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Design & Development of Graphical User Interface (GUI) for Communication Link with PSK Modulation using Adaptive Equalization

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Abstract: Due to the scarcity of the frequency spectrum, we usually filter the transmitted signal to limit its bandwidth. So, that efficient sharing of the frequency resource can be achieved. Moreover, many practical channels are band-pass and, in fact, they often respond differently to inputs with different frequency components, i.e., they are dispersive. The resulting interference, inter-symbol interference (ISI), degrades the error performance of the communication system. There are two major ways to mitigate the detrimental effect of ISI. The first method is to design band-limited transmission pulses which minimize the effect of ISI. The second method is to filter the received signal to cancel the ISI introduced by the channel impulse response. This approach is generally known as equalization. In this paper we have adopted adaptive equalization technique to reduce ISI and have compared with the existing techniques. Also, we a graphical user interface (GUI) has been developed for making the work user friendly so that everyone can use it with ease.

Keywords: MATLAB, Adaptive Equalization, Inter-symbol Interference (ISI), Graphical User Interface (GUI).

1. INTRODUCTION

In telecommunication, inter-symbol interference (ISI) is a form of distortion of a signal in which one symbol interferes with subsequent symbols. This is an unwanted phenomenon as the previous symbols have similar effect as noise, thus making the communication less reliable. ISI is usually caused by multipath propagation or the inherent non-linear frequency response of a channel causing successive symbols to "blur" together. The presence of ISI in the system introduces errors in the decision device at the receiver output. Therefore, in the design of the transmitting and receiving filters, the objective is to minimize the effects of ISI, and thereby deliver the digital data to its destination with the smallest error rate possible. Ways to fight inter-symbol interference include adaptive equalization and error correcting codes.

2. MULTIPATH PROPAGATION

One of the causes of inter-symbol interference is what is known as multipath propagation in which a wireless signal from a transmitter reaches the receiver via many different paths. The causes of this include reflection (for instance, the signal may bounce off buildings), refraction (such as through the foliage of a tree) and atmospheric effects such as atmospheric ducting and ionospheric reflection. Since all of these paths are different lengths - plus some of these effects will also slow the signal down - this results in the different versions of the signal arriving at different times. This delay means that part or all of a given symbol will be spread into the subsequent symbols, thereby interfering with the correct detection of those symbols. Additionally, the various paths often distort the amplitude and/or phase of the signal thereby causing further interference with the received signal.

2.1 Countering ISI

There are several techniques in telecommunication and data storage that try to work around the problem of inter-symbol interference.

- Design systems such that the impulse response is short enough that very little energy from one symbol smears into the next symbol.
- Separate symbols in time with guard periods.
- Apply an equalizer at the receiver, that, broadly speaking, attempts to undo the effect of the channel by applying an inverse filter.
- Apply a sequence detector at the receiver, that attempts to estimate the sequence of transmitted symbols using theViterbi algorithm.

2.2.1 Adaptive Equalizers

As in any Feedback System in a adaptive equalizer has two parts one is Forward path and another is Feedback path. The Feedback path provides the output data to a equalizer so that it can compare the output and input.

2.2.2 Weighted Equlization

There are two types of weighted equalizers

a) Fixed Weight Equalizers- These equalizer normally used for the cases where frequency response of the

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channel is constant. In such type of system once the weights fixed it cannot be changed.

b)Adaptive Weight Equalizers- These systems are used sequence and output varied time to time. Figure1 shows adaptive fixed equalizer.

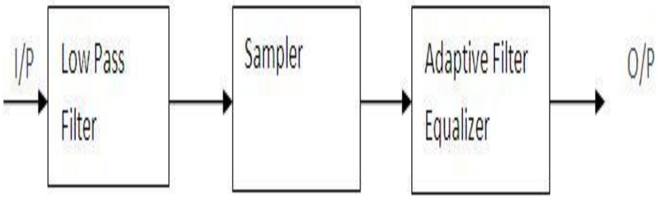

Figure 1: Adaptive weight Equalizer

Adaptive equalizers works in two methods either the receiver information is used to generate error signal or a reference training bits are used which is compared to a known transmission bit sequence and thus if there is any change in timing of bit it can be corrected by calculating the difference between the initial time calculated by training bit. Adaptive equlizers initially produces some error because equalizers tries to get used to itself.

