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Abstract: In the initial stage of the Rabigh power plant, Saudi Arabia, the steam turbine Linear Variable Differential Transformers (LVDTs) are absolute, and their feedback are hunting. To obtain the data, a questionnaire has been distributed to a sample of 42 individuals across seven of the power plant's fields. Our target has been identified respondents through a process of stratified random sampling based on two categories, each containing three participants. These categories comprise the plant's senior management and lower-level employees. The majority of employees elect to change the LVDT to a new type with a Direct Current (DC) volt output. As a result, we detect no further noise and no further hunting in our circuit.

Keywords: Rabigh city, Linear transformers, Power plant, SCADA control system and AGC control system, HRSG system, LCD.

1 Introduction

To meet the challenges of generating electrical energy for the various development sectors, Saudi Electricity Company (SEC) has implemented a plethora of projects and plans for third parties to cover the short and medium terms. Among the most prominent of its existing projects is Rabigh Power Plant, which is being expanded through the phase's system. The power plant is in Rabigh, on the Red Sea coast, 145 km north of Jeddah, and is one of the principal power stations in the western region due its contributing in excess of 32% of the main network's total generation capacity. The plant was put into service in four stages, entering the first phase at 1406 Ah. Over the course of its lifetime, the plant has undergone expansions subject to the best technical developments in the field, leading SEC to contract with the largest global enterprises in its operations [1].

In February 2011, civil works were launched for the Rabigh Stage VI steam-power plant project, which was awarded to Doosan Sunning Corporation in Korea. The project is considered significant for the Kingdom and the Middle East in general, with the plant reaching a total output of 2680 MW by 2014, produced via four generating units, each with a capacity of 670 MW. In December 2007, SEC closed three contracts to expand Rabigh Power Plant (Stage V) and connect it to the western network, adding 960 MW to supply Rabigh in order to strengthen the electrical system and meet the increasing demands for power in the Makkah and Madinah regions. Its expansion contract included the addition of 16 EA 7 gas units that burn raw fuel, with all its electrical and mechanical accessories and major lifting adapters being supplied by General Electric. The first generating unit in the Rabigh plant expansion project was installed in May 2009, while the project works were completed in June 2010, which included leveling the expansion land and augmenting the plant's storage capacity with four fuel tanks with a total capacity, as well as establishing electrical systems and an automatic control system to operate the units. The total area of Rabigh Power Plant is 5,700,000 m^2 (see Figure 1), and its capacity is 7668 MW [2].

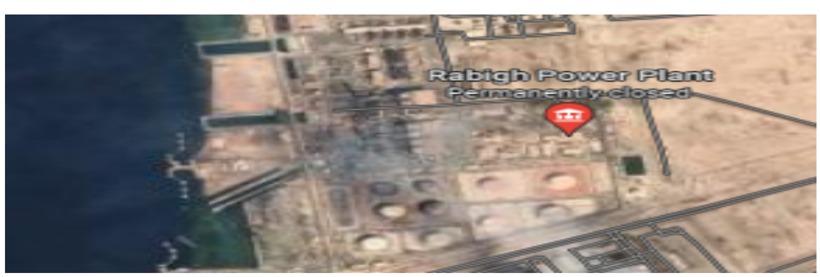

Fig. 1: Map of Rabigh Power Plant

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Stage I of the Rabigh Power Plant comprises four steam turbines and a control system operated by Emerson "Ovation," which runs constantly, depending on the overhaul, and is shut down in winter. The maximum power generation from stage I is 1040 MW. It is linked with substation 1 and connected to Jeddah LDC, which can control the output as per the frequency calculated by the Supervisory Control and Data Acquisition / Automatic Generation Control (SCADA/AGC) control system (Table 1).

Table 1: Stage I Overview Information

Unit Manufacturer	MW	Fuel Type	Total (MW)
Mitsubishi	260	Heavy fuel oil or light Arabian oil	1040

Stage II consists of eight ABB gas turbines and a Heat Recovery Steam Generator (HRSG). Each four gas turbines and the HRSG connects to a steam turbine as a combined-cycle unit under a control system operated by ABB "Symphony plus," which runs depending on the load required and the overhaul schedule and shuts down in winter. Stage II generates a maximum of 696 MW (illustrated in Figure 2). It is linked with substation 1 and connected to Jeddah LDC, which can control the output as per the frequency calculated by the SCADA/AGC control system (Table 2) [2].

