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Vibration Control of Cantilever Beam using Resonant Sensor

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Abstract: LabVIEW based active vibration control by using piezoelectric type resonant sensor is used to suppress the vibration produced in a mechanical system to make more stable vibrations produced by the system should to be controlled. In this paper the characteristics of a resonance control system is based on maintaining the proper frequency, the controller that is realized as a virtual instrument and programmed in the LabVIEW environment, data acquisition and control is implemented by using myRIO. The simulation results in active control vibrating beam using PID controller. The proposed control technique achieves good vibration suppression and it can be tuned to satisfy the requirement.

Keywords: LabVIEW, myRIO, Piezoelectric Sensor

I. INTRODUCTION

Control of flexible structures vibration is an important issue in industries. Many engineering applications required to maintain stability especially for a precise performance like aerospace systems, satellites, etc. The flexible materials having low rigidity and having very small damping ratio are susceptible to vibration and it can cause a destructive large vibration amplitude and long decay time result in instability, Poor performance and in fatigue.

Active Vibration control of a smart cantilever beam at resonance, a comparison between conventional and real time control the real time operating system is used to reduce operating time here windows based LabVIEW used [1][12]. Development of a LabVIEW based controller for Active Vibration Control of Panel Structure using Piezoelectric Wafer in this paper PID algorithm through myRIO [2]. Active vibration control of SMA actuated structures using fast output sampling based sliding mode control for advanced controlling is given in this paper light weight material is controlled so SMA is not required [3]. Sliding mode controller with multi sensor data fusion for Piezoelectric actuated structure in this paper for both sensing and actuating a piezoelectric sensor is used [4]. Parametric modelling and FPGA based real time active vibration control of a piezoelectric laminate cantilever beam at resonance in this paper SI-system identification tool is used to get the transfer function of a cantilever beam [5]. A Driver for Piezoelectric transducer with control of resonance MOSFET based electronic driver circuit is used to control the resonance frequency in this paper audio frequency oscillator is used to produce frequency and controlled by using labVIEW[6]. Intelligent tuning of vibration mitigation process for single link manipulation using fuzzy logic in this paper tuning of PID is done through auto tuning [7] [13]. Vibration control of a smart cantilever beam using strain rate feedback in this paper fluctuations produced because of vibrating beam is given as a feedback [8]. A labVIEW based data acquisition systems for vibration monitoring and analysis in this paper labVIEW is used for both signal acquisition and controlling [9]. Phase locking control of the coriolis meter's resonance frequency based on virtual instrumentation in this paper frequency is only getting controlled [10]. In this paper, vibration is measured and controlled using PZT sensors. The controlling is done through piezoelectric sensor. It is an inverse sensor, while giving supply it will produce vibration and by placing it in a vibrating medium it will produce voltage. validation for a neural network model of non-linear system [11]in this paper cantilever beam model have identified. smart coriolis mass flow meter [14] in this paper we have controlled the vibration produced in a beam to improve the stability in measurement, design and simulation of coriolis mass flow tube in meso and micro level to determine the resonant frequency [15] in this paper resonant frequency is found for cantilever beam.

The paper address on how to suppress the vibration produced in a cantilever beam. Using NI-MYRIO the acquired vibration gets controlled through PID controller. The controller's output is fed back to one of the actuator. The control signal produced by the PID is based upon the vibration detected. The controlled vibration signal will suppress the vibration produced by the disturbance.

The system design of cantilever beam is identified in the section 2. Auto tuning for pid controller in matlab has been discussed in section 3.the experimental design of cantilever beam has been discussed in section 4.The dimensional details of cantilever beam has been discussed in section 5.control logic for vibration control in section 6.conclusion is discussed in section 7.Acknowledgement is discussed in section 8.

II. SYSTEM IDENTIFICATION OF CANTILEVER BEAM

To control the system using PID controller, the transfer function of a particular system is required to the transfer function of a cantilever beam is identified using System Identification tool in Matlab. Two variables are known, one is frequency and another is voltage are the two variables to be known to identify the transfer function.

