Hardware Design of Wireless Physical Token Ring System for Mobile and Cellular Communication

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Abstract: A wireless network system based on an infrared and Laser scanning physical token ring architecture (W-PTRS) was designed, built, and tested successfully. The network provides a different way of utilizing the concept of token ring network but with a higher efficiency related to the speed of data transfer and the ability to parallel process client–server requests leading to a new concept of token ring system, which will not fail simply because of ring breakage. The study proposes a new wireless communication protocol, which is neither IEEE802.11 nor Bluetooth. This newly developed protocol could prove to be an excellent communication media if supported by industry. If implemented, this wireless system will provide an alternative but efficient way of wireless communication.

Keywords: Cellular Network, Mobile Communication, Token Ring, Wireless LAN, Protocols, Infrared

INTRODUCTION

In the last few years a new type of Local Area Network (LAN) has appeared [5, 6]. This new type of LAN, which is the wireless LAN, provided an alternative to the traditional LANs based twisted pair, coaxial cable, and optical fiber. The wireless LAN serves the same purpose as that of a wired LAN and that of conveying information among devices attached to the LAN. But with the lack of physical cabling to tie down the location of a node on a network, the network can be much more flexible whereby moving a wireless node is easy, as apposed to the large amount of labor required to add or move the cabling in any other type of network. Also going wireless maybe a better choice where the physical makeup of the building makes it difficult or impossible to run wire in the building.

Wireless is ideal for portable computers, using wireless connections allow portable computers to still be portable without sacrificing the advantages of being connected to a network. Wireless can also be used in combinations with cabled LAN. In that all the machines that will require relative mobility will be connected wirelessly. Wireless communications use transmissions techniques such as Spread Spectrum, Narrow Band Microwave, Infrared, and Laser [16, 17].

In this study a new approach to wireless communication networking is carried out. This approach is based on using infrared and laser devices to carry out network communications whereby the behavior of the designed system emulates the token ring protocol, as the transmission will not begin until the server(s) accept a token binding from a client(s), which is achieved using an infrared and laser locking system in the network.

A wireless local area network (LAN) is a flexible data communications system implemented as an extension to or as an alternative for, a wired LAN. Using advanced communication technology, wireless LANs transmit and receive data over the air, minimizing the need for wired connections. Thus, wireless LANs combine data connectivity with user mobility.

Wireless LANs have gained strong popularity in a number of vertical markets, including the health-care, retail, manufacturing, warehousing, and academia. These industries have profited from the productivity gains of using hand-held terminals, notebook computers, and cellular mobile phone to transmit real-time information to centralized hosts for processing. Today wireless LANs are becoming more widely recognized as a general-purpose connectivity alternative for a board range of applications.

The widespread reliance on networking in business and meteoric growth of the internet and online services are strong testimonies to the benefits of shared data and shared resources. With wireless LANs, users can access shared information without looking for a place to plug in, and network managers can set up or augment networks without installing or moving wires. Wireless LANs offer mobility, installation speed, simplicity, installation flexibility, and reduced cost-of-ownership.

Overview of Wireless LAN Technology: Manufacturers of wireless LANs have a range of technologies to choose from when designing a wireless

LAN solution. Each technology comes with its own set of advantages and limitations [8-22].

Narrowband Technology: A narrowband radio system submits and receives user information on a specific radio frequency. Narrowband radio keeps the radio signal frequency as narrow as possible just to pass the information. Undesirable cross talk between communications channels is avoided by carefully coordinating different users on different channel frequencies.

Spread Spectrum technology: Most wireless LAN systems use spread-spectrum technology; a wideband radio frequency technique developed by the military for use in reliable, secure, mission-critical communications systems. Spread-spectrum is designed to trade off bandwidth efficiency for reliability, integrity, and security. In other words, more bandwidth is consumed than in the case of narrowband transmission, but the tradeoff produces a signal that is, in effect, louder and thus easier to detect, provided that the receiver is not tuned to the right frequency, a spread-spectrum signal looks like background noise. There are two types of spread spectrum radio: frequency hopping and direct sequence.