Fig. 2: Location View of Stage II

Table 2: Stage II Overview Information

Type of Unit	MW	Fuel	Total (MW)
ABB	Gas Turbine: 55 Steam Turbine: 128	light Arabian processed oil	696

Stage III consists of four steam turbines and a control system operated by Emerson "Ovation," which runs regularly, depending on the overhaul, and shuts down in winter, as shown in Figure 3. Stage III outputs a maximum of 532 MW. Linked with substation no 1, it is connected to Jeddah LDC, which controls the output, as per the frequency calculated by the SCADA/AGC control system (Table 3) [1].

Fig. 3: Top view of Stage III

Table 3: Stage III Overview Information

Type of Unit	MW	Fuel	Total (MW)
Japan	266	Heavy fuel oil or light Arabian oil	532

Stage IV comprises four GE gas turbines and an HRSG, which connect to a steam turbine as a combined cycle unit. This unit is then controlled by a system operated by ABB "Symphony plus," which runs continuously depending on the load required and the overhaul schedule, with the units being shut down in winter. Stage IV (Figure 4) generates a maximum of 384 MW. Linked with substation no 1, it is connected to Jeddah LDC, which regulates the output, as per the frequency calculated by the SCADA/AGC control system (Table 4) [2].

Fig. 4: Overview of Stage IV

Table 4: Stage IV Overview Information

Type of Unit	MW	Fuel	Total (MW)
GE	Gas Turbine: 61 Steam Turbine: 140	light Arabian processed oil + Diesel	384

Stage V consists of 16 GE gas turbines. Each of the four gas turbines has one electrical switchgear room and are controlled from a system operated by GE "Mark Vie," which is in continuous operation, depending upon the load required and the overhaul schedule, with the units being shut down in winter. Stage V generates a maximum of 1152 MW (as given in Figure 5). Linked with substation 2, it is connected to Jeddah LDC, which controls the MW, as per the frequency calculated by the SCADA/AGC control system (Table 5) [2].

Fig. 5: Overview of Stage V

Table 5: Stage V Overview Information

Type of Unit	MW	Fuel	Total (MW)
GE	72	light Arabian processed oil + Diesel	1152

Stage VI comprises four steam turbines and a control system operated by "Mark Vie," which runs continuously, depending upon the overhaul, and shuts down in winter. Stage VI outputs a maximum of 3000 MW(Shown in Figure 6). Linked to substation 2, it is connected with Jeddah LDC, which controls the power generation, as per the frequency calculated by the SCADA/AGC control system (Table 6) [2].

Fig. 6: Overview of Stage VI

Table 6: Stage VI Overview Information

Type of Unit	MW	Fuel	Total (MW)
GE	750	Heavy fuel oil	3000

Stage VII is made up of 12 GE gas turbines. Each of the four gas turbines has one electrical switchgear room and a control system operated by GE "Mark Vie," which runs constantly, depending upon the load required and the overhaul schedule, and shuts down in winter. Maximum Stage VII generates a maximum of 864 MW. Linked with substation 2, it is connected to Jeddah LDC, which controls the output, as per the frequency calculated by the SCADA/AGC control system (Table 7).

Table 7: Stage VII Overview

Type of Unit	MW	Fuel	Total (MW)
GE	72	light Arabian processed oil + Diesel	864

A linear variable differential transformer (LVDT) is an electromechanical sensor that converts mechanical motion or vibrations—specifically rectilinear motion—into a variable electrical current, voltage or electric signals, and vice versa. Actuating mechanisms are used primarily for automatic control systems or as mechanical motion sensors in measurement technologies. The classification of electromechanical transducers includes conversion principles or types of output signals.

In brief, a linear transducer produces a voltage output relative to the parameters being measured (such as force) for simple signal conditioning. LVDT sensor devices are sensitive to electromagnetic interference; however, electrical resistance can be reduced with shorter connection cables to eliminate significant errors. A linear displacement transducer requires three to four connection wires for the power supply and output signal delivery.

Structurally, an LVDT is a hollow metallic cylinder in which a shaft—or pushrod—of smaller diameter moves freely back and forth along the cylinder's long axis. The shaft terminates in a magnetically conductive core, which must be encapsulated within the cylinder, or coil assembly, when the device is operating, the block diagram of the proposed functional is given in Figure 7.

