GIGABIT INTERFACE CONVERTER

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Submitted to the Faculty of Electrical Engineering, Military College of Signals, National University of Sciences and Technology, Islamabad in partial fulfillment for the requirements of a B.E Degree in Electrical (Telecommunication) Engineering

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بسم الله الرحمن الرحيم

ABSTRACT

Gigabit interface converter (GBIC) is a high data rate transmission and reception device. GBICs can be fabricated in a number of technical specifications depending upon the usage and availability of resources for the users. GBIC however will have to follow the technical specifications of IEEE's protocol 802.3z which are discussed in detail in this report. GBIC module's design and implementation has been discussed in detail and the requirements both for user and fabrication have been discussed in detail. Device will be a hot-swappable device which offers great ease to the user since saving the trouble of rebooting every time the device is to be used.

DECLARATION

No portion of this work presented in this dissertation has been submitted in support of another award or qualification either in this institution or elsewhere.

DEDICATION

This project is dedicated to our parents and our project supervisor, Col Dr Abdul Rauf, who have been a constant source of encouragement for us and to our teachers who gave us the inspiration throughout our degree.

CERTIFICATE OF CORRECTNESS AND APPROVAL

It is certified that the work contained in the thesis titled “Gigabit Interface Converter”, carried out by Muhammad Waqar Azeem, Muhammad Haseeb-ur-Rehman Khan and Muhammad Hamza Mahmood under supervision of Col Dr Abdul Rauf in partial fulfilment of the degree of Bachelor of Electrical (Telecommunication) Engineering is correct and approved.

Approved By

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Dr Abdul Rauf

Project Supervisor

Department of EE, Military College of Signals, NUST

ACKNOWLEDGEMENT

All praises for ALLAH who gave us the strength and determination and enlightened us with the requisite knowledge on portion of this subject to complete this project. We gratefully acknowledge the continuous guidance and motivation provided to us by our project advisor Col Dr Abdul Rauf, without his personal supervision, advice and timely help completion would not have been possible.

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TABLE OF CONTENTS

LIST OF ABBREVIATIONS

GBIC	Gigabit Interface Converter
IEEE	Institute of Electrical and Electronics Engineers
ULP	Upper Level Protocol
NIR	Near Infrared
LX/LH	Long haul cable system
PCB	Printed Circuit Board

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Purpose:

Gigabit Interface Converter (GBIC) will be designed for use in domestic as well as professional communication environments with special focus on local area networking capability. However GBIC will be able to communicate and make the devices superfast because of direct communication of the computing devices over optical fibre medium. Hence GBIC will target both domestic usage of personal computing and professional usage of communication computers allowing faster communication by removing conventional copper wired networks.

1.2 Project Description:

Gigabit Interface Converter (GBIC) is a fast data transmission and reception device which provides hot swapping functionality for various communication systems and network devices working on Ethernet protocol of IEEE. This GBIC module will be designed on the IEEE 802.3z standard under the specifications of 1000Base-LX standard which is enclosed in the IEEE 802.3z. The final product will be compromised of a GBIC module ready to plug and play with connectivity of optical fibre cable at one end and plug connectivity at the other for any communication device. The aim of this project is to design a transceiver according to the required standards for fast and smooth data transmission between optical fibres and communication devices working on Ethernet protocol and then making the device hot swappable for easy plug and play. 1000Base-LX standard will be used for this purpose which is enclosed in IEEE 802.3z. While designing GBIC, the emphasis will be on the transceiver circuitry which is the main functioning circuit in the module. After the design is complete, this module will be able to communicate data at 1 Gbps. Devices which have the ability to communicate at such high speeds will be attached to one end of the device while the optical fibre will be at the other end.

