Implementation of Web Based Intelligent Substation Power Equipment Monitoring and Controlling System

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Abstract— **The paper proposes an innovative design to develop a system based on ARM micro controller that is used for monitoring the voltage, current and temperature of a substation and to protect the system from the rise in mentioned parameters. Providing the protection to the distribution transformer can be accomplished by shutting down the entire unit and displays the values at substation display unit. Moreover the system displays the same on a PC at the main station which is at a remote place by using the Ethernet it is possible by ENC28J60.**

Keywords- **distributed system; on-line monitor; ENC28J60**

I. INTRODUCTION

Electricity is an extremely handy and useful form of energy. It plays an ever growing role in our modern industrialized society. The electrical power systems are highly non-linear, extremely huge and complex networks. Such electric power systems are unified for economical benefits, increased reliability and operational advantages. They are one of the most significant elements of both national and global infrastructure, and when these systems collapse it leads to major direct and indirect impacts on the economy and national security. A power system consists of components such as generators, lines, transformers, loads, switches and compensators. However, a widely dispersed power sources and loads are the general configuration of modern power systems. Substation apparatus failure plays a major role in reliability of power delivery systems. Traditionally, most utilities perform regular maintenance in order to prevent equipment breakdown. Condition-based maintenance strategy monitors the condition of the equipment by measuring and analyzing key parameters and recommends optimum maintenance actions. Equipment such as transformers and standby batteries which are valuable and critical assets in substations has attracted increased attentions in recently years.

II. DESIGN OF THE DISTRIBUTED ON-LINE MONITORING SYSTEM OF SUBSTATION POWER EQUIPMENT

In the IEC61850-based distributed communication networks and systems, the communication between the process level and bay level uses the serial Ethernet. In a distributed network, there are a large number of sensors. Merging unit is the important component of digital output interface. The distributed on-line monitoring system of substation power equipment, based on IEC61850, is shown in figure 1. In the system, Merging unit, which adopt ARM MPU, collects the field signal and realizes signal processing, such as signal amplification, signal modulation, A/D conversion etc, packets the sampling value according to the standard format (IEC61850 9-2 adopts the Ethernet code format), and directly sends the sampling value to Ethernet. Merging unit contains the functions of data acquisition and signal processing, data synchronization, information exchange. Monitoring unit realizes the field data acquisition via Ethernet and calculation of the monitoring parameters.
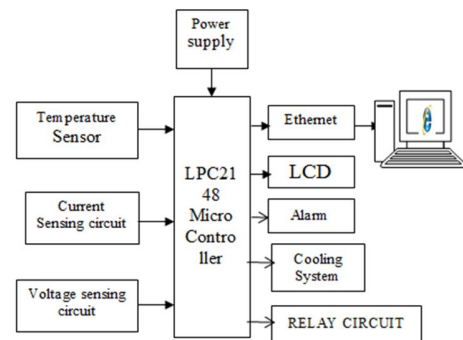

Fig. 1   Block Diagram

This project makes use of an onboard computer which is commonly termed as microcontroller. This onboard computer can efficiently communicate with the different sensors being used. The controller is provided with some internal memory to hold the code. The controller is programmed using Embedded C language. In this project mainly we are using a micro controller, and an ADC. Here ADC is used for monitoring voltage, temperature and current. According to the set values which are fixed in micro controller, the voltage levels, current levels and temperature levels are monitored and these are controlled through microcontroller in such a way that if voltage is increased or decreased then the relay is operated that is transformer is tripped. In the same way when temperature is increased the cooler is on. And all these values will be fed to the pc through serial port network. Even this can be controlled

manually through PC. Hence the substation is monitored and controlled.

III. DESIGN OF THE SYSTEM

A. Voltage sensing circuit

This circuit is used to measure the AC voltage. It converts AC 230v into 5v DC, for this we use step-down transformer [6], bridge rectifier, capacitor filter and voltage dividing circuit.

