Polish Academy of Sciences
University of Engineering and Economics in Rzeszów
University of Life Sciences in Lublin

MOTROL

COMMISSION OF MOTORIZATION AND ENERGETICS IN AGRICULTURE

AN INTERNATIONAL JOURNAL
ON OPERATION OF FARM
AND AGRI-FOOD INDUSTRY MACHINERY

Vol. 20, No 1

LUBLIN – RZESZÓW 2018

C O N T E N T S

MOTROL. Commission of Motorization and Energetics in Agriculture – 2018. Vol.20. No.1. 79-82

CREATION OF THE METOD AND SCHEMES FOR SUPPRESSION OF OUT-OF-BAND INTERFERENCE

Taras Hutsol[1], Nataliya Kosulina[2], Liudmyla Mykhailova[1]
[1]State Agrarian and Engineering University in Podilia
St. Shevchenko, 13, Kamyanets-Podilsky, Ukraine. E-mail: tte-nniekt@ukr.net
[2]Kharkiv Petro Vasylenko National Technical University of Agriculture
St. Alchevskyh, 44, Kharkov, Ukraine. E-mail: tte-nniekt@ukr.net

Summary. Subject of this article is theoretical substantiation of the adaptive algorithm of suppression of out-of-band interference. Substantiation is based on the method of signal isolation from the background of additive interference. The essence of the method is to pass a mixture of signal and interference through a filter in which interference is suppressed while the signal practically does not change. In order to estimate the efficiency of the scheme of the additive compensator for out-of-band interference and to calculate the output signal-to-interference ratio the method of minimum mean square error was used.

Key words: out-of-band interference; interference suppression filter; signal / noise at the output of the filter; mean square error.

INTRODUCTION

During the life course of any biological object a complex appearance of the physical field arises. Their special distribution and the change in the timeline provide with significant biological information, which can be used, in particular, in order to the veterinary and medical diagnostic purposes. Since the physiological activation of the animals' internals relates particularly to the pathologic process in them, and is accompanied by a rise in their thermogenesis and internals blood flow, it can be registered by using the data of heat mapping. The foregoing states the fact that the blood should be one of the main study subjects in assessing the state of an animal organism, and also while studying the electromagnetic field radiation of its organism.

As a result of the literary sources analysis, it was determined that the structure and receiver sensitivity of the animals infrared rays will depend on the method and circuit design for suppression of out-of-band interference [1, 12].

The suppression of out-of-band interference in the radiometer receiver can be seen as an aspect of the task of the optimum filtration, when the signal and noise are passed through the filter, in which the noise is suppressed, but the signal is not changed. The suppression algorithm of out-of-band interference that can be synthesized on the basis of this method is a solution of the Wiener-Hopf equation [2].

To create an additive compensator of out-of-band interference (ACOI) it is important to undertake a theoretical study, related to the obtained proportions for the suppression algorithm of out-of-band interference upon criterion of the minimum mean square error (MMSE) in the complex differential form [3].

ANALYSIS OF RESEARCHES AND PUBLICATIONS

Today, the method of the minimum mean square error was widely distributed in the adaptive system theory [3, 4]. The algorithm that can be synthesized on the basis of this method is a solution of the Wiener-Hopf equation through the steepest descent method with the help of an approximation, which is that the square of a single sample of the error signal at the output of the additive compensator of out-of-band interference (ACOI), and is accepted as the assessed value of the mean square error MSE [5].

Therefore, the given algorithm MMSE requires minimal information on the interference parameter and could provide with a basis for the practical application and realization of the adaptation theory while the complex system construction. However, the mathematical justification of this algorithm was currently held only in discrete time, and known results were obtained in the quasistatic approximation [4-7], leading to the limited prospects usage of the obtained algorithms to suppress interference in complex dynamical systems.

Since the optimal resolution of the adaptive compensation problem is, as a rule, physically unrealizable [4, 5], a quasi-optimal algorithm of suppression of out-of-band interference must be obtained, and which could be relatively easily realized physically [4]. Furthermore, it is important to provide it with the rapid convergence in time to the optimal resolution [4-13], i.e. could ensure suppression in real time, but not in the process of post-processing [4].

OBJECTIVES OF RESEARCH

Subject of research is the suppression process of out-of-band interference with the help of the additive compensator of out-of-band interference.

Objective of research is the theoretical analysis of the method and schemes of suppression of out-of-band interference in radiometer receiver.

