



Active Vibration Control using Labview

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Abstract: Vibration is a mechanical phenomenon where by oscillations occur about an equilibrium point. In many cases, however, vibration is undesirable, wasting energy and creating unwanted sound. This paper presents results on active control schemes for vibration suppression of flexible aluminium cantilever beam with bonded piezoelectric actuators and sensors. The direct output feedback based active vibration control has been implemented on a cantilever beam using Lead Zirconate-Titanate (PZT) sensors and actuators. Three PZT patches were used, one as the sensor, one as the exciter providing the forced vibrations and the third acting as the actuator that provides an equal but opposite phase vibration/force signal to that of sensed so as to damp out the vibrations. The designed algorithm is implemented on Lab VIEW 2014 on Windows 7 Platform.

Keywords: Active vibration control, Piezoelectric patches, Aluminium cantilever beam, LabVIEW.

I. INTRODUCTION

In this paper, undesired mechanical vibrations and noise can be avoided or minimized by active vibration control. LabVIEW software is used to control vibration and my-DAQ(Data Acquisition) is used as interfacing device. Active vibration control is the active application of force in an equal and opposite fashion to the forces imposed by exert the vibration is periodic, then the control system may adapt to the ongoing vibration, thereby providing better cancellation than would have been provided simply by reacting to each new acceleration without referring to past accelerations this work was implemented using LabVIEW 2014 on Windows 7 platform.

A study of materials used for vibrations is given in [1]. The sensing of vibration by the PZT in cantilever beam is studied in [2]. The dimensions of the beam and the calculation of the resonant frequency is given in [3]. Tuned vibration absorbers (TVA) have been used since the beginning of the 20th century to reduce disturbing vibrations [4]. The investigation on a dynamic inertial mass actuator that has been developed previously is discussed in [5]. The study of signal converting and storing the process data is discussed in [6]. Vibrating structure is possible by the use of piezoelectric sensors and actuators coupled with feedback algorithms. The direct output feedback based active vibration control has been implemented on a smart cantilever beam at its resonant frequency using PZT (Lead Zirconate Titanate) sensors and actuators in [7]. The vibration control of flexible structures using Active Force Control (AFC) method is studied, experimentally. The AVC(Active Vibration Control)-AFC controller design is

implemented to a full clamped flexible plate system to evaluate its vibration attenuation performance. The system's dynamic model considering the collocated placement of the sensor and actuator is derived within the LabVIEW environment [8]. Exceptional properties of piezoelectric lead zirconate titanate (PZT) films and ceramics to convert mechanical forces into an electric field or vice versa make them appropriate in extensive applications in a vast array of areas including sensors and actuators [9].

In this paper, three PZT patches are used one as sensor, other two as actuator and exciter. Disturbance to exciter is given by using Function Generator. Vibration is sensed by the piezoelectric sensor and given as input to the computer controller through LabVIEW DAQ card. The output signal is given as input to the piezoelectric actuator.

II. MEASUREMENT OF RESONANT FREQUENCY OF CANTILEVER BEAM

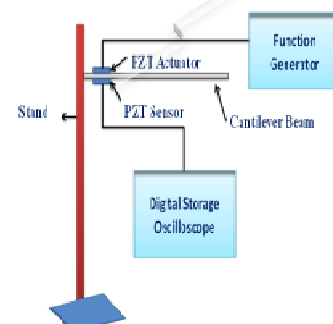


Fig .1. Schematic diagram for finding resonant frequency



The resonance frequency of the cantilever beam is obtained using the connections given as in Fig.1. Resonance is a phenomenon in which a vibrating system or external force drives another system to oscillate with greater amplitude at specific frequencies. Frequencies at which the response amplitude is a relative maximum are known as the system's resonant frequencies or resonance frequencies. The input is given to the actuator by using the function generator at the maximum voltage of 20V and frequency is varied continuously till the beam get vibrated. The resonant frequency of the beam is 13 Hz. Fig.2. represents the resonant frequency taken from LabVIEW.

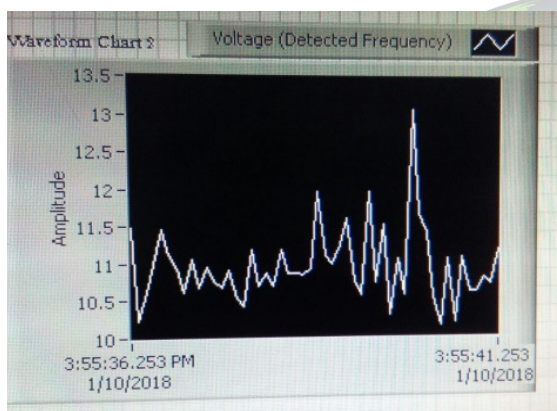


Fig. 2 Resonant frequency

From the concept of machine vibrations, the natural frequency of the vibrating beam is determined by using the formula:

$$\omega_n = \sqrt{k/m}$$

where ω_n = the natural frequency of the beam (rad/sec)

$$\omega_n = 2\pi f_n$$

k= beam stiffness.