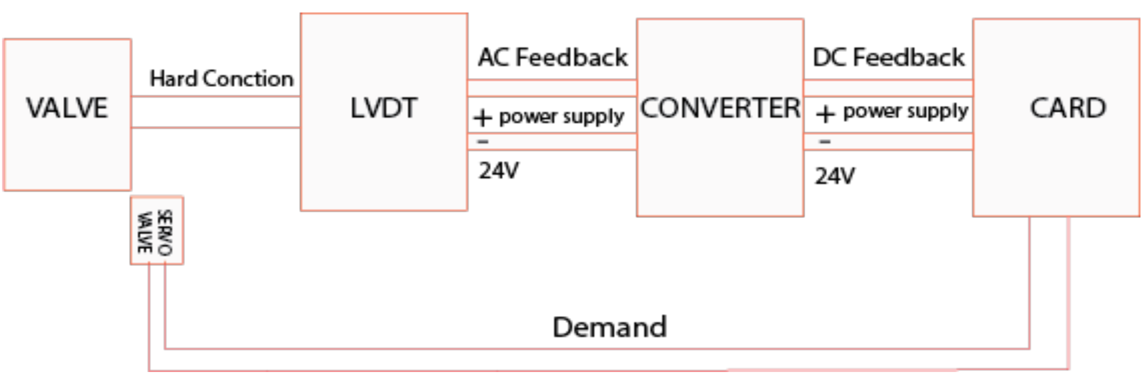

Fig. 7: Block Functional Diagram

The components of the circuit are the valve, servo valve, LVDT, converter, and the servo card. The LVDT is installed with the valves and has four wires connecting it to the converter (two for the feedback signal and two for the power supply); four wires connecting the converter to the card (two for the feedback signal and two for the power supply); and two wires connecting the card to the servo valve for valve movement demand.

When sending demand signals from the card to the servo valves, the valve begins to move, causing the LVDT to also move, providing feedback to the converter and from the converter to the servo card. For example, when giving demands to the servo valve to open by 10%, the valve will move until the LVDT provides feedback of 10% to the card: which means it indicates a 10-% opening in the base.

2 Literature Review

2.1. Introduction

The LVDT signal conditioning adopted by the power plant enhances the displacement (amplitude) and direction (phase) measurements for the core of the variable transformer, based on the signal conditioning in the AC and DC converters. Hence, it facilitates the implementation of the OP-Amp circuit, phase lag compensators, phase modulators and compensators, bias setter, and amplitude modulator. A study of the linear variable differential transformers designed to measure the displacement in the transformer's performance at the Rabigh plant generated a significant dataset for the validation of the LVDT's structural performance [3]. The results highlighted the need to advance the design and development of the subsequent correlational aspects of the theoretical framework. Nevertheless, studies published by Rasoava [4] generated critical outcomes concerning the probable design features for the performance of LVDTs in power stations.

Further research on LVDT technology has focused on the flexural loading of the machine component to establish the mid-span displacement, as in a PIV analysis. However, it confirmed that the strength of reinforced concrete beams with load-displacement curves in Saudi's national power stations could be attributed to their ideal design. The repeated findings of structural instability analyzed by Masi and et. al. [5] demonstrated a significant correlation between the functional ability of a plant's LVDT and its observable design characteristics. A critical analysis of power generation at different stages provides adequate statistical information regarding the application of LVDTY technology in power plants for improved structural stability and performance efficiency in the power generation units [6].

Numerous studies in pace analyzed the design and performance of LVDTs globally. Flammini, and et. al. monitored the impact of the surface settlement of an LVDT during centrifuge tests to validate its performance [7]. However, their performance parameters were based on power generation efficiency in Rabigh power plants, and the study was conducted on the displacement value analysis of the PIV to match the electrical loading of the LVDT data. The study further evaluated the LVDT's performance against the structural design of its user interface components, and thus revealed a positive correlation between the structural decision and the power output. Conversely, a study by Ponernacki and Martin [8] of transformer designs in Saudi supported data that the component displacement is an important design consideration. Further, they aimed to establish the implications of the transformer design in the performance efficiency of dynamic power plants in Rabigh, Saudi Arabia. Throughout the research, their test validations provided significant data to inform the design criteria of LVDTs in the seven stages of power production in the region [3].