To reach the objective it was necessary to fulfill the following tasks:

1. To prove generalized structural scheme of the additive compensator of out-of-band interference.
2. To determine the efficiency of the suppression additive compensator of out-of-band interference and calculate the signal / noise at the output.

THE RESULTS OF RESEARCH

To justify theoretically the suppression adaptive algorithm of out-of-band interference the general structural scheme shown in Fig. 1 was used.

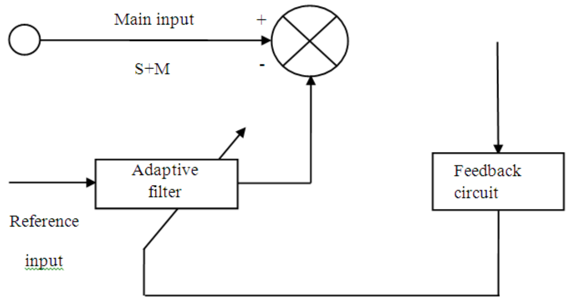

Fig.1. General structural scheme of adaptive compensator: S, M, N – useful and interfering signals

Consequently, N is correlated to M, but they are not statistically interrelated, or it is weakly correlated to S [3]. Based on this scheme the suppression adaptive algorithm of out-of-band interference was synthesized: where: RSGD – reference signal generation device; AF – adaptive filter.

Synthesizing scheme (Fig. 2) has one common input (for the main and reference inputs), which is the main input for the compensating circuit. Useful signal and frequency-separable (out-of-band in relation to useful) interference go to this input. In the reference signal generation device (RSGD), the useful signal is filtered, as a result of which interference will be received on the input of the adaptive filter of the adaptive interference compensator (AIC) that are correlated only to interference in the main input. At the same time, the synthesized adaptive algorithm should definitely determine the structure and characteristics of the adaptive compensator construction of out-of-band interference [3-7]. To synthesize the schemes for suppressing frequency-separable signals with a useful signal, it is necessary to obtain an equation for the analogue MMSE algorithm in the complex domain.

Let us write down the equation for the interfering signal X (out-of-band signal load on the reference input of AIC and for the parameter transfer function AF W as follows [10]:

$$X(S) = X_R + iX_I, \qquad (1)$$

$$W(t;S) = W_R + iW_I, \qquad (2)$$

where: R and I – real and imaginary components of the complex quantities; i –unit imaginary number; S – argument of the Laplace transform.

Let us write down the equation for the error signal and the signal in the main input of AIC Y as follows [10]:

$$\varepsilon(t;S) = \varepsilon_R + i\varepsilon_I, \qquad (3)$$

$$Y(S) = Y_R + iY_I. \qquad (4)$$

As far as the input and output quantities are presented in complex form, thus, the algorithm should provide with the reconstruction of both imaginary and real components of the parametric transfer function AF. Therefore, the output signal AF Z is in complex form, the records can be represented as follows [10]:

$$Z(t;S) = Z_R + iZ_I. \qquad (5)$$

Let us write down the equation in short form for the error signal in output of AIC and the signal in output AF [11]:

$$\varepsilon(t;S) = Y(S) - Z(t;S), \qquad (6)$$

$$Z(t;S) = W(t;S)X(S). \qquad (7)$$

Since the synthesized algorithm provides with the reconstruction of both the imaginary and real components of the parametric transfer function *W (t, S)*, under this, the following conditions are fulfilled [11]:

$$\lim_{t\to\infty} \varepsilon_R = \varepsilon_{R\min}, \qquad (8)$$

$$\lim_{t\to\infty} \varepsilon_I = \varepsilon_{I\min}. \qquad (9)$$

Notably, the most appropriate for this minimization of the objective function is the average power of the signal in output of AIC:

$$E[\varepsilon(t;S)\varepsilon^*(t;S)] = E[\varepsilon_R^2 + \varepsilon_I^2] = E[\varepsilon_R^2] + E[\varepsilon_I^2], \qquad (10)$$

where: E is the symbol of the mathematical expectation of a random variable is collected in parentheses: an asterisk (*) means a complex conjugate (since both components of the error signal $\varepsilon(t,S)$ are shifted 90° in phase relative to one other, their minimization is not possible in isolation).