Whenever the input AC voltages changes, then the output DC voltages also changes, this output voltages is given to ADC pin of controller for processing [3].

B. Current sensing circuit

This circuit is used to measure the output load current. In this we use 230/6v step-down transformer in current transformer mode, the output voltage of this transformer will change according to the load current [9][3]. This output voltage will be given to rectifier circuit for converting into DC and then to voltage divider circuit to generate compatible voltage for ADC of micro controller,

Whenever the load power consumption changes, then the output DC voltages also changes, this output voltages is given to ADC pin of controller for processing.
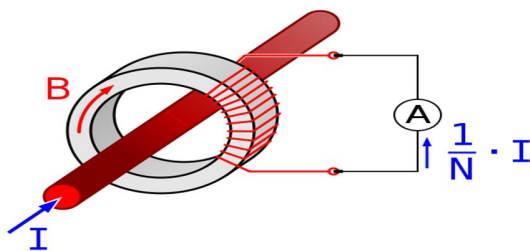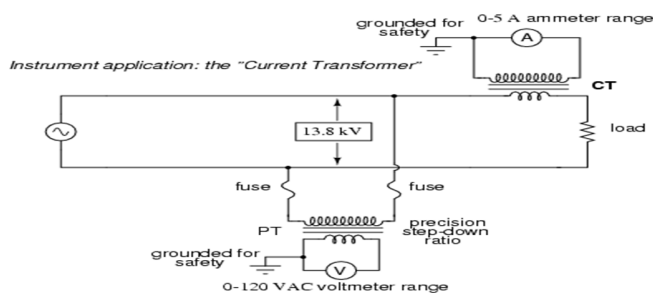

Fig. 2 current transformers.

Fig. 3. Current and voltage Sensing Circuit

C. ENC28J60 (Stand-Alone Ethernet Controller with SPI Interface)
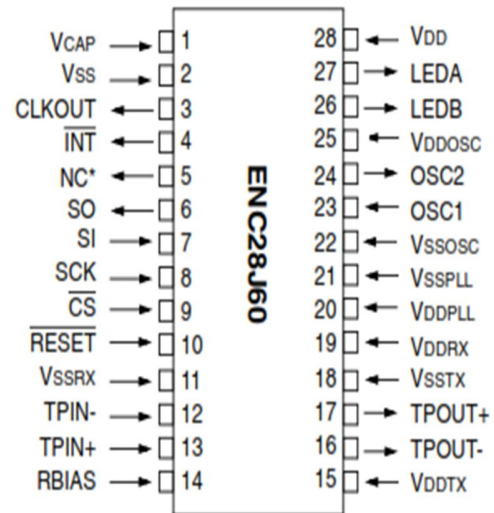

Fig. 4 ENC28J60 pin diagram

The ENC28J60 is a stand-alone Ethernet controller with an industry standard Serial Peripheral Interface (SPI) [10]. It is designed to serve as an Ethernet network interface for any controller equipped with SPI. The ENC28J60 meets all of the IEEE 802.3 specifications. It incorporates a number of packet filtering schemes to limit incoming packets. It also provides an internal DMA module for fast data throughput and hard-ware assisted checksum calculation, which is used in various network protocols. Communication with the host controller is implemented via an interrupt pin and the SPI, with clock rates of up to 20 MHz. Two dedicated pins are used for LED link and network activity indication. A simple block diagram of the ENC28J60 is shown in Figure 2. A typical application circuit using the device is shown in Figure 3. With the ENC28J60, two pulse transformers and a few passive components are all that is required to connect a microcontroller to an Ethernet network.

