THE MODELLING OF COMMUNICATION CHANNEL WITH RELAY'S FADING BY USAGE OF ADAPTIVE FILTERS

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The main idea of this article is modelling of communication channel with Relay's fading by usage of adaptive filters, in order to get characteristics of signal's dependences at channels correspondent exits.

The channel simulation – it is a task for adaptive filter creation with variable weighting coefficients, where experimentally taken data of signal's statistical characteristics was used.

The multi beam channel model should have two equal filters with variable weighting coefficients. One of the filters should work in the regime of adaptation and it should set simultaneously the found value of weighting coefficients to the second filter through which the signal under testing is transferred.

Keywords: *adaptive filtration, communication channel, signal processing, relay's fading*

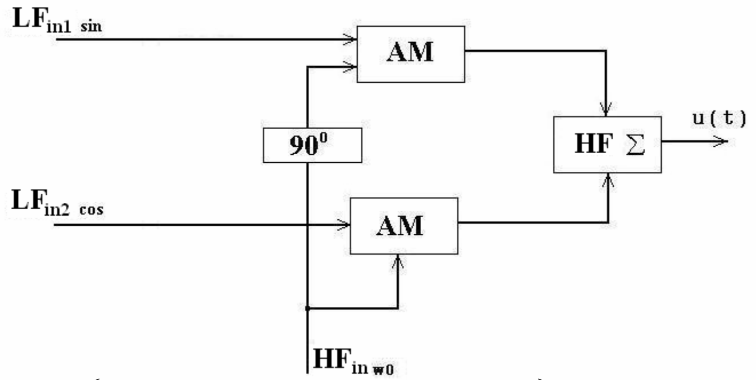
For the multi-beam channel's modelling we need to have a special electronic model (a channel simulator) that could define the output signal when on the input of the channel a signal with any kind of modulation has been received.

Using such a model, different ways of signal's fading control could be investigated, as well as we could compare these methods and then choose the best methods for signals with different kinds of modulation.

At this time in all known methods there are two main ways of channel's modelling. The first one is to make a model of the channel with the help of statistical signal's data without any modulation on the output of the real communication channel. The second way is analytical modelling of multi-path wave propagation [1, 2].

There are structural schemes of signal normalization at the outputs of multi-path channels (see Fig.1 and Fig.2), where statistical characteristics of signals without modulation (on the outputs of real communication channels) have been used.

There is a scheme (Fig.1) that realizes a method of signal's normalization with the help of quadrature modulation [1] at the multi-path channel's output.



$$u(t)=\left\{\sum_{m=-\infty}^{\infty}(-1)^m u(2m\,\Delta t)\sin c\left[\pi\,\Delta F\,(t-2m\,\Delta t)\right]\right\}\cos 2\pi f_0 t-$$
$$-\left\{\sum_{m=-\infty}^{\infty}(-1)^{m+i+1} u(2m\,\Delta t+\Delta t)\sin c\left[\pi\,\Delta F\,(t-2m\,\Delta t-\Delta t)\right]\right\}\sin 2\pi f_0 t$$

Figure 1. *Method of signal's normalization with the help of quadrature modulation at the multi-path channel's output*

To realize this scheme we need to have statistical characteristics of sine and cosine amplitude's envelope of the signal at multi-path channel's output that has been taken experimentally.

There is a scheme (Fig.2) that realizes a method of signal's normalization with the help of modulation of tire carrier by envelope's and phase's readings of the signal at multi-path channel's output [1].

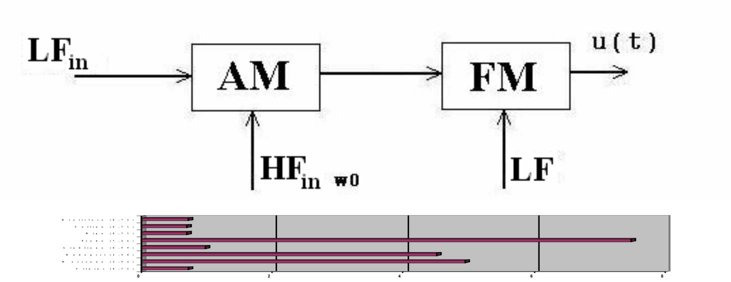


***Figure 2**. Method of signal's normalization with the help of modulation of tire carrier by envelope's and phase's readings of the signal at multi-path channel's output*

It is needed to have statistical characteristics of signal's envelope and phase at multi-path channel's output that has been taken experimentally for the realization of that scheme.

