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M-Bus Compatible Meter Reading and Billing Process

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----------ABSTRACT----------
In distribution systems reading the meters, which are spread a large area, is an important problem. Automatic meter reading systems provide an economic solution to problem of collecting data interpret it accurately. The M-Bus (Meter Bus) was developed to fill the need for a system for the networking and remote reading of utility meters, for example to measure the consumption of gas or water in the home. When interrogated, the meters deliver the data they have collected to a common master, which can be a computer connected at periodic intervals to read all meters of a building. In this study, the software has been developed for billing and remote reading of meters. This software will interrogate M-Bus meter at periodic intervals, will transfer consumption data from meter to computer, will calculate consumption and will make an invoice in this data center, if necessary.
KEYWORDS*:M-Bus, Automatic meter reading, Calorimeter, Meter, Monitoring System.*

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I. INTRODUCTION

It is a necessity to use energy efficiently for economic and social welfare. It is important to optimize energy usage and raise awareness between users about energy usage. There are different systems in houses which consume energy. Increase in use of modern devices and on the other hand limited energy sources have made it necessary to use energy in smart ways [1-3]. Reading meters in a large area is an important problem in distribution systems. Automatic meter reading systems represent an economical solution for collecting and assessing meter data without mistake.

Previously traditional electromechanic meters could only follow energy. But the disadvantage of this system was that only energy consumption could be monitored. So, consumers only knew total consumption rate and they were not aware of the consumption rate of their personal devices. One of the basic problems in many countries was "changing adjustment of the device". Consumers made it a habit to change meters for making it read lower rates which cause financial loss of public institutions [1-3]. Within the scope of this text; studies are done for reading of M-Bus compatible meters by automatic meter reading systems and billing process. The smart meters requirements are rapidly evolving in response to competitive market forces and various governmental regulations mandating smart grid deployments in most areas of the world [4, 5].

As compare to legacy electronic meter, present electronic meter is smart, and can provide a range of intelligent functions such as dynamic pricing, demand response, remotely power connect/disconnect; outage management, network security, and reduction of non-technical losses [5-7]. Increased power consumption and exhausted natural resources have been forcing the human to research methods and make laws for saving power in recent years, which should induce reduction of power consumed in the home, but not in other areas. It is because power used in the home is a typical example of consumptive one. Another reason is the increasing power consumption due to more and more consumer electronics and their new functions according to the development of home network [8-10].

Automatic meter reading system basically needs communication network between utility company and each wattmeter, and there are many technologies as candidates to build up M-Bus communication network [8-10]. Software M-bus Serial Communicator is developed for remote reading of tax instruments data in m-bus network. It is new efficient software for remote read out of all kinds of consumption meters. M-Bus (Meter Bus) is developed for meeting the need of network systems and distance meter reading. M-Bus cater for systems which work with distance energy or battery included user meters. When commanded, meters deliver the data for being gathered in a common central unit. A portable computer can be used for metering all devices of a building periodically [1-3, 11].

II. M-BUS SERIAL COMMUNICATION PROTOCOL

2.1 General Information

M-Bus is a low cost house electronic system. M-Bus is used for metering gas, water and electric consumption from a distance. M- Bus can be executed remotely or by a battery. Meters transmit the data to master when it is necessary and the data can be read in different levels by connecting via a computer. M-Bus applications can be used in alarm systems, flexible lighting installations and heating controls [1-3].

