Palestine Polytechnic University

College of Engineering and Technology

Electrical and Computer Engineering Department

Graduation project Introduction

Design Optical Communication System and Transmission Video Signal through it

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Abstract:

This project aim to design and implement an optical communication system using fiber optic, this system consists of transmitter, receiver and the optical fiber as communication channel.

In our system we will study the power that will be emitted by the optical source and launched into the optical and then to detected on the receiver.

The light power will be transmitted will be enough to cover all optic transmission losses ,and deliver enough light to the detector to achieve the desired signal to noise ratio or bit error rate to transmit avoid signal.

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Chapter 1

introduction

1.1 prefaces.

1.2 project importance.

1.3 project objectives.

1.4 literature review.

1.5 requirements.

1.6 time plane.

1.7 expected cost.

1.8 project risks.

1.9 road map.

Chapter one

Introduction

1.1Preface:

Optical fibers are extremely thin stands to ultra pure glass designed to transmit light signals from transmitter to receiver these signals represent electrical signals that include in any compression video audio or data information.

Modern fiber optic communication systems can be extra ordinary complex as the data rates ,channel counts ,and transmission distance increase however the basic principle behind fiber are relatively simple .

The most important part in the transmitter design is the light emitter diode which have to convert the input electrical signal into optical signal have specified power which can travel through the fiber channel then enter the receiver which decode the light by photo detector to return back to its original form.

There is more than one type of electronics part can be used in the system design we choose the more suitable to the application we tend to applied at the system .we will explain the choice reason for every part in the chapter s later.

1.2 Project importance:

The importance of this project stems of its dependency on the fiber optic technology for communication. the reason for choosing the fiber optic is that it is extremely convient in communication for several reason will be discussed later in our object, also since optical communication using fiber optical is one of the most important technique in communication over long distance these years, it have a lot of advantages over other media like electromagnetic waves or copper wires.

This project aim to give good understanding for the design of optical fiber communication system.

1.3 Project objective:

The main objectives of the project are:

1- To design and implement a complete communication system using fiber optic.

2- To use the designed system in application (send video signal) to ensure its efficiency.

3- To study the optical power can be transmitted through the fiber channel.

4- can be detected by the receiver even it will suffer from attenuation in many parts in the system.

5- To study the communication losses in the system.

1.4 literature review:

Literature review related to fiber optic

1-Caries Res. 1997:-

Digital Imaging Fiber-Optic TransIllumination (DIFOTI-TM), a new method for the reliable detection of dental caries. Images of teeth obtained through visible-light, fiber-optic transillumination (FOTI) is acquired with a digital CCD camera, and sent to a computer for analysis with dedicated algorithms. The algorithms were developed to facilitate the location and diagnosis of carious lesions by the operator in real time, and provide quantitative characterization for monitoring of the lesions. The DIFOTI method has been tested by imaging teeth in vitro. The results suggest the superior sensitivity of DIFOTI for detection of a proximal, occlusal and smooth-surface caries vis-à-vis radiological imaging.

A novel fiber-optic sensor used for small internal curved surface measurement is presented. A measurement principle based on beam reflection is described. Theoretically calculated curves and measured values are given. The results provide an essential theoretical and design basis for the measurement of curved surfaces with fiber-optic sensor. This sensor, which is composed of eight symmetrically cross-arranged receiving fibers and one centered emitting fiber, can accomplish distance measurement with high vertical resolution of 0.1 μm through compensation of the impacts caused by fluctuations of the surface reflectivity and light power.

Yong Zhao, Pengsheng Li, Chenshuang Wang and Zhaobang Pu

24 March 2000.

Methemo globinemia, a condition associated with cyanosis and diminished pulse oxymora values, has been reported after use of local anesthetics to facilitate fiber optic intubations. The majority of reports in the literature detail this development during diagnostic procedures such as endoscope and bronchoscope. A case of methemoglobinemia in a multiple-injury patient with an unstable compressive-flexion injury of the cervical spine undergoing fiber optic intubations is presented.

Journal of Spinal Disorders & Techniques:

June 2006 - Volume 19

1.5 Requirements:

The project need hardware components which include electronics like resistances ,lasers, photo detector for the circuit design and also we need a software program (orcade program) to understand the how these circuits will work in the design, and MATLAB to make interfaces, the, also we will use a pc computer to load the video signal from it to the transmitter circuit and to but the digital data that carry the video into the circuit we will use microprocessor to arrange them into frames to send them serially in the fiber after demultiplexing the three essential frames (red, green ,and blue) with the synchronized signal.

1.6 Time plane:

The time plane and task descriptions for first semester is shown in table 1.1

Table (1.1) Time Plane

Week Task	1	2	3	4	5	6	8	9	10	11	12	13	14	15	16

Data gathering & Analyzing															
Requirement analysis															
Studying fiber Optical															
Studying the design of tr. &the rec. using orcade															
Documentation															

1.7 Estimated cost:

The estimated cost of the project hardware is shown in the table (1.2):

Components	Cost ($)
laser	100
photo detector	20
Fiber cable	10
other electronic and electrical components	40

1.8 project risks:

The project may face some problems and risks that we have to declare in the early time

Of the project design and manipulation, and the project must avoid those problems to

Work in its high efficiency, so when we find a risk we try to solve it without affecting

The total project as much as we can, the risks such as:

1- Illness or absence of the team member.

2- Technology specification change.

3- Unavailability of some project needed components under the pressure of

4- Political environments.

5- Some of project component not work correctly, it will affect the whole system.

6- Lack of experience using lab instrument.

7- Latency of some component arrival.

1.9 project road map:

The project consists of eight chapters each chapter describe a specific area of the Project the contents of each chapter as follow:

Chapter one "introduction":

This chapter gives a general idea about the project, explain the project importance , and main objective, also it contain literature review of the studies related to our Project, besides it include requirements, the time plane, road map .and the total Estimated cost of the project..

Chapter two "theoretical back ground":

This chapter gives a clear picture about the system theoretical background related To main feature of the fiber optic cable**s**.

Chapter three "the system design":

In this chapter we will study the receiver and the transmitter design, the signal Transmission in the fiber

And of course the losses in the system design.

Chapter four "video transmission":-

How to enter the signal video in the transmitter and modulate it with the optical Carrier and how to demodulate in the receiver.

Chapter

2

THEORATICAL BACKGROUND.

2.1 light wave system component.

2.2 fiber optic.

2.2.1 Principle of operation.

2.2.2 Fiber optic types.

2.2.3 Fiber optic advantages.

Chapter Two

Theoretical background

This chapter provide an illustrate back ground for the project related topics, and

Components

2.1 light wave system component:

The general block diagram of fig (2.1) applies to fiber –optic communication system, the only difference being that the communication channel is the optical fiber channel, the other two components (the transmitter and the receiver) design to the need of this optical channel.

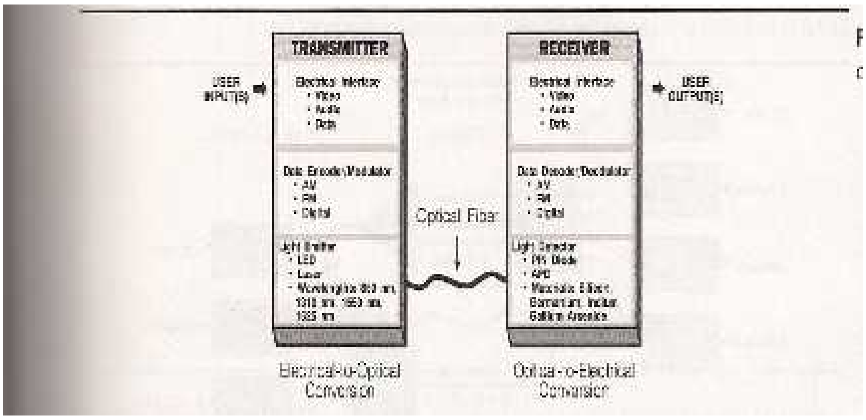

Fig (2.1) optical communication system.

The role of the optical channel is to transpose the optical signal from the

Transmitter into a receiver without distorting it. Most light wave system use optical

Fiber as the communication channel because silica fiber can transmit light with

Losses as small as 0,2dB/Km.

Even then, optical power reduce about 1%after 100Km for this reason fiber losses

Remain an important design issue and determines the repeater or amplifier spacing
Of a long –haul light wave system .

2.2fiber optic cables:

Optical fibers are extremely thin strand of ultra pure glass designed to transmit light signal from a transmitter to a receiver, these signals represent electrical signals that include, in any combination video, audio, or data information.

The raw material of optical fiber must be transparent to the light emitted from the light source included in the transmitter. But the term optical fiber is generic as it concerns lots the raw material of optical fiber must be transparent to the light emitted from the light source included in the transmitter. But the term optical fiber is generic as it concerns lots of types of fibers of different materials (glass, plastic, etc) with different dimension and performance (for example, the attenuation range from less than 1dB/Km).

The fiber consists of three main regions.

1-The core: it consists of a cylinder of transparent material having different characteristics with a certain refractive index n1. Its range in diameter from 9 micron (Mm) to 100 micron in the most used fiber.

2-the cladding: the cladding surrounding the core and so it's a coaxial layer of another transparent material with refractive index n2, (lower than that of the core), the cladding confines the light in the core, the cladding typically has diameter of 125 micron.

The core and the cladding complete the make the structure of the fiber acting as optical waveguide.

The core and the cladding cannot be separated and generally the consist of the same material (glass-glass or plastic-plastic), some times they are made of different material (core of glass and cladding of plastic).

The dimension of core and cladding are currently indicated with the values of their two diameter (expressed in Mm) separated by a bar.

EX. Fiber 50/125 means a fiber having a core with diameter of 50Mm and a cladding with the diameter of 125Mm.

2-the coating layers : is the outer region of the optical fiber and it also called the buffer or the coating ,and it’s a plastic material provide protection and preserves since the mechanical structure of the fiber is too fragile there fore it is reinforced with various coating layers . These layers are:

-primary buffer, of epoxy plastic resin (diameter of 250 Mm for fiber with cladding of 125Mm).

-intermediate buffer, of silicon (diameter of 410Mm).

-secondary buffer, of plastic material (diameter of 900Mm).

2.2.1 Principle of operation:

The principle of total internal reflection governs the operation of optical fiber. The refractive index in the cladding material is lower than that the core .

2.2.2Fiber optic types:

1-Single mode fiber: an optical fiber that carries only one ray of light, the ray of light can contain several wavelengths.

The normalized frequency in this type is less than 2.405 and the radius of fiber core should be less than 3.2μm.

2-Multi-mode optical fiber multimode fiber or MM fiber or fiber is a type of optical fiber mostly used for communication over shorter distances, such as within a building or on a campus. Typical multimode links have data rates of 10 Mbit/s to 10 Gbit/s over link lengths of up to 600 meters—more than sufficient for the majority of premises applications.

Multimode fiber has higher "light-gathering" capacity than single-mode optical fiber. In practical terms, the larger core size simplifies connections and also allows the use of lower-cost electronics such as light-emitting diodes (LEDs) and vertical-cavity surface-emitting lasers (VCSELs) which operate at the 850 nm and 1300 nm wavelength (single-mode fibers used in telecommunications operate at 1310 or 1550 nm and require more expensive laser sources. Single mode fibers exist for nearly all visible wavelengths of light).[2] However, compared to single-mode fibers, the limit on speed time's distance is lower. Because multi-mode fiber has a larger core-size than single-mode fiber, it supports more than one propagation mode; hence it is limited by modal dispersion, while single mode is not. Also, because of their larger core size, multi-mode fibers have higher numerical apertures which means they are better at collecting light than single-mode fibers. Due to the modal dispersion in the fiber, multi-mode fiber has higher pulse spreading rates than single mode fiber, limiting multi-mode fiber’s information transmission capacity.

Single-mode fibers are most often used in high-precision scientific research because the allowance of only one propagation mode of the light makes the light easier to focus properly.

2.2.3fiber optic advantages:

1-immunity from Fiber optic hold a great advantage over copper media since it can handle high speed signal over extended distance, the main advantage of fiber include:

- Ectromagnetic (EM) radiation and lighting: because the fiber itself is made from dielectric (no conducting) materials, it's unaffected by EM radiation.

2- Immunity from electromagnetic is important in modern aircraft designs .and it is the key reason to use fiber devices in commercial security and intelligent transportation system.

3- Lighter weight: this feature refer to the fiber optic itself, in real world applications copper Cables can often be replaced by fiber optic cables that weight at least ten times less.

4- For long distance, a complete fiber optic system (optical fiber and cable, plus the supporting electronics) also has a significant weight advantage over copper system; this is not true for short System, because fiber optic system almost always require more elaborate, and thus larger and Heavier electronics than copper system.

5-Higher band width:

Fiber has higher band width than any alternative available; the band width of the copper is limited, A modern fiber optic system with similar or superior signal quality for 50 miles or more without Needing intermediate amplification (repeaters), even at that, most modern fiber optic communication System uses less than a few percentage of fiber inherent band width.

6- Better signal quality:

Because fiber is immune to EM interference, has lower loss per unit distance, and wider band width, Signal quality is usually better compared to copper.

7- Lower cost:

This advantage has to be qualified .fiber certainly cost less for long distance application, however, For signal transmission requirements over distance of few feet, copper will be cheaper and always Will be. The cost of fiber itself is cheaper per unit distance than copper if band width and transmission distance requirements are high.

Fiber and copper systems can be compared by finding a break even distance, at distance shorter Than break even point the copper is cheaper and vise versa.

The electronics and the electro optics used on each end of the fiber was the limitation of fiber Optic systems today and for concerned of glass being very brittle and prone to breakage .in fact Glass in many times stronger than steel, and optical fiber are so small that they are flexible.

