On-Line Monitoring of AC Induction Motors Using ARM and CAN Bus System

K.Anand, P.Manikandan, A.G.Karthikeyan

***Abstract*— This paper presents an on-line distributed induction motor monitoring system based-on the ARM (Advanced RISC Machines), which is integrated with the embedded and CAN (Controller Area Network) bus technologies. The hardware structure of the system with the ARM microprocessor S3C2410X and CAN bus controller MCP2510 is introduced; the accomplishment of software of motor on-line monitoring system is also described. Compared to the complicated construction and low integration of traditional motor testing systems, this system has a reasonable structure with less external expansion units, and can carry out data transmission in real time, effectively, and with lower power cost and more reliability.**

***Index Terms*— *ARM; CAN bus; distributed; monitoring system*.**

I. INTRODUCTION

As one of the important electric equipments, induction motors are widely used in various areas from commercial manufacture to agricultural industry. However, some unpredictable reasons, such as the thermal, electrical and mechanical stress, mechanical failures, may cause the induction motors damage. It is necessary to monitor motors real-time and effectively so as to insure their continuous and safety operation without expensive failures [1-5].

With the rapid development of computer technology, communication technology, and integrated electric circuit technology, more advanced methods have been arising in the motor detecting and monitoring.

There are many researchers who put forward some integrated motor protection systems for induction motor monitoring [2-4]. Some researchers develop protection systems for monitoring electrical faults in induction motor by analyzing the motor currents. On the other hand, as in [2-3], the authors show from experimental results that faults in bearings make unpredictable and broadband changes in the motor currents, and they find that the bearing failures, because of their precise nature, have a clear indicator for diagnosing motor faults.

By using ARM embedded and CAN bus technologies, this paper puts forward an on-line distributed induction motor monitoring system based-on ARM and CAN bus.

With its characteristics of simple construction, cost-effective, flexible extension, and so forth, this system can be used widely in different environment and fields.

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II. HARDWARE ARCHITECTURE OF ON-LINE DISTRIBUTED INDUCTION MOTOR MONITORING SYSTEM

The distributed system is an application that executes a collection of protocols to coordinate the actions of multiple processes on a network, such that all components cooperate together to perform a single or small set of related tasks. At the recent years, the distributed system has been increasingly applied in many safety-critical systems, such as the low-level applications in the industrial plants, the high-level in the military and nuclear systems, etc.

The embedded system is devices used to control, monitor, or assist the operation of equipment, machinery or plants. It makes the application as the center and computer as its foundation. Its hardware and software can be tailored. It can be applied in the dedicated cosmputer system, which has strict requirements for the function, reliability, cost, size, and power.

The CAN bus is an effective serial communication network, which can support the distributed and real-time control. Its bus standard has been formulated as international standard by the International Organization for Standardization (ISO) and is regarded as one of the most promising field buses [6-7].

The on-line distributed induction motor monitoring system can be used to monitor a set of motors that work together in the field, such as an industrial plant. In this system, there are many nodes (up to 110 nodes) that are connected each other with the CAN bus. At each node, one hardware subsystem is responsible to monitor one motor and transmit the data of the tested motor to the center of the system, which is also one node in the distributed network.

In this monitoring system, the embedded ARM microprocessor S3C2410X is responsible for monitoring each node of the entire system [8]. On-site motor parameters at each node can be acquired via the CAN bus.

After filtered and amplified by the front-end signal conditioning circuit, the parameters can be transmitted directly to the A/D Conversion circuit of S3C2410X. The data exchange between the S3C2410X and CAN transceiver can be realized via the CAN bus. The S3C2410X is applied to analysis, process, and store the detected motor data from the sensors so as to complete the on-line system monitoring [9-10].

The hardware architecture of each node of on-line distributed motor monitoring system mainly includes the ARM microcontroller, CAN bus controller, signal acquisition and regulation circuit, A/D conversion circuit, system monitoring and protection, real-time clock, and power. The hardware architecture of each node of on-line distributed induction motor monitoring system is shown as Fig.1.

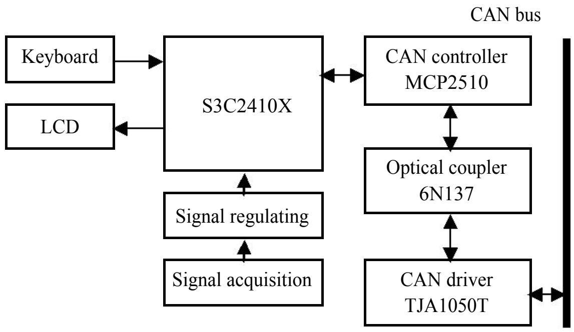

Fig1.The hardware architecture of each node of distributed induction motor monitoring system

A. Features of ARM microcontroller and CAN bus controller

In this system, the ARM microprocessor S3C2410X is used as the core of data acquirement and data-process system. As mentioned in the user's manual of Samsung's S3C2410X, the S3C2410X microprocessor is designed to produce hand -held devices and general applications with cost-effective, low-power, and high-performance microcontroller solution in small die size [11].

