Software Model of PRS Transmitter, Channel and Receiver

Stanyo Kolev[1], Dobri Dobrev[2], Alexander Aydemirski[3]

Abstract – **We have made a software simulation of PRS system with first class, second grade transforming but the achieved results were not satisfying. And as We wanted to gain better results in detecting and correcting the errors, we have made another experiment using a system with third class, sixth grade transforming. The experiments and some graphical results are presented in this paper.**

Keywords – **PRS, PRS system**

I. Introduction

Partial Response Signaling finds many applications in the modern digital world. Manufacturers use it lately as a better way for transferring data in and out from hard disk drives, for example. As we got acquainted with the PRS signaling, we figured out that it can find its place in open air data transmission. So we have made a software model of such PRS system. Which is presented in this paper.

II. Software Model of PRS System

The correlated signal is a signal with three or more levels. In order to achieve correlation between the symbols we need a suitable limitation of frequency band for the channel or a proper coding of the binary signal. In Figs. 1. and 2 are shown the two ways of forming the correlated signal.

Let the digital stream from the data source {a} is generated by binary sygnal with *n* symbols: {a} = {a_1, a_2, ... a_n}. As a rezult of the limitation of frequency band in the channel Fig.1. or the proper coding Fig.2, we can achieve a correlated signal {c} with many levels. The C_n symbol of this signal can be considered as correlated by all symbols of the binary signal {a} with the proper coefficients κ_1, κ_2, ... κ_n, as shown in Eq.1.

$$Cn = \kappa 1an + \kappa 2\ an-1 + ... + \kappa na1 \qquad (1)$$

According to the order and the values of the coefficients, we can distinguish several classes of correlated signals, which differ by number of levels, their shape and spectral density.

Data for forming of five classes of correlated signals is given in Table I.

[1]M.Sc. Stanyo Kolev Assoc.Prof. is with the Faculty of Radio Communications, Technical University of Sofia, 8, Kliment Ohridski St., Sofia 1000, Bulgaria, E-mail: s_kolev@market.bg

[2]Ph.D. Dobri Dobrev Assoc.Prof. is with the Faculty of Radio Communications, Technical University of Sofia, 8, Kliment Ohridski St., Sofia 1000, Bulgaria, E-mail: dobrev@tu-sofia.bg

[3]M.Sc. Alexander Aydemirski is with the Faculty of Radio Communications, Technical University of Sofia, 8, Kliment Ohridski St., Sofia 1000, Bulgaria, E-mail: aydemirsky@netbg.com

First we are going to made a model of PRS system with a logical processing, i.e. coding. In Fig.3. is shown a software model of PRS system from first class, second grade.

TABLE I
Weight Coefficients

Class	Order	Weight Coefficients									Number of levels
		K1	K2	K3	K4	.	.	.	.	Kn	
0	1	1									2
1	2	1	1								3
	3	1	1	1							4
	4	1	1	1	1						5
	n	1	1	1	1	1	.	.		1	n+1
2	3	1	2	1							5
	7	1	2	3	4	3	2	1			9
	n	1	2	3	.	.	.	3	2	1	n+2
3	3	2	1	-1							5
	7	-1	1	-2	3	-2	1	-1			7
4	3	1	0	-1							3
	7	1	2	1	0	-1	-2	-1			3
5	5	-1	0	2	0	-1					5
	9	1	0	-2	0	3	0	-2	0	1	7

