The Driven-by System of Automatic Meter Reading (AMR): An Alternative to Analogue Meter Reading System in Nigeria

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ABSTRACT

Prepaid Power Metering System is essentially designed to proffer a plausible solution to the current billing system existing in Nigeria. It is a computerized system of billing where a consumer would purchase power in kilowatt per hour (kWh) before power is consume. The consumer will continue to enjoy this service so long as the power credit unit is not exhausted. Two major essential components were discovered in the course of this design, the communication system and a power meter interface module. This study make use of a microcontroller, digital and analog-digital circuit and an application program to establish an Automated Meter Reading (AMR) System for this application. There are a number of technologies that use AMR, each with its own cost structure and value points. The AMR discussed exhaustively in this work is driven-by system which is the closest in quality to manual or analog meter reading system and is recommended for Nigeria as an under-developed nation.

Keywords: *Prepaid Power Metering System, Automated Meter Reading, Analog Meter Reading*

INTRODUCTION

Prepaid Power Metering System is a technological break-through in the application of electronics to the process of electricity power metering system. Prepaid Power Metering System has come up with great improvement and accuracy compared to the obsolete method of electricity metering which is normally achieved manually through on – the spot reading measurements. This invention is much better than the mechanical meters as it will incorporate power line communication to reduce the cost of integration and the number of control errors due to corrupted data transmission, and consequently enhancing the reliability of the system. In a drive-by system, transmitter is mounted on the meters; send a signal to a meter reading device located in the utility van. As the van drives through a neighborhood, the meter readings would be downloaded through a radio frequency (RF) signal processors. Analog reading system faced with challenges such as fast expansion of residential consumers that are not readily accessible to the meter readers. Apart from poor accessibility to the consumer's meter in Nigeria, the task of taking the meter reading manually is too laborious, painstaking, cumbersome and ineffective as many consumers may not be available on visit and hence, denied access to the meter to be read. Due to AMR real-time communication with utility meters and service points create three significant services of value as (i) on demand meter reading (ii) outage management (iii) demand response contracts. On demand meter readings requires the ability to collect

specific meter readings at any time. Outage management requires the data communication to occur in real-time. And demand response contract require the ability to manage loads and monitor power consumption continuously through two-way data communication. Drive-by solutions are inadequate for real-time data communication. The Automated Meter Reading (AMR) employed in this work have enabled utilities to change business processes from reading meters manually to downloading meter readings automatically. The potential cost savings for utilities are enormous. The entire workforce that were once charged with the menial tasks of visiting residences, industries and so on to record readings in a log book and consequently keying the meter reading into the billing system have been utterly replaced by this AMR which is an arrangement of hardware and software that collects meter readings of entire cities with a single click of the button.

RESEARCH METHOD AND EVOLVING TECHNOLOGY

The method employed in AMR technology is drive-by system. On this discovery, Transmitters, mounted onto the meters themselves, send a signal to a meter reading device located in the back of a utility van. As the van drives through a neighborhood, the meter reading would be downloaded. This technology requires the implementation of RF signal processors to transmit the data, database software to collect the meter readings, and interface software to validate data and hold it for billing purposes (Bimal, 1998). The state-of-the art rarely stands still and AMR technology is no different. There are varieties of technologies, each with its own cost structure and value points. Eric body of Plexus Research provided an installation cost to performance roadmap for AMR. An adoption of his roadmap is provided as in figure 1. As depicted in the chart below, other technologies using the AMR was highlighted. Cell Net, now replaces the need for drivers to collect meter readings with wireless networks that span entire utility service areas through its application software (CellNet Software) and a cellular network. Other evolving technologies include Power line Technology by HUNT, TWAYS Network; this enables electricity utilities to collect meter readings over their existing Power line transmission networks, TANTALUS network have enabled utilities to deploy a meter reading system that gathers meter data in real time.

