Mems 3-Axis Accelerometer Based Black Box for Fragile Package Damage Identification

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Abstract: The main aim of this project is to develop a MEMS 3-AXIS ACCELEROMETER BASED BLACK BOX for fragile package damage identification monitoring. The system consists of cooperative components of an accelerometer, micro controller unit and Gps module .in the time of crash, at user end when the package is found damaged due to transport the details of its damage can be determined using this black box. The system is compact and easy to install in the package and consume low power. The system has been tested in real world cargo applications. The test results show that it can display the UTC Time, latitude and longitude with high accuracy.

Keywords -3-Axis Accelerometer, Black box, fragile package, GPS tracking system, Micro Electro Mechanical Systems,

I. INTRODUCTION

The fragile package transport via ships is a major problem in Asian countries. Despite awareness campaign, this problem is still increasing due to improper packaging, selection of right size box etc. the number of fragile packages are damaged because of don't know the information or data related to the package. These cause huge social and economic burdens to people involved. Therefore, several research group and major fragile device manufactures including pharmaceutical *companies* have developed safety devices to protect damages from crashes. However, good safety device for fragile package is difficult to implement and very expensive.

Alternatively, intelligence schemes such as fall or damage identification with tracking system have also recently been devised to notify the damaged package, the main aim of this project is to develop a MEMS 3-axis accelerometer based black box for fragile package damage identification monitoring. When the package is found damaged due to transport the details of its damage can be determined using this black box.

II. SYSTEM BLOCK DIAGARAM

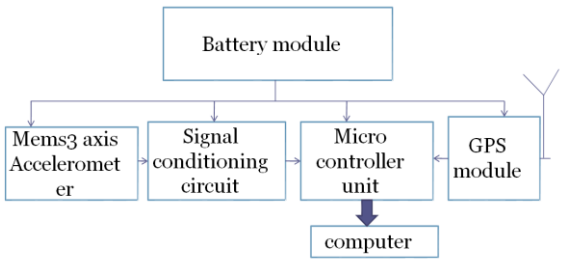

Fig.1 Block diagram

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The system consists of cooperative components of an Accelerometer, Microcontroller Unit (MCU) and GPS device. Battery Module is used to avoid for power disconnection during accident or crash. MEMS Accelerometer GPS based electronic damage identifier is developed to detect the Shocks or Vibrations in the Package. This is compact in size used to detect impact. Accelerometer signal received from accelerometer is fed to a signal conditioning circuit that filters the unwanted signals and boost the desired signal. The desired digital data is fed to microcontroller unit. The GPS module is used to record geographical data (latitude, longitude) corresponding to the accelerometer vibrations. A high performance 16 bits MCU is used to process and store real –time signal from the accelerometer. In MCU using improved version of PIC16F77A. PIC stands for peripheral interface controller. The unit also incorporates flash memory for recording this data and serial peripheral interface is provided to log the data to a pc for analysis. Microcontroller communicates with the help of serial communication; it takes the data from the GPS receiver and stores the information in the MEMS 3-axis accelerometer based black box. The micro controller takes only latitude and longitude of the application.

III. SPECIFICATIONS

(A) Battery Module:
5 volts, 5 watts hours.
(B) MEMS 3-AXIS ACCELEROMETER:
+5V operation @1ma current, High Sensitivity (800mV/g @ 1.5g.
(C) Microcontroller:
16 bit controller, RISC Architecture, built in 10 bit ADC, built in SPI.
(D) Gps module:
High sensitivity -160dBm.
Searching up to 65 Channel of satellites GPS L1 C/A Code Supports NMEA0183 V 3.01 data protocol. Real time navigation for location based services.
Works from +5V DC signal and outputs 9600 bps serial data.

IV. METHOD OF DETECTION

In our signal processing the original data is classify into two classes, fall and not fall. In this system the input data accelerometer was kept and processed in real- time with sampling rate of 60 Hz or higher. The signal from MEMS Accelerometer was converted by 10 bits ADC in to integer range between 0 and 1023.The sensor was embedded in a fragile package to fix the accelerometers axis so that the response of acceleration data is well-defined[2,4]. The classification of the fall detection utilized the 3-axis acceleration signal from MEMS

