A

DISSERTATION REPORT

ON

THREE PHASE SMART METER

IS SUBMITTED AS A PARTIAL FULFILLMENT OF THE

MASTER OF TECHNOLOGY

IN

EMBEDDED SYSTEMS

BY

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(2015PEB5341)

UNDER THE GUIDANCE OF

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MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

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JAIPUR RAJASTHAN 302017

CERTIFICATE

This is to certify that the M. Tech. thesis report entitled "**THREE PHASE SMART METER"** has been successfully completed and presented by **ANIRUDDH NAGAR (2015PEB5341)** in partial fulfilment of the degree of **Master of Technology** in **EMBEDDED SYSTEMS** in the Department of Electronics and Communication Engineering during the academic year **2015-2017**. To the best of my knowledge and belief that this work has not been submitted elsewhere for the award of any other degree.

The work has been found satisfactorily carried out by him during his internship at GRAMPOWER INDIA Inc. under my supervision and is approved for submission.

Date : 10-July-2017

Place : MNIT, Jaipur

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DECLARATION

I **ANIRUDDH NAGAR** hereby declare that the dissertation entitled "**THREE PHASE SMART METER"** being submitted by me in partial fulfillment of the degree of **Master of Technology** in **EMBEDDED SYSTEMS** in the Department of Electronics and Communication Engineering during the academic year **2015-2017** in an Internship Project carried out by me at the organization GRAMPOWER INDIA Inc., and the contents of this dissertation work in full or in parts have not been submitted to any other Institute or University for the award of any degree or diploma. I also certify that no part of this dissertation work has been copied or borrowed from anywhere else. In case any type of plagiarism is found, I will be solely and completely responsible for it.

Date : 10-July-2017

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Date : 10-July-2017 **ANIRUDDH NAGAR**

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ABSTRACT

A Three Phase Smart Meter is based on microcontrollers and IC's. The Firmware for microcontroller has been written in C-language. This digital meter does not have any mechanical rotating parts. The total Energy consumed is calculated by using the output pulses of the IC and the microcontroller internal counter value. If power cut occurs and the supply is restored, smart meter starts it reading from the stored values. A Three Phase Smart Meter prototype has been implemented to measure a load current up to 60A and line to neutral voltage up to 240V.

The measured energy data is important for the study of maximum energy demand, especially for domestic sector. Meters in market nowadays are found to be expensive. It is because their operation requires the use of expensive hardware. This Three Phase Smart Meter is robust, informative enough and is capable of detecting variety of tampers. It is very useful for the purpose of simple data gathering.

In olden days, the accurate measure of power supply and subsequent billing for domestic properties has been achieved by electromechanical meters. Although this meters were widely used, It has several disadvantages including short term accuracy, cost of calibration and limited communication. These limitations can be overcome by using Three Phase Smart meters with which it is possible to gain long term accuracy by removing analogue components which are prone to drift over temperature and time. The aim of this project is to build an electronic smart meter which can calculate instantaneous power for all power factor values and can give pulse output even at low frequency. This pulse output is further used by microcontroller to calculate energy in terms of KWh and display it on LCD. The microcontroller also calculates the maximum demand, detects various tampers such as magnetic tamper, neutral missing and cover open. It serves as interface between RTC, EEPROM and the LCD display.

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THREE PHASE

SMART METER

Thesis

by Anirudh Nagar

Chapter 1

THREE PHASE
SMART METER
ARCHITECTURE

1.1 Introduction

Energy Meter is a device used to measure electrical energy consumed by electrical devices. It helps the utility to account for the amount of energy used by its consumer.

In old days, Standard mechanical meters were used to measure electricity, but these meters had some drawback. These meters were unable to detect Electrical-Energy theft. It was not possible to limit energy usage through them, leading to a very uneven and less efficient energy distribution and consumption. These meters did not have any provision for recording energy consumption data. Also, the meters were unable to record any misdoings with itself by the consumers.

All these drawbacks are now overcome with the Digital Smart Meters. They have an LCD to display various parameters related to energy. They have provision to record last 6 months data. They can detect a variety of events and tampers. They can communicate to the servers and thus supports energy metering data analytics. They supports variable pricing for different slabs.

They have provision to transmit the energy consumption data to the utility in a fixed interval of time. This time is configurable. It can be minutes, hours, days or weeks. This feature helps the utility to analyse the energy consumption graph for various regions and thus allows utility to plan energy distribution accordingly.

These meters also support prepaid feature. Thus allowing all kind of consumers to have electricity connection.

