International Journal of Engineering Research and Development (IJERD) ISSN: 2278-067X
Recent trends in Electrical and Electronics & Communication Engineering
(RTEECE 17th – 18th April 2015)

Interfacing of MODBUS devices with Large Scale Integrated Control System

Aniruddh Mali[1], Ramesh Joshi[2]
[1]*L.D. College of Engineering, Ahmedabad*
[2]*IPR, Gandhinagar*
[1]aniruddhkmali@gmail.com
[2]rjoshi@ipr.res.in

Abstract:- Research and development institutes/ organizations comprise large scale integrated system for experimental research. Indian manufacturing industries also comprise the same for mass production. Logic controllers, data acquisition and measurement instruments, switching devices, scaling machines, etc. are being used widely in industry. It needs to be controlled and monitored constantly during its operation round the clock for failsafe operation to improve productivity. Different types of interface modules have to be integrated with it for controlling purpose. It is needed to have a control system which constantly monitors each component of it. MODBUS protocol supported devices are available in market which provides ease of interfacing with any platform oriented data acquisition and control (DAC) system. It also supports different communication media which provides flexibility as well feasibility of integration with control system. It avails complete control of each physical component of the system on a mouse click event. User has the full fledge control to drive the system. This paper describes a case study of integration of MODBUS devices with large scale integrated control system with its comparison.

Keywords:- MODBUS, DAC, Logic controller, acquisition,monitoring

I. INTRODUCTION

Large Scale Integrated Control System (LSICS) is needed to control, operate and maintain large scale complex machine system in research field. Industries have manufacturing plants for mass production established in a large geographical area, where each component/unit is at very large distance. There are a number of instruments, devices and switches used to run the complete system without fail. Each component has to be monitor manually which cause engagement of a number of human resources as well time consuming. It also causes human errors. All these devices have different interface facility for data communication as well control. Some of devices have proprietary protocols specifically developed for the hardware. DAC provides facility to design & develop a rugged, sustainable as well feasible control system. It should have feasibility to integrate any device with the system. MODBUS supported devices can be integrated with complex control system using available media easily. Logic controllers, etc. devices are available with MODBUS support in industry. This paper describes interfacing of MODBUS supported devices with LSICS. It has been explained with a case study of both research fields as well industry problem solution.

II. LARGE SCALE INTEGRATED CONTROL SYSTEM

A number of test and measurement instruments, devices and protection system/ interface are being used with high voltage (HV) power supplies, which are further integrated with large scale complex machines. Proprietary instruments and devices have its own device driver/protocol for communication/ interfacing with control system i.e. DAC. It is needed to develop specific device driver/protocol for each such instruments/devices which cause consumption of time as well makes the system more complex. It also causes increased data traffic at control side. Further, it also need separate electronic interface for power requirement compatibility which increase cost also. This electronic interface needs power arrangements for its operation. It increases electronic hardware support in the system. Voltage signal level constraint is an important factor in such system because parent system avail the output on high voltage level which needs to be step down. DAC system need low voltage level i.e. 5V based technology. It needs to be compensating to synchronize the complete system along with proper isolation of each stage. We have taken two case studies i.e. (1) RF research and (2) Power consumption monitoring using energy meter. Both cases have explained in following section of the paper. Application and utilization of MODBUS protocols has been explained with these two case studies which provide

industry oriented solution.

A. HVPS in RF research and development

HV power supplies (HVPS) integrated RF systems are widely used in RF research and development all over the world in fusion reactors as well microwave applications. Fig. 1 shows snapshot an industrial HVPS.

HVPS has a control circuit, driver circuit and protection circuit for failsafe operation. It needs high speed switching during its operation. With advancement of technology, PLCs are used to control its signal flow for the same which comprise analog and digital control signal. HVPS has manual mode of operation. It can be operated remotely using PLCs which can be programmed using ladder logic. There are a number of multifunctional control signals to drive the complete system using DAC which comprises integrated control sections. As such power supplies produce MW (mega watt) level power at a particular frequency ranges from Hz to GHz, it needs optical isolation with DAC as well load i.e. fusion reactor machine. The complete system is on large scale and has integrated with multidisciplinary environment. It's a challenging task to integrate a new component/section with such complex system. Further, waveguides are used as transmission media to carry RF generated power to deliver at load which is identified as 'Transmission Line' (Tx), manufactured from high conducting copper material. To match impedance of produced power in different transmission lines, it has to be moved mechanically/manually. A combination of PLC and stepper motor can be used to drive it. In this case,it is possible to operate Tx lines remotely. MODBUS provides a universal communication interface to such multidisciplinary system. MODBUS protocols are widely used in industry to control and operate logic controllers.