The inclusion of surface settlement of the test data obtained in the LVDT process coupled with centrifuge model tests on the geo-grid soil wall constructed with marginal backfill to reinforce with weaker layers that rapidly experience deformation. As such, it influences the rate of geogrid settlement. A sequential analysis of structural stability is critical for successful design performance, especially by focusing on limiting potential instability and interpreting the differential strength implications. Pei analyzed normalized surface movements against potential grid-reinforced soil walls in gas power plants [6]. The drastic deterioration in the system's failure to activate highlights the importance of LVDT tests for structural performance for design techniques in power stations [9]. Greater inclusivity of the instrument's design characteristics promotes adaptability and use onsite and a better understanding of observed power output in designs for the satisfactory correlation with structural component failure characteristics.

Moreover, Ponernacki and Martin analyzed displacement measuring techniques using an LVDT with limited range, as per the systems requirement for recalibration, to facilitate the replacement of winding coils in the transformer [8]. This accelerates fluctuations in the excitation frequency at working temperatures on displacement measuring systems. Nevertheless, this study of geotextiles reinforcing soil settlement relied on surface strain and settlement mechanisms obtained from LVDT data interpretations to provide accurate information on structural stability for power production plants. In addition, a study of LVDT performance by Zhongxun and Zhonghua [9] investigated the maximum mid-span deflection of an LVDT in terms of its explosive charge weight in gas power plants. Furthermore, an increase in the thickness of the steel tube had a significant effect on the cross-sectional geometry, via the confinement effect, and benefited the loading performance in the test algorithm. The LVDT design's structural performance was superior under axial loading compared with lateral loading, which was marred by severe deterioration [10].

2.2. Sensor Design

A study conducted by Santhosh and Akanksha explored the LVDT as a position sensor in power plants for particle acceleration through a contactless sensing mechanism [3]. The results yielded potential displacement data with a high level of accuracy. The utilization of LVDTs in power plants depends on their design characteristics and functional efficiency in being able to withstand hard radiation [11]. The resolution and accuracy of the sensor dictate the conditioning characteristics of elements adopted in the conditioning electronics and correction algorithms in the design of the components to achieve efficient data collection. A focus on digital conditioning techniques to gather radiometric readings fosters high linearity and accuracy in the detection of low signal-to-noise ratios for collimator applications. An increased dependency on DC applications accelerates interference in an LVDT's magnetic fields, leading to a measurement error [5].

Therefore, the LVDT sensor encounters maximum flux density due to the high current cable supply transfers line magnets due to the limited separating distance of the cables to the transformer. In a study of magnetic power cycles, Breeze found an intense occurrence in the measurement error according to the LVDET readings, which cast doubt on the reliability and accuracy of the LVDT component itself [12]. However, when an LVDT sensor is in the ideal, low position, it creates high rejection of the external constant or the varying magnetic fields that exploits the finite elements simulator. This subsequently reduces the magnetic flux and thus the potential measurement error in the LVDT system, which is achieved through the polarization sequence. Pei further proposed that complications in the LVDT working principles were related to a variation in the external magnetic field [6]. Moreover, the incorporation of rejection components in the design improved the accuracy of the measurements obtained through the design variables [3].

The design provisions accelerate the adoption of the LVDT as a position sensor in the establishment of mean positions in power plants. The gadget has gained increased application in power generation plants with critical operating conditions—such as gas power plants, turbine-controlled power plants in a geothermal field, or nuclear plants—to measure the displacement of components within a system. The moveable core of the transformer facilitates positioning measurements, and as the core advances towards the coil, the amplitude of magnetic flux produced by the primary coil increases, causing a significant drop in the voltage across. As such, the variation in voltage between the secondary coils enables an evaluation of the core's position [13]. Nevertheless, this project monitors the performance of the LVDT against the longitudinal rejection of the magnetic field reading obtained through appropriate shield design to enhance DC polarization in the magnetic media. Additionally, the local slope around the generic points affects the sensitivity of the amplitude and the permeability of different materials. Thus, it accelerates the linear bias, which affects the LVDT's sensing ability of the LVDT. Further interpretation of the shield design accelerates the performance efficiency of the LVD in power generation plants.

