Department of Electronic Engineering
N.E.D. University of Engineering & Technology

PRACTICAL WORK BOOK

For the course

<u>OPTOELECTRONICS & MICROWAVE SYSTEM (EL-485)</u>
<u>For B.E (EL)</u>

Instructors name:____________________________
Student Name: _____________________________
Roll No.:________________ Batch: _____________
Semester :_____________ Year:_______________
Department: _________________________________

LABORATORY WORK BOOK
FOR THE COURSE

EL-485 OPTOELECTRONICS & MICROWAVE SYSTEM

Prepared By:

Ms. Sabika Ashraf (Lecturer)

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Approved by:

The Board of Studies of Department of Electronic Engineering

Optoelectronics & Microwave System Laboratory Manual Contents

S. No.	Dated	Cognitive/ Psycho. level	CLO	List of Experiments	Signature
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2.		P3		Measurement of numerical aperture (NA) of step index single mode, step index multimode and graded index multimode	
3.		P3		To measure the optical power emitted and observe characteristic curve of the LED	
4		P3		To observe the attenuation & coupling loss in optical fiber	
5.		P2		To analyze the operational characteristics and parameters of Photodiode used as photo detector in fiber optic system	
6		P3		To analyze the transmission characteristic of LED & laser source	
7.		P3		To get familiar with digital communication systems & to measure pre-bias current of the LED, Emitted power	
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10.		C3	3	Design L-section matching network circuit to match 100 Ω source resistance to a 1000 Ω load at a frequency of 1.8 GHz and verify	
11.		C3	3	Design π-matching network to match given source resistance to a 1000 Ω load at the frequency of 1.8 GHz and verify	
12.		C4	3	Design T-matching network to match given source resistance to a 50 Ω load at the frequency of 1.8 GHz and verify	
13.		C4	3	Design the circuits to match 50 Ω source resistances to a given complex load using absorption approach, at the frequency of 75 MHz and verify	
14.		C5	3	Design the circuit to match 50 Ω source resistance to a complex load having 40 pF capacitor in parallel with 600 Ω resistance, using resonance approach, at the frequency of 75 MHz and verify	

LAB SESSION 01

Analysis of basic structure and types of the optical fiber

Student Name: ___________________________________
Roll No.:_______________ Batch: _________________
Semester :_____________ Year:____________________

Total Marks	Marks Obtained

Remarks (if any) :_______________________________

Instructor Name:________________________________

Instructor Signature:_______________Date:________

NED University of Engineering and Technology, Karachi
Department of Electronic Engineering

Course Code: ________________ Course Name: ________________________________

Laboratory Session No. ____________ Date: ____________________

Psychomotor Domain Assessment Rubric-Level P3					
Skill Sets	Extent of Achievement				
	0	1	2	3	4
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Weighted CLO (Psychomotor Score)	
Remarks	
Instructor's Signature with Date:	

LAB SESSION 01

OBJECT

Analysis of basic structure and types of the optical fiber

EQUIPMENT

- Light Source
- Cable #3
- Cable #4
- Cable #5

THEORY

An optical fiber (or fiber) is a glass or plastic solid rode that carries light along its length with the help of the total internal reflection. It consists of core and cladding. The refractive index of the core is greater than the cladding. They can be either single mode or multi-mode fibers.

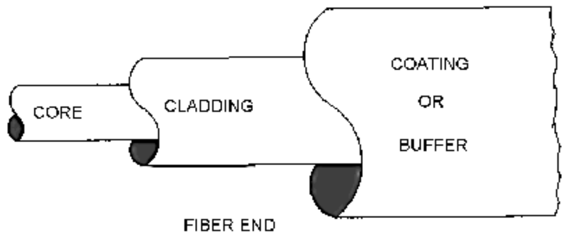


Figure 1: Optical Fiber

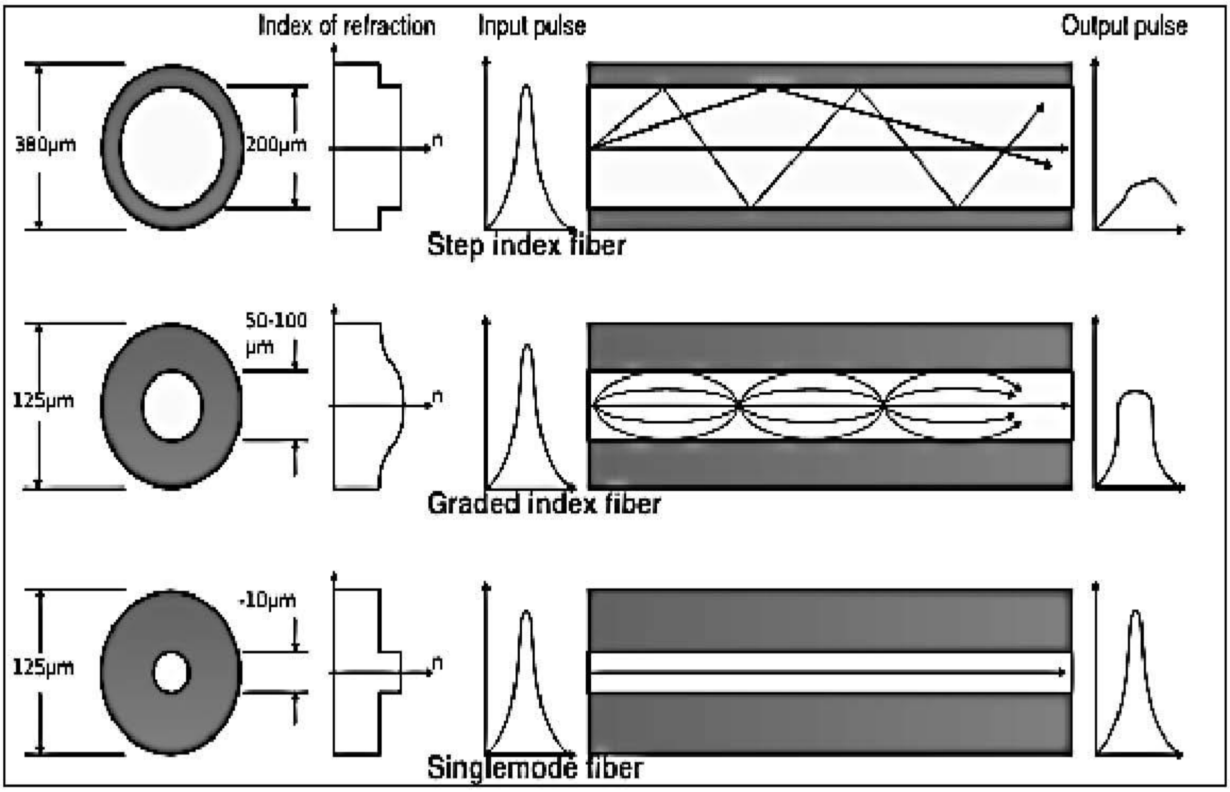
MULTI-MODE FIBER

Fiber with large core diameter (greater than 10 micrometers) may be analyzed by geometric optic s. Such fiber is called multi-mode fiber, from the electromagnetic analysis. In a step-index multi-mode fiber, rays of light are guided along the fiber core by total internal reflection. Rays that meet the core-cladding boundary at a high angle (measured relative to a line normal to the boundary), greater than the critical angle for this boundary, are completely reflected. The critical angle (minimum angle for total internal reflection) is determined by the difference in index of refraction between the core and cladding materials. Rays that meet the boundary at a low angle are refracted from the core into the cladding, and do not convey light and hence information along the fiber. The critical angle determines the acceptance angle of the fiber, often reported as a numerical aperture. A high numerical aperture allows light to propagate down the fiber in rays both close to the axis and at various angles, allowing efficient coupling of light into the fiber. However, this high numerical aperture increases the amount of dispersion as rays at different angles have different path lengths and therefore take different times to traverse the fiber. A low numerical aperture may therefore be desirable.

In graded-index fiber, the index of refraction in the core decreases continuously between the axis and the cladding. This causes light rays to bend smoothly as they approach the cladding, rather than reflecting abruptly from the core-cladding boundary. The resulting curved paths reduce multi-path dispersion because high angle rays pass more through the lower-index Periphery of the core, rather than the high-index center. The index profile is chosen to minimize the difference in axial propagation speeds of the various rays in the fiber. This ideal index profile is very close to a parabolic relationship between the index and the distance from the axis.

SINGLE MODE FIBER

The most common type of single-mode fiber has a core diameter of 8–10 micrometers and is designed for use in the near infrared. The mode structure depends on the wavelength of the light used, so that this fiber actually supports a small number of additional modes at visible wavelengths. Multi-mode fiber is manufactured with core diameters as small as 50 micrometers and as large as hundreds of micrometers (by comparison). The normalized frequency V for this fiber should be less than the first zero of the Bessel function J0 (approximately 2.405). Single mode fiber has the least dispersion and hence is used for longer distances.



as

Figure 2: Step Index, Graded Index, Single Mode Fiber

PROCEDURE AND OBSERVATION

Connect the given optical fiber with the light source and observe the light patters and the diameter of the fiber.

OPTICAL FIBER	TYPE	INNER DIAMETER	OUTER DIAMETER
Cable#3 is			
Cable #4 is			
Cable #5 is			

RESULT

LAB SESSION 02

Measurement of numerical aperture (NA) of step index single mode, step index multimode and graded index multimode

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Roll No.:_______________ Batch: _________________
Semester :_____________ Year:___________________

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Remarks (if any) :______________________________

Instructor Name:________________________________

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LAB SESSION 02

OBJECT

Measurement of numerical aperture (NA) of step index single mode, step index multimode and graded index multimode.

EQUIPMENT

- Provided optical cables
- Laser Source
- Measurement bench

THEORY

Numerical Aperture is defined as the light gathering capability of the fiber mathematically given by:

$$NA = \sin \theta A$$

$$\sin \theta A = (D/2L)$$

Where:

- L is the distance between the cable end and the measurement bench L=20mm
- D is the diameter of the acceptance cone

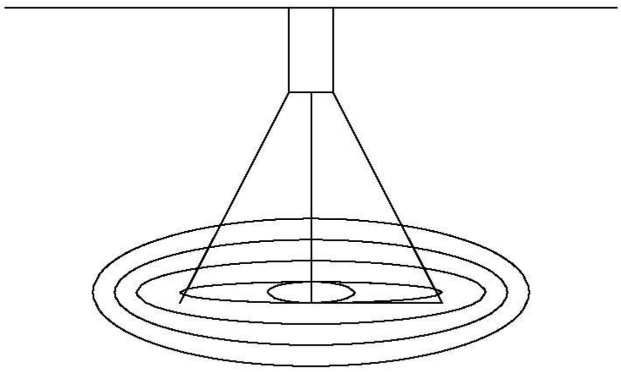

Figure 2.1: Numerical Aperture of a Fiber

PROCEDURE

1. Insert one end of the cable into the laser source (660nm) and other end into the measuring bench
2. Activate the laser source
3. Evaluate the diameter of the lightened area
4. As we move from cable 3 to cable 5 the brightness of the light point decreases as it is the function of the core diameter and the light become focused at single point

OBSERVATION

(Diameter of each circle is 2 mm)

Cable 3 (200/230) µm (step index multimode)

D =____

NA =____

Cable 4 (62.5/125) µm (graded index multimode)

D =____

NA = ____

Cable 5 (09/125) µm (step index single mode)

D =____

NA =____

RESULT

It has been observed that as the diameter of the core decreases the NA also decreases as the light gathering capability is the function of core diameter.

LAB SESSION 03

To measure the optical power emitted and observe characteristic curve of the LED

Student Name: ____________________________________
Roll No.:________________ Batch: __________________
Semester :_____________ Year:_____________________

Total Marks	Marks Obtained

Remarks (if any) :_________________________________

Instructor Name:__________________________________

Instructor Signature:________________Date:_________

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Instructor's Signature with Date:	

LAB SESSION 03

OBJECT

To measure the optical power emitted and observe characteristic curve of the LED

EQUIPMENT

- Power supply psu or ps1
- Testing module MCM-40
- Multimeter
- Optical power meter

THEORY

The commonest optical sources are light-emitting diodes (LED) and laser diodes (LD). Both these diodes can be used to generate radiations at different wavelengths, corresponding to the windows where fibers show the minimum attenuation.

