IJMRT: Volume (2), Issue 4, 2020 ISSN (Print) : 2663-2381
ISSN(Online) : 2663-4007

International Journal of Multidisciplinary Research Transactions

(A Peer Reviewed Journal)
www.ijmrt.in

# Comparison of Vibration Control in Cantilever Beam and U-Tube Coriolis Massflow Meter using LabVIEW

**Sakthivel.B[1], Vimalathithan.A[2], Prabakaran.B[3], Sachin.M[4], Aravind.P[5*], Shanmugavalli.M[6]**

[1,2,3,4] *Student, Instrumentation and Control Engineering, Saranathan College of Engineering, India*
[5] *Assistant Professor, Instrumentation and Control Engineering, Saranathan College of Engineering, India.*
[6] *Professor, Instrumentation and Control Engineering, Saranathan College of Engineering, India*

[*] Corresponding author

---

## Abstract

LabVIEW based Active vibration control by using Resonant sensor (Peizo electric sensor-PZT) to suppress the vibration produced in a mechanical system to make the system 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.

Before controlling the amplitude of vibration in cantilever beam(VPP) = 6 8V.After controlling the amplitude of vibration in cantilever beam (VPP) = 2. 7V. Before controlling the amplitude of vibration in U-tube coriolis mass flow meter(VPP) = 1.88V.After controlling the amplitude of vibration in U-tube coriolis mass flow meter (VPP) = 1. 64V.

**Keywords:** LabVIEW, myRIO, Cantilever beam, U-tube Coriolis mass flow meter.

---

## 1. 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. In this paper the controlling is done through peizo electric 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.



Analysis and Suppression of Mechanical Coupling Vibrations of Coriolis Mass Flow meter, piezoelectric sensor to analyze vibration magnitude [1] Finite Element Analysis of the Influence of Vibration Disturbance on Coriolis Mass Flow Meters, vibration is the measure of both flow and actuator [2]Design and Simulation of Fluidic Flowmeter for the Measurement of Liquid Flow in Micro channel Electromagnetic flowmeter measurement and numerical computation of laminar flow transport pipeline flow quantity Genetic algorithm to select a set of closure relationships in multiphase flow models, only laminar flow is analyzed and the flow rate is nothing but a phase difference between two sensors output[3], Improved Correlation Algorithm in Coriolis Flow Meter, PID control algorithm is used Active Vibration control of a smart cantilever beam at resonance, a comparison between conventional and real time control there real time operating system is used to reduce operating time here windows based LabVIEW used [4]Development of a LabVIEW based controller for Active Vibration Control of Panel Structure using Peizo electric Wafer in this paper PID algorithm through Myrio [5] Active vibration control of SMA actuated Structures using fast output sampling based sliding mode control for advanced controlling in this paper light weight material is controlled so SMA is not required [3]Sliding mode controller with multi sensor data fusion for Peizo actuated structure in this paper for both sensing and actuating a peizo electric sensor is used[5]Parametric modelling and FPGA based real time active vibration control of a peizo electric laminate cantilever beam at resonance in this paper SI-system identification tool is used to get the transfer function of a cantilever beam[6]A Driver for Peizo electric 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[7], Intelligent tuning of vibration mitigation process for single link manipulation using fuzzy logic in this paper tuning of PID is done through auto tuning [8]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[9] A labview based data acquisition systems for vibration monitoring and analysis in this paper labview is used for both signal acquisition and controlling [10], Phase locking control of the coriolis meter‘s resonance frequency based on virtual instrumentation in this paper frequency is only getting controlled[11], In this paper, vibration is measured and controlled using PZT sensors. Parametric modelling and FPGA based real time active vibration control of a piezoelectric laminate single U-tube at resonance SI-system identification tool is used to get the transfer function of a single U-tube[5]. 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 linearsystem[11] . single U-tube model have identified.smartCoriolis mass flow meter[14] . 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] . resonant frequency is found for single U-tube. The paper address on how to suppress the vibration produced in a single U-tube. 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.

Our main objective is 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 fedback 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.

