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Development of an Automated Electronic Estimation Weighing Scale

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Abstract: *Analog weighing scales suffer from a lack of precision while reading the output and they can easily be manipulated by any technically biased individual. In this paper, the development of an automated and price estimating weighing device is considered. It aims at developing a means to a framework to evaluate estimated weight in analog to digital forms, such as to obtain higher precision in estimation and calibration. The circuit consists of a Load Cell as the sensor, an amplifier to boost the low signal from the sensor, an Atmega328 microcontroller, a 16x2 Liquid crystal display, and a few additional glue components. The 20 kg load cell converts the pressure from the load to an equivalent electrical signal which will be sent to the Hx711 IC module. Hx711 amplifies and processes the corresponding output to the Atmega328 microcontroller. The system uses the 4x3 keyboard to input the unit cost per kg to the electronic scale. The microcontroller automatically adjusts the signals with the load cell amplifier module's guide, thus sending the estimated cost to the Liquid crystal display module. The circuit was designed, constructed, and tested to show that a computerized electronic weighing system can be locally and cheaply made. Comparison with the state-of-the-art scale shows that the constructed digital scale was accurately calibrated without errors.*

Keywords: *Weighing scale, microcontroller, load cell, display, calibration.*

1. INTRODUCTION

Precise weight estimation has been the desire of humans of all ages. Hence different methodologies, devices, and gadgets were invented for uses in both domestic and industrial purposes. The previously invented weighing techniques were manual, less accurate, and not reliable enough. Likewise, they were characterized by calibration problems. They are large when compared to the newly invented ones, also they are not fast enough as it takes a while before giving out the measured weight [1]–[3]. For some, the actuators were designed from electromechanical components requiring currents of slightly higher magnitude. The resolution is lower, whereby it becomes difficult to differentiate weights with slight differences. The display is based on a rotating pointer, that often oscillates before settling down. Therefore, the analog scale consumes more power and its efficiency is low [2], [4].

Irregularities in the prices of products for sale, product prices for shipment, and recipes in the restaurant kitchen are becoming more alarming. The use of digital weighing scales in a restaurant, shipping agencies, and price tags will be essential as they maintain consistent portion size, provide accuracy in measurement, and helps to bill customers accurately. It also helps to manage inventory effectively, thus ensuring a greater profit margin. Thus, designing and constructing a cheaper and more efficient digital weighing scale will be of great advantage[5], [6]. Such will be more accurate and efficient. It is convenient to use for the producer, seller, and the buyer.

The idea relies on sensing transducers that convert the measured analog quantities to an equivalent electrical voltage or current. They also give their outputs on a digital display (seven-segment display) and screens [4], [7]. A few weighing scale structures have been introduced in a lot of distributions, and they all show their distinctive special features in the methodologies [5], [6], [8]. In [9], the use of a load cell transducer was introduced, it works along with an analogue to digital converter to produce a readout on a digital display. The paper gives a guide on the selection of a load cell. The methodology seems simple and gives fewer errors.

In [10], a digital weighing machine was also designed around the load cell. An effort was made in making it a controllable weighing transducer by improving the signal filtering, hence measurement accuracy and weighing speed were enhanced. Digital filtering techniques were used to remove measurement noises from the system. The paper proposed another filtering algorithm and circuit design for a weighing system.

Paper [11] presents the development of a spring-weighing device with a capacity of 400N. The performance evaluation was done with simple standard weights of different loads. The result shows one revolution and 50 degrees deflection on full-scale at a maximum load of 400N(40kg). The initial sensitivity was a 1-degree deflection caused by a load of 100g. The system was of high resolution and easier to operate. Unfortunately, the mechanical spring weighing system is less effective than the use of an electrical transducer.

The focus of this work is to design and construct a digital weighing machine system. The circuit is designed to accept the preprogrammed price per Kg of an item, after taking a measurement, the device displays the equivalent total price concerning the product weight.