Frequency-Hopping Spread Spectrum Technology: Frequency-hopping spread-spectrum (FHSS) uses a narrowband carrier that changes frequency in a pattern known to both transmitter and receiver. Properly synchronized, the net effect is to maintain a single logical channel. To an unintended receiver, FHSS appears to be short-duration impulse noise.

Laser Communication System: Laser Technology is cost effective option for short-haul connectivity. The technology received ill-deserved comments regarding performance. However, when properly installed and maintained its very reliable and efficient.
The key item for determining whether laser technology is appropriate for an application is path distance. Since this technology is visual, it is imperative that clear line of sight is achieved and maintained. An additional consideration is the stability of the mounting surface/structure. Any building sway, normally associated with tall structures, must be avoided or considered in the installation and equipment choice. Furthermore, the systems may be compared to a light pipe-what is actually input is received at the other end of the path.
In addition to orientation and mounting conditions, a major cause of ineffective performance is attempting to extend the technology beyond its distance limitations.
Despite the design considerations mentioned, a well-planned installation can provide bandwidths up to 155Mbps and beyond.

Narrowband Microwave: Microwave technology is not really a LAN technology. Its main use is to interconnect LANs between buildings. This requires microwave dishes on both ends of the link. The dishes must be in line-of-sight to transmit and collect the microwave signals. Microwave is used to bypass the telephone company when connecting LANs between buildings.
One major drawback to the use of microwave technology is that the frequency band used requires licensing by the FCC. Once a license is granted for a particular location, that frequency band cannot be licensed to anyone else, for any purpose, within a 17.5 mile radius.

Infrared: Infrared LANs use infrared signals to transmit data. This is the same technology used in products like remote controls for television and VCRs. These LANs can be setup using either a point-to-point configuration or a sun-and-moon configuration where the signals are diffused by reflecting them off of some type of surface.
The major advantage of infrared is its ability to carry a high bandwidth, but its major disadvantage is that they can easily be obstructed, since light cannot pas through solid objects.

System Design: In a typical wireless LAN configuration, a transmitter/receiver (transceiver) device, called an access point connects to the wired network from a fixed location using standard cabling, at a minimum, the access point receives, buffers, and transmits data between the wireless LAN and the wired network infrastructure. A single access point can support a small group of users and can function within a range of less than one hundred to several hundred feet. The access point (or the antenna attached to the access point) is usually mounted high but may be mounted essentially anywhere that is practical as long as the desired radio coverage is obtained [1-4].
End users access the wireless LAN through wireless-LAN adapters, which are implemented as PC cards in notebook or palmtop computer, as cards in desktop computers, integrated within hand-held computers, or integrated in cellular phones. Wireless LAN adapters provide an interface between the client network operating system (NOS) and the airwaves via an antenna. The nature of the wireless connection is transparent to the NOS.

Hardware Design: The system consists of laser diode based transceivers connected to both clients and servers. The server transceiver is mounted on a circular plate with a software controlled DC-Motor used to move it in a circular motion covering 360 degrees. In effect, emulating a token ring system. Table 1 summarizes the system components.

Software Design: Firstly, the software waits for the client to switch a light ON to begin transmission, after that the server reads the file name which must be transmitted, and then the client sends a signal to the server that it is ready for transmission and waits a replying signal. After that the server sends a zero signal to indicate the start-bit, followed by seven-bits indicating the stop bits.

The client sends a signal to indicate that it received the data, and then it switches off and start the scanning process (Token Passing) again.

The data is transmitted bit by bit using parallel port by shifting the data bit by bit seven times. Hence, the system makes use of the functionality of parallel port to connect multi client-server system that transmits the wireless data serially. Fig.1 and 2 represent the transceiver protocol [7-10].

The transceiver of the designed system is based on generating and receiving signals that are compatible with the parallel port. A sensor receives the signal; the output of the sensor is buffered via D-Flip-Flops and directed to the parallel port status register to be read by the software.

In transmitting the data from the parallel port output, a signal driver consists of D-Flip-Flop that provides the required signal for the transmitting diode. A Voltage regulator is used to provide the ICs and diode with stable 5V voltage source.