1.3 System Model Diagram:

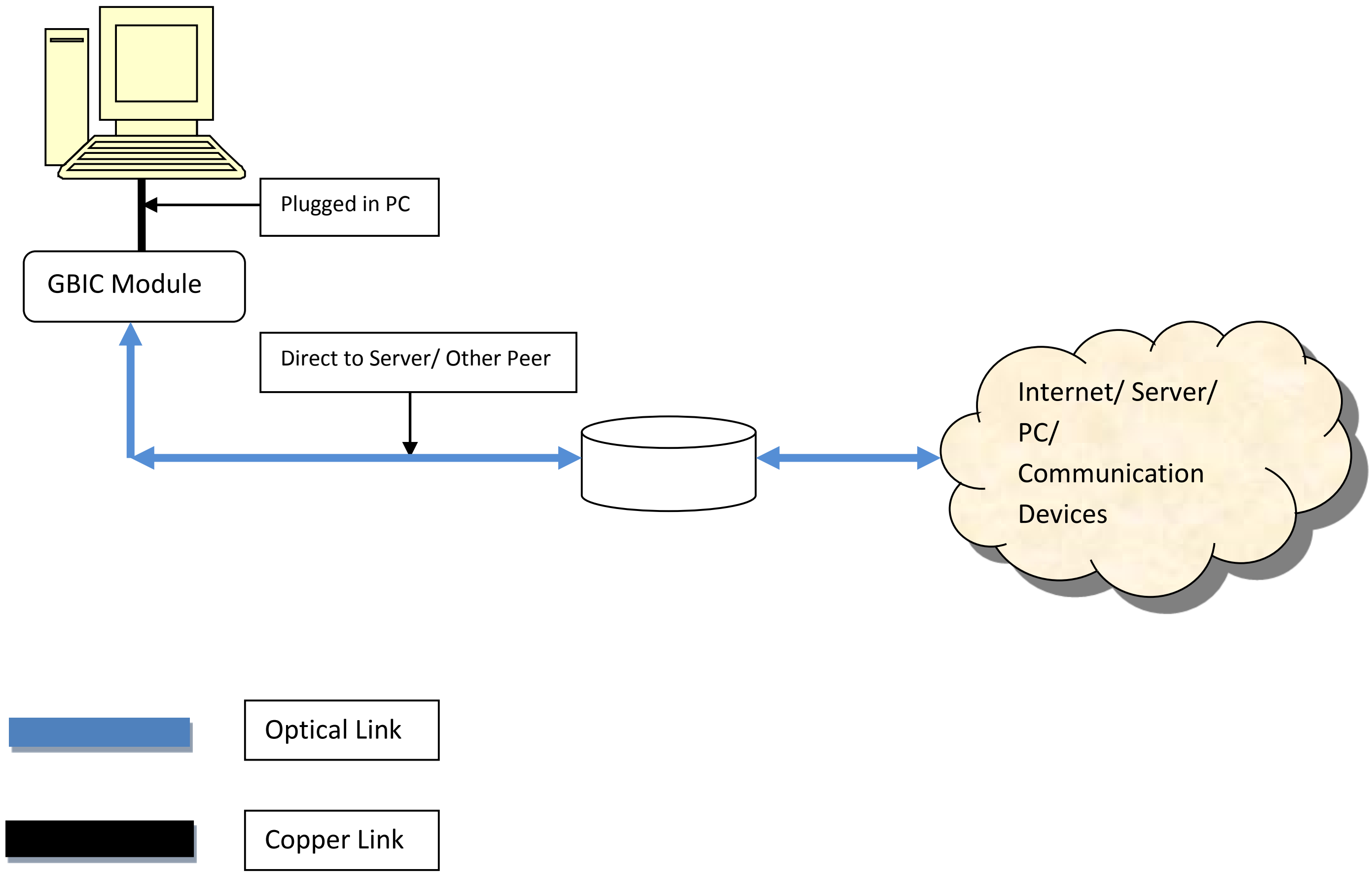

Figure 1-System Model Design

The project resulted product will be able to communicate data at high rates not less than 1000 megabits per second or 1 gigabits per second. Devices able to communicate on gigabit per second rates need only to be connected directly with the GBIC module and optical fibres at opposite ends. This solution is both easy to apply and economic since there is no need to update the entire system for optical communication. The feature of hot swapping makes it time saving for both the user and the machine and hence allows to readily start communicating at high data rates of gigabits per seconds. This module can be both used for domestic and commercial purposes without any further changes.

CHAPTER 2

SCOPE, SPECIFICATIONS AND DELIVERABLES

2.1 Scope:

Due to the increasing need of high data rates and advancement in technology at a very fast rate, faster data transfer is rapidly becoming one of the most basic human needs nowadays. So to cater for this need, Gigabit Interface Converters are a very useful device as they provide faster data transmission and reception and are easy to use (plug and play).

2.2 User Requirements:

User requirements will only comprise of a personal computer, laptop or any other communication device which has a network interface card able to communicate at gigabit per second communication rates. Users will be able to plug the device directly in this network interface card and their devices will be able to communicate at gigabit per second rate at once because the device is planned to be hot-swappable device i.e. plug-and-play.

Previously various modules for gigabit communication have been developed by leading network solutions manufacturers which are able to operate under different physical media including copper cables and optical fibre. In optical fibres further modules have been designed to communicate using either single mode or multi-mode fibre as per users' choice; however both have their own specifications on the basis of data rates and signal loss.

2.3 Technical Specifications

The implementation of GBIC in this project will be according to the 1000BASE-LX/LH standard as defined by IEEE 802.3z standard. The details of this protocol are mentioned as below.

Operating Wavelength	1310 nm
Source Type	Near Infrared (NIR) Light
Range	10 Kilometers
Optical Power Ratings	Min. Output Power: -9.5dB m Min. Receiver Sensitivity: -19 dB m

The '1000' in the 1000Base-LX/LH specifications means that up to 1 gigabit per second data rate will be achieved while 'base' shows that Baseband will be used. The 'LX/LH' refers to the long-haul cable system for communication, i.e. for up to 10 Kilometres range.

The source of this device will be the Near Infrared (NIR) Light with the operating wavelength of 1310 nm.

2.4 Deliverables:

Final form of the project will comprise of one device which will be hot-swappable and will be designed keeping in focus the technical specifications, to be mentioned below .By ‘hot-swappable device’ it is understood that users will be able to plug and continue the activities without there being a need to reboot the devices. The device can then be used for commercial as well as domestic purposes on normal communication devices like computers and laptops with a network interface card supporting at least 1 gigabit per second communication rates.

2.5 Applications:

One of the important applications of GBICs is that they can be used for large scale up gradation of communication systems with low budget. This allows the companies using bigger systems to upgrade their devices to higher data rates and achieve better results at a price very lower than what it would take to upgrade these systems using other resources than the GBIC.

Apart from this, GBICs can effectively be used in situations where links are to be changed regularly from optical medium to other media, usually Ethernet. Since GBICs are converting Optical signals to Ethernet signals and they are hot swappable i.e. you can plug and use them without rebooting your system; they are the best option to be used in such situations,

Another important application of GBICs is in high end communication systems like workstations and supercomputers which can support large data rates as well as they are required to work at rates unparalleled to any other systems. So these devices can surely use GBICs for fulfilling their needs.

Also, in data ware houses and high speed internet servers, the data rates are very high and require devices which can help them maintain these rates without much loss. So in such scenarios, GBICs can be very useful for maintaining these high data rates.

Another application of GBICs can be that they can serve as a backup device if main optical fibre system fails. Although this might require more than one GBIC since the optical fibre system is a very big and complex system and one GBIC will certainly not be enough to handle it all.

One of the simpler and important applications of GBICs is local area networking and network switches for high speed data transfer. Data can easily be transferred at very high rates with ease while using GBICs. Also, since the device is hot swappable, it will not affect the normal working of the system at all.

So, GBIC can be considered as a very useful device especially in devices requiring high data rates. It is easy to use and is also portable due to its small size. Thus, it is a handy device with a lot of applications.

