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Improvement of Binary Frequency Shift Keying Modulation Performance

Rahmad Hidayat[1*], Rushendra[2], Ellisa Agustina[2], Salamatul Afiyah[3], Yudi Herdiana[4], Andrew Ghea Mahardika[1], Ninik Sri Lestari[1]

[1]Sekolah Tinggi Teknologi Mandala, Bandung, Indonesia
[2]Universitas Mercu Buana, Jakarta, Indonesia
[3]Universitas Islam Negeri Sunan Gunung Djati, Bandung, Indonesia
[4]Universitas Bale Bandung, Indonesia

Email: rhidayat4000@gmail.com

Abstract. M-ary frequency shift keying (FSK) is a low-power, low-data-rate modulation scheme currently used by manufacturers of data transmission equipment. Inter symbol interference (ISI) occurs in all communication systems. To analyze the effect of the raised cosine filter and adaptive equalizer on reducing the ISI, the binary FSK (BFSK) modulation technique has been studied extensively in this research. In this study, we have selected the square root raised cosine filter and the sign least mean square (LMS) equalizer. The bit error rate (BER) performance of the 2-FSK system with the additive white Gaussian noise (AWGN) channel is evaluated and analyzed with the help of Simulink. The best BER value of 1.7e-03 was obtained in this study.

1. Introduction

M-ary frequency shift keying is a power-efficient modulation scheme whose performance improves as the amount of frequencies employed (M) increases at the cost of increased complexity and narrower bandwidth efficiency. This scheme has been considered beneficial in low rate low power applications. There is a gap, however, between the efficiency of theoretical M-ary FSK systems and that of real-world systems using M-ary FSK modulation schemes. In most implementations, binary FSK is used, mostly to send critical control information. Some of the uses of BFSK are wireless medical telemetry, wireless PC peripherals, wireless speakers and headphones, personnel safety, flood level monitor, crane control, and industrial apps, tire pressure monitor, monitor water salinity, temperature and density, and rail temperature monitor [1], [2].

Channel characteristics that aren't optimal cause communication channel distortion. Inter symbol interference is caused by this distortion in the communication channel, and if not treated properly, can result in an error in the data received by the receiver. A receiver with an equalizer will be built to reduce ISI to solve this problem. Since the channel characteristics are not known in advance in most communication systems that use an equalizer, or the channel response is time-variant, an equalizer that can operate dynamically in response to changes in the time-variant channel response is needed. Adaptive equalization is the name of this strategy. We can reduce the occurrence of ISI by using adaptive equalization, which reduces the error from information data obtained by the receiver. A classical technique for visualizing the effect of inter symbol interference (ISI) is the eye pattern which can be equipped with the measurement of the bit error rate (BER). ISI is determined by overlapping multiple segments of the received waveform over a fixed window, which shows how different symbol combinations might theoretically generate ISI. The eye is open for an optimal channel of square root

Nyquist pulses on both ends. The eye, on the other hand, is closed for the dispersive channel. An open eye indicates that we can make accurate single-sample symbol decisions by using the right sampling times, while a closed eye indicates that symbol recovery would require more complex equalization techniques [3], [4]. The problem is how to make an adaptive equalizer simulation that can reduce BER due to ISI for communication with BFSK modulation and how is the performance of the equalizer in performing the equalization process on that communication and to what extent the effect of adding a raised cosine filter on the existing circuit. The purpose of this research is to design an adaptive equalizer system model that can reduce BER due to ISI in communication systems with BFSK modulation. Then study and analyze the performance of the adaptive equalizer system with the Sign LMS algorithm. The raised cosine filters were added to further improve existing performance.

In an underwater communication system with the additive white Gaussian noise (AWGN) channel without an adaptive equalizer and using the LMS algorithm adaptive equalizer in testing 100,000 bits. At the same Eb / No, which is 3 dB, without using the LMS equalizer algorithm the value of BER = 2.29x10-2 is obtained, while using the LMS equalizer the value of BER = 1.8 x10-4, this research was conducted by [5]. Also, the performance of different modulation techniques and channel coding was analyzed on the basis of BER over the AWGN channel [6].

The amount of the symbol error probability (Pb) and the bit error rate (BER) on the M-FSK is given by [7].

$$Pb = BER = \frac{M\,P_e}{2M-2} \tag{1}$$

$$P_e = \frac{M-1}{2}\,erfc\left(\sqrt{\frac{E}{2N_o}}\right) \tag{2}$$

While the BER plot against Eb / No for non-coherent BFSK is shown in figure 1.

