An-Najah National University.

Faculty Of Engineering and Information Technology.

Electrical Engineering Department.

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Senior project II

Smart Energy Metering and Control System.

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Dedication:

For Our Palestine …

For Our University …

For Our Teachers …

For Our Family …

We Present This Research …

Acknowledgement:

This thesis acknowledgement is a tribute to all the people who made our academic journey worthwhile, I would like to thank my supervisor Dr. Haneen Al-Ott, whose unwavering support has been instrumental in the completion of this project.

Our project would not have been possible without the endless help and support from my colleagues.

Special thanks also go to my family, whose constant encouragement fueled my perseverance during the completion of this dissertation.

Disclaimer:

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List of abbreviations

CT: Current Transformer

PT: Potential transformer

TOU: Time of use

AMI: Advanced metering infrastructure

CIU: Customer interface unit

MDMS: Meter data management system

RTC: Real time clock

DCU: Data concentrator unit

GSM: Global system for mobile communication

GPRS: General packet radio service

PLC: Power line carrier

LoRa: Long range communication

RF: Radio frequency

Abstract

In this Project, our aim is to present an efficient module derived from the system outlined in senior project I. Our objective is to tangibly illustrate the interplay among different system elements and their integration with the software. We seek to emphasize and delve into the communicative dimension, particularly focusing on PLC communication. Moreover, we intend to integrate a smart meter into the exhibition, providing a comprehensive insight into its internal workings.

Chapter one: Summary of senior project I and introduction to senior project II

1.1 Summary of senior project I

In the previous senior project, we discussed the smart meter's internal components, and the function of each component.

We also highlighted the numerous functions of the smart electricity meter, and the advantages it has over traditional electricity meters.

Moreover, the communication aspect was briefly discussed.

1.2 Introduction to senior project II

In this project, we will introduce the software responsible for management, control, and remote reading and writing of smart electricity meters.

We will also discuss in detail, the method of PLC communication, in addition to, international and local standards/configurations of smart electricity meters, and display a live mini module consisting of a single-phase smart meter, a data concentrator unit, and a load.

The mini module that we will show, has been set up for a month prior to the discussion of this report, in order for us to collect useful data.

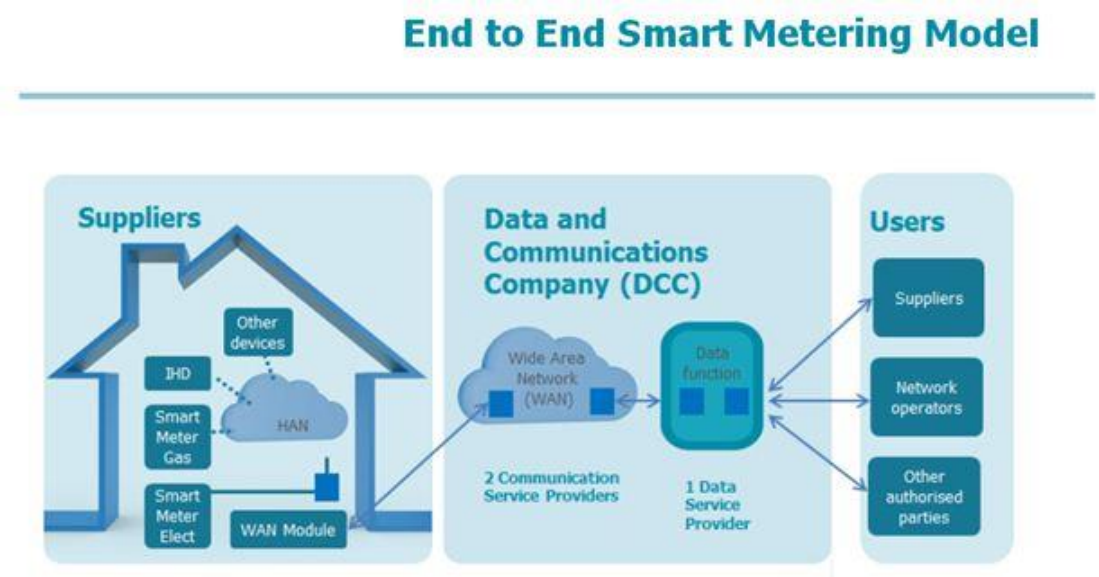

FIGURE 1: a picture of the mini module.

Chapter Two: Features, advantages, international and local standards

2.1 Protections

- Voltage Fluctuation Protection: this is one of the most important features of smart meters, having an internal relay, this type of protection triggers the meter's internal relay (to trip), if the source voltage is out of the previously set range, this protects the meter itself, and also customer's appliances, this protection can be broken down as follows:

- Over-voltage Protection: according to Fury Trade, a company specialized in this field, and with sales of over 70,000 smart meters locally, most customers ask for the overvoltage threshold to be set to 260 Volts, meaning that if the supply voltage, exceeds 260 volts, the meter relay will automatically trip.

Internationally, this threshold is mostly set to 110% of Un.

- Under-voltage Protection: similar to overvoltage protection, the smart meter also provides the protection from low voltage (which usually causes shorter lifespan of electrical appliances), Fury Trade has informed us that most of their customers set this threshold to 180 volts.

Internationally, this threshold is mostly set to 85% Un.

- Over - load protection: similar to the voltage fluctuation protection, smart meters provide protection from high loads, a load threshold is previously set by the utility, once the customer exceeds this limit, the smart meter internal relay will automatically trip.

Locally, this is usually set to 32 amperes, while international standards vary, where single phase meters' threshold is set to 80 amperes, and three phase meters' threshold is set to 100 amperes.

2.2 Tampering detection

Smart meters provide a variety of features to detect tampering including:

- Open cover detection: When someone opens the end terminal cover or meter cover during the use of the meter, the meter will store and record the open cover event with time, and an alarm will be issued at the same time (such as the alarm light on the meter; the one with remote communication will send an alarm to the system platform in real

time); the smart meter with load control can disconnect the relay to stop the power supply.

- Magnetic field detection: Magnetic field detection means that when the magnet is close to the energy meter, the meter will store and record the magnetic field event time, and an alarm will be issued at the same time (such as the alarm indicator on the panel;

Those with remote communication will send alarms to the system platform in real time); Smart meters with load control can disconnect the relay to stop the power supply.

2.3 Bidirectional measurement

Unlike traditional electricity meters, which only measure the electricity consumed from the grid, bidirectional meters can accurately measure both consumption and generation, typically associated with renewable energy sources like solar panels or wind turbines.

2.4 Emergency credit

Smart meters allow customers to make use of emergency credit features in the following manners:

- A predefined amount of credit that can be activated once the main credit reaches 0 Kwh, by pressing a certain button on CIU.
- An automatic activation of emergency credit during certain periods (holidays, weekends, and late-night hours) when vending stations are not working.

2.5 Accurate bills

Estimated bills will be a thing of the past, as smart meters regularly send your energy usage to your utility for billing.

2.6 control of your home energy use

Your installer will teach you how to read a smart meter - it's easy, and allows you keep track of your usage in real time if you use a smart display.

You will be able to easily identify how you are using energy and if any of this is unnecessary.