1.2 Block Diagram

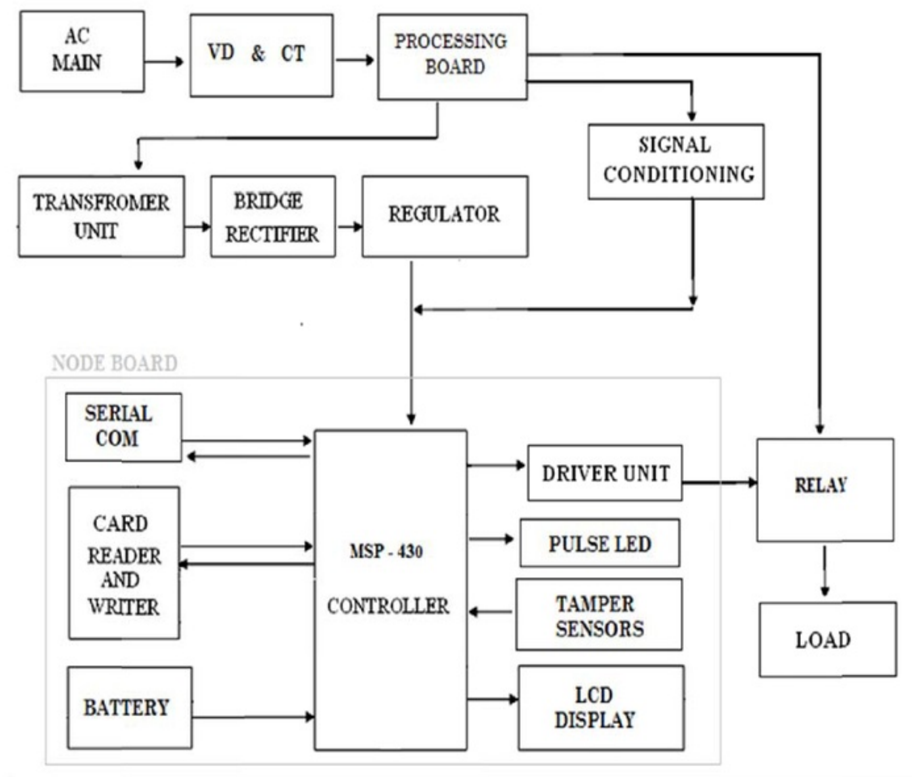


Figure 1.1: Architecture of Three Phase Smart Meter

1.2.1 Voltage Measurement:

Voltage dividers produces Output voltage (Vout) which is a fraction of Input voltage (Vin). Input voltage is distributed among the divider components. The high voltage is applied across the divider circuit; the divider outputs a low voltage which is within the meter's input range. The meter accepts this low voltage range and multiply it by a known factor to gain the original voltage.

In the above figure, V_{in} is the high input voltage to the meter. This input voltage gets distributed across the components R1 & R2.

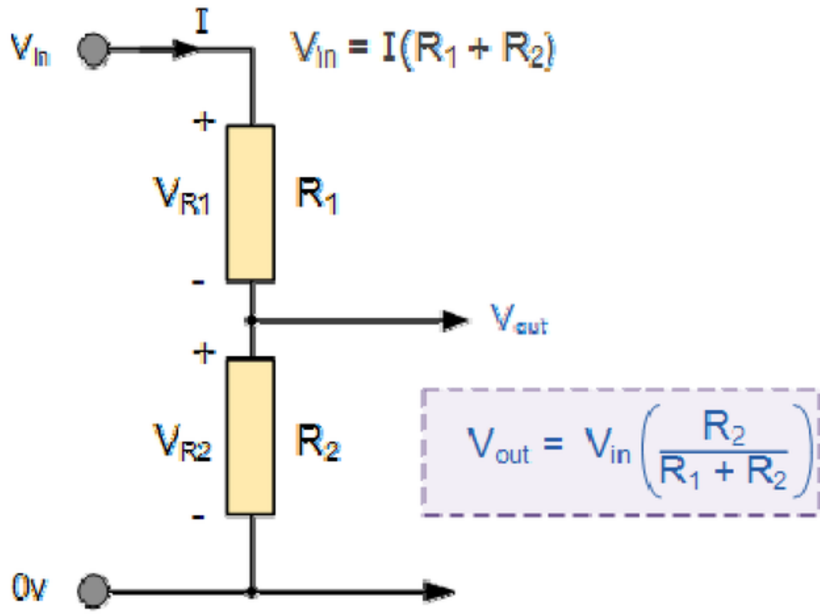


Figure 1.2: Voltage Divider circuit

The value of R1 & R2 is taken such that the voltage drop across R2 falls in the meter measuring voltage range. V_{R2} is the voltage drop across R2, which is in the measuring range. This voltage is then multiplied by the amplification factor to get the original measure of the voltage.

1.2.2 Current Measurement:

Current transformer (CT) is used for measuring alternating electric currents. Current transformer isolates the meter from the very high voltage at the input side.

When current at the input is too high to apply directly to the meter a CT produce a low current which is proportional to the current in the measuring range of the meter.

The figure below shows a current transformer. The wire that holds high current passes through the CT. The CT has N number of windings in the secondary circuit. A low current due to induction is generated in the secondary circuit. This current again lies in the meter measurement current range.

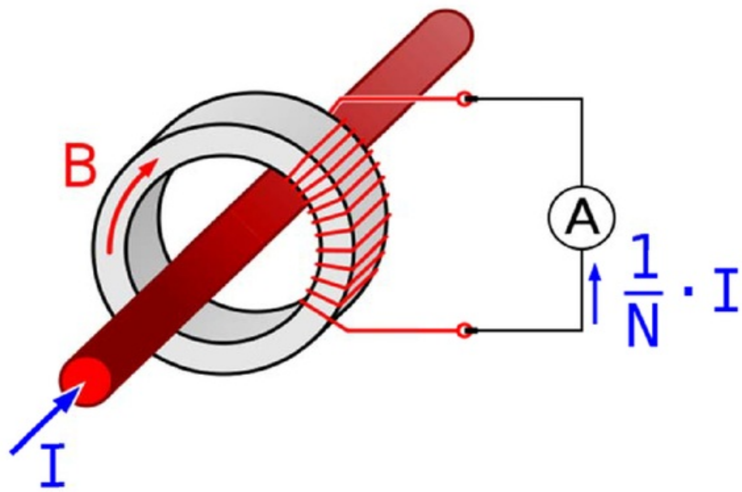


Figure 1.3: An AC current transformer

The low measured current is then multiplied by a known amplifying factor 'N' to get the original value of the current.

1.2.3 Processing Board:

The task of this board is to use the current and voltage raw values to calculate other metering parameters like active power, apparent power, reactive lead power, reactive lag power etc. It has 3.3 Volt Battery backup for both RTC & µ-Controller. This battery also powers Node Board.