M=modal mass.

Table 1
Properties of the Aluminium beam

Parameter	Value
Length (L)	035m
Width (b)	0.025 m
Thickness (h)	0.003 m
Modulus (E)	$7.1 \times 10^{10} \text{ N/m}^2$

Density (ρ)	2700 kg/m^3
Mass Density (M)	0.06075 kg/m
Modal Mass (m)	0.015377 kg

Table 2.
Properties of PZT

Properties	PZT-5H
Density	7350 kg/m^3
Elastic Stiffness Matrix	
C11	$12.6 \times 10^{10} \text{ N/m}^2$
C12	$7.95 \times 10^{10} \text{ N/m}^2$
C13	$8.41 \times 10^{10} \text{ N/m}^2$
C33	$11.7 \times 10^{10} \text{ N/m}^2$
C44	$2.33 \times 10^{10} \text{ N/m}^2$
Piezoelectric Strain Matrix	
E31	6.5 C/m^2
E33	23.3 C/m^2
E15	17 C/m^2
Dielectric Matrix	
ϵ_{11}	$1.503 \times 10^{-8} \text{ F/m}$
ϵ_{22}	$1.503 \times 10^{-8} \text{ F/m}$
ϵ_{33}	$1.503 \times 10^{-8} \text{ F/m}$

Complete modal analysis of the smart system was achieved as well as analysed by shown in table1 and table2.

III. BLOCK DIAGRAM

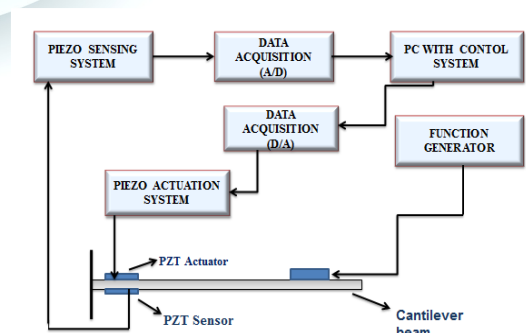


FIG. 3. Block diagram



From the above block diagram it is given that the PZT exciter is excited using a function generator which is usually a piece of electronic equipment used to generate different types of electrical waveform over a wide range of frequencies this waveform can either repetitive or single shot. An voltage range of about 20v at frequency of 13Hz is given as excitation. PZT materials consist of polarised ions within the crystal. PZT sensor senses the vibration and produce charge output in proportion to the generated vibration.

DAQ is a interfacing device which is used to interface sensor signals with the LabVIEW software. Analog to Digital converts inside the DAQ converts analog sensor signals into digital values. After that inversion of the sensor signal is performed using designed LabVIEW program and the output signal is multiplied with some gain and given to the PZT actuator to suppress the vibration. PZT actuator converts an electrical signal into a precisely controlled physical displacement.

IV. DAQ ACQUISITION SYSTEM

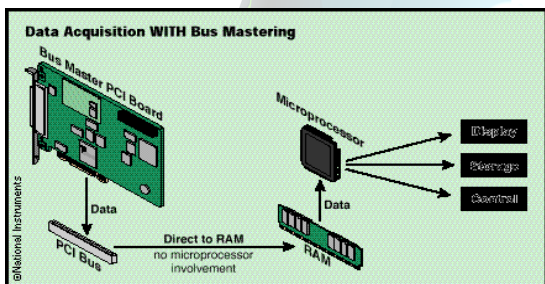


Fig.4. Schematic Diagram Of DAQ

Data acquisition is the process of sampling signals that measure real world physical conditions and converting the resulting samples into digital numeric values that can be manipulated by a computer. Data acquisition systems (abbreviated with the acronym DAS or DAQ) typically convert analog waveforms into digital values for processing. The components of data acquisition systems include:

1. Sensors that convert physical parameters to electrical signals
2. Signal conditioning circuitry to convert sensor signals into a form that can be converted to digital values.
3. Analog-to-digital converters, which convert conditioned sensor signals to digital values.

Data acquisition applications are controlled by software programs developed using various general purpose

programming languages such as BASIC, C, FORTRAN, Java, Lisp, and Pascal. There are also open-source software packages providing all the necessary tools to acquire data from different hardware equipment.

These tools come from the scientific community where complex experiment requires fast, nexible and adaptable software. Those packages are usually custom fit but more general DAQ package like the Maximum Integrated Data Acquisition System can be easily tailored and is used in several physics experiments worldwide.

