Experiment no.: **Date of Performance:**

Title: Study of baseband receiver performance in the presence of Noise using suitable setup/kit.

Objectives: 1) To study block diagram of baseband receiver
2) To study addition of noise in channel
3) To study effect of noise on transmitted signal
4) To find BER

Equipment's: 1) Experimental Kit
2) Power supply
3) DSO 20MHz
4) connecting cables

Theory:

Bit Error Rate, BER is used as an important parameter in characterising the performance of data channels. When transmitting data from one point to another, either over a radio/ wireless link or a wired telecommunications link, the key parameter is how many errors will appear in the data that appears at the remote end. As such Bit Error Rate, BER is applicable to everything from fibre optic links, to ADSL, Wi-Fi, cellular communications, IoT links and many more. Even thought the data links may utilise very different types of technology, the basics of the assessment of the bit error rate are exactly the same.

Bit error rate, BER basics

When data is transmitted over a data link, there is a possibility of errors being introduced into the system. If errors are introduced into the data, then the integrity of the system may be compromised. As a result, it is necessary to assess the performance of the system, and bit error rate, BER, provides an ideal way in which this can be achieved. Unlike many other forms of assessment, bit error rate, BER assesses the full end to end performance of a system including the transmitter, receiver and the medium between the two. In this way, bit error rate, BER enables the actual performance of a system in operation to be tested, rather than testing the component parts and hoping that they will operate satisfactorily when in place.

Bit error rate BER definition

As the name implies, a bit error rate is defined as the rate at which errors occur in a transmission system. This can be directly translated into the number of errors that occur in a string of a stated number of bits. The definition of bit error rate can be translated into a simple formula:
BER=Errors/Total Number of Bits

If the medium between the transmitter and receiver is good and the signal to noise ratio is high, then the bit error rate will be very small - possibly insignificant and having no noticeable effect on the overall system However if noise can be detected, then there is chance that the bit error rate will need to be considered.

The main reasons for the degradation of a data channel and the corresponding bit error rate, BER is noise and changes to the propagation path (where radio signal paths are used). Both effects have a random element to them, the noise following a Gaussian probability function while the propagation model follows a Rayleigh model. This means that analysis of the channel characteristics are normally undertaken using statistical analysis techniques.
For fibre optic systems, bit errors mainly result from imperfections in the components used to make the link. These include the optical driver, receiver, connectors and the fibre itself. Bit errors may also be introduced as a result of optical dispersion and attenuation that may be present. Also noise may be introduced in the optical receiver itself. Typically these may be photodiodes and amplifiers which need to respond to very small changes and as a result there may be high noise levels present.

BER and Eb/No

Signal to noise ratios and Eb/No figures are parameters that are more associated with radio links and radio communications systems. In terms of this, the bit error rate, BER, can also be defined in terms of the probability of error or POE. The determine this, three other variables are used. They are the error function, erf, the energy in one bit, Eb, and the noise power spectral density (which is the noise power in a 1 Hz bandwidth), No.
It should be noted that each different type of modulation has its own value for the error function. This is because each type of modulation performs differently in the presence of noise. In particular, higher order modulation schemes (e.g. 64QAM, etc) that are able to carry higher data rates are not as robust in the presence of noise. Lower order modulation formats (e.g. BPSK, QPSK, etc.) offer lower data rates but are more robust.
The energy per bit, Eb, can be determined by dividing the carrier power by the bit rate and is a measure of energy with the dimensions of Joules. No is a power per Hertz and therefore this has the dimensions of power (joules per second) divided by seconds). Looking at the dimensions of the ratio Eb/No all the dimensions cancel out to give a dimensionless ratio. It is important to note that POE is proportional to Eb/No and is a form of signal to noise ratio.
It is possible to define the bit error rate in terms of a probability of error.

$$\mathbf{POE=12\ (1-erf)}\sqrt{\frac{Eb}{N0}}$$

Where:

erf = error function
E_b = energy in one bit
N_o = power spectral density (noise in 1Hz bandwidth).

It is important to note that E_b / N_o is a form of signal to noise ratio.
The energy per bit, E_b can be determined by dividing the carrier power by the bit rate. As an energy measure, E_b has the unit of Joules. N_o is a measure of power (joules per second) per Hz (seconds), and as a result E_b / N_o is a dimensionless term and can be expressed simply as a ratio.

Factors affecting bit error rate, BER

It can be seen from using E_b / N_o, that the bit error rate, BER can be affected by a number of factors. By manipulating the variables that can be controlled it is possible to optimise a system to provide the performance levels that are required. This is normally undertaken in the design stages of a data transmission system so that the performance parameters can be adjusted at the initial design concept stages.

- ***Interference:*** The interference levels present in a system are generally set by external factors and cannot be changed by the system design. However it is possible to set the bandwidth of the system. By reducing the bandwidth the level of interference can be reduced. However reducing the bandwidth limits the data throughput that can be achieved.
- ***Increase transmitter power:*** It is also possible to increase the power level of the system so that the power per bit is increased. This has to be balanced against factors including the interference levels to other users and the impact of increasing the power output on the size of the power amplifier and overall power consumption and battery life, etc.
- ***Reduce bandwidth:*** Another approach that can be adopted to reduce the bit error rate is to reduce the bandwidth. Lower levels of noise will be received and therefore the signal to noise ratio will improve. Again this results in a reduction of the data throughput attainable.
- ***Lower order modulation:*** Lower order modulation schemes can be used, but this is at the expense of data throughput.

Baseband receiver:

Procedure:

1) Select clock signal 64K
2) Set PRBS generator using DIP switch
3) Connect output of PRBS generator to input of PAM block
4) Connect output of PAM block to input of error bit adder
5) Connect output of error bit adder to DATA IN of SCRAMBLER block, also connect clock to CLK IN of SCRAMBLER
6) Connect output of SCRAMBLER to transmission channel TX IN
7) Connect output of transmission channel TX OUT to ADDER block DATA IN
8) Connect NOISE SOURCE block OUT to ADDER block NOISE IN
9) Connect output of ADDER block to RX IN of RX FILTER
10) Connect output of RX FILTER to IN of DECISION DEVICE
11) Connect output of DECISION DEVICE to DATA IN of REGENERATOR block , also connect clock to CLK IN of REGENERATOR

12) Connect output of REGENERATOR to DATA IN of REGENERATOR block , also connect clock to CLK IN of UNSCRAMBLER
13) Connect output of UNSCRAMBLER to RX IN of BER meter, as well as connect output of PAM block to DATA IN of BER meter.

Observations:

1) Set knob of transmission channel and RX filter to position 2, keep noise source block knob to minimum level, note down BER.
2) Set knob of transmission channel and RX filter to position 2, change noise source block knob to intermediate level, note down BER.
3) Set knob of transmission channel and RX filter to position 2, change noise source block knob to maximum level, note down BER.
4) Perform above three steps by keeping knob of transmission channel and RX filter to position 3 as well as for 4 and 5, note down BER

Conclusion: ____

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Name of Teaching Staff:	**Signature**