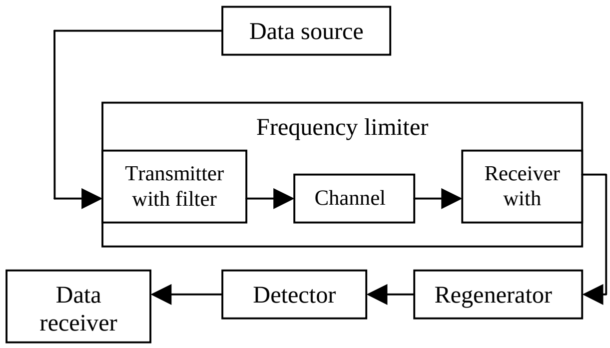

Fig. 1. Block diagram of PRS system with frequency limitation

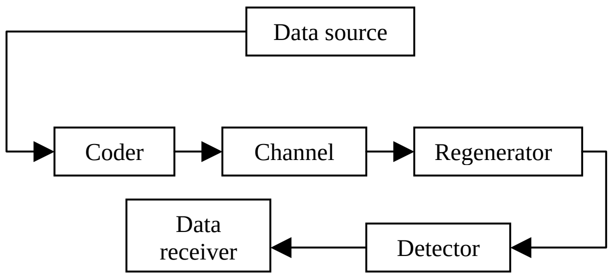

Fig. 2. Block diagram of PRS system with appropriate coding

The data source is made with the generator of odd NRZ row with normal distribution. The coder is made by next blocks: Memory1, Logical schemes – Logical Operator and Logical Operator1, as well as LO and LO1; Gain1 and recapitulator. The channel is made by recapitulator, which sums up the signal after the transmitter and the signal by the noise generator. The last imitates the presence of interference and different noises in the channel, which can have influence over the system – transmitter, channel, and receiver. The receiver is synthesized by an amplitude filter (AM filter) and error detector (Err Detect). The amplitude filter and the error detector are two separate systems. Their schemes are shown in Figs. 4 and 5.

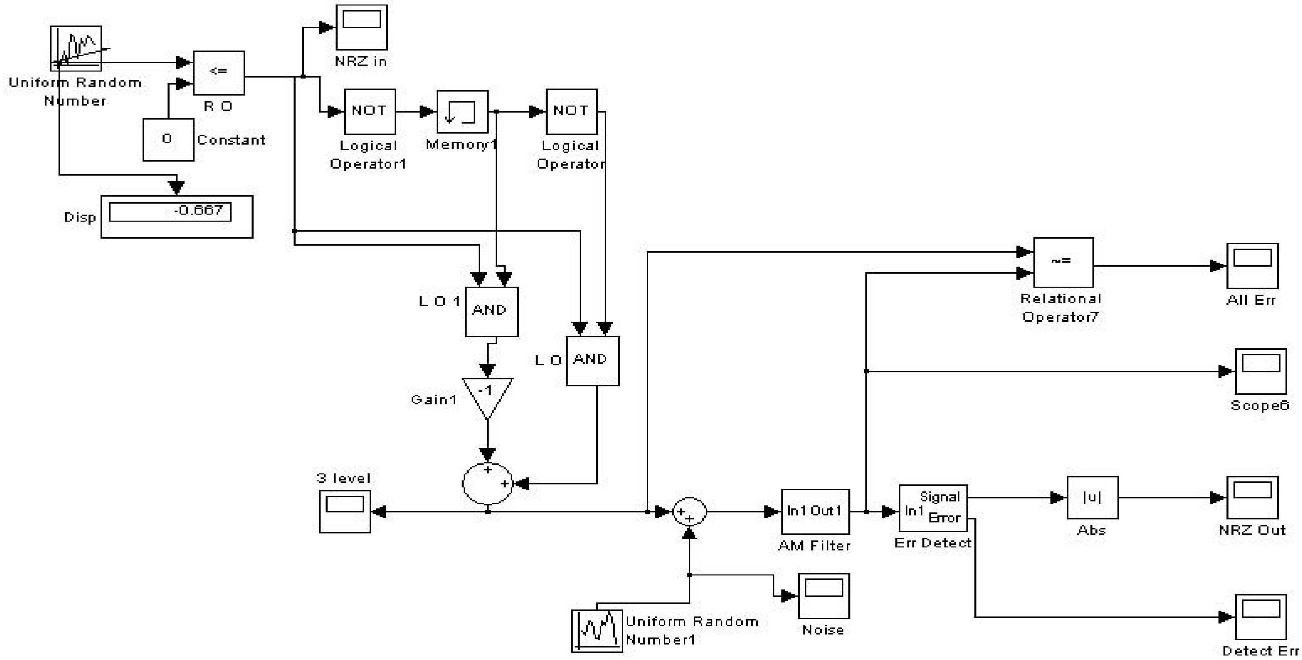

Fig. 3. Software model of PRS system I class II order

We have to note that a modulator is not included in the transmitter, because the channel is made by error generator, whose signal recapitulates with the main signal.

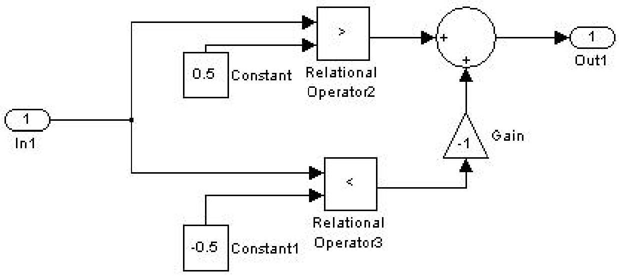

Fig. 4. Amplitude filter

Transformation in binary NRZ signal needs only binary detector (Abs).

