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أنظمة الاتصالات

Smart Meter Reading Based on DLMS/COSEM Protocol

قراءة العدادات الذكية بالاعتماد على بروتوكول DLMS/COSEM

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إقـــرار

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Smart Meter Reading Based on DLMS/COSEM Protocol

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نتيجة الحكم على أطروحة ماجستير

بناءً على موافقة شئون البحث العلمي والدراسات العليا بالجامعة الإسلامية بغزة على تشكيل لجنة الحكم على أطروحة الباحث/ **عيسى عمر عيسى علوان** لنيل درجة الماجستير في **كلية *الهندسة*** قسم الهندسة الكهربائية – أنظمة الاتصالات وموضوعها:

قراءة العدادات الذكية بالاعتماد على بروتوكول DLMS/COSEM

Smart Meter Reading Based on DLMS/COSEM Protocol

وبعد المناقشة التي تمت اليوم الأربعاء 13 شعبان 1438هـ، الموافق 2017/05/10م الساعة العاشرة صباحاً، اجتمعت لجنة الحكم على الأطروحة والمكونة من:

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وبعد المداولة أوصت اللجنة بمنح الباحث درجة الماجستير في كلية *الهندسة*/ قسم الهندسة الكهربائية – أنظمة الاتصالات.

واللجنة إذ تمنحه هذه الدرجة فإنها توصيه بتقوى الله ولزوم طاعته وأن يسخر علمه في خدمة دينه ووطنه.

والله ولي التوفيق،،،

نائب الرئيس لشئون البحث العلمي والدراسات العليا

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Abstract

This research project aims at designing a system for Managing Electrical Grids based on Power Line Communication Carrier (PLCC). A comprehensive study and investigation for the relevant hardware equipment and software protocols is conducted. Three case studies of similar work of pilot projects are analysed from Palestine in Gaza strip and West bank cities. It is found that all these projects are utilizing smart meters compliant with the DLMS/COSEM protocol, which is a world-wide standard for automatic meter reading (AMR). However; none of them uses locally developed software instead all of them rely on software packages which are not only expensive but also complicate the developing procedure, fault diagnosis and–maintenance. Consequently, we focused on the low level programming to demonstrate the implementation of DLMS/COSEM protocol using a standard programming language VB6. The implemented application successfully communicates with any DLMS-Compliant meter and retrieves the basic readings such as energy, current, and voltage along with the time stamp.

Keywords: A Power Line Communication, A Power Line Carrier Communication, PLCC, Broadband, DLMS, COSEM, HDLC, OBIS, Managing Electrical Grids, Automatic Meter Reading (AMR), smart meters, smart Grid.

الملخص

يهدف هذا المشروع البحثي إلى تصميم نظام يساهم في ادارة الشبكات الكهربائية بحيث يكون نظام الاتصالات و نقل المعلومات عبر خطوط الطاقة نفسها(PLCC)، من خلال استخدام اجهزة ذكية مثل العداد الذكي لقراءة قيم جهد و تيار و قدرة الكهرباء ووسائل واجهزة نقل المعلومات عبر خطوط نقل الكهرباء بالإضافة الي برتوكول (DLMS\COSEM)، فقد تم اجراء دراسة شاملة حول المعدات اللازمة والتحقق من البروتوكولات المستخدمة والبرمجيات المناسبة.

تم دراسة وتحليل ثلاث مشاريع تجريبية مشابهة، فوجدت جميعها تستخدم العدادات الذكية المتوافقة مع بروتوكول (DLMS\COSEM) الأقوى والأكثر انتشاراً في هذا المجال و الذي يعد معيارا عالميا لقراءة العدادات الأوتوماتيكية(AMR)، ومع ذلك فإن أي منها لا تعمل على برامج مصممة محلياً بل تستخدم برمجيات جاهزة، باهظة الثمن، لا يمكن تطويرها محلياً، صعبة التشخيص للأعطال و معقدة الصيانة.

وبناءً على ذلك، ركزنا على البرمجة بلغة الآلة ومفردات لغة التجميع، لمعرفة كيفية بنية وتراكيب بروتوكول (DLMS\COSEM) ونتمكن من استخدامه بجدارة والتواصل من خلاله مع العدادات الذكية مستخدمين في ذلك لغة البرمجة فيجوال بيسك الإصدار السادس.

نجح التطبيق الذي أعد خصيصاً في هذا البحث نجاحاً كلياً بالاتصال مع العدادات الذكية المتوافقة مع برتوكول (DLMS) وتم تنفيذ بعض العمليات مثل إرسال أوامر قراءة التاريخ والوقت، قراءة فرق الجهد، قراءة التيار، وتم استلام النتائج بدقة لكل منها.

وَقُل رَّبِّ زِدْنِي عِلْمًا

[طه: 114]

Dedication

I dedicate this work to the pure soul of my mother, who taught me how to write and encouraged me through all my life stages.

Acknowledgment

I am grateful and thankful to Almighty Allah for granting me will and strength to reach this stage of my life.

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List of Abbreviations

AAQE	Application Association Response
AARQ	Application Association Request
AMI	Advanced Meter Infrastructure
AMR	Advanced Metering Reading
APDU	Application Layer Protocol Data Unit
COSEM	Companion Specification for Energy Metering
DLMS	Device Language Message Specification
DS	Down Stream
EEPROM	Electrically Erasable Programmable Read Only Memory
HANs	Home Area Networks
HDLC	High level Data Link Control
IC	Integrated Circuit
IEEE	Institute of Electrical and Electronics Engineers
LV	Low Voltage
LLC	Logical Link Control
M V	Medium Voltage
MPDU	Model to Protocol Data Units
OBIS	Object Identification System
OEM	Original Equipment Manufacturer
OFDM	Orthogonal Frequency-Division Multiplexing
PDU	Layer Protocol Data Unit
PLC	Power Line Communication
PLCC	Power Line Communication Carrier
PQ	Power Quality
PQDA	Power Quality Data Analytics
SCADA	Supervisory Control And Data Acquisition
SNRM	Set Normal Response Model
TI’s	Texas Instruments
US	Up Stream
GEDCO	Gaza Electricity Distribution Corporation
NEDCO	North Electricity Distribution Company
PRIME	Power line Related Intelligent Metering Evolution
FEC	Forward Error Correction

Chapter 1

Introduction

Chapter 1
Introduction

1.1 Background

One of the biggest problems of Gaza strip is a shortage of electricity. And until now there is no solution like as a new power station. And there is one interim solution to this problem. This solution is the timetable for the distribution of electricity to consumers. According to the amount of energy available, a distribution table for the amount of electricity was organized on the neighborhoods within the cities, as further details will be provided in this chapter. Therefore, this humble research is interested in helping manage the solution in partially to this problem by designing a system for Managing Electrical Grids based on Power Line Communication Carrier (PLCC). Where utilizing smart meters compliant with the DLMS/COSEM protocol, which is a world-wide standard for automatic meter reading (AMR).

1.2 The Classical Electrical Grid

This type of grid is a large power network for supplying electricity from suppliers to consumers. It may consist of multi types of generating stations, some of them using Diesel and others using gas. These generating stations produce electrical power, the grid contain high-voltage transmission lines that carry power from distant sources to demand centers, and distribution lines that connect individual customers as shown in Figure (1.1)

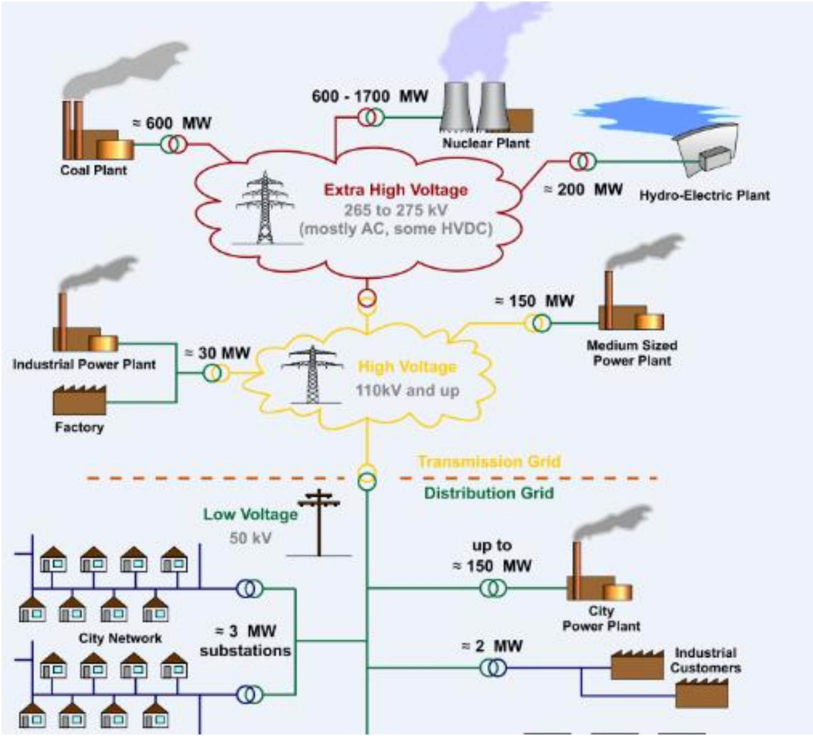


Figure (1. 1): Planet stations

Main power stations may be located near a fuel source, or it might be using renewable energy sources. Main power stations are often located away from cities. To reach at the consumer side, the power is stepped down from a transmission level voltage to a distribution level voltage as shown in (Figure 1.2), (Sivanagaraju, S. 2008).

1.3 Local Electrical Energy situation and its Problems in Gaza Strip

1.3.1 The Electrical Grid of Gaza Strip

The electrical grid at Gaza strip is a large power network for distributing electricity from suppliers to consumers. It consists of one generating station using Diesel. (www.pec.ps, Palestine Electric Company). This station produces from 40 to 120 MW electrical powers. The grid has also multiple power sources, such as the electricity lines from Israel and Egypt (www.penra.gov.ps, Palestinian Energy and Natural Resources Authority). The grid contains high-voltage transmission lines that carry power from distant sources to demand centers, and distribution lines that connect individual customers as shown in (Figure 1.2). ***The current state of the electrical grid is a complex case because there are several problems***:

- Gaza is under Israeli occupation.
- Gaza is under siege.
- Gaza is classified as a very poor region.
- Congestion of population, annually increasing number of population leading to significant annual electricity need growth.

The aforementioned problems lead to the inability of the authorities to provide electricity adequately.

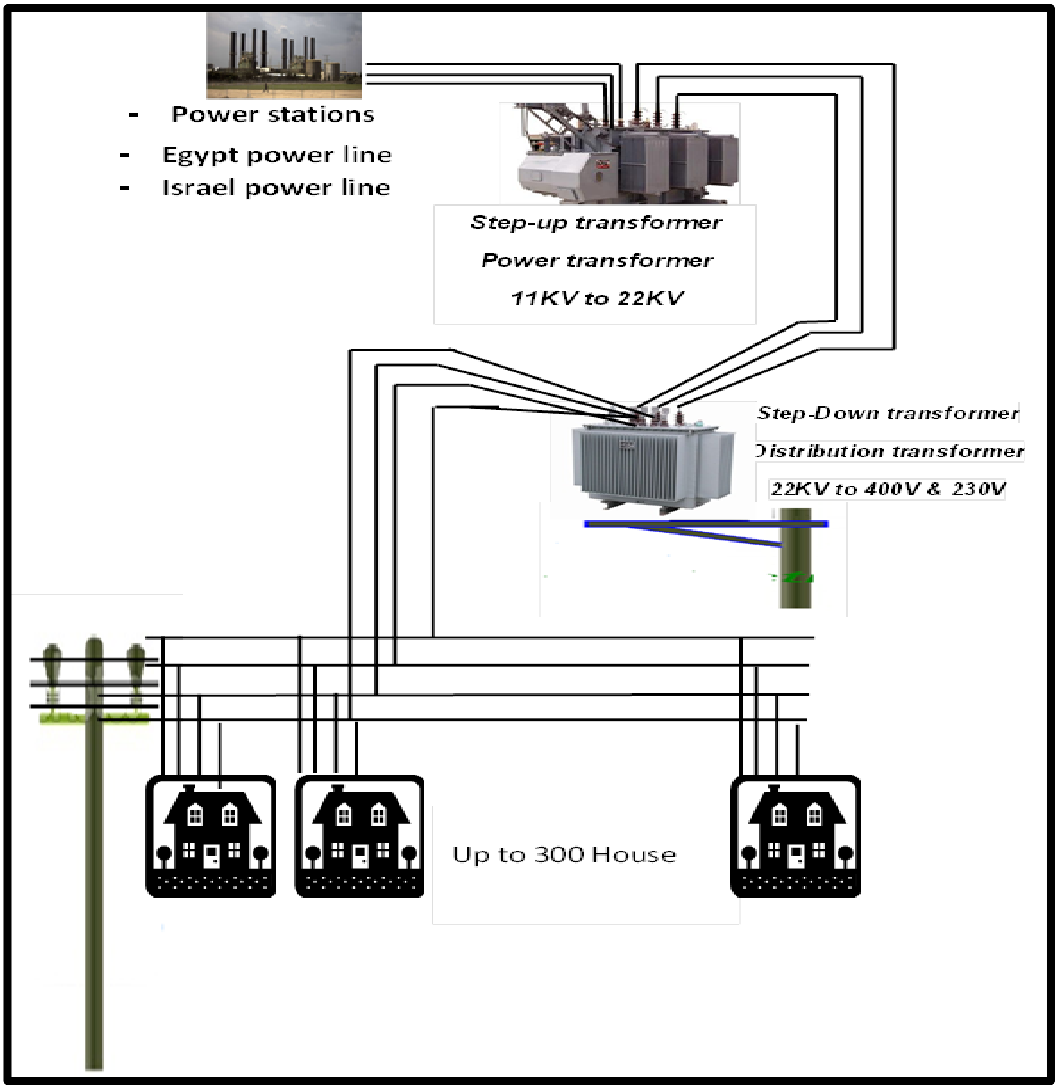


Figure (1. 2) The Electrical Grid of Gaza Strip

1.3.2 Electrical Energy Sources in the Gaza Strip

- As shown in (Figure 1.3) Electrical Energy Sources in the Gaza Strip from three main sources:

- Power station-Palestine Electric Company-(PEC) produces from 40 to 120 MW (www.gedco.ps, Gaza Electricity Distribution Corporation).
- Israel power line supplies up to 120 megawatt.
- Egypt power line supplies up to 17 megawatt.

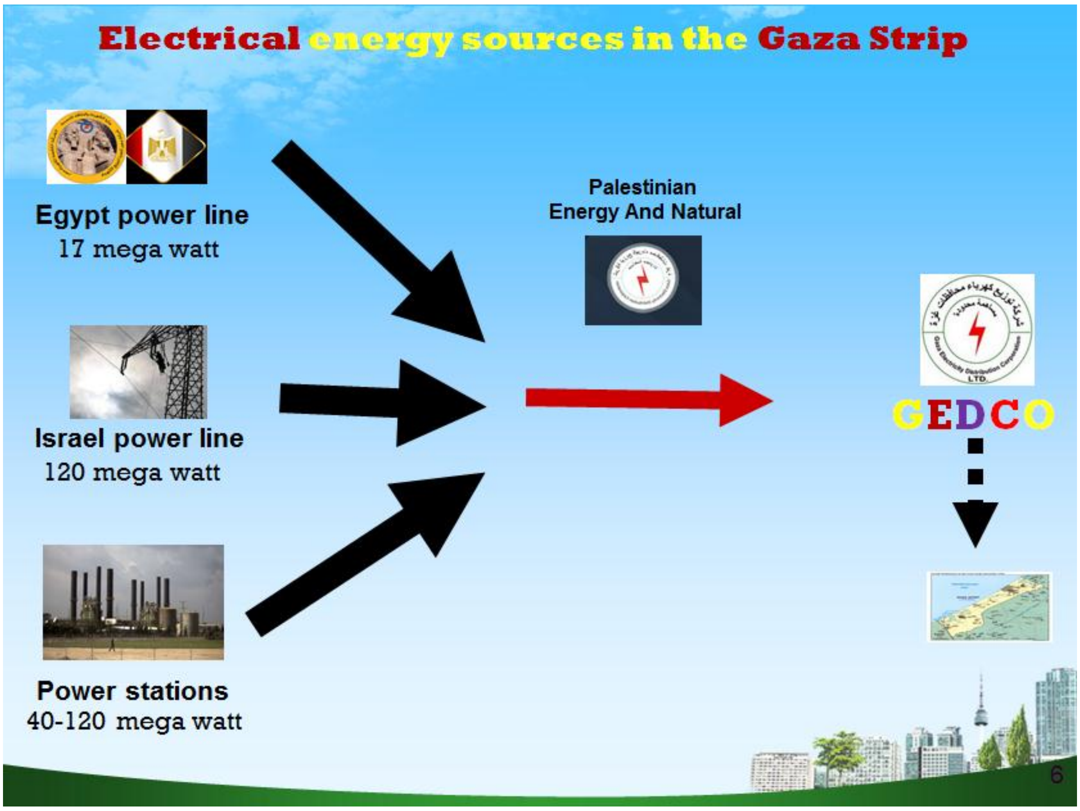


Figure (1. 3): Electrical energy sources in the Gaza strip

Power Station

There is only one Power station owned by the Palestine Electric Company (PEC). This station is a diesel power station located away from Gaza city. It is capable of generating from 40 to 120 MW of electrical power. PEC was established in 1999, with commercial operation of the power plant at 140 MW.

In June 2006, Israeli air force has done air attacks, which targeted the PEC station, causing extensive damage, stoppage and reducing the power plant's capacity. Re-operation of the power plant commenced in October 2006. The station currently works at varying capacities from 40 MW to 120 MW, depending on availability of diesel fuel. The station completely stops working sometimes when fuel is not available due to the political circumstances explained earlier.

Israel Power Line

There are ten Israeli lines that supply electricity to Gaza strip. Each line carries 12 MW. These lines are distributed to different provinces. Therefore, a total of 120 MW were supplied from Israeli lines. They are distributed as follows:

- Gaza City: 4 lines.
- North Gaza strip (Jabaliya, Beit Lahiya): 2 lines.
- Central Province: 2 lines.
- Khan Yunis: 1 line.
- Rafah: 1 line.

The power lines above are connected by agreement between the Palestinian Energy Authority and the Israeli side. But the supervision, distribution and maintenance of these lines are the duties of GEDCO.

Egypt Power Line

Gaza Strip gets only 17 MW from Egypt through Rafah city. The power line from Egypt is connected based on an agreement between the Palestinian Energy Authority and the Egyptian government. However, the supervision, distribution and maintenance of this line are the duty of GEDCO.

1.4 Total Electricity Available and Shortfall Percentage

According to a statement made by GEDCO (www.gedco.ps, Gaza Electricity Distribution Corporation). The total electrical power energy needed in Gaza strip is about 450 MW. However, the available electrical power is calculated as follows;

Total of available electrical energy =40+120+17=177 MW.

So, GEDCO faces a deficit of = 450-177 = 237 MW. Therefore, the energy shortfall percentage is about 52% of the needed electric power.

Notes: the ratio of shortfall decreases and increases depending on:

1- Variations of electrical power consumption in winter and summer.

2- Availability of diesel, sometimes the power station is turned off (siege condition).

3- Power lines connecting from Israel or Egypt may crash or disconnect as a political decision.

Accordingly, the problem lies in the inability of GEDCO to provide electricity to consumers, and there is one interim solution to this problem. This solution is the timetable for the distribution of electricity to consumers. According to the amount of energy available, a distribution table for the amount of electricity was organized on the neighborhoods within the cities. Therefore, the electricity is available for 8 hours and then cut for a period of 8 hours. This solution has caused suffering, confusion in the lives of citizens, and downgrading to the economy.

1.5 Gaza Electricity Distribution Corporation (GEDCO)

The GEDCO has the following tasks:

First: Receiving electricity from energy sources

Second: Distributing power evenly to the Gaza strip provinces.

Third: Providing customer services, maintenance process and development within cities.

Fourth: Collecting electricity bills.

1.6 Palestinian Energy and Natural Resources Authority

The Palestinian Energy and Natural Resources Authority (PENRA) has some roles in solving the problem of electricity in Gaza, listed as follows:

1. The signing of the agreement with the Israeli side regarding the electricity lines from the Israeli side.
2. The signing of the agreement with the Egyptian government regarding the electricity line from the Egyptian side.
3. Supervising the operation of the power station.
4. Providing the necessary diesel fuel from the Israeli side or donors to run the power station.

1.7 Proposed Solutions

Smart solutions using smart meters and DLMS\COSEM protocol applicable on PLCC supporting to solve the problem.

The researcher suggests designing a system for managing electrical grids based on Power Line Communication Carrier (PLCC). An extensive and deep searched is done to utilize the DLMS/COSEM protocol and smart meters, which is widely used in these types of applications. This study was facilitated smart meters, DLMS\COSEM protocol, concentrators, and modems reading as well as load shedding by utilizing communication through the power lines themselves. The researcher gets this result and creating a small system that will be tested on internal electrical grid of the Islamic university, then presented for the specialists at the Gaza electrical distribution company. It is expected that the research results will attract attention of decision makers. Consequently, they may implement similar idea of project on the medium voltage lines.

Thus, in future, we propose a solution to manage distribution transformers from a centralized control room in GEDCO.

Using the result of a project, a new electrical management system that could help to solve problem or add a good contribution by proposing a system that is a difference than systems that use GSM or Wi-Fi because PLCC uses the power lines themselves. Thus saving in costs. But other systems that use Wi-Fi or GSM, utilize other network services and need to sign a contract with service provider companies.

1.8 Research Methodology

Methodology and mechanisms followed in the project, started of researching about the research problem, going on visits to places of pilot projects, practical applications, monitoring, record the results at the end, aggregation and revision of the results. The methodology followed can be listed as below:

1. Searching deeply around electrical power and its problem in Gaza Strip.
2. Attending conferences and workshops that focused on electrical power problems and possible solutions.
3. Visiting places of projects carried out as solutions or attempts to solve the electricity problems.
4. Studying PLCC, protocols used DLMS\COSEM and other protocols.
5. Finding all the equipment needed for the project and looking for alternative devices.
6. Purchasing and testing equipment and devices.
7. Operating and connecting of equipment and devices.
8. More application at houses and labs.
9. Collection and revision of the results.
10. Results documenting.

1.9 Thesis organization

In the first chapter, an introduction is given on the electricity networks, electric power situation and its problem in Gaza Strip, and the solution proposed in this research.

In the second chapter, we are going to talk about the literature survey, previous studies of the problem and related technologies, such as Power Line Communication (PLC), Power Line Carrier Communication (PLCC), OFDM, Broadband, DLMS\COSEM, Protocols, Software protocols, energy meter types.

In the third chapter, display types of meters, and focusing of smart meters and COSEM\DLMS Protocol, where we used it in our experiments.

In the fourth chapter, detailed explanation is given to case studies and attempts for smart grid in Gaza Strip, solutions that have been developed, problems and obstacles faced in these case studies:

Case Study (1); A pilot project Tal al-Hawa - Gaza City.

Case Study (2); A pilot project Municipality of Abassan Al-kabeera.

Case Study (3); A Pilot project Aqraba Municipality – Nablus City

In the fifth chapter presents the experimental work that was done as part of this research study.

1- Send and receive data and the Internet through 1 phase line using TP-link Power line adaptor.
2- Connecting DELTA devices with computer and router through 1 phase line using TP-link Power line adaptor.
3- Connecting to ISKRA smart meters using DLMS\COSEM protocol through 1 phase line using TP-link Power line adaptor.

The experimental work aimed at designing a system for Managing Electrical Grids based on Power line Communication Carrier (PLCC). It was planned to investigate and utilize the communication protocol. This experimental facilitate meters reading as well as load shedding by utilizing communication through the power lines themselves without using other networks or other communications systems such as GSM.

Finally, in chapter 6, the conclusions and recommendations of the study are presented.

