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Radim KLEČKA[*], Jiří TŮMA[**], Miroslav MAHDAL[***]

VIBRATION MEASUREMENT WITH PULSE AND DSPACE EQUIPMENT

MĚŘENÍ VIBRACÍ SE SYSTÉMY PULSE A DSPACE

Abstract

This contribution describes techniques and results of measurement with TIRA vibration generator. A method of experimental modal analysis allows next restore of vibration data. The goal is check validity of head expanders and screw connection. This process is based to using ME'scope environment. Another goal is check possibilities of dSPACE platform to vibration measurement. This task includes design of connection between dSPACE system and power amplifier, creating of graphical user interface and analyzing main configuration parameters to improve quality of drive signal.

Abstrakt

Příspěvek se věnuje postupům a výsledkům měření, zahrnující vibrační generátor TIRA. Cílem je ověřit vliv rozšiřujících nástavců pro ukotvení testovaných struktur, při analýze vibrací pomocí definovaného budícího signálu. V případě rozměrově větší plošiny byla provedena experimentální modální analýza, včetně zpětné rekonstrukce pohybu v prostředí ME'scope. Druhým hlavním cílem je realizace ovládání vibrátoru prostřednictvím simulátoru dSPACE. Jedná se o vytvoření spojovací kabeláže, vhodného grafického rozhraní a analýzu hlavních konfiguračních parametrů pro dosažení požadované kvality budícího signálu.

1 INTRODUCTION

Theoretical and also experimental test methods have been developed for many years. The theoretical technique of dynamic analysis uses finite element method (FEM). Real component or structure is required to experimental procedure. The experimental methods allow to check dynamic properties obtained by calculation in simulation software. Necessary condition is right excitation of the structure. The excitation is based to using impulse hammer or vibrator. The hummer is suitable for bigger and massive system [PAZDERA, MAZŮREK 2007].

2 VIBRATION TEST EQUIPMENT

There are several types of exciter principle: pneumatic, hydraulic, mechanical, electro-dynamic and piezoelectric. The electro-dynamic vibration generators are most commonly used.

[*] Ing., Department of Control Systems and Instrumentation, Faculty of Mechanical Engineering, VSB - Technical University of Ostrava, 17. listopadu 15, 708 33 Ostrava-Poruba, tel. (+420) 597 324 227, e-mail radim.klecka@gmail.com

[**] prof. Ing. CSc., Department of Control Systems and Instrumentation, Faculty of Mechanical Engineering, VSB - Technical University of Ostrava, 17. listopadu 15, 708 33 Ostrava-Poruba, tel. (+420) 597 323 482, e-mail jiri.tuma@vsb.cz

[***] Ing., Department of Control Systems and Instrumentation, Faculty of Mechanical Engineering, VSB - Technical University of Ostrava, 17. listopadu 15, 708 33 Ostrava-Poruba, tel. (+420) 597 324 118, e-mail miroslav.mahdal@vsb.cz

Vibration testing solution includes power amplifier TIRA Type BAA 120 and electro-dynamic vibrator TIRA Exciter 100 N. The power amplifier has been designed to drive any vibration or modal exciter requiring a 120 VA. The maximum current (RMS) is 6 A and maximum voltage (RMS) is 22 V. The TIRA exciter has a useable frequency range from 2 Hz to 7 kHz with top level of velocity 1,5 m/s. The maximal travel range is 25,4 mm. The TIRA Exciter 100 N has mass restriction of tested structure. Upper mass limit for vertical direction is 3 kg and 0,5 kg in horizontal direction [TŮMA, KULHANEK 2007; TŮMA, SMUTNY, KOČÍ 2003].

3 ANALYSING HEAD EXPANDER

There are a wide range of various head expanders and head plates to maximize the versatility of any electro-dynamic shaker. The head expanders are manufactured from light-weight magnesium alloys, providing high strength-to-weight ratio. The additional mass is also used to study output vibration according a drive signal. The PULSE platform measured vibration and generated drive signal (white noise and swept sine signal with frequency span 6,4 kHz). The response of extension platform was measured with vibrometer Ometron VH-1000-D and accelerometers Type 4508 B. The vibrometer VH-1000-D is used for non-contact measurement of surface vibration velocities in the frequency range from 0,5 Hz to 22 kHz. Figure 1 and 2 show spectrum of drive signal and response of exciter with and without additional mass.