This code can find and correct only errors that take “1 as “-1” or the opposite, which rarely met in the real channel, due to the big distinction in levels. If we take in consideration that in coding the sequence “01” is forbidden, we can made a device to find these errors. This is what the “Err Detect” block does.

For modeling of this system, as well as taking the experimental results we used Matlab 6.5.

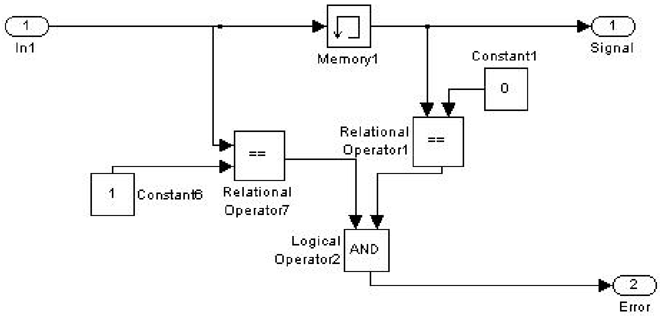

Fig. 5. Error Detector

In the scheme of the suggested model of PRS system we have put some functional blocks, which lead out graphical information for the signal in the most imporatnt points. After completing the fiftieth iteration we can observe the following progress of the signal.

The NRZ signal before the transmitter is shown in Fig. 6.

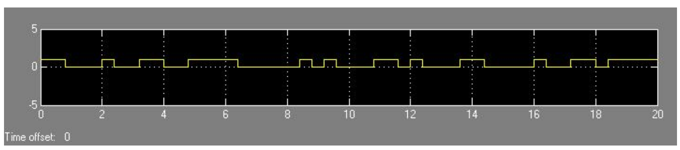

Fig. 6. NRZ in

In Fig. 7 we can see the signal after the transmitter and before the channel. As we can see the signal has three levels.

