An Improved Automated Digital Power Frequency Meter for Power Holding Company of Nigeria (PHCN)

Peter T. O., Onuodu F. E.

Abstract— There is a need to improve Digital Power Frequency Meter for Power Holding Company of Nigeria (PHCN). The major setback is that any small error in the frequency readings of the meter system employed by the Power Holding Company of Nigeria (PHCN) can lead to substantial loss of revenue by the company. The precision and efficiency of frequency meter often determine the performance and benefit of the meter. The precision of frequency meter measurement is directly related to the frequency method employed. The proposed system was implemented with PHP Programming Language due to its unique Graphical User Interface as Frontend, and MySQL Relational Database Management System (RDBMS) as backend. Furthermore, we adopted Structured System Analysis and Design Methodology (SSADM) in this approach. Our accuracy rate of 9.95% clearly shows that our proposed system outperformed other existing ones. This work will serve as useful tool in calibrating other frequency meters deployed by individuals as well as organizations. In addition, this work could be beneficial to Power Holding Company of Nigeria (PHCN), to Oil and Gas Companies, to Water Boards and to any other organizations that deals with fiscal metering in Nigeria.

Keywords— Automated, Digital, Power, Frequency Meter, Power Holding Company of Nigeria, Measurement System, Graphical Interface.

1. INTRODUCTION

Digital Frequency meter is a common measuring instrument and it can be used not only in general single measurement but also in other fields. The precision and efficiency of frequency meter often determine the performance and benefit of the meter. The precision of frequency meter measurement is directly related to the frequency method employed. There are two basic frequency measurement methods, namely the frequency

method and the period measurement method. The Frequency measurement method records the number of pulse of the measured signal N by a counter in a given time rate TG, thereby getting the frequency of the measured signal f = N/TG.

The accuracy of the measurement method depends on gate

time and counting value of counter and therefore it is relatively suitable for measuring high frequency signal.

The period measurement method measures one cycle time T

of the measured signal and computes its frequency f = 1/T.

The measuring accuracy of the period measurement depends on the timing precision of the system and therefore the digital frequency meter carries out the

measurement of the unknown frequency on the basis of the values of some parameters (among them the clock frequency and the synchronism between the unknown signal and the clock signal of the instrument).

The student can estimate the effects of both the frequency meter parameters and the characteristic of the unknown frequency signal by changing the parameter settings of the device as well as those of the unknown signal.

Moreover, in order to evaluate the effect of a noise signal superimposed to the unknown signal in terms of the frequency estimation, a noise generator has been also integrated.

It allows for experiencing how a small amount of noise as well as a large amount can affect the estimation of the unknown frequency [1].

There is a need to improve Digital Power Frequency Meter for Power Holding Company of Nigeria (PHCN). The major setback is that any small error in the frequency readings of the meter system employed by the Power Holding Company of Nigeria (PHCN) can lead to substantial loss of revenue by the company. The precision and efficiency of frequency meter often determine the performance and benefit of the meter. The precision of frequency meter measurement is directly related to the frequency method employed. The proposed system was implemented with PHP Programming Language due to its unique Graphical User Interface as Frontend, and MySQL Relational Database Management

- *Peter T. O. concluded his Bachelor's degree in Department of Computer Science, N Open University Nigeria, Port Harcourt Study Centre.*
- *Onuodu F. E. is a Senior Lecturer in the Department of Computer Science, University of Port Harcourt, Nigeria. E-mail: gonuodu@gmail.com*

System (RDBMS) as backend. Furthermore, we adopted Structured System Analysis and Design Methodology (SSADM) in this approach. Our accuracy rate of 9.95% clearly shows that our proposed system outperformed other existing ones. This study will serve as a regulation provider and automated checks on the use of frequency meters by individuals as well as organizations. In addition, this work could be beneficial to Power Holding Company of Nigeria (PHCN), to Oil and Gas Companies, to Water Boards and to any other organizations that deals with fiscal metering in Nigeria.

This work thus understudies the simulation and development of an automated digital frequency meter to aid the Power Holding Company of Nigeria (PHCN).

2. RELATED WORKS

2.1 Digital Power Frequency Meters

An electricity meter or power meter is a device that measures the amount of electric power consumed by a residence, business or an electrically powered device.

Electricity meters are typically calibrated in billing units, the most common one being the Kilowatt hour (kWh). The Power Holding Company of Nigeria (PHCN) which supplies the electricity installs the Power Frequency Meters to measure the amount of electricity consumed by each of its customers [2].

A frequency meter has a small device which converts the sinusoidal voltage of the frequency into a train of unidirectional pulses. The frequency of input signal is the displayed count, averaged over a suitable counting interval out of 0.1, 1.0, or 10 seconds. These three intervals repeat themselves sequentially. As the ring counting units reset, these pulses pass through the time-base-gate and then entered into the main gate, which opens for a certain interval. The time base gate prevents a divider pulse from opening the main gate during the display time interval. The main gate acts as a switch when the gate is open; pulses are allowed to pass. When the gate is closed, pulses are not allowed to pass that means the flow of pulses get obstructed.

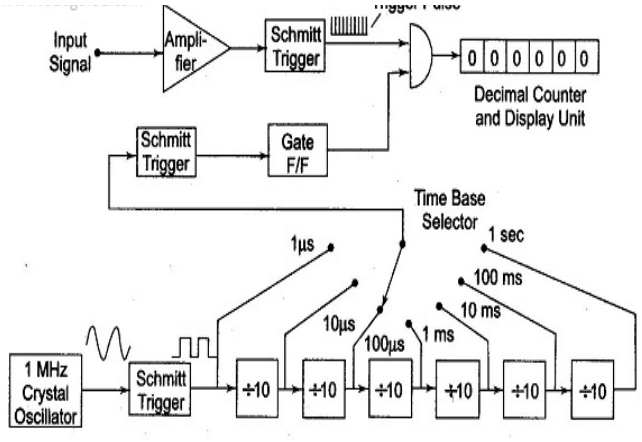

Fig. 2.1. Operating Principle of the Digital Power Meter.

