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A Systematic Review of LabVIEW Applications in Acquisition of Sensor Data

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Abstract: Data acquisition (DAQ) is a process in which raw transducer signals are converted to computer readable data so that computers can store and manipulate that data. This is done by converting continuous signal in discrete samples and then converting that sampled signal into digital signal using ADC (Analog to Digital Converter). Specialized hardware is used as an interface between the DAQ system and the computer called DAQ card. Data Acquisition (DAQ) is widely used in Research and Development, Quality Control, Testing. DAQ cards can be supplemented with DAQ software. LabVIEW is a commonly used software for DAQ applications. LabVIEW i.e. Laboratory Virtual Instrumentation Engineering Workbench is a software by NI (National Instruments). LabVIEW is a graphical programming language and is widely used by scientists and engineers. This article tries to summarize the recent advancements in data acquisition technology and also explains the utility of LabVIEW software in DAQ applications related to temperature measurement.

Index Terms **– LabVIEW, DAQ**

I. INTRODUCTION

A typical data acquisition system consists of a transducer, signal conditioning circuit, ADC, DAQ hardware, computer. A transducer can be called as an interface between the data acquisition system and the physical world. The transducer's job is to pick up on physical factors and produce the associated signal. The signal generated by the transducer has a high amount of noise and hence must undergo some signal conditioning and hence signal conditioning circuits are used. The conditioned signal is an analog signal and hence it cannot be stored and processed as data by computers. The Analog to Digital Converters are required to convert the digital signal into analog signal. The digital signal is then processed and stored as data in computers. To interface the DAQ system with the computer a specialized hardware is used called DAQ card. Various DAQ cards are present in the market Compact DAQ, Compact RIO, PXI to name a few.

LabVIEW is a widely used software for Data acquisition and virtual Instrumentation. Initially released in 1986 by National Instruments, The software is programmed in C and C++ programming languages. Since then the National Instruments has been continuously coming up with newer versions of the software. LabVIEW software comes in two types, traditional LabVIEW software and the next generation of LabVIEW called LabVIEW NXG. The traditional LabVIEW is the software that was released in 1986 and has since undergone decades of development. However developers thought that the decades old code of LabVIEW was limiting their ability to incorporate new features into the software, so they decided to rewrite the underlying code to develop the next generation of LabVIEW called LabVIEW NXG. LabVIEW NXG has some extra features that traditional LabVIEW does not have, like the ability to zoom but most of the features are the same. Traditional LabVIEW is still widely used because of its hardware compatibility. Another version of traditional LabVIEW also exists called 'LabVIEW community edition' which has all the features of traditional LabVIEW and is free to use, but its use is limited to personal use and is not open for academics and commercial use.

LabVIEW is a graphical programming Language and uses the dataflow programming approach, which means a node will not execute until and unless it has received data from the nodes that are connected to it. A LabVIEW file has two windows namely front panel and block diagram. Front panel acts as the user interface in which the user can feed data and view output. Block diagram is where we write logic of our LabVIEW programs.

In this article we aim to briefly summarize the applications of data acquisition(mostly but not limited to temperature data) and LabVIEW. We have cited work from 40 research articles from different journals and also collected a fraction of our information from books and the internet. While doing the survey our focus was on LabVIEW programs that were implemented in data acquisition applications. In literature review we have provided a comprehensive table that will give readers some insights into a wide range of LabVIEW applications in temperature data acquisition. The applications of LabVIEW for other applications is provided further in the article.

II. LITERATURE SURVEY

L Hu et al[1], proposed a measurement method for thermocouple sensors on the inner surfaces of the piston, cylinder head, and cylinder liner. Additionally, a method for measuring the temperature of the moving parts of a marine low-speed engine is suggested. A labVIEW-based temperature field test system for low-speed marine engines is developed using the layout plans for the temperature measuring locations and the handling of the test items. The work proposes an experimental method for thermal load analysis and builds the test platform.
Haobin et al[2], Created a temperature monitoring virtual instrument, using which a single variable test was created to carry out a cortical bone drilling test. The test results demonstrate that the virtual instrument is capable of measuring drilling temperature data accurately over a predetermined time period and Through experimental study, the optimal spindle speed and feed rate are determined, providing theoretical suggestions for practical clinical treatment. Temperature sensors are K-type thermocouples, a signal amplification component is AD595, and a LabVIEW-based virtual instrument is created. and constructed for temperature monitoring of cortical bone drilling by combining data acquisition, sensor, and computer technologies.

