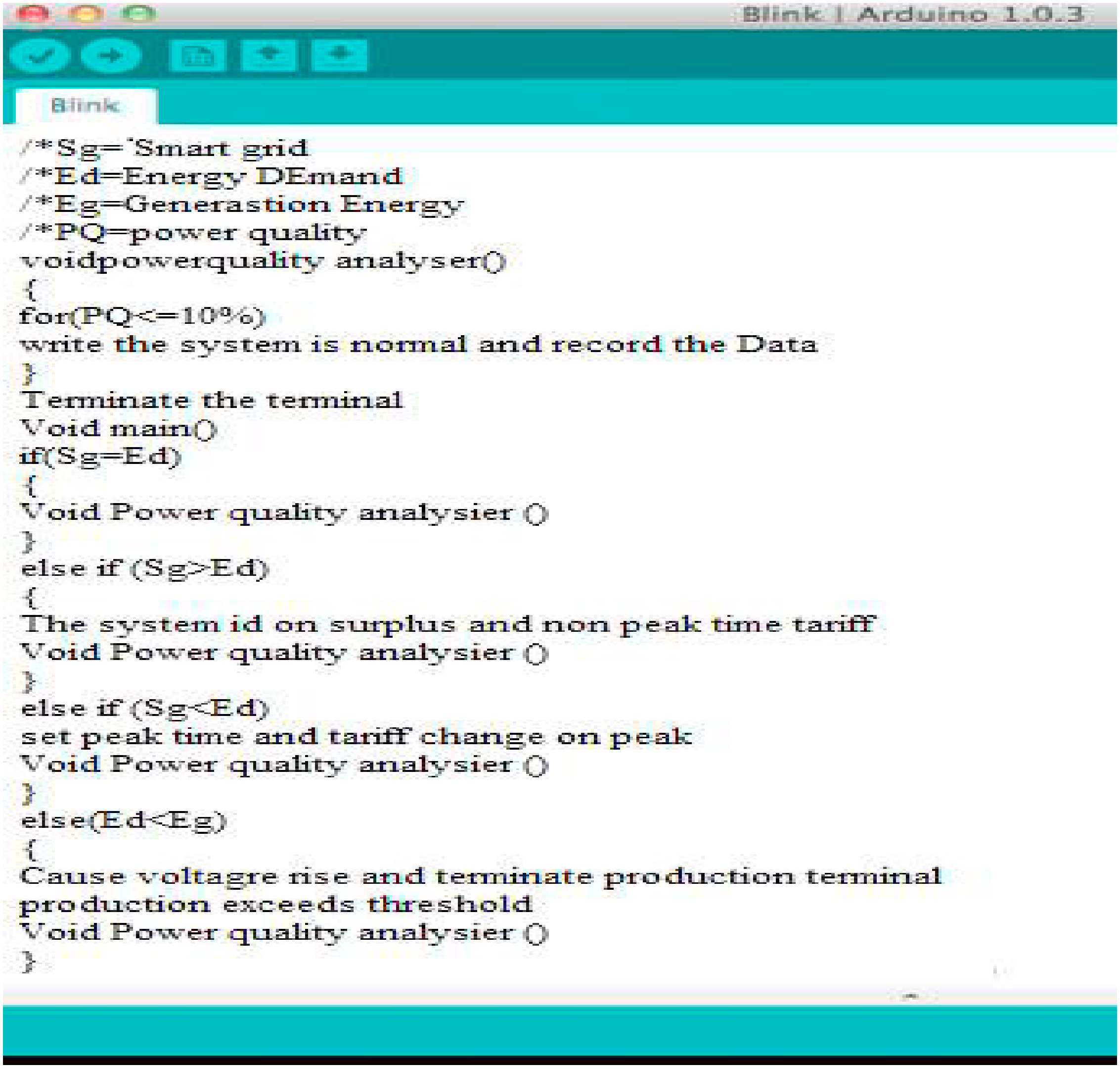

Fig. 6. Algorithm in Arduino

7. Result

Various situations have implemented in the above algorithm, and a simulation assessment has approved the equivalent. The controller module performs the functions mentioned above, such as dynamic power control techniques to maintain voltage breakdown. The primary condition of the controller is that the general application of the network, demand with grid power and power made of the threshold voltage; the framework is in a safe and functioning working zone. When this condition leveled, if the grid power is lower than consumer demand and consumer demand is satisfied with the capacity of generation or shortage, the network is operated to be at peak time, and the tax has not calculated in the same way. In other ways, this case is supposed to be non-stop time, the consumer demand is lower than the actual generation, and the grid works safely at the power level stored in the limit. In the following cases, profits decline and the generation of frameworks occurrences a negative impact from the voltage sage. This demonstrates an increase in voltage, ends at the final target, maintains the power factor, and causes frequency, causing grid instability and associated loads. After all, things considered, the controller will stop the connection with distributed generation to the grid, to reduce