A. Acquiring Signal

The use of DAQ Assistant express VI is to create a task in NIDAQmx.NI-DAQmx is a programming interface to communicate with data acquisition devices. Getting stated with DAQ taking a NIDAQmx measurement in LabVIEW. Fig. 2.4 shows the acquired sensor sensor by using DAQ.

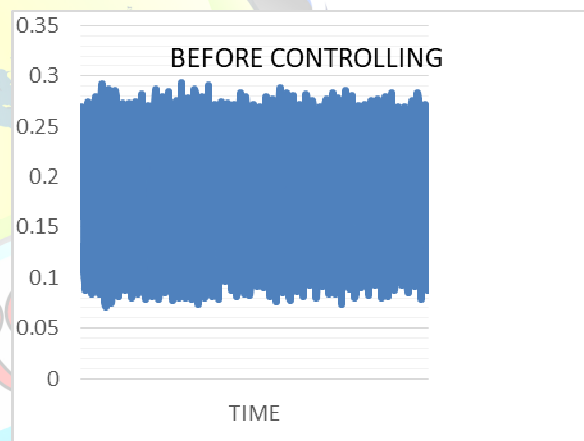


Fig.5.Acquired signal

Steps to acquire sensor signal using DAQ:

- Left click on Block diagram to open the Function palette.
- From Function palette click on Express.
- Click on Input and open DAQ Assistant.
- Double click on DAQ Assisstant to change the sample acquisition mode and to set the Maximum and minimum voltage.
- Click on OK.

Vibration Control of Cantilever Beam

The analog signal from the sensor is acquired by using DAQ and the acquired signal is processed in the LabVIEW



software. Here the acquired signal is multiplied with some gain factor and then the signal is inverted. Thus the inverted signal is the given to the DAQ generation to reduce the vibration.

B. Generating Signal

DAQ device is used to generate the control signal which is to suppress the vibration. The inversion of the control signal is given as control signal to suppress the vibration in cantilever beam. Fig. 2.6 shows the generated signal from DAQ.

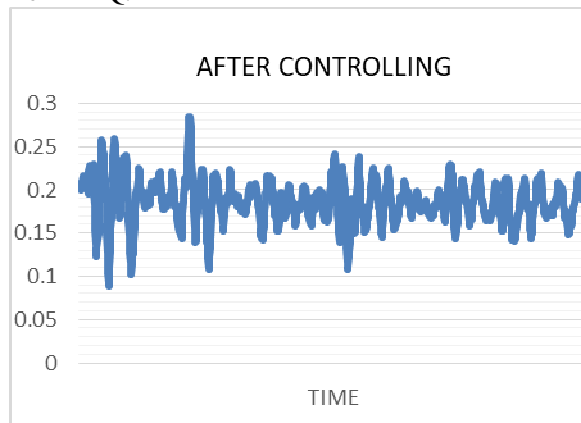


Fig. 2.6. Generated signal

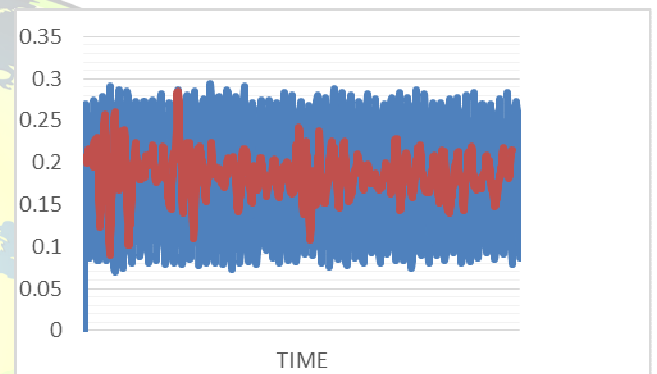
Steps to generate signal using DAQ:

- ❖ Place a DAQ Assistant on the block diagram
 - Right-click on the block diagram and select Express»Output»DAQ Assistant
 - Place the DAQ Assistant on the block diagram by left-clicking
- ❖ Configure DAQ Assistant type
 - Select Generate Signals »Analog Output »Voltage
 - Select Dev1 (or the name of your device if not Dev1)
 - Select ao0
- ❖ Configure generation settings
 - Select Continuous Samples for Generation Mode
 - Enter 100 for the Samples to Write
 - Ensure the Use Waveform Timing checkbox is checked

- Select OK to apply these settings
- Select Yes when prompted to automatically create a While Loop

V. CONCLUSION

The active vibration control of the smart system is achieved using LabVIEW. Vibration suppression of smart beam using the piezoelectric patch structure is experimented. An experimental set-up is developed to obtain the active vibration suppression of smart beam by generating an equal and opposite force on the other side of the actuator by using DAQ.



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