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# Vibration Control of Single U-tube Coriolis Mass Flowmeter 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 single U-tubeCoriolis mass flow meter to make more stable vibrations produced by the system should be controlled. In this paperthe 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. Active control of vibration in U-tube using PID controller. The proposed control technique achieves good vibration suppression and it can be tuned to satisfy the requirement. Before controlling vpp=1.88, after controlling = 1.64.

**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 meterials 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.

Analysis and Suppression of Mechanical Coupling Vibrations of Coriolis Mass Flowmeter, 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 inMicrochannelElectromagnetic flowmeter measurement andnumerical computation of laminar flow transportpipeline flow quantityGenetic 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 [4],Genetic algorithm to select a set of closure relationships in multiphase flow models, LabVIEW based PID controllers used[5],Smart Coriolis mass flowmeter the vibration produced because of flow is getting suppressed [6]Active Vibration control of a smart single U-tubeat resonance, a comparison between conventional and real time control the real time operating system is used to reduce operating time here windows based LabVIEW is used [7][12]. Development of a LabVIEW based controller for Active Vibration Control of Panel Structure using Piezoelectric Wafer PID algorithm through myRIO [8]. Active vibration control of SMA actuated structures using fast output sampling based sliding mode control for advanced controlling is given light weight meterial is controlled so SMA is not required [9]. Sliding mode controller with multi sensor data fusion for Piezoelectric actuated structure . for both sensing and actuating a piezoelectric sensor is used[10]. 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 linear system[11]. single U-tube model have

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identified.smart Coriolis 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 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.

### II. SYSTEM IDENTIFICATION OF SINGLEU-TUBECORIOLIS MASS FLOWMETER

To control the system using PID controller, the transfer function of a particular system is required to the transfer function of a single U-tube 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.

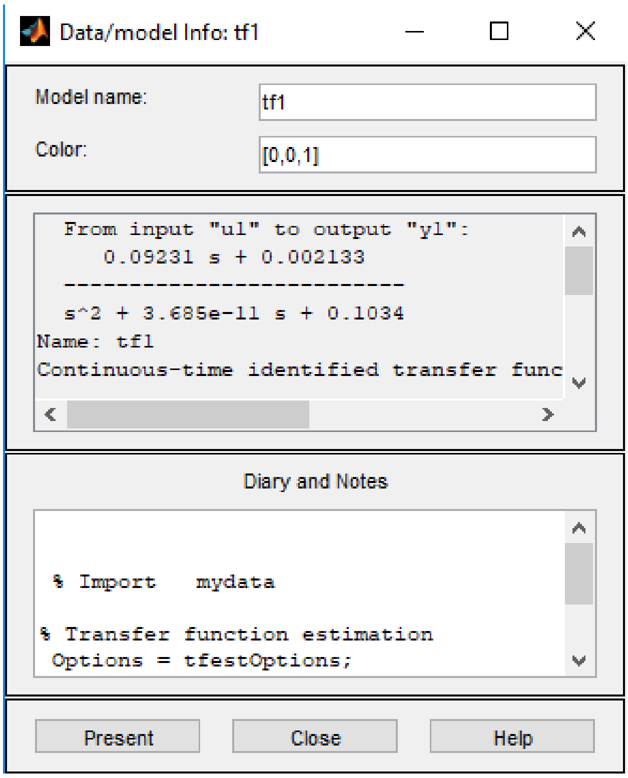


FIG-1 SYSTEM IDENTIFICATION TOOL IN MATLAB

TRANSFER FUNCTION:

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

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.

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### 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.
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.

