EXP.NO. 14 POWER BUDGETING AND RISE TIME BUDGETING IN FIBER OPTIC LINK

14.1 OBJECTIVE:

To perform power budgeting and rise time budgeting in the Fiber optic link.

14.2 SOFTWARE REQUIRED:

Scilab

14.3 INTRODUCTION:

Link power budget:

The optical power budget in a fiber-optic communication link is the allocation of available optical power (launched into a given fiber by a given source) among various loss-producing mechanisms such as launch coupling loss, fiber attenuation, splice losses and connector losses, to ensure that adequate signal strength (optical power) is available at the receiver.

Power budget refers to the amount of loss a data link can tolerate while maintaining proper operation. In other words, it defines the amount of optical power available for successful transmitting signal over a distance of optical fiber. Power budget is the difference between the minimum (worst case) transmitter output power and the maximum (worst case) receiver input required. The calculations should always assume the worst-case values, in order to ensure the availability of adequate power for the link, which means the actual value will always be higher than this. Optical power budget is measured by dB, which can be calculated by subtracting the minimum receiver sensitivity from the minimum transmit power:

$$P_B(\text{dB}) = P_{TX}(\text{dBm}) - P_{RX}(\text{dBm})$$

When performing power budget calculation, there are a long list of elements to account for. The basic items that determine general transmission system performance are listed here.

Fiber loss: fiber loss impacts greatly on overall system performance, which is expressed by dB per km. The total fiber loss is calculated based on the distance × the loss factor (provided by manufacturer).

Connector loss: the loss of a mated pair of connectors. Multimode connectors will have losses of 0.2-0.5 dB typically. Single-mode connectors, which are factory made and fusion spliced on will have losses of 0.1-0.2 dB. Field terminated single-mode connectors may have losses as high as 0.5-1.0 dB.

Number and type of splices: Mechanical splice loss is generally in a range of 0.7 to 1.5 dB per connector. Fusion splice loss is between 0.1 and 0.5 dB per splice. Because of their limited loss factor, fusion splices are preferred.

Power margin: power budget margin generally includes aging of the fiber, aging of the transmitter and receiver components, additional devices, incidental twisting and bending of

the fiber, additional splices, etc. The margin is needed to compensate for link degradation, which is within the range of 3 to 10 dB.

Rise-time budget:

A rise-time budget analysis is a convenient method for determining the dispersion limitation of an optical link. This is particularly useful for a digital link. In this approach the total rise time t_{sys} of the link is the root-sum-square calculation of the rise times from each contributor t_i to the pulse rise-time degradation, that is, if there are N components in a link that affect the rise time then.

$$t_{sys} = \sqrt[2]{\sum_{i=1}^{N} t_i^2}$$

The five basic elements that may limit the system speed significantly are the transmitter rise time t_{TX}, the modal dispersion rise time t_{MOD} of multimode fiber, the chromatic dispersion rise time t_{CD} of the fiber, the polarization mode dispersion rise time t_{PMD} of the fiber, and the receiver rise time t_{RX}.

$$t_{sys} = \sqrt[2]{t_{TX}^2 + t_{MOD}^2 + t_{CD}^2 + t_{PMD}^2 + t_{RX}^2}$$

The purpose of rise time budget is to ensure that the system operates properly at intended bit rate. Generally the total transition-time degradation t_{sys} of a digital link should not exceed 70 percent of an NRZ (non-return-to-zero) bit period or 35 percent for RZ (return-to-zero) data.