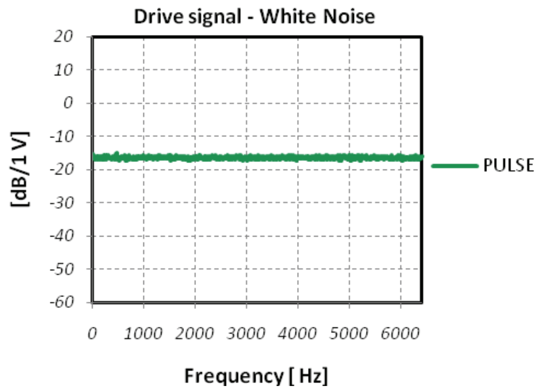

Fig. 1 Spectrum of drive signal

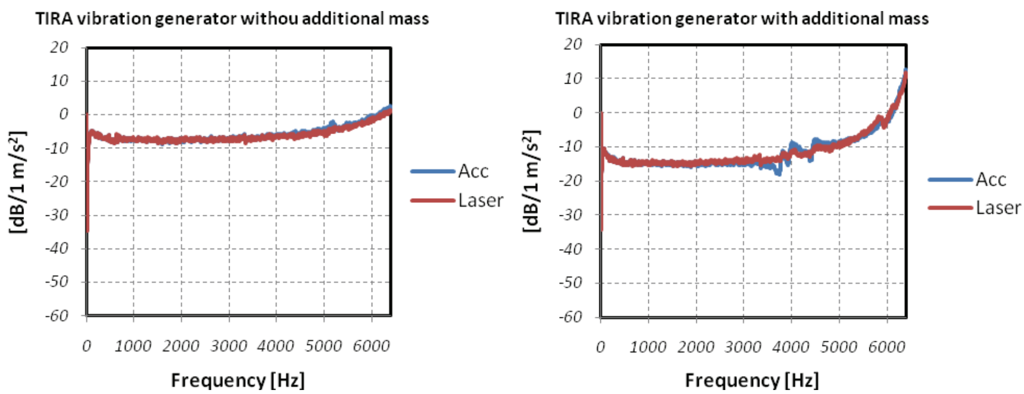

Fig. 2 Spectrum of vibration – exciter with and without additional mass

The figure 1 shows flat frequency spectrum (white noise). The output vibration contains high level of vibration on right side. Distortion of the curve is more visible with addition mass. The measurements were repeated also in horizontal and vertical position. Both directions provided same graphs.

The figure 3 shows frequency characteristic of unloaded power amplifier (TIRA Type BAA 120).

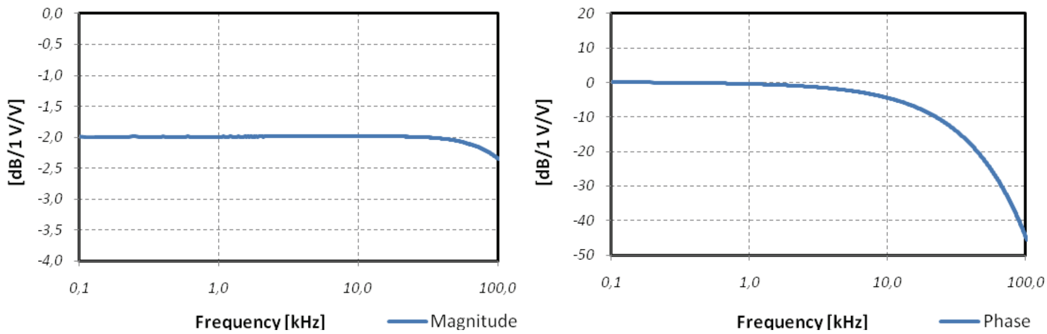

Fig. 3 Frequency characteristic of power amplifier

4 EXPERIMENTAL MODAL ANALYSIS

The second expander is bigger head plate for mounting tested structure. The frequency response function of the plate was analyzed for 98 points. The PULSE system generated Swept Sine signal and random signal (white noise) to amplifier module. The frequency span of white noise was 6,4 kHz. The Swept Sine drive signal had defined start frequency 4 Hz, stop frequency 6,4 kHz and linear sweep rate 1 kHz/s. The response to drive signal was measuring with vibrometer Ometron. Acquired data were displayed, analyzed, and stored on LabShop and ME'scope software.

The ME'scopeVES (Visual Engineering Series) is software tools for visualization, analyzing and documentation the static and dynamic behaviour of machinery and structures. The main goal is displays spatially acquired vibration, acoustic, and other engineering data on a 3D model of a test structure or measurement surface. The ME'scope allows interactively draw a 3D model of test structure and import time or frequency domain measurements taken from the structure. Software interactively displays operating deflection shapes and mode shapes on the 3D structure model.

The information about current amplifier output and signal of accelerometer were used as a reference to calculation frequency response function (FRF). The accelerometer was situated in the middle of the plate. Figure 4 shows FRF graphs with 98 curves.

