



DESIGN AND CONSTRUCTION OF A MULTIPLE SPRING LVDT-BASED DIGITAL WEIGHING SYSTEM

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ABSTRACT: This project focuses on the design and construction of a digital weighing system utilizing a multiple spring Linear Variable Differential Transformer (LVDT) mechanism. Traditional weighing systems often face limitations in accuracy and reliability, particularly in research applications. By integrating multiple springs, the proposed system enhances sensitivity and load distribution, allowing for precise weight measurement across varying loads. The LVDT, known for its high accuracy and robustness, serves as the primary sensing element, converting linear displacement into an electrical signal. The LVDT converts the weight into electrical signals which are read and interpreted by an ATMEGA328 (Arduino) microcontroller. The ATMEGA328 then utilizes algorithms to convert the electrical signals into a weight value, which is displayed on a liquid crystal display (LCD). This system is able to measure weights up to a precision of 165g and can be employed in a variety of applications where precise weight measurements are required. The digital interface facilitates real-time weight display and data logging which enhancing user interaction. Through extensive testing and calibration, the system demonstrates consistent performance, with minimal drift and high repeatability. The implementation of this digital weighing system has potential applications in laboratories, quality control, providing a reliable solution for modern weighing challenges. The project not only contributes to the field of measurement technology but also serves as a foundation for future advancements in digital weighing systems.

Keywords: LVDT, multiple spring, weighing system, microcontroller, Arduino.

INTRODUCTION

In many different sectors and applications, accurate and reliable weighing systems are critical to inventory management, process optimization, quality control, and regulatory compliance. The precision, sensitivity, and real-time data capture of traditional weighing techniques, such as strain gauges, load cells, and mechanical balances, are limited (Sawhney, 2011).

The use of linear variable differential transformers (LVDTs) in weighing systems has drawn a lot of attention as a solution to these drawbacks. According to Baumeister and Marks (1967), LVDTs are transducers that translate linear displacement into an electrical signal. They have the ability to measure in real time and have excellent linearity and intrinsic precision. Advantages of the LVDT technology include resistance to environmental influences, immunity to temperature changes, and the capacity to function in challenging environments.

To improve accuracy, stability, and responsiveness in weighing applications, a multiple spring LVDT-based digital weighing system appears to be a viable alternative. The system can more uniformly distribute the load and increase load-bearing capability by using multiple springs in conjunction with LVDTs, resulting in precise and trustworthy weight measurements.

The goal of the multiple spring LVDT-based digital weighing system is to provide a comprehensive solution that is suited to real-world applications while overcoming the drawbacks of conventional weighing systems. Benefits of this method include increased accuracy and stability. Furthermore, the system's digital architecture makes it possible for seamless connection with other control systems, which promotes effective control and monitoring in industrial settings.

In order to design and build an effective multiple spring LVDT-based digital weighing system, this project will investigate the fundamentals of LVDT operation and its applicability for weighing applications in detail. Innovative design elements, including a multiple spring mechanism, will be incorporated into the system to maximize load distribution and boost precision. In order to guarantee dependable and user-centered operation, the project will also concentrate on integrating microcontroller-based data gathering with an intuitive interface.

A thorough analysis of the accuracy, linearity, repeatability, and stability assessments of the multiple spring LVDT-based digital weighing system will be carried out. To show the system's efficacy in real-world scenarios, its performance will be contrasted with conventional weighing techniques.

The results of this work should greatly advance the field of weighing systems by offering a sophisticated and dependable substitute for conventional techniques. In a variety of sectors, the multiple spring LVDT-based digital weighing system offers the ability to increase process effectiveness, optimize inventory management, and provide real-time monitoring and control (Howard 2003). Furthermore, the results of this study could provide a basis for future developments and uses of LVDT technology in the measurement and instrumentation industries.

MATERIALS AND METHOD

The materials involved in the development of an LVDT based digital weighing system includes; Aduino UNO, LCD, Cable and connectors, Resistor, capacitor

