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Research Article

Adaptive filter and pulse-shaping for interference cancellation of differential quadrature phase-shift keying modulation

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ABSTRACT

Differential quadrature phase-shift keying (DQPSK) modulation methods and variations are commonly used in wireless communication, including high-speed optical fiber, Bluetooth, and satellite communication. DQPSK cannot be isolated from possible interference with its present application. The interference cancellation process has been observed and analyzed using a device model built in this study. The core components of the supporting block for this device model have raised cosine filters for pulse shaping and adaptive filters. The presence of these core components has resulted in a dramatic improvement in device efficiency, according to robust Simulink data. The best bit error rate (BER) of 5.7e-03 provides evidence of this.

Keywords: DQPSK, interference, bit error rate, Simulink

Introduction

The differential quadrature phase-shift keying (DQPSK) modulation is used in long-haul optical or bluetooth communications networks, for example. There are often possible impairments in the process of transmitting information due to attenuation, noise, multipath fading, and distortion due to the modulation process. There's a possibility that one system is competing with another. Wireless sensor network systems, for example, can interfere with WiFi and Bluetooth systems, and vice versa [1][2]. Meanwhile, the interference is one of the main problems in current communication operations [3]. By building a better device setup, the challenge is how to preserve the presentation of the DQPSK system that is subject to interference attacks. The aim of this study is to suggest a DQPSK system configuration that includes an adaptive filter and a raised cosine as a pulse-shaping filter, as well as to evaluate the end-to-end DQPSK system's interference cancellation efficiency. In the formula for bit error rates (BER), observations were made on the key data.

The BER meter can be used to investigate interference by looking at the device's output. Simulating the circuit generated by the OFDM pulse shaping device in [2] reduces inter-carrier interference (ICI). In comparison to the OFDM scheme, the simulation results in terms of BER vs. Eb/No proposed that REC ISP pulse shaping and ISP pulse shaping are more effective in reducing ICI no-implemented pulse

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formation. Another alternative is to perform a comparative study. Inter-carrier interference is reduced by simulating the circuit created by the OFDM pulse shaping system in [2]. The simulation findings in terms of BER vs. Eb/No suggested that REC ISP pulse shaping and ISP pulse shaping are more efficient in minimizing ICI no-implemented pulse forming as compared to the OFDM scheme. Another choice is to do a contrast analysis. BER on additive white Gaussian noise (AWGN), Rayleigh, and Rician channels using MATLAB Simulink, GUI, and BER Tool on OFDM systems, CDMA to optical systems are compared in different studies to see how well they perform [4-9].

Adaptive Filter

The adaptive filter has an input of x(n), a weight of w(n), and an output of y. (n). According to the equation, the output y(n) is formed as a linear mixture of the delayed input sequence samples x(n). The equation is according to [10]:

$$y(n) = \sum_{i=0}^{N-1} w_i(n)x(n-1) \quad (1)$$

The filter coefficient can be modified using adaptive filter algorithms. The simplest algorithm is the least mean square (LMS), which reduces the instantaneous square error rather than the mean square error. LMS has a disadvantage since the learning parameter increases the convergence rate, but the error is larger [11].

The weight value vector equation for the LMS algorithm formula for the graph of the steepest descent process is: [12]

$$w(n+1) = w(n) + \frac{1}{2}\mu[-\nabla(E\{e^2(n)\})] \quad (2)$$

where the step-size parameter is expressed in μ. The sum of $e^2(n)$, which is the LMS algorithm's convergent character power, namely the average error value squared between the output beamformer y(n) and the reference signal, is determined as follows:

$$e^2(n) = \left[d^*(\mathrm{n}) - \mathrm{w}^{\mathrm{h}}\mathrm{x}(\mathrm{n})\right]^2 \quad (3)$$

In the weight value update equation above, the vector of a gradient is:

$$\nabla_w(E\{e^2(n)\}) = -2r + 2Rw(n) \quad (4)$$

The calculation to find the realtime matrix values of r and R is the key issue with the steepest descent process. Meanwhile, the LMS algorithm makes the estimation simpler by using the instant values r and R in addition to the real values r and R. The desired signal arrives at angle θo, and the interference signal arrives at angle θi. This instant value is S(t) for the desired signal and ui(t) for the interference signal.

$$R(n) = x(n)x^h(n) \quad (5)$$
$$r(n) = d*(n)x(n) \quad (6)$$

The following equation can be used to calculate the weight update value:

$$w(n+1) = w(n) + \mu x(n)[d^*(n) - x^h(n)w(n)] = w(n) + \mu x(n)e^*(n) \quad (7)$$

