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Digitized Load Cell with Advanced Reporting and Weighing Algorithms

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Abstract: A load cell convert a force into electrical signal through a mechanical arrangement and it usually consists of four strain gauges in a Wheatstone bridge configuration. The electrical signal output is typically of the order of a few mill-Volts and requires an instrumentation amplifier before it can be used. The output of the transducer is plugged into an algorithm to calculate the force applied to the transducer. Load cells are high cost of the order of 25,000/- to 2,000,000 /- rupees or more. These load cells can get easily damaged by large pressure or by high voltage. This paper represents a load cell with a totally new way. The load cell is designed on a shaft and potentiometer typical arrangement which helps to develop a highly efficient and effective load cell application. The output of the potentiometer was given to an ADC. ADC converts this voltage to digital signal which was interfaced with a computer. The computer program written in vb.net displays the converted output that is the weight. The circuit interfaced with computer was cost effective and maintenance free. The circuit requires 5V supply. The developed efficient load cell can be implemented in weighing load on goods at retail shops, bag Filling Machine, tank dispensing, Liquid Separation etc.

Keywords: ADC, potentiometer, load cell, amplifier, transducer, Wheatstone bridge.

I. INTRODUCTION

In most cases, force or stress cannot be measured directly, but the deformations they generate. Thus, when an object is weighed on a scale, it is the extension of the spring that is measured, and the weight is calculated using Hooke's law with the measured spring displacement. In a similar manner, load cells have sensors that measure the deformations induced under loading that relate to the magnitude of the applied load. When the deformation is defined as the change in length per unit length of a given object, it is called strain. Of the strain-measuring systems that are available for practical applications, the most frequently used device for strain measurement is the electrical-resistance strain gage [1].

A load cell usually consists of four strain gauges in a Wheatstone bridge configuration. Load cells of one strain gauge or two strain gauges are also available. The electrical signal output is typically in the order of a few mill volts requires an instrumentation amplifier before it can be used. The output of the transducer is plugged into an algorithm to calculate the force applied. In industrial applications, hydraulic (or hydrostatic) is probably the second most common, and these are utilized to eliminate some problems with strain gauge load cell devices [1, 2]. A hydraulic load cell might be a more effective device in outdoor environments. Other types include piezoelectric load cells and vibrating wire load cells, which are useful in geo-mechanical applications due to low amounts of drift [3]. Every load cell is subject to "ringing" when subjected to abrupt load changes. This stems from the spring-like behaviour of load cells. In order to measure the loads, they have to deform. As such, a load cell of finite stiffness must have spring-like behaviour, exhibiting vibrations at its natural frequency. An oscillating data pattern can be the result of ringing. Ringing can be suppressed in a limited fashion by passive means. Alternatively, a control system can use an actuator to actively damp out the ringing of a load cell. This method offers better performance at a cost of significant increase in complexity [4].

Load cells consist of specially designed structures which perform in a predictable and repeatable manner when a force is applied. The force applied is translated into a voltage by the resistance change in strain gages which are intimately bonded to the transducer structure. The amount of change in resistance indicates the magnitude of deformation in the transducer structure and hence the load the applied [5].

A regulated 5 to 20 volt DC or AC excitation is required (between A and D). When a force is applied to the transducer structure the Wheatstone bridge is unbalanced causing an output voltage between B and C which is proportional to the applied load [6]. Mostly all load cells manufactured follow a wiring code established by the Western Regional Strain Gage committee as revised in May 1960 is shown in Fig.1.

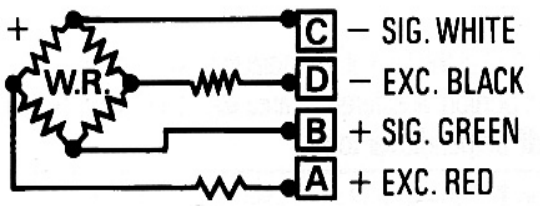

Fig.1. Wiring code of load cell

Mostly the vehicles are weighted in two stages: 1. when no load is applied on vehicles and 2. When vehicle is fully loaded. In case if the petrol tank of vehicle is full or in

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case if certain load is already on the vehicle when it is weigh then there are some chances of fraud. This fraud is impossible to detect as the vehicle travels from one market yard to another there is no actual communication between the two market yard that is been done. Moreover there is no as such software available along with load weighing system that helps to compare and kind of loaded vehicle with an empty one. That creates more scope for fraud in market yard weighing management [7, 8].
The main purpose was to replace the load cell Wheatstone circuit with digitized load cell, which is of low cost and almost maintenance free. The digitized load cell can be easily calibrated using hardware calibration or software calibration.
.NET is the set of all functions calls in the windows API. These functions provide common features such as displaying dialog boxes, multiple-document-interface and single-document-interface windows, accessing the base functions, such as security features or component services and so on [9, 10].