## 2. SECTION DETAILS

To control the system using PID controller, it requires a transfer function of a particular system. Here 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 with two parameters the transfer function is found.

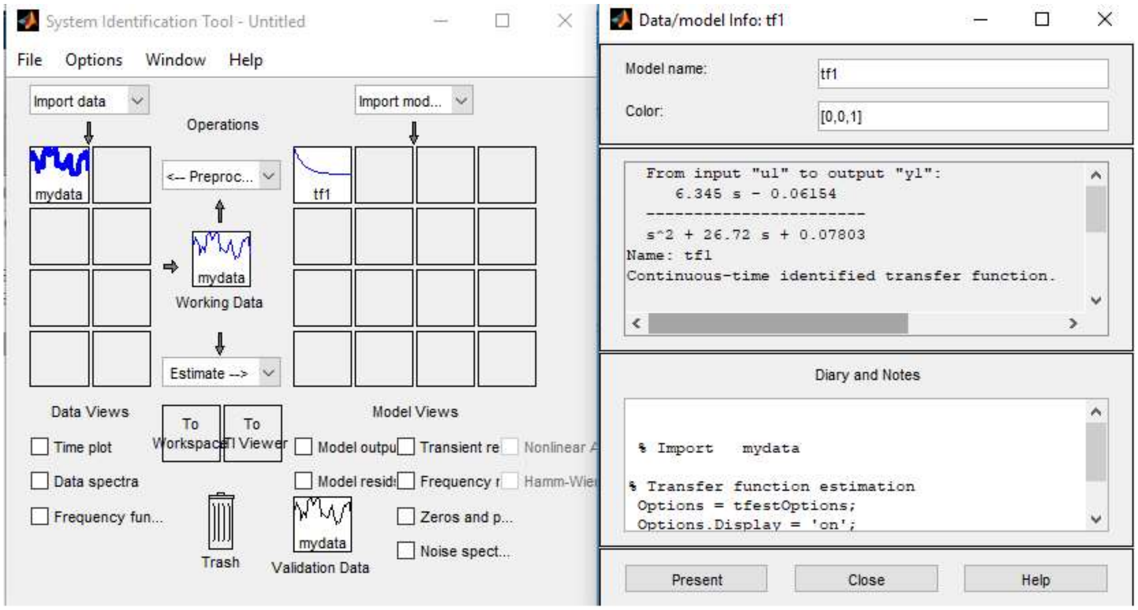


**Fig-1 SHOWS THE SYSTEM IDENTIFICATION TOOL IN MATLAB FOR CANTILEVER BEAM**

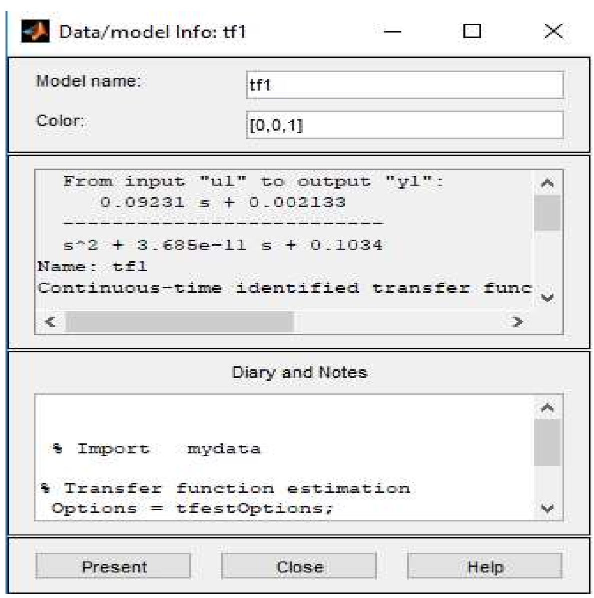


**Fig-2 SHOWS THE SYSTEM IDENTIFICATION TOOL IN MATLAB FOR U-TUBE**

The transfer function obtained is a mathematical model of cantilever beam. With this transfer function the exact PID values are known using various methods in Matlab. Here auto tuning method is used.

