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# Creeping and Drifting Correction of Sensor Using Adaptive Method

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**ABSTRACT:**This paper presents a method of dynamic compensation of creeping and drifting error of load cell response using Adaptive technique. The case is illustrated by showing how the response of a load cell can be improved. The load cell is a sensor, whose output gives an damped oscillatory response due to creeping and drifting error, in which the measured values contribute to the response parameter. So, a compensation technique is used to track the variation of the measured values to facilitate the investigation using response compensation. The first step is to make a mathematical model of a load cell response with creeping and drifting secondly, the output is digitized by a proper sampler and suitable A/D converter. After verifying the simulated output, a model of an adaptive technique to minimize the oscillation in the output due to creeping and drifting will be made and the corrected digital data again converted to analog form by proper D/A converter for using in real system. The whole system constitutes a dynamic sensor for achieving creep and drift compensation response.

**Keywords:**Adaptive technique, Creeping, Drifting, Dynamic sensor, Load cell, Response compensation, Sampler, A/D converter, D/A converter.

## I.INTRODUCTION

Load cells are used in various weighing applications. Output of Load Cell is proportional to applied pressure. It is observed that load cell output changes rapidly with respect to time due to creeping and drifting error although the transducer, i.e., load cell is sufficiently well-behaved to a stable value. So, the weight measured by load cell is distorted. Since signal processing and control system cannot accomplish appropriately, if they pick up fallacious data, so remuneration of the inadequacy of sensor response is one of the major complication in sensor research. Redundant signals, parameter drift, non-ideal frequency response, nonlinearity and cross sensitivity arefive major drawbacks in primary sensors [1].

For testing the characteristics of Load Cell are done according to the National Conference of Weights and Measures publications 14 [2]. In this work, creep and drift responses obtained from the load cell tested by simulation. Load Cell creep is the difference between initial response when force applied and the response at a later time. Whereas, drift means the random change of load cell initial output when pressure applied with respect to time. It is seen that all the characteristics, i.e., linearity, creeping, drifting, hysteresis, over a temperature range of -10 to 40 degree centigrade.

A new type of creeping model is examined by Pontius and Mitchell [3]. A rheological model of load cell behavior by Mitchell and Baker [4] shows the mathematical model of creep. In this paper creep and drift of load cell both have been examined.

The complication of the load cell responses specially creeping and drifting is studied,and it is seen that investigator has come up with a very wide literature inspection concerning response [2]. This complication has been dealt with help of few techniques. Software solutions for sensor compensation are surveyed [3]. Analog adaptive techniques have been used to minimize transient behavior of load cell [5]. In some cases digital adaptive algorithms have been proposed for this purpose [6]. Also application of an artificial neural network can also be appropriate for intelligent weighing systems [7]. Other methods, such as manipulating a Kalman filter and nonzero initial condition have been applied for dynamic weighing systems [8].

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In this report, a new model for load cell with creeping and drifting both positive and negative are made designed mathematically and then a standard process is being approached by us for dynamic compensation of creeping and drifting error of the load cell response using an adaptive technique. Under section III, the mathematical modeling of load cell with creeping and drifting has been accomplished. After that, in section IV, load cell response rectification has been furnished through some rectification method. The cogent synthesis of the adaptive filter formation has been explained in section V. Section VI then presents the results of simulations as carried out with the help of a computer. The conclusions are revealed in section VII.

## II.RELATED WORK

Earlier the adaptive technique is implemented by Mehdi Jafaripanah and Bashir M. Al-Hashimi in their paper 'Application of Analog Adaptive Filters for Dynamic Sensor Compensation' [8] where they suggested analog adaptive technique to the area of dynamic sensor compensation. Stephen C. Stubberud also suggested in his paper 'Online Sensor Modeling Using a Neural Kalman Filter' [9] that the adaptive technique can be provided for online calibration for the sensor models. But the pioneer paper on this field is 'Characterizing the creep response of load cells' [4] by Von R. A. Mitchell and S. M. Baker. In their paper they proposed a search algorithm to solve the non linear least square problem for the multiple stiffness and time constants of their suggested model. Pontius and Mitchell showed how the creep is attributable to thermo-elastic effect in their paper 'Inherent Problems in Force Measurement' [3]. A Rheological Model for load cell behaves shown by Mitchell and Baker shows that how a sudden application of force creates drift & creep. All the above works are mainly based on the analog technique.
But here in this paper the total process taken by adaptive technique is in discreet method which is an advanced one in order to get the optimized corrected response of creeping and drifting in a load cell.

