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MULTI-FUNCTION AUTOMATIC MEASUREMENT PLATFORM

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Abstract. *Based on industry-oriented needs, a multi-function automatic measurement platform that includes over 20 kinds of sensors and measurement devices is developed and constructed. The NI USB DAQ-card is applied for external data acquisition and Labview is used for software design. The 20+ kinds of sensors and measurement devices are chosen by market investigation and expert interview. The built-in automatic measurement platform possesses superior advantages such as programmable, excellent data analysis, remote measurement, low cost and easy to maintain. Practical measurements were carried out to demonstrate the capabilities of this automatic measurement platform.*
Keywords: Multi-function, Automatic, Measurement, Platform

1. **Introduction.** The practical competence indicators for automatic measurement technology course (AMTC) of industry-oriented needs are studied in [1]. The results show the study included 27 practical competence indicators that also belong to six dimensions for AMTC. One of the most important parts, automatic measurement platform, is developed in this research. Today with the development of computer technology, a virtual instrumentation-based experimenting environment was designed and engineered, called LabVIEW. LabVIEW is a data-flow graphical programming language (G-program), which plays an important role in the virtual instrument development [2-4]. The vision of LabVIEW is to be a revolutionist solution for engineers and scientists, precipitating faster development time, lower costs and greater flexibility than traditional instrumentation. A comparison of virtual instruments with traditional instruments is show in Table 1 [5].

When we developed the LabVIEW programming (software) engineers and scientists were enabled to develop their own measurement instrumentation quickly, with an open platform of the personal computer, without restrained. Virtual instruments are not only applicable to laboratory work but industrial applications as well. Figure 1 shows the appearance of a traditional measurement instrument and a virtual one.

The virtual instrument technique is a new technology that uses modular hardware with highly efficient and flexible software to conduct all kinds of signal testing. The modular hardware structure is shown in Figure 2.

LabVIEW is graphic program software developed by NI Company, and LabVIEW programs include virtual instruments and the software development platform [6-8].

The data acquisition process inputs the real-world physical signals into a computer for further signal processing and analysis [9]. NI USB-6009 which possesses a USB interface is used as the data acquisition device in this study shown in Figure 3 [10].

The developed multi-function automatic measurement platform system contains about 20 sensors. The corresponding programs include front panel and block diagram design. Signals are acquired and applied using the NI DAQ card [11]. The control system scheme fits into the mathematical state model developed and studied in [12-14].

TABLE 1. Comparison of virtual and traditional instruments

	Virtual Instruments	Traditional Instruments
Function	User define	Immovable
Interface	Software	Hardware
Extensibility	Diversity	Limited
Development	Open	Close
Technology update	Quickly	Slowly
Maintenance	Easy	Difficult
Price	Cheap	Expensive
Recycling	High	Fixed

