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Research paper

Measuring and maintaining acceleration records obtained from 3D MEMS

K. Ravali [1] *, DR. ASR.Murty [1], V. Pavani [1], B. Prathyusha [1]

[1] Dept. of Electronics and Communication Engineering, KLEF, Vaddeswaram
**Corresponding author E-mail: anjanaravali@gmail.com*

Abstract

Tracing or tracking of an object or a link is needed in many engineering applications. Achieving it in real time applications using MEMS or the traditional accelerometers is also a well-known method. Measuring acceleration in [3] directions is needed in handling equipment, material transfer and in manufacturing industry.
In this work, Calibration of accelerometer sensor ADXL335 is carried out first to show the accurate values of „g". Then, the measurement of acceleration is carried out as per the code written in Arduino IDE. ADXL335 is interfaced with NODE MCU. NODE MCU uses HTTP protocol to send the measured acceleration values to cloud platform. ThingSpeak is the cloud platform chosen for this purpose. ThingSpeak requires selection of a number of fields. Here we have three values to be taken to cloud (X, Y and Z directions).For display purposes a mobile is used in conjunction with MIT App Inventor. Acceleration record files can be obtained that may be processed further. The application contains three buttons forward, side and vertical which displays the acceleration values across X, Y and Z directions respectively. The acceleration values are further integrated to obtain velocity and displacement .It can be done through 2 ways like ana- log integration and digital integration. But the analog integration is reliable only to measure the sinusoidal steady state values. So the digital integration is much better for obtaining a displacement signal from acceleration. It is possible to use these components for further processing and applications like ultrasonic applications, military devices namely mixers, elevators, mechanically handling equipment"s and information handling devices like iPad, phones etc.

Keywords: *Accelerometer; Calibration; MEMS; Thing Speak; NODE MCU*

1. Introduction

In many of the engineering applications measuring the accelerations in multi-directions is very important. Piezo electricity based Accelerometers using quartz and barium are already known. Over eight decades engineers and scientists across the world are working on accelerometers. Acceleration is measured generally only in one direction (X-Y-or Z-axis). But with the help of MEMS (Micro Electro Mechanical Sensors) we could be able to measure the acceleration in all the three orthogonal directions simultaneously. Piezo sensors are used in many applications and in areas such as manufacturing and also in industries these can also be used in some medical instruments like CT (computed tomography) scan and patient orientation automation devices etc. At present the big- gest application markets are industries and manufacturing sectors for piezoelectric devices later followed by the automotive industry. Understanding that every smart phone, tablet and pad need at least six sensors for automatic screen rotation to take place. Thus we could see the increasing demand and uses of accelerometer. This is being increased with the advent of MEMS and Wi-Fi applica- tions around IOT. With the help of piezo devices and MEMS ac- celeration can be measured from 0.1g to 10g .Rise times could be in microseconds. This can be used in many ultrasonic applications and also in mechanical devices like elevators, lifts, mechanical
Nictation devices like pads, phones etc., where acceleration plays real vital role and also in some machines where the measuring acceleration in all the three directions is very important(X, Y and Z directions).MEMS uses the latest methodology in order to measure the acceleration in all the three possible orthogonal direc- tions. The wireless accelerometers which are available in market are of less cost in comparison with other types of wired accel- erometers.

2. Components description

MEMS (Micro-electromechanical systems) are a technology used to make tiny integrated devices that combine electrical and mechanical components. They are fabricated using integrated circuit (IC) batch processing techniques and can range in size from a few micrometers to millimeters. These devices can generate effects on the large scale as they have the ability to sense, control and actuate on the micro scale these device are fabricated using IC (Integrated Circuit) technology, the micromechanical components are fabricated by developed manipulations of silicon and other substrates using process of micromachining.
MEMS devices are usually very small. MEMS are used to fabricate Levers, gears, pistons as well as motors and steam en
gines. However, MEMS is not just making things out of silicon or the miniaturization of mechanical components, it is a manufacturing technology for designing and creating complex and sophisticated mechanical devices and systems as well as their integrated electronics using batch fabrication techniques.
MEMS components and devices began appearing in numerous commercial products and applications like accelerometers used to control airbag deployment in vehicles, pressure sensors for medical applications and inkjet printer heads. Today, they have been used as micro positioners in data storage systems and in projection

displays as well. However, MEMS are also going to be applied within telecommunications (optical and wireless), biomedical and process control areas.

