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Design & Development of a Novel Technique to Reduce Inter-symbol Interference using Decision Feedback Equalization

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Abstract: ***Now a days the scientists' main motive is to reduce Inter-symbol Interference (ISI) in modern communication systems. In this paper, we have modeled a channel and applied output to different equalization techniques like Frequency Flat, Frequency Selective, Decision Feedback and compared their result and found out that the Decision Feedback Equalization is the best one to reduce ISI. In this modeling we have used PSK modulation as a reference for channel modulation technique.***

Keywords: Equalizer, ISI, DFE, PSK, MATLAB

1. Introduction

A signal comprise of different frequency components and these components shows different attenuation pattern while passing through same environment. Some of them more attenuated and others are less, but at the receiver we need to process the entire signal equally to get a good quality signal. For this purpose we use equalization

2. Equalization

Equalization is basically an act of balancing of different frequency components. That means the frequency components will be processed according to the quality received.

In modern communication techniques, it is used to reduce inter symbol interference and for recovery of the transmitted BITs. These may be either of linear type or non linear type. The following equalizers are commonly used in digital communications:

- Linear Equalizer: It processes the equalization incoming signal with a linear filter this of two types
  a) Minimum Mean Square error equalizer
  b) Zero Forcing Equalizer
- Decision Feedback Equalizer: In this equalizer the filtered output again feedback to the system so that original signal can be constituted.
- Blind Equalizer: These equalizers does not depend upon the channel through which signal passes
- Adaptive Equalizer: This type of equalizer is most widely used as it can modify its parameters automatically according to the feedback provided by processed data and thus accommodates channel statics also. It is frequently used phase shift keying and very useful in minimizing the effect of parameters like multipath propagation and Doppler shift.

In this paper we have used three types

i. Frequency Flat
ii. Frequency Selective
iii. Decision Feedback

I) Frequency Flat Equalizer This type of equalizer is also known as non weighted equalizer means whatever the frequency components or whatever the channel conditions exists it will process the entire signal equally. So it may be useful for small signal or a channel with low noise and low inter symbol interference

II) Frequency Selective Equalizer This type of equalizer is also known as weighted equalizer means it will process the received data according to the frequency of signal. The biggest drawback of this system is that it cannot change its weights automatically even if the channel conditions are changed. So in this type of system the output should be checked continuously and change the parameters accordingly when needed.

III) Decision Feedback Equalizer This is the best equalizer in its category as it can change its parameters automatically. In this system a part of processed signal is feedback to the input and is compared with the incoming signal. The error signal generated by this method is used to modify the parameters. Initially this equalizer is fed with some training sequence which is continuously modified by feedback system.

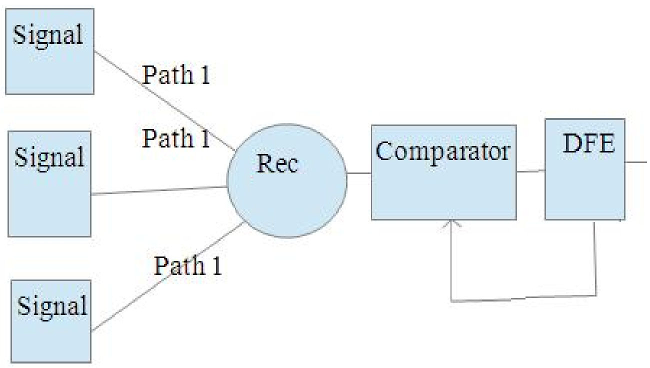

Figure 1

3. Results & Discussion

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 the MATLAB coding is as under which is self illustrative for describing parameters:

3.1 Frequency-Flat Fading Channel

The script shows 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. Figure 2 shows the response of frequency flat fading channel.