CHAPTER 3

LITERATURE REVIEW

The IEEE 802.3z standard for gigabit Ethernet was the basic theme of this project. This standard helps increase the speed of Ethernet even up to 1 billion bits per second for connecting the servers, routers and switches. The whole project was designed with the help of this standard and it served as the basic guide for the project. This standard was actually designed with the objective of achieving higher data rates than ever before by utilizing the latest signalling technology and network design methods. This standard served as the foremost step towards the up-gradation of Ethernet local area networks. This standard further defined the interoperation of gigabit interface with different sub layers which included the 1000Base-X physical layer and the 1000Base-T coding layer. The 1000Base-X further included the 1000Base-LX fibre optic transceiver, the 1000Base-SX fibre optic transceiver, and the 1000Base-CS copper transceiver for use with single/multi-mode fibre, only multi-mode fibre and shielded copper cable, respectively. The 1000Base-T coding layer included the 1000Base-T physical medium attachment sub layer for use with unshielded twisted pair. The specifications used in this project were the 1000Base-LX transceiver standard.

The US 6418121 B1 citation is another important document in this project as it helped in the design of the transceiver circuitry used in the Gigabit Interface Converter. For the most part, this design consisted of some basic components available in the market like voltage dividers, transistors, resistors and capacitors. These components were small-form factor components to keep the device as small as possible for easy use and mobility.

A list of publications with details of other modules and protocol variants of IEEE 802.3z standard is as:

Citing Patent	Filing date	Publication date	Applicant	Title
US7872979	Dec 11, 2007	Jan 18, 2011	Foundry Networks, Llc	System and method to access and address high-speed interface converter devices
US8320401	Dec 27, 2010	Nov 27, 2012	Foundry Networks, Llc	System and method to access and address high-speed interface converter devices
US20110083141	Aug 10, 2010	Apr 7, 2011	Rovi Technologies	Interactive television systems having pod modules and

Citing Patent	Filing date	Publication date	Applicant	Title
			Corporation	methods for use in the same
WO2008092900A1	Jan 30, 2008	Aug 7, 2008	IBM	Communicating configuration information over standard interconnect

A brief description of these citations is given below.

High-speed transceiver devices, such as GBIC-type transceivers, are accessed and addressed. Identification information (including manufacturer name, model, and compliance codes) is placed in data fields of the transceivers. An algorithm checks each port in each module of a host system to determine if a transceiver is present. If a particular transceiver is present, then algorithms store the port address of the transceiver in memory and enable the transceiver to be read from or written to.[1]

A communications module includes a data channel and a termination impedance controller. The data channel is operable to translate data signals in at least one direction between a transmission cable interface and a host device interface. The data channel has variably configurable termination impedance at a host device node that is connectable to a host device. The termination impedance controller is operable to set the variably configurable termination impedance of the data channel to match the termination impedance to the host system.[2]

A mechanism is provided for storage enclosures to communicate with one another using pre-existing cables allowing the user to dynamically attach different types and speeds of Fibre Channel enclosures together. The mechanism uses a transmit disable line and receive loss of signal line of a small form-factor pluggable optical cable to provide a communication link between enclosures before the Fibre Channel loop is setup and stable.[3]

Fibre Channel and Gigabit Ethernet are high speed data transfer interfaces that can be used to interconnect workstations, mainframes, supercomputers and storage devices. Supporting numerous channel and network Upper Level Protocols (ULPs), Fibre Channel allows faster data transfer over longer distances between a larger number of devices or communication points.[4]

CHAPTER 4

DESIGN AND DEVELOPMENT

Transceiver circuitry is adapted for use in a gigabit interface converter module to process receive and transmit signals in a differential format. The circuitry is installed between, and coupled to a plug connected to a host and a receptacle connected to a transmission medium. This means that an optical fiber will be connected on one end of the transceiver while the other end is connected to the communication system which uses the Ethernet protocol.

4.1 Design Requirements

Material resources required will include optical fibre cable (single-mode). We are using 1000Base-LX/LH standard defined by IEEE 802.3z standard for this GBIC. The ‘1000’ here shows that the data rate will be 1000 megabits per seconds. ‘Base’ shows that Baseband will be used while ‘LX/LH’ shows that it is a long haul cable system. Other resources include hardware components for fabrication of GBIC circuitry using PCB fabrication techniques. In addition to the hardware resources, the software applications for designing of circuits and simulation purposes will be needed.

The components include common electronic devices such as diodes, operational amplifiers, resistors, capacitors and logical gates.

4.2 Design Specifications

The designing of GBIC mostly revolves around the transceiver circuitry. This circuit consists of four main sub-circuits inside. These sub-circuits have different functions, which, along with other components, form a complete transceiver circuit (Fig 1). These sub-circuits are:

i. Power Management
ii. Signal Detector
iii. Module Definition
iv. Serial ID

Apart from this, the transceiver also contains the inventive transmit and receive circuits and a transmit disable circuit. These circuits are also important constituents of the whole transceiver body.

On the outside, the transceiver is connected to a receptacle at one end and a plug at the other which are used for connection to optical fibre and the communication system.