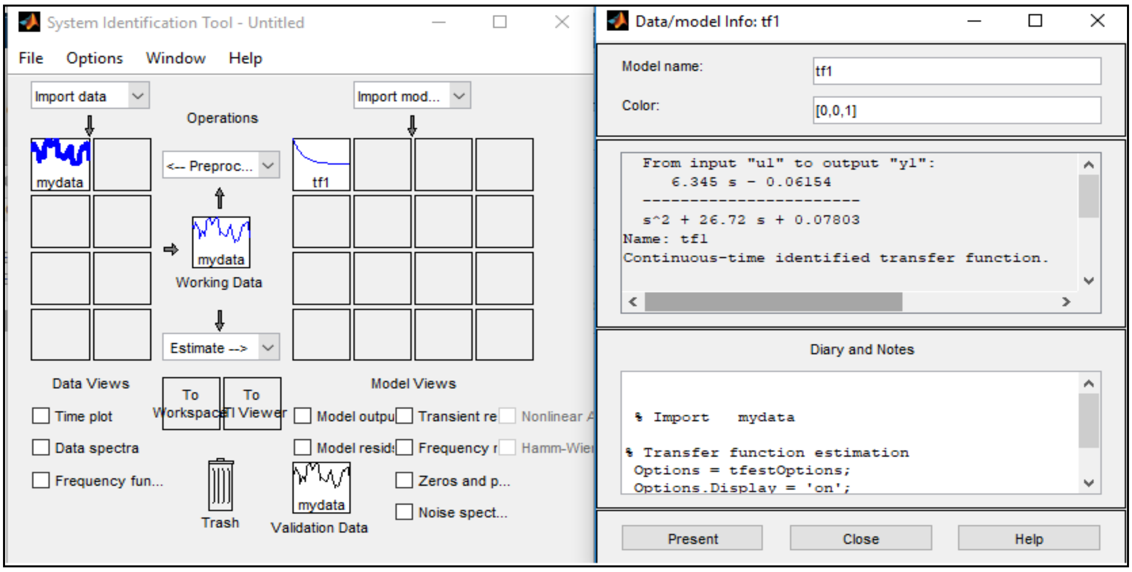

Fig-1 Shows the System Identification Tool in MATLAB

The transfer function obtained is the mathematical model of cantilever beam. The exact PID values are obtained in Matlab using auto tuning method. First step is to create a variable table and import that data in system identification tool. Second step is to choose the operations and change to time domain, in this paper with respect to frequency variation there will be a change in voltage. So, time domain is chosen and the values are estimated. The transfer function for the required system is identified.

Transfer function of the system is given below,

$$\frac{6.45s-0.06}{s^2+26.72s+0.07}$$

There are one zero and two poles, it can be added if it is required. But more number of poles make the system less stable. Transfer function of the system is used to obtain the relationship between input and output signal. A block diagram represents the signal flow, each block refers to the function of a particular operation. All the control system requires a transfer function to produce a required output through a reference input an effective control system should be less sensitive to the disturbance, Transfer function refers to the laplace transform of input to the laplace transform of output with zero initial condition.

III. AUTOTUNING IN MATLAB

Various methods are available in tuning of PID gains, in plant modelling and a non-linear system designing. In this way to identify the perfect PID values auto tuning method is used, against a physical model auto tuning algorithm works in real time. With this auto tuning time response parameters can also be determined like rise time, settling time, peak time, and overshoot.

System identification requires more information about the data in each and every instant, which is obtained from the process by getting more information the result of tuning, it would be more accurate. By having less information makes the system not perform in a more optimized way.

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The conventional method of tuning like Zeigler Nichols and Cohen Coon methods requires time response parameters, which are not suitable for non-linear systems, and an advanced control algorithms like Particle swarm optimization and Ants colony optimization requires multiple parameters, and it takes more time to find an optimal or best fitted value.