Relationship between the optical output power and the optical input power in a fiber optic system. It is measure of the decay of signal strength or loss of light power that occurs as light pulses Propagate through the length of the fiber; the decay along the fiber is exponential.

Attenuation in optical fiber is caused by several intrinsic and extrinsic factors. Two intrinsic factors Are scattering and absorption. The most common form of scattering, ray Leigh scattering (As fig 2.3) is caused by microscopic non-uniformities in the optical fiber.

Nearly 90% of the total attenuation can be attributed to it. It becomes important when the size Of structure in the glass it self are comparable in size to the wavelength are less affected than short wavelength. The attenuation coefficient (α) decreases as the wavelength (λ) increase and is Proportional to $\lambda^{\wedge}4$. Rayleigh scattering increase sharply at short wave length.

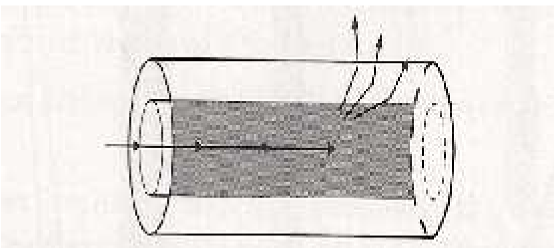

Fig (2.2) ray Leigh scattering

Absorption illustrated in (fig 2.4) can be caused by the molecular structure of the material, impurities in the fiber such as metal ions, OH- ions (water), and atomic defects such as unwanted oxidized elements in the glass composition, these impurities absorb the optical energy and dissipate the light as a small amount of heat.

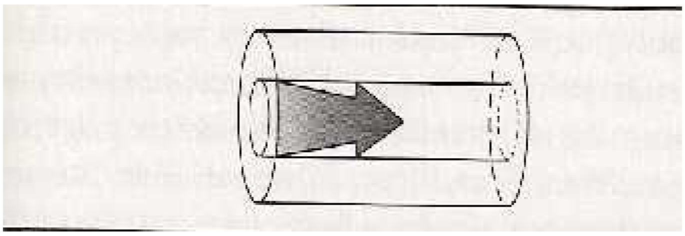

Fig (2.3) Absorption

In optical fiber link, other losses can be due to too narrow loops in the path of the optical cable (Bending losses as in fig 2.5) or to junction of more lengths of fiber.

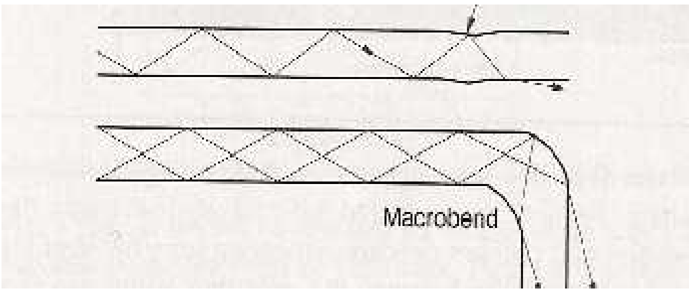

Fig (2.4) bending losses

The amount of attenuation caused by an optical fiber is primarily determined by its length and the wavelength of the light traveling through the fiber. There are also many secondary tertiary factors that contribute.

Chapter 3

System design

3.1 introductions.

3.2 transmitter design.

3.2.1 The optical source.

3.2.2 Transmitter design.

3.2.3 The multiplexer.

3.2.4 The modulator.

3.2.5 Driving circuit.

3.3 receiver design.

3.3.1 Optical receiver components.

3.3.2 Photodiodes and its types.

3.4.2.2 Avelanch photodiodes (APD).

3.4.2.3 Wavelengths.

3.4.3 Demodulator.

3.4.4 Functional block of optical receiver .

3.4.4.1 Front End .

3.4.4.2 Linear channel .

3.4.4.3 Data recovery .

Chapter Three

System design

3.1 introduction:

To transmit a signal in optical communication system we have to design a suitable transmitter to generate the suitable signal to be transmitted through a fiber optic cable. In order to transmit an optical signal into optical channel we have to convert the input data into optical rays to spread in the channel and then in the receiver side we reconverted the light into electrical by the photo detector. And for this reason in the design we will consider the optical source in the transmitter and the photo detector in the receiver the most important parts in the whole design.

Equipments &
components require for
system design
(laser,photodetectot,etc)

Software (mat lab) to
make electronic interface

Transmitter and receiver
design
Buy optical fiber cable
Then connect the
Communication system

Take digital video signal
from DVI of PC

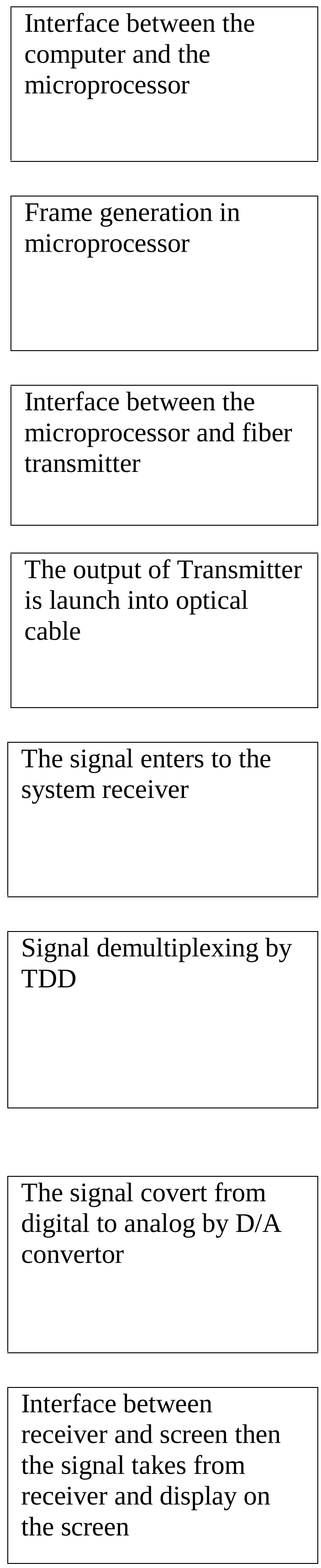

Fig (3.1) block diagram of project

3.2 transmitter design:

3.2.1 The optical source:-

This optical sources are many types from cheap lead s which directly driven by signal sources to the sophisticated transmitter using externally modulated distributed –feed back laser.

In our project we tend to use a laser as an optical source in the transmitter circuit which can change its parameter (intensity, frequency, or phase) in response of the data to be transmitted.

But as most optical sources laser change its intensity according to the electrical data .in this way we can convert the electrical signal (in our project will be video) to an optical signal which can be injected into the optical channel "fiber optic cable".

We can also use an light emitter diode "led" instead of laser the two light emitter have the following characteristics:

1) Overall small size.
2) High radiance; they emit a lot of light in a small area.
3) Small emitting area "the area is comparable to the dim of optical fiber core ".
4) Very long life "height reliability".
5) Can be modulated on and off" at high speed.

The laser as the led operates on the p-n junction principles, but the lasers have an advantage over LED.

The most narrow emission angle and the emission spot are very small, usually in microns in diameter and for this reason Avery high percentage of light can be easily focused into the fiber, more than 50%". And also it's the fastest of the light emitter types and since we need to transmit a video signal and to get high bit rate this means fast light emitter and so we choose the laser diode.

Light emitter performance characteristics:

In the design of the optical communication system we should understand the basic characteristics and determine them in our design:

1) peak wave length :

The wavelength at which the source emits the most power and it should be matched to the wave length that is transmitted with the least attenuation through the optical fiber.

The most common peak wave length is near 780nm, 850nm, 1310nm, 150nm, and 1650nm.

2) spectral width :

In practice the light emitted from an LED or laser will be in average of wave length Centered at peak wave length and this range will be called the spectral width of the source.

3) Emission pattern :

The pattern of the emitted light affect the amount of light that can be coupled into the optical fiber, ideally the size of the emitting region should be similar to the diameter of the fiber core.

4) Power :

The best result would be achieve by coupling as much of source power into the fiber as possible.

The key requirement is that the output power of the source be strong enough to provide sufficient power to the detector at the receiver, consider the attenuation in the fiber and the power losses in the coupling.In general the laser (in mW) is more powerful than the LED (in MW).

To calculate the needed laser power,All the losses in the system should be considered, and these losses are:

1-losses in transferring light from source into fiber.

2-connector losses.

3-splice losses.

4-coupler losses.

5-Fiber losses.

6- fiber to receiver coupling losses.

We need enough light power to cover all optical transmission losses and deliver enough light to the receiver to achieve the desired signal to noise ratio or bit error rate.And also design should leave some extra margin above the receiver minimum requirements to allow for system aging, fluctuation and repairs, such as splicing a broken cable.

5) speed:

The source should turn on and off fast enough the band width limits of the system.

The speed given is according to source rise or fall time.

The time requires going from 10% to 90% of peak power and laser have faster rise and fall times than LEDs.

6) Spectral characteristic:

The spectral characteristics for the laser are shown in the fig. (3.1)

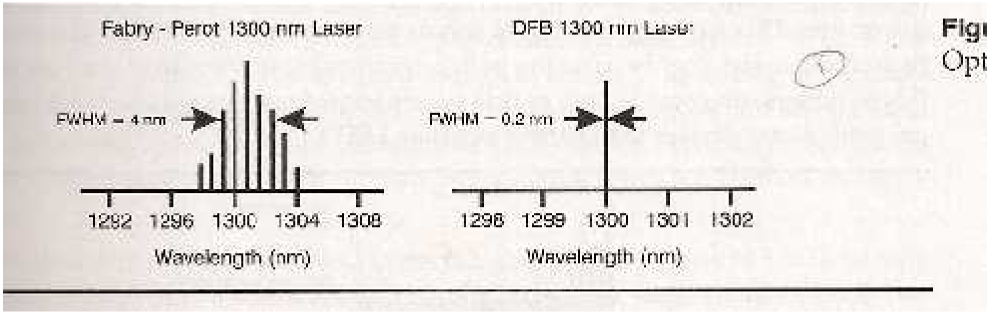

Fig (3.2) the spectral characteristics for the laser.

The fig above shown the spectral characteristic For the laser diode there is two types the first one emit nine discrete line in nine different frequencies this type called multimode laser diode or "fabry-perot laser".

Helium –neon (he Ne) laser which emit at a single line at 633nm, fabry perot emit at multiple, closely spaced wave lengths simultaneously.
The light from the multimode laser less coherent than the light from (HeNe) laser, and this wider spectrum because some additional dispersion in the fiber but it minimize other problem when using multimode fiber, and since we will use a single mode fiber, we are not concerned to explain it.

3.2.2 Transmitter design:-

The role of an optical transmitter is to convert the electrical signal into optical form and to launch the resulting optical signal into the optical fiber but in practice the problem is not easy like that ,first how to take a digital form of video signal and how to send this digital video stream serially in the optical fiber. In this chapter we will explain the technique we will use to send this *stream* of bits.

The optical transmitter consists of an optical source, multiplexer, a modulator and a channel coupler.

Semiconductor laser or light emitting diode are used as optical source because of their compatibility with the optical- fiber communication channel.

The optical signal is generated by modulating the optical carrier wave.

The optical sources need a good deal in order to get a good communication system using fiber.

Every component in the transmitter has a special task to do in the transmission.

3.2.3 The multiplexer:

Multiplexer is combined the multiple signals to generate one signal for transmission. there are many types of multiplexing in optical fiber transmission such as: frequency division multiplexing, time division multiplexing, and wavelength division multiplexing, but the suitable type for this project is time division multiplexing, time and frequency division multiplexing are done before the signal goes to the transmitter, but the frequency division for analog signal and the time division for analog signal, the wavelength division multiplexing is done optically.

1- Time division multiplexing: in this type the two or more digital signals are combined to give one higher speed signal, by interleaving the bits from separate streams. Usually is done before sending signal to the transmitter.

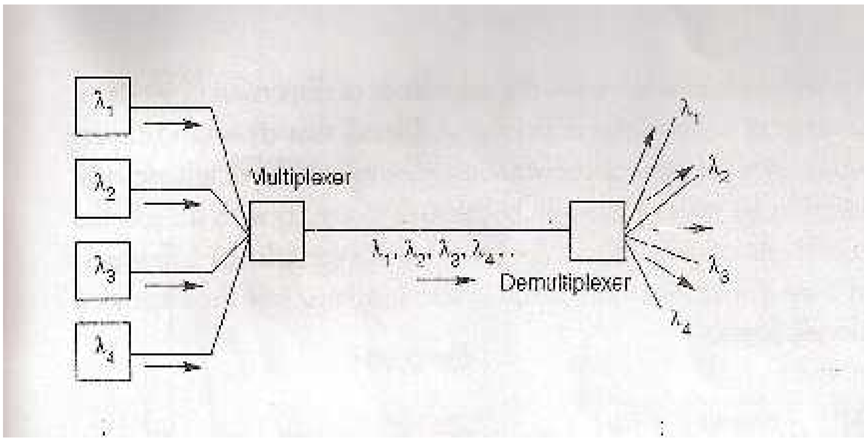

Fig (3.3) time division multiplexing and demultiplexing

3.2.4 The modulator:

impose a signal on a steady light beam passing through it make as turning the laser beam off and on chipping the beam into a series of pulses that Carrey the signal ."Sometimes blocking the beam and sometimes transmitting it".
And the electrical driving circuit for supplying current to the optical source.