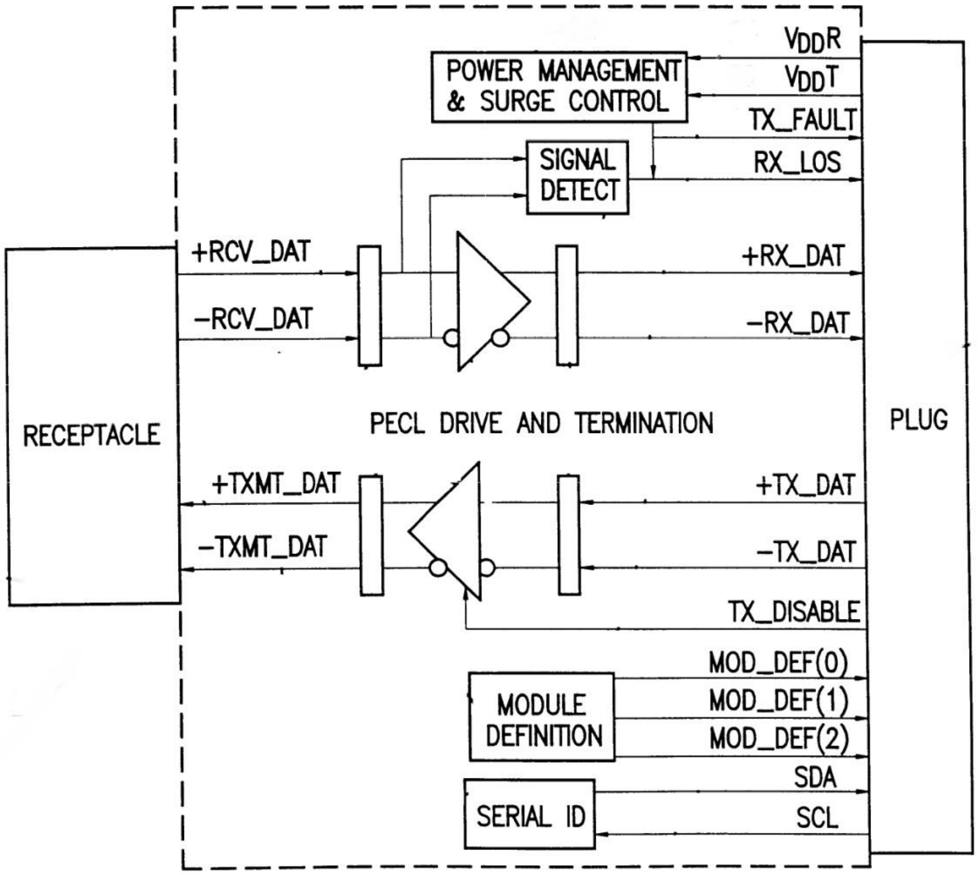

Figure 2- is a block diagram of transceiver circuitry according to the GBIC module standard

The design of the GBIC starts with the design of the transceiver circuit. For this purpose, the first job is to design the four main sub-circuits inside the transceiver. These circuits use simple electronic components like diodes, logic gates, resistors and capacitors. After the completion of these circuits, they are connected to different other components shown in the circuit diagrams (Fig 3 and Fig 4) and then the transceiver circuit is designed. For this purpose, simulations will also be required to validate the design before the actual hardware implementation is started.

In the working state, the plug is attached to the communication system (host), which provides to the circuitry power and differential signals for transmission and the circuitry provides to the transmission medium amplified differential transmission signals. The transmission medium provides to the circuitry received differential signals and the circuitry provides to the host a signal detect indication when the differential of the received differential signals falls below a predetermined differential threshold and when the received differential signals switch at greater than a predetermined rate. The circuitry further provides to the host amplified differential signals corresponding to the differential signals provided to the circuitry by the transmission medium. The inventive circuitry comprises a current supply and an operational amplifier having an inverting input, a non-inverting input and an output. A first controllable switching element is coupled to the current supply and to the non-inverting input of the operational amplifier. A second controllable switching element is coupled to the current supply and to the inverting input of the operational amplifier. A third controllable switching element is coupled to the current supply and to the inverting input of the operational amplifier. The second controllable switching element has a control terminal coupled to receive a first of the differential signals provided by the transmission medium and the third controllable switching element has a control terminal coupled to receive a second of the differential signals provided by the transmission medium. The control terminals of the second and third controllable switching elements are further coupled to a fixed bias voltage and the control terminal of the first controllable switching element is coupled to a bias voltage equal to the fixed bias voltage plus one half the predetermined differential thresholds. Accordingly, the output of the operational amplifier is at a first level when the differential of the received differential signals exceeds the predetermined differential threshold and is at a second level when the differential of the received differential signals is less than the predetermined differential threshold.

The figures which explain the parts of the circuitry are shown.

