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ACCELEROMETER BASED G -FORCE MEASUREMENT ON VARIOUS DYNAMIC COMPONENTS OF AN AUTOMOBILE WIRELESS SENSOR NETWORK

IOT based approach towards standard Data Acquisition Systems

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***Abstract*— The system constructed is system of wireless Sensor Network using Arduino, Xbee and an accelerometer to measure g force for automobiles. Each sensor is a self contained system with its own trans-receiver and a battery. It is enclosed inside a metal container to be mounted on a moving part to measure its g-force. G force is a parameter used in designing and optimizing mechanical parts for finding or evaluating their mechanical stresses respectively.**

These nodes will greatly help in building a Flexible wireless network around the automobile so that we can verify the simulated model with actual real world data which will be generated. This paper deals with the formation of wireless sensor and control nodes.

***Keywords*—Arduino , IOT, Xbee , WSN (wireless sensor network)**

I. INTRODUCTION

The **Internet of Things** (**I.o.T**) is the network of physical objects, devices, vehicles, buildings and other items which are embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data. IOT is being increasingly being used in Wireless Sensor Network. It consists of various sensory and actuator nodes which connect and communicate to a Wireless Control Node. This type of architecture is being increasingly used in testing scenarios. In automotive sensors tests are ever changing. Therefore there is need for a robust and flexible sensor network or DAQ (Data Acquisition System). In this paper we attempt to build and test a robust and reliable wireless Sensor network using ADXL 335, a 3 axis Accelerometer of ± 3g, Arduino and Xbee for wireless communication. [1]A wireless node will have an accelerometer, Arduino microcontroller and basic battery pack. Control node consists of Xbee Trans-receiver (receiver spelling) and Arduino connected to a Personal Computer, to be plotted for future reference. Accelerometer is an electromechanical device when physical shock, force is applied electrical output is received which is either an analog voltage level or a PWM cycle. Accelerometer can be divided into a mass and damper system. It can be simulated in Simulink.

II. ANALOGY OF THE SYSTEM .

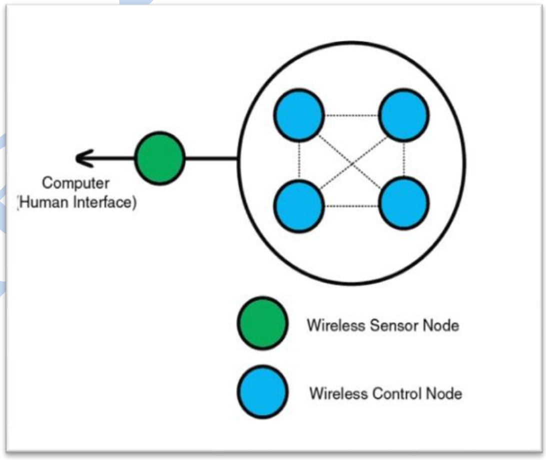

Fig 1 : Basic Structure of a Wireless Sensor Network

A. Wireless Sensor Node

Node contains a self contained system with a radio and various sensors. These sensors can contain but are not limited to Accelerometers, Gyroscopes and IMU (Inertia Measurement Unit).

B. Wireless Control Node

The control node is responsible for receiving and transmitting data from the user. The node generally can contain an Arduino, or any medium as a high performance platform. The data can be displayed on a HMI (Human Machine Interface)

III. NETWORK

Wireless Sensor Network can be easily configured by the user to activate or deactivate various sensor nodes to optimize test parameters, which aids in flexibility.

IV. STRUCTURE OF THE WIRELESS SENSOR NODE

The node consists of the following blocks: Xbee radio (trans-receiver), Accelerometer, Battery pack. This entire electrical assembly is enclosed in a metal container. This will protect the assembly from the external harsh environment.

C. Xbee Radio (Transreciever)

Xbee is most critical component of the system. Xbee is of IEEE 802.15.4 protocol. IEEE standard 802.15.4 intends to offer the fundamental lower network layers of a type of wireless personal area network (WPAN) which focuses on low-cost, low-speed ubiquitous communication between devices. It can be contrasted with other approaches, such as Wi-Fi, which offer more bandwidth and require more power. The emphasis is on very low cost communication of nearby devices with little to no underlying infrastructure, intending to exploit this to lower power consumption even more. The basic framework conceives a 10-meter communications range with a transfer rate of 250 Kbit/s. Tradeoffs are possible to favor more radically embedded devices with even lower power requirements, through the definition of not one, but several physical layers. Lower transfer rates of 20 and 40 Kbit/s were initially defined, with the 100 Kbit/s rate being added in the current revision. Xbee has a range of 1- 100 meters making it an ideal choice our test environment. As it has adequate signal strength and integrity to overcome most of the obstacles.

D. ADXL 335 (Acclerometer)

[6]The ADXL335 is a complete 3-axis acceleration measurement system. The ADXL335 has a measurement range of ±3 g mini-mum. It contains a poly-silicon surface-micro-machined sensor and signal conditioning circuitry to implement open-loop acceleration measurement architecture. The output signals are analog voltages that are proportional to acceleration. The accelerometer can measure the static acceleration of gravity in tilt-sensing applications as well as dynamic acceleration resulting from motion, shock or vibration. ADXL 335 is a ratio metric output device i.e. output fluctuates in accordance with the given supply voltage.

