International Journal of Data Warehousing and Mining
Volume 19 • Issue 1

Secure Transmission Method of Power Quality Data in Power Internet of Things Based on the Encryption Algorithm

Xin Liu, State Grid Shandong Electric Power Research Institute, China*
Yingxian Chang, State Grid Shandong Electric Power Company, China
Honglei Yao, State Grid Shandong Electric Power Research Institute, China
Bing Su, State Grid Shandong Electric Power Research Institute, China

ABSTRACT

As a new mobile communication technology in the era of the internet of things, 5G is characterized by high speed, low delay, and large connection. It is a network infrastructure to realize human-computer and internet of things in the era of the internet of things. Power quality data is the efficiency with which a power grid delivers electricity to users and expresses how well a piece of machinery uses the electricity it receives. The waveform at the nominal voltage and frequency is the goal of power quality research and improvement. The power internet of things (IoT) is an intelligent service platform that fully uses cutting-edge tech to enable user-machine interaction, data-driven decision-making, real-time analytics, and adaptive software design. The process by which plaintext is converted into cipher text is called an encryption algorithm. The cipher text may seem completely random, but it can be decrypted using the exact mechanism that created the encryption key.

KEYWORDS

Encryption Algorithm, Graphical User Interface, Power Internet of Things, Power Quality Data, Secure Channel, Secure Transmission Method

INTRODUCTION

As a new mobile communication technology in the era of the Internet of Things, 5G is characterized by high speed, low delay and large connection. It is a network infrastructure to realize human-computer and Internet of Things in the era of the Internet of Things. Power quality may be considered the compatibility between an electrical outlet's output and the load hooked into it. The phrase refers to the electrical power that propels an electrical load and the load's capability of performing as intended (Jasiński et al.,2020). The earliest method of measuring harmonics. The input signal is amplified and fed into a set of bandpass filters with a fixed center frequency, which is an integer multiple of the working frequency, and then the harmonic components and their amplitudes are measured.

DOI: 10.4018/IJDWM.330014
*Corresponding Author

This method has a simple circuit structure, low cost, low output impedance, and easy control of quality factors. However, the center frequency of the filter is very sensitive to the parameters of the components and is influenced by the external environment, so it is difficult to obtain the ideal amplitude and phase frequency characteristics, and when the grid frequency fluctuates, the detection accuracy is low and the detected harmonic current contains more fundamental components. Fast Fourier transform, wavelet transform and quadratic transform methods are available. Comparing voltage measurements between precise parallel models can effectively register the same voltage level is a straightforward approach for a professional to evaluate their system energy efficiency without needing complicated equipment (Singh et al.,2020). The power quality report displays the quantity and intensity of voltage sags, swells, and transients over time. It has susceptibility curve visualizations and waveform characteristics (Kaushik et al.,2020). The insulator flashover caused by lightning strike or the action of power protection device triggered by discharge to ground can cause voltage dips. Non-linear loads, which show nonlinear characteristics due to their output voltage and current relationships, lead to a brief voltage dip at a node in the power system and are an important cause of voltage dips. Clients receive a concise overview of the load, power factor, and harmonic data results in the Power Quality Survey reports. The report will contain suggestions to fix issues when quality concerns are found (Jasiński et al.,2020).

OVERVIEW OF USAGE POWER QUALITY DATA IN POWER INTERNET OF THINGS AND ITS IMPACT

Complete, all-around, global superpower modeling the Internet of Things is built taking into account the powerful traits and possibilities for the IoT and their practical use, the requirements of network expansion, and information gathering through the smart grid. This architecture encompasses the accessibility at the terminals, port, networking, system, program, and data security (Wang & Wang, 2018). In this article, a power Internet of Things analysis monitoring system was used for various purposes, including data collecting and fault analysis, to increase the power distribution system (Kong et al.,2019).

The suggested system improves power quality using an IoT-based power monitoring strategy in a solar PV grid network. Development of photovoltaic power plant monitoring system with real-time statistics of power station and revenue, monitoring equipment failure, remote view of power station status, etc. IoT technology can be divided into three different layers based on the internal technology framework: the sensing layer, the network layer and the application layer. The perception layer is the lowest layer of the IoT system in terms of overall structure, and is an essential component to help the IoT to develop comprehensive perception; the network layer is based on the Internet and related local area networks and other network systems to collect relevant data for real-time and accurate transmission, and its existence makes the IoT The role of the application layer is to adopt scientific and intelligent ways and means to process relevant data and design personalized services according to the actual needs of customers. The proposed algorithm provides a sophisticated and cost-effective solution for measuring faults and maximum power point tracking, ensuring controlled output and supporting full power extraction from PV panels. The goal of this work is to monitor and control grid statistics for reliable and efficient power delivery to hybrid generation systems. The Internet of Things is considered as a network of electronic embedded devices, physical objects, network connections and sensors capable of sensing, analyzing and exchanging data. Power quality issues are proposed to be overcome by the system by monitoring faulty solar panels and improving power quality. The output obtained from the hybrid system is fed to the grid through a 3ɸ voltage source inverter, which is more reliable and maintains the power quality. The power obtained from the whole hybrid setup is measured by sensors in the IoT-based module. In addition to this, the PV voltage is increased by a boost converter and the best reliability is obtained by a perturbation observation method. Challenges in IoT-

Smart Grid integration have to be overcome for the network to operate efficiently. The proposed work is innovative since it presents an internet-of-things-based algorithm for monitoring and controlling solar power to produce voltage and keep it constant for a grid-connected hybrid system (Balakishan et al.,2022). In this research, an IoT-based power theft monitoring and control system is proposed, one that can track the flow of electricity throughout the whole distribution grid from both the origin and the endpoints. This real-time information will allow for automated or manual power shutoffs during power theft (Mohanty et al.,2021).

Infrastructure improvements have been made possible because of my country's advancing social economy and the rapid growth of the electricity sector. Many researchers focus in this network era on implementing better connections between the encryption algorithm based on the power quality information as a source of authority in the IoT (Tang & Ding, 2021). There is a rise in the production and dissemination of digital pictures in the public sphere as a direct result of the widespread adoption and use of communication technologies. For example, sensors may be used to monitor and analyze crowd conditions in real time (Jiang et al.,2021).

Providing safe, consistent, and low-carbon emission energy supply to off-grid areas, Micro Grid (MG) networks have emerged as a viable option. Power Quality Disturbances (PQD) are a prevalent problem that impairs the efficiency of the MG network and its use on a local level in secure transmission methods for power quality data (Suganthi et al.,2021). The Internet of Things (IoT) is a sophisticated information technology application with the potential to enhance industrial output and provide everyday conveniences. IoT networks are particularly vulnerable to attacks due to their reliance on unreliable power sources and their tendency to broadcast data (Zhang et al.,2021). In a power grid, transmission lines are responsible for moving electricity from one location to another. They may transport alternating or direct current or a hybrid of the two. Furthermore, electricity may be transmitted through either overhead or subsurface wires (Cai & Yao, 2021).

To train dispersed IoT devices without requiring data sharing, a new distributed collaborative AI technique known as Federated Learning (FL) has emerged as a potential game-changer for many intelligent IoT applications (Nguyen et al.,2021) & (Alazab et al.,2021). From a brief history of FL and IoT to a discussion of how the two are starting to intersect, this article thoroughly introduces the developing uses of FL in IoT networks (Yao & Ansari, 2021).

Based on the above discussion, the challenge of improving power quality data in power IoT based on the encryption algorithm using the Secure Transmission Method enabled Federated Learning (STM-FL) has been designed, and the contribution has been listed here.