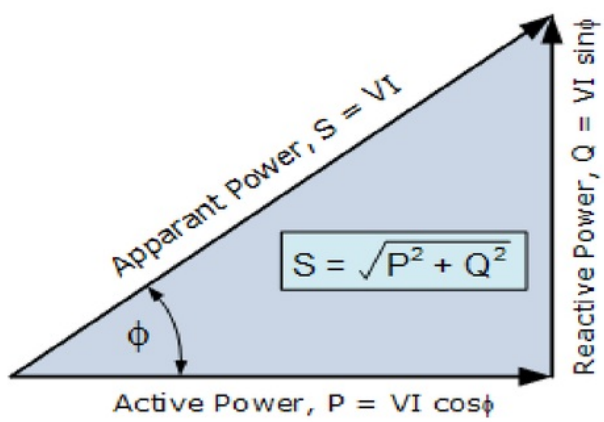


Figure 1.4: Power Triangle

1.2.4 Signal Conditioning:

This block helps the meter to identify whether the voltage, current, power or energy are from R-phase, Y-phase or B-Phase with respect to neutral. It also specifies if the parameters are related to neutral only.

1.2.5 Node Board:

Node Board is the upper board of the meter. It is the main part responsible for the smart behaviour of the meter. It has following components embedded on it:

- MSP430 µ-Controller
- Real Time Clock
- LCD display
- External Flash (2MB)
- Cover Open Detect button
- LCD Scroll push button
- Serial Communication Port
- Optical Communication Port
- Radio Craft Module

Node board is responsible for scaling the raw values of different parameters and displaying them on LCD. It is also responsible for generating surveys of given time interval. It has an NVM storage wherein the logs of different profiles such as Load Survey Profile, Billing Profile, Daily Profile & Event Profile are stored.

Our main firmware is programmed in this MSP430 controller. It controls the RF & IRDA serial communication. It also controls the Relay operations.

Chapter 2

THREE PHASE
SMART METER
FEATURES

2.1 Overview

The aim of this chapter is to provide the behaviour of three-phase smart energy metering and its logging. It provides the overall picture of meter's functioning and logging.

This Smart Meter uses Radio Frequency (RF) technology to provide two-way communication between the DISCOM and homes or business. This smart meters automatically form a sub-GHz RF Mesh network on the 865 MHz free band. This allows the meters to securely send the data via nearby meters.

The meter records the metering information periodically and transmits the information via a dedicated radio frequency (RF) network back to the DISCOM. Each meter is embedded with a network radio, which transmits meter data to a Data Concentrator Unit (DCU). The DCU collects data from each meter in the grid and sends it directly back to Gram Power's servers in real time using GPRS. The DISCOMs can so view live and historical data and derive meaningful insights from the distribution network.

To collect data from *Target Meter* the network of meters created will communicate using intermediate meters as a bridge and relay the data to the Data Concentrator Unit via the gateway. This DCU can therefore reliably gather data from the farthest meter using this intelligent network of meters. The intelligent wireless communication network that the smart meters form is able to detect in real time any meter tampering. In addition, our grid monitoring algorithms are able to identify theft on distribution lines as well. Theft detection sensors put at various locations in the grid enable automatic islanding of theft areas thereby ensuring grid stability and revenue generation.

The network of meters is self-healing and ad hoc. The ad hoc communications technology can autonomously form network of smart meters recognising each other without any configuration setting nor change. In the event that a smart meter in the network is degraded or broken, the network automatically reconfigures without human intervention. The network of such devices is in form of mesh where data are transmitted by hopping through number of smart meters until the destination. Our smart meters have clocked 800 meters of communication range, which is almost 10 times the industry average, while also consuming the least amount of power.

2.2 Goals

2.2.1 Energy Metering

2.2.2 Real-Time Data Collection

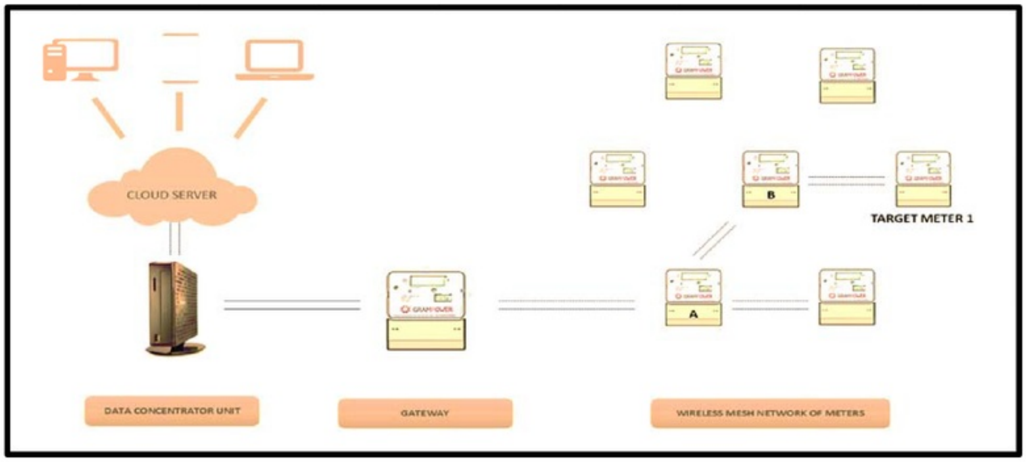


Figure 2.1: Data Collection Unit

Firmware Upgrade Over The Air :-

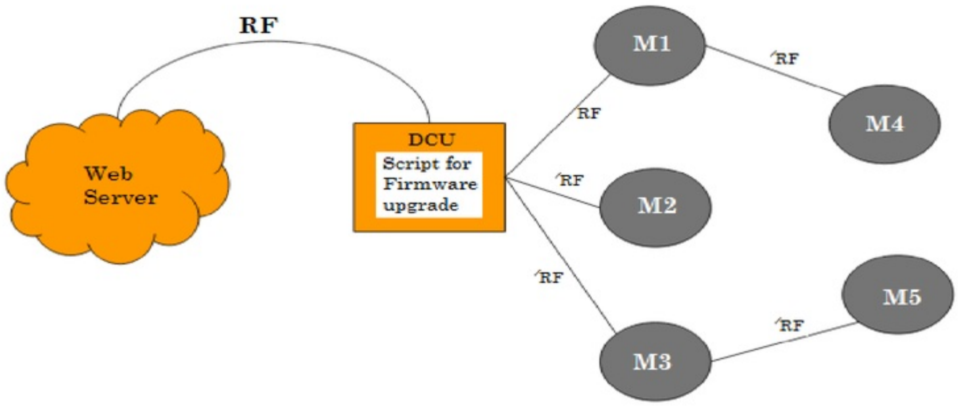


Figure 2.2: Firmware Upgrade over the Air

When there is some update require in the meter's firmware, the new firmware can be upgraded into the meters from the server side. Meters among themselves forms a mesh network and thus passing on the new firmware to each and every meter. The data collection unit takes care of any failures if occur during firmware upgrade. The DCU retries again in case of failure and repair if some packets lost during up gradation activity.