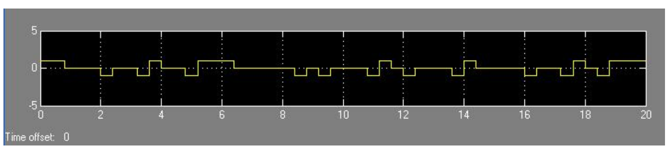

Fig. 7. Signal after the transmitter

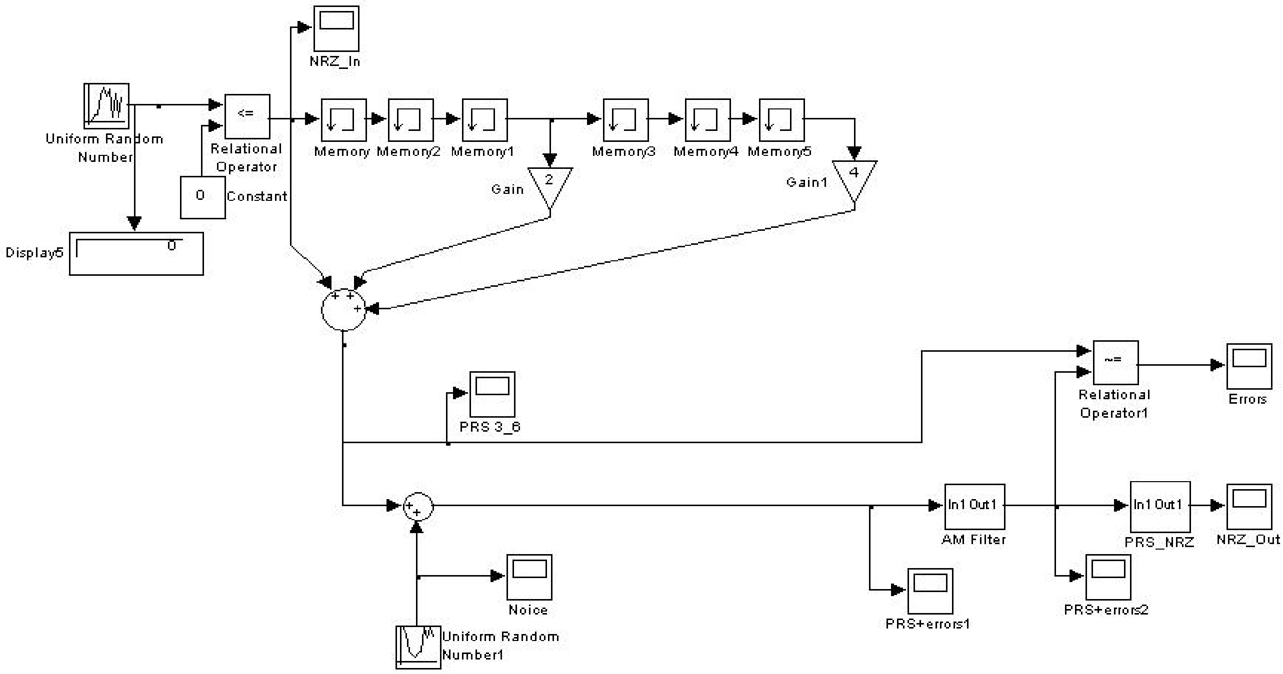

Fig. 12. Software model of PRS system III class VI order

The noise signal, recapitulated to the signal from the transmitter, in order to simulate real conditions in channel, can be seen in Fig. 8.

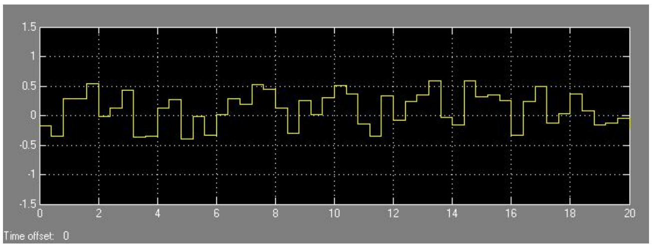

Fig. 8. Noise added in the channel

The signal of the errors is shown in Fig. 9.

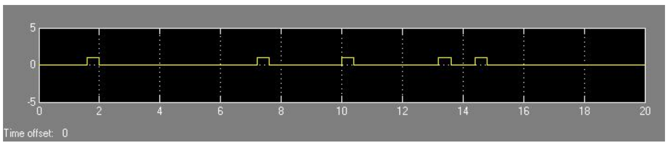

Fig. 9. Errors

The NRZ out signal can be seen in Fig. 10.

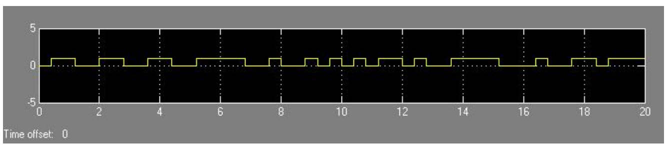

Fig. 10. NRZ out

The signal of the detected in the system errors is shown in Fig. 11.

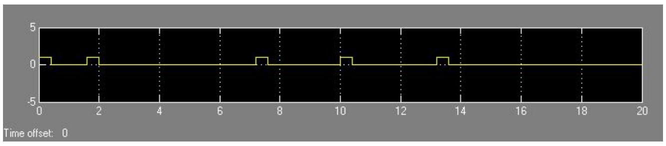

Fig. 11. Detected errors

In the “Scope All Err” Fig. 9. are shown all the errors added in the channel and in “Detect Err” are shown only detected errors, which are detected due to the forbidden combination. As we can see from 5 errors, the system has detected only 4, but they did not correct them. This is indicated with the level “1” in the exit “Detect Err”.

If we compare Figs. 6 and 10, i.e. signals “NRZ in” and “NRZ out”, we can see that if in level “1” only the errors are transmitted, the only undetected error is the error from the fifth “1” in “All Err”.

In this experiment with PRS system, made up of transmitter, channel and receiver, we used first class, second grade transforming, and we couldn’t achieve good results. The system doesn’t detect and doesn’t correct all the errors. At the expense of this the realization of the decoder is very simple and relevantly cheap.

In order to achieve good results from the experiment, we have searched a different resolution. We wanted to gain better results in detecting and correcting the errors, so we made another experiment using a system with third class, sixth grade transforming, which is shown in Fig. 12. The system uses eight grade amplitude manipulation and the Viterbi algorithm for detecting.

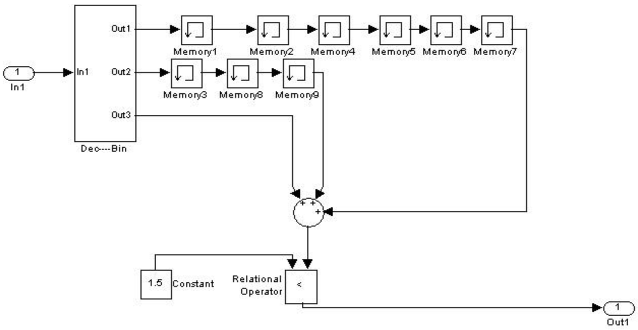

Fig. 13. PRS-to-NRZ

The next figures show the signal in particular points of the model. Their order is identical to that shown above.