Chapter 2

Literature survey

Chapter 2

Literature survey

2.1 Communication technologies using existing grid:

These are technologies that allow information to be carried on signals that can be sent and received using existing electricity grid lines. Therefore, in these technologies, many theories and principles of communications are applied. Such fields of communications principles include, Frequency Shift Keying, Phase Shift Keying and Quadrature Amplitude Modulation. Using these technologies, we can use power lines for controlling systems and networks of houses.

In a given power line cable, the bandwidth varies if a change in physical parameters like length, diameter and separation between power carrying cables. Bandwidth increases with increase in separation between live and neutral cables but an increase in cable length causes reduction in the channel bandwidth. While an increase in the cable diameter makes the bandwidth to reach its maximum value at a certain diameter and then drop off. This maximum bandwidth diameter has no effect on its value if the cable length is changed, but if the separation between the cables is modified to n times the present separation then the maximum bandwidth is achieved at a diameter that is also n times the present diameter. These characteristics are of great importance in determining the achievable maximum bandwidth within a household. As the data rate is dependable upon the bandwidth, the maximum reliable data rate can also be estimated using these parameters (Akarte, Punse, & Dhanorkar, 2014).

2.1.1 Power Line Communication (PLC)

That grid of power lines used by technology to carrying data as well as transmitting electric power. PLC does not require a separate communication line it used the same line of the power grid and can be easily installed. So it is connected to various networks through a backbone network. Moreover, devices of PLC can be connected and accessed to a system easily by plugging the power cord into an electrical outlet. Therefore, PLC has been considered as one of the most appropriate technologies for smart meter reading systems and automatic control systems to realize advanced metering infrastructure (AMI) systems, which is an essential part of a smart grid (Carcelle, 2009).

2.1.2 POWER-LINE Carrier Communication (PLCC).

Also known as Power line Digital Subscriber Line (PDSL), mains communication, power line telecom (PLT), power line networking (PLN), or Broadband over Power Lines (BPL) are systems for carrying data on a conductor also used for electrical power transmission as shown in (Figure 2.1). (Akarte, Punse, & Dhanorkar, 2014).

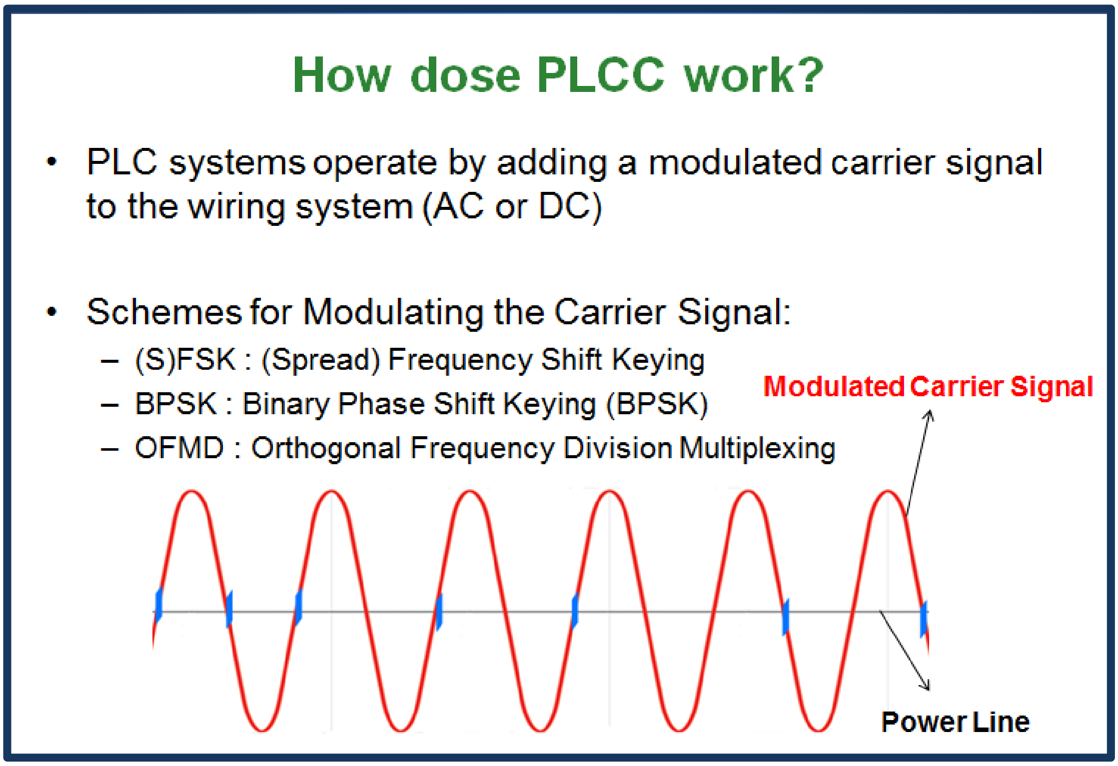


Figure (2. 1): OFDM in PLCC

2.1.3 Types of PLCC

PLC can be broadly grouped as narrow band PLC and broadband PLC, also known as low frequency and high frequency respectively. They may also be grouped as AC or DC. Functionally, there are four basic forms of power-line communications.

- **Narrowband in-house applications**: where household wiring is used for low bit rate services like home automation and intercoms.

- **Narrowband outdoor applications.** These are mainly used by the utility companies for automatic meter reading and remote surveillance and control.
- **Broadband In-house** mains power wiring can be used for high speed data transmission for home networking**.**
- **Broadband over Power Line**: outdoor mains power wiring can be used to offer broadband internet access, (www.eetimes.com/document.asp, What is Power Line Communication).

PLCC can be applied based on three categories of power line:

First: Low Voltage

The low voltage power line network is a new set-up for providing an access to high speed transmissions. The model of Broadband Power Line Communications(BPLC) is a feasible mode to build an in-house communication network or to access the internet. First of all, it will be beneficial to know the typical distribution network structure and topology. The supply lines of 220/380V low-voltage supply network begin at a transformer station and then extend over 250 meters, generally.

For example, up to twelve supply lines can lead out from the transformer station and every supply line can feed up to 30 residential connections. The network can meet all requirements of home automation and management system. Data broadcast over power lines begins after the Low Voltage side of the distribution transformer, which travels up to the customers' building through Low Voltage network. The Low Voltage electrical network has become the most attractive medium for high-speed digital communication down to an ever-increasing demand as a result of the progress in communication and information technologies. The Low Voltage network is an extensive spread network with the distribution transformer secondary as the central node and many loads connected in parallel. In contrast to the other wired communication mediums, the power line arrangement was optimized mainly for 50 or 60 Hz and was not intended for data transmission. Therefore, Low Voltage power cables present an extremely harsh environment for high frequency signals (Sharma, 2010).

Second: Medium Voltage

This system is efficiently applied in distribution automation system such as remote reading meter, load monitoring, SCADA system etc. The medium-voltage carrier communication system consists of medium voltage power line, data acquisition terminal, coupling equipment and carrier modem. Electric Substation comprises data acquisition terminals, memory unit and clock. It can read meters automatically and store the data till transmission to with the centre substation.

Data transfer may be also possible through optical cable or phone line at the same time. The coupling device has coupling capacitance and filters. The electric substation carrier modem feed the signals in the mode of one to N i.e. Inside the electric substation, the main modem communicates with a number of second modems at the sub line.

Third: High Voltage

A High Voltage power line carrier system consists of three distinct components. They are the terminal assemblies, the coupling & tuning equipment and the high voltage system itself. Coupling information signals to power line through interfacing circuits is a difficult task because power line and the communication system operate at two distinct boundaries i.e. very low frequency and high power for the power line and very high frequency and very low voltage and current levels for communication channel. Coupling to power-line conductors are accomplished by using high voltage coupling capacitors to pass the carrier signals, while blocking 50 Hz power from the carrier equipment. The coupling circuit must be designed such that it is capable to withstand the high power at power line system as well as capable to prevent any damage being done to the electronic side of the communication system. At the same time it must be reliable enough to make certain that data bits are transported on to the power line very correctly. There are some draw backs of high voltage PLCC including the expense of coupling and isolation components. Isolation is required because several independent PLCC channels are used on each line section of a large network. Since line sections are joined at substation buses, there is a possibility for mutual interference between PLCC signals. High levels of isolation between channels on the same frequency are difficult to provide across substation buses. Transmitting electricity at high voltage reduces the fraction of energy lost to resistance. For a given amount of power, a higher voltage reduces the current and thus the resistive losses in the conductor. (Sharma, 2010).

2.1.4 Advantages and Disadvantage of Power Line Communication

There are always pros and cons for applicability of a system. One should carefully go through these factors before implementation of the particular system. The knowledge of advantages and drawbacks helps in accepting and designing the desired technique. The acceptance and system design are generally application oriented. Given below are the benefits and inconvenience of using power line carrier communication.

Advantages

When we use power line network as a communication channel there are a number of advantages. The power network reaches every socket in our homes. The power line network has excellent geographical coverage and very good performance characteristics as it uses existing cable infrastructure for both communication and power which makes it an independent communication network in the world. In power line communication network one of its main advantages is that its low cost efficient as it makes use of existing wires and cables already installed in our homes and no further cost has to be spent on installation of new cables, hence it is a substitute for wireless and cable communication. It can be installed anywhere in any home or place without any further cost on cables and installation and it can even reach remote places where communication has not reached but electricity is present. Hence it is a very good solution for communication applications especially in backward places and villages (***Wolf, 2012 May).***

Disadvantages

In power line communication the parameters such as noise, impedance and attenuation, are unpredictable and can change with time, frequency and place which does not happen in case of wired communication mediums such as coaxial cables and Unshielded Twisted Pair (UTP). Certain factors like installation and high performance in case of power line communication are dependent on various architectures of the electrical network being used and Interoperability problems with different kind of equipment's is also a main disadvantage of power line communication.

Power line communication does not have a set of standards and guidelines as well as a price at which it can be used. Power line communication needs high frequency current lines, which can operate at 50-60 Hz to 400 Hz frequency and one of the main drawbacks is the legal restrictions on frequency bands which limit data rates, contaminated noise is also unreliable. Power Loss in Power line communication is directly proportional to the square of current, and also proportional to distance. But in case of Low Voltage networks channels they are usually hostile, unusual and unpredictable as the fact that they are designed electrical energy transmission and not communication purposes. (***Wolf, 2012 May).***

2.1.5 Applications of PLCC

Most modern Power Line Carrier Communication systems operate with a carrier frequency of 1MHz to 30MHz. Power Line Carrier Communication (PLCC) is also used in home entertainment and Internet home appliances and its one of the major applications is telecommunication, teleportation and tele-monitoring between electrical various substations through high voltages power lines operating at 110kV, 220kV, 400kV. In Power line communication the mains wiring used for data communication as a main of a wiring network is used in nearly every house. Hence, the installation expenses for power line communication network involved will be reduced, compared to other communication systems. Due to these applications power line communication results in a very good alternative for the automation technology, especially in case of domestic applications. In today world power-line-communication is being used for many applications to control various systems such as street lighting or energy management systems. In homes the so called "baby-phones" are very popular in which power line communication is used in which low quality analogue voice signals is transmitted through a 230V mains wiring. In comparison to the old analogue systems used for communications, digital data which is transferred using the power-line as communication media is a very useful alternative for domestic applications, particularly for devices which are already connected to the mains (e.g. Washing machines or refrigerators, linked together for energy management (Li, & Jia, 2008, November). Power line communication saves the biggest part of installation costs, if it is used in buildings where electric wiring is already present hence no need for wiring separately for communication. Hence power line communication meets the customers' needs for low cost. Indoor power line communication should not be mixed with outdoor power line communication as both are different from one another regarding the availability of frequency bands and the maximum signal levels. The result of Experiments we were done indoor power line communication is capable of transmitting information at a rate of 2.1 Mbps (megabits per second) at a very low cost, on the other hand, wireless testing at the same time and the same devices (modem, computer) the result was 1.8 Mbps.

For domestic applications, this rate of data transmission is good enough as in most of the cases in domestic applications the devices have to transmit only control signals such as on/off, dimming values etc. (Krishna, Siddhartha, Kumar, & Jogi, 2014).

Power line carrier communications (PLCC) used as a way to solve many of the problems associated with inverter-based islanding prevention methods. When the PLCC signal is lost, the receiver can command the inverter(s) to cease operation, or it can open its own switch to isolate the PV inverter and load from the PCC. PLCC-based islanding prevention could facilitate the use of PV as a backup power supply because the receiver could disconnect the customer from the PCC with a utility signal without deactivating the inverter itself. This possibility could enhance the value of PV and other distributed generation to the utility and to the customer.

It is possible to use an existing utility PLCC signal for islanding prevention, without interfering with its normal utility use and without decoding the information in the signal. The PLCC methods are currently used to load shed with signals sent from the utility to non-critical loads during periods of high loads and is used today in areas where there are high population density and industrialized customers. Alternatively, the automated meter reading is using signals sent from the customer to the utility in a small number of distribution areas. To be effective in this scheme, the PLCC signal should have three characteristics. First, it must be sent from the utility end to the customer end. Several PLCC systems used for automatic meter reading use a signal that is sent only from the customer end to the utility end. These could be used as part of a harmonic detection scheme as previously described, but obviously not as a PLCC-based continuity test of the line. Second, the signal should utilize a continuous carrier. If the carrier is intermittent, the ability to use it as a line continuity test is lost, because it is not possible to differentiate between a loss of signal due to a break in the line and a loss of signal due to the cessation of transmission without decoding the signal. Also, the use of a continuous carrier makes the system essentially fail-safe, in that a failure of the transmitter or receiver results in a loss of the PLCC signal that would cause a PV inverter shutdown. Third, the signal should be one that will propagate well throughout the distribution network to which PV inverters are connected. Because the series inductances of transformers will block any high-frequency signals, this requirement will necessitate the use of low-frequency signals. Sub-harmonic signals would be preferred, as these would propagate easily throughout the system and would not be mistakenly produced inside an island except under highly abnormal conditions.

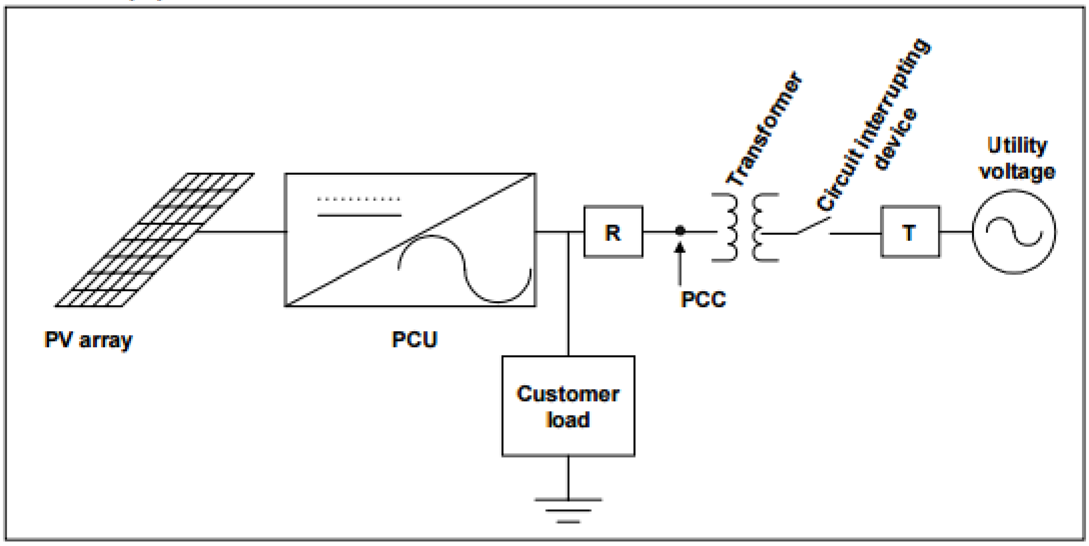


Figure (2. 2): System Configuration Including a PLCC Transmitter (T) and Receiver (R)

They used smart meters, DLMS\COSEM protocol, Concentrates, modems to get new results, and making a new electrical management system to solving the problem or added a good contribution off Evaluation of islanding detection methods for photovoltaic utility interactive power systems (PVPS, 2002).

2.2 OFDM

An Orthogonal Frequency Division multiplexing (OFDM) system consists of a transmitter and a receiver as shown in (Figure 2.3) and (Figure 2.4) An OFDM transmitter modulates the data to be transmitted then converted from serial to parallel

N sub-carriers. Inverse Fast Fourier Transform (IFFT) is performed on each sub-carrier data to convert it to time domain and a cyclic prefix is added . (Anatory, Theethayi, Thottappillil, Mwase, & Mvungi, 2009).

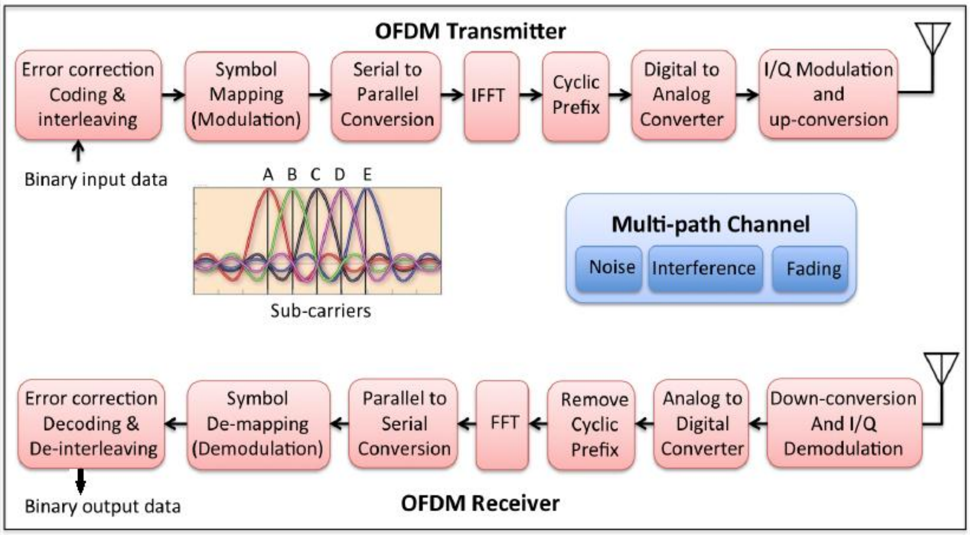


Figure (2. 3): OFDM Transceiver Block Diagram

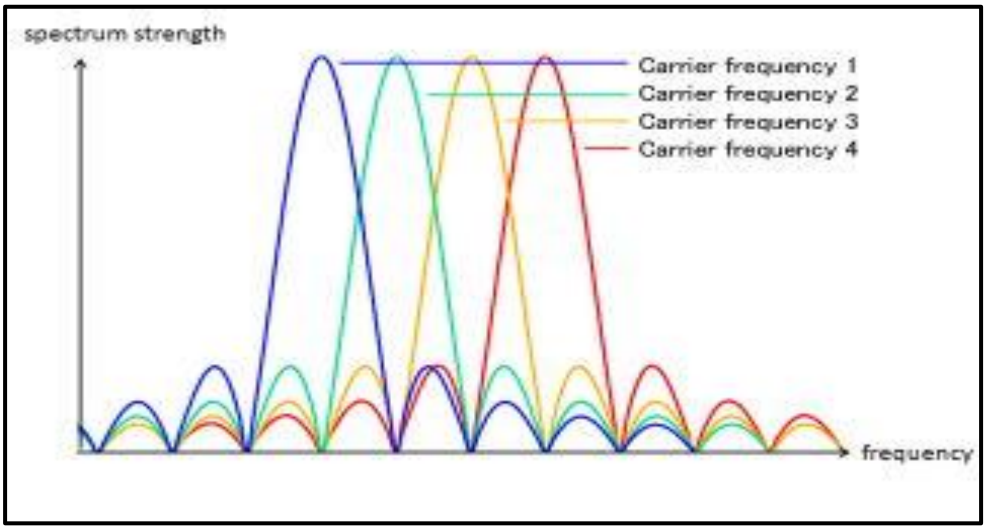


Figure (2. 4): OFDM Transceiver Block Diagram

2.3 broadband

In 2004 The National Telecommunications and Information Administration (NITA) define BPL or Broadband over Power Line, is an Internet over high voltage transmission lines approach. The BPL connection is proposed but has not yet been released, as they study interference.

NTIA identified three different network architectures used by BPL equipment vendors.

System #1 employs Orthogonal Frequency Division Multiplexing (OFDM) to distribute the BPL signal over a wide bandwidth using many narrow-band sub-carriers. System #2 also uses OFDM as its modulation scheme, but differs from System #1 in the way it delivers the BPL signal to the subscriber's homes. System #3 uses Direct Sequence Spread Spectrum (DSSS) to transmit the BPL data over the MV power lines.

So we can define Broadband over power lines (BPL) as high-speed Internet access anywhere, anytime that is what we've increasingly come to expect in the 21st-century information age (Krishna, Siddhartha, Kumar, & Jogi, 2014). BPL is solution to join old telephone wiring or the room to internet or expensive for a telecoms company to provide broadband, also called EOP (Ethernet over power) a way of piping broadband to your home and channelling it from one room to another using the standard electricity supply as shown in (Figure 2.5).

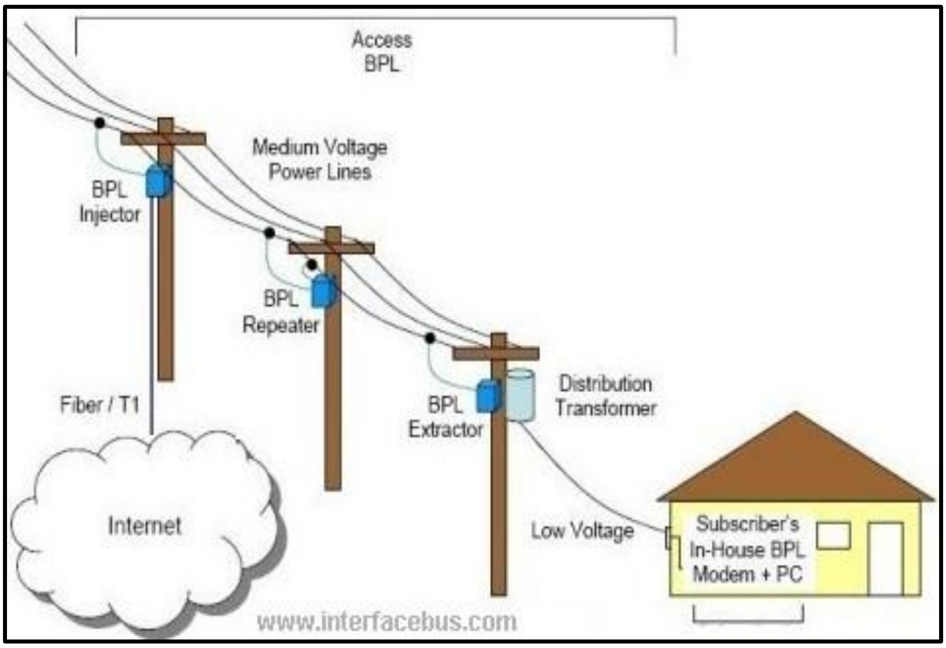


Figure (2. 5): Broadband over powre lines

2.4 Scope and Objectives:

This research project aims at designing a system for Managing Electrical Grids based on Power line Communication Carrier (PLCC). It is planned to investigate and utilize the DLMS/COSEM protocol, which is widely used in these types of applications. This study will facilitate Smart meters reading as well as load shedding by utilizing communication through the power lines themselves. The system will be developed at the Islamic university where it will be tested on its internal electrical grid and then presented for the specialists at the electrical distribution company. It is expected that the research results will attract attention of decision makers; consequently, they will implement the project on the medium voltage lines. Thus, we propose a solution to manage distribution transformers from a centralized control room.

So, the following explanatory paragraph as an example to understand the relationship between concepts of a project and its component PLCC, smart meter, DLMS\COSEM protocol, Concentrates, modems and System for Electrical Power Management in the Distribution Grids.

