Remote Monitoring Energy Management System using LonWorks and Modbus Communication Protocol

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Abstract - ***This paper focuses on the features of prudent monitoring and communication protocols used for Remote Monitoring Energy Management System (RMEMS). Devices installed independently for monitoring energy and process are normally incompatible to communicate with other devices due to which the plant technical personnel often felt difficult to integrate the independent automation and control devices into a single integrated system due to their lacking in interoperability. There are most compatible and widely used interoperability communication protocols today are LonWorks and Modbus. The requirement of RMEMS, nodes specification, wiring configuration using i-Lon smart server is presented in this paper along with brief comparison between these two communication protocols.***

Key Words: *RMEMS, Energy nodes, Physical nodes, LonWork, Modbus, i-Lon smart server*

1. INTRODUCTION

The current energy crisis reveals the importance of energy conservation in all areas. The energy management includes effective producing and efficient operation of major energy consuming utilities [1]. The remote monitoring energy management system (RMEMS) is a system of computer-aided tools used by operators to monitor, control, and optimize the performance of the energy intensive electrical utilities. RMEMS system analyzes the various circumstances under which the energy has been consumed higher than what is needed than the process and personal requirements considering the changing the environmental parameters. This requires a large number of sensors and a distributed database system to analyze the energy variations. The monitor and control functions are developed by using communication protocols and smart server (i-LON). This paper dealt with RMEMS built with LonWorks / Modbus communication protocols. Both the protocols can be used in the industries and commercial places for energy management system. Energy produced and supplied to us with a great hardships but we easily ignore how much energy is consumed to produce [2]. Energy can be saved to a great extent by properly managing the energy while ensuring reliability of critical loads. The intelligent remote monitoring energy management system can be used in the industries / commercial buildings to analyze the energy flow, requirement, excess consumption and ways to minimize the excess consumption without affecting the normal production and increase the efficiency of all energy consuming utilities.

2. REQUIREMENTS FOR RMEMS

1. PC with RMEMS software
2. Communication protocols
3. PCLTA card & iLon server for web connectivity
4. Energy nodes (HT and LT)
5. Physical node
6. Digital I/O nodes for control
7. Transmitters for measuring temperature, flow, pressure

2.1 HT/LT Energy Node

It is a comprehensive electrical energy transmitter based on the state of art energy measurement solution and neuron processor with embedded communication protocol. It can be used for measurement of either HT or LT three phase 3 or 4 wire system.

- The Energy Meter shall be calibrated for class I accuracy and be accurate to ± 1% from 5 % to 100 % of the rated current.
- The Energy Meter shall consist of three Current Transformers (CTs) with the power metering electronics embedded inside the enclosure with LCD display for local display and calibration pulse LED.
- The LT Energy Meter shall directly accept any voltage input from 170-280 VAC (Phase to neutral).
- The HT Energy meter shall accept inputs from industry standard instrument transformers (110 VAC secondary PTs and 5 A secondary CTs).

- The Energy Meter shall be internally isolated to 2kV AC.
- The Energy Meter case isolation shall be 600 VAC.
- Energy Meter shall have built-in LONTALK or Modbus protocols for data communications on twisted pair FTT to allow multipoint communication to other host devices, with a data rate of 78000 baud.
- The Energy Meter shall be installed as part of Energy Management System.
- The information and capabilities provided by the Energy Meter shall include the following:
    - Current, per phase & three-phase total
    - Voltage, per phase & three-phase total, phase-to-phase & phase-neutral
    - Real Power (kW), per phase & three-phase total
    - Reactive Power (kVAR), three phase total
    - Apparent Power (kVA), three phase total
    - Power Factor, per-phase & three-phase total
    - Real Energy (kWh), three phase total

2.2 Wiring Configuration

The internal circuit configuration of energy node is shown in Fig.1 given below. It consists of signal conditioning, measurement, neuron processor, display and power supply functional blocks. One energy node having 12 terminals in which 6 for CTs built inside of it, 3 for voltage, one is for ground, remaining two are communications cables which are working based on Lon works and Modbus communication protocols.