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 cantilever beam:

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

Transfer function of u-tube coriolis mass flowmeter:

$$\frac{0.09231s + 0.00213}{s^2 + 3.685e^{-11}s + 0.1034}$$

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.

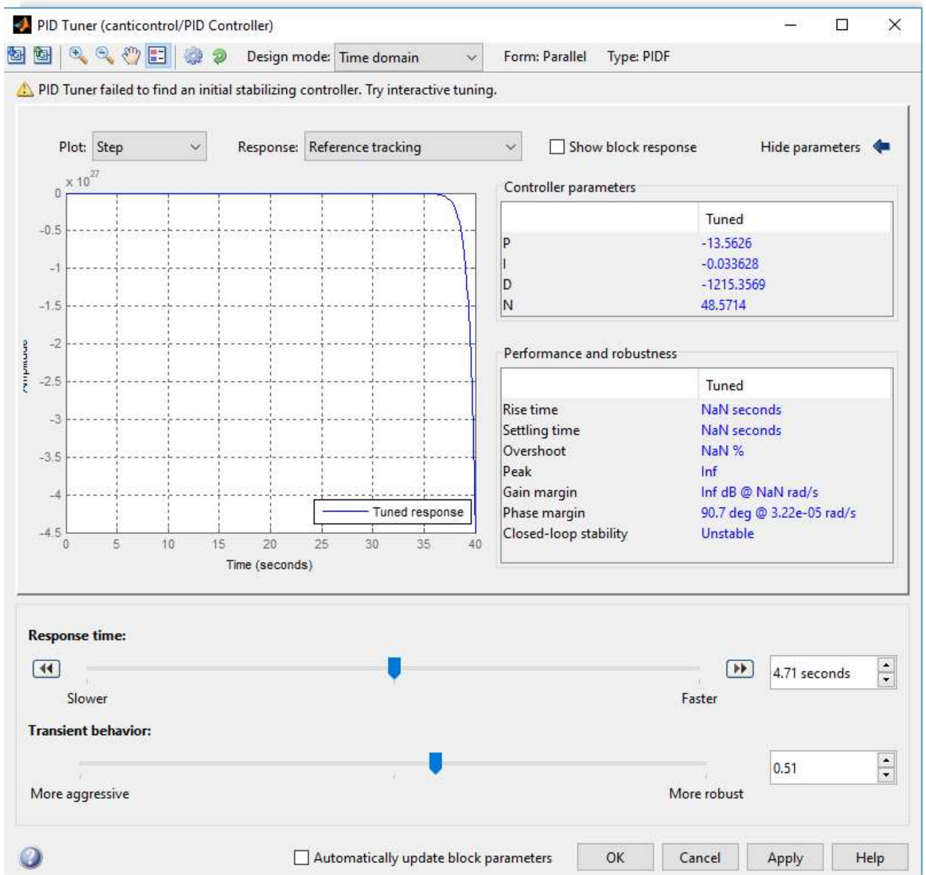


**FIG-3 AUTOTUNNING IN MATLAB**

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.

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.



**3. Experimental setup of cantilever beam and u-tube coriolis massflow meter**

In this experiment the setup consists of an aluminium cantilever beam with one fixed end and three piezoelectricsensors that is used to actuate and sense.