3.2.5 Driving circuit:

We need driving circuit to supply the optical source with an electrical power and also modulated the light output with accordance with the signal which we need to transmit. The driving circuits depend on the application requirements data format, and the light source LED can be driven by suitable current source however semi conductor laser must be biased to current level near threshold and then modulated through an electrical time dependent signal.

The driving circuit is designed to supply a constant bias current as it supply the modulated electrical signal ,and in order to keep the average optical power constant we use a servo loop .as shown in the fig.(3.4)

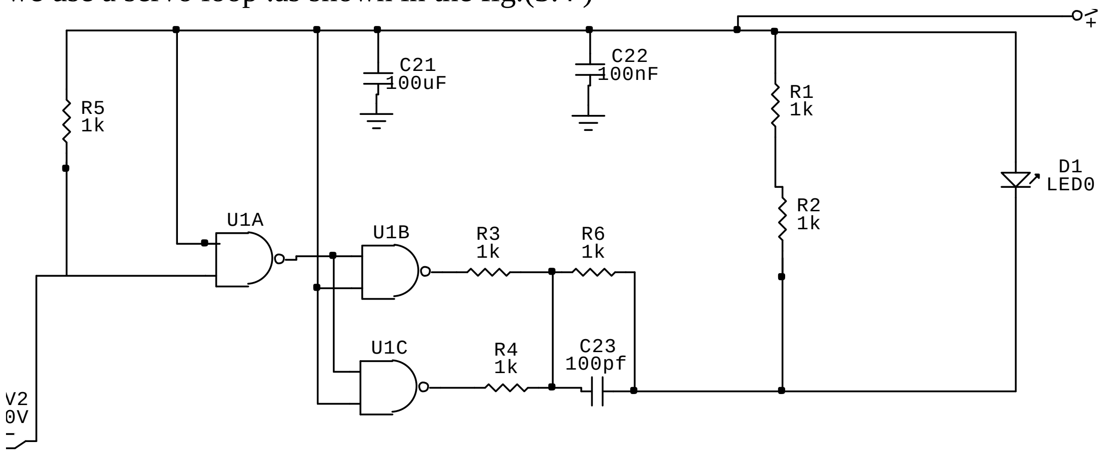

Fig (3.4) the driving circuit of transmitter.

In this simple drive circuit that control the average optical power through feed back mechanism, a photo diode monitors the laser out put and generates the control signal which used to adjust the laser bias level.

The bias –level control is essential the laser threshold is sensitive to the operating temperature, the threshold increase with aging of the transmitter.

In the drive circuit shown in fig (3.4) the drive signal will applied as voltage to the base of transistor .so it modulates the drive current through the laser diode, the detector packaged with the laser monitor output providing feed back to an amplifier (at right) which adjust the bias applied to the laser diode ,thus controlling average power level .

The signal represented by a voltage of +5V corresponding to the binary datum 1 , and by a voltage of 0V corresponding to the binary datum 0 , is applied to a network NAND gates. Theses three gates are connected as inverter: the first one acts as separation buffer ,but the other two gates are connected in parallel and generate a certain current quantity.

The driving circuit can be connected to the led , and the resistor R58 has been connected to obtain the current value across the leds.

3.3 Source fiber coupling:

The power from light source can be in a rang about 100mW for laser to ten microwatt for LEDs ,but not all the power can be used in practice since some of the power will be lost in the system.

Optical fiber and in the transmitting design objective is to couple as much as can into the fiber core .The amount of the power that can be coupled is dependent on the used optical source and on the fiber mode.

The power which delivered into an optical fiber depends on the angle over which light is emitted, the size of the light –emitting area the alignment of the source and fiber, and the light collection characteristics of the fiber as shown in the fig. (3.5)

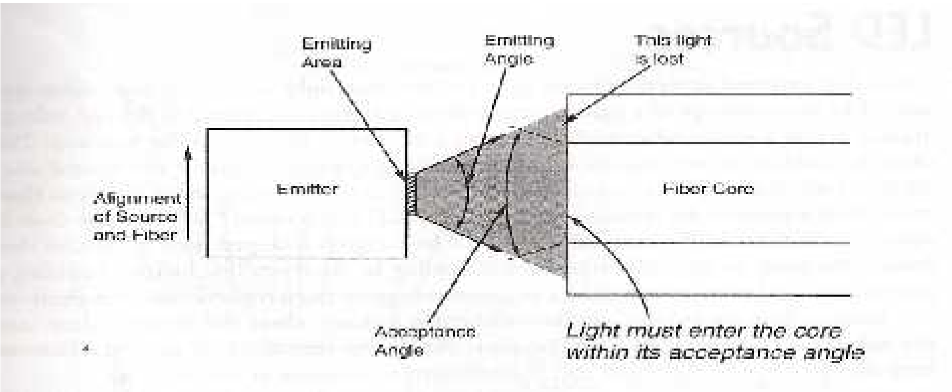

Fig (3.5) the light collection Characteristic

The light intensity is not uniform over the entire angle at which light is emitted but rather falls off with distance from the center.

Typically laser emit light that spread at an angle of 10-20%,but the light the light spread out at larger angle s.And so the coupling amount can be vary from 1%in the case when we couple alight from a LED into a single mode fiber into about 40-50% if we choose a laser .and increase to 80%if we use an improved type of laser diode (VCSEL s) since its light have circular spot size.

And the coupling efficiency also changes with numerical aperture.

The optical interface between light source and fiber can various forms.

One way is the integration of a fiber optic connector by internal optics, including a collimating and some times a short fiber segment.

The second way of interfacing is short fiber pigtail that collects light from the emitting area and deliver it out side the case where it can be spliced to an external fiber, the choice depend on factors including cost ,the connection is temporary or permanent ,type of fiber ,importance of minimizing interconnection loss ,and operating environment.

The most important issue in the coupling is that to keep efficiency stable and not to change with time.

Using fiber that is tapped or has lenses tip or by added external lens to improve the coupling efficiency but it will be very expensive.

3. 4 receiver Design

3.4.1 Optical receiver components:

Receiver is an important device in optical fiber communication systems that convert optical signal into electrical signal to recover the transmitted signal.

It consist many components such as coupler, photodetector, demodulator, demultiplexer.

The coupler focuses the received signal onto the detector.

The detector is used to convert optical signal into electrical signal according to converting the variation of power into a varying electrical current.
There are many types of photo detector such as phototransistor, photomultiplier, and photodarlingtons but the suitable one can be used in fiber system is semiconductor photodiodes.

Photomultipliers are not suitable for optical fiber system because of their large size, and high voltage requirement and also used for small area.
Pyroelectric photo detectors are not suitable for optical fiber systems since their speed is limited.
Phototransistor can be used for low cost and low speed systems and not able to detect the low levels of lights (limited to system operating below MHz range).
Photodarlingtons consist of two transistors and it is not suitable for optical fiber system because the second transistor increases noise & lowers power.
In our project we want to use the semiconductor photodiode as detector because of it is properties and characteristics.

3.4.2 Photodiodes and its types:

Photodiodes is a type of detector that convert light into current also it is used in optical communication system according to small size, high sensitivity, fast response, high reliability, low noise, low cost and high performance since the optical signal that comes from fiber is distorted and weakened.

The types of semiconductor photodiodes that used in fiber optic systems are the PN junction, pin photodiodes and avalanche photodiode (APD) but many photodiodes are used PIN junction rather than the other types.

Photodiodes look like led's in their shapes and they have two wires one of these wire is longer than the other, the longer wire is called anode and the shorter is called cathode.

Under forward bias the conventional current moves from the anode towards the cathode and the photocurrent flows from cathode.

There are many types of photodiodes, pn junction, and pin junction and avelanch photodiodes.

3.4.2.1 PN junction and PIN junction:

PN consist of P-type and N-type semiconductor and the region between two types is called the PN junction.

The free electrons (-ve) and positive holes will be produced if the electron that belong sufficient energy is excited.

PIN junction consists of intrinsic material between p-type and n-type materials.

If the absorption occurs in the depletion region or the majority carriers diffuse across it (majority carrier refers to electron in n-type materials or the holes in p-type materials) the electron move to the cathode and holes move to the anode and the photocurrent will be produced.

When the PN junction is connected with external battery with it is positive pole connected to the n-type material and negative pole to the p-type material so that the junction is reverse bias.

At reverse bias the width of depletion region increases so that the number of electron hole pairs increase and the bandwidth will be increase.

Optical communication system use photodiodes with reverse bias since it is faster than forward bias and it is more sensitive to lights.

Also the reverse bias reduces the noise that produced by current so that the SNR is decreased.

PN diodes operate in unbiased (zero bias) mode but the PIN operates in reverse bias mode so that the depletion region is more wide in PIN rather than PN junction .also the PIN is faster and more sensitive to light rather than PN junction.

The photodiodes used in reverse bias mode, the bias voltage for PIN is 5 to 20V.

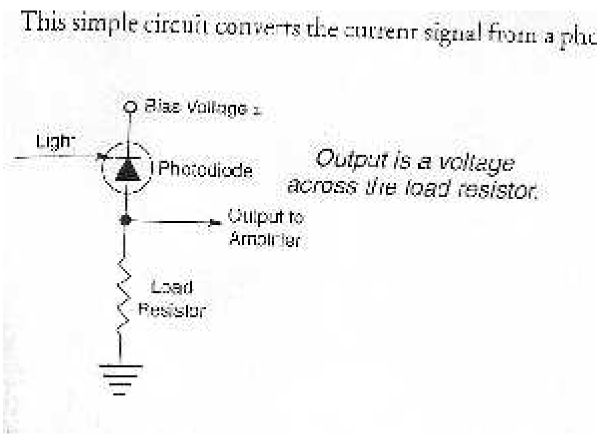

Fig (3.6) basic circuit of photoconductive PIN or PN photodiodes

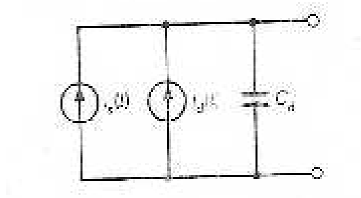

Fig (3.7) photodiodes equivalent circuit

3.4.2.2 Avelanch photodiodes (APD):

Bias circuit should be control voltage to avoid APD breakdown to exceed.

This type of photodiodes has an interval amplification stage and requires high bias voltage (100 to 300V) and high sensitive of the bias voltage of the photodiodes.

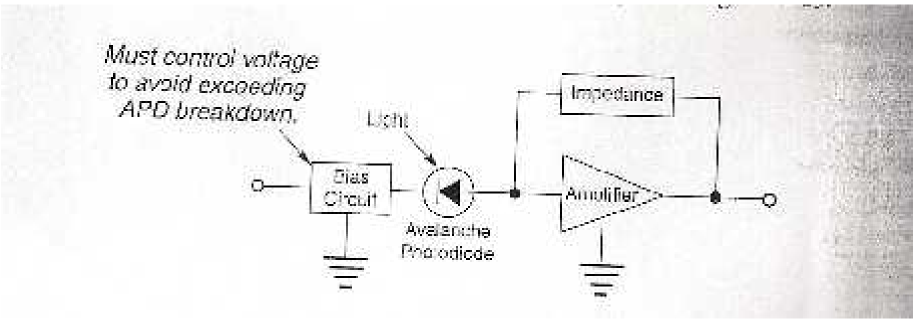

Fig (3.8) equivalent circuit of APD detector

In our project we want to use the PIN semiconductor photodiodes as detector since it is properties is good and do not require a high bias voltage.

3.4.2.3 Wavelength:

The sensitivity of the receiver depends on the type of detector used and the amplification stage circuit and the detector parameters depend on wavelength and the condition of operation.

Detector is made from different material. Each material has specific wavelengths.

The speed and dark current different according to detector material type can be used.

Silicon is used at 600 to 1000nm and germanium can be used at 1300nm.

The germanium detector slower and noisier than silicon detector and other types of detectors operate at one wavelength so that the silicon is the most suitable one.

3.4.3 Demodulator:

In optical communication device and the optical communication system whose size is small, cost is low and power consumption is low using DPSK modulation/ demodulation.

This provide excellent in reception sensitivity and use in a long distance optical communication systems.

3.4.4 Functional block of optical receiver:

The optical receivers divided into three functional parts are front end, linear channel and data recovery.

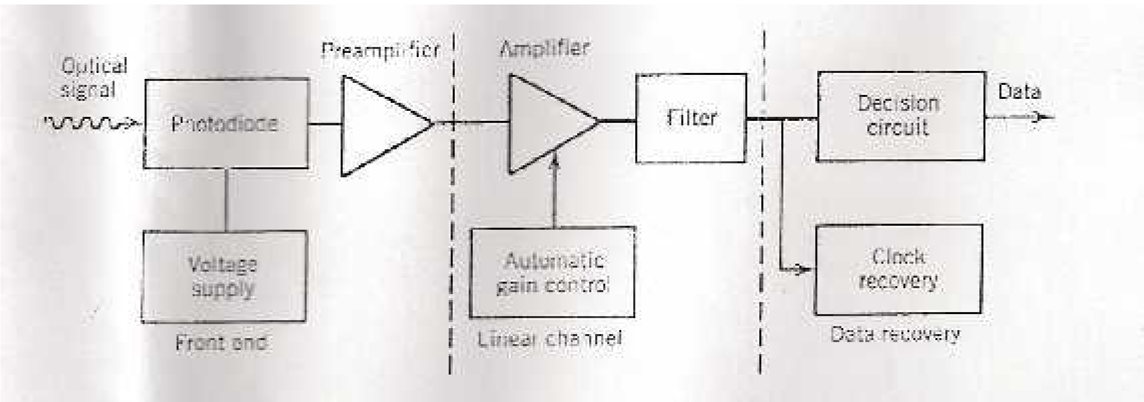

Fig (3.9) block diagram of optical receiver

3.4.4.1 Front end:

The first part of receiver, it consists of photodiodes as detector, low noise amplifier and voltage supply.

