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Implementation and Effect of Sensor Technology in Building Level Balancer using Programmable Integrated Circuit Microcontroller

N. R. Mohamad[1], M. S. Ab. Ghani[2], A. Salleh[3], N. M. Z Hashim[4], N. A. Ab. Hadi[5],

[1,2,3,4]Center for Telecommunication Research and Innovation (CeTRI), Faculty of Electronic & Computer Engineering, Universiti Teknikal Malaysia Melaka (UTeM), Malaysia
[5]Faculty of Engineering Technology, Universiti Teknikal Malaysia Melaka (UTeM), Malaysia
[1]najmiahradhi@utem.edu.my, [2]mohdsabriabghani@gmail.com [3]azahari@utem.edu.my, [4]nikzarifie@utem.edu.my, [5]nikazran@utem.edu.my

***Abstract**: Recent advances in sensor technology would lead to a new trend of instrumentation system that can be used in the construction industry. In this paper, a level balancer has been developed which is an instrument that can be used in the construction sector for measuring and determining the equality between two pillars height (elevation) and horizontal surfaces. Similarity and equality of the surface and elevation is important in the construction sector to ensure that the structures can be stay strong and avoid the building from collapse. This paper proposed a level balancer with two methods that are using a combination of magneto-resistive sensor and laser and the other one is using barometric sensor based on Programmable Integrated Circuit (PIC) microcontroller. In method 1, the level balancer is built with magneto-resistive sensor for measuring angles, combined with Liquid Crystal Display (LCD) screen for displaying horizontal angle of 180 degrees, and a specially built laser device. This combination of devices can produce a horizontal straight line at angle 180 degrees to ensure that the elevation between two pillars is same. Meanwhile, method 2 consists of a barometric sensor for measuring altitude attained, and LCD screen for displaying altitude value. This project can be implemented as level balancer measuring tool by labor and building developer with accuracy almost 99.9% and the 0.01% error can be neglected.*

***Keywords:** Level Balancer, Programmable Integrated Circuit (PIC), Magneto-Resistive Sensor, Barometric Sensor*

1. INTRODUCTION

Nowadays, a variety of tools or technologies either sophisticated or traditionally used in the construction sector are for the purpose of facilitating the developer and labors so that the construction of buildings can be completed quickly and easier. The elevation between two pillars or roof surface must be uniform and balanced so that the design is strong and the building structure is safe for occupancy. Typically, the labor used the concept "scales of water" to measure the equilibrium of elevation between two pillars of a building. The water is filled in the transparent tube and then both ends of the tube are marked as shown in Figure 1. The function of this method is to measure the elevation between two pillars or two walls. In addition, labor is also difficult to measure the similarity of elevation between two pillars or elevation between the two walls. Currently, labor is using transparent rubber tube that filled with water into the tube for measuring the equilibrium of elevation between two pillars or walls. The water level at both ends of the tube was used as a mark of elevation equation. This is because the water level at both ends of the tube is located at the same elevation based on atmospheric pressure. By using this method, the problem will happen when the labor attempt to measure the equilibrium of elevation between two pillars or wall which has a large distance between the two points. The longer transparent rubber tube is needed to be used to solve the problem. It will be another trouble if they don't have that long transparent rubber tube. In addition, the water that is filled in the tube should always be changed in order to avoid it from becoming turbid. The water must be always clear because it is hard to make reading when the water becomes turbid. Since it needs to be changed accordingly, it seems that more water will be wasted. These are among some of the problems that occur in the use of measuring instruments available at present.

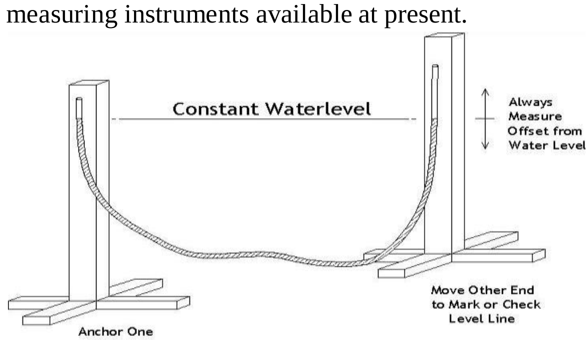

Figure 1 Traditional scale of water concept

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Another method is using a water bubble for measuring or detecting of surface as shown in Figure 2. There are several problems encountered when using those traditional tools mentioned such as those tools are only uses water concept to determine the equality and balance of surface. This measurement is not accurate because human vision cannot detect the small changes in the position of the water bubble to ensure that it is right on the corner angle of 180° horizontal. If the problem is not solved, it will cause the slope surface. For example, the labor wants to build the floor of a building, if the surface is steep, it may cause the water reservoirs on the floor. This clearly shows the importance of using the accurate measurement tool before constructing any structure or floor so that it has the appropriate level.

