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Tilt Measurement And Vibration Detection Using PSoC

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***Abstract* – This review paper builds a smart Tilt Measurement and Vibration Detection system for industrial manufacture. There are a number of smart Measurement systems established for smart grids, bridges or machine system management, temperature/ humidity monitoring and so on. 3Axes accelerometer has many applications such as in vehicles for motion control, mobile phones for motion activated functions, computers, medical appliances like pace maker and home appliances. It measures the acceleration in x, y and z direction and processes data for calculation constant. Depending upon gravitational constant the tilt level and vibration levels are decided.**

Keywords — PSoC Axes Accelerometer, GPRS, G-Constant.

I. INTRODUCTION

The mixed-signal programmable system-on-chip (PSoC) architecture for high-volume low-cost applications is presented. Programmable analog, digital, and clocking circuits are combined with flash memory and a microcontroller to provide a platform for single-chip solutions for low-cost consumer applications. Both programmable analog and digital circuits are designed to support a moderate level of abstraction, balancing flexibility against cost and performance. A rough comparison of alternative approaches based on functionality and cost is presented.

Accelerometers are electromechanical devices that measure different kinds of acceleration for instance static and dynamic acceleration.

Currently there are few systems existing to measure tilt or orientation of the object and to detect the vibration using 3-axis accelerometer. One of the systems available is to design acceleration sensor with the help of Data Acquisition System. But it is not always possible to wire sensor directly to acquisition equipment when the sensors are to be located on a rotating member and in very hostile environment – very high temperature, volatile liquids, and high humidity.

The objective of this study paper is to explore the monitoring system for "Tilt Measurement and Vibration Detection using PSoC" for bridges and machines. Bridges in a city are important engineering salvations for basic civil life, with safety as critical factor. The Programmable System On Chip (PSoC) chip is a self-selecting digital or analog input and output unit that can significantly decrease the number of required peripheral parts and quickly fulfil the design needs [1].

Some applications in which accelerometers are used are as follows:

Mobile Phones: Used for motion activated functions, gaming, free-fall detection, and vibration control.

Vehicles: Used for crash testing, robotics, motion control, and skid detection.

Computers: Used in computers and computer peripherals such as mouse, for motion activated functions, gaming, and tilt sensing.

Medical Appliances: Used in pacemaker and blood pressure measurement applications.

Home Appliances: Used in appliances such as washing machines for spin and vibration measurement.

II. RELATED WORK

A lot of researches work has been in PSoC (Programmable System-on-Chip) is a family of mixed-signal arrays first made by Cypress

MicroSystems (CMS), a subsidiary of Cypress Semiconductors. This features a microcontroller and configurable integrated analog and digital peripherals. PSoC is software configured, mixed-signal array with a built-in MCU core. The core is a Cypress proprietary, 8-bit Harvard architecture design called the M8C. PSoC has three separate memory spaces: paged SRAM for data, Flash memory for instructions and fixed data, and I/O Registers for controlling and accessing the configurable logic blocks and functions. This is a self-selecting digital or analog input and output unit that can significantly reduce the number of required peripheral parts and quickly fulfil the design needs [1]. PSoC also consists of digital and analog programmable blocks like filters, Analog-to-Digital Converter (ADC) and Digital-to-Analog Converter (DAC)s, inverting, non-inverting and operational amplifiers, counters, timers etc.. It also supports Inter integrated circuit (I2C), Serial Peripheral Interconnect (SPI), Universal Asynchronous Receiver Transmitter (UART), Universal Serial Bus (USB) communications along with Radio Frequency (RF) [2]. Qiu. D., Gao, L have presented the Virtual Reality Technology in the paper 'Application of virtual reality technology in bridge structure safety monitoring'. The dangers of bridge transition section deformation hazards prevalent in the national highways. It affects not only the safety of traffic, speed, comfort, performance, highway transport efficiency, but also affects the life of the vehicles. More seriously it may lead to accidents. So the deformation monitoring of the bridge approach has become an important research topic for urban highway operation. Virtual reality technology is an immersive interactive technology which is based on computer technology and data processing technology. Virtual reality technology is used to build the three dimensional model of the bridge, and on this basis, the advanced safety monitoring of bridge is implemented [3].Thiesse, F., Michahelles, F have mentioned in the paper 'Embedded interaction interacting with the internet of things' that in addition to bridge monitoring, there are great number of three axis accelerometer applications, one of which, provides a force and torque analysis suggestion when reducing the ingredients. This literature presents the underlying concepts of embedded interaction, the technological and conceptual phenomena of seamlessly integrating the means for interaction into everyday artifacts. Technically, this requires embedding sensing, actuation, processing, and networking into common objects. Conceptually, it requires embedding interaction into user's everyday tasks [4]. Rong Liu have presented in the paper 'The Analysis and Design of Urban Bridge Safety Early-warning' that the security issues relating to the urban bridge have aroused the attention of the engineering field and bridge management institutions all over the world, and one of the hotspot questions discussed at home and abroad comes to the establishment of safety early-warning system for urban bridge. Urban bridges are crucial lifeline works for a city, whose security impact on citizen's essential life and they play an indispensable role in extreme situations, such as natural disasters and war. During construction stages and service time, urban bridges will be damaged or destroyed by environmental effect, chemical reactions, vehicles, human activities, and so on[5].

III. SYSTEM ARCHITECTURE

Figure 1 shows the block diagram of the project. G-sensor is nothing but 3-axes accelerometer. It senses the acceleration in x,y and z direction. From these acceleration values the gravitational constant G is calculated. Depending upon the value of G, the tilt level and vibration level is decided.