Preamplifier:

The receiver includes more than one amplification stage. The first one is called preamplification.

The optical signals that reaches the receiver are weak and distorted because the effect of attenuation so that the preamplifier can be used to amplify the electrical signal to generate a strong signal. This preamplifier also called the front-end amplifier.

The preamplifier can be classified into two types; a high impedance and transimpedance.

High impedance receiver amplifier:

Rl is large quantity to increase the input voltage of the preamplifier and reduce the thermal noise to improve the sensitivity of the receiver and increase the distance of the transmission.

If the bandwidth less than the bit rate a high impedance amplifier can not be used.

Equalizer is used to increase the bandwidth.

The low and high frequencies are amplified by different factor since the low frequency components affect but attenuation and distorted more than the high frequency components.

One method of increasing the BW if the sensitivity is not of concern is decreasing Rl this is resulting a low impedance amplifier so that in this case we need another type of preamplifier.

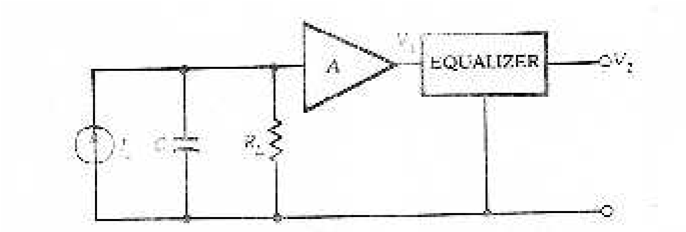

Fig (3.10) equivalent circuit of high impedance preamplifier

Transimpedance amplifier:

the second type of front-end amplifier that used in optical fiber receiver.

Transimpedance amplifiers have improved characteristic compared with high impedance amplifier such as dynamic range also it has high sensitivity and large bandwidth.

Rl is large value since the existence of feedback around an inverting amplifier and so the inverting amplifier and so the impedance decreases by a factor of G.

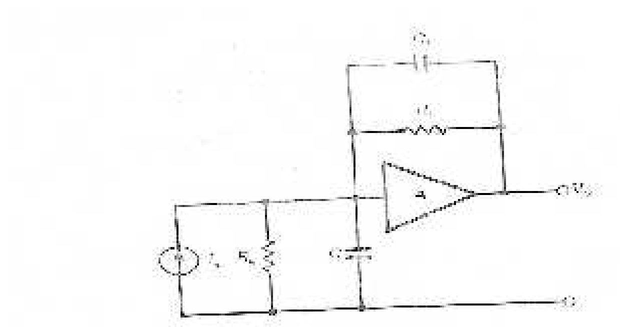

Fig (3.11) equivalent circuit of transimpedance amplifier

In our project we want to use the transimpedance amplifier to operate as preamplifier since it is improved characteristic.

The most electronic devices require input signal as voltage not current and using voltage easier than using current so that the output of photodiodes is converted.

3.4.4.2 Linear channel:

This part of receiver consists of the following components; the main amplifier, filter and automatic gain control (AGC).

The main amplifier is a high that uses to amplify the output signal of the preamplifier to produce the required signal.

The automatic gain control is control the gain of amplifier automatically to make a limitation of the average output power to a fixed level irrespective of incident average optical power at the receiver.

The filter is low pass filter type that removes the undesired frequencies and perform the shape of voltage pulses. Using the low pass filter decreases the noise so that the SNR ratio is increase and minimizes the intersymbol interference.

3.4.4.3 Data recovery:

The data recovery is the last part of optical receiver and it is contains the decision circuit and clock recovery circuit.

In this part of receiver we will to recover the original digital signal.

Clock recovery circuit synchronize the process of decision circuit and provide the bit slot information (Tb= 1/B) to the decision circuit.

The decision circuit makes comparison between the output of linear channel and a threshold level at sampling time that determined clock recovery circuit and make a decision which part of signal represents bit 0 or represents bit 1.

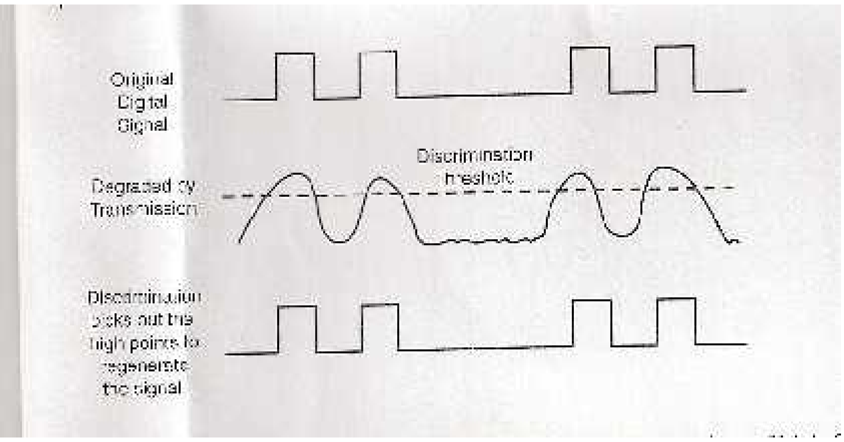

Fig (3.12) operation of decision circuit

3.4.5 driving circuit:

The Optical signal carried by the fiber is detected by the PIN photodiode included in the detector. The photodiode generates a current proportional to the incident radiation. The trans-impedance amplifier,assembled inside the same detector, supplies an output voltage proportional to the input current.

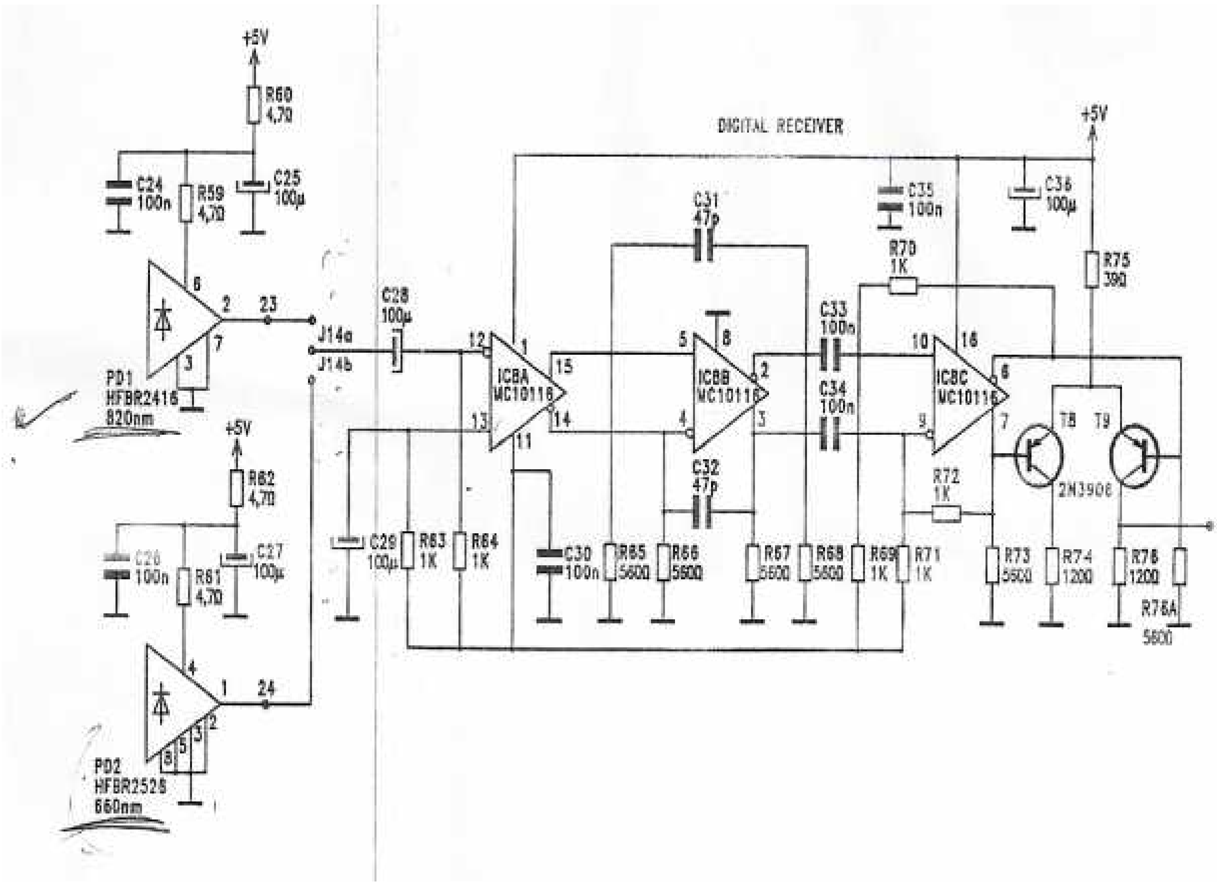

Fig (3.13) equivalent circuit of optical receiver

The detector can be connected to the following circuit .the voltage signal is amplified and squared by three consecutive gates (IC-8MC10116) and it is applied to the convertor (transistor T8-T9).

The photodetector_ is coupled in AC or DC to the amplifier,and the capacitor blocks the direct current offset.this prevent the passage of a possible direct current offset superimposing the signal.this can be obtained through the use of coders .

Chapter 4

Video transmission

4.1 Introduction.

4.2 video transmission requirements.

4.3 transmission media.

4.4 Digital video transmission through optical system.

Chapter four

Video Transmission

4.1 Introduction:

Video signal is an analog signal and separated into voice, data and synchronization Signals.

Video signals transmission is complicated than sending of voice and data.

Digital system converts the time varying electrical signal into streams of 0's and 1's That represents the binary data.

Video signals encode continually the picture and sound changing. The image of video Principles based on the scanning and the picture contains many parallel lines with Different intensity along the line.

Video signal consist of three primary colors, blue, red and green and each color has Electron beam differ from the other beams. Also the video signal contains the voice And synchronization signal.

Video signal contains the information that required to draw the lines. These lines have different intensity along the lines.

The signal through the lines can transmit point by point from one line to another.

The video signal encodes the color, brightness and sound of each point.

The way that the signal carries information depends on the format of encoding.

4.2 video transmission requirements:

Video signal require more transmission capacity than voice and digital data.

Data rates can be reduce by a factor of 10 to 60 for video transmission, by using sophisticated digital compression, and they depend on the picture series transmission, so that the single images can not compressed much.

Transmitter talk to receiver, so that video signals can bee transmitted in standardized formats.

Video is transmitted at 50 to 550MHz. the video bandwidth extend from 0 to 5.5MHz.

Video transmission generally is over single mode fiber at 1300 or 1550nm.

4.3 transmission media:

The transmission media that we want to use in fiber optics.

A single powerful laser source can produce optical signal to multiple nodes, so that reducing transmitter cost. The laser in this case split among the fiber delivered to separate nodes that receive the same signal.

Video transmission through fiber requirements vary widely and also requires high quality of transmission. The cost of

Fiber transmission has many advantages such as light weight, small size, high signal quality, long transmission distance, and immunity to electromagnetic interference, also offers more subtle advantages, notably avoiding the need to adjust transmission equipment to account for differences in cable length.

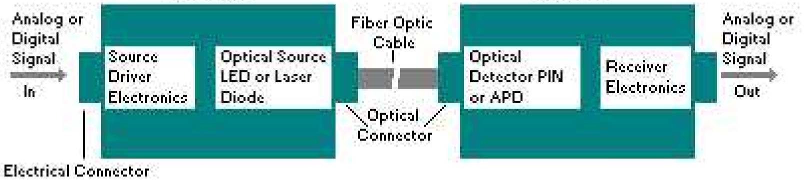

Fig (4.1) optical communication systems

4.4 Digital video transmission through optical system:

The conversion of analog video inputs to digital values is the principle of the digital video signal transmission over optical fiber.

At the transmissions end: there are A/D converters that encode the baseband video channels, and then the digital channels are multiplexing by TDM, and send to the laser of the transmitter. The digital signal convert into light pulses, and the laser is turn on for one and off for zero.

At the receiving end: the light pulses converted into electrical pulses, and demultiplexing by TDD, after that the electrical pulse sends to D/A converter for converting the information into baseband video signal.

In this project the video signal can be taken from DVI port of PC in digital form, so that we do not need A/D convertor. It contains the three primary colors; red, blue, and green, we will concern in specific out pins which indicate the color of the video signal.

The fig (3.4) shows the pin out from the DVI .the data sheet specify the signal that out from every pin.

The red color being in pin1 pin 2 pin 21 pin20 and the green is out from pin4 pin5 pin9 and pin 10 and the blue from pin 12 pin13 pin17 pin 18.

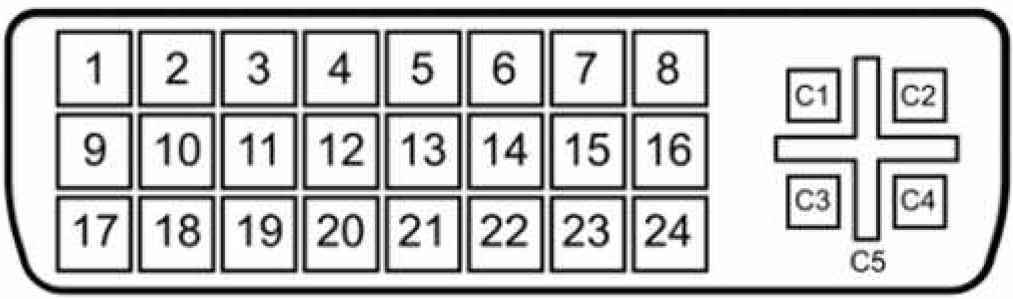

Fig (4.2) the DVI out pin.