2.5 Signification

A new System for Managing Electrical Grid, using PLCC and the following component and technology: Smart meters, DLMS\COSEM protocol, Concentrators, and Modems. to get a new result, by applying a new electrical management system that should be help to solving the problem or add a good contribution different than system using GSM or WI-FI because PLCC used the line grid themselves, then get less cost, but other system using WI-FI or GSM, they used other network and need to sign a contract with other company according to its conditions.

2.6 Limitations

One of the biggest problems of Gaza Strip is the diminution of electricity. GEDCO can't provide electricity to Gaza Strip24/7 for the following reasons:

1- Weakness in the Central power generation capacities.
2- Citizens don't pay their bills.
3- Electricity loss in public power line.
4- Illegal stealing for electricity in Gaza strip from some customer.

So GEDCO needs a computerized communication system to transferring control signal and data through the high voltage and medium voltage to controlling of extra transformer smart meter and to distribute electricity equally hours over all Gaza Strip areas, as cut/plug the current.

Also, GEDCO often cannot control the main power network because:

1- The main transformer was built in Gaza border of the hot point with Israeli army, so in most cases, to access these areas they need long time each requires the process of security coordination and intervention through international Red Cross (www.gedco.ps, Gaza Electricity Distribution Corporation).
2- Natural disasters and rain caused the closure of the main streets.

Here the communication technology & PLCC is too necessary to control of power over power lines and transformer as cut/plugging the current as needed maintenance process. The methods and technology that are used in GEDCO depend on traditionally electricity distribution as the following:

1- Generating of electricity from Central power generation.
2- Buying electricity through the high voltage lines from Israeli.
3- Import electricity from Egypt.
4- Connecting the available electricity through the previous three points to the major distribution transformers (central transformers).
5- Distributing Electricity from the central transformers to medium adapters.
6- The power distribution transformers from big and medium size adapters into smaller ones inside the larger neighborhoods.
7- Electricity distributed from micro-transformers within neighborhoods to subscribe, consumers across sub cables.
8- Smart meters or special hours calculated the value of electricity that is consumed monthly.
9- The employees of GEDCO monthly will read the value consumed from meters and multiply it in 0.5-NIS to calculate it and print the bills.

2.9.1 Disadvantages of the previous methods for managing electrical grid.

The previous process is very rudimentary so it has the following disadvantages:

First, for dealing with consumer:

1- A number of subscribers does not pay monthly bills.
2- Electricity theft easy from subscriber.

3- Unable to connect/disconnect electricity remotely to the consumer at an emergency event but it is done manually.
4- Don't knowing instantaneous consuming and unable to monitoring the value of consumption specific subscriber.

Second, for dealing with power network (central transformer & sub transformer).

1- Tuning transformer connection was handled by an employee using switch adapters or contactor, so it is impossible to do it in some cases such as the fear of war and bombing at border areas, and difficult in cases of floods.
2- This process is very cumbersome in the case of distribution electricity evenly, where the company cutting power of transformer from specific area and link power to different area as a periodic timetable to be equally distribution electricity for areas.
3- In the case of transformer power load less than required electricity, it will cause an overload of the transformer so drop and cutting electricity, and in case transformer power load over than needed electricity, it will it will lose electricity without using.

Chapter 3

Smart meters and

Protocols

Chapter 3

Smart meters and Protocols

3.1 Electrical meters:

There are many types of electrical meters, Electrical smart meter, Traditional electrical meter and Digital electrical meter, so in this research, we focus on the first type, Electrical smart meters as a part of problem solution (http://www.energyineducation.ie, How to Read Your Electricity Meter).

3.1.1 Type of meters:

1. Traditional or Mechanical electrical meter.

The reason of use electrical meters is to account for electrical consumption, and determine the cost.

Figure (3. 1): Traditional electrical meter

2. Digital electrical meter

The reason of using Digital electrical meter is:

1- To account of electrical consumption, and determine cost as prepaid quantity.

2- Help customers to rationing consumption.

3- Stopping consumption without paying.

Figure (3.2): Digital electrical meter

3. Electrical smart meter.

We can define Smart meter as a new kind of gas, water and electricity meter that can digitally send meter readings and data to your energy supplier and can used for monitoring and management consumption processing, also its receiving variable update, order commands control. This can ensure more accurate energy bills. Smart meters also come with monitors, so you can better understand your energy usage.

Smart meters can be single phase or three-phase or poly phase and it can be with integrated GSM/GPRS modem. The whole current meter allows for direct connection of three-phase wiring with loads up to 120A. The smart meter using DLMS\COSEM protocol is a simple, speedy installation procedure. An optional switching device for remote client disconnection can also be installed. Remote reading by Sentinel software online.

Some kinds of smart meters like as ISKRA MT375 working on Three Phase Electric Smart Meter with GSM Modem (Whole Current) has several functions that make power management system too easy to serve the customer.

Smart meter using DLMS\COSEM Protocol to connect with power management system.

The reason of using smart meters is to control of electrical consumption, an attempt to provide electricity 7/24, management of grid using technology that gives higher efficiency solutions for the power grid problems.

Examples for electric smart meters used in pilot project in Gaza Strip:

Example (1): ***ISKRA ME372 Single Phase Smart Electric Meter with GSM Modem.***

The ME372 is the UK Standard single-phase smart meter with built-in GSM/GPRS modem for AMR

Features

- built in GSM/GPRS modem
- 100 Amp (BS5685) OFGEM approved
- accuracy class 1 (MID B)
- Import and export, both active and reactive power
- Pulse output
- Highly accurate class 1 accuracy
- Integrated real time clock backup
- RS485 (optional)
- Optical interface IEC 62056-21 mode C protocol
- Event logging for tamper detection
- Integrated switch

Figure (3. 2): Electrical smart meter

Product Description:

The ME372 is the OFGEM approved UK Standard single-phase smart meter with built-in GSM/GPRS modem for AMR. The ME372 will record a half-hourly load profile of energy consumption and energy generation. This telemetry and the total meter reading are sent remotely by SMS or GPRS communication. Configuring the meter for AMR and setting the meter's parameters can be done locally through the optical communications port, or remotely when fitted with a SIM card and using the manufacturer's parameterization software. Remote reading by Sentinel software online.

Example (2): ***ISKRA MT375 Three Phase Electric Smart Meter with GSM Modem.***

The main features of MT375 is the UK Standard poly-phase smart meter intended for industrial and commercial metering, This meter is the three-phase equivalent of the ME372 with integrated GSM/GPRS modem and The whole current meter allows for direct connection of three-phase wiring with loads up to 120A.

Example (3): ***ISKRA P2LPC Data Concentrator for DLC meters.***

The main features of P2LPC is works with the ME371 DLC single phase and MT371 DLC Poly Phase family of meters to communicate and collect data across the low voltage network in compliance with the DLMS/COSEM communication protocol. The concentrator can communicate with a data collection facility using a range of different communication options, including GSM/GPRS, PSTN, ISDN, and Ethernet. The P2LPC is 'plug and play' so that it can automatically discover and install meters on the DLC network. Up to 1024 meters can be installed on each DLC meter network, supported by a single P2LPC Data Concentrator. (Arzberger, Dieper, Dirnberger, Dornseifer, Frank, & Liebezeit, 2012).

Figure (3. 3): Concentrator for DLC meters

Example (4): Holley DTSD5RS Three Phase Electronic Meter specification:

- lace of Origin: Zhejiang, China (Mainland)
- Brand Name: HOLLEY
- Model Number: DTSD545
- Display Type: Digital Only
- Phase: Three Phase
- Accuracy Class: 0.5S
- Output Voltage: 220v/230v/240v
- Operating Temperature: -25℃~70℃
- Dimensions: 298.7mm*170mm*78.8mm
- Standard: IEC62053-21, KEMA
- Pulse Constant: 1000~10000 imp/kWh

For more specification details see appendix (B)

Figure (3. 4)Holley smart meter

3.2 Smart meters Protocols

3.2.1 Types of Protocols

There are several types of protocols related to smart grids most widely used are:

- **DLMS/COSEM:** Device Language Message Specification/ Companion Specification for Energy Metering
- **PRIME:** Power line Intelligent Metering Evolution
- **Meters and More**
- **G3-PLC**
- **OSGP :** Open Smart Grid Protocol

3.2.2 DLMS\COSEM Protocol

As we have said previously it is planned to investigate and utilize the DLMS/COSEM protocol, which is widely used in these types of applications. This study will facilitate smart meters reading as well as load shedding by utilizing communication through the power lines themselves, to solve a problem Electrical Power Management in the Distribution Grids.

- **DLMS layer**

Device Language Message Specification. A layer that accesses the COSEM objects, to construct and transport the messages, a generalised concept for abstract modelling of communication entities, DLMS is responsible for data transport (http://www.dlms.com, DLMS User Association)

- **COSEM layer**

Companion Specification for Energy Metering. This is an object model that implements revenue and smart meter various registers and functions, such as tariff, load profile, max demand, and energy registers, etc... It is an application layer data modelling as well as rules for data identification by means of Object Identification System (OBIS).

What is DLMS/COSEM?

- An object model, to view the functionality of the meter, as it is seen at its interface(s).
- Identification system for all metering data.
- A messaging method to communicate with the model and to turn the data to a series of bytes.

- A transporting method to carry the information between the metering equipment and the data collection system.

- The DLMS/COSEM standardization framework is based on the principle of one common data model and application layer, used over a range of communication media. This principle reflects the fact that the data model standards are driven by the Table of Open System Interconnection communication standards are driven by technology evolution. As shown in Table (1.1).
- DLMS/COSEM specifies the COSEM data model, the DLMS application layer protocol and communication profiles. It continuously evolves to meet new requirements. It is the only global standard for meter data exchange adopted by global, regional and national standards organizations (http://www.dlms.com, DLMS User Association)

3.2.3 Four books describe DLMS\COSEM

The Blue Book Specifies the functional data model of the meter as seen through its interfaces. Using the object oriented approach, it specifies COSEM objects that interact with each other to realize the functions required. The objects – and the data they hold – are identified by the OBIS codes.

The Green Book Specifies how to access data and how to transport the resulting messages over the communication media. DLMS application layer services allow establishing secure associations between applications running in meters and central systems, and accessing COSEM objects to read / write data and execute actions remotely. Pull and push operation is supported. The Green Book also specifies how application data and messages are protected using cryptographic algorithms. Communication profiles specify how DLMS/COSEM is used over various communication channels and media. Lower protocol layers use widely accepted international standards.

The Yellow Book Specifies abstract conformance test plans and the testing and certification process.

The White Book Contains a glossary of terms that help understanding the specification.

3.2.4 The concepts of DLMS\COSEM communication

A main concepts and knowledge of DLMS/COSEM are needed to communicate with Devices.

1- The Physical Device

Our meter is a Physical device it has a unique physical address, A physical address is the hardware-level address. Physical address. is often referred to as its MAC (Media Access Control) address. It's had six bytes long and consists of six hexadecimal numbers.

2- The Logical Device

A physical device hosts one or several Logical Devices. Like as electricity or gas meter. Each logical device has an address, called the logical device address. Each physical devices has management logical device must has at least description of all the logical devices available in the physical meter, with their logical addresses and names.

3- The COSEM Classes and object instances

Logical device is container for COSEM object, attributes and methods. The first attribute of each object is its Logical Name.

4- The Logical Name

A logical name is another name for **OBIS code its consists** of a string of 6 values defined according OBIS.

5- The Association object

Each logical device contains at least one object of class Association LN or Association SN. Has an attribute (attribute 2) called the object list containing the list of all objects available in the logical device. Furthermore, the association object has the predefined logical name 0.0.40.0.0.255. Therefore, we can find out what objects are available in a logical device just by reading its object list.

6- The most important elements of devices

1- Each physical device has a management logical device, at address 1.

2- A management logical device hosts a list of all the available logical devices in the physical device. This list is the second attribute of the object of class SAP Assignment, with the predefined name 0.0.41.0.0.255. Each list item consists of the name and the address of a logical device.

3- Each logical device hosts a list of all its available objects. This list is the second attribute of the object of class Association, with the predefined name 0.0.40.0.0.255. Each list item consists (among others) of the logical name and the class of an object.

4- The Client-Server(requests \ responses) model. The application is the client sends requests, and the meter as server answers responses.

5- System addressing. Each side of the connection has an address.

6- Connecting the layers. There are 3 layers of the HDLC profile are the Physical layer, the HDLC layer and the Application layer.

7- The physical layer. Physical layer is the lowest layer, It is the layer 1 in the OSI model. It boils down to a simple (3-wires) serial cable between a COMM. Port of PC and the appropriate connector of meter.

8- The HDLC layer. HDLC layer is next layer.MAC addresses is most important are the HDLC-addresses. The client MAC address is a byte value, it identifies the client. We will use 16 (decimal) which means a public client.

The meter MAC address is divided in two parts:

- The upper part is the logical device address.
- The lower part is the physical device address.

9- HDLC layer, the client address is always a byte, the server address consists of two parts and there are three variants:

- One byte addressing. There is just an upper address. It is a byte value.

10- Two bytes addressing. There is an upper address on 1 byte and a lower address on 1 byte.

- Four bytes addressing. There is an upper address on 2 bytes and a lower address on two bytes.

Note that not all manufacturers support the three variants.

7- The Application layer

The Application layer is last layer. After having connected the physical layer and the HDLC layer, we have to connect the Application layer. If users of system send an Association request they expect an Association response.

Application Association REquest (AARQ request)
This is the first command must be started for all connections and device types. Telling the device if authentication is used and whether Long Name or Short Name reference is used. The packet can be generated with AARQRequest method and it uses **UseLogicalName** and **Authentication** properties so make sure these are set to correct values. AARQ sent by the client application layer to the server application layer.

8- Application Association Response (AARE request)

Once the full reply is received parse it with ParseAAREResponse method. This method sets the relevant settings to the GXCOSEM component and return a collection of manufacturer specific tags if there was. AARE sent by the server application layer to the client application layer.

9- Reading Profile Generic objects

The request is generated using ReadProfileGenericData.

Notes :

1- If row indices are used the logical name of the first column must be null.

2- DLMS Application component may supports HDLC Addressing by 1, 2, 4 Bytes and can communicate using HDLC, TCP/IP or UDP. It supports Lowest, Low and High Level authentications. Both Long and Short Name Association Types are supported.

OSI Model				
	Data unit	**Layer**	**Function**	**DLMS/COSEM**
Host layers	Data	7. Application	Network process to application	Application like GXDLMSDirector
		6. Presentation	Data representation, encryption and decryption, convert machine dependent data to machine independent data	COSEM
		5. Session	Interhost communication, managing sessions between applications	DLMS
	Segments	4. Transport	End-to-end connections, reliability and flow control	DLMS
Media layers	Packet/Datagram	3. Network	Path determination and logical addressing	
	Frame	2. Data link	Physical addressing	HDLC or IEC 62056-47
	Bit	1. Physical	Media, signal and binary transmission	Gurux Media like Serial, TCP/IP

Table(3. 1): Open System Interconnection

3.2.5 OBIS

The Object Identification System makes it possible to identify the data items used in common electricity metering equipment. The main advantage of OBIS is the definition of a unique code for data of interest in energy measurement. The general structure of the obis code is composed by six values as hexadecimal numbers (A,B,C,D,E,F) Every single value has a range and a standard definition that makes possible to uniquely identify data items. It is also possible to identify proprietary codes for manufacturer specific purposes. Standard codes cannot be reused from manufacturers with different meaning, on the other hand, an object defined by a manufacturer may be standardized if its use is of common interest. With the OBIS code even the tariff rates can be exchanged between meters and a remote host (Attianese, Del Giudice, Landi, Paciello, & Pietrosanto, 2013).

3.2.6 HDLC frames

HDLC frame can be transmitted synchronous or asynchronous serial communication links. Those links have no mechanism to mark the beginning or end of a frame, so the beginning and end of each frame must be identified. This is done by using a frame delimiter, or flag, which is a unique sequence of bits that is guaranteed not to be seen inside a frame. This sequence is '01111110', or, in hexadecimal notation, 0x7E. Each frame begins and ends with a frame delimiter. A frame delimiter at the end of a frame may also mark the start of the next frame. A sequence of 7 or more consecutive 1-bits within a frame will cause the frame to be aborted (Bormann, 1999).

When no frames are being transmitted on a simplex or full-duplex synchronous link, a frame delimiter is continuously transmitted on the link. Using the standard NRZI encoding from bits to line levels (0 bit = transition, 1 bit = no transition), this generates one of two continuous waveforms, depending on the initial **state:**

Frame format

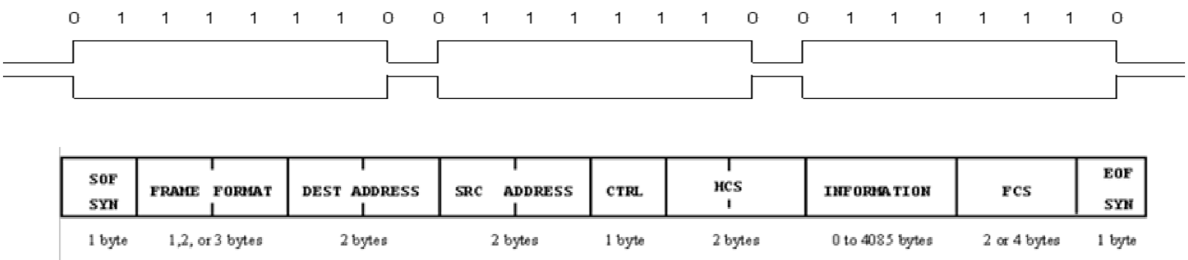


Figure (3. 6): Frame format

The image above shows a standard HDLC frame format type 3, according to Clause H.4 of ISO/IEC 13239: 2002. ISO/IEC 62056-46 specifies this frame format further:

- The **SOF SYN** and **EOF SYN** flags are always 0x7E. When sending consecutive frames, the EOF SYN of a frame may be used as the SOF SYN of the next frame.

- The **FRAME FORMAT** field is 2 bytes in length. It contains 4 bits indicating the format type (in this case type 3: 011010), one segmentation bit and 11 bits indicating the frame length.
- The address fields **DEST ADDRESS** and **SRC ADDRESS** are both 2 bytes in length. Addressing is described in paragraph 4.7.1 of ISO/IEC 13239: 2002.
- The control field **CTRL** is one byte and is described in paragraph 6.4.3.2 of the described part 46.
- The header check sequence field **HCS** is 2 bytes in length.
- The **INFORMATION** field may be any sequence of bytes and in the case of a data frame it will contain the *MAC Service Data Unit* (MSDU).
- The frame checking sequence field FCS is 2 bytes in length.

The result is:

0x7E	FRAME FORMAT	DEST ADDRESS	SRC ADDRESS	CTRL	HCS	INFORMATION	FCS	0x7E
1 byte	2 bytes	2 bytes	2 bytes	1 byte	2 bytes	0 to 4085 bytes	2 bytes	1 byte

Figure (3. 7): Frame checking sequence result

Now we can locate MAC frames in a data stream. Spotting 0x7E is easy, giving rough points to split up the data-stream into parts. Of course, the frame format field will be a good way to check whether the frame is correct or has been cut down too much. After that, the information field can be taken out and examined further as shown in (Figure 2.3)

3.2.7 HDLC Operations and Frame Types:

There are three fundamental types of HDLC frames.

- Information frames, or **I-frames**, transport user data from the network layer. In addition, they can also include flow and error control information piggybacked on data.
- Supervisory Frames, or **S-frames**, are used for flow and error control whenever piggybacking is impossible or inappropriate, such as when a station does not have data to send. S-frames **do not** have information fields.
- Unnumbered frames, or **U-frames**, are used for various miscellaneous purposes, including link management. Some U-frames contain an information field, depending on the type (Bormann, 1999).

3.2.8 I-Frames (user data): CTRL BYTE

. The sub-fields in the control field define these functions.

The least significant bit (first transmitted) defines the frame type. 0 means an I-frame. Except for the interpretation of the P/F(Poll/final) field, there is no difference between a command I frame and a response I frame; when P/F is 0, the two forms are exactly equivalent (Simpson, 1994).

Some types frame
93// frame type SNRM (Set Normal Response Mode).
73// frame type UA (Unnumbered acknowledge).
10// frame type I frame,

Explanation how can I read frame type?

I	R R R P/F S S S 0
RR	R R R P/F 0 0 0 1
RNR	R R R P/F 0 1 0 1
SNRM	1 0 0 P 0 0 1 1
DISC	0 1 0 P 0 0 1 1
UA	0 1 1 F 0 0 1 1
DM	0 0 0 F 1 1 1 1
FRMR	1 0 0 F 0 1 1 1
UI	0 0 0 P/F 0 0 1 1

For Example: how SNMR = 93
From (Table: 2) SNRM = 100P 0011 when Poll is 1 SNMR will be = 1001 0011 these number from binary so, 0011 = 3 in Hexadecimal and 1001 = 9

Binary	1001	0011
Hexadecimal	9	3

Table(3. 2): Frame type

Chapter 4

Case Studies

Chapter 4
Case Studies

4.1 Case Study No 1: Pilot project Tal al-Hawa - Gaza City

GEDCO decided segmentation problem to be solved through several ideas, as creating a pilot project for supplies of electricity 24 hours daily as follows:

The project was implemented as a sample of 160 Houses +32 buildings in the area (Tal al-Hawa - Gaza City). The Electricity connected for eight hours 220 V, capacity of 20 A. It's increased or decreased depending on availability of electricity from the power plant. Electricity is then connected in the next eight hours or rest of the day with a 220V capacity of 2 Amps Using smart metering and controlling system.

1. **The executing agency:**

Department of customer services, Electricity Distribution Company

2. **Reasons of implementing this pilot project:**
   - Daily Power outages for customers, so it is intended to supply customers with electricity for 24 hours at least at a rated current of 2 amps.
3. **Project goals**
   - Trying to manage and control the power grid by computerized way.
   - Supply customer of electricity 24 hours at least of 2 A at specific area of the project.
   - Studying the possibility of applying the idea to the whole electricity grid in the Gaza Strip.
4. **Steps and implementation mechanism:**
   - Step (1)- The company allocated Tal al-Hawa district to be the targeted area of the project implementation as following: the project was implemented of a sample of 160 House everyone have one smart meter, but 32 building in the area every building have from 20 to 24 flats. So, every building has one smart meter called Concentrator and every flat has one normal smart meter.
   - Step (2)- Drawing geographical maps of the buildings in place.
   - Step (3)- Building a technical executive team.