The function of the instrument is to indicate whether a surface is horizontal (level) or vertical (plumb). Different types of spirit levels may be used by carpenters, stonemasons, bricklayers, other building trades workers, surveyors, millwrights and other metalworkers, and in some photographic or video graphic work. But all of the spirit levels use the same concept; only the appearance might be different according to the usage suitability.

Figure 2: Water bubble concept

2. DESIGN METHODOLOGY

Overall, the system designed comprised of hardware design and software development. The general block diagram of level balancer system is shown in Figure 3.

The magneto resistive sensor, HMC5677 is a fully integrated compass module that combines 2-axis magneto-resistive sensors with the required analog and digital support circuits, and algorithms for heading computation. By combining the sensor elements, processing electronics, and firmware into a 6.5 mm by 6.5 mm by 1.5 mm package, Honeywell offers a complete, ready to use electronic compass. This provides design engineers with the simplest solution to integrate high volume, cost effective compasses into wireless phones, consumer electronics, vehicle compassing, and antenna positioning [1]-[3]. Figure 4 shows the HMC5677 magneto-resistive sensor which used to measure the rotation angles.

The barometric sensor (MSBA200) is a new generation of high resolution altimeter sensors from MEAS Switzerland with SPI and I2C bus interface. This barometric pressure sensor is optimized for altimeters and barometers with an altitude resolution of 10 cm. The sensor module includes a high linearity pressure sensor and an ultra low power 24 bit analogue to digital converter with internal factory calibrated coefficients. It provides a precise digital 24 Bits pressure and temperature value and different operation modes that allow the user to optimize for conversion speed and current consumption. A high resolution temperature output allows the implementation of an altimeter function without any additional sensor [4] – [6].

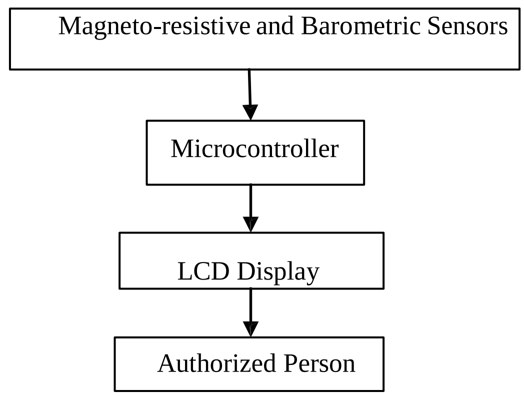

Figure 3: Block diagram of system

Figure 4: Magneto resistive sensor

The MSBA200 can be interfaced to virtually any microcontroller. The communication protocol is simple, without the need of programming internal registers in the device. The small dimensions of only 5.0 mm x 3.0 mm and a height of only 1.0 mm allow for integration into mobile devices. This new sensor module generation is based on leading Micro Electromechanical (MEMS) technology and latest benefits proven experience and know-how in high volume manufacturing of altimeter modules, which

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has been widely used for over a decade. The sensing principle employed leads to very low hysteresis and high stability of both pressure and temperature signal. Figure 5 shows the barometric sensor that functions as the atmospheric pressure measurement. This sensor has very good resolution that able to measure the small atmospheric pressure change.

The microcontroller PIC16F877A is the brain of the system which one of the PIC Micro Family microcontroller. The advantages of this microcontroller are very easy to use, the flash memory technology can be write-erase until thousand times, low cost, low consumption, easy handling and flexibility [7]- [10].

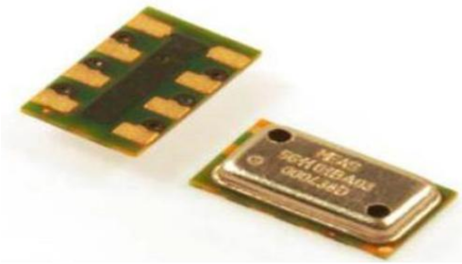

Figure 5: Barometric sensor

Figure 6 shows the electronic circuit designed by using Proteus software. The circuit comprises of two sensors which is barometric sensor and magnetic sensor that control by one microcontroller PIC16F877A. Magnetic sensor is mounted on the electronic circuit to measure changes in surface angle or movement of these tools. While the software used is MPLAB and CCS compiler. The function both of software is acting as a "writing program" to embed into the PIC16F887A program. The altitude attained by barometric sensor can be displayed in the MPIDE software that connected to the computer by using RS232 cable. These two sensors connected together in microcontroller by using integrated circuit (ICC) protocol.