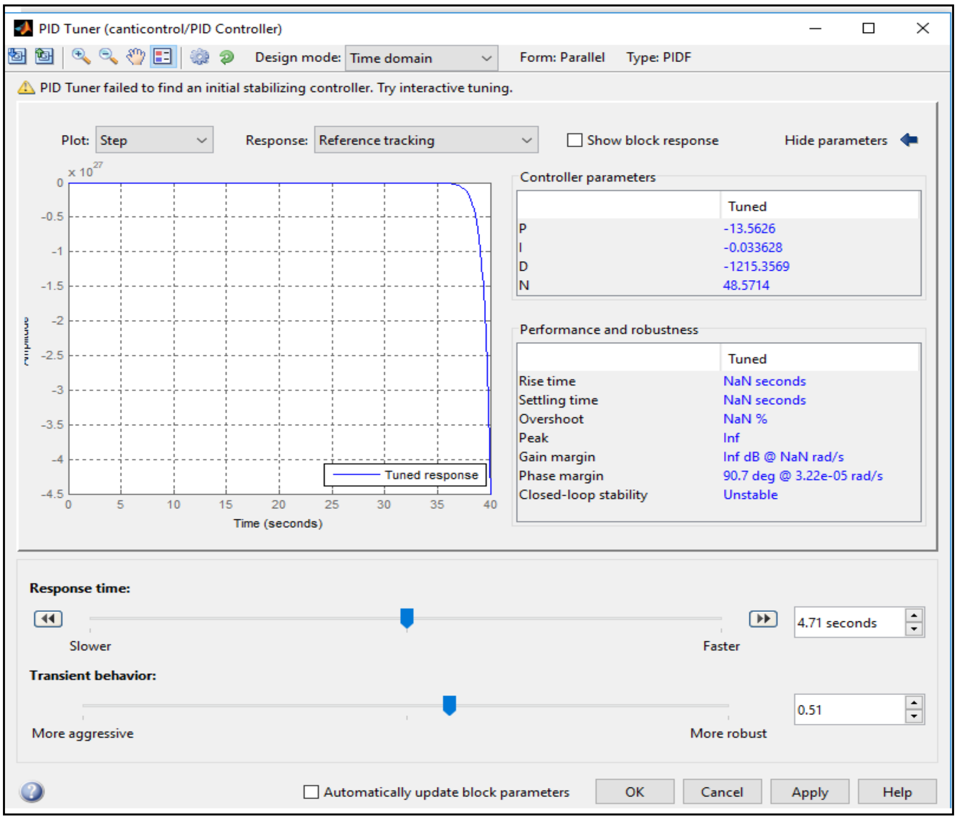

Fig-2 Autotunning in MATLAB

IV. EXPERIMENTAL SETUP OF CANTILEVER BEAM

The experiment setup consists of an aluminium cantilever beam with one fixed end and three piezoelectric sensors one is to actuate, second is used to sense, and third is to give disturbance. Fig3 shows the experimental setup of cantilever beam vibration control.

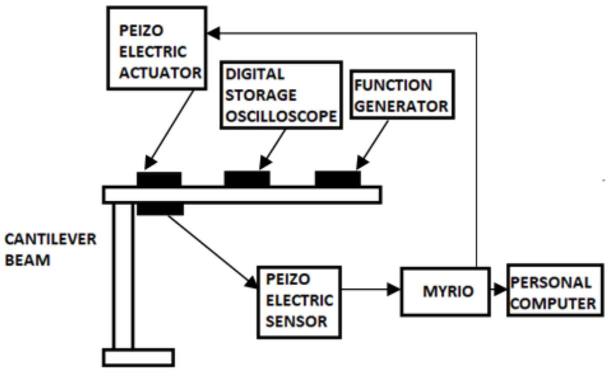

Fig 3- Schematic of Cantilever Beam Vibration Control

The control system constructed for studying the control of the resonance frequency in a cantilever beam shown in fig. Aluminium beam is straight and fixed at one end. a Piezoelectric patch located at the corner of the beam is to maintain its harmonic vibration. The excitation force is proportional to the electric current that flows through the actuator, which is measured as the voltage drop across the parallel sensor. The exciter is supplied from an external function generator whose excitation frequency can be varied by the voltage control signal. The beam vibration is detected by a piezoelectric sensor fixed at the corner of the beam. The sensor's output of the controller through LabVIEW using myRIO is converted in to the voltage signal and applied to MYRIO to analyse the signal. The signal detected is given to the PID controller to suppress the vibrations. Feedback signal is produced by the controller given to the piezoelectric actuator on the top left of the beam. The cycle continuous until the vibration is getting suppressed.