The LED is a particular diode which emits light through process of recombination of the electron-hole pairs due to a forward bias of the junction The optical power emitted is a function of the forward driving current .At present the LEDs in the 1st windows are made of gallium arsenide or of the ternary compound with aluminum (ALGaAs/GaAs), the LEDs in the 2nd e 3rd windows are made of indium gallium-arsenide-phosphide (InGaAsP/InP). The most significant parameters of LED are:

1. Output wave length
2. Output spectral width
3. Output optical power: it ranges in some tens of µW, and depends on the forward driving current
4. Frequency response

PROCEDURE

Optical power emitted by LEDs

1. Power the module
2. Disconnect the jumper j11-j13 and connect the jumper j12b, so that the circuit can be arranged as shown in fig 3.1. this configuration includes the LED at 660nm, forward polarized through the bias trimmer (p4)
3. Measure the voltage v10 across the resistor of 10Ω connected in the series of LED (between TP15 and ground). the forward current if crossing the Led in expressed by the following formula:
4. IF =v10 /10 [v10 in mv, If in ma]
5. observe the intensity of the light emitted by the LED
6. Power increase as current increase

Characteristic Curves of LEDs

1. Disconnect the jumper j11-j12 and connect the jumper j13b, so that circuit can be arranged as shown in figure 3.2. this configuration includes the LED at 820nm, forward polarized through the bias trimmer (p4)

2. Measure the voltage Vf across the LED (between TP14 and TP15) and the voltageV10 across the resistor of 10Ω connected in the series of LED (between TP15 and ground). The forward current if crossing the Led in expressed by the following formula:

   IF =v10 /10 [v10 in mv, If in ma]
3. Connect the LED to optical power meter through cable3(200/230)
4. Vary the BIAS trimmer P4 and measure Vf , V10 , IF and optical power Pout
5. Plot the curve for the optical power of LED versus IF and of IF versus VF
6. Change cable 3 with cable 4(50/125) and then with cable 5 (10/125) and observe the reading. of optical power

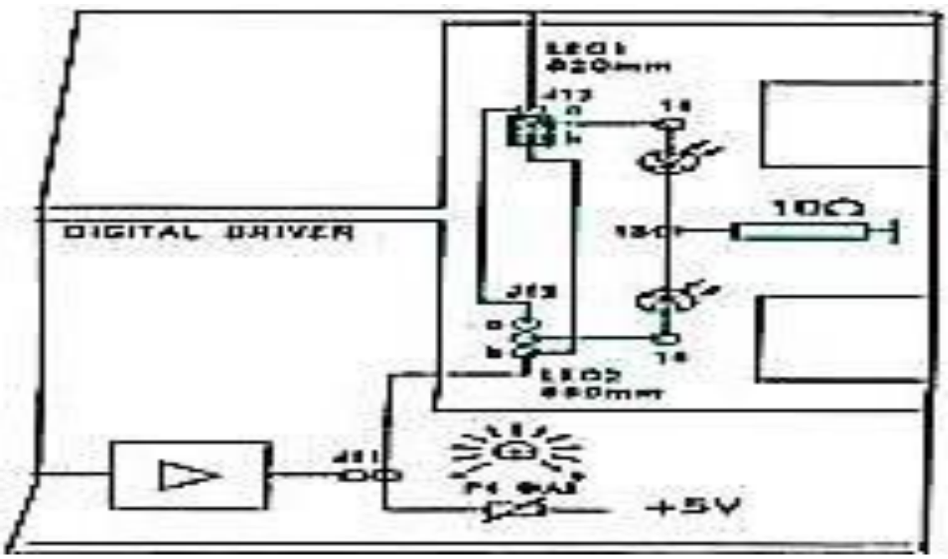

Figure 3.1: Connection Diagram Figure 3.2: Connection Diagram

OBSERVATION

Sr No	V_f mV	V_{10} mV	$I_{F\ =V10}$/10 mA	P_{out} dBm

RESULT

• Characteristic curves of LED source is observed
• By changing the fiber optic cables it was observed that the optical power decreases as the Numerical Aperture of the cable decreases

LAB SESSION 04

To observe the attenuation & coupling loss in optical fiber

Student Name: ____________________________________
Roll No.:________________ Batch: ___________________
Semester :_____________ Year:____________________

Total Marks	Marks Obtained

Remarks (if any) :_________________________________

Instructor Name:__________________________________

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Weighted CLO (Psychomotor Score)	
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Instructor's Signature with Date:	

LAB SESSION 04

OBJECT

To observe the attenuation & coupling loss in optical fiber

EQUIPMENT

- Power supply psu or ps1
- Testing module MCM-40
- Multimeter

THEORY

In the case of optical fiber, when the light crosses an absorbing medium the luminous energy decreases as distance increases. The loss in a fiber length (attenuation) is expressed by the ratio between the power entering one end of the fiber (PIN) and power coming out from the opposite end (Pout). Attenuation is normally measured in decibel:

$$Att\ (dB) = 10 \log (Pout/Pin)$$

It can ranges from some db/m for plastic fiber, to fraction of dB/km for glass fibers.

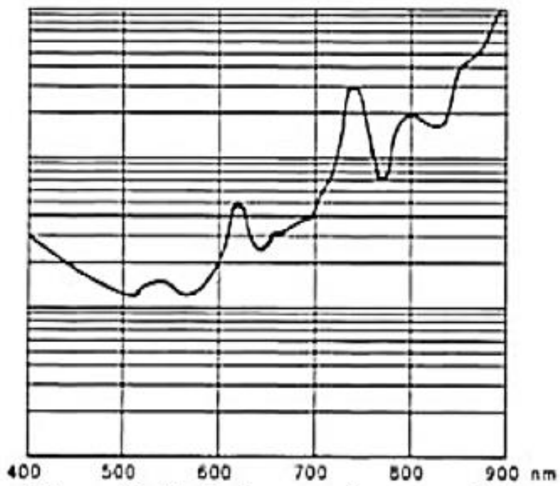

Figure 4.1: Typical attenuation curve of a plastic fiber

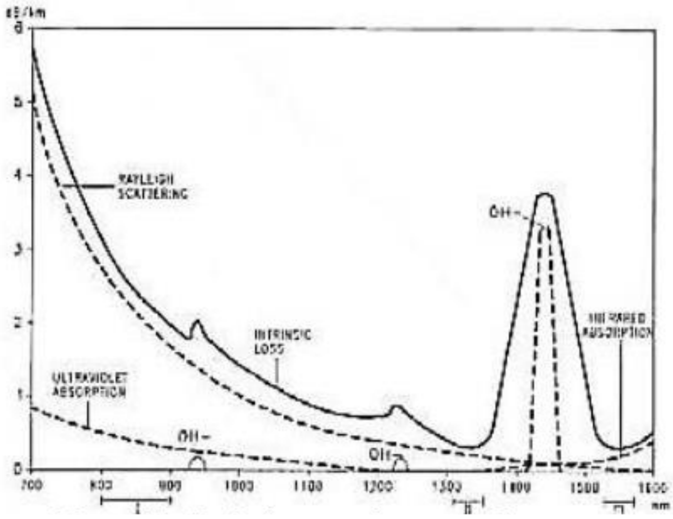

Figure 4.2: Typical attenuation curve of a single-mode glass fiber

The attenuation of the light signal due to the fibers depends on the wave length and on the material which the fiber has been constructed with. In glass fiber the main causes of attenuation are the absorption losses and the scattering losses. Combining these losses lead to plotting the intrinsic attenuation curve like that shown in the fig 4.1 whereas the fig 4.2 shown the attenuation curve of a glass fiber.

Following losses leads to attenuation

ABSORPTION LOSS

When the light photons have a certain value of energy, the atoms of glass of the core (SiO2) absorb a part of this energy. This phenomenon depends on wavelength and there are two different absorption zones, occurring in the infrared spectrum and in the ultra violet spectrum. Furthermore, during the chemical process of glass manufacturing, various metallic impurities are trapped in the core, among these impurities there are also some ions OH- which provoke absorption peaks at discrete value of wavelength.

SCATTERING LOSS

They are due to the granular structure (at microscopic level) of the material which the fiber is constructed with. This structure includes some scattering centers which are material point that scatter the radiation in all directions; even backwards this phenomenon is called Rayleigh scattering or material scattering.

OTHER LOSSES

In an optical fiber link, other can be due to too narrow loops in the path of the optical cable (Bending losses), or to junction of more lengths of fiber. Of course they are not intrinsic losses of the fiber, but they depend on cable laying.

PROCEDURE

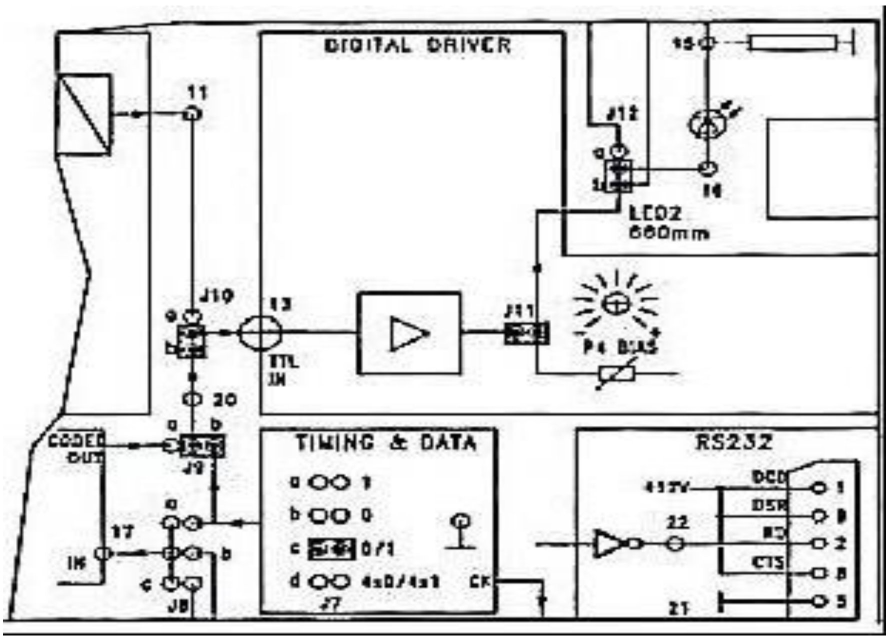

Figure 4.3: Connection Diagram

ATTENUATION OF THE FIBER WITH INCREASE IN LENGTH

1. Power the module
2. Disconnect the jumper j13 and connect j7c-j9b-j10b-j11-j12b, so that the circuit can be arranged as it is shown in fig 4.3. This configuration includes the LED and the

photodiode at 660 nm; moreover an alternating data signal (0/1) is applied to the input of the digital driver

3. Connect the LED to the photodiode through the cable # 1,ST-St adapter and cable 6
4. Set the bias trimmer (p4) to its intermediate position. connect j15b and observe the waveform in TP24 (voltage detected by the assembly “photodiode +Tran impedance amplifier”) on the oscilloscope
5. Record the amplitude vout1 of the square wave detected
6. Replace the cable # 1(plastic fiber of 1.5m) with the cable # 2(plastic fiber of 5 m) and
7. measure the new amplitude vout2 of the received signal, in TP24

- Calculate vout2/ vout1=________________________________

COUPLING AND BENDING LOSSES

1. Keep the same condition of the previous test (LED and photodiode at 660 nm connected through the cable # 2)
2. Observe the waveform in TP24, on the oscilloscope
3. Loose the fiber connector inserted in the ST-ST adapter and gradually move it away from the same adapter (and hence from the second ST connector inserted in the adapter)
4. Note that the amplitude of the receive signal decrease as the connection is loosen, it also depends on the angle at which the connector of the source and of the detector are connected
5. Bend the fiber and observe the wave form it will be observed that for sharp bends the wave form is more attenuated as the bending losses increases