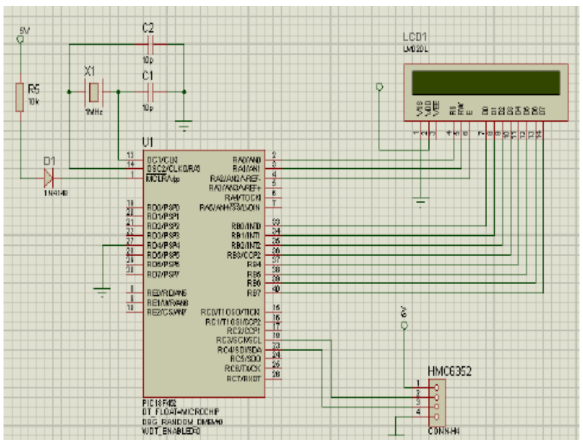

Figure 6: Level balancer circuit

3. RESULT AND ANALYSIS

Figure 7 shows the overall of the system. Its very effective and portable due to small size and light. This tool is easy to use, just attach this tool on the surface to be measured, it will automatically measure the angle or slope surface and we can see the result on the LCD screen. In addition, this tool can mark the equilibrium of elevation between two pillars or walls by fixing this tool at the pillar or wall and push the button (On / Off) laser. A straight line was produced by the laser beam to be emitted at the other desired pillar or wall. So, we know that the elevation is uniform between it.

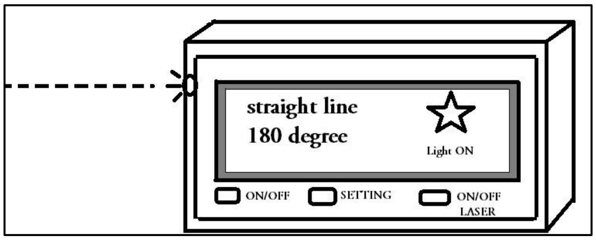

Figure 7: Level balancer system

The real product after all the process already finished is shown in Figure 8. The red push button is for on/off the laser when the detected angle is 180° that means the flat surface. Figure 9 shows the environment of project implementation. The real device was applied at the one of the two pillars to get the equilibrium of elevation. The laser then transmitted toward another pillar when the detected angle is 180°. The laser light that exposed at another pillar is assumed as the same elevation.

Figure 10 below is about the altitude attained after use the level balancer by using a barometric sensor. The elevation increased uniformly when the device is lifted-up slightly. Figure 11 below show the project implementation of the created device. Before the building is built, the first thing that must consider is the elevation of two pillars. This is because to ensure the stability of the building. The elevation between two pillars must measure so that it is in balance between both of the pillar. The first point of desired elevation is marking then the second point at the next pillar is measured as same as the elevation of the first point to make sure it in balance.

Figure 8: Real device

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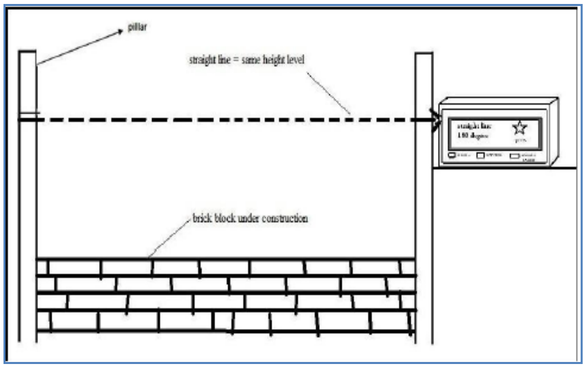