2.1.1 Types of Power Meters

Frequency Power Meters operate by continuously measuring the instantaneous voltage (volts) and current (amperes) to give energy used (in joules, kilowatts-hour, etc). The meters fall into two basic categories:

1. Electromechanical meter
2. Electronic meter

A. Electromechanical meter

The electromechanical meter functions by counting the revolutions of a non-magnetic, metal disc which rotates at a speed proportional to the power passing through the meter. The number of revolutions is thus proportional to the energy usage. The voltage coil consumes a small and relatively constant amount of power, usually around 2 watts which is not registered on the meter [2].

The current coil similarly consumes a small amount of power in proportion to the square of the current flowing through it typically up to a couple of watts at full load, which is registered on the meter. The disc is acted upon by two coils. One coil is connected in such a way that it produces a magnetic flux in proportion to the voltage and the other produces a magnetic flux in proportion to the current. The field of the voltage coil is delayed by 90 degrees, due to the coils inductive nature, and calibrated using a long coil. A permanent magnet exerts an opposing force proportional to the speed of rotation of the disc, the equilibrium between these two opposing forces results in the disc rotating at a speed proportional to the power or rate of energy usage. The disc drives a register mechanism which counts the number of revolution. This type of meter is used on a single phase AC supply.

The amount of revolution represented by one revolution of the disc is represented by the symbol 'kh' which is given in units of watts-hours per revolution. The value 7.2 is commonly seen using the value of kh one can determine

their power consumption at any given time by timing the disc with a stop watch.

P = 3600 kh/t to complete one revolution

Where t = time in seconds taken by the disc, P = power in Watts

For example if kh = 7.2 as above, and one revolution took place in 14.4 seconds the power is 1800 Watts. This method can be used to determine the power consumption of household devices by switching them one by one [3].

B. Electronic Meter

Electronic meters display the energy used on an LCD or LED display, and some can also transmit readings to remote places. In addition to measuring energy used, electronic meters can also record other parameters of the load and supply such as instantaneous and maximum rate of usage demands, voltages, power factor and reactive power used.

They can also support time of day billing for example recording the amount of energy used during on-off peak hours.

C. Solid State Design

The meter has a power supply, a processing engine, communicator engine (microcontroller), a metering engine and other add on modules such as real time clock (RTC), LCD display, communication ports/modules and so on.

PHCN (power Holding Company of Nigeria) the operating electric power utility company in Nigeria is currently deploying energy prepayment meters in Nigeria. These electronic meters are intended to replace the old post-payment meters. This document looks at some benefits of this new prepayment meters first to PHCN and then to average electric power consumers in Nigeria. The new energy prepayment meters if well handled by PHCN will increase her revenue. First, since new meters are prepayment meters it will reduce the overhead that usually characterize house-to-house recovery of revenue as was almost the case in the past [2].

The new energy metering system has some anti-tamper facilities that will largely discourage meter tampering by Nigerian consumers.

Another benefit of these new energy prepayment meters to PHCN is that it will enable her to determine the actual energy demand in Nigeria. This is because most of her consumers will now be within PHCN ranks.

Automated Meter Reading (AMR) technology, Electrical Utilities (EUs) has been exploiting their own infrastructure to bill their customers in an efficient and economical way. Since the amount of data that has to be sent is quite low related to the available time to perform this task, AMR applications have been demanding low bit rates. At this moment, Electrical Utilities are exploring and demanding their services as load and alarm management, remote monitoring and disconnections, etc. In this context, the low voltage modems should provide more throughputs while keeping the cost of the hardware low. The results of this low complexity AMR technology are that in order to deploy an AMR network, the cost of the equipment on the customer premises and the added value services that the system provides are two key factors in its business case.

According to [4], it describes the different methods by which distribution transformer loads can be allocated for power-flow studies. Individual distribution loads are calculated using four different methods of allocation. The results of the power flow studies are compared to those determined using the actual customer meter readings.

The electromechanical based power meters are rapidly being replaced by digital power meters which offer high accuracy and precision. Now the generation of electric power meters is that of AMRs. Various features offered by AMR are given below:

1. Higher Speed
2. Improved load profile
3. Automatic Billing invoice
4. Real time energy Cost
5. Tampering Alarm warning
6. Remote power switches ON/OFF
7. Load balancing

A microprocessor-based automatic meter reading system is implemented, which provides a cost-effective, reliable, and interference free data transfer between remote meter-reading units and the utility control centre. The meter reading and management processes are free from human involvement. Based on the existing telephone networks, it is very flexible for the utility companies to access, service and maintain this meter reading system. A user friendly and window based user interface is designed.

D. Vibrating-Reed Frequency meter

The vibrating-Reed Frequency meter is one of the simplest devices for indicating the frequency of an ac source. Vibrating reed frequency meters are usually in circuit meters. They are used on power panels to monitor the frequency of the ac.

E. Moving-Disk Frequency meter

They can be used to spot check the frequency of power sources or equipment signals. One coil tends to turn the disk clockwise and the other counter clockwise. Magnetizing coil A is connected in series with a large value of resistance. Coil B is connected in series with a large inductance and the two circuits are supplied in parallel by the source.

2.2 Relational Database Management System

A Relational Database Management System is made up of Relational Databases. A Relational Database is a Database that uses tables to store information [5].

2.2.1 Benefits of Relational Databases

i. It is flexible in structure.
ii. It is easy to operate.
iii. User friendly interface
iv. Compatible with other computer application programs. Etc.

2.2.2 Basic features of Relational Databases

i) Data Integrity: This implies on the accuracy and validity of the data in the Database.

ii) Insertion: This is the process of adding new data to the database

iii) Retrieval: This is the process of recovering specific data from the Database. Also, it is a unique phenomenon also known as querying.

iv) Update: This is the process of adding the most recent information to the database.

v) Deletion: This is the process of removing unwanted data from a Database.

vi) Data Sharing: This is the ability of the Database to share data concurrently (at the same time) among multiple users.

vii) Data Encryption: This is the ability to change information in the Database to a secret code (i.e. The System of letters, numbers or symbols) for the purpose of security. E.g. you must enter a password in order to access some Databases [6].

