A Remote Web System for Testing PVDF Sensors

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Abstract- In this article we describe the remote driving, via Internet, of the ultrasound sensor that can work in two different ways, for locating and sizing isolated scatterers and for ultrasonic ranging by real-time digital phase measurements. The sensor is located in the laboratory of Electrical Measurements of the Technical University of Iaşi, Romania, while the remote control is located in the BioMechatronics Laboratory of the University of Magna Græcia at Catanzaro, Italy.

I. Introduction

There are many ways to take the measurements and to share the results to the web. With network technologies is no more necessary that control and execution unit to be one and only. The most appropriate procedure is to perform a fully remote control instrument via Internet providing fully access for changing process parameters. A virtual instrument that commands the instruments and manages all the data flows is running on the server computer and the results are posted on Internet and received by client computer.

II. The principle of ultrasonic sensors

Hemicylindrical piezo-plolymer transducers, designed to vibrate in the length extensional mode, in the past have been investigated for airborne ultrasonic measurements in both industrial and robotic applications. The ultrasound transducers are fabricated with a 40 µm thin film of PVDF (or PVF2) silver metallised on both large surfaces [1]. The free piezoelectric film which is first uniaxial stretched along the length and after polarized along the thickness direction by high electric fields, vibrates in the length extensional mode. By curving the film in a semicylindrical shape and blocking the two extremities in P’ and P” (figure 1) with copper pins, as a consequence of the modified geometry, the extensional motion is converted in the radial direction and ultrasonic waves are generated in the frequency range of 30 kHz up to 120 kHz (figure 2). The transducer was properly designed to match with a high signal-to-noise ratio amplifier and a λ/4 back reflector included in the same structure [2] [3].

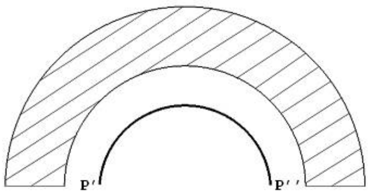

Fig. 1 Cross section of the unimodal PVDF transducer that can operate alternatively as transmitter or receiver. The λ/4 back reflector is also shown

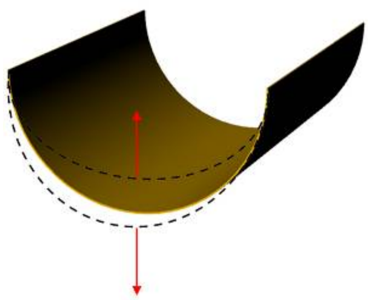

Fig. 2. Particular arrangement and radial vibration mode of the piezoelectric sheet

In the actual arrangement, the distance between the two ends is fixed at 7.5 mm, thus imposing the resonance frequency of 61 kHz. The piezo-polymer foil is free to vibrate forward and backward, at a resonance frequency that is inversely proportional to the bending radius. Figure 3 shows the signal received by the transducer at the output of the low noise amplifier after reflection on a flat target located at a distance of 35 cm during the pulse-echo mode functioning.