Figure 9: Project implementation

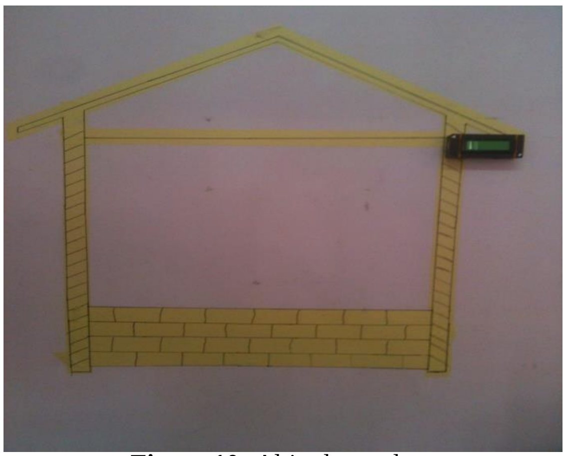

Figure 10: Altitude result

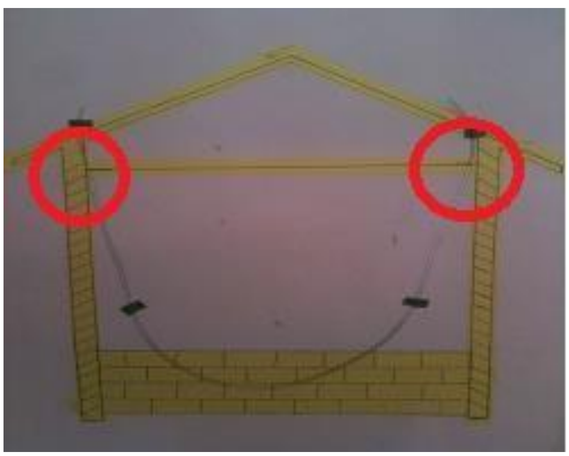

Figure 11: Marking the desired elevation

Figure 12 shows that the second point of elevation is measured so that the elevation between first and second pillar is uniform. The device lift-up slightly from bottom to top till the value of altitude for second pillar is same with the first pillar. Then, the "scale of water" used to measure the accuracy of the created device. The "scale of water" is the most accurate device, but it is difficult to execute since it must handle by two persons. Figure 13 shows that the implementation of "scale of water" to measure the accuracy of the created device. The result is very positive because the accuracy of the created device is almost 99% and there is only the very small error that can be neglected. The red circled region in the figure below is the level "scale of water" use to test the accuracy of the created device. The red circled region in the figure above is zooming to see the accuracy of the device. Figure 14 shows that the accuracy of the created device that uses to mark the first and second point of elevation before makes the straight line. The straight line and water level is t the same level that means the elevation both of them is equal and lastly it proved that the device is highly accurate.

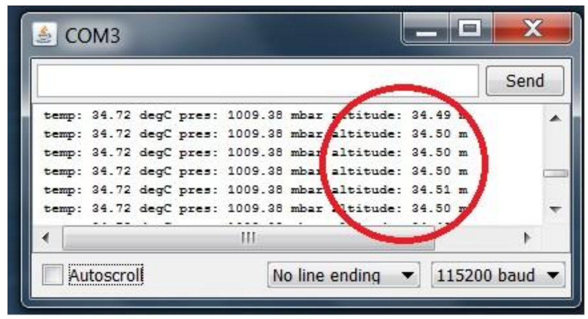

Figure 12: Setting the altitude uniformly

Figure 13: Testing the accuracy of the device

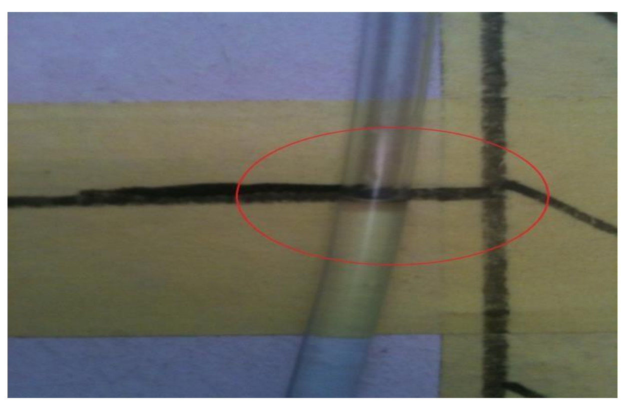

Figure 14 Elevation between water level and straight line

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4. CONCLUSION

This level balancer is successfully built and verified the reliability using sensor technology using PIC. It has a great factor which can make it the best choice to replace the traditionally used tools to determine the balance and equilibrium of elevation between two pillars or floor of a building. At construction site, the tool is built without forgetting about the durability which can be used in a long period with cheap maintenance cost. Besides, this project also can be used in angle measuring for bridge construction and solve the problems that involved with any angle measuring. In future, the system have the potential to commercial for construction industry.

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