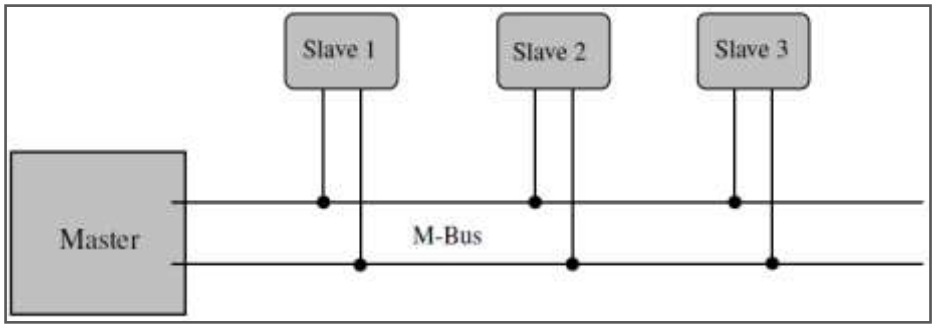


Fig. 1. M-Bus working principle working diagram

Bus system is developed by Texas Instruments Deutschland GmbH and Techem GmbH cooperation and Professor Doctor Horst Ziegler from Paderborn University. Advantages of the M-Bus usage can be sorted as below; simple two wired data way interface for slaves, changeable polarity, high speed transmission, short circuit protection, low cost components per slave and easy to use components. Also preload of M-Bus drivers by ThereGate company and technical support in case of a problem can be counted as an advantage as well.
Other reasons of choosing M-Bus system are; it supports up to 250 slaves, represents optional bus topology, there are a user group who commit themselves to develop the application and provides problem solving and mistake free data transmission by existing modulation [1-3, 12].

2.2 M-Bus Working Principle

Communication in M-Bus system is controlled by a master. A typical M-Bus system is of one master, a series of slave and a two wired connection cable as shown Fig. 1.

Slave is always shunted to communication media. Bits are expressed as below for powering slaves remotely.
Transferring bits from master to Slave is achieved successfully by changing voltage level. Logic "1" equals to +36 volts in output of data way driver which is a part of master. When Logic "0" is sent, repeater decreases data way tension 12V and brings it to +24 volts [1-4].

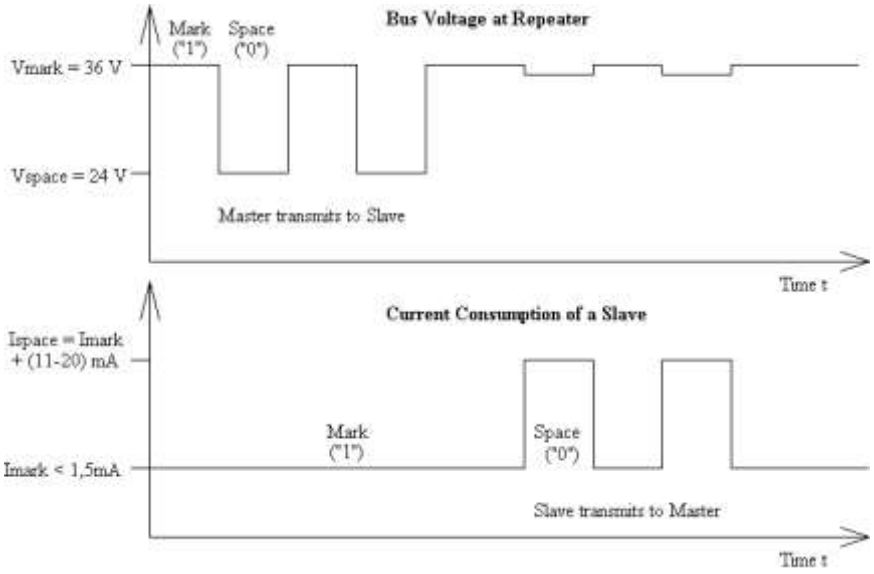


Fig. 2. Presentation of bits in M-Bus system

Transferring bits from master to Slave is achieved successfully by changing voltage level. Logic "1" equals to +36 volts in output of data way driver which is a part of master. When Logic "0" is sent, repeater decreases data way tension 12V and brings it to +24 volts [1-4].

Sending bits from Slave to master as a response is achieved successfully by modeling current consumption. Logic "1" is represented by a constant current which is until 1.5 mA. In logic "0" Slave current is increased around 11-20mA additionally Presentation of bits in M-Bus system is as shown Fig. 2.