There is a scheme (Fig.3) where analytical modelling of multi-path wave propagation has been shown.

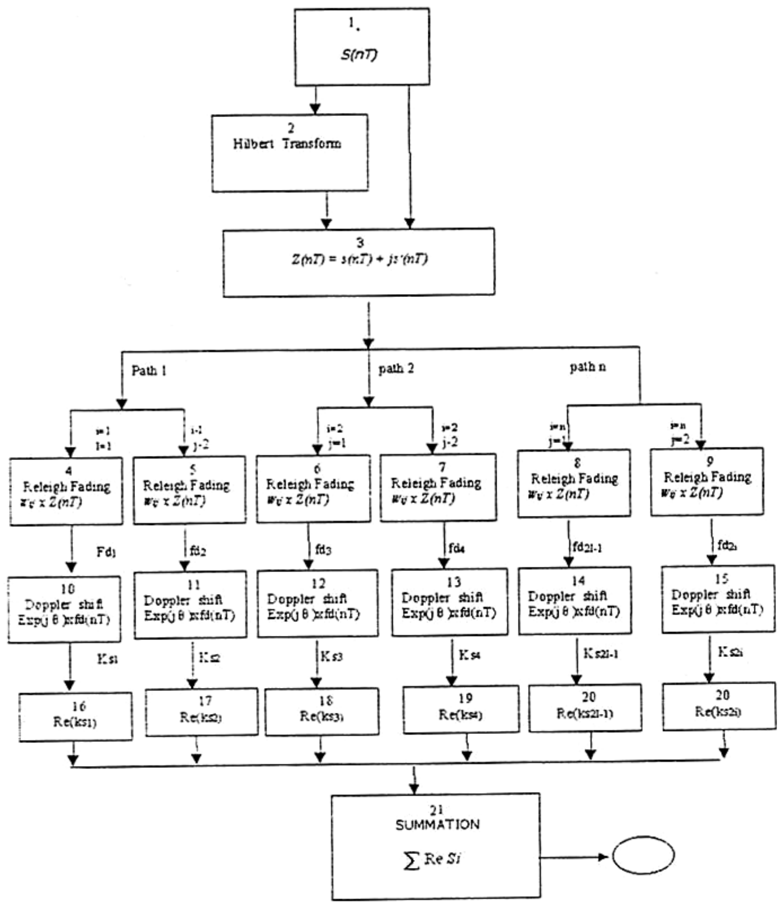


***Figure 3.** Analytical modelling of multi-path wave propagation*

It is needed to model separate beams (with the help of Hilbert transform, Relay's delay, Doppler shift) for realizing this scheme. Then the real part of every complex signal has been allocated and added to each other in consecutive order.

From all the methods mentioned above, only the last one has a possibility to get a response when signals with any kind of modulation are sends on the input of the system.

But the most important disadvantage of the last method is that the result depends on the amount of signal's copies that was added to each other. And, because of this, it is very difficult to identify such a model with real communication channel.

The identification of the model to a real communication channel needs to have additional experimental researches.

Nowadays, adaptive methods of system's identification are developed. Those methods could be also used in multi-path channel's modelling as well [3, 4].

The basic element of systems with adaptive identification is a linear adaptive adder [3, 4]. This is a transversal filter with variable weighting coefficients that is shown on Fig.4.