## III.MATHEMATICAL MODEL

The mathematical model of load cell with creeping and drifting are given in the following figure, where input and gain of the load cell are 'x' and 'a' respectively. The output of the load cell will be then 'ax'. Drifting and creeping signals, $\Sigma a_i$and $\Sigma e^{\pm b_i t}$respectively are also added with 'ax' and the final output obtained is given by
$R=a_0x+\Sigma a_i+\Sigma e^{\pm b_i t}$……………………… (1)

Where,Rrepresents the load cell response, trepresents time of load cell since the application of force, $a_0$ is the output of the equilibrium level, as $t$ goes to a very large value. $a_i$ and $b_i$ describe drift coefficient and time constant respectively.

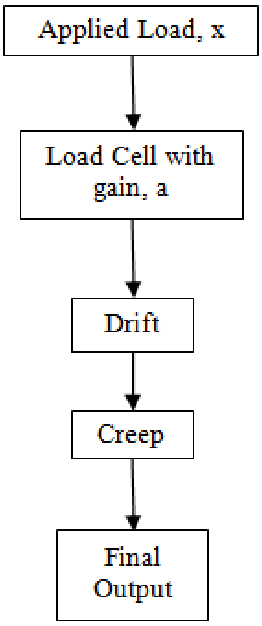


Fig. 1 Output of Load Cell due to Creep and drift

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In the above figure, Drift is represented by $\Sigma a_i$ and creep by $\Sigma e^{\pm b_i t}$ , as shown in equation (1), which shows the final output of a load cell.

Drift means the output of the load cell is different from its original output with respect to time. The nature of drift is random, i.e. the output of load cell is not stable. As well as drifting, output of load cell is also contaminated by creeping mainly due to the ageing of load cell. Creeping is either growing or decaying. Here, exponential grow or decay is assumed. Depending on the nature, creeping is of two types, positive and negative. Positive creeping is increasing exponentially and represented by $\Sigma e^{+b_i t}$, where negative creeping decreases exponentially and represented by $\Sigma e^{-b_i t}$. The behavior of creeping and drifting are shown in following figure:

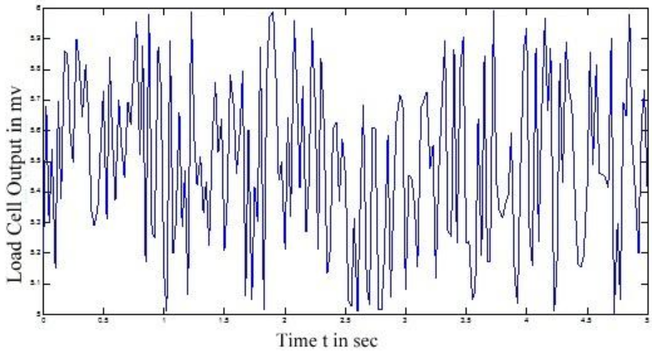


Fig. 2 Drifting of Load Cell

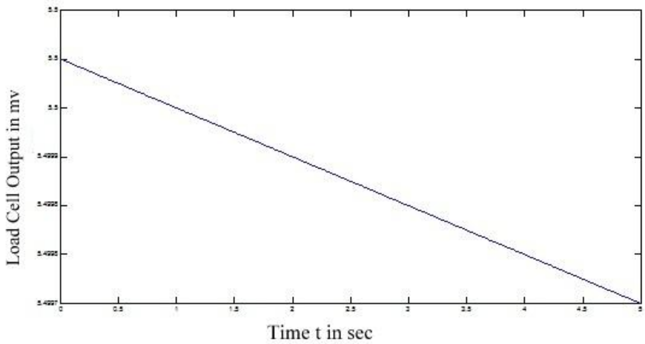


Fig. 3 Creeping of Load Cell

## IV.LOAD CELL RESPONSE RECTIFICATION

To optimize the unsystematic behavior of the load cell due to creep and drift, an adaptive technique is used. A sampler is used to make the load cell output discrete. The creeping and drifting behaviors of sensor are minimized by adaptive filtering method. For this purpose, an adaptive filter assigned with a weight vector D is considered to accommodate all of the parameters of the adaptive filter, i.e. components of D weight vector are used for the adaptive filter according to sensor inherent parameters.

$D= [f^1\ f^2\ f^3\ f^4 \ldots]^T$………… (2)

The components of $D= (f^1\ f^2\ f^3\ f^4$ etc) can be calculated for different values of the measurands. As it is defined that D rely upon the value of *m*, it can be written like D(*m*). When a new measurand brings about, m is unknown at that time. As the filter having the inverse characteristic, the parameters of the adaptive filter cannot be set to correct values. Thus an adaptive rule is suggested to accurate the parameters of the adaptive filter along with the values of measurands. Generally, in good adaptive method, an adaptive algorithm, like Least Mean Squares (LMS) techniques can be considered.