K. Beneda et al[3], published a study where the primary objective was to provide an advanced More sophisticated data regarding engine behavior with various fuels can be collected using the data collecting system for the turbojet test bench. The new system is built on entirely new DAQ hardware that was selected for the particular test bench environment based on previous system component experiences. The operating system's compatibility with the new hardware did not necessitate extensive rewriting because it was created in LabVIEW; however, the relevant changes will also be covered here.

P. Verma et al[4], Introduced a LabVIEW model that continuously monitors the individually stimulated dc motor and displays the real-time performance characteristics. Data Acquisition System (DAQ) and LabVIEW version 2017 are used to do this.
J. Zhu et al[5], Recent years have seen an increase in short circuit fault current due to rapidly increasing power demands. It is The capacity requirements for fault current limitation are challenging for the traditional circuit breaker to achieve. But a warm temperature Using the HTS quench features, superconducting fault current limiters (SFCL) can instantly safeguard power systems. A new path for protecting the electrical grid has been opened up by the widespread use of SFCL.As a result, SFCL has an advantage in terms of lowering circuit breaker capacity. In this article, a brand-new self-triggering SFCL with a magneto-biased field was suggested. This SFCL has a reactor with two split superconducting split non-inductive high temperature modules. balanced windings,as well as a circuit breaker. The experimental platforms for evaluating the transport properties of the SFCL unit are ready. A high-speed Data Acquisition (DAQ) System developed onLABVIEW by NI Corporation is used to conduct the tests. A SFCL unit's critical current and AC loss characteristics have been evaluated and contrasted while taking joints' impacts into account. This SFCL has been validated, and experimental studies have confirmed its technical viability in power networks.

P. H .P Llamera et al[6], Effective failure characterization and fault isolation of devices that only malfunction in a specific range of temperature, frequency, and voltage are issues in the field of failure analysis. In these situations, failure localization is accomplished through soft defect localization. Two devices with output voltage temperature dependency failure during hot and cold temperatures are in need of assistance with soft fault localization, a LabVIEW programme was used and built in this study. Additionally, the Hamamatsu iPhemos' Dynamic Analysis by Laser Stimulation (DALS) capability was used to carry out the soft fault localization procedure.

C. Shuo et al[7], Many issues, such as ineffectiveness and a low level of automation, are present in the verification of the temperature sensor in Chinese autonomous weather stations. Although there is a great need for verification, the prefectural metrological verification departments' system is unable to fully provide it. This study updates the original temperature sensor verification system into a multi-channel automatic verification system to address these issues. The system architecture, hardware design, and software design were each covered in detail. By using the higher computer programme to manage the system, eight temperature sensors may be verified simultaneously, and fully automated operation is achieved. a typical computer system. Performance, efficiency, and cost are all areas where our system excels. The study's conclusions added valuable new insight on temperature sensor verification.

Pacco and Honorato Ccalli[8], Since we are currently in the Intelligent Industry or Industry 4.0 age, it is crucial that this technology be applied in scenarios that allow us to mimic and model any necessary processes. Here, the production of tulips in a greenhouse is the issue at hand. One of the most stunning springtime events is the tulip flowering in Holland, which is something that everyone wants to replicate. .In order to cultivate tulips in a greenhouse in the Peruvian city of Ilo, Moquegua, this research project will simulate how to control the temperature and irrigation schedule there. Fuzzy logic from National Instruments and LabView software version 16 were used to simulate temperature control and watering time in the production, activating and deactivating the chiller as necessary, in order to achieve this. With regard to the irrigation variable, the sensor informs the system whether plants should receive high, medium, or low irrigation frequency irrigation and when and for how long.. Additionally, it alerts the system to any departure above or below the target temperature (15°C), keeping it consistent throughout the procedure. The simulation to control greenhouse temperature and irrigation time produced the expected results because the chiller runs by activating or deactivating the system to maintain the desired temperature and the irrigation period is controlled by humidity.