$$t_{sys} = \frac{0.7}{BW} \text{ for RZ}$$

$$t_{sys} = \frac{0.35}{BW} \text{ for NRZ}$$

14.4 PRELAB QUESTIONS:

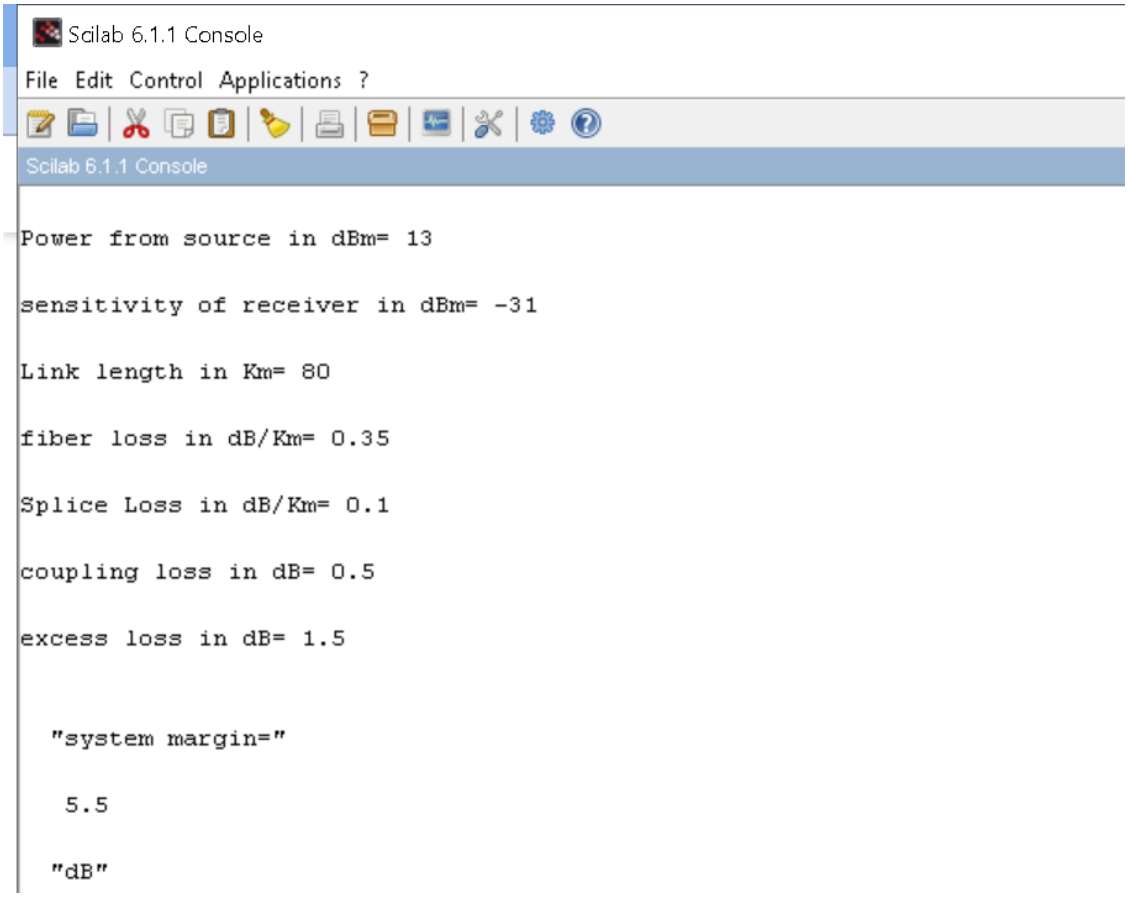
1. What is the purpose of rise time budget analysis?
2. What is the use of power budget in fiber optic system?
3. What are the factors to be considered in Link power budget?
4. Give the range of system margin in link power budget?
5. What are the system components of system rise time?

14.5 PROGRAM:

Power Budgeting

```
  //Sample values
 //Ps = 13 ( input power in dBm)
 //Pr =  −31( sensitivity of receiver )
 //L=80( Link length in Km)
// Loss =0.35( fiber loss in dB/Km)
//SL=0.1( Splice Loss in dB)
//CL=0.5( coupling loss in dB)
//EL=1.5( excess loss )
clear ;
close ;
clc ;
Ps= input (“Power from source in dBm=”);
Pr= input (“sensitivity of receiver in dBm=”);
L= input (“ Link length in Km=”);
Loss = input (“fiber loss in dB/Km=”);
SL= input (“Splice Loss in dB/Km=”);
CL= input (“coupling loss in dB=”);
EL= input (“excess loss in dB=”);
Pt=Ps -Pr;
SM=Pt -(2* CL+ Loss *L+SL*L+EL)
disp (“system margin=” ,SM, “dB”);
```

SAMPLE OUTPUT:



Rise time Budgeting

```
// Sample values
// t s=10 ( rise time of the led source in ns)
//IMD=6 ( intermodal dispersion in ns/Km)
//L=10 ( link length in Km)
//PB=2 ( pulse broadening in ns /Km)
// td=8(response time of detector in ns)
//F=1(1−RZ  return to zero format , 2−NRZ−non return to zero format )
clear ;
close ;
clc ;
ts= input (“ rise time of the led source in ns ”);
```

IMD = input (“ intermodal dispersion in ns/Km”);

L= input (“link length in Km=”);

PB= input (“pulse broadening in ns /Km=”);

td= input (“response time of detector in ns =”);

disp (“Directory 1− RZ return to zero format , 2−NRZ non return to zero format”);

F= input (“Format=”);

Tsys =1.1* sqrt (ts ^2+(L* IMD)^2+ td ^2+(L*PB) ^2) ;