By changing your behavior in response to the readings on the smart display, it is possible to make savings on your electricity bills,

The display shows:

- energy used in the last hour, week and month
- level of current electricity use is high, medium or low
- real time updates for electricity and half hourly updates for gas

2.7 No more meter readings

You won't have anyone coming round asking to read your meter, as the information is sent to the utility digitally.

Benefits for prepayment customers

2.8 See your credit

Prepay householders can see how much credit they have left using the in-home display, as well emergency credit balance, debt balance and alerts if credit is low.

2.9 The easiest way to top up

You can top up however suits you, by phone, online or at your local shop.

2.10 Accessing your meter is no longer a chore

There is no longer a need to access the meter to input a top up card or key as this can be done remotely.

2.11 Switch between prepay and credit

Customers may be able to switch between prepay and credit without needing an installer to visit the home.

2.12 Fuel economy

Smart meters allow suppliers to better predict demand, helping to shape energy infrastructure to become more reliable and efficient.

Chapter Three: PLC communication.

Power Line Carrier (PLC) communication is a method that uses electrical power lines for data transmission. This technology leverages existing power infrastructure, making it a cost-effective and versatile solution for a variety of applications. Here's a detailed overview:

3.1 Basic Principles:

1. **Carrier Signal Injection**

   Data is modulated onto a carrier signal and injected into the power lines. This carrier signal travels along the power lines, enabling communication between devices connected to the same electrical network.

2. **Frequency Bands**

   PLC systems typically operate in specific frequency bands to avoid interference with the primary purpose of power lines, which is to transmit electricity. Frequencies can range from low (kilohertz) to high (megahertz) depending on the application.

3.2 Types of PLC:

1. **Narrowband PLC**

- Operates in the lower frequency range (3-500 kHz).
- Suitable for applications like smart metering, grid monitoring, and low-speed data transmission.
- Has a longer range but lower data rates.

2. **Broadband PLC**

- Operates in the higher frequency range (1.8-250 MHz).
- Used for high-speed internet access, multimedia distribution, and home networking.
- Offers higher data rates but has a shorter range.

3.3 Applications

1. **Smart Grid**

- Enables real-time monitoring and control of the electrical grid.
- Facilitates demand response, energy management, and outage detection.

2. **Home Automation**

- Connects home appliances and systems for centralized control and monitoring.
- Supports Internet of Things (IoT) applications within homes.

3. **Internet Access**

- Provides broadband internet access using the existing electrical infrastructure.
- Useful in areas where traditional broadband installations are challenging.

4. **Industrial Automation**

- Connects sensors, actuators, and control systems in industrial environments.
- Facilitates remote monitoring and control of industrial processes.

3.4 Advantages

1. Utilizes Existing Infrastructure

- Reduces the need for new cabling and infrastructure investment.
- Easy to implement in buildings and areas with extensive power line networks.

2. Cost-Effective

- Leverages the existing power line infrastructure, minimizing additional costs.
- Simplifies network deployment and maintenance.

3. Wide Coverage

- Power lines reach almost every location where electricity is available.
- Suitable for both urban and rural areas.

3.5 Challenges

1. Noise and Interference

- Power lines are noisy environments, and interference can affect communication reliability.
- Mitigation techniques such as error correction and advanced modulation schemes are used.

2. Signal Attenuation

- High-frequency signals attenuate more rapidly over long distances.
- Repeaters and amplifiers may be needed to extend the range.

3. Regulatory Issues

- Different countries have specific regulations and frequency bands for PLC.
- Compliance with local regulations is essential.

3.6 Technologies and Standards

1. **G.hn**

- A unified standard for home networking over power lines, coaxial cables, and phone lines.
- Supports high data rates and robust performance.

2. **HomePlug**

- A family of standards for high-speed power line communication.
- Widely used for home networking and smart grid applications.

3. **IEEE 1901**

- A standard for broadband over power lines, providing guidelines for high-speed data transmission.

4. **PRIME (Powerline Intelligent Metering Evolution)**

- A standard focused on narrowband PLC for smart grid applications.
- Optimized for energy metering and utility management.

3.7 How PLC communication applies in our project

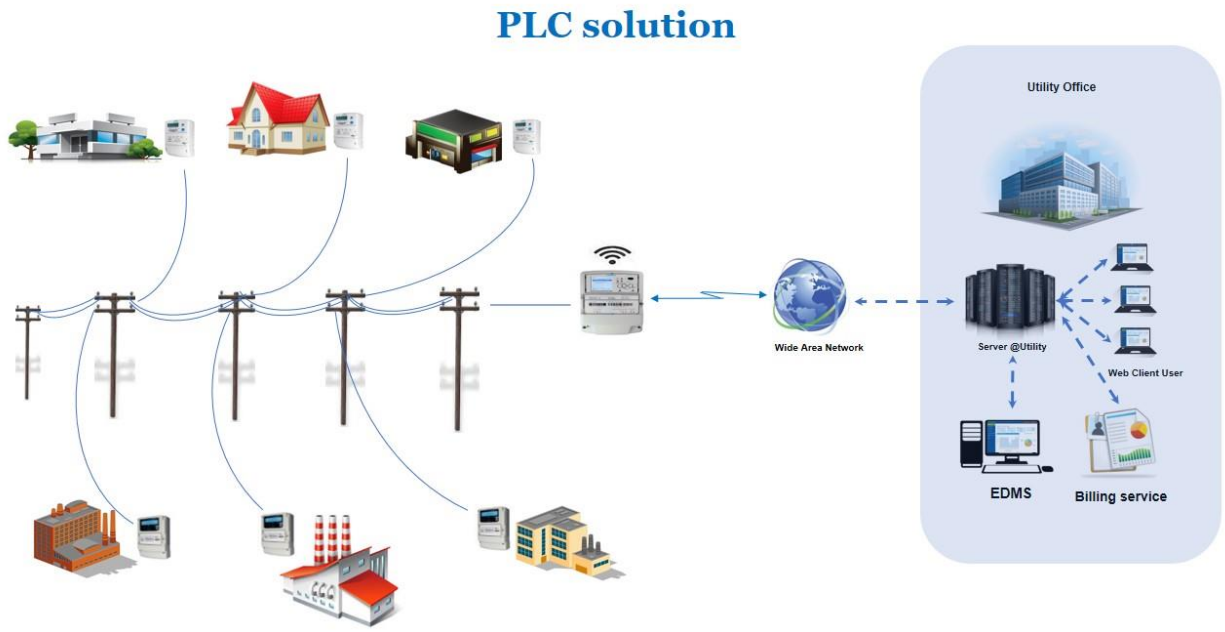

Figure 2: PLC communication overview.

3.8 Conclusion

Power Line Carrier communication is a versatile and efficient technology that leverages existing power infrastructure for data transmission. Its applications range from smart grids and home automation to broadband internet access and industrial automation. While it offers numerous advantages, such as cost-effectiveness and wide coverage, it also faces challenges like noise, interference, and signal attenuation. Advanced technologies and standards continue to evolve, enhancing the performance and reliability of PLC systems.

Chapter Four: Meter Data Management System (MDMS)

4.1 Introduction

The software is a crucial part of the smart metering system, it allows utilities to vend, manage, remotely read, and remotely control, smart electricity meters. It provides alerts whenever unusual activities like tampering are detected by the smart electricity meter.