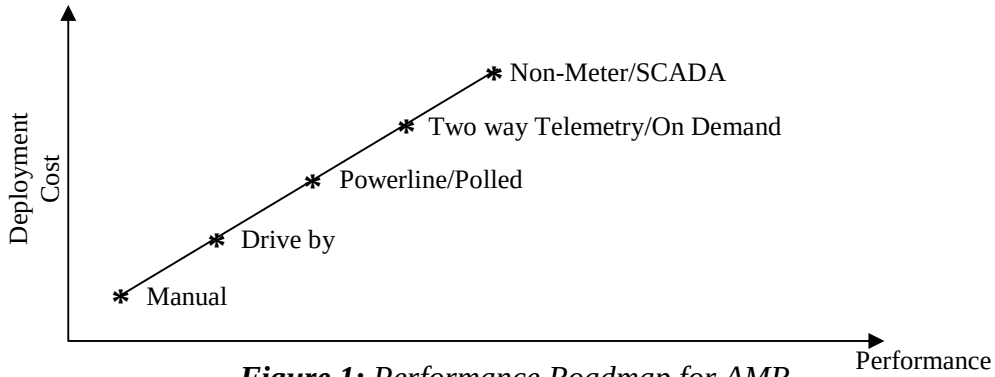

Figure 1: *Performance Roadmap for AMR*

Smart Synch network employs two-ways telemetry over public or private networks. The most affordable of all these technologies in term of cost of installation and maintenance is driven-by system that is considered in this work.

Increasing Market Demand in Automatic Meter Reading (AMR): Automating the business process of reading meters is a large investment. In America as a typical example, a single Automatic Meter Reading (AMR) sale to any single one of the 189 top US investor owned utilities is valued between $100 and $200 million. Moreover, AMR is a global market with expressed demand across the developed nations. Nigeria as one of the underdeveloped nations of the world should endeavour to follow suit. The high price of AMR adoption is related to the work required to produce, install, and integrate the technology throughout the million plus service points in a typical investor owned utility service area, an idea extracted from Bimal (1998). AMR market is not only large but fast growing. Economist report anticipated growth for the technology sector is on an encouraging rate. The disparity of growth in favour of AMR reflects the saturation of enterprise database solutions and the untapped latent market potential in machine-to-machine communication.

Shifting Business Requirements: The intention, aspiration and motive of this paper is to a very large extent to displace the meter reading workforce which does not require more than monthly meter readings from residential service points and perhaps any minute interval meter readings from large commercial and industrial service points. For residential meters which are vast majority of the service points a drive-by AMR solution was sufficient. In this drive-by AMR solution, a radio module mounted on the meter would wirelessly send the meter reading to a radio transreceiver mounted within a utility van as the van drives by the service point. Depending on the interfacing program, certain minute interval data from large commercial and industrial service point via dedicated or commercial telecommunication systems. The value of transforming the business process of reading meters from mundane manual labour to automated technology persists today, however, new business requirements which expands the financial impact of automatic meter reading and meter management, have evolved. These new business requirements are related to the overall shift in the environment of the utility competitors towards the creation of a real-time institution with real-time reaction speeds. While most consumers are still billed once a month, AMR, due to its real-time communication with utility metes and service points creates three new significant services of value as (i) On demand meter readings (ii) Outage Management (iii) Demand Response Contracts. On demand meter reads require the ability to collect specific meter readings at any time. Outage management requires the data communication to occur in real-time. And demand response programme require the ability to manage loads and monitor power consumption continuously through a two-way data communication. However, Drive-by solutions are inadequate for real-time data communication.

Prepayment Operation: The prepayment meters used are called Electricity Dispensers (ED). A token is purchased from a vending machine referred to as Credit Dispensing Unit

(CDU). The popular vending machine used by AMR was designed by a German Phycist called Eskom in eighteen (18) century. A purchase token is taken home by the customer and entered into their ED. If the token is valid, the ED accepts the token and adds the Credit (amount of units on the token in kWh) to the credit currently in the ED. The customer is then free to consume electricity until the credit recorded in the ED runs out, at which time the ED interrupts the electricity supply. The customer buys token for their specific ED and it cannot be used in any other ED. Such a token is therefore worthless for any other consumer, removing any incentive to steal it (Olatunbosun, 2003).