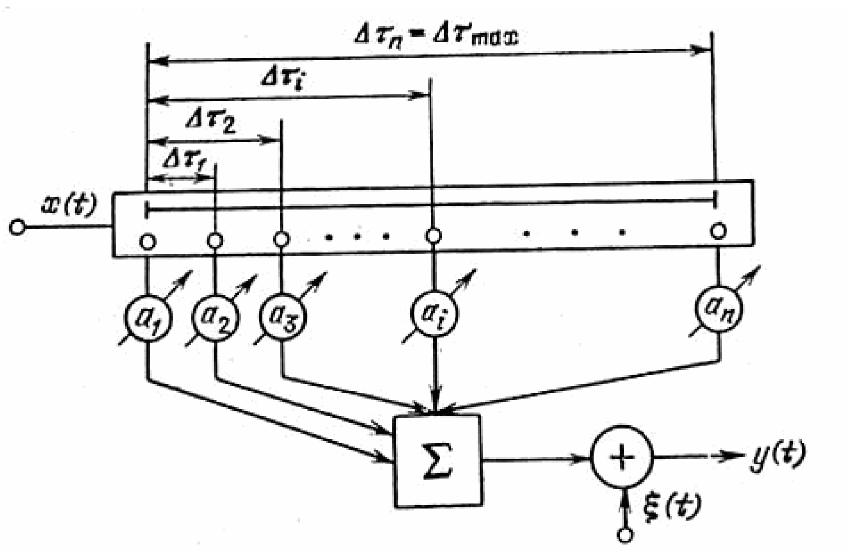


Figure 4. *Linear adaptive filter*

So, going on this way, for multi-path channel modelling it is needed to create an adaptive filter with variable weighting coefficients that are selected in real time and are used in the system. For separating two operations that are made simultaneously (the selection of coefficients and passing signal through the system) we should make those operations in two parallel ways.

The scheme of adaptive model for multi-path radio waves propagation (Fig. 5) is shown.

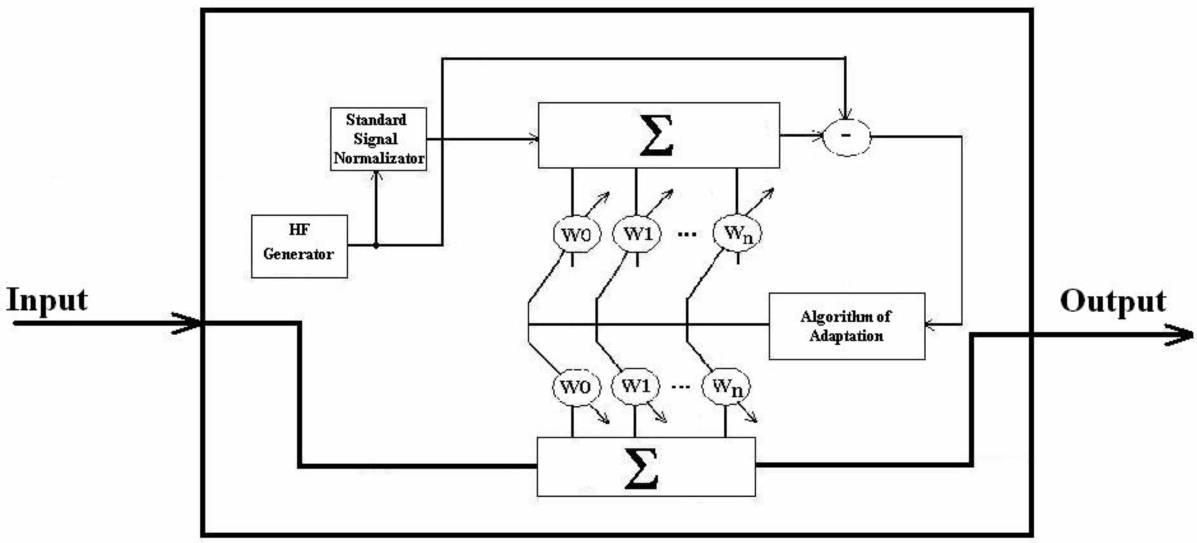


Figure 5. *Scheme of adaptive model for multi-path radio waves propagation*

This multi-path channel has two identical filters with variable weighting coefficients. One of those filters operates in adaptation mode to the test signal. The test signal is formed with the help of method that is shown on Fig.2. This exact method of the test signal forming has been chosen because we had real statistical characteristics of signal's envelope and phase at the output of multi-path channel that was received experimentally [5]. As the algorithm of adaptation a method of least square estimator has been taken. The value of weighting coefficients from the first filter are given to the second one, which is intended to pass through it signals with any kind of modulation.