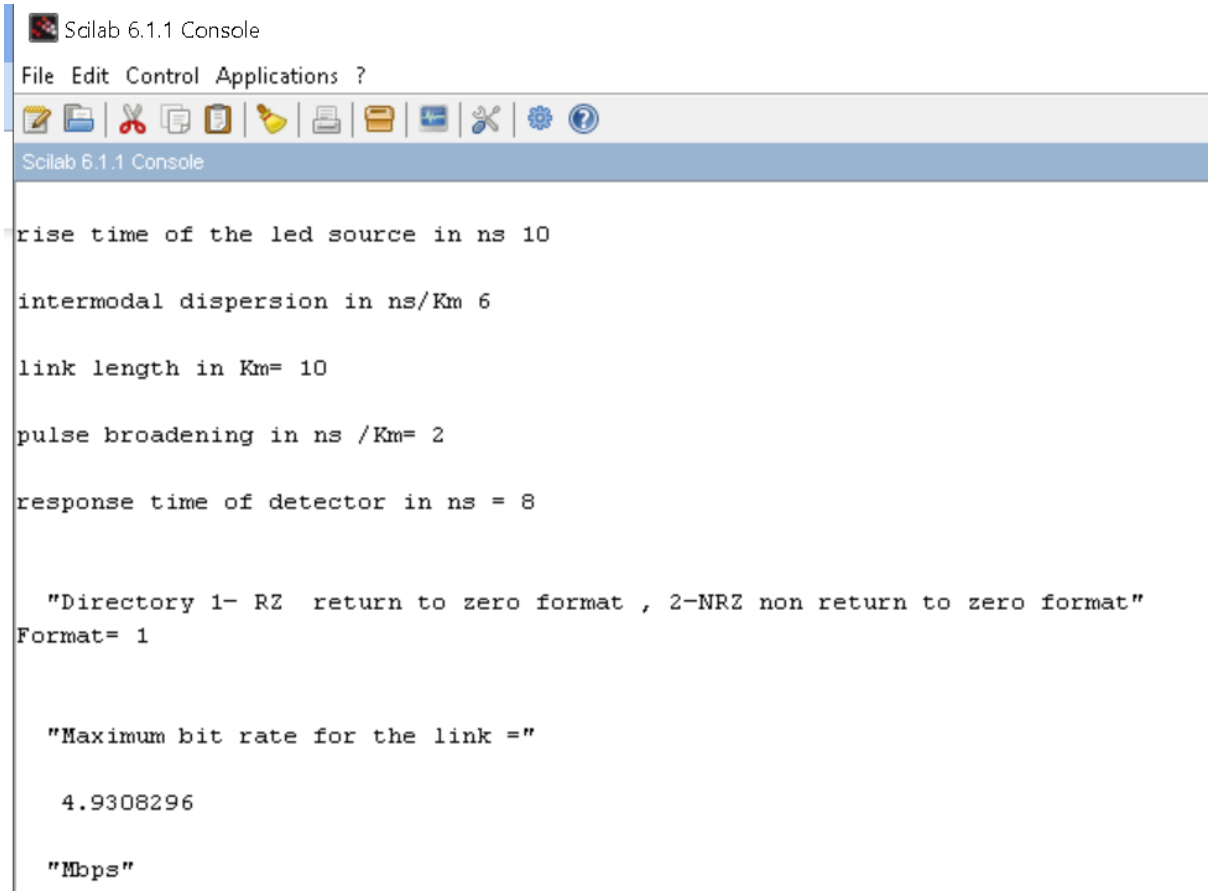
if F ==1 then Bt =0.35*1 e3/ Tsys // since Tsys is in nano sec and Bt is expressed in Mbps)

else Bt =0.7*1 e3/ Tsys

end

disp (”Mbps” ,Bt ,”Maximum bit rate for the link =”);

SAMPLE OUTPUT:



14.6 POSTLAB QUESTIONS:

1. Assume a 10 km single mode fiber link of fiber attenuation 0.35 dB/km at 1310nm with 2 connector pairs of each 0.75 dB loss and 2 splices of each 0.1 dB loss. Calculate link budget.
2. Laser Tx has a rise-time of 25 ps at 1550 nm and spectral width of 0.1 nm. Length of fiber is 60 km with dispersion 2 ps/(nm.km). The InGaAs APD has a 2.5 GHz BW. What is the required rise-time budget of the system for NRZ signalling?
3. The specifications of the light sources are converted to equivalent rise time in rise time budget. Why?

14.7 RESULT

Thus power budgeting and rise-time budgeting is calculated for the given parameters of the fiber optic link