2.2.3 Types of Relational Databases

i) Microsoft Office Access
ii) MySQL
iii) Oracle

2.3 Previous literature

According to [7], they presented a new real-time frequency sensor used as hardware counter measure and the main aim of the frequency sensor is to determine when the period of the *clock* signal is within an allowed range counting the cycles number of a timing scale during a *clock* signal cycle. The initialization of the sensor includes the initialization of both measured (henceforth *delay*) and *cmp* signals, while the *out* signal stores the previous value of the *cmp* signal, *i.e.*, the result of the early cycle in *clock* (*test* from now on) signal. When a new active transition (a rising transition has been considered) arrives in the *test* signal, the *delay* signal increases until another new rising transition arrives or its maximum value has been achieved. During a same cycle of the *test* signal, the behavior of the *cmp* signal is the following: when the *delay* signal does not achieve the minimum value, the *cmp* signal is low, indicating the period is out of the allowed range; when the *delay* signal is between its minimum and maximum values, the *cmp* signal is high, indicating the period is within the allowed range; finally, when the *delay* signal is higher than the maximum value, it is low indicating the period is out of the allowed range again.

This research proposed that a new initialization of the sensor begins with a new rising transition in the *test* signal, and so, the *cmp* signal is stored in *out* signal. At this moment, the frequency sensor obtains two data points: if the period is within the allowed range, and, if so, the period of the *test* signal stored in the *delay* signal. These data are used by the output block in order to implement the final action of the sensor.

[8] presented a paper to design the digital frequency meter with frequency analyzing module. As a measuring frequency's instrument, the cymometer often refer to as electronic counter in modern electronic technology. Its basic function is to measure the signal frequency and this frequency counter has a wide range of applications. It is not only used in the general simple instrument's measurement, but also used in teaching, research, high-precision instruments measuring, industrial control and other areas. Currently, the high-performance and simple-structure electronic products have become the mainstay of market. In this project, the cymometer not only measure the frequency but also determines the jitter, glitches status etc., Digital Frequency Meter were designed using VHDL language and simulated using Modelsim 6.3v simulator. In order to increase the efficiency of the system, sleep mode concept is introduced, which reduces unwanted circuit power utilization.

[9] analyzed the design of Electronic Power Network Frequency Measurement System based on Lab view Virtual Panel and analyzed the electrical signal parameters of computer measurement algorithms, mostly based on synchronous sampling, which is phase-locked loop (PLL) technology, it will realize completely synchronized in a cycle of the signal.

The accuracy of the synchronous sampling to some extent depends on the power system frequency in real time and accurate measurement. To eliminate the impact of harmonics on the measurement results, frequency measurement circuit need low-pass filter to filter harmonic. Hardware frequency measurement method is simple and quick response, but it needs some hardware overhead.

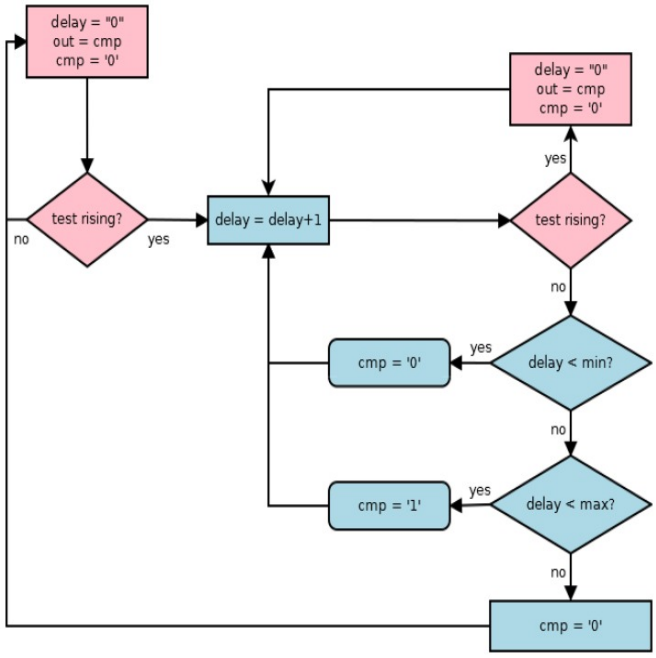

Fig. 2.2. Behavior of the Sensor signal circuit meter.

The second figure shows the building blocks of the proposed sensor fulfilling the above behavior. The local oscillator provides a known time scale that is free of attacks, whereas the aim of the transition detector is to initialize the operation of the sensor. The measurement block indicates an attack situation depending on the period of the *test* signal. These three components form the core of the sensor and provide information related to the existence of an attack and the period of the *test* signal. Finally, the output block provides the final action of the sensor. A typical action is to advise the protected system to erase some confidential information. However, in this work, a free attack clock is generated, and thus, the operation of the system can continue despite any attempted attack. A free attack clock has the same period of the *test* signal when not under attack, or a flat level otherwise.

3. MATERIALS AND METHODS

3.1 Analysis of the Existing System

This section understudies the existing analog system of meter reading existing in homes and offices as well as corporate buildings. It points out the advantages as well as the disadvantages of the adoption of the analog system of meter reading and in the subsequent section of this research proposes a replacement for the existing system using a digitally operated power frequency meter. In most houses in Nigeria, the electricity billing system is completely manual. The electric meters are situated in the houses, offices and factories etc .Meter readers go to the place which are generally situated inside the house and take the meter reading. Most of the time the owner gives some extra money to the meter reader person to have less meter reading and as a result corruptions occur and actual payment is not received by the service provider. So the provider faces a huge amount of loss in every year. At this present situation, it's very necessary to implement AMR in Nigeria. Millions of Analog meters are already used in our houses, offices, industries. So we are not proposed any new meter.