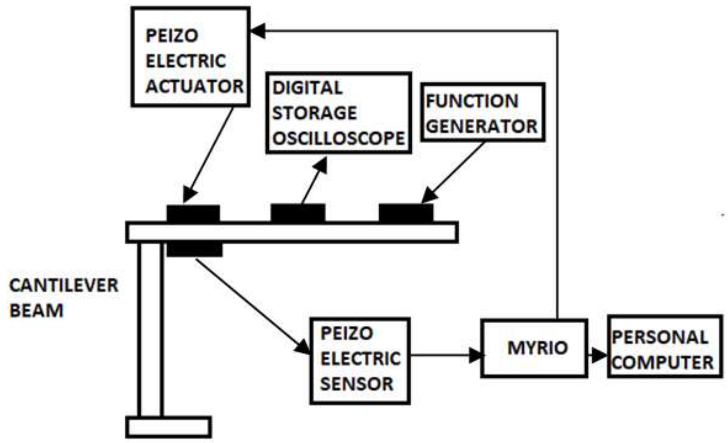


**FIG -4 BLOCKDIAGRAM OF CANTILEVER BEAM CONTROL**

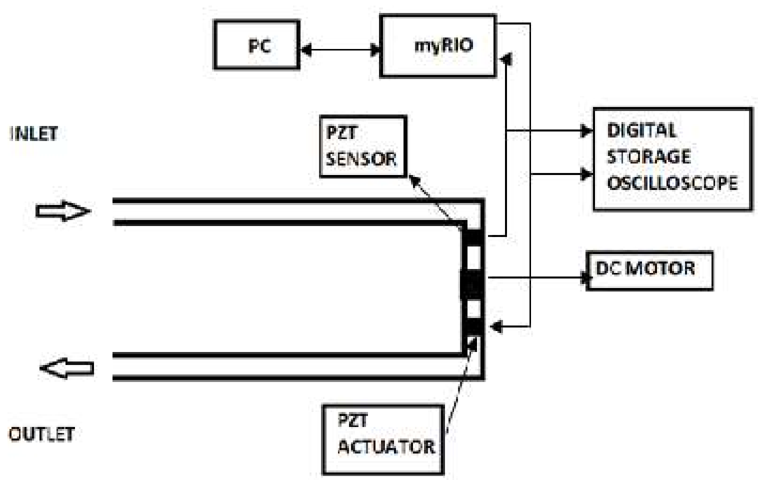


**FIG -4 BLOCKDIAGRAM OF U-TUBE CORIOLIS MASSFLOW CONTROL**

The control system constructed for studying the control of the resonance frequency in a cantilever beam shown schematically. Aluminium beam is straight and fixed at one end. An electromagnetic exciter 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 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 peizo electric actuator on the top left of the beam.
The cycle continuous until the vibration is getting suppressed. The disturbance generated by using function generator will make the cantilever beam to vibrate, that vibration is getting measured by using peizo electric sensor on the bottom side of the beam.