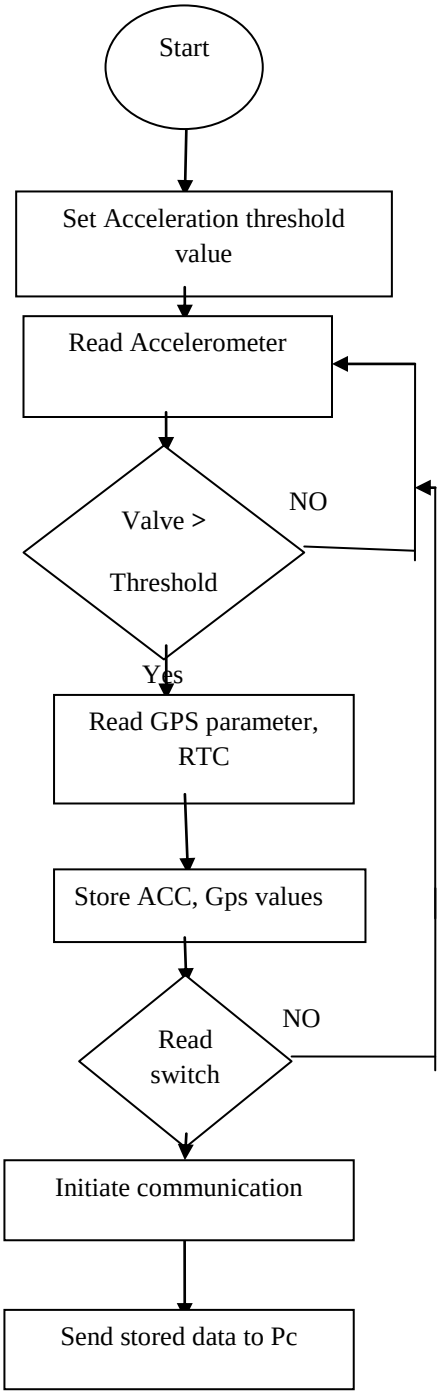

Fig.2 .Flowchart of fragile package Damage identification

Accelerometer and the ground speed from GPS module. In general fragile package fall can be classified as linear fall and non-linear fall. The linear fall is concerned about fall without external force, which is free falling condition that only z-axis acceleration changes. The non-linear fall occurs by the external force. The non linear fall detection is decided by all 3-axis acceleration data from accelerometer and the ground speed from GPS module. To determine the accelerometer output ,two frames of acceleration data, which include 3-axis acceleration at present time(t) and prior time(t-1), are used for analysis. For a linear fall ,the z-axis acceleration follows free falling condition which is given by

$$|A_z| \geq 9.7 \text{ m/s} \qquad (1)$$

Where the A_z is the z-axis acceleration. In non- linear fall the change of acceleration between two consecutive frames should be more than 15.5m/s2.The non-linear fall condition is given by

$$|A_{n,t} - A_{n,t-1}| \geq 15.5 \text{ m/s2} \qquad (2)$$

Where the An t is acceleration from x, y or z coordinate at the present time frame and An t-1is acceleration parameter from x, y or z coordinate in the previous time frame. The Flowchart of fragile package damage identification shown in fig.2. After system starts Microcontroller periodically get 3-axis acceleration data from accelerometer .If acceleration value is greater than the threshold then read GPS parameters and RTC(real time constant) else read accelerometer. After read the parameters store acceleration, GPS values. After read switch if yes initiate communication and send stored data to PC. Else read accelerometer [3,5].

V. RESULTS

Typical data for fragile package fall without external force is shown in Fig 3. For linear fall,only acceleration on z-coordinate is used to determine the crash.

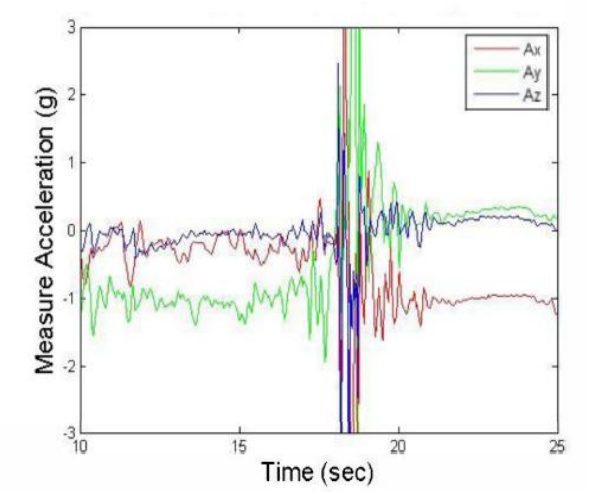

Fig 3 Typical acceleration data for a linear fall case

Fig 4.shows typical data of a non-linear fall obtained from accelerometer with 60Hz sampling rate. The condition of non-linear fall according to (2) can be met on some axes or all three axes.The results of non-linear fall can be divided into two parts, first crashing and second ground hitting.

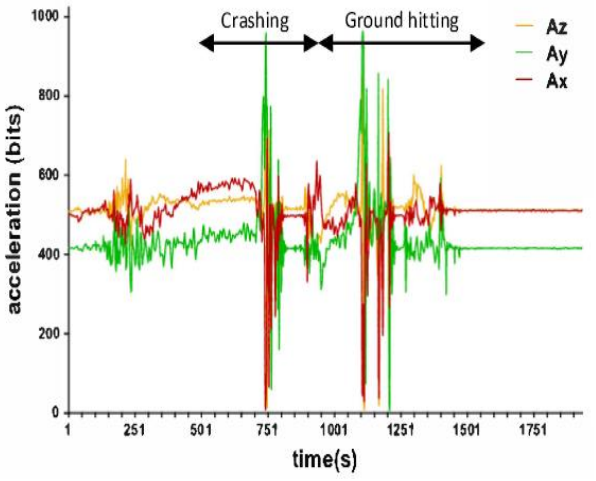

Fig 4 Typical acceleration data for a linear fall case

Fig. 5. Gps module

Fig. 6. MEMS 3 axis accelerometer

Fig .7. Hardware interfacing

Hardware kit was connected to PC using USB port, the pc displays the following parameters such as universal time constant (UTC), GPS information (only latitude & longitude) related to fragile package transportation.

VI. CONCLUSION

In this paper MEMS 3- axis accelerometer based black box has been developed for fragile package damage identification. The system can detect type of crash from accelerometer signal using threshold algorithm and GPS information. And also displays the universal time constant (UTC), GPS information (only latitude & longitude) related to fragile package transportation.

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