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Computer-Controlled Vibration Testing

Conventional closed-loop analog vibration testing systems cannot provide real-time displays of test specimen response during test, and their performance cannot be corrected during a test because time constants, filter bandwidths, and other control functions cannot be readily altered. Moreover, conventional systems cannot be fully automated for analog control of random noise testing, and they inherently are subject to drift and must be periodically recalibrated.

A digital control system which is completely under computer command has been constructed to make possible fully automated control of random-noise vibration tests. The system is capable of providing real-time analysis with a continuously improving confidence level and, because the computer-controlled system can be preprogrammed, it is possible to verify spectral test patterns prior to actual testing and to avoid operator error in setting up test parameters.

Preprogrammed test specifications can be either tape-fed or introduced by a conversational computer language. Test excitation is produced by pseudo-random noise generated by digital techniques, but the excitation, although seemingly random in nature, has a predictable format; accordingly, randomness is injected in a manner which introduces very little variance into the power spectral density (PSD). This feature makes it possible to estimate the output PSD to a given confidence level much more rapidly than is possible with the purely random excitation that is obtained from Gaussian noise generated by the usual analog techniques. Precisely reproducible test spectra can be generated at any time.

The digital control system includes a Fourier processor, which is a special-purpose computer with a hard-wired, built-in algorithm for effecting a fast Fourier transform of time samples of the acceleration signal. The Fourier processor is in communication with the minicomputer of the digital control system via a specially-designed interface, and the transforms are used to compute the relative amplitudes of the frequency components in the observed test spectrum Estimates of the PSD are produced in the minicomputer by averaging the square of the moduli of the successive transform outputs from the Fourier processor; the estimates are in terms of bandwidth, resolution, and confidence level. The average test spectrum thus obtained is compared with a reference spectrum to produce a resultant in the form of an amplitude spectrum. This is multiplied by the pseudo-random noise signal and the resultant is subsequently transformed by a novel double sum-and-difference technique to produce a digital signal which can be converted to analog form for driving the excitation system.

During the test, the spectral response is displayed on a cathode ray tube which is integral with the Fourier processor, and a digital plotter is interfaced with the computer to plot results upon completion of the test. Test results are expressed as a power spectrum and in spectral ratios.

Some of the attractive features of the vibration testing system are: the short time required to reach a steady state, the increased accuracy of spectrum definition (there are no gaps as in the conventional noise sources), and a true Gaussian amplitude distribution of the resulting signals.

The computer-controlled vibration testing system possibly can be used for controlled shock-tests; for example, with the described system, it is possible to

(continued overleaf)

introduce initially the response characteristics of the total test system, and then to devise an input pulse which can produce the desired acceleration transient. Such a test would be operated as a semi-closed loop system.

Note:

Requests for further information may be directed to:

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Reference: TSP 73-10138

Patent status:

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning non-exclusive or exclusive license for its commercial development should be addressed to:

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