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THE ELECTROMAGNETIC INTERFERENCE IN CASE OF ON BOARD NAVY SHIPS COMPUTERS` - A NEW APPROACH

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Abstract: *The electromagnetic interference in case of onboard navy ships computers'- A New Approach presents a dynamic-statistical modeling applied to computer's ship that works in condition of complex electromagnetic disturbances - a new modality to analyze and predict the effects of electromagnetic disturbances upon the electronic computers. On a navy ship, like a complex electromagnetic system, the electronic microcomputers are submitted to a large ensemble of disturbances, transmitted by field and by conduction. Due to the complexity of this phenomenon and the dynamic-random character of the interferences processes, the traditional methods, such a tests and measurements, becomes insufficiently. The proposed method, named Box-Jenkins Methodology, a dynamic-statistical modeling based on time series/dynamic series is applied to computer's ship that works in condition of complex electromagnetic disturbances. It offers, beside the tests and measurements methods, a dynamic-statistical modeling possibility of the complex electromagnetic interference and the prediction on a short time horizon of the computers' stability and safety.*

Introduction

A navy ship represents a complex electromagnetic system on which the electronic microcomputers are submitted to a large scale a disturbing frequencies (50Hz-20GHz).

Such disturbances are constituted by the dynamical-random combinations of some signals, transmitted by conduction and by field.

The traditional method used for the EMI evaluation, based on tests and measurements, becomes insufficiently, due to the complexity of the dynamical-random character of the disturbances.

The proposed method - the methodology for analyze and prediction of time series (dynamic series), on a short time, named "Box-Jenkins Methodology"- offers the possibility to identify the computer evolution and its stability in presence of a great number of disturbances. Even more, this one permits to predict this evolution on a short time [1],[2],[3].

It is important to emphasize that this method is a complementary one to the traditional methods.

The idea of the method

The main idea of this method consists in the fact that a data series, characterizing a dynamic-random process: Zt, Zt-1, Zt-2…, strongly dependent, could be considered as being generated by filtering of an independent statistic value series: at, at-1, at-2…, having a fixed distribution function (usually normal, with null average and σ2 dispersion) (fig.2.1) [2], [3].

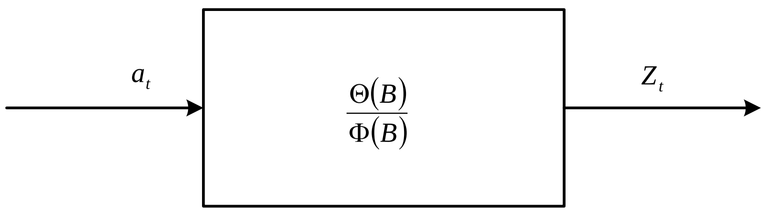

Fig.2.1. Analyzed process such a linear filter

The sequence {at} represents a white noise type process.

The {Zt} values of the analyzed process- the answer of the microcomputers of the electromagnetic disturbances on their whole – picked up at equal time intervals(ms, s, m, h etc.), represents a time series (dynamic series); this series will be submitted to a subsequent processing.

If we note $\Theta(B)/\Phi(B)$ the transfer function of a linear filter, we can write:

$$Z(t) = \frac{\Theta(B)}{\Phi(B)} = \frac{1-\Theta_1 \cdot B^1 - \Theta_2 \cdot B^2 - ... - \Theta_q \cdot B^q}{1-\Phi_1 \cdot B^1 - \Phi_2 \cdot B^2 - ... - \Phi_p \cdot B^p} \cdot a_t \quad (2.1)$$

In according to the relation(1) the time series {Zt} can be interpreted as being the exit of the linear filter and the values {at} – the input of the filter.

Θ(B) represents an autoregressive operator(AR), and Φ(B) – a sliding average operator(MA), in case of a parametric model of the process; B is a delay step operator, given by relation:

$$B \cdot Z_t = Z_{t-1} \quad (2.2)$$

The relation (2.1) allows us to represent the current values of the dynamic-random process by its previous values and by a current and previous values of the white noise.

The problem is to determine some parametric models, such as (2.1), for the analyzed process, named "ARMA" models.

