Wireless Computer Communication Using Laser Beam

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ملخص

أصبحت الاتصالات اللاسلكية خياراً أساسياً في الاتصالات الحاسوبية وذلك بسبب التوفير في كلفة مد خطوط الاتصال وإمكانية بناء معماريات ديناميكية مرنة. هذا البحث يقدم نموذجاً لنظام لاسلكي لنقل البيانات الرقمية باستخدام أشعة الليزر. وقد تم مناقشة المعدات وبروتوكولات الاتصال لهذا النموذج بالتفصيل ويتميز البروتوكول المستخدم في هذا النموذج بقدرته على تمرير البيانات بين الأجهزة وذلك يسمح في إنشاء شبكة حاسوبية لاسلكية. وتشير نتائج دراسة النظام المقترح على أن أدائه يعتمد بصورة كبيرة على ونوعية الخلايا الضوئية المستخدمة.

ABSTRACT

Wireless Communications starts to prove its self as an alternative for computer networking that save cabling cost and provide dynamic topology. This paper presents a prototype for a wireless data communication system using laser beam. The hardware and communication protocol are also discussed. The protocol allows the forwarding of packets to other computers,

which allows the creation of computer wireless network rather than a communication between two points. The performance results obtained showed that, the communication speed depends on the quality of the photo cells used. By using a normal quality photo cells, a communication speed performance about 1 KB(Kilo byte)/sec can be obtained.

1. Introduction:

In 1956, the first transatlantic copper wire cable allowed simultaneous transmission of 36 telephone conversations; a cause for celebration then, a paltry number today. Other cables followed; by the early 1960s, overseas telephone calls had reached 5 million per year. Then came satellite communication in the middle 1960s, and by 1980, the telephone system carried some 200 million overseas calls per year. But as demands on the telecommunication system continued to increase, the limitations of current technology became glaringly apparent. Then, in the late 1980s, came the fruition of a variety of efforts to find the Holy Grail of communication–the harnessing of light itself as a way to communicate [6].

All forms of modern communication–radio and television signals, telephone conversation, computer data–rely on a carrier signal, a wavelike electromagnetic oscillation with a particular frequency. Electro-magnetic signals are described in terms of their wavelength (the distance between the peaks of two waves) or their frequency (expressed in hertz, the number of wave cycles per second); the shorter the wavelength, the higher the frequency. By modulating the carrier, we can encode the information to be transmitted; the higher the carrier frequency, the more information a signal can hold.

Copper wire is limited to a frequency of only 1 megahertz, or 1 million cycles per second, enough to carry a few dozen-voice channels; at higher frequencies, the wire's electrical resistance increases substantially. Coaxial cables–consisting of a solid conductor placed inside a hollow one to channel the signal between them and shield it from interference–became predominant after World War II and were used for trunk lines between cities; they can carry frequencies of up to 10 gigahertz, or 10 billion cycles per second. Unfortunately these coaxial cables are relatively expensive to lay over long distances, and even satellite and earthbound micro wave systems, which operate at frequencies of up to 40 gigahertz, began to reach their practical limit in terms of information-carrying capacity per channel.

The idea of using visible light as a medium for communication had occurred to Alexander Graham Bell back in the late 1870s, but he did not have a way to generate a useful carrier frequency or to transmit the light from point to point. In 1960, an idea first introduced by Albert Einstein more than 40 years earlier bore practical fruit with the invention of the laser. This achievement prompted researchers to find a way to make visible light a communication medium–and a few years later fiber optics arrived.

The first test came at AT&T in Atlanta in 1976. Work crews installed two fiber-optic cables–each 2,100 feet long and containing 144 fibers–by pulling them through standard underground ducts, which required the cables to negotiate sharp bends. To everyone's immense relief, installation did not break any of the fibers, nor did the tight bends degrade their performance. Commercial service began the next year in Chicago, where a fiber-optic system carried voice, data, and video signals over 1.5 miles of underground cable that connected two switching offices of the

Illinois Bell Telephone Company [6].

2. Wireless Communication:

Computer Communication is considered as one of the most important area for computer industry. The need for sharing resources, and distributing processes forced the computer industry to develop fast and reliable communication systems. One of the important cost factors in any networking system is the cables and their related operation such as digging and other cabling infra structures. Wireless Communications starts to prove its self as an alternative for computer networking that save cabling cost and provide dynamic topology (i.e. topology can be modified without the need to change any wires or connections as the case in cables network). The idea of using laser in communication (fiber optics) was explained in the previous section. However laser also can be used for wireless communication. This paper introduces a wireless communication system using laser beam. The idea behind using laser beam for data communication is as follows: when a laser photo cell (will be referred as laser detector device) detects a laser beam pulse , It will generate a voltage level + 5V (correspond to a logical level high or 1), otherwise it is considered 0.