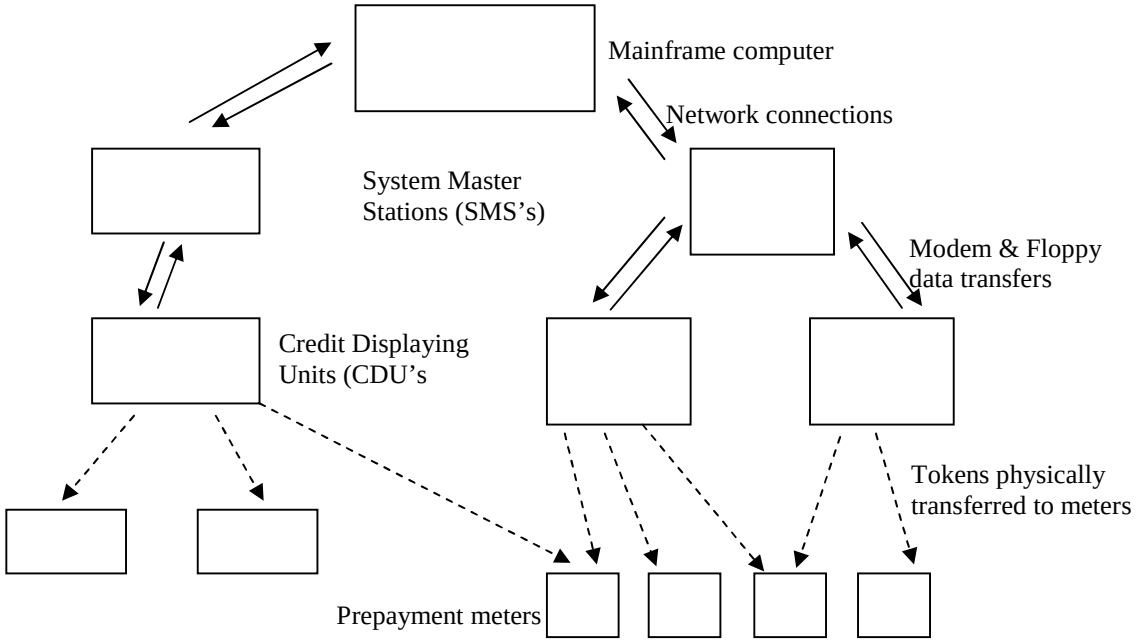

Figure 2: *Eskom Prepayment System*

Token Technologies: Although, there are two types of token technologies for our EDs-by Eskom, yet both types are of a use-once-and-dispose nature. We have a Numeric token and a Disposable paper card with a magnetic stripe. For the purpose of this research, we made use of Numeric token which is a normal paper slip on which the Vending machine prints a 20 digit number. The number is to be entered into the ED, via a keyboard on the meter. The numeric token is preferred since it does not have to be physically transported as it can be sale over the telephone.

Hardware Implementation of AMR: Basically, this research hardware implementation focuses on two major parts that makes AMR as (i) The Digital Kilowatt hour meter (kWh) which is made up of Metering IC KAD7676 and the PIC17F874 microcontroller and (ii) Interface module which interfaces with the central bill server and the software which runs on the Bill server according to Fakolujo (2003). The arrangement of the metering system

is such that, the meter is installed at the consumer end. The system is activated when a consumer scratch-card which contains a random combination of numbers are entered through the meter keypad while pressing the send key, the microcontroller sends an encrypted version of the number combination to the Bill server.

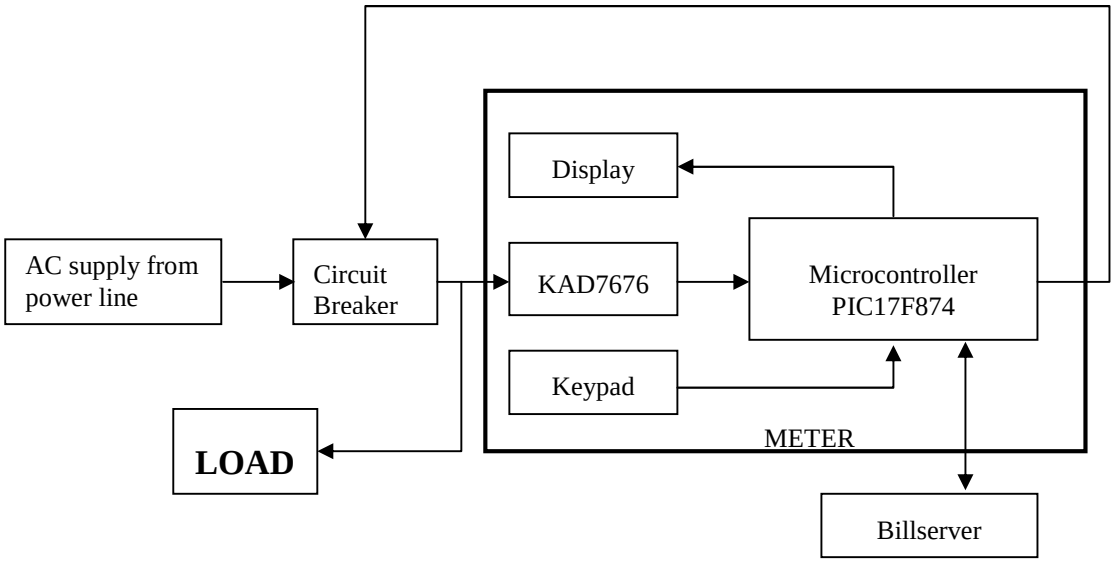

Figure 3: *Block diagram of the Metering System*

The Bill server receives the encrypted message and decodes back to the original combination of numbers. There exists on the Bill server, a database of valid number combinations. The Bill server in this case is a personal computer. The Bill server runs through the database and checks if the number sent is present. Three events are possible after this check.