2.3 M-Bus Telegram Format

According to IEC 870-5, three different data integrity classes (I1, I2 and I3) are envisaged for the transmission of remote control data. The data integrity class is a measure of the quotient between the rate of undetected false messages and the probability of faulty bits during transmission.

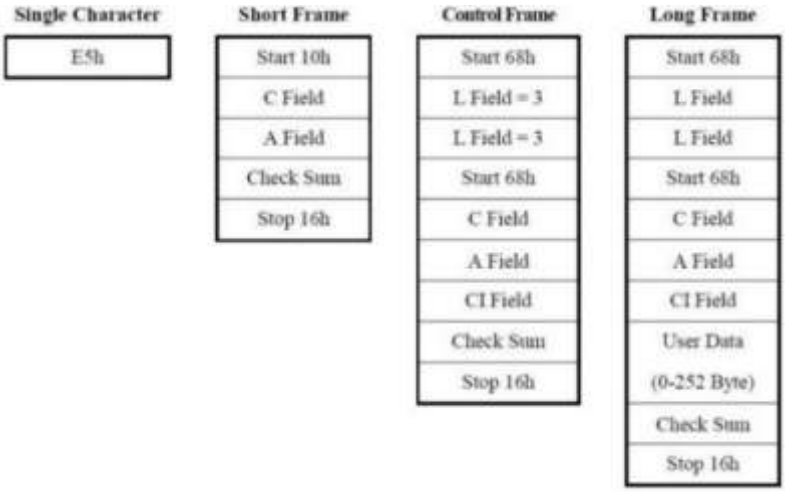


Fig. 3 Telegram formats for M-Bus protocol

For the data integrity classes mentioned above, various format classes have been identified, in which measures to recognize transmission faults are defined. For the M-Bus protocol of the data link layer the format class FT 1.2 is used, which is contained in the data integrity class I2, which specifies a Hamming Distance of four. The format class FT 1.2 specifies three different telegram formats, which can be recognized by means of special start character [1-4, 12].

In Fig. 3, the telegram formats used for the M-Bus will now be explained.

Single Character: This format consists of a single character called as E5h. It serves for accepting of transmission

Short Frame: This format is of a stable length and initiates with 10h characters. Later on C field, a field, checksum and 16h, which is the ending character, takes place in telegram.

Long Frame: In long frame length (L field), it takes place two times in telegram after the 68h, which is the initiate character. It is followed by function field (C field), address field (A field) and control information field (CI field). L field gives user data input rate.

Control Frame: The control sentence conforms to the long sentence without user data, with an L field from the contents of 3. The check sum is calculated at this point from the fields C, A and CI.

III. M-BUS PROTOCOL APPLICATION

M-Bus is an economical solution for reading scattered network communication and different producers' warming, gas, water and energy meters remotely. It reads per device energy consumption data within long time intervals with very little mistake and provides transmission in very long distances by using simple standard cables.

3.1. General View of System

Consumption meters which are used in houses and industrial business are connected to a main master via M-Bus. This system supports all meters which are connected to each other with electricity power, gathers data, creates consumption profiles and transmits them to consumption records and billing center.

Today, saving of energy has become the most important issue in many countries due to the increase in energy consumption [13, 14]. Meter reading data are transmitted from modem either directly from serial interface or indirectly via phone lines or via optical interfaces. M-Bus data transfer and interfaces are heat flow

meters called EN 1434–3 in Europe standards [15-18].

Incoming data is collected in main computer and recorded to database. Various users can view it and make analyses by using proper software. They can also execute billing processes by using billing software. A web server application can be used in processing data, so a new system comes out via internet which can be used all around the world [19-21].

When it comes to big complexes, M-Bus consumption-billing data are generally transmitted to parallel building control systems and these data function as a part of building management concept.