The features of the system are:

- The calibration in project is possible in 2 stages: software based calibration and hardware based calibration.
- The software is enabled with manual calibration and automatic calibration facility.
- Dynamic graphs are obtained during runtime so there will be more precise reading available for the user.
- Software is integrated with email facility so that it is easily possible for user to communicate the reading with other.
- Relational database maintained in SQL logs of all the transactions are maintained in database.
- Total accounting of day to day transactions is possible, reports are generated as well.
- Excess weight is detected and automatic gate closing is possible

Purpose
The main purpose was to replace the load cell Wheatstone circuit with digitized load cell, which is of low cost and almost maintenance free.. The next main concern is the calibration. The digitized load cell can be easily calibrated using hardware calibration or software calibration.
Here with the guidelines of embedded system we have built a Weighing System which is used to weight the load and accordingly control the different applications.
The digitized load cell stands a good replacement circuit to traditional load cell being its advantages proving it to be a better option than any other traditional circuit. The digitized load cell can be easily applied to multiple load cell applications.

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II. EXPERIMENTAL SETUP

The Measurement of load is a fundamental part of the several industries. So design a new a system that is capable for this type of measurement with advanced technology. This research work introduced a new method of weight measurements. The load cell, Analog to digital Converter, Amplifier is used in this research work are available in market on commercial basis. This research work has advantage of simple design and errorless, high accuracy measuring systems. The main theme of this paper is implementation of simple method for measurement of load with the help of advanced instrumentation.

Analog to digital converter (ADC): ADC0804 is an 8 bit successive approximation analogue to digital converter from National semiconductors. The features of ADC0804 are differential analogue voltage inputs, 0-5V input voltage range, no zero adjustment, built in clock generator, reference voltage can be externally adjusted to convert smaller analogue voltage span to 8 bit resolution etc [11]. The pin out diagram of ADC0804 is shown in the Fig.2.

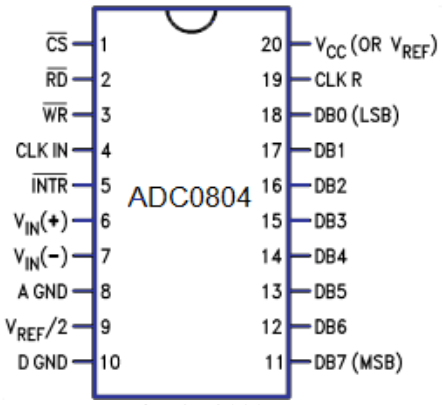

Fig.2. ADC IC0804 pin outs

When weigh is applied on the assembly there is rotation in the crack shaft arrangement. This rotation in crack shaft arrangement causes the potentiometer to rotate pot can give variations up to 2.5mA is shown in Fig.3.

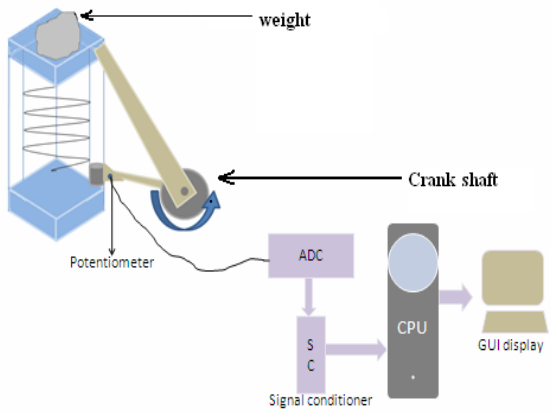

Fig.3. Block diagram of digitized, load Cell

This variation in pot is given to pin no 6 of ADC 0804. The ADC converts the variations into its equivalent digital

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output. The Input from ADC data pins is taken through LPT cable. Using device driver that are manually designed converts the digitized output into its equivalent form. The reading are checked for excess weight, if excess weight is found then the control pin C1 is triggered using equivalent instruction out (&h37As,&hEAs). If excess weight is removed from the system then motor stops to operate, in this stage the control pin other than c1 and c2 are triggered to take the input.

Crank shaft Arrangement:
The crankshaft, casually abbreviated to crank is the part of an engine which translates reciprocating linear piston motion into rotation. To convert the reciprocating motion into rotation, the crankshaft has "crank throws" or "crankpins" as shown in Fig.4, additional bearing surfaces whose axis is offset from that of the crank, to which the "big ends" of the connecting rods from each cylinder was attached.

