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Implementing Optical Port Data Communication in Energy Meters using DLMS/COSEM

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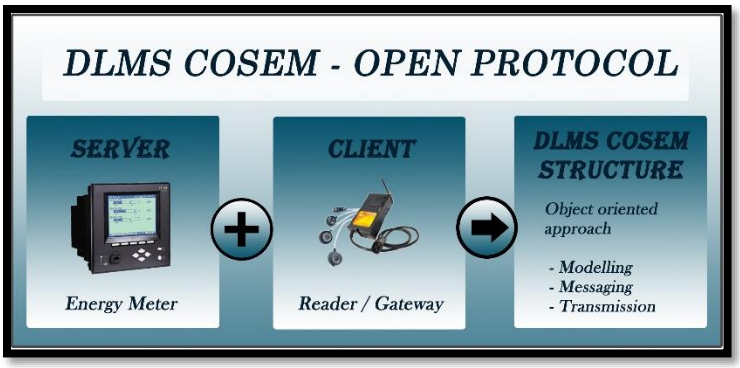
***Abstract*: -**
Energy meters are used for commercial purposes to record consumption of energy by consumer and correspondingly billing the consumer. Indian metering industry is a heterogeneous one with multiple communication protocols so even though there are many communication technologies used today for meter reading applications they lack the properties of interoperability and homogeneity. The presented solution describes a microcontroller-based device, which works on an Open Protocol, that provides real time local data display and record, for several electrical parameters, acquired from a power and energy meter device through optical communication. The open protocol used here is IEC 62056, which helps to overcome most of the challenges regarding data acquisition, uniformity and homogeneity among various energy meter manufacturers in India. The proposed system focuses on DLMS COSEM Metering application protocol and provides guidelines on the implementation of DLMS COSEM in clients (data collection units) as well as in servers (Meters). The device is designed to be connected in a home, or residence, which makes it very useful as an interface for Optical Port Data Communication.

Keywords: *Energy meter, DLMS, COSEM, Optical communication, IS15959*

I. INTRODUCTION

Energy meters are used for commercial purpose i.e., to record consumption of energy by consumer and correspondingly billing the consumer. In these days in every sector, there are number of customers which use the electricity but they are not satisfied with the services provided by power distribution companies. Electricity authority & the government realizes problems occurring in the existing transmission network, such as increasing cost due to poor operational efficiency, environmental impacts and an ongoing demand for energy. The idea of remote metering was born in the 1960s. Initially, remote pulse transmission was used, but this has gradually been replaced by using various protocols and communication media. Today's energy meters are data loggers. Now-a-days,



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meters with complex functionality are based on the latest electronic technology, using digital signal processing, with most functions being implemented in firmware. They give much more than just energy readings. Meters have a large amount of data, which is not practical to read using the given display and can be better read electronically.

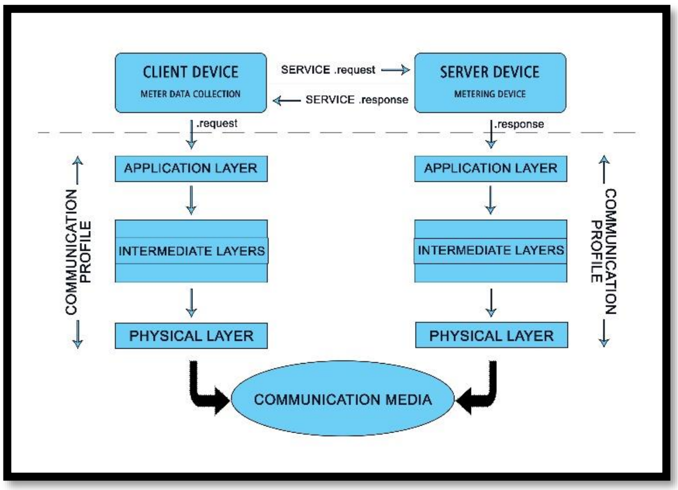
Fig. 1. DLMS/COSEM Open Protocol Structure