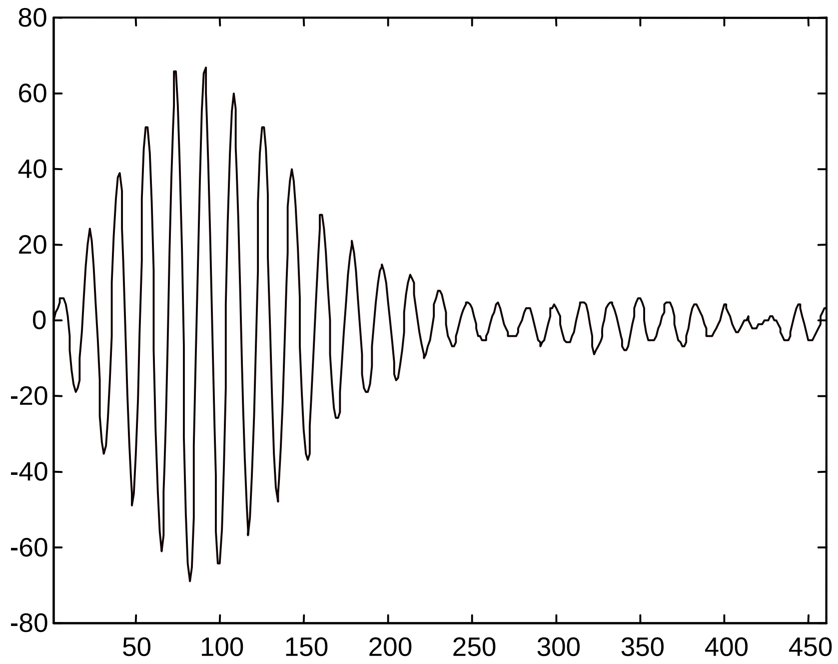

Fig. 3. Typical signal received by the transducer in the pulse-echo mode. The transmitter was exited by a high voltage Dirac like pulse generated by a Panametrics 5058 PR

Single frequency transducers (resonating at 61 kHz) were used in the pulse-echo mode for ranging, while two linear arrays of transducers (resonating at 61 kHz and 83 kHz respectively) were arranged according to SAFT reconstruction (synthetic aperture focusing technique reconstruction), for location and sizing of wires, polymer extruded materials, and for 3D imaging in medicine (2). However, the most important application of the curved ultrasound sensor is the emulation of the behavior of bat biosonar, in both the constant frequency and frequency modulated modes. In the constant frequency mode the transducer is driven with a sinusoidal burst at frequency of 60 kHz, while in the frequency modulated mode the frequency decrease from 60 to 50 kHz, by tacking advantage from the very low quality factor Q = 6 of the transducer [3].

III. The remote system

A. Software support

LabView is a powerful software package that can be used to design user interfaces to interactively control the systems in a graphical environment taking advantage of many programming tools and by creating virtual instruments that mirror real ones allowing remote users to collaborate in real time. This software package is produced by National Instruments and has world wide acceptance and presence at this time. It provides a quick and easy access to instrumentation control and a very large database of drivers for DAQ cards, various computer interfaces (GPIB, serial etc) and instrument drivers [4].

Web Publishing Tool was implemented first in LabView 6. Now version 8.20 is out and has better remote access features (figure 4). Any application can be published as a web file using a built-in Web Server. This approach has advantages (user monitoring and security features) and disadvantages (it requires to download and install the LabView Run-Time Engine on the client computer) [5].

