Health monitoring of an power amplifier using an ethernet controller

[1]Sharadha N, [2]J Pushpanjali

[1]Student, [2]Assistant Professor
Bangalore institute of technology
Bangalore, India

Abstract—the computer network and the internet technology have brought a rapid development of embedded systems in the industrial production, which are used in the daily life. However a large number of devices don't have the network interface and hence cannot transmit data in the network. The main advantage of the proposed communication is the use of low cost stand alone Ethernet controller and existing network infrastructure to relay data between the embedded system and a host PC creating a viable and cost effective alternating to the current microcontroller communication protocols. This paper presents the development of an Ethernet controller for a power amplifier to monitor and control the power amplification characteristics. An Ethernet interface with general purpose microcontroller is implemented for power amplifier. SPI and RS232 helps in communicating with Ethernet controller and general purpose microcontroller, Ethernet controller and power amplifier.

Keywords—ethernet controller; Atmel controller; power amplifier; SPI

I INTRODUCTION

In any system, the power amplifier is important. It is the most costly device and consumes most of the supply power. The power amplifier with Ethernet controller options plays a significant role in monitoring and controlling operation in real time. For this purpose the power amplifier needs a physical communication port with the network. The design and implementation of such Ethernet interface for power amplifier with microcontroller is proposed in this paper. The power amplifier communicates with the Ethernet controller through SPI (serial peripheral interface) port. The Ethernet controller ENC28J60 is the main element manufactured by the Microchip Company, according to IEEE 802.3 standards along with the MAC and PHY modules. The Ethernet controller ENC28J60, an RJ45 connector and few passive components along with general purpose microcontroller is connected to the network and it works at a speed of 64Mbps.

II THE FUNDAMENTAL COMPONENT

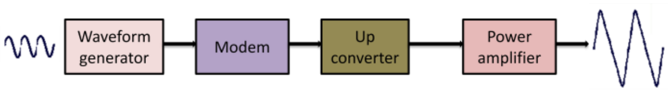

Figure 1: transmitter section

An amplifier is an electronic device which is used to increase the power of a signal. It is present at the transmitter section's final stage. The RF devices play an important role in designing the power amplifier. The requirements for amplification are as varied as the systems where they are used. The common requirements for all amplifiers include frequency range, gain, power output, linearity, thermal stability, noise power matching, bandwidth. To monitor and control all this factors there is a need for power amplifier controller [3].

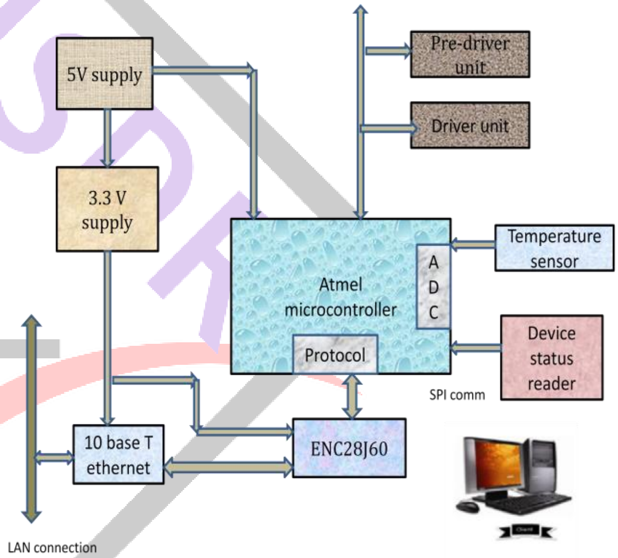

Figure 2: The power amplifier controller

The system uses the ENC28J60 Ethernet controller as a standalone controller by the Microchip Company. ATMEL 89C51ED2 microcontroller is used as a general purpose controller. The SPI interface provides full duplex communication to realize synchronous serial data transmission between the CPU and low speed peripheral devices.

III THE DESIGN INTERFACE

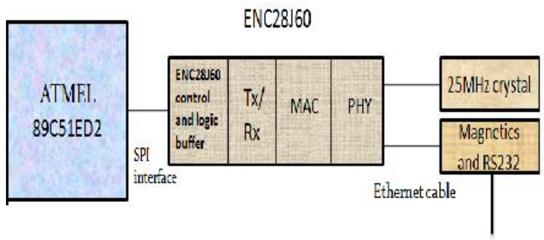

Figure 3: The system's structure

A. ATMEL Microcontroller module :

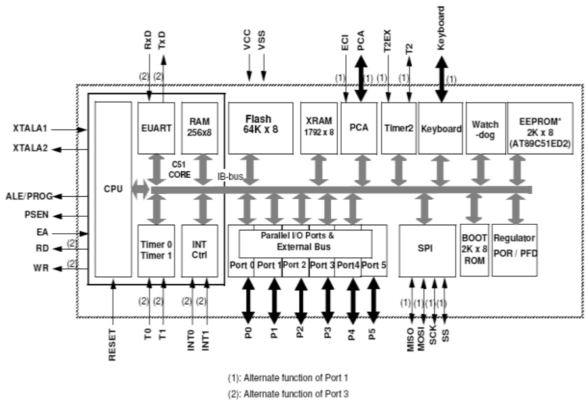

Figure 4: Atmel AT89C51ED2 module

A highly integrated microcontroller chip contains all the components comprising a controller. It includes a CPU, RAM, ROM, I/O port and timers. The reason for using Atmel as an 8 bit microcontroller in our application is because of its high throughput and serial peripheral interface [1].