The PSK modulation has been used for a communication link for simulation purposes. The different parameters have been adjusted for setting simulation parameters and creating equalizer objects and for better understanding a graphical user interface (GUI) has been developed using graphical user interface development environment (GUIDE). GUIDE provides a set of tools for creating graphical user interfaces (GUIs). These tools greatly simplify the process of laying out and programming GUIs.

Laying Out the Simple GUI in GUIDE

The GUI developed using GUIDE of MATLAB may be shown as:

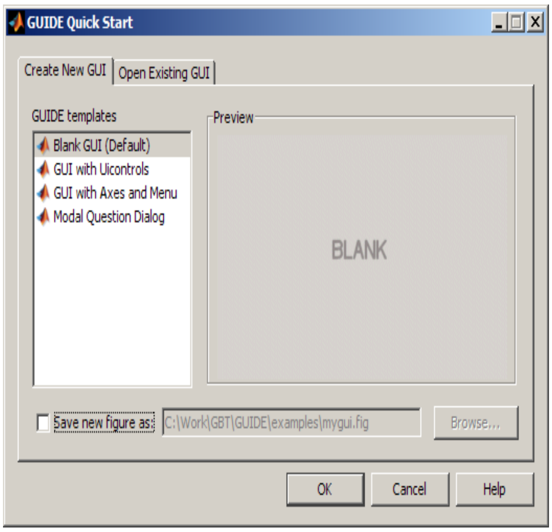

Figure 2: Opening a new GUI

where frequency response vary with time. In these systems the output of the system is compared with the reference

We can start GUIDE by typing guide at the MATLAB prompt. The GUIDE Quick Start dialog displays, as shown in the figure 2.

In the Quick Start dialog, select the Blank GUI (Default) template. Click OK to display the blank GUI in the Lawet Editor, as shown in the figure 3.

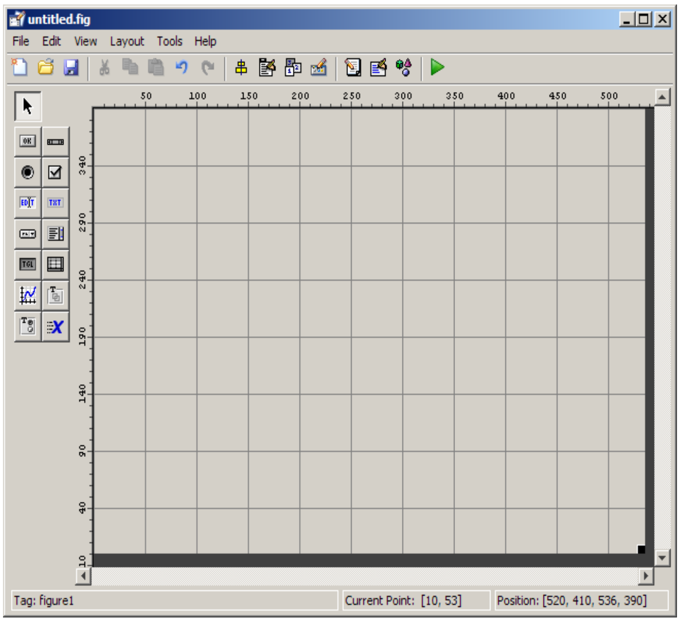

Figure 3: Blank GUI

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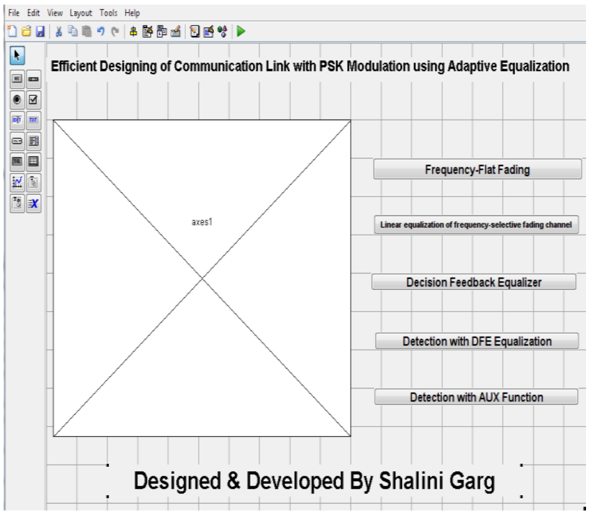