Locked system is used to control the starting of the transceiver, which consists of stepper motor and a light sensor. The client consists of wireless signal transceiver circuit with a light source; the client's light is switched ON when the user wants to communicate with the server. The stepper motor rotates with a sensor light to seek for clients. The motor stop rotating when it finds a light, it stops the rotation and sends a signal to the client and waits for a hand shaking signal from the client, when the hand shaking signal is received, a transceiver protocol is started and begin files transmission. After ending the transmission, the light of a client is switched OFF and the motor begins to rotate seeking other clients.

The server controls and rotates the scanning system in search for clients requesting data communication. Once it finds the clients it stops the rotation and locks in preparation for data exchange to start. Fig. 5 shows the interfacing module that synchronizes and controls the transmission and reception process.

The circuit employs the 74HC/HCT151, 8-inputs multiplexer to implement a parallel to serial signal conversion (data selection) and interface control signals generated via D-Flip-Flops with clock signal generated from the 4060 binary counter. For the communication process to take place between the server and the clients, synchronization has first to occur as follows:

* A pulse from the computer to clear previous signals resets the handshaking Flip-Flop.
* A waiting period is assigned for the output of the hand-shaking Flip-Flop to change from 0 to 1 for transmission process to start.
* Once the Flip-Flop output switches from 0 to 1, the computer will output data and resets the hand shaking flip-flop signal again.
* The process continues until a complete frame is transmitted.