3.1.1 Advantages of the Existing System

The existing analog system of meter reading has a few advantages and these are reviewed in this section:

i) The analog electric meter model is modifiable and easily adjustable.

ii) It enhances portability, scalability and promotes performance as regards electric power meter readings.

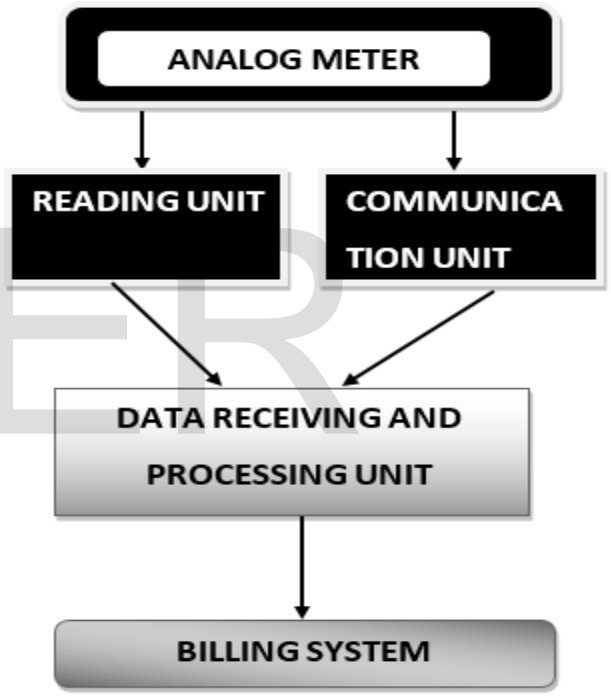

Fig. 3.1. Existing System Architecture

3.1.2 Disadvantages of the Existing System

i) In the manual system of meter reading of electricity meters, a meter reader has to visit every meter location periodically and read the meter value manually.

ii) Traditional analog electric meters unlike digital meters transmit meter readings through wiring systems.

ii) It does not support the implementation of MySQL Servers as its data warehouse. This will not enable skilled data miners in the PHCN to properly carry out queries using Data Manipulation Languages, Data Definition Languages and Data Control Languages.

3.2 Analysis of the Proposed System

The proposed system is an automated Digital Power Frequency Meter and these are electronic devices that track and record customers' home electricity use. Electric utilities have been replacing old, analog meters that are read manually once a month with new, digital smart meters that automatically capture information about electricity consumption and transmit it back to electric companies. Smart meters can provide quick, accurate measurements of electricity use without the need for estimated monthly bills or visits from meter readers. On the other hand, there are some concerns that smart meters can and do collect unnecessary information about hourly electricity use, thus violating users' privacy. The proposed digital power meters offer the following benefits and challenges to electric utilities, customers, and the environment.

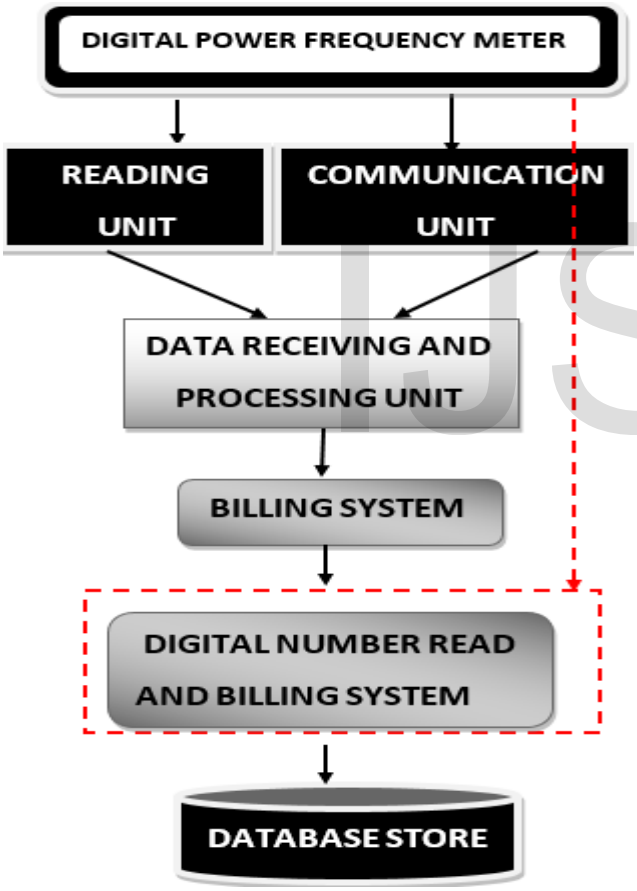

Fig. 3.2. Proposed System Architecture

3.2.1 Advantages of the Proposed System

There are several benefits of the Proposed System since it offers a lot of advancements over the existing analog system of meter reading and these are documented in this section of the research: The proposed Digital power frequency meters can benefit the electric company by:

1. Eliminating manual meter reading,
2. Monitoring the electric system more quickly,
3. Making it possible to use power resources more efficiently,
4. Providing real-time data useful for balancing electric loads and reducing power outages (blackouts),
5. Enabling dynamic pricing (raising or lowering the cost of electricity based on demand),
6. Avoiding the capital expense of building new power plants,
7. Helping to optimize income with existing resources.

After the electric company has fully installed its advanced metering infrastructure, smart meters can benefit the electricity customer by

1. Offering more detailed feedback on energy use,
2. Enabling them to adjust their habits to lower electric bills,
3. Reducing blackouts and system-wide electric failures.

Digital Frequency meters can ultimately benefit the environment by:

1. Preventing the need for new power plants that would produce pollution,
2. Curbing greenhouse gas emissions from existing power plants,
3. Reducing pollution from vehicles driven by meter readers.