The presence of a magnetic sensor circuit in the system facilitates accurate measurements of displacement with minimal deflections due to the elimination of external environmental influences on the transformer's efficiency. A study of innovative aspects of the sensory mechanism in LVDT components by Masi and et.al [5] provided an elaborate response to the impact of the shielding layers' efficiency. They performed a correlation relative to the maximum acceptable drift position based on the material characteristics expressed in the structural models. Pei developed a low-frequency damping sensor for seismic attenuation to interpret the gravitational wave interferometer and mirror position relevancy in an analysis of the behavior of gasses directed to a turbine for generating electricity from deep wells in the Rabigh regions, which were found to fall around the seismic zones [6]. Further design interpretation based on the 3D architecture offers information on the extent to which the LVDT geometry accelerates the measurements of vertical displacements in the system [14].

2.3. Shield Design

Santhosh and Akanksha presented a cylindrical shield design integrated into the sensor's magnetic circuit to aid with optimal performance [3]. The study evaluated the potential implications of magnetic circuit separation through a coaxial cylindrical shield to optimize projected magnetic sensor constraints. Thus, structural considerations to dimension, material and separation distance between the shield layers generated essential design parameters for attaining efficiency in the shield at an instantaneous drift position in preliminary simulations. The consideration of flux densities for non-uniform cores supplied critical information for the research analysis to realize success in the shielding efficiency. The consistency in the collection and dissemination of the data on the power plant's key operational characteristics explains the success of the design features that accelerated the variability attributes and promoted overall functional reliability in the LVDT system in the ridge analysis. The design of an LVDT by Ponernacki and Martin assessed the implication of the longitudinal flux density on the perceived magnetic fields and its relevancy in measuring maximum drift position fields [8], based on the order of drifts that enhance the measurement of magnetic flux [13]. Thus, it indicates the flux attenuation factor.

The research further explores longitudinal interference factors in cylindrical shields that affect LVDT performance in determining displacement. FLANN simulation software has been found to accelerate the acquisition of high magnitude permeability for the reduction of field interference. Next, the adoption of a multilayer topology in the shield interpretation generates critical data for an in-depth evaluation of probable attachments to the structural performance in versatile operating environments. Similarly, optimization of the air gaps between layers in terms of thickness moderation enhances the sensor's dimensions. A single-layer shield LVDT designed with material that guarantees high permeability was used to analyze the implications of the external layers in shield designs [15]. Further study of low-carbon-iron cylindrical foils as an essential component in the dynamic sensor magnetic circuit is desirable for longitudinal flux analysis. Increased modelling simulation technology relies on the mesh characteristics of the design preferential in voltage generation techniques. The First Fourier Transform algorithm accelerates the interpretation of performance variables based on radiometric value functions [13].

Masi and et. al. explored maximum mid-span deflection based on the charge weight [5]. Their cross geometrical analysis of the performance of transformers in developed countries confirmed a positive correlation between the charge weight and deflection spans for the benefit of lateral loading. A strain field analysis of the LVDT in a study by Pei relative to the transformer design specification exhibited a better correlation between the structural stability of the transformer and the probable output [6]. However, the study evaluated the implications of the transformer's structural stability relative to the design specifications. The performance efficiency of the transformer adopted in this study incorporated a flexural design in its mechanical components relative to the weight distribution and balances [8].

The study conducted by Hoselitz, which tested LVDT performance through consideration of the primary and secondary windings of the transformer in Saudi, emphasized the need for calibration [13]. Thus, it supports the notion that excitation frequency at ambient temperature improves performance output. Similarly, the research on LVDT performance in Asia correlated the functional efficiency of the transformer in the hydroelectric power plant with the linearity in its power output. Moreover, the transformer's performance in both cases tended to be optimal at ambient operating temperatures. In contrast, this research focuses on the adoption of LVD transformers for diverse power plants in Rabigh, which generate the highest power in the Asian region [16]. The coil characteristics considered in understanding the efficiency of transformer designs in the study by Ponernacki and Martin focused on the electrical and electronic components of the LVDT [8]. Therefore, the focus on transformer production efficiency in gas power plants established the dynamics of coil design and selection in the prevailing operating temperatures within the region.

The study explores the LVDT magnetic displacement sensors that accelerate the measurement of the positions. The predominant environmental conditions within Saudi power generation plants enhance the benefit of LVDTs in analyzing the measurable constraints that are perceived to correlate significantly with the desired outcome. The low temperatures provide critical information on the probable ease of implementing radiation hardness [14]. That said, the consistency in the hard variation attributes of an LVDT's performance in terms of sine wave topology accelerates effective sensor performance for the test parameters in power plants in Rabigh. Coil excitation and component resolutions depend on the overriding performance conditions [7].