the grid power. The methodology for controlling dynamic increases in power flow is called a voltage control procedure that functions and is performed by the controller. The next part is the appropriate phase, considering the land acquisition model with two beams, which places the delay in transport the package and the transport rate of the communication in the plotted figure:

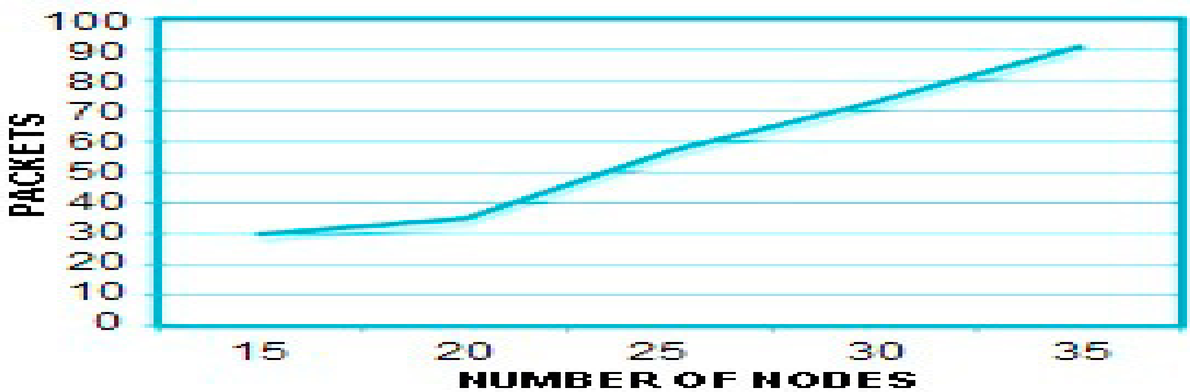

Fig.7. The ratio with Number of Packets and number of Nudes

Figure 7 shows the number of packets supplied by the WSN from the plotted graph. It is clear that there are 91 collections of 35 nodes in the system. The measurement of the system changed from 15 to 35, and the quantity of the package is changed individually from 29 to 91. The investigation has given shows that the proposed strategy is set more than the current framework as a result of the insensitive thought patterns of transmitted and trouble caused by EMI / EMC.

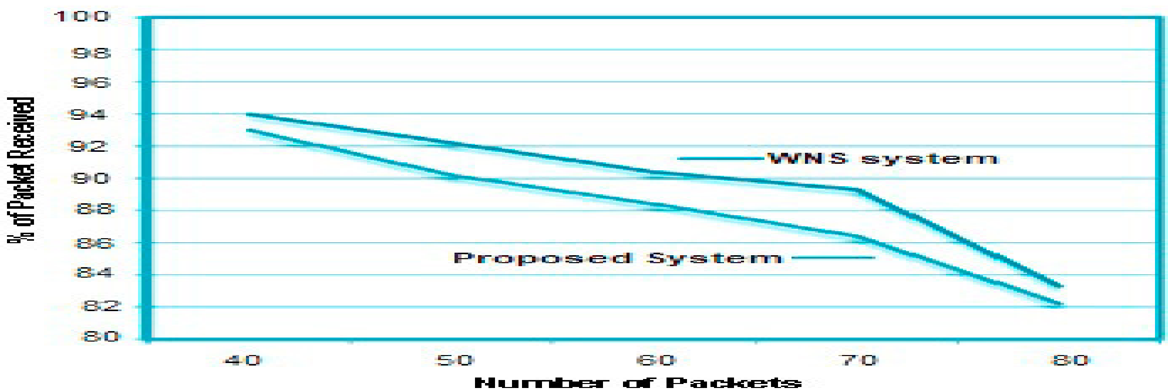

Fig.8. The ratio of number of delivery packets and the number of packets

Figure 8 maps the packet delivery rate versus the number of nodes shown from the Figure 7 above and the range of 94 packages for 80 packages of 34 packages is 84.2. The profile of energy consumption from various system estimates shows in Figure 9 is a plot of the number of nodes and energy consumption (J).