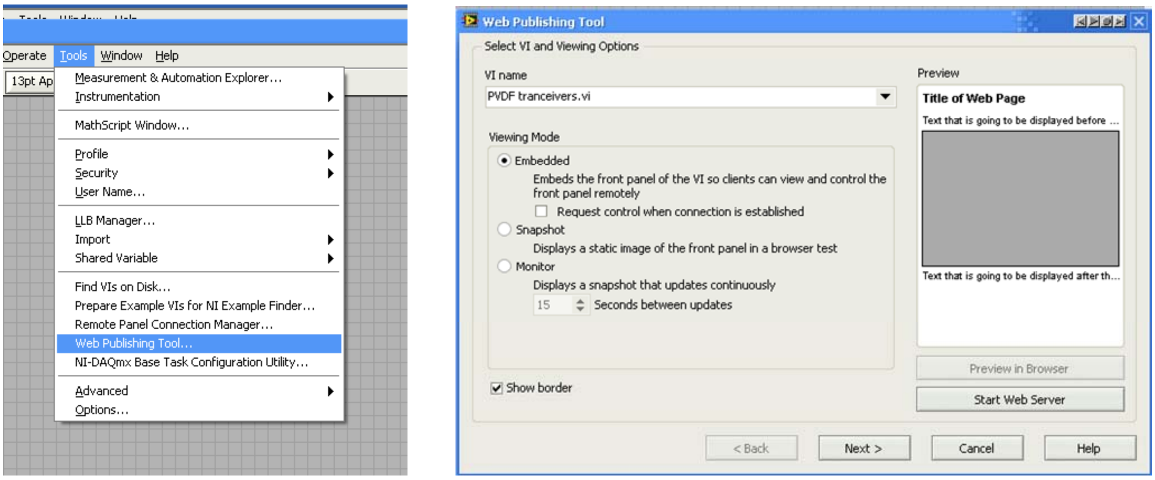

Fig. 4. Web Publishing Tool command and its configuration window

The first step is to build the LabView application for coordinating the data. This instrument will be published as a web page providing full control of the instruments and of the parameters to be measured. An important characteristic is that on the web server can be declared a list of users providing three levels of accessibility (viewing and controlling, only viewing and deny access). The web page is accessible via TCP/IP protocol, so the client computer must have this protocol installed. The address of the web page will be like „http://IP/PVDF tranceivers.html" where the **IP** is a static Internet Protocol Address available from anywhere.

B. Hardware support

Figure 5 presents the block diagram of the remote measuring system. The main part is a virtual instrument that is running on the server computer. This one controls all the data flows between the client computer and the hardware part of the system. The user commands via Internet the test signal parameters like frequency, amplitude and receives the results. It is also a possibility to download the data files for ulterior analyzing and processing.

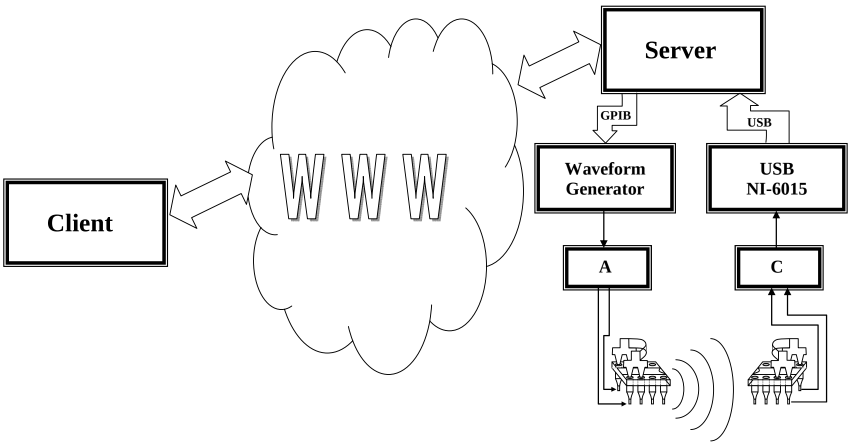

Fig. 5. Web System's Architecture

The necessary signal is generated with a Sony Tektronix instrument via GPIB (General Purpose Interface Bus). The amplifier consists in a high-voltage, high-current operational amplifier in non-inverting circuit followed by a step-up ferrite core transformer. We use an OPA544 that allows 60V peak to peak output. As the transformer increase by 7.9 times we can obtain approximately 470V. Ultrasound signal is generated by the US transmitter and received by a similar sensor denoted as the receiver. Practically, any of these sensors can be used as a transmitter or a receiver. The output signal is first conditioned (block C) and then acquired with a National Instruments USB acquisition board. The values are listed on a front panel and saved into a data file for post processing.

IV. Final setup and experimental results

Because these sensors are made to simulate the bat bio-sonar to test them we need to generate the same signals as the bat. It emits four CF-FM harmonics composed by the fundamental CF_1-FM_1, at 30.5 kHz, followed by a downward chirp, in which the frequency is reduced to 20 kHz, and three higher harmonics, CF_2-FM_2 at 61 kHz, CF_3-FM_3 at 92 kHz and CF_4-FM_4 at 123 kHz (see figure 6). CF-FM signals are actually generated first by generating a burst signal CF, at frequency f_H (for instance 61 kHz) and then driving the transducers with the downward chirp (from f_H=61 kHz to f_L=50 kHz). The size of actual transducer is optimized to generate the second harmonic of the bio-signal, CF_2 at 61 kHz, and the relative downward chirp, FM_2 down to 50 kHz. However the transducers with different bending radius, which resonate at 30.5 kHz, 92 kHz and 123 kHz were fabricated and tested [6][7].