Further studies of five-wire models as the perceived legs of the coil demonstrate that they increase the performance of the transducer concerning the perceived power generation capacity of the individual points. Close analysis of magnetic fields improves the perceived correlation of the structural stability of accuracy in measurements. Increased flow measurements through feedback controls show a satisfactory correlation with the measurable variables, including pressure and temperature, in the power plant that affect its overall power output. The LVDT measuring instrument facilitates the reading of flow characteristics in the turbine operation designed to rotate the armature between the large magnets. Consequently, this enhances the generation of electricity in the gas, nuclear or geothermal stations, as in the cases recorded at the Rabigh power plants [8].

In terms of design, the study by Masi and et.al. investigated the symmetrical aspects of the LVDT coil assembly, which separates the magnetic permeability of the core through axial movements [5]. The demodulation analysis of the mechanical coupling on an AC power source and the voltage provided adequate data to support the installation and adoption of the LVDT system in the Rabigh power network in Saudi regions. The degree with which structural evaluation takes place is an essential consideration when selecting transformers for a Saudi power plant. The research by Ponernacki and Martin [8] examined the core material as a means of ascertaining the sensor characteristics; nevertheless, it focused on an electromechanical sensor for converting mechanical motion or vibrations of the rectilinear motions into the generation of a variable electrical market [17].

Ponernacki and Martin studied the impact of the magnetic characteristics of the core materials in the power output efficiency [8]. The coil's hollow bores, characterized by axial motion, comprised part of the design of the sensory system. Further analysis was carried out on the ferromagnetic materials used in the sensory systems in transformer development, and the design of the pushrods was found to be equally important in LVDST-dependent power plant construction. In addition, the design of the magnetic core was investigated in terms of its low coactivity and core losses, as evidenced in its material characteristics. The research further looked at optimum transformer efficiency in multistage power production systems, which affects their structural stability. The study on hydropower plants in developing nations revealed an intense instability in the flux densities of LVDT applications. The LVDT based on voltage and current manipulation produced the best results with respect to service delivery and performance criteria. Consequently, the implementation of this technology in Rabigh power plants generated a significant output in terms of its overall design structure [13].

3 Methodology

3.1. Research Design

This investigation adopted a quantitative survey research design that established a relationship between LVDT performance and the power plant's design characteristics. The power output in the plant's labor management efficiency and the perceived threat based on the pressure variations. The research design facilitated rapid collection of both primary and secondary data that provided reliable information for the research questions as in the perceived thresholds. The data generated through structured questionnaires supports the correlation analysis of the research variables. The research designated for the Rabigh region of Saudi Arabia, which lies on a latitude of 20.9978^0 to 22.8519^0 and a longitude of 38.8339^0 to 38.9616^0 E, on the eastern side of the Red Sea. The site consists of seven principal power generation plants that are critical in the application of LVDT technology and its implications. The site was selected due to its ability to transmit enormous power to the region, which elevates the potential benefits of the measuring systems in the sector. The study covered the seven power plants via holistic sampling and incorporated stratified sampling of the employees and management [3].

3.2. Sample and Sampling Techniques

The sample consisted of 42 respondents drawn from the seven Rabigh power plants through stratified random sampling based on two categories, with three respondents per category: senior management and lower-level employees. The 2015 Power Generation Report on the energy and petroleum ministry in Saudi cites the Rabigh region as the hub of the country's electricity supply [5]. Thus, this study on the applicability of efficient measuring systems using the new technology of the LVDT was a significant attempt to precisely evaluate the plant's operating conditions relative to its output efficiency. The sample size was determined in accordance with the rationale developed by Krejcie and Morgan [18], the Sampling strata for the study is given in Table 8.

Table 8: Sampling strata for the study

Strata	**Stage I**	**Stage II**	**Stage III**	**Stage IV**	**Stage V**	**Stage VI**	**Stage VII**	**Total**
Senior management	3	3	3	3	3	3	3	21
Lower level Employees	3	3	3	3	3	3	3	21
Total	3	3	3	3	3	3	3	42

3.3. Research Instrument

The sampling techniques adopted in the primary and secondary data collection involved surveys containing structured interview questions. The employees were targeted to carry out precise function tests of the LVDT transducer owing to their direct involvement in the plants, which was deemed a significant advantage; as evidenced, they provided the requisite information. The performance temperature and pressure of the fluid at the inlet to the turbines, data on flow rates, and the complexity of collecting readings from the LVDT machine formed the basis of the questionnaire. The utilization of the "half-split" approach aided in the development of the pilot questionnaire used during the reconnaissance, and when the Pearson formula was applied to the data, this produced a correlation coefficient of 0.82. Thus, it demonstrated the utmost reliability [7].