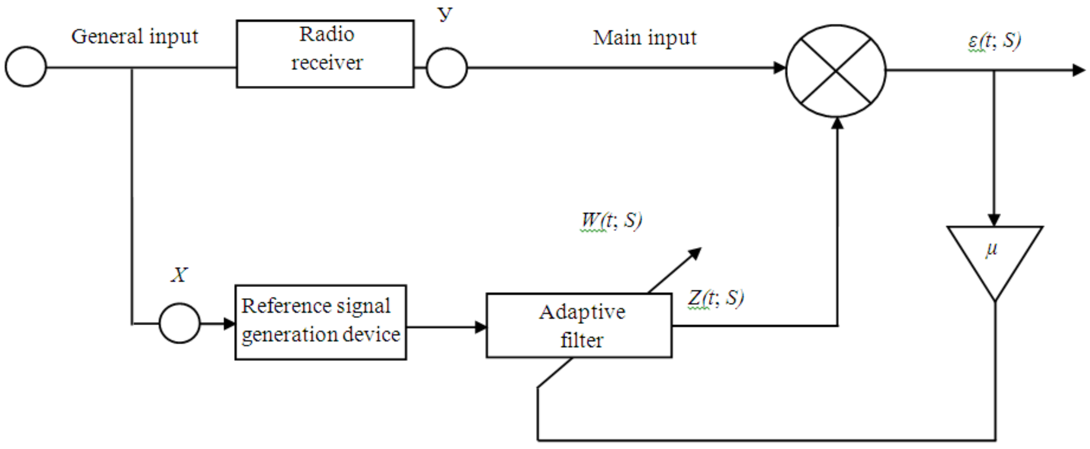

Fig. 2. Functional summary scheme of an analog ACOI

The equation for the complex-conjugate error to the signal looks as follows:

$$\varepsilon^*(t;S) = Y^*(S) - W^*(t;S)X^*(S). \quad (11)$$

Let us find the instantaneous value of the gradient ∇ of the quantity $[\varepsilon(t,S)\varepsilon^*(t,S)]$ along the real and imaginary components:

$$\nabla_R[\varepsilon(t;S)] = \varepsilon(t;S)\{\nabla_R[\varepsilon^*(t;S)]\} + \varepsilon^*(t;S)\{\nabla_R[\varepsilon(t;S)]\} = \varepsilon(t;S)\{-X^*(S)\} + \varepsilon^*(t;S\{-X(S). \quad (12)$$

$$\nabla_I[\varepsilon(t;S)\varepsilon^*(t;S)] = \varepsilon(t;S)\{[\varepsilon^*(t;S)]\} + \varepsilon^*(t;S)\{\nabla_I[\varepsilon(t;S)]\} = \varepsilon(t;S)\{iX(S)\} + \varepsilon^*(t;S)\{-iX^*(t;S\}. \quad (13)$$

Applying the steepest descent method to the real and imaginary components of the parametric transfer function AF by means of their reconstruction along the corresponding assessed gradient value, taken with a minus sign, we have:

$$\frac{dW_R}{dt} = -\mu\nabla_R[\varepsilon(t;S)\varepsilon^*(t;S)], \quad (14)$$

$$\frac{dW}{dt} = -\mu\nabla_I[\varepsilon(t;S)\varepsilon^*(t;S)]. \quad (15)$$

In response to the equation (6) we can write:

$$\frac{dW(t;S)}{dt} = \mu\{\nabla_R[\varepsilon(t;S)\varepsilon^*(t;S)] + i\nabla_I\varepsilon(t;S)\varepsilon^*(t;S). \quad (16)$$

Further, using the equations (12) and (15), we finally have the unknown formula for the analog compensation algorithm of out-of-band interference upon the MMSE criterion in complex differential form [10]:

$$\frac{dW(t;S)}{dt} = -2\mu\varepsilon(t;S)X^*(S). \quad (17)$$

In Fig. 2 the general operating scheme of one-dimensional AIC constructed in accordance with the obtained analog adaptive algorithm of MMSE in the spectral domain is presented [10].

CONCLUSIONS

1. The influence of high frequency electromagnetic field of the radio-frequency voltage zone on the phase of animal skin cover will slow down the inflammation process, improving the blood circulation, microcirculation of blood and lymph, increasing the absorption of oxygen by tissues, activation of regenerative processes that will lead to recovery of the animal. The application of low-energy electromagnetic fields for restoring animal skin cover is considered to be significantly different from the existing physical and therapy procedures.

2. In theory, suppression of out-of-band interference (for example, through an image channel) can be implemented with the help of one AIC if its parameters (its own dynamic range, working band) are coordinated with the parameters of compensated interference.

1. The synthesized MMSE algorithm is justifiable and unbiased, and obtained efficiency while its implementation is high enough, accordingly this algorithm can be used to compensate out-of-band interference in dynamic systems.