D. Núñez et al[9], This study focuses on the outcomes of applying an Extended Kalman Filter (EKF) on a pneumatic levitator and only using sphere position measurements to estimate ball and air speeds. Using offline real system data that was later processed by LabVIEW software, the EKF is implemented. First, the non-linear dynamics of the levitator's mathematical model is taken into account. The sphere position, sphere speed, and air speed are the three system states. Finally, it is possible to estimate the air speed and sphere speed using an EKF. These estimates are then verified by measuring the sphere location and calculating the sphere speed using offline system data.

Q. Wang and G. -p. Yang[10], The electromagnetic compatibility, or EMC, of the vehicle controller is frequently a design issue. Although Vector provides full software and hardware testing tools, its cost is significant, and it is less useful during the controller development phase. The widely used and established LabVIEW programming language is employed in this study to create the test system for evaluating the controller's EMC issue. Instead of using the CANanalyzer, the Kavser is employed as a diagnostic tool. These test systems are affordable, simple to create, capable of meeting the demands, and give controllers additional possibilities.

R. Kolla et al[11], Engineering is increasingly valuing real-time data. By creating innovative techniques for operating and monitoring systems using both real-time and archived data, utilities are strengthening their systems. One of the crucial elements for more effective regulating and monitoring is the system's frequency information. It is crucial to obtain low-cost, real-time frequency data as soon as possible. This study describes better Phase-Locked-Loop data capture for frequency monitoring using a Raspberry Pi (PLL). This article discusses the following subjects: (i) Using a Raspberry Pi, the Multi-chip Package (MCP) 3008, and LabVIEW, the entire real-time data collection process. (ii) modelling of the enhanced PLL with data acquisition system to process real-time data and extract frequency and amplitude information.
Afsarimanesh, N., & Pathan[12], When selecting a transducer for a particular application, dependable operation is quite important. This project report provides a detailed characterization of the thermister and RTD. The majority of industrial and research instrumentation utilizes thermal transducers. These transducers, which can measure a variety of parameters, are marketed by various manufacturers. For quality control and to ensure the production of these devices, the manufacturer must test in big quantities. Additionally, the results of this test would be used to improve quality control and the manufacturing schedule. Additionally, before going into production, any advancement in processing technology suggested by research and development operations must be assessed. However, prior to using such transducers, users would need to test the crucial parameter before putting it to a particular use.

D. Meng[13], A vital part of operating vibration machinery is the vibration motor. If the vibration motor defect is not identified at an early stage, the motor would gradually deteriorate to the point of damage, shutting down. As a result of the periodic vibration force it experiences while in operation, vibration motor fault signals differ from those of regular motors. In this study, a system for real-time monitoring of vibration motor condition monitoring and problem detection is built using LabVIEW software. In order to track the performance of the vibration motor, the system analyzes the frequency spectrum of the fft, shows the waveform in real time, and monitors the stator current signal.To avoid a major and complicated failure, evaluate the vibration motor at an early stage and in a timely manner.

Y. He, L. Mao and B. Jing[14], With the quick advancement of automated production lines, target sorting and part inspection have seen a significant increase in the usage of machine vision inspection. In this paper, an automated production line-based part detection system based on LabVIEW machine vision is described. The target detection area must first be calibrated in order to follow the part's target, identify the parts in the image more rapidly, and pre-process the image to reduce the impacts of noise, light sources, and other environmental factors. This is necessary in order to retrieve the actual part on the production line. The coordinate position is used to get the two-dimensional coordinates, and the pixel coordinates are converted to the actual coordinates.. or the purpose of extracting the contour information, an object's feature is extracted. The qualifying number is displayed in real time on the front panel and the matching template is set up to perform template matching on the part. Information about eligibility, success rates, real-time image capturing, and other things By choosing different tracking templates and matching templates, this system may quickly trace the target components and perform template matching to discover those unqualified portions.