3.4. Validity Measurement Tools

In the study, the five-point Likert scale was applied for the variance in the reliability of the LVDT performance tests as well as the preference in use while collecting data on the power plant operating conditions. For each questionnaire, there were five test variables with a definite level of permissible inputs on LVDT performance. The use of a pilot study strengthened the face validity of the adopted research instrument [12].

3.5. Data Analysis

The grouping of raw performance data collected from the respondents in their commitment to consistency and accuracy pertains to the LVDT technology. Thus, it accelerated the survey techniques implemented in the design correlation relative to the parametric considerations. Further responses on the magnetic flux density distributions and field intensity across the LVDT transducer provided simulations for the data collection and analysis. The arrangement of the research results was systematic and facilitated the computation of the collected data. The quantitative survey generated intensive data, which was crucial for the implementation of ANOVA (the formula for data analysis) to produce a significant correlation [8]. Furthermore, an in-depth analysis of the LVDT affects the efficiency of the measurements in providing a true representation of the conditions within the power plant. The system reactor remains a critical consideration in the advanced technological competency of designs. The input of the participants in the data collection and analysis was critical for the overall success of the project in ascertaining the impact of the LVDT component in power generation plants in the Rabigh region.

4 Case Study

4.1. Problem

In stage (1) unit (3), while this unit is running, we notice a disturbance in the load. Upon investigation, we discover an LVDT feedback is hunting. We check the demand for the valve; it is stable (no hunting). Additionally, we check the valve in the field; it is hunting. We then disconnect the LVDT from the valve and open it manually to 20%. We subsequently verify the feedback and find it is unstable (hunting). This means that our problem lies in the LVDT feedback, not in our control valve. Furthermore, this hunting from the LVDT causes the control valve to hunt, which damages the LVDT and leads to hunting in some systems in the unit.

4.2. Observation

The LVDT output signal is in the AC voltage, which will create a near-persistent noise.

This type of LVDT will take at least 90 days to arrive at the power plant.

The AC/DC converter in our system may be causing the noise.

Continuous hunting will damage our LVDT.

4.3. Solution

First, we must install a noise remover in our circuit. This solution is difficult to implement because the old LVDT is damaged, and the new one will take at minimum of 90 Days to arrive at the plant.

Second, we must replace the LVDT with a new type that has a DC-voltage output. This will remove the noise, and we also won't need an AC/DC converter (Figure 8).

Fig. 8: AC/DC Converter

4.4. Implementation

We implement the second solution and find a new type of LVDT. However, this type has an mA output, and our card only receives voltage. Thus, we switched the mA output to DC voltage, by installing resistance in parallel with the LVDT output.

4.5. Converting the output from mA to Volt (The Modified Block Functional Diagram is given in Figure 9).

- The LVDT output from 0 to 20mA.
- The card input ranges from 0 to 5V.
- Calculate the resistance using this equation: R = V/I = 5V/20mA = 250 ohms.

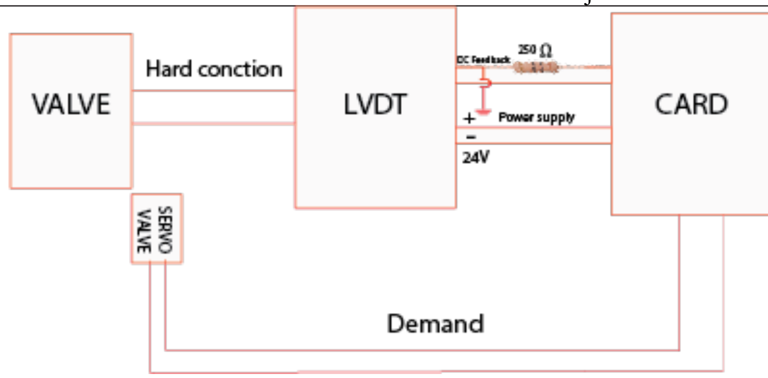

Fig. 9: Modified Block Functional Diagram

4.6. Results

- Following the calibration, we find no more noise or hunting in our circuit. As a result, our servo also saves.
- The megawatt is stable now because of no more hunting; this is cheaper than the old LVDT.
- An AC/DC converter costs nothing.
- More reliable than the old LVDT and readily available.