The software also serves as a billing platform, where utilities can send their customers with postpaid meters, periodic electricity bills.

In this chapter, we will discuss, in depth, various functions the software provides.

4.2 Vending and Management

- Management : MDMS allows utilities to manage user accounts, tariffs, location, operation mode, and various useful information.

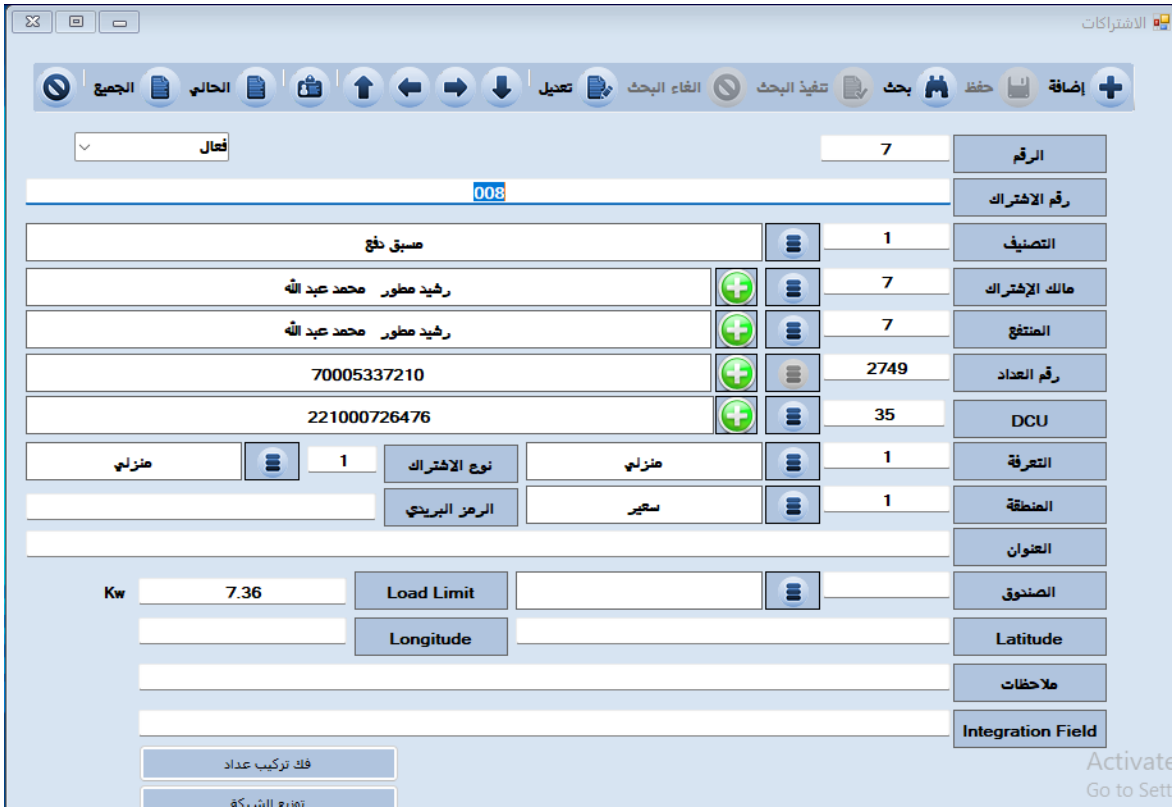

Figure 3: customer information.

- Vending:

  The Vending process consists of 3 main steps:

  1. Identifying customer
  2. Vending
  3. Acquiring token and sending it remotely to meter

Figure 4: vending screen.

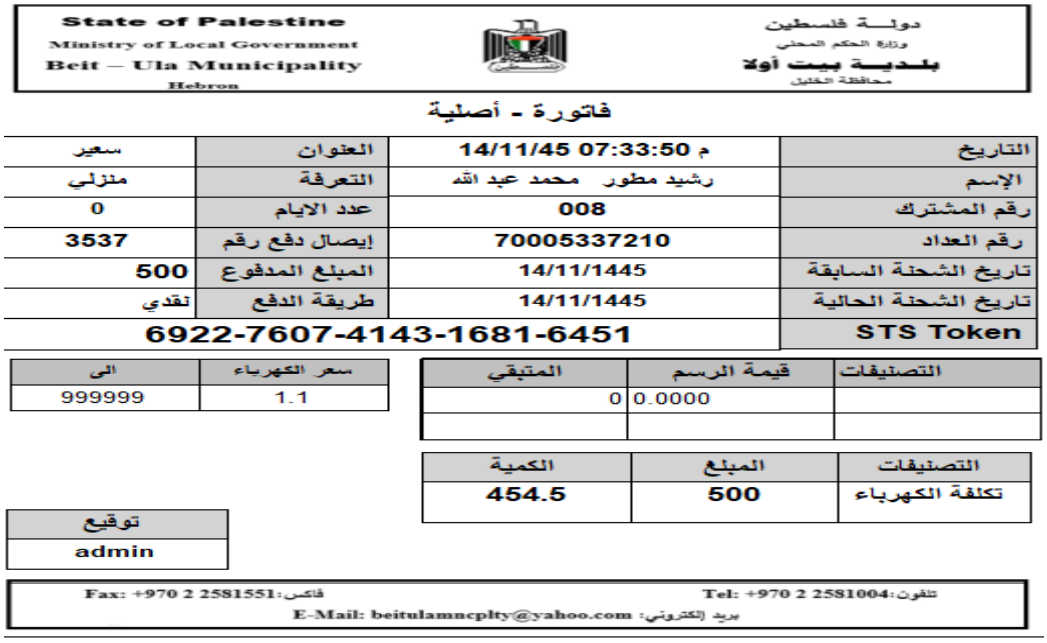

Figure 5: invoice with 20 digit token.

Token	Value	إعادة الإرسال	تحديث	الرد من العداد	وقت الرد من العداد	وقت المعالجة	رقم العداد
1975-3790-3428-6866-0731	Kwh 453.6	إعادة الإرسال	تحديث	Passed	7:53 2024-05-05 PM	7:53 2024-05-05 PM	70005337210
6941-6746-8754-8126-7620	Kwh 67.3	إعادة الإرسال	تحديث	Passed	9:29 2024-04-24 AM	9:28 2024-04-24 AM	70005337210
6553-5680-8147-1433-8599	Kwh 40.9	إعادة الإرسال	تحديث	Passed	5:49 2024-04-21 PM	5:48 2024-04-21 PM	70007126223
6756-2816-4414-6746-5133	Kwh 40.9	إعادة الإرسال	تحديث	Passed	5:48 2024-04-21 PM	5:47 2024-04-21 PM	70007126223
5289-3872-8183-1468-1133	Kwh 40.9	إعادة الإرسال	تحديث	Passed	5:18 2024-04-21 PM	5:17 2024-04-21 PM	70007126223
1535-5666-8118-2072-7652	Kwh 40.9	إعادة الإرسال	تحديث	Passed	4:52 2024-04-21 PM	4:52 2024-04-21 PM	70007126223
6786-7081-9277-1003-2901	Kwh 40.9	إعادة الإرسال	تحديث	Passed	4:46 2024-04-21 PM	4:46 2024-04-21 PM	70007126223
5539-5799-7656-3562-2373	Kwh 40.9	إعادة الإرسال	تحديث	Passed	4:11 2024-04-21 PM	4:11 2024-04-21 PM	70007126223
1548-0451-0601-7588-7496	Kwh 40.9	إعادة الإرسال	تحديث	Passed	4:10 2024-04-21 PM	4:10 2024-04-21 PM	70007126223
4504-7066-2749-6789-3433	Kwh 156.4	إعادة الإرسال	تحديث	Passed	4:09 2024-04-21 PM	4:08 2024-04-21 PM	70007126223

Figure 6: send token screen.