After the stage of choosing the optimum model, it follows the stage of parameters estimation. Then, the model is submitted to a validation procedure and, finally, to a prediction stage.

The prediction procedure is a short time horizon and offers precious information about the most probable evolution of the computers’ stability in the disturbing environment.

The stages of the method

Practically, the main stages of this methodology are the following:

Stage 1. Model identification

In this stage it used two measuring instruments to analyze the statistic independence between data of series: the autocorrelation estimated function – facr and the partial autocorrelation estimated function – facrp.

In order to express the statistic relation between the data of series, Box and Jenkins suggested a family of models ARMA (p, d, q)(P,D,Q), where (p, d, q) refers the unseasonable character of the model and (P, Q, D) – the seasonable character. These models are called Autoregresive and Sliding Average Models. The facr and facrp theoretical functions are associated to these models.

Finally will be chosen the model of the analyzed series for witch the estimated functions *facr* and *facrp* are closest to the theoretical functions *facr* and *facrp*.

The chosen of this model imposes to pass to the next stages: estimation of parameters and validation of the model.

Stage 2. Estimation of the parameters

We determine, in this stage, the estimated values for the parameters of the chosen model, in certain conditions of stationarity and reversibility. If these conditions are not fulfilled, the model will be rejected.

Stage 3.Validation and diagnosis of the model

The next stage consists of the validation of the model. In other terms, the chosen model must to fulfill the quality procedure asked by „Box-Jenkins” methodology.

Stage4. Prediction of the analyzed data series

The prediction problem assumes the obtaining the future values (on a short horizon of time) of the initial series, respectively {Zt+1, Zt+2, …} values, conditioned by the data of analyzed series till the “t” moment; this moment represents the origin of the prediction stage.

The implementation of the method

In order to implement the „Box-Jenkins” methodology on board of the navy ship, the following software tools have been used:

the program-package TS-System (System identification and parameters estimation) [4];

the program DAqS-DATA ACQUISITION SYSTEM [5], for data acquisition;

the program-package SELFTEST, for testing the susceptibility of the microcomputers (EUT-Equipments Under Test) at the complex electromagnetic disturbances [6].

Also, for acquisition of the data is used the process board type IMP 35951 SOLARTRON INSTRUMENTS Ltd., U.K. (20 channels, 10-20 μA, -12V +12V).

The EUT (Equipment Under Test) were consisted of two PC 486 computers.

The research was performed in two stages. In the first stage: the determination of the susceptibility of the microcomputers at the global electromagnetic disturbances on board; in the second stage: the prediction of there susceptibility.

Measurements have been made for 10 operating Modes of a navy ship, from starting the electric generators, up to the operating the Navigation Stations, Radar Stations, Radio Stations.

The distribution of data for Mode 3 is presented in fig.2.2.

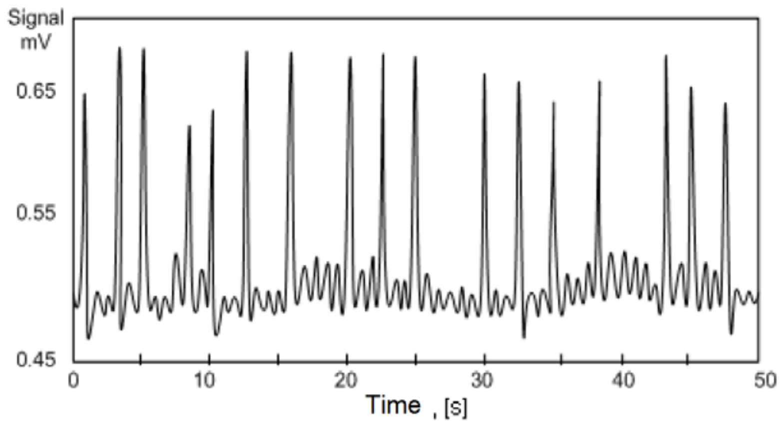

Fig.2.2. Distribution of data for Mode 3

The values of autocorrelation function for 20 values of the delay, as well as the value of the statistic test “T” show that there is a correlation in data. The correlation matrix of the model coefficients are presented in Table 2.1, for 5 Modes of operation.

