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# Web Based Remote Fault Analysis of Electrical Drives Using Microcontrollers

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***Abstract*: Electrical energy is finding increasing application in industrial and commercial fields. An electrical drive possesses a number of inherent advantages over the other forms of conventional drives. This paper describes the design and implementation of distributed embedded system to diagnose the faults in electrical drives from the remote place through a web page considering various parameters like voltage, speed, vibration etc.. This system design uses an embedded processor module, Ethernet module and bus interface. Here the drives, which are to be controlled, are connected through the bus on the web server circuit. The web-server is connected to the LAN. The client PC is also connected to the same LAN. By typing the IP-address of PC on the web server, the user gets a web page on screen that contains all the information about the status of the drives. The user can also control the drives interfaced to the web-server. Occurrence of faults, variation in parameters is found through remote diagnostics. SPI communication module connects processor and the Ethernet modules. The system aimed at consuming less power, hardware complexity is reduced using embedded processor and the terminal data can be transmitted and received efficiently.**

***Keywords*: LAN, Ethernet, Remote diagnostics.**

## 1. Introduction

Currently industrial drives are controlled by the microcontroller. However, a large number of drives do not have a network interface and data from the devices cannot be transmitted in network. Hence a design of embedded processor based Ethernet interface is used. The data acquisition equipment can be communicated through SPI interface and transmit to remote host computer via Ethernet interface. In the existing system, PC acts as both server and client. The power consumption will be very high. To reduce the power consumption, an embedded processor is used. In the system, the data can be transmitted between host and serial device (server & client). Flexibility is the key attribute for this system and can be easily adopted be to the needs of the industrial environment

## 2. System overview

The main purpose of the design is to provide efficient monitoring and controlling of drives from the remote places. In this system, the data are entered by switch to the embedded processor unit. Each action of the drive is stored in the memory through Ethernet controller. Status of each drive in the industry is monitored through web server in the client place. If the client wants to change the action of the devices, the data can be entered through web page. This data is taken by the embedded processor and then corresponding information is given to device via relay. The overall flow diagram is given in Fig. 1.

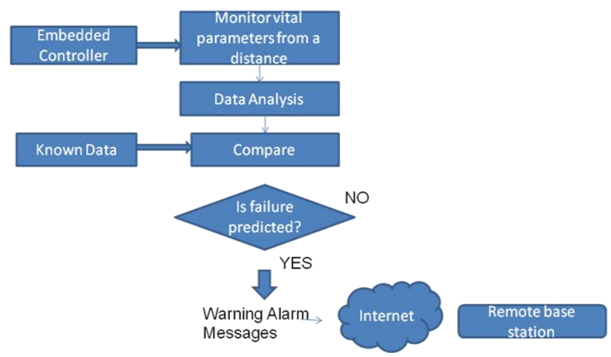


Fig. 1. Flow Diagram (Process Elements for Remote Diagnostics)

The embedded controller monitors the vital parameters viz. voltage, current, speed, vibration and the data are analyzed. Analyzed data is compared with known data and if there is a mismatch, failure is predicted and immediately, warning messages are sent to the remote base station via internet. For example, in an induction motor, rotor faults, bearing failures can be easily detected through remote diagnostics.

## 3. System design

### A. *Proposed model*

The main objective of the design is to make efficient monitoring system that has the capability of remote monitoring and data transmission is done by the Ethernet interface. Fig 2 shows the proposed system model. The proposed system model is divided as Lab side and the Control Centre with a diagnostic server on each side. The e-diagnostics operation in the proposed system model is well-defined by a set of designed framework messages as follows:

- An error message is delivered to the Data Acquisition server (DAS) by the equipment every time a fault occurs.
- DAS passes error messages to the onsite diagnostic server (ODS).
- ODS searches the local diagnostic database (available in the Lab side) for the diagnostic solution based on

the error message which is called as the checkpoint solution.

- Based on the checkpoint solution, DAS by itself with the help of onsite engineers may troubleshoot the equipment.
- The diagnostic status is reported by the DAS to the ODS.
- Whenever a solution is not found or the fault cannot be remedied, then an error message is sent by the DAS to the remote diagnostic server (RDS).
- RDS reports the DAS with the checkpoint solutions obtained from remote diagnostics system.
- DAS then reports the diagnostic status to the ODS and to the RDS to complete remote diagnostic operation.