The microcontroller used is ATMEL AT89C51ED2. It has high performance, 64Kbytes of flash memory which can be used as memory block code and for data. It brings down the clock frequency to any value, including DC, without any loss of data. Hence this fully static design feature of Atmel microcontroller is used to reduce system power consumption.

The pulse width modulation, high speed input/output and counting capabilities such as alarms, motor control, smart card readers are some of the added features of Atmel AT89C51ED2 microcontroller. A 64Kbytes of flash memory can be programmed either in parallel mode or in serial mode. One more added feature of Atmel microcontroller to be used in this application is that it provide programmable serial universal asynchronous receiver transmitter (UART) and SPI which can be used to control power amplifier characteristics [2].

B. Ethernet controller module :

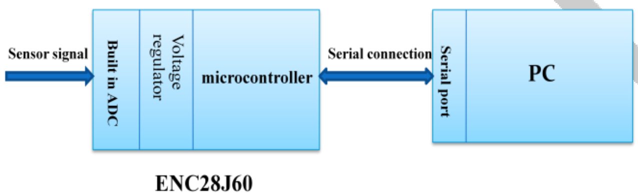

Figure 5: The Ethernet module

The newly introduced ENC28J60 serves as a standalone Ethernet controller manufactured by the microchip company. The 28 pins of the controller provide the required functionality. It simplifies the space related issues in the designing of any embedded system with Ethernet controller. IEEE standards 802.3 are used in designing of Ethernet controller to serve as an Ethernet network interface for any controller equipped with SPI. Also it ensures reliability of network connections and data transmission.

Ethernet controller is widely used as an efficient internet access method. The microcontroller is embedded with the TCP/IP protocol stack using which data transmission is easier. The Ethernet buffer memory is used for sending and receiving data. The PHY registers are used by the PHY module configuration for control and status acquisition [4].

ENC28J60 Ethernet controller is made up of seven main functional modules for data transmission- SPI interface, Bus interface, control register , Ethernet buffer, DMA access to buffer, PHY (physical) layer module, MAC (medium access control) layer module. The microcontroller does not support automatic duplex negotiation. If it is connected to an automatic duplex negotiation enabled network switch or Ethernet controller, the ENC28J60 will be detected as an half duplex mode. To communicate in full duplex mode, the ENC28J60 and remote node must be configured for full duplex operation.

C. SPI interface :

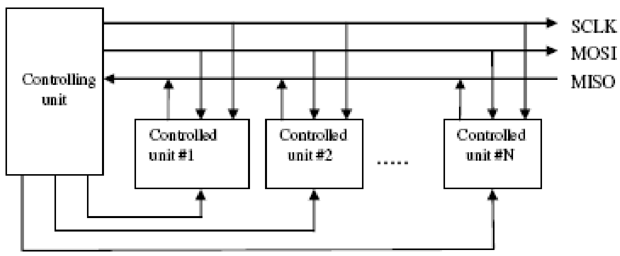

Figure 6 : SPI bus architecture

The synchronous serial data transmission between the CPU and low speed peripheral devices operating in full duplex mode of communication is realized using SPI interface. Its data transfer rate is up to several Mbps and operate in master-slave mode. The master-slave operation is by four wire serial bus protocol which includes SCLK, MOSI, MISO and /SS. SCLK is the common clock in the entire SPI bus, MOSI is the master output and slave input, MISO is the host input and slave output and /SS is used to mark slave [4].

The clock signal is provided by the master to achieve synchronization. It controls when data can change and when it is valid for reading. RS232 and other asynchronous protocol do not use a clock pulse but the data must be timed very accurately. Since SPI has a clock signal, the clock can vary without disrupting the data. The data rate will change according to the changes in the clock rate. This makes SPI ideal when the microcontroller is clocked.