3.2. M-Bus Technology

M-Bus system's technical properties fulfill remote meter reading necessities completely. These properties are [1-4];

• A simple, duplex cable with inverse polarity protection is used for data transmission and power supply.
• 250 user can communicate with a cable around 1000m. Flexible bus topology, star and tree configurations can be provided in any segments.
• System can be developed by the help of repeater or Masters by uniting segments with network.
• Standard transmission rate which is 2400 can be adjusted to a value between 300 and 38400 Baud for special applications.
• As the system is electrically insulated and short circuit protected, user errors does not cause any failure in data way.
• It provides high data security by its high signal level, data way tracking and definition.
• It has automatic error detection feature.

3.3. M-Bus System Structure

M-Bus system is used in Automatic Meter Reading (AMR), communication of an M-Bus concentrator or data center and water energy meters' communication [9, 21-23].

M-Bus system simply uses who unpolarised cable for trustable meter reading, remote reading, remote control, incremental pricing, time based pricing, collective service, prepaid billing and etc., different options. Controlling and applying this data way system is simple and economical [20-23].

A simple meter reading system consists of a few M-Bus meter (water meter, energy meter etc.), an M-Bus concentrator (collector) and a data center computer. All meters in the building are connected to a two wired data way. This data way is then connected to M-Bus concentrator (collector). Concentrator communicates between data center computer and RS232 interface directly. First, data center sends the software to concentrator as a meter reading instruction. As soon as concentrator receives the instruction, it comments it and sends to indicated meter or meters. Meter(s) send back the requested data back to concentrator, concentrator packs the data and sends to data center for recording, printing, researching, billing and etc. processes [20].

IV. SYSTEM COMPONENTS FOR M-BUS NETWORKS

M-Bus is an economical solution for remote reading of heat, gas, water and energy meters of different producers which are scattered to a large area. It reads per device energy consumption data within long time intervals with very little mistake and provides transmission in very long distances by using simple standard cables. M-Bus is a European standard with its data transfer and its interfaces called [16-18].

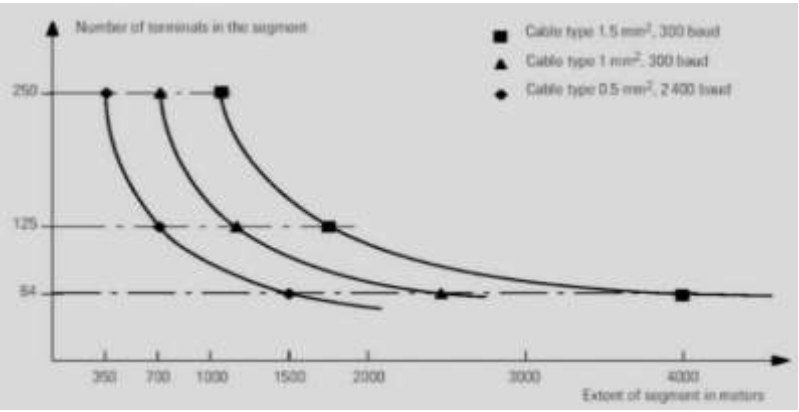


Fig. 4. Number of M-Bus devices connected to cable length

A standard two wired cable is used as transmission device for M-Bus. Maximum distance between Slave and repeater should be 350 meters; this length corresponds to 29Ω cable resistance. This distance is valid

for maximum 300 and 9600 Baum transmission speed and maximum 250 Slaves standard structures [1-4]. M-Bus cable is protected for inverse polarity and cables can be replaced [24]. The maximum allowed length of the cables must be strictly adhered to, otherwise transmission errors could occur, causing functional disturbances, as shown Fig 4.

M-Bus master requires and manages terminal devices data up to 250. Master reads interconnected consumption devices in some specific time intervals and keeps data in its memory permanently. Updated meter reading data can be reached any time if a screen is integrated to master [16-18].

M-bus Micro Masters, which are used for connecting to laptops, are suggested for mobile use. These are used in personal terminal devices and reading small systems until ten terminal devices. Master application works on a laptop which it is connected and laptop provides power for micro master and all terminal devices which are connected to it [24].