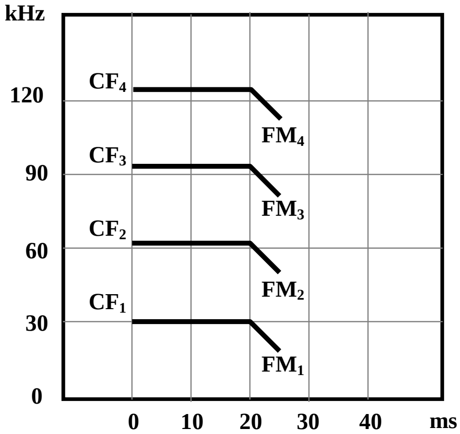

Fig. 6. Four harmonics for PVDF testing

Figure 7 presents the web page that allows full control of the signal parameters and the acquired data. This web page is accessed remotely from another laboratory. The burst signal is obtained by triggering the output of the waveform generator with a rectangular signal generated by a data acquisition board.

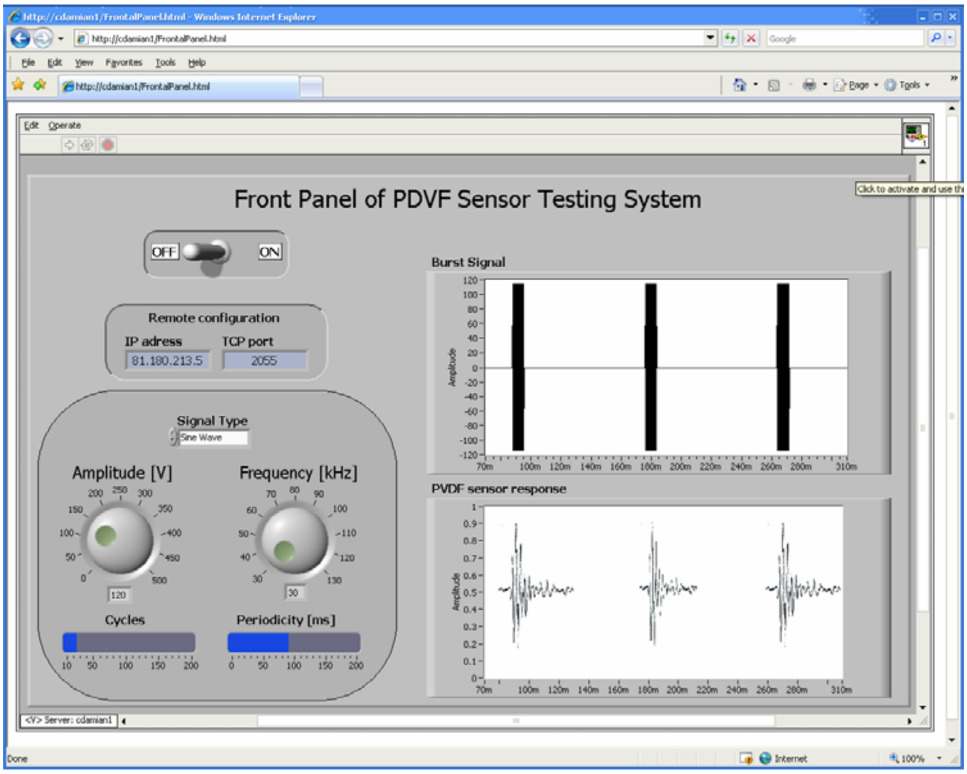

Fig. 7. HTML page with System's Front Panel

The four components of the signal CF-FM may be generated by only one PVDF transducer in which the resonance frequency can be continuously controlled, although with a consistent risk of mechanical damage at lowest and highest resonance frequency.

IV. Conclusions

A remote system for ultrasonic sensors testing has been presented. The principal instrument is a web server that manages the input-output dataset provided by the PVDF sensors. The advantages with respect with other techniques is the possibility of remote controlling, with high accuracy the frequency, the amplitude and other parameters of the generated signal. The sensor is located in the laboratory of Electrical Measurements of the Technical University of Iaşi, Romania, while the remote control is located in the BioMechatronics Laboratory of the University of Magna Græcia at Catanzaro, Italy.

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