4.7. Total Cost and MW Saving

The total cost and saving are given in Table 9 below:

Table 9: Total Cost and Saving (MW)

Payment			
Unit	Load (MW)	Total (Capacity + Energy)	
		Hours	Days
Steam units (1–4)	260	16,744 SAR	401,856 SAR

When I notice the problem with the LVDT, I see the MW drubbed to the half load at 130 MW/day, which is also the total cost drub to 200,928 SAR.

4.8 Spare Part Cost and Total Saving

The spare part costs and the total saving are given in Table 10 below:

Table 10: Spare Part Cost and Total Saving

	Price	No. of LVDTs	Total
Price for old 3 LVDT's	34,500 SAR	3	103,500 SAR
Price for new 3 LVDT's	2,000 SAR	3	6,000 SAR

This main cost saving on the spare part is 103,500 – 6,000 = 97,500 SAR. Additionally, the MW saving is 200,928 * 90 Days = 18,083,520 SAR.

Total saving: 18,181,020 SAR

5 Results and Discussion

The implication of non-linear compensation plans in the cascaded in the algorithm of the LVDT structure enhance accuracy in the parameters and thus the accuracy of evaluating the testable parameters in the study. The performance characteristics obtained through the research sustain accurate deduction in terms of the parametric attributes of the LVDT concept. Therefore, the design accelerated the desired analysis of the sequential generic approach to the perceived circuit designs in support of the interpretational analysis of the operating conditions of the Rabigh power plants in Saudi. The study focused on sensor performance, as reflected in the design characterization, which improved the efficiency of the variable in attaining the desired performance based on the simulated tests adopted for data collection. The research outcome increased the preference for using the LVDT in the measurement of displacements, pressure, force, flow and other parametric engineering quantities relevant to the design of the structures. The research further demonstrated that the sensitivity and resolution of the LVDT provided reliable statistical outcomes along with related critical information. The FLANN captured in the research produced significant information for the compensations throughout the analysis of the

Saudi power plants. The incorporation of the sensors in the framework generated favorable criteria, with the findings indicating steady growth and progress in the use of new technology for recording engineering parameters. The benefit of the structural stability of the design parameter enabled a focus on the prominent attribute of the parametric conditions for improvements in design characterization.

The application of a simple reverse approach accelerated the performance of the computer-based controller that operates as the user interphone. The concept improves participation and adoption of the technology in the study with respect to the sensory mechanisms in the actuator system. The design provides increased competency-based analysis through its structural design parameters. The application of the design variables in the development of the LVDT test module forms essential elements for the delivery of research variables in the technological scope. The position and direction of the tunnels of the turbine influence the primary and secondary coil voltage distributions in the LVDT components. Moreover, the analysis and interpretation of the statistical outcome contributes reliable data to the research outcome. The inclusion of the programming language accelerates the efficiency with which the LVDT performs the design functions. The research findings on the performance of the LVDT offer valid information on the displacement variables, as in the deism parameters.

6 Conclusion

The research herein monitored performance variables in gas and steam power generation plants, allowing room for subsequent research on LVDT performance in plants generating alternative sources of electricity. For instance, hydroelectric or wind power plants could be studied to improve comparative analysis. In order to solve the hunting problems from LVDT feedback occurs in Rabigh power plant stage (1) unit (3), we proposed two solutions. First one is to install a noise remover in the feedback circuit, which is difficult to implement because the old LVDT is damaged. However, the second solution is to replace the current LVDT with a new type that has a DC-voltage output. This will remove the noise, and we also won't need an AC/DC converter. The saving energy in 200,928 MW per day and the saving amount is 401,856 SAR per day.

Declarations

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Availability of Data and Material

NA

Code Availability

NA

Author Contributions

Dr. Mohammed Khouj is responsible for all the work, the paper is a single author.

Ethics Approval

This research did not require ethical approval. Data Availability Statement Data associated with the manuscript is public and has been referenced appropriately.

Consent to Participate

NA

Consent for Publication

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Conflict of interest

I declare that there is no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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