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In this work an adaptive method has designed with the assist of the mean square criterion. The optimization of the cost function can be accomplished adaptively by utilizing the least mean square (LMS) algorithm. The LMS algorithm updates of coefficient vector as given in equation

$C_{k+1}= C_k + 2\mu e_k r_k$…………….. (3),

Where $r_k$ represents the input Fig. 3 Creeping of Load Cell vector, $C_k$ represents the weighted vector; $e_k$ and μ are the error signal the step size respectively. The adaptation speed of the adaptive filter is controlled by the step size μ.

The final output of load cell due to creep and drift is sampled at a regular interval. Now, the desired value will be the median of the Load Cell response ($V_k$) as best value instead of mean value.

In order to furnish the adaptive filter, a reference signal for the adaptive algorithm should be developed. For the preliminary adaptation of the filter coefficients, it is required the receiver to be able to generate the same data sequence. This known data sequence is referred to as the training sequence. During the training period, the desired signal is used as a reference signal. The error signal is defined by the difference between the desired and obtained value and described as

$e_k= (R*D) – V_k$…………… (4),

Where, Ris the input sequence of adaptive filter to be corrected,

Dis the filter coefficient,

$V_k$ is the optimized version of R.

In this technique, it can be considered that the decisions in the output take place most of the time, and the output decisions can be used as reference signal. In the decisions directed mode, the error signal can be defined as the difference between true value and the optimized value of the erroneous input.

The mean square error (MSE) for the filter in the *n*th time instants is defined as

$MSE=E|e_k|^2$……………. (5)

According to MSE we optimize the adaptive filter coefficient and minimize the error.

## V. AN ADAPTIVE APPROACH

In this section we consider an adaptive technique to minimize the error shown in Fig.4.

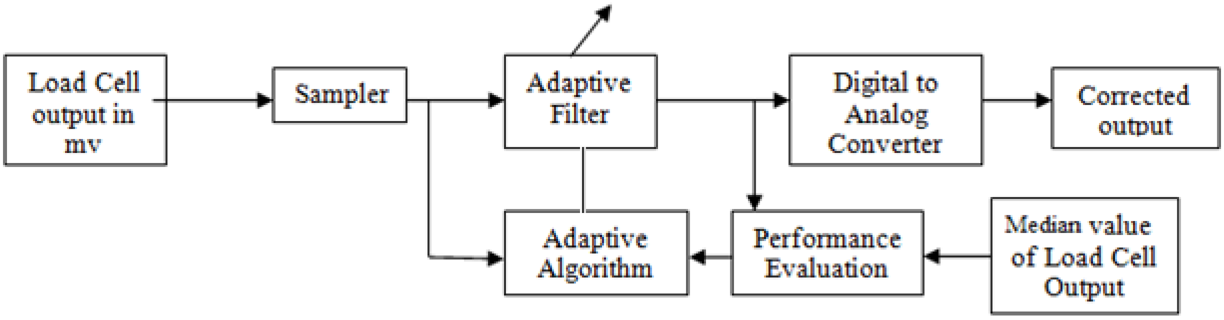


Fig. 4 Adaptive correction technique of load cell output

Load cell output is sampled and the sampled output is connected to adaptive block for rectification.

$E(k) = V_k - y[k] = V_k - \sum_{j=0}^{n} f_j r[k-j]$……………… (6)

Where

r[k] is the sampled output from the load cell.

$V_k$ is the best optimized signal for a particular load input.

$J_{LMS} = \frac{1}{2} avj\{e^2[k]\}$………….. (7)

An algorithm for minimization of $J_{LMS}$ with respect to $i_{th}$ filter coefficient $f_i$is

$f_i[k+1] = f_i[k] - \mu \frac{dJ_{LMS}}{df_i} \mid f_i = f_i[k]$……………… (8)

μ is the step size of adaptive block.

$f_i$is the filter coefficient.