3. System Architecture:

Figure 1 shows the general architecture of the system. The system can be divided into two main parts, namely:

1- The physical device

2- The controller driver

3.1 The Physical Device:

The physical device consists of the electronic circuit that is responsible for:

1- Laser Beam Generator / Detector Circuit (LBGD)

2- The PC Hardware Interface (HWI)

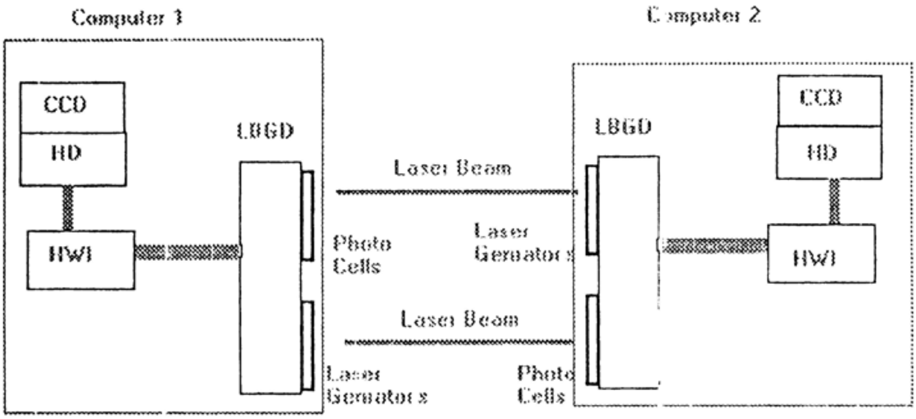

Figure 1: System Architecture

The circuit diagram for the physical device is illustrated in appendix A. Despite its simplicity, LBGD circuit plays a vital role in determining the communication speed and distance. Laser beams generators vary in their power, and for the time required to start generating laser beam. Beside that detectors also vary in the time required to detect a laser pulse and converting it to a particular voltage level.

The PC hardware interface (HWI) is the media through which the computer can communicate with the first component. During transmission, the HWI is responsible for turning on the laser beam generators that correspond to (1) bits, and turning off the generators that correspond to the (0) bits. On the other side (i.e. receiving), the HWI is responsible for acquiring the state of the laser beam detectors. In the current implementation the HWI can control 8 generators (connected to port A of the 8255 PIA), and 8 detectors (connected to port B of the 8255 PIA). The port C is reserved to handshaking bits. This allows a full duplex communication.

To transmit a byte, a series of handshaking operations are done through port C (see the communication protocol section). Then the byte is loaded into port A of the 8255 PIA. After a very short period (depends on the type of the generators used) the generators connected to the (1) bits in port A will start to generate a laser pulse. Finally, all the generators will be turned off by loading port A by 0. On the other side, the received byte is loaded into port B.

3.2 The Controller Driver (CD):

The controller driver represents the software part of the system. It consist of two main layers:

1- The Hardware Driver (HD)

2- The Communication Control Driver (CCD).

The hardware driver is responsible for controlling the 8255 PIA functions and carry out all the hardware software requirement for the CCD driver. The driver accomplish this through three main commands: Write port, read port and initialize. The write/read port commands write/read a data in/ from one of the three data ports of the 8255A. However the CCD use these two commands to write on port A and to read from port B only. The initialize command is used to initialize the 8255A for the required initialization by writing the suitable byte into the control register. This driver can be used for any device that is using the 8255 PIA.

The CCD carries out the communication work. The CCD implements the communication protocol to transfer a particular packet to another computer. It also responsible for generating the packet and initialize it with all the required control data.

4. The Communication Protocol (CP):

The CP assures the delivery of the data from one computer to another. It accomplishes this by a set of predefined steps agreed by the two computers. The protocol defines two control bits at each side of the communicated computers:

1- C_{ti} bit: Transmit bit for computer i. when C_{ti} is set to 1, then it indicates that computer i wants to transmit one byte.

2- C_{ri} bit : Receive bit for Computer i. C_{ri} is turned on then it indicates that computer I is ready to receive data. Setting this bit to zero (after it was 1) indicates that the byte is received

To send a byte from computer 1 to computer 2, the CP performs the following steps (Setting any bit to 1 will generate a laser beam by the generator connected to this bit).

1- Computer 1 declares that it wants to send a byte by setting the C_{t1} to 1.

2- Once computer 2 detects the laser beam it responses by setting C_{r2} to 1. If computer 2 is not ready to receive then nothing is done and computer 1 will wait for a predefined period then it will retry again.