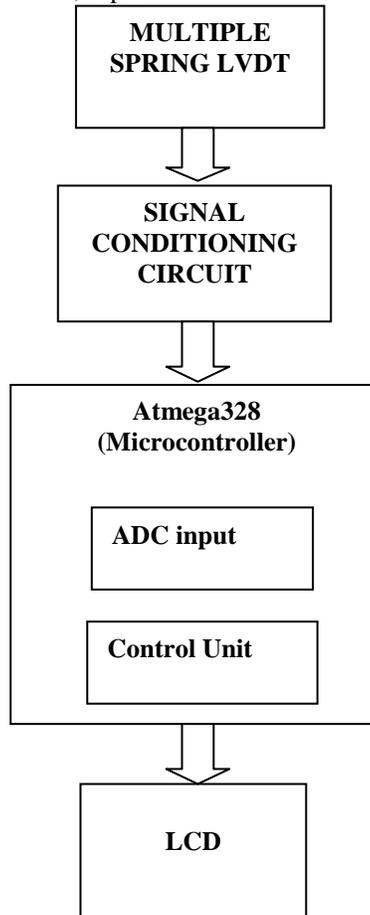


Fig. 1.1 Block diagram of the complete system

The block diagram above illustrates the complete setup of the system. The multiple springs provides mechanical support and sensitivity to the load. The springs are designed to compress under the weight of the object being measured. They allow for a proportional displacement, which is critical for accurate weight measurement. The stiffness and configuration of the springs can affect the system's sensitivity and range. They are incorporated into the LVDT under the sensing element of the LVDT. The LVDT is a type of electromechanical transducer that converts linear displacement into an electrical signal. When a weight is applied, the springs compresses, causing the core of the LVDT to move. This movement changes the inductance in the LVDT coils, producing a varying AC signal corresponding to the displacement. The output is linear and can be calibrated to represent weight. The raw output (AC signal) is sent from the LVDT to the signal conditioning circuit for processing. The signal conditioning circuit enhances the signal from the LVDT for better accuracy and stability. The raw output from the LVDT is often weak and may contain noise. The signal conditioning circuit amplifies this signal and filters out any unwanted noise or interference. It may include operational amplifiers, filters (resistor and capacitor), and other components to ensure that the signal is clean and suitable for further processing. The signal conditioning circuit typically converts the raw AC output from the LVDT into a usable DC signal for the microcontroller. The result from the signal conditioning circuit is then sent to the microcontroller (ATmega328). The microcontroller is the central processing unit of the setup, it reads the conditioned voltage from the signal conditioning circuit and processes it to determine the weight and drives the result to the LCD (Liquid crystal display). The microcontroller used in this work is the ATmega328, it contains a built in ADC (analog-to-digital converter) that converts analog DC voltage from the signal conditioning stage into a digital value. The ADC typically has a 10-bit resolution, meaning it can represent the input voltage as values from 0 to 1023. Contained also in the microcontroller is the control unit, this reads the ADC continuously. It converts the digital ADC value into weight measurement using a calibration factor derived from known weights. The control unit of the microcontroller also handles the timing and updates for displaying the weight on the LCD.

Finally, the processed information from the microcontroller is sent to the LCD which displays the weight of the object measured. The LCD can be connected directly to the microcontroller's digital pins or through an I2C interface for simplified wiring. The LCD can display additional information, such as units (e.g., kg, g). Each of these stages plays a crucial role in the overall functionality of the digital weighing system. From sensing the weight with the LVDT to processing and displaying the measurement, each component works together to provide accurate and reliable weight readings.

RESULTS AND DISCUSSION

4.1. Experimental Setup

A prototype of the LVDT-based weight measurement system was built in accordance with the guidelines in Chapter 3 in order to undertake the testing. The system was made up of an LCD, a microcontroller unit (MCU), a signal conditioning circuit, and an LVDT sensor. Prior to testing, a calibration procedure was carried out to guarantee precise and trustworthy