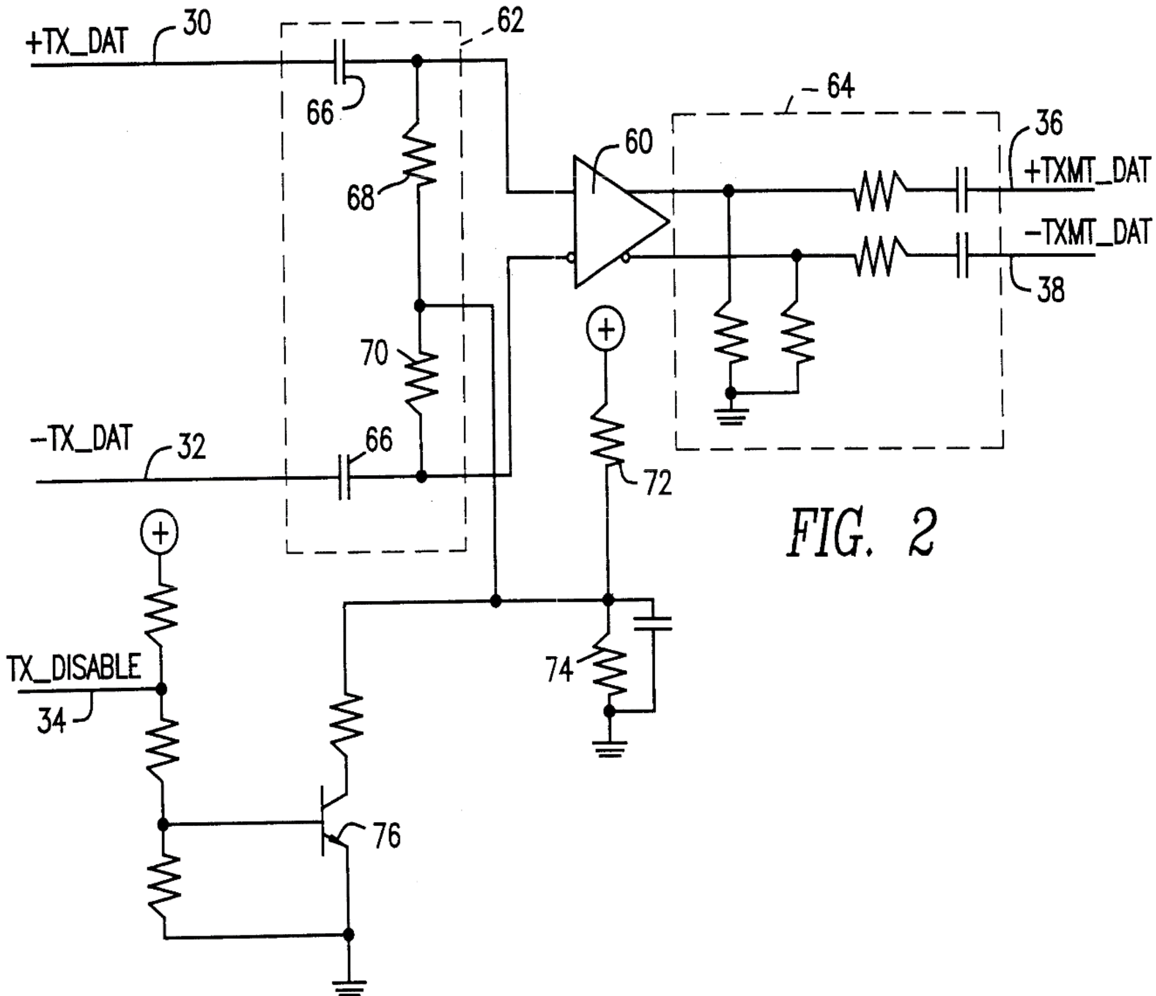

FIG. 2

Figure 3- is a schematic circuit diagram of inventive transmit circuitry including transmit disable circuitry [4].

This Transmit Circuitry receives the data signals from the host and couples it to the output termination circuit. When the Transmission Disable Signal **34** is low, the GBIC works in normal conditions. However, if the Transmission Disable Signal is turned high by the host, the transmitter **76** conducts thus disabling the GBIC.

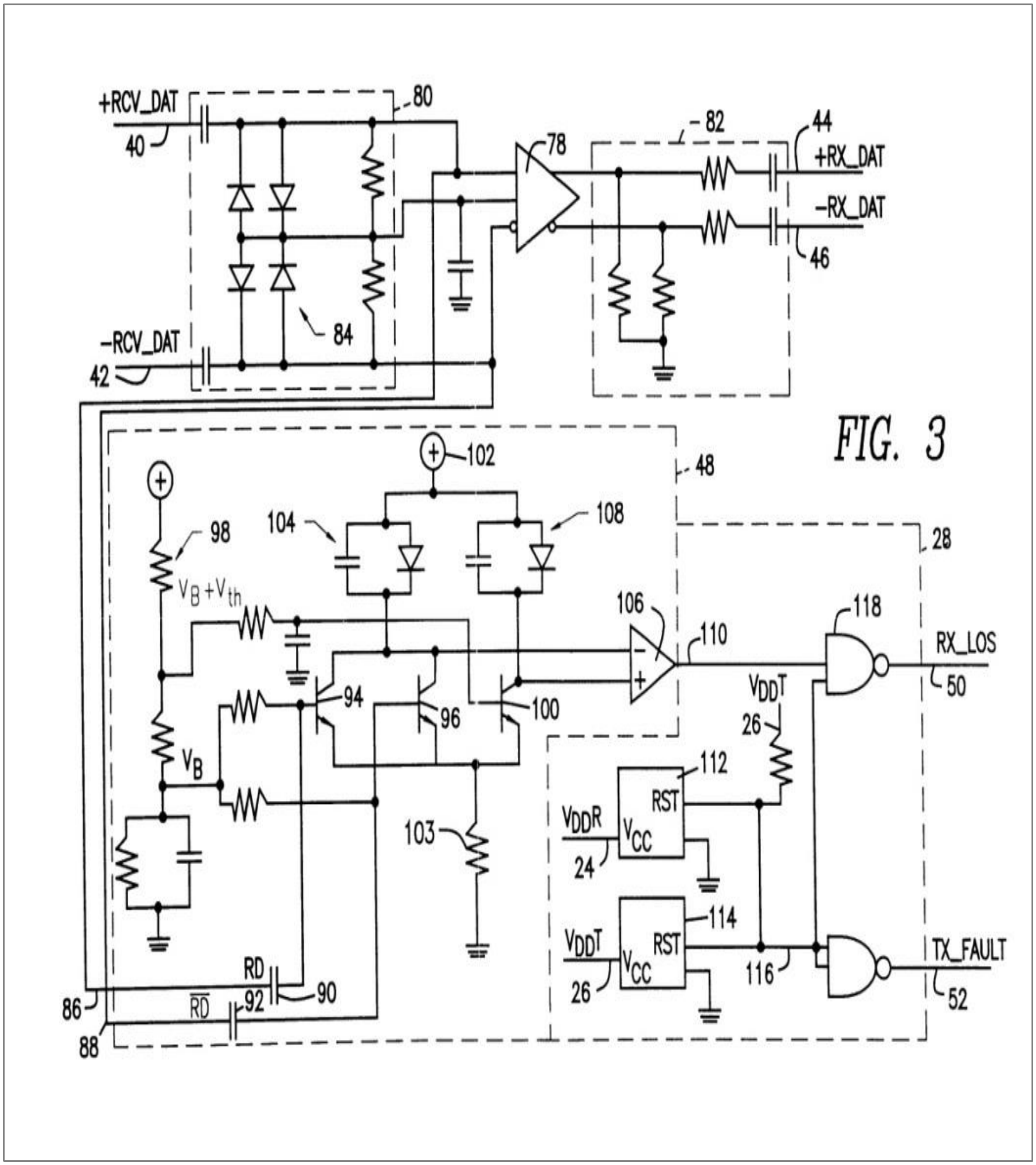

Figure 4- is aschematic circuit diagram of inventive receive circuitry showing the loss of signal detect circuitry and the power management and surge control circuitry [4].

This figure shows the 'Signal Detection' circuit which is numbered as 48 here, and the portion represented by number 28 is the 'Power Management' part of the circuitry.

4.3 Circuit Design and Implementation

The design of the transceiver circuitry has been completed. The circuit designs have been completed in PROTEUS (circuit design software).The resulting circuit diagrams are attached in the demonstration outline section of this document.