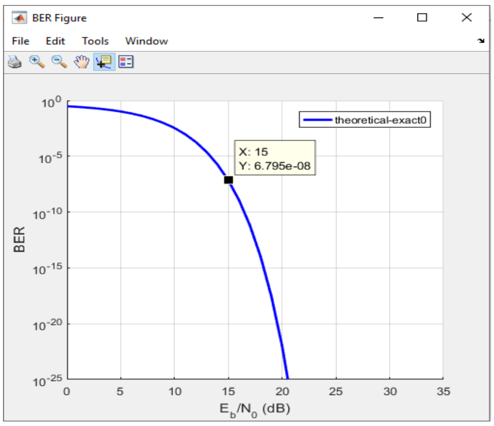

Figure 1. BER graph of BFSK non-coherent

2. Methodology

This research was built from the Simulink block shown in figure 2. Starting from a binary generator in Bernoulli format. The binary signal is then BFSK modulated. Before and after the medium channel, the raised cosine filter with the "square root" shape filter does its job. The equalizer is installed before the demodulator to further improve the quality of reception, and the result is an error rate observation through a bit error meter. Comparisons are made between the BER values before and after the equalizer. To complete the observation, the spectrum shape of the modulated signal was measured.

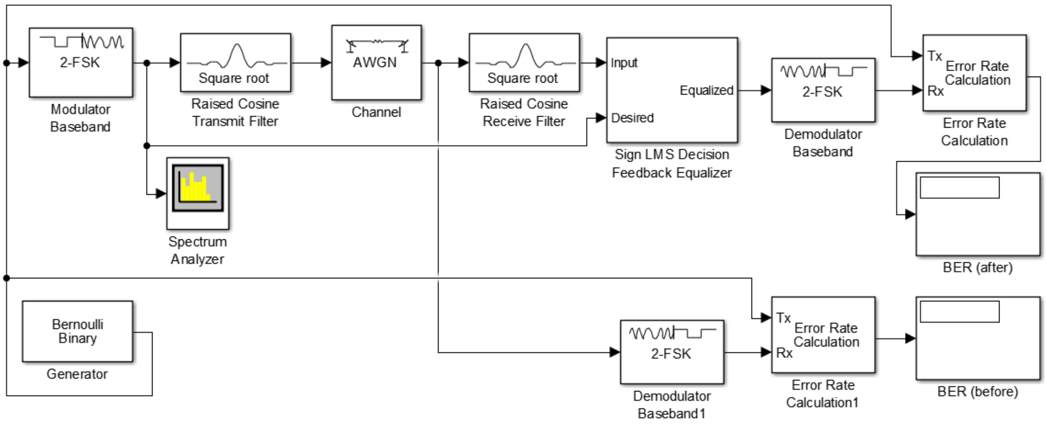

Figure 2. Simulink block of BFSK system

Table 1 lists the simulation parameters that we took.

Table 1. Simulation parameters

Parameters	Value
Filter shape	Square root
Raised cosine filter, roll-off (α)	0.2
Filter span in symbol	10
Output samples per symbol	8
Filter length	81
Channel	AWGN
Eb/No	40 dB
Step size, μ	0.01
Sample time	0.001 s
Sample per frame	10000

3. Results and Discussion

The spectrum of the BPSK signal output from the modulator is shown in figure 3.

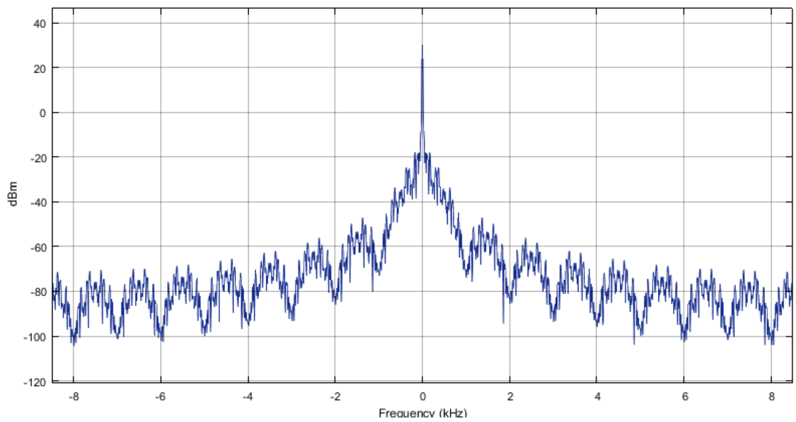

Figure 3. BFSK spectrum

While the impulse response of the design-raised cosine filter is shown in figure 4 and the pole-zone plotting can be seen in figure 5. The zero pole shows the filter system is stable.