4.3 Other important features

As previously mentioned, the MDMS provides numerous features that can be useful to both, the utility, and customers

4.3.1 Remote connect/disconnect

Utilities are able to remotely connect and disconnect consumer supply

TokenType	Value	إعادة الإرسال	تحديث	الرد من العداد	وقت الرد من العداد	وقت المعالجة	رقم العداد
Relay Connect	0	إعادة الإرسال	تحديث	Passed	8:17 2024-05-22 PM	8:17 2024-05-22 PM	70005337210
Relay Connect	0	إعادة الإرسال	تحديث	Passed	8:34 2024-05-04 PM	8:34 2024-05-04 PM	70005337210
Relay Disconnect	0	إعادة الإرسال	تحديث	Passed	8:33 2024-05-04 PM	8:33 2024-05-04 PM	70005337210
Relay Disconnect	0	إعادة الإرسال	تحديث	Off line	8:33 2024-05-04 PM	8:33 2024-05-04 PM	70005337210
Relay Connect	0	إعادة الإرسال	تحديث	Passed	8:31 2024-05-04 PM	8:31 2024-05-04 PM	70005337210
Relay Connect	0	إعادة الإرسال	تحديث	Off line	8:30 2024-05-04 PM	8:30 2024-05-04 PM	70005337210
Relay Connect	0	إعادة الإرسال	تحديث	Off line	8:20 2024-05-04 PM	8:20 2024-05-04 PM	70005337210
Relay Connect	0	إعادة الإرسال	تحديث	Passed	9:36 2024-04-24 AM	9:36 2024-04-24 AM	70005337210
Relay Disconnect	0	إعادة الإرسال	تحديث	Passed	9:36 2024-04-24 AM	9:36 2024-04-24 AM	70005337210
Relay Connect	0	إعادة الإرسال	تحديث	Passed	9:26 2024-04-24 AM	9:26 2024-04-24 AM	70005337210

Figure 7: relay connect screen.

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4.3.2 Map

When defining the customer account, the X and Y coordinates are added to the customer profile, which are then displayed on an actual map. This helps service provider to locate the meter for any future maintenance.

Figure 8: map showing meter location.

4.3.3 Meter reading:

As previously mentioned, smart systems allow utilities to remotely read data from meters, this data includes, but not limited to the following:

- Instantaneous supply voltage
- Instantaneous load
- Power factor
- Relay status
- Current credit
- Total import active energy
- Total export active energy

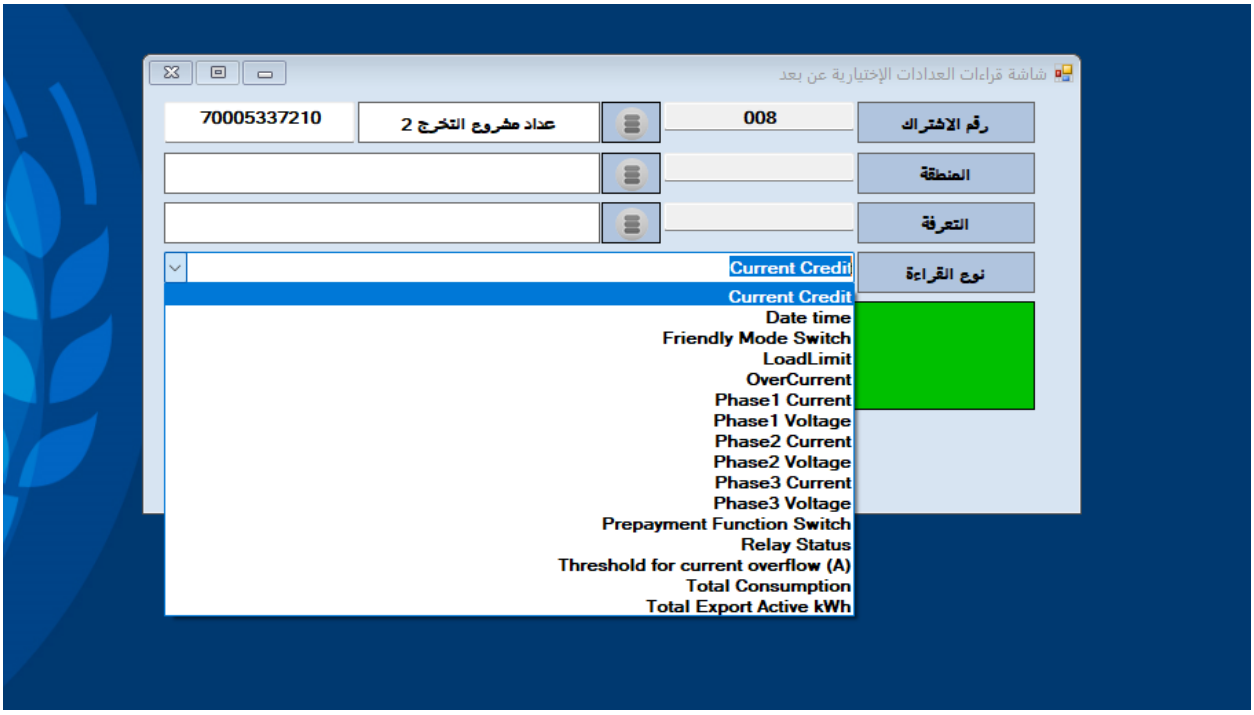

Figure 9: instantaneous reading screen.