One of the major components of operational cost in an electrical utility system is the cost of acquiring data on consumption of the thousands of consumers, spread over a large geographical area, connected to the system. Typically, acquiring data on energy consumption is accomplished by making a meter reader visit the premises of each and every consumer and record data manually. Time and again loss of revenue to the utility occurs because of human errors in acquiring data on the consumption of individual consumers. Automating the entire process of acquiring data and billing will reduce the cost by eliminating human intervention in meter reading. The task of collecting data on electricity consumption without human intervention is popularly known as automatic meter reading (AMR). To facilitate automatic data collection, the metering systems should be networked. The earlier Common Meter Reader Instrument (CMRI) had a hardware/ software that used different communication protocols as provided by various manufacturers to download data from the meters of respective manufacturers, all of which were generally supplied with their own data exchange formats or protocols. To ensure interoperability of energy meters, implementing open protocol was the only true solution. Today for Indian power sector "IEC 62056 Electricity metering – Data exchange for meter reading, tariff and load control" which is commonly known as Device Language Message Specification (DLMS) and Companion Specification for Energy Meters (COSEM), is adopted for implementation in meters as the open protocol for meter data exchange. This series of IEC standards are supported by the Indian Companion Specification as IS 15959. This proposed system aims to enhance the homogeneity in different makes of meters by developing a common meter reading instrument that follows DLMS COSEM protocol and reads any meter data accurately and efficiently.

II. LITERATURE SURVEY

This main concept of this proposed system revolves around an Open Protocol called DLMS/COSEM which is used here for the purpose of data exchange. The DLMS/COSEM specification specifies an interface model and communication protocols for data exchange with metering equipment. DLSMS/COSEM Open Protocol follows a client/server model where data collection systems play the role of the client and metering devices play the role of the server. For communication to the server many options are available as wired or wireless such as, power lines, cable networks, RF modules, GSM modules, Zigbee, which are studied by different researchers. Different approaches were used by the researchers to simplify the meter reading process and increase the overall efficiency of the process.

DLMS/COSEM User Association formulates and maintains the documentation of world-wide established standards of DLMS/COSEM. The Green Book Edition 9 [1] describes the complete technical information about the DLMS/COSEM protocol. The DLMS/COSEM specification specifies



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an interface model and communication protocols for data exchange with metering equipment. The objective of DLMS/COSEM is to specify a standard for a business domain-oriented interface object model for metering devices and systems, as well as services to access the objects. This Technical report, the "Green Book" specifies the DLMS/COSEM application layer, lower protocol layers and communication profiles. DLMS/COSEM uses the concepts of the Open Systems Interconnection (OSI) model to model information exchange between meters and data collection systems. Data exchange between data collection systems and metering devices is based on the client/server model where data collection systems play the role of the client and metering devices play the role of the server. The client sends service requests to the server which sends service responses. In addition, the server may initiate unsolicited service requests to inform the client about events or to send data on pre-configured conditions.

Fig. 2. Client-server model and communication protocols

Blue Book Edition 12.2[2] guide describes the basic principles on which the COSEM interface classes (ICs) are built. It also gives a short overview on how interface objects – instantiations of the ICs – are used for communication purposes. Data collection systems and metering equipment from different vendors, following these specifications, can exchange data in an interoperable way. In order to access COSEM objects in the server, an application association (AA) shall first be established with a client. AAs identify the partners and characterize the context within which the associated applications will communicate. OBIS provides a unique identifier for all data within the metering equipment, including not only measurement values, but also abstract values used for configuration or obtaining information about the behaviour of the metering equipment. The ID codes defined in this document are used for the identification of:

i. logical names of the instances of the Interface Classes, the objects
ii. data transmitted through communication lines
iii. data displayed on the metering equipment

A technical document issued by Bureau of Indian Standards [3] provides a suitable approach to the implementation of the IEC-62056 standards and this Indian Companion Specification in such devices. For each logical device the DLMS/COSEM server shall support one association with properties, objects, and access rights adequate for transferring the stored data of the corresponding meter to the BCS in an efficient manner. The server within the HHU is not required to support ad-hoc access or selective access to the data that differs from the requests which were earlier used to read the data from the meter. HHUs (Hand Held Units also called CMRI or MRI) may retrieve data from DLMS/COSEM Meters conforming to this standard using the communication ports. HHUs shall provide a DLMS/COSEM server interface to the BCS (Base Computer System — the Data collection software) over a suitable communication medium. We learn more about the CMRI and its functions through another technical report issued by Central Electricity Authority [4] which states CMRI supports two modes of operation: CLIENT_MODE and SERVER_MODE. In CLIENT_MODE, CMRI reads and displays selectively or all the instantaneous values, Energy values and demand values, etc., that are specified in ICS. CMRI downloads data from the various meters. CMRI also uploads programmable parameters for desired meters. In SERVER_MODE, CMRI uploads to BCS all the downloaded data from various meters.