Then we will arrange the digital data that carry the colored signal into frames (using the microprocessor) that its arrangement is known in the received part.
then these signals must enter to the microprocessor to form the frames, this frame consist of the three colours,voice,and synchronization .to make the last step also we need interface between PC and MP,the frame enter to transmitter, at transmitter the signal are multiplexing by TDM ,and send to the laser.

The transmitter launches the signal into optical fiber cable, after that the signal reaches the receiver. at the receiver signal are demultiplexing by TDD to divide the signal in it's original components, then it convert to digital by using D/A convertor, at last the signal takes from receiver and display on screen.

Appendix A

Data Sheet:

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Chapter 1

introduction

1.1 prefaces.

1.2 project importance.

1.3 project objectives.

1.4 literature review.

1.5 requirements.

1.6 time plane.

1.7 expected cost.

1.8 project risks.

1.9 road map.

Chapter one

Introduction

1.1Preface:

Optical fibers are extremely thin stands to ultra pure glass designed to transmit light signals from transmitter to receiver these signals represent electrical signals that include in any compression video audio or data information.

Modern fiber optic communication systems can be extra ordinary complex as the data rates ,channel counts ,and transmission distance increase however the basic principle behind fiber are relatively simple .

The most important part in the transmitter design is the light emitter diode which have to convert the input electrical signal into optical signal have specified power which can travel through the fiber channel then enter the receiver which decode the light by photo detector to return back to its original form.

There is more than one type of electronics part can be used in the system design we choose the more suitable to the application we tend to applied at the system .we will explain the choice reason for every part in the chapter s later.

1.2 Project importance:

The importance of this project stems of its dependency on the fiber optic technology for communication. the reason for choosing the fiber optic is that it is extremely convient in communication for several reason will be discussed later in our object, also since optical communication using fiber optical is one of the most important technique in communication over long distance these years, it have a lot of advantages over other media like electromagnetic waves or copper wires.

This project aim to give good understanding for the design of optical fiber communication system.

1.3 Project objective:

The main objectives of the project are:

1- To design and implement a complete communication system using fiber optic.

2- To use the designed system in application (send video signal) to ensure its efficiency.

3- To study the optical power can be transmitted through the fiber channel.

4- can be detected by the receiver even it will suffer from attenuation in many parts in the system.

5- To study the communication losses in the system.

1.4 literature review:

Literature review related to fiber optic

1-Caries Res. 1997:-

Digital Imaging Fiber-Optic TransIllumination (DIFOTI-TM), a new method for the reliable detection of dental caries. Images of teeth obtained through visible-light, fiber-optic transillumination (FOTI) is acquired with a digital CCD camera, and sent to a computer for analysis with dedicated algorithms. The algorithms were developed to facilitate the location and diagnosis of carious lesions by the operator in real time, and provide quantitative characterization for monitoring of the lesions. The DIFOTI method has been tested by imaging teeth in vitro. The results suggest the superior sensitivity of DIFOTI for detection of a proximal, occlusal and smooth-surface caries vis-à-vis radiological imaging.

A novel fiber-optic sensor used for small internal curved surface measurement is presented. A measurement principle based on beam reflection is described. Theoretically calculated curves and measured values are given. The results provide an essential theoretical and design basis for the measurement of curved surfaces with fiber-optic sensor. This sensor, which is composed of eight symmetrically cross-arranged receiving fibers and one centered emitting fiber, can accomplish distance measurement with high vertical resolution of 0.1 μm through compensation of the impacts caused by fluctuations of the surface reflectivity and light power.

Yong Zhao, Pengsheng Li, Chenshuang Wang and Zhaobang Pu

24 March 2000.

Methemo globinemia, a condition associated with cyanosis and diminished pulse oxymora values, has been reported after use of local anesthetics to facilitate fiber optic intubations. The majority of reports in the literature detail this development during diagnostic procedures such as endoscope and bronchoscope. A case of methemoglobinemia in a multiple-injury patient with an unstable compressive-flexion injury of the cervical spine undergoing fiber optic intubations is presented.

Journal of Spinal Disorders & Techniques:

June 2006 - Volume 19

1.5 Requirements:

The project need hardware components which include electronics like resistances ,lasers, photo detector for the circuit design and also we need a software program (orcade program) to understand the how these circuits will work in the design, and MATLAB to make interfaces, the ,also we will use a pc computer to load the video signal from it to the transmitter circuit and to but the digital data that carry the video into the circuit we will use microprocessor to arrange them into frames to send them serially in the fiber after demultiplexing the three essential frames (red, green ,and blue) with the synchronized signal.

1.6 Time plane:

The time plane and task descriptions for first semester is shown in table 1.1

Table (1.1) Time Plane

Week Task	1	2	3	4	5	6	8	9	10	11	12	13	14	15	16

Data gathering & Analyzing															
Requirement analysis															
Studying fiber Optical															
Studying the design of tr. &the rec. using orcade															
Documentation															

1.7 Estimated cost:

The estimated cost of the project hardware is shown in the table (1.2):

Components	Cost ($)
laser	100
photo detector	20
Fiber cable	10
other electronic and electrical components	40

1.8 project risks:

the project may face some problems and risks that we have to declare in the early time of the project design and manipulation, and the project must avoid those problems to work in its high efficiency, so when we find a risk we try to solve it without affecting the total project as much as we can, the risks such as:

1- Illness or absence of the team member.

2- Technology specification change.

3- Unavailability of some project needed components under the pressure of

4- political environments.

5- Some of project component not work correctly, it will affect the whole system.

6- Lack of experience using lab instrument.

7- Latency of some component arrival.

1.9 project road map:

The project consists of eight chapters each chapter describe a specific area of the project the contents of each chapter as follow:

Chapter one "introduction":

This chapter give a general idea about the project ,explain the project importance ,and main objective ,also it contain literature review of the studies related to our project ,besides it include requirements ,the time plane ,road map .and the total estimated cost of the project..

Chapter two "theoretical back ground":

This chapter gives a clear picture about the system theoretical background related to main feature of the fiber optic cable**s**.

Chapter three "the system design":

In this chapter we will study the receiver and the transmitter design, the signal transmission in the fiber

And of course the losses in the system design.

Chapter four "video transmission":-

How to enter the signal video in the transmitter and modulate it with the optical carrier and how to demodulate in the receiver.

Chapter

2

THEORATICAL BACKGROUND.

2.1 light wave system component.

2.2 fiber optic.

2.2.1 Principle of operation.

2.2.2 Fiber optic types.

2.2.3fiber optic advantages.

Chapter Two

Theoretical background

This chapter provide an illustrate back ground for the project related topics, and Components

2.1 light wave system component:

The general block diagram of fig (2.1) applies to fiber –optic communication system, the only difference being that the communication channel is the optical fiber channel, the other two components (the transmitter and the receiver) design to the need of this optical channel.

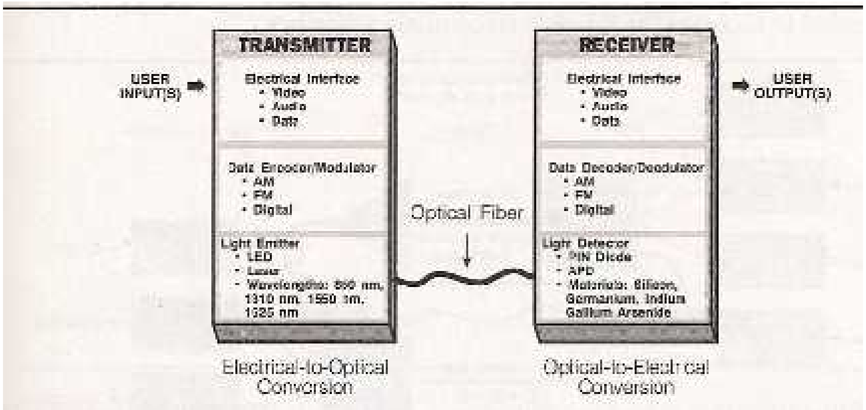

Fig (2.1) optical communication system.

The role of the optical channel is to transpose the optical signal from the transmitter into a receiver without distorting it. Most light wave system use optical fiber as the communication channel because silica fiber can transmit light with losses as small as 0,2dB/Km.

Even then ,optical power reduce about 1%after 100Km for this reason fiber losses remain an important design issue and determines the repeater or amplifier spacing of along –haul light wave system .

2.2fiber optic cables:

Optical fibers are extremely thin strand of ultra pure glass designed to transmit light signal from a transmitter to a receiver, these signals represent electrical signals that include, in any combination video, audio, or data information.

The raw material of optical fiber must be transparent to the light emitted from the light source included in the transmitter. But the term optical fiber is generic as it concerns lots the raw material of optical fiber must be transparent to the light emitted from the light source included in the transmitter. But the term optical fiber is generic as it concerns lots of types of fibers of different materials (glass, plastic, etc) with different dimension and performance (for example, the attenuation range from less than 1dB/Km).

The fiber consists of three main regions.

1- The core: it consists of a cylinder of transparent material having different characteristics with a certain refractive index n1. Its range in diameter from 9 micron (Mm) to 100 micron in the most used fiber.

2-the cladding: the cladding surrounding the core and so it's a coaxial layer of another transparent material with refractive index n2, (lower than that of the core), the cladding confines the light in the core, the cladding typically has diameter of 125 micron.

The core and the cladding complete the make the structure of the fiber acting as optical waveguide.

The core and the cladding cannot be separated and generally the consist of the same material (glass-glass or plastic-plastic), some times they are made of different material (core of glass and cladding of plastic).

The dimension of core and cladding are currently indicated with the values of their two diameter (expressed in Mm) separated by a bar.

EX. Fiber 50/125 means a fiber having a core with diameter of 50Mm and a cladding with the diameter of 125Mm.

3- the coating layers : is the outer region of the optical fiber and it also called the buffer or the coating ,and it's a plastic material provide protection and preserves since the mechanical structure of the fiber is too fragile there fore it is reinforced with various coating layers . These layers are:

-primary buffer, of epoxy plastic resin (diameter of 250 Mm for fiber with cladding of 125Mm).

-intermediate buffer, of silicon (diameter of 410Mm).

-secondary buffer, of plastic material (diameter of 900Mm).

2.2.1 Principle of operation:

The principle of total internal reflection governs the operation of optical fiber. The refractive index in the cladding material is lower than that the core .

2.2.2 Fiber optic types:

1- Single mode fiber: an optical fiber that carries only one ray of light, the ray of light can contain several wavelengths.

The normalized frequency in this type is less than 2.405 and the radius of fiber core should be less than 3.2μm.

2-Multi-mode optical fiber multimode fiber or MM fiber or fiber is a type of optical fiber mostly used for communication over shorter distances, such as within a building or on a campus. Typical multimode links have data rates of 10 Mbit/s to 10 Gbit/s over link lengths of up to 600 meters—more than sufficient for the majority of premises applications.

Multimode fiber has higher "light-gathering" capacity than single-mode optical fiber. In practical terms, the larger core size simplifies connections and also allows the use of lower-cost electronics such as light-emitting diodes (LEDs) and vertical-cavity surface-emitting lasers (VCSELs) which operate at the 850 nm and 1300 nm wavelength (single-mode fibers used in telecommunications operate at 1310 or 1550 nm and require more expensive laser sources. Single mode fibers exist for nearly all visible wavelengths of light).[2] However, compared to single-mode fibers, the limit on speed time's distance is lower. Because multi-mode fiber has a larger core-size than single-mode fiber, it supports more than one propagation mode; hence it is limited by modal dispersion, while single mode is not. Also, because of their larger core size, multi-mode fibers have higher numerical apertures which means they are better at collecting light than single-mode fibers. Due to the modal dispersion in the fiber, multi-mode fiber has higher pulse spreading rates than single mode fiber, limiting multi-mode fiber’s information transmission capacity.

Single-mode fibers are most often used in high-precision scientific research because the allowance of only one propagation mode of the light makes the light easier to focus properly.

2.2.3fiber optic advantages:

1-immunity from Fiber optic hold a great advantage over copper media since it can handle high speed signal over extended distance, the main advantage of fiber include:

- Ectromagnetic (EM) radiation and lighting: because the fiber itself is made from dielectric (no conducting) materials, it's unaffected by EM radiation.

2- Immunity from electromagnetic is important in modern aircraft designs .and it is the key reason to use fiber devices in commercial security and intelligent transportation system.

3- Lighter weight: this feature refer to the fiber optic itself, in real world applications copper Cables can often be replaced by fiber optic cables that weight at least ten times less.

4- For long distance, a complete fiber optic system (optical fiber and cable, plus the supporting electronics) also has a significant weight advantage over copper system; this is not true for short System, because fiber optic system almost always require more elaborate, and thus larger and Heavier electronics than copper system.

5-Higher band width:

Fiber has higher band width than any alternative available; the band width of the copper is limited, A modern fiber optic system with similar or superior signal quality for 50 miles or more without Needing intermediate amplification (repeaters), even at that, most modern fiber optic communication System uses less than a few percentage of fiber inherent band width.

6- Better signal quality:

Because fiber is immune to EM interference, has lower loss per unit distance, and wider band width, Signal quality is usually better compared to copper.

7- Lower cost:

This advantage has to be qualified .fiber certainly cost less for long distance application, however, For signal transmission requirements over distance of few feet, copper will be cheaper and always Will be. The cost of fiber itself is cheaper per unit distance than copper if band width and transmission distance requirements are high.

Fiber and copper systems can be compared by finding a break even distance, at distance shorter Than break even point the copper is cheaper and vise versa.