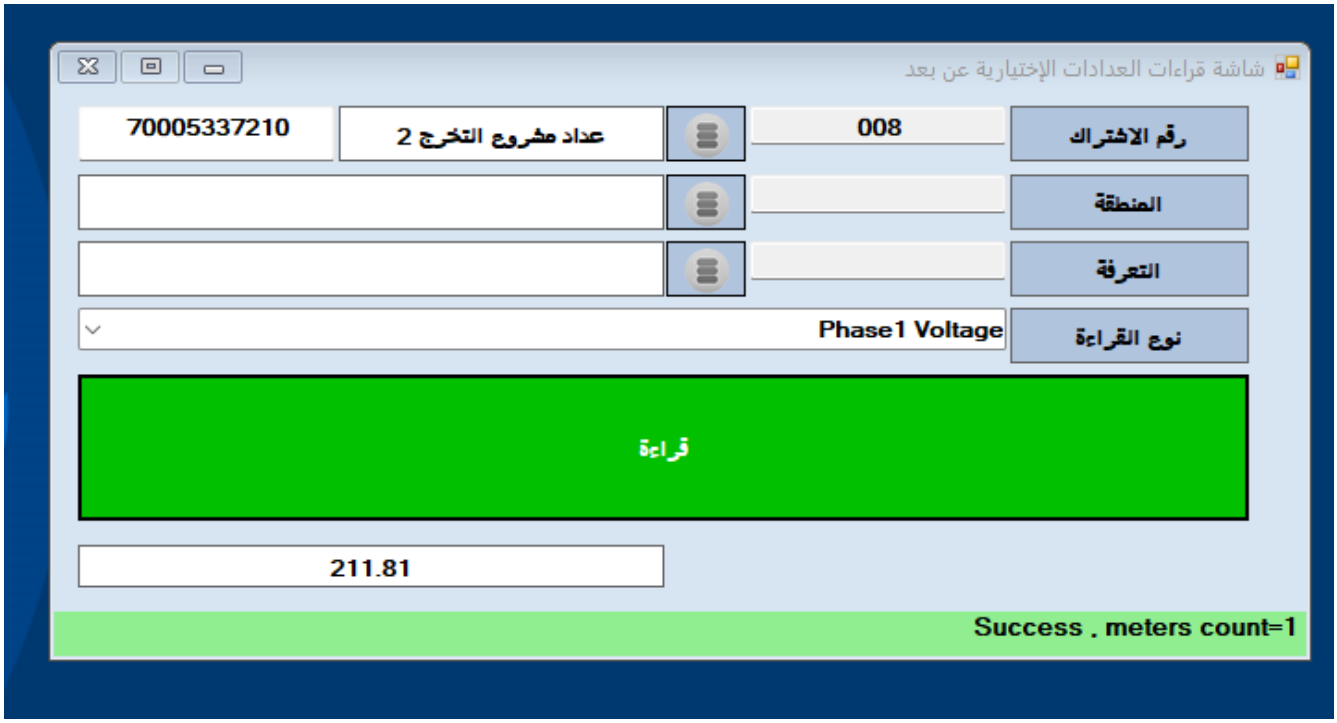

Figure 10: instantaneous one phase voltage.

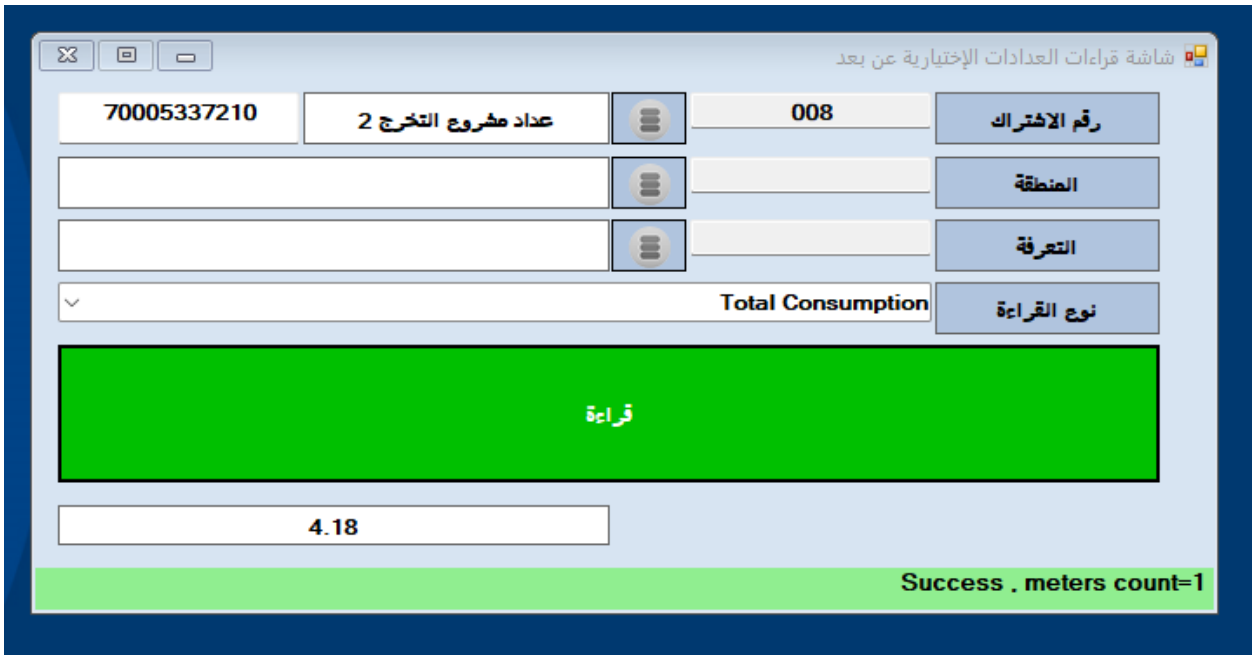

Figure 11: instantaneous total consumption.

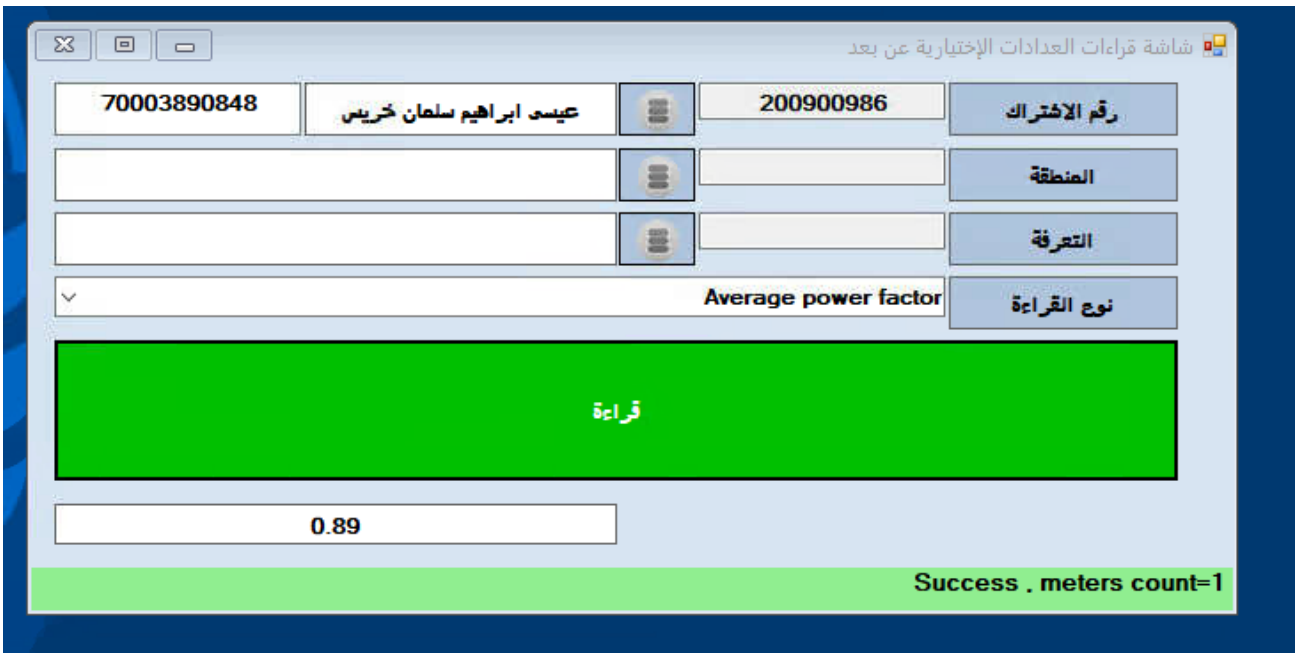

Figure 12: instantaneous average power factor.