Pradish M. et. al has defined in his technical report [5] the important characteristic of DLMS/COSEM i.e., Interoperability. Interoperability could be defined as "The ability of a system or a product to work with other systems or products without special effort on the part of the customer". Any system can read any meter and no special involvement of vendors. The report [5] also describes that the choice of communication medium is equally important as it along with protocol which assures

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seamless connectivity in the chosen distribution network and ensure successful implementation of the application. The application software at either end aided by a common open protocol can exchange required information as and when needed protocol which assures seamless connectivity in the chosen distribution network and ensure successful implementation of the application. On the same grounds, the paper by Gordon Struklec et. al [6] adds that DLMS/COSEM covers all the AMR/AMI application fields and supports all the communication media (except maybe wireless mesh networks). The lack of the PC client application which includes all (or most of) DLMS features and which is able to interpret data in a user-friendly way makes the integration process more difficult and more time-consuming. Main function of an Automatic Meter Reading (AMR) system is gathering meter data for billing in an automated way. Various standard-based techniques enable local or remote connections to meters, e.g., IEC62056-21, IEC62056-31, M-bus, GSM, GPRS, PSTN, Internet, PLC. As stated here, for the proposed system we are using IEC62056-21 which is also known as the DLMS/COSEM Protocol.

While reviewing the previous research work on the proposed system, it was found that different approaches were opted by the researches to implement different models realized using same protocol and concept but different methodology and components were used for different applications. Subrata Biswas et. al. in her paper [7] described a PC based Energy meter billing system for home and commercial buildings. She explains how the PC based energy meter monitoring system can gather data for remote reporting. Radio frequency used in this PC based power monitoring system can take many forms. The more common ones are handheld, mobile, satellite and fixed network solutions. The software used for her model is written in C-sharp because C# language is intended to be a simple, modern, general-purpose, object-oriented programming language and it can be modified. Hiren R. Zala et. al. proposed in his paper [8] an Energy Meter Data Acquisition System with Wireless Communication for Smart Metering Application in which he used an effective technology of MSP430G microcontroller and CC2500 RF transceiver that saves the power very much. The message collection of the meter readings at the utility office is done with the use of one SIM300 based GSM module same used in the center node and data collector software Ozeking. The drawback of this system is that a GSM module has to be connected with each Energy meter which will increase the overall cost of the system.

Whereas F. Dragan et. Al describes another approach in his paper [9] where he proposed a Local Monitoring / Recording and Display Device for Power Electricity Meter, using IEC 62056–21 which is a Local AMR application device for DLMS-COSEM based Power Meters. In this model, the RS232 serial interface is used to connect the device with the power meter using an appropriate physical layer communication protocol, like IEC 62056-21. Parameters are identified using short OBIS codes, each value being followed by its measure unit. A simple message exchange consists of pairs of “queries”, “acknowledgements” and “responses”.

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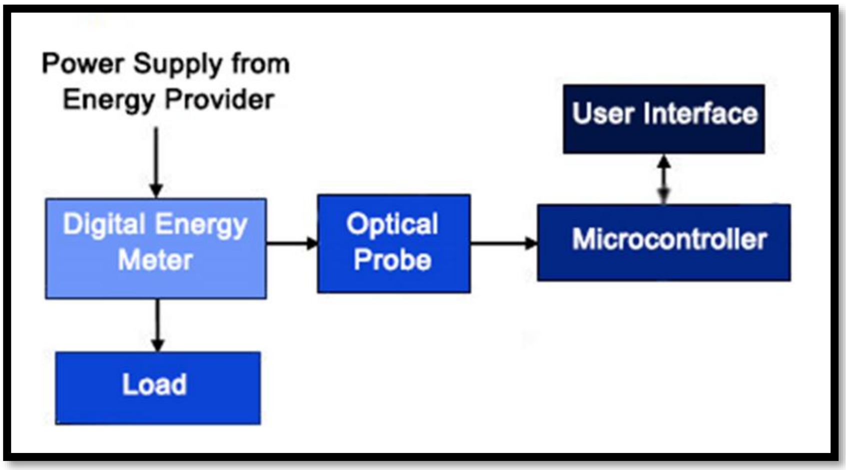
FIG. 3. BLOCK DIAGRAM OF OPTICAL PORT DATA COMMUNICATION USING DLMS/COSEM