Table 1: System Components

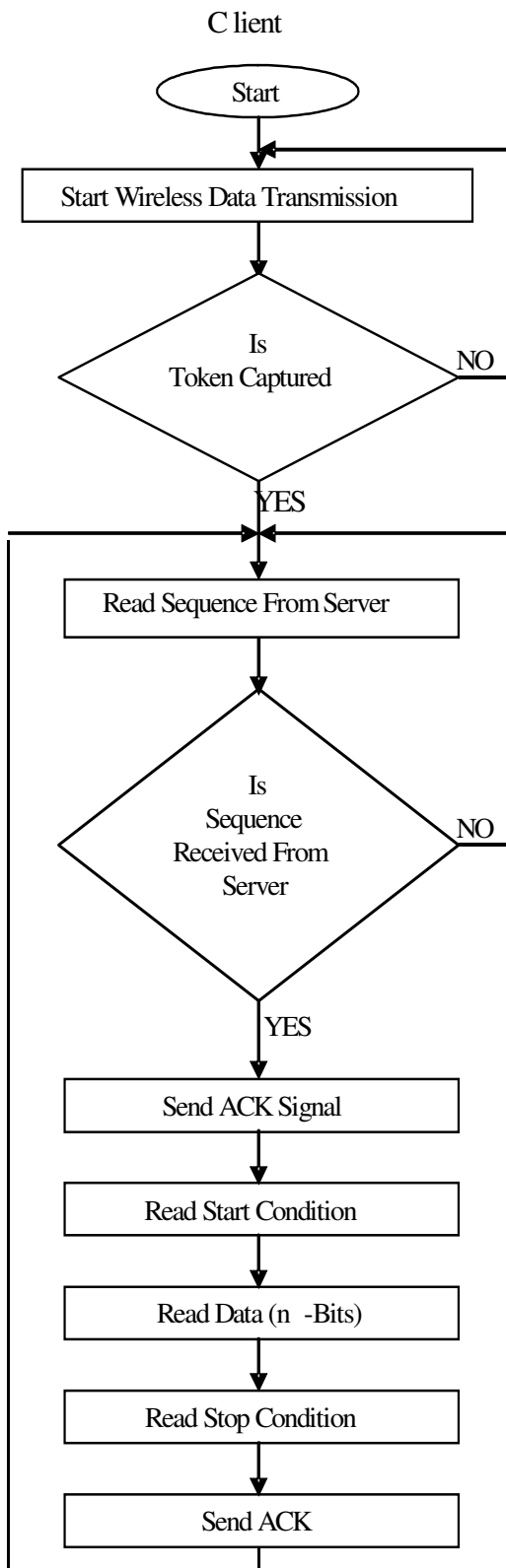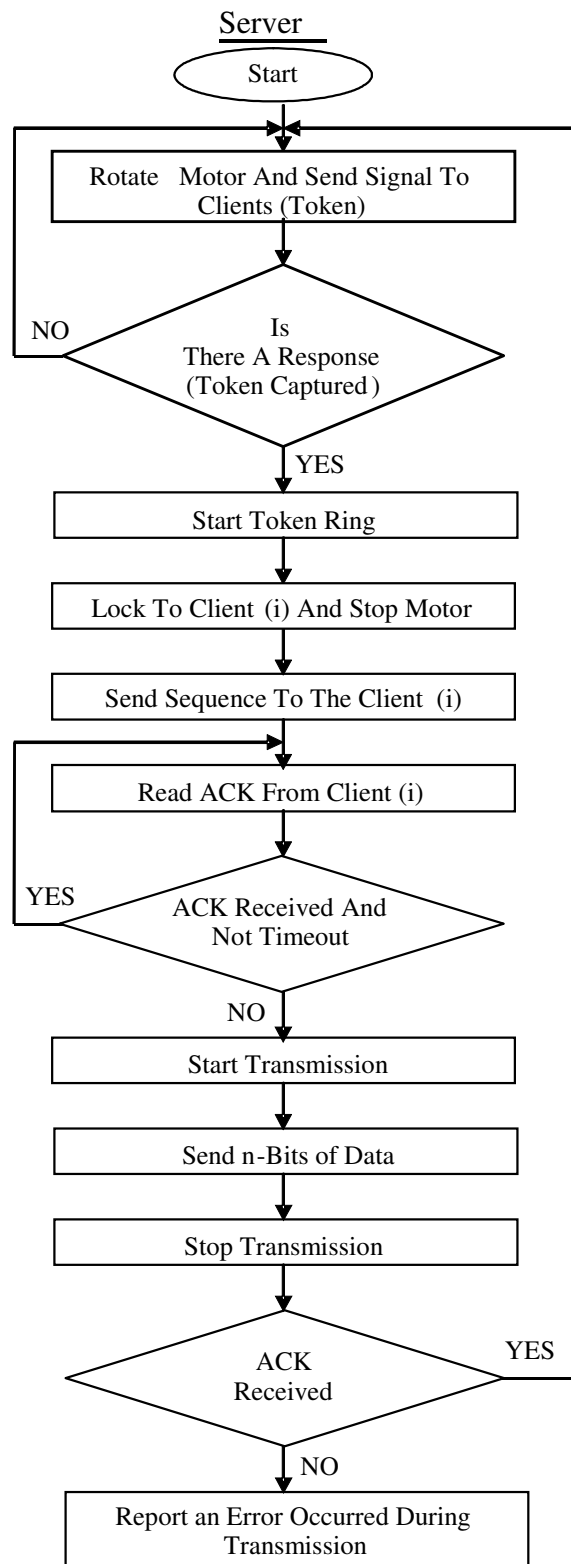| Component Name	Numbers	Description
Binary Ripple Counter	74HC/HCT4040	12 stage binary ripple counters with a clock input, an overriding asynchronous master reset input and twelve parallel outputs
Dual D-type flip-flop	HEF4013B	Dual D-type flip-flop which features independent set direct, Clear direct, clock inputs and outputs
AND	HEF4081B	Positive quadruple 2-input AND function
Binary Counter	4060	Binary counter with three oscillator terminals (RS, RTC and CTC), ten buffered outputs (O3 to O9 and O11 to O13) and an overriding asynchronous master reset input
Multiplexer	74HC/HCT151	8 input high speed Si-gate CMOS devices
Shift register	74HC/HCT595	8-Bit serial/serial or parallel-out shift register with output latches; Tri-state
Hex Inverter	MCI4069UB	Hex Inverter
Operational Amplifiers	TL074	Low noise operational amplifier with low input BIOS and Offset currents and fast slew rate
Voltage Regulators	LM7805	Three terminal regulators
Eight Darlington Arrays	UTC2803	High-voltage, high-current Darlington Arrays drivers comprised of 8 NPN Darlington pairs
Stepping motor driver	BA6846FS	Motor driver with a maximum output current of 0.5A incorporating special logic which allows 3 modes of operations: forward, reverse, and power save