Figure 4: GUI for Adaptive Equalization

After the simulation of above file, the result may be shown in figure 5:

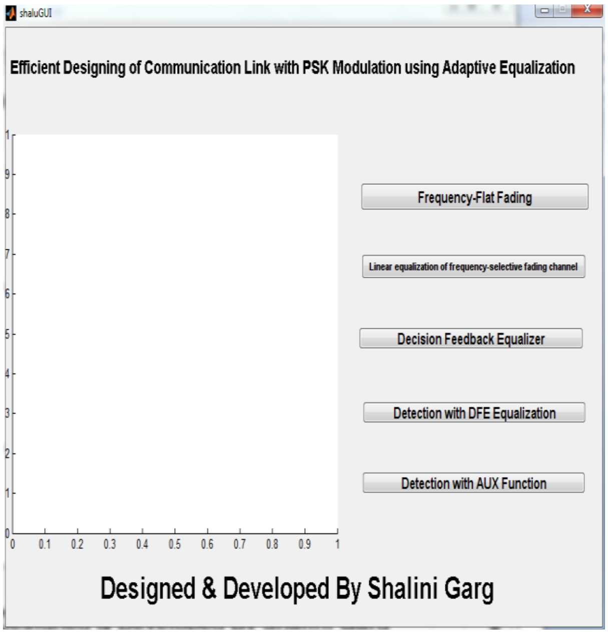

Figure 5: GUI after simulation of Adaptive Equalization

Parameters related to PSK modulation and the transmission blocks have been adjusted. The block consists of 3 parts; One of them is to train the sequence and thereafter pay-loading & tailing the sequence. Each uses the similar PSK scheme. The function of training and tail sequences is equalization. We have taken

Symbol period = 1e-6
Number of bits per PSK symbol = 2
number of modulation levels = 2
Number of payload symbols = 800
Number of training symbols = 200
Number of tail symbols = 40

3. Transmit/Receive Filters Design using GUI

Structures have been created which contain information regarding the transmit and receive filters. Each filter is having a square-root raised cosine frequency response which is implemented with an FIR structure. The transmit and receive filters include up-sampling and down-sampling, respectively, and both use an efficient poly-phase. These multi-rate filters retain state from one transmission block to the next, like the channel object. The peak value of the impulse response of the filter cascade is 1. The transmit filter uses a scale factor to ensure unit transmitted power. To construct the pulse filter structures, this algorithm uses an auxiliary function

3.1 Frequency-Flat Fading Channel

Begin with single-path, frequency-flat fading. For this channel, the receiver uses a simple 1-tap LMS (least mean square) equalizer, which implements automatic gain and phase control. We have taken ratio of symbol energy to noise power spectral density (dB) = 20

Before the first run, the script displays the initial properties of the channel and equalizer objects. For each run, a MATLAB figure shows signal processing visualizations. The red circles in the signal constellation plots correspond to symbol errors. In the "Weights" plot, blue and magenta lines correspond to real and imaginary parts, respectively. Figure6 shows the response of frequency flat fading channel.

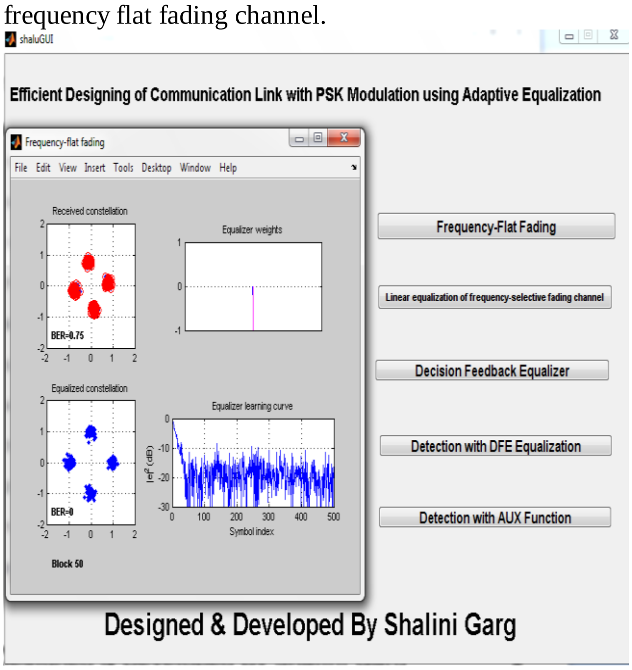

Figure 6: GUI response for Frequency Flat Fading Channel

3.2 Frequency-Selective Fading Channel and Linear Equalizer

The receiver uses an 8-tap linear RLS (recursive least squares) equalizer with symbol-spaced taps. The simulation uses the channel object from Simulation 1, but with modified properties.