The electronics and the electro optics used on each end of the fiber was the limitation of fiber Optic systems today and for concerned of glass being very brittle and prone to breakage .in fact Glass in many times stronger than steel, and optical fiber are so small that they are flexible.

Relationship between the optical output power and the optical input power in a fiber optic system. It is measure of the decay of signal strength or loss of light power that occurs as light pulses Propagate through the length of the fiber; the decay along the fiber is exponential.

Attenuation in optical fiber is caused by several intrinsic and extrinsic factors. Two intrinsic factors Are scattering and absorption. The most common form of scattering, ray Leigh scattering (As fig 2.3) is caused by microscopic non-uniformities in the optical fiber.

Nearly 90% of the total attenuation can be attributed to it. It becomes important when the size Of structure in the glass it self are comparable in size to the wavelength are less affected than short wavelength. The attenuation coefficient (α) decreases as the wavelength (λ) increase and is Proportional to λ^4. Rayleigh scattering increase sharply at short wave length.

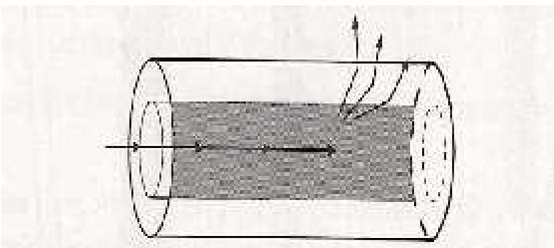

Fig (2.2) ray Leigh scattering

Absorption illustrated in (fig 2.4) can be caused by the molecular structure of the material, impurities in the fiber such as metal ions, OH- ions (water), and atomic defects such as unwanted oxidized elements in the glass composition, these impurities absorb the optical energy and dissipate the light as a small amount of heat.

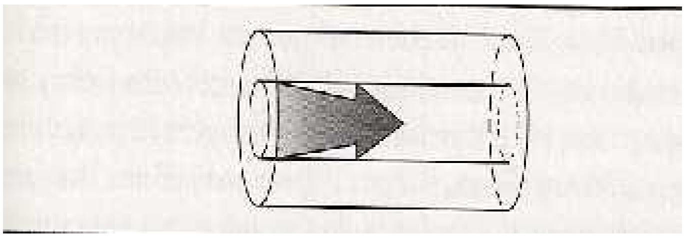

Fig (2.3) Absorption

In optical fiber link, other losses can be due to too narrow loops in the path of the optical cable (Bending losses as in fig 2.5) or to junction of more lengths of fiber.

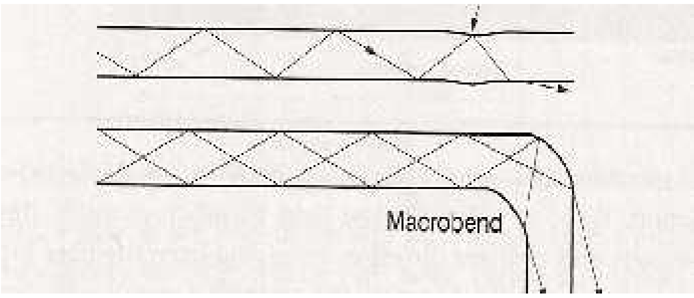

Fig (2.4) bending losses

The amount of attenuation caused by an optical fiber is primarily determined by its length and the wavelength of the light traveling through the fiber. There are also many secondary tertiary factors that contribute.

Chapter 3

System design

3.1 introductions.

3.2 transmitter design.

3.2.1 The optical source.

3.2.2 Transmitter design.

3.2.3 The multiplexer.

3.2.4 The modulator.

3.2.5 Driving circuit.

3.3 receiver design.

3.3.1 Optical receiver components.

3.3.2 Photodiodes and its types.

3.4.2.2 Avelanch photodiodes (APD).

3.4.2.3 Wavelengths.

3.4.3 Demodulator.

3.4.4 Functional block of optical receiver .

3.4.4.1 Front End .

3.4.4.2 Linear channel .

3.4.4.3 Data recovery .

Chapter Three

System design

3.1 introduction:

To transmit a signal in optical communication system we have to design a suitable transmitter to generate the suitable signal to be transmitted through a fiber optic cable. In order to transmit an optical signal into optical channel we have to convert the input data into optical rays to spread in the channel and then in the receiver side we reconverted the light into electrical by the photo detector. And for this reason in the design we will consider the optical source in the transmitter and the photo detector in the receiver the most important parts in the whole design.

Equipments & components require for system design (laser,photodetectot,etc)

Software (mat lab) to make electronic interface

Transmitter and receiver design
Buy optical fiber cable
Then connect the Communication system

Take digital video signal from DVI of PC

Interface between the computer and the microprocessor

Frame generation in microprocessor

Interface between the microprocessor and fiber transmitter

Signal enter to the transmitter

Signal multiplexing by TDM and send it into laser

The output of Transmitter is launch into optical cable

The signal enters to the system receiver

Signal demultiplexing by TDD

The signal covert from digital to analog by D/A convertor

Interface between receiver and screen then the signal takes from receiver and display on the screen

Fig (3.1) block diagram of project

3.2 transmitter design:

3.2.1 The optical source:-

This optical sources are many types from cheap lead s which directly driven by signal sources to the sophisticated transmitter using externally modulated distributed –feed back laser.

In our project we tend to use a laser as an optical source in the transmitter circuit which can change its parameter (intensity, frequency, or phase) in response of the data to be transmitted.

But as most optical sources laser change its intensity according to the electrical data .in this way we can convert the electrical signal (in our project will be video) to an optical signal which can be injected into the optical channel "fiber optic cable".

We can also use an light emitter diode "led" instead of laser the two light emitter have the following characteristics:

1) Overall small size.
2) High radiance; they emit a lot of light in a small area.
3) Small emitting area "the area is comparable to the dim of optical fiber core ".
4) Very long life "height reliability".
5) Can be modulated on and off" at high speed.

The laser as the led operates on the p-n junction principles, but the lasers have an advantage over LED.

The most narrow emission angle and the emission spot are very small, usually in microns in diameter and for this reason Avery high percentage of light can be easily focused into the fiber, more than 50%". And also it's the fastest of the light emitter types and since we need to transmit a video signal and to get high bit rate this means fast light emitter and so we choose the laser diode.

Light emitter performance characteristics:

In the design of the optical communication system we should understand the basic characteristics and determine them in our design:

1) peak wave length :

The wavelength at which the source emits the most power and it should be matched to the wave length that is transmitted with the least attenuation through the optical fiber.

The most common peak wave length is near 780nm, 850nm, 1310nm, 150nm, and 1650nm.

2) spectral width :

In practice the light emitted from an LED or laser will be in average of wave length Centered at peak wave length and this range will be called the spectral width of the source.

3) Emission pattern :

The pattern of the emitted light affect the amount of light that can be coupled into the optical fiber, ideally the size of the emitting region should be similar to the diameter of the fiber core.

4) Power :

The best result would be achieve by coupling as much of source power into the fiber as possible.

The key requirement is that the output power of the source be strong enough to provide sufficient power to the detector at the receiver, consider the attenuation in the fiber and the power losses in the coupling.In general the laser (in mW) is more powerful than the LED (in MW).

To calculate the needed laser power,All the losses in the system should be considered, and these losses are:

1-losses in transferring light from source into fiber.

2-connector losses.

3-splice losses.

4-coupler losses.

5-Fiber losses.

6- fiber to receiver coupling losses.

We need enough light power to cover all optical transmission losses and deliver enough light to the receiver to achieve the desired signal to noise ratio or bit error rate.And also design should leave some extra margin above the receiver minimum requirements to allow for system aging, fluctuation and repairs, such as splicing a broken cable.

5) speed:

The source should turn on and off fast enough the band width limits of the system. The speed given is according to source rise or fall time.

The time requires going from 10% to 90% of peak power and laser have faster rise and fall times than LEDs.

6) Spectral characteristic:

The spectral characteristics for the laser are shown in the fig. (3.1)

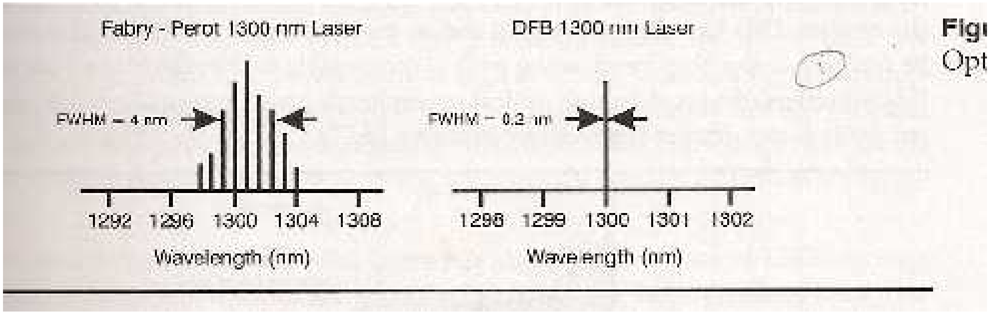

Fig (3.2) the spectral characteristics for the laser.

The fig above shown the spectral characteristic For the laser diode there is two types the first one emit nine discrete line in nine different frequencies this type called multimode laser diode or "fabry-perot laser".

Helium –neon (he Ne) laser which emit at a single line at 633nm, fabry perot emit at multiple, closely spaced wave lengths simultaneously.

The light from the multimode laser less coherent than the light from (HeNe) laser, and this wider spectrum because some additional dispersion in the fiber but it minimize other problem when using multimode fiber, and since we will use a single mode fiber, we are not concerned to explain it.

3.2.2 Transmitter design:-

The role of an optical transmitter is to convert the electrical signal into optical form and to launch the resulting optical signal into the optical fiber but in practice the problem is not easy like that ,first how to take a digital form of video signal and how to send this digital video stream serially in the optical fiber. In this chapter we will explain the technique we will use to send this *stream* of bits.

The optical transmitter consists of an optical source, multiplexer, a modulator and a channel coupler.

Semiconductor laser or light emitting diode are used as optical source because of their compatibility with the optical- fiber communication channel.

The optical signal is generated by modulating the optical carrier wave.

The optical sources need a good deal in order to get a good communication system using fiber.

Every component in the transmitter has a special task to do in the transmission.

3.2.3 The multiplexer:

Multiplexer is combined the multiple signals to generate one signal for transmission. there are many types of multiplexing in optical fiber transmission such as: frequency division multiplexing, time division multiplexing, and wavelength division multiplexing, but the suitable type for this project is time division multiplexing, time and frequency division multiplexing are done before the signal goes to the transmitter, but the frequency division for analog signal and the time division for analog signal, the wavelength division multiplexing is done optically.

1- Time division multiplexing: in this type the two or more digital signals are combined to give one higher speed signal, by interleaving the bits from separate streams. Usually is done before sending signal to the transmitter.

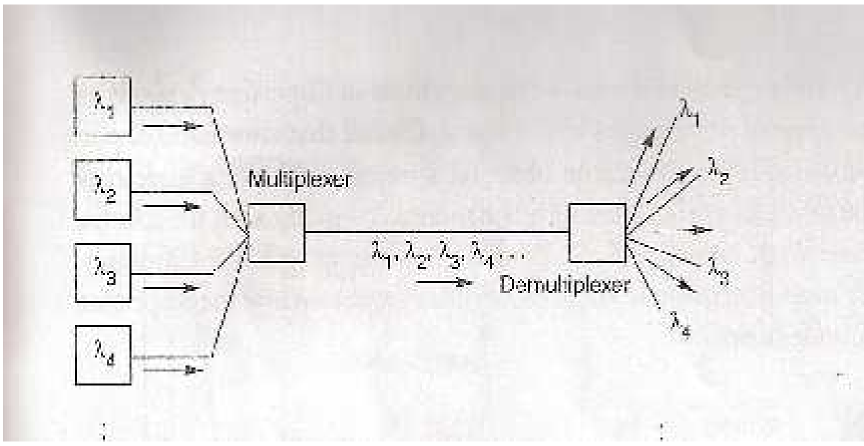

Fig (3.3) time division multiplexing and demultiplexing

3.2.4 The modulator:

impose a signal on a steady light beam passing through it make as turning the laser beam off and on chipping the beam into a series of pulses that Carrey the signal ."Sometimes blocking the beam and sometimes transmitting it".

And the electrical driving circuit for supplying current to the optical source.

3.2.5 Driving circuit:

We need driving circuit to supply the optical source with an electrical power and also modulated the light output with accordance with the signal which we need to transmit. The driving circuits depend on the application requirements data format, and the light source LED can be driven by suitable current source however semi conductor laser must be biased to current level near threshold and then modulated through an electrical time dependent signal.