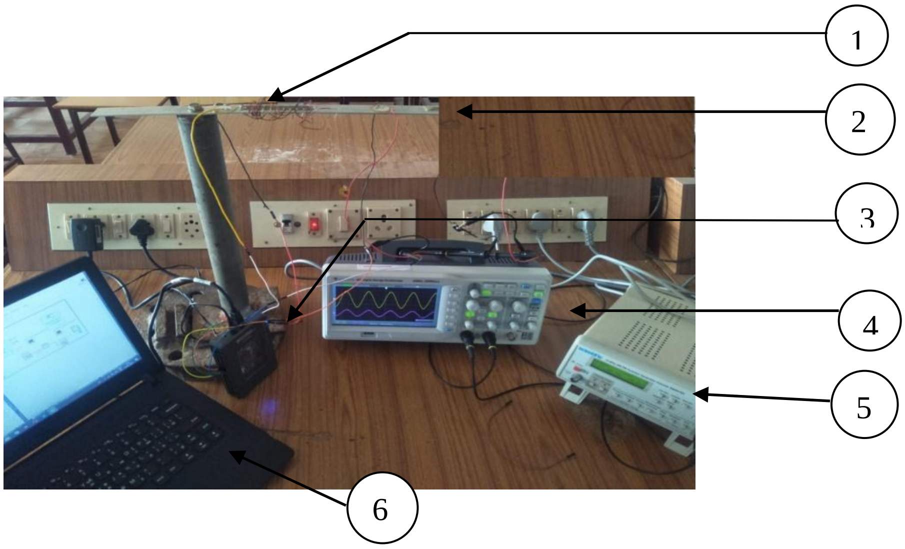

Fig-4 Experimental Setup of Cantilever Beam

1- Piezoelectric Sensor
2- Cantilever beam
3- myRIO
4- Digital Storage Oscilloscope
5- Audio Frequency Oscilloscope
6- Personal Computer

V. CANTILEVER BEAM DIMENSIONAL DETAILS

Table 1: Dimensions and Material Property of Cantilever Beams

Parameters	Symbol	Measurements
Length (m)	L	0.35
Width (m)	B	0.025
Thickness (m)	H	0.003
Modulus (N/m^2)	E	$7.1*10^{10}$
Density (kg/m^3)	P	2700

Piezo Electric Actuation: The Audio Frequency Oscilloscope provides input to the circuit. The input voltage given from an AFO is 10V and varying frequency. The output terminal of AFO is connected to the piezoelectric actuator which supplies the input disturbances. Then the output of piezoelectric actuation unit is given to the piezoelectric actuator which vibrates when input is applied.

Table 2: Dimensions and Material Property of Peizo Electric Sensor

Parameters	Symbol	Measurements
Length (m)	*Lp*	0.0765
SWidth (m)	*B*	0.0127
Thickness (m)	*Ta*	0.0005
Young's Modulus (Gpa)	*Ep*	47.62
Density (kg/m^3)	$\rho\ p$	7500
Piezoelectric strain constant (mV^{-1})	d 31	$-247x10^{-12}$
Piezoelectric stress constant($Vm\ N^{-1}$)	g31	$-9x10^{-3}$

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VI. CONTROL FOR VIBRATION CONTROL

Laboratory Virtual Instrument Engineering Workbench is a graphical programming language which is highly use full for data acquisition, measurement and control. This is due to the vast array of data acquisition cards and measurement systems, which is supported by LabVIEW and as well as relatively easy by advanced software that can be programmed.

