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Research of the Frequency Spectrum of Mechanical Vibrations of Nonstationary Radio-electronic Systems

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Abstract

The results of experiment about revealing of external vibrating influence character on the nonstationary radio-electronic systems established on a ground-based transport vehicle are adduced. The analysis of oscillation process of radio-electronic systems in the conditions of external dynamic influences in the bottom and top part of a operating range has been carried out. It is shown that for support of reliable functioning of nonstationary radio-electronic systems development of existing vibration research methods and tests operation methods of nonstationary radio engineering systems on vibrostability and vibration strength is necessary.

Keywords: Vibration, a Deformation Component, Phase Shift, Radio-electronic Systems, Tests.

Introduction

Now high demands are made to parameters of reliability of nonstationary radio-electronic systems (RES). Mechanical influences are one of the significant destabilising factors leading to faults of products. According to bench tests of spaceship "Apollo" 43,8 % of faults are caused by vibrating influences are caused by vibrating influences, 4 % by shock, 0,1 % by static power influences [1]. In this connection carrying out of laboratory-bench tests of influence of vibration by means of special methods and means must be provided. Tests are spent according to requirements of the international standards, one of which basic principles is the principle of equivalence of test conditions to operative conditions [2]. Therefore the parameter estimator of vibrating influence on nonstationary RES in real operating conditions is of great interest.

Organisation of the Experiment on Research Frequency Spectrum of Mechanical Vibrations of Nonstationary Radio-electronic Systems

For data acquisition of vibration influence during tests vibration-survey converters (VSC), placed in test-points (TP) are used. The signal from VSC to TP is used in a control system supporting stabilisation of the transmitting vibrator function. TP places on a surface of test object. In most cases movement of a real transport vehicle is not rectilinear. Therefore the vibrating influences transferred in RES from a fastening contour, it is necessary to divide on two components: the inertial influence characterising movement of a contour with RES as whole (absolutely solid body) and the deformation influence arising owing to elastic deformations of a contour.

At identical levels of vibration acceleration in TP movements of fixing points at inertial and deformation influences essentially differ. In top subrange there are the dynamic effects connected with elastic deformations of RES fastening contour. In this case except inertial influence RES is exposed to deformation influence at which fixing points can make antiphase elastic motions [1, 3].

For research of deformation influence we carry out the analysis of a spectrum of fixing bonk frequencies (in the given experiment it is TP), intended for fastening nonstationary RES (fig. 1). Time of movement of a transport vehicle on a dirt road has made 10 minutes.

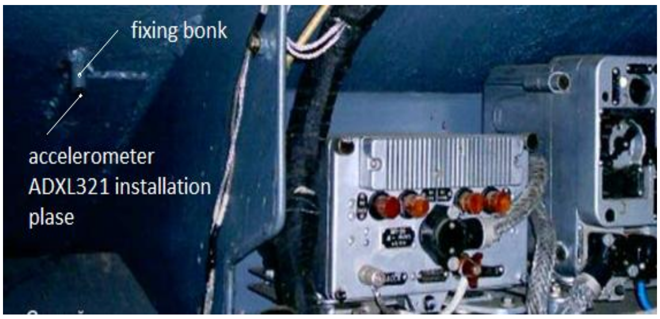

Fig. 1. The accelerometer ADXL321 installation place on fixing bonk of a transport vehicle

For data acquisition it is used accelerometer ADXL321, having a frequency range from 0,5 Hz to 2,5 kHz, therefore the signal range is limited by the filter of the bass frequencies of Bessel of 6th order with frequency of a cut 2,5 kHz.

Research of the Top Range of a Frequency Spectrum

According to State Standard 306.1.1-99 tests by a method 100-1 are spent in a range of frequencies 0,2 $f_{кр}$-1,5 $f_{кр}$, but not above 20 kHz, where $f_{кр}$-critical frequency of a product. Critical frequency is the frequency on which an effect of wrong functioning RES or deterioration of its operational characteristics appears [4]. On fig.2 the measured spectrum of frequencies during using of window function of Hamming is presented.

During tests by a method 100-4 in accordance with State Standard 30630.1.8-2002 [4] extinction frequency is limited 2000 Hz. On fig.2 the spectrum of vibrations in TP of a transport vehicle is shown. According to a principle of the maximum equivalence to this spectrum there should correspond a spectrum of test signals. Thus, it is expedient to limit a frequency range of research of a deformation component of real accelerogram to frequency 2 kHz.

On fig. 3 and 4 accelerograms, measured by two sensors fixed on fixing bonks, located on distance 8 and 26 sm., are presented.