All interface integrated consumption meters can be used as M-Bus devices or slaves. Interface and device are supported by the power acquired from data way. Interface module launches terminal device by internal power source or initiates data storage process to permanent storage (EEPROM) in case of power failure. Devices which are lack of power supply or internal battery can only work as long as master works [16-19].M-Bus consumption meters, which are of wide product range as water, heating, electricity and gas, are offered to market by a lot of manufacturers.

Pals line out consumption meters which are commonly used, can be connected to M-Bus system by pals converter module. Modules can read one or more input and keep on working without energy loss by its internal battery. Input pals are converted into consumption values by adjustable parameters [24].

Analog converter modules are proper for connecting consumption meters or 4-20mA voltage output sensors to M-Bus system. It is possible to acquire results for heat, pressure, filling level and flow speed by this system. Generally an external power package is necessary for the operation of these modules [9, 16-18].

Primary Addresses:To read out all installed slaves the master software must know all the slaves, which are connected to the bus. Therefore the software searches for slaves with primary addressing by sending a Request for data from the M-Bus Slave to all allowed addresses (1...250) with all available Baud rates. The master notes used primary addresses with the respective Baud rates.

Secondary Addresses:The secondary addressing described in the preceding section draws attention to the problem of determining the secondary addresses of slaves connected to the bus. The master can after this read out the slaves making use of secondary addresses with previous selection. Testing all possible identification numbers with the master software would take years, since the identification number offers millions of combinations. For this reason, a procedure was developed for the rapid and automatic determination of already installed slaves [1-4].

In case there are multi user sets up, M-Bus can be divided into segments which are created with the desired topology and up to 250 terminals. Each segment is controlled with a repeater output which communicates with master's output. Input level of the repeater is same with input level of terminal device. Basically, repeater is nothing but an analog level converter.

M-Bus billing center:Billing center consists of a server which gathers consumption data from M-Bus networks by remote data reading and record them into its database.

V. RESULTS AND DISCUSSION

Visual Basic 2010 is used in developing program as it is possible to use various devices for visual design and providing convenience for programming. Main advantage of Visual Basic is that a duty which may take days by other programming languages can be executed in minutes by Visual Basic.

There is a 3 steps approach for creating VB programs:

1. Design the appearance of your application.
2. Assign property settings to the objects of your program.
3. Write the code to direct specific tasks at runtime.

5.1. Software interface design

Interface of the software is designed by using Visual Basic 2010. Desired features of the programmer are determined before starting to design interface and menus are created based upon these features.

As shown Fig. 5, there are menus both in left and right sides of the program. All features of the program can be used in both menus. Functions of the menus are explained below in order:

Fig. 5. Software Interface

Client Register**:** It is used for client registrations in the application.
Meter Register**:** It is used for the register process of the meters in the application.
Assigning Meter **:** It is used for determining which meter belongs to which client.
Reading Adjustment **:** It is the section which makes adjustments about connection and billing.
Reading: It is used for reading all meters connected to reading center.
Monthly Data: It is used for the data of building's total cost, number of clients, etc.
Billing **:** It is used for monthly billing process of clients complying with laws and regulations.
Periodic Consumption: It is used for gathering total monthly consumption data

5.2. Adjusting Baud Rate

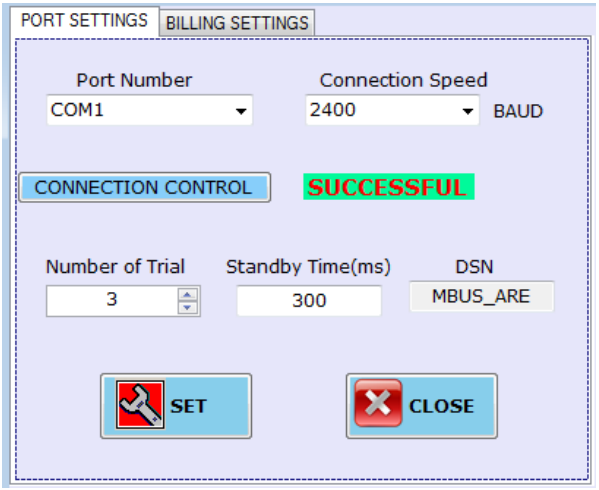


Fig. 6. Reading adjustment screen

It states the speed of the computer which is used for collecting data. It can be 300, 2400 or 9600 Baud and it corresponds to M-Bus Baud speed used in existing situation. Some of the M-Bus level rotator, which are

