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DESIGNING OF ETHERNET INTERFACE FOR COMMUNICATION

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Abstract: During the last years, Ethernet increasingly became the most extensively used local area networking (LAN) technology. It became also attractive for several other fields of application like industry, avionics, automotive and telecommunication. The prolonged application of this technology is principally due to its considerable assets like reduced cost, expandability and flexibility. However, Ethernet has been improved to fulfil with the specific conditions of several application fields, mainly in industrial automation. Several new features are being added up to the standard Ethernet to make it much more versatile namely the addition of full duplex capabilities, auto negotiation, fault diagnostic abilities to name a few. These features really add enormous strength to the basic Ethernet and improving the way the communications are carried out over the network. Security is another major feature that is been gaining importance these days, as it helps in safe and sound delivery of information across networks. This project aims to develop a hardware based Ethernet module which will act as an interface for the already existing relay controller to communicate with the external world. Communication will occur in either half duplex or full duplex modes via the twisted pair interface with data rates of 10Mbps or 100Mbps respectively using the TCP/IP protocol. Thus providing an interface for the controller to communicate and transfer data across the network and creating a way to remotely control the relay using TCP/IP protocol.

Keywords: Ethernet, IEEE protocols, TCP/IP, controller, MAC, PHY, Magnetics.

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INTRODUCTION

Ethernet is by far the most widely used local area networking (LAN) technology in the world today. Market surveys indicate that hundreds of millions of Ethernet network interface cards (NICs), repeater ports, and switching hub ports have been sold to date, and the market continues to grow. In total, Ethernet outsells all other LAN technologies by a very large margin.

Past decade saw the rise of industrial revolution which caused many industries to emerge. Newer machineries and systems were developed so as to ease off the work and to achieve a higher productivity. One of the problems was that the machineries was that it needed continuous supervision from technical personnel which limited the overall versatility of the devices interms of the area of deployment. Like for instance, a device being deployed in a high temperature zone or underwater or nuclear sites has its own set of problems.

Here a monitoring of the device needs to be done remotely, which is exactly the main reason for taking up this project. As per our analysis, Ethernet is the most common and affordable mode of remote communication.

Hence, in our project we are trying to develop a prototype which will add an Ethernet interface to the controller with MAC feature to be able to communicate remotely to the monitoring station. This is what we are trying to achieve through this paper.

The paper is organized in the following manner: Section I: Introduction, Section II: IEEE 802.3 ETHERNET, Section III: Working of the prototype, Section IV:Components used, Section V:Design tools, Section VI: Testing, Section VII: Discussion and Section VII concludes the paper.

II.IEEE 802.3 ETHERNET

The term Ethernet is often used to refer to all carrier sense multiple access/collision detection (CSMA/CD) LANs that generally conform to Ethernet specifications, including IEEE 802.3. When it was developed, Ethernet was designed to fill the middle ground between long-distance, low-speed networks and specialized, computer-room networks carrying data at high speeds for very limited distances. Ethernet is well suited to applications where a local communication medium must carry sporadic, occasionally heavy traffic at high peak data rates.

Stations on a CSMA/CD LAN can access the network at any time. Before sending data, CSMA/CD stations “listen” to the network to see if it is already in use. If it is, the station wishing to transmit waits. If the network is not in use, the station transmits. A collision occurs when two stations listen for network traffic, “hear” none, and transmit simultaneously. In this case, both transmissions are damaged, and the stations must retransmit at some later time. Backoff algorithms determine when the colliding stations retransmit. CSMA/CD stations can detect collisions, so they know when they must retransmit[1][2][3][4].

II.I ETHERNET FRAME

Preamble (7 bytes)	Start of Frame Delimiter (1 byte)	Dest. Address (2/6 bytes)	Source Address (2/6 bytes)	Length (2 bytes)	802.2 Header+Data (46-1500 bytes)	Frame Checksum (4 bytes)

The preamble tells receiving stations that a frame is coming. The byte before the destination address in both an Ethernet and a IEEE 802.3 frame is a start-of-frame (SOF) delimiter. This byte ends with two consecutive one bits, which serve to synchronize the frame reception portions of all stations on the LAN. Immediately following the preamble in both Ethernet and IEEE 802.3 LANs are the destination and source address fields.

Both Ethernet and IEEE 802.3 addresses are 6 bytes long. Addresses are contained in hardware on the Ethernet and IEEE 802.3 interface cards. The first 3 bytes of the addresses are specified by the IEEE on a vendor-dependent basis, while the last 3 bytes are specified by the Ethernet or IEEE 802.3 vendor. The source address is always a unicast (single node) address, while the destination address may be unicast, multicast (group), or broadcast (all nodes). In Ethernet frames, the 2-byte field following the source address is a type field. This field specifies the upper-layer protocol to receive the data after Ethernet processing is complete.

If data in the frame is insufficient to fill the frame to its minimum 64-byte size, padding bytes are inserted to ensure at least a 64-byte frame. After the data field is a 4-byte FCS field containing a cyclic redundancy check (CRC) value. The CRC is created by the sending device and recalculated by the receiving device to check for damage that might have occurred to the frame in transit.