The paper's primary aims:

- This project aims to provide a framework for discussing the overall structure of a system for info on voltage stability.
- Since problems with security, malware risks, and privacy comprise power issues elsewhere in the body, a block structure based on a power IoT evaluation index system has been devised to facilitate such power quality data.
- The encryption algorithm in power quality data in power IoT is built on trusted events development that eliminates information and development paths in symmetric encryption
- The Secure Transmission Method enabled Federated Learning (STM-FL) has been designed and developed for power quality data in power IoT.
- The experimental result has been validated with a combined evaluation model regarding performance, accuracy, prediction ratio, evaluation, and efficiency.

The remaining studies are arranged as follows: Chapter 2 includes a literature review of studies that evaluate the existing method, Chapter 3 recommends a plan for STM-FL and its implications, Chapter 4 provides experimental analysis, and Chapter 5 provides a conclusion and prospects.

IMPACTS AND IMPLICATIONS OF POWER QUALITY DATA IN POWER IOT

Kumar, L. A et al. (2021) introduced the smart-grid expansion in the power system is greatly influenced by improvements in energy efficiency. However, when applying non-linear loads, the present energy meter becomes challenging to monitor and regulate. There is distortion in the current and voltage waveforms due to the programmed regulation, which decreases power quality. The Fourier Transform is a linear form of the integral transform. It is generally used to reversibly transform a signal between the time and frequency domains, and has many applications in physics and engineering, especially in the analysis of signals in our power quality process. The Discrete Fourier Transform (DFT), on the other hand, is the sampling of the continuous Fourier Transform in the time and frequency domains, respectively, so it is in discrete form. The Fast Fourier Transform (FFT), as can be seen from its name, is a fast algorithm for computing the discrete Fourier transform (DFT) of discrete sequences. To calculate the discrete Fourier transform directly, it is too large to analyze the signal. To improve the accuracy and reduce errors such as spectral leakage, the fast Fourier transform is used. The Fast Fourier Transform (FFT) controls and calculates the proposed intelligent energy meter. The microcontroller may determine an array of instantaneous power-related metrics using voltage and current-measured values. A current shunt and power monitor with I2C or SMBUS compatible interface is used, which monitors both parallel voltage drop and bus power supply voltage. 0.002R resistor is connected between IN and OUT, which can measure DC voltage 0~36V and bus common-mode current, and the current range is -20~20A. In actual use, INPUT is connected to the positive pole of power supply and GND is connected to the negative pole of power supply. The information is sent to the Thing Speak cloud service and stored in various fields for easy tracking. The information stored in thing speak is voltage, current and power.

Goswami G et al. (2021) explained that IoT solutions provide rapid, precise access from afar equipment in commercial and public settings. With remote access, it's much less of a problem when there are hybrid loads, which previously caused system ambiguities. Multiple power quality concerns were unearthed the combination of non-linear loads and high-performance converters based on power electronics. The model details the study of risk and singles out the architectural difficulties of the Power Management Unit (PMU) in IoT gadgets. A Shunt Active Power Filter (SAPF) is activated by a reference current generated via hysteresis current control to lower frequency deviations in the distribution supply. Adaptive learning-based control technique for real-time applications of IoT device power management controllers and converters was confirmed by the experimental setup. Power management should vary depending on the end application. The power management system must be more refined to optimize system performance.

Shobanadevi, A et al. (2022) proposed the exponential growth of information technology has lowered the barrier to entry for digital information and the IoT. With digital image processing, digital content may be stored and distributed with less effort and overhead in terms of time and physical space. These methods, however, compromise the secrecy of digital data. The proposed method's fundamental goal is intended: to create a data-concealing approach that makes verifying digital information more difficult by keeping the Peak Signal-to-Noise Ratio (PSNR).

Zhang X et al. (2021) detailed that the Traditional Power Grid (TPG) is evolving into an intelligent grid because of the country's significant progress in Artificial Intelligence Technology (AIT) and communication technologies. The implementation of IoT-based IoT-powered applications provides proof of the progress of information technology and combines information on how much electricity each home uses. However, the Internet of Things will also encounter some challenges, driven by big data obviously, prone to a series of data privacy and ownership issues. In addition, power data has previously not received sufficient attention, lack of systematic collection means and hardware support, and poor access to real-time, accurate and effective operational information of the power system. There is not yet a sound theoretical system and practical support for issues such as low data volume as well as high quality data and information acquisition.

Hu, W et al. (2019) introduced algorithms used in conventional routing that can be recharged in the always-on Internet of Things that have issues with unequal energy consumption and the early death of nodes, which this study aims to address. With this work, the author has created a node-specific pricing model in a Wireless Sensor Network (WSN) based on the electromagnetic propagation theory. Considering the power needs of wireless sensor nodes, this led to the evolutionary transformation of the communication energy optimizer into the network lifetime optimal solution. Experiments reveal that the two suggested algorithms outperform Shortest Path Routing (SPR) and predicted duty-cycled wakeups minimum routing regarding energy efficiency, network lifetime, and network reliability.

Meena, H et al. (2022) detailed that power quality issues have grown more critical due to the widespread use of non-linear loads, a wide range of power electronic technologies, switching loads, and digital computers. Since these gadgets might be a source of power quality issues, safeguarding them has also been scrutinized. However, various Power Quality Disruptions (PQDs) cause these devices to malfunction and stop working. The deviation of voltage, current or frequency that leads to the failure or non-function of power equipment, which includes voltage deviation, voltage fluctuation and flicker, three-phase unbalance, temporary or transient overvoltage, waveform distortion and harmonics, voltage transient and short time interruption, etc.

Jasiński M et al. (2020) proposed that Virtual Power Plants (VPP) are ongoing even though the idea was first suggested. Case study analysis of existing facilities is currently the mainstay of academic inquiry. Virtual Power Plant (VPP) is a cloud-based distributed power plant that aggregates distributed energy resources (DER) to enhance generation capacity to trade or sell power in the electricity market. to participate as a special power plant in the power market and grid operation with a coordinated power management system. Renewing operational concepts and generating socio-economic benefits Hydroelectric Power Plant (HPP) It is undoubtedly of great importance to solve the problem of energy shortage in national economic development, improve the ecological environment, and promote the coordinated and sustainable development of regional economy. In addition, vigorous development of hydropower business will be conducive to narrowing the gap between urban and rural areas, improving rural production and living conditions, and playing an irreplaceable role in promoting local agricultural production, raising farmers' income, accelerating the pace of poverty eradication, promoting national unity and maintaining social stability. HydroPower Plants (HPP) and energy storage systems focus on this article's examination of a VPP in Poland. Power Quality (PQ) concerns were chosen for this detailed examination. The study compares the results of using a global index for point- and area-based evaluations. Additionally, the issue of marked data is addressed. At last, the effect of VPP on PQ is calculated.

Bagdadee, A. H et al. (2020) explained the sensors in this smart power system regularly assess the grid's power output and report their findings to the responsible parties. Electricity is sent to the area designated by the installed capacity of the grid, and clients are informed of when power will be generated and delivered through a Global System for Mobile communications (GSM) texting service. Increased cooperation between grid operators is now possible, which will help keep electricity quality high. When a power quality issue or voltage spike occurred, the dynamic controller handled it. The control performance of a monitoring system in a smart grid has been shown and studied using appropriate methods and controllers.

Brinkel, N. B. G et al. (2020) detailed the fast changes in PhotoVoltaic (PV) system output that occur during cloud transients have the potential to severely impact the Low-Voltage (LV) power supply grid where photovoltaic cells are heavily used. This research suggests a method for smoothing out changes in PV output by adjusting the Electric Vehicles (EVs) charged and evaluating the method's efficacy. The proposed method demonstrates that EV technology may help reduce more excellent charging rates for EV consumers in exchange for reduced amounts of observable and annoying light flicker.