2.1. ADXL335

ADXL335 is a tri-axial accelerometer that gives Analog voltage output with regulator IC. It measures acceleration within range of ±3 g. It measures the static acceleration of gravity as well as dynamic acceleration along with tilt-sensing applications like motion, shock, or vibration. These are generally low-power devices which require current typically in micro or mille-ampere range. A triple axis accelerometer consumes very low power and noise
– Only 320uA! The sensor has a full sensing range of +/-3g.
Features

- 3V-6V DC Supply Voltage
- Onboard LDO Voltage regulator
- Can be interface with 3V Microcontroller.
- All necessary Components are populated.
- Tap/Double Tap Detection
- Free-Fall Detection
- Analog output

ADXL335 Module Specification	
Interface :	3V3/5V Microcontroller
Voltage Requirement:	3 - 6V DC
Output format:	Analog output
Measuring range:	±3g
Measuring values(-3 to +3):	X (+325 to -274) Y (+330 to -275) Z (+310 to 275)

Fig. 1: Accelerometer Specifications.

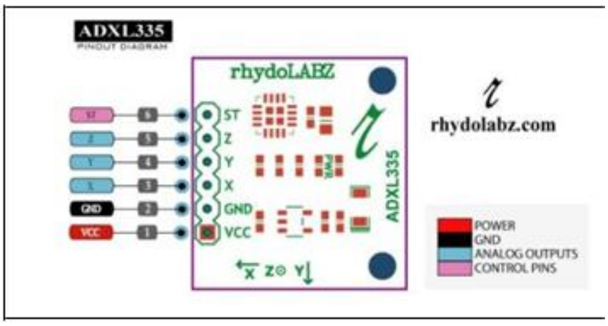

Fig. 2: Pin Diagram.

Pin No	Pin Name	I/O	Details
1.	VCC	Power IN	Positive Power supply,5V Regulated Power
2.	GND	Power GND	Ground
3.	X	O/P	X channel output
4.	Y	O/P	Y channel output
5.	Z	O/P	Z channel output
6.	ST	I/P	Self test

Fig. 3: Pin Description.

2.2. Node MCU (ESP8266)

Express if Systems designed a micro controller named as ESP8266. The ESP8266 itself is a self-contained Wi-Fi networking solution offering as a bridge from existing micro controller to Wi-Fi and is also capable of running self-contained applications. This module comes with a built in rich assortment of pin-outs and a USB connector. With the help of a micro USB cable, you can connect Node MCU dev kit to your laptop and flash it without any trouble, just like Arduino. It is also immediately breadboard friendly.
Specifications

- Voltage: 3.3V.
- Wi-Fi Direct (P2P), soft-AP.
- Current consumption: 10uA~170mA.
- Flash memory attachable: 16MB max (512K normal).
- Integrated TCP/IP protocol stack.
- Processor: Ten silica L106 32-bit.
- Processor speed: 80~160MHz.
- RAM: 32K + 80K
- GPIOs: 17 (multiplexed with other functions).
- Analog to Digital: One input with 1024 step resolution.

• +19.5dBm output power in 802.11b mode
802.11 support: b/g/n

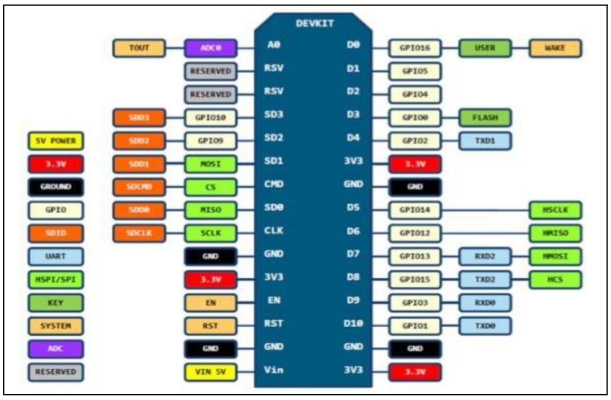

Fig. 4: Node MCU Pin Diagram.