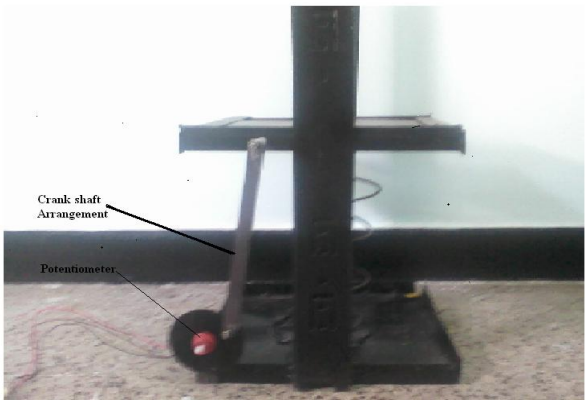

Fig.4. Crank Shaft and potentiometer arrangement

GUI Interface: The GUI interface of the application mainly consists of front end designed using vb.net. The device drivers for converting the LPT port input to the desired form. The interface have options like taking average of the inputs, calibrations, conversion from one form to another etc. the back end of the GUI have a database storage facility which helps in storage of the input data in database to keep the track of the records. The load cell application is consisting of a particular crank and shaft arrangement which is attached to a potentiometer.

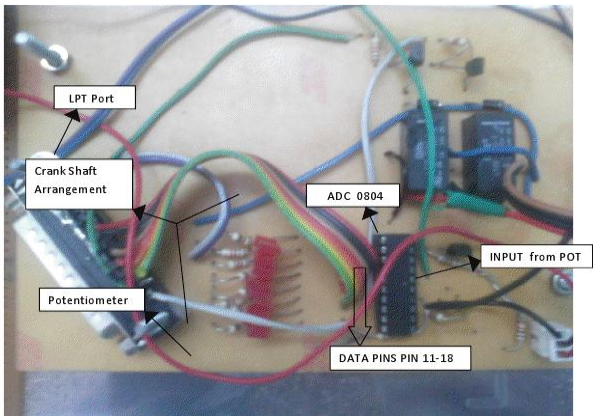

Fig.5. Interface diagram

This potentiometer output was used to convert the electric signals to digitized signals. This output is fed to the LPT port of the computer as shown in interface Fig.5.

A VB.net application converts these signals into its concern reading. The overall package of the system is shown in Fig.6.

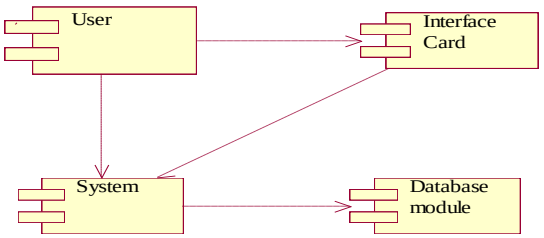

Fig.6. Package diagram

The system flow diagram and overall flowchart of the system is shown in Fig.7 and Fig. 8 respectively.

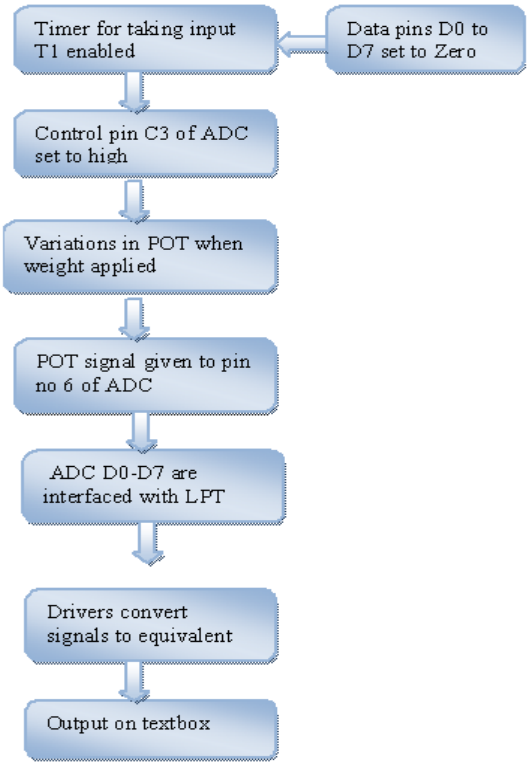

Fig.7. System flow diagram

Design of LPT Port Interface
Line Print Terminal is the parallel port interface on IBM PC-compatible computers. It was a de facto industry standard for many years and was finally standardized as IEEE 1284 in the late 1990s. Today, the parallel port interface is seeing decreasing use because of the rise of Universal Serial Bus and FireWire devices; along with network printing using Ethernet.

