KEMENTERIAN PENDIDIKAN TINGGI

JOJAPS

eISSN 2504-8457

POLITEKNIK MALAYSIA PORT DICKSON

Journal Online Jaringan Pengajian Seni Bina (JOJAPS)

Temperature Measurement Virtual Instrument Using LabVIEW

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Abstract

Helium-Neon (HeNe) lasers and photodiodes are used to measure light reflection's strength on a solid surface. Changes in temperature on the solid surface that light emits on will result in changes in the refractive index. Thus, temperature changes can be measured based on changes in the refractive index. The refractive index is taken based on the power and energy obtained using a photodiode, which is then used as input to a virtual instrument developed using LABVIEW software. A virtual instrument is an interface between the user and the contactless temperature measurement system.

Key-word: - LABVIEW, He-Ne laser, Non-contact measurement, Temperature

1. Introduction

Temperature is the physical property most widely measured by sensing technology. Contact sensing brings the sensor in physical contact with a substance or object. Therefore, this may damage the perceived object's surface. The sensor itself is used in very high-temperature conditions and may not be appropriate for rotating or moving objects. Contact sensing is slow to respond relative to non-contact sensing. This research proposed a non-contact temperature measurement system that predicts the temperature change based on the sensed object's reflected energy using a helium-neon laser as the light source. This method could overcome the problem that occurred when contact sense being applied. The helium-neon laser was selected to be implemented in this research based on the ability to emits a beam with a specific wavelength at a long coherence length.

This project aims to instrumentally detect the temperature on a surface using a helium-neon laser. The objectives are to interpret the data to give temperature reading by a virtual instrument developed using LabVIEW software. The works focus on developing a non-contact temperature measurement using a helium-neon laser with a less complicated system setup. The limitations for the results are to validate system measurements with a thermocouple data logger.

2. Methodology

2.1 Introduction

The non-contact temperature measurement method could benefit a wide area of measuring applications, including measuring a moving target, hazardous location, ultra-high temperature that could damage contact sensor, mechanically or chemically hostile, and measuring from a great distance. The non-contact measurement method can also be faster than the conventional contact measurement method. Due to its ability to measure without contact, it is the best choice for a non-destructive test. It could extend life because there will be no mechanical wear compared to the conventional contact measurement method. Lasers are devices that produce intense beams of light that are monochromatic, coherent, and highly collimated. The wavelength (color) of laser light is too pure (monochromatic) when compared to other sources of light, and all of the photons (energy) that make up the laser beam have a fixed phase relationship (coherence) concerning one another.

Light from a laser typically has shallow divergence. It can travel over great distances or focus on a tiny spot with a brightness that exceeds that of the sun. Because of these properties, lasers are used in a wide variety of applications in all walks of life.

2.2 National Instrument LabVIEW software

Laboratory Virtual Instrument Engineering Workbench is a programming environment used to create programs using a graphical notation (connecting functional nodes via wires through which data flows); in this regard, it differs from traditional programming languages, C++, or Java, which is text-based programming. However, LabVIEW is much more than a programming language. It is an interactive program development and execution system designed for people, like scientists and engineers, who need to program as part of their jobs. The LabVIEW development environment works on computers running Windows, Mac OS X, or Linux. LabVIEW can create programs that run on those platforms and Microsoft Pocket PC, Microsoft Windows CE, Palm OS, and various embedded platforms, including Field Programmable Gate Arrays (FPGAs), Digital Signal Processors (DSPs), and microprocessors.

2.3 Data Flow and the Graphical Programming Language

The LabVIEW program development environment is different from standard C or Java development systems in one important respect: While other programming systems use text-based languages to create lines of code, LabVIEW uses a graphical programming language, often called "G," to develop programs in a pictorial form called a block diagram. Graphical programming eliminates many syntactic details associated with text-based languages, such as putting semicolons and curly braces. Visual programming allows users to concentrate on data flow within the application because its simple syntax does not obscure what the program is doing. Figure 1 and Figure 2 show a simple LabVIEW user interface and the code behind it.