2.3 Specifications

2.3.1 Standards Compliant

2.3.1.1 IS 13779 [June 2007]

2.3.1.2 IS 15959 [April, 2011]

2.4 Technical Specifications

Sr. No.	Particulars	Details
2.4.1	**Current in each phase**	i) Imax = 60A ii) Ib = 10A iii) Starting current = 0.2% of Ib (20mA)
2.4.2	**Accuracy**	
2.4.2.1	**Current Range**	5% of Ib to Imax
2.4.2.2	**Voltage Range**	-40% to +20% of Vref (240V)
2.4.2.3	**Frequency Range**	+/- 5% of rated frequency (50Hz)
2.4.2.4	**PF Range**	0-lag-unity-lead-0
2.4.2.5	**Temperature Range**	As per IS: 13779
2.4.3	**Operating Range**	110V - 288V
2.4.4	**Load Switch rating**	90A
2.4.5	**Tamper Detection Features**	Phase missing, Voltage unbalance, Over voltage, Low voltage, Current reversal, CT open, current unbalance, Over current, CT bypass, Cover open, Magnet, Low PF, Neutral disturbance. Tampers according to IS15959
2.4.6	**RF Communication**	Range - 300m line of sight Operatingfrequency-865 MHz

	Specifications	
2.4.6.1	**Indication LEDs**	i) Only Red LED blinking – No communication ii) Both Red and Blue LED toggling – Communicating with gateway
2.4.7	**Battery**	
2.4.7.1	**RTC**	610 mAh
2.4.7.2	**Micro-controller**	610 mAh
2.4.8	**Power loss in each current circuit at basic current in VA**	< 1 VA
2.4.9	**Power loss in each voltage circuit at reference in VA & watt**	< 1 VA, 1.5 W
2.4.10	**Meter constant**	1600 impulses/KWh
2.4.11	**Status LED's**	i) Communication status LED's ii) Meter Pulse LED
2.4.12	**UI**	
2.4.12.1	**Parameters available on auto scroll**	KWH, KVAH, KVARH, Current MD
2.4.12.2	**Screens in Manual Scroll**	Date, time, meter info, KWH, KVAH, KVARH, Billing history, tamper info, switch status
2.4.12.3	**Screens during Power OFF**	KWH, KVAH, KVARH, tamper count
2.4.13	**Sealing**	

	arrangement	
2.4.13.1	**Meter body**	Meter sealed with tamper evident numbered hologram seals one on each side. Provision for two numbered polycarbonate seals on sealing screws for utility.
2.4.13.2	**Meter Terminal block**	1 no. sealing provision for terminal cover screw.
2.4.13.3	**Degree of protection against dust, moisture etc**	IP51

2.5 Event Detection & Capturing

Any exceptional/fraud/tamper condition is considered as an event, Unique identifier is assigned to occurrence and restoration of all possible events. Events are categorised on to the following categories based on IS15959:

2.5.1 Event Detection

The meter is capable of detecting 7 categories of events, named as

2.5.1.1 Voltage Related Events

2.5.1.2 Current Related Events

2.5.1.3 Power Related Events

2.5.1.4 Transaction Related Event

2.5.1.5 Others Related Events

2.5.1.6 Non-rollover Events

2.5.1.7 Control Events

2.5.1.1 Voltage Related Events

2.5.1.1.1 R/Y/B - Phase Missing Potential - Occurrence

2.5.1.1.2 R/Y/B - Phase Missing Potential - Restoration

2.5.1.1.3 Over Voltage in any Phase - Occurrence

2.5.1.1.4 Over Voltage in any Phase - Restoration

2.5.1.1.5 Low Voltage in any Phase - Occurrence

2.5.1.1.6 Low Voltage in any Phase - Restoration

2.5.1.1.7 Voltage unbalance - Occurrence

2.5.1.1.8 Voltage unbalance - Restoration

2.5.1.1.1.a	**Missing Phase (R, Y, B)**	Voltage of any phase goes to 0V
2.5.1.1.1.b	**Voltage Unbalance**	Voltage Condition: Voltage in all three phases must be greater than 144V (Vmax – Vmin) > 10% of Vmax Current Condition: Any of the phase current must be greater than 1A. (Ir/Iy/Ib) > 1A
2.5.1.1.1.c	**Over Voltage**	Voltage Condition: Voltage of a particular phase must be greater than 115% of Vref (Vx > 276V) Current Condition: Current must be greater than 1A for the same phase (Ix > 1A)
2.5.1.1.1.d	**Low Voltage**	Voltage Condition: If the voltage for a particular phase Vx is greater than 40% of Vref and less than 75% of Vref (96V < Vx <180V) Current Condition: Current for the same phase must be greater than 10% of I basic (Ix > 1A)

Note: For each of the event captured 'cumulative tamper count' value will be incremented.