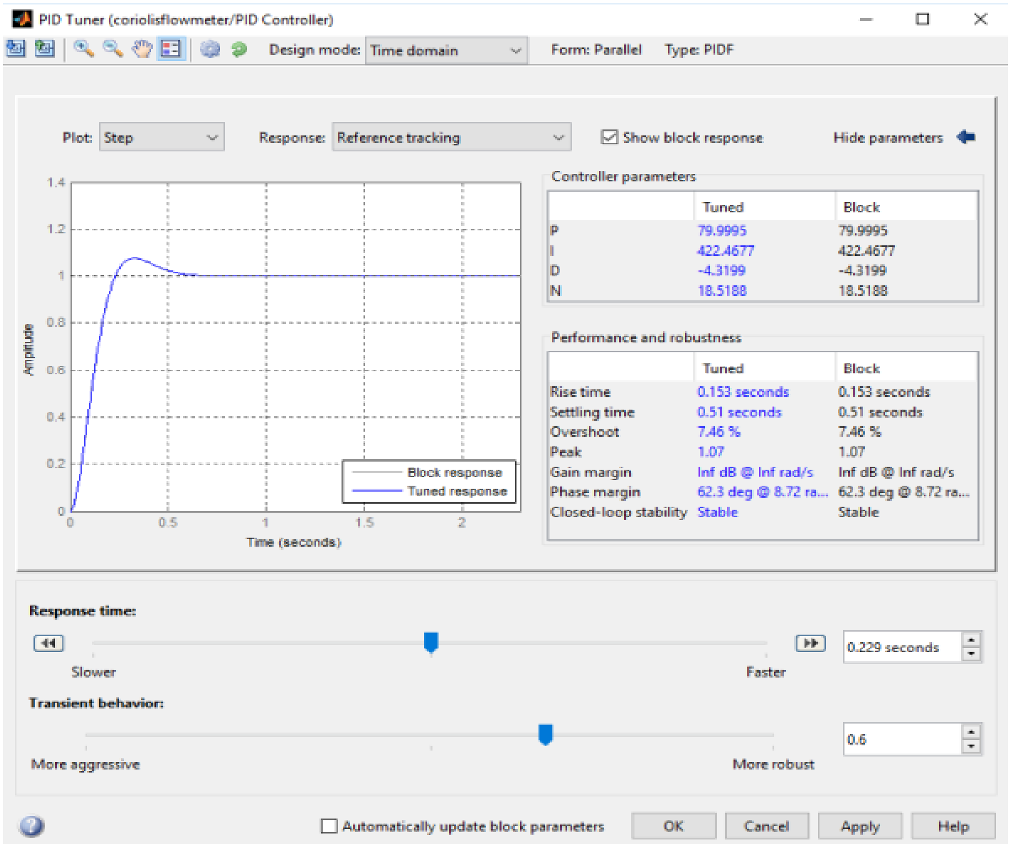


FIG-2 AUTOTUNNING TOOL IN MATLAB

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### IV. EXPERIMENTAL SETUP OF SINGLE U-TUBE

The experiment setup consists of an U-tubeCoriolis meter 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 single U-tubeCoriolismeter vibration control.

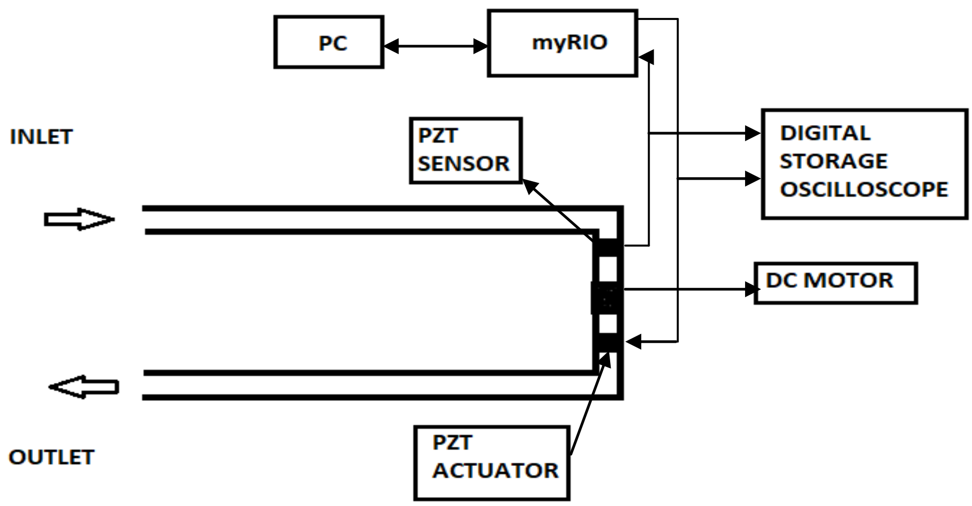


FIG 3- SCHEMATIC OF SINGLE U-TUBE VIBRATION CONTROL

The control system constructed for studying the control of the resonance frequency in a single U-tubeCoriolismeter shown in fig. Aluminium beam is straight and fixed at one end. an 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.