ATTENUATION OF THE FIBER AS A FUNCTION OF WAVELENGTH

1. Remove the jumper j12b and connect the j13b, in order to use the LED and the photodiode at 820nm
2. Connect the LED 1 to the photodiode PD1 through the cable #1 (plastic fiber of 1.5m)
3. Connect j15a and observe the waveform in TP23
4. Record the amplitude vout3 of the square wave detected
5. Replace the cable #1 (plastic fiber of 1.5 m) with the cable #2 (plastic fiber of 5 m) and measure the new amplitude vout4 of the signal received, in TP23

- Calculate vout4/ vout3 = ______________________________

RESULT

- It has been observed that the attenuation increases as the cable length increases
- The plastic fiber cable offer greater attenuation at 820nm then on 660nm

LAB SESSION 05

To analyze the operational characteristics and parameters of Photodiode used as photo detector in fiber optic system

Student Name: ________________________________

Roll No.:________________ Batch: ________________

Semester :_____________ Year:____________________

Total Marks	Marks Obtained

Remarks (if any) :________________________________

Instructor Name:________________________________

Instructor Signature:________________Date:________

Laboratory Session No. ____________ Date: ____________________

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Weighted CLO (Psychomotor Score)	
Remarks	
Instructor's Signature with Date:	

LAB SESSION 05

OBJECT

To analyze the operational characteristics and parameters of Photodiode used as photo detector in fiber optic system

EQUIPMENT

- Power supply psu or ps1
- Testing module MCM-40
- Oscilloscope

THEORY

Photo detector can transform an optical incident signal into an electric signal. The main requirements of a photo detector are:

1. High sensitivity that is capacity of absorbing the maximum quantity of incident radiation
2. High response rate, in order to detect very narrow light pluses
3. Limited dimensions, low coast, reliability

The commonest photo detectors used in fiber optic system are the PN and PIN photodiode and avalanche photodiodes (APD).

Operating Principle

The operating principle of photo diodes is based on a particular property of semiconductor: that is, a photon absorbed by the semiconductor generates an electron-hole pair, applying a reverse bias to a PN junction generates a reverse current proportional to the incident light radiation. The performance of a photodiode can be improved if a slightly doped layer, called I (intrinsic), is sandwiched between P and N layers. These diodes are called PIN photodiodes after detector the signal is amplified by;

1. High impedance amplifier or
2. Trans-impedance pre-amplifier

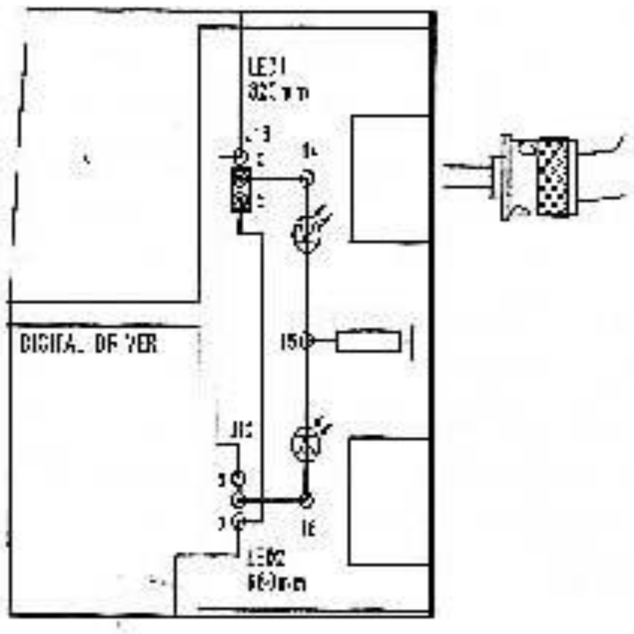
In the first case, the current (proportional to the light signal) generated by the photo detector crosses a resistor across which a voltage signal is developed, then this signal is amplified and in the trans-impedance pre-amplifier, the current is directly transformed into voltage, by effect of the feedback due to the resistance.

Hence, vout = Ir .R

As regards sensitivity and noise, high impedance pre-amplifier offer better performance, whereas trans-impedance show a broader pass band.

PROCEDURE

1. Power the module
2. Disconnect the jumper j11-j12 and connect the jumper j13b, so to produce the circuit of fig 5.1. The configuration includes the LED at 820 nm, forward biased with the BIAS trimmer (P4). Turn p4 completely to the right (maximum bias voltage)
3. Connect the LED 1 and the photodiode PD! (820 nm) through the cable #3 (fiber 200/230)
4. Connect a volt meter (or the DC oscilloscope) to TP23, where the voltage supplied by the detector is measured. Consider that the measured voltage is proportional to the current generated by the photodiode.
5. Now shift the fiber from the LED 1 (820 nm) to the LED 2 (660 nm) remove the jumper j13b and connect the jumper j12b
6. Measure the new voltage at the output voltage of the detector (TP23)
7. Disconnect the jumper J11-J13 and connect the jumper J12b,so that the circuit can be arranged as shown in fig 5.2
8. Connect the LED 2 to the photodiode 660 nm (PD2), using the cable #2 (plastic fiber), the ST-ST adapter and the HP-ST connector
9. Connect a voltmeter (or the DC oscilloscope) to TP24, where the voltage generated by the detector is measured. consider that the measured voltage is proportional to the current supplied by the photodiode
10. Now move the fiber from the LED 2 (660 nm) to the LED 1 (820 nm).remove the jumper J12b and connect the jumper J13b
11. Measure the new voltage at the output of the detector (TP24)



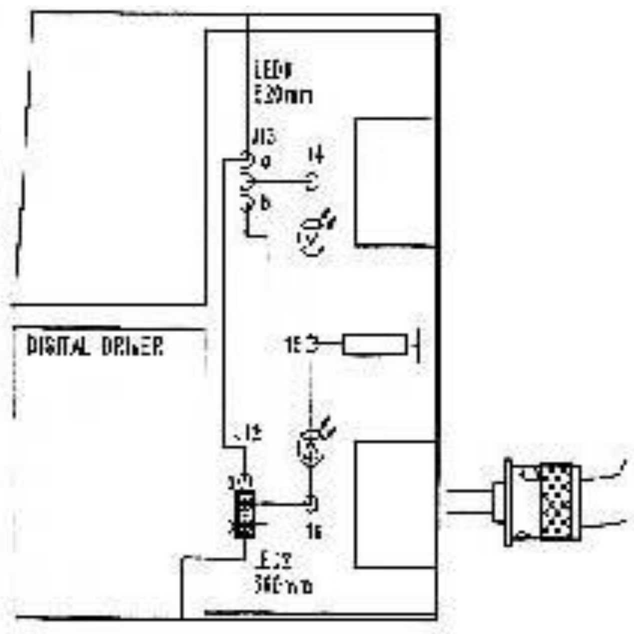


Figure 5.1: Connection Diagram Figure 5.2: Connection Diagram

RESULT

• In the case when PD1 is connected with LED 2 the detected voltage is lower, because PD1 reaches its maximum sensitivity at 820nm
• In the case when PD2 is connected with LED 1 the detected voltage is lower (actually it coincides with the voltage measured without optical signal), because the photodiode PD2 reaches its maximum sensitivity at 660 nm and the attenuation of the fiber is higher at 820 nm than at 660 nm.

Therefore, it can be concluded that that photo diode PD1 reaches its maximum sensitivity at 660 nm and PD2 at 820 nm.

LAB SESSION 06

To analyze the transmission characteristic of LED & laser source

Student Name: ______________________________
Roll No.:________________ Batch: ___________________
Semester :_____________ Year:____________________

Total Marks	Marks Obtained

Remarks (if any) :________________________________

Instructor Name:__________________________________

Instructor Signature:________________Date:_________

NED University of Engineering and Technology, Karachi
Department of Electronic Engineering

Course Code: ______________ Course Name: ______________________________

Laboratory Session No. __________ Date: ____________________

Psychomotor Domain Assessment Rubric-Level P3					
Skill Sets	Extent of Achievement				
	0	1	2	3	4
Equipment Identification Sensual ability to **identify** equipment and/or its component for a lab work	Unable to identify the equipment	Able to identify very few equipment and components to be used in lab work	Able to identify some of the equipment and components to be used in lab work	Able to identify most of the equipment and components to be used in lab work	Able to identify all of the equipment as well as its components
Procedural Skills Displays skills to act upon sequence of steps in lab work	Unable to either learn or perform lab work procedure	Able to slightly understand lab work procedure and perform lab work	Able to somewhat understand lab wok procedure and perform lab work	Able to moderately understand lab work procedure and perform lab work	Fully understands lab work procedure and perform lab work
Response Capability to imitate the lab work on his/her own	Unable to imitate the lab work	Able to slightly imitate the lab work	Able to somewhat imitate the lab work	Able to moderately imitate the lab work	Fully imitates lab work
Observation's Use Displays skills to perform related mathematical calculations using the observations from lab work	Unable to use lab work observations for mathematical calculations	Able to slightly use lab work observations for mathematical calculations	Able to somewhat use lab work Observations for mathematical calculations	Able to moderately use lab work Observations for mathematical calculations	Fully use lab work observations for mathematical calculations
Equipment Use Sensory skills to describe the use of the equipment for the lab work	Unable to describe the use of equipment	Rarely able to describe the use of equipment	Occasionally describe the use of equipment	Often able to describe the use of equipment	Regularly able to describe the use of equipment
Equipment Handling **equipment care** during the use	Doesn't handle Equipment with required care	Rarely handles equipment with required care	Occasionally handles Equipment with required care	Often handles Equipment with required care	Handles equipment with required care
Ability to troubleshoot errors and try to resolve with/without the supervision or guidance	Unable to troubleshoot experimentation errors and resolve them	Able to troubleshoot experimentation errors but cannot resolve them	Able to troubleshoot experimentation errors and resolve them under supervision	Able to troubleshoot experimentation errors independently but need guidance in resolving them	Able to troubleshoot experimentation errors and resolve them without supervision or guidance

Weighted CLO (Psychomotor Score)	
Remarks	
Instructor's Signature with Date:	

LAB SESSION 06

OBJECT

To analyze the transmission characteristic of LED & laser source

EQUIPMENT

- Educational Panel
- Provided optical cables
- Oscilloscope

THEORY

The basic concept behind the optical transmitter is that it converts electrical input signals into modulated light for transmission over an optical fiber. The input signal determines the characteristics of the resulting modulated light, which may be turned on and off or may be linearly varied in intensity between two predetermined levels.

There are two commonly· used optical sources for generating the light pulses. These are light emitting diode (LED) and Laser Diode (LD). Laser diode with its version as injection-laser diode (ILD) is commonly employed. Both the sources funnel the light pulses into the fiber-optic medium where they transmit themselves down the fiber cable and are placed in very close proximity to the light emitting region to couple as much light as possible into the fiber.
The amount of light emitted by LED or ILD is required to be coupled with the fiber in the optical fiber system. The optical light, which is getting into optical fiber, is a function of a number of factors. These are the intensity of the optical source, the area of the light-emitting surface, the acceptance angle of the fiber, and the losses due to reflections and scattering.

PROCEDURE

Checking the channel transmission speed

Both LED and LASER source are used with respective photodiode receivers, to consider the performance of the carrier out transmission channel in terms of speed.