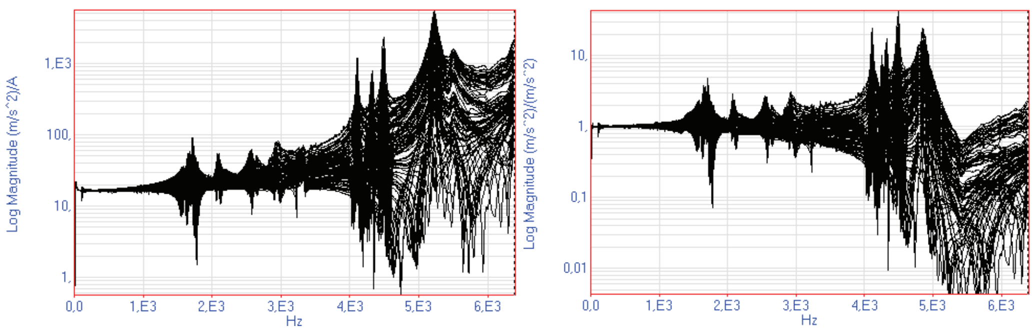

Fig. 4 Frequency response function (Ometron - Amplifier Current; Ometron - Accelerometer)

The head plate was drawn in ME'scope software as free-dimensional virtual structure. A frequency-based ODS (Operating Deflection Shapes) allows you to see how a structure behaves at a single frequency. The virtual structure corresponds with grid of measurement points. Figure 5 shows two modes of vibration - 4,1 kHz and 5,2 kHz.

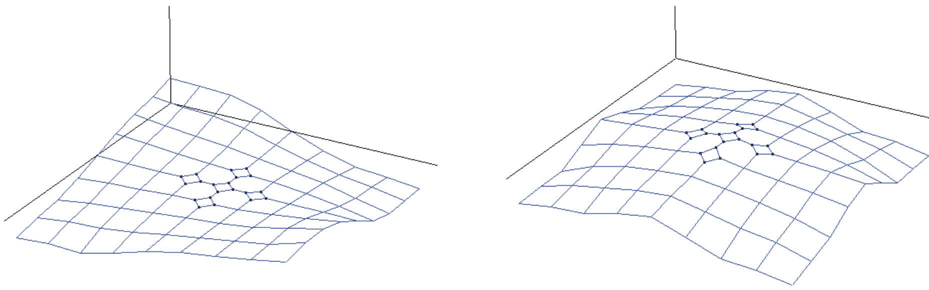

Fig. 5 Modes of vibration – 4,1 kHz and 5,2 kHz

The curves show, the head expander is usable to 1,4 kHz. The final recommendation is mounting of tested components to central parts of plate.

5 CONTROL OF VIBRATION GENERATOR BY DSPACE SIMULATOR

The realized measurement was based on signal analyzer – PULSE. The real-time platform dSPACE offers alternative hardware equipment to generation drive signals. The realization includes the design of connection between dSPACE system and power amplifier, to create of graphical user interface and to analyze main configuration parameters to improve quality of drive signal [dSPACE 2004].

The output of dSPACE system (harmony signal with frequency 1 kHz) was measured with sample frequency 524 288 Hz in first step. Results in figure 6 represent expanded time of the measurement. This situation was repeated for various fixed step size – 100 µs, 50 µs, 20 µs and 13 µs.

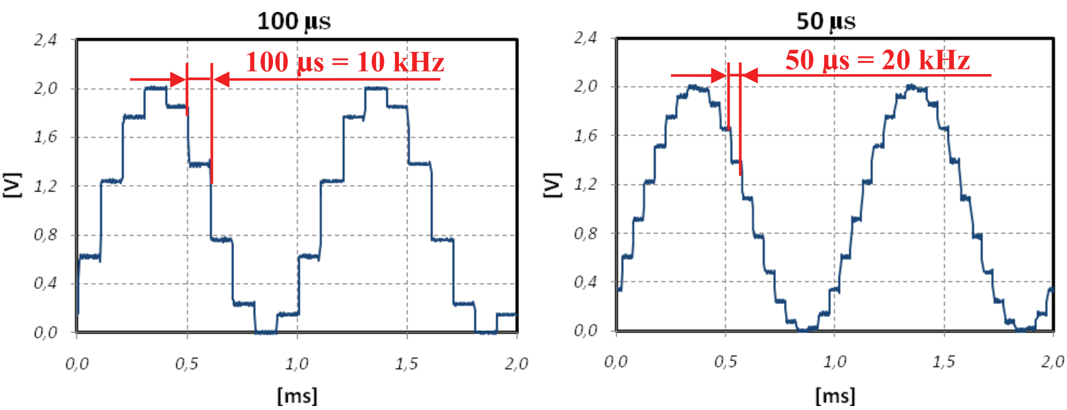

Fig. 6 Output signal of D/A converter in dSPACE platform (step size 100 µs and 50 µs)

The simulation scheme has been designed in MATLAB/Simulink environment. The Real-Time Workshop converts the Simulink models to real-time C code and automatically builds programs that can be run in the real-time system. The application is uploaded into the dSPACE processor after conversion to C code. Designed application for processor board is very simple and limited value of fixed step size is 13 µs. More complex simulation scheme requires higher step size, but this situation allow set very low time interval.