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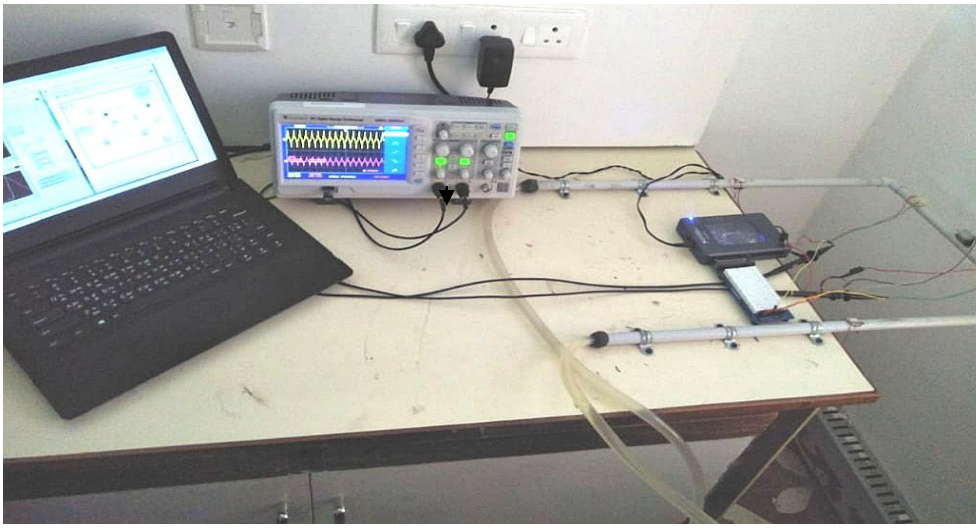

FIG-4 EXPERIMENTAL SETUP OF SINGLE U-TUBECORIOLIS MASS FLOWMETER

## V. SINGLE U-TUBECORIOLISMETER DIMENSIONAL DETAILS

**TABLE 1: DIMENSIONS AND METERIAL PROPERTY OF SINGLE U-TUBECORIOLIS MASS FLOWMETER**

| **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 supplies the input disturbances. Then the output of piezoelectric actuation unit is given to the piezoelectric actuator which vibrates when input is applied.

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**TABLE 2: DIMENSIONS AND METERIAL PROPERTY OF PEIZO ELECTRIC SENSOR**

| Parameters | Symbol | Measurements |
|---|---|---|
| Length (m) | $L_p$ | 0.0765 |
| SWidth (m) | $B$ | 0.0127 |
| Thickness (m) | $T_a$ | 0.0005 |
| Young's Modulus (Gpa) | $E_p$ | 47.62 |
| Density (kg/m$^3$) | $\rho_p$ | 7500 |
| Piezoelectric strain constant (mV$^{-1}$) | $d_{31}$ | $-247\times10^{-12}$ |
| Piezoelectric stress constant( Vm N$^{-1}$) | $g_{31}$ | $-9\times10^{-3}$ |