(i) The number sent is present: The Bill server sends an acknowledgement back to the consumer and this will reflect the amount of energy purchased by the consumer.

(ii) The number sent has been earlier used: The acknowledgement sent informs the consumer that he is trying to enter an already used combination.

(iii) The number sent is invalid: The acknowledgement sent informs the consumer that he is trying to enter an invalid combination. It is only in the first case, that the message sent generates a response from the meter.

The microcontroller receives the acknowledgement and decodes to find out how much energy is purchased. This amount is stored in the memory of the microcontroller. At the same time, the microcontroller issues a control signal that energizes the circuit breaker to connect the consumer to the grid power supply.

Metering Network of AMR: The attention of this research is focused on a single-phase metering. The KAD7676 in conjunction with many others complex components as shown in the block diagram below function adequately. The function of this part is to convert the

energy consume to frequency pulses which is used to drive the counter of the microcontroller (Robert and Nashelsky, 1998).

Control Circuit of AMR: The microcontroller (PIC 17F874) is the central part of this research work. It controls the activities of the circuit breaker, controls the display and performs the energy count and responds to input from the keypad.

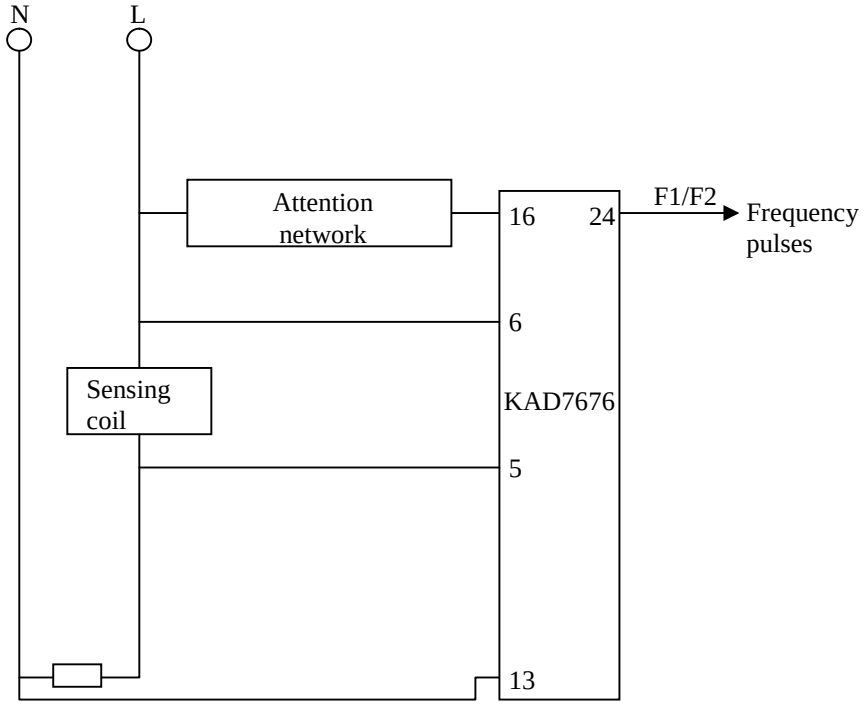

Figure 4: *Block Diagram of Metering Network of AMR*

Microcontroller and The Metering Network Interface: The counter in conjunction with the three input NAND gates was employed as an interface to divide the pulse count by 100 and also serves as buffer between the KAD7676 PC and PIC17F874 microcontroller, as well as provides matching voltage levels between them. The current levels still differ so a diode is provided between the counter and the microcontroller to prevent the microcontroller from sinking too much current when there is no pulse (Robert and Nashelsky, 1998).

Power Supply: The power consumption by the ICs is very low. A regular bridge rectifying circuit was used.

Counter: The counter here registered the frequency count which has been calibrated to be equal to the energy consumption of the load. This is connected to the display for the meter readout.

Application Program: The choice of our application program is assembly language (Fakolujo, 2003) – written to the PIC, this encrypts the inputs from the keypad and send the encrypted data to the Bill server. This program also receives control data from the PIC to direct the operation of the circuit breaker.