3.3 Methodology

The Methodology used for the Proposed System is Structured System Analysis and Design Methodology (SSADM). SSADM is mostly used for the development of fuzzy and information systems in the process of replacing an existing system with a new system.

i) **Techniques used in SSADM:**

The most important techniques that are used in SSADM are as follows:

a) **Logical data modeling:**

This is the process of identifying, modeling and documenting the data requirements of the system being designed.

b) **Data Flow Modeling:**

This is the process of identifying, modeling and documenting how data moves around an information system. Data Flow Modeling examines processes (activities that transform data from one form to another), data stores (the holding areas for data), external entities (what sends data into a system or receives data from a system), and data flows (routes by which data can flow).

A two-stranded process: Entity Behavior Modeling, identifying, modeling and documenting the events that affect each entity and the sequence (or life history) in which these events occur, and Event Modeling, designing for each event the process to coordinate entity life histories.

3.3.1 Requirement of the Proposed System

i) Online Backend.

ii) Webcam

iii) 2GB RAM Size
iv) 64 bits Operating System PC
v) MySQL Relational Database Management System
vi) Data Source and user guide documents

3.3.2 Source of Data used in the Design of the Proposed System

i) Xampp Server Journals
ii) MySQL e-books
iii) Web-based Information System e-books.
iv) Information from Project Supervisor.

4. RESULTS AND DISCUSSION

4.1 Systems Implementation

The implementation of the system is the main focus of this chapter. The features and choice implementation language will be discussed. Also discussed in this chapter is the system testing strategies. The target computer requirements are explained as well as the software maintenance issues that arise in this system.

System implementation centers on migrating the developed system from test environment to production environment. Application usage occurs in the software life cycle and covers other tasks such as:

1. System specification,
2. Program testing and debugging,
3. Detailed documentation.

This section discusses all this sub activates within implementation phase.

4.2 Choice and Justification of Programming Language Used

The programming language used to implement the system is typically chosen based on the features offered by the language that make it suitable for solving the problem at hand here. Hypertext Pre-Processor (PHP), Structured Query Language was used to develop the Automated Digital Frequency Meter.

4.2.1 PHP: Hypertext Preprocessor

The Hypertext Pre-processor is a widely-used open source general-purpose scripting language that is especially suited for web development and can be embedded into HTML. PHP is a script language and interpreter that is freely available and used primarily on Linux Web Servers.

4.2.2 Structured Query Language (MySQL)

MySQL is a fast easy to use open source relational database management system (RDBMS) that serves as a popular choice of database for use in the development of applications. MySQL workbench is activity developed by Oracle, and is freely available for use. MySQL is a client-server based DBMS that is easier to install and use than its commercial competitors, and the fact that MySQL is open Source is strongly in its favour as the DBMS used for the development of the proposed system. MySQL ships with many command line tools, from which the main interface is MySQL client. MySQL consists of a MySQL server, several utility programs that assist the administration of the MySQL databases

4.3 Implementation Algorithm

We analysed the existing and proposed system algorithms and the proposed algorithm was found to be an upgrade over the existing system and hence implemented for the development of the proposed system in this research as shown.

Both Algorithms use variables model for their implementation, Number of load meter as a, b and c

I. Existing Algorithm

Step 1:
START
Step 2:
NUMBER OF LOAD PARAMETERS AS A, B, C
Step 3:
CALCULATE A, B, C, AS SUM OF LOAD METER GIVEN AS X
X = A + B + C
Step 4:
COMPUTE ILLEGAL LOAD (D1= 2, 3, 4 ...BUT NOT LESS THAN 1)
Step 5:
CALCULATE Y = X * D
Step 6:
IF Z = X
Step 7:
CONTINUE
Step 8:
OUTPUT Z
Step 9:
SAVE
Step 10:
STOP

ii. The Proposed (Modified) Algorithm

Step 1:
START
Step 2:
NUMBER OF LOAD PARAMETERS AS A, B, C
Step 3:
CALCULATE A, B, C, AS SUM OF LOAD METER GIVEN AS X

X = A + B + C

Step 4:

COMPUTE ILLEGAL LOAD (D1= 2, 3, 4 ...BUT NOT LESS THAN 1)

Step 5:

CALCULATE Y = X * D

Step 6:

IF Z = X

Step 7:

CONTINUE

Step 8:

OUTPUT Z

Step 9:

PROCESS DATA RECEIVING UNIT

Step 10:

CHECK DATA PROCESSING AND READING UNIT

Step 11:

COMPUTE DIGITAL NUMBER READ FOR DIGITAL FRQUENCY METER

Step 12:

MATCH Z WITH BILLING SYSTEM

Step 13:

CHECK IF Z < Y

Step 14:

IF YES

Step 15:

DISPLAY ILLEGAL LOAD DETECTED

Step 16:

SEND SMS ALERT TO **PHCN**

Step 17:

STOP

4.3.1 Comparative Analysis of the Existing and Proposed Algorithms

We analysed the comparative analysis of several existing algorithms. Firstly, [10] in their work on Minimizing Household Electricity Theft in Nigeria using Digital Power Electricity Prepaid Meter developed an energy efficient and low cost solution for street lighting system using Global System for Mobile Communication (GSM) and General Packet Radio Service (GPRS). The experimental set-up allowed the operator to turn off the lights when not required, regulate the voltage supplied to the street-lights and prepared daily reports on glowing hours. A prepaid energy meter like-mobile phone was proposed and contained a prepaid card analogous to mobile SIM card. Distance coverage is the major limitation for this kind of system because the Bluetooth technology works effectively at close range.

Furthermore, [8] presented a paper to design the digital frequency meter with frequency analyzing module. As a measuring frequency's instrument, the cymometer often refer to as electronic counter in modern electronic technology. Its basic function is to measure the signal frequency and this frequency counter has a wide range of applications. It is not only used in the general simple instrument's measurement, but also used in teaching, research, high-precision instruments measuring, industrial control and other areas.

Also, [9] analyzed the design of Electronic Power Network Frequency Measurement System based on Lab view Virtual Panel and analyzed the electrical signal parameters of computer measurement algorithms, mostly based on synchronous sampling, which is phase-locked loop (PLL) technology, it will realize completely synchronized in a cycle of the signal.