- Step (4)- Installing smart meters for all houses (160 house, every house has one a smart meter that contains SIM card connected with the GSM network (jawwal mobile network) As shown in Figure(4.1),Figure(4.2)
- Step(5): Installing smart meters types Iskra ME372 single phase and MT372 3-phase to all 32 buildings, every building has from 20 to 24 flats. So every building has one meter - smart meter called Concentrator and every flat has one normal smart meter. All smart meters for each flat into main distribution board were grouped and connected in electricity sequentially-with serial number - and connected to the concentrator. As shown in Figure(4.3)
-

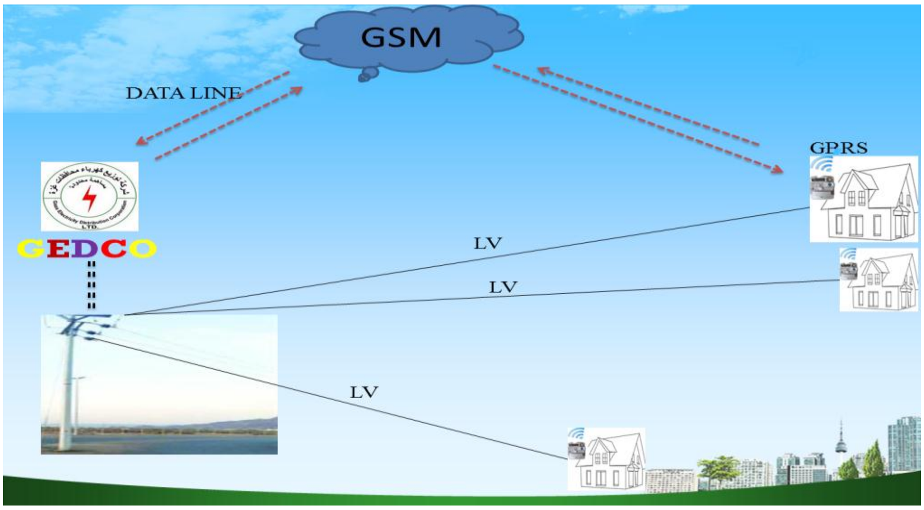


Figure (4. 1): Connection between single home with GEDCO-Smart meter\GPRS

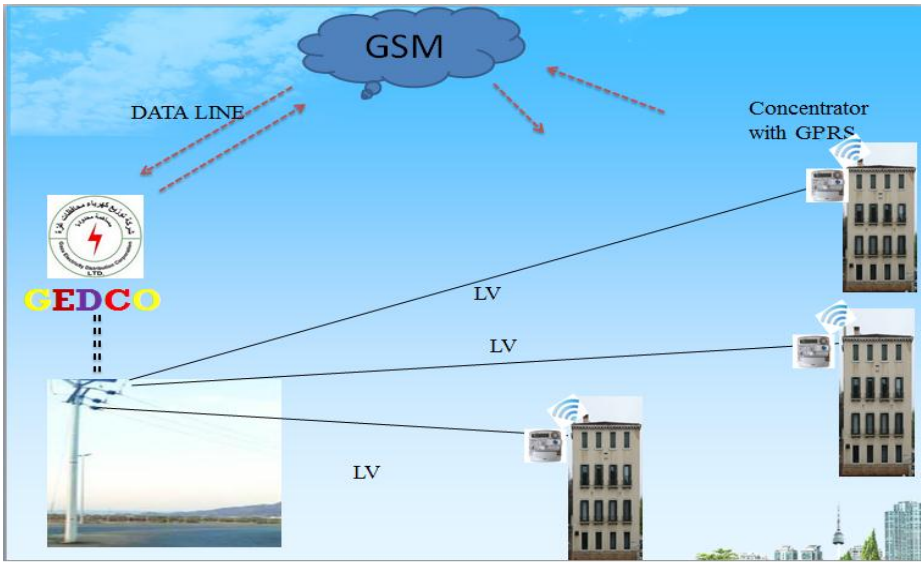


Figure (4. 2): Connection between building has multi-flat with GEDCO-concentrator \ GPRS

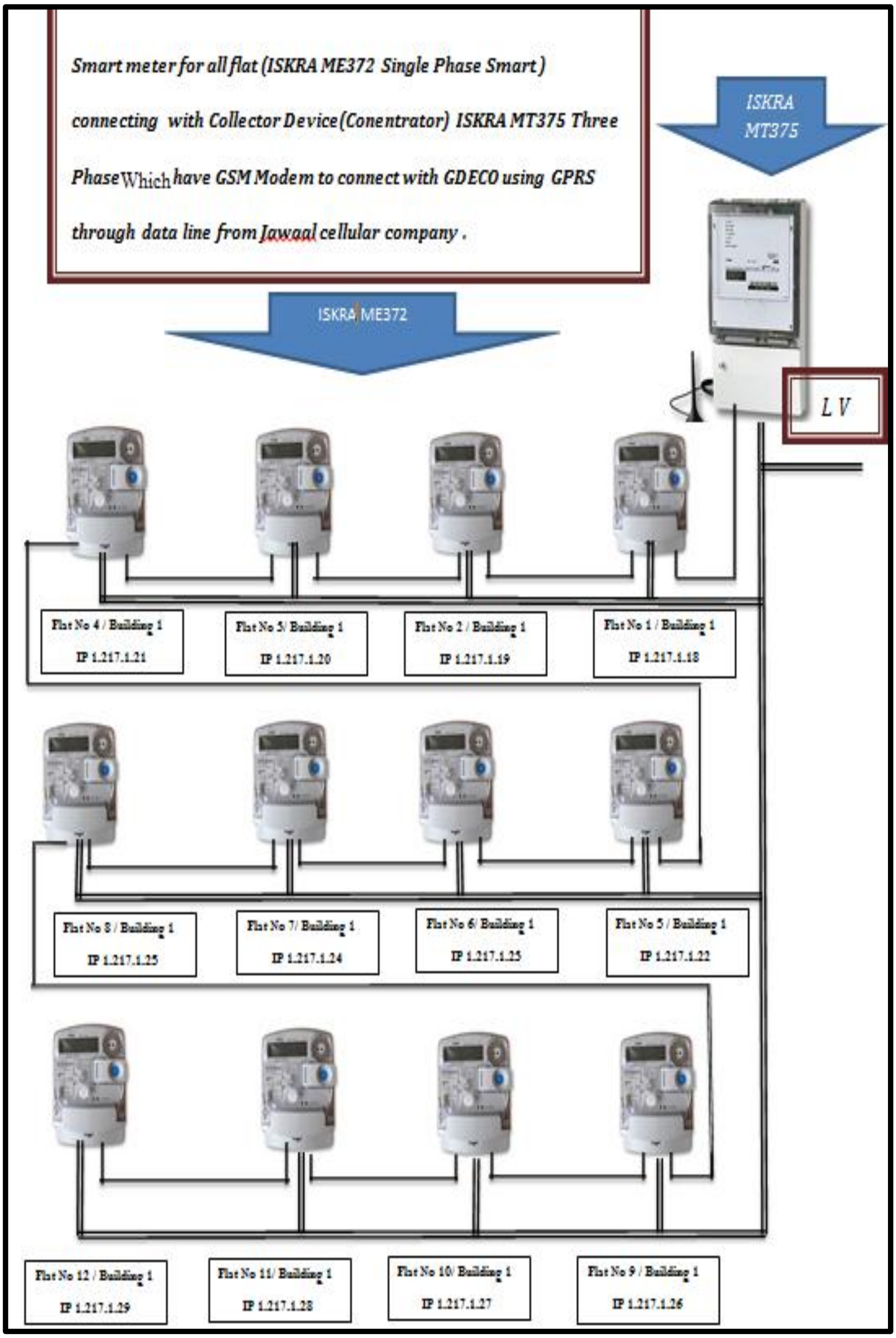


Figure (4.3): Connection topology between smart meters and concentrator

Figure (4.4):Smart meter connection

Figure (4.3):The serial connection of Smart meters

-

- Step (6)- In the case of each house separately.

  They gave the smart meter static IP, the IP address is the same as the SIM card number, and linked all smart meters through GPRS SIM card with computer software system using TCP.

- Step(7)- In the case of the building has many flats, they gave each smart meters a static IP which started from no.18 mandatory as shown in Figure(4.3) and next smart meter has the next number and so on. Then connected all smart meters to be reached serially, through port has an AP title where the first two slot are input and last two slot are output. Then they connected the first smart meter with concentrator, then linked the concentrator through GPRS with computer software system using data line technology, that connected with static IP to GEDCO server (computer software system) that has public IP, connection based on VPN technology.
- Step (8)- Administration and process control of smart meters started by the computerized system (GEDCO server (computer software system).

5. **Protocols and software:**

- They used DLMS\COSEM protocol, and Demo software from Iskra company, HDLC, RS485.

6. **Testing of the system**

- When power provides 20 amp capacity, the system seems normal, over a period of 8 hours, but when a power outage the system works on supplying electricity of capacity 2 amperes, where smart meters was programed.
- Activation system operations control and management process to serve subscribers.

7. **Disadvantages and Troubleshooting**

Problem (1)- In some houses, smart meters lose contact with the system. As a result of the following disadvantages:

1. Mismatched place smart meters (electricity room) underground. So, connection to the GSM network is very weak, and it is sometimes lost. This causes a problem in communication for the smart meters.

Solution 1: The system tries to reconnect with concentrator or smart meters several times, and technical team starts maintenance of defects.

2. When the power failure and returned some smart meters lose contact to the system for up to 20 minutes.

Solution 2: The system tries to reconnect with concentrator or smart meters several times, and the technical team starts maintenance of defects. Or maintenance team must restart the transformer.

Problem (2)- Some smart meters when converting from 20 A to 2 A keep an electrical connection process capacity of 20 Amps, and vice versa; respectively.

Solution: Maintenance team must cut off the power and turning on the transformer.

Problem (3)- The smart meters were programmed to work with schedule time as follows:

From 7 am until 15:00 by capacity of 20 A

From 15:00 until 23:00 by capacity of 2 A

From 23:00 until 7:00, by capacity of 20 A

So, any change of schedule time turning off / turning on the transformer, even just minutes smart meters doesn't work correctly with the system.

Solution: Sorry, there is no real solution, but maintenance team try turning off / turning on the transformer. So the smart meters must be upgraded.

Problem (4)- Connection between smart meters and control system through DATA LINE - GSM (external network communication) causing slow to contact, especially when it reconnect after a failure case.

Solution: There is no real solution, they looking for a solution as another communication method within a different system like as PLCC between smart meters and transformers using concentrators on transformers. or updating generation to G3.

Problem (5) - The system Rreads and controlling through SMS messages, so it's too expensive.

Solution: Provide communication and control by another system.

Problem (6) Smart meters used ISKRA ME372 single phase and MT372 3 phases made by ISKRA company production that must connected sequentially with concentrator. So, if cutting wire any of them, the contact will be lost with other smart meters.

Solution: Smart meter type must be upgrade.

Problem (7)- The subscriber can’t figure out the capacity of power by amperes automatically. So, it causes confusion and breakdowns in electrical equipment in houses.

Solution: System must be updated.

Problem (8)- Crews executive inexperienced.

Solution: 1- Training of technical and engineering teams globally or in partnership with the Department of Electricity in universities.

2- Partnership with local specialized companies.

Problem (9)- There is no similar previous projects.

Solution: Activation scientific research.

8. The results:

1. The system did not achieve the desired goals.
2. The project was stopped.

4.2 Case Study No 2: Pilot project Municipality of Abassan alkabeera:

A pilot project implemented Under supervision Municipality of Abassan alkabeera: The project implements to Energy conservation through monitoring and control of government and public buildings as follows:

1. ***Beneficiaries of the project:-***

The project is implemented on a lot of buildings (government and public buildings like police station, hospital, schools) Electricity arrived for eight hours 220 v, capacity of 20 amps. Electricity arrived next eight hours 220v capacity of 2 amps., They are planning to use GSM, smart meters, management software system to conserving of Energy through monitoring and control

The goal of pilot project:

- Increase energy efficiency
- Taking into consideration that smart meters will be able to work in the future as ON-grid with solar energy and generators.

2. ***The steps that have been implemented until now:***

Step(1) They Allocated Abassan Alkabeera to implement the project as shown in Figure (4.6) as a following:

The project is implemented on a sample Determine target building as 60 public buildings everyone have one smart meter.

Step (2) Built a technical executive team.

Step (3) Drawing geographical maps of the buildings in place.

Step (4) Determine expected consumption energy of each building.

Step (5) Develop a plan and measures to reduce energy consumption and save energy consumption.

Step (6) Survey (by Densitometer transmitter) degree transmitter network GSM, to positioning place of smart meters that have GSM chip.

Step (7) Tender Awarded to supply provider of Smart meters required type ISKRA382 3Phase and 1Phase. As shown in Figure(4.8)
For more specification of Smart meters ISKRA382 3Phase and 1Phase see appendix (B)

Figure (4. 4): Distribution of smart meters network in Abasan Al Kabira pilot project

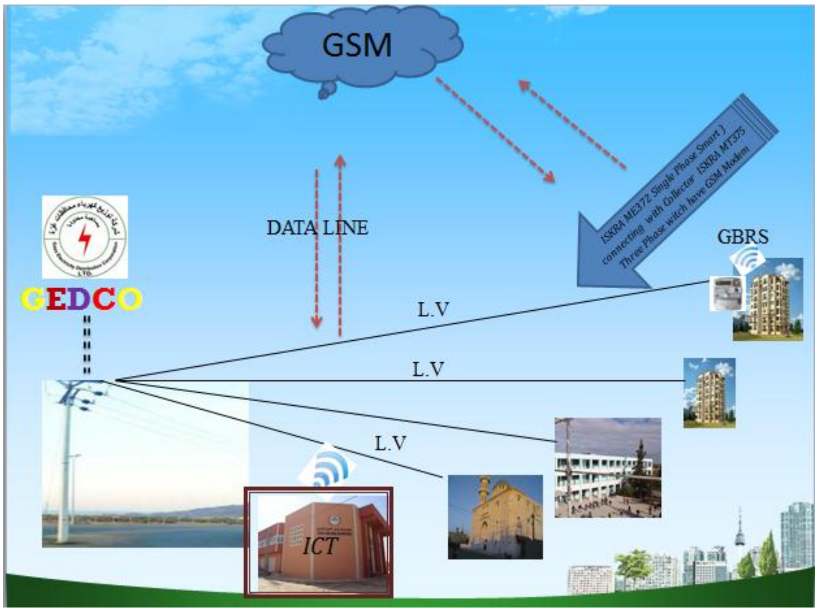


Figure (4. 5):Connection between Smart meters for buildings and (ICT) information communication technology center

Figure (4. 6):Type of smart meters in Abassn Al-kabeera pilot project

The protocol used to communicate with the smart meters DLMS\COSEM using GPRS.
The decision maker in the project contracted with supplier of smart meters and software system to supply and follow up.

3. Results:

1. **The project under processing.**

4.3 Case Study No 3: Pilot project Aqraba Municipality – Nablus City

North Electricity Distribution Company (NEDCO) decide to develop an electrical grid through re-management and update equipment, as creating a pilot project for full control and management of electricity 24 hours daily as follows:
The project was implemented on a sample of 20 building in the area (Aqraba - Nablus City). as shown in Figure (4.9)

1. The executing agency:

Department of customer services, North Electricity Distribution Company (NEDCO).

2. Project equipment specification

1- PRIME FCC PLCModule Specification, see appendix(b)

3. **ESEP project Chart:**

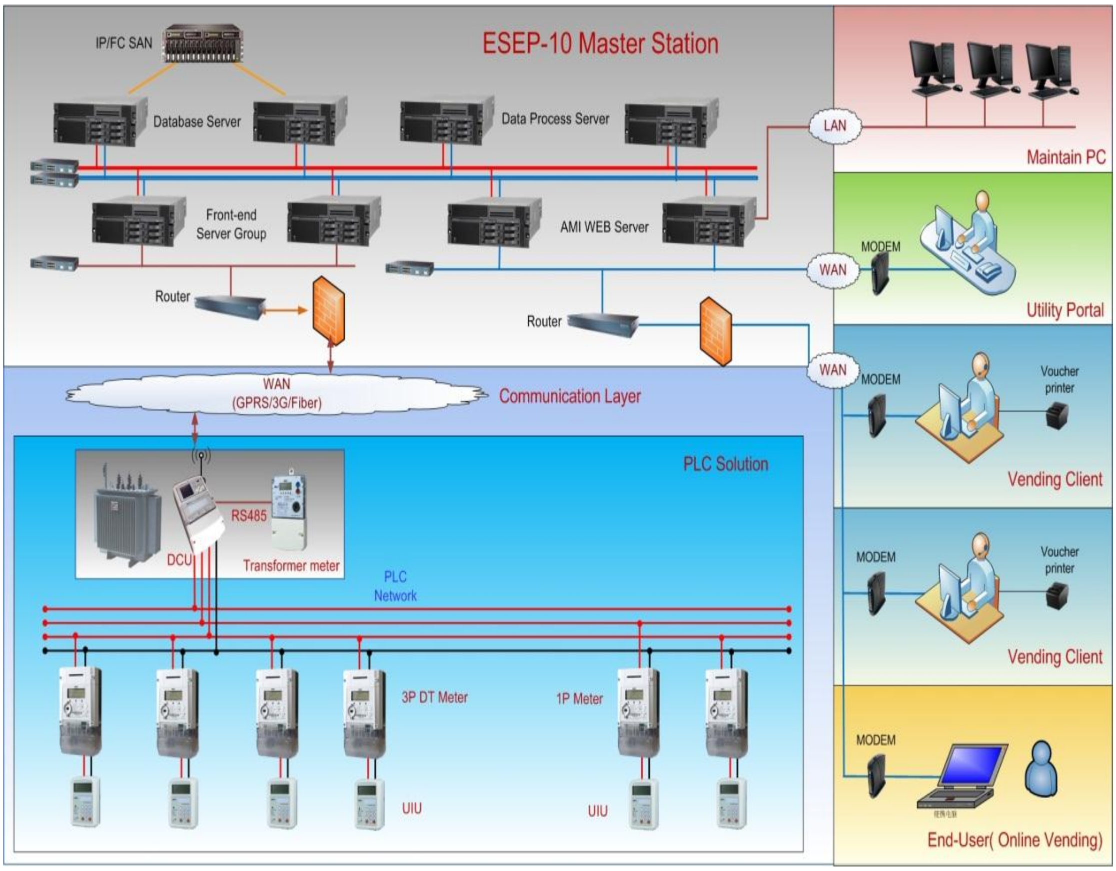


Figure (4. 7):Project Chart - Aqrabaa - Nablus City

4. **Project goals**

- Trying to manage and controlling the power grid by computerized way over PLC.
- Studying the possibility of applying idea on the overall electricial grid in west bank.

5. **Steps and implementation mechanism:**

Step (1) The company Allocated Aqraba district to implement the project as a following:

- The project was implemented on a sample of 20 building.
- Every building has one electrical prepaid meter(Holley2).

- Then add PLC modem-Built-in RISECOMM PLC MODEM, the modem connected with user interface unit (UIU) in the same building by FSK/PLC technology.
- the prepaid meters connected to the grid by PLCC using DCU device with Powerline Intelligent Metering Evolution –PRIME.

Step (2) Installing Concentrator on transformer (DCU PRIME FCC PLC Module).

Step (3) connected each DCU contain SIM card GPRS network (jawwal mobile network).

Step (4) administration and Process control of smart meters started by the computerized system (Nablus Electricity Distribution Company server).

6. Protocols and software:

- They used FSK\PLC, PRIME protocol, and enterprise software from HOLLEY LTD, RS485,GBRS

7. Testing of the system

- The system was tested over 20 building with 4 DCU only as a pilot project.
- The system operations control and management process was a successfull.

8. Management System screens

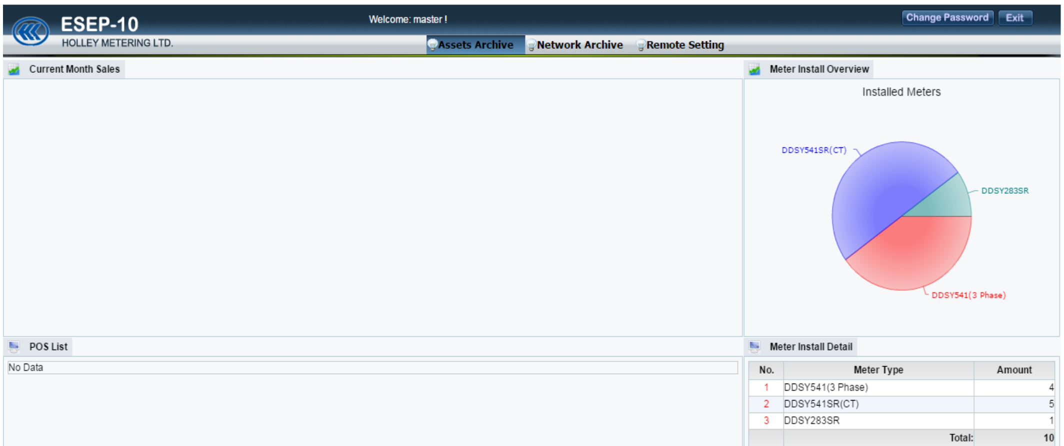


Figure (4.8):Main management system screen, Aqrabaa project, Nablus City

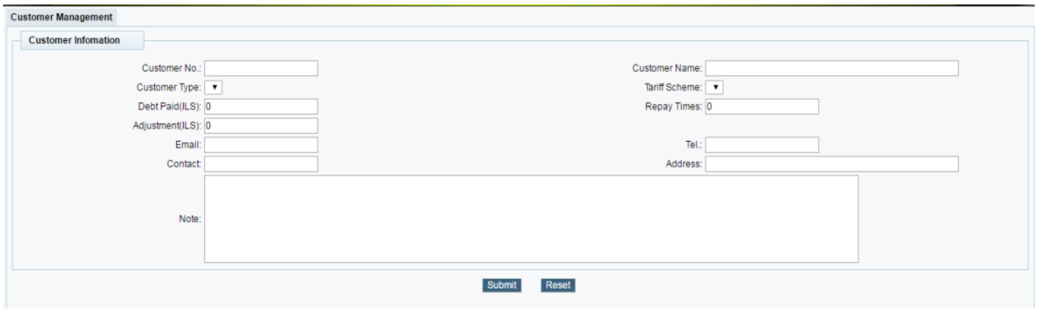


Figure (4.9):The screen of customer information-details, Aqrabaa project, Nablus City.

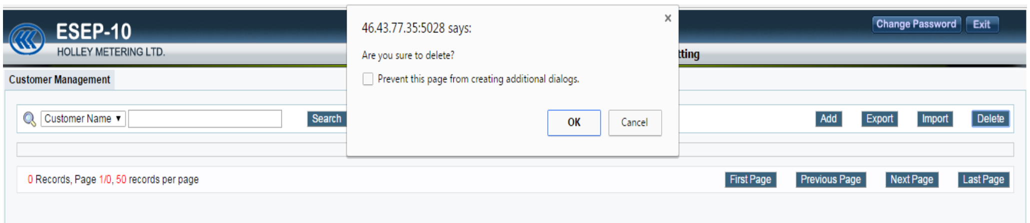


Figure (4. 10):The screen of customer information, Aqrabaa project, Nablus City.

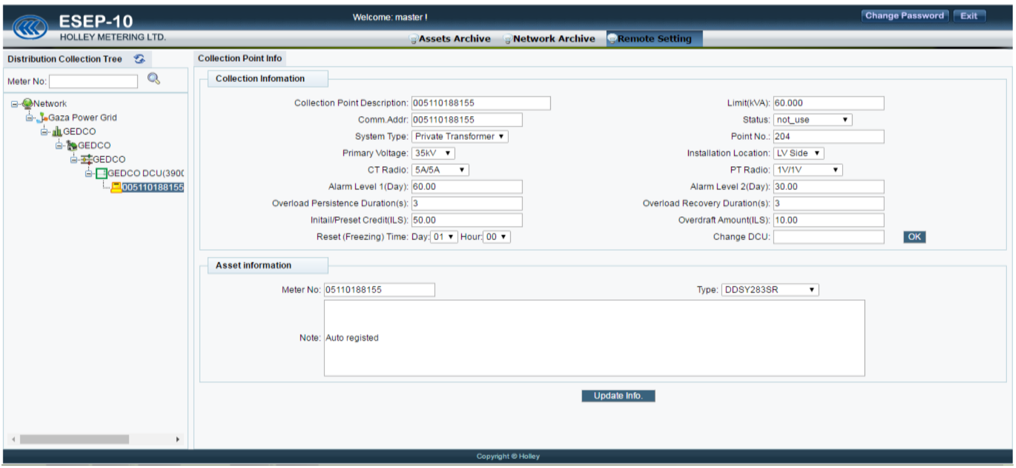


Figure (4. 11) Distribution Grid Tree - GEDCO-DCU- Details

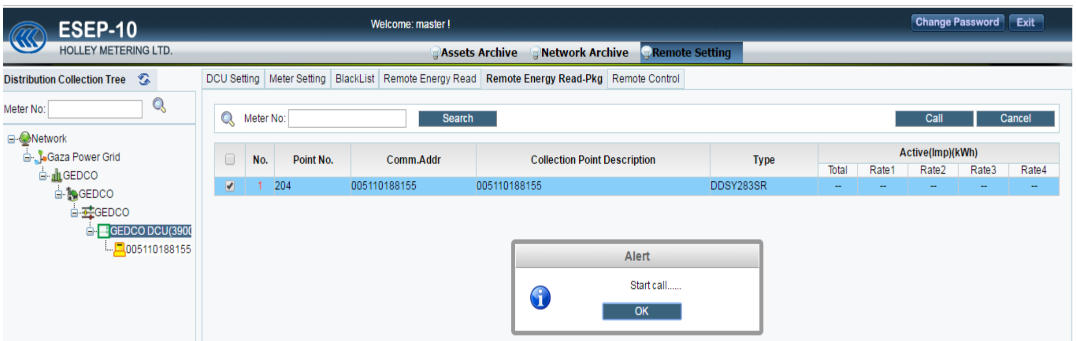


Figure (4. 12): Distribution Collection Tree Remote Setting

9. disadvantages and Troubleshooting

1- Problem of communication and loss of communication for the DCU may happen.