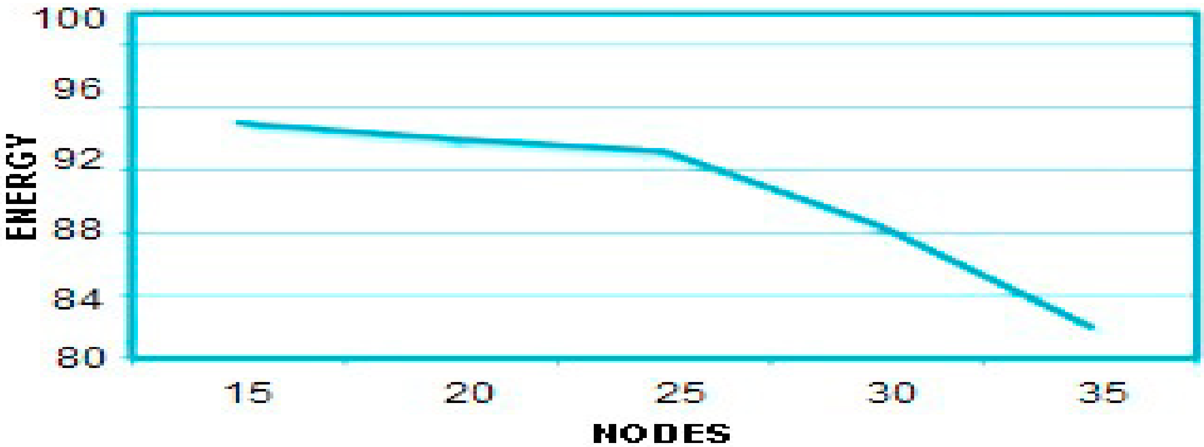

Fig.9. The ratio of energy consumption and the number of nodes

The primary energy is expected to be 100 J, and the typical energy consumption rate per node is 7.75 J. The remaining 80J of energy can access after the following transmission of 35 nodes in the system. Along these lines, the levels of transport and package delay consider, and exemplary implementation attracts attention in the system with energy consumption of at least 20J.

8. Conclusion

In this paper, implement and approve an effective power control procedures that build a wireless network module and a control systems stable for controlling separate intelligent network substations from voltage increases and voltage control technology in parallel monitoring power quality. This system has achieved better reliability in different situations are distinguished for control methodology requirements such as dynamic power control, single power quality control. Through this research and planning, the framework provides smart electricity meters with an environmentally friendly energy productivity framework. As a digital and automated intelligent power meter has maintained power quality and reduce power quality problem in the network. Theft of power can overcome because no mechanical part can focus on change. Smart measurement framework based on the power flow sensor neutralized the weaknesses of the conventional power measurement framework and used for electrical loads. In this paper, those demonstrate the effective implementation of internet-based methods to monitor electricity supply and usage situations on a real-time source.

Acknowledgements

This work was supported by Hohai University under China Scholarship Council (CSC) no:2017GXZ019296

References

[1] Jasmeet Chhabra and Punit Gupta,(2016) “IoT based Smart Home Design using Power and Security Management,” IEEE International Conference on Innovation and Challenges in Cyber Security, Vol.1, pp. 6-10.

[2] Vamsikrishna Patchava, Hari Babu Kandala, and P. Ravi Babu, (2015)“A Smart Home Automation Technique with Raspberry Pi using IoT,” IEEE International Conference on Smart Sensors and Systems(IC-SSS).

[3] M. A. Altahrawi, M. Ismail, H. Mahdi, and N. Ramli, (2017) “Routing protocol in a hybrid sensor and vehicular network for different mobility scenario,” 2017 IEEE 13th Malaysia International Conference on Communications (MICC), Johor Bahru, , pp. 113-118.