## 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.

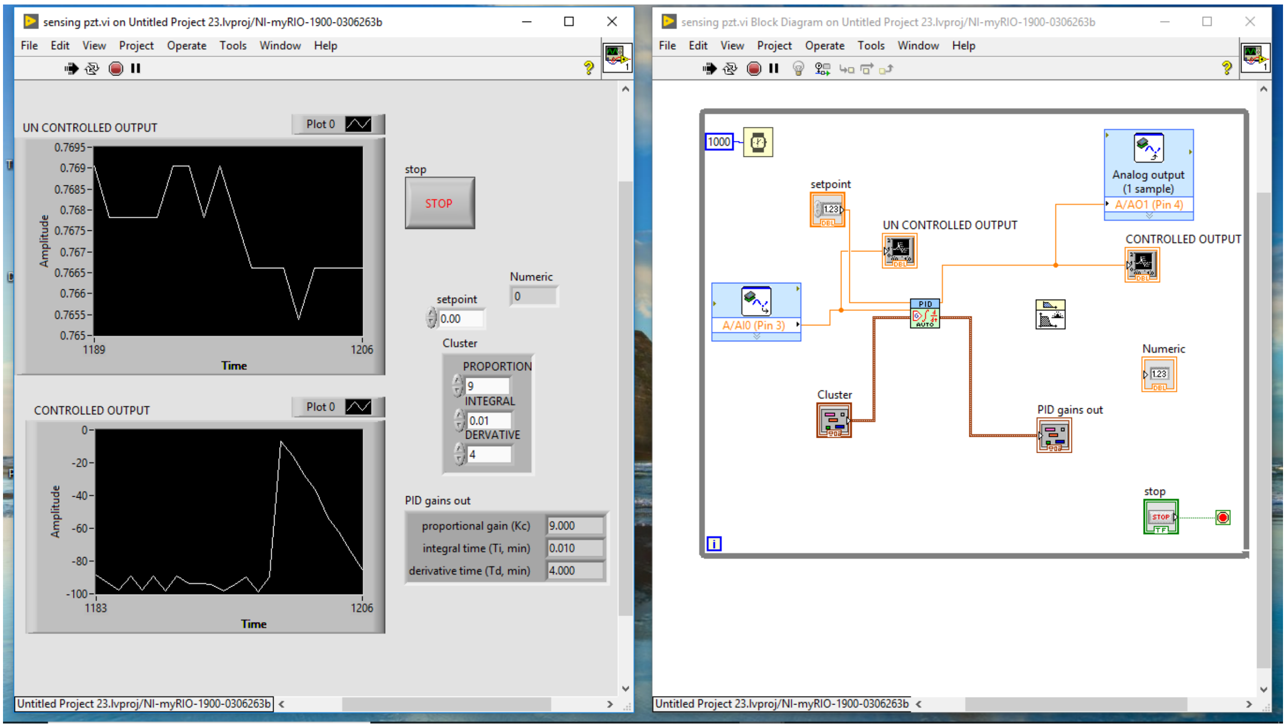


FIG-5 FRONT PANEL OF SINGLE U-TUBE VIBRATION CONTROL

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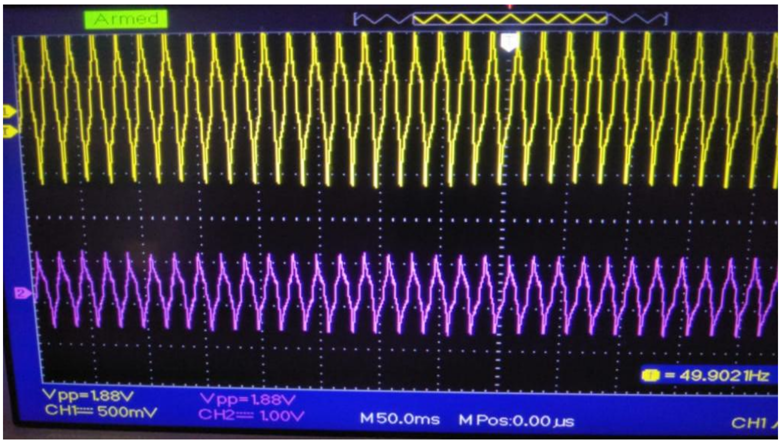


FIG-6 OUTPUT WAVEFORM OF SINGLE U-TUBECORIOLIS MASSFLOWMETER BEFORE CONTROLLING

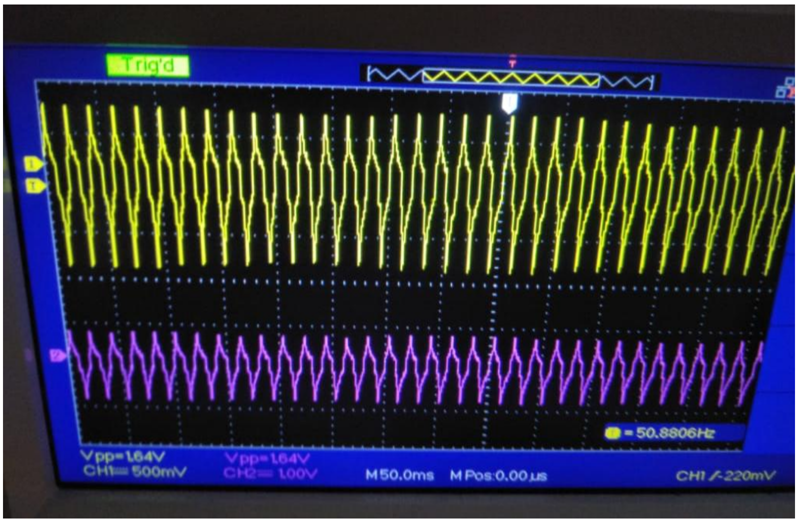


FIG-7 WAWEFORM OF SINGLE U-TUBECORIOLIS METER AFTER CONTROLLING

## VII. CONCLUTION

The control of vibration in the single U-tube Coriolismeter using piezoelectric sensors in a platform of LabVIEW has been presented. The vibration of single U-tube Coriolismeter 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.

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