Wireless Vibration Frequency Tap Test Tool for Aerospace and Automobile Engines (WVF3T)

N. Mini[1], D. Revathy[2], Shruthi Dubey[3], L. Jiban Priya Devi[4]
[1,2,3]*Student, Department of ECE, Sri Muthukumaran Institute of Technology, Chennai, India*
[4]*Assistant Professor, Department of ECE, Sri Muthukumaran Institute of Technology, Chennai, India*

***Abstract*: A sensor is an object whose purpose is to detect events or changes in its environment, and then provide a corresponding output. From machine shafts and bearings to hard disk performance, vibration causes machine damage, early replacement and inflicts a major hit on accuracy. The necessity to monitor vibration arises from the fact that vibrations produced by machinery are vital indicators of machinery health. A vibration sensor measures the first vibrational movements in any electrical machine. The conventional method of testing vibration sensors is to strike it with a plastic mallet and check for the vibrational response which indicates that the sensor is working. Normally vibration sensors are flimsy and any kind of hard impact on the sensor body may damage the sensing element/ internal construction which will result in a sensor failure. Instead of producing vibrations using a mechanical hammer, an electronic tool is designed using a vibration driving circuit which can be used to produce vibrations at variable frequency and duty cycle values. The purpose of this instrument is to provide damage free mechanical impact to the vibration sensor. Such device is essential to avoid sensor failure by manual impact by hammer. Thus vibrations produced by the various mechanical parts are measured with highest accuracy and eliminated to ensure the effective operation of the machine in a long run.**

***Keywords*: Vibration driving circuit, electronic tool, variable frequency**

1. Introduction

Vibration is a natural phenomenon induced by automobile engines and aerospace engines generating vibration energy over a wide range of frequencies. The resulting vibration environment can be severe with respect to structural fatigue and damage to components. To insure the structural and functional integrity of the vehicle systems, it is necessary to determine the vibration environment of a vehicle and components. Hence, continuously monitoring vibration levels over time allows the plant engineer to predict problems before serious damage occurs. Machinery damage and costly production delays caused by unforeseen machinery failure can be prevented. When pending problems are discovered early, the plant engineer has the opportunity to schedule maintenance and reduce downtime in a cost effective manner. Vibration analysis is used as a tool to determine machine condition and the specific cause and location of machinery problems. This expedites repairs and minimizes costs. The testing of vibration sensor is done by striking it with the hammer. As known vibration sensor are flimsy material it can be easily get damaged with the force of the hammer and if the damaged sensor is used to monitor the vibrations in the engine there will be a lack of accuracy and in case, if the vibrations produced by the engines is more then it may lead to machinery damage. In this paper we have developed intelligent electronic tool to test the vibration sensor without any damage with high accuracy monitoring system of vibrations produced by the automobiles and aerospace engines.

2. Methodology

Machinery vibration monitoring programs are effective in reducing overall operating costs of industrial plants. Vibrations produced by industrial machinery are vital indicators of machinery health. Machinery monitoring programs record a machine's vibration history. A wireless transceiver model has been developed to transmit and receive the vibration values using the concept of data acquisition. The transceiver module consists of arduino interfaced with nrf24l01 transceiver. The LPC 2148 controller generates PWM like signals at a particular pin based on the firmware code input into it. These signals are of a particular fixed frequency and possess variable duty cycles which can be changed using hard input externally through transceiver module. The AND gate accepts these signals as input to boost their output. This is in turn is fed to the driver IC L293D which acts as a buffer between the microcontroller and the vibrator to prevent the latter from drawing too much current from the controller thus damaging it. The vibrator present in the robotic arm changes speed and hence the vibration amplitude owing to the changes in the voltage applied resulting from the variable duty cycles present in the PWM like signals. The robotic arm is controlled using wireless transceiver module. When the wireless instruction is passed to the robotic arm the nipple of the arm housing the vibrator now touches the digital vibration sensor and transfers the vibration to it. On sensing the vibration the vibration sensor sends the digital output to LPC2148 and it is converted to analog output. This analog signal is wirelessly acquired by the transceiver module and using GUI a graphical screen display the variation of vibration in terms of vibration unit ‘G’. We can also use LCD to display the output.