1. Use the following test generator: PLUSE 1, PULSE2 and DATA PATTERN, those are the three digital signal generators in particular:
2. **PULSE1:** square-wave with adjustable duty cycle and frequency. When the duty cycle is minimum and frequency maximum, OUT 8 output provides a square-wave over 60Mb/s
3. **PULSE 2:** square wave with fixed frequency and duty cycle of the 50% The OUT 9 output provides a square-wave of 2Kb/s
4. **DATA PATTERN:** digital signal that can be selected 0, 1, 0/1 4x0/4x1. In the condition
5. 0/1 (maximum bit rate) the OUT 10 output provides a square wave of 256 kb/s

850nm LED

1. Use the DIGITAL DRIVER and LED SOURCE 1 sections
2. Set the AN/DIG switch to DIG
3. Connect the jumper between TP14 and ground.
4. Connect the F.O OUT 1 output to the F.O IN 1 input with an optical cable "4"
5. Set both AN/DIG switches to DIG
6. With a BNC-BNC co-axial cable, connect the OUT 9 output of the PLUSE 2 to the IN 2 input of the DIGITAL DRIVER 1
7. Connect the oscilloscope to Out 2 of the DIGITAL RECEIVER 1 and check that the signal is properly received
8. Change the test generator PLUSE 2 with DATA PATTERN and check that the signal is properly received
9. Change the test generator DATA PATTERN with PLUSE 1 and check that the signal is properly received. When the frequency is adjusted to the maximum and the duty-cycle to the minimum the characteristic of the received signal worsen because the channel does not allow so high speeds

1310nm LASER

1. Use the section composing the TX 3
2. Connect the F.O OUT 3 output to the F.O IN 3 input with an optical cable "4"
3. Set the ON switch to LASER ON
4. With a BNC –BNC coaxial, connect the OUT 9 output of the PLUSE 2 to the IN 4 input of TX 3
5. Connect the oscilloscope to OUT 4 of RX 3 and check that the signal is not properly received: the channel does not allow the transmission of digital signal with low bit rates
6. Change the test generator PLUSE 2 with the DATA PATTERN and check that the signal is properly received now: the channel enables the transmission of a signal with this bit rate (256kb/s)
7. Change the test generator DATA PATTERN with PLUSE 1 and check that the signal is still properly received. Besides when the frequencies is adjusted to the maximum and the duty cycle to the minimum and the duty cycle to the minimum, the characteristic of the received signal are highly better in the last case where the channel uses the LED source
8. Check that there are the same characteristic also with mono-mode fiber "5"that is used, in fact for high speed because it introduces very low modal dispersion

OBSERVATION

850nm LED source and 1310nm LASER source:

Wave form at Out 2 and Out 4 in case of:

PULSE2

DATA

PATTERN:

PLUSE1:

RESULT

LAB SESSION 07

To get familiar with digital communication systems & to measure pre-bias current of the LED, Emitted power regulation and analyze waveforms of transmitted and received signals using different fiber

Student Name: __________________________________
Roll No.:________________ Batch: ___________________
Semester :_____________ Year:____________________

Total Marks	Marks Obtained

Remarks (if any) :________________________________

Instructor Name:__________________________________

Instructor Signature:________________Date:________

NED University of Engineering and Technology, Karachi
Department of Electronic Engineering

Course Code: ______________ Course Name: ______________________________

Laboratory Session No. __________ Date: ____________________

Psychomotor Domain Assessment Rubric-Level P3					
Skill Sets	**Extent of Achievement**				
	0	1	2	3	4
Equipment Identification Sensual ability to **identify** equipment and/or its component for a lab work	Unable to identify the equipment	Able to identify very few equipment and components to be used in lab work	Able to identify some of the equipment and components to be used in lab work	Able to identify most of the equipment and components to be used in lab work	Able to identify all of the equipment as well as its components
Procedural Skills Displays skills to act upon sequence of steps in lab work	Unable to either learn or perform lab work procedure	Able to slightly understand lab work procedure and perform lab work	Able to somewhat understand lab wok procedure and perform lab work	Able to moderately understand lab work procedure and perform lab work	Fully understands lab work procedure and perform lab work
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Equipment Handling **equipment care** during the use	Doesn't handle Equipment with required care	Rarely handles equipment with required care	Occasionally handles Equipment with required care	Often handles Equipment with required care	Handles equipment with required care
Ability to troubleshoot errors and try to resolve with/without the supervision or guidance	Unable to troubleshoot experimentation errors and resolve them	Able to troubleshoot experimentation errors but cannot resolve them	Able to troubleshoot experimentation errors and resolve them under supervision	Able to troubleshoot experimentation errors independently but need guidance in resolving them	Able to troubleshoot experimentation errors and resolve them without supervision or guidance

Weighted CLO (Psychomotor Score)	
Remarks	
Instructor's Signature with Date:	

LAB SESSION 07

OBJECT

To get familiar with digital communication systems & to measure pre-bias current of the LED, Emitted power regulation and analyze waveforms of transmitted and received signals using different fiber

EQUIPMENT

- Educational panel
- Tester
- Oscilloscope
- Optical power meter including the windows 1st /IInd 850/1310nm
- Provided optical cables

THEORY

Introduction to Digital Communication System

The Educational Panel contains three kinds of a digital communication system that are good for the transmission of TTL digital signals:

1. 2 communication system with LED source
2. 1 communication system with LASER source

Both these communication system are based on the same operating principal: the light signal to be transmitted undergoes an ON/OFF modulation.
Obviously they have different characteristics and performance indicating a different use.

Digital transmitter with LED TX1 TX2 source

TX1 and TX2 consist in two equal sections:

1. DIGITAL DRIVER 1 (2) it constitutes the LED bias stage. There is a circuit that clip the TTL input signal and biased Led through the BIAS potentiometer
2. LED SOURCE 1 (2) it constitutes the stag containing the luminous source with output of ST F.O OUT 1 (2) connector. A jumper on TP14 and 16 is present to carry out the bias current measurement

Digital receivers with detector RX1 and RX2

RX1 and RX2 consists in two equal section

1. PIN PD DETECTOR 1 (2) constitutes the reception stag containing the PIN optical photodiode detector, with input of ST F.O IN 1 (2) connector. The photo detector current output is amplified by a trans impedance pre-amplifier (mounted in the same container of the photodiode) that provides a voltage output proportional to the input current

2. DIGITAL RECEIVER 1 (2) constitutes the stag processing the signal of the last stag. In particular, there is a voltage limiter amplifier couples in a.c (operating on the switch threshold), a threshold comparator circuit providing a PECL signal

(pseudo ECL) straight and negated (to increase the switching speed)and a current converting the PECL signal into TTL levels (0/5 v) that are provided across the output.

Digital transmitter with laser TX3 source

TX3 consists in two sections

1. **DIGITAL LASER DRIVER** constitutes the laser basing stag. There is the converter circuit from TTL level in PECL (straight and negated component), the modulator and bias circuit with ON switch
2. **LASER SOURCE** constitutes the stag containing the light source with ST F.O out 3 connector output. There is the photo diode of the APC for bias control

Digital receiver with avalanche detector RX3

RX consists in two sections

1. **AVALANCHE PD DETECTOR constitutes** the reception stag containing the avalanche photo diode optical detector, with ST F.O IN 3 connector Input. The Photodiode is biased with constant current to reduce the influence of temperature. The output is amplified and sent to the next voltage stage
2. **DIGITAL LASER RECEIVER** constitutes the stage processing the signal of the last stage. In particular there is a filter limiting the band of the output signal from the pre-amplifier, to limit the noise and so to increase the sensibility of the receiver. Then, there is a stage amplifying limiting and providing the signals to the separator stage with PECL output (straight and negated).At last, there is the converter stage of levels from the PECL to the TTL. Besides, there is a detection circuit for the input signal with signaling LED when the level is lower than the detection threshold

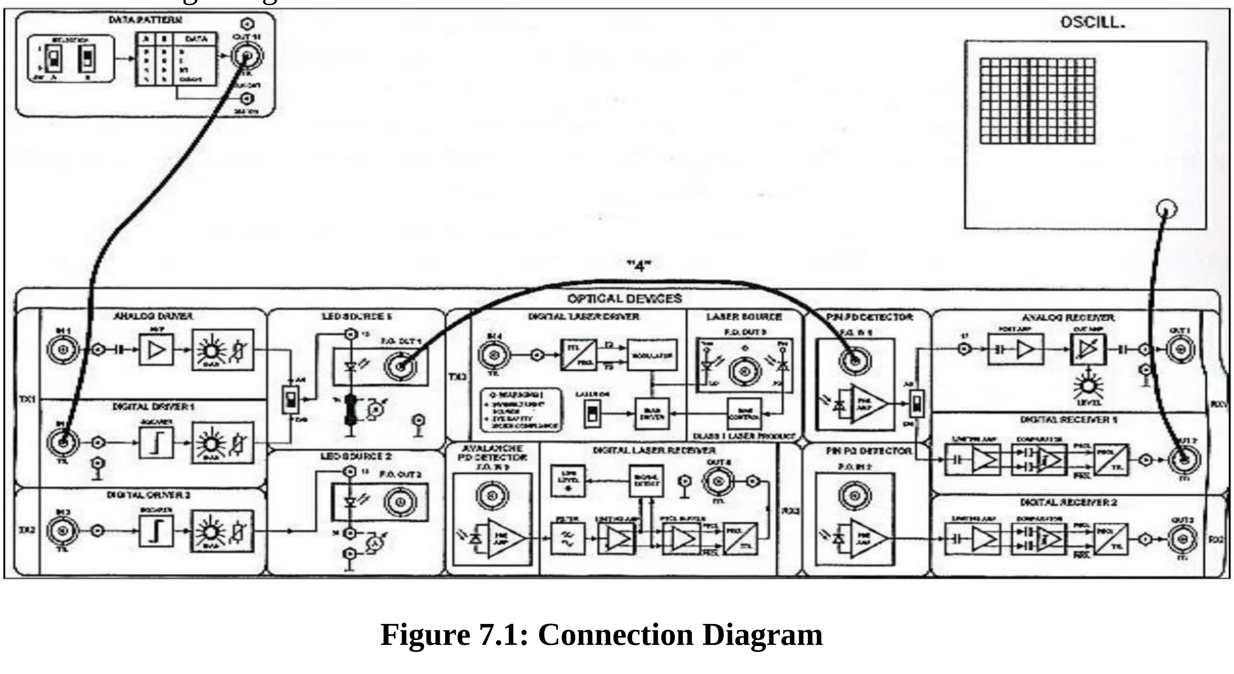


Figure 7.1: Connection Diagram

PROCEDURE

Pre-bias current of the LED

1. Power the panel with the provide power supply use the DIGITAL DRIVER 1 and LED SOURCE 1 sections
2. Use the DIGITAL DRIVER 1 and LED SOURCE 1 section
3. Disconnect any jumper between TP14 and ground and insert a tester configured as ammeter (range in mA)
4. Set the AN/DIG switch to DIG
5. In this configuration, this 850 nm LED is used directly biased via the BIAS potentiometer.
6. Adjust the BIAS potentiometer to the minimum
7. In these conditions, there is no input signal (0v to IN2)
8. Inside the receptacle, see that the LED, although being driven by a low level signal, is not completely off. Besides, the emitter intensity depends on the position of the BIAS potentiometer
9. In these conditions, there is pre-bias current even if the digital driving signal is to zero, so the LED is always lightly on.
10. Check that, adjusting the BIAS potentiometer from the minimum to the maximum, the pre bias current changes from about 40 to 80 mA
11. Set the AN/Dig switch to AN
12. Now, check that the pre-biasing range is between 10mA to 80mA about, attesting that a higher range is necessary for the analog signal in respect to the digital signal operation

Emitted power regulation

1. Set the AN/DIG switch to DIG
2. With a BNC-BNC coaxial cable, connect the OUT 10 output of the DATA PATTERN to the IN 2 input of the DIGITAL DRIVER 1
3. Set the switches SW A to 0 and SW b to 1, so to drive the circuit with a signal fixed to +5V (logical Level 1)
4. Via the fiber with identifier “4” (62.5/125) connect the source (F.O ‘OUT 1) to the optical power meter, and turn it on
5. On the meter, select the wave length of 850 nm and the reading in dBm
6. Check that direct current If flowing across the LED depend on the BIAS potentiometer regulation and so does the maximum optical power emitted by the LED, too

Wave form of the transmitted signal

1. Set the SW A switches to 1 and SW B to 0, so to drive the TTL circuit with a 0/1 alternated data signal
2. Connect the oscilloscope to the test point of the IN 2 input and to TP13
3. Check that in TP13 there is a voltage over the LED threshold (over the BIAS regulation
4. With the power meter, Check that the emitted power follows the same variation law, too

Wave from of the received signal

1. Set up the circuit as in fig 7.1
2. In this configuration the LED and the 850nm PIN photodiode are used
3. Set the AN/DIG switch to DIG in the transmission section and to AN in the reception section
4. Via the fiber with identifier "4" (62.5/125) connect the source (F.O OUT 1) to the F.O IN 1 input of the PIN photodiode detector
5. Connect the oscilloscope to TP13 to TP17
6. Check the Wave from of the transmitted and the received signal, i.e. of TP13 (voltage across the LED) , TP17 (voltage detected together with the "photodiode
7. + trans-impedance amplifier unit), OUT 3 (received TTL signal, TTL signal, after the reception AN/DIG switch is set to DIG).