Client

Start

Start Wireless Data Transmission

Is Token Captured — NO

YES

Read Sequence From Server

Is Sequence Received From Server — NO

YES

Send ACK Signal

Read Start Condition

Read Data (n -Bits)

Read Stop Condition

Send ACK

Server

Start

Rotate Motor And Send Signal To Clients (Token)

NO — Is There A Response (Token Captured)

YES

Start Token Ring

Lock To Client (i) And Stop Motor

Send Sequence To The Client (i)

Read ACK From Client (i)

YES — ACK Received And Not Timeout

NO

Start Transmission

Send n-Bits of Data

Stop Transmission

ACK Received — YES

NO

Report an Error Occurred During Transmission

Fig.1: The Client Transceiver Algorithm

Fig.2: Client Transceiver System
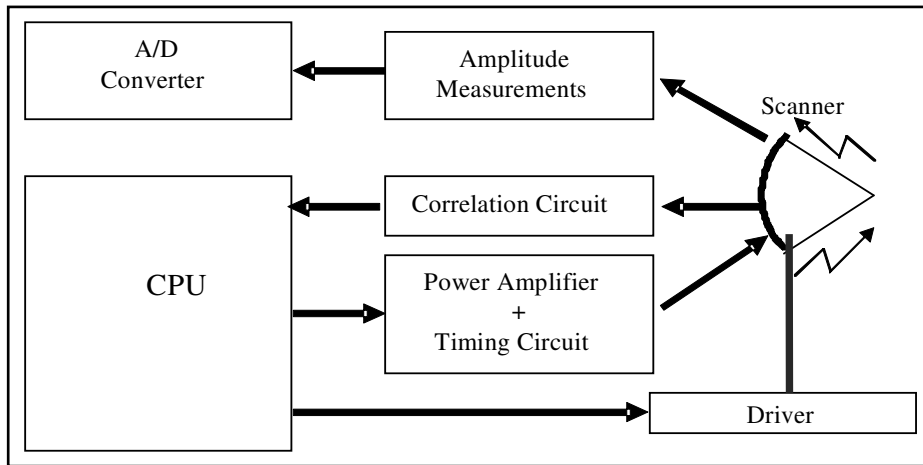
Fig.3 Server Transceiver And Scanner Control System
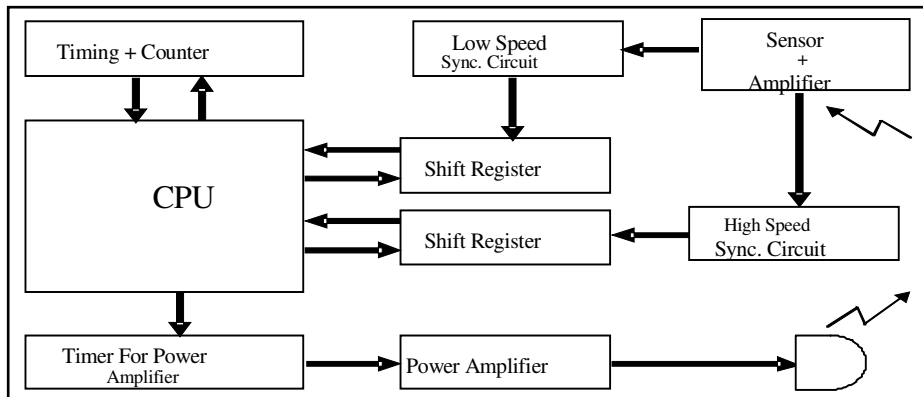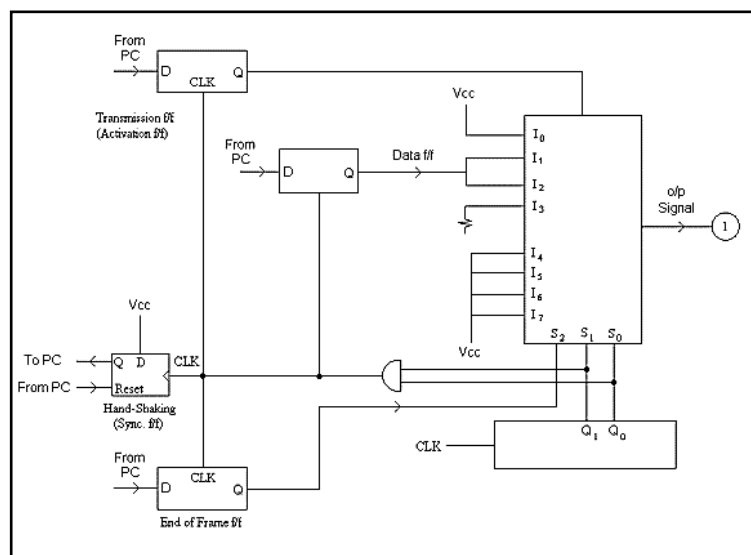
Fig.4 Client Transceiver System