Linear equalization parameters are

No. of weights = 8;

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RLS algorithm forgetting factor = 0.99;
Figure 7 shows the response of frequency selective fading channel and linear equalizer.

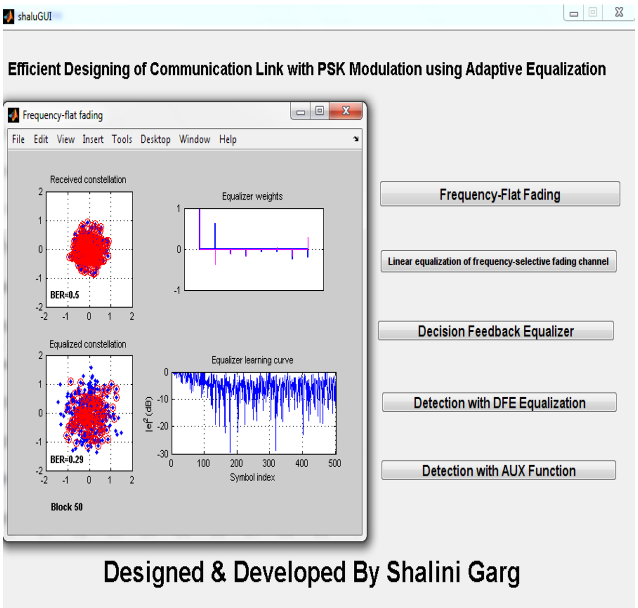

Figure 7: GUI response of Frequency-Selective Fading Channel and Linear Equalizer

3.3 Adaptive Equalizer

The receiver uses a adaptive equalizer with a six-tap fractionally spaced forward filter (two samples per symbol) and two feedback weights. The DFE uses the same RLS algorithm. The receive filter structure is reconstructed to account for the increased number of samples per symbol. This simulation uses the same channel object.

Adaptive equalization parameters are:
Number of feedforward equalizer weights = 6
Number of feedback filter weights = 2
Figure 8 shows the response of adaptive equalizer.

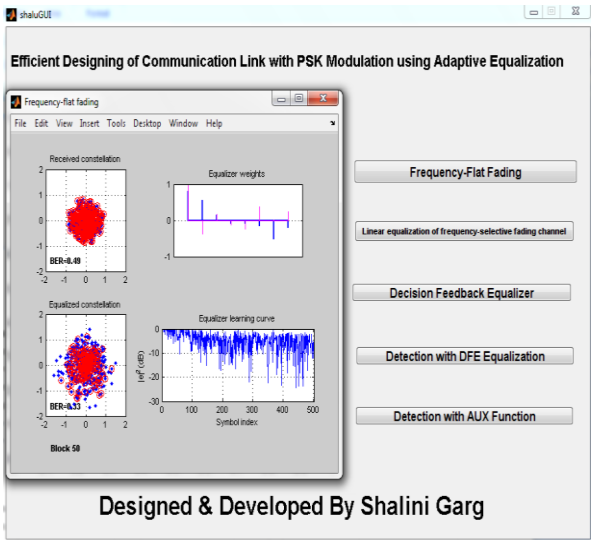

Figure 8: GUI Response of Decision Feedback Equalizer (DFE)

Detection Using DFE Equalization:

This script simulates a communication link with PSK modulation, raised-cosine pulse shaping, multipath fading, and adaptive equalization. The symbols will be passed through a pulse shaping transmit filter. This process also involves up-sampling using an efficient poly-phase filter implementation.