2. METHODOLOGY

The design of a suitable circuit for an automated weighing scale follows the block diagram of Figure 1. It consists of a load cell with its amplifier connected to the microcontroller. To input the unit cost of an item, a keypad is attached to the microcontroller. In addition to the power supply, the system has a display screen to show the measured weight in Kg and the equivalent cost.

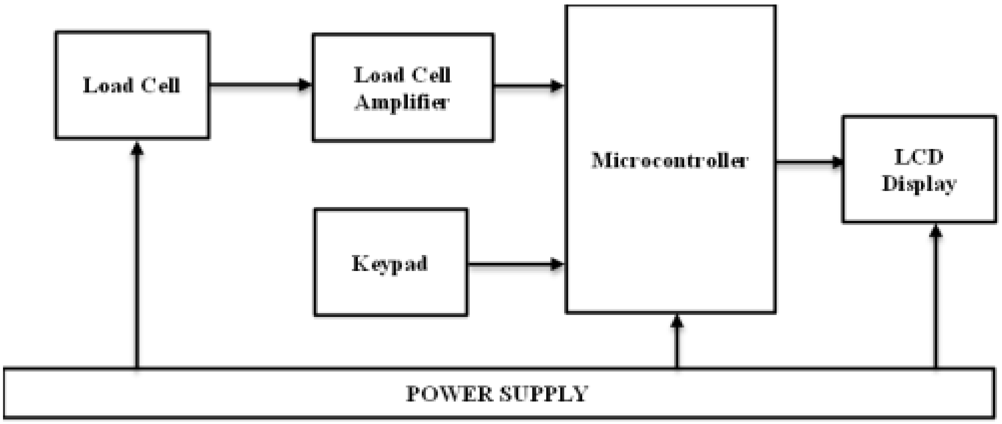


Figure 1: Block diagram of an automated weighing scale

2.1 Load cell and Amplifier

A load cell is a sensor that converts quantities such as strain, pressure, weight, or force into an equivalent electrical signal. Hence the electrical signal varies in proportion to the load on the sensor. Figure 2 presents a 20kg aluminum alloy electronic weight sensor (load cell) with its associated HX711 amplifier module. It has a dimension of 23.25cm x 17.00cm x 4.00cm as length x Width x Height. The load cell itself weighs 0.31kg. It has four leads and is driven by 5-10V as the output voltage changes in proportion to the applied force. The sensor has one end fixed while the second end is left floating. For use, there is an arrow by the side showing the direction in which gravity is being applied [1], [12], [13].

The HX711 is an integrated circuit (IC) that enables the load cells to measure weight. When this amplifier is connected to a microcontroller, it reads the difference in the value of the resistance of the load cell. With few computations and calibrations, it becomes possible to produce an accurate weight measurement. Figure 3(a) shows the physical diagram of the HX711 module and while the internal structure is shown in Figure 4(b). The module has an operating voltage range between 2.7V to 5V while the operating current peaks at 1.5mA[13].

Figure 2: 20kg aluminum alloy electronic weight sensor (load cell)

2.2 Microcontroller (Atmega328p)

The microcontroller chosen for this work is the Atmega328p. It is an 8-bit Microcontroller that comes with 32KB onboard flash memory. It has a reduced instruction set (RISC) architecture with 1024B electrically erasable programmable read-only memory (EEPROM), a two kilobyte of Static RAM, and 23 input and output lines that are general purpose but 32 working registers that are general purpose as well. Other features can be seen in [10], [14] It can be powered by voltage ranging between 1.8V to 5.5V. As shown in Figure 1, the microcontroller interfaced with the load cell and the keypad such as to display the estimated weight on the liquid crystal display (LCD).