Control Signals for ADC 0804:
The 4 control pins and equivalent addressing of the pins in Hexadecimal format are C1=EAx, C2=E9x, C3=FFx and C4=E3x

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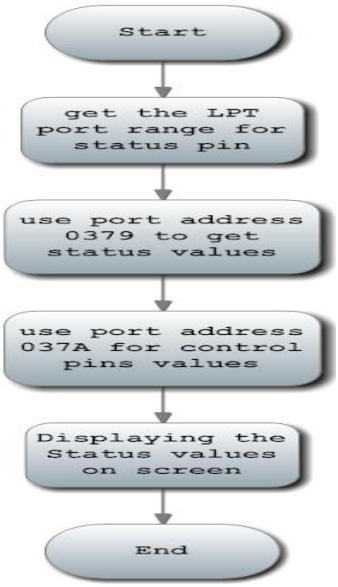

Fig.8. Flow chart of overall working of the system

Operations performed by ADC 0804 control pins: C1-rotate motor in forward direction and C2-rotate motor in reverse direction

Addressing of LPT port: &h378s- Addressing of Data pins of ADC ie. D0-D7 and &h37As-Addressing of Control register of ADC

Instruction used for ADC interfacing: Inp is used for inputting the data from any particular port of the pc. The standard format available for input of the data is: Inp(port address in short), Example: Inp(&h378s)

Out: The data is output to particular LPT port using the instruction out. The standard format for output of the data is: Out (Port address, Values), Example: Out (&h37As,&hEAs)

III. RESULTS

Microsoft Visual Studio is an integrated development environment (IDE) from Microsoft. It was used to develop console and graphical user interface applications along with. Visual Studio includes a code editor and a machine-level debugger. Other built-in tools include a forms designer for building GUI applications, web designer, class designer, and database schema designer. It accepts plug-ins that enhance the functionality at almost every level—including adding support for source-control systems and visual designers for domain-specific languages or toolsets for other aspects of the software development lifecycle.

The system generated weighing form is shown in Fig.9. It shows start, stop, graph and option icons. The present screen had shown the 0.5Kg load. User interactive and attractive icons and fields are defined and developed.

Fig.10 shows the database relationship.

Visual Studio supports different programming languages by means of language services, which allow the code editor and debugger to support nearly any programming language, provided a language-specific service exists. Built-in languages include C/C++ (via Visual C++), VB.NET (via Visual Basic .NET), C# (via Visual C#), and F# (as of Visual Studio 2010). Support for other languages such as M, Python, and Ruby among others is available via language services installed separately. It also supports XML/XSLT, HTML/XHTML, JavaScript and CS S. Individual language-specific versions of Visual Studio also exist which provide more limited language services to the user Microsoft Visual Basic, Visual J#, Visual C#, and Visual C++.