4.3.4 Alerts

the MDMS contains a notification center to display all alerts and events that occur on the smart meter, examples of the alerts that the MDMS displays are:

- Terminal cover removed
- Strong DC field detected
- Replaced battery
- Invalid clock
- Reverse current
- Over Power
- Overvoltage
- undervoltage

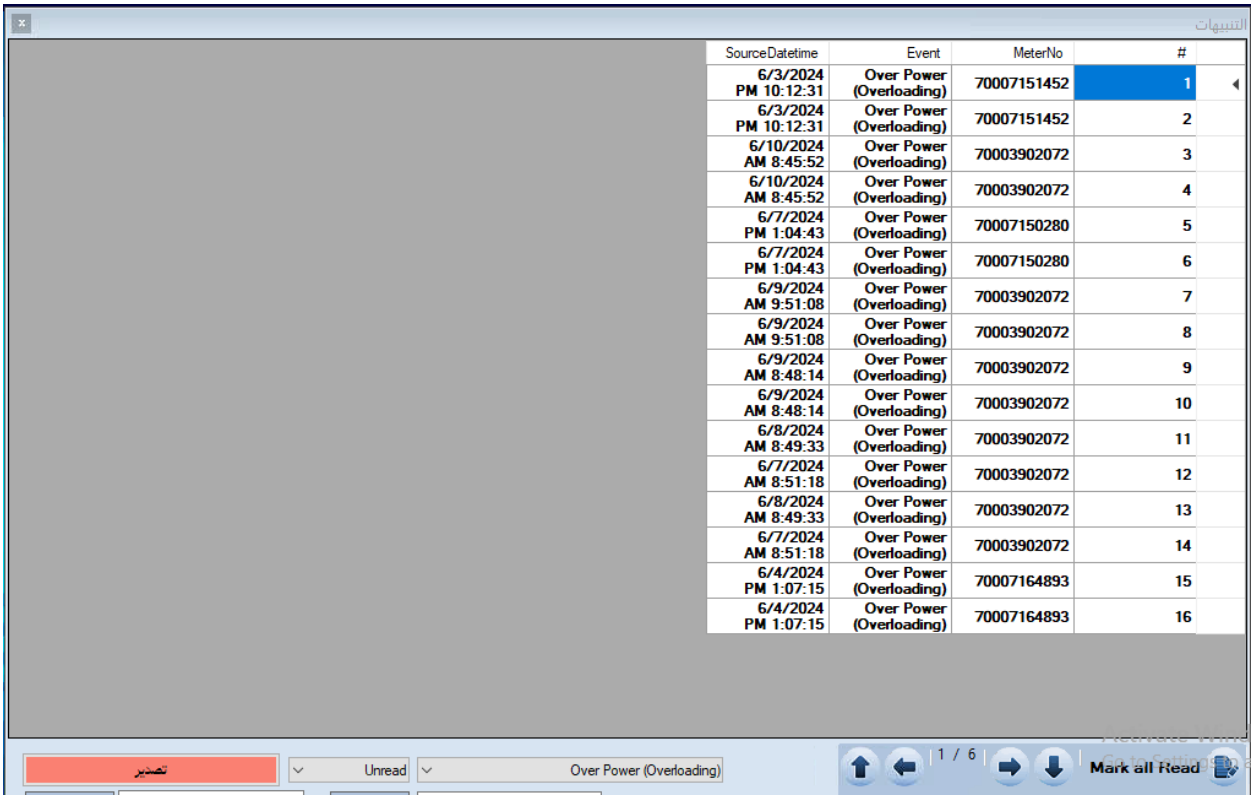

Figure 13: alert screen.

4.3.5 Load profile

In addition to instantaneous readings, MDMs enables utilities to automatically retrieve meter readings from customer meters, this feature is referred to as load profile; where the users choose a set of readings they wish to receive automatically at preset intervals.

تقرير قراءات العدادات الإختيارية عن بعد-جميع القراءات

admin

2024-06-10 8:38:26PM

نوع القراءة : Current Credit, Date time, Friendly Mode Switch, LoadLimit, OverCurrent, Phase1 Current, Phase1 Voltage
من تاريخ : 2024/06/01
الى تاريخ : 2024/06/10
تصنيف القراءة : ReadProfile

#	رقم الإشتراك	اسم المشترك	العداد	نوع القراءة	قيمة القراءة	المنطقة	التعرفة	تاريخ القراءة
1	008	عداد مشروع التخرج 2	70005337210	Phase1 Voltage	214.39	سحر	منزلي	2024-06-06 11:30:00AM
2	008	عداد مشروع التخرج 2	70005337210	Phase1 Current	0.00	سحر	منزلي	2024-06-06 11:30:00AM
3	008	عداد مشروع التخرج 2	70005337210	Phase1 Voltage	211.84	سحر	منزلي	2024-06-06 12:00:00PM
4	008	عداد مشروع التخرج 2	70005337210	Phase1 Current	0.00	سحر	منزلي	2024-06-06 12:00:00PM
5	008	عداد مشروع التخرج 2	70005337210	Phase1 Voltage	209.67	سحر	منزلي	2024-06-06 12:30:00PM
6	008	عداد مشروع التخرج 2	70005337210	Phase1 Current	0.00	سحر	منزلي	2024-06-06 12:30:00PM
7	008	عداد مشروع التخرج 2	70005337210	Phase1 Voltage	211.31	سحر	منزلي	2024-06-06 1:00:00PM
8	008	عداد مشروع التخرج 2	70005337210	Phase1 Current	0.00	سحر	منزلي	2024-06-06 1:00:00PM
9	008	عداد مشروع التخرج 2	70005337210	Phase1 Voltage	210.17	سحر	منزلي	2024-06-06 1:30:00PM
10	008	عداد مشروع التخرج 2	70005337210	Phase1 Current	0.00	سحر	منزلي	2024-06-06 1:30:00PM

Figure 14: load profile report.

4.4 Recommendations:

It is important to mention that our team (Izz, Enad, Ameer) provided several recommendations to the software provider, some were implemented, others are under process. Examples of features the were recommended and implemented are:

- Map
- Counter of power failures
- Numerator of CT ratio
- Denominator of CT ratio

Chapter Five: Hardware components

In this chapter, we will discuss the hardware components used in the project, the importance, and the role every component plays in the system:

5.1 Meter

as previously mentioned, smart systems deal with several types of meters including single phase meters, direct three phase meters, and indirect three phase meters. Meters are the backbone of this system and are installed for customers for accurate readings.

smart meters provide a variety of useful functionalities for both customers and service providers, like:

- Events: meter records events like clock malfunction, low battery, meter malfunction, and high temperature.
- Alarms: Alarms with LCD, LED, and Buzzer
- Anti tampering: meter contains up to 7 sealing positions, terminal cover, module cover, and meter cover sealing.
- Billing record: the meter can store, in its memory, up to 13 months of billing data, and calculate net monthly consumption of energy (difference between import and export).
- Firmware upgrade: meter firmware can be upgraded remotely, for any changes or additions on the meter functionality
- CIU: the availability of CIU makes it easy for customers to fill up credit, view consumption record, and other important readings, without having to reach the meter directly.