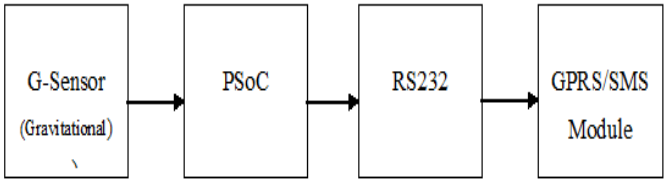

Fig.1. System Architecture

The purpose of the system is to sense the respective acceleration levels along the X, Y and Z-directions, that is, it can be employed to detect whether the object is horizontally or vertically oriented or the vibration level. Obtain the 3 axis gravitational acceleration value (G). Calculate value of G in reference with the benchmark value. Check the absolute value of G of X-axis, Y-axis and Z-axis. According to standard values, send the message of excess tilt or earthquake.

.*A.* Types of Accelerometers

Accelerometers are divided based on their output type, sensing method, manufacturing technology, and other properties. When output type is considered, accelerometers can have either analog or digital output. The analog output accelerometers often have voltage as the output, while digital output accelerometers have Pulse Width Modulated (PWM) waveform, I2C, or SPI. The choice between the analog and digital type depends on the interface hardware.

- Analog accelerometers output the most raw data form and their measurement is highly flexible. The speed and accuracy with which the analog output is measured changes with the hardware it is interfaced with.
- Digital PWM output accelerometers involve intensive computation and timing analysis to get the acceleration from the waveform.
- Accelerometers with digital communication output (I2C/SPI) have Analog to Digital Convertors (ADC) and digital communication modules integrated into the chip along with the basic analog output accelerometer. This added hardware is fixed function and increases the cost of the accelerometer. These accelerometers provide easy interface to a larger digital system, but are least flexible. With digital accelerometers, parameters such as resolution, sampling speed, bandwidth, and SNR are limited to a narrow selection range.

Currently there are few systems available to measure tilt or orientation of the object and to detect the vibration using 3-axis accelerometer. One of the systems available is to design acceleration sensor with the help of Data Acquisition System. But it is not always possible to wire sensor directly to acquisition equipment when the sensors are to be located on a rotating member and in very hostile environment – very high temperature, volatile liquids, and high humidity.

Accelerometers are electromechanical devices that measure different types of acceleration such as static and dynamic acceleration. Static acceleration includes the orientation with respect to earth and dynamic acceleration involves movement and vibration.

Microprocessors with some external hardware can interface with the digital communication output accelerometers. However, this does not work with digital PWM and analog output accelerometers. Microcontrollers can interface with digital PWM and digital communication output types, but not to the analog output accelerometers. The PSoC device has the flexibility of interfacing with all types of accelerometers.

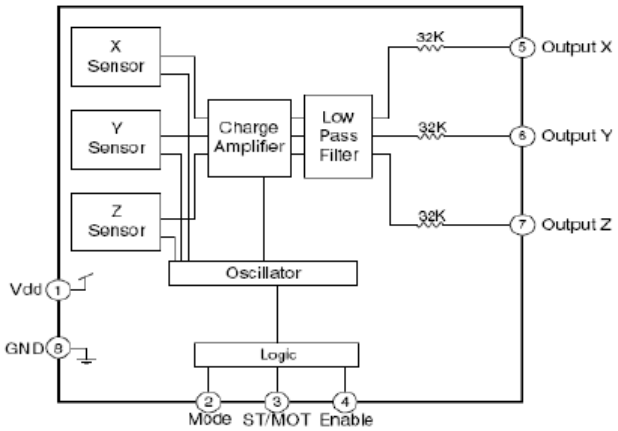

Fig 2 Functional Diagram of Accelerometer

The sensor element in the accelerometer works on the principle of differential capacitance. Here, the acceleration causes displacement in the silicon structure, resulting in a change in capacitance. The ASIC is included inside the package to convert change in capacitance into

analog voltage, which is proportional to acceleration. It also features a programmable low pass filter. Thus the output voltages can be read directly by the ADC and processed accordingly.

The voltages on the X, Y, and Z axes are measured directly with a single ADC by multiplexing the input ports. The accelerometer has an internal low pass filter and thus it is not implemented in PSoC. The block diagram of the system is shown in fig.

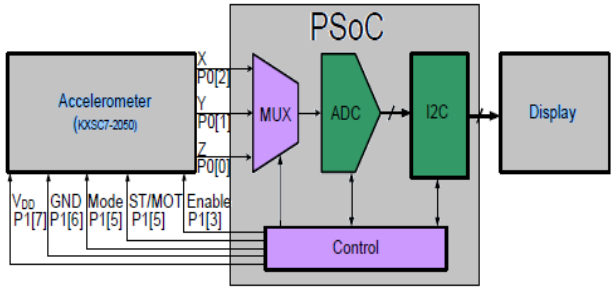

Fig 3:Interfacing of 3 Axes accelerometer with PSoC

The output of the ADC block can be processed using digital blocks, displayed using an LCD module, or transmitted using the UART, I2C, or SPI digital communication modules available in this chip. The example project makes use of I2C UM and transfers the data via the external I2C-USB Bridge hardware. The output is then plotted using the Cypress I2C-USB Bridge software.

IV. CONCLUSION

This study employed a FLAG-PSoC-1605A development board to establish a bridge or machine tilt monitoring.

Safety issues of bridge engineering are closely related to the people's safety of lives and properties. Bridge accidents occur frequently, so new idea or new mechanism must be introduced into management system to improve bridge security, and then to protect the safety of public possessions and lives, which is the uppermost aim[1].

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