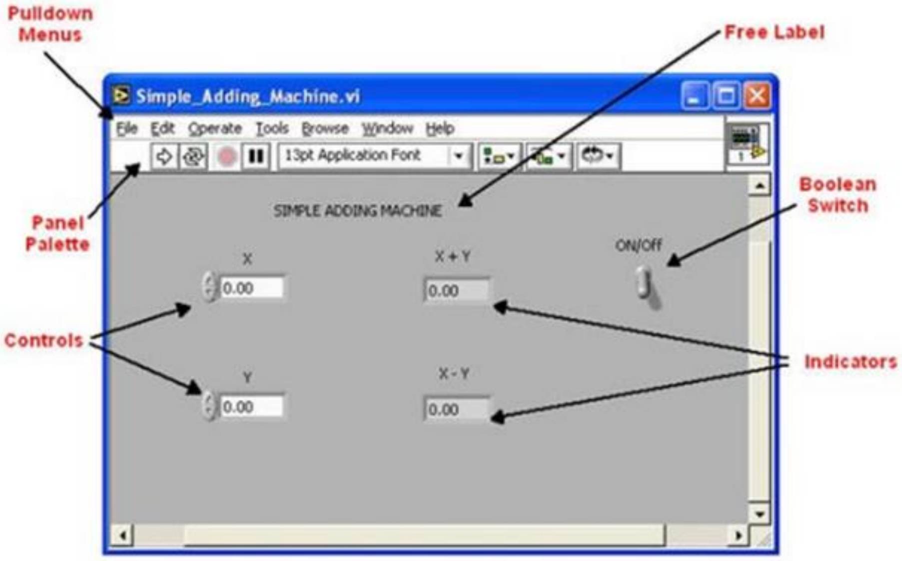

Figure 1 LabVIEW user interface or also called as Front Panel

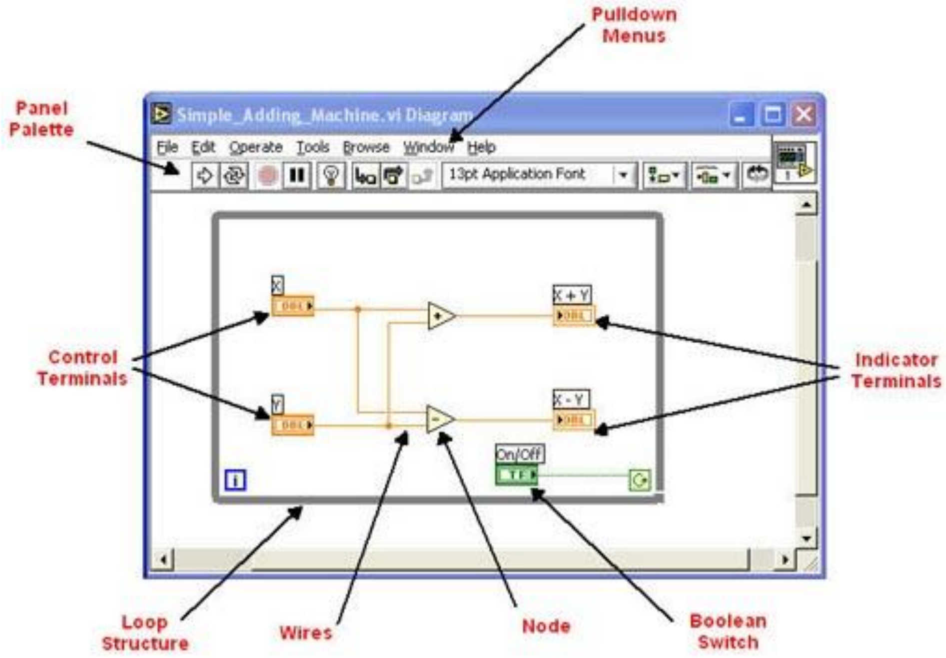

Figure 2 LabVIEW graphical code or also called a Block Diagram.