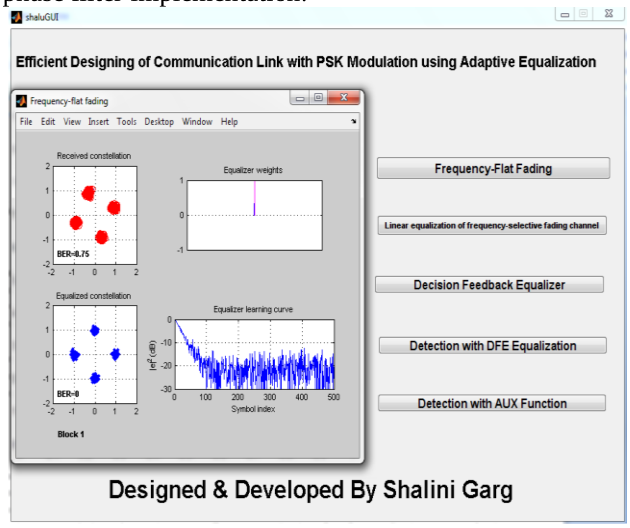

Figure 9: GUI Response of Detection Using DFE Equalization

The transmitted signal is then passed through a multipath channel and a receive filter matched to the transmit filter response. The receiver filtering down-samples is implemented using an efficient poly-phase filter implementation. The variables of transmission filters and receiver filters are passed out of the adaptive pulse-filter functions because they are structures that retain states between calls.

Detection with AUX Function

This technique uses the following auxiliary functions:
a) It first filters a signal with a pulse filter.
b) Detects PSK signal and perform error calculations.
c) Visualizes signal processing and performance.
d) Checks for workspace variables

Workspace Variables for Channel:

Channel Type	: 'Rayleigh'
InputSamplePeriod	: 5.0000e-007
MaxDopplerShift	: 20
PathDelays	: 0
AvgPathGaindB	: 0
NormalizePathGains	: 1
PathGains	: 0.3099 - 0.9074i

Workspace Variables for Equalization

Equalization Type	: 'Linear Equalizer'
Algorithm Type	: 'LMS'
nWeights	: 1
StepSize	: 0.0300
Weights	: 0

It passes symbols through a pulse shaping transmit filter. This process also involves up-sampling using an efficient poly-phase filter implementation. The transmitted signal is then passed through a multipath channel and a receive filter matched to the transmit filter response. The receiver filtering down-samples using an efficient poly-phase filter implementation. The variables transmission and receive are passed out of the adaptive equalization pulse filter functions, because they are structures that retain states between calls.

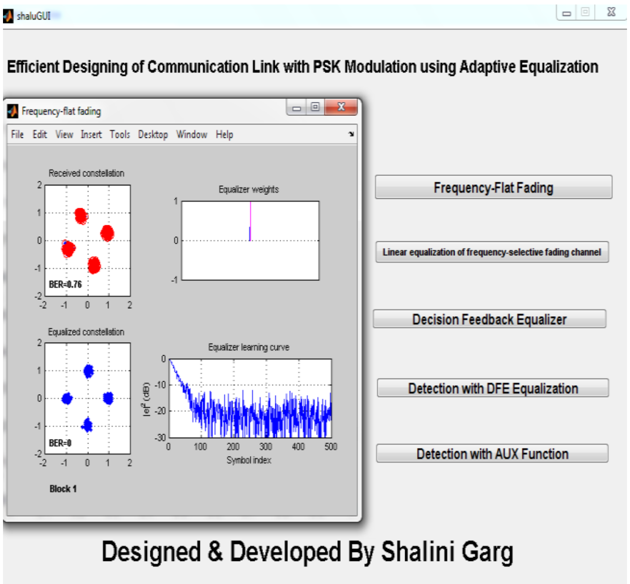

Figure 10: GUI Response of Detection Using AUX function

The auxiliary function has been used because we want to do a similar operation after equalization. In addition to detecting data and computing the BER, this function also returns indices for the symbols corresponding to bit errors. The process is applied to detection without and with equalization and satisfactory results are obtained.

CONCLUSION

The inter-symbol interference has been reduced drastically using adaptive equalization without making significant changes in the original structure. From the consequences it is obvious that the receive filter arrangement for adaptive equalization is restructured to account for the augmented number of samples per symbol with the equivalent channel entity as in linear equalization. Further, the system is more balanced now. Consequently, we can articulate that the equalization using adaptive Equalizer enhances the competence of the modern digital communication system. The whole system has been realized using the MATLAB by developing a Graphical User Interface (GUI), which makes the system more user friendly.

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