3. Block Diagram

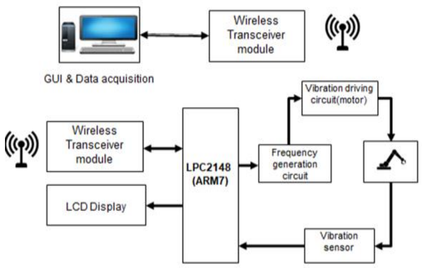


Fig. 1. Block diagram

A. *ARM7 LPC2148 controller*

ARM controllers are a family of 32-bit microcontrollers developed by Advanced RISC Machines, Ltd. in the 1980s. Today ARM controllers power a wide variety of electronic devices, including mobile phones, tablets, multimedia players and more. The NXP (founded by Philips) LPC2148 is an ARM7TDMI-S based high-performance 32-bit RISC Microcontroller. A RISC-based computer design approach means ARM processors require significantly fewer transistors than typical processors in average computers.

Fig. 2. Arm controller

B. *Piezoelectric sensor*

The rugged, solid-state construction of industrial piezoelectric sensors enables them to operate under most harsh environmental conditions. They are unaffected by dirt, oil, and most chemical atmospheres. They perform well over a wide temperature range and resist damage due to severe shocks and vibrations. Most piezoelectric sensors used in vibration monitoring today contain internal amplifiers.

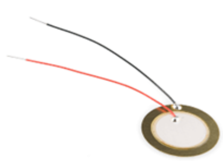


Fig. 3. Piezoelectric sensor

C. *Vibrator (DC motor)*

Vibration motor is a compact size coreless DC motor used to informs the users of receiving the signal by vibrating, no sound. Vibration motors are widely used in a variety of applications including cell phones, handsets, pagers, and so on. The main features of vibration motor are the magnet coreless DC motor are permanent, which means it will always have its magnetic properties (unlike an electromagnet, which only behaves like a magnet when an electric current runs through it); another main feature is the size of the motor itself is small, and thus lightweight.

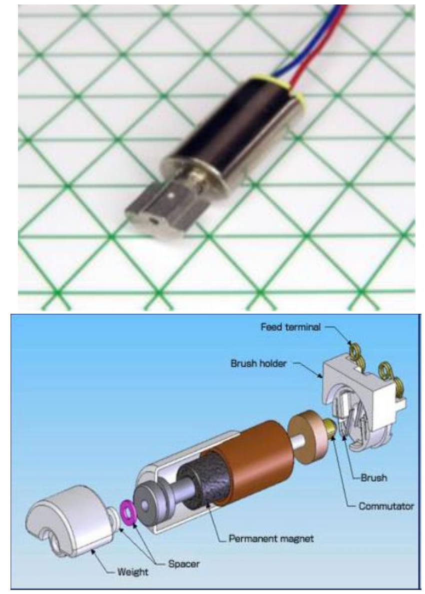


Fig. 4. Internal view of vibration motor

D. *Vibration driving circuit*

The L293 and L293D are quadruple high-current half-H drivers. The L293 is designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply

Applications

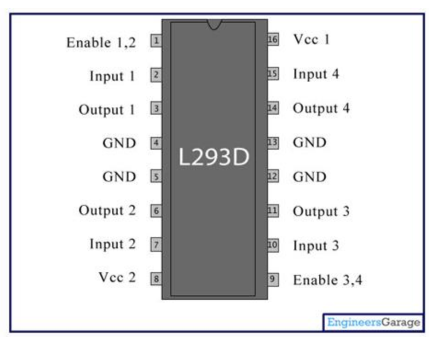


Fig. 5. Vibration driving circuit

E. *LCD display*

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. LCD Display is used to display the duty cycle ratio of the PWM wave generated.