The analyzed frequency measurement method is simple and quick response, but it needs some hardware overhead.

Table 4.1

Comparative Analysis of the Existing and Proposed Algorithms

ALGORITHM	FEATURES	ACCURACY RATE (%)
Maheswari et al (2013)	energy efficient and low cost solution	4.15
Sunkara et al (2014)	frequency analyzing module	5.00
Xinling et al (2012)	Electronic Power Network Frequency Measurement	9.50
Orire's Algorithm (2018)	Digital power frequency computation	9.95

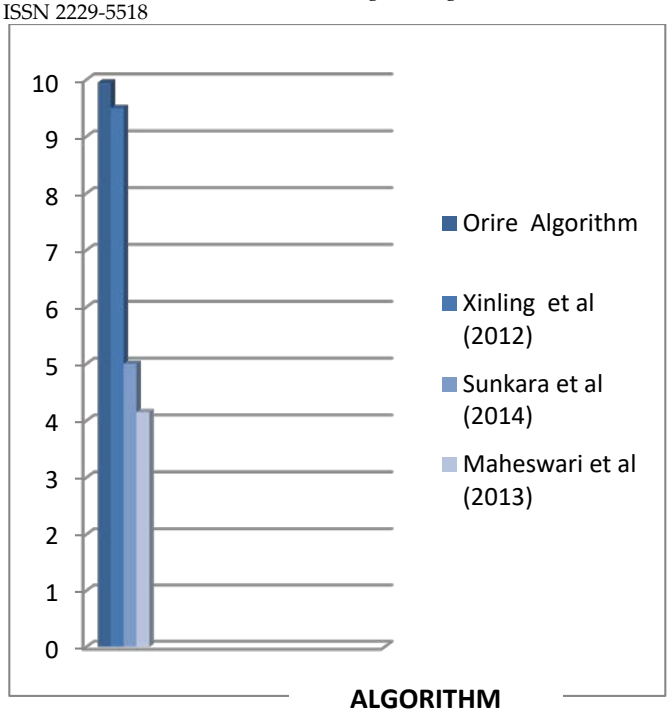

Fig. 4.1. Algorithm Vs. Accuracy Rate Chart

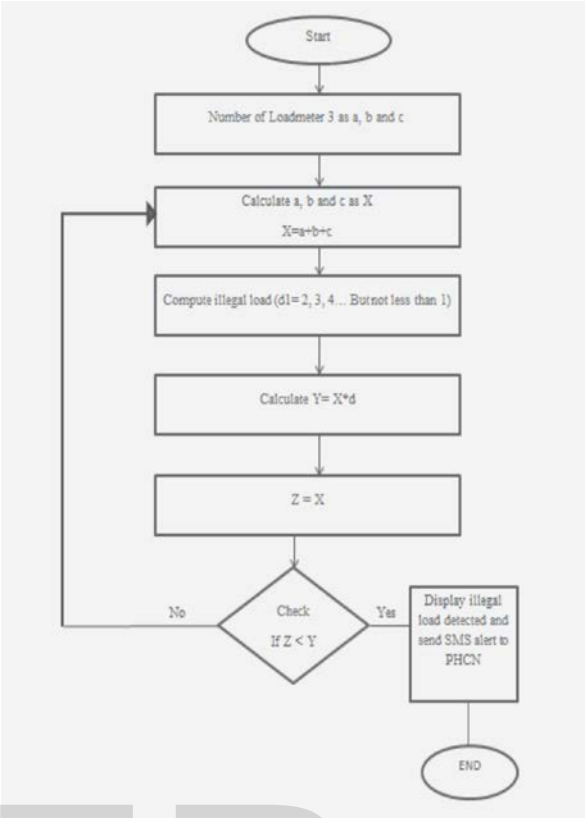

Fig. 4.2. Flowchart of the Proposed System

4.4 System Requirements

This section considers the requirements that must be met by the target system to enable the developed software application function as required. The target computer system requirement will be discussed in the area of software and hardware requirements.

4.4.1 Software Requirements

The table shows a list of the software requirements for the proposed system to function.

Table 4.2
Software Requirements for the Target System.

Component	Requirement
Operating System	Windows 2000,XP,VISTA,7
Data base Engine	MySQL 5
Web Server	Apache web server
IDE	SUBLIME
Framework	PHP, MySQL

4.3.2 Flowchart of the Proposed Algorithm

4.4.2 Hardware Requirements

The table shows a list of the software requirements for the proposed system to function.

Table 4.3
Hardware Requirements for the Target System.

Component	Requirement
RAM	512MB or higher
Hard disk	10GB or higher
Processor	1.2GHz or higher

4.4.3 Software Maintenance Issues

Software maintenance is the modification of software products after delivery to correct faults, to improve performance or other attributes. This section focuses on the software maintenance issues. The maintenance of software is in response to finding a previously unknown error in the environment in which the system functions and working to eliminate the errors. Software maintenance also provides non-corrective measures as it also serves as an opportunity to improve the performance of the software to suit the needs of the users if it becomes necessary for the user requirements to be improved on or changed. Maintenance as related to this research would be discussed in three areas, corrective maintenance, preventive maintenance and adaptive maintenance.

4.5 System Maintenance

System maintenance is a necessary measure in software maintainability issues as it strives to improve software components so that preventive maintenance can be carried out reliably. Components with the design weakness or errors must be designed to improve reliability. This maintenance task should be performed to identify, isolate and rectify a fault so that the failed software component or system can be restored to an operational condition within the tolerance or limits established for in-service operations.

4.5.1 Preventive Maintenance

Preventive maintenance involves a schedule of planned maintenance actions aimed at the prevention of breakdowns and failures. The primary goal of preventive maintenance is to prevent the failure of software components or equipment before it actually occurs. It is designed to preserve and enhance component reliability by replacing worn components before they actually fail. In the light of this research, preventive measures should include regular updates of software.