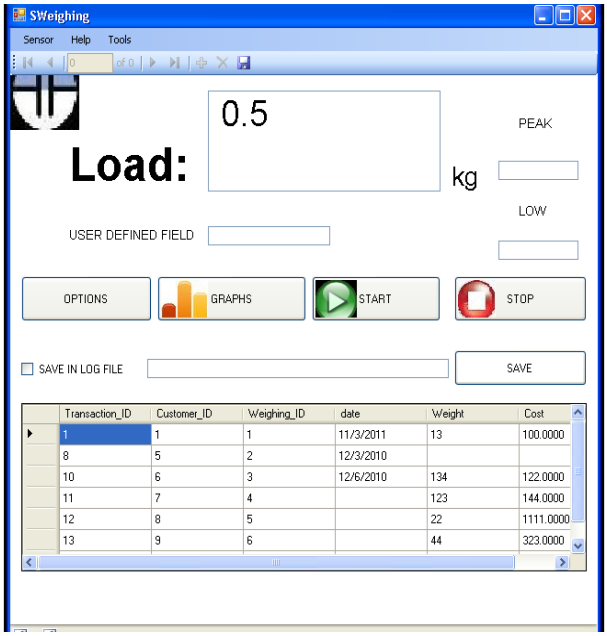

Fig.9. System generated weighing form

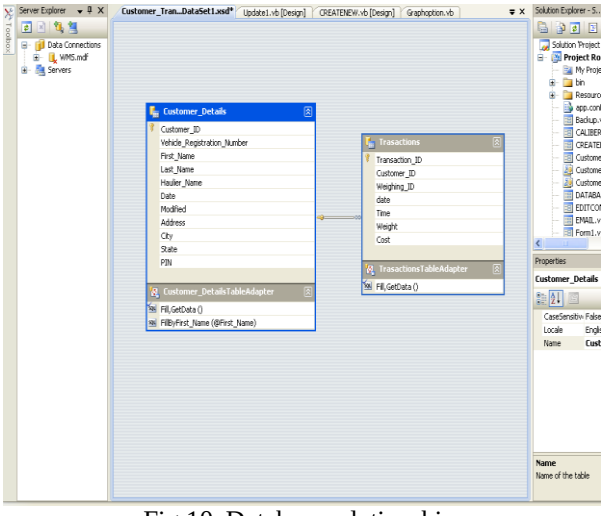

Fig.10. Database relationship

Features: VB.NET

1. Full support for classes and Object Oriented Programming, including inheritance, and operator overloading.
2. A consistent and well-defined set of basic types.
3. Inbuilt support for automatic generation of XML documentation.
4. Automatic cleanup of dynamically allocated memory.

5. The facility to mark classes or methods with user-defined attributes.
6. Full access to the .NET base class library, as well as easy access to the Windows API.
7. Pointers and direct memory access are available if required but the language is designed in such a way that u can work without them in almost cases.
8. Support for properties and events in the style of VB.
9. Just by changing the compiler options we can generate executable or library of .NET components (same as ActiveX in VB).

Software platforms:
Operating Systems- Windows XP/Windows 2000 / 2003
Application Libraries- NET Classes
Language- Vb.NET

Hardware platform:
CPU -Pentium IV
Memory-256 MB RAM
Display Options- Computer Screen
Input Device- Network interface card

TESTING
Testing helps is verifying and validating if the software is working as it is intended to be working. This involves using Static and Dynamic methodologies to test the application.

Software Testing
Testing is a process of executing a program with the intent of finding an error. A good test case is one that has a high probability of finding an as yet undiscovered error. A successful test is one that uncovers an as yet undiscovered error.

Unit Testing
In computer programming, a unit test is a method of testing the correctness of a particular module of source code. The idea is to write test cases for every non-trivial function or method in the module so that each test case is separate from the others if possible. This type of testing is mostly done by the developers.

White Box Testing
White box testing is a test case design method that uses the control structure of the procedural design to derive test cases. Test cases can be derived that

1. Guarantee that all independent paths within a module have been exercised at least once
2. Exercise all logical decisions on their true and false sides.
3. Execute all loops at their boundaries and within their operational bounds, and
4. Exercise internal data structures to ensure their validity.

Basis Path Testing
This method enables the designer to derive a logical complexity measure of a procedural design and use it as a guide for defining a basis set of execution paths. Test cases that exercise the basis set are guaranteed to execute every statement in the program at least once during testing.

Black box testing
Black box testing attempts to derive sets of inputs that will fully exercise all the functional requirements of a system. It is not an alternative to white box testing. This type of testing attempts to find errors in the following categories- Incorrect or missing functions, Interface errors, Errors in data structures or external database access, Performance errors, Initialization and termination errors.

IV. CONCLUSION

There are various analog methods for measuring the weight of the load of the vehicles, like scales but there are many disadvantages. Therefore making a weight sensor that can measure the weight digitally with different load checking and reports generations seems to be necessary. The digitized load cell stands a good replacement circuit to traditional load cell being its advantages proving it to be a better option than any other traditional circuit. The digitized load cell can be easily applied to multiple load cell applications.
The system fulfils all the aspects of requirement specification and implementing the concept to meet its requirement in the specified area. We have worked out and removed the bugs that occurred during the designing of the software code and hardware circuits. The developed system has gone through all the phases of development, requirement, designing, testing, configuration management etc. The system has many future scopes and gives a way to more technological advancement in future.

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BIOGRAPHY

Vijay S. Kale (M.Sc., M.Phil, Ph.D., PGDIM, ADCSSA) is working as an Associate Professor (Department of Electronic science, KTHM College, Nashik, Maharashtra, India). He has been in the teaching profession (UG and PG) since last 28 years. He has been presented research paper in international conferences (USA, Bangkok). He published research papers in national and international journals. He received R. Chandrasekhar award from Indian Physics Association (IPA), Savitribai Phule Pune University (SPPU), Pune. He has written five books. He worked as project guide for M.Sc. (Electronic Science) and research guide to M. Phil. students. He has worked on several academic committees and Electronic Science Board of studies member (BOS) of SPPU, Pune. Presently he is working as an active Vocational Ad-hoc BOS member. He has worked as a resource person in refresher course, workshop etc. He is presently working on ARM microcontroller based sensor application, Wireless sensor application, e-CALLISTO etc.

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