REFERENCES

1. Industrial interference. Test methods for sources of industrial radio interference. – M.: Publishing house of standards, 1984.
2. **Kuzmin V.B. 1982.** Construction of group solutions in spaces of clear and fuzzy binary relations / V.B. Kuzmin. – M.: Nauka.
3. **Burakov V.A., Zorin L.A. 1976.** Adaptive signal processing in antenna gratings // Foreign radioelectronics. – № 8. 35-39.
4. **Undrow B. 1975.** Adaptive interference cancellers. Principles of construction and application / B. Undrow. – TIIER. 12, 69-97.
5. **Bikhoveniy M.A. 1984.** Application of multi-channel interference cancellators in communication channels // Radioteknika. – № 12. 9-16.
6. **Maksimov M.V. 1976.** Protection against radio interference / M.V. Maksimov. – M.: Sov. Radio.
7. **Loshin V.I., Komarov V.M., Nesterenko N.I. 1983.** Adaptive antenna arrays in broadband communication channels // Foreign radioelectronics. – № 5. 3-23.
8. **Kamenev E.F. 1985.** Methods of processing signals in the presence of interference in communication lines // Radio and communication. – M.
9. **Bristod T.A. 1980.** Application of adaptive interference cancellators for radio communication and radiolocation: Express information // Radio engineering of ultrahigh frequencies. – № 22. 16-20.
10. **Tikhonov V.I. 1982.** Statistical radio engineering. Radion and connection / V.I. Tikhonov – M.
11. **Tsypkin Y.Z. 1977.** Basics of the automatic system theory / Y.Z. Tsypkin. – M.: Nauka.
12. **Gutsol T., Cherenkov A. 2017.** Analysis of noise immunity and the electromagnetic environment in the areas of remote diagnostics of the state of animals with radiometric receiver. Bulletin of the Kharkiv National Technical University of Agriculture named after Petr Vasilenko. Technical sciences, 186. 144-145.
13. **Hutsol T. 2017.** Analysis of circuit solutions of radiometric receivers. Bulletin of the Kharkiv National Technical University of Agriculture named after Petr Vasilenko. Technical sciences, 187. 107-108.
14. **Pantsyr Y., Garasymchuk I., Hutsol, T., Gordiychuk I. 2018.** Energy Parameters' Calculation of a Hybrid Heat Supply System for a Private House in the Conditions of Western Part of Ukraine. Renewable Energy Sources: Engineering, Technology, Innovation. 765-780.
15. **Cherenkov A., Kosulina N., Sapruca A. 2015.** Theoretical Analysis of Electromagnetic Field Electric Tension Distribution in the Seeds of Cereals Research journal of Pharmaceutical, Biological and Chemical Scinces. November – December. RJPBCS 6(6). 1686 – 1694.

16. **Borysevych V. 1992**. Zahalna veterynarna medytsyna [General Veterinary Surgery]. Kyiv: Vyshcha shkola, 480.
17. **Kalynychenko A.V., Hordyichuk Y.I. 2006.** Raspredelenye vnutrennykh elektromahnytnykh polei v potohennykh kokakh nakhodiashchykhsia pod vozdeistvyem vneshneho elektromahnytnoho izluchenyia [Distribution of external magnetic fields in pathogenic cocci]. Enerhosberezhenye, энerhetyka, энerhoaudyt. Obshchehosudarstvennyi nauchno-proyzvodstvennyi ynformatsyonnyi zhurnal. 11, 31-36.
18. **Ymmoreev I.Y. 2010.** *Spatio-temporal changes UWB signals during the emission and reception of large antennas.* Ymmoreev I. Y. IV All-Russian Conference “Radiolocation and Radio Communication" Institute of Radio Engineering and Electronics, Russian Academy of Sciences, 29 November − 3 December, 615-620.
19. **Kalinichev V.I. 2009.** Ultra-wideband mirror antenna with horn irradiator H-shaped cross section. Kalinichev V.I., Kaloshin V.A., Pangonis L.I. III All-Russian Conference "Radiolocation and radio communication", IREE RAS, 68-71.
20. **Kun Z. 1967.** Microwave Antennas. Z. Kyun; translation from German under the editorship of M.P. Dolukhanov. L., Shipbuilding, 518.
21. **Potapsky P., Garasimchuk I., Kozak A., Mikhailova M. 2015.** Theoretical justification for creating an impulse generator for increasing the immunity of animals. MOTROL Commission of motorization and energetics in agriculture: Polish Academy of sciences. Vol. 17,.5, 62-65.