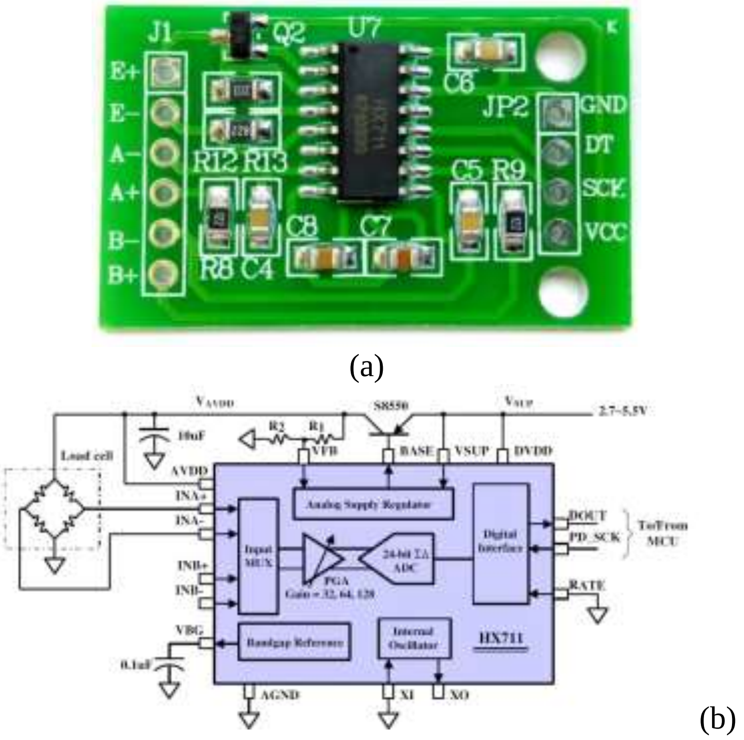


Figure 3: (a) HX711 load cell amplifier (b) Internal structure of HX711 ©SparkFun Electronics

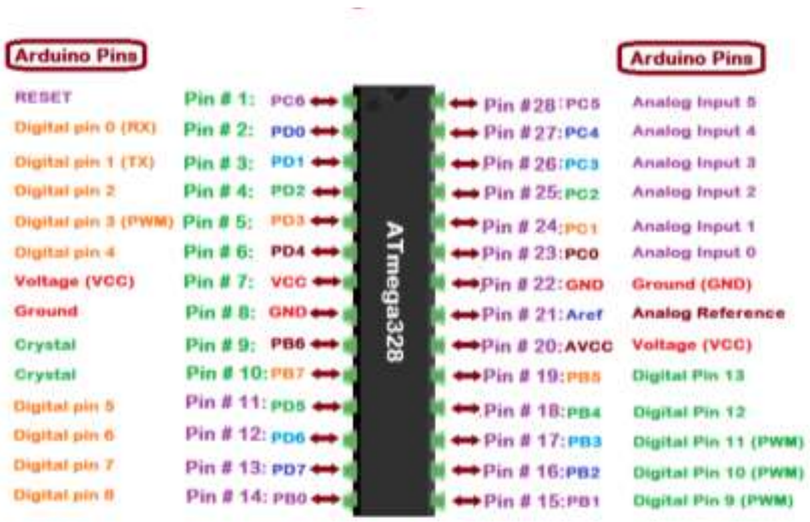


Figure 4: Atmega328 pinout [14]

2.3 Keypad (Membrane keypad)

There are several types of a keypad, for this work, a membrane type was selected. Membrane keypads are made of thin plastic with an adaptable coating. They come in sizes like 4×1, 4×3, 4×4, etc. They work alike, regardless of their size. An exceptional feature about them is that they are covered by a cement backing so that you can stick them to something. The paper backing must be stripped off.

The 4×4 keyboard has 16 keys that are arranged in a 4x4 matrix form. As shown in Figure 5, the switch pad has 8 pins female header, a contact resistance of 500Ω, and an insulation resistance of 100MΩ. It is very flexible to use with a rebound time of 1 ms. The push button has a long lifespan of up to 100 million times, hence it can last for a long time while in a circuit. A special membrane switch is underneath each key and all these membrane switches are linked to one another with a conductive trace that forms a 4×4 grid matrix beneath the pad.

Figure 5: 4x3 and 4x4 Matrix keypad

2.4 Liquid Crystal Display (LCD)

In recent, electronic gadgets come with LCDs. They are commonly used to replace cathode ray tubes and seven-segment displays. They are slender and consume extremely less power while in use. A diagram of a 16x2 LCD is shown in Figure 6. It is programmable with no restriction to the display of custom characters and sometimes animations. It has a wide range of applications in various circuits and gadgets[8].