Wave form

Use of different kind of fiber

1. Remove, now the 62.5/125 fiber (cable "4") and connect the 200/230 fiber (cable "3")
2. Turn the BIAS potentiometer completely rightward (maximum bias current)
3. Examine the Wave-form in TP17
4. The signal amplitude is null in respect to the last case, as detector receive a too high optical power and is in saturation. This is due to the fact that the power inserted into fiber by the source in higher with the 200/230 fiber (cable "3") as this has a higher numerical opening although the 200/230 fiber has a higher attenuation than the 62.5/125 one, this is scarcely affecting due to the short cable length.
5. Reducing the emitted optical power BIAS control or lightly setting the fiber further from the detector or the LED, you can see that the detected signal take the right, shapes beside the amplitudes is superior than that with the 62.5/125 fiber.
6. Repeat the last measurement using the mono mode 9/125 fiber cable "5" The optical power at the fiber output is very low, practically negligible due to the very small numerical opening mono mode fiber. For this reasons, the reception is impossible. There is only the BIAS voltage.

7. Repeat the last measurement using the plastic fiber (cable"1" 1.5 m) the plastic fiber attenuation at 850nm is higher than the one of the glass fiber, and so the received signal (TP17) has smaller amplitude.
8. Change the 1.5m plastic fiber with the 5-m one (cable "2") as the fiber is longer, the optical signal is attenuated more.

RESULT

LAB SESSION 08

To carry out transmission of an audio signal using fiber optics as a backbone

Student Name: ________________________________
Roll No.:________________ Batch: __________________
Semester :_____________ Year:____________________

Total Marks	Marks Obtained

Remarks (if any) :________________________________

Instructor Name:________________________________

Instructor Signature:________________Date:________

Laboratory Session No. ______________ Date: ______________________________

Psychomotor Domain Assessment Rubric-Level P2

Skill Sets	Extent of Achievement				
	0	1	2	3	4
Equipment Identification Sensual ability to **identify** equipment and/or its component for a lab work	Unable to identify the equipment	Able to identify very few equipment and components to be used in lab work	Able to identify some of the equipment and components to be used in lab work	Able to identify most of the equipment and components to be used in lab work	Able to identify all of the equipment as well as its components
Procedural Skills Displays skills to act upon sequence of steps in lab work	Unable to either learn or perform lab work procedure	Able to slightly understand lab work procedure and perform lab work	Able to somewhat understand lab work procedure and perform lab work	Able to moderately understand lab work procedure and perform lab work	Fully understands lab work procedure and perform lab work
Equipment Use Sensory skills to **describe** the use of the equipment for the lab work	Unable to describe the use of equipment	Rarely able to describe the use of equipment	Occasionally describe the use of equipment	Often able to describe the use of equipment	Regularly able to describe the use of equipment
Safety Adherence Following of **safety** procedures	Doesn't follow Safety procedures	Rarely follow safety Procedures	Occasionally follow Safety procedures	Often follow safety procedures	Fully follow safety procedures
Equipment Handling **equipment care** during the use	Doesn't handle Equipment with required care	Rarely handles equipment with required care	Occasionally handles Equipment with required care	Often handles Equipment with required care	Handles equipment with required care

Weighted CLO (Psychomotor Score)	
Remarks	
Instructor's Signature with Date:	

LAB SESSION 08

OBJECTIVE

To carry out transmission of an audio signal using fiber optics as a backbone

EQUIPMENT

- Educational panel
- Provided optical cables
- Co-axial cables with BNC connector

THEORY

A fiber-optic cable provides a pipeline that can carry large amounts of information. Copper wires or copper coaxial cable carry modulated electrical signals but only a limited amount of information, due to the inherent characteristics of copper cable. Free-space transmission, such as radio and TV signals, provides information transmission to many people, but this transmissions scheme cannot offer private channels. Also, the free-space spectrum is becoming a costly commodity with access governed by the FCC. Fiber-optic transmission offers high bandwidth and data rates, but it does not add to the crowded free space spectrum.

PROCEDURE

1. Power the panel with the provided power supply
2. Connect OUT 6 port of Test Generator module to IN 1 port of Analog driver section
3. Make sure the switch is at AN position in Analog driver section
4. Join POINT 14 of LED Source 1 with ground
5. Connect F.O.OUT 1 port to F.O.IN 1 port of Pin PD detector using provided fiber cable
6. Set switch to AN position
7. Connect Analog Receiver OUT 1 port to Audio IN of Speaker 1 or Speaker 2

RESULT

LAB SESSION 09

Introduction to Agilent ADS circuit simulation tools for matching networks

Student Name: ________________________________
Roll No.:________________ Batch: ___________________
Semester :_____________ Year:____________________

Total Marks	Marks Obtained

Remarks (if any) :_________________________________

Instructor Name:__________________________________

Instructor Signature:________________Date:________

Cognitive Domain Assessment Rubric				
Skill Sets	**Extent of Achievement**			
	0	**1**	**2**	**3**
Software Identification Sensual ability to **identify Software** and/or its component for a lab work	Unable to identify the **Software**	-	-	Able to identify **Software** as well as its components
Software Use Sensory skills to **describe** the use of the **Software** for the lab work	Unable to describe the use of **Software**	Rarely able to describe the use of **Software**	Mostly able describe the use of **Software**	Regularly able to describe the use of **Software**
Procedural Skills Displays skills to carry out sequence of steps in software based lab work	Unable to carry out software based lab work with desired commands/ components identification/ connections	Rarely able to carry out software based lab work with desired commands/ components identification / connections	Mostly able to carry out software based lab work with desired commands/ components identification/ connections	Regularly able to carry out software based lab work with desired commands/ components identification/ connections
Observation's Use Displays skills to perform related mathematical calculations using the observations from lab work	Unable to use software based lab work observations for/ to support mathematical calculations	Rarely able to use lab work observations for/ to support mathematical calculations	Mostly able to use lab work observations for/ to support mathematical calculations	Mostly able to use lab work observations for/ to support mathematical calculations
Group Work Contributes in a group based lab work	Never participates	Rarely participates	Occasionally participates and contributes	Regularly participates and contributes

Weighted CLO (Score)	
Remarks	
Instructor's Signature with Date:	

LAB SESSION 09

OBJECT

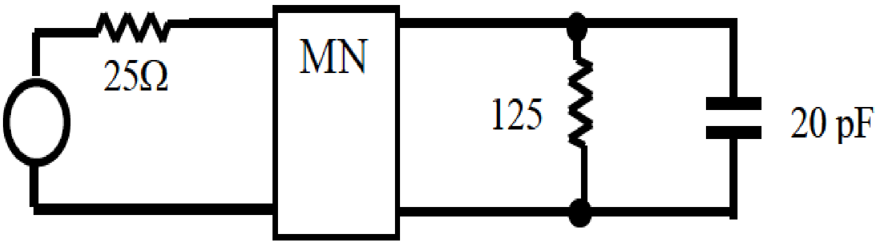
Introduction to Agilent ADS circuit simulation tools for matching networks.

THEORY

ADS provide a vast array of simulation mode and models. ADS is oriented toward microwave applications, we will find that it contains a much larger library of transmission line and passive component models that include non-idealities of these components. An AD is capable of many different types of circuit analysis, electromagnetic models, and active device models. At the beginning it can seem quite difficult to use when faced with a blank schematic. This practical will get you started using the simplest and most basic operations. As you progress in this course, you will become familiar with other techniques.

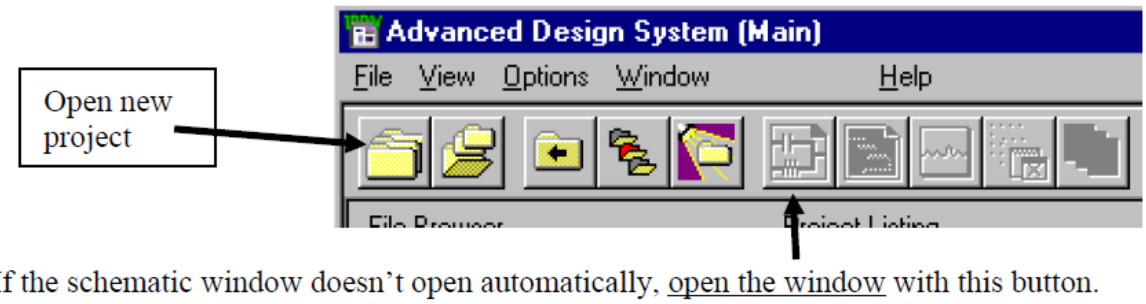
BUILDING A SCHEMATIC TO DESCRIBE A CIRCUIT

Here is a circuit with a 25 ohm source and a complex load. In this example, a matching network to match source to load is to be evaluated.



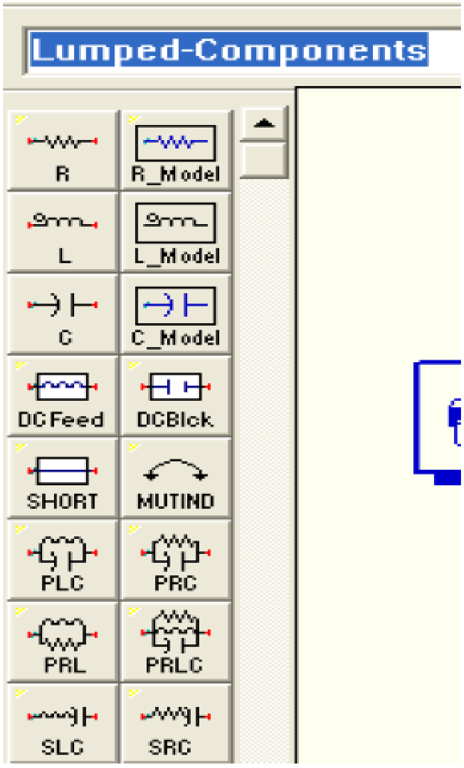
The matching network can make use of either distributed or lumped elements. You will be learning how to design such networks soon. The procedure below illustrates how to simulate this circuit in ADS.

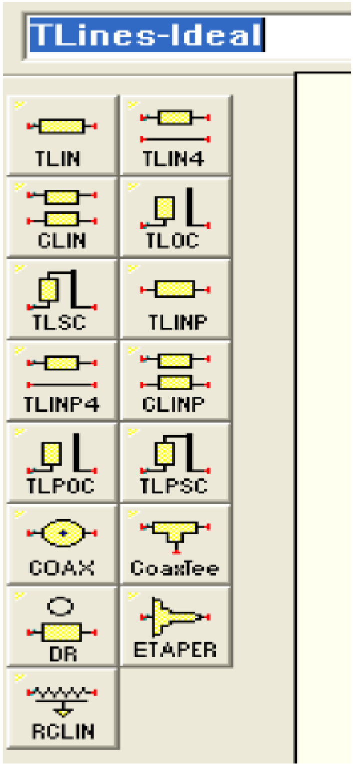
1. Startup ADS: Start > Programs > Advanced Design System 2005A > Advanced Design System
2. Open up a new project if the project has already been created, then opens it up by double clicking on its project name



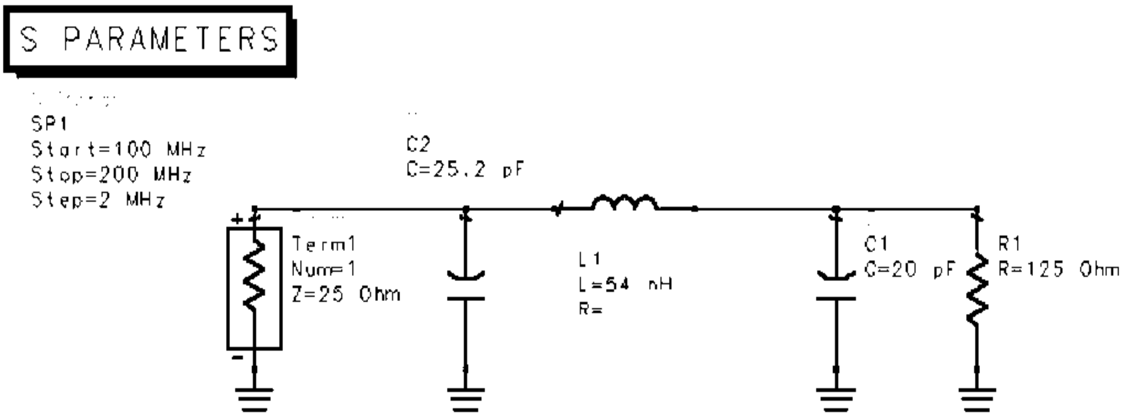
3. **Construct the schematic diagram**

Most all of the circuit icons can be placed with the mouse cursor - just point and click. To complete the placement of a particular part, hit Escape. The menus on the left edge of the schematic allow you to select from a wide range of components, simulation modes, and behavioral models. Circuit elements can be selected from the Lumped Component menu which includes such things as R, L, C, combinations of these, and ideal transformers. The T-line menu includes various types of transmission line circuit elements, ideal or modeled for the particular geometries of microstrip or other planar line configurations.