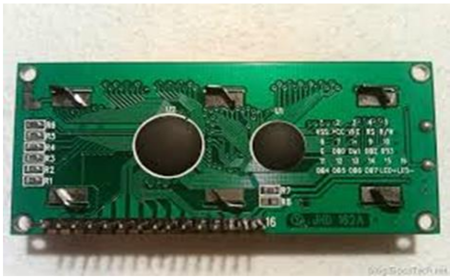


Fig. 6. LCD display

F. Wireless Transceiver module

1) nRF24L01

nRF24L01 is a single chip radio transceiver for the world wide 2.4 - 2.5 GHz ISM band. The transceiver consists of a fully integrated frequency synthesizer, a power amplifier, a crystal oscillator, a demodulator, modulator and Enhanced ShockBurst™ protocol engine.

Fig. 7. nRF24L01

2) ARDUINO

This is the Arduino Uno R3. In addition to all the features of the previous board, the Uno now uses an ATmega16U2 instead of the 8U2 found on the Uno (or the FTDI found on previous generations). This allows for faster transfer rates and more memory. No drivers needed for Linux or Mac (inf file for Windows is needed and included in the Arduino IDE), and the ability to have the Uno show up as a keyboard, mouse, joystick, etc.

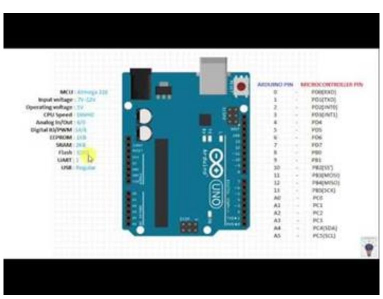


Fig. 8. Arduino

3) Robotic ARM

A robotic arm is a type of mechanical arm, usually programmable, with similar functions to a human arm; the arm may be the sum total of the mechanism or may be part of a more complex robot.

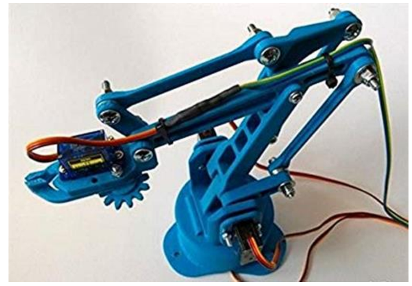
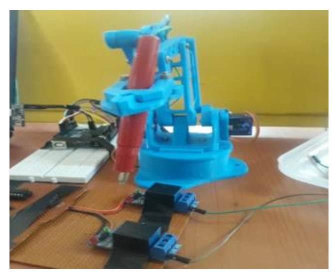


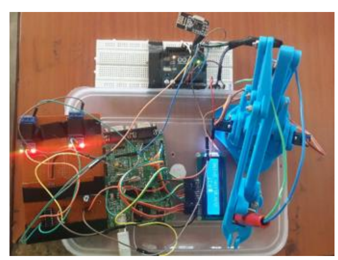
Fig. 9. Robotic ARM

A robotic arm is a type of mechanical arm, usually programmable, with similar functions to a human arm; the arm may be the sum total of the mechanism or may be part of a more complex robot. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement.[1][2] The links of the manipulator can be considered to form a kinematic chain. The terminus of the kinematic chain of the manipulator is called the end effector and it is analogous to the human hand.

4. Experimental result



(a)



(b)

(c)

Fig. 10. Experimental result

5. Conclusion

This tool was designed in the most compact manner possible for qualification testing of a vibration sensor and thus the objective of the project was met. The primary criteria being compactness was also fulfilled. Using this tool automobile and space industries can qualify the vibration sensors used in their applications. The absence of brute force testing on the vibration sensor protects it and the presence of a regulated input adds to the accuracy of testing. The use of a detachable mechanical arm expands the flexibility of using the tool for field test purposes. Due to its simple construction and user friendly interface, it becomes even easier for technical personnel to make use of it. This tool can also act as a cost saving technique in industries where minimization of funds and maximization of the output for each department is necessary.

6. Future scope

Owing to time constraints the analog values of the vibration wasn't obtained from the sensor. For future expansion the output obtained will be validated with the input given from the vibrator to obtain a much accurate output. On comparison of the output with the input the vibration senor will be passed as sound.

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