IV HARDWARE CIRCUIT CONNECTION

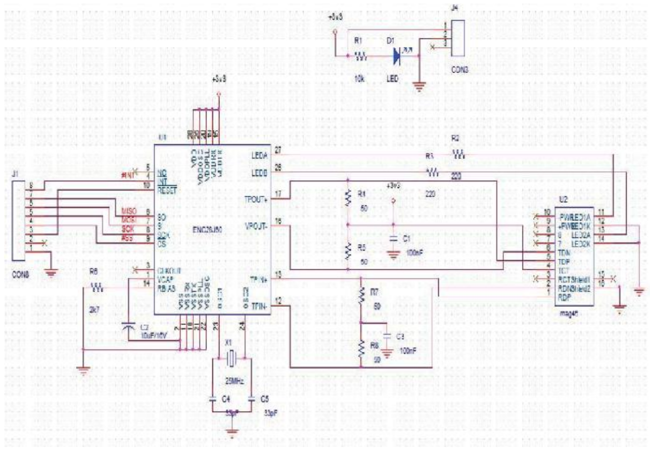

Figure 7: The hardware circuit of ENC28J60

The Atmel AT89C51ED2 microcontroller is used as the processor module. It is the core part of the design architecture which is used to complete the complex operations and receive data from the slave module. The slave module used here is an Ethernet controller ENC28J60. Internal TCP/IP protocol stack is achieved by the Atmel microcontroller. It drives the network interface controller ENC28J60.To achieve this Ethernet controller is made up of isolation transformer and Ethernet internet access.

The local network equipment is formed by Ethernet controller and microcontroller. To transmit and receive the data frames network interface- media access control sub layer and physical sub layer is used

The SPI interface in the module provides the data link between the SPI port and Ethernet controller. SPI interface is used to realize synchronous serial data transmission between the CPU and low speed peripheral devices. Full duplex mode of communication is used. The transfer rate between the serial data streams and IP data packets which is to be controlled is specified. The IP packets received or sent through reading and writing the Ethernet interface module.

Clock oscillator, reset circuit, network transformers, other external components and LED configuration unit modules are included in designing the hardware circuit. The serial level conversion module converts the +5V power supply (TTL level) to RS232 level. The ENC28J60 Ethernet controller works with voltage of +3.3V and the working voltage of ATMEL microcontroller is +5V. Voltage level conversion is done for the Ethernet controller to coordinate with Atmel microcontroller working voltage. Four differential send pins and receive pins integration with a central tapped transformer RJ45 socket connection is used. LED A and LED B pins are present which supports functions like automatic reset when the polarity is changed [1][2].

At the end of the Ethernet network router, a computer is connected which helps in testing the system hardware. Atmel microcontroller is connected to the same end of the router.

V SOFTWARE REQUIREMENT

The program code in an Ethernet driver manages communication between the controller chip and a higher level in the network protocol stack. The application code provides the IP addresses, port numbers and data to send and call a function which will accordingly send the datagram or wait to receive data in the datagram addresses to a destined port. The main software required for Ethernet communication is implemented using Keil, Atmel Flip, and Herculus software.

Function Description:

The header files enc28j60.h which is included in the project file, help to use various functions to control the various registers of the IC and to read and write from the buffer memory of the IC.

1) uint8_t enc28j60Read(uint8_t address);
address is the address of the control register to be read
It returns the value of the control register.

2) void enc28j60ReadBuffer(uint16_t len,uint8_t *data);
It stores len bytes of data in the memory pointed by the data pointer.

3) void enc28j60Write(uint8_t address,uint8_t data);
It writes 8 bit data to the control register.

4) void enc28j60WriteBuffer(uint16_t len,uint8_t *data);
It writes len bytes of data to the transmit buffer.

5) void enc28j60PhyWrite(uint8_t address,uint16_t data);
Writes 16 bit data to the PHY register whose address is given.

6) Void WriteOp(ENC28J60_BIT_FIELD_CLR,uint8_t address,uint8_t data);
data field will be : if bit 0 and 6 are to be cleared we will send 01000001

7) void WriteOp(ENC28J60_BIT_FIELD_SET, uint8_t address,uint8_t data);
·data field will be initialized to send bits

System operational flow:

The proposed system operates in two fields- master-slave controller and SPI interface. In both the units firstly initialize the microcontroller, I/O ports and set the direction of all devices.

To initiate the communication first master-slave controller sends an ARP request packet to the control module and waits for its response. The IP addresses and a checksum is computed on the header. IP datagram is forwarded to the Ethernet controller driver ENC28J60 for sending on the network. On receiving an IP datagram from the Ethernet controller driver, it ascertains the IP header from the datagram analyzes the IP checksum and compares the result with received value. As per the checksum matching rule, the Ethernet controller computes its value and compares it to the received checksum. Use the destination port number to decide where to store the received data. The current status of the I/O devices is indicated by the LED.