Table2.1. Correlation matrix of the coefficients

No. mode	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
Mode 1	1.000				
Mode 2	0.912	1.000			
Mode 3	0.924	0.863	1.000		
Mode 4	0.926	0.860	0.988	1.000	
Mode 5	0.926	0.880	0.987	0.976	1.000

It can see that the rates of correlation of data have values between 0,860 and 0,988, what shows a strong correlation of the signals in Mode 3.

The some conclusions can be drawn if we analyze the spectral density function (PSD).

Table 2.2 shows the result of model’s parameters’ estimation.

Table2.2. Results of model’s parameters’ estimation

Coefficient	Estimated Value	Standard Error	Value of T-test	Low limit	Upp limit
Phi	-0.231	0.088	-2.623	-0.407	-0.055
Theta	0.729	0.061	12.021	0.608	0.850
Theta 10	0.700	0.056	12.777	0.590	0.809

Consequently this signal can be put in the form of some parametric models, such as (2.3):

$$(1-\Phi\cdot B)Z_t = (1-B^{10})^2(1-\Theta_1\cdot B)(1-\Theta_{10}B^{10})\cdot a_t, \quad (2.3)$$

respectively:

$$(1+0{,}231B)Z_t = (1-B^{10})^2(1-0{,}729B)(1-0{,}700B^{10})a_t \quad (2.4)$$

The spectral density function (fig. 2.3) shows that the analyzed series can be put in a „Box-Jenkins” model.

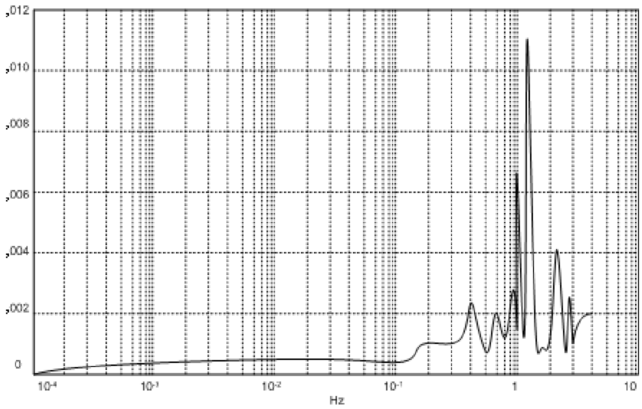

Fig. 2.3. The spectral density function

The results of validation stage of the model point out that it passes the test made on the bases of residues analysis. It can pass to the prediction of data series.

The prediction of data evolution, performed on the bases of the choused model was made on a 20 values horizon (together with 50 values of the initial series) (fig. 2.4).

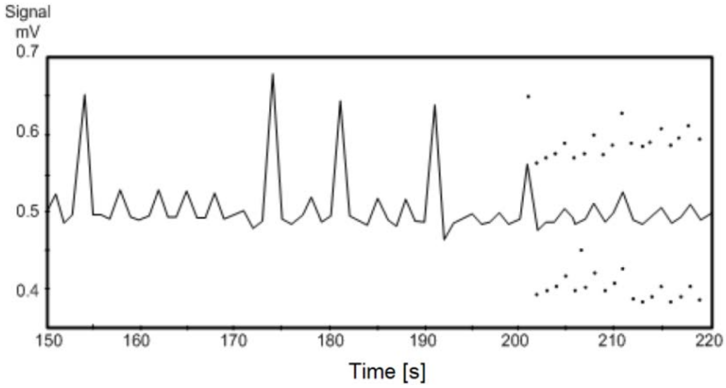

Fig.2.4 Prediction of data series

The trust limits (up and low) are given with 95% probability.

Note. For this model have been used 9 iterations; number of available data = 200 .

CONCLUSIONS

During 10 experiments, the computers under test have normally behaved. However it is possible that other experiments to affect their behaviour.

The obtained results demonstrated that the electromagnetic interference in case of electronic microcomputers can be put in parametric models and can be predict by means of this methodology; more of this, there are a qualitative method and a software support to implement its, with favorable implications in the antidisturbance protection strategy of navy ship.

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