The S3C2410X is a 16/32-bit RISC microprocessor; it has a CPU core – ARM920T RISC processor designed by Advanced RISC Machines (ARM), Ltd. The ARM920T implements MMU, AMBA BUS, and Harvard cache architecture with separate 16KB instruction and 16KB data caches, each with an 8-word line length. The 10-bit CMOS analog to digital converter (ADC) of the S3C2410X is a recycling typed device with 8-channel analog inputs. The ADC converts the analog input into 10-bit binary digital codes at a maximum conversion rate of 500KSPS with 2.5MHz A/D converter clock. The A/D converter operates with on-chip, sample-and-hold function and power down mode is supported [11].

The MCP2510 is a stand-alone CAN controller developed to simplify applications that require interfacing with a CAN bus. The MCP2510 supports CAN 1.2, CAN 2.0B Passive, and CAN 2.0B Active versions of the protocol, and is capable of transmitting and receiving standard and extended messages. It is also capable of both acceptance filtering and message management. It includes three transmit buffers and two receive buffers that reduce the amount of microcontroller (MCU) management required. The MCU communication is implemented via an industry standard Serial Peripheral Interface (SPI) with data rates up to 5Mb/s [12].

The S3C2410X is connected with MCP2510 through SPI synchronous serial interface in this system.

B. CAN bus data acquisition

Three phase currents and voltages of the stator of each of the different fields of motors are measured in this system, which cover the 6 channel analog inputs of the S3C2410. Signals of three phase currents and voltages of the stator are acquired by the sensor circuits so as to achieve electrical isolation from the strong electricity. Voltage and current sensors are used SPT204A and SCT240B, respectively. Because the A/D conversion circuit of S3C2410X can only accept 0~3.3V voltage signal, but the signal after the sensors circuits is the sinusoidal signal with positive and negative half waves, therefore, the regulation circuit need to amplify, and filter the acquired signal to 0~3.3V range to meet A/D conversion necessary requirements.

Under normal circumstances, we should connect the TXCAN (output pin of transmitter) and RXCAN (input pin of receiver) to the CAN bus driver so that the acquired data can be transmitted timely and safely to the data monitoring system. The TJA1050T shown in the Fig.1 is the CAN bus driver, which is the interface between MCP2510 and physical bus. The TJA1050T provides the capability of differential transmission and acceptance for the MCP2510 to the physical bus.

To improve the anti-jamming capability of the monitoring system further, the TXCAN and RXCAN cannot be connected to the TJA1050T directly. In contrast, the high-speed optical coupler 6N137 is used to connect with the TXD and RXD of the TJA1050T. Two power supplies used in the optical coupler circuit should be separated. Therefore, the small power isolation module of B0505S is used in this system to realize the isolation of the two power supplies. In this way, a better electrical isolation in each node of the bus can be achieved.

Similarly, to enhance the safety and anti-disturbance in the interface between TJA1050T and CAN bus, two small capacitors are connected in parallel between the ground and TJA1050T to filter out high frequency interference on the bus and to have the ability of anti-electromagnetic radiation. The capacity of the capacitors depends on the number of nodes and the baud rate of the MCP2510.

In order to improve the topological ability of the network nodes, a damping resistance of 120Ω should be connected between both ends of the CAN bus. This resistor plays an important role in matching bus impedance. If this resistor was not connected, it would make the ability of anti-disturbance and reliability of digital communication reduce greatly; even worse, the communication even would not work. To reduce the interference of the electromagnetic field, the shielded twisted pair is used. And according to the practical experience, the shield of the shielded twisted pair must not be grounded.

III. SOFTWARE OF ON-LINE DISTRIBUTED MOTOR MONITORING SYSTEM

The software mainly includes two parts main program and the CAN bus driver program.

A. The main program

The main program is chiefly responsible for calling the interface of CAN bus driver program to receive and transmit data. Furthermore, it also includes the data processing program, data display program. Fig.2 is the flow chart of the main program.

The data process is responsible for numerical calculation of the collected data and obtaining the collected data's corresponding real-time RMS; the data display is responsible for displaying the real-time RMS of the three phase voltages and currents of the stator and their waveforms.

