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BER- Measurement at an optical fiber link

Labwork No.
AToOC 4

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laboratory session:

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Group:

Group 12

Name:

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LAB REPORT

BER (BitErrorRate)-Measurementof anopticalfiberlink

Control Questions

Q1. How does the BER Tester operate?

A: Bit Error rate is a metric which can be employed to characterize the performance of communication system. It is a key parameter in any data communication link.
The concept of BER is simple, a bit stream is sent through a channel which can be optical fiber or radio link and the received bit stream is compared with the original bit stream.

BER = Number of bits in error/ Total number of bits transmitted

For instance, if 10000 bits are transmitted out of which 100 bits are received in error, so the BER would be 1% or 0.01.

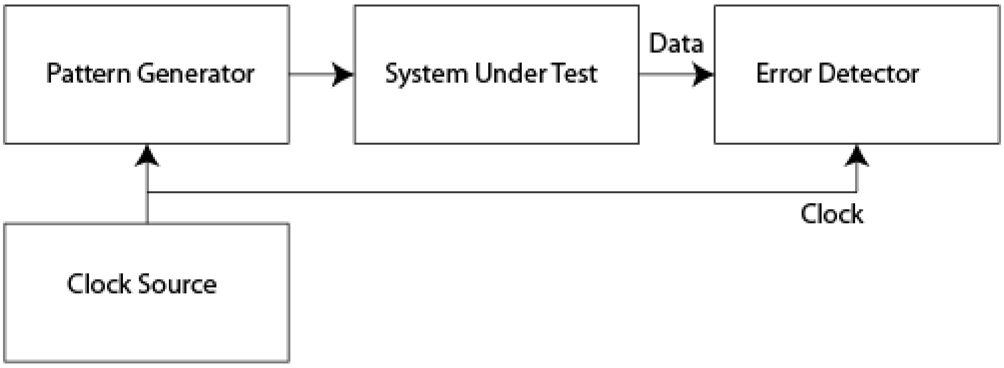


Figure: 1 BER Tester

The Main block of BER Tester are:

- Patter Generator: This block generates a defined test pattern and transmit it to the device under test.
- Error Detector: This block counts the error which are generated by the device under test.
- Clock source: This block integrates both the pattern generator and the error detector.

The pattern generator produces a test code which is applied to the system under test and the clock signal is then send to the error detector to integrate the initial code. The error detector has its own pattern generator which produces the exact mirror image of the pattern generator. An error is stored **whenever the received bit differs from transmitted bit.**

Q2. How does the BER change when the insertion loss of the optical fiber link is increased? Explain the reasons?

A: When signal is transmitted through the fiber some energy is lost between two fixed point. Insertion loss measure the amount of energy that is lost as the signal arrive at the receiving end of the fiber. It is expressed in dB or decibels and it must be positive as it shows amount of signal lost with the comparison from input and output power. And longer the cable the greater will the insertion loss and too high insertion loss will cause higher bit error rate (BER) which will cause the equipment to fail and transmission will be lost.

Q3. How does the BER change when the dispersion of the optical fiber link increases? Explain the reasons.

A: Dispersion in optical fiber causes the pulse widening. Dispersion is spreading of light pulse in time as it propagates down the fiber this is due to as the speed of light depends on its wavelength and propagation. Dispersion also causes intersymbol interference as the adjacent pulse interfere with each other this will make the communication system loss reliability. Due to this effect the BER is increased and the pulse broadening and intersymbol interference between adjacent pulses causes increase in BER at receiver end.
The type of Dispersion that effect the optical fiber are:

- Modal Dispersion.
- Chromatic Dispersion.

Q4. What is the main type of dispersion in the experiment when the optical link consists of SM fiber?

A: In Single mode fiber dispersion occur are:

- Chromatic Dispersion: It is caused by spreading of signal over time resulting due to different speed of light ray. This dispersion causes broadening of each transmitted mode over time.

- Polarization Mode Dispersion: This is caused due to stresses within the fiber and forces applied to the fiber from outside world which will cause the refractive index of glass to slightly differ in the two polarization modes thus this two polarization mode arrives at slightly different time at the end of fiber.

Q5. Would you expect any directionality when measuring the BER? Discuss the problem with regards to the existing laboratory setup?