Figure 6: LCD pinout

The pin out of the 16×2 LCD consists of the ground at Pin1. Pin2 connects the VDD of +5V to the microcontroller. Pin4 serves as the Register Select or Control Pin. Pin5 is the Read, Write, and Control Pin. It flips the presentation between the action of reading or composing. Pin 6 is the Enable or Control Pin. It performs the Read and Writes operations. This pin is usually kept high and continuously held high to the microcontroller unit. Pins 7 to 14 are the data pins, they transmit information to the showcase. These pins are employed in either 4-wire or 8-wire mode. In a 4-wire mode, only four pins are affiliated with the microcontroller unit, whereas 8-pins are associated in the 8-wire mode.

2.4 Circuit Design and Microcontroller Programming

The block diagram can be developed into a circuit as shown in Figure 7. The codes were written in Arduino environment, following the flow chat of Figure 8. The circuit drafting, design, and simulation were aided by the Proteus software. The circuit consists of the power section designed to produce a 5V output from a 9V adaptor or Battery. The 7805 regulator IC with associated capacitors is used to clip the terminal voltage to 5V. This output is meant to supply the microcontroller, the LCD, and the HX711 load cell amplifier.

After successful simulation, the circuit was transferred to proteus PCB (printed circuit board) layout for printing to transfer the simulation result to a real-time project.