W. Cai, B. Wang and S. Zhang[15], Although digital oscilloscopes are frequently employed in signal measuring and processing systems, they are limited to dealing with signals, and raw waveform data must be manually saved. More significantly, we suggested a labVIEW implementation strategy in this research to create a user interface that can be used to remotely control two oscilloscopes and acquire data via a network. This system has a number of oscilloscope-specific functions in addition to some additional ones.

X. Liu *et a*[16], In order to achieve the spacecraft temperature measurement in the space simulation space vacuum heat environment, real-time monitoring of the spacecraft structure.A distributed temperature monitoring system based on fiber temperature sensors is created to detect changes in temperature and determine the health status of the spacecraft. First, a hardware system for monitoring the temperature of dispersed optical fibers was developed employing the fiber temperature sensor's properties. Second, a real-time reading of the fiber grating's center wavelength value connected to the fiber grating demodulator was made possible by the modular design of LabVIEW. Temperature data acquisition, presentation, and storage are all made possible by the decoupling method of stress. In a vacuum low temperature setting, the distributed temperature monitoring system's repeatability is tested at both high and low temperatures. During three tests, the monitoring system proved to be incredibly repeatable and capable of detecting the structural components of the spacecraft's temperature in a low-temperature vacuum.

S. Kaissari et al[17],The work in this abstract explains how a Wireless System using a sensor network for remote monitoring in real time solar-electric (PV) panel. This suggested system is made up of There are three components: (a) a sensor node that contains five sensors, including: Panel temperature, relative humidity, and ambient temperature are examples of a wind and weather station that has been calibrated in a licenced laboratory, light detectors (c) The transmitting base station for the aggregate the user, (c) the user interface, and (d) data from the sensor node LabVIEW interface application is used. using wireless transfer of information between the sensor node and base station was made possible by a cheap, effective, and low power consumption. transceiver. They were sent using a brand-new, customised hybrid transmission mechanism based on the measurements of the PV panel. The temporal, the event mode, the request mode, and the mode are all combined in it. Real-time PV panel monitoring is effectively provided by the suggested system for follow-up and failure diagnostics.

Y. Gangrekar and P. Chaudhari[18],Due to the fierce competition in the market and the rising demand for products, industries must produce at extremely high rates, which is only achievable with automation. The dependability and quality of the finished product are much improved thanks to automation, which also helps to eliminate many related issues including human mistake. This study employs a microcontroller and LabVIEW software to build and develop a straightforward, low-cost system that supervises and controls automated assembly line sorting for a small local product manufacturing sector, simulating the use of SCADA in large-scale process industries. Various indicators, including temperature and level, are measured in real time with the aid of this project. process management is additionally provided by changing factors like motor speed and direction. It is possible to fully log these collected real-time characteristics with the aid of LabVIEW software, which is then kept in databases like excel sheets where additional operations may be carried out or data can be sent to other systems.

I. A. Ershov and O. V. Stukach[19],A measurement result's traceability is a crucial characteristic. It is accomplished through routine calibration or verification of the measuring device. Due to the steady expansion in the number of measuring tools, existing ways of transferring physical quantities to measuring devices are rendered useless. The calibration's time increases. When a measuring device is sent to a recognised body for calibration, the owner is left without compensation. The benefits to improving our understanding of the IoM are illustrated by the results of this paper's review of all these distant calibration-related features. An innovative technique for calibrating voltmeters remotely is suggested in the paper. Utilizing programmable measurement devices is the foundation of this strategy. The method's fundamental concept is the automation of the calibration measurement process through a hardware-software complex. A certified centre employee used software and Ethernet to perform the calibration. The study presents a novel hardware-software system for remote calibration of voltmeters.. A controller, a signal generator, as well as temperature and humidity sensors, are all part of the complex.