This modelling was made in application Matlab. But because of manuscript volume's limits it is not possible to present the body of this program there.

The testing results of model for passing through the system signals with amplitude modulation when depth of fading has been changed (Fig. 6) are shown.

When the amplitude on channel's output is normalized, the time scale estimates the depth of fading when the amplitude of the signal is lower than a threshold value to a length of signal's sample at the channel's output.

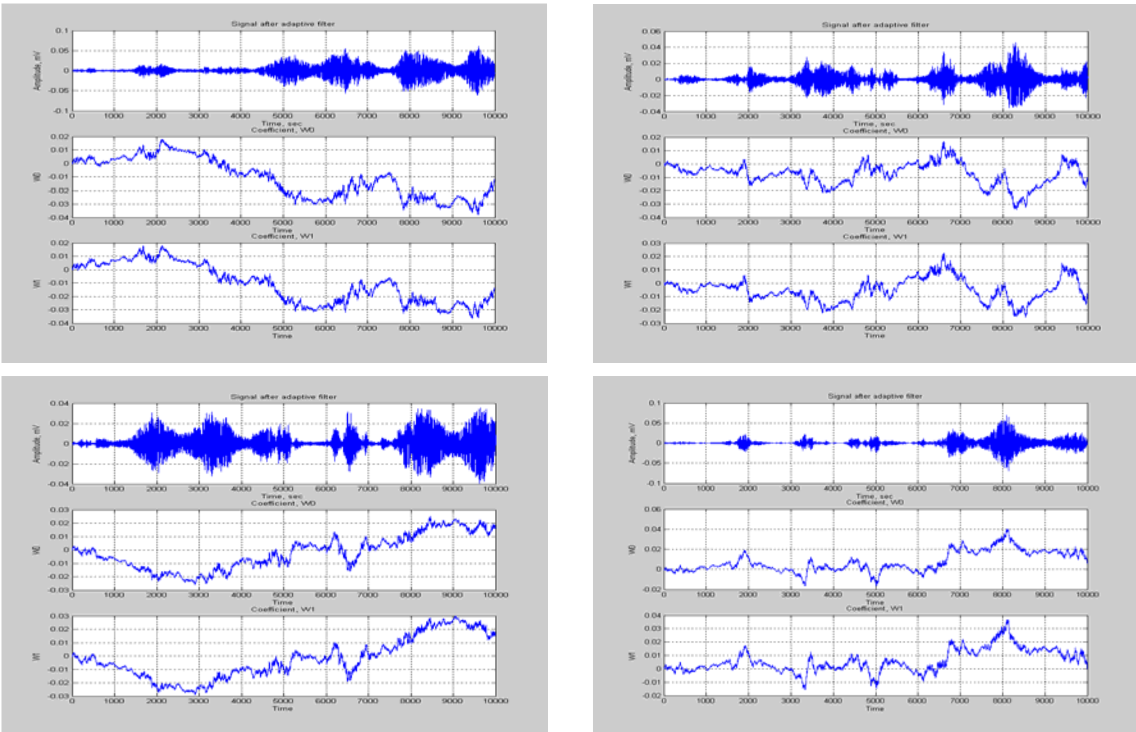


Figure 6. *Testing results of model for passing through the system signals with amplitude modulation when depth of fading has been changed*

The results after model testing are shown in three diagrams. The signal at the channel's output and behaviour of two weighting coefficients in the model are shown. These coefficients correspond to a process of signal normalization. At the diagrams presented above we could see that this model could help us in modelling multi-path channels with changeable depth of fading.

References

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