When using a power sensor with the FieldMax II (like the models PM10, PM30, PS10, OP-2, etc.), the meter will always update its readings at 10Hz. This VI is set to run at 20Hz to ensure that the measurement buffer is being appropriately cleared so that new readings are always being read into the VI. Suppose measurements are being made with a pyroelectric energy sensor (like the models J-25MB-LE, J-50MB-YAG, etc.). In that case, the meter will always update at whatever rate the laser pulses are being fired (up to a maximum of 300Hz). So the timing of this loop may need to be adjusted if running at higher rep rates than the 20Hz, this loop is currently set for.

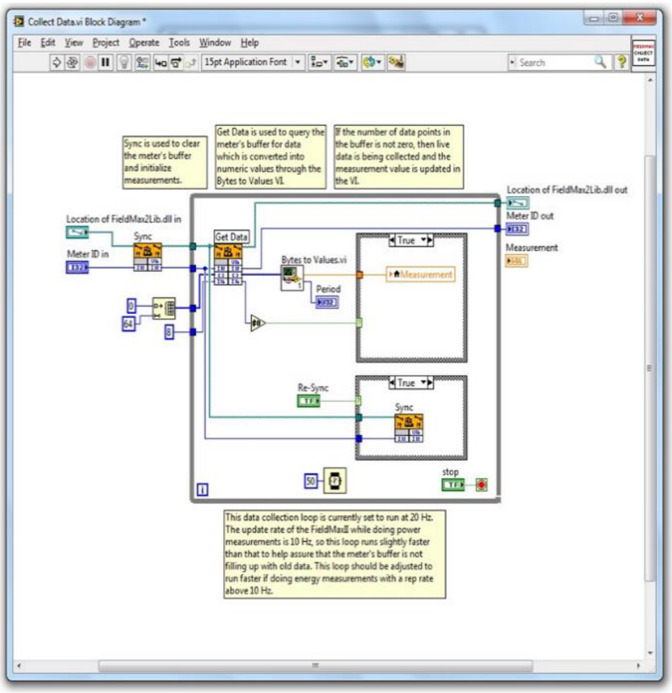

Figure 3 Collect data VI block diagram.

3.1 Introduction

The technique measures the change in the surface reflectivity, which is affected by the vapor's density, to obtain the temperature change at the surface. Thus at the start of the experiment, the system can reach thermal equilibrium at known reference temperature with a corresponding reference reflectivity at the liquid surface. The laser beam intensity, sensitivity, and photodetector will not, in general, be identical. Thus these differences are accounted for as follows.

3.2 Temperature measurement with heating and cooling process

To validate the laser-based measurement technique, experiments were performed on a liquid whose temperature was measured by a separate, independent approach. A K-type thermocouple was used to monitor the temperature of the surface. The thermocouple had a probe with approximately 2mm in diameter and could measure the temperature of 10oC to 150oC in range. This contact-based thermocouple temperature was then taken as the correct temperature for the system with which the laser-based technique was compared. Figure 4 shows the temperature change measured during the heating process, and Figure 5 shows the temperature change calculated during the cooling process. Both models included the temperature measurement using laser-based technique and temperature measurement using a thermocouple.