III. METHODOLOGY

The above block diagram describes the proposed system. This system broadly consists of a meter which acts as a server while the reader device acts as the client. As described in the block diagram, the Digital Energy Meter acts as an interface between the user and the power supply from the energy provider. The Reader device consists of an Optical sensor, a microcontroller and a user interface (Laptop/PC). Common Optical Probe with Optical band width 900 to 1000 Nano meters is used here whose optical eye is connected to the meter and the USB end is connected to the Microcontroller. The Optical sensor acts as a communication channel between Meter and Reader. Its main function is to collect data through the Optical port present on the Energy Meter. Microcontroller acts as the heart of the proposed system. Here we are using Arduino Uno (ATMEGA 328P) as our microcontroller. It establishes an association between the server (Energy Meter) and the Client (Reader). The main function of the microcontroller unit is to interpret the data received from the meter. The Laptop/PC acts as the user interface between the user and the Reader device. It displays the data acquired from the meter for better understanding and acts as a terminal to send commands to communicate with the Server (Energy Meter). For this system, we use Laptop as the User Interface which is connected with the Microcontroller unit.

According to the proposed methodology, we put together a reader device using Arduino Uno (ATMEGA 328P) and connecting it to the Energy Meter through the Optical probe. With the help of the terminal displayed on the User Interface, we establish an association with the Energy meter after successfully completing a process called “Hand-shake”. Later on, we communicate with the Energy Meter and acquire data from it in the form of electrical parameters which is made visible on the User Interface Display.

IV. EXPERIMENTATION AND RESULTS

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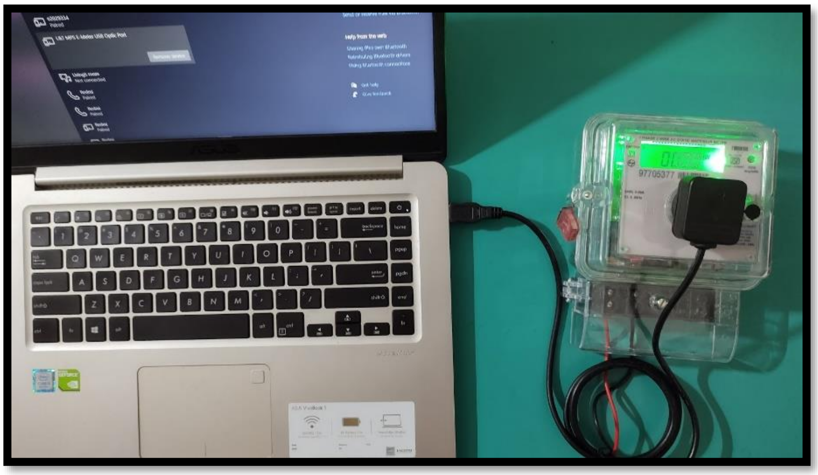

Fig. 4. Arrangement of components for Handshake process

The initial steps of the proposed system implementation involved testing the Python3 code written to establish communication with the meter. The meter (L&T EM101+) was connected to the laptop through the COM3 port using the Optical probe which had the optical sensor. This Optical Probe plays the most important role of transmitting data from the both ends. The handshake process was tested on with this setup in order to move forward with the implementation on the microcontroller. The Handshake process is a process which basically means getting authenticated by the meter for the future communication. Once the authentication is completed the meter expects an acknowledgement string which further initiates the data exchange with the meter. This can be carried out from any microcontroller once the programming task is completed. We, for the purpose of the proposed system, selected the Arduino Uno board for its added advantages. A USB port module was additionally attached to the Arduino board to help the probe connect with the board. This complete set-up forms the client-side device that we intended to create as an objective of the proposed system.

First part of data exchange involves initialization and changing the transmission speed. Each telegram is concluded with Windows line ending (CR+LF). The communication starts with Request telegram which might contain up to 32 characters Device address field. If no address is specified, all devices try to answer back sending their identity. The identity telegram contains 3 characters code of the meter manufacturer (represented by XXX), one character to identify supported baud rates (Z field) and meter identification. To trigger data readout from the meter, reader sends Acknowledge which contains baud rate control (Z) and selection between data readout mode and programming mode (Y). If data readout mode is selected, meter indicate start of sending data (STX character) and promulgate most important metering data. Each COSEM object is transmitted as a single line which contains object OBIS code and value. The ending sequence contains transmission end character (ETX) and one byte of block check character (BCC) to ensure data block integrity. Each parameter in data block is sent as a separate line, the content is composed according to the IEC 62056-61 standard.