From the above discussion, challenging characteristics such as security and privacy concerns, malware risks, and privacy concerns of power quality data in power internet of things are taken into consideration as the significance of using an encryption algorithm. This research discusses the Secure

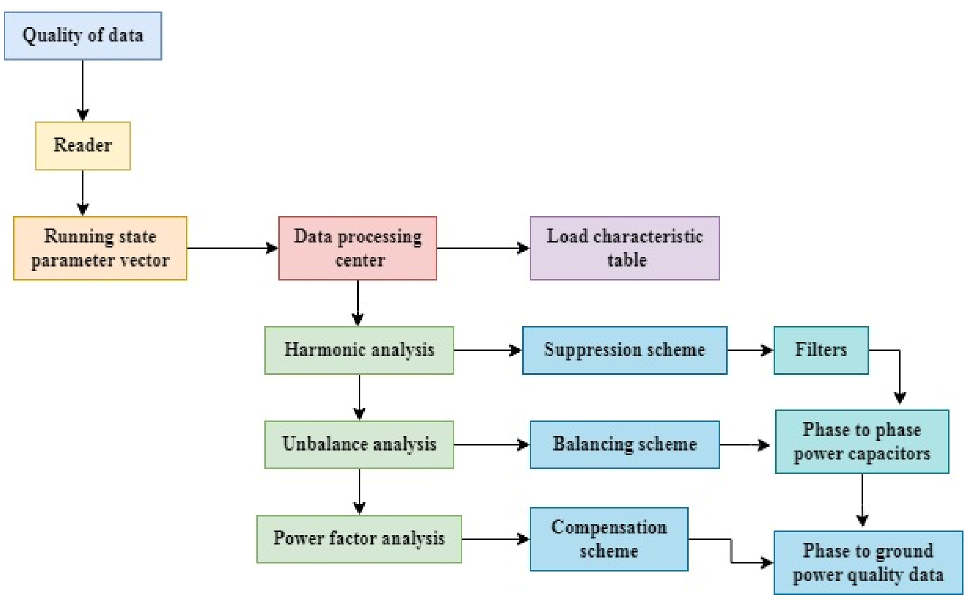
Transmission Method enabled by Federated Learning (STM-FL), which helps to predict performance, accuracy, prediction ratio, and evaluation.

SECURE TRANSMISSION METHOD ENABLED FEDERATED LEARNING AND ITS DISCUSSION

Power quality is the efficiency with which a power grid delivers electricity to users and the capacity of a piece of machinery to use the electricity it is fed. The general framework for power quality data is discussed below.

Figure 1 illustrates quality data used in the tracking of machinery operating under settings that are both complicated and seemingly time-varying. On the other hand, passive tags track(Use tags between 800 and 915M frequencies) and record devices whose statuses remain constant throughout the operation. Information is collected and utilized to monitor and report on the operational status of the linked device in real-time. They are malleable enough to be set up in a way that best suits the needs of whatever electrical device is being monitored.The presence of voltage, also called potential difference or potential difference, in the electrical energy mass. Waveform, which represents the shape of the signal. The frequency, which is the number of periodic changes completed per unit of time. These factors record the coding and operating state of the voltage transformer. All you need to know for passive tags is the on/off status of the linked electronic appliance and the tag's registration number. For this reason, the tag of passivity is often used, and the information on the coding and operating status of power transformers are recorded by power quality, allowing the reader to always know the equipment's condition. To achieve multi-point sequential knowledge interaction, the reader must take full advantage of voltage stability technical benefits, such as the ability to quickly and precisely gather and summaries data on the operational status of machinery and then send this information to a central processing facility in the form of tabular data.Voltage technology is stable, facilitating the grid to maintain long-term static stability, preventing the system from voltage collapse accidents and improving the safe operation of future power systems.

Figure 1. General framework power quality data



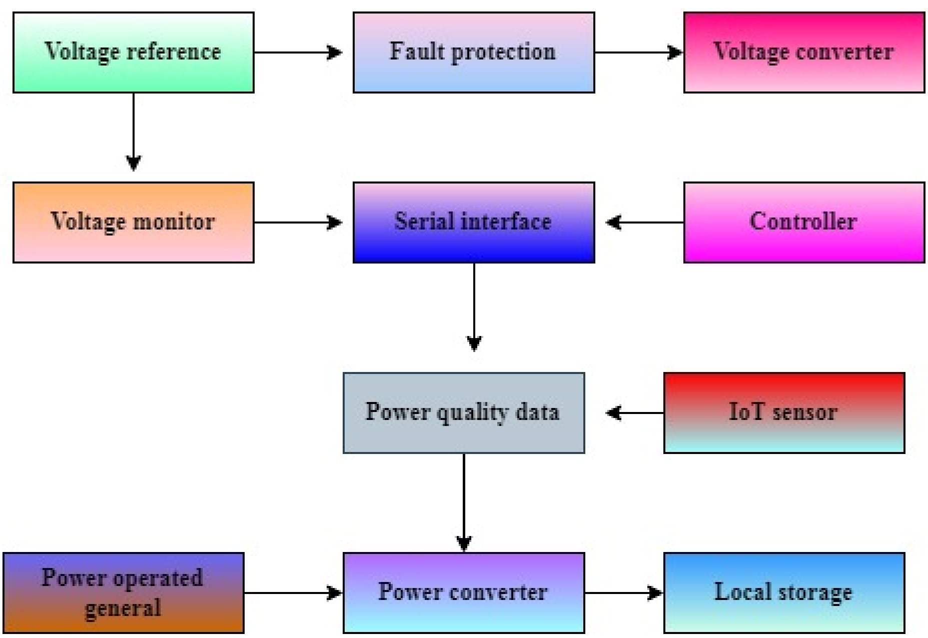
After the information testing facility receives the actual information from the scanner and does the necessary computations, the voltage stability improvement technique and modifying proposed in this study will be put into action. Second, information such as the electrical system's load current, voltage magnitude, harmonics frequency, and other such details was requested and gathered. Energetic and harmonics wave feature matrices were generated for each phase as a consequence. Then, the obtained data will be analyzed and calculated to accomplish goals, including minimizing three-phase imbalance, squelching harmonic waves, compensating for reactive power, and acquiring fine-grained control over filter and capacitor settings.

When the system is powered on, the voltage transformer and current transformer (voltage transformer uses the principle of electromagnetic induction, on the closed core, there are two windings with different turns and mutual insulation, the primary winding N1 is connected to the power supply side, and the secondary winding N2 is on the output side. As the primary winding and secondary winding are on one core, according to the law of electromagnetic induction, an induced electric potential E2 with the same frequency but different values will be generated in the secondary winding.

Because of the different number of turns, the induction electromotive force of two windings is different, the specific numerical relationship is: N1/N2=U1/U2, according to the national standard, the output voltage value of voltage transformer secondary side is 100V.

Then, the microcontroller and the sensor ATT7022E transmit the data through the SPI bus communication protocol, and the ADC channel samples the processed electrical energy value and sends it to the microcontroller to obtain the voltage and current values through data analysis and calculation formula. The resulting data is sent from serial port 2 to the RS 485 bus, which in turn sends it to the receiver (figure 2). The voltage data is analyzed as: value = (float) (ReadSampleRegister(0x0D + i)) 8 192.0; the current data is analyzed as: value = (ReadSampleRegister(0x10 + i) & 0x7FFFF)/8 192.0; the frequency data is analyzed as: value = (float) (ReadSampleRegister(0x10 + i) & 0x7FFFF) /8 192.0; the frequency data is analyzed as: value = (float) (ReadSampleRegister(0x0D + i)) 8 192.0; the frequency data is analyzed as value = (float) (ReadSampleRegister(0x1C) 8 192.0). The transmitting segment collects the power data, processes the voltage and current as well as the displayed power

Figure 2. Receiver software design flow



through the algorithms in the program, and finally the data storage and analysis function uploads the data to the design part of the platform.

