MODEL-FOLLOWING ADAPTIVE EQUALIZER

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ABSTRACT: A new methodology for adaptive equalizers design, that could be considered as a kind of generalized and frequency selective Automatic Gain Control (AGC) circuits, is presented. This method is based on model reference adaptive systems (MRAS), and has been obtained by applying modern Control Theories to Communication Systems [5]. Apart from the robustness, its main advantages are that a feed-back channel is not required, and that it's not based on iterative or recursive algorithms (not convergence problems). Analytical and simulation results are presented.

1.- Introduction.

Communications systems through turbulent or reflecting media have the problem of the fluctuations in the received signal level. During last years several adaptive control strategies have been proposed in order to compensate channel variations such as fadings. In this paper a study of an hyperstable adaptive system is presented, which constitutes an alternative to the adaptive ones based on variable rate transmission [1] and to adaptive systems that require an identification of the channel characteristics (by using isolated test pulses or random sequences) in order to find the optimal set of tap gains after certain number of iterations [2][4]. The adaptation method here proposed is not based on Wiener or Kalman structures, and although its applications are similar than the Widrow's Adaptive Interference Canceled [7] [3] [2], the obtained adaptive law is easy to implement if the communication system has a carrier pilot or if a reference cosine wave is send.

Non-linearities or parametric variations in the channel or in the first stages of the receiver are considered in the design. The main advantages are that a feed-back channel is not required, and that it's not based on iterative algorithms (as the classical gradient-type one). Neither the tap gain adjusting algorithm convergence nor the number of iterations are a problem for the proposed adaptive system.

The basic idea is well-known: to nullify the error between the received carrier (or reference input) and a signal reconstructed by an oscillator (which could be synchronized with the transmitter carrier oscillator, like in several homodyne receptors). The methodology to design a control system capable to nullify this error by using the hyperstability theory is presented in the paper. If the transmitted signal is narrow-band (high carrier frequencies), it's possible to take the habitual assumption

that carrier variations are an indicator of the transmitted signal ones. This supposition is studied by computer simulation.

Finally some technological aspects to implement the adaptive system are presented.

2.- System structure.

The proposed method is based on the scheme of figure 1. The adaptation system is devoted to nullify the error $e(t)$ between the received carrier $x_c(t)$ and the locally generated reference one, $x_m(t)$. It could be considered as a kind of synchronous demodulator where the received carrier is continuously compared with the expected one in order to correct alterations in the transmission (module and phase).

FIG.1.- System structure.

3.- Design of the adaptation system.

The adaptation method described above can be modeled according to figure 2, where the reference model imposes the desired behaviour of the set channel - RF stage and filter.

FIG.2.- Adaptation system model.

According to Popov Hyperstability Theory [6], if the model is decomposed in a linear part ($H(s)$) and a non-linear one ($M(s)$), the overall system will be asymptotically hyperstable if the linear part is real and strictly positive and the non-linear one fulfills the passivity relation:

$$\eta(0,t) = \int_0^t \gamma^T \rho dt \geq -\gamma_0^2 \quad (1)$$

0, $B_1 = 42/900$, $B_2 = 1/900$. Carrier separator is based on a second order band-pass filter with $\xi = 0.3$ and $\Omega_0 = 5$.

Although the results of figure 5, the performances are not good in ASK simulations. By using a more selective carrier separator, (crystal or PLL based), the results are significantly improved. Figure 6 shows time responses of the same system when a good carrier separator is used. In this case modulating signal has a band-width of $\Omega = 3$, and the carrier frequency is $\Omega_0 = 10$. Channel parameters are $\xi = 0.7$, gain = 0.7 and $\Omega_0 = 30$.

Figure 7 shows the same results when channel varies to $\xi = 0.35$, gain = 0.7 and $\Omega_0 = 6$. Spectra comparison (obtained from a FFT of time responses) when channel is $\xi = 0.2$, gain = 0.7 and $\Omega_0 = 20$ is shown in figure 8.

FIG.5.- Time simulations with a low selective carrier separator.

FIG.6.- Time simulations with an improved carrier separator. (1: transmitted signal. 2: received without adaptation. 3: received with adaptation).

FIG.7.- Responses with a bad channel. (1: transmitted signal. 2: received without adaptation. 3: received with adaptation).

FIG.8.- Spectra comparison.(1: transmitted signal. 2: received without adaptation. 3: received with adaptation).

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