RESULTS AND DISCUSSION

The Voltage Controlled Oscillator (VCO) of the meter reading device frequency output was fed into an oscilloscope at different values of the load power and the waveform obtained as illustrated in the graph below.

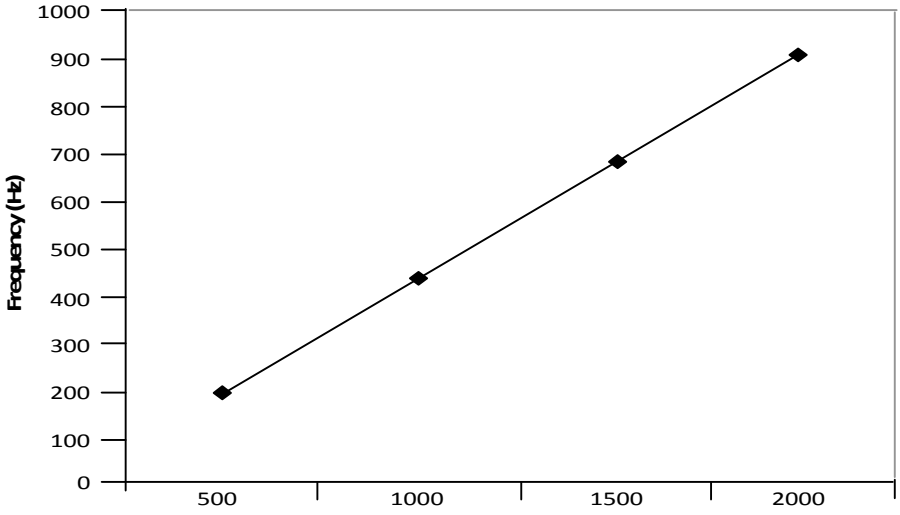

Figure 5: *Graph of VCO output Vs Load.*

The potential difference across the sensor was measured with a digital multimeter at different values of load power as indicated in the graph below (an excerpt from the work of Olatunbosun, 2003).

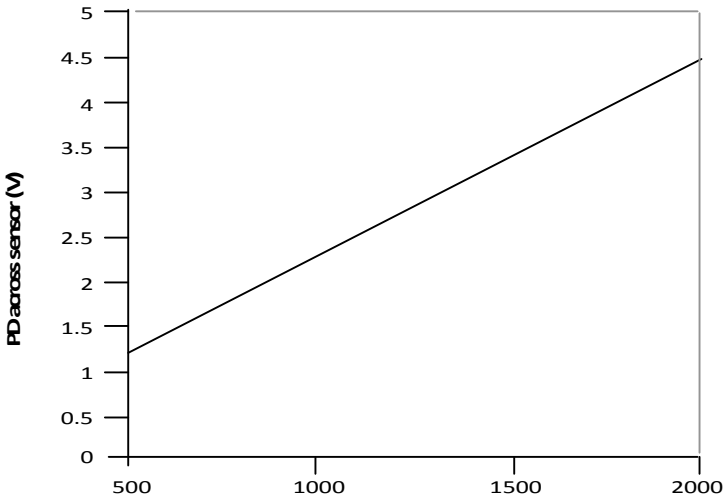

Figure 6: *Graph of Potential Difference across Sensor Vs Load.*

Problems Encountered: Interfacing the AC load line to the circuit was the first major problem. It was difficult to get the exact isolation transformer. A high resistance isolation transformer ratio of roughly 1:3 is desirable for this work and was eventually implemented to solve this problem. Interfacing the signals to the computer and getting signals out of the computer. An opto-isolator was considered to completely isolate the parallel port from the meter. Random signal error due to spices in the counter stages were also noticed that produces unusual reading.

CONCLUSION AND RECOMMENDATIONS

The general operation and performance of this research is dependent on the user who is prone to human error such as entering the wrong pin code or card number, but its performance met expected specifications. This research combines so many useful factors such as prompt revenue generation, consciousness of wastage of power supply by the consumers, availability of constant power supply, and a promising productivity future for the country. However, this research leaves scope for further development. Hence, the adoption of a more complicated AMR as it has been earlier mentioned is desirable (see extract figure 1) so that the meter readings can be made to record energy consumption real time, made the connection between Bill server and the meter to provide for remote meter reading, so that the Bill server program can be modified to access the meter reading of any remote meter and a communication protocol worked such that addresses are assigned to meters, so that Bill server can control more than one meter.

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