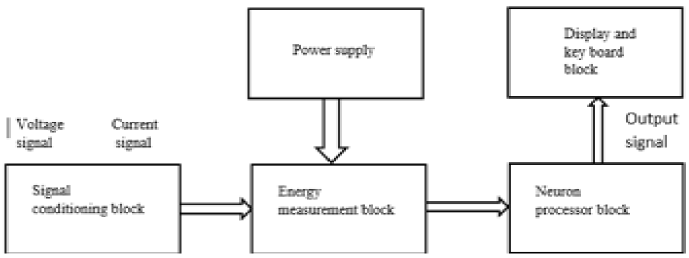

Fig – 1: Internal circuit configuration of energy node

2.3 Physical Node

Physical node is used for connecting the physical parameters to the network for measurement of process parameters. The hardware is based on the 16 bit Serial Sigma delta A/D converter and neuron processor. The firmware is developed in such a way it allows the user for configuration in accordance with specific parameters.

Specifications:

Input of Each channel	: 4-20 mA or 0 to10V
Accuracy	: +/- 1%
Parameters monitored	: Temperature, level, pressure
Display	: 6 digit seven segment
LED display	: LEDs for status and units
Output	
Network interface	: FTT on twisted pair
Operating temp	: 0-60°C
Communication	: Lon Works/Modbus
Distance	: 0.3-1.2K.M.
Baud Rate	: 38-78kbps
Cabinet	: Industrial Panel Mounting

2.4 Digital I/O Node

It provides 24 digital I/O channels, which can be configured either as input or output. The input channels can be used for checking the ON / OFF status of feeders, circuit breakers and loads like pumps, fans heaters, coolers, etc. The output channels can be used for control (such as demand controllers, voltage tap changers, power factor controllers, tripping of circuit breakers etc.)

Specifications

No of I/O Channels	: 24
Output of 8 channels	: Relay outputs
Parameters monitored	: Any digital I/O signals
Network interface	: RS-485
Communication	: Lon Works/Modbus
Distance	: .3-1.2K.M.
Baud Rate	: 9600

3. COMMUNICATION PROTOCOLS

3.1 LonWorks

LonWorks is a proprietary protocol invented by the Echelon Corporation. The Lon Work standard is based on the proprietary communications protocol called Lon Talk [3]. The Lon Talk protocol establishes a set of rules to manage communications within a network of cooperating devices. Lon Talk addresses the issue of how devices communicate; it does not consider the content of the communication [4]. A second protocol, known as LonWorks, defines the content and structure of the information that is exchanged. The LonWorks platform supports a wide range of communications media. Lon Works is a distributed control system that operates on a peer-to-peer basis, meaning any device can communicate with any other device on the network or use a master-slave configuration to communicate between intelligent devices.

3.2 Modbus

The Modbus protocol was developed during the 1970s by Mod icon, Inc. for use in industrial automation systems with programmable controllers [3]. Today it is one of the most widely used means for connecting electronic equipment in industrial applications. Its simplicity is also making it a useful tool for achieving interoperability in building automation applications. Modbus consists of a messaging structure designed to establish master-slave, client-server communications between a wide ranges of intelligent devices. It supports traditional serial and Ethernet protocols. It is a truly open standard and is one of the most widely used protocols in the industrial manufacturing environment. There is no charge for using the protocol nor are there licensing fees [6]. Tools and resources that can be used to expedite installation and support operations are available on-line.

The original version of Modbus included two transmission modes: ASCII and RTU. More recently, Modbus/TCP was developed; allowing the Modbus protocol to be transmitted over TCP/IP based networks. While Modbus was initially designed for use in industrial applications, its use has rapidly spread to building automation, transportation, and energy applications. Its strengths include openness, simplicity, and minimum hardware requirements. Another significant benefit is the protocol's use of the TCP/IP transport protocol, the same protocol used by the Internet [7]. This means that Modbus can readily be used over the Internet.

3.3 i-Lon Smart Server

The i.LON® Smart Server is a low-cost, high-performance controller, network manager, router, remote network interface, and Web server that connects LONWORKS®, Modbus, and M-Bus, and devices to corporate IP networks or the Internet[6]. The top view of i-LON smart server is shown in Fig. 2. The Smart server features a built-in Web server that allows Web access to all the data managed and controlled by the Smart Server, as well as built-in applications for alarming, scheduling, logging, and translating data types [8, 9].