Thing speak platform
Thing Speak is a platform which exclusively provides services for building many Internet of Things applications .ThingSpeak offers many capabilities like visualizing the collected data in the form and graphs, ability for collaborating apps with web services and other Application Program Interfaces(APIs).
In Thing Speak the core element is „Thing Speak Channel‟. Which is used to store the data send to Thing Speak and consists of the elements shown below?

1) For storing the data that we send "Eight" fields are provided, these fields can be used to store the data from the sensors.
2) Three location fields which Can be used for the storage of lon- gitude, latitude and the elevation. These are very useful for track- ing any moving device or vehicle.
3) One status field to describe about the data that is stored in the channel.

To use Thing Speak and to create a channel in it, we need to sign up. Once, the channel was created we can send the data from the sensor (or) other applications that have measured values to the cloud and then allow Thing Speak to process the data sent. We can also retrieve the date sent to it whenever required.

2.4. MIT app inventor

Google is the one who originally provided "APP Inventor". It is an open source web application for android version and now it is maintained by the MIT (Massachusetts Institute of Technology).
It helps fresher‟s for creating applications in android operating systems. MIT App Inventor uses a graphical interface that is simi- lar to the Star Logo (The Next Generation)TNG user interface. Graphical interface will allow the users to drag visual objects and drop visual objects, to develop an app which can run on Android operating systems. In creating this App Inventor, Google done a significant research on educational computing and online develop- ing environments.

3. Problem statement and methodology

The long and continuous usage of the elevators in such conditions may lead to only breakdown maintenance that is costly .In general break-down maintenance is substituted well by periodic- maintenance all over.

The devices, which are already available in the market like portable vibration, meter, acceleration sensor etc., give extreme readings or ranges. These devices are costlier for measuring the acceleration changes. But through the usage of MEMS wireless devices like Tri-axial accelerometer, whose cost is very low compared to traditional acceleration measurement devices and measure the acceleration values accurately. The main idea of this project is to sense the very minute changes in the acceleration components during the traversing. The output obtained from the accelerometer is normally a voltage signal, it can be converted into the required acceleration values through programming the Arduino, The con- tinuous changes in the acceleration values was sensed by the Tri- axial accelerometer and sensed values are send to cloud through NodeMCU

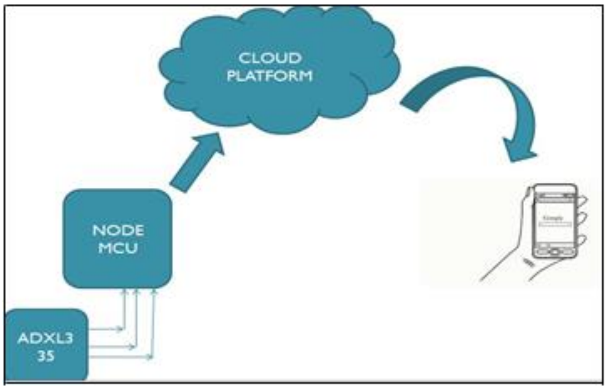

Fig. 5: Block Diagram.

Velocity and displacement .It can be done through [2] ways like analog integration and digital integration. But the analog integration is reliable only to measure the sinusoidal steady state values. So the digital integration is much better for obtaining a displacement signal from acceleration.

4. Working

Firstly, the calibration of accelerometer sensor ADXL335 is carried out to show the accurate values of „g". Then the measuremen of acceleration is carried out as per the code written in Arduin IDE. ADXL335 is interfaced with NODE MCU. NODE MCU uses HTTP protocol to send the measured acceleration values to the cloud platform. Thing Speak is the cloud platform we have chosen. Thing Speak requires selection of number of fields as we do have three values to be taken to cloud (X, Y and Z directio values) we have chosen three fields. Thus the values are sent to the cloud. For convenience we have designed a mobile applicatio namely Acceleration Display through MIT App Inventor. The application contains three buttons forward, side and vertical which displays the acceleration values across X, Y and Z directions re- spectively. The acceleration values are further integrated to obtain
velocity and displacement .It can be done through 2 ways like analog integration and digital integration. But the analog integra- tion is reliable only to measure the sinusoidal steady state values. So the digital integration is much better for obtaining a displace- ment signal from acceleration.