2- PRIME protocol has high Forward Error Correction (FEC) (Hoch, 2011).So, it will be using a large number of SMS, and this is very costly.

Solution: DLMS\COSEM Protocol can solve problem of using a large number of SMS causing by Forward Error Correction that happens with PRIME protocol (Corchado, Manero, Cortés, Sanz& Díez 2016).

10. Results:

1- The project under development.

Chapter 5

Experimental Work

Chapter 5

Experimental Work

5.1 Experiments of Broadband as Application Technology over PLC.

Broadband broadly categorized into two types :

1. Access Broadband
2. In-house Broadband

In Low Voltage broadband over power lines (BPL), a wide range of power-line communication technologies are needed for different applications, ranging from home automation to Internet access. The BPL systems utilize electric power lines not owned, operated or controlled by an electricity service provider, such as the electric wiring in a privately owned building. Broadband devices are connected to the in building wiring and use electrical sockets as access points the only thing that the user has to do is plug the modem into the socket and connect it to the computer. In--house BPL systems use the electrical outlets available within a building to transfer information between computers and other home electronic devices and appliances, which eliminate the need to install additional wires among devices. Electrical Companies can use broadband for system data communication needs

- Automated metering.
- Voltage control.
- Remote equipment monitoring.
- Energy management.

5.1.1 Experimental Router management over PLC

Experimental Router NETIS management using Broadband as application technology over PLC that manage the router option using operating system Microsoft windows 7 and internet protocol version 4 TCP/IPv4.

Experimental work steps:

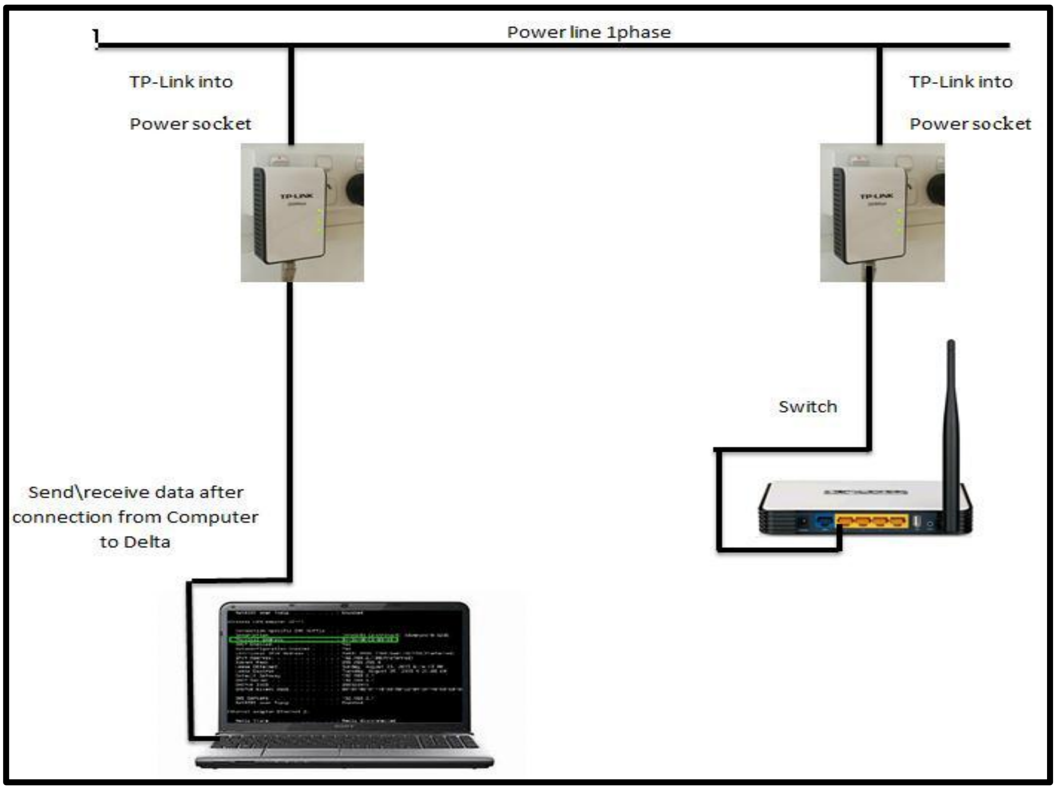
1- Plug first TP-link Ethernet adaptor into a common wall socket, (a BPL modem is plug_and_play)

2- Plug first TP-link Ethernet adaptor an Ethernet modem.

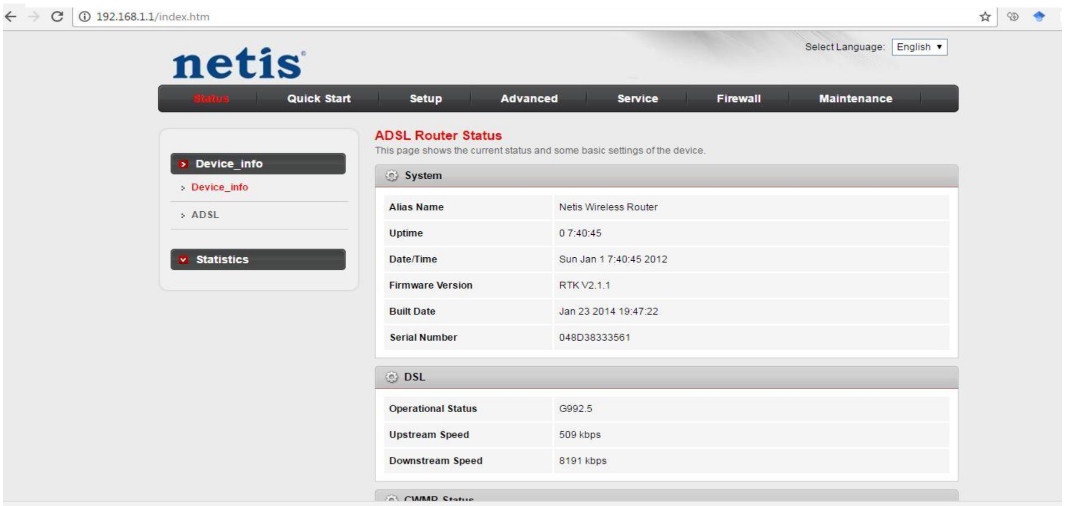
3- Plug second TP-link Ethernet adaptor into another a common wall socket, in same phase.

4- Connect the second TP-link Ethernet adaptor cable running to laptop and access to modem through it.

5- Using TCP/IPv4 connects to modem and using HTTP web manages it. Type command http://192.168.1.1 , then start to managing process.



Figure(51 .): Connection between laptop and router through power line 1 phase using TP-Link power line adaptor



Figure(5 .2):Result of command of configuration router

The Result:

The experiment in-home was successfully repeated with the following observations:

- The signal quality decreased in-home because of many electrical devices works on the electrical network.
- Length of the distance between modems
- In the case of connected with a direct cable, a successful experiment was carried out on a 200 meter.(I have investigated actually.)

5.1.2 Experiment of managing DELTA devices over PLC

PLC network for the programmable logic controllers at the automation lab.

Experiment of managing DELTA devices using Broadband as application technology over PLC that manage the DELTA devices option and operations order using operating system Microsoft windows 7, ladder programming language and internet protocol version 4 TCP/IPv4.

Experimental works steps:

1- Plug first TP-link Ethernet adaptor into a common wall socket, (a BPL modem is plug_and_play)
2- Plug first TP-link Ethernet adaptor an Access point adaptor.
3- Connect all DELTA devices with Access point as shown in (Figure 4.3), (Figure 4.4).
4- Plug second TP-link Ethernet adaptor into another a common wall socket, in same phase.
5- Connect the second TP-link Ethernet adapter with the cable to the laptop.
6- Give all one IP address in the same class as for example the first DELTA device IP address 10.10.18..190
7- Give the Access point IP address 10.10.18.1
8- Give the laptop IP address 10.10.18.199
9- Using TCP/IPv4 protocol connect Access point.

10- Managing and controlling system using a command of ladder programming language.

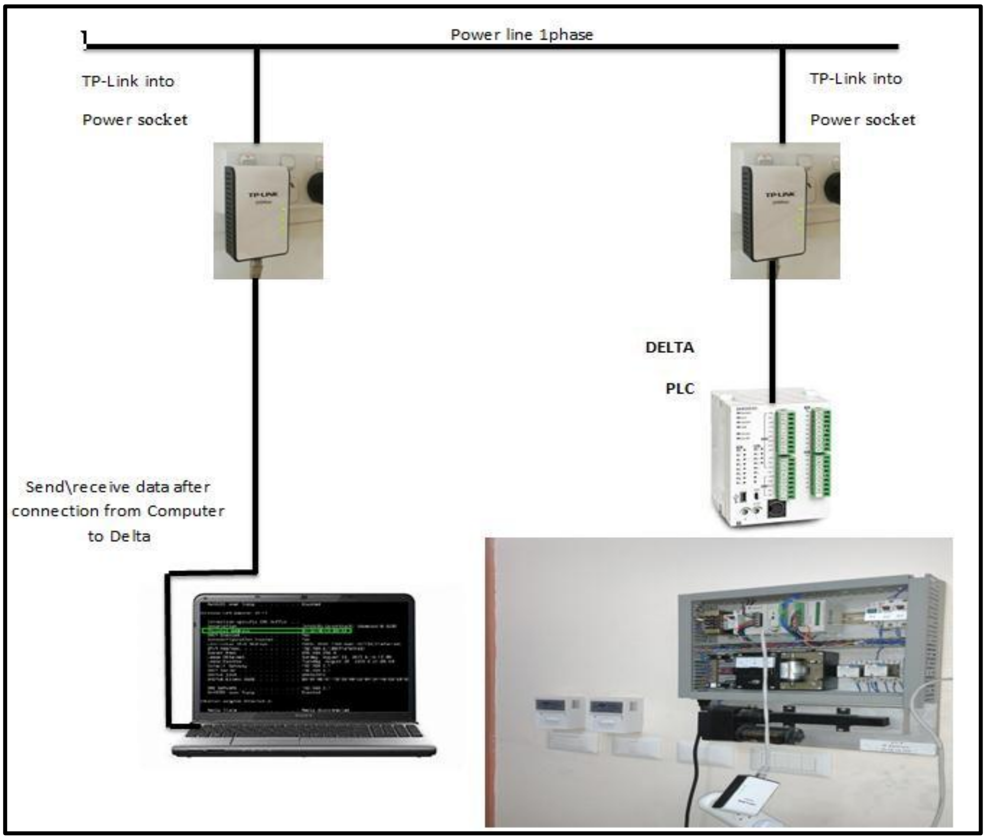


Figure (5. 3): Connection between computer and DLTA device over PLCC at the same electric phase

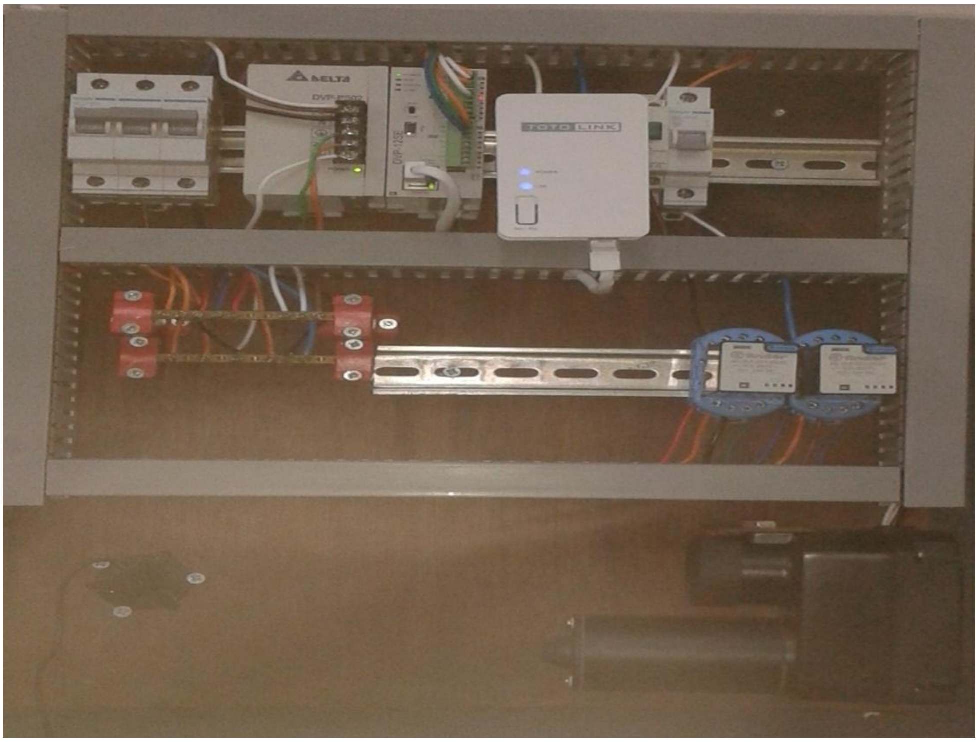


Figure (5.4):Control board of programmable logic control lab.

Figure (5. 5):Lab of programmable logic control was connecting using TP-Link Adaptor over PLCC.

The Result of experimental:

- The experiment in the lab was successfully done.
- All boards of programmable logic control lab in the Islamic university was connecting together using TP-Link Adaptor over PLCC and connect wireless to computers using the Access point as shown in (Figure 4.5).
- The devices were connected without needing to a wired computer network, therefore saving in costs.
- Students can manage, connect, and conduct experiments as shown in (Figure 4.6).

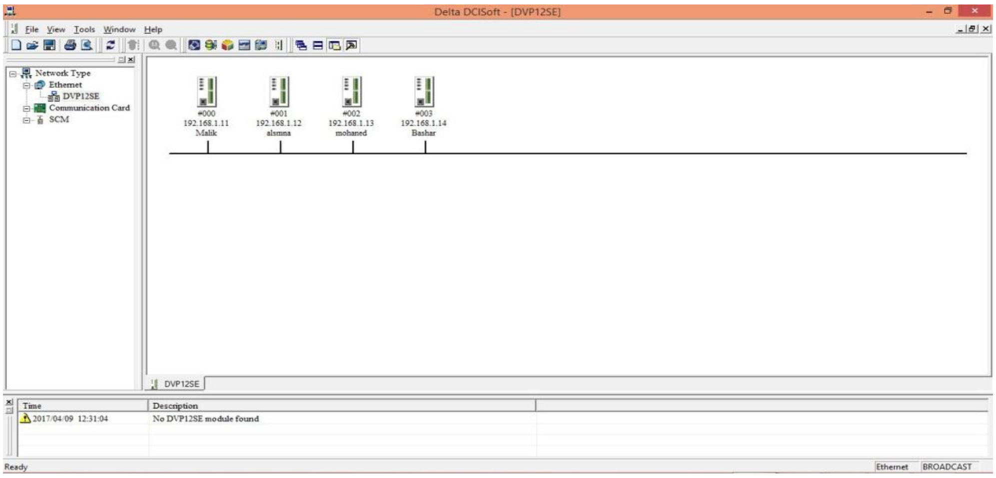


Figure (5. 6): The result of programmable logic control experimental using software (Delta -DCI-soft).

5.2 Prepaid meter with UIU or CIU User/ Customer Interface Unit over PLC

- The User interface unit (UIU) device works by contact with the prepaid meters over PLC on the same electrical phase line.
- The UIU observe Instantaneously update values in prepaid meters such as current, voltage, balance.
- The connection between UIU and prepaid meter use DLMS\COSEM protocol.

5.3 Experimental work on the DLMS\COSEM Protocol

A new System Managing Electrical power grid by PLCC. Using Holley DTSD5RS Three Phase Electronic Meter, DLMS\COSEM Protocol, OBIS code, converter modules from USB to RS485 and Visual Basic6.

5.3.1 How the system works with PLCC:

Firstly computer communicates with smart meter by sending AARQ command and receive AARE, through the converter from Comm.Port to the RS485 and then via power line to smart meter by using OFDM over broadband.
Experimental of managing smart meters devices, (Holley DTSD5RS Three Phase Electronic Meter) using DLMS\COSEM Protocols over Broadband as application

technology for PLCC that manage the Electrical power smart meter devices option and operations order using OBIS code as shown in (Figure 4.7)

5.3.2 System components:

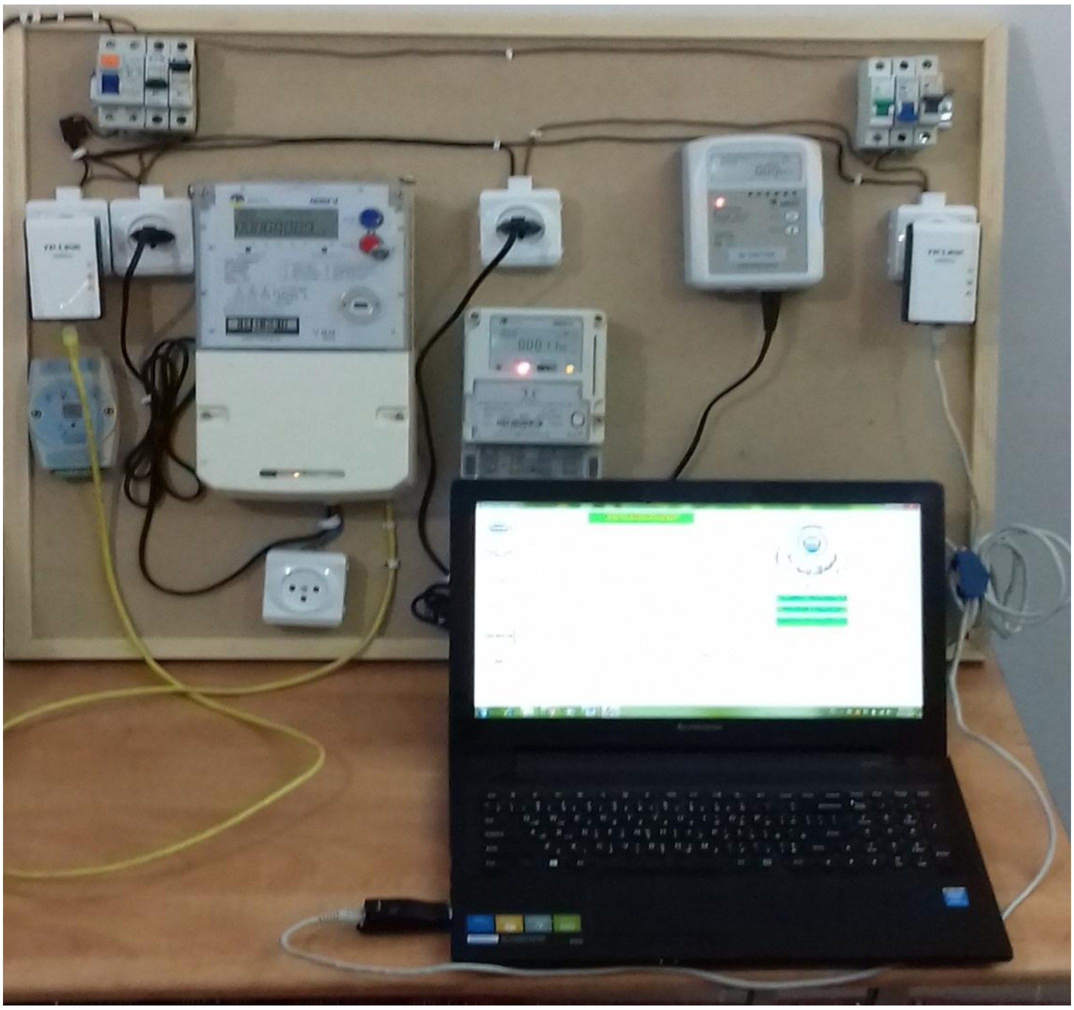


Figure (5. 7): Application of managing smart meter using DLMS\COSEM Protocol

Application file called :IUG-DLMS-Analyzer, DLMS\COSEM protocol, OBIS code, Holley DTSD5RS Three Phase Electronic Meter, converter module from USB to RS485, electrical power, computer with operating system and vb6.

1- Application specification:

- Application name : IUG-DLMS-Analyzer
- Application type: Controlling and management application.
- Application command: command of visual basic 6 Programming language.
- Application protocols : DLMS\COSEM

2- DLMS\COSEM protocol specification: according type IEC62052-11

3- OBIS code: comply with smart meter registers and DLMS\COSEM protocol.
4- Holley DTSD5RS Three Phase smart meter as shown specification at 2.6.1 example (4).
5- Computer specifications: computer has CPU Corei3, USB 3 port, RAM 2 GB, OS Windows7 and Visual basic 6.
6- Converter modules from USB to RS485 specification: A module converts from USB to RS485.

5.3.3 Experimental work steps:

5.3.3.1 Phase (1) Test of application GXDLMS-Director

1- As shown in (Figure 4.7), (Figure 4.8) configure computer Operating system Microsoft windows 7, Visual basic 6 programming language and Comm. port3 as communication port.
2- Plug the Smart meter (Holley DTSD5RS Three Phase Electronic Meter) with 1 of phase port cable then to a common wall socket.
3- Plug first RS 485 connector with port 23,24 in smart meter and the second with converter module from USB to RS485 into computer Figure (4.8).

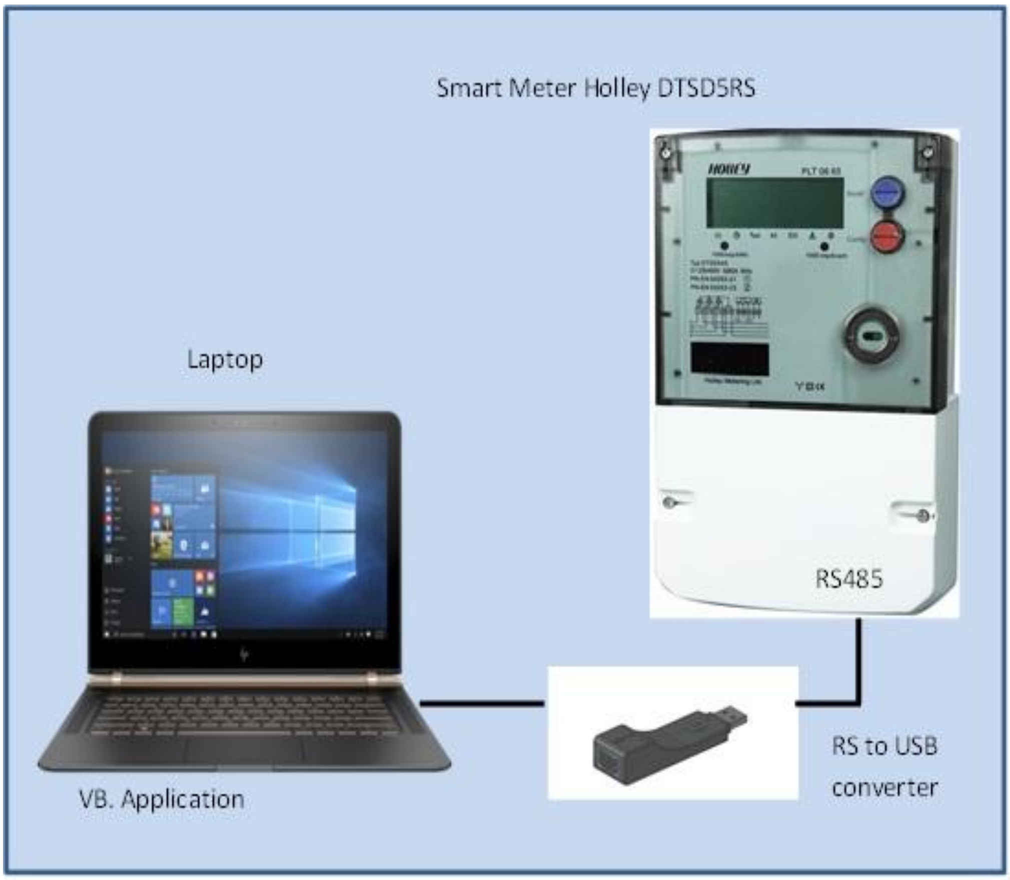


Figure (5. 8):IUG-DLMS-Analyzer equipment

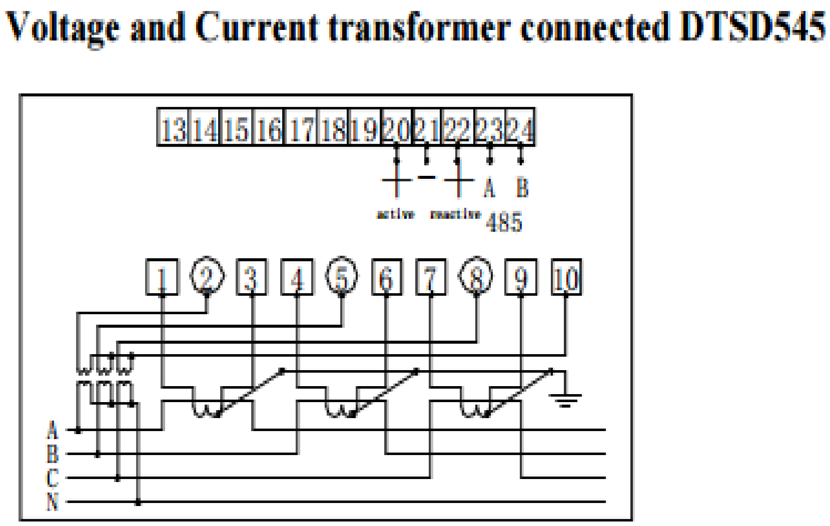


Figure (5.9): Voltage and Current port connected

4- Setup GXDLMSDirector Application file and run the application short name GURUX.