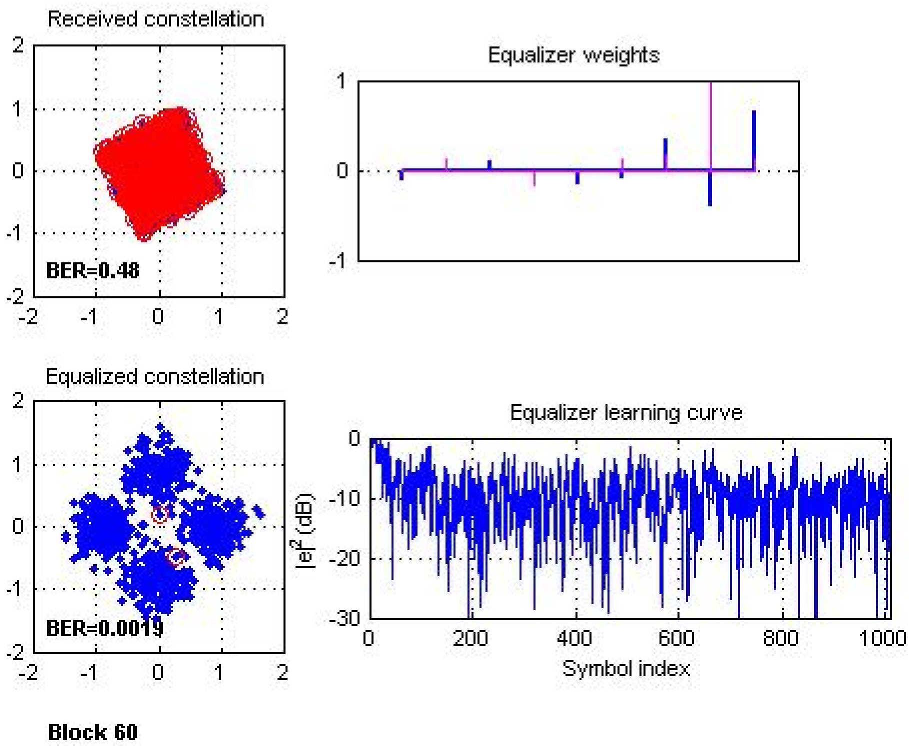

Figure 2: Response of Frequency Flat Fading Channel

Parameters for rayleigh
Tsym = 1e-6;
bitsPerSymbol = 2;
M = 2.^bitsPerSymbol;
nPayload = 800;
nTrain = 200;
nTail = 30;
nWeights = 9;
stepSize = 0.2;
alg = lms(stepSize);
working fine with this step size but beyond this its performance degrades very rapidly

Output of MATLAB

chan =

ChannelType: 'Rayleigh'
InputSamplePeriod: 1.6667e-007
DopplerSpectrum: [1x1 doppler.jakes]
MaxDopplerShift: 30
PathDelays: 0
AvgPathGaindB: 0
NormalizePathGains: 1
StoreHistory: 0
StorePathGains: 0
PathGains: 0.3099 - 0.9074i
ChannelFilterDelay: 0
ResetBeforeFiltering: 0
NumSamplesProcessed: 0

eqObj =

EqType: 'Linear Equalizer'
AlgType: 'LMS'
nWeights: 9
nSampPerSym: 1
RefTap: 1
SigConst: [1x4 double]
StepSize: 0.2000
LeakageFactor: 1
Weights: [0 0 0 0 0 0 0 0 0]
WeightInputs: [0 0 0 0 0 0 0 0 0]
ResetBeforeFiltering: 1
NumSamplesProcessed: 0

3.2 Frequencies-Selective Fading Channel and Linear Equalizer

The receiver uses a 9-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 = 9;
RLS algorithm forgetting factor = 0.99;

Tsym = 1e-6;
bitsPerSymbol = 2;
M = 2.^bitsPerSymbol;
nPayload = 800;
nTrain = 200;
nTail = 30;

Figure 3 shows the response of frequency selective fading channel and linear equalizer.