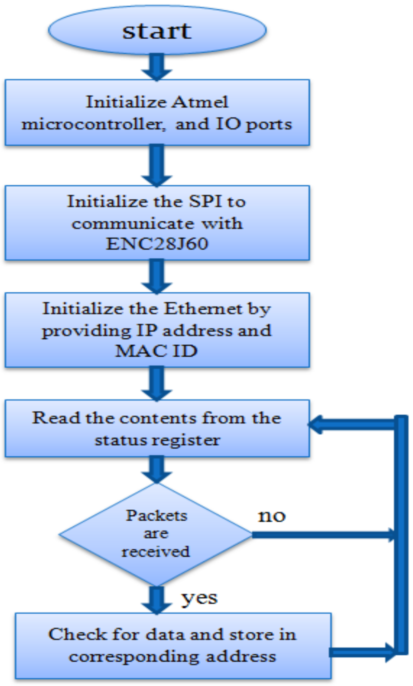

Figure 8: The master-slave operational flow

In the Ethernet task, in order to receive the data from the Ethernet system, the local IP address and subnet mask must be set firstly. The data which is received is analysed accordingly to TCP/IP protocol and then stored into SPI receiving buffer. At last the analysed data are sent to the SPI serial device through SPI interface driver.

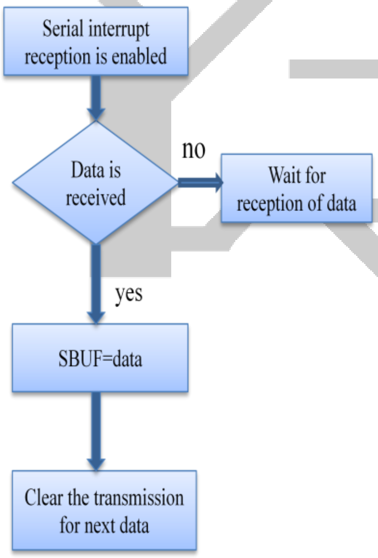

Figure 9: The SPI interface flow diagram

After the software and hardware have been completed the generated codes are compiled and downloaded to the target system for testing. The codes include hardware system start-up code, general purpose operating system in Embedded C. In this system PC is used to monitor the status of the transducers. IP address and subnet mask are set in both computers to know that the communication between them is in the same network. When the IP address of host is given as input by ping command, the result shows that the Ethernet is connected between the computer and ATMEL microcontroller.

The main window looks like following image:

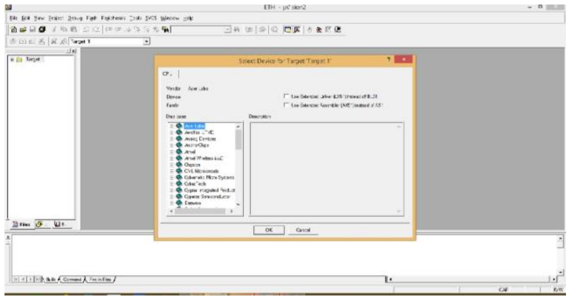

Figure 10: keil vision window

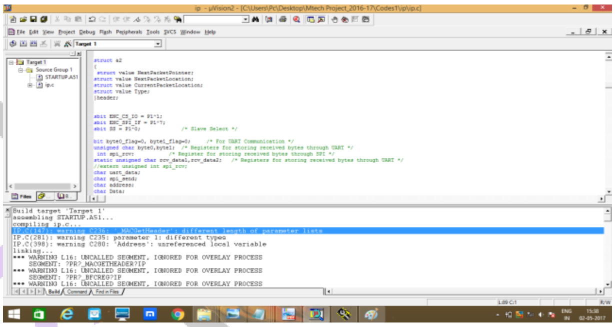

Figure 11: creating of C file

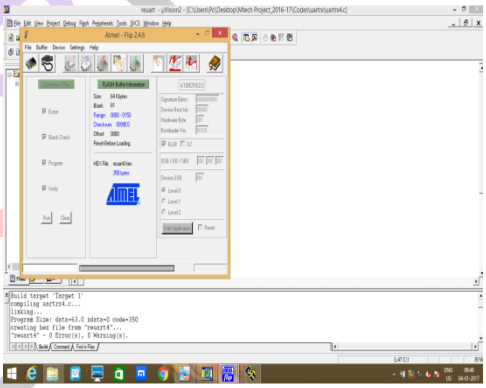

Figure 12: creating of C file

VI CONCLUSION

An embedded Ethernet interface based on Atmel processor is designed in order to monitor and control the sensor data with SPI interface to network. The ethernet interface now developed offers an effective solution, making low cost, robust in operation for power amplifier controller. It has different input and output pins for connecting various switches externally for industrial purpose. Here TCP/IP is used which define a set of rules to enable computers to communicate over a network, specifying how data should be package, addresses, routed and delievered to the right dstination. The system is compact, simple and flexible which is suitable for any applications. This design can be widely used in remote data monitorin and controlling the system in industry. The future work on this can be implemented for higher transmission rates like 100 Mbps.

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