Note(1): GXDLMSDirector open source application but we didn't find Holley devices in devices list. So we developed the application by changing specifications, functions and parameters, then added Holley LTD Devices into GXDLMSDirector Application file.

5- Click on file menu and Choice add Holley device as show in (Figure 4.10).

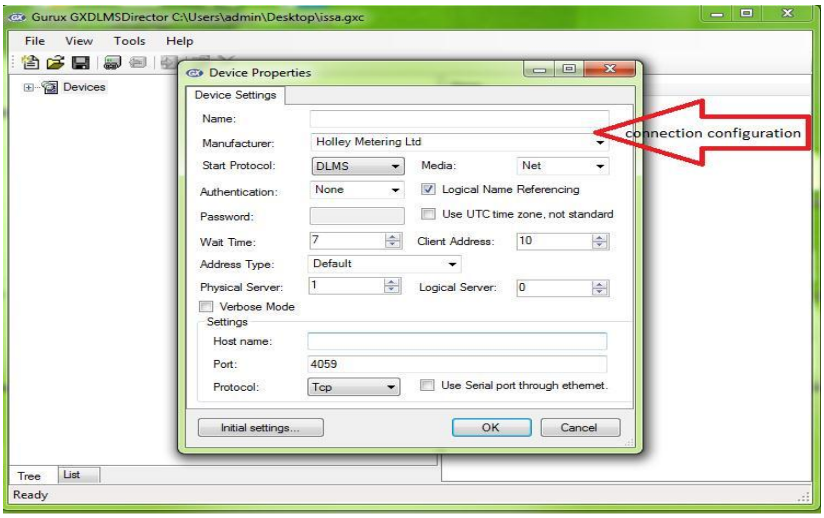


Figure (5. 10): Addig a new device

6- Click connect command button as show in (Figure 4.11).

Note(2): In first connection GXDLMSDirector read all register OBIS code for all object devices in smart meter or device. And classified them to gather packet information from the device.

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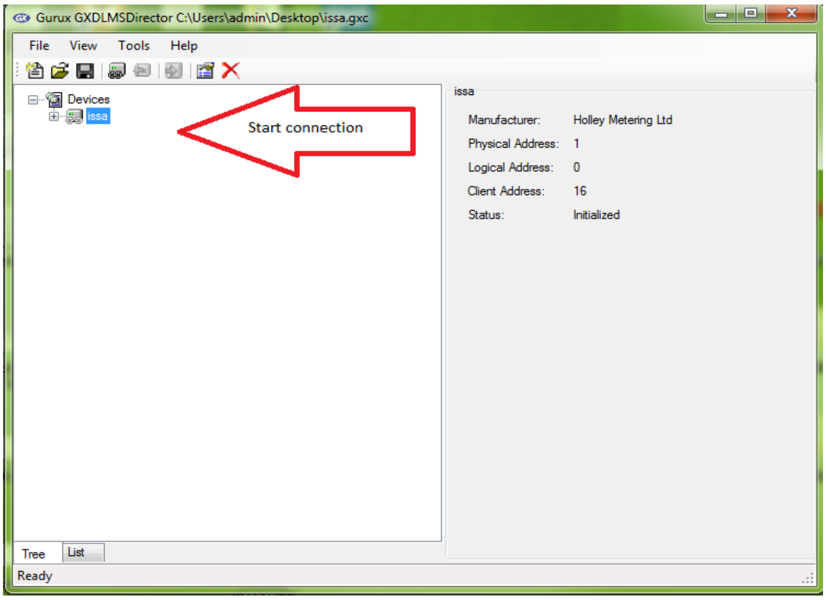


Figure (5. 11):Gurux Start up

7- Test Application command button for example read time.

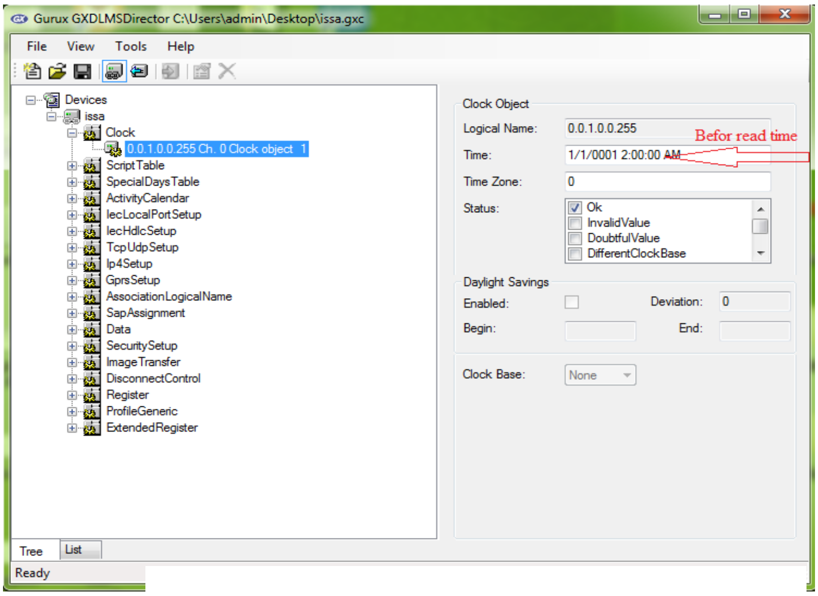


Figure (5. 12): Read time

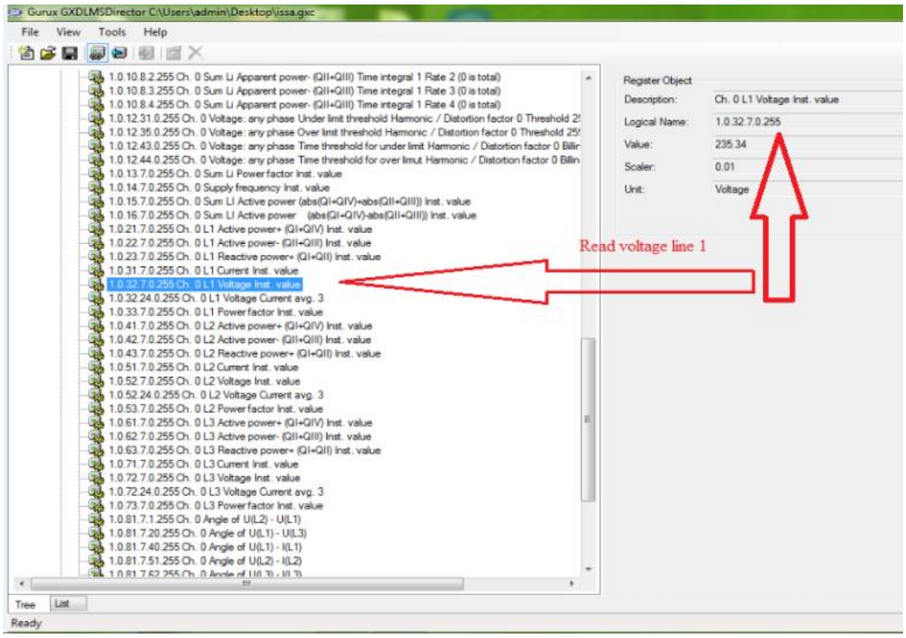


Figure (5. 13):Read voltage line 1

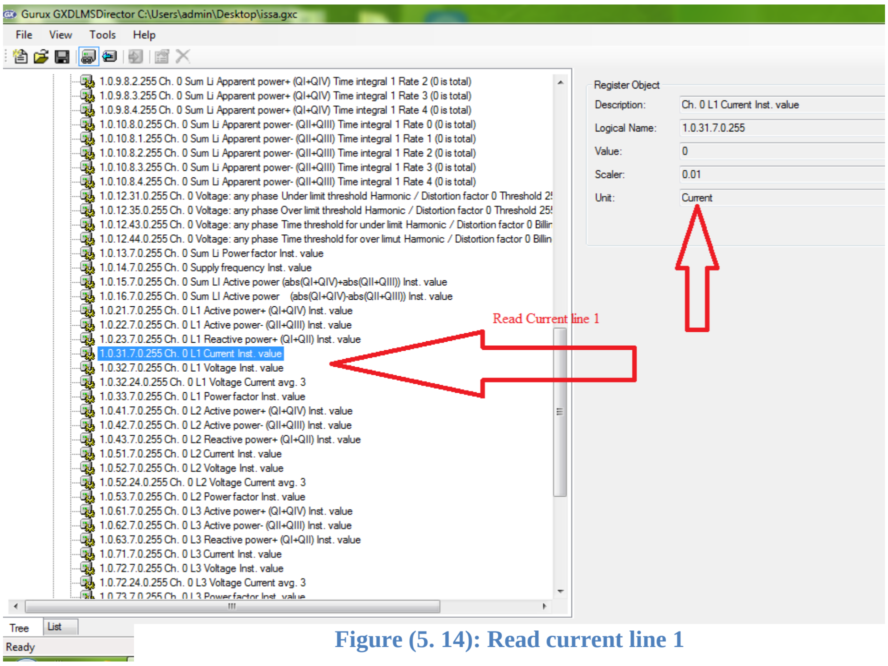


Figure (5. 14): Read current line 1

Remember that You will get information just if connection was successfully done.

Note (2): GXDLMSAnalyzer is Demo application.

- Experimentally, Gurux system sending the instructions to make start connection processes, reading time, date, voltage and disconnect, and receiving the response for every process separately.

- Protocol communication and negotiation are done Using HDLC frame and OBIS code, then decoding from HEX to decimal.

- Interpreted the code using information assume in the four books that describe the protocol.

5.3.3.2 Phase (2) Create application IUG-DLMS-Analyzer

Creating application IUG-DLMS-Analyzer using Visual Basic6 programming language uses the instructions to connect from register directly through protocol DLMS\COSEM and OBIS.

As we said on note(2) above GXDLMSAnalyzer is Demo application, therefore we can't apply all operations management system. So, created a new application using programming language visual basic 6 was done, that used DLMS\COSEM protocol and OBIS code to contact with registers of smart meters to do full control management system as a following:

1- System installation and connection

1- As show in Figure(5.8) configure computer Operating system Microsoft windows7, Visual basic6 programming language and Comm.port3 as communication port.

2- Plug the Smart meter (Holley DTSD5RS Three Phase Electronic Meter) with 1 of phase port cable then to a common wall socket.

3- Plug first RS 485 connector with port 23, 24 in smart meter and the second with converter module from USB to RS485 within the computer.

4- The communication between Computer system software using Comm. Port 3 and DLMS\COSEM, IPV4 and HDLC will done by ICE62056-21E mode

2- Running and testing the system

1- Run visual basic 6 Application file that is named as IUG-DLMS-Analyzer.

2- Click on initialization connect command button.

3- Click on SNMR connect command button.

4- Test other command button for example read line 1 voltage, Read current inst. and Read date and time.

5- Read Date\Time
6- Read voltage
7- Disconnect
8- Using DLMS/COSEM does change, update, read, write and manage the smart meter.

   Remember that: You will get information just if connection was successfully done.

3- Operating procedures for IUG-DLMS-Analyzer Application expect to do the following Functions**:**

1- Energy measurement.
2- Demand measurement.
3- Monitoring.
4- Controlling
5- Management

4- Starting IUG-DLMS-Analyzer

IUG-DLMS-Analyzer application use DLMS/COSEM instructions and commands is written to simplify communication with DLMS/COSEM devices. Describe and specify the component that you can easily manage DLMS/COSEM devices, by using the data connection, and the manufacturer of your choice. The Application interfaces, instructions, commands, and methods are describing how does the experiment work.

A. Connection Initialization

1- Click the connection initialization button.
- Connection defining Comm.Port values: Z is the most important part of the device and is defined in a single number:
- MSComm1.CommPort = 3
- MSComm1.Settings = "9600,n,8,1"
- MSComm1.RThreshold = 1
- MSComm1.PortOpen = True
- OLD = 0
- n = 0

2- Command Send DLMS\COSEM connection message.

3- IUG-DLMS-Analyzer application will use serial Comm.Port3 Plugin with converter module to connect with other smart meter in the system then communication start.
4- The protocol handshake before starting to communicate using DLMS protocol,
   - Initializing serial connection (7E A0 07 03 21 93 0F 01 7E).
   - The Received data message(7E A0 1E 21 03 73 C3 7A 81 80 12 05 01 80 06 01 80 07 04 00 00 00 01 08 04 00 00 00 01 53 3B 7E)
5- Command message Send AARQ request(21 10 FB AF E6 E6 00 60 1D A1 09 06 07 60 85 74 05 08 01 01 BE 10 04 0E 01 00 00 00 06 5F 1F 04 00 40 1E 1D FF FF E7 25 7E)
6- The Received data message (7E A0 37 21 03 30 6C 7C E6 E7 00 61 29 A1 09 06 07 60 85 74 05 08 01 01 A2 03 02 01 00 A3 05 A1 03 02 01 00 BE 10 04 0E 08 00 06 5F 1F 04 00 00 10 1C 01 90 00 07 28 73 7E).

B. Application Association REquest (AARQ request)

This is the first command must done for all connections and device types. Telling the device if authentication is used and whether Long Name or Short Name reference is used. The packet can be generated with AARQRequest method and it uses **UseLogicalName** and **Authentication** properties so make sure these are set to correct values. AARQ sent by the client application layer to the server application layer.

C. Application Association Response (AARE request)

Once the full reply is received parse it with ParseAAREResponse method. This method sets the relevant settings to the GXCOSEM component and return a collection of manufacturer specific tags if there was. AARE sent by the server application layer to the client application layer.

D. Reading Profile Generic objects

The request is generated using ReadProfileGenericData.

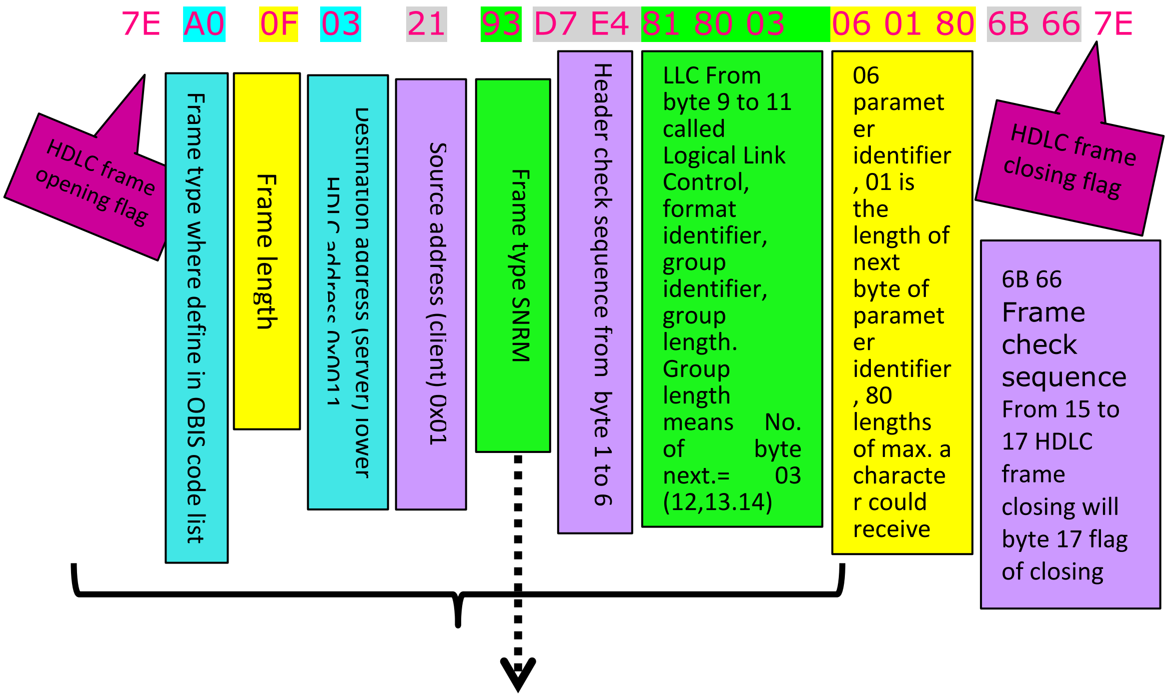
Notes:

1. If row indices are used the logical name of the first column must be null.
2. DLMS Application component may supports HDLC addressing by 1, 2, 4 Bytes and can communicate using HDLC, TCP/IP or UDP. It supports Lowest, Low and High Level authentications. Both Long and Short Name Association Types are supported.

5.3.3.3 Examples explain details for DLMS/COSEM information exchange:

Example (1): SNRM/UA frame exchange with HDLC parameter negotiation

Sent frame: 7E A0 0F 03 21 93 D7 E4 81 80 03 06 01 80 6B 66 7E



I	R	R	R	P/F	S	S	S	0
RR	R	R	R	P/F	0	0	0	1
RNR	R	R	R	P/F	0	1	0	1
SNRM	1	0	0	P	0	0	1	1
DISC	0	1	0	P	0	0	1	1
UA	0	1	1	F	0	0	1	1
DM	0	0	0	F	1	1	1	1
FRMR	1	0	0	F	0	1	1	1
UI	0	0	0	P/F	0	0	1	1

For more details see the following tables of examples:

Example (1): SNRM/UA frame exchange with HDLC parameter negotiation

Sent frame: 7E A0 0F 03 21 93 D7 E4 81 80 03 06 01 80 6B 66 7E

No.	Byte No.	Byte content	Frame type		Explanation
1	1	7E	HDLC frame opening flag	From byte 1 to 8 called HDLC header	7E is constant flag has two cases, first when comes the first byte of frame called opening flag, second when comes end of frame called closing flag
2	2,3	A00F	frame type and length		A0(Hex) = 160 (Dec) frame type where define in OBIS code list. 0F (Hex) = 15 in (Dec) frame length means No. of byte nextA0. From byte 3 to 17
3	4	03	destination address (server) lower HDLC address 0x0011		destination address (server) lower HDLC address 0x0011 // upper HDLC address is the default (1)
4	5	21	source address (client) 0x01		21// source address (client) 0x01
5	6	93	frame type SNRM (Set Normal Response Mode)		93// frame type SNRM (Set Normal Response Mode), 73// frame type UA (Unnumbered acknowledge), 10// frame type I frame. information field with HDLC parameters not present, defaults are proposed
6	7,8	D7 E4	Header check sequence		check sequence from byte 1-6
7	9,10,11	818003	format identifier, group identifier, group length	LLC	Group length means No. of byte next.= 03 (12,13.14) From byte 9 to 11 called Logical Link Control
8	12,13,14	060180	parameter identifier/length /value – maximum information field length receive		06 parameter identifier, 01 is the length of next byte of parameter identifier, 80 lengths of max. a character could receive
	15,16	6B 66	Frame check sequence		From 15 to 17 HDLC frame closing will byte 17 flag of closing
8	17	7E	HDLC frame closing flag		

Received frame:

7E A0 1E 21 03 73 C3 7A 81 80 12 05 01 80 06 01 80 07 04 00 00 00 01 08 04 00 00 00 01 53 3B 7E

No.	Byte No.	Byte content	Frame type		More details
1	1	7E	HDLC frame opening flag	From byte 1 to 8 called HDLC header	opening flag
2	2,3	A01E	frame type and length		A0(Hex) = 160 in (Dec) frame type where define in OBIS code list. 1E (Hex) = 30 in (Dec) frame length means No. of byte next A0. From byte 3 to 32
3	4	21	destination address (client) 0x01		destination address (client) lower 0x01
4	5	03	source address (server) lower HDLC address 0x0011		source address (server) lower HDLC address 0x0011
5	6	73	frame type UA (Unnumbered acknowledge)		93// frame type SNRM (Set Normal Response Mode), 73// frame type UA (Unnumbered acknowledge), 10// frame type I frame.
6	7,8	C37A	Header check sequence		check sequence from byte 1-6
7	9,10,11	818012	format identifier, group identifier, group length	LLC	(81) format identifier, (80) group identifier where define in OBIS code list, Group length means No. of byte next from byte 12 to 29, where 12 (Hex) = 18 in (Dec)
8	12,13,14	050180	parameter identifier, length, value – maximum information field length transmit		(05) parameter identifier, (01) is the length of next byte of parameter identifier, 80 lengths of max. information transmit.
9	15,16,17	060180	parameter identifier, length, value – maximum information field length receive		(06) parameter identifier, (01) is the length of next byte of parameter identifier, 80 lengths of max. information receive.
10	18,19,20,21, 22,23	070400000001	parameter identifier, length, value – window size transmit		(07) parameter identifier, (04) is the length of next byte of parameter identifier from byte 20 to 23,size transmit (01)
11	24,25,26,27,	08040000000	parameter		(08) parameter identifier, (04) is

	28,29	1	identifier/length/value – window size receive		the length of next byte of parameter identifier from byte 26 to 29,size receive (01)
12	30,31	533B	Frame check sequence		From 15 to 17 HDLC frame closing will byte 17 flag of closing
13	32	7E	HDLC frame closing flag		

Example (2) : AARQ/AARE exchange

AARQ request, Sent frame:

7E A0 2B 03 21 10 FB AF E6 E6 00 60 1D A1 09 06 07 60 85 74 05 08 01 01 BE 10 04 0E 01 00 00 00 06 5F 1F 04 00 00 10 1C FF FF 5B 10 7E