4.5.2 Staff Training and Installation

The amount of training required for various categories of personnel will depend upon the system and the skills presently available. The system analyst will be required to ensure that all persons involved with the new system were capable of making it be produced as part or development from the system. Course either full time or part time should often be run by the computer manufacturer or educate the staff.

4.5.3 System Testing Strategies

This section is concerned with testing and debugging of the programs and general processes involved in achieving the objectives of the system requirement. System testing is conducted on a complete integrated system to evaluate the system's compliance with its specified requirements. Modifications can be made at this stage to the design specification of the system. Changes made at this point would be less costly when compared to making such changes when the system is fully operational. The system strategies explored in this research are unit and integration testing.

4.5.4 Unit Test

The primary goal of unit testing is to take the smallest piece of testable software in the application, isolate it from the remainder of the code and determine whether it behaves exactly as it is expected to behave. Each unit is tested separately before integrating them into modules to test the interfaces between modules. Unit testing has proven its value in that a large percentage of defects are identified during its use.

This approach allows for automation of the testing process, reduces difficulties of discovering errors contained in more complex pieces of the application and test coverage is often enhanced because attention is given to each unit. During the unit testing, carried out by the researcher, some errors were raised and all of them were rectified with satisfactory result.

4.5.5 Integration Testing

Integration testing is a logical extension of unit testing. In a simplest form, two units that have already been tested are combined into a component and the interface between them is tested. A component in this sense refers to an integrated aggregate of more than one unit. In a realistic scenario, many units are combined into the components which are in turn aggregated into larger parts of the system.

In this research, lower level components were tested first and the output was then used to facilitate the testing of the higher level components in the system. This process was repeated until the component at the top of the hierarchy is tested.

4.6 Discussion of Results

User interfaces are the access points where users interact with designs. Graphical user interfaces (GUIs) are designs' control panels and faces. User interface design or UI design generally refers to the visual layout of the elements that a user might interact with in a website, or technological

product. This could be the control buttons of a radio, or the visual layout of a webpage. User interface designs must not only be attractive to potential users, but must also be functional and created with users in mind. User interface design can dramatically affect the usability and user experience of an application.

User interface designs should be optimized so that the user can operate an application as quickly and easily as possible. The user interface is shown in Fig. 4.6.1.

4.6.1 User interface design layout of the Login Page

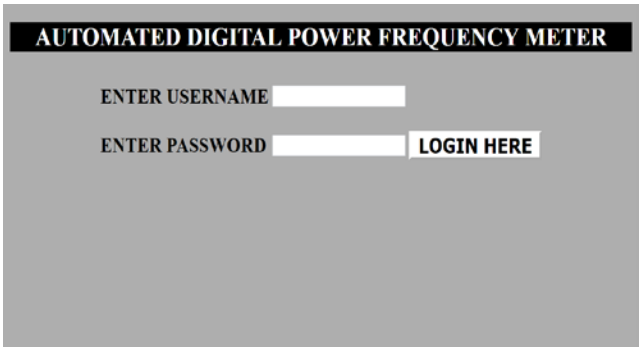

Fig. 4.6.1. User interface layout design of the Login Page

Fig. 4.6.1, shows the login page of the Automated Power Meter Application which is the first page of the application.

4.6.2 Digital Meter Login Validation Page

The Digital Meter Login Validation Page is displayed, as shown in fig. 4.6.2.

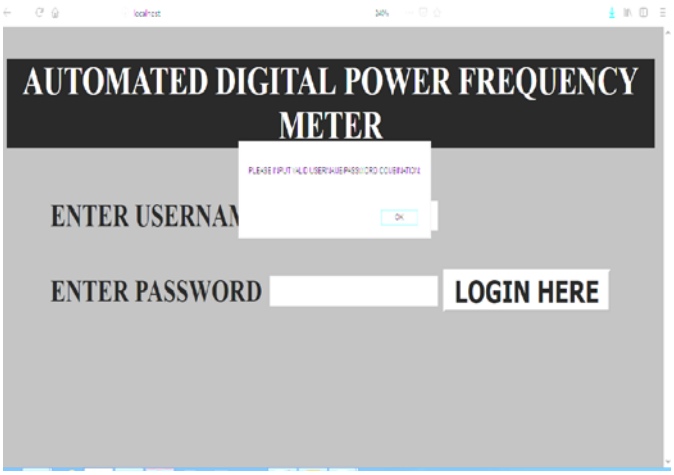

Fig. 4.6.2. Digital Meter Login Validation Page

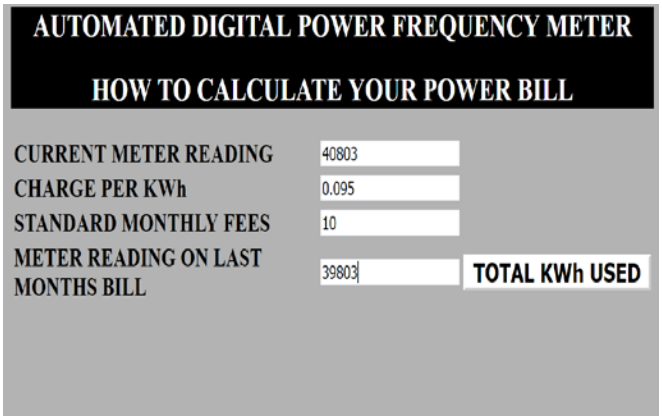

Fig. 4.6.3. Calculate Power Bill Page

Fig. 4.6.3, Shows the Power Bill Calculation Page. The page requests the subscriber to input the current meter reading asa well as the meter reading on last months bill and then subtracts the Last Months Bill from the current Meter reading to give the total Kilowatts used. The total Kilowatts user per hour is then multiplied by the charge per Kilowatt hour to give the total energy charge. The total energy charge is added to the standard monthly fees to compute the total Power Bill used.