3- When computer 1 detects the laser beam from C_{r2}, it loads the byte in port A, and turns the C_{t1} off.

4- Now Computer 2 will detects that is now off (i.e. no laser beam) and it reads port B. After reading the byte, computer 2 turns off the C^{r2} bit, to indicate receiving the byte.

The CP generates a packet of 134 bytes. The packet structure is a s follows

1- data length (1 byte)

2- Source Computer (2 bytes)

3- Final Destination (2 bytes)

4- Data (zero up to 127 bytes)

5- Check sum (2 bytes)

The packet allows a variable length data (zero up to 127 bytes) to be transferred between two computers. The actual length of the transmitted data is stored in the data length field. The source and destination field is used in case of a routing technique to transmit data through many computers to a final destination.

5. System Performance:

In order to measure the performance of the system, the designed hardware is used to transfer files of sizes ranges from 1KB up to 5KB. The results obtained are shown in figure Table1. Figure 2 shows a graphical representation for these results. The results showed that communication speed for all cases is around 1 KB/sec.

Size (in Kilobyte)	Time in Seconds
1KB	1.02
2KB	1.97
3KB	2.9
4KB	3.93
5KB	4.87

Figure 2: Performance results

The performance of any laser system is effected by two main factors, namely: the quality of equipment (detectors and generators), and the frequency of the laser beam used. The equipment used in this paper are of low cost. Using high quality equipment (with much higher cost) may improve the performance for laser beam to reach multiple mega bits /sec which is close to available commercial system such as [8].

6. Conclusion:

Laser beam can be used for a wireless transfer of data between two computers. The speed of transmission and distance between the two computers is effected by the quality of the laser beam generators and detectors used. The advantages that this system over the available commercial systems can be summarized as follows:

1- The designed system allows a full duplex communication. 8 bits of data can be transferred in both directions in parallel. Available systems allows serial communications only.

2- The system allows a network of more than two computers to be established. The proposed protocol allows forwarding packets to other computers. The available systems allows point to point communication (communication between two computers).

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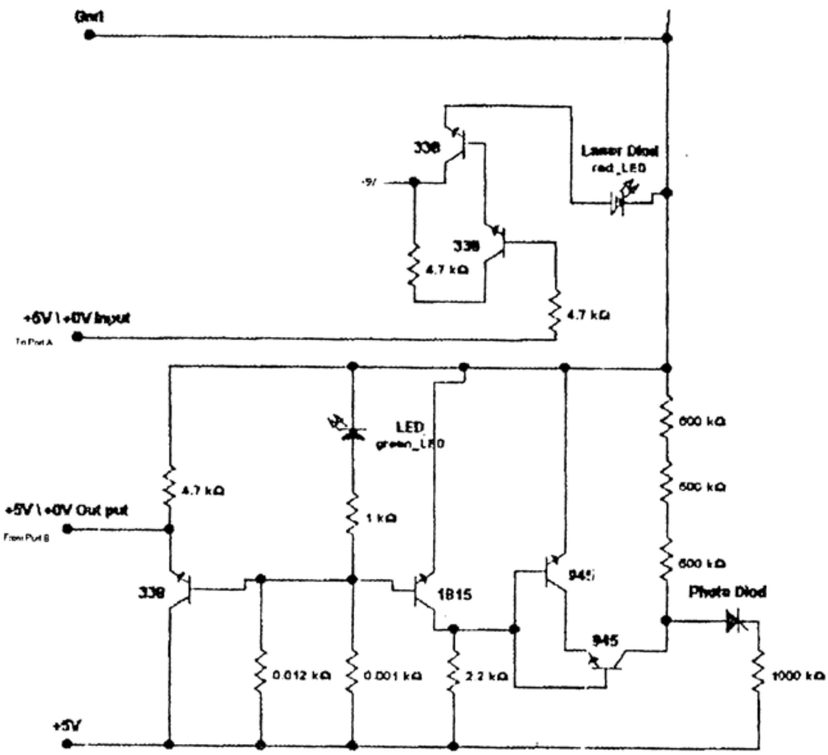
Appendix A
The Hardware Diagrams

A.1 The LBGD Circuit

The Diagram below shows the LBGD circuit for one laser beam generator /detector. The same circuit is duplicated 8 times n order to transfer and receive one byte.



A.2 The PCHI Circuit

The PCHI Circuit is the hardware that interfaces the computer hardware and the LBGD circuit. All the I/O operations are done through the 8255A PIA. The address decoding for the card are done by the 74LS588N 8 bits comparator. This IC compares the bits A2 up to A9 of the address bus with those selected by the user through DIP. If the address matches the IC will select the 8255A PIA.