**FIG-5 EXPERIMENT SETUP OF CANTILEVER BEAM**

**FIG-6 EXPERIMENT SETUP OF U-TUBE CORIOLIS MASS FLOW METER**

**4. Labview Control Logic**

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

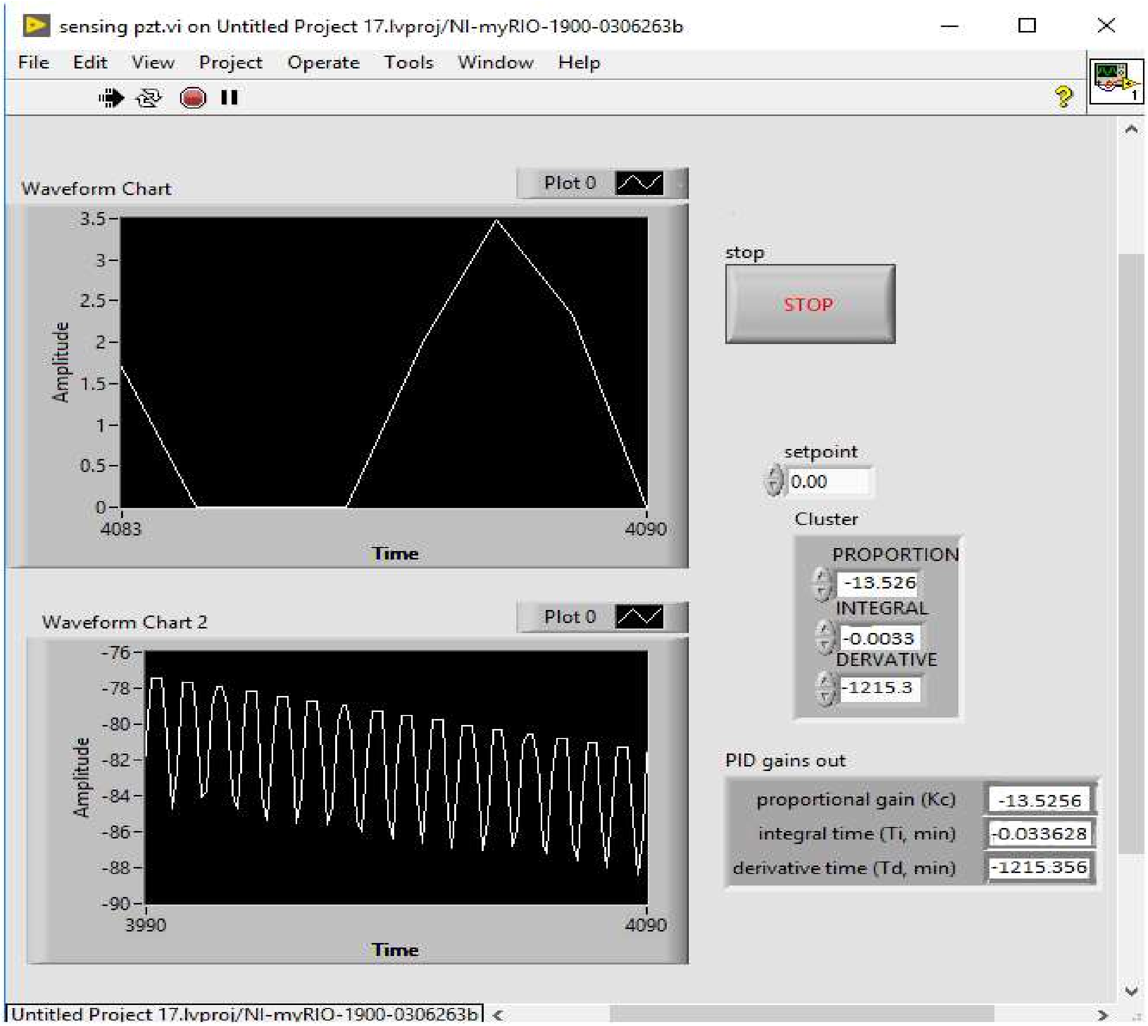


**FIG 7-FRONT PANEL**

**DIGITAL STORAGE OSCILOSCOPE OUTPUT**

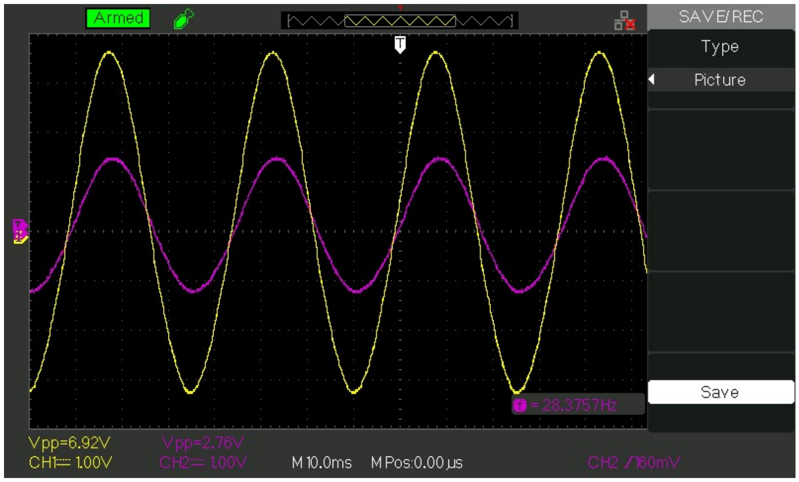


**FIG -8 DSO OUTPUT**

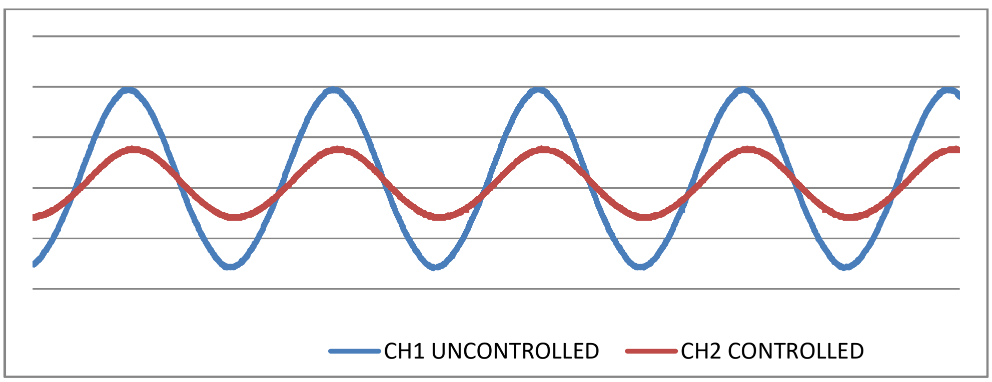


**FIG – 9 CONTROLLED AND UNCONTROLLED VALUES**

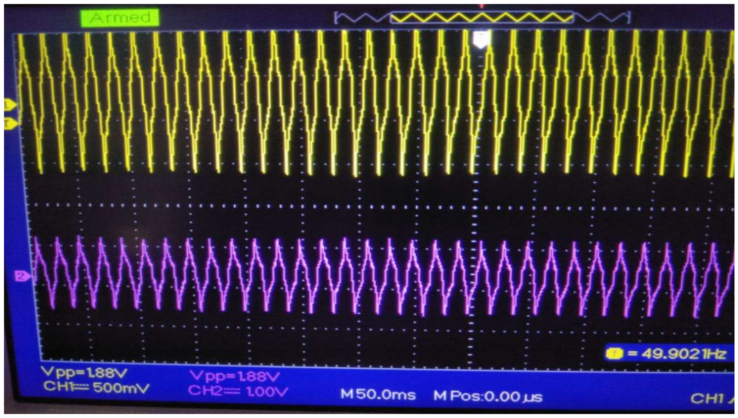