- ☐ It is a Stand-Alone Ethernet Controller with SPI Interface.
- ☐ IEEE 802.3 compatible Ethernet controller.
- ☐ Supports Full and Half-Duplex modes.
- ☐ Programmable automatic retransmit on collision.
- ☐ 8-Kbyte transmit/receive packet dual port SRAM
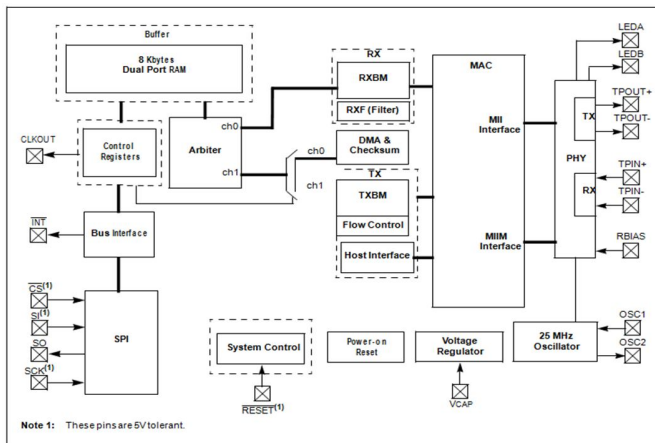- ☐ Supports Unicast, Multicast and Broadcast packets

Fig. 5   ENC28J60 Block Diagram

LPC2148 is interfaced to Ethernet module by SPI protocol. SPI is quite straightforward. It defines features any digital electronic engineer would think of if it were to quickly define a way to communicate between 2 digital devices. SPI is a protocol on 4 signal lines.
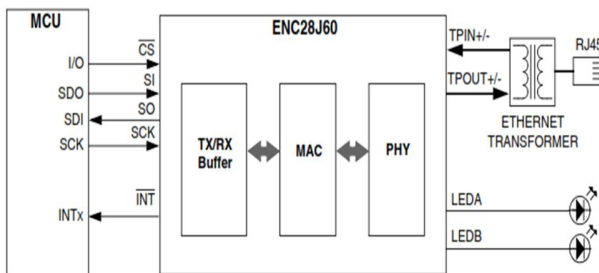

Fig. 6 Typical ENC28J60 Based Interface

1. A clock signal named SCLK, sent from the bus master to all slaves; all the SPI signals are synchronous to this clock signal;
2. A slave select signal for each slave, SSn, used to select the slave the master communicates with;
3. A data line from the master to the slaves, named MOSI (Master Out-Slave In)
4. A data line from the slaves to the master, named MISO (Master In-Slave Out).

SPI is a single-master communication protocol. This means that one central device initiates all the communications with the slaves. When the SPI master wishes to send data to a slave and/or request information from it, it selects slave by pulling the corresponding SS line low and it activates the clock signal at a clock frequency usable by the master and the slave. The master generates information onto MOSI line while it samples the MISO line.

Four communication modes are available (MODE 0, 1, 2, 3) that basically define the SCLK edge on which the MOSI line toggles, the SCLK edge on which the master samples the MISO line and the SCLK signal steady level (that is the clock level, high or low, when the clock is not active). Each mode is formally defined with a pair of parameters called 'clock polarity' (CPOL) and 'clock phase' (CPHA).