A: Directionality in BER tester is explained as that if we change the transmitting cable with receive cable the BER will remain same. BER can be affected by attenuation, channel noise, bit synchronization problems etc. By manipulating the variables this variable can be controlled and can optimize the system. Factors such as interference can be reduced by reducing the bandwidth, but reducing bandwidth limits the data throughout the system.

Q6. What is the maximum BER you may observe?

A: BER measure the input and output signal to check the number of bits received in error. It is frequently expressed as probability.

BER = E(t)/N(t)

Where, E(t) = Number of bits in error over time ‘t’

N(t) = Total number of bits transmitted over time ‘t’

The maximum BER is 10^{9} and 10^{-3} is the BER we observed during lab session.

Q7. What is the purpose of system reserve?

A: If any small variation in the system occurs it should not decrease the system performance so to avoid this system reserve is used. System reserve in optical fiber are allocated for power budget calculation and to overcome losses when transmitting data from one fiber to another.

Q8. Explain the parameter "dispersion power penalty" and its sources

A: Dispersion in a system is due to variation in speed of light rays and spreading of light pulse in time as it propagates down the fiber. The pulse broadening affects the system performance as the part of bit energy spreads in neighboring bits causing intersymbol interference and reduction in pulse energy because there is energy spread due to dispersion.

And its sources are:

- Dispersion Broadening: It affects the performance at the receiver side due to intersymbol interference and the energy of pulse is reduced due to optical pulse boarding.

- Frequency chirp: A chirp is a signal in which the frequency increases or decreases with time and as the frequency chirp is imposed is imposed on pulse it gets broadened.

- Modal noise: This effect shows a degradation of signal to noise ratio at the receiver due to fluctuating amplitude of received signal.

- Other sources are mode partition noise, reflection feedback and noise and extinction ratio.

Laboratory Session Tasks:

4.1

- Bit Error Rate Tester is used to test the quality of signal transmission of single components or complete systems. It sends the signal 34 Mega Bits per second to the optical transmitter.
- Optical transmitter converts the electrical signal into the optical signal and it sends the data to optical attenuator.
- Optical attenuator is reconfigured with 3dB at 1550nm wavelength.
- Optical attenuator is used to eliminate the attenuation from the transmitted signal and output of the attenuator goes to the Y-coupler.
- Y-coupler is included in transmission line. It divides the receiving signal into two parts:-
- Optical Power Meter: Optical Power Meter is used to measure the optical power from receiving end.
- Optical Receiver: It converts the optical signal into electrical signal.

- On Digital Oscilloscope, we observed the eye diagram for three different cases.

    - We calculated the transmitted optical power on optical power meter. So,
        - **Power (Ptx) = -8.18 dBm**
- and received optical power at power meter is
    - **Power (Prx) = -25.50 dBm**

4.2

We increased the attenuaion from 3dB till we got the first error. At 19.1dB, we got the first bit error rate. At this point, we also measured the optical power from optical power meter.
BIT ERROR RATE COUNTER (EC) = -8.18
BIT ERROR RATE ON 25.2dB Attenuation = 5.37E-02
P = -25.50dBm

System Budget:

To ensure that fiber-optic connections have sufficient power for correct operation, we need to calculate the link's power budget, which is the maximum amount of power it can transmit. When we calculate the power budget, we use a worst-case analysis to provide a margin of error, even though all the parts of an actual system do not operate at the worst-case levels. To calculate the worst-case estimate of power budget (P_B), we assume minimum transmitter power (P_T) and minimum receiver sensitivity (P_R):

$P_B = P_T – P_R$

The following hypothetical power budget equation uses values measured in decibels (dB) and decibels referred to one milliwatt (dBm):

$P_B = P_T – P_R$

In our system, we observed, P_T= -8.18dbm ; P_R=-25.50 dbm

P_B = –8.18 – (- 25.50)