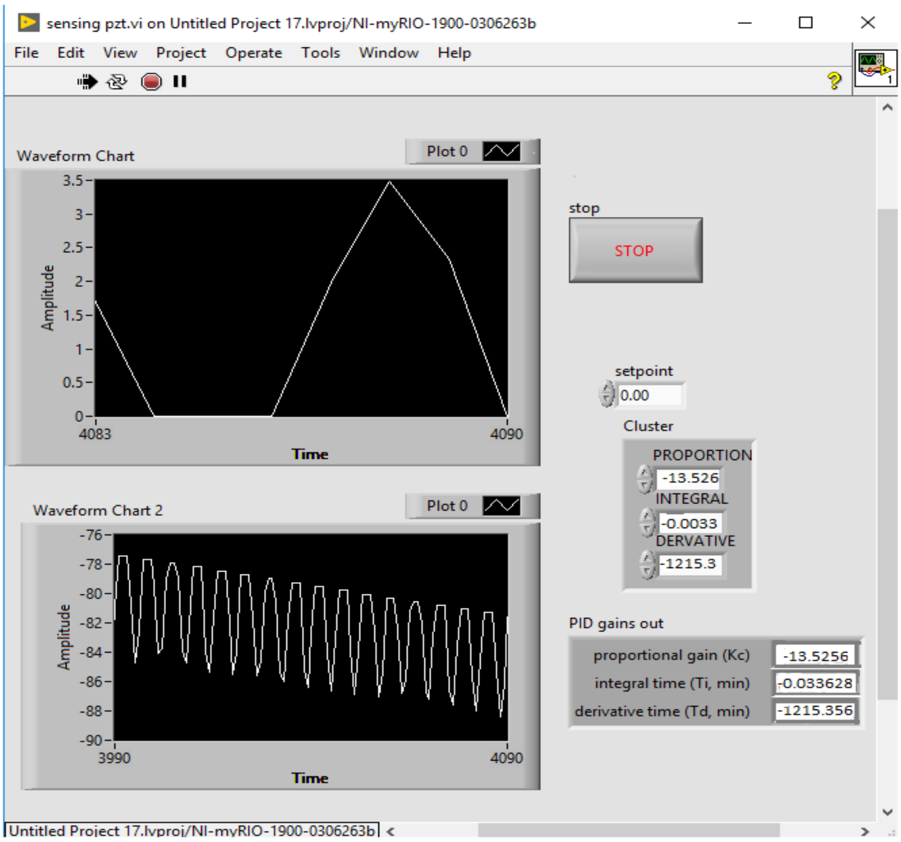

Fig-5 Front Pannel of Vibration Control

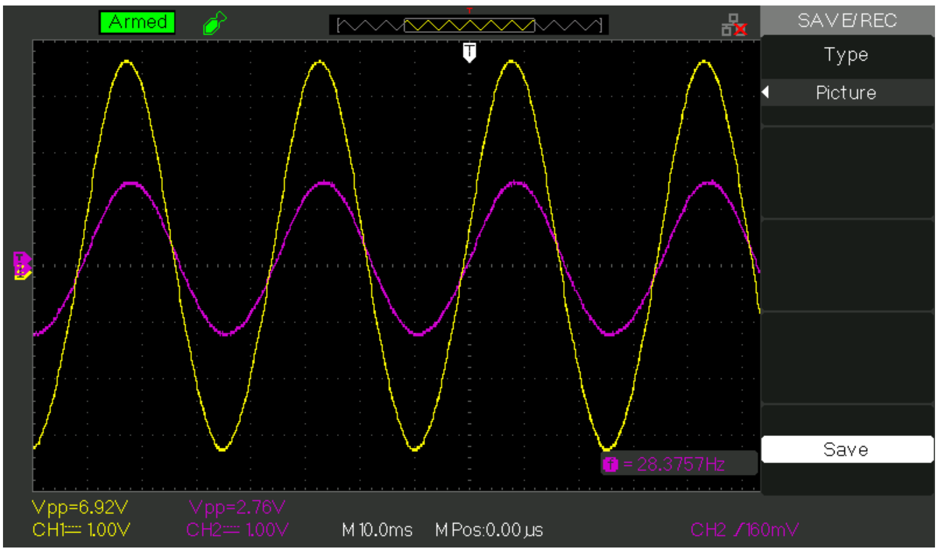

Fig- 6 Digital Storage Osilloscope Output

In this digital storage oscilloscope output, yellow waveform refers to uncontrolled vibration and purple waveform refers to controlled vibration. Initially the vibration produced by a cantilever beam is Vpp=6.92, after controlling vibration produced is Vpp=2.76. In this experiment we achieved 39% of vibration suppression.

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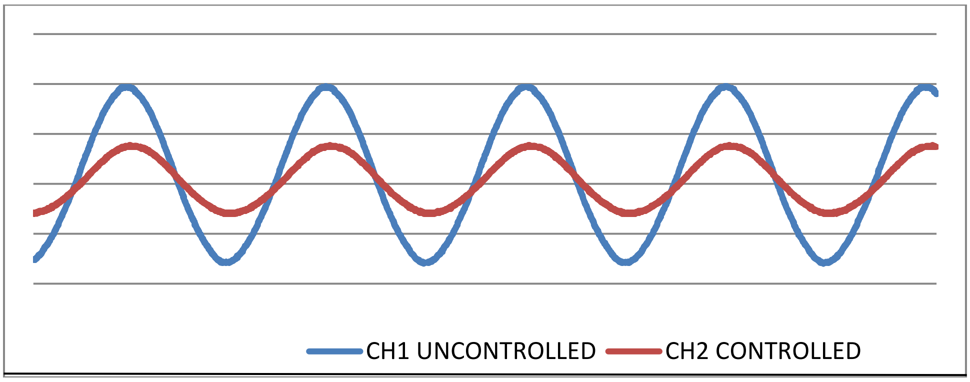

Fig – 7 Controlled and Uncontrolled Values

VII. CONCLUTION

The control of vibration in the cantilever beam using piezoelectric sensors in a platform of LabVIEW has been presented. The vibration of cantilever beam before and after controlling is been investigated. The experiment results in the reduction of amplitude of vibration. Data acquisition and controlling process gets simplified with the help of NI myRIO.

VIII ACKNOWLEDGEMENT

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