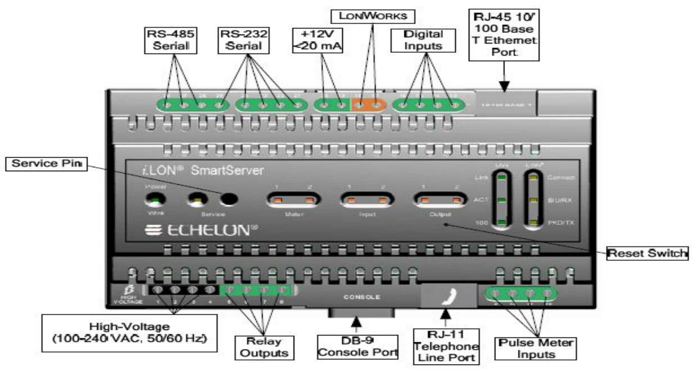

Fig – 2: Top view of i-LON Smart Server

3.4 Remote Monitoring Energy Management System (RMEMS)

The energy nodes elaborated and tested as per specification is connected to i-LON smart server [10]. The i-LON smart server is a flexible energy manager and has a web server that is integrated to it. This manages the energy nodes that are connected to it and links them to the operator workstations. The server has inbuilt data logger and schedulers that stores and retrieve the data from the node. The server has the advantages that a large number of nodes can be connected at the same time and monitored as well. The smartness of this system is further enhanced by the fact that i-LON server can be interfaced with IP based application. Wiring configuration of energy nodes connected with RMEMS is shown in the following Fig.3.

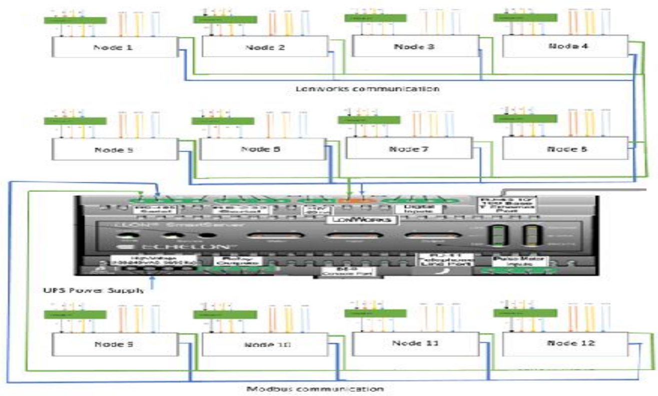

Fig – 3: Wiring configuration of energy nodes connected in RMEMS

The energy meters connected to the server can be monitored remotely and configured. The photo images as shown in the figures 4-9 depicts the implementation of remote monitoring energy management system using the stand alone computer and i-LON smart server [11].

The data from the individual energy nodes are obtained using twisted pair cable to smart server. The smart server has both the slots for LonWorks communication and Modbus communication. Further these values are transferred to using RJ45 cable. Thus a large number of nodes can be simultaneously monitored. i-LON smart server has the provision for being introduced with the internet. This makes the whole system as a web based monitoring system.

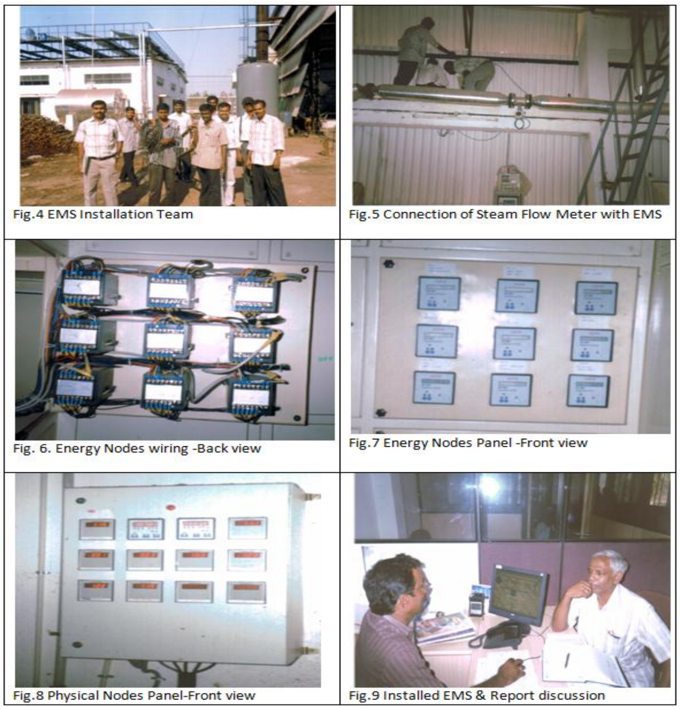
Fig.4 EMS Installation Team
Fig.5 Connection of Steam Flow Meter with EMS
Fig. 6. Energy Nodes wiring -Back view
Fig.7 Energy Nodes Panel -Front view
Fig.8 Physical Nodes Panel-Front view
Fig.9 Installed EMS & Report discussion