No.	Byte No.	Byte content	Frame type		More details
1	1	7E	opening flag	From byte 1 to 8 called HDLC header	7E is constant flag has two cases, first when comes the first byte of frame called opening flag, second when comes end of frame called closing flag
2	2,3	A02B	frame type and length		A0(Hex) = 160 in (Dec) where define in OBIS code list frame type. 2B (Hex) = 43 in (Dec) frame length means No. of byte next A0. From byte 3 to 45
3	4	03	destination address (server)		destination address (server) lower HDLC address 0x0011 // upper
4	5	21	source address (client) lower		21// source address (client) 0x01
5	6	10	frame type I frame		93// frame type SNRM (Set Normal Response Mode), 73// frame type UA (Unnumbered acknowledge), 10// frame type I frame.
6	7,8	FBAF	Header check		check sequence from byte 1-6

			sequence		
7	9,10,11	E6E600	format identifier, group identifier, group length	L L C	(E6) format identifier, (E6) group identifier where define in OBIS code list, Group length (00)
8	12,13	601D	AARQ tag and length		(60) AARRQ tag, 1D (Hex) = 29 (Dec) is the length of sub frame from byte 14 after (AARQ and length) to byte 42 before Frame check sequence bytes.
9	14,15,16,17,18, 19,20,21,22,23, 24	A1090607 608574050 80101	Application context name tag, length and encoded value		This application association is established with lowest level security, so authentication components are not present
10	25,26	BE10	(BE) tag of AARQ, (10) length for AARQ user field.		(BE) tag of AARQ, 10 (Hex) = 16 (Dec) is the length of sub frame from byte 27 after (AARQ tag and length) to byte 42 before Frame check sequence bytes.
11	27,28	040E	encoding the choice for user-information (OCTET STRING, universal) and length		(04) encoding the choice for user-information (OCTET STRING, universal), 0E (Hex) = 14 (Dec). is the length of sub frame from byte 29 after (AARQ tag and length) to byte 42 before Frame check sequence bytes
12	29	01	tag for xDLMS-Initiate request		
13	30	00	usage field for dedicated-key		

			component – not used		
14	31	00	usage field for the response allowed component – not used		
15	32	00	usage field of the proposed-quality-of-service component – not used		
16	33	06	proposed DLMS version number 6		proposed DLMS version number used from frame check sequence
17	34,35	5F1F	tag for conformance block		used from frame check sequence
18	36	04	length of the conformance block		used from frame check sequence (04) (Hex) = 4 (Dec), length of the conformance block from byte 37 to 40
19	37	00	encoding the number of unused bits in the bit string		
20	38,39,40	00101C	conformance block		
21	41,42	FFFF	client-max-receive-pdu-size		FF (Hex) =255 (Dec) that means client of protocol data unit PDU can receive 255 character from every Byte.
22	43,44	5B10	Frame check sequence		From 15 to 17 HDLC frame closing will byte 17 flag of closing
13	45	7E	HDLC frame closing flag		

AARE Request, Received frame:

7E A0 37 21 03 30 6C 7C E6 E7 00 61 29 A1 09 06 07 60 85 74 05 08 01 01 A2 03 02 01 00 A3 05 A1 03 02 01 00 BE 10 04 0E 08 00 06 5F 1F 04 00 00 10 1C 01 90 00 07 28 73 7E

No.	Byte No.	Byte content	Frame type		More details
1	1	7E	opening flag	From byte 1 to 8 called HDLC header	7E is constant flag has two cases, first when comes the first byte of frame called opening flag, second when comes end of frame called closing flag
2	2,3	A0 37	frame type and length		A0(Hex) = 160 in (Dec) where define in OBIS code list frame type. 37 (Hex) = 55 in (Dec) frame length means No. of byte next A0. From byte 3 to 57
3	4,5	21, 03	destination and source addresses		destination address (server) lower HDLC address 0x0011 // upper, source address (client) 0x01
5	6	30	frame type		93// frame type SNRM (Set Normal Response Mode), 73// frame type UA (Unnumbered acknowledge), 10// frame type I frame.
6	7,8	6C 7C	Header check sequence		check sequence from byte 1-6
7	9,10,11	E6E700	format identifier, group identifier, group length	LLC	(E6) format identifier, (E7) group identifier where define in OBIS code list, Group length (00)
8	12,13	6129	AARQ tag and length		(61) AARRQ tag, 29 (Hex) = 41 (Dec) is the length of sub frame from byte 14 after (AARQ and length) to byte 54 before Frame check sequence bytes.
9	14,15,16, 17,18,19, 20,21,22, 23,24	A10906076 0857405080 101	Application context name tag, length and encoded value		This application association is established with lowest level security, so authentication components are not present

10	25,26	A203	tag and length of the result component		(A2) tag of AARQ, 03 (Hex) = 3 (Dec) is the length of sub frame from byte 27 after (AARQ tag and length) to byte 29
11	27	02	encoding the choice for the result (INTEGER, universal)		(encoding the choice for the result (INTEGER, universal)
12	28,29	0100	length and value of result (accepted)		Check length of result component
13	30,31	A305	tag and length for the result-source-diagnostic component		The response Check the component identification comparing with AARQ tag and length
14	32,33	A103	tag and length of the case-service-user choice		
15	34	02	encoding the choice for result-source-diagnostic (INTEGER, universal)		
16	35,36	0100	length and value of result-		

			source-diagnostic		
18	37,38	BE10	tag and length for AARE user-field		
19	39,40	040E	encoding the choice for user-information (OCTET STRING, universal) and length		
20	41	08	tag for xDLMS -Initiate. response		xDLMS for more information negotiation
	42	00	usage field of the negotiated-quality-of-service component		
	43	06	negotiated DLMS version number 6		DLMS\COSEM updated Protocol version 6, used from frame check sequence for negotiated
	44,45	5F1F	tag for conformance block		Use to check conformance data
	46	04	length of the conformance block		used from frame check sequence (04) (Hex) = 4 (Dec), length of the conformance block from byte 47 to 50

	47	00	encoding the number of unused bits in the bit string		
	48,49,50	00 10 1C	negotiated conformanc e block		
	51,52	1090	server-max-receive-pdu-size		10 (Hex) =16 (Dec), 90(Hex) =144 (Dec) protocol data unit PDU can receive 16,144 character from two Byte.
	53,54	0007	VAA name (0x0007 for LN referencing)		
22	55,56	0C52	Frame check sequence		From 15 to 17 HDLC frame closing will byte 17 flag of closing
13	57	7E	closing flag		

Example (3): Read Date and Time object.

in this example will connect to the smart meter and Read object type "Clock index"

sent frame : 7E A0 19 03 21 32 6F D8 E6 E6 00 C0 01 C1 00 08 00 00 01 00 00 FF 02 00 60 1A 7E

No.	Byte No.	Byte content	Frame type		More details
1	1	7E	opening flag	From byte 1 to 8 called HDLC header	7E is constant flag has two cases, first when comes the first byte of frame called opening flag, second when comes end of frame called closing flag
2	2,3	A019	frame type and length		A0(Hex) = 160 in (Dec) where define in OBIS code list frame type 19 (Hex) = 25 in (Dec) frame length means No. of byte next A0. From byte 3 to 27
3	4	03	destination address (server)		destination address (server) lower HDLC address 0x0011 // upper
4	5	21	source address (client) lower		21// source address (client) 0x01

5	6	32	frame type		93// frame type SNRM (Set Normal Response Mode), 73// frame type UA (Unnumbered acknowledge), 10// frame type I frame.
6	7,8	FBAF	Header check sequence		check sequence from byte 1-6
7	9,10,11	E6E600	format identifier, group identifier, group length	L L C	LLC bytes, (E6) format identifier, (E6) group identifier where define in OBIS code list, Group length (00)

8	12,13	C001	GET.request.normal C0(Hex) = 192 (Dec) 01(Hex) = 1 (Dec)		The CHOICE for get-request-normal is [1], i.e. 0x01. Hence, Get-Request-Normal is encoded as C001. This is followed by the encoding of invoke-id-and priority etc.
					Get-Request ::= CHOICE{
					//get-request-normal [1] IMPLICIT Get-Request-Normal,
					//get-request-next [2] IMPLICIT Get-Request-Next,
					// get-request-with-list [3] IMPLICIT Get-Request-With-List}

9	14	C1	invoke-id and priority		Get-Request-Normal ::= SEQUENCE
					{
					// invoke-id-and-priority Invoke-Id-And-Priority,
					// cosem-attribute-descriptor Cosem-Attribute-Descriptor,
					// access-selection Selective-Access-Descriptor OPTIONAL
					}

10	15,16	0008	interface class 8, clock		From COSEM Identification System and Interface Classes, the Register of Clock Profile generic = 8 (8) means : Clock, class_id: 8 NOTE: Identification code of the class range 0 to 65 535. The class_id of each object is retrieved together with the logical name by reading the object_list attribute of an "Association LN" / "Association SN" object.

					class_id-s from 0 to 8191 are reserved to be specified by the DLMS UA. from 8 192 to 32 767 are reserved for manufacturer specific interface classes. from 32 768 to 65 535 are reserved for user group specific interface classes.
11	17,18,19,20,21,22	00000100 00FF	logical name, OBIS code of the clock		Logical name 6 digit each digit from from 0 to 255.so (0000010000FF) = (00,00,01,00,00,ff) in hex = (0,0,1,0,0,255)in dec. the logical name is unique, not repeated.
12	23,24	0200	asking for 2ed attribute, logical name		Sent Code of DLMS\COSEM protocol to registers of devices asking of object attribute to get results, so the second attribute of clock object to get date and time.
13	25.26	60 1A	Frame check sequence		From 25 to 26 HDLC frame closing will byte 27 flag of closing
14	27	7E	HDLC frame closing flag		

Received frame:
7E A0 1E 21 03 30 5C 0A E6 E7 00 C4 01 C1 00 09 0C 07 E1 03 1A 07 0F 3B 33 00 FF FF 00 76 1A 7E

No.	Byte No.	Byte content	Frame type		More details
1	1	7E	opening flag	From byte 1 to 8 called HDLC header	7E is constant flag has two cases, first when comes the first byte of frame called opening flag, second when comes end of frame called closing flag
2	2,3	A01E	frame type and length		A0(Hex) = 160 in (Dec) where define in OBIS code list frame type. 1E (Hex) = 30 (Dec) frame length means No. of byte next A0. From byte 3 to 32
3	4	21	destination address (client) 0x01		21// destination address (client) 0x01
4	5	03	source address (server) lower		source address (server) lower HDLC address 0x0011 // upper HDLC address is the default (1)
5	6	30	frame type		93// frame type SNRM (Set Normal Response Mode), 73// frame type UA (Unnumbered acknowledge), 10// frame type I frame.
6	7,8	5C 0A	Header check sequence		check sequence from byte 1-6
7	9,10,11	E6 E7 00	format identifier, group identifier, group length	LLC	LLC bytes, (E6) format identifier, (E7) group identifier where define in OBIS code list, Group length (00)

8	12,13	C401	GET.response. normal
			C4(Hex) = 196 (Dec)
			01(Hex) = 1 (Dec)
					Get-Response ::= CHOICE
					{
					//get-response-normal [1] IMPLICIT Get-Response-Normal,
					// get-response-with-datablock [2] -- IMPLICIT Get-Response-With-Datablock,
					//get-response-with-list [3] IMPLICIT Get-Response-With-List
					}

9	14	C1	invoke-id and priority		Get-Response-Normal ::= SEQUENCE { invoke-id-and-priority -- Invoke-Id-And-Priority,

					result -- Get-Data-Result }
10	15	00	Get-Data-Result choice data		Get-Data-Result choice data
11	16,17	09 0C			octet string (12)
12	18,19	07 E1	Byte of: Year date		results of the second attribute of clock object to get date and time. (07E1)hex = (2017) dec, there are date of year.
	20	03	Month March		(03)hex = (3) dec, there are date of Month.
	21	1A	Day: 26		(1A)hex = (26) dec, there are date of the day.
	22	07	Sunday		(07)hex = (7) dec no. day of the week, Sunday
	23,24,25	0F 3B 33	Time 3:59:51		Byte from 23 to 25 get time (0f) hex = (15)dec, (3b) hex = (59)dec, (33) hex = (51)dec
	26	FF	hundredths not specified		
	27.28	0078	deviation 120 minutes		
	29	00	status OK		
13	30,31	76 1A	Frame check sequence		From 30 to 31 HDLC frame closing will byte 32 flag of closing
14	32	7E	HDLC frame closing flag		

Example (4): Read Register object\ L1 Voltage Inst. value.

in this example will connect to the smart meter and Read object "Register \ L1 Voltage Inst. value "

Note: Holley smart meter Type DTSD545-G three phase so we will read 1phase L1 voltage.

sent frame : 7E A0 19 03 21 FE 0F D4 E6 E6 00 C0 01 C1 00 03 01 00 20 07 00 FF 02 00 85 83 7E

No.	Byte No.	Byte content	Frame type		More details
1	1	7E	opening flag	From byte 1 to 8 called HDLC header	7E is constant flag has two cases, first when comes the first byte of frame called opening flag, second when comes end of frame called closing flag
2	2,3	A019	frame type and length		A0(Hex) = 160 in (Dec) where define in OBIS code list frame type. 19 (Hex) = 25 in (Dec) frame length means No. of byte next A0. From byte 3 to 27
3	4	03	destination address (server)		destination address (server) lower HDLC address 0x0011 // upper
4	5	21	source address (client) lower		21// source address (client) 0x01
5	6,7,8	FE0FD4	Voltage Register address		Check voltage Inst. value
7	9,10,11	E6E600	format identifier, group identifier, group length	LLC	LLC bytes, (E6) format identifier, (E6) group identifier where define in OBIS code list, Group length (00)

8	12,13	C001	GET.request.normal C0(Hex) = 192 (Dec) 01(Hex) =	From (12 to 16) Get request – get power voltage	The CHOICE for get-request-normal is [1], i.e. 0x01. Hence, Get-Request-Normal is encoded as C001. This is followed by the encoding of invoke-id-and priority etc.
					Get-Request ::= CHOICE{
					//get-request-normal [1] IMPLICIT Get-Request-Normal,

			1 (Dec)		//get-request-next [2] IMPLICIT Get-Request-Next, // get-request-with-list [3] IMPLICIT Get-Request-With-List}

9	14	C1	invoke-id and priority		Get-Request-Normal ::= SEQUENCE
					{
					// invoke-id-and-priority Invoke-Id-And-Priority,
					// cosem-attribute-descriptor Cosem-Attribute-Descriptor,
					// access-selection Selective-Access-Descriptor OPTIONAL
					}

10	15,16	0003	Register class_id=3, Total Positive Active Energy Register		From COSEM Identification System and Interface Classes, the Register of Active energy Profile generic = 3 (3) means : register, class_id: 3 NOTE: Identification code of the class range 0 to 65 535. The class_id of each object is retrieved together with the logical name by reading the object_list attribute of an “Association LN” / ”Association SN” object. class_id-s from 0 to 8191 are reserved to be specified by the DLMS UA. from 8 192 to 32 767 are reserved for manufacturer specific interface classes. from 32 768 to 65 535 are reserved for user group specific interface classes.
11	17,18,19,20,21,22	01 00 20 07 00 FF	logical name, OBIS code of the register voltage: 1.0.32.7.0.255		Logical name 6 digit each digit from 0 to 255.So (0100200700FF) = (01.00.20.07.00.ff) in hex = (1.0.32.7.0.255)in dec. the logical name is unique, not repeated.
12	23,24,25,26,27	02 00 85 83 7E			HDLC frame closing flag

Received frame : 7E A0 13 21 03 1E AF 49 E6 E7 00 C4 01 C1 00 12 5A F5 A6 3F 7E

No.	Byte No.	Byte content	Frame type		More details
1	1	7E	opening flag	From byte 1 to 8 called HDLC header	7E is constant flag has two cases, first when comes the first byte of frame called opening flag, second when comes end of frame called closing flag
2	2,3	A013	frame type and length		A0(Hex) = 160 in (Dec) where define in OBIS code list frame type. 13 (Hex) = 19 (Dec) frame length means No. of byte next A0. From byte 3 to 21
3	4	21	destination address (client) 0x01		21// destination address (client) 0x01
4	5	03	source address (server) lower		source address (server) lower HDLC address 0x0011 // upper HDLC address is the default (1)
5	6	1E	frame type 30		93// frame type SNRM (Set Normal Response Mode), 73// frame type UA (Unnumbered acknowledge), 10// frame type I frame.
6	7,8	AF49	Header check sequence		check sequence from byte 1-6
7	9,10,11	E6 E7 00	format identifier, group identifier, group length	LLC	LLC bytes, (E6) format identifier, (E7) group identifier where define in OBIS code list, Group length (00)
8	12,13	C401	GET.response.normal C4(Hex) = 196 (Dec)		Get-Response ::= CHOICE { //get-response-normal [1] IMPLICIT Get-Response-Normal, // get-response-with-datablock [2] -- IMPLICIT

			01(Hex) = 1 (Dec)		Get-Response-With-Datablock,
					//get-response-with-list [3] IMPLICIT Get-Response-With-List
					}

9	14	C1	invoke-id and priority		Get-Response-Normal ::= SEQUENCE
					{
					invoke-id-and-priority -- Invoke-Id-And-Priority,
					result -- Get-Data-Result
					}

10	15	00	Get-Data-Result choice data		Get-Data-Result choice data
11	16	12			octet string (12)
12	17,18	5A F5	Voltage Instantiation L1=232.85 V		results of class –id :3 attribute of register object to get voltage (5AF5)hex = (232.85) dec, there are value of voltage inst.
13	19,20	A6 3F	Frame check sequence		From 30 to 31 HDLC frame closing will byte 32 flag of closing
14	21	7E	HDLC frame closing flag		

Example (5): Read Register object\ L1 Current Inst. value

in this example will connect to the smart meter and Read object "Register \ L1 Current Inst. Value

sent frame : 7E A0 19 03 21 54 5F DE E6 E6 00 C0 01 C1 00 03 01 00 1F 07 00 FF 02 00 DC 79 7E

No.	Byte No.	Byte content	Frame type		More details
1	1	7E	opening flag	From byte 1 to 8 called HDLC header	7E is constant flag has two cases, first when comes the first byte of frame called opening flag, second when comes end of frame called closing flag
2	2,3	A019	frame type and length		A0(Hex) = 160 in (Dec) where define in OBIS code list frame type. 19 (Hex) = 25 in (Dec) frame length means No. of byte next A0. From byte 3 to 27
3	4	03	destination address (server)		destination address (server) lower HDLC address 0x0011 // upper
4	5	21	source address (client) lower		21// source address (client) 0x01
5	6,7,8	54 5F DE	Current Register address		Check Current Inst. value
7	9,10,11	E6E600	format identifier, group identifier, group length	LLC	LLC bytes, (E6) format identifier, (E6) group identifier where define in OBIS code list, Group length (00)
8	12,13	C001	GET.request. normal C0(Hex) = 192 (Dec) 01(Hex) = 1 (Dec)	From (12 to 16) Get request – get power voltage	The CHOICE for get-request-normal is [1], i.e. 0x01. Hence, Get-Request-Normal is encoded as C001. This is followed by the encoding of invoke-id-and priority etc. Get-Request ::= CHOICE{ //get-request-normal [1] IMPLICIT Get-Request-Normal, //get-request-next [2] IMPLICIT Get-Request-Next, // get-request-with-list [3] IMPLICIT Get-Request-With-List}

9	14	C1	invoke-id and priority		Get-Request-Normal ::= SEQUENCE
					{
					// invoke-id-and-priority Invoke-Id-And-Priority,
					// cosem-attribute-descriptor Cosem-Attribute-Descriptor,
					// access-selection Selective-Access-Descriptor OPTIONAL
					}

10	15,16	0003	Register class_id=3, Total Positive Active Energy Register		From COSEM Identification System and Interface Classes, the Register of Active energy Profile generic = 3 (3) means : register, class_id: 3 NOTE: Identification code of the class range 0 to 65 535. The class_id of each object is retrieved together with the logical name by reading the object_list attribute of an "Association LN" / "Association SN" object. class_id-s from 0 to 8191 are reserved to be specified by the DLMS UA. from 8 192 to 32 767 are reserved for manufacturer specific interface classes. from 32 768 to 65 535 are reserved for user group specific interface classes.
11	17,18, 19,20, 21,22	01 00 1F 07 00 FF	logical name, OBIS code of the register voltage: 1.0.31.7.0.255		Logical name 6 digit each digit from 0 to 255.So (01 00 1F 07 00 FF) = (01.00.1f.07.00.ff) in hex = (1.0.31.7.0.255)in dec. the logical name is unique, not repeated.
12	23,24, 25,26, 27	02 00 DC 79 7E			HDLC frame closing flag

Receive frame : 7E A0 13 21 03 1E AF 49 E6 E7 00 C4 01 C1 00 10 01 56 03 B1 7E

No.	Byte No.	Byte content	Frame type		More details
1	1	7E	opening flag	From byte 1 to 8 called HDLC header	7E is constant flag has two cases, first when comes the first byte of frame called opening flag, second when comes end of frame called closing flag
2	2,3	A013	frame type and length		A0(Hex) = 160 in (Dec) where define in OBIS code list frame type. 13 (Hex) = 19 in (Dec) frame length means No. of byte next A0. From byte 3 to 21
3	4	21	destination address (client)		destination address (client) lower HDLC address 0x01 // upper
4	5	03	source address (server) lower		21// source address (server) 0x0011
5	6,7,8	1E AF 49	Current Register address		Check Current Inst. value
7	9,10,11	E6E700	format identifier, group identifier, group length	LLC	LLC bytes, (E6) format identifier, (E7) group identifier where define in OBIS code list, Group length (00)

8	12,13	C4 01	GET.request .normal C4(Hex) = 196 (Dec) 01(Hex) = 1 (Dec)	From (12 to 16) Get request – get power voltage	The CHOICE for get-request-normal is [1], i.e. 0x01. Hence, Get-Request-Normal is encoded as C401. This is followed by the encoding of invoke-id-and priority etc.
					Get-response ::= CHOICE{
					//get-Response-normal [1] IMPLICIT Get-Response -Normal,
					//get- response -next [2] IMPLICIT Get-Response -Next,
					// get- Response -with-list [3] IMPLICIT Get-Response -With-List}

9	14	C1	invoke-id and priority		Get- Response -Normal ::= SEQUENCE {

					// invoke-id-and-priority Invoke-Id-And-Priority,
					// cosem-attribute-descriptor Cosem-Attribute-Descriptor,
					// access-selection Selective-Access-Descriptor OPTIONAL
					}

10	15,16	0010	Register class_id=16, Current.		From COSEM Identification System and Interface Classes, the Register of current Profile generic = 16 (12) means : register, class_id: 18 NOTE: Identification code of the class range 0 to 65 535. The class_id of each object is retrieved together with the logical name by reading the object_list attribute of an "Association LN" / "Association SN" object. class_id-s from 0 to 8191 are reserved to be specified by the DLMS UA. from 8 192 to 32 767 are reserved for manufacturer specific interface classes. from 32 768 to 65 535 are reserved for user group specific interface classes.
11	17,18	01 56	Active current = 0156 Hex = 324 Dec		results of class –id :16 attribute of register object to get voltage (0156)hex = (342) dec, there are active current 342 Watt.
12	19,20, 21	03 B1 7E			HDLC frame closing flag

5.3.4 System software screen:

5.3.5 Explanation of System software code on Appendix(A).

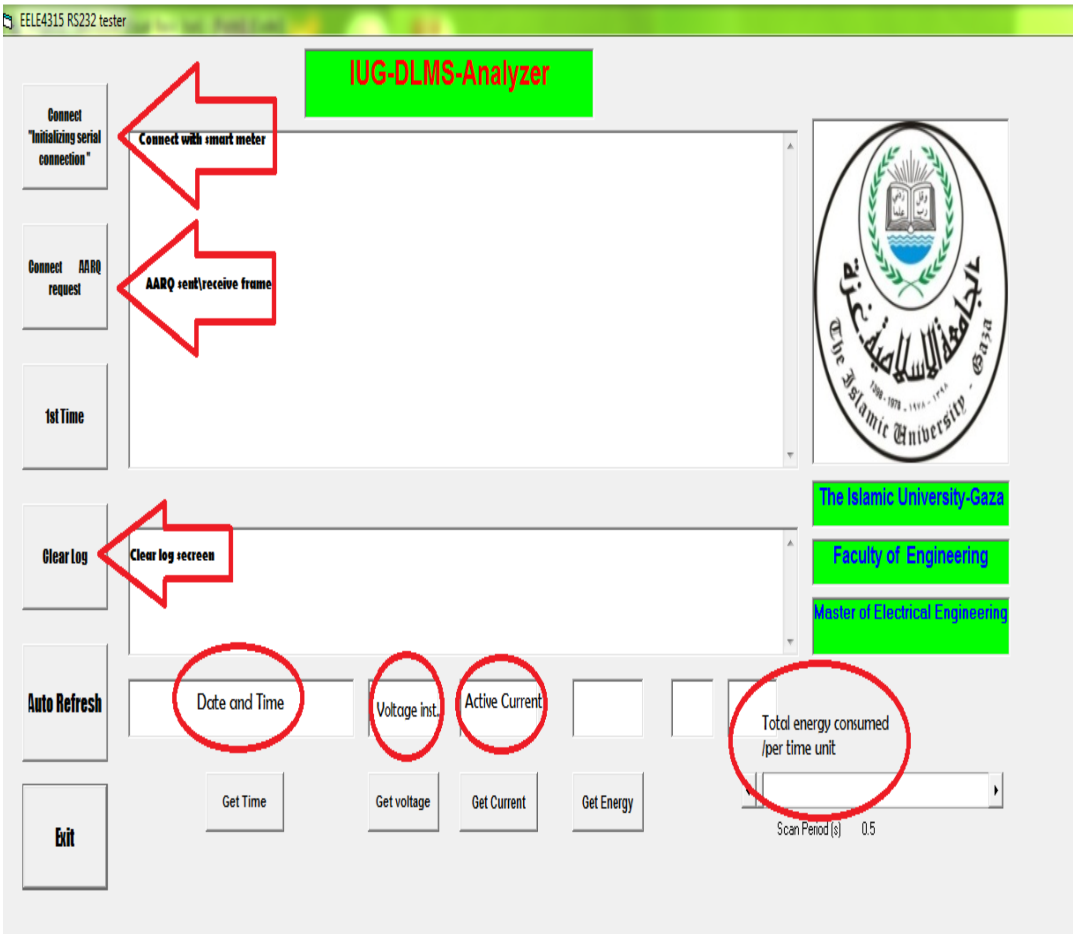


Figure (5. 15): IUG-DLMS-Analyzer

Chapter 6

Results and Conclusions

Chapter 6

Results and Conclusions

6.1 Results and Conclusions

The Electrical energy crises are getting worse every year in the Gaza Strip. Becoming scares and valuable resource, this energy has to be well monitored, utilized, and rationally consumed. It is believed that smart grid is the key solution to this goal. The system operator will be able to allocate this resource for end consumers depending on their rational behavior. Meanwhile, subscribers will be able to track their consumption record and work seriously to improve it hoping to have the service along the whole day. Most probably they will be motivated to upgrade their electrical equipment and lighting devices to more electrically efficient and reschedule some activities to be away from peak hours.