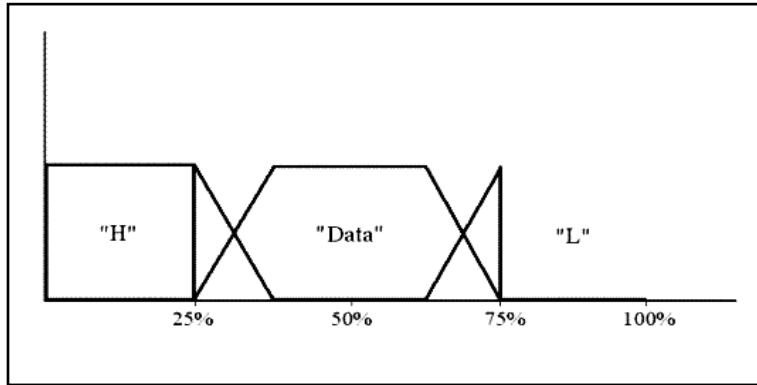Fig.5 Interfacing and Synchronization System
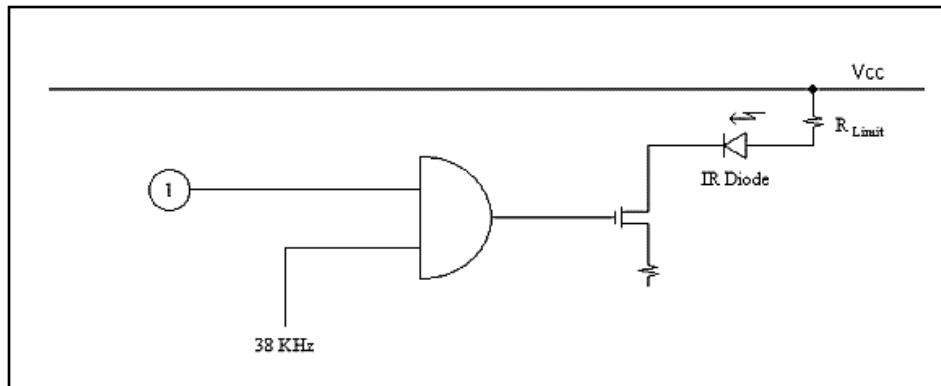
Fig.6 Transmitted Data Format