The algorithm of LMS is opened with the free value w (0) for the weight vector at n = 0. The weight vector's sequential correction then jumps to the mean squared error with the smallest value. The LMS algorithm is then outlined as follows:

$$Output,\ y(n) = w^h x(n) \quad (8)$$
$$Error,\ e(n) = d^*(n) - y(n) \quad (9)$$
$$w(n+1) = w(n) - \mu x(n)e^*(n) \quad (10)$$

Differential QPSK

The DQPSK together with OQPSK is a type of differential modulation that is widely used in digital communications. Knowledge is carried in DQPSK by establishing a specific stage with a single symbol in comparison to the preceding symbol. DQPSK uses phase differences between adjacent symbols to eliminate complications created by a lack of phase synchronization between the transmitter and receiver. The DQPSK constellation uses four dissimilar symbols (M = 4) to coordinate two bits per symbol [1][13].

Methods

This study uses the Simulink block as a system model that we propose in figure 1, where the complete parameters are as in table 1. The main block starts with a random integer generator, DQPSK modulator, channel, DQPSK demodulator, and sink in the form of a BER meter. Meanwhile, a source of interference (interferer) is added to the system before entering the channel. The channel type we chose was AWGN. Error rate simulation is done by observing the results and comparing them without adaptive filters. The type of adaptive filter we use has the least mean square (LMS) algorithm. We take the Eb / No range in this simulation of 2-20 dB and display the simulation results in table 2 and table 3. The raised cosine filter we chose in this study was a square root type with a roll-off factor (α) ranging from 0.25-0.30.

Table 1. Simulink parameters

Block	Parameter	Setting
Random Integer Generator	Set size	1
	Initial seed	37
	Sample time	0.001 s
	Sample/frame	100
	Output data	double
DQPSK Modulator Baseband	Constellation ordering	Gray
	Ph.rotation	pi/4 rad
DSP Sinewave (interferer)	Frequency	100 Hz
	Amplitude	1 volt
	Phase offset	0 rad
	Gain, G	2-5 dB
Raised cosine	Roll-off (α)	0.25-0.30
AWGN Channel	Eb/No	10 dB
	Bits/symbol	2 bits
LMS Filter	Filter length	32
	Step size (μ)	0.01 - 0.1
DQPSK Demod. Baseband	Constellation ordering	Gray
	Ph.rotation	pi/4 rad
Error Rate Calculation	Rx delay	0
	Compu.delay	0
Display	Decimation	1