in the market, do not support speed values over 2400 Baud, and so we should be careful about it. Adjusted Baud speed should be same as M-Bus device's Baud speed. As the Baud speed differs according to the used meter, M-Bus billing software allows different speed values [24].Adjusting transmission speed can be done by "Reading Adjustment" option, as shown Fig. 6.

5.3. Meter Reading Screen

SAYAÇ NO	ÜRETİCİ FİRMA	ENDEKS	BİRİM	DEĞER5
34354358	DFS	0026031400	Energy [Wh]	Heat_(outlet)
52	WZG	0	Volume [l]	Warm_Water
52	WZG	0	Volume [l]	Warm_Water
34307270	TCH	000000340	Volume [l]	Water
34307270	TCH	000000340	Volume [l]	Water

Fig. 7. Meter Reading Values

It is the screen that registered devices of the system are read and recorded for billing as shown Fig. 7. When "Read All Meters" button is pressed, all reading data of meters, which are connected to system, are added to list if there is not any problem with the connection.
Below values are required after reading process:
ID (Meter ID):It is an eight numbered M-Bus ID number. Serial number is determined as a factory setting and labeled on the meter.
Manufacturer**:** It is the three numbered manufacturer code followed by a successful meter reading. Manufacturer code is only readable, not editable. For example: ELS
Generation**:** It views the software version of the connected M-Bus meter or M-bus module. This area cannot be changed, readable only. For example: Gen-01, Gen-02
Model:It shows the model of the connected device. It cannot be changed, readable only.
Status:It shows the status of the connected device. This area cannot be changed, readable only.
Article:It defines the article which is metered by the chosen meter. Choice: Water, Hot water, cold water, Hot/Cold water, Gas, Electricity, etc.
Value**:** Consumption values which are acquired from the meters after the reading are viewed in value section. Unit of the value which is acquired from value section differs according to type of the meter. M3 meters are used in water and gas meters and kWh units are used in electricity meters and calorimeters.

5.4. Billing Screen

Billing software is developed as fully compatible with Regulation of Sharing of Heating and Hygienic Hot Water Costs in Central Heating Systems [24-25].

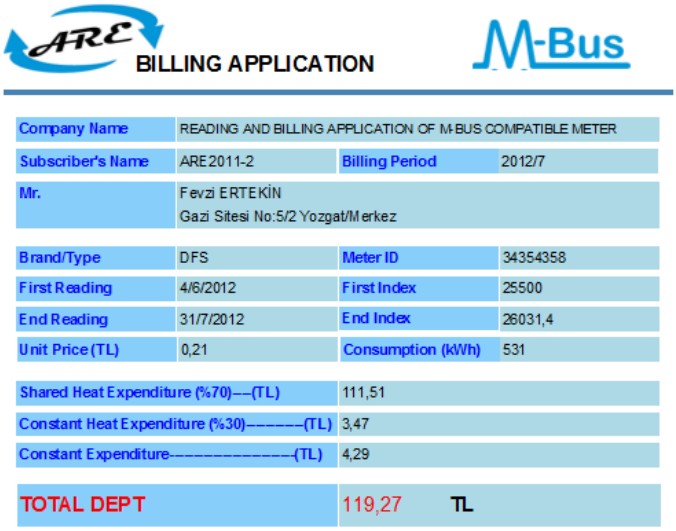
Monthly billing data can be screened after entering meter number and billing period to the invoicing screen. Regulation of Sharing of Heating and Hygienic Hot Water Costs in Central Heating Systems, which is published by Ministry of Public Works in 2008, is based on preparing invoices. Invoices are prepared by using below formula of the regulation;