M. Chattal et al[20],Industrial automation (IA) significantly lowers the requirement for human workforce, human labour, and financial resources. Numerous control systems, such as Supervisory Control and Data Acquisition (SCADA) and Programmable Logic Controller (PLC) systems, are playing a key role in the automation of various industries as a result of the rapid rise in sensors, control, and automation technologies. The automation of an industrial system using tools like PLC, Lab VIEW, and the internet is the main topic of this study. The PLC control mechanism is implemented in the proposed system utilising PLC Fatek. By installing a real-time controlling and monitoring system that is interfaced with a cheap PLC (FATEK) and perfect acquisition software LABVIEW for automation and cost optimisation, pertaining to a typical industrial manufacturing system, the desired outcome for industrial automation is accomplished.This study's primary goal is to automate the mixing of hot water and limestone powder in order to reduce the risk to employees' health and the likelihood of accidents.

Gauri Bhosale et al[21], have discussed in their article how an interdisciplinary perspective helped to build a number of traditional biomedical experimental tasks. Numerous of them have been created by combining the expertise of sensors, electronics, microprocessors, and LABVIEW software. It is the goal of the exercises shown here to introduce pupils to basic fundamentals of biomedical equipment, from the needs for sensing to the analysis of the collected data. Along with improving their foundational knowledge, this teaches students how to apply difficult ideas to practical situations and lab research. Measurement of physiologically important parameters is the focus. Various other signals and systems can also use a similar principle. Complex and pricey equipment can be successfully replaced by useful, low-cost hardware using the suggested approach.

Table 1: Comparison of various LabVIEW applications

Author	**Sensors used**	**LabVIEW application**	**References**
L. Hu, J. Yang, Y. Yu, D. Gong and C. Wang [2020]	Thermocouple	Temperature field test system is developed using LabVIEW.	[1]
Haobin, Huyahui, Zhengqinchun, H. Xin and C. Chao [2019]	K Type Thermocouple	Users can view the amplitude fluctuation of the obtained voltage on a waveform diagram in the LabVIEW control panel to monitor how the temperature fluctuates during drilling. .	[2]
K. Beneda, L. Kavas and B. Varga [2020]	Thermocouple, RTD	It was created in LabVIEW utilising Express VI building blocks, which may be simply replaced by equivalent blocks in the event that the measuring hardware is altered. Due to this design, only a small number of the original software's adjustments were necessary.	[3]
P. Verma, G. Gokulakrishnan and K. Sathishkumar [2019]	LM35, CNY70	To determine whether the Separately Excited DC Motor LabVIEW model is functioning properly or not, reference values are first simulated for the model. The motor is then connected to the LabVIEW model through the data acquisition system to enable ongoing monitoring. The individually excited DC motor speed control experiment is carried out for both real-time continuous monitoring and to confirm the accuracy of the LabVIEW model.	[4]
J. Zhu et al [2021]	--	To calculate the superconducting unit's AC loss, The voltage and current signals of the superconducting current limiting device are analysed by a LabVIEW programme.	[5]
P. H. P. Llamera, C. J. G. Garcia-Awitan, F. R.	--	With the help of LabVIEW software, which was designed and utilised for failure characterisation and Two devices that failed in hot and cold conditions due to output voltage temperature dependency were localised.	[6]

Cruz and G. Magwili [2019]			
C. Shuo, L. Jianyu, J. Tao, L. Huanqian and D. Yueqiang [2020]	4 Wire Temperature Sensor (RTD)	LabVIEW application ensures the cascade connection between standard temperature generator standard temperature collector and multichannel module.	[7]
Pacco, Honorato Ccalli [2022]	Humidity Sensor	The LabVIEW graphical programming environment was used to create a genetic algorithm for instrumentation control and optimization.	[8]

III. CONLUSION

This paper has given a brief review of LabVIEW applications in various domains. We have surveyed 15 research articles from various journals. This is given in the form of a literature survey and a comprehensive table that allows readers to navigate through a plethora of literature related to LabVIEW applications.

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