[4] R. Janapati, C. Balaswamy, and K. Soundararajan, (2018) “Enhancement of localized routing using CDPSO in WSN,” Conference on Signal Processing and Communication Engineering Systems (SPACES), Vijayawada, 2018, pp. 16-19.

[5] Padma Nyoman Crisnapati, Nyoman Kusuma Wardana,(2016) “Rudas: Energy and Sensor Devices Management System in Home Automation,” IEEE publication Symposium (TENSYMP), p.p. 184-187.

[6] Ming Wang, Guiqing Zhang,(2013) -IoT-based Appliances Control System for Smart homes," IEEE Publication, International Conference on control & Information Processing(ICICIP), Vol.11,p.p. 744-747.

[7] Bagdadee, A.H. & Zhang, L. J. Electr. Eng. Technol. (2019). https://doi.org/10.1007/s42835-019-00220-y

[8] Niaz Morshed, Muid- Ur- Rahman, Rezaul Karim, and Hasan U. Zaman, (2015)"Microcontroller Based Home Automation System Using Bluetooth, GSM, Wi-Fi and DTMF," IEEE International Conference on Advances in Electrical Engineering, Vol.17, pp. 101-104.

[9] Erol-Kantarci, M. and Mouftah, (2015) Energy-Efficient Information and Communication Infrastructures in the Smart Grid: A Survey on Interactions and Open Issues. *IEEE Communications Surveys & Tutorials*, 17, 179-197. http://dx.doi.org/10.1109/COMST.2014.2341600

[10] Divya, N., Kovendan, A.K.P. and Sridharan, D. (2015) Energy-Efficient Data Acquisition System for Increasing the Lifetime for WSN.

[11] V. Koryachko, D. Perepelkin and V. Byshov, (2017) "Approach of dynamic load balancing in software defined networks with QoS," 6th Mediterranean Conference on Embedded Computing (MECO), Bar, pp. 1-5.

[12] A. B. Yagouta, M. Jabberi, and B. B. Gouissem, (2017) "Impact of Sink Mobility on Quality of Service Performance and Energy Consumption in Wireless Sensor Network with Cluster Based Routing Protocols,"IEEE/ACS 14th International Conference on Computer Systems and Applications (AICCSA), Hammamet, pp. 1125-1132.

[13] Bagdadee AH, (2016) "Imitation intellect Techniques Implement for Improving PowerQuality in Supply Network, inIEEE International Conference on Signal Processing, Communication, Power and Embedded System (SCOPES) **DOI:** 10.1109/SCOPES.2016.7955611

[14] P. S. Lakshmi, M. G. Jibukumar and V. S. Neenu, "Network lifetime enhancement of multi-hop wireless sensor network by RF energy harvesting," (2018) International Conference on Information Networking (ICOIN), Chiang Mai, 2018, pp. 738- 743.

[15] Siano, P. (2014), Demand Response and Smart Grids—A Survey. *Renewable and Sustainable Energy Reviews*, 30, 461-478. http://dx.doi.org/10.1016/j.rser.2013.10.022

[16] Bagdadee AH (2016) "To reduce the impact of the variation of power from renewable energy by using supercapacitor in Smart grid" WSEAS TRANSACTIONS on POWER SYSTEMS Vol.11, USA.

[17] Suryadevara, N.K., Mukhopadhyay, S.C., Kelly, S.D.T. and Gill, S.P.S. (2015) WSN-Based Smart Sensors and Actuator for Power Management in Intelligent Buildings. *IEEE/ASME Transactions on Mechatronics*, 20, 564-571.

[18] Bagdadee AH, (2017) Power Quality Analysis by the Ripple Technique. Journal of Applied and Advanced Research 2(4): 227–234 . http://dx.doi.org/10.21839/jaar.2017.v2i4.74

[19] B. Kim, K. Hwang (2017), "Cooperative Downlink Listening for LowPower Long-Range Wide-Area Network. Sustainability," vol. 9, No. 4, Paper ID 627.

[20] B. R. Chen, S. M. Cheng and J. J. Lin, (2017) "Energy-Efficient BLE Device Discovery for the Internet of Things," Fifth International Symposium on Computing and Networking (CANDAR), Aomori, pp. 75-79.