III.WORKING OF THE PROTOTYPE

For the Ethernet module there is no separate transmitter and receiver sections. Each and every component acts as a transmission section when in transmission mode and while in reception mode the same components becomes the part of receiver section.

In transmission mode, the data which needs to be transferred from the main controller to a distantdestination will first convert the data into a form which is understandable for the MII. This conversion is carried out by the MAC (medium access control) block. The media-independent interface (MII) was originally defined as a standard interface used to connect a Fast Ethernet (i.e., 100 Mbit/s)media access control (MAC) block to a PHY chip. Being media independent means that different types of PHY devices for connecting to different media (i.e. twisted pair copper, fibre optic, etc.) can be used without redesigning or replacing the MAC hardware.

The MII bus (standardized by IEEE 802.3u) connects different types of PHYs (physical transceivers) to media access controllers (MAC). Thus any MAC may be used with any PHY, independent of the network signal transmission media. The MII bus transfers data using 4-bit words (nibble) in each direction (4 transmit data bits, 4 receive data bits).

This data in the form of nibbles are received by the PHY. In the PHY the data is serialized, passed through encoder (consisting of 4B/5B encoding and NRZ-I, MLT-3 encoding) and then to the transmission pins. This signals reach the primary winding of the magnetics which is basically the transformer with common mode choke. The signal is induced onto the secondary winding from which the data flows towards the RJ-45 port. A twisted pair cable is usually connected to RJ-45 port which is responsible to carrying the data towards the prescribed destination.

Almost the same things occur when the module works in **Reception mode,** in reverse order. Here data received at by the RJ-45 is sent to PHY via magnetics and from there sent to MII interface in the form of nibbles. From there it reaches the controller, which carries out necessary actions based on the data received.

IV.COMPONENTS USED

A.PHYSICAL LAYER TRANSCEIVER:

A PHY connects a link layer device (often called MAC as an abbreviation for media access control) to a physical medium such as an optical fiber or copper cable. A PHY device typically includes a Physical Coding Sublayer (PCS) and a Physical Medium Dependent (PMD) layer. The PCS encodes and decodes the data that is transmitted and received. The purpose of the encoding is to make it easier for the receiver to recover the signal.

B. MAGNETICS:

Magnetics refers to the transformer that is used in the circuit. It is a module with 1:1 ratio and a common mode choke that serves two main purposes,

a) To provide electrical isolation between the Ethernet module and the transmission medium.

b) Transfer the data signals from the PHY transceiver towards the transmission medium (twisted pair cable) via RJ-45 port.

C. REGISTERED JACK -45:

A Registered Jack (RJ) is a standardized telecommunication network interface forconnecting voice and data equipment to a service provided by a local exchange carrier or long distance carrier.

It has 8 pins out of which only 4 are used for 10/100Mbps communications. The 4 pins form two pairs, one each for transmission and reception respectively. The data to be transmitted is fed by the transformer. The data flows out through an unshielded twisted pair cable (UTP) with a 100ohms differential impedance.

V. DESIGN TOOLS

This section describes the tools that were used to design the printed circuit board.

A. DXDESIGNER

To create a schematic in dxdesigner, the first step is to create the symbol for the integrated circuit chip. Once that is done, the next process is to create a footprint. Footprint defines the layout of a particular component to be placed on the PCB.It defines the dimensions and point of contacts that the component will make with the pcb[6].

Once symbol and footprint is done, they are pin mapped with each other so as to create the complete part, which in turn represents component as a whole.

The schematic is sketched out using the parts made and interconnecting them as per the circuit diagram. In this way, schematic is created. The completed schematic is send to Expedition for pcb layout process.

C. EXPEDITION

This tool links the schematic created in dxdesigner with the parts to be placed on the pcb through a process known as Forward annotation[7].

The parts are placed within the defined PCB periphery and traces are routed with specific impedance and trace width.

Plane placement is the next process, wherein the ground and power planes are defined and connections are made using vias.

The next step is to create the silkscreen which labels each of the component placed and then gerbers are generated, which are pcb compatible files and help the pcb manufacturers to fabricate the pcb.

VI. TESTING

The testing process will be carried out using LPC microcontroller with MAC capabilities. The controller will generate necessary data to be sent across the network. This data will be received by the PHY from MAC and will be send towards the destination through a UTP cable connected at the RJ-45 interface. The data packets that are send and received will be monitored using a Network analyser software like the Wireshark.

VII. DISCUSSION

The IEEE 802.3 Ethernet protocol was studied extensively along with the TCP/IP protocol suite. Essential building block were identified that was needed to be designed so as to create the interface. The components for each block was decided and circuitry was developed. Once the circuit design was completed, it was sketched out using dxdesigner and then xpedition was used to create the pcb layout. Once the pcb is ready, the testing will be carried out as described in the testing section.

VII. CONCLUSION

A prototype hardware model was designed and hardware was developed so as to create an interface which would allow the controller device to communicate remotely via internet using TCP/IP protocol.

It allows supervisors to monitor the status of the device deployed in the field remotely and in real time and send necessary control signals for proper functioning of the device.

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