The uncontrolled rectification stage refers to the process of charging the dc-side capacitor by using a three-phase bridge-type uncontrolled rectification circuit consisting of a shunt diode reversed by the main circuit switching tube. Because this phase is not controlled, it is called the uncontrolled rectification phase. A current limiting resistor is set in the uncontrolled rectification stage to suppress the current inrush in this stage. Energy distortions can have a negative impact on electricity supply and winter heating, and large increases in energy prices globally, pushing up production costs and household expenses and jeopardizing economic recovery. With the development of IoT technology, IoT networking optimization technology is used for smart power management to improve the sustainability of power supply, and research on smart power management methods, combining technologies such as utility introduction, AC supply and distribution, DC supply and distribution, battery and DC remote supply to improve the intelligence of power management, reduce the output power consumption of power management system and improve the output efficiency of power supply. Since IoT devices are designed to minimize power consumption, they may only be active for a short period of time and spend most of their lifetime in "sleep" mode. Accurately measuring the power consumption profile of a device in all operating modes may present challenges in using common current measurement techniques such as shunts, digital multimeter DMMs or current probes. In sleep mode, the current may be in the 'nA' or 'uA' range; in active mode, for example, when transferring data, the current may suddenly change to the 'mA' to 'A' range. In addition, these larger peaks in current demand typically occur within microseconds, and power conversion can be challenging for some test instruments. While they can be very accurate when used in the right environment, using the current shunt for such measurements can be problematic due to the large dynamic range involved (multiple shunts may be required). Even with multiple shunts, it may be necessary to test active and sleep modes separately, which makes it difficult to obtain a true picture of current loss. In addition, due to the inherent voltage drop, there is an inherent risk of shunt shock to the test equipment if too large a value is chosen to maximize the dynamic range. To solve these challenges, we need to combine network communication technology and Internet of Things (IoT) technology with crystal oscillation and internal voltage adjustment method to achieve optimal scheduling and intelligent control of power supply. The ARM Cortex-M0 processor kernel is used for the integrated design of the smart power management system, and the DSP high-speed signal processing technology is used for the integrated information processing of the smart power management system. It is known that the designed smart power management system has good power management energy balance, reduces the total energy consumption, improves the output power gain, and has better power management performance. As a result, many IoT devices need controller subsystems to ensure that converted power is adequately conditioned. Energy-saving electrical and low-resistance cables can be used to save energy through the use of inverters.

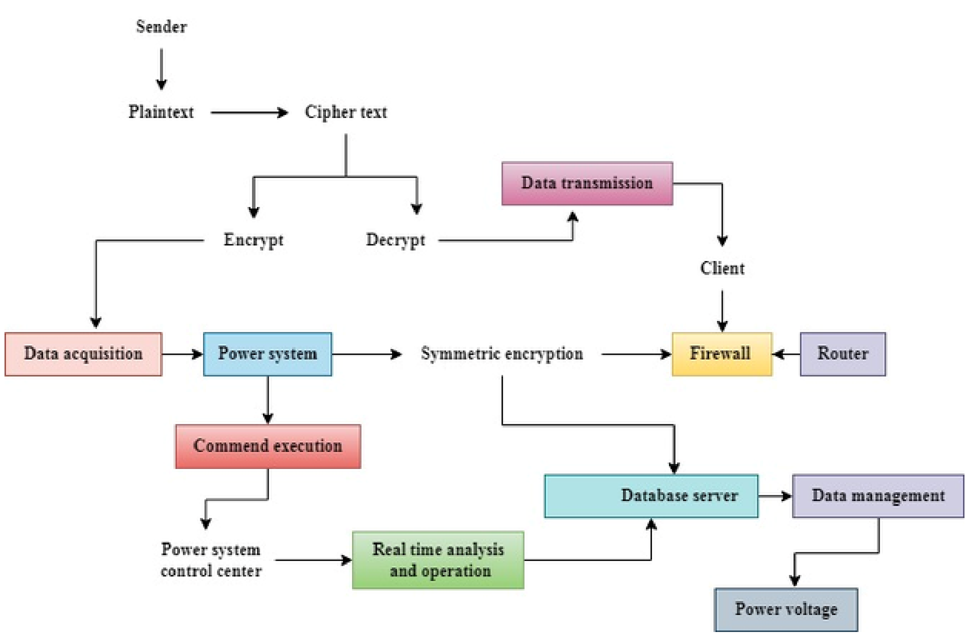
Transient power interruptions, lighting damage, harmonic distortion, extended power interruptions, voltage dips, surges, electrical noise, etc. Harmonics cause additional losses in equipment and reduce efficiency. The danger of power quality problems is destructive. For example, the overvoltage caused by harmonic resonance during lightning wave shock, capacitor and cable line switching often causes insulation and mechanical damage to electrical equipment, thus affecting the normal operation of the power system; relay protection devices cause false operation due to harmonic and negative sequence interference resulting in large-scale power outages in the grid can cause huge economic losses; short-time power supply interruption (Outage) or voltage dips (dip or sag) may lead to production chaos or industrial smelting products of a large number of scrap or even endanger personal safety.Therefore, factors that mainly influence the power quality data in power IoT are to be predicted. Deviations in voltage, current or frequency cause the power-using equipment not to work properly. The power supplied to the sensitive equipment and the grounding system set up may not be used for normal operation. thiThe factors that affect the quality of power are:

1. Factors of natural phenomena, such as lightning, storms, rain and snow, etc., affect the power quality and cause accidents in the power grid, resulting in lower reliability of power supply.
2. Factors of automatic protection and normal operation of power equipment and devices, such as start-up and shutdown of large power equipment, tripping and reclosing of automatic switches, etc., which affect power quality and cause temporary reduction of rated voltage, fluctuation and flicker, etc.
3. The factors of non-linear load and impact load of power users, such as steel making, electrified locomotive operation, etc., have an impact on power quality, causing a large amount of harmonic interference, voltage disturbance, voltage fluctuation and flicker in the utility grid. Then, better performance is discussed as shown in Figure 3.

Figure 3 illustrates empirically investigates how various security methods use energy and use power nodes (sites) as platforms in this article. First, create a micro-power measuring circuit to determine how much power different security methods use on sensor nodes. Next, present a suite of cutting-edge code optimization techniques for enhancing the energy efficiency of various security algorithms. Security algorithms include symmetric encryption and asymmetric encryption, symmetric encryption includes Data Encryption Standard (DES) and Advanced Encryption Standard (AES). Asymmetric encryption includes RSA, DSA, ECC.

Finally, suggest a set of guidelines on applying security methods in sensor network nodes, including cryptography choices, parameter setup, and the like, based on a thorough examination of measurement data. For symmetric-key encryption and decryption to work, the plaintext or cipher text must be processed repeatedly with a replacement key. The lookup table and loop unfolding are two optimization methods often employed in software implementations to speed up execution time. To better understand how to optimize code to decrease energy usage, look at the context of an encryption technique. The overall energy consumptions for all three loop unfolding approaches grow dramatically and significantly when employing four lookup tables to construct the algorithm. The three loop algorithms are FFT, FSNR, GSM. The energy required