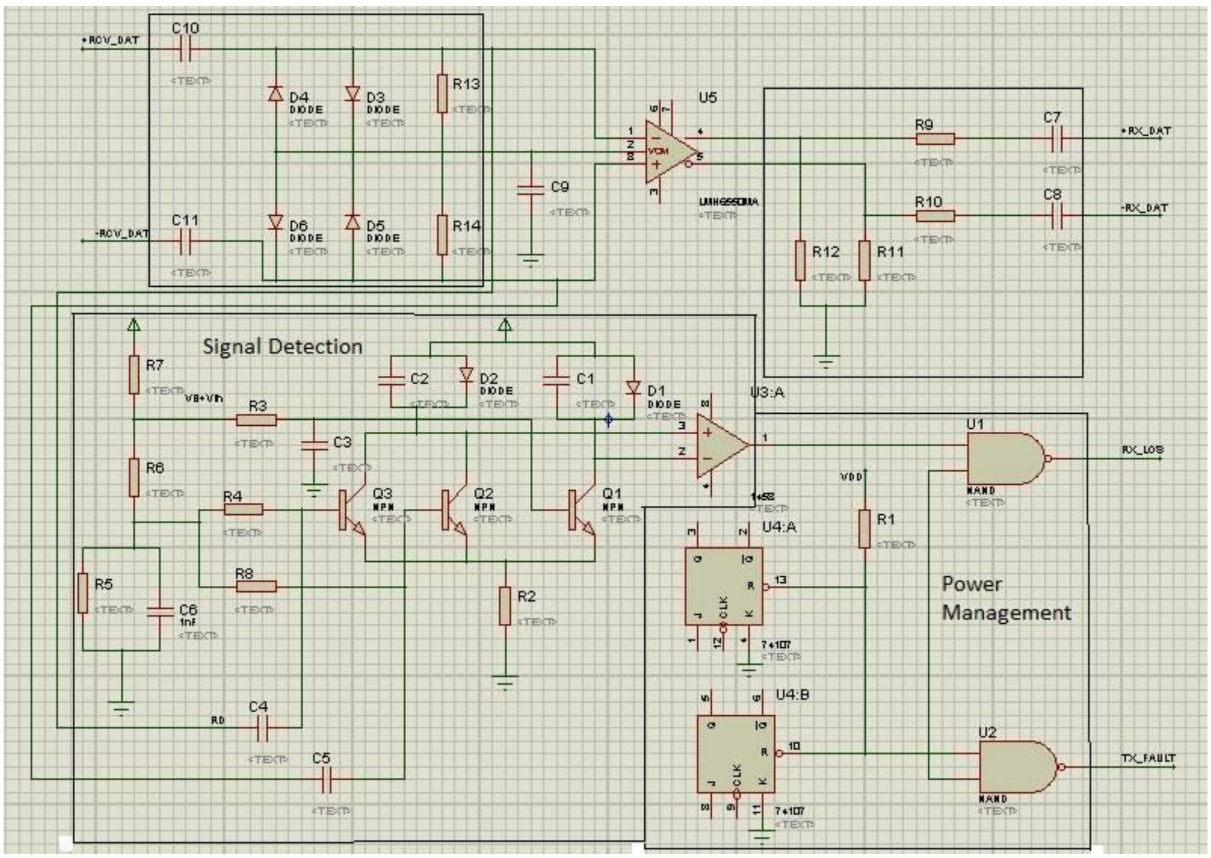

Figure 5- Circuit Design of Transceiver

The above designed circuit has all parts as mentioned in the design portion of the report. These were further created in hardware form and then after testing, compatibility and other issues were resolved.

CHAPTER 5

RESULTS AND ANALYSIS

The results for GBIC testing mainly comprised of data transmission and the speeds related to the data transmission. For the purpose of testing, the procedure was divided into two phases mentioned as:

i. Connectivity Testing
ii. Speed Testing of Transceiver

i. Connectivity Testing

For checking the success of connectivity of the modules at ends A and B; following network configuration was used at the ends A and B:

On the end A of the communication link established amongst two laptops the network configuration is as follows:

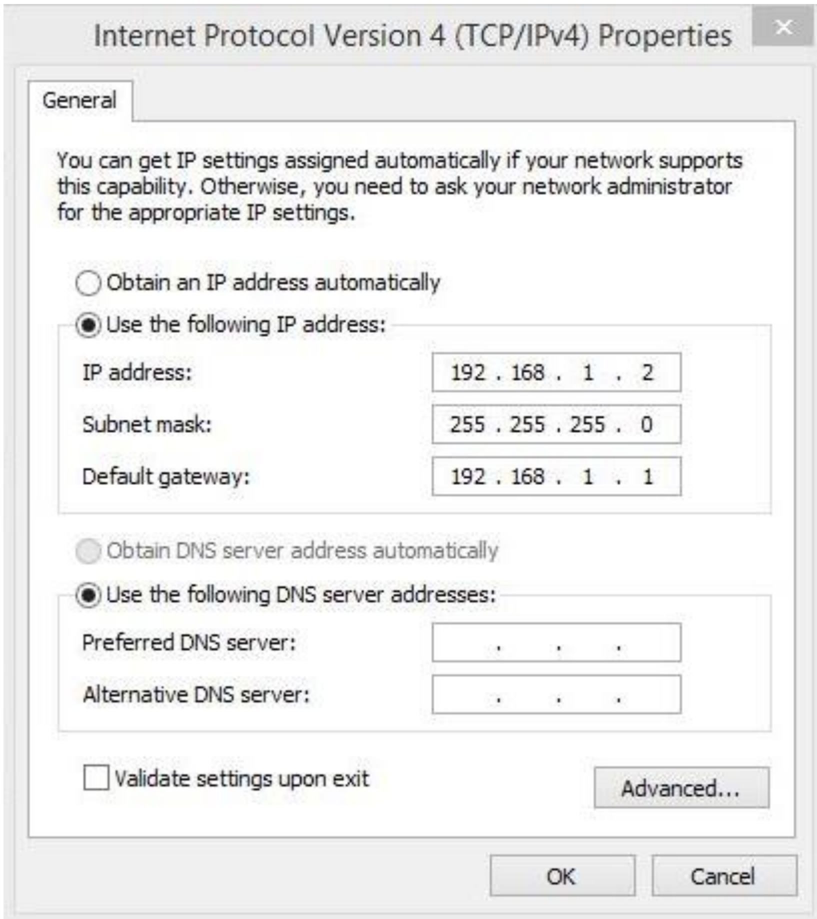

Figure 6- Network Configuration at End-A

Similarly for the end B of the same communication link the network configurations were as depicted in the following figure:

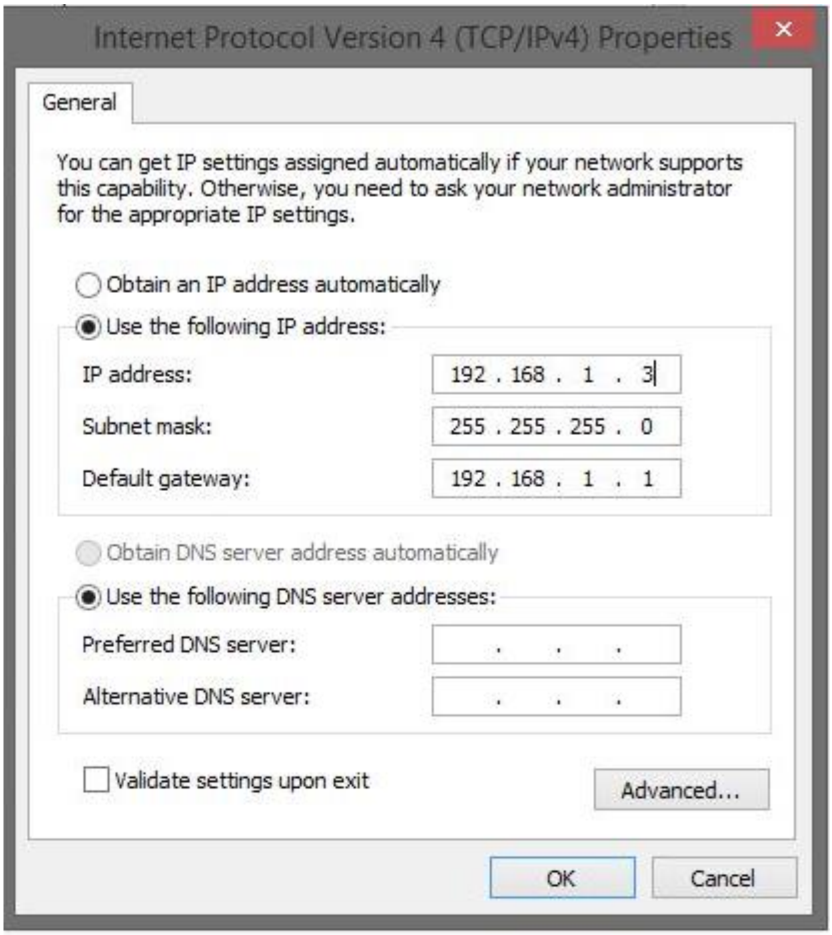

Figure 7- Network Configuration at End-B

For checking the connectivity the ping tests were run on both ends to ensure proper communication through the designed GBIC modules and ensuring that optical fibre links are running successfully. The following results were seen when ping tests were run on both ends of the communication link and showed a successful establishment of link amongst the two laptops designated End-A and End-B. The ping test results were as:

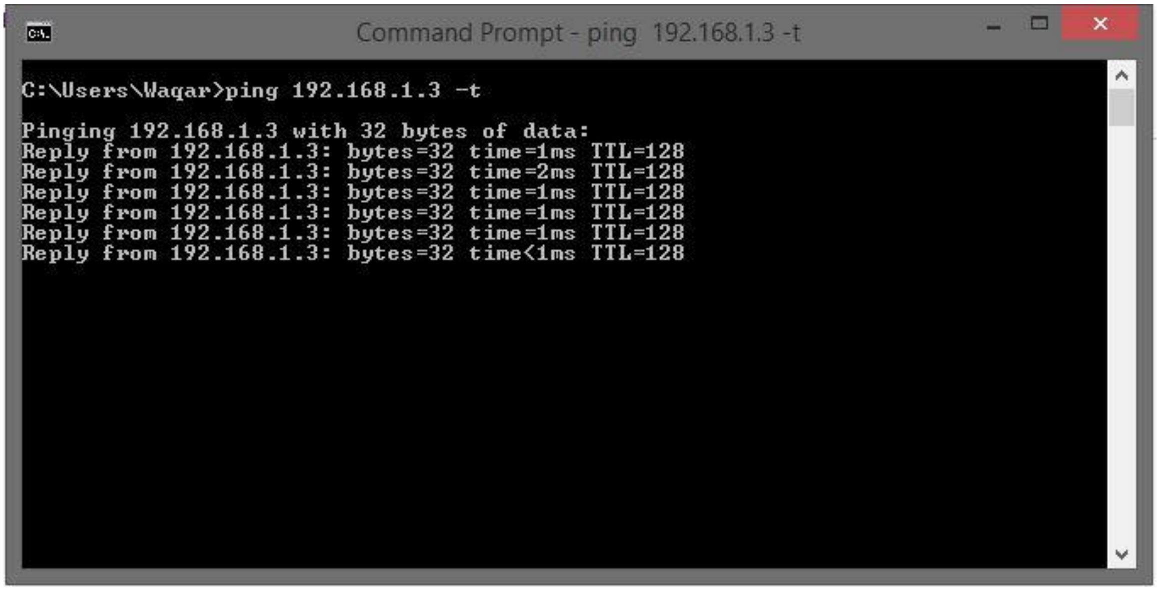

Figure 8- Ping Test Run at End-A

And for the End-B the ping tests were run with the results shown below:

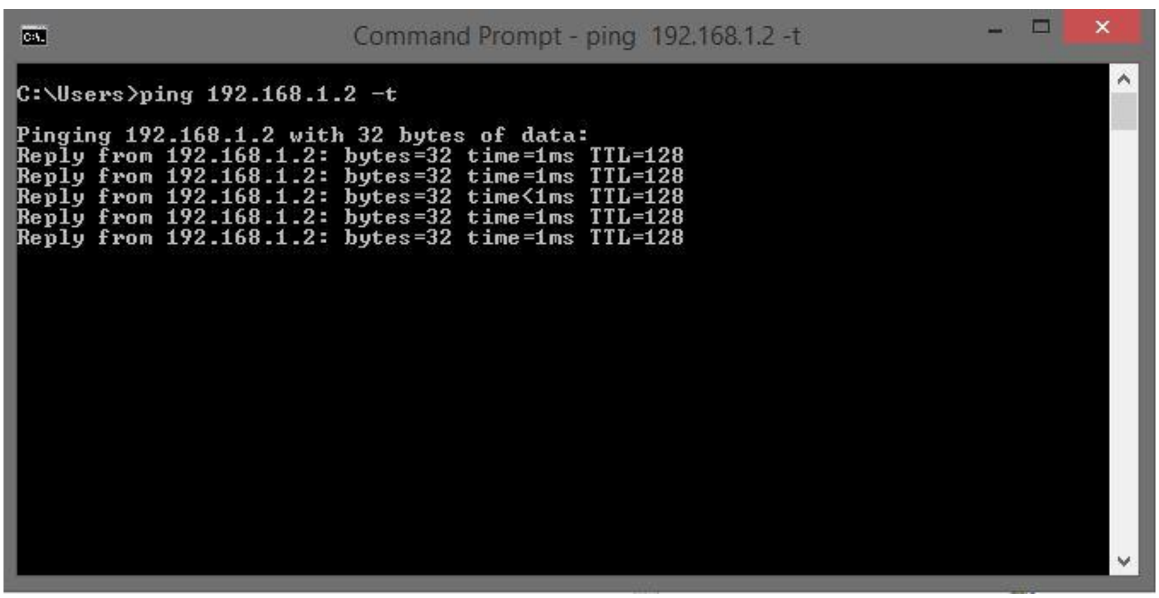

Figure 9- Ping Test Run at End-B

ii. Speed Testing of Transceiver

For testing the speed of the transceiver, a file of 1 Gigabytes was transmitted from End-A to End-B. The transceiver is capable of transmitting data at 1 Gbps (where 1 byte=8bits) so 1 Gbps = 128 Megabytes per second. For the time being the testing was done on the laptops which are equipped with FE (fast Ethernet ports) which are capable of transmitting up to 100 Megabits per second only which conversely means (100 Megabits per second = 12.5 Megabytes per second). This means that the Ethernet cards are creating a bottleneck in the link where theoretically 12.5 Megabytes per second can be ideally achieved. When a file of approximately 1 Gigabytes was transferred the following results were seen as a test of speed:

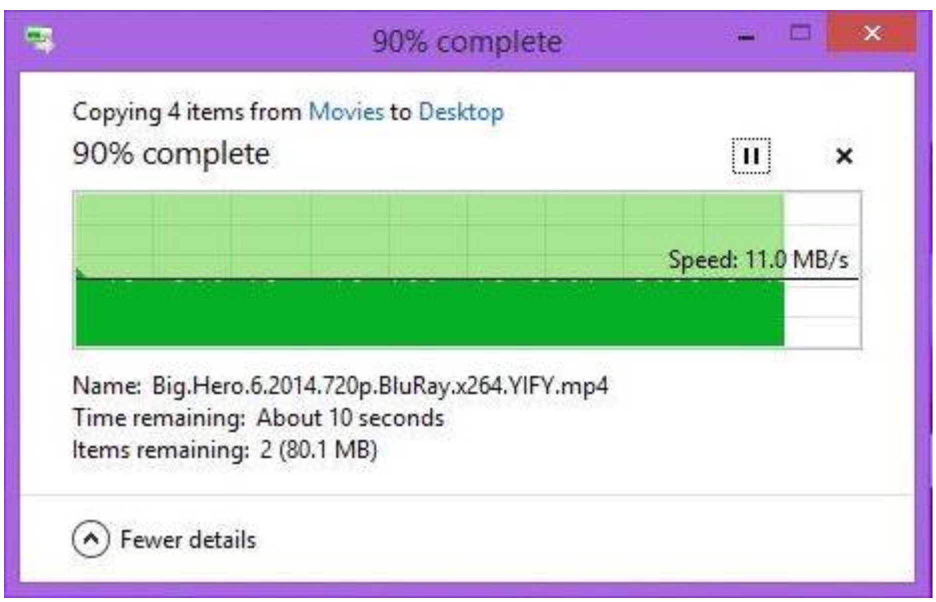

Figure 10- Speed Test Result

The maximum achieved speed was 11.5 Megabytes per second which is almost approaching to the theoretically predicted 12.5 Megabytes per second. The difference of 1 MB per second is due to certain losses in the link. These include fibre losses, insertion losses at the connectors, the up and down conversion losses in the module and the copper losses in the Ethernet cable (Cat-5).

CHAPTER 6

RECCOMMENDATIONS FOR FUTURE WORK

For the time being the module is working on a 5.0 volts AC powered adapter. One recommendation could be about making significant changes in the module circuitry to achieve the portability by devising a system where the module is powered by directly from a PC, Laptop or any other communication system by directly plugging in to a local port such as a Universal serial bus (USB) port etc. In this way the module will no longer require an active AC or other power source and can be used in remote environments.

Regarding the performance of the module the speed enhancement fixes can be done. Further research on the GBIC module can lead to decreasing fibre losses and insertion losses with the module. These are the minor losses which can be deep searched and methods may be devised for improvement of signal loss and hence improvement of speed.

CHAPTER 7

CONCLUSION

GBIC is a high end, high speed data communication device which can be interfaced with multiple communication systems which have RJ-45 Ethernet connectivity. Gigabit interface converter provides interface conversion to and from optical fibre and Ethernet cables. This device is compatible with computers, laptops, data servers and high end gigabit rate operated network cards in network equipment. The fabrication of GBIC is a practical implementation of IEEE 802.3z protocol with its variant 1000 Base LX/LH standard which essentially indicates the long haul communication over optical fibre which is considered to be up to 10 Km. GBICs can be used in large data centres, FTTH scenarios, telephony networks, CCTV and other security networks and to connect data servers in large data warehouses.

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