All these are documented and computed as shown on the preceding page of the application as Figure 4.6.4

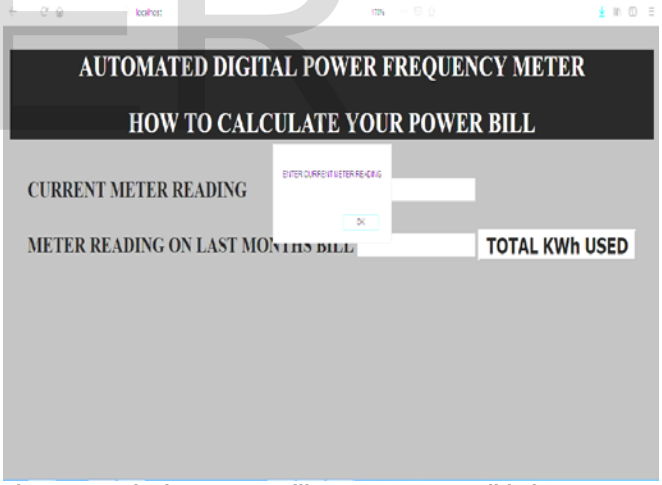

Fig. 4.6.4. Calculate Power Bill Current Meter Validation Page

4.6.3 Calculate Power Bill Page

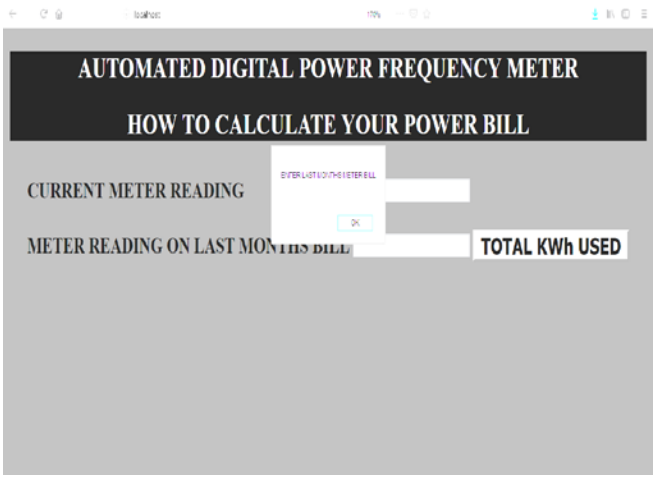

Fig. 4.6.5. Calculate Power Bill Last Months Meter Validation Page

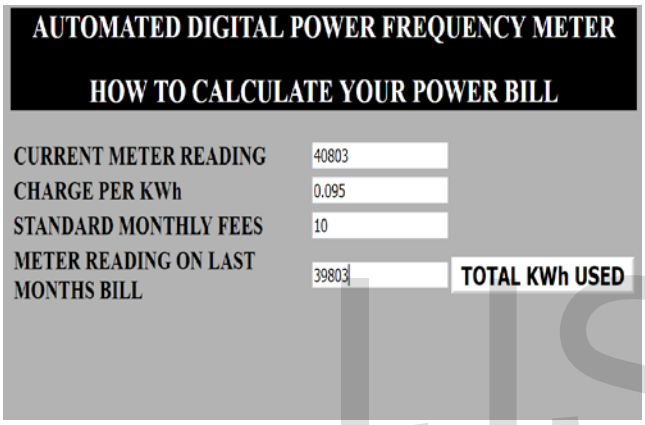

Fig. 4.6.6. Simulated Values For Current Meter And Last Months Bills

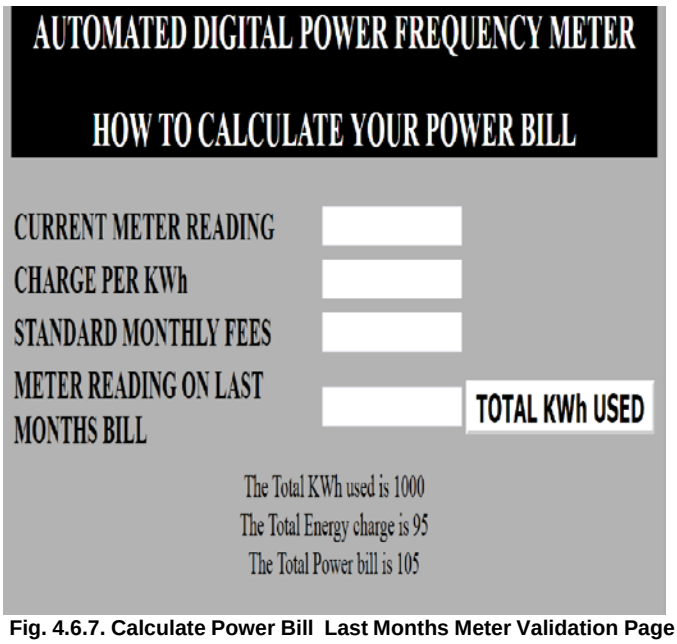

Fig. 4.6.7. Calculate Power Bill Last Months Meter Validation Page

```php
<?php
    if(isset($_POST['cmeter']) )
    {
    $cmeter= $_POST['cmeter'];
    $charge= $_POST['charge'];
    $fees= $_POST['fees'];
    $meterread= $_POST['meterread'];
    $kwh = $cmeter - $meterread;
    $totalenergy =  $kwh * $charge;
    $totalbill = $totalenergy + $fees;
    echo " The Total KWh used is " . $kwh;
    echo " The Total Energy charge is  " . $totalenergy;
    echo " The Total Power bill is " . $totalbill;
}
?>
```

Fig. 4.6.8. Back-End Of The Power Bill Computation Page

4 CONCLUSION

The purpose of this research is thus to shed light on the development of an automated digital power frequency meter for the Power Holding Company of Nigeria. It aims at explaining the phases and stages required for designing an automated digital power meter. The stages are explained in a simple way so that developers can use these steps as guidelines for designing in the most effective way. Chapter one thus sheds light on the background to the study, the aim and objectives of the study, significance and the scope of the study, chapter two deals on literature review and chapter three focuses on the materials and methods, chapter four focuses on the results and discussion.

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