To create an algorithm that can be easily implemented, it is necessary to evaluate this derivative with respect to the parameter of interest. This is

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$\frac{dJ_{LMS}}{df_i} = \frac{d}{df_i} avj\left\{\frac{1}{2} e^2[k]\right\} \approx avj\left\{\frac{1/_2 de^2}{df_i}[k]\right\} = avj\{e[k]\frac{de[k]}{df_i}\}$……… (9)

$\frac{de[k]}{df_i} = \frac{ds[k-\delta]}{df_i} - \sum_{j=0}^{n} \frac{df_j}{df_i} r[k-j] = -r[k-i]$……… (10)

Since $\frac{ds[k-\delta]}{df_i} = 0$ and $\frac{df_j}{df_i} r[k-j] = 0$ and substituting the above equations, the update for the adaptive element is

$f_i[k+1] = f_i[k] + \mu avj\{e[k]r[k-i]\}$………….. (11)

Typically, the averaging operation is suppressed since the iteration with small step-size itself has a low pass averaging behavior. This result is commonly called the Least Mean Squares algorithm for direct linear impulse response coefficient adaptation

Response coefficient adaptation is:

$f_i[k+1] = f_i[k] + \mu avj\{e[k]r[k-i]\}$**……………..** (12)

When all things are correct, the recursive algorithm converges to the vicinity of the block least squares answer for the particular value used in forming the delayed recovery error. As long as µ is nonzero, if the underlying composition of the received signal changes so that the error increases and the desired filter coefficients change, then reacts accordingly. It is this tracking ability that earns in the label is adaptive.

## VI.SIMULATION RESULT

In this section creeping and drifting error of load cell and Adaptive compensation model is being examined.
Fig. 5 shows load cell output with creeping and drifting for a particular load.

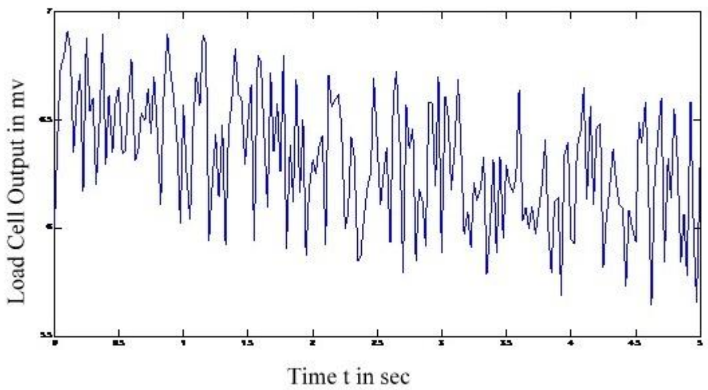


Fig. 5 Load Cell Output with Creeping and Drifting

Load cell output signal is sampled by a proper sampler. Fig 6 shows the sampled version of Load Cell output with Creep and Drift.

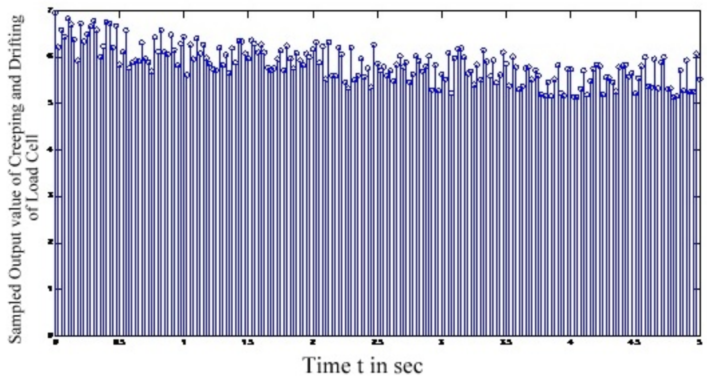


Fig. 6 Sampled version of Load Cell output of Creep and Drift

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A. Reference Signal

Reference signal is basically generated for adaptation purpose. In this work, we examine the output of load cell when it is subjected to a standard known weight for a period. Basically reference signal is the median value of Load cell output for a particular time. So the reference signal is the approximated value of subjected load. Here reference signal is the step signal which is discrete in nature in this work. The amplitude of the step signal is proportional to the median value of the signal output subjected to applied load. So we may call reference signal as the best approximated value of delayed version of load cell output.
Adaptive filter coefficient is varied by the error signal i.e. difference between original load cell output and reference signal.
In this paper the optimization of adaptive filter coefficient has been done during the reference period. We examined the behavior of load cell with respect to various load is equal. The final simulated result is shown below where the adaptive technique is adopted to optimize the Drift and Creep error of the Load Cell.