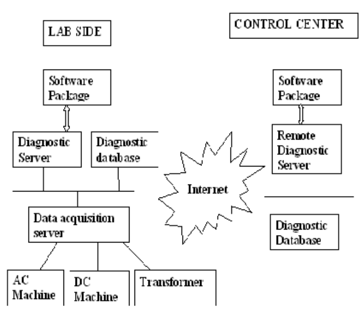


Fig. 2. Proposed system model

### B. Hardware architecture

The hardware design of the remote monitoring system consists of an embedded processor (microcontroller DSPIC-4011), CPLD, analog to digital converter, display unit, signal conditioning unit, sensors, storage system and communication interface. DSPIC 30F4011 is a 16-bit digital signal controller with various features including DSP Engine features, high performance modified RISC CPU< peripheral features, motor control PWM module features, Quadrature encoder interface module features, analog features, special microcontroller features like enhanced flash program memory, data EEPROM memory, self-reprogrammable under software control , programmable code protection etc. The basic architecture of the hardware is shown in Fig.3. Various signals from different equipment like AC machine, DC machine, transformers or circuit breakers, after signal conditioning are picked up by the sensors and converted to digital signals by the analog to digital converter. The data transmission with DSPIC and the A/D collection are controlled by the programmable data chip. RS-232, USB and Ethernet data communication way are designed in the system for the purpose of providing equipment operating condition information. This part is embedded in the devices as an independent hardware module. Alarm messages are sent through the network according to the equipment running status and provide the function of historical data query and information document management.

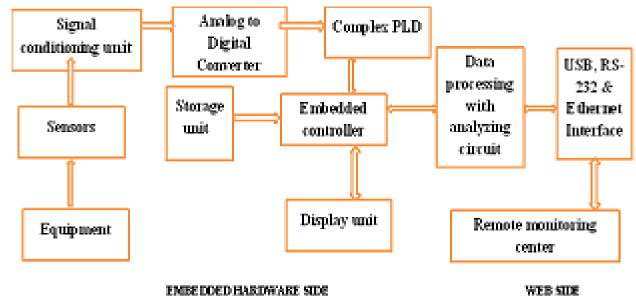


Fig. 3. Basic hardware architecture

### C. System internal structure

Fig 4 shows the system structure of network interface, SPI communication module connected between processor module and Ethernet module. Processor module is the core part of the design, in which the embedded chip LPC2148 is used to complete the complex operations. An ARM processor in the structure is replaced by DSPIC for its inherited features. The main purpose of the design is to make traditional monitoring system have the capabilities of remote monitoring or data transmission by introducing Ethernet interface it. In the design, structured modular design method is adopted and the system is mainly composed of SPI communication module, processor module and Ethernet interface module,

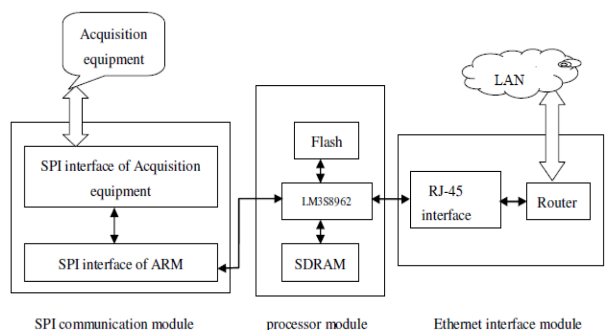


Fig. 4. System Internal Structure

In the module, data link between SPI port and Ethernet is established, SPI data stream format is specified, the transmission rate between serial data stream and IP data packets is controlled and IP packet is received or sent through reading or writing Ethernet interface module. In the Ethernet interface module, the collected data are uploaded to a PC via Ethernet interface and the commands from the host computer are received commands to control the data acquisition system. The web-server and client is connected to the LAN. When giving the IP-address of LAN on the web browser, the user gets a web page on screen; this page contains all the information about the status of the drives. The user can also control the devices interfaced to the web-server.

## 4. Communication module design

### A. SPI interface

SPI interface is used to realize synchronous serial data transmission between CPU and low-speed peripheral devices by way of full-duplex communication. Its data transfer rate is up to several Mbps. It achieves a transfer rate of 2Mbps. Fig 5 shows the communication module. SPI interface works in master-slave mode and it includes four signals: SCLK, MOSI, MISO, and SS. SCLK is the common clock in the entire SPI bus, MOSI is the master output, slave input, and MISO is the host input, slave output and SS is used to mark slave. In two devices which communicate with each other via SPI bus, the slave is low level and host is high level in SS pin.