It is clear from fig. 3 that signals are almost identical, while on fig. 4 areas with antiphase motion of fixing points are observed, that specifies in presence of a deformation component of vibrating influence.

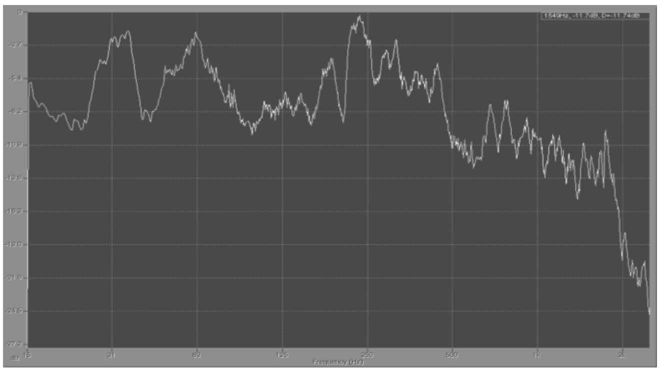

Fig. 2. Spectrum of vibration frequencies of nonstationary radio engineering system

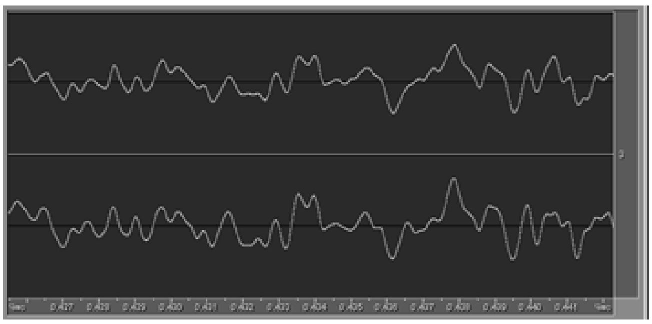

Fig. 3. Accelerograms of two fixing points on distance of 8 sm.

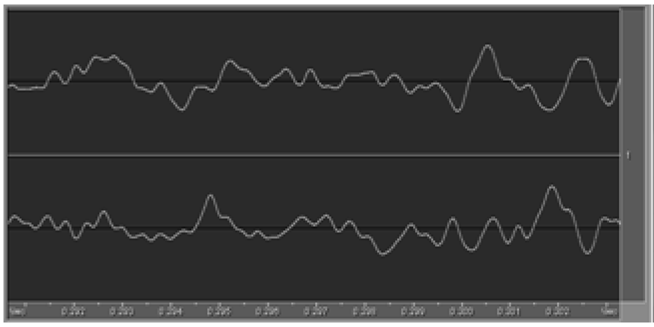

Fig. 4. Accelerograms of two fixing points on distance of 26 sm.

Research of the Bottom Range of a Frequency Spectrum

Theoretical researches [3, 5] influences of a remote vibration source on investigated object by means of fixing elements have shown that the difference of phases in two opposite fixing points on frequency 2 kHz can reach 90 °, and with the subsequent growth of frequency the difference of phases increases also.

However the results of the spent experiment specify what even on frequencies to 500 Hz there are the significant displacement caused by dynamic deformations of a contour of fastening of a transport vehicle. Accelerograms of two fixing points on distance of 26 sm. after processing by the digital filter of the bass frequencies with cutoff frequency of 500 Hz are shown on fig. 5.

Thus, if the vibration propagation medium represents a construction in which bonded surfaces contact with each other under different corners, sources of vibration more than one (chain tracks, motor, transmission) and propagation directions of waves from them are various, in the single moments of time points of fastening RES will be able to move antipodally even in a low-frequency range.

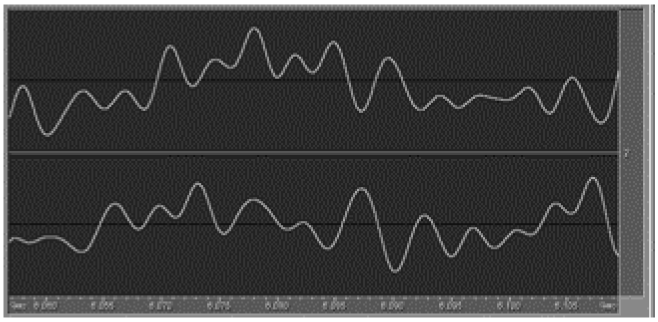

Fig. 5. Accelerograms after processing by the digital filter

Conclusions

Thus, results of an experimental research of a deformation component of the external vibrating influence measured in fixing bonks of RES, located on a transport vehicle, have shown that dynamic deformations effect not only in the top frequency range. So, the neglect of deformation component of vibration leads to significant distortions of the valid picture of dynamic stressing of nonstationary RES.

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Refereces

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