2.5.1.2 Current Related Events

2.5.1.2.1 Phase - (R/Y/B) Current reverse - Occurrence

2.5.1.2.2 Phase - (R/Y/B) Current reverse - Restoration

2.5.1.2.3 Phase - (R/Y/B) Current Open - Occurrence

2.5.1.2.4 Phase - (R/Y/B) Current Open - Restoration

2.5.1.2.5 Current unbalance - Occurrence

2.5.1.2.6 Current unbalance - Restoration

2.5.1.2.7 Current bypass - Occurrence

2.5.1.2.8 Current bypass - Restoration

2.5.1.2.9 Over Current in any phase - Occurrence

2.5.1.2.10 Over Current in any phase - Restoration

2.5.1.2.1.a	**CT reverse** **(R,Y,B)**	Phase current in each phase must be greater than 0.49A. Current should flow in the reverse direction. Interchange Phase into Phase out.
2.5.1.2.1.b	**CT open** **(R,Y,B)**	Difference between measured neutral current and calculated neutral current is greater than 1A Phase current for a particular phase is less than 2A
2.5.1.2.1.c	**Current Unbalance**	All phase current greater than 1A Imax – Imin > 30% of Imin
2.5.1.2.1.d	**Current Bypass**	All phase current must be greater than 20% of I basic (Ir & Iy & Ib > 2A) Difference between measured neutral current and calculated neutral current should be greater than 1A.
2.5.1.2.1.e	**Over Current**	Current Condition Ix > 120% of Imax

Note: For each event occur ‘cumulative tamper count’ value will be incremented.

2.5.1.3 Power Related Events

2.5.1.3.1 Power Failure - Occurrence

2.5.1.3.2 Power Failure - Restoration

2.5.1.4 Transaction Related Events

2.5.1.4.1 Real-time clock, date and time

2.5.1.4.2 Demand integration period

2.5.1.4.3 Profile capture period

2.5.1.4.4 Single-action schedule for billing dates

2.5.1.4.5 Activity calendar for time zones, etc

2.5.1.5 Others Related Events

2.5.1.5.1 Influence of permanent magnet or AC/dc electromagnet - Occurrence

2.5.1.5.2 Influence of permanent magnet or AC/dc electromagnet - Restoration

2.5.1.5.3 Neutral Disturbance - HF and dc - Occurrence

2.5.1.5.4 Neutral Disturbance - HF and dc - Restoration

2.5.1.5.5 Very Low PF - Occurrence

2.5.1.5.6 Very Low PF – Restoration

2.5.1.5.1.a	**Magnet**	i) Meter should be immune to magnets less than 0.27T. No tamper should be detected. ii) For magnets greater than 0.27T, magnetic tamper should be detected and meter should run in Imax
2.5.1.5.1.b	**Neutral Disturbance**	Phase to Neutral voltage for any two phase must be greater than 350V Other phase should be 0V

2.5.1.5.1.c	**Very Low PF**	Voltage Condition: Vx > 60% of Vref i.e Vx> 144V Current Condition: Ix > 10% of Ib PF condition PFx < 0.4 in any of the phase

Note: For each of the event captured 'cumulative tamper count' value will be incremented.

2.5.1.6 Non-rollover Events

2.5.1.6.1 Meter cover opening - Occurrence

2.5.1.6.1.a	**Cover open**	i) Should be detected at greater than 1mm gap ii) CO tamper should persist if once occurred

2.5.1.7 Control Events

2.5.1.7.1 Meter load disconnected

2.5.1.7.2 Meter load connected

Note: No parameters shall be captured along with the event.

2.5.2 Capture Parameters for Events

For each of the events, the following list of parameters will be captured

2.5.2.1 Date and Time of event

2.5.2.2 Event Code

2.5.2.3 Current Ir

2.5.2.4 Current Iy

2.5.2.5 Current Ib

2.5.2.6 Voltage Vr

2.5.2.7 Voltage Vy

2.5.2.8 Voltage Vb

2.5.2.9 Power factor - R phase

2.5.2.10 Power factor - Y phase

2.5.2.11 Power factor - B-phase

2.5.8.12 Cumulative Energy, kWh

2.6 Load survey

Load survey is an essential feature of the smart meter. If enabled, surveys are generated at the end of a configurable (i.e. 15,30 minutes) survey interval. These surveys containing metering information are stored in non-volatile memory

Load survey stores (padded zero values if the meter is powered up even for a small amount of time sufficient for it to boot up and record the power up event) during the 24 h period, it shall store and return the block load profiles for the entire 24 h duration.

2.6.1 Load Survey Parameters

Every survey generated has the following parameters:

2.6.1.1 Real Time clock, date and time

2.6.1.2 Current Ir

2.6.1.3 Current Iy

2.6.1.4 Current Ib

2.6.1.5 Voltage Vr

2.6.1.6 Voltage Vy

2.6.1.7 Voltage Vb

2.6.1.8 Block energy, kWh

2.6.1.9 Block energy, kVArh(lag)

2.6.1.10 Block energy, kVArh(lead)

2.6.1.11 Block energy, kVAh

The parameters listed above are for load survey and are logged as per block period time, parameters from serial no. 2 to 7 are the average values during the block period time & stored at the end of that time block and from serial no. 8 to 11 are the actual energy consumption during that time block.

2.7 Daily Profile

Meter supports daily profile as per IS15959, it is similar to Load survey only, but the change is its interval and recorded parameters, the recording interval is 24hr.

2.7.1 Daily Profile Parameters

2.7.1.1 Date & Time

2.7.1.2 Real Energy

2.7.1.3 Lag only Reactive Energy

2.7.1.4 Lead only Reactive Energy

2.7.1.5 Apparent Energy

2.8 Billing Profile

Meter supports Billing profile, and it happens on the 1st of every month by default. Date can be set to any date-time of the month and it will generate billing accordingly. Meter supports up to 6 billing histories then rollover happens.

2

current cycle billing parameters are readable as the values of the latest billing period, on demand. Meter supports Maximum demand feature for active energy and apparent energy with appropriate time-stamp. MD resets after each billing cycle, following are the parameters available in billing according to IS15959.