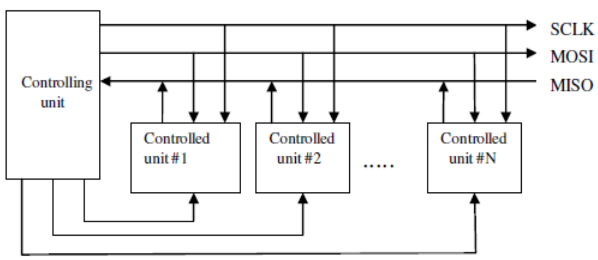


Fig. 5. Communication module

In the design the mode of single master and multi slave is adopted.

### B. *Ethernet interface*

Ethernet controller is divided into two layers in the Ethernet module according to its functions and it is shown in Fig. 6. First is the media access controller (MAC) layer and the second is network physical (PHY) layer. They correspond to Layer 2 and Layer 1 in ISO model. MAC layer takes care of the data sending and receiving. It also provides an interface to PHY through an internal medium independent interface.

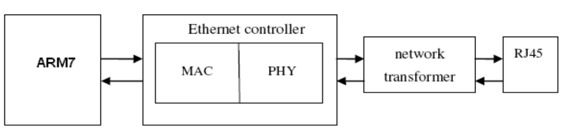


Fig. 6. Ethernet controller and Ethernet

### C. *Data transmission*

In order to transmit the data from SPI serial to Ethernet, two system tasks are established one is to receive front-end data through SPI interface and the other is to transmit data to Ethernet. Data arriving at SPI port are stored into SPI sending buffer and packaged according to TCP/IP protocol. This is SPI receiving task. In the Ethernet receiving task, in order to receive the data from the Ethernet, the local IP address and subnet mask must be set firstly, and the appropriate UDP port is opened to monitor whether there are data in UDP port

## 5. Software design

The system flow design is shown in Fig.7. The Programming of this design is done using embedded C. Keil compiler is used to compile the program. The program can be downloaded into the chip using Philips Flash programmer. The processor is initialized first and it signals from the LAN through SPI bus. The signal checks whether the processor port is ready. Once the processor port is ready, it sends the status to the monitoring device. By typing the IP address on the web page, the status of the devices will be displayed in the web. From the web, the status of the device can be known and if the client wants to change the status of the device, client can enter the corresponding data and the device can be monitored or controlled.

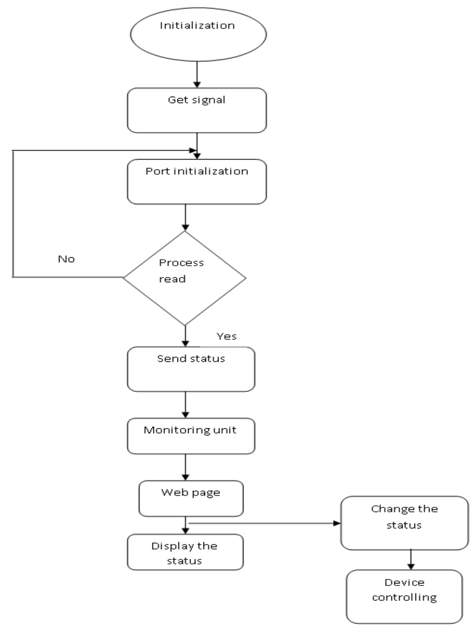


Fig. 7. System flow design

## 6. Conclusion

The design of an embedded distributed control and acquisition system using embedded processor is presented with Ethernet interface. In order to transmit the data from an existing device with SPI interface to network, an embedded Ethernet interface based on embedded processor is designed. The SPI serial data and Ethernet data packets can be converted to each other by software programming. This system provides real time application of monitoring and controlling of electrical drives viz. AC machine, DC machine, Transformers, Circuit breakers and other industrial devices. Faults like rotor faults, bearing faults etc. can be diagnosed in an efficient way. Various parameters like voltage, current, speed, torque, temperature and vibration are considered for diagnostics. Using Ethernet interface and SPI interface the network control can be achieved. Thus embedded system provides low cost, low power consumption and compact system for industrial applications.

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