Figure 3. Power quality data in power IoT based on the encryption algorithm



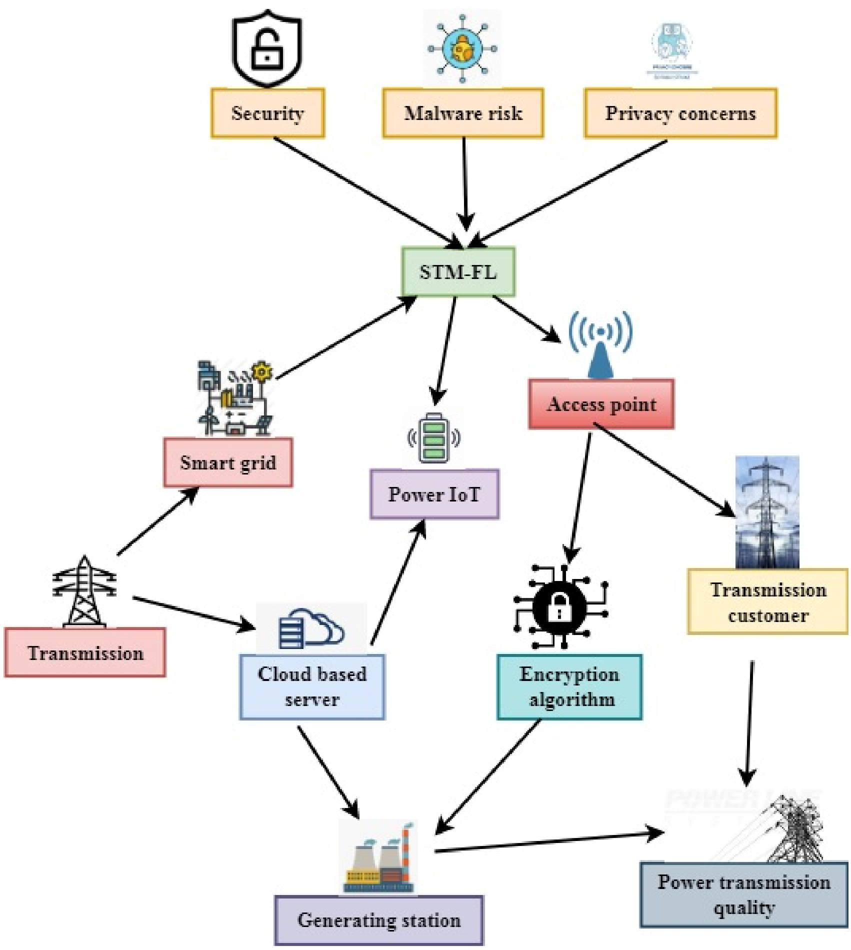
to unfold a one-time loop is the lowest, whereas the energy required to develop is high. The energy penalty incurred due to efficiency improvements is the primary driver of the dramatic increase in energy consumption. The above discussion on the power quality data power IoT in the encryption algorithm pathway for STM-FL helps to predict the power quality data as influenced by security, malware risk, and privacy corners, as discussed: STM-FL activation function may be seen as the collection of transfer functions applied to produce the desired output based on input and feedback, effectively deciding the construction of power quality data in power IoT. Power management should vary depending on the end application. The power management system must be more refined to optimize system performance. Hence this research has included STM-enabled FL, which helps to predict the power quality data in power IoT based on the encryption algorithm, which is discussed as shown in Figure 4.

STM-FL steps:

Step1: The power quality data step is a lot more critical than it seems at first.

Step2: The assessment index method used in power quality data is based on the power IoT. This creates several problems, including security, malware risk, and privacy cancers.

Figure 4. Conceptual structure inspired by the STM-FL



Step3: The belief in power quality data through power IoT systems upon which encryption algorithms are built eradicates information and resource information in symmetric encryption.
Step4: The purpose of creating the STM-FL was to verify existing power quality data in the Power IoT system platform.

Figure 4 illustrates the phrase smart grid refers to the future generation of electrical grids that integrates a control system with information and communication technology. As shown in Fig. 4, the system must be dynamic and include bidirectional communication. The system's primary goal is to rapidly identify and implement remedies to issues via constant monitoring and automated processes. Because of this, fewer people are needed to ensure the security, safety, and high quality of the electricity supplied to everyone. One may attain smart grid technology with the integration of modern technologies.

Compared to traditional grid architecture, the smart grid's modular design and high performance make it ideal for adding new technologies and integrating different hardware without disrupting the system's overall operation. A Potential Transformer (PT) is a device that reduces dangerous high voltages on the power grid to more manageable low voltages on the secondary circuit. The isolator may be as simple as a solitary wooden pole resting on a cross arm, with little space between the conductors and the ground. The data generated by the edge network, which represents the Internet of Things, is growing exponentially. The other extreme consists of metal lattice buildings that include bundles of conductors with significant gaps between them and the ground.

The difficulty of realizing an input load prediction in collaboration with multiple parties' jobs increases when power consumers pay more significant concern to protect the privacy of their electrical use information and are less likely to provide data. Most power load forecasting techniques have been centralized in the past, with local data typically being uploaded directly to a central node where the forecasting task is executed. Traditionally, this has meant that only the estimation of future performance and effectiveness have been prioritized, but the confidentiality and safety of the load forecasting data have been ignored.

$$H = \frac{p}{\sqrt{p^2 + q^2}} \tag{1}$$

From equation, 1 H is the power quality data from the p for reactive power injection in q to the power grid by the filter for power quality data:

$$x\left(n\right) = \sum_{n=0}^{N-1} x\left(k\right) * w_N^n * 100 \tag{2}$$

$x\left(n\right)$ is the process comprising the real and imaginary parts of the voltage and $x\left(k\right)$ the current platform requires a user account to log in to n and access the various data N, sent by the energy meter w for equation 2 in the power of quality data in capacity IoT.

$$I = \sqrt{\frac{i^2\left(g\right)}{f}} \times i\left(n\right) \tag{3}$$

I is the average energy output in a specific time interval, i^2 the currents share the same phase difference, g implies assuming there is no other kind of burden involved and f the power density is being mirrored. The load is termed reactive if it consumes all electricity. $i(n)$ in equation 3 for the power quality data encryption algorithm.

The Power Factor (PF) is computed by dividing Real Power by Appearance Energy. It relates to the capacity of the installation's power equipment to transform electric charge into useful outputs like heat, spinning, or light.

$$power\ factor = \cos\theta = \frac{Real\ power(w)}{Apparent\ power(va)} \tag{4}$$

The PF value varies from 0 to 1, indicating whether the load is resistive, inductive, or capacitive. When the power factor equals 1 $\cos\theta$, power transfer occurs. The load is entirely capacitive if the current leads voltage by $Real\ power(w)$ phase. The demand is inductive if the current lags behind the power by 90o period. When the power factor is low, the load drives more current, resulting in more energy wasted in the electrical network power that is seen $Apparent\ power(va)$. The majority of the load in the electrical system is inductive. As a result, the industry often employs a parallel capacitive load coupled to increase power factor equation 4 in STM-FL.

RESULT AND DISCUSSION

The research concludes that the STM-FL effectively predicts and validates the power quality data in power IoT compared with the association rule mining method based on performance, accuracy, prediction ratio, and efficiency, which are discussed as follows.

Dataset Description: For this experimental analysis. Power Quality (PQ) is important because it affects the sinusoidal signal of the power line and has immediate consequences for utilities and consumers. Non-linear behaviors in loads related to different PQ shocks are introduced by the a priori unknown characteristics of the Distributed Energy Resources (DER).

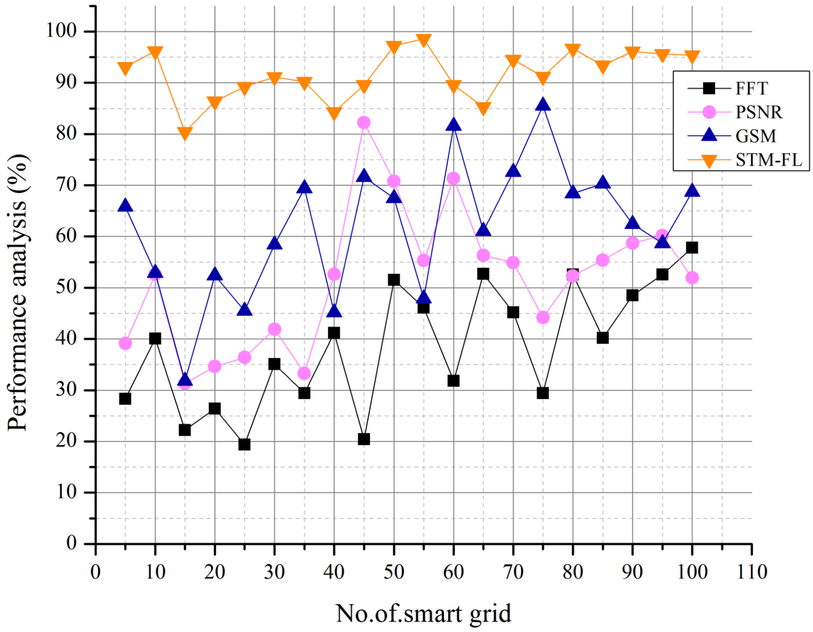
$$F = \frac{\Delta A_i}{\Delta x^t} \times \Delta u_i(t) \tag{5}$$

F is the performance analysis of power quality data in ΔA_i is the factor of effect that somewhat influences confusion in a randomized state. Δx^t and $\Delta u_i(t)$ is effective only on the degree to which controller input ambiguity in equation 5.