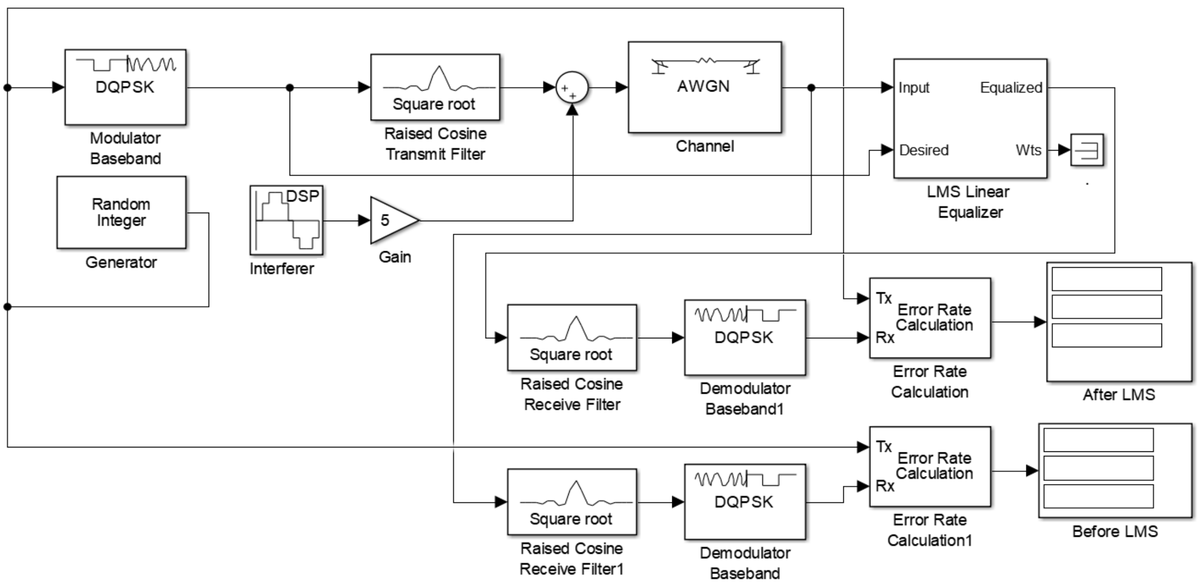

Figure 1. System model

Results and Discussions

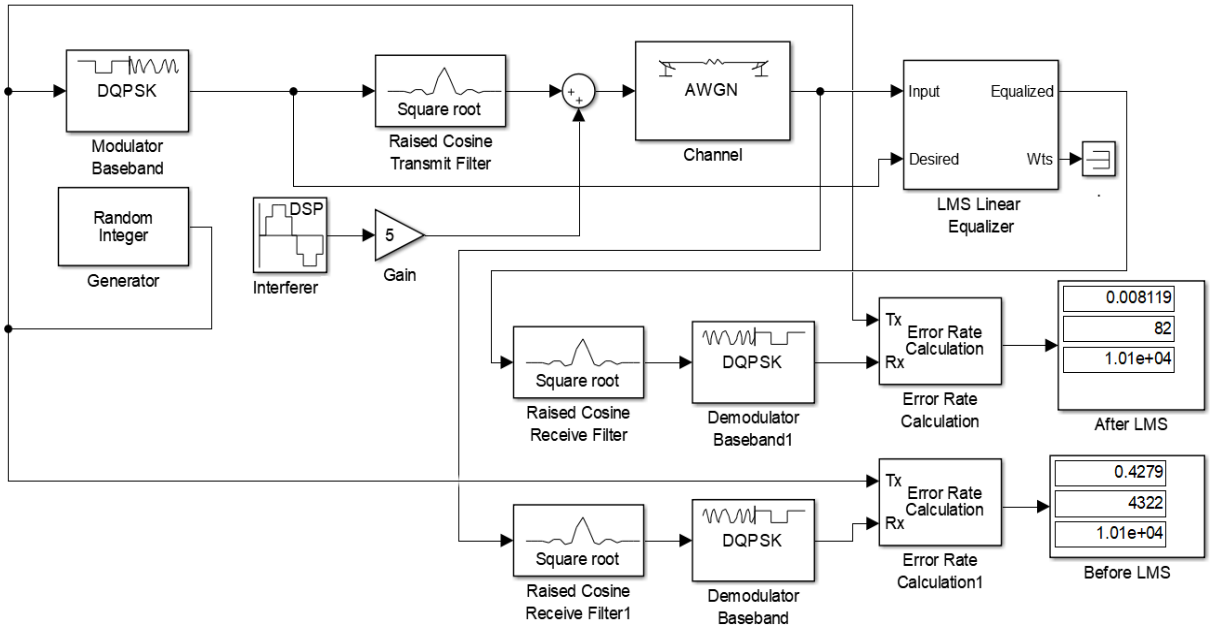

Figure 2. BER result (Eb/No=10dB; μ=0.05)

As a sample capture of the Simulink results shown in Figure 2 above.

Table 2. BER for α=0.25; G=5dB

Eb/No (dB)	μ	BER (before LMS)	BER (after LMS)
20	0.05	0.03515	0.01782
10	0.01	0.42790	0.02307
10	0.05	0.42790	0.00812
10	0.10	0.42790	0.00792
5	0.10	0.53830	0.00743

Table 3. BER for α=0.25; μ=0.1

Eb/No (dB)	Gain, G (dB)	BER before LMS)	BER (after LMS)
5	4	0.55820	0.00713
5	3	0.57270	0.00733
4	4	0.56570	0.00683
3	4	0.57080	0.00634
3	2	0.58720	0.00614
2	2	0.58760	0.00574

It can be seen in the last two tables, that adaptive filter enhancement can improve system performance by improving the bit error rate. The improvement in BER is increasingly visible when Eb / No is lowered at the interferer gain which remains 5 dB as shown in table 2 to 0.00743. If the step size (μ) is enlarged above 0.1, the error rate will get better or the number of bit errors will decrease. Likewise, by decreasing the gain of the interferer, it can be seen that the BER is getting better at 0.00574 or the equivalent of 58-bit errors, which is when the Eb / No of the AWGN channel is also reduced to 2 dB. In the case of increasing the roll-off to 0.3 on the same other parameters, the effect of this improvement is not seen. When compared to research conducted by [9] with a BER of 0.477 for various roll-off factors, the effect of the LMS linear equalizer as an adaptive filter shows a significant role in suppressing bit errors or improving BER.

Conclusion

The interference cancellation mechanism in the proposed block was observed and analyzed by adjusting each parameter to achieve the best BER efficiency. BER is used to represent the numerical value of all parameters. The findings indicate that this device configuration's efficiency is significantly aided by the existence of the elevated cosine filter under review. The pulse-shaping function is well performed by the chosen raised cosine filter parameters. Similarly, in interference cancellation, the LMS adaptive filter will increase the efficiency of digital communication. A comparative review was performed, as with the findings and analysis above, in which the BER value was higher, 5.7e-03 in this report. The configuration will be fitted with sub-blocks in the future to further investigate the use of discrete FIR filters of the current DQPSK scheme against the risk of inter-carrier interference (ICI).

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