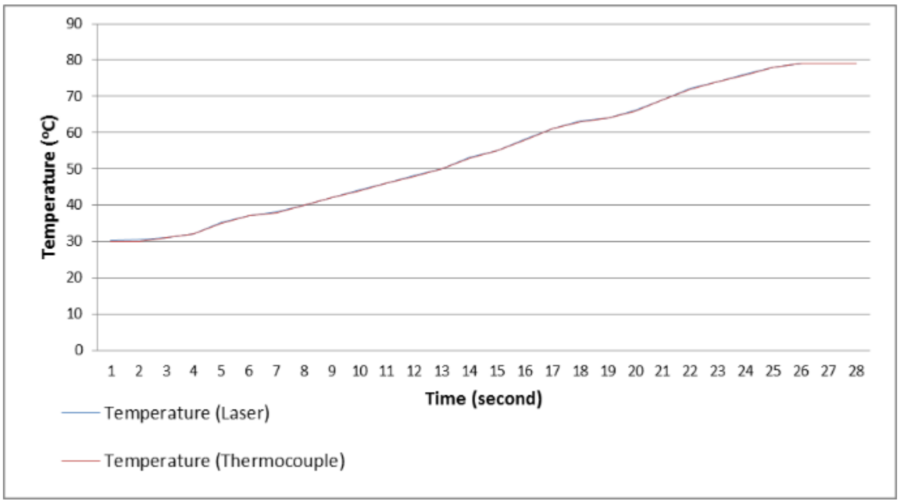

Figure 4 Temperature measurement (°C) versus time during heat plate heating process.

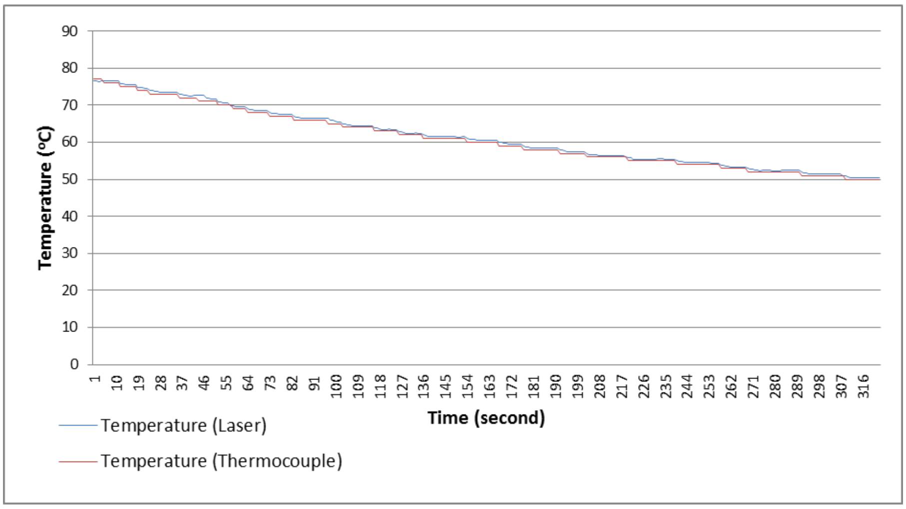

Figure 5 Temperature measurement (°C) versus time during heat plate cooling process (air-cooled).

Based on the graph plotted in Figure 4 and Figure 5, the temperature measurement during the heating and cooling process of the metallic heating plate for both method, using helium-neon laser and a thermocouple, it is observed that the measurements from the helium-neon laser were parallel to what was obtained using a thermocouple data logger. However, the helium-neon laser readings were smoother in terms of the signal's continuity, thanks to the high-sensitivity photodetector and power/energy meter that provides reading up to 4 compared to the data logger, which only provides up to 2 decimal points. The heating and cooling process temperature measurements were made several times with an hour-long interval between experiments to ensure the heating plate and the helium-neon diode back to their normal condition. These repeated experiments need to be carried out to test for the experimental setup's durability and to ensure the acceptability of the measurements obtained using the proposed non-contact helium-neon laser-based temperature measurement method. Figure 6 and Figure 7 show the raw data of the temperature measurement obtained using a helium-neon laser from the view of the LabVIEW VI interface. The readings were set to be captured every second and logged automatically for further observation and analysis.