Fig. 1: High Voltage Power Supply (HVPS)

B. Power consumption monitoring using energy meter

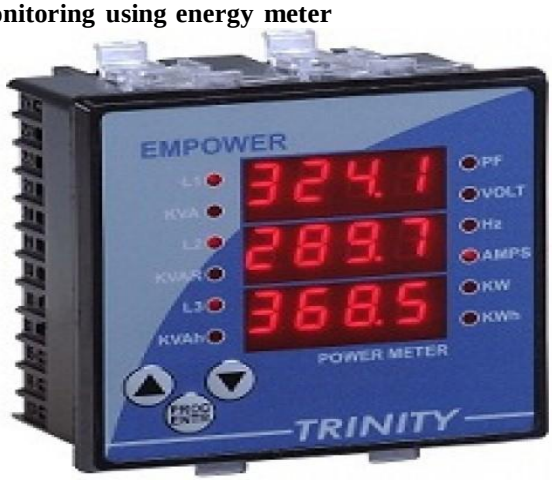

Fig. 2: Energy meter

Industrial plants are established on a large geographical area for mass production especially in manufacturing industry. It needs high voltage input requirement to run the plant. It needs to monitor power consumption to the load i.e. plant round the clock during production. Proprietary energy meters are available in market to monitor power consumption. These energy meters are connected with 3 phase high voltage line, assemble in panel with lamp indicators. It shows power consumption in unit of 'kWh'. There are a number of energy meters are mounted in panels to monitor power consumption in production unit of the plant. It has to be monitor and record unit value periodically which consume time as well engage human resource. Fig. 2 shows proprietary energy meter. It has serial as well Ethernet interface.

III. INTERFACING WITH MODBUS DEVICES

MODBUS protocol supported devices can be interfaced with any system at ease. It provides communication interface over any network i.e. RS232, RS485 and Ethernet. It requires range of MODBUS addresses for a specific device which needs to be interfaced. This protocol defines a message structure that controllers will recognize and use, regardless of the type of networks over which they communicate. It describes the process a controller uses to request access to another device, how it will respond to requests from the other devices, and how errors will be detected and reported. It establishes a common format for the layout and contents of message fields.

A. MODBUS transactions on serial interface

The MODBUS protocol establishes the format for the master's query by placing into it the device (or broadcast) address, a function code defining the requested action, any data to be sent, and an error–checking field. The slave's response message is also constructed using MODBUS protocol. It contains fields confirming the action taken, any data to be returned, and an error–checking field. If an error occurred in receipt of the message, or if the slave is unable to perform the requested action, the slave will construct an error message and send it as its response. The master can address individual slaves, or can initiate a broadcast message to all slaves. Slaves return a message (called a 'response') to queries that are addressed to them individually. Responses are not returned to broadcast queries from the master.

B. MODBUS transactions on other network i.e. Ethernet/MAP

It uses a peer–to–peer technique, in which any controller can initiate transactions with the other controllers. Thus a controller may operate either as a slave or as a master in separate transactions. Multiple internal paths are frequently provided to allow concurrent processing of master and slave transactions.

C. Query–Response Cycle

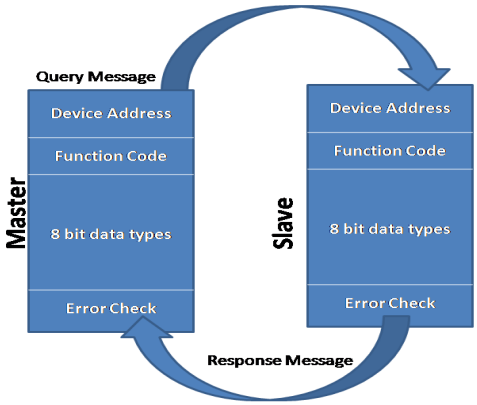

Fig. 3: Flow of query-response cycle

Fig. 3 shows query-response cycle which has been used in interfacing of MODBUS devices with large scale integrated control system. Each query consist device address, function code which describe a particular function i.e. read/write and its data type with error check. Master generated a query with these

information which later on replied by slave device on a particular network.

D. Different interfacing methods

MODBUS has serial and Ethernet interface facility. It supports ASCII, RTU mode in serial interface. Proprietary PLCs are provided with SCADA/HMI development software packages which can be used to interface it using MODBUS. It has to be purchase a separate license for such software packages. OPC Server is very famous for such interface development. National Instruments (NI) provides OPC server based interface facility based on MODBUS protocols, identified as 'NI OPC'. It has capability to communicate with any PLC which is an added advantage. It has communication drivers already avail with the server.