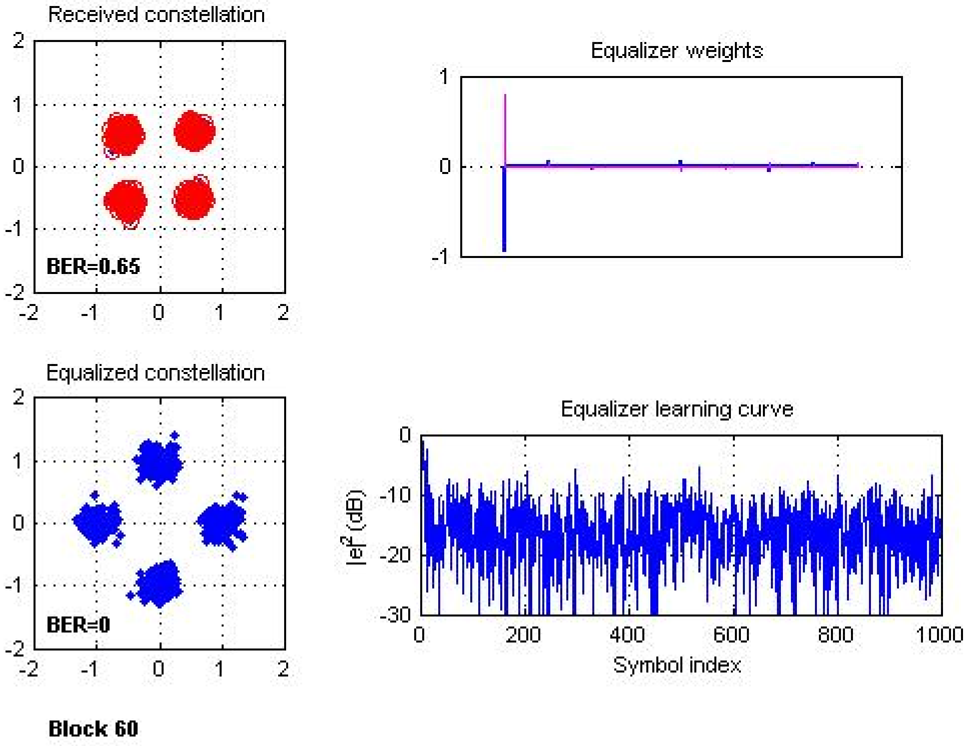

Figure 3: Response of Frequency-Selective Fading Channel and Linear Equalizer

Output of MATLAB

eqObj =

EqType: 'Linear Equalizer'
AlgType: 'RLS'
nWeights: 9
nSampPerSym: 1
RefTap: 9
SigConst: [1x4 double]
ForgetFactor: 0.9900
InvCorrInit: 0.1000
InvCorrMatrix: [9x9 double]
Weights: [0 0 0 0 0 0 0 0 0] WeightInputs: [0 0 0 0 0 0 0 0 0]
ResetBeforeFiltering: 1
NumSamplesProcessed: 0

avgBER2 = 0.0131

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 as in 3.2. The receive filter structure is reconstructed to account for the increased number of samples per symbol. This simulation uses the same channel object as in 3.2. Adaptive equalization parameters are:

- Number of feed-forward equalizer weights =9
- Number of feedback filter weights = 2

Figure 4 shows the response of adaptive equalizer.

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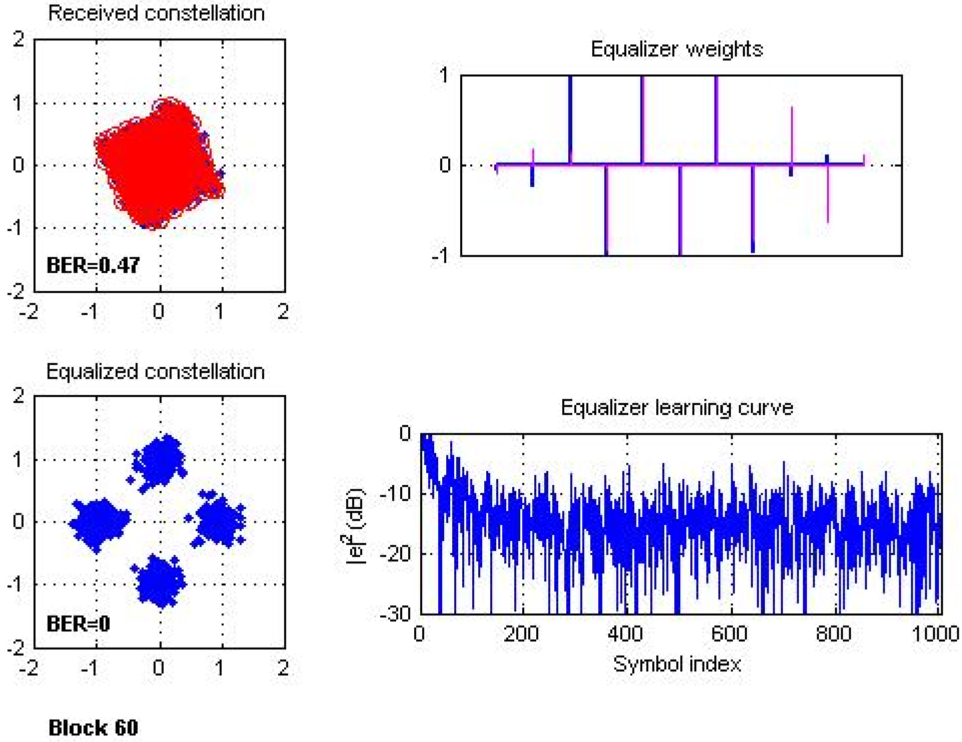

Figure 4: Response of Decision Feedback Equalizer (DFE)

eqObj =

EqType: 'Decision Feedback Equalizer'
AlgType: 'RLS'
nWeights: [9 2]
nSampPerSym: 2
RefTap: 9
SigConst: [1x4 double]
ForgetFactor: 0.9900
InvCorrInit: 0.1000
InvCorrMatrix: [11x11 double]
Weights: [0 0 0 0 0 0 0 0 0 0 0]
WeightInputs: [0 0 0 0 0 0 0 0 0 0 0]
ResetBeforeFiltering: 1
NumSamplesProcessed: 0
avgBER3 = 1.9792e-004

4. Conclusion

It is evident that the received filter structure for Decision Feedback Equalization is re-organized to account for the augmented number of samples per symbol with the equivalent channel entity as in linear equalization. Consequently, it can be concluded that the equalization using Decision Feedback Equalizing enhances the competence of the communication system.

5. Future Scope

In future the purposed work may be implemented on FPGA platform for more realistic, economically viable and efficient results which may alter the current scenario of expensive communication systems drastically by reducing its cost.

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