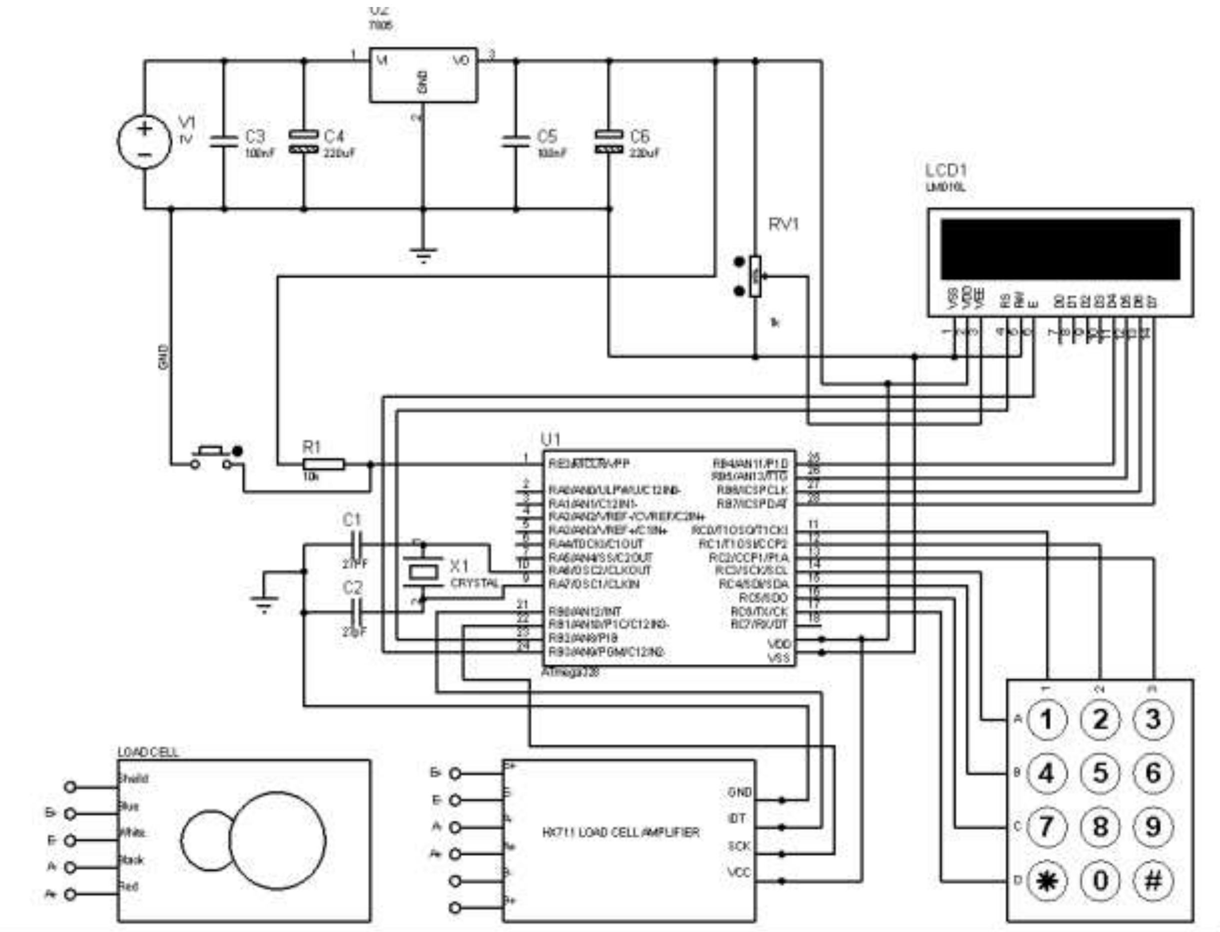


Figure 7: Circuit Diagram of the digital price scaling

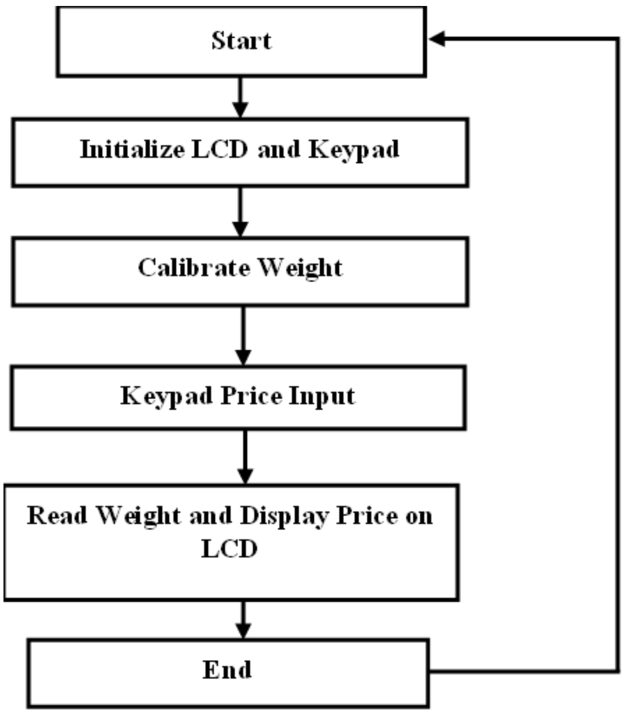


Figure 8: System flowchart

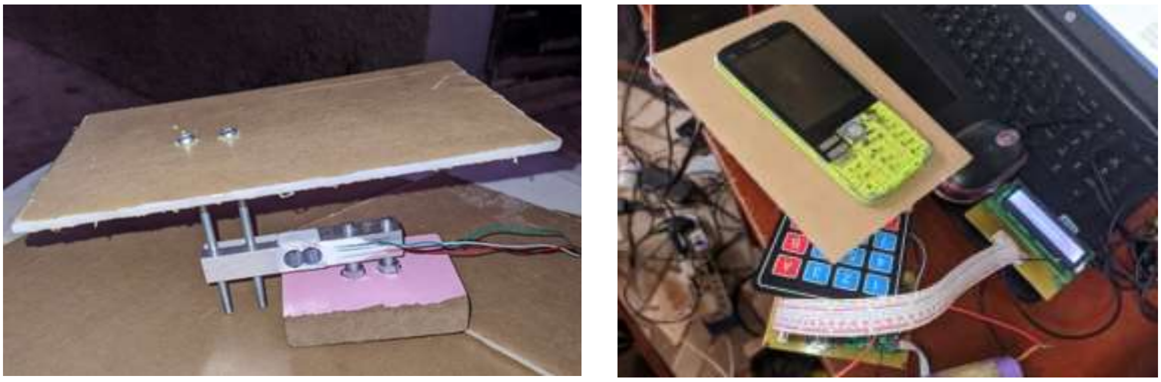
3. RESULTS AND DISCUSSIONS

The circuit of Figure 7 was constructed following the methodology and flow chart presented in the previous section. The construction stages, calibration, testing, and validation of performance are presented in this section.