2.8.1 Billing Profile Parameters

4

2.8.1.1 Billing date

2.8.1.2 System power factor for billing period (Average power factor for the entire billing period)

2.8.1.3 Cumulative energy, kWh

2.8.1.4 Cumulative energy, kWh for TZ1

2.8.1.5 Cumulative energy, kWh for TZ2-TZ8

2.8.1.6 Cumulative energy, kVArh (Lag)

2.8.1.7 Cumulative energy, kVArh (Lead)

2.8.1.8 Cumulative energy, kVAh

2.8.1.9 Cumulative energy, kVAh for TZ1

2.8.1.10 Cumulative energy, kVAh for TZ2-TZ8

2.8.1.11 MD, kW (Maximum for the entire billing period)

2.8.1.12 MD, kW for TZ1

2.8.1.13 MD, kW for TZ2-TZ8

2.8.1.14 MD, kVA (Maximum for the entire billing period)

2.8.1.15 MD, kVA for TZ1

2.8.1.16 MD, kVA for TZ2-TZ8

2.8.1.17 Active MD Timestamp

2.8.1.18 Apparent MD Timestamp

2.8.1.19 Total Power on Duration

2.9 UI Display

Meter has three modes of UI displays

2.9.1 Auto Scroll

2.9.2 Manual Scroll

2.9.3 Super sleep (No Mains Mode)

Maximum number of display provided in UI for auto scroll is 14, for Manual scroll, it is 109 and for super sleep, it is 6.

2.9.1 Auto Scroll

This is the mode where UI scrolls continuously within their scrolling period, as and when User presses push button mode gets transferred into Manual scroll mode

To come back in auto scroll mode after pressing button wait around 10 seconds scroll will switch to the Auto mode automatically

If button pressed then wait for few seconds auto scroll will appear immediately, or directly after powering on the meter observe the scroll states.

UI provides flexibility of jumping from one parameter to another parameter by pressing scroll button continuously for 5 seconds.

2.9.2 Manual Scroll

This is the UI mode where user needs to press push button to enter in this mode, press continuously every second to observe the next display or to watch it user need to press, User can only enter into this mode by pressing the push button.

UI provides flexibility of jumping from one parameter to another parameter by pressing scroll button continuously for 5 seconds.

2.9.3 Super Sleep Mode

This is the mode where there is no power into meter, still, user can have an experience of meter with limited parameters on display, this mode contains single press auto scroll feature by which it means user need to press once to see UI screens in super sleep mode or low power mode.

All displays has been displayed with some random values to show how they will actually look like in the meter. Energy in super sleep mode will display decimal less values with kWh, kVAH, kVARh units.

E.g.

Let suppose energy is 1234.56kWh, then in super sleep mode display will be like 1234kWh, and the displays will be same for all kinds of energy's available in this mode.

2.10. Auto Scroll Displays

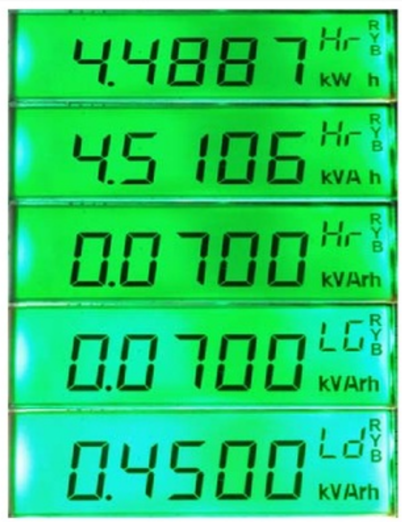
Sr. No.	State Name	Display
2.10.1	**LCD Check**	
2.10.2	**Real Time Clock Date & Time**	

2.10.3	**Cumulative Energy kWh**	
2.10.4	**Cumulative Energy KVAh**	
2.10.5	**Cumulative Energy KVARH (LAG)**	
2.10.6	**Cumulative Energy KVARH (LEAD)**	
2.10.7	**KW (MD), KVA(MD)**	
2.10.8	**Average Monthly Power Factor**	
2.10.9	**Tamper Count**	

2.10.10	Cover Open	
2.10.11	Switch State	
2.10.12	Over Load	

2.11 Manual Scroll Displays

Sr. No.	LCD Display Check	
2.11.1	Application FW	
2.11.2	Meter Serial Number	
2.11.3	DLMS FW Version	
2.11.4	Instantaneous Phase Voltages(R, Y,B)	
2.11.5	Instantaneous Phase Currents(R ,Y,B)	

2.11.6	**Instantaneous Phase PF(R,Y,B)**	
2.11.7	**Frequency**	
2.11.8	**Neutral Current**	
2.11.9	**Instantaneous active power(R,Y, B) in kW**	
2.11.10	**High Resolution KWH, KVAH, KVARH(LAG), KVARH(LEAD)**	
2.11.11	**Cumulative KWH for 6 months with present month**	

2.11.12	**Cumulative KVAH for 6 months with present month**	
2.11.13	**Cumulative KVArH (LAG) for 6 months with present month**	
2.11.14	**Cumulative KVArH (LEAD) for 6 months with present month**	
2.11.15	**Averagely Month PF**	
2.11.16	**MD (KW) of 6 months**	
2.11.17	**MD (KVA) of 6 months**	

		
2.11.18	**Power On Hours**	
2.11.19	**Number of Switch Open or Close operations**	
2.11.20	**Load Limit**	
2.11.21	**Tampers**	

2.11.22	**Power Off Screens**	

Above all displays are available on UI, few conditional displays are also there like, All Tampers screen, C-Open in super sleep mode, HILOAD screen, all displays will occur only if their persistence found.

During Super-sleep two KWh screens will be provided one in start and one in last auto scroll, this last screen will fade away if and only if Cover-Open tamper occurs in the meter. Smooth transition has been provided to move from SS to mains or mains to SS.