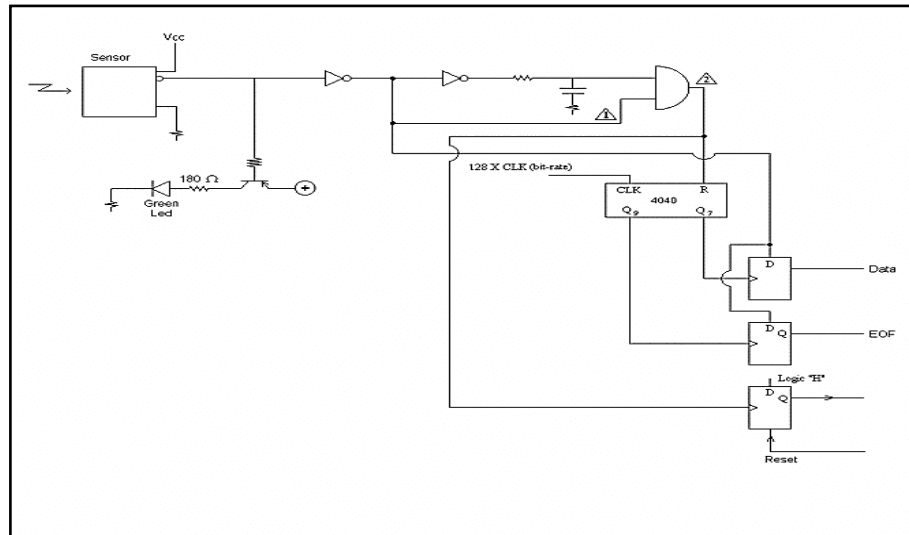Fig. 7: Optical Transmission Circuit
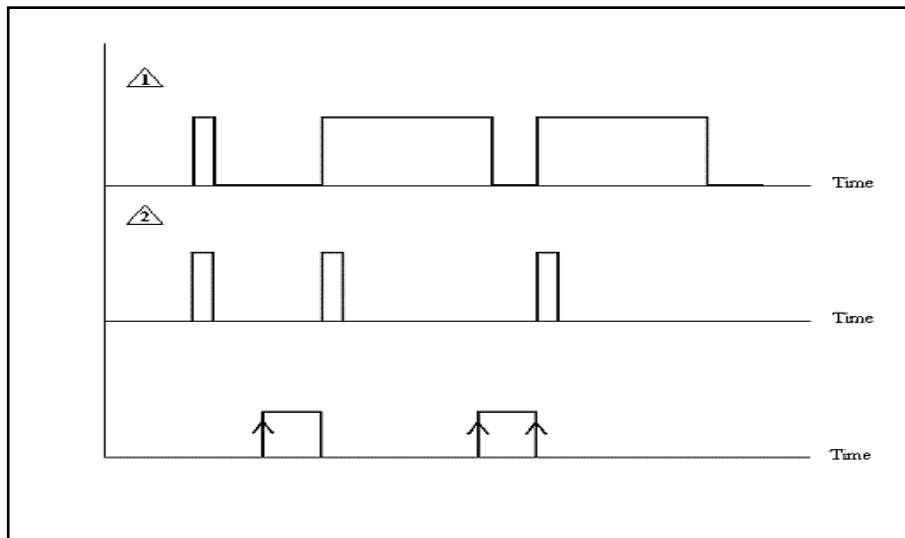

Fig. 8: Optical Receiving Circuit

Fig. 9: Received Data Format

The data is synchronized and buffered by the D-flip flop devices (HEF4013B) as shown in Fig. 5. Before being selected by the multiplexer, the data format allows 25% for low, 25% for high logic levels, 50 % for data. The data signal is converted to optical form for wireless transmission to take place as shown in Fig.7.

The transmitted signal is modulated to 38 KHz in order to avoid interference from surrounding devices. At the receiving end the computer reconstructs the transmitted frame and extracts the data.

The receiving computer awaits the start of the bit stream by monitoring the output of bit synchronization process of D-Flip-Flop via the input/output port. When the output goes high, it signals the start of bits arrival, the received data signals are sampled at the middle to ensure stability, the receiving PC the resets the hand shaking line waiting for new inputs. Changing the status of the D-flip-flop from 0 to 1 signals the end of frame.

CONCLUSION

The designed W-PTRS, which was successfully built and tested, proved to be an excellent tool as a non-standard wireless LAN application. In addition, it serves as a connectivity network for any one with a device equipped with IR TX\RX system that can connect to it and access network and internet services. This is much like "a stop station" or transit station provides parallel Client-Server connectivity, which can be modeled as a multiple ring arrangement. The concept of Multi-Token Rings (MTR) is a very important topic to research into, in terms of wireless efficiency and data security, especially when more than one type of wireless sensors are used as in our system. As a new protocol, the system can provide a very efficient way of data communication between clients and servers. It does however need to be supported and standardized in order for people to feel its real benefits.

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