There are many approaches to build a smart grid. Basically, it consists of three components:

1) **Smart meters**
2) **A Communication network**
3) **A management software.**

It is intended in this work to study the Palestinian efforts done in this era and seek for a possible contribution. Two pilot projects in the Gaza Strip and one in the west bank are addressed. In Gaza, they utilized Iskra smart meters while Holley smart meters are utilized in the West Bank pilot project. Regarding the communication network, In Gaza Strip they utilized the RS485 bus to link smart meters within each residential building to a concentrator device which is connected to the backbone network through the GSM network. On the other hand, Power line communication modems are adopted to link smart meters to the concentrators which are also connected to the backbone network through the GSM network. For the management software, all these pilot projects are utilizing software packages which is not locally developed and most of our involved engineers lack the knowledge of smart meters' communication protocol implementation. We found that the pilot projects implemented in Palestine are adopting the DLMS/COSEM protocol which is a world-wide standard for automatic meter reading. Studying the protocol specification, we found it constructive to demonstrate how to communicate with these meters using a standard programming language. The implemented application successfully communicates with any DLMS-Compliant meter and retrieves the basic readings such as energy, current, and voltage along with the time stamp. Therefore, it is recommended to encourage developing software packages locally.

For the communication network we recommend using PLCC as it reduces monthly rent cost of the GSM carrier and enhances integration, security and independency.

6.2 Future work

Farther future work is needed to investigate the medium voltage power line modems. We plane to design a backbone network passed on that technology to support the future smart grid of the Gaza Strip.

We are recommended to:

- Continuing research on the project.
- Create an expert team from Gaza Strip, able to implement a huge project, and able to create a software system for managing electrical grids.
- Establishing a smart grid laboratory at the Islamic University - Gaza.
- Teaching students the courses related to building smart Grid.

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The Reference List

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Appendix

Appendix A: Information on Appendices

System software code Explanation

N0te: The code details can be obtained from the appendix

Define a general declaration

```
Dim D_(9) As Byte

Dim D0(17) As Byte

Dim D1(45) As Byte

Dim OutData(27) As Byte

Dim DH(15) As Byte

Dim D2(11) As Byte

Dim D3(11) As Byte

Dim D4(11) As Byte

Dim D5(11) As Byte

Dim buf(27) As Byte

Dim RecBuf As String

Dim Vbuf(3) As Byte

Dim VL As Long

Dim V As Single

Dim s As String

Dim m, Node As Byte

Dim x, OLD As String

Dim n As Integer
```

When clicking on command get current button, the following code has frame initial connection, running on smart meter by DLMS\COSEM   to make initial connection with meter device

```
Private Sub CmdInitConnect_Click()

    'Text1.Text = Text1.Text + vbCrLf + "<- 7E A0 0F 03 21 93 D7 E4 81 80 03 06 01
    80 6B 66 7E" + vbCrLf

    MSComm1.Output = D0

    End Sub

    Private Sub CmdAARQAARE_Click()
```

```
        'Text1.Text = Text1.Text + vbCrLf + " <- 7E A0 2B 03 21 10 FB AF E6 E6 00 60 1D A1 09 06 07 60 85 74 05 08 01 01 BE 10 04 0E 01 00 00 00 06 5F 1F 04 00 00 10 1C 01 90 B2 6D 7E" + vbCrLf

        MSComm1.Output = D1

    End Sub
```

When clicking on command CmdGetTime, the following code has frame time and date register, running on smart meter by DLMS\COSEM to make initial connection with meter device

```
    Private Sub CmdGetTime_Click()

        For m = 0 To 14

           OutData(m) = DH(m)

        Next m

        For m = 15 To 25

           OutData(m) = D2(m - 15)

        Next m

        OutData(26) = &H7E

        MSComm1.Output = OutData

        RecBuf = ""

    End Sub
```

When clicking on command CmdGetVolt, the following code has frame voltage register object (logical name 1.0.32.7.0.255), running on smart meter by DLMS\COSEM to get voltage value with meter device

```
    Private Sub CmdGetVolt_Click()

        For m = 0 To 14

           OutData(m) = DH(m)

        Next m

        For m = 15 To 25

           OutData(m) = D4(m - 15)

        Next m

        OutData(26) = &H7E

        MSComm1.Output = OutData

        RecBuf = ""

    End Sub
```

When clicking on command get current button, frame has the following code running on smart meter by DLMS\COSEM

```
Private Sub CmdGetCurrent_Click()
For m = 0 To 14
   OutData(m) = DH(m)
Next m
For m = 15 To 25
   OutData(m) = D3(m - 15)
Next m
OutData(26) = &H7E
MSComm1.Output = OutData
RecBuf = ""
End Sub
```

when software starting, the default setting form load as the initial setting of comm.Port, arrays value, Initializing the serial connection must be as in the following code

```
Private Sub Form_Load()
    MSComm1.CommPort = 3
    MSComm1.Settings = "9600,n,8,1"
    MSComm1.RThreshold = 1
    MSComm1.PortOpen = True
    OLD = 0
    n = 0
    '7E A0 07 03 21 93 0F 01 7E
    D_(0) = &H7E
    D_(1) = &HA0
    D_(2) = &H7
    D_(3) = &H3
    D_(4) = &H21
    D_(5) = &H93
    D_(6) = &HF
    D_(7) = &H1
    D_(8) = &H7E
'Initializing serial connection
'Send SNRM request
```

'7E A0 0F 03 21 93 D7 E4 81 80 03 06 01 80 6B 66 7E

D0(0) = &H7E

D0(1) = &HA0

D0(2) = &HF

D0(3) = &H3

D0(4) = &H21

D0(5) = &H93

D0(6) = &HD7

D0(7) = &HE4

D0(8) = &H81

D0(9) = &H80

D0(10) = &H3

D0(11) = &H6

D0(12) = &H1

D0(13) = &H80

D0(14) = &H6B

D0(15) = &H66

D0(16) = &H7E

'Send AARQ request

'7E A0 2B 03 21 10 FB AF E6 E6 00 60 1D A1 09 06 07 60 85 74 05 08 01 01 BE 10 04 0E 01 00 00 00 06 5F 1F 04 00 00 10 1C 01 90 B2 6D 7E

D1(0) = &H7E

D1(1) = &HA0

D1(2) = &H2B

D1(3) = &H3

D1(4) = &H21

D1(5) = &H10

D1(6) = &HFB

D1(7) = &HAF

D1(8) = &HE6

D1(9) = &HE6

D1(10) = &H0

```
D1(11) = &H60
D1(12) = &H1D
D1(13) = &HA1
D1(14) = &H9
D1(15) = &H6
D1(16) = &H7
D1(17) = &H60
D1(18) = &H85
D1(19) = &H74
D1(20) = &H5
D1(21) = &H8
D1(22) = &H1
D1(23) = &H1
D1(24) = &HBE
D1(25) = &H10
D1(26) = &H4
D1(27) = &HE
D1(28) = &H1
D1(29) = &H0
D1(30) = &H0
D1(31) = &H0
D1(32) = &H6
D1(33) = &H5F
D1(34) = &H1F
D1(35) = &H4
D1(36) = &H0
D1(37) = &H0
D1(38) = &H10
D1(39) = &H1C
D1(40) = &HFF '&H1
D1(41) = &HFF '&H90
```

```
D1(42) = &H5B '&HB2
D1(43) = &H10 '&H6D
D1(44) = &H7E

DH(0) = &H7E
DH(1) = &HA0
DH(2) = &H19
DH(3) = &H3
DH(4) = &H21
DH(5) = &H32
DH(6) = &H6F
DH(7) = &HD8
DH(8) = &HE6
DH(9) = &HE6
DH(10) = &H0
DH(11) = &HC0
DH(12) = &H1
DH(13) = &HC1
DH(14) = &H0
' get time
'7E A0 19 03 21 32 6F D8 E6 E6 00 C0 01 C1 00 08 00 00 01 00 00 FF 02 00 60 1A 7E
'7E A0 19 03 21 32 6F D8 E6 E6 00 C0 01 C1 00 03 01 00 1F 07 00 FF 02 00 DC 79 7E
D2(0) = &H8
D2(1) = &H0
D2(2) = &H0
D2(3) = &H1
D2(4) = &H0
D2(5) = &H0
D2(6) = &HFF
D2(7) = &H2
D2(8) = &H0
```

```
D2(9) = &H60
D2(10) = &H1A
'get Current
'03 01 00 1F 07 00 FF 02 00 DC 79
D3(0) = &H3
D3(1) = &H1
D3(2) = &H0
D3(3) = &H1F
D3(4) = &H7
D3(5) = &H0
D3(6) = &HFF
D3(7) = &H2
D3(8) = &H0
D3(9) = &HDC
D3(10) = &H79
'get voltage
'7E A0 19 03 21 FE 0F D4 E6 E6 00 C0 01 C1 00 03 01 00 20 07 00 FF 02 00 85 83 7E
'7E A0 19 03 21 10 7F DA E6 E6 00 C0 01 C1 00 03 01 00 20 07 00 FF 02 00 85 83 7E
D4(0) = &H3
D4(1) = &H1
D4(2) = &H0
D4(3) = &H20
D4(4) = &H7
D4(5) = &H0
D4(6) = &HFF
D4(7) = &H2
D4(8) = &H0
D4(9) = &H85
D4(10) = &H83
'Power L1  03 01 00 15 07 00 FF 02 00 D2 50
D5(0) = &H3
```

```
        D5(1) = &H1
        D5(2) = &H0
        D5(3) = &H15
        D5(4) = &H7
        D5(5) = &H0
        D5(6) = &HFF
        D5(7) = &H2
        D5(8) = &H0
        D5(9) = &HD2
        D5(10) = &H50
    End Sub
```

Disconnect with Comm.Port

```
    Private Sub Form_Unload(Cancel As Integer)
        MSComm1.PortOpen = False
    End Sub
```

Function to convert from Hexadecimal to Decimal

```
    Function Hex2Dec(HexStr As String) As Byte
    On Error Resume Next
    Hex2Dec = CByte("&H" & HexStr)
    End Function
    Private Sub MSComm1_OnComm()
    x = MSComm1.Input
    If (x <> "") Then y = Asc(x) Else y = &H24
    M1 = Int(y / 16)
    If M1 < 10 Then M1 = M1 + &H30 Else M1 = M1 + &H37
    M2 = y And 15
    If M2 < 10 Then M2 = M2 + &H30 Else M2 = M2 + &H37
    If (x <> "") Then
    If Asc(x) = &H7E And Asc(OLD) = &H7E Then
      Text1.Text = Text1.Text + vbCrLf & Chr$(M1) + Chr$(M2) + " "
    Else
```

```
   Text1.Text = Text1.Text + Chr$(M1) + Chr$(M2) + " "
End If
RecBuf = RecBuf & x
End If

Dim i, i2 As Integer
Dim z1, z2, year1, year2, year3, MINUTS, SEC As String

z1 = Chr(&H7E) & Chr(&HA0) & Chr(&H1E) & Chr(&H21) & Chr(&H3) & Chr(&H52) &
Chr(&H48) & Chr(&H4A) & Chr(&HE6)
z2 = Chr(&H7E) & Chr(&HA0) & Chr(&H1E) & Chr(&H21) & Chr(&H3) & Chr(&H54) &
Chr(&H7E) & Chr(&H2F) & Chr(&HE6)

If (x <> "") Then OLD = x Else OLD = 0

i = InStr(RecBuf, z1)
If i = 0 Then i = InStr(RecBuf, z2)
If i <> 0 And Len(RecBuf) >= i + 31 Then
   year1 = Asc(Mid$(RecBuf, i + 17, 1))
   year2 = Asc(Mid$(RecBuf, i + 18, 1))
   'year3 = Hex(year1) & Hex(year2)

   Hrs = Asc(Mid$(RecBuf, i + 22, 1))
   MINUTS = Asc(Mid$(RecBuf, i + 23, 1))
   SEC = Asc(Mid$(RecBuf, i + 24, 1))

  year3 = 256 * year1 + year2

   year3 = Str(year3) & "  Time is       " & Str(Hrs) & ":" & Str(MINUTS) & ":" & Str(SEC)
   Text3.Text = year3
   RecBuf = Mid$(RecBuf, i + 32)
End If
```

```
Dim VL1h, VL1l, VL1 As Single
'7E A0 13 21 03 1E AF 49 E6 E7 00 C4 01 C1 00 12 5A F5 A6 3F 7E        V
'7E A0 13 21 03 54 F1 A4 E6 E7 00 C4 01 C1 00 12 00 00 03 B1 7E        I
'7E A0 15 21 03 54 6B EF E6 E7 00 C4 01 C1 00 17 00 00 00 00 79 A7 7E   E
z1 = Chr(&H7E) & Chr(&HA0) & Chr(&H13) & Chr(&H21) & Chr(&H3)
i = InStr(RecBuf, z1)
If i <> 0 And Len(RecBuf) >= i + 20 Then
   VL1h = Asc(Mid$(RecBuf, i + 16, 1))
   VL1l = Asc(Mid$(RecBuf, i + 17, 1))
   VL1 = (256 * VL1h + VL1l) / 100
   If OutData(18) = &H1F Then Text7.Text = VL1
   If OutData(18) = &H20 Then Text6.Text = VL1
   If OutData(18) = &H15 Then TxtEnergy.Text = VL1 * 100

   RecBuf = Mid$(RecBuf, i + 20)
End If

Text2.Text = RecBuf
Text4.Text = Len(RecBuf)
End Sub
```

Function to scheduled castes in timer modulus when click auto refresh command to result in automatically every second

```
Private Sub Timer1_Timer()
        n = (n + 1) Mod 6
        Select Case n
                        Case 0:
                           MSComm1.Output = D0
                        Case 1:
                           MSComm1.Output = D1
                        Case 2:
                           DH(5) = &H32
                           DH(6) = &H6F
```

```
DH(7) = &HD8
CmdGetTime_Click
Case 3:
DH(5) = &H54
DH(6) = &H5F
DH(7) = &HDE
CmdGetVolt_Click
Case 4:
DH(5) = &H76
DH(6) = &H4F
DH(7) = &HDC
CmdGetCurrent_Click
Case 5:
DH(5) = &H98
DH(6) = &H3F
DH(7) = &HD2
CmdEnergy_Click
End Selec
Text5.Text = n
End Sub
```

The following code makes Auto read Current, voltage and time every 1 second by change setting of timer option and set result in the text boxes.

```
Private Sub CmdAutoRefresh_Click()
If Timer1.Enabled = True Then
Timer1.Enabled = False
Else
Timer1.Enabled = True
End If
RecBuf = ""
Text1.Text = ""
End Sub
```

This Code makes Clean the information text boxes.

```
Private Sub CmdClearLog_Click()
    RecBuf = ""
    Text1.Text = ""
    Text2.Text = ""
    'MSComm1.Output = D_
End Sub
```

This Code Close the system project.

```
Private Sub CmdEXIT_Click()
    End
End Sub
```

Appendix B: Information on Smart meters specification

1. *Features of Smart meters ISKRA ME372*

Item	**Parameters**
Accuracy(kWh)	Class 0.5S (IEC62053-21)
Measuring current(A)	1(6)A, 5(6)A
Minimum current	0.05lb
Starting current	0.001lb
Rated voltage (Un)	3x58/100~69/120V 3x110/190~133/230V 3x220/380~240/415V 3x58/100~240/415V extended operating voltage range:
Operating voltage range	0.8Un~1.15Un
Operating frequency	50Hz/60Hz
Communication interface	1 circuit optical interface 1 circuit RS485 or GPRS
Communication Protocol	Local: IEC62056-21 Remote: DLMS HDLC
Optical interface	IEC standards
TOU (Optional)	Tariff control available, up to 4 tariffs
Load Profile (Optional)	Minutes/Hourly/Daily/Monthly Load Profile
RTS	≤0.5s/day (Normal Temperature)
RTS Support	10 years battery operation life Operating for at least 2 years in case of any power failure
Backup battery	Battery can be replaced
Pulse constant	1000~10000 imp/kWh
Power consumption	Current circuit power consumption ≤2.2VA Voltage circuit power consumption ≤1.8W/10VA
Compression strength	4kV, 50Hz, 1 minute
Anti-surge Voltage Current	 6kV, 1.2/50µs 5kA, 8/20µs
Immunity to short-circuit current	30 Imax
Anti-magnetic	Anti-strong magnetic, magnetic detection and display
Protection	IP54
Operating temperature range	-25°c~+70°c
Storage temperature	-40°c~+85°c
Anti-tamper	open meter cover, open terminal cover, current reverse
Dimension(L*W*H)	298.7mm*170mm*78.8mm
Weight	Approx. 1.2kg

2. *Features of Smart meters ISKRA382*

- Remote connection/disconnection
- Multi-Energy management (gas, water, heat)
- Extensive anti-tampering features
- Customer port for in-house display (RJ11)
- Secure communication with encryption and authentication

- Photovoltaic friendly design
- Integrated demand/response functions
- DLMS protocol for easy integration
- Import/export energy measurement
- The Iskra ME382 meter is approved according to IEC 62052-11, IEC 62053-21, IS0 9001, EN 50470-1, EN 50470-3.
- Incorporates a fully integrated GSM/GPRS modem that can be exchanged with integrated RS485 communications interface for block installations.
- 100A Direct Connected
- Single Phase Network
- OFGEM Approved
- Import/Export Energy
- Tariff control input
- Small size modern design
- Accuracy class: 2 or 1
- Voltage range: 1.15 Un
- Max. current: 85A or 100A
- Reference voltage: 230V
- Reference frequency: 50/60Hz
- Operating temp. range: -25 to+60° C
- Extended temp. range:-40 to +70° C
- Storage temperature: -40 to+85° C
- Self-consumption current 0.5VA
- Self-consumption Voltage 2W / 10VA
- Short-circuit current: 30 Imax
- Time-of-use measurement of active energy and maximum demand (in up to 8 tariffs)
- Load-profile registration
- Digital Display in compliance with VDEW specification, with two modes of data display
- Internal real-time clock
- Two keys: Reset and Scroll key
- Optical port (IEC 62056-21 standard) for local meter programming and data downloading
- Built-in interface (IR) and GSM/GPRS modem for a remote two-way communication, meter programming and data downloading
- Wired M-Bus

- Alarm input
- Non-potential key input
- Opto-MOS: switching functionality (for low current loads), metropulse functionality (configurable energy pulses)
- Bi-stabile relay: switching external loads up to 6A, external disconnector functionality
- Integrated disconnector with 1-phase meters
- Detectors of the meter and the terminal block covers opening.
- Disconnector for remote disconnection / reconnection of the customer premises.
- M-Bus for reading other meters (heat, gas, water)
- Remote display ON/OFF configuration
- Two different console type (reduced and normal)

Functionality

Measurement features

- Two way ("energy") measurements
- Active energy & power, 4Q Reactive energy
- & power, Apparent energy & power, Instantaneous value of voltage, Current, Power factor, Frequency and Power
- Absolute measurement of active energy & power

Tariff functions

- Time-of-use (TOU) measurement of active energy and maximum demand (up to 8 tariffs, 12 seasons, 12 weekly programs, 16 masks, 16 switches)

Load profiles

- Two Load profiles with different daily and hourly registration periods with up to 32 objects
- Four separate profiles for sub-metering (M-bus)
- Seven separate Event logs for different objects

Communication

1. Full DLMS-COSEM and IEC 1107 compliance Four independent communication interfaces:
   – Optical port
   – RJ11 (for in-house display)
   – M-bus (wired)
   – GSM/GPRS/UMTS Power quality
2. Voltage sag, swell and cut, Daily peak and minimum, Voltage and current asymmetry, Power failure

Unit Specifics

- Backlit LCD display
- Detection of opening main and terminal cover External magnetic field detector
- Detection of meter wiring
- Prepayment
- In-house display support
- Power quality supervision
- Photovoltaic ready
- Secured communication channels
- Switching device up to 3x100A (UC3)
- Remote FW upgrade
- RTC (Super-Cap)

3. PRIME FCC PLCModule Specification

Item	Sub-item	Parameter
Basic	Standard reference voltage Un	3x230 V
	Extended operating voltage range	0.5Un~1.3Un
	Operating frequency	50Hz(±5%)
	Limit operating temperature range	-45℃ ~ +75℃
	Limit temperature range for storage and transport	-45℃ ~ +85℃
Parameters	Type of modulation	OFDM
	Communication phase of PLC	Three phase

Item	Sub-item	Parameter
	PLC frequencies（kHz）:	
	f0	260.742
	f1	261.230
	f2	261.718
	f3	262.207
	f4	262.695
	f5	263.183
	f6	263.671
	f7	264.160
	F96	307.617
	PLC output level (dBμV)	120
	PLC coverage distances(m):	Average: 1000m Maximal: 3000m
	Data Security	128-bit end-to-end encryption for PLC communication
	Network establishment structure	Tree network topology
	Applicable standards	IEC 61334-5-4 IEC 61334-4-32 IEC 62056 IEC 61000 PRIME specification revision v1.3 PRIME specification revision v1.4
	Data transmission rates	Up to 128kbps
Mechanical Characteristics	Dimensions(LxWxH)	100mmx75mmx35mm
	Weight	0.1kg

1- Built-in RISECOMM PLC MODEM Specification

Item	Sub-item	Parameter
Parameters	Type of modulation	BPSK
	Communication phase of PLC	Three phase
	PLC frequencies（kHz）:	132
	PLC output level (dBμV)	120
	PLC coverage distances(m):	Average: 1000m Maximal: 3000m
	Network establishment structure	Tree network topology
	Applicable standards	EN50065-1 EIA-709.2
	Data transmission rates	Up to 5400bps