P_B = 17.32 dB

4.3

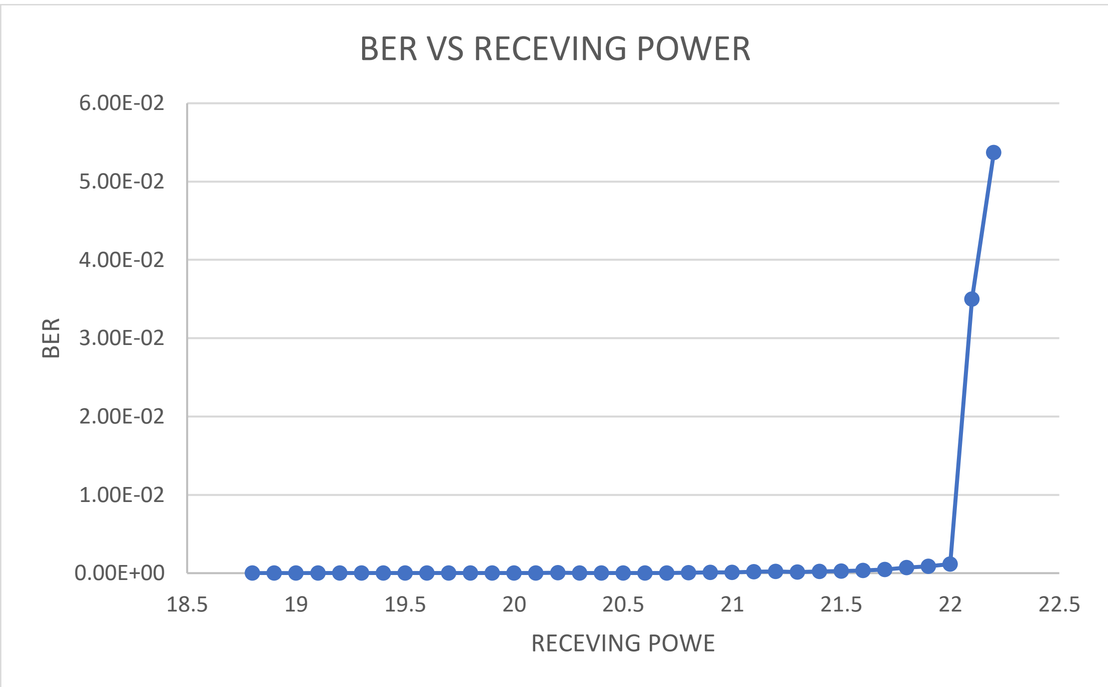
Record the BER graph as a function of the attenuation starting at a BER of 10^ -9. For this purpose increase the attenuation of the fiber link by increments of 0.1dB after every measurement cycle.

SR.NO :	BER (Bit Error Rate)	Attenuation (dB)
1	5.81E-09	18.8
2	9.699E-08	18.9
3	1.522E-09	19.0
4	3.104E-08	19.1
5	4.26E-08	19.2
6	1.057E-07	19.3
7	1.251E-07	19.4
8	2.74E-07	19.5
9	4.54E-07	19.6
10	6.68E-07	19.7
11	8.322E-07	19.8
12	1.33E-06	19.9
13	2.34E-06	20.0

14	4.183E-06	20.1
15	5.124E-05	20.2
16	1.06E-05	20.3
17	1.07E-05	20.4
18	1.72E-05	20.5
19	2.909E-05	20.6
20	3.522E-05	20.7
21	6.40E-05	20.8
22	7.84E-05	20.9
23	1.183E-04	21.0
24	1.71E-04	21.1
25	2.12E-04	21.2
26	1.43E-04	21.3
27	2.19E-04	21.4
28	2.50E-04	21.5
29	3.44E-04	21.6
30	4.58E-04	21.7
31	6.94E-04	21.8
32	8.59E-04	21.9
33	1.16E-03	22.0
34	3.50E-02	22.1
35	5.37E-02	22.2

In the starting of bit error rate measuring, we observed the receiving power
P = -25.92dBm at λ = 1550nm.