Fig - 4 – 9: Installation of RMEMS

The monitoring parameters obtained from each node can be seen at the remote location. Hence, there is a possibility for the users to develop the applications like performance analysis of connected loads, fuel analysis, billing, maximum demand estimation, process optimization and control for efficient energy usage including the use of renewable energy sources.

3.5 Comparison between LonWorks and Modbus Communication Protocol

1. Polarity: - LonWorks terminal interface is polarity insensitive. In Lon Works communication if twisted pair cables are polarity sensitive or insensitive then terminal location can be interchanged. While Modbus is polarity sensitive, so does not matters that twisted pair cables are polarity sensitive or not, but it works only on polarity based terminals.

2. Economical: - LonWorks system tends to be more expensive due to the cost of licensing the protocol and co-ordinate it. As it has been earlier mentioned that Modbus does not require any license for establishment of network, so it is less costly than Lon Works [7, 12].

3. Proprietary: - LonWorks is a proprietary protocol that has been some success among 2nd and 3rd tier BAS (building automation system). Proprietary protocol refers to that protocol the metering device originally designed to use. This protocol supports the complete set of data acquisition capability offered by metering device. Where Modbus is a non-proprietary protocol among both meter manufacturer and building automation manufacturer. It is supported by many building automation system companies [7].

4. Communication: - LonWorks is not used to communicate energy use histories. Modbus used to communicate status. The calling devices construct data histories by making data request from meters. If the calling device calls the various meters at different times the resulting data histories may have timestamps that are not aligned. If the calling device is not connected to meter, is off-line, or is turned off, there will be a gap in the meter data history record

Table 1-3 depicts the physical characteristics, transport mechanism and general performance comparison of Lon Works and Modbus protocols respectively.

Table -1: Show physical characteristics of communication protocols

Sr. No	Parameters	Physical characteristics	
		LonWorks	Modbus
1	Network topology	Bus, ring, loop, star	Line, star, tree, network w/segments
2	Physical media	Twisted pair, fiber, power lines	Twisted pair
3	Max. devices(Nodes)	32,000/domain	250 nodes per segment
4	Max. distance	2000m @78kbps	350 m

Table -2: Transport mechanism of Lon Works and Modbus protocols

Sr. No	Parameters	Transport mechanism	
		LonWorks	Modbus
1	Communication method	Master /Slave peer to peer	Master /slave
2	Transmission process	1.25 Mbps full duplex	300bps -38.4 kbps
3	Data transfer size	228 bytes	0-254 bytes
4	Arbitration method	Carrier sense, multiple	Peer to peer, token passing access
5	Error checking	16 bit CRC	16 bit CRC

Table - 3: General performance comparison of communication protocols

Sr. No	Parameters	Performance	
		LonWorks	Modbus
1	Cycle time (250 discrete 16 nodes with 16 I/os)	20 ms	< 1 ms
2	Cycle time (128 analog 16 nodes with 8 I/os)	5 ms @ 1Mbps	< 1 ms
3	Block transfer of 128 bytes 1 node	5 ms @ 1 Mbps	1ms

4. CONCLUSIONS

The present investigation was made to study the remote monitoring energy management system using Lon Works and Modbus communication protocols. It was observed that Modbus based RMEMS was compatible for small and medium scale industries due to small distance criteria i.e. 350 m whereas Lon Works was compatible for large scale industries with a region of 2000 m . Lon Works can also be used in small and medium scale industries but the cost of that RMEMS would be higher for the reason that the Lon Works based RMEMS system require licensing for the entire network. Modbus does not compatible for large industries due to slow transmission process of 300bps- 38 kbps. Lon works is preferred for large scale industries due to its enhanced (i.e. 1.25 Mbps full duplex) transmission process and its capability of accommodating 32000 communication nodes in single domain.

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BIOGRAPHIES

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