Figure 5 illustrates the performance analysis of power quality technicians utilizing diagnostic tools to test many parameters in real-time as part of a power quality investigation. Constantly monitoring and analyzing power cables for the disruption that might interrupt the dependable supply of energy or harm devices hooked into the grid is the primary function of voltage stability testers. The key to getting correct power data is that the voltage and current phasors be in their proper relations, which these analyzers can measure. The proposed STM-FL showed the highest performance value, a 95.19% improvement compared to other existing methods.

$$M = K_j - Q^1 * \sqrt{P} \tag{6}$$

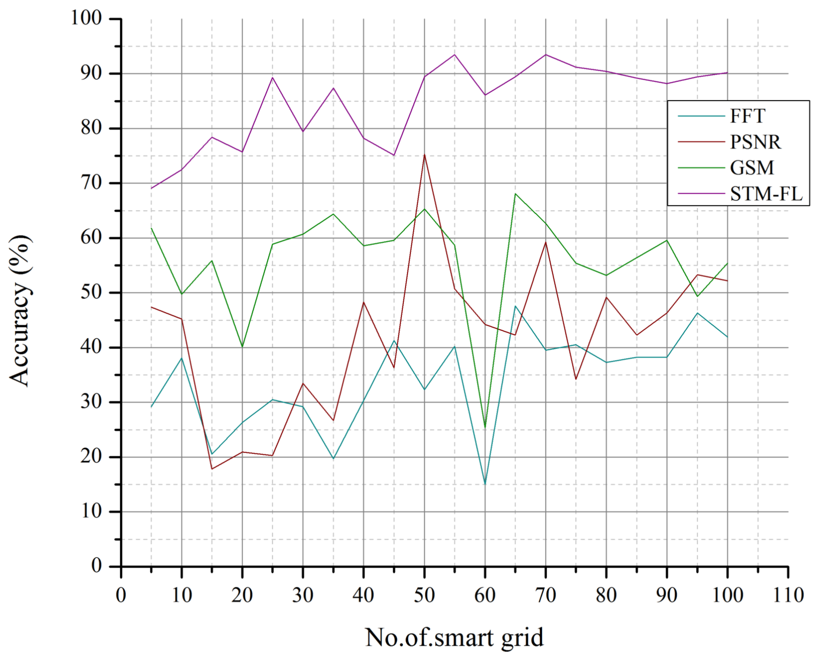
Figure 5. Performance analysis of power quality data



M is the accuracy analysis of K_j pays the influence on the control input from Q^1 partial uncertainty observer in controller gain $\sqrt{P}$ the distortion power factor in equation 6.

Figure 6 illustrates accuracy to the recent explosion in network technology, decades, a future where computing is ubiquitous resources exist in the world today. Talking shops through networks are gaining in popularity with people nowadays. The grid uses digital signals to communicate information, which hazard of being listened to in 92% or accessed without permission. The capacity to encrypt communications before sending them is vital significance in ensuring the safety of widespread. Firstly, high-quality power is more efficient, especially in computing systems. The volt measurements enable manometers to monitor the same voltage level, one of which is a "probably average" kind of device. This ensures that the equipment uses as little energy as possible while performing effectively. Compared to other existing methods, FFT and PSNR, the proposed method STM-FL is higher in accuracy ratio. The grid uses digital signals to communicate information, which hazard of being listened to in 92% or accessed without permission. The capacity to encrypt communications before sending them is vital significance in ensuring the safety of widespread. Firstly, high-quality power is more efficient, especially in computing systems. The volt measurements enable manometers to monitor the same voltage level, one of which is a "probably average" kind of device. This ensures that the equipment uses as little energy as possible while performing effectively. Compared to other existing methods, FFT and PSNR, the proposed method STM-FL is higher in accuracy ratio. The grid uses digital signals to communicate information, which hazard of being listened to in 92% or accessed without permission. The capacity to encrypt communications before sending them is vital significance in ensuring the safety of widespread. Firstly, high-quality power is more efficient, especially in computing systems. The volt measurements enable manometers to monitor the same voltage level, one of which is a "probably average" kind of device. This ensures that the equipment uses as little energy as possible while performing effectively. Compared to other existing methods, FFT and PSNR, the proposed method STM-FL is higher in accuracy ratio.

Figure 6. Accuracy of power quality based on STM-FL



$$L = u_{ph} - u_d + u_0 \quad (7)$$

L is the efficiency analysis in u_{ph} is the photovoltaic current; u_d is the diode current; u_0 is the reverse saturation current in equation 7.

Figure 7 illustrates the efficiency of power quality analysis used to evaluate an electrical system's reliability and effectiveness. When assessing power quality, this method considers the current of electricity and other aspects like grounding and harmonics. Power quality tools are used in power networks to guarantee a steady breeze. The voltage and frequency of the electricity flowing through the grids must be kept within their respective tolerances at 91%. The waveform must be completely sinusoidal. Energy conservation implies optimizing energy use in response to the needs of a given application, which can only be achieved via high power quality. The only way to cut down on energy waste is to determine whether the programmer can make more efficient use of the power. Effective energy decisions may be made with the help of an energy audit conservation. An audit is conducted to find energy waste without compromising productivity or expansion. Compared to other existing methods, FFT, and PSNR, the proposed method STM-FL is higher in efficiency ratio prediction.

$$S_{ij} = \frac{p_{ij}}{p_{ij\ \max}} \times L_{ij} \quad (8)$$

where p_{ij} is the force at work in the stem, and $p_{ij\ \max}$ is the total volume of electricity that a limb can handle under load. L_{ij} in the line for transmitting information in S_{ij} is the prediction in equation 8.

Figure 7. Efficiency analysis of power quality

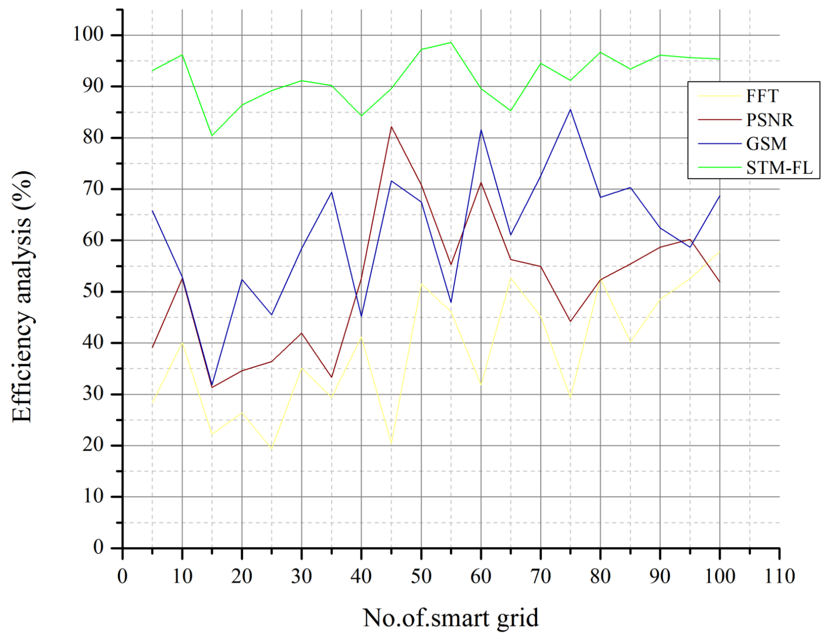


Figure 8 predicts that the widespread use of non-linear loads, including power converters, rectifiers, and induction motors, has resulted in a dramatic increase in the need for sophisticated power infrastructure ovens, battery chargers, etc., significantly degrade the quality of the electricity that reaches the consumer. Load distortions due to non-linear loads energy source. These disturbances also are integer multiples of the primary frequency of the power cable and are referred to as overtones of 89%. The non-integral multiples of the intermediate frequencies are known as inter-harmonics. Deterioration is brought on by voltage harmonics electromagnetic interference due to poor insulation and coordination between the capacitor bank, windings, power lines, and current harmonics. Compared to other existing methods, FFT, PSNR, and GSM, the proposed STM-FL is higher in predicting power, as shown in Figure 8.