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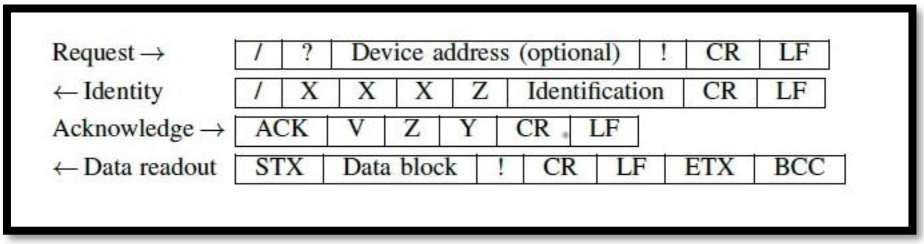
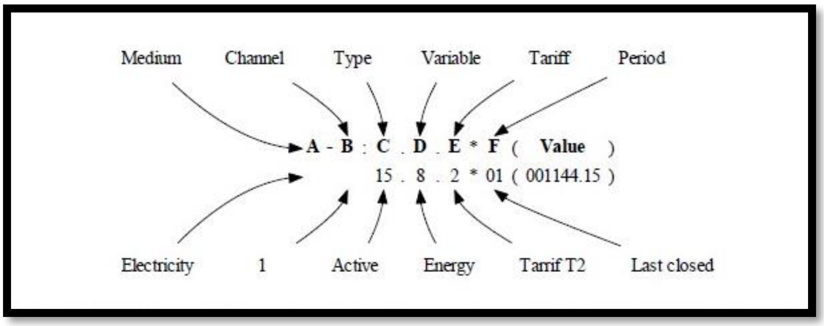


Fig.5. IEC 62056-21 Protocol Telegram Types

To match content of the line with particular data items registered by the meter, understanding of OBIS codes is required. The code consists of (up to) 6 group sub-identifiers marked by letters A to F (Figure 6). All these do not need to be present in the identifier - groups A and B are often omitted. In order to decide to which, group the sub-identifier belongs, the groups are separated by unique



separators. Thousands of OBIS codes have been defined, they cover metering data as well as configuration of metering equipment and meter status for all types of utility metering applications including: electricity, gas, heat and water.

Fig. 6. Example of OBIS code for Absolute active energy

For better understanding of readout message structure, refer figure 7 which shows an example of complete data readout process from the energy meter.

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```
---->
/?1!
<----
./LTT597705377
---->
ACK
050
<----
STX
0.0.0(LTT97705377)
0.9.1(172751)
0.9.2(100209)
1.8.0(343642.9*kWh)
2.8.0(1958.9*kWh)
3.8.0(120.7*kvarh)
4.8.0(7068.5*kvarh)
1.6.0(18014*kW)(10-02-01 00:15)
2.6.0(0*kW)(10-02-01 00:15)
3.6.0(186*kvar)(10-02-01 00:15)
4.6.0(366*kvar)(10-02-01 00:15)
1.2.0(275663*kW)
2.2.0(2158*kW)
3.2.0(54*kvar)
4.2.0(5683*kvar)
1.8.1(150967.3*kWh)
1.8.2(104673.3*kWh)
1.8.3(88002.3*kWh)
2.8.1(1958.9*kWh)
2.8.2(0.0*kWh)
2.8.3(0.0*kWh)
3.8.1(55.1*kvarh)
3.8.2(2.8*kvarh)
3.8.3(62.8*kvarh)
4.8.1(3125.7*kvarh)
```

Fig. 7. Example of Communication with Energy Meter.

V. CONCLUSIONS

There are many communication technologies used today for meter reading applications, but lack the properties of interoperability and homogeneity. Device described in the proposed system is a solution for meter reading system with capabilities of local display of electrical parameters. In advancement, wireless modules can be used along with other technologies and result can be further improved.

VI. SCOPE FOR FUTURE ENHANCEMENTS

Creating a smart meter architecture minimizes human intervention in metering, billing and collection process and helps in reducing theft by identifying loss pockets. It requires a two-way communication network, control center equipment and software applications that enable near real-time gathering and transfer of energy usage information. India is aiming to replace the present-day digital meters with the smart meters in near future. In terms of future enhancements, the Reader device introduced in the proposed system will act as an important intermediate block which will simplify the process of bridging the present model of digital meters to the aimed smart meters without incurring heavy losses as well as cutting down the expanses of replacing and discarding the old digital meter. Our reader device basically turns the present-day digital meters to be compatible with the aimed Smart meters.

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