**FIG-10 OUTPUT WAVEFORM OF SINGLE U-TUBE CORIOLIS MASSFLOWMETER BEFORE CONTROLLING**

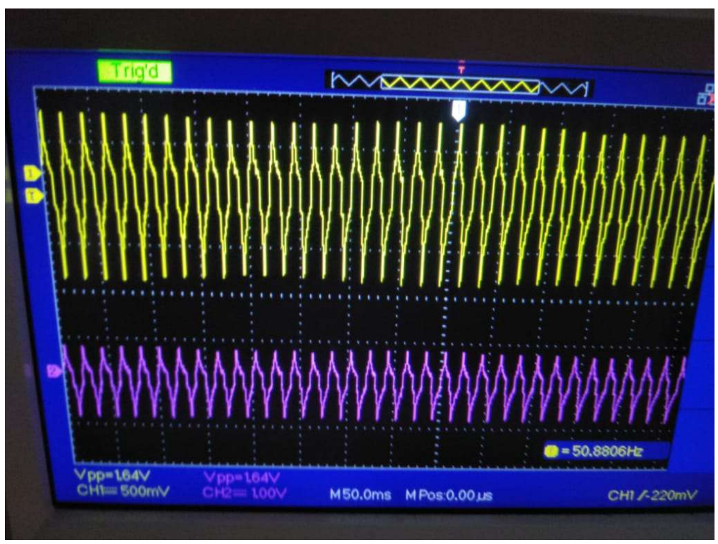


**FIG-11 WAWEFORM OF SINGLE U-TUBE CORIOLIS METER AFTER CONTROLLING**

## 5. Cantilever Beam Dimension Details

**Table 1: Dimensions 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 |

*5.1 Peizo Electric Actuation:*

The AFO 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 piezo actuator which supplies the input disturbances. Then the output of piezo actuation unit is given to the piezo actuator which vibrates when input is applied.