$$V = \sqrt{\frac{1}{n} v\left(t\right) - i\left(t\right) \times k\Delta t} \tag{9}$$

$v\left(t\right)$ is the graphing voltage over time, $i\left(t\right)$ is the happening right now as a function of the time, n is the number of specimens, $k\Delta t$ is the data collection with endpoints at around the same distance from one another in V is the evaluation analysis in equation 9.

Figure 9 illustrates the system's primary function is to provide advanced warning of changes to power parameters and an alert mechanism that triggers an alert when the amount of electrical energy used exceeds the predetermined limits. A clause also allows the energy surplus to be reduced by delivering electricity while people aren't at the station. The voltage wave angle at any given moment is determined to be less than or equal to the reference value, the zero crossing of the adjacent positive cycle at that instant may be used as a time reference of 85%. A great deal of study has gone into the power meter. However, very little has been done on the active power meter, especially for long-distance tracking, data archiving, and dynamic power augmentation. A more refined power factor meter layout

Figure 8. Power quality prediction based on STM-FL

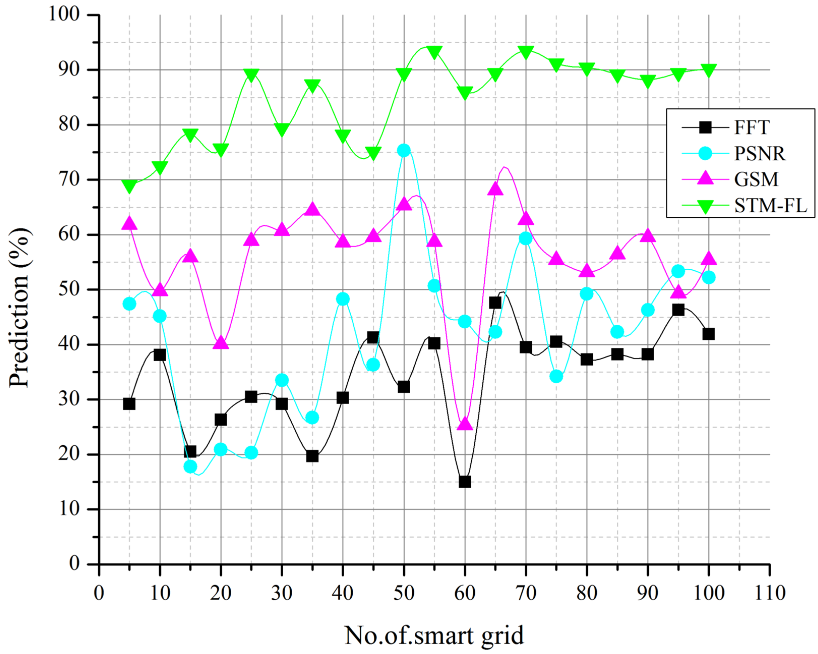
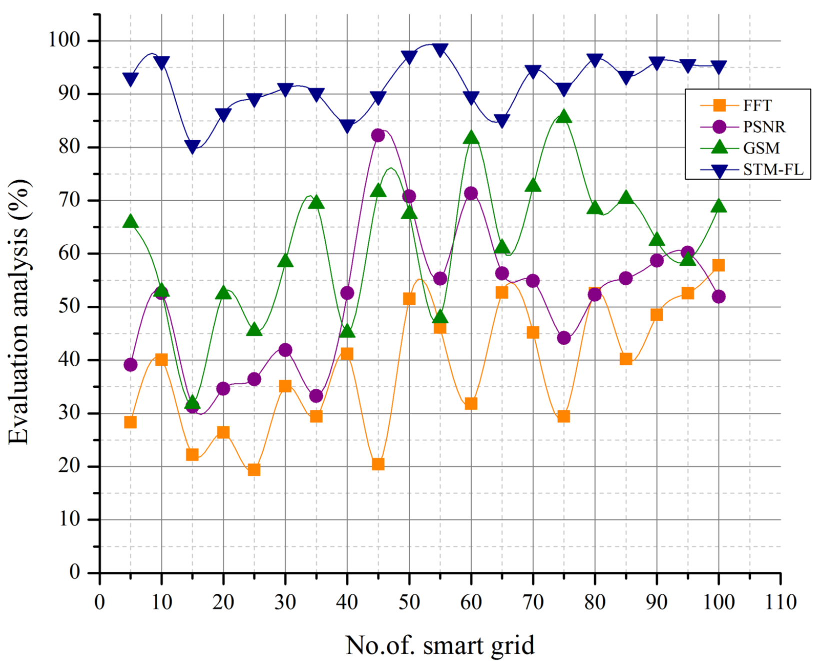


Figure 9. Evaluations analysis for power quality based on STM-FL



was shown. It improves and expands upon the prior arrangement by simulating power factor increase, evaluating performance using various gadgets, and creating capacity for remote monitoring and recording data. Compared to other methods now in use, the suggested STM-FL is higher.

CONCLUSION

As a new mobile communication technology in the era of the Internet of Things, 5G is characterized by high speed, low delay and large connection. 5G is the network infrastructure that enables the connection of people and things in the Internet of Things era. From these methods, FFL, PSNR, and GSM from power quality data ability are not predicted; it is effective using STM-FL methods, the advantages are expected correctly, and the experimental analysis is compelling. The implementation of coexistence mode ensures stable and reliable communication. This paper presents the research of Fourier transform in modern times. The research of domestic and foreign workers in power quality in the Internet of Things is described. This paper creates the STM-FL to meet the growing demand for association rule mining models. The paper looks at some common basic methods for secure symmetry and shows three standard techniques for evaluating energy efficiency codes for covert communications. Power quality auditing and monitoring can only be done efficiently with the help of cutting-edge technology that uses various sensors and algorithms to improve the efficiency and accuracy of parameterization. Current research recommends the Short Term Memory Fuzzy Logic (STM-FL) model, a federated learning-based load forecasting approach. The model is composed of all edge nodes together and achieves accurate prediction of load demand. Extensive modeling provides accurate load forecasting; the STM-FL model reduces the risk of providing sensitive information. The information contained in each edge node is retained within the network. Planning for the future includes adjusting the model settings to obtain the best results. Improves model performance while reducing time complexity. Realizes real-time, accurate acquisition, conditioning calculations and analysis of three-phase three-wire and three-phase four-wire voltage/current signals, and displays the voltage and current RMS values, voltage harmonics, and frequency of grid power.

DATA AVAILABILITY

The figures used to support the findings of this study are included in the article.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

FUNDING STATEMENT

This work was supported by the State Grid Shandong Electric Power Research Institute "Research on Key technologies of mobile application security analysis of Power Internet of Things" (No. 520626220019).