Figure 7 compares output signals from PULSE/dSPACE platform and also exciter behaviour. Both system generated white noise signal with frequency span 6,4 kHz. The dSPACE step size equals to 50 µs. This time limit is comparable with quality of PULSE system output.

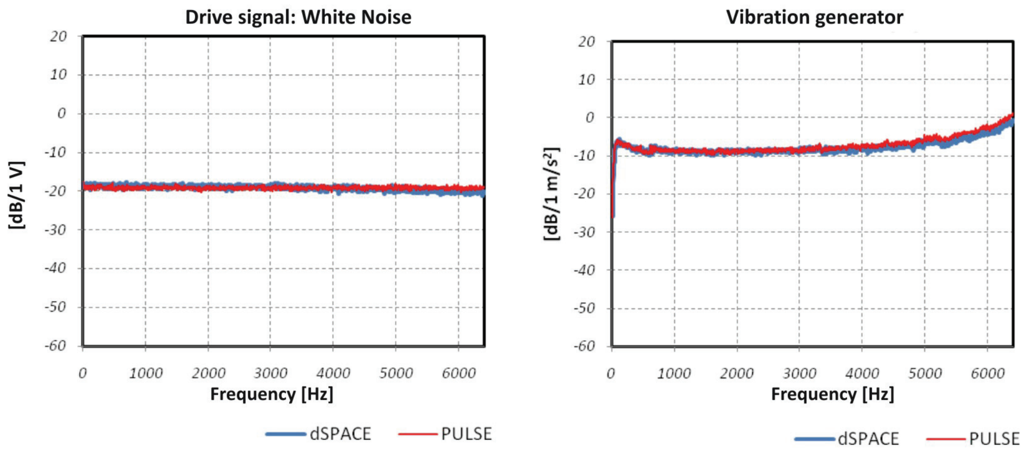

Fig. 7 Comparison: dSPACE-PULSE

Figure 8 shows the hardware and their possibilities of interconnection. Schematic connections correspond to real interaction due to other components.

Fig. 8 Connection of hardware devices

Implementation of dSPACE system includes also graphical user interface designed in software tool – ControlDesk. The ControlDesk provides all functions to control, monitor and automate experiments. This interface allows define two types of generation signals (white noise, harmonic signal) and their main parameters. The created graphical user interface for vibration control we can see in the figure 9. The graphical panel contains three main suitable parameters to defined harmonic signal. The input virtual instruments let you change these parameter values. The shape of output curve is visible in the bottom part.

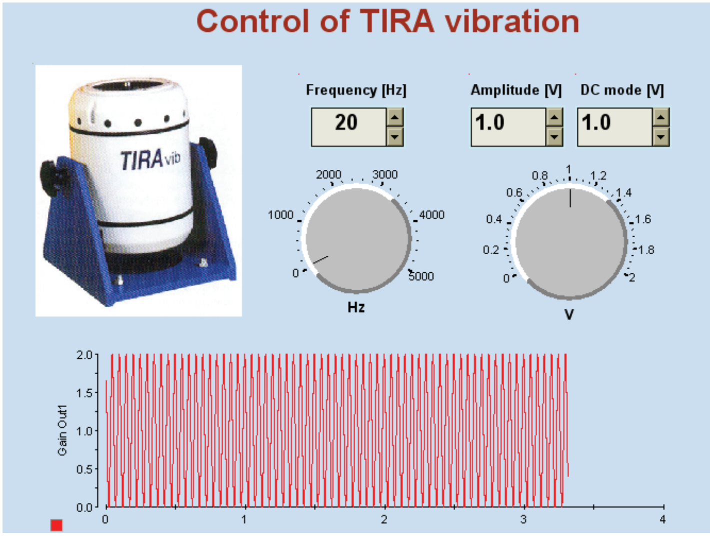

Fig. 9 Graphical user interface for vibrator control

6 CONCLUSIONS

Measurement with additional mass on TIRA vibrator showed distortion on higher frequency. The modal analysis of bigger head expander showed, the head plate is usable to 1,4 kHz. Other recommendation is mounting of tested components to central parts of the plate. The standard head expanders are produced from magnesium and frequency limit is usually 2 kHz.

The PULSE analyzer is complex hardware and software system to various measurements. The real-time platform (dSPACE) offers alternative equipment for measurement task. The main goal of dSPACE devices is focused to Hardware-in-the-Loop simulation, but high computing power can be use also to various vibration measurements. The generated signal by dSPACE system is comparable with PULSE, if calculation step size is equal or lower than 50 µs. This contribution was elaborate with financial support of FRVS 1607/2009/G1 project.

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