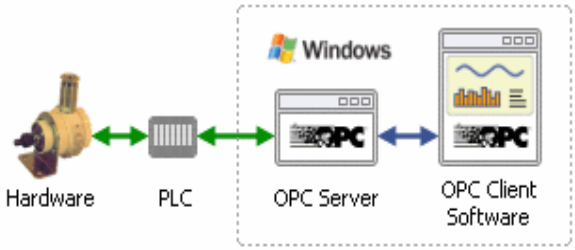

Fig. 4: OPC server communication method

1. OPC Server

OPC stands for 'OLE for Process Control' provides an interface to access data from many different software packages, which supports different protocols. It can be used for integration of PLC based HVPS to large scale DAC control system. Fig. 4 shows typical communication setup of OPC server with software as well load. Fig. 5 shows snapshot of NI OPC server using which any MODBUS supported device can be interfaced. Particular channel access has to be created in it by selecting interface media i.e. serial, Ethernet. Communication parameters can be set using a wizard provided by it. It can be used as a industrial solution in RF research environment for HVPS. It is needed to purchase a license of this software package.

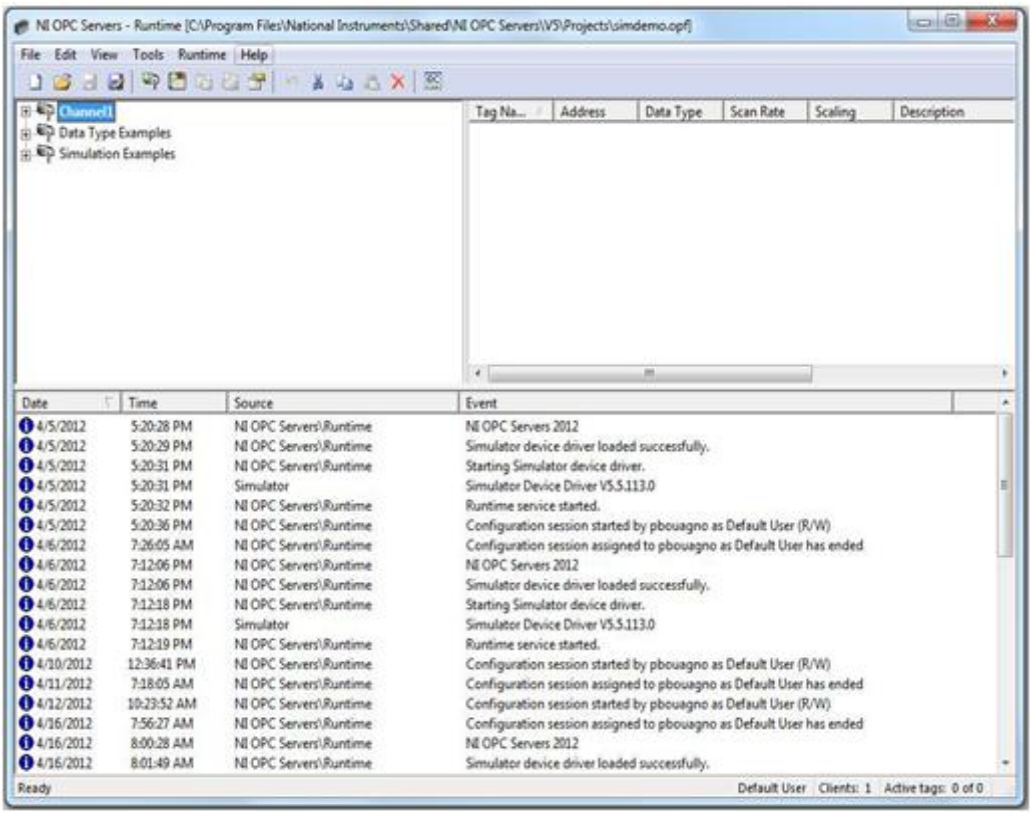

Fig. 5: OPC Server

2. PYMODBUS

It's a software package which supports python/java environment. It is a full MODBUS protocol implementation using twisted for its asynchronous communications core. It can also be used without any third party dependencies (aside from pyserial) if a more lightweight project is needed. It's a light weight and occupies very less space on computer system. It's an open source software package. It can be used with EPICS/CSS GUI development software packages which are also open source technology. It is totally free software packages. User does not need to pay for it. It provides high speed runtime data updating.

E. Summary

NI OPC can be used to interface PLC based HVPS with large scale DAC system. It provides low cost solution with high data transfer speed. Each component can be integrated at ease. It provides a single API for data communication as well controlling and monitoring of the system.

Energy meter has 2 wires RS485 interface, supported by MODBUS protocols. NI LabVIEW can be used to develop a graphical user interface for it. It provides uninterrupted communication. A single RS485 to USB adapter can be used to connect it to PC on which 31 devices can be connected.

IV. CONCLUSIONS

In both cases, MODBUS protocols are found as best solution for interfacing slave devices with large scale integrated control system. It support different communication media as well provides data redundancy.

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