$$P_1 = 0{,}7 \times M \times \frac{S}{S_T} \qquad (1)$$

$$P_1 = 0{,}3 \times M \times \frac{A}{A_T} \qquad (2)$$

$$P = P_1 + P_2$$

M : Total heat consumption cost of the building (TL)
P : Total consumption cost of the common area (TL)
P_1 : Consumption cost of the common area according to heat meter (TL)
P_2 : Common consumption cost of the common area (TL)
S : The value which is read by the meter in the common area.
S_t : Sum of the values of all heat meters in the building
A : Closed area of common areas (m^2)
A_t : Sum of area of common areas in the building (m^2).



BILLING APPLICATION

Company Name	READING AND BILLING APPLICATION OF M-BUS COMPATIBLE METER		
Subscriber's Name	ARE2011-2	Billing Period	2012/7
Mr.	Fevzi ERTEKİN Gazi Sitesi No:5/2 Yozgat/Merkez		
Brand/Type	DFS	Meter ID	34354358
First Reading	4/6/2012	First Index	25500
End Reading	31/7/2012	End Index	26031,4
Unit Price (TL)	0,21	Consumption (kWh)	531
Shared Heat Expenditure (%70)---(TL)		111,51	
Constant Heat Expenditure (%30)-------(TL)		3,47	
Constant Expenditure----------(TL)		4,29	
TOTAL DEPT		119,27 TL	

Fig**. 8.** Sample Invoice

The fully automatic remote meter reading is a simple reading method and routine operation in an m-bus network. The continuous flow of data is controlled and evaluated centrally, and the high data actuality permits efficient energy data management. Current consumption as shown Fig. 8 can be read out whenever required, the individual reading intervals can be adjusted at any time and data evaluations are possible as desired

The M-Bus (Meter Bus) was developed to supply the need for remote reading of utility meters, for example, for measuring the consumption of gas or water meter in the home. When interrogated, the meters deliver the data they have collected to a common master, which can be a computer connected at periodic intervals to read all utility meters of a building.

VI. CONCLUSION

Meter reading and billing processes can be done automatically by remote meter reading technique. Shorten the time between these processes can become possible by automatic meter reading systems. Illegal use on the basis of meters can be easily determinable by point control. Although client tracking is possible in invoice system only after two or three unpaid invoices, instant followings can be done in remote reading system.

Meter reading processes, which could only be done by checking each meter and consist of recording index values, have improved enormously. Changing market conditions has brought new necessities in energy sector.First investment on M-Bus systems has been made by German Techem GmbH Company. After that in order of; German Siemens AG, Denmark Danfoss GG companies have penetrated into international market with their own products.

M-Bus (meter bus) communication system is a protocol which works in communication network such as Profi-Bus, Can-Bus or Mod-Bus. This system performs each function with a wire which makes dual data transfer. It is necessary to use multi wire in other communication systems (especially in dual way communication systems). Considering dual data transfer, energy transmission and easiness for the users, this system is the most accurate method for heating cost sharing and remote meter reading.

This interface, which is easy to use, minimizes error rate, makes it easy to read heating meters and calorimeters automatically. In this study, it is no longer necessary to control each meter and read consumed energy data. This application can read the meters automatically in specific days of week/month.

Supported communication method (M-Bus), presents different alternatives for the environments that meters can be used. It also supports common meter communication problems independent of brand and models. All meters, which are connected to M-Bus system, can be read by data transmission from an external unit directly or indirectly. This system provides a more flexible observation for the energy balance of the buildings and increases quality of life.

Reading meter values can be done without mistake by M-Bus software which is prepared within this study. Besides it provides opportunity of billing of consumption values of the meter.

This study can be used in M-Bus compatible meter reading applications and similar projects as a reference in the future. Also this study, which introduces and studies M-Bus detail, will guide to people and institutions who will study about this subject.

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