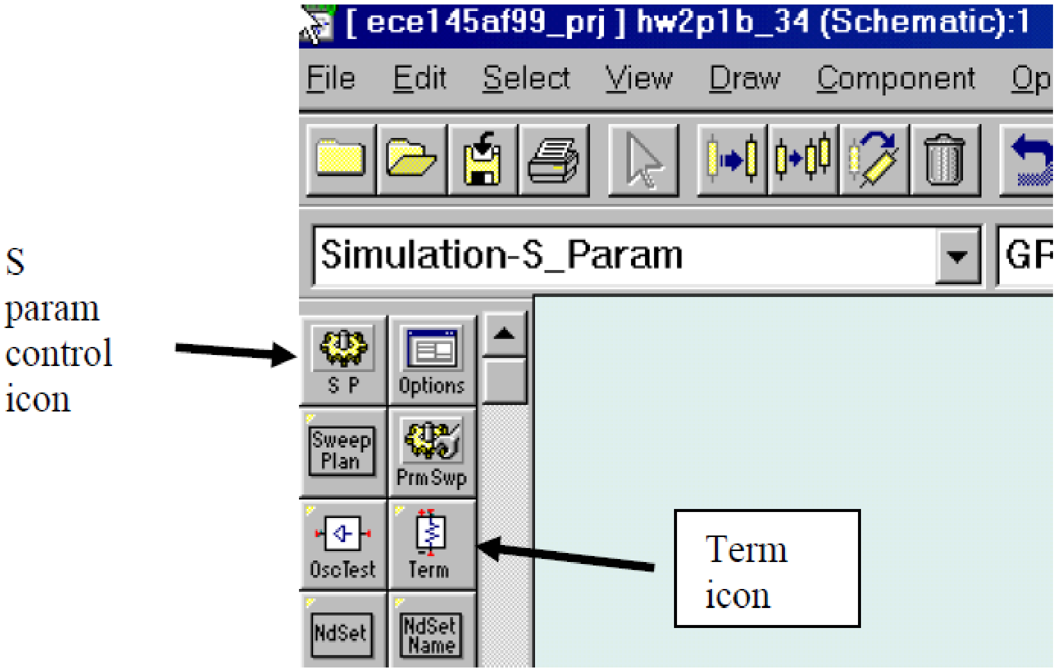
Here is an example of a circuit which accomplishes the matching function and is composed of lumped components.



Often when placing components, the component text appears in an inconvenient location, blocking the text of other components. Use the F5 key to move the text. Select the component, hit F5, and drag the text to the new location. Then hit Esc to complete the move.

SIMULATION MODE: S-PARAMETERS

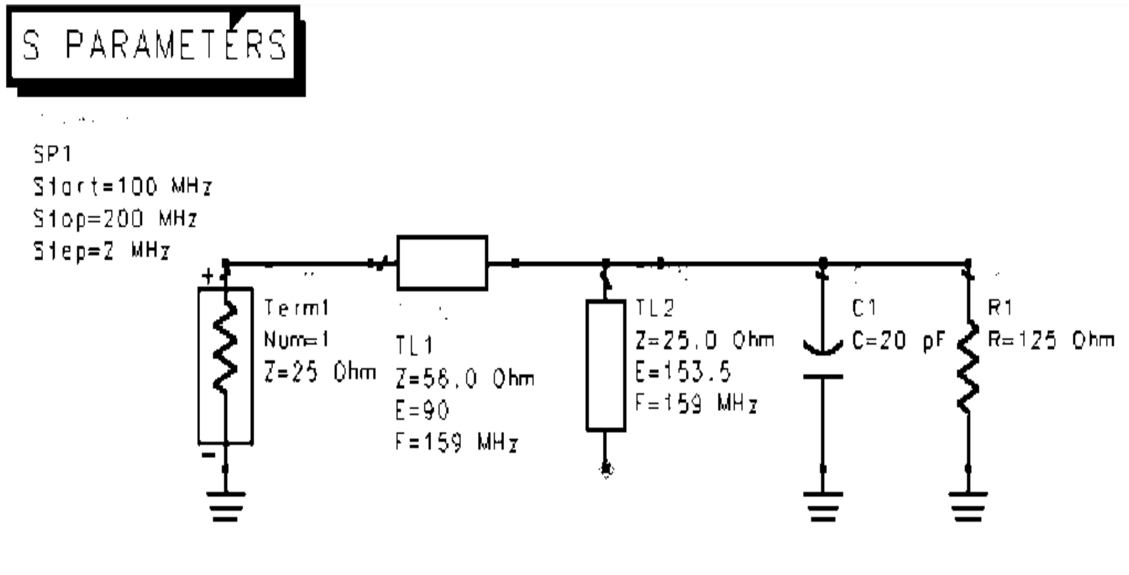
We will use the S-Parameter simulation mode in ADS quite frequently. This conducts a small-signal AC analysis1. Because S-parameters are defined with respect to normalizing impedance Zo, terminations must be assigned to all inputs and outputs of the network. In the example above, the input termination impedance (Term) is set to 25 ohms because we were using a source with 25 ohm impedance. No generator is required when simulating S parameters. The term serves this function. The term icon is found in the Simulation-S_Param menu This opens the palette of components shown below:



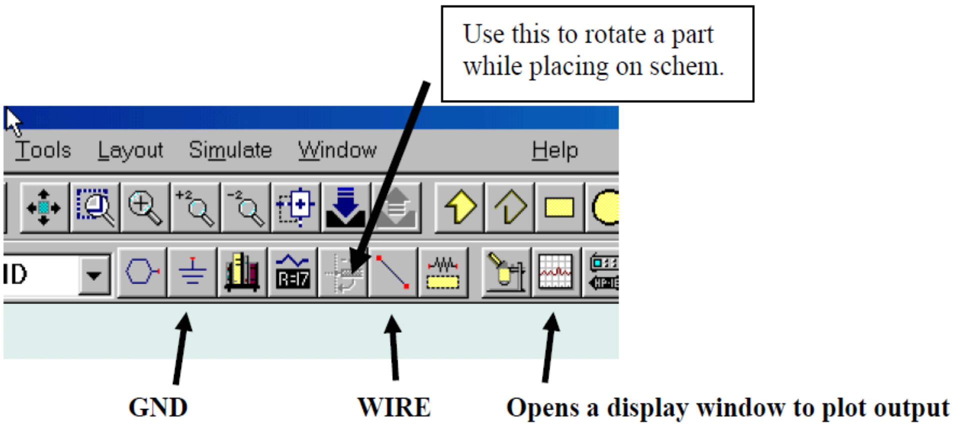
Small signal analysis linearizes all component models. Thus, the outcome of the simulation is independent of amplitude.
In our example, there is only one port. Thus, only S11 will be calculated. Recall that the normalized forward and reflected waves are calculated relative to the normalizing impedance. Thus, S11 depends on the value of Zo.

$$b_1 = \frac{V_{ref}}{\sqrt{Z_o}}$$

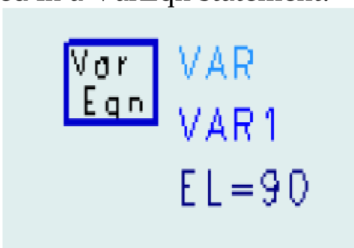
Add the S PARAMETERS control icon. Set your Start Frequency, Stop Frequency, and Step Size.



Connect the parts together using the wire and ground icons. End placement as always with Esc.



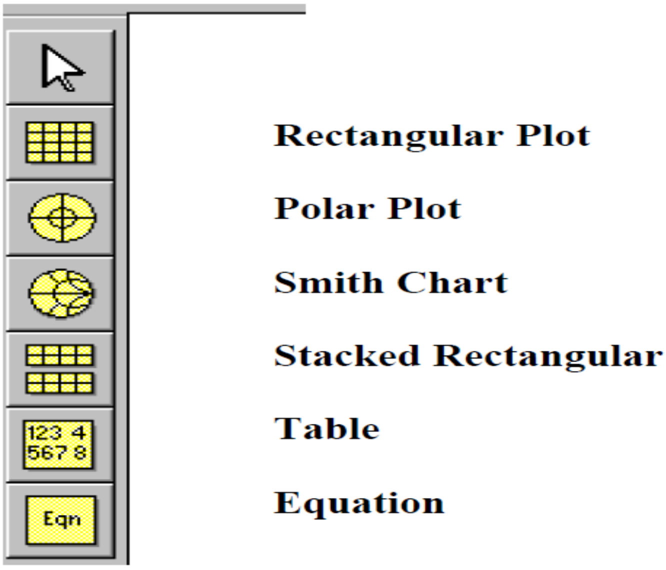
Note that any variable that you require must first be defined in a VarEqn statement:



4. Save the schematic file with the disk button or use Save As in the File menu.
5. Hit F7 to run the simulation. A data file will be saved with the same name as the schematic and a display window will be opened automatically.

DATA DISPLAY WINDOW

The display window provides several options. To select the output variable to be displayed, click on one of the icons.



EXERCISE

Make a matching network to match source to load and by performing above described operations display your result.

LAB SESSION 10

Design L-section matching network circuit to match 100 Ω source resistances to a 1000 Ω load at a frequency of 1.8 GHz and verify

Student Name: ________________________________
Roll No.:_______________ Batch: _________________
Semester :_____________ Year:___________________

Total Marks	Marks Obtained

Remarks (if any) :______________________________

Instructor Name:_______________________________

Instructor Signature:_______________Date:________

Cognitive Domain Assessment Rubric				
Skill Sets	**Extent of Achievement**			
	0	**1**	**2**	**3**
Software Identification Sensual ability to **identify Software** and/or its component for a lab work	Unable to identify the **Software**	-	-	Able to identify **Software** as well as its components
Software Use Sensory skills to **describe** the use of the **Software** for the lab work	Unable to describe the use of **Software**	Rarely able to describe the use of **Software**	Mostly able describe the use of **Software**	Regularly able to describe the use of **Software**
Procedural Skills Displays skills to carry out sequence of steps in software based lab work	Unable to carry out software based lab work with desired commands/ components identification/ connections	Rarely able to carry out software based lab work with desired commands/ components identification / connections	Mostly able to carry out software based lab work with desired commands/ components identification/ connections	Regularly able to carry out software based lab work with desired commands/ components identification/ connections
Observation's Use Displays skills to perform related mathematical calculations using the observations from lab work	Unable to use software based lab work observations for/ to support mathematical calculations	Rarely able to use lab work observations for/ to support mathematical calculations	Mostly able to use lab work observations for/ to support mathematical calculations	Mostly able to use lab work observations for/ to support mathematical calculations
Group Work Contributes in a group based lab work	Never participates	Rarely participates	Occasionally participates and contributes	Regularly participates and contributes

Weighted CLO (Score)	
Remarks	
Instructor's Signature with Date:	

LAB SESSION 10

OBJECTIVE

Design L-section matching network circuit to match 100 Ω source resistance to a 1000 Ω load at a frequency of 1.8 GHz and verify;

1. **When load resistance is reflected towards source side, it will be equal to source resistance.**
2. **When source resistance is reflected towards load side, it will be equal to load resistance.**

SOFTWARE

Windows and Advance System Design (ADS) installed PCs.