ACKNOWLEDGMENT

The authors would like to show sincere thanks to those techniques who have contributed to this research.

REFERENCES

Alazab, M., Rm, S. P., M, P., Maddikunta, P. K. R., Gadekallu, T. R., & Pham, Q.-V. (2021). Federated Learning for Cybersecurity: Concepts, Challenges, and Future Directions. *IEEE Transactions on Industrial Informatics*, *18*(5), 3501–3509. doi:10.1109/TII.2021.3119038

Bagdadee, A. H., Hoque, M. Z., & Zhang, L. (2020). IoT based wireless sensor network for power quality control in smart grid. *Procedia Computer Science*, *167*, 1148–1160. doi:10.1016/j.procs.2020.03.417

Balakishan, P., Chidambaram, I. A., & Manikandan, M. (2022). Improvement of power quality in grid-connected hybrid system with power monitoring and control based on internet of things approach. *Electrical Engineering & Electromechanics*, (4), 44–50. doi:10.20998/2074-272X.2022.4.06

Brinkel, N. B. G., Gerritsma, M. K., AlSkaif, T. A., Lampropoulos, I., van Voorden, A. M., Fidder, H. A., & van Sark, W. G. J. H. M. (2020). Impact of rapid PV fluctuations on power quality in the low-voltage grid and mitigation strategies using electric vehicles. *International Journal of Electrical Power & Energy Systems*, *118*, 105741. doi:10.1016/j.ijepes.2019.105741

Cai, W., & Yao, H. (2021). A secure transmission method of network communication data based on symmetric key encryption algorithm. *Wireless Personal Communications*, 1–12.

Goswami, G., & Goswami, P. K. (2021). Self-adaptive learning based controller to mitigate PQ issues in internet of things devices. *International Transactions on Electrical Energy Systems*, *31*(5), e12888. doi:10.1002/2050-7038.12888

Hu, W., Li, H., Yao, W., & Hu, Y. (2019). Energy optimization for WSN in ubiquitous power internet of things. *International Journal of Computers, Communications & Control*, *14*(4), 503–517. doi:10.15837/ijccc.2019.4.3572

Jasiński, M., Sikorski, T., Kaczorowska, D., Rezmer, J., Suresh, V., Leonowicz, Z., Kostyla, P., Szymańda, J., & Janik, P. (2020). A case study on power quality in a virtual power plant: Long term assessment and global index application. *Energies*, *13*(24), 6578. doi:10.3390/en13246578

Jasiński, M., Sikorski, T., Kaczorowska, D., Rezmer, J., Suresh, V., Leonowicz, Z., Kostyla, P., Szymańda, J., & Janik, P. (2020). A case study on power quality in a virtual power plant: Long term assessment and global index application. *Energies*, *13*(24), 6578. doi:10.3390/en13246578

Jasiński, M., Sikorski, T., Kostyła, P., Leonowicz, Z., & Borkowski, K. (2020). Combined cluster analysis and global power quality indices for the qualitative assessment of the time-varying condition of power quality in an electrical power network with distributed generation. *Energies*, *13*(8), 2050. doi:10.3390/en13082050

Jiang, D., Liu, L., Wang, X., & Rong, X. (2021). Image encryption algorithm for crowd data based on a new hyperchaotic system and Bernstein polynomial. *IET Image Processing*, *15*(14), 3698–3717. doi:10.1049/ipr2.12237

Kaushik, R., Mahela, O. P., Bhatt, P. K., Khan, B., Padmanaban, S., & Blaabjerg, F. (2020). A hybrid algorithm for recognition of power quality disturbances. *IEEE Access : Practical Innovations, Open Solutions*, *8*, 229184–229200. doi:10.1109/ACCESS.2020.3046425

Kong, X., Xu, Y., Jiao, Z., Dong, D., Yuan, X., & Li, S. (2019). Fault location technology for power system based on information about the power internet of things. *IEEE Transactions on Industrial Informatics*, *16*(10), 6682–6692. doi:10.1109/TII.2019.2960440

Kumar, L. A., Indragandhi, V., Selvamathi, R., Vijayakumar, V., Ravi, L., & Subramaniyaswamy, V. (2021). Design, power quality analysis, and implementation of smart energy meter using internet of things. *Computers & Electrical Engineering*, *93*, 107203. doi:10.1016/j.compeleceng.2021.107203

Meena, H., Meena, H. K., & Saxena, D. (2022, February). Classification of power quality disturbances with DWT based effective feature extraction. In *2021 4th International Conference on Recent Trends in Computer Science and Technology (ICRTCST)* (pp. 314-320). IEEE. doi:10.1109/ICRTCST54752.2022.9781895

Mohanty, S., Iqbal, M. M., & Thampi, P. (2021, June). Controlling and Monitoring of Power Theft using Internet of Things. In *2021 International Conference on Design Innovations for 3Cs Compute Communicate Control (ICDI3C)* (pp. 111-115). IEEE. doi:10.1109/ICDI3C53598.2021.00031

Nguyen, D. C., Ding, M., Pathirana, P. N., Seneviratne, A., Li, J., & Poor, H. V. (2021). Federated learning for internet of things: A comprehensive survey. *IEEE Communications Surveys and Tutorials*, *23*(3), 1622–1658. doi:10.1109/COMST.2021.3075439

Shobanadevi, A., Maragathm, G., Gangadharan, S. M. P., Soni, M., Kumar, R., Tran, T. A., & Singh, B. K. (2022). Internet of Things-Based Data Hiding Scheme for Wireless Communication. *Wireless Communications and Mobile Computing*, *2022*, 2022. doi:10.1155/2022/6997190

Singh, R. R., Yash, S. M., Shubham, S. C., Indragandhi, V., Vijayakumar, V., Saravanan, P., & Subramaniyaswamy, V. (2020). IoT embedded cloud-based intelligent power quality monitoring system for industrial drive application. *Future Generation Computer Systems*, *112*, 884–898. doi:10.1016/j.future.2020.06.032

Suganthi, S. T., Vinayagam, A., Veerasamy, V., Deepa, A., Abouhawwash, M., & Thirumeni, M. (2021). Detection and classification of multiple power quality disturbances in Microgrid network using probabilistic based intelligent classifier. *Sustainable Energy Technologies and Assessments*, *47*, 101470. doi:10.1016/j.seta.2021.101470

Tang, X., & Ding, C. (2021). Information security terminal architecture of power transportation mobile internet of things based on big data analysis. *Wireless Communications and Mobile Computing*, *2021*, 2021. doi:10.1155/2021/5544716

Wang, Q., & Wang, Y. G. (2018, October). Research on power Internet of Things architecture for smart grid demand. In *2018 2nd IEEE Conference on Energy Internet and Energy System Integration (EI2)* (pp. 1-9). IEEE. doi:10.1109/EI2.2018.8582132

Yao, J., & Ansari, N. (2021). Secure federated learning by power control for internet of drones. *IEEE Transactions on Cognitive Communications and Networking*, *7*(4), 1021–1031. doi:10.1109/TCCN.2021.3076167

Zhang, S., Kong, S., Chi, K., & Huang, L. (2021). Energy management for secure transmission in wireless powered communication networks. *IEEE Internet of Things Journal*, *9*(2), 1171–1181. doi:10.1109/JIOT.2021.3079455

Zhang, X., Zhang, R., & Chen, F. (2021, July). Bad data filtering algorithm of power internet of things based on artificial intelligence technology. In *2021 International Conference on Machine Learning and Intelligent Systems Engineering (MLISE)* (pp. 280-284). IEEE. doi:10.1109/MLISE54096.2021.00058

Xin Liu works in the State Grid Shandong Electric Power Research Institute.

Yingxian Chang works in State Grid Shandong Electric Power Company.

Honglei Yao works in the State Grid Shandong Electric Power Research Institute.

Bing Su works in the State Grid Shandong Electric Power Research Institute.