5. Theoretical analysis

Table 1 Comparison of theoretical and practical values of acceleration (a_x) of a simple pendulum

Angle(degree)	Theoretical(acceleration (A_X) in g)	Practical (acceleration(A_X) in g)
+/-15	0.267	0.24
+/-10	0.174	0.11
+/-5	0.087	0.07
0	0.000	0.01

Fig. 6: Calibration of Accelerometer.

6. Output graphs

6.1. Thing speak

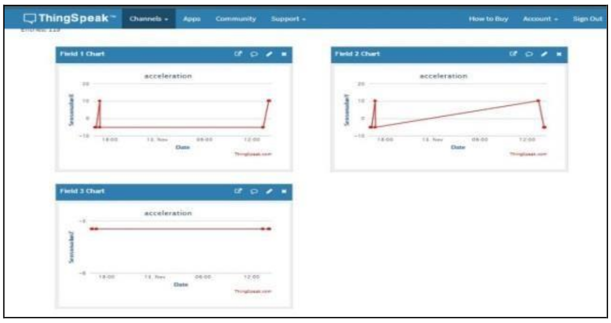

Fig. 7: Tri Axis Acceleration.

6.2. MIT app inventor

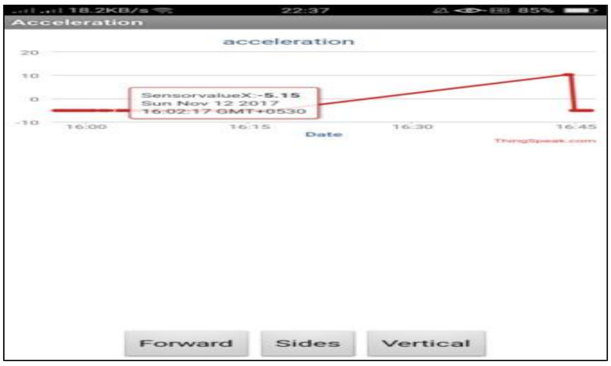

Fig. 8: On X-Axis.

Fig. 9: On Y-Axis.

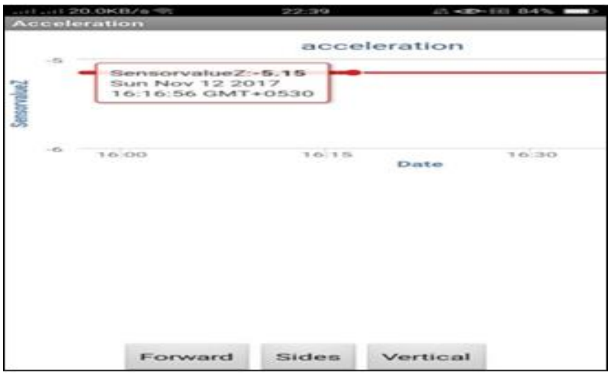

Fig. 10: On Z-Axis.

7. Conclusion

Using ADXL335, the acceleration is measured in [3] orthogonal directions. The obtained data is sent to the cloud using Node MCU with the help of Thingspeak platform such that the acceleration versus time graphs are obtained which can be accessible anywhere anytime. The mobile application using MIT App Inventor is also developed for convenience where the acceleration values can be displayed in the form of graphs in [3] orthogonal directions.

8. Future work

This project work has raised some interesting questions that could be the basis for future work on this topic. Perhaps a technique could be developed to find accurate values for the initial condi- tions, position and velocity measurement. Interestingly, because these quantities were unknown the double integration approach is to be developed. By perform a single integration on acceleration data we can get velocity data. Then obtained data over integration can be compared to the data obtained by direct measurement. One would expect this comparison to be more accurate than the double integration. There would be one less stage of integration and filtering so errors should be smaller.

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