The load cell uses a strain gauge to detect stress and strain, therefore the load cell needs to be mounted in such a way that it can detect any type of strain or stress caused by any object being scaled. Every time the scale is powered on, there is a need for calibrating, the reason for that is that the plate on which the material will be placed has its weight, hence this weight needs to be subtracted from the total weight recorded by the load cell before displaying the resultant value.

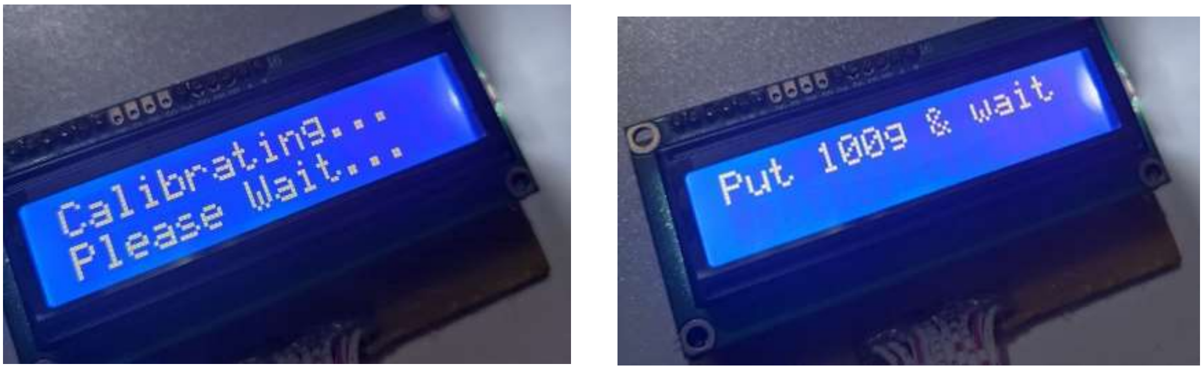
Figure 9 (a) presents the mounting of the load cell. When the scale has been powered on, it needs to be calibrated first with a device of known weight (100g) to ensure accuracy with the usual conventional digital scales. The calibration was done with a phone since the weight is specified in the datasheet. This calibration process is presented in Figure 9(b).

Following the calibration, a message pops out, requesting the user to put the item to be scaled and wait, the weight of the item will then be displayed. After this, another message will be displayed on the screen, requesting the user to enter the price per kg for the item. Figures 10 (a) and (b) show the user putting the price equivalent per kg of the item on the scale to determine the total price of the item.



(a) (b)

Figure 9: (a) Load cell mount (b) Calibrating the scale



(a) (b)

Figure 10: (a) Internal calibration putting the price per kg (b) Required calibration weight

Figure 11 presents the section of the circuit showing the total price after entering the price per kg. The complete digital weighing scale is presented in Figure 12 with the screen and the keypad alone. To improve the weighing capacity, a microcontroller-based weighing system was developed. The system was tested using a calibrated weight to verify precision and reliability, it was discovered that the system gives an exact high-precision throughput. Following the result of Table 1, the system displays an effective and efficient reading with the accuracy of up to three decimal points for applied weight.