The driving circuit is designed to supply a constant bias current as it supply the modulated electrical signal ,and in order to keep the average optical power constant we use a servo loop .as shown in the fig.(3.4)

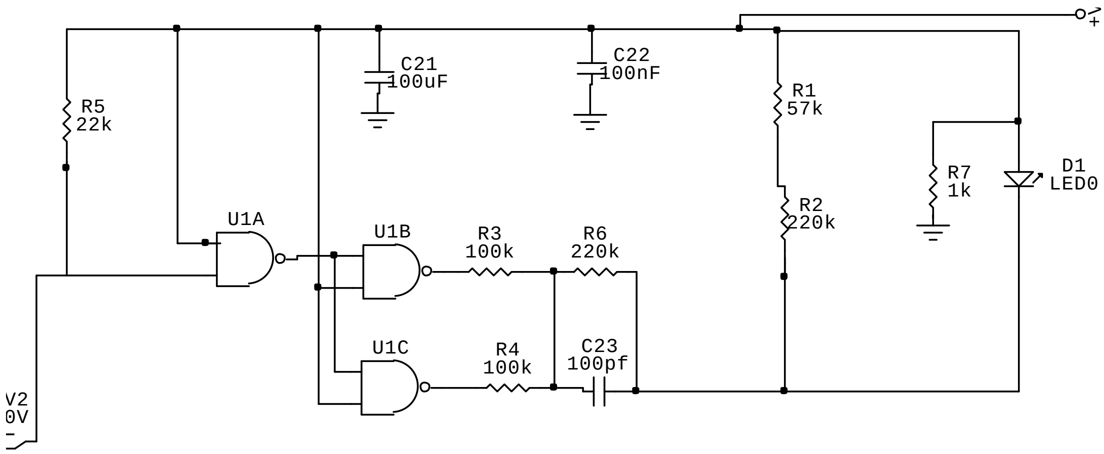

Fig (3.4) the driving circuit of transmitter.

In this simple drive circuit that control the average optical power through feed back mechanism, a photo diode monitors the laser out put and generates the control signal which used to adjust the laser bias level.

The bias –level control is essential the laser threshold is sensitive to the operating temperature, the threshold increase with aging of the transmitter.

In the drive circuit shown in fig (3.4) the drive signal will applied as voltage to the base of transistor .so it modulates the drive current through the laser diode, the detector packaged with the laser monitor output providing feed back to an amplifier (at right) which adjust the bias applied to the laser diode ,thus controlling average power level .

The signal represented by a voltage of +5V corresponding to the binary datum 1 , and by a voltage of 0V corresponding to the binary datum 0 , is applied to a network NAND gates. Theses three gates are connected as inverter: the first one acts as separation buffer ,but the other two gates are connected in parallel and generate a certain current quantity.

The driving circuit can be connected to the led , and the resistor R58 has been connected to obtain the current value across the leds.

3.3 Source fiber coupling:

The power from light source can be in a rang about 100mW for laser to ten microwatt for LEDs ,but not all the power can be used in practice since some of the power will be lost in the system.

Optical fiber and in the transmitting design objective is to couple as much as can into the fiber core .The amount of the power that can be coupled is dependent on the used optical source and on the fiber mode.

The power which delivered into an optical fiber depends on the angle over which light is emitted, the size of the light –emitting area the alignment of the source and fiber, and the light collection characteristics of the fiber as shown in the fig. (3.5)

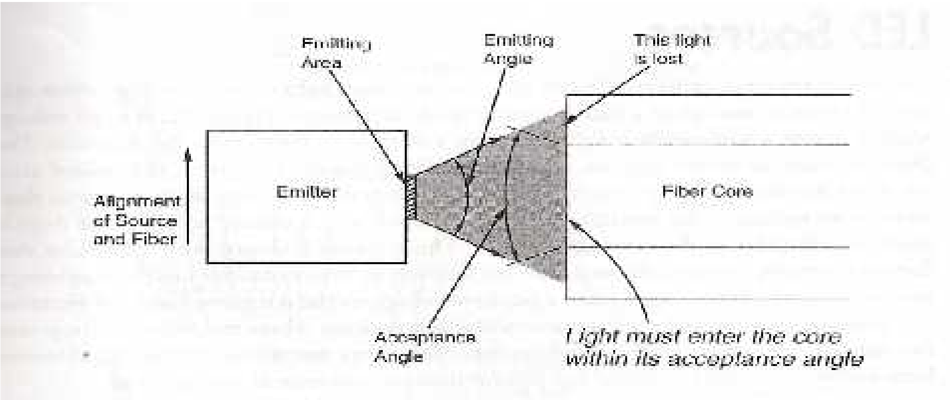

Fig (3.5) the light collection Characteristic

The light intensity is not uniform over the entire angle at which light is emitted but rather falls off with distance from the center.

Typically laser emit light that spread at an angle of 10-20%,but the light the light spread out at larger angle s.And so the coupling amount can be vary from 1%in the case when we couple alight from a LED into a single mode fiber into about 40-50% if we choose a laser .and increase to 80%if we use an improved type of laser diode (VCSEL s) since its light have circular spot size.

And the coupling efficiency also changes with numerical aperture.

The optical interface between light source and fiber can various forms.

One way is the integration of a fiber optic connector by internal optics, including a collimating and some times a short fiber segment.

The second way of interfacing is short fiber pigtail that collects light from the emitting area and deliver it out side the case where it can be spliced to an external fiber, the choice depend on factors including cost ,the connection is temporary or permanent ,type of fiber ,importance of minimizing interconnection loss ,and operating environment.

The most important issue in the coupling is that to keep efficiency stable and not to change with time.

Using fiber that is tapped or has lenses tip or by added external lens to improve the coupling efficiency but it will be very expensive.

3. 4 receiver Design

3.4.1 Optical receiver components:

Receiver is an important device in optical fiber communication systems that convert optical signal into electrical signal to recover the transmitted signal.

It consist many components such as coupler, photodetector, demodulator, demultiplexer.

The coupler focuses the received signal onto the detector.

The detector is used to convert optical signal into electrical signal according to converting the variation of power into a varying electrical current.

There are many types of photo detector such as phototransistor, photomultiplier, and photodarlingtons but the suitable one can be used in fiber system is semiconductor photodiodes.

Photomultipliers are not suitable for optical fiber system because of their large size, and high voltage requirement and also used for small area.

Pyroelectric photo detectors are not suitable for optical fiber systems since their speed is limited.

Phototransistor can be used for low cost and low speed systems and not able to detect the low levels of lights (limited to system operating below MHz range).

Photodarlingtons consist of two transistors and it is not suitable for optical fiber system because the second transistor increases noise & lowers power.

In our project we want to use the semiconductor photodiode as detector because of it is properties and characteristics.

3.4.2 Photodiodes and its types:

Photodiodes is a type of detector that convert light into current also it is used in optical communication system according to small size, high sensitivity, fast response, high reliability, low noise, low cost and high performance since the optical signal that comes from fiber is distorted and weakened.

The types of semiconductor photodiodes that used in fiber optic systems are the PN junction, pin photodiodes and avalanche photodiode (APD) but many photodiodes are used PIN junction rather than the other types.

Photodiodes look like led's in their shapes and they have two wires one of these wire is longer than the other, the longer wire is called anode and the shorter is called cathode.

Under forward bias the conventional current moves from the anode towards the cathode and the photocurrent flows from cathode.

There are many types of photodiodes, pn junction, and pin junction and avelanch photodiodes.

3.4.2.1 PN junction and PIN junction:

PN consist of P-type and N-type semiconductor and the region between two types is called the PN junction.

The free electrons (-ve) and positive holes will be produced if the electron that belong sufficient energy is excited.

PIN junction consists of intrinsic material between p-type and n-type materials.

If the absorption occurs in the depletion region or the majority carriers diffuse across it (majority carrier refers to electron in n-type materials or the holes in p-type materials) the electron move to the cathode and holes move to the anode and the photocurrent will be produced.

When the PN junction is connected with external battery with it is positive pole connected to the n-type material and negative pole to the p-type material so that the junction is reverse bias.

At reverse bias the width of depletion region increases so that the number of electron hole pairs increase and the bandwidth will be increase.

Optical communication system use photodiodes with reverse bias since it is faster than forward bias and it is more sensitive to lights.

Also the reverse bias reduces the noise that produced by current so that the SNR is decreased.

PN diodes operate in unbiased (zero bias) mode but the PIN operates in reverse bias mode so that the depletion region is more wide in PIN rather than PN junction .also the PIN is faster and more sensitive to light rather than PN junction.

The photodiodes used in reverse bias mode, the bias voltage for PIN is 5 to 20V.

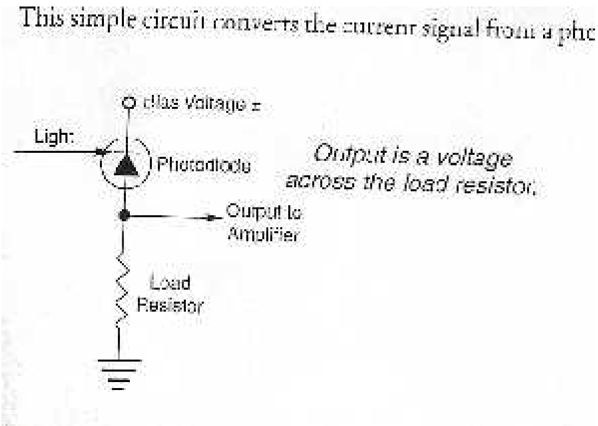

Fig (3.6) basic circuit of photoconductive PIN or PN photodiodes

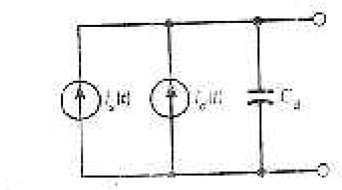

Fig (3.7) photodiodes equivalent circuit

3.4.2.2 Avelanch photodiodes (APD):

Bias circuit should be control voltage to avoid APD breakdown to exceed.

This type of photodiodes has an interval amplification stage and requires high bias voltage (100 to 300V) and high sensitive of the bias voltage of the photodiodes.

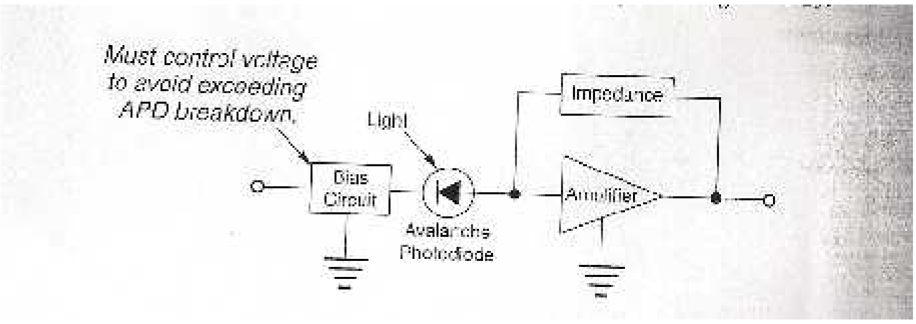

Fig (3.8) equivalent circuit of APD detector

In our project we want to use the PIN semiconductor photodiodes as detector since it is properties is good and do not require a high bias voltage.

3.4.2.3 Wavelength:

The sensitivity of the receiver depends on the type of detector used and the amplification stage circuit and the detector parameters depend on wavelength and the condition of operation.

Detector is made from different material. Each material has specific wavelengths.

The speed and dark current different according to detector material type can be used.

Silicon is used at 600 to 1000nm and germanium can be used at 1300nm.

The germanium detector slower and noisier than silicon detector and other types of detectors operate at one wavelength so that the silicon is the most suitable one.

3.4.3 Demodulator:

In optical communication device and the optical communication system whose size is small, cost is low and power consumption is low using DPSK modulation/ demodulation.

This provide excellent in reception sensitivity and use in a long distance optical communication systems.

3.4.4 Functional block of optical receiver:

The optical receivers divided into three functional parts are front end, linear channel and data recovery.

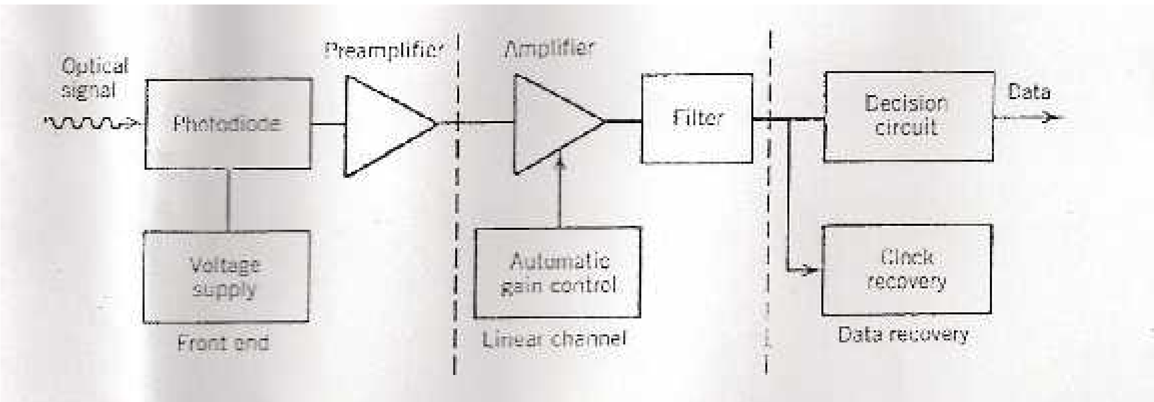

Fig (3.9) block diagram of optical receiver

3.4.4.1 Front end:

The first part of receiver, it consists of photodiodes as detector, low noise amplifier and voltage supply.

Preamplifier:

The receiver includes more than one amplification stage. The first one is called preamplification.

The optical signals that reaches the receiver are weak and distorted because the effect of attenuation so that the preamplifier can be used to amplify the electrical signal to generate a strong signal. This preamplifier also called the front-end amplifier.

The preamplifier can be classified into two types; a high impedance and transimpedance.

High impedance receiver amplifier:

Rl is large quantity to increase the input voltage of the preamplifier and reduce the thermal noise to improve the sensitivity of the receiver and increase the distance of the transmission.

If the bandwidth less than the bit rate a high impedance amplifier can not be used. Equalizer is used to increase the bandwidth.

The low and high frequencies are amplified by different factor since the low frequency components affect but attenuation and distorted more than the high frequency components.

One method of increasing the BW if the sensitivity is not of concern is decreasing Rl this is resulting a low impedance amplifier so that in this case we need another type of preamplifier.