Figure 15:single phase smart meter.

5.2 Data concentrator unit (DCU)

Data concentrator unit also play an important role in smart metering systems, they are responsible for data collection from smart meters (by means of PLC communication, or RF communication). If the DCU is installed on a transformer, and uses PLC communication to communicate with meters, it will be able to pick up (read and control) all meters that are part of this given transformer. Once the readings are collected by the DCU, they are then compared with the reading of the indirect three phase (CT) meter installed on the same transformer, which will then allow us to calculate line loss for the transformer.

Figure 16: DCU.

5.3 Contactor

A contactor is a switch operated by electricity, used to turn an electrical circuit on or off. It includes a coil and a set of contacts that open and close to manage the flow of electricity to a load. Contactors are frequently utilized in industrial and commercial settings to control large motors, lighting systems, heating elements, and other high-power electrical equipment. They are built to safely and efficiently handle high currents and voltages, making them crucial components in electrical control systems.

5.4 customer interface unit (CIU)

A Customer Interface Unit (CIU) of a smart meter is a device that delivers real-time energy consumption information to the user. It generally shows data like current usage, historical consumption trends, and cost details, allowing consumers to effectively monitor and manage their energy use. The CIU interacts with the smart meter, aiding users in making informed decisions to enhance energy efficiency and lower costs.

5.5 Load

During this project, a light load was used to monitor the consumption throughout the testing phase of the project, it was also used to test functionalities like remote connect and disconnect of meter relay.

5.6 Cables

2.5mm cables were used to connections throughout the project.

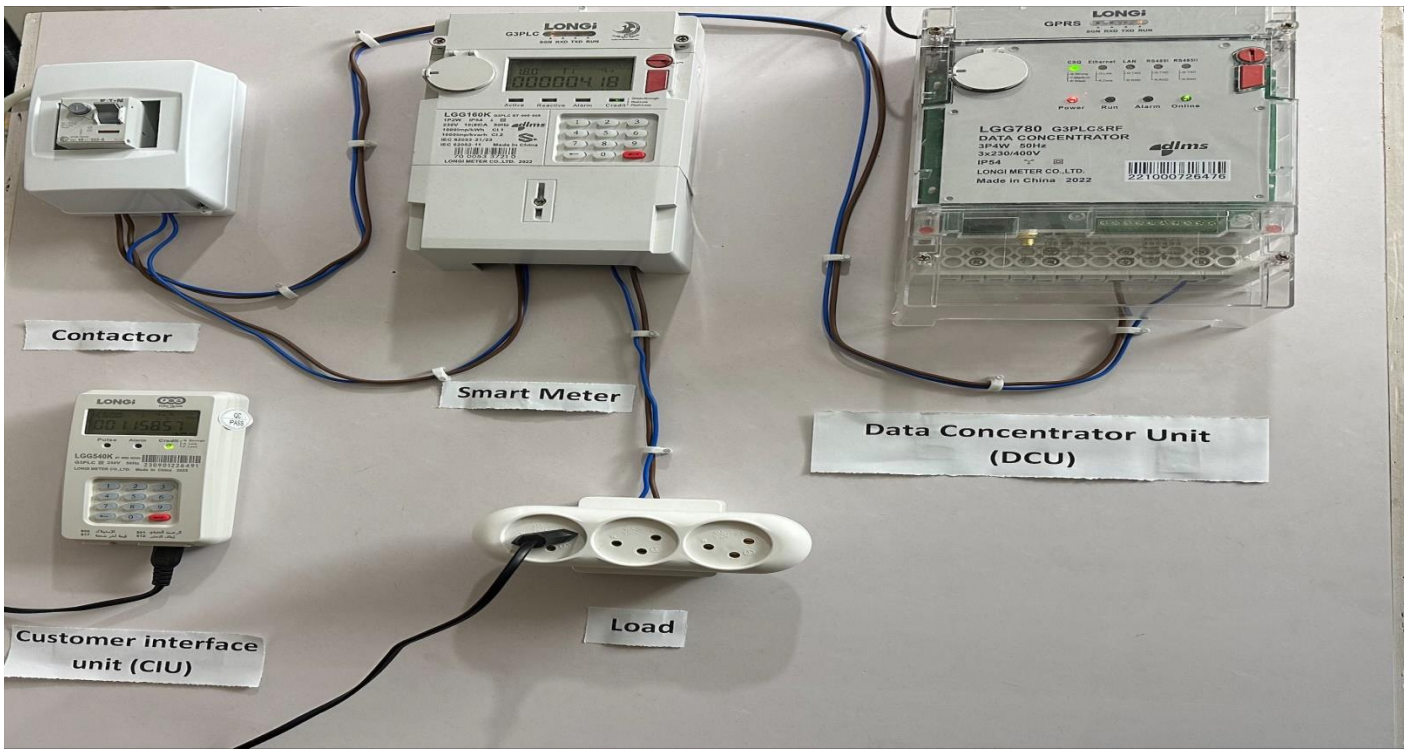

Figure 17: live image of the smart meter module.

Chapter Six: Smart meter international standards

Throughout the project, we used smart meters of the brand Longi, a recognized manufacturer based in China, this company manufactures its meters according to the following international standards:

6.1 Meter

Description	Value
Rated voltage	230V
Operating voltage range	70%Un~120%Un
Rated Current and Starting Current	5(80)A and 0.4%Ib
Rated frequency	50Hz
Pulse Constant	1000imp/kWh 1000imp/kvarh
Accuracy Class	Cl.1 for Active Cl.2 for Reactive
Power Consumption	Voltage circuit < 1W or 5VA, Current circuit < 0.2VA
Battery and Life	Replaceable Lithium battery, life more than 15 years
Tropical working temperature	-40℃ to +70℃, Humidity is up to 95%
EMC Performance	Impulse voltage > 8KV, AC voltage > 4KV, Short circuit current > 3KA, Electrostatic Discharge > 8KV&15KV etc.
Protection class	IP54 comply with IEC60529 Insulation grade II
Housing material	Polycarbonate with non-conductive, high impact, smooth finish, durable, non-flammable, UV stabilized, UV resistant and high resistance to weathering
Dimension	220mmX130mmX72mm

in addition to the following communication protocols:

- International open protocol
- IEC62056-21 E mode DLMS
- HDLC DLMS and TCPIP DLMS

6.2 DCU

Data concentrator units are manufactured according to the following international standards:

Description	Value
Rated voltage	230V
Operating voltage range	70%Un~120%Un
Rated Current and Starting Current	5(80)A and 0.4%Ib
Rated frequency	50Hz
Pulse Constant	1000imp/kWh 1000imp/kvarh
Accuracy Class	Cl.1 for Active Cl.2 for Reactive
Power Consumption	Voltage circuit < 1W or 5VA, Current circuit < 0.2VA
Battery and Life	Replaceable Lithium battery, life more than 15 years
Tropical working temperature	-40℃ to +70℃, Humidity is up to 95%
EMC Performance	Impulse voltage > 8KV, AC voltage > 4KV, Short circuit current > 3KA, Electrostatic Discharge > 8KV&15KV etc.
Protection class	IP54 comply with IEC60529 Insulation grade II
Housing material	Polycarbonate with non-conductive, high impact, smooth finish, durable, non-flammable, UV stabilized, UV resistant and high resistance to weathering
Dimension	220mmX130mmX72mm

Chapter Seven: Comparison between smart meters and traditional meters

Understanding Smart Meters and Traditional Meters

Smart and traditional meters differ in their method of monitoring electricity usage. At the forefront of energy metering evolution, smart meters offer unparalleled interactivity and data provision, outperforming traditional meters.