To first estimate the response of the accelerometer a mathematical model of the accelerometer in Simulink to better estimate the response of the accelerometer in real world environment. Various graphs of voltage and current against time were generated to better facilitate understanding of the response of the accelerometer. Accelerometer was modeled in Simulink using the datasheet to adjust parameters like sensitivity (mV/gee), static voltage at 0 g, bandwidth of the accelerometer.

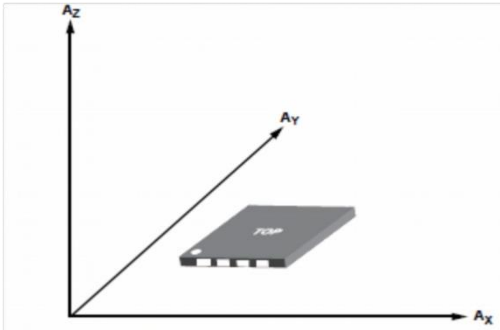

Fig 2: Basic Axes Sensitivity of the Accelerometer

E. Batttery Pack

The wireless node needs to be a self sufficient system with its own power source. Battery pack requirements were noted from the datasheet as follows

Xbee 1 mW wire Antenna	3.3V	50 mA
ADXL335	3.6V	350 mA

After the following considerations 9V (IEC- 6F22) Zinc – Carbon Battery was selected as it is cheap and 500 mAh capacity does satisfy our current requirements.

F. Wireless Control Node :-

The wireless control node is made up by a simple circuit containing an Arduino Uno and a Xbee trans-receiver. The Arduino is used as a translator for the computer and for easy acquisition and displaying of data. It allows easy reconfiguration of nodes.

G. Other sensors :-

Various sensors can be interfaced with the wireless node for example

a) Flex sensor :- This is a type of variable resistor which changes the resistance of the strip after it is physically deformed. They can be used on placed where they is relative movement along a fulcrum.

b) *Gyroscope:-* This sensor can be used to measure the rotational velocity of an object. Thus using this sensor you can measure the spin of an object it is placed on. In case of automobile it also can be used to measure roll,pitch and yaw of the automobile going into the sharp turns and curves.

H. Applications :-

A. Suspension Tuning:-

[5]Suspension Tuning is a critical in any automobile sport. It allows the team to better adapt the car to the terrain responses, making the tires keeping contact with the ground at all times

thus more efficiently transferring power from the tires to the ground effectively, thus making them faster than the other team. Accelerometer G-force data can be used as follows. Following equations describe how data will be used for suspension setup:-

[2][3][4]The fundamental differential equation of motion for a single degree of freedom system having damped free vibrations is

$m\ddot{x} + c\dot{x} + Kx = 0$

Where,

m=mass of the body kg

K=stiffness of spring, N/m

c=damping coefficient, N-s/m

x=displacement of the body from equilibrium position m

$\dot{x}$=velocity of body m/s

$\ddot{x}$=acceleration of the body m/s2

The accelerometer gives the reading proportional to the acceleration of the sensor. By finding out the output values at 0 and 1 g's and by interpolation we can find out the actual values of acceleration ($\ddot{x}$) the sensor is sensing. By recording the values of acceleration with respect to time we can find the values of instantaneous velocity and position by using the 3 laws of motion.

s=ut+1/2at2

v=u+at

v2=u2+2as

Where,

s=x= displacement

v=$\dot{x}$=final velocity

u=initial velocity

a=$\ddot{x}$=acceleration

t=time

Circular natural frequency is given as ω_n

$\omega_n = \sqrt{(K/m)}$

Critical damping coefficient is given as,

$c_c = 2m\,\omega_n$

Where,

c_c =critical damping coefficient

m=mass of body

ω_n =circular natural frequency

Damping ratio is given as,

$\xi = c/c_c$

Where,

ξ=damping coefficient

c=damping coefficient

c_c =critical damping coefficient

Substituting the value of c_c in above equation,

$\xi = c/2m\,\omega_n$

Substituting the value of ω_n in above equation,

$\xi = c/2\sqrt{(Km)}$

The damping coefficient for a passenger vehicle is kept between 0.2 to 0.3 for comfortable ride and 0.5 to 0.7 for racing vehicle for better traction and contact between tire and road.

By assuming the value of damping factor and solving the two simultaneous equation below we can find the practical or actual value of 'K' and 'c' and tune the suspension to get the desirable setup.

$$\xi = c/2\sqrt{(Km)}$$

$$m\ddot{x} + c\dot{x} + Kx = 0$$

B. Measuring Stresses on components:-

In automotive sports various mechanical components are subjected to extreme stresses and fatigue loading. This might lead to failures .They can be categorized into 2 ways: -

i. High shock failures: - Components fail when subjected to extreme forces higher than they are capable of handling.
ii. Fatigue failures: - These types of failures occur when the mechanical components are subjected to repetitive stresses.

The data collected from the accelerometer – wireless node can help reduce and eliminate these failures in the components.

V. Conclusion

Thus this paper illustrates a modern approach in the classic Data Acquisition System, Where the system is divided into separate self contained into blocks .This makes the system modular, robust, and flexible.

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