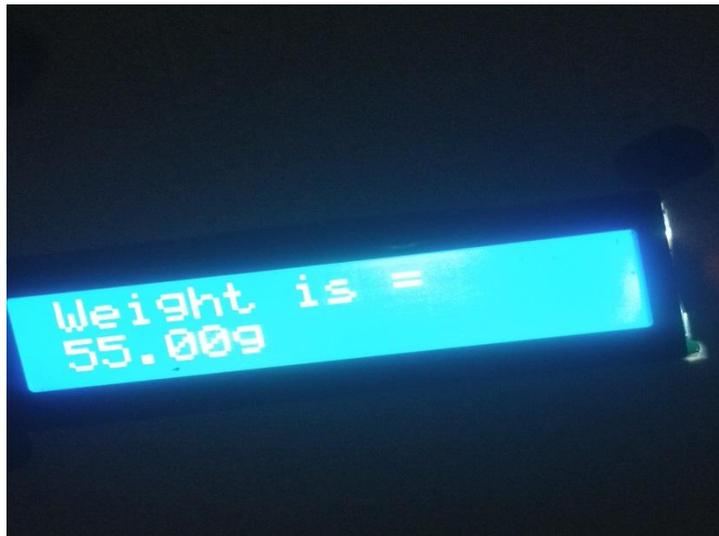


Fig 4.1. The device being tested

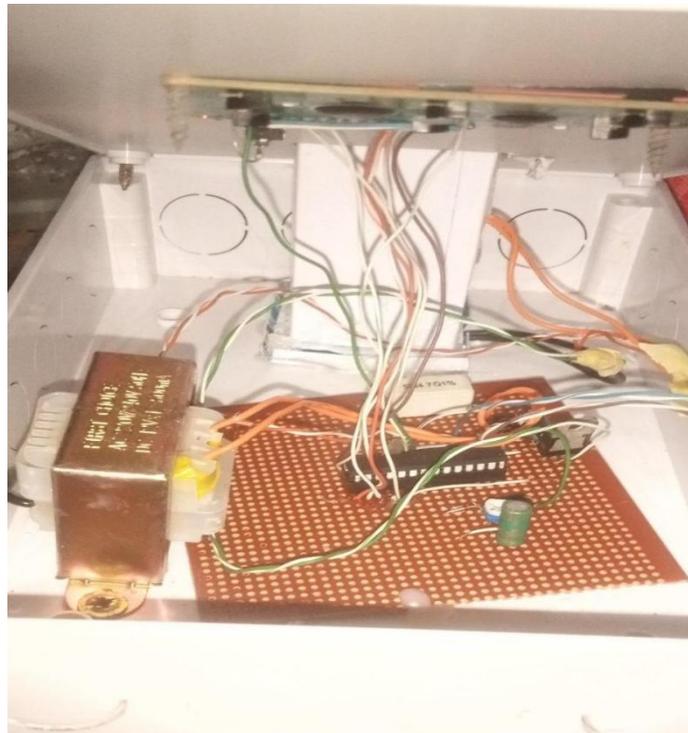


Fig. 4.2. Shows the internal circuit connection

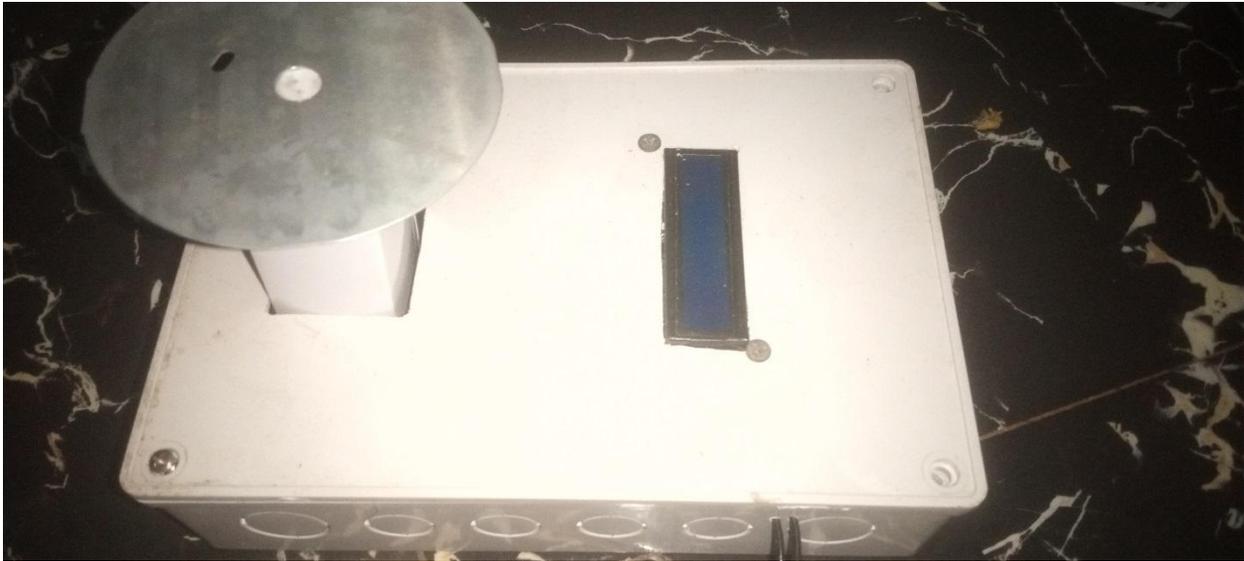


Fig. 4.3. The complete project

A 55-gram bar of premium soap was used to test the device, and the readout was precise. Another 55-gram bar of soap was placed on top of it, and it accurately measured 110 grams. The readout from the system was accurate and consistent up until the fourth bar of soap was added, at this point it became inconsistent.

Accuracy test

The manufactured weighing device's readings were compared to those from a regular weighing machine for the accuracy test, and the readings were found to be similar with some fluctuation for weights above 165 grams. The tabulated reading is shown below.

Table 4.1. Results from the constructed weighing device vs the Standard weighing scale

S/N	Constructed weighing device	Standard weighing scale (gram) W_b	Difference ($W_a - W_b$)
1	55	55	0
2	110	110	0
3	165	165	0
4	225	220	5
5	285	275	10

The mean difference W_m is calculated by the equation $W_m = \sum \frac{(W_a - W_b)}{N}$

Where N is the number of measurements taken. From the above table, the mean difference is calculated to be 3.