2.12. Over the air communication

Communication remotely happens in two ways to the Head end system:

2.12.1 Autonomous communication

2.12.2 On demand communication

1. Red LED - Indicates the RF modem is working

Figure 2.3: Red LED

2. Blue LED - Indicates the modem is connected to the DCU.

Figure 2.4: Blue LED

2.12.1 Autonomous communication

The ecosystem of concentrator and the smart meter allows for periodic collection of data through the data concentrator. This data collection process is pre-configured and does not need any manual intervention. The collection period can be configured in the concentrator or remotely using the HES. The following data is collected in the periodic data collection:

Sr. No.	**Field**	**Description**
2.12.1.1	**Timestamp**	The timestamp (date and time) to which the rest of the data corresponds to
2.12.1.2	**Phase Voltages**	Instantaneous voltage at above timestamp
2.12.1.3	**Phase Currents**	Instantaneous current at above timestamp
2.12.1.4	**Active Power**	Instantaneous active power at above timestamp
2.12.1.5	**Phase Power Factors**	Instantaneous power factor at above timestamp
2.12.1.6	**Frequency**	Instantaneous voltage at above timestamp
2.12.1.7	**Active Energy**	Active energy measured by the meter till above timestamp
2.12.1.8	**Reactive Energy**	This variable is always zero as of now
2.12.1.9	**Tamper Flags**	All live tamper events at the above timestamp

The period of data collection is configurable. When a smart meter is deployed on field, the concentrator periodically collects "bundles" from each meter. However, if the RF connectivity is down, then the bundles during the period when RF connectivity is down cannot be collected by the concentrator. To mitigate this problem, the bundles are also stored internally by the meter in a flash chip which can be retrieved at a later interval.

The parameters for defining the rate at which bundles are stored internally can be different than the interval at which the concentrator collects data from the meters. The following two parameters can be used to configure internal bundle storage:

1. {start time}: This defines the time from which the bundle storage would begin

2. {Interval in minutes}: This defines the time period at which the bundles are stored internally. As of the present implementation, the interval can only be a divisor of 60.

2.12.2 On Demand Data Collection

The user/utility can retrieve/configure the follow things on demand basis:

2.12.2.1 All metering parameters – Voltage, Phase current, Neutral current, Power Factor, Frequency, Tamper info, Maximum demand

2.12.2.2 Load survey configuration/ retrieval

2.12.2.3 Tamper record configuration/Retrieval

2.12.2.4 System's current status

No Event/Tamper will lose with the above methodologies of data collection, this provides the flexibility of keeping all the event/records in the concentrator, and this is applicable in both Autonomous and On-demand data collection.

Chapter 3

THREE PHASE

SMART METER
SOFTWARE SUPPORT

3.1 Report downloads Through Android Application

Android App provides the flexibility of downloading reports; here are some of the snapshots of GRAMPOWER's report app. It provides facility of emailing as well.