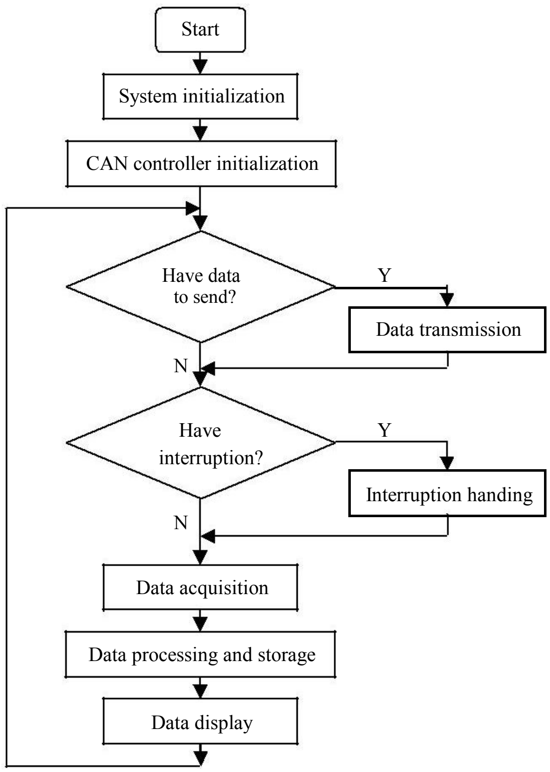

Fig.2. The software of main program

B. The CAN bus driver program

The CAN bus driver program consists of the functions of initializing CAN controller, transmitting data, receiving data, and handling interruption.

- Initialization of CAN controller is mainly to realize parameters setting of CAN bus, such as software reset of CAN controller, and setting CAN bus band rate, work mode of interrupt, acceptance filter mode, work mode of CAN controller, etc. Fig.3 is the initialization of CAN controller.

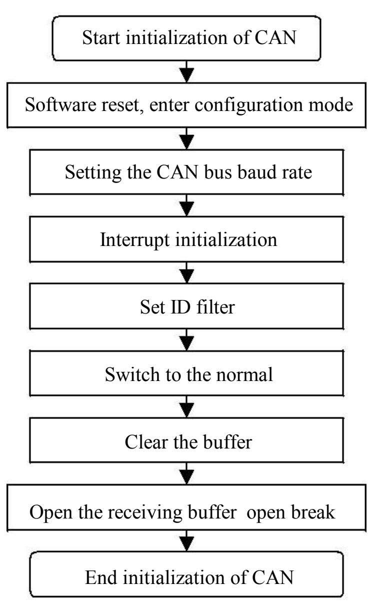

Fig.3. initialization of CAN controller

- After the Initialization of CAN controller, the acquired data are transmitted. The motor parameters should be made in a specific format to form a packet before they are transmitted to the sending buffers of the CAN controller. And the packet is sent to the CAN bus by using the sending command. The sending function returns immediately after starting the transmission. It can be determined whether sending function is successfully with inquiring the status bit of TCS.
- The function of receiving data is responsible for the reception of the data packet and processing the abnormal situations, such as false alarms and receiving overflow. The CAN controller puts the motor data from the CAN bus to the CAN buffers. In fact, receiving data is just to read from the receiving buffer of the CAN controller. The receiving function is to receive the motor data by means of interrupting, which can improve the efficiency of receiving process. Therefore, in the initialization, it must insure to open the receiving interruption. In the subroutine of interruption service, the interruption register is read to determine whether the interrupt symbol is received. If it is, the receiving buffer is read. The chart of the subroutine of interruption service is shown in Fig.4.

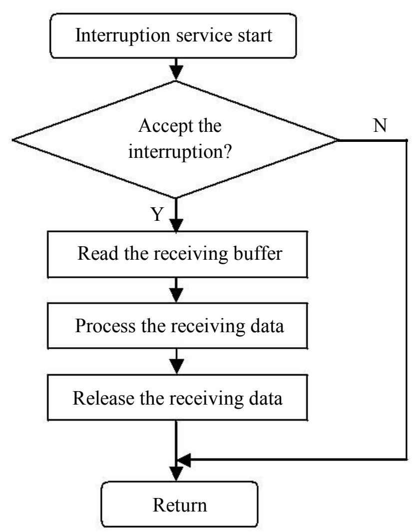

Fig 4. Chart of the subroutine of interruption service

CONCLUSION

The on-line distributed induction motor monitoring system has been described. This system has the characteristics of low-cost, rational construction and easy expansion. The ARM microprocessor S3C2410X is adopted to carry out motor monitoring function; the S3C2410X has abundant internal resources, and has the high reliability and the strong ability of real-time data communication and anti-disturbance. The CAN bus technology is also used in the data transmission, which increases the data transmission speed and facilitates the fault-tolerant design. The future work will be to simplify the extension of the CAN bus and enhance the reliability and stability of the system.

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