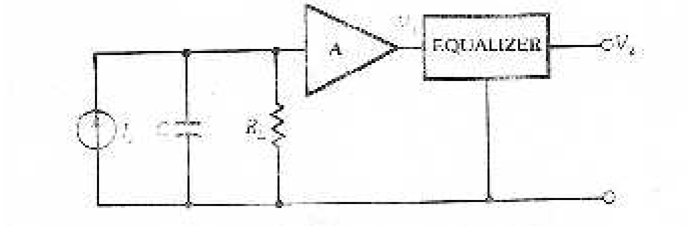

Fig (3.10) equivalent circuit of high impedance preamplifier

Transimpedance amplifier:

the second type of front-end amplifier that used in optical fiber receiver.

Transimpedance amplifiers have improved characteristic compared with high impedance amplifier such as dynamic range also it has high sensitivity and large bandwidth.

Rl is large value since the existence of feedback around an inverting amplifier and so the inverting amplifier and so the impedance decreases by a factor of G.

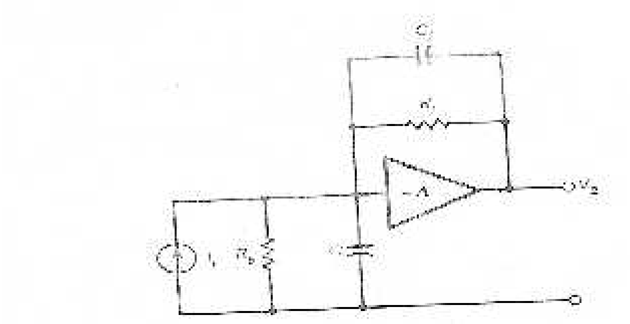

Fig (3.11) equivalent circuit of transimpedance amplifier

In our project we want to use the transimpedance amplifier to operate as preamplifier since it is improved characteristic.

The most electronic devices require input signal as voltage not current and using voltage easier than using current so that the output of photodiodes is converted.

3.4.4.2 Linear channel:

This part of receiver consists of the following components; the main amplifier, filter and automatic gain control (AGC).

The main amplifier is a high that uses to amplify the output signal of the preamplifier to produce the required signal.

The automatic gain control is control the gain of amplifier automatically to make a limitation of the average output power to a fixed level irrespective of incident average optical power at the receiver.

The filter is low pass filter type that removes the undesired frequencies and perform the shape of voltage pulses. Using the low pass filter decreases the noise so that the SNR ratio is increase and minimizes the intersymbol interference.

3.4.4.3 Data recovery:

The data recovery is the last part of optical receiver and it is contains the decision circuit and clock recovery circuit.

In this part of receiver we will to recover the original digital signal.

Clock recovery circuit synchronize the process of decision circuit and provide the bit slot information (Tb= 1/B) to the decision circuit.

The decision circuit makes comparison between the output of linear channel and a threshold level at sampling time that determined clock recovery circuit and make a decision which part of signal represents bit 0 or represents bit 1.

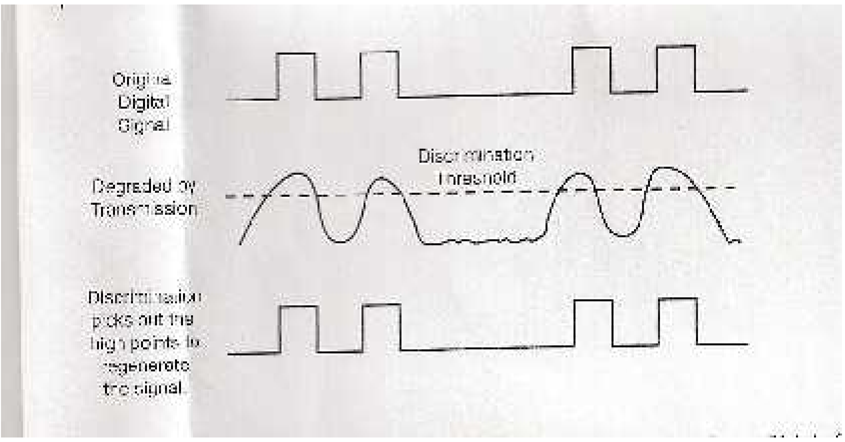

Fig (3.12) operation of decision circuit

3.4.5 driving circuit:

The Optical signal carried by the fiber is detected by the PIN photodiode included in the detector. The photodiode generates a current proportional to the incident radiation. The trans-impedance amplifier,assembled inside the same detector, supplies an output voltage proportional to the input current.

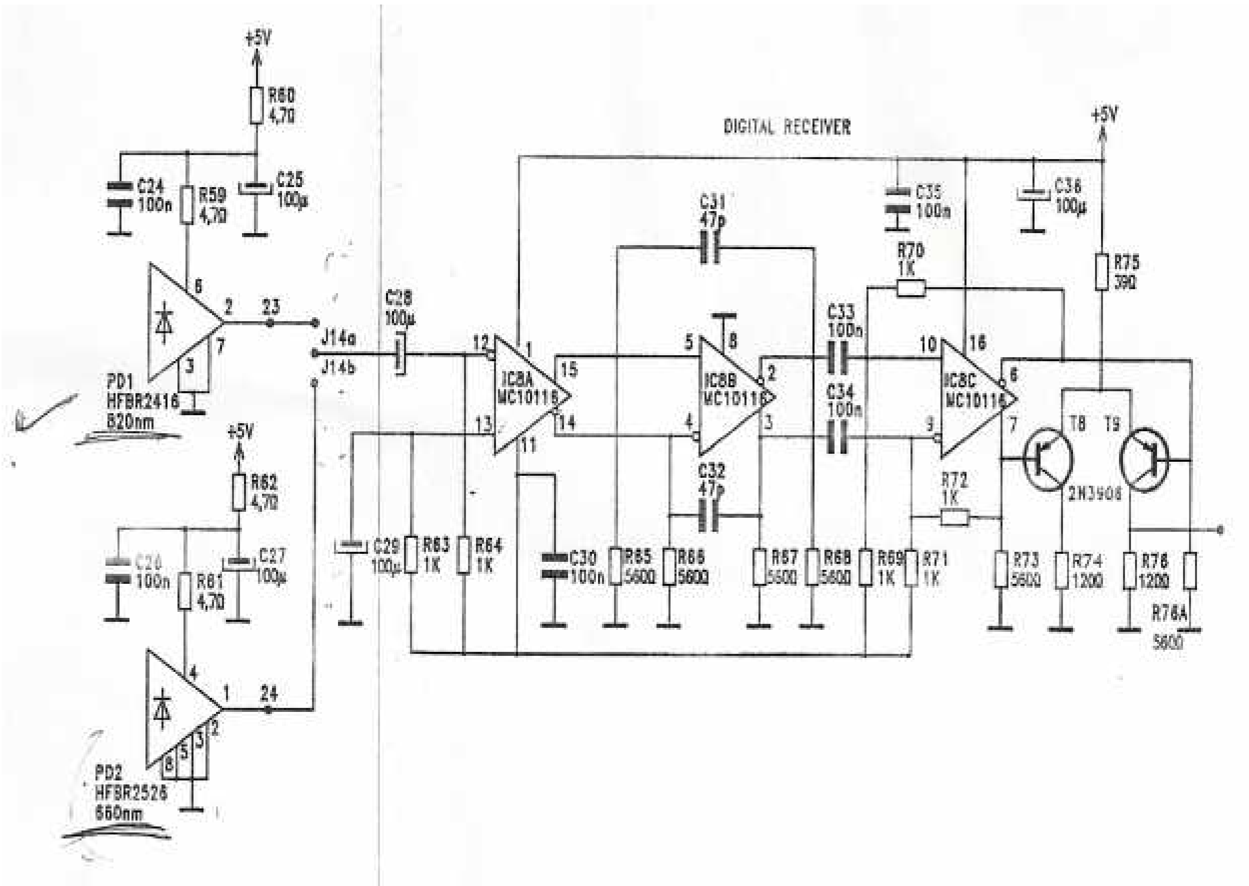

Fig (3.13) equivalent circuit of optical receiver

The detector can be connected to the following circuit .the voltage signal is amplified and squared by three consecutive gates (IC-8MC10116) and it is applied to the convertor (transistor T8-T9).

The photodetector_ is coupled in AC or DC to the amplifier,and the capacitor blocks the

direct current offset.this prevent the passage of a possible direct current offset

superimposing the signal.this can be obtained through the use of coders .

Chapter 4

Video transmission

4.1 Introduction.

4.2 video transmission requirements.

4.3 transmission media.

4.4 Digital video transmission through optical system.

Chapter four

Video Transmission

4.1 Introduction:

Video signal is an analog signal and separated into voice, data and synchronization Signals.

Video signals transmission is complicated than sending of voice and data.

Digital system converts the time varying electrical signal into streams of 0's and 1's That represents the binary data.

Video signals encode continually the picture and sound changing. The image of video Principles based on the scanning and the picture contains many parallel lines with Different intensity along the line.

Video signal consist of three primary colors, blue, red and green and each color has Electron beam differ from the other beams. Also the video signal contains the voice And synchronization signal.

Video signal contains the information that required to draw the lines. These lines have different intensity along the lines.

The signal through the lines can transmit point by point from one line to another.

The video signal encodes the color, brightness and sound of each point.

The way that the signal carries information depends on the format of encoding.

4.2 video transmission requirements:

Video signal require more transmission capacity than voice and digital data.

Data rates can be reduce by a factor of 10 to 60 for video transmission, by using sophisticated digital compression, and they depend on the picture series transmission, so that the single images can not compressed much.

Transmitter talk to receiver, so that video signals can bee transmitted in standardized formats.

Video is transmitted at 50 to 550MHz. the video bandwidth extend from 0 to 5.5MHz.

Video transmission generally is over single mode fiber at 1300 or 1550nm.

4.3 transmission media:

The transmission media that we want to use in fiber optics.

A single powerful laser source can produce optical signal to multiple nodes, so that reducing transmitter cost. The laser in this case split among the fiber delivered to separate nodes that receive the same signal.

Video transmission through fiber requirements vary widely and also requires high quality of transmission. The cost of

Fiber transmission has many advantages such as light weight, small size, high signal quality, long transmission distance, and immunity to electromagnetic interference, also offers more subtle advantages, notably avoiding the need to adjust transmission equipment to account for differences in cable length.

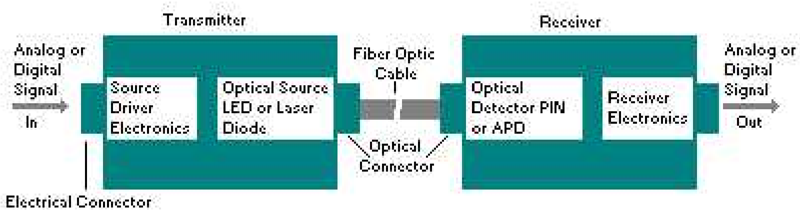

Fig (4.1) optical communication systems

4.4 Digital video transmission through optical system:

The conversion of analog video inputs to digital values is the principle of the digital video signal transmission over optical fiber.

At the transmissions end: there are A/D converters that encode the baseband video channels, and then the digital channels are multiplexing by TDM, and send to the laser of the transmitter. The digital signal convert into light pulses, and the laser is turn on for one and off for zero.

At the receiving end: the light pulses converted into electrical pulses, and demultiplexing by TDD, after that the electrical pulse sends to D/A converter for converting the information into baseband video signal.

In this project the video signal can be taken from DVI port of PC in digital form, so that we do not need A/D convertor. It contains the three primary colors; red, blue, and green, we will concern in specific out pins which indicate the color of the video signal.

The fig (3.4) shows the pin out from the DVI .the data sheet specify the signal that out from every pin.

The red color being in pin1 pin 2 pin 21 pin20 and the green is out from pin4 pin5 pin9 and pin 10 and the blue from pin 12 pin13 pin17 pin 18.

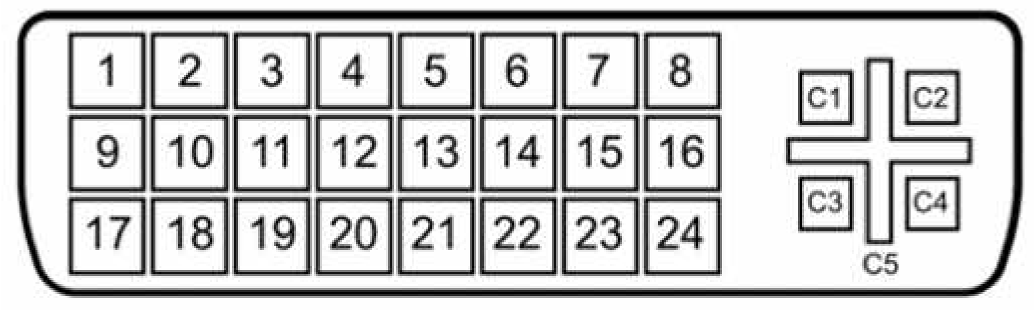

Fig (4.2) the DVI out pin.

Then we will arrange the digital data that carry the colored signal into frames (using the microprocessor) that its arrangement is known in the received part.
then these signals must enter to the microprocessor to form the frames, this frame consist of the three colours,voice,and synchronization .to make the last step also we need interface between PC and MP,the frame enter to transmitter, at transmitter the signal are multiplexing by TDM ,and send to the laser.

The transmitter launches the signal into optical fiber cable, after that the signal reaches the receiver. at the receiver signal are demultiplexing by TDD to divide the signal in it's original components, then it convert to digital by using D/A convertor, at last the signal takes from receiver and display on screen.

Appendix A

HFBR1414 Data Sheet:

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