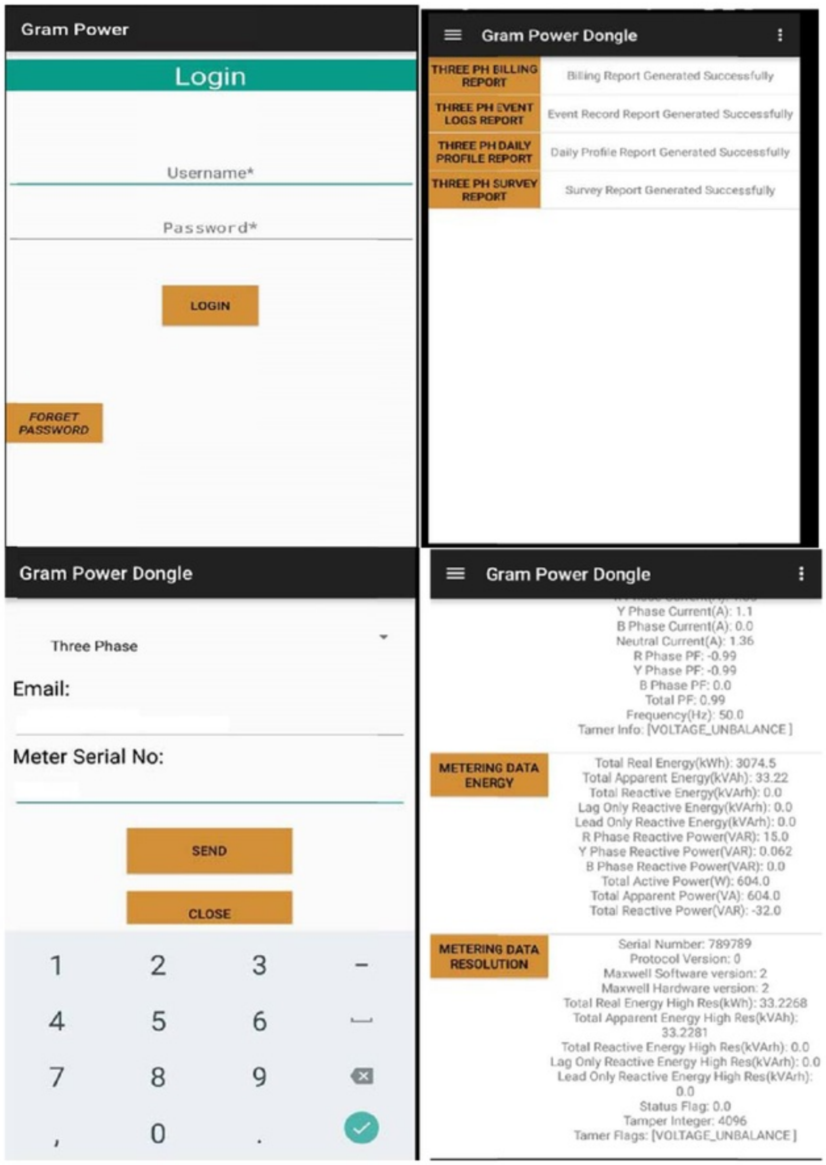


Figure 3.1: Screens of Mobile app

3.2 DLMS support software: GURUX

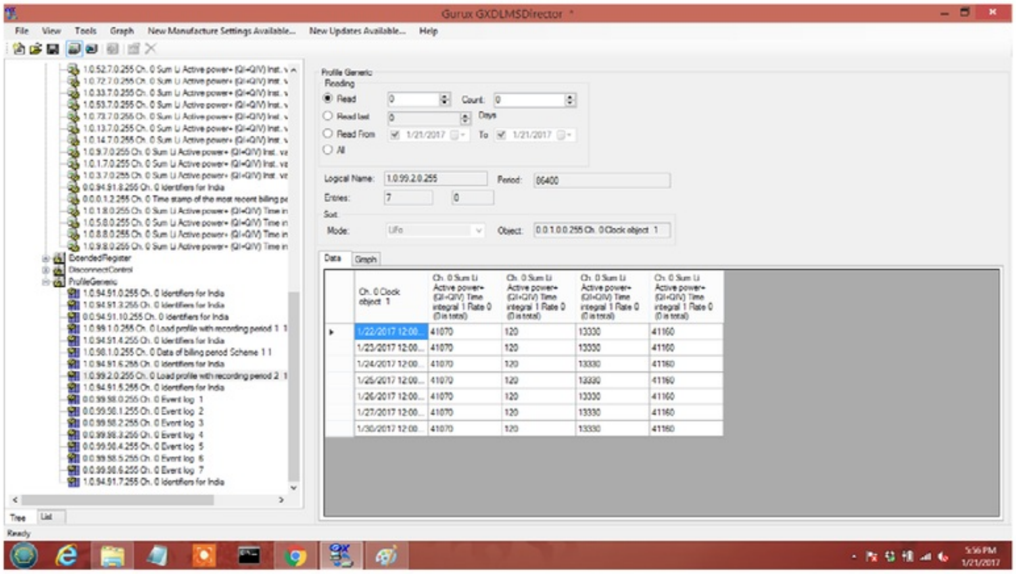


Figure 3.2: Screens of GURUX

3.3 BRAMHA – A meter customisation tool

Figure 3.3: Screens of UI customisation tool

3.4 FET – Pro430 Lite

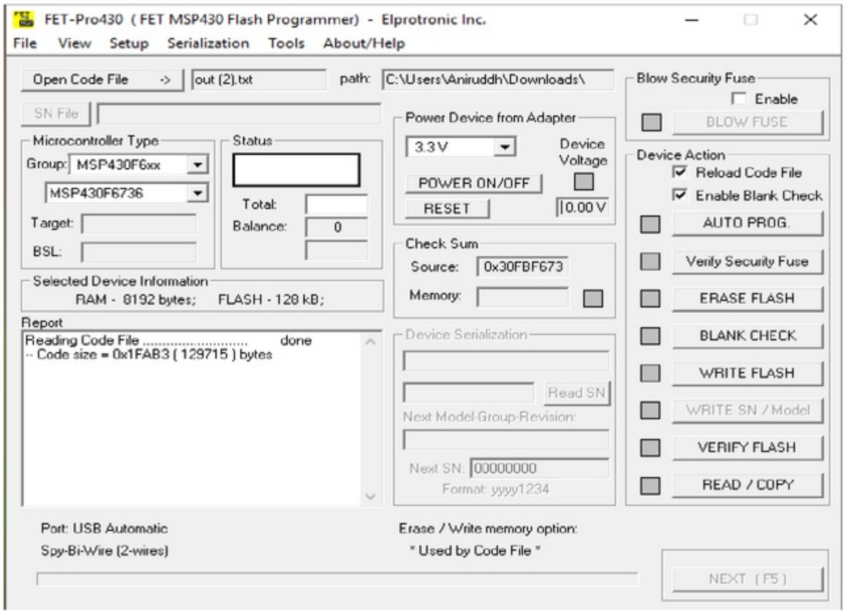


Figure 3.3: Screens of FET

3.5 Installation Guide

3.5.1 Connection Diagram

Terminal of TPM-RF v1.0 is having the following convention for the safe connections.

Input: 1S, 2S, 3S, 0S   Output: 1L, 2L, 3L, 0L

1S, 2S, 3S, 0S corresponds to R-phase, Y-Phase, B-Phase and Neutral mains supply respectively whereas 1L, 2L, 3L, 0L corresponds to o/p i.e. load terminals.

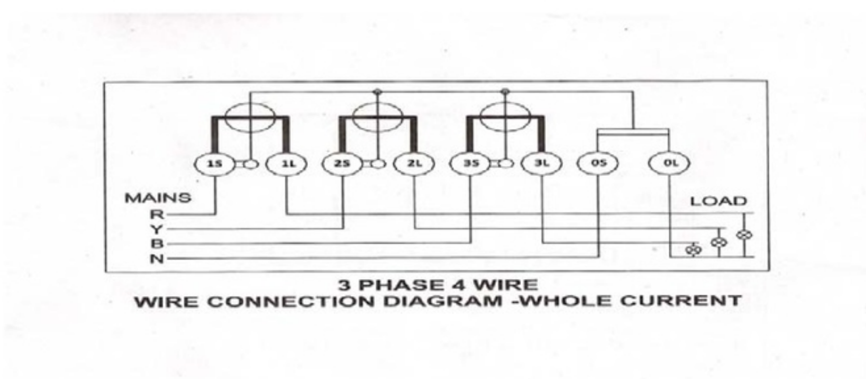


Figure 3.4: Terminal connection diagram

REFERENCES:

- IS 15959 [April 2011]– Bureau of Indian Standards
- IS 13779 [June 2007]—Bureau of Indian Standards
- http://www.grampower.com/
- http://www.ti.com/lsds/ti/microcontrollers-16-bit-32-bit/msp/overview.page?HQS=msp430
- https://radiocrafts.com/applications/wireless-sensor-networks/
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