Figure 11: Total price after entering a price per kg

Figure 12: Completed project

Table 1: Weight validation

S/N	Weight scale weights	Standard Weight	Measured Weight	Load cells Weight (g)			Average (g)
				Test 1	Test 2	Test 3	
1	1Kg	1Kg	1Kg	999	999	999	999
2	2Kg	2Kg	2Kg	2000	2000	2000	2000
3	10Kg	10Kg	10Kg	9999	9999	9999	9999
4	15Kg	15Kg	15Kg	14999	14999	14999	14999
5	20Kg	20Kg	20Kg	20000	20000	20000	20000

4. CONCLUSION

For automated measurement, an electronic weighing scale device was developed, and the functionality of the parts was presented. This system was configured to digitally display weight measurements. The device produced comprised a load cell that read about 0 to 20 kg of mechanical energy (weight). The measurement from the load cell sensor was amplified by the HX711 amplifier module. The measured data was converted to digital form and transferred to the ATmega328 microcontroller. Apart from coordinating the operations of the circuit, the microcontroller also processes the data. The microcontroller transmits the processed information to the LCD module. This development can be further innovated by making the scale to store the price per kg for each product to be scaled such that, when the items are scaled, it will no longer display a prompt message asking the user to enter the price per kg. After scaling any item, the scale automatically computes the equivalent total price concerning the data stored.

REFERENCES

[1] Weisser, H., Gesamtbetriebsrat-Bizerba, V., Keinath, R. & Philipp-Matthäus-Hahn-Museum, L. (2008). *History of Weighing - Part: The Evolution of Weights, Scales and Weighing*. http://www.hennef.de/uploads/media/History_of_Scales_Part_4_EN_Bizerba_News_2-11.pdf.
[2] Büttner, J., & Renn, J. (2016). The Early History of Weighing Technology from the Perspective of a Theory of Innovation. *Journal for Ancient Studies*, *6*, 757–776.
[3] Euler, W. (2010). *History of Scales - Part 1: Scales and Weighing in the Course of Time*.
[4] City, H. C. M. & Nam, V. (2007). *Handbook on Mechanical Weighing Scales* (Issue September).
[5] Mudgal, A., Kumari, A., Mittal, A., Agarwal, A., & Choudhary, V. (2020). Design and Development of a Smart Weighing Scale for Sugar Mill. *International Journal of Computer Applications*, *176*(23), 31–33.
[6] Rikame, S. N. & Kulkarni, P. W. (2012). Solar Based Digital Electronic Weighing Machine. *International Journal of Science and Research (IJSR)*, *3*(6), 2589–2593.
[7] Das, S., Karmakar, A., Das, P. & Koley, B. (2019). Manufacture of Electronic Weighing Machine Using Load Cell. *IOSR Journal of Electrical and Electronics Engineering*, *14*(4), 32–37.
[8] Dathwade, B. P., Raghu, J. M., Kiran, P. & Manjunath, N. (2016). Design and Fabrication of Weighing Machine Made Up of Epoxy Matrix Composite Material Embedded with Load Cell. *IJIRST –International Journal for Innovative Research in Science & Technology*, *3*(02), 17–23.
[9] Gaikwad, K. D. & Dahikar, P. B. (2013). Design And Development of Novel Weighing Scale System. *International Journal of Engineering Research & Technology (IJERT)*, *2*(5), 1668–1671.
[10] Dahikar, P. B, & Patle, K. S. (2013). Design of an Embedded Platform for Digital Weighing System to Enhance Measuring Capabilities. *International Journal of Innovative Research in Computer and Communication Engineering*, *1*(8), 1881–1887.
[11] Awopetu, O. O., Erinle, T. J. & Fasan, O. J. (2015). Development of 400 Newton Spring Weighing Machine. *Journal of Multidisciplinary Engineering Science and Technology(JMEST)*, *2*(Issue 2), 47–53. www.jmest.org.
[12] Kamble, V. A., Shinde, V. D. & Kittur, J. K. (2020). Overview of Load Cells. *Journal of Mechanical and Mechanics Engineering*, *6*(3), 22–29.
[13] Sarah, A. (2017). Getting Started with Load Cells. In *SparkFun Electronic*. https://learn.sparkfun.com/tutorials/getting-started-with-load-cells/all
[14] AVR Studio®. (2016). ATmega328P 8-bit AVR Microcontroller with 32K Bytes In-System Programmable Flash DATASHEET. In *ATmel*. https://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-7810-Automotive-Microcontrollers-ATmega328P_Datasheet.pdf.