THEORY

The simplest and the most widely used matching circuit is the L network or 2-elements matching network. The circuit receives its name because of the component orientation, which resembles the shape of letter "L" as shown in figure:

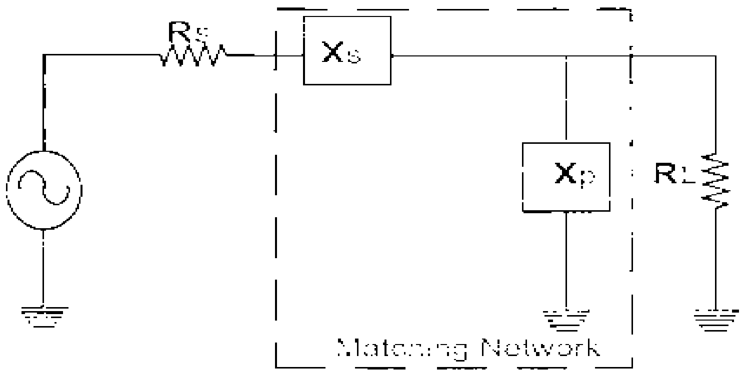


Figure10.1: L-match network, when $R_L > R_S$

The matching network can easily be designed using the following equations:

$$Q_s = Q_p = Q = \sqrt{\frac{R_{high}}{R_{low}} - 1}$$

$$Q_s = \frac{X_s}{R_s}$$

$$Q_p = \frac{R_p}{X_p}$$

Where,

Qs = the Q of the series leg

Qp = the Q of the shunt leg

R_p & X_p = the shunt resistance and shunt reactance respectively

R_s & X_s = the series resistance and series reactance respectively

PROCEDURE

1. Select a suitable impedance matching network configuration according to your given task (low or high pass configuration, series or parallel reactance at source or load side etc)
2. Design schematic on the .dsn Window on ADS by using lumped-components from ADS library given at the top of extreme left as shown in figure:
3. For simulation, select AC simulation from ADS library and select the range of frequencies with step size for which you want to simulate.
4. Now run the simulation. After completion of simulation, data display window will appear.
5. Click on the rectangular box option present at the extreme left palette of the window and drag it to empty display window.
6. Now define independent and dependent variables for the plot and select data type that you want to examine like magnitude, dB, dBm, phase plot etc.
7. Plot can be display in different types (smith, tabuar, list form etc) by selecting the option at the top of the plot window.

OBSERVATION AND RESULT

Provide your final matching circuit including source and load resistance with detailed calculations. (Attached additional sheet if required)

There are four possible L-networks depending upon the orientation of inductor/s and capacitor/s as well as comparison of source and load resistances. Sketch all types of L-match networks with their resultant diagram.

LAB SESSION 11

Design π-matching network to match given source resistance to a 1000 Ω load at the frequency of 1.8 GHz and verify

Student Name: ____________________________________

Roll No.:_______________ Batch: _________________

Semester :____________ Year:___________________

Total Marks	Marks Obtained

Remarks (if any) :______________________________

Instructor Name:________________________________

Instructor Signature:_______________Date:________

Cognitive Domain Assessment Rubric				
Skill Sets	**Extent of Achievement**			
	0	**1**	**2**	**3**
Software Identification Sensual ability to **identify Software** and/or its component for a lab work	Unable to identify the **Software**	-	-	Able to identify **Software** as well as its components
Software Use Sensory skills to **describe** the use of the **Software** for the lab work	Unable to describe the use of **Software**	Rarely able to describe the use of **Software**	Mostly able describe the use of **Software**	Regularly able to describe the use of **Software**
Procedural Skills Displays skills to carry out sequence of steps in software based lab work	Unable to carry out software based lab work with desired commands/ components identification/ connections	Rarely able to carry out software based lab work with desired commands/ components identification / connections	Mostly able to carry out software based lab work with desired commands/ components identification/ connections	Regularly able to carry out software based lab work with desired commands/ components identification/ connections
Observation's Use Displays skills to perform related mathematical calculations using the observations from lab work	Unable to use software based lab work observations for/ to support mathematical calculations	Rarely able to use lab work observations for/ to support mathematical calculations	Mostly able to use lab work observations for/ to support mathematical calculations	Mostly able to use lab work observations for/ to support mathematical calculations
Group Work Contributes in a group based lab work	Never participates	Rarely participates	Occasionally participates and contributes	Regularly participates and contributes

Weighted CLO (Score)	
Remarks	
Instructor's Signature with Date:	

LAB SESSION 11

OBJECTIVE

Design π-matching network to match given source resistance to a 1000 Ω load at the frequency of 1.8 GHz and verify;

1. **When load resistance is reflected towards source side, it will be equal to source resistance.**
2. **When source resistance is reflected towards load side, it will be equal to load resistance.**

SOFTWARE

Windows and Advance System Design (ADS) Installed PCs.

THEORY

The limitation of L network is that the designer does not have a choice of circuit Q and simply once the source and load impedances are determined, the Q of the network is defined. In matching network the lack of circuit-Q versatility can be a hindrance. To overcome this disadvantage 3-element network is used which enables the designer to select any practical value of circuit Q. One of the 3-elements networks is called a Pi network because of its resemblance with the Greek letter π as shown in figure:

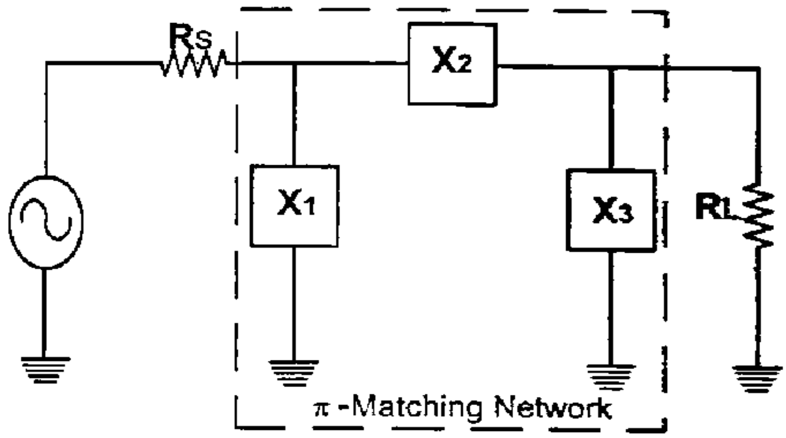


Figure 11.1: π-matching network

The Pi network is composed of two back-to-back L networks that are both configured to match the load and source to a virtual resistance present between the two networks junctions. The virtual resistance must be smaller than either source or load resistance because of the geometry of the circuit.

The matching network can easily be defined using the following equations:

$$Q=\sqrt{\frac{R_H}{R}-1}$$

$$Q_s=\frac{X_s}{R_s}$$

$$Q_p=\frac{R_p}{X_p}$$

Where,

R_H = the largest terminating impedance of source or load resistance

R = the virtual resistance

Q_s = the Q of the series leg

Q_p = the Q of the shunt leg
R_p & X_p = the shunt resistance and shunt reactance respectively
R_s & X_s =the series resistance and series reactance respectively

PROCEDURE
Follow the same instructions as mentioned in previous lab 10.

OBSERVATION AND RESULT
Provide your final matching circuit including source and load resistance with detailed calculations. (Attached additional sheet if required)
There are four possible π-networks depending upon the orientation of inductor/s and capacitor/s as well as comparison of source and load resistances. Sketch all types of π-match networks with their resultant circuit.

LAB SESSION 12

Design T-matching network to match given source resistance to a 50 Ω load at the frequency of 1.8 GHz and verify

Student Name: ________________________________
Roll No.:________________ Batch: ________________
Semester :_____________ Year:____________________

Total Marks	Marks Obtained

Remarks (if any) :______________________________

Instructor Name:________________________________

Instructor Signature:________________Date:________

Cognitive Domain Assessment Rubric				
Skill Sets	**Extent of Achievement**			
	0	**1**	**2**	**3**
Software Identification Sensual ability to **identify Software** and/or its component for a lab work	Unable to identify the **Software**	-	-	Able to identify **Software** as well as its components
Software Use Sensory skills to **describe** the use of the **Software** for the lab work	Unable to describe the use of **Software**	Rarely able to describe the use of **Software**	Mostly able describe the use of **Software**	Regularly able to describe the use of **Software**
Procedural Skills Displays skills to carry out sequence of steps in software based lab work	Unable to carry out software based lab work with desired commands/ components identification/ connections	Rarely able to carry out software based lab work with desired commands/ components identification / connections	Mostly able to carry out software based lab work with desired commands/ components identification/ connections	Regularly able to carry out software based lab work with desired commands/ components identification/ connections
Observation's Use Displays skills to perform related mathematical calculations using the observations from lab work	Unable to use software based lab work observations for/ to support mathematical calculations	Rarely able to use lab work observations for/ to support mathematical calculations	Mostly able to use lab work observations for/ to support mathematical calculations	Mostly able to use lab work observations for/ to support mathematical calculations
Group Work Contributes in a group based lab work	Never participates	Rarely participates	Occasionally participates and contributes	Regularly participates and contributes

Weighted CLO (Score)	
Remarks	
Instructor's Signature with Date:	

LAB SESSION 12

OBJECT

Design T-matching network to match given source resistance to a 50 Ω load at the frequency of 1.8 GHz and verify;

1. **When load resistance is reflected towards source side, it will be equal to source resistance.**
2. **When source resistance is reflected towards load side, it will be equal to load resistance**.

SOFTWARE

Windows and Advance System Design (ADS) Installed PCs.

THEORY

The limitation of L network is that the designer does not have a choice of circuit Q and simply once the source and load impedance are determined, the Q of the network is defined. In matching network the lack of circuit-Q versatility can be a hindrance. To overcome this disadvantage 3-elements network is used which enables the designer to select any practical value of circuit Q. In previous lab we had designed a 3-elements network called T network. The circuit receives its name because of the components orientation, which resembles the shape "T" as shown in figure.

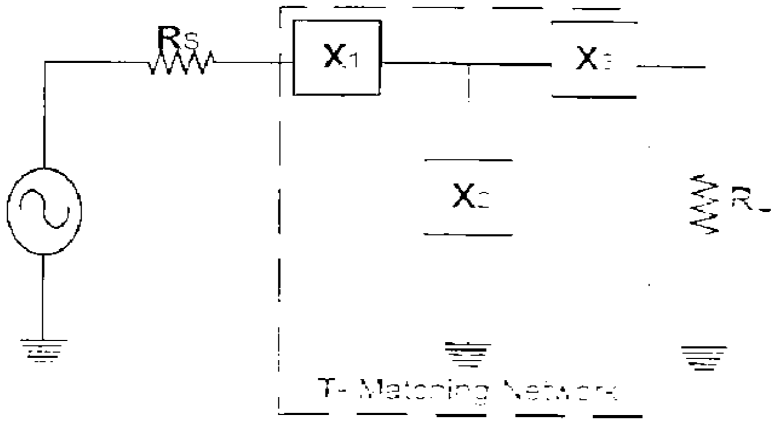


Figure 12.1: T-matching network

The design of the 3-elements T network is "flip-flopped" of the L sections of Pi network. Therefore, virtual resistance which present between the two networks junction is larger than either source or load resistance because of the geometry of the circuit.

The matching network can easily be defined using the following equations:

$$Q=\sqrt{\frac{R}{R_{small}}-1}$$

$$Q_s=\frac{X_s}{R_s}$$

$$Q_p=\frac{R_p}{X_p}$$

Where,

R_{small} = the smallest terminating impedance of source or load resistance

R = the virtual resistance

Q_s = the Q of the series leg

Q_p = the Q of the shunt leg

R_p & X_p = the shunt resistance and shunt reactance respectively
R_s & X_s =the series resistance and series reactance respectively

PROCEURE
Follow the instruction as mentioned in previous lab 10.