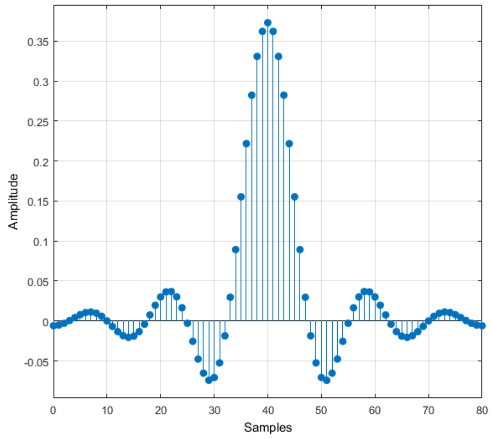

Figure 4. Impulse response

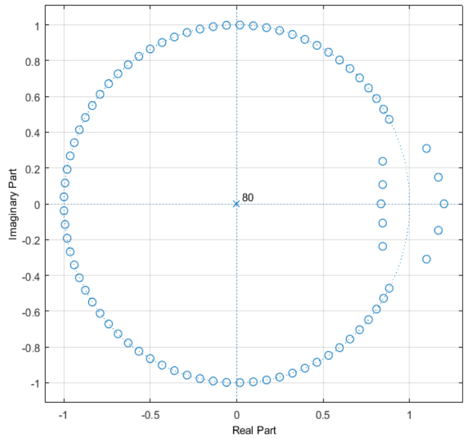

Figure 5. Pole-zero plot

The full research results are summarized in figure 6 and table 2.

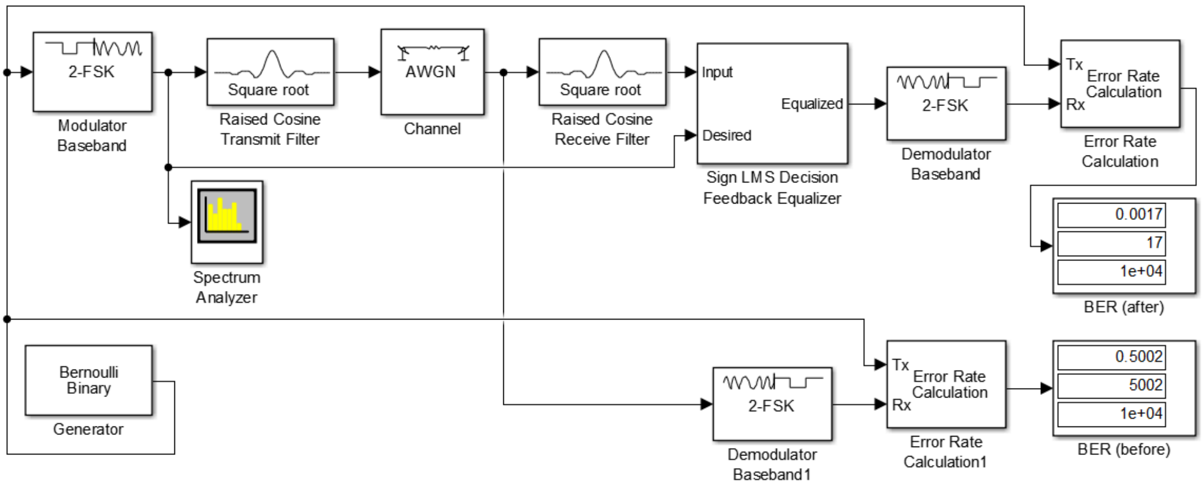

Figure 6. BER result

Table 2. BER result

Equalizer (Eq) (μ = 0.01)	**Eb/No of AWGN (dB)**	**ERROR without Raised Cosine filter**			**ERROR with Raised Cosine filter**		
		Before Eq. (BER)	**After Eq. (BER)**	**After Eq. (bit)**	**Before Eq. (BER)**	**After Eq. (BER)**	**After Eq. (bit)**
Without	40	0.2258	0.2258	2258	-	-	-
Eq.	40	0.2258	0.0777	777	-	-	-
Sign LMS	40	-	-	-	0.5002	0.0017	17
Sign LMS							

No error is shown when the monitor position is before the AWGN channel. This shows that purely the channel effect results in an error of 2258 bits or a BER of 0.2258. With the same Eb / No size, giving the Sign LMS equalizer can reduce the error to 777 bits. And the BER value is getting better with the installation of the Raised Cosine filter, which is 0.0017 or the equivalent of only 17-bit errors.

4. Conclusion

In this study, the binary FSK (BFSK) modulation technique has been studied extensively. The performance of the 2-FSK system with the AWGN channel is assessed and analyzed with the aid of Simulink. Simulink's results show that the adaptive equalizer and raised cosine filter used in the modulator (transmitter) and demodulator (receiver) play a very important role in evaluating and improving the performance of this BFSK modulation scheme.

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