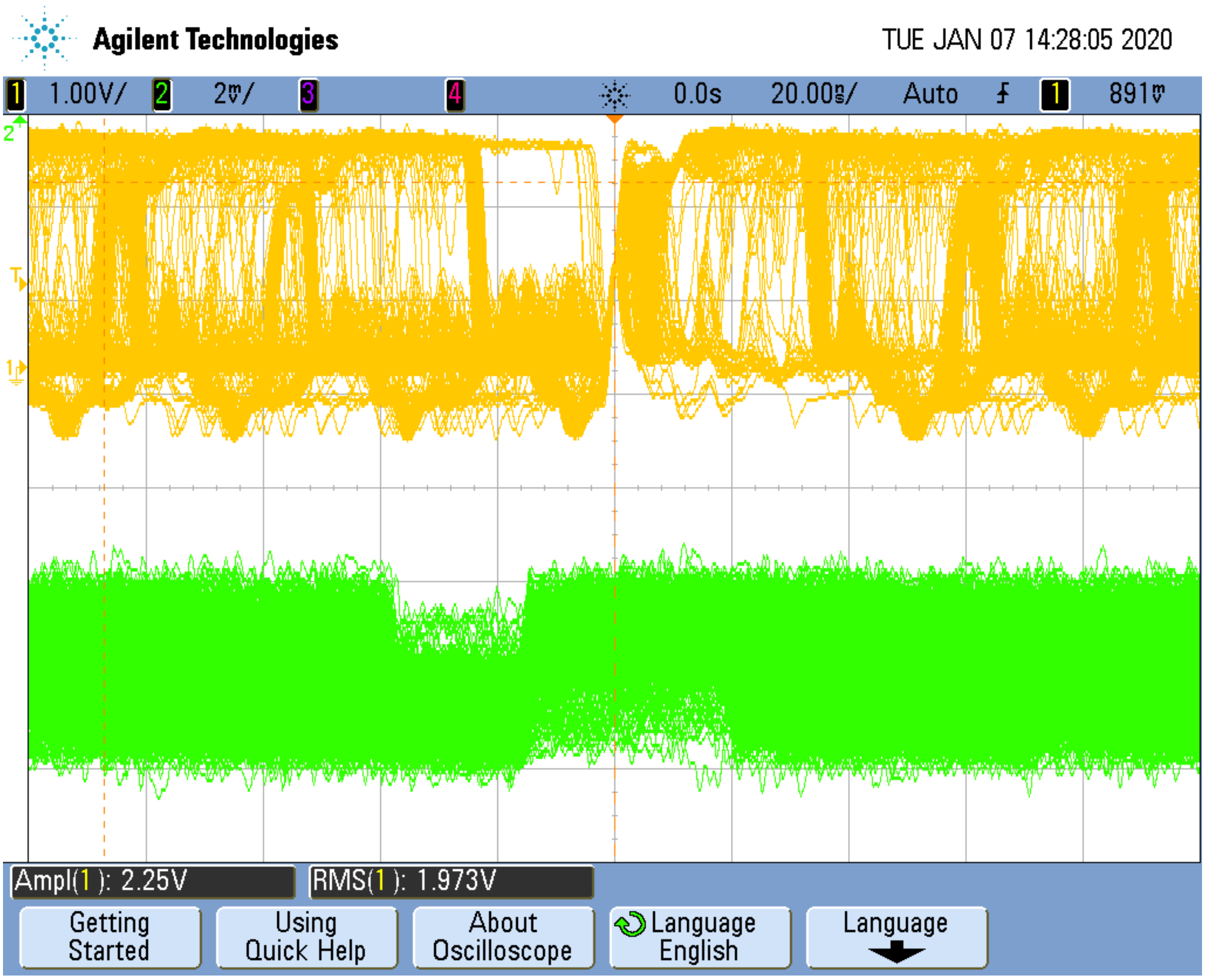
And in the end of practical we measured receiving power
P2 = -28.05dBm at λ = 1550nm.



Eye Diagram:

The data eye diagram is a representation of a high speed digital signal that allows key parameters of the electrical quality of a signal to be quickly visualized and determined. We took three eye diagrams reading during BER graph. The eye pattern is obtained by displaying the received signal on the oscilloscope. The time base of the scope is triggered at a fraction of the bit rate, and it thus yields a sweep, lasting several bit intervals. The oscilloscope then shows the superposition of many traces of bit intervals from the received signal. The oscilloscope pattern is simply the input signal cut up every couple of bit intervals and then superimposed on top of one another.