OBSERVATION AND RESULT
Provide your final matching circuit including source and load resistance with detailed calculations. (Attached additional sheet if required)
There are four possible T-networks depending upon the orientation of inductor/s and capacitor/s as well as comparison of source and load resistances. Sketch all types of π-match networks with their resultant circuit.

LAB SESSION 13

Design the circuits to match 50 Ω source resistances to a given complex load using absorption approach, at the frequency of 75 MHz and verify

Student Name: ___________________________________
Roll No.:_______________ Batch: __________________
Semester :_____________ Year:___________________

Total Marks	Marks Obtained

Remarks (if any) :________________________________

Instructor Name:_________________________________

Instructor Signature:_______________Date:________

Cognitive Domain Assessment Rubric				
Skill Sets	**Extent of Achievement**			
	0	**1**	**2**	**3**
Software Identification Sensual ability to **identify Software** and/or its component for a lab work	Unable to identify the **Software**	-	-	Able to identify **Software** as well as its components
Software Use Sensory skills to **describe** the use of the **Software** for the lab work	Unable to describe the use of **Software**	Rarely able to describe the use of **Software**	Mostly able describe the use of **Software**	Regularly able to describe the use of **Software**
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Observation's Use Displays skills to perform related mathematical calculations using the observations from lab work	Unable to use software based lab work observations for/ to support mathematical calculations	Rarely able to use lab work observations for/ to support mathematical calculations	Mostly able to use lab work observations for/ to support mathematical calculations	Mostly able to use lab work observations for/ to support mathematical calculations
Group Work Contributes in a group based lab work	Never participates	Rarely participates	Occasionally participates and contributes	Regularly participates and contributes

Weighted CLO (Score)	
Remarks	
Instructor's Signature with Date:	

LAB SESSION 13

OBJECTIVE

Design the circuits to match 50 Ω source resistances to a given complex load using absorption approach, at the frequency of 75 MHz and verify;

1. **When load resistance is reflected towards source side, it will be equal to source resistance.**
2. **When source resistance is reflected towards load side, it will be equal to load resistance.**

SOFTWARE

Windows and Advance System Design (ADS) Installed PCs.

THEORY

In real world most of the sources and loads have complex input and output impendences i.e. they contain both resistive and reactive components (R±jx) like transmission lines, transistors, antennas etc. so, it is necessary to know how to deal with complex loads to manage stray reactance.

Approaches that are used to deal with complex loads are:

Absorption

Resonance

Here in this lab we are going to discuss absorption method. Prudent placement of each matching element is the necessary step to absorb any stray reactance into the impedance – matching network itself. The two possible cases are shown in figure:

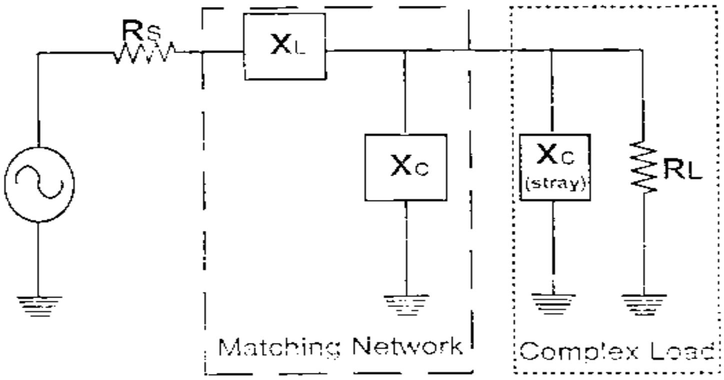

Figure 13.1: L-match network with parallel complex load

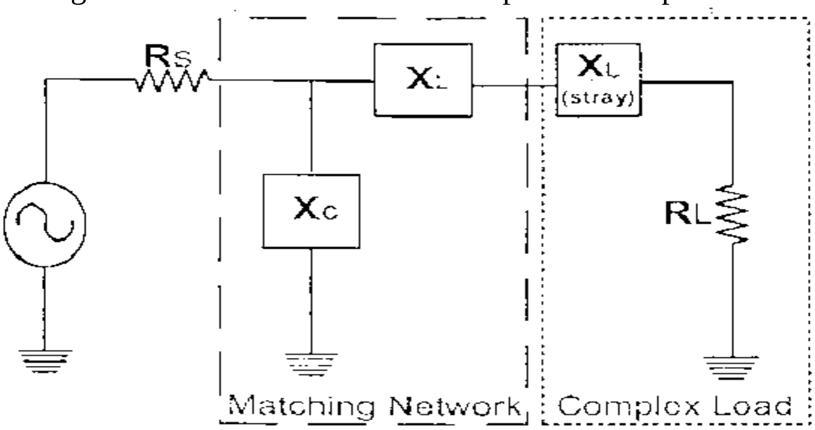

Figure 13.2: L-match network with the series complex load

The stray component values are subtracted from the calculated element values, leaving new element values (C' and L') which are smaller than the calculated values and now finally we place these components having values C' and L' into the circuit as appropriate matching network.
The equations for matching network design will remain same as we discussed in previous lab depend upon the type of matching network.

PROCEDURE

Follow the same instructions as mentioned in previous lab.

OBSERVATION AND RESULT

Provide your final matching circuit including source and load resistance with detailed calculations. (Attached additional sheet if required)

LAB SESSION 14

Design the circuit to match 50 Ω source resistance to a complex load having 40 pF capacitor in parallel with 600 Ω resistance, using resonance approach, at the frequency of 75 MHz and verify

Student Name: ________________________________
Roll No.:________________ Batch: ___________________
Semester :_____________ Year:____________________

Total Marks	Marks Obtained

Remarks (if any) :______________________________

Instructor Name:_________________________________

Instructor Signature:________________Date:_________

Cognitive Domain Assessment Rubric				
Skill Sets	**Extent of Achievement**			
	0	**1**	**2**	**3**
Software Identification Sensual ability to **identify Software** and/or its component for a lab work	Unable to identify the **Software**	-	-	Able to identify **Software** as well as its components
Software Use Sensory skills to **describe** the use of the **Software** for the lab work	Unable to describe the use of **Software**	Rarely able to describe the use of **Software**	Mostly able describe the use of **Software**	Regularly able to describe the use of **Software**
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Observation's Use Displays skills to perform related mathematical calculations using the observations from lab work	Unable to use software based lab work observations for/ to support mathematical calculations	Rarely able to use lab work observations for/ to support mathematical calculations	Mostly able to use lab work observations for/ to support mathematical calculations	Mostly able to use lab work observations for/ to support mathematical calculations
Group Work Contributes in a group based lab work	Never participates	Rarely participates	Occasionally participates and contributes	Regularly participates and contributes

Weighted CLO (Score)	
Remarks	
Instructor's Signature with Date:	

LAB SESSION 14

OBJECTIVE

Design the circuit to match 50 Ω source resistance to a complex load having 40 pF capacitor in parallel with 600 Ω resistance, using resonance approach, at the frequency of 75 MHz and verify;

1. **When load resistance is reflected towards source side, it will be equal to source resistance.**
2. **When source resistance is reflected towards source side, it will be equal to load resistance.**

SOFTWARE

Windows and Advance System Design (ADS) Installed PCs.

THEORY

In real world most of the sources and loads have complex input and output impedances i.e. they contain both resistive and reactive components (R±jX) like transmission lines, transistors, antennas etc. So it is necessary to know how to deal with complex loads to manage stray reactance.
Approaches that are used to deal with complex load are:
Absorption
Resonance
In this lab we are going to discuss another method called Resonance to deal complex loads. It is possible to use both approaches at the same time. But if the stray element values are larger than the calculated element values, absorption cannot take place. In this situation the concept of resonance is used. In this approach to resonate any stray reactance with an equal and opposite reactance at the operating frequency the following equations are used;

$$L=\frac{1}{\omega^2 C_{stray}}$$

$$C=\frac{1}{\omega^2 L_{stray}}$$

The two possible networks are shown in figure 14.1 and 14. 2.

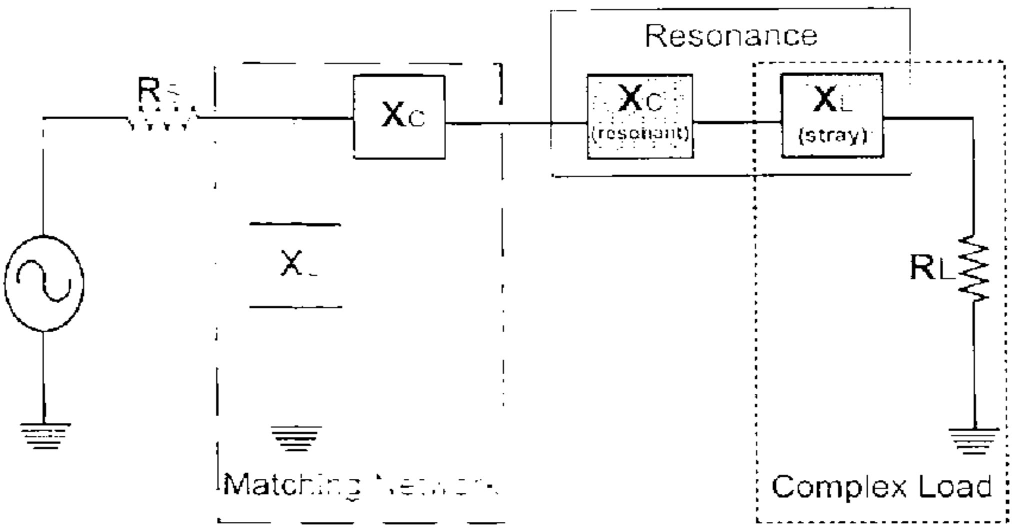

Figure 14.1: L-match network with series complex load

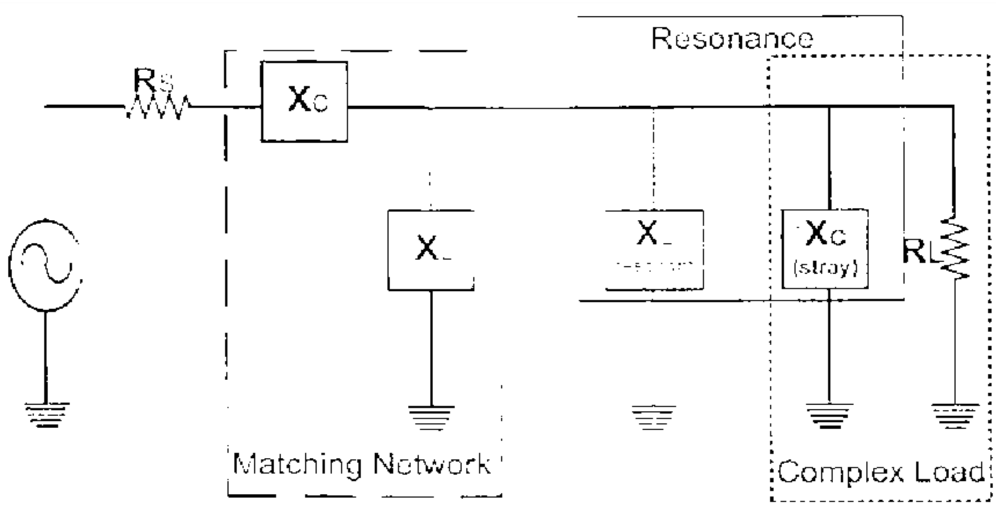

Figure 14.2: L-match network with parallel complex load

Once the stray reactance turned out, the matching network design can be proceed in a similar way as for the two pure resistances. The equations for the matching network design will remain same as we discussed in previous lab depend upon the type of matching network.

PROCEDURE

Follow the same instructions as mentioned in previous lab.

OBSERVATION AND RESULT

Please, provide your final matching circuit including source and load resistance with detailed calculations. (Attached additional sheet if required)