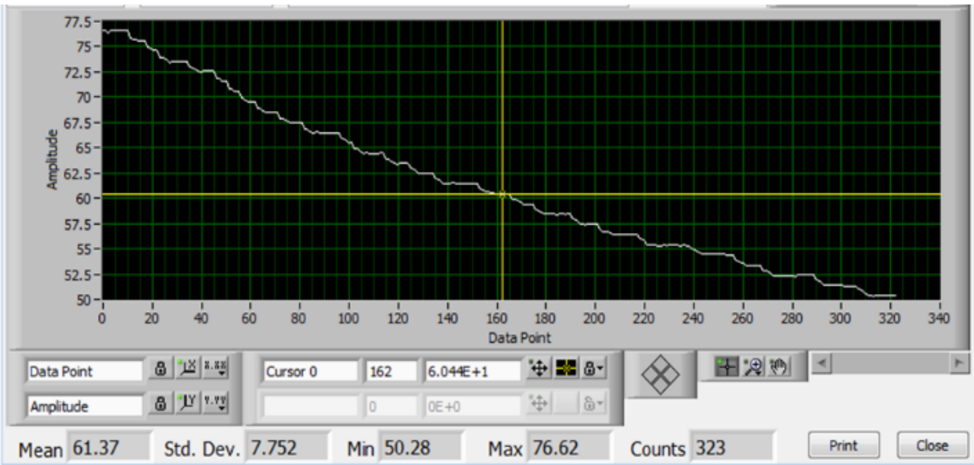

Figure 6 Laser power change through a cooling process (raw data).

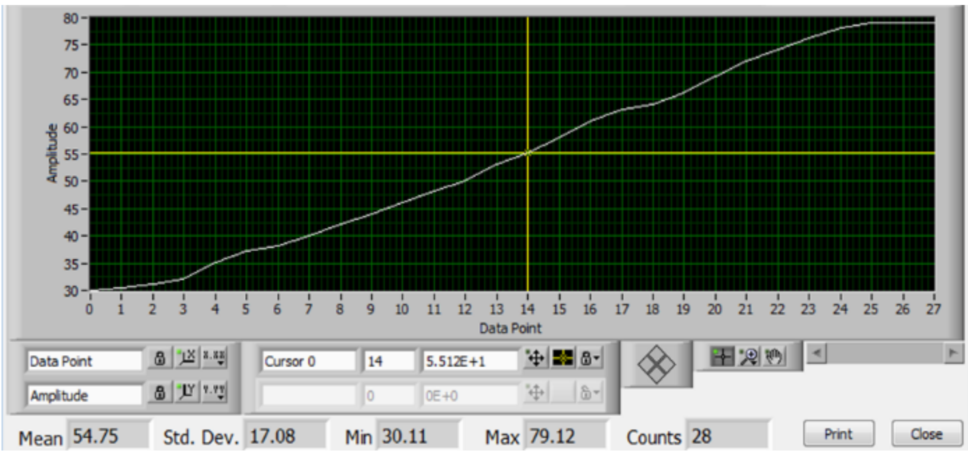

Figure 7 Laser power change through a heating process (raw data).

4. Conclusion

The experimental setup was used to measure a standard laboratory metallic heating plate's temperature during the heating and cooling process of the heating plate. In terms of the user interface developed using LabVIEW, the VI (virtual instruments) system integrates various laboratory equipment and controls the experiment data acquisition process using a single computer via GPIB, USB, RS232, or parallel ports. It achieves synchronous control of equipment and real-time laser-beam power data acquisition. Data display, saving, and analysis can also be accomplished using the reported VI system. Furthermore, the VI system can monitor the running of individual instruments and change laser power in real-time.

Therefore, the user can timely judge, analyze, and on-site process information, and high resolution of the reflected laser beam power can be easily achieved. The VI system was tested extensively and applied in the determination of surface temperature by measuring the temperature. The VI system promotes and expands the capabilities of individual instruments, and it is intelligent improving for existing hardware sources of a laboratory. Lots of complicated functional operations are merely finished at the click of a button on the VI system. The VI system avoids a manual error during the separate instrument control, data acquisition, and data processing but ensures the accuracy and repeatability of experimental data and improves an experiment's efficiency. Furthermore, the VI system has wide expandability of functions, and it is not restricted to the measuring and monitoring process, but more than someone could imagine. The VI system implementation is growing from days to days, and a new field of usage will be discovered. Further research could be done to compare and validate the results with other temperature measurement equipment/method. Non-contact temperature measurement using a helium-neon laser could be the solution for ultrahigh temperature or measurement in a hazardous area. The proposed setup in this research could be considered to measure temperature in both situations.

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