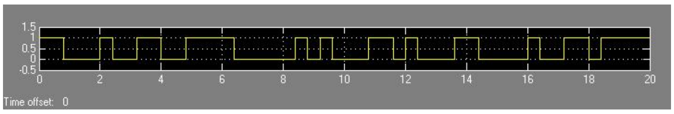

Fig. 14. NRZ in

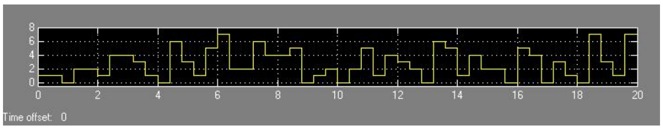

Fig. 15. Signal after the transmitter

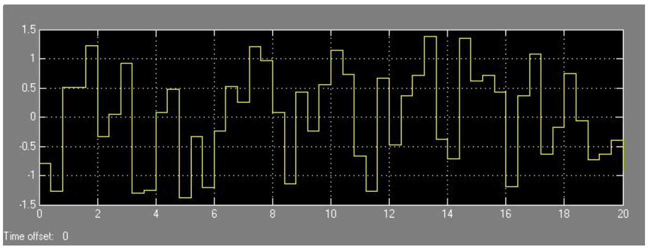

Fig. 16. Noise added in the channel

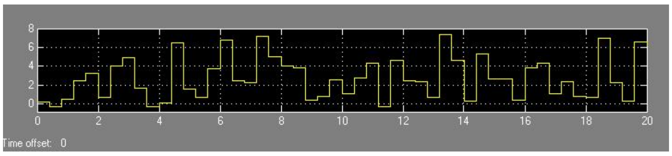

Fig. 17. PRS signal with the added noise

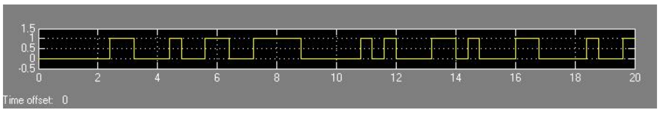

Fig. 18. NRZ out

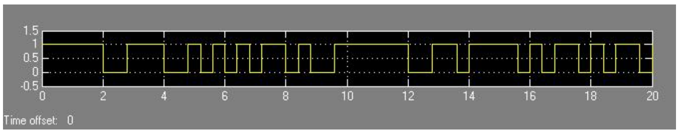

Fig. 19. Detected errors

In this simulation from 50 transmitted symbols, only 17 are received correctly. The others are errors. The decoder has detected and corrected these errors. The above figures show respectively: NRZ in signal, correlated signal with eight levels; the signal before the receiver with eight levels; NRZ out signal, at the exit of the detector. The latter signal is the same as the “in” signal, but delayed seven times.

From this simulation we can see, that the PRS system, that consists of a transmitter, a channel and a receiver, and which is third class sixth level is very resistant to noises. Unlike the system from first class, second grade, this system is relatively more complex. This leads to more expensive model. And yet this complexity and rising of the cost is right for the occasions, where the correct detection of the signal is needed.

III. Conclusion

In this paper the software model of PRS system, consisted of transmitter, channel and receiver, was presented. As the size of this paper is limited we have shown only two PRS systems. But we think that PRS signaling can and will find more and more applications in today’s communications.

References

[1] Добрев Д. М., "Цифрови радиорелейни станции", Техника, 1987год.

[2] Kamilo Feher, "Digital Communications", 1981 by Prentis Hall

[3] Prabhu V. K., "ISI Performance of systems with Correlated Digital Signal", IEEE Transactions on communications, October 1973

[4] Георги Стоянов, "Теоретични основи на съобщителната техика", София, Техника 1987 год.

[5] A. Papoulis, Probability, Random Variables and Stochastic Processes, 3rd ed. New York: McGraw-Hill, 1991

[6] Mark C. Reed, "Iterative Receiver Techniques for Coded Multiple Access Communication Systems", University of South Australia, 1999

[7] Stefan Stanescu, Victor Soare, "Partial Response and Viterbi Detection Channel Simulator for Digital Magnetic", http://www.ici.ro/ici/revista/sic2000_3/art06.html