4.4



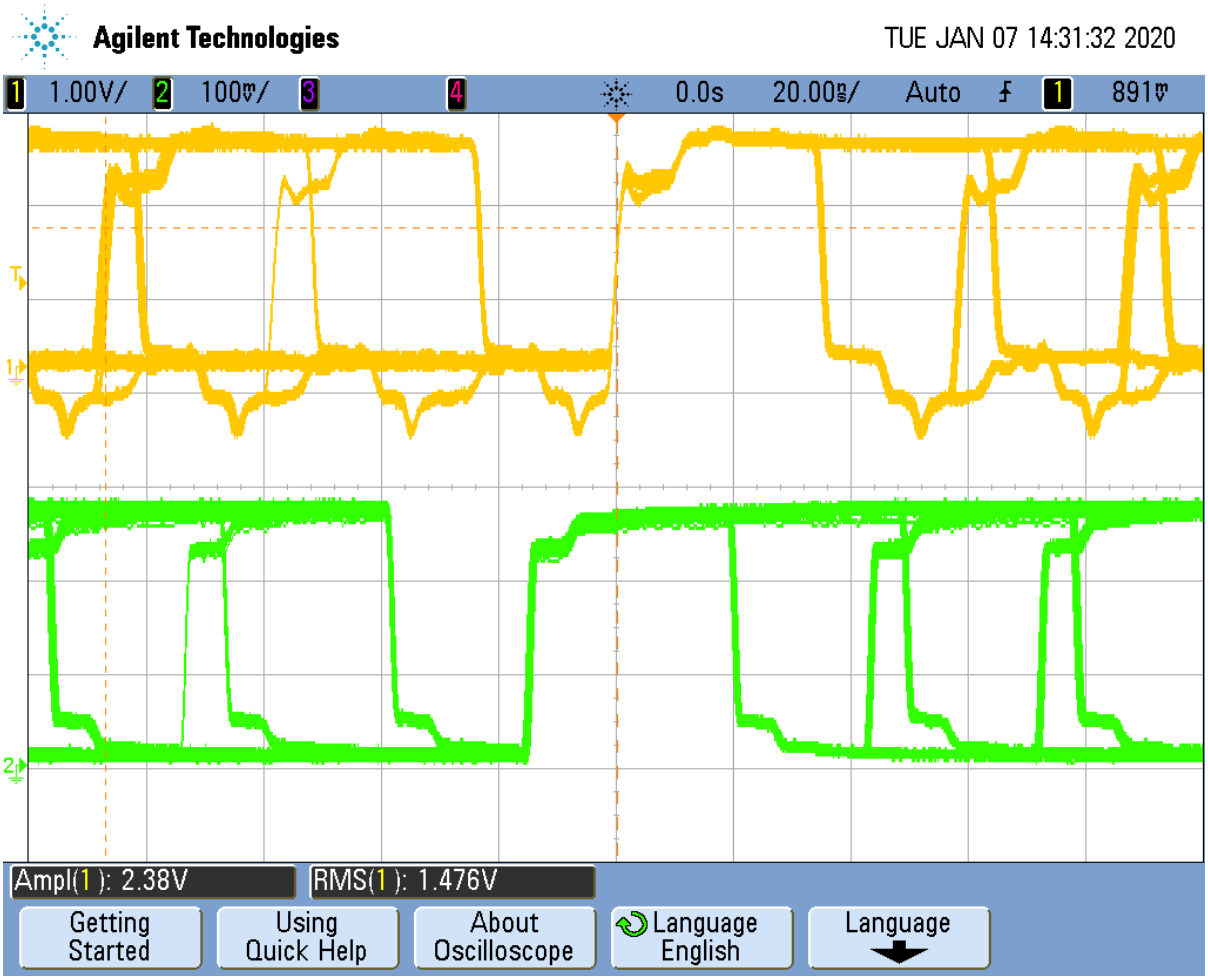
At 25dB attenuation:

In the Eye Diagram below the Yellow signal represent Optical Signal and the Green signal represent the electric form of the signal as their is greater attenuation in the signal of 25dB the Signal is completely distorted and the signal values cannot be determined from it.

At 21.8dB Attenuation

In the Eye Diagram below the Yellow signal represent Optical Signal and the Green signal represent the electric form of the signal as the attenuation in the signal of 21.8dB the Signal is not completely distorted and the signal values

can be determined form it also the eye diagram layer can be seen clearly but it has noise signal in it.



At 3dB Attenuation

In the Eye Diagram below the Yellow signal represent Optical Signal and the Green signal represent the electric form of the signal as the attenuation in the signal of 3dB. The Signal is almost visible and the difference between the eye diagram layer can easily seen and the signal values can been determined easily with only a little amount of distortion

CONCLUSION:

During the lab session, we discussed about the basic parameters of the optical fiber, its components and amplifiers. We also took the information about instruments, which we used to measure Bit error rate and we took the eye opening diagram about Optical and Electrical signals due to changing the attenuation.