A master/slave pair must use the same set of parameters – SCLK frequency, CPOL, and CPHA for a communication to be possible. If multiple slaves are used, that are fixed in different configurations, the master will have to reconfigure itself each time it needs to communicate with a different slave. SPI does not define any maximum data rate, not any particular addressing scheme; it does not have a acknowledgement mechanism to confirm receipt of data and does not offer any flow control. Actually, the SPI master has no knowledge of whether a slave exists, unless 'something' additional is done outside the SPI protocol. For example a simple codec won't need more than SPI, while a command-response type of control would need a higher-level protocol built on top of the SPI interface. SPI does not care about the physical interface characteristics like the I/O voltages and standard used between the devices. Initially, most SPI implementation used a non-continuous clock and byte-by-byte scheme. But many variants of the protocol now exist, that use a continuous clock signal and an arbitrary transfer length.
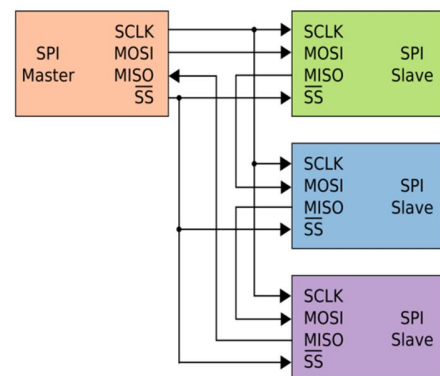
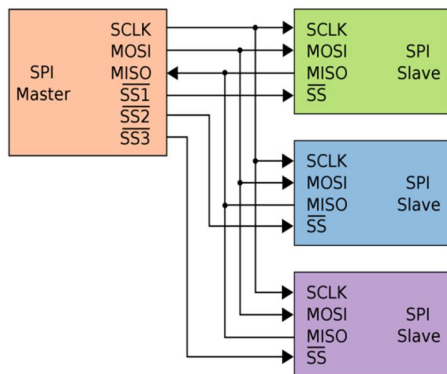

Fig. 7   Daisy chain configuration.

Fig. 8   Independent slave configuration

This protocol has two configurations one is independent slave configuration as shown in figure 7 and another one is daisy chain configuration as shown in figure 8. In the independent slave configuration, there is an independent chip select line for each slave. This is the way SPI is normally used. Since the MISO pins of the slaves are connected together, they are required to be tri-state pins.

Some products with SPI bus are designed to be capable of being connected in a daisy chain configuration, the first slave output being connected to the second slave input, etc. The SPI port of each slave is designed to send out during the second group of clock pulses an exact copy of what it received during the first group of clock pulses. The whole chain acts as an SPI communication shift register; daisy chaining is often done with shift registers to provide a bank of inputs or outputs through SPI. Such a feature only requires a single SS line from the master, rather than a separate SS line for each slave.

Ethernet module ENC28J60 is connected using SPI protocol. This Ethernet module is connected to internet through RJ 45 jack which have 8 pins. This Ethernet module ENC28J60 has 8kb of buffer to collect the frames m the controller then that data is uploaded to internet. For showing this values in the internet assign one address to the Ethernet module, by using this web address we can log into the web page which is created by html coding. In this web page we have two sections one is for monitoring section which shows the sensor values another one is control section. Through the control section we can on and off the substation when we notice any problems. This will help to EB department to monitor the substation status where ever they are in the world.

IV. RESULT

The project "IMPLEMENTATION OF WEB BASED INTELLIGENT SUBSTATION POWER EQUIPMENT MONITORING AND CONTROLLING SYSTEM" was designed such that the devices can be monitored and also controlled from anywhere in the world using Ethernet. In this paper we have presented a design of a system based on ARM microcontroller that is used to monitor and control the voltage, current and temperature of substation and automatically controlled.

V.   CONCLUSION

The proposed system has been designed to monitor the substation's essential parameters continuously throughout its operation. If the microcontroller recognizes any increase in the level of voltage, current or temperature values the unit has been made shutdown in order to prevent it from further damages. The system not only controls the distribution transformer in the substation by shutting it down, but also displays the values throughout the process for user's reference. This claims that the proposed design of the system makes the distribution transformer more robust against some key power quality issues which makes the voltage, current or temperature to peak. Hence the distribution is made more secure, reliable and efficient by means of the proposed system.

VI.   FUTURE SCOPE

In future we can use this project in several applications by adding additional components to this project. This project can be extended by using GPRS technology, which helps in sending the monitored and controlled data to any place in the world. The temperature controlling systems like coolant can also use in places where temperature level should be maintained. By connecting wireless camera in industries, factories etc. we can see the entire equipment's from our personal computer only by using GPRS and GPS technology. The monitoring and controlling of the devices can be done from the personal computer and we can use to handle so many situations.

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