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A DSP SYSTEM APPLIED TO ELECTROMECHANICAL IMPEDANCE-BASED SHM ARCHITECTURE

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ABSTRACT

The Electromechanical Impedance (EMI) method has been regarded as a promising tool for Structural Health Monitoring (SHM) in real time. Usually, massive, high-cost, single-channel impedance analyzers are used to process the time domain data, aiming at obtaining the complex, frequency-dependent, EMI functions, from which features related to the presence, position, and extent of damage can be extracted. However, for large structures, it is desirable to deploy an array of piezoelectric transducers over the area to be monitored and interrogate these transducers successively so as to increase the probability of successful detection of damage in an early phase. Lastly, researches have proposed efficient and low cost systems to obtain the EMI functions, through the use of hybrid methods, but still massive and relatively expensive. In this context, a miniaturized, low-cost, highly expandable SHM architecture for monitoring an array of multiplexed piezoelectric transducers is proposed. The proposed architecture does not use costly fast Fourier transform analyzers/algorithms or requires a digital computer for processing. The processing (generation and acquisition) is made by a Digital Signal Processor (DSP), a fast, low-cost, and flexible microprocessor in which a dedicated software can ran embedded. The DSP can generate excitation signals to interrogate the PZTs patches ranging the frequency in a large band, achieving the bests signals to each patch. Moreover, the processor acquires the response signal to process and calculate the required data. The main advantages of using this system are, besides the low cost, the reduced size and weight, making it ideal to aeronautical applications and others ones that these characteristics are critical.

Keywords: digital signal processing, structural health monitoring, electro-mech. impedance.

INTRODUCTION

Among the various existing structural health monitoring (SHM) methods, the so-called electromechanical impedance (EMI) technique has been regarded as one of the most promising ones for use in industrial engineering structures. Basically, according with a previous investigation (Sun, 1995), it was identified failures by monitoring the structure's mechanical impedance that will exhibit variations in the presence of structural damage. Since it is difficult to directly obtain the structure's mechanical impedance, a piezoelectric transducer, most frequently a PZT (lead-zirconate-titanate) ceramic patch bonded to the monitored structure (or embedded into it) is used as a sensor-actuator device. The electric impedance of the PZT is directly related to the mechanical impedance of the host structure.

The architecture of the proposed system use a hybrid topology in which hardware and software approaches are combined together to measure the amplitude and phase of the impedance from each PZT. A similar architecture was proposed previously using a signal generator to excite the piezoelectric transducers, achieving a lower cost and compacter system than a classical impedance analyzer (Finzi, 2010).

The idea proposed is to use a digital signal processor (DSP) to generate the signal that interrogate continuously the transducers and measure the phase and the current I_{PZT} using hardware. The impedance Z is calculated by an embedded software into DSP. The main advantages of this method are the following:

- The computational complexity of the software is reduced to N (where N is the number of frequency points).
- I_{PZT} can be sampled at lower rates and with a sampling rate independent of the excitation frequency.
- Phase θ is digitally measured using a Two-Edge Counter (TEC), which is present in every DSP. It requires a resolution of 16 bits, at least, for better results.

RESULTS AND CONCLUSIONS

The prototype is being implemented and presents a 12-bit analog-digital converter to ensure speed and high sampling rate. The most of DSPs do not have a built-in digital-analog converter, so a high performance external one is being implemented as well. Some simulations with a specific IDE (Integrated Development Environment) from Texas Instruments give us an estimated signal (excitation) behavior (see Fig. 1).

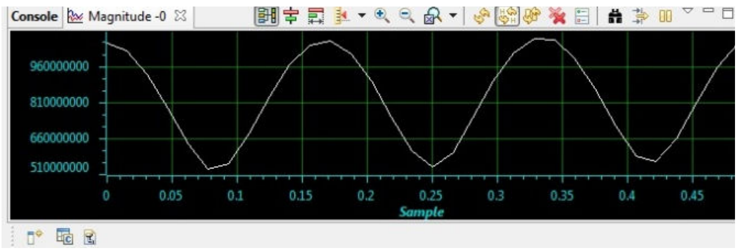

Fig. 1 - Code Composer Studio© v.4 debugging the signal generation software.

This simulation shows that is possible generate a signal using a DSP and further, ensure the needed flexibility to generate a complex excitation one. Data acquisition experiments are being implemented as another perspective, integrating all the analysis processing within DSP.

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REFERENCES

[1]-Sun F, Chaudhry Z, Liang C and Rogers CA. Truss structure integrity identification using PZT sensor-actuator. J Intell Mater Syst Struct 1995; 6: 134-139.

[2]-Finzi Neto RM, Steffen Jr V, Rade DA and Gallo CA. Proposal of a solid state switching and signal conditioning system for structural health monitoring based on piezoelectric sensors/actuators. In: PACAM XI - 11th Pan- American Congress of Applied Mechanics, 2010, Foz do Iguaçu, PR-Brazil.