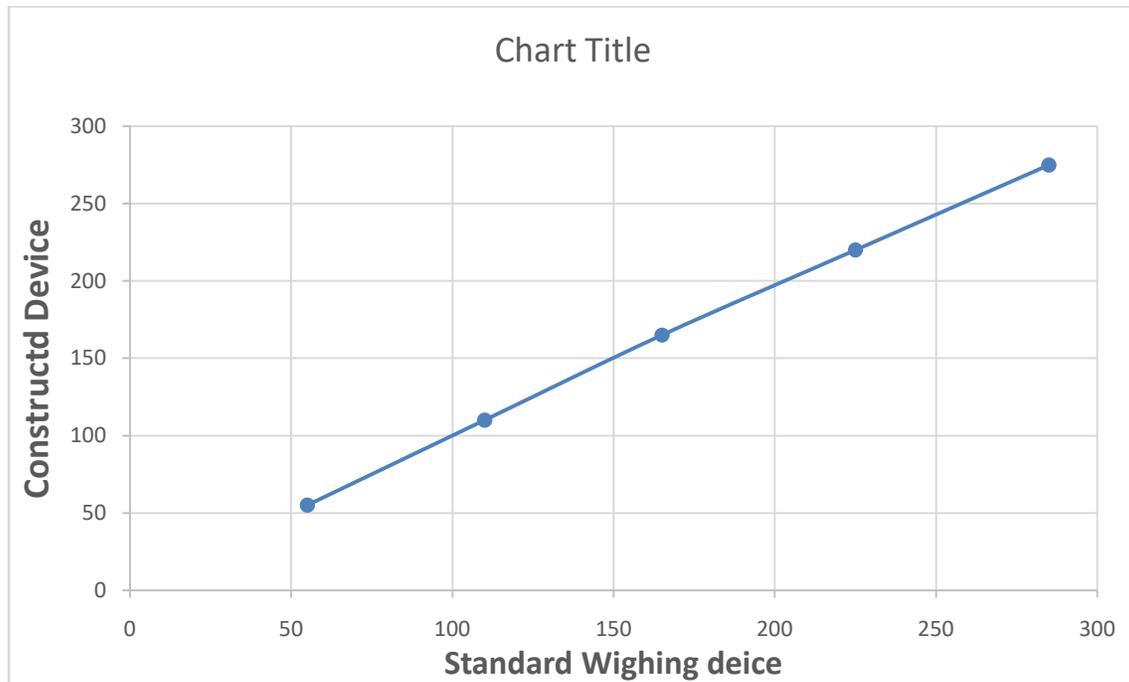


Fig. 4.4. Graph of constructed device against standard weighing device

4.4. Discussion

A range test was conducted to find the range of stimuli which may be converted by a sensor. It represents the highest possible input value that can be applied to the sensor without causing an unacceptable large inaccuracy (Saeedifard et al., 2012). The range was found to be 0 – 165g. The sensor in the research is the spring in the weighing scale which senses the applied force and converts it to an extension that is linearly proportional to the applied load. The upper limit value of the device corresponds to the maximum compression achievable on the spring.

4.4.1. Accuracy:

In the test to determine the accuracy of the device, it is seen that the difference are positive. This is why the graph of the standard measurement shift downward from the graph of the constructed scale. The highest difference reached was 10g while the lowest difference was 0g. The mean of the difference was found to be 3 g. this implies that if 3 g is added to all measurements of the constructed weighing scale a more accurate result would be obtained.

CONCLUSION

The multiple spring LVDT-based digital weighing system designed and constructed in this research work is an accurate, reliable, and low-cost alternative to commercial weighing systems. The system's design and construction were successful in achieving the research work's objectives.

The system has the potential to be used in various applications, including industrial, agricultural, and domestic settings. Its accuracy and precision make it suitable for use in applications that require precise weight measurements.

Acknowledgements

God Almighty has shown me a great deal of kindness and mercy, especially during this study, for which I am eternally grateful. For their assistance, support, and guidance throughout this research effort, I also want to thank the following people: Before anything else, I want to express my gratitude to my supervisor, Dr. R.A.O. Osakwe, for his important advice, motivation, and support. The direction of this project has been greatly influenced by his experience and insights. I would also like to express my appreciation for the support and encouragement I received from the staff members of physics department, Federal University of Petroleum Resources as I conducted my research. They helped me accomplish my objectives, and their contributions were priceless. I want to express my gratitude to my family and friends for their continuous support and inspiration during this effort. My motivation and inspiration to push myself to do my best have been sustained by their faith in me. Finally, I'd like to thank everyone who took part in the study for taking the time to talk to me about their experiences. This project would not have been feasible without their contribution. I want to thank everyone who has helped me finish this project once again for their assistance.

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