Recognizable by their digital displays and absence of a regular meter reader, smart meters continuously record and communicate your energy consumption directly to your energy supplier, ensuring that your bills are based on actual usage rather than estimates.

Traditional meters, usually analog, hark back to an earlier era, necessitating a meter reader's physical visit and manual reading submissions to bypass the complications of estimated billing.

Smart Meter

A smart meter is an advanced digital device that records the consumption of electric energy, gas, or water and communicates that information to the utility provider for monitoring and billing purposes.

Smart meters present a significant advancement, equipping homeowners with an array of sophisticated features that reshape our perception of electricity meters.

For instance, installing a smart meter reader over an electricity meter will provide you with accurate real-time data on electricity supply along with tracking down electricity consumption

smart meter offers you:

1. Monitor your energy consumption in real-time, receiving insights that can guide you to make smarter energy choices.
2. Eliminate the need for a meter reader, as automatic readings are sent to your energy provider—no more estimated bills or manual meter readings.
3. Detect issues and facilitate speedy resolutions that minimize inconveniences.
4. The ease of automated readings from smart meters

5. Enhanced precision in measuring energy use and promoting energy efficiency
6. Instantaneous feedback on energy consumption patterns
7. Differential pricing structures that encourage using power during non-busy times, which may result in reduced expenses for energy.

Moreover, these generation smart meters are not only savvy in tracking usage but also in detecting issues, facilitating speedy resolutions that minimize inconveniences.

Traditional Meters: Analog Technology and Manual Readings

Relying on manual meter readings to measure electric energy usage, traditional meters are characterized by their analog dials and uncomplicated design.

The energy meter only tells a part of your energy story, with the full narrative often lost between infrequent readings and the risk of human error.

When a meter reading is not submitted, energy suppliers are forced to estimate your usage, which can lead to discrepancies in your bill—sometimes in the supplier's favor, other times in yours.

With the advent of energy meters, this issue can be significantly reduced, providing a clearer picture of how much energy is being consumed.

The absence of real-time monitoring capabilities is a significant handicap, leaving you without the insights needed to manage your energy consumption effectively.

Comparing the Advantages and Disadvantages

In evaluating the advantages and disadvantages of smart meters against traditional meters, the consideration must extend beyond the convenience of automatic readings and the familiarity of traditional methods.

Smart meters often come with a higher initial installation cost, but many energy providers are now offering free installation to offset this expense.

This makes the transition to smart metering a more attractive proposition for those looking to gain more control over energy, and its data, and surely minimize water utility risks, save money, and remain sustainable in the long run.

Benefits of Smart Meter

The benefits of a smart meter are manifold. They include:

- Accurate billing, free from the risks and uncertainties of estimated bills
- Real-time monitoring of energy usage, displayable
- Immediate feedback through real-time data on energy consumption, enabling you to make prompt adjustments that can lead to significant savings.

- Supplying vital data during peak times and emergencies, which expedites issue identification and efficient power restoration
- Tracking energy usage in detail, allowing you to shift consumption to off-peak times and take advantage of lower rates
- Contributing to more efficient energy management

Cons of Traditional Meters

The drawbacks of traditional meters are notable. Manual readings can lead to less accurate energy usage data, as they lack the currency and precision of smart meter automatic readings.

Smart meters in rare hot conditions, around 1,600 out of 2 million meters were discovered to exhibit accelerated internal clock rates. This equates to a meter failure rate of 0.08%, or less than one-tenth of a percent. In contrast, reports show that analog meters have a failure rate typically around 3%, indicating they fail at rates approximately 40 times higher than those observed in the case of defective smart meters.

Inconsistency in submitting manual readings can result in financial problems for energy users, and present high risks in terms of data and energy-level conservation for energy utilities.

Given what has been mentioned throughout this chapter, it is highly recommended, for customers to immediately switch from traditional meters to smart meters, to make use of the many features that smart meters provide.

Smart meter	Traditional meter
offer advanced features, provide real-time data on energy usage.	often analog or electromechanical meters, measure electricity consumption but do not provide any real-time information or advanced functionalities.
automated data collection process, sending usage information remotely to utility companies.	Data from traditional meters is typically collected manually by utility worker.
use various communication technologies (such as cellular networks or dedicated communication networks) to transmit data in real-time. This enables utilities to have a more up-to-date understanding of energy consumption patterns.	Traditional meters do not have communication capabilities. The data is collected during periodic readings, and there is no real-time communication with utility providers.
can be remotely managed and updated, allowing for tasks such as firmware updates, meter reprogramming, or disconnection/reconnection	Changes or updates to traditional meters often require a physical visit by utility personnel.
awareness can lead to more informed decisions about energy usage	Consumers typically have limited visibility into their energy usage until they receive a bill.
more accurate and timely data for billing, reducing the likelihood of billing discrepancies.	Billing with traditional meters relies on manual readings, which can sometimes lead to errors or delays.

Chapter eight: Cost

A part of this project and the previous one, a rough estimate of the cost of the smart metering system, for a utility with 500 customers, and it was found to be as per the table below:

Item	Rough unit cost (USD)	Quantity	Rough total cost (USD)
Single phase smart electricity meter	100	400	40000
three phase smart electricity meter	250	100	25000
Meter cabinet	25	500	12500
Current transformer meter	400	5	2000
Data concentrator unit	1000	5	5000
Server hardware	1500	1	1500
Server software	10000	1	10000
Database manager	800/per month	1	800
Installation	30	500	15000
		Total	111800

Chapter nine: Conclusion

Smart electricity meters offer significant advantages over traditional meters, improving the experience for both consumers and utility providers. They provide accurate billing through real-time data, eliminating the need for estimates and reducing billing disputes. Consumers benefit from enhanced control over their energy usage, with the ability to monitor consumption in real-time and utilize cost-saving opportunities like time-of-use billing.

For utility providers, smart meters enhance operational efficiency by enabling remote readings and better grid management, allowing for quicker detection and resolution of issues. Environmentally, smart meters promote energy efficiency and support renewable energy integration, helping to reduce carbon footprints.

In conclusion, smart electricity meters represent a major advancement in energy management, delivering accuracy, convenience, cost savings, and sustainability. They are an essential upgrade for modernizing electricity consumption and billing processes.

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