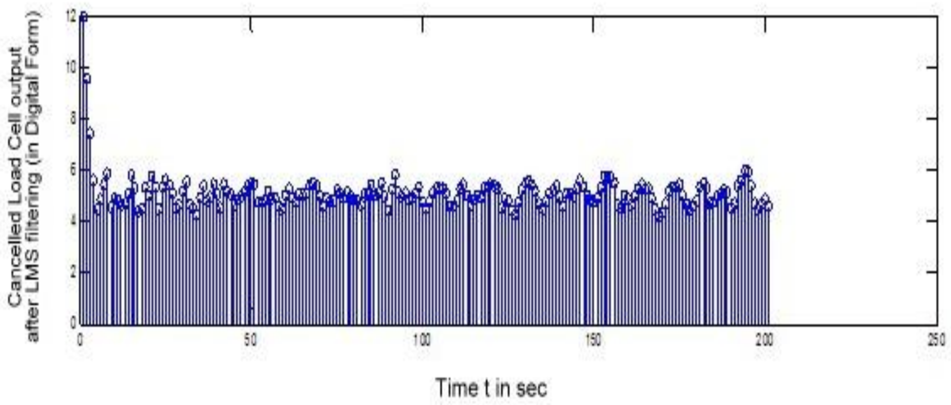


Fig. 7 Corrected Load Cell Output after LMS filtering in Digital version

After we get the corrected output from Adaptive section is discrete in nature. Then the output signal is passed through a Digital to Analog (D/A) Converter so that the analog output can be taken. The output of the analog simulated result is given below:

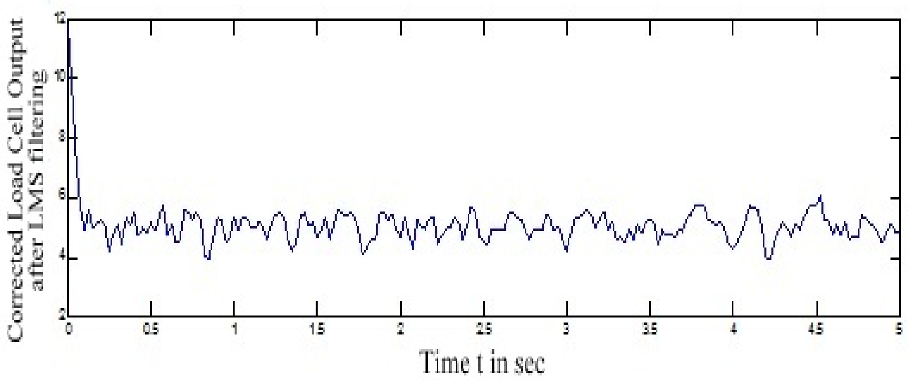


Fig. 8 Corrected Load Cell Output after LMS filtering in Analog version

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## VII.CONCLUSION

In this paper it has been shown that it is possible to perform effective response compensation of sensor output using digital adaptive technique which better may be called discrete adaptive technique. It has been demonstrated with creep and drift error in load cell. This technique may also be implemented on other sensors. It has been shown that how non linearity in the sensor can be compensated by adaptive technique. The feasibility of proposed technique has been shown by simulation and experimental results. The circuit development of the proposed work is in progress.

## .REFERENCES

[1] J.E. Brignell and N.M. White, “Intelligent SensorSystem,” Computer Communication Journal, vol. 32, no. 18, pp. 1983-1997, Dec.20
[2] Natl. Conf. Weights and Meas. Publication 14, Sec. 2, Chap. 3, Checklist for Load Cells, 1994.
[3] P. E. Pontius and R. A. Mitchell, “Inherent Problems in Force Measurement,” Exper. Mech, pp. 81-88, 1982.
[4] R. A. Mitchell and S. M. Baker, “Characterizing the Creep Response of Load Cells,”VDI-Berichte, vol. 3, no. 12,pp. 43–48, 1978.
[5] J.E. Brignell, “Software techniques for sensor compensation,”Sens.Actuators, vol. 25 no. 27, pp. 29-35, 1991.
[6] M. Jafaripanah, B. M. Al-Hashimi, and N. M. White, “Load cell response correction using analog adaptive techniques,”in Proc. IEEE Int. Symp. Circuits Systems (ISCAS), Bangkok, Thailand, pp. IV752–IV755, May 2003.
[7] S. M. T. Alhoseyni, A. Yasin, and N. M. White, “The application of artificial neural network to intelligent weighing systems,” Proc. IEE—Sci.,Meas. Technol., vol. 146, pp. 256–269, Nov 1999.
[8] M. Jafaripanah, B. M. Al-Hashimi, “Application of Analog Adaptive Filters for Dynamic Sensor Compensation,” IEEE Transactions On Instrumentations and Measurement,vol. 54, no. 1, pp. 245-251, Feb 2005.
[9] Stephen C. Stubberud, “Online Sensor Modeling Using a Neural Kalman Filter,” IEEE Transactions On Instrumentations and Measurement,vol. 56, no. 4, pp. 1451-1458, Aug 2007.

## BIOGRAPHY

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