**Table 2: Dimensions Of Peizo Electric Sensor**

| **Parameters** | **Symbol** | **Measurements** |
|---|---|---|
| Length (m) | *Lp* | 0.0765 |
| Width (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 | $-9x10^{-3}$ |

*5.2 Piezo Sensing Unit*

The piezo crystal sensing terminal is connected to the input of piezo sensor. The vibration is sensed and displayed in the sensing unit. The output of the piezo sensing unit is connected to the input of the DSO.



**Conclusion:**

Thus the control of vibration is obtained in the cantilever beam using LabVIEW. Data acquisition and controlling process gets simplified with the help of NI MYRIO. Finally through the experiment the effective vibration control is established For many applications it requires high stability for measurement and quality control process. To achieve this active vibration controller plays the crutial role.

**REFERENCES**

[1] QiaoShaojie, Wang Shuai, ZhengDezhi, Fan Shangchun-Analysis and Suppression of Mechanical Coupling Vibrations of Coriolis Mass Flowmeter2010 International Conference on Intelligent Computation Technology and Automation978-0-7695-4077-1/10 $26.00 © 2010 IEEEDOI 10.1109/ICICTA.2010.213

[2] Yao Kai, Zhao Jianhui, Li FanFinite Element Analysis of the Influence of Vibration Disturbance on Coriolis Mass Flow Meters2010 International Conference on Intelligent Computation Technology and Automation978-0-7695-4077-1/10 $26.00 © 2010 IEEEDOI 10.1109/ICICTA.2010.213

[3] Liu Shigang1, Xie Dailiang1*, Tao Shan2Design and Simulation of Fluidic Flowmeter for the Measurement of Liquid Flow inMicrochannelElectromagnetic2012 Third International Conference on Digital Manufacturing & Automation

[4] Arunshankarjayabalan ,Umapathy,Sliding mode controller with multi sensor data fusion for Peizo actuated structure,2011 –Rasearch gate

[5] KV Gangatharan ,Arun P ParameshvaranParametric modelling and FPGA based real time active vibration control of a peizo electric laminate cantilever beam at resonance -2014-Reasearch gate

[6] F J Arnold , RL XiemenesR.Aruthur , S SMuhlenA Driver for Peizo electric transducer with control of reasonance- -2015-science direct

[7] Ahmed A , Ali Rana Abdul Rahman lateel Mohamed waelsaseedIntelligent tunning of vibration mitigation process for single link manipulation using fuzzy logic 2017-science direct

[8] ReissomWeldigiorgis ,Prasad Krishna , K V GangatharanVibration control of a smart cantilever beam using srain rate feedback 2014 –science direct

[9] Asan Gain A labview based data acquisition systems for vibration monitoring and analysis 2002-SCRND

[10] JozeKutin, Andrej smercnik , Ivan BajsicPhase locking control of the coriolis meter ‘s resonance frequency based on virtual instrumentation-2003 science direct

[11] S. Ramachandran, P.Aravind, V.Venkataraman, G.Subramanian, "Validation of a Neural Network Model for a Nonlinear Process by Parameter Estimation", International Journal of Applied Engineering Research, Volume 9, Number 24 , Pages 29051-29062, ISSN 0973-4562, 2014

[12] P Aravind, S M Girirajkumar, "Effectiveness of Error Recursion Technique on Real Time Closed Loop Pressure Process using validated model by NARX- Recurrent Neural Network tool", Journal of Electrical Engineering, ISSN (Print): 1582-4594, Volume 19, Edition 3, July 2019, pp 1-6.

[13] P Aravind, S M Girirajkumar, The Book entitled on "Idea for automating industrial plant operation" Lambert Academic International Publishers, Germany(2018), ISBN: 978-613-9-86295-5.

[14] M.shanmugavalli, umapathi,uma smart Coriolis mass flow meter –published on Elsevier 1/5/2010

[15] RM saravanan, christ W raj, M shanmugavalli design and simulation of Coriolis mass flow tube in meso and micro level to determine the resonant frequency-journal-middle east journal of scientific research flowmeter measurement and numerical computation of laminar flow transportpipeline flow quantity