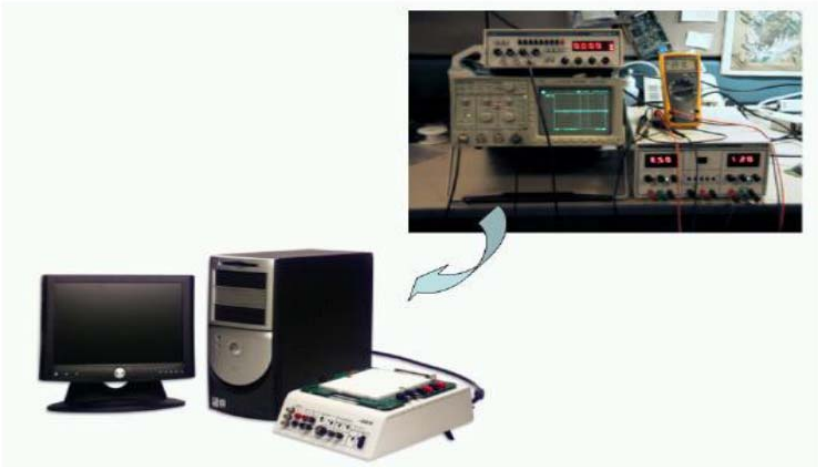


FIGURE 1. Appearance of traditional measurement instrument and virtual one

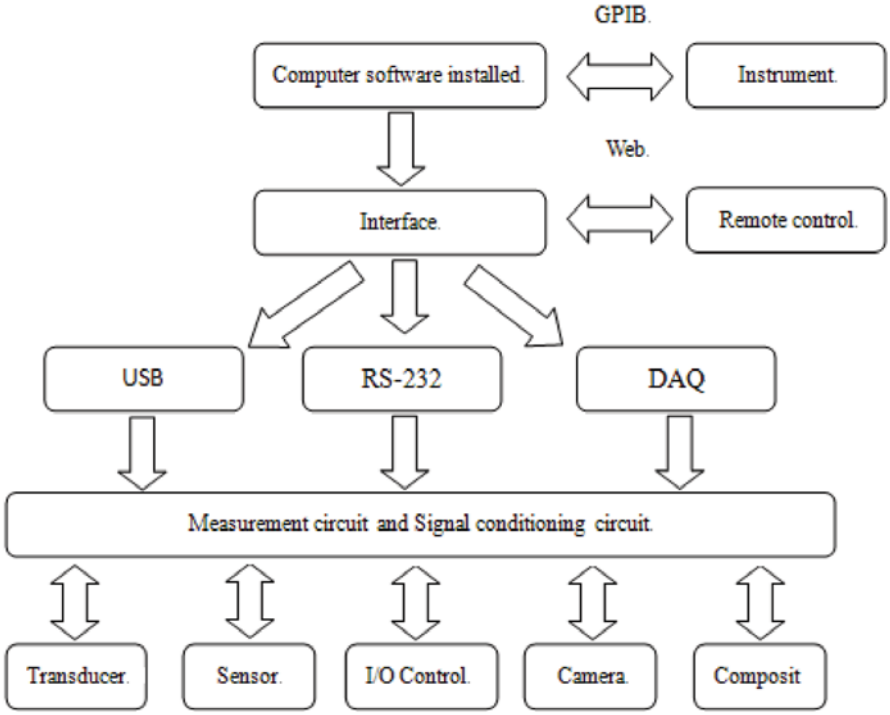


FIGURE 2. Communication interface model

FIGURE 3. NI USB-6009

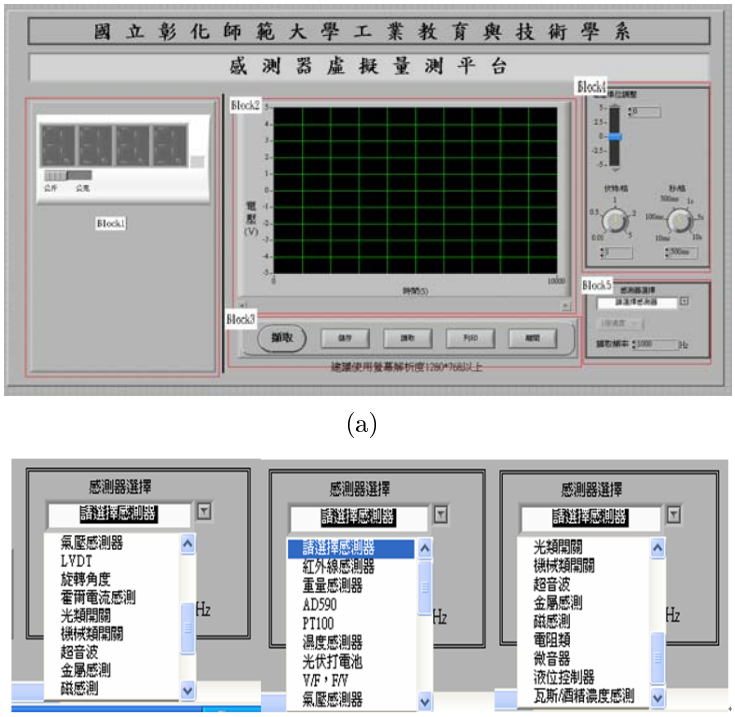
2. **System Establishment and Operation.** The established system includes both hardware and software. The hardware includes a computer, USB-DAQ, about 20 kinds of often seen sensors and measurement devices, chosen through expert consultation and literature investigation. The software contains front panel and block diagram design.

2.1. **Hardware parts.** The multi-functional device measurement platform provides over 20 kinds of sensors and measurement devices for users. Through DAQ-Card, acquired data from every sensor are converted into physical signals for further processing by NI LabVIEW. The sensors and measurement devices are classified and interface easily with the corresponding function. It contains (1) Infrared joules switch; (2) Weight sensor; (3) PD100; (4) AD590; (5) Humidity sensor; (6) Solar cells; (7) V/F converter; (8) Pressure sensor; (9) LVDT; (10) Rotary angle sensor; (11) Hall current; (12) Light type switch; (13) Machinery; (14) Ultrasonic; (15) Magnetic sensor; (16) Proximity switches; (17) Metal sensing; (18) Resistance class; (19) Microphone; (20) Liquid level controller; (21) Gas/Fumes concentration sensor; (22) Alcohol sensor.

2.2. **Software part.** In the measurement platform, NI LabVIEW is applied to design front panel and block diagram for different kinds of measurement sensors and devices. This platform was developed to be user-friendly; therefore, every measurement function is designed in that regard. For example, the metal detection panel was designed for detection of substances in close proximity to metal, the alcohol detection panel was designed for the detection of alcoholic liquids, and the solar cell measurement panel was designed for different type of illumination causing different color change in the display window.

The multi-function automatic measurement front platform is designed as Figure 4, showing the weight measurement function is selected. Figure 5 is block diagram of Figure 4.

In Figure 4, Block1 shows the display window for measured weight. Block2 is the measured signal obtained by computer through the DAQ card. Block3 contains function buttons including leave button, read button, print button, save button and data acquisition button. Block4 contains voltage adjustment in X scale, time adjustment in Y scale and off-set adjustment. Bock5 shows the panel selection list selection and sampling rate setting.



(a)

(b)

FIGURE 4. (a) The front panel of multi-function automatic measurement platform for weight measurement and (b) the measurement function panel selection list of the multi-function automatic measurement platform embedded in block 5

In Figure 5, the design for block1 contains data acquisition and analog to digital data transformation. The design of block2 filters signals for further use. The design of block3 is designed to lock the function list selection to avoid platform malfunction. Block4 is for controlling the adjustment knobs for the signal display window. Block5 is for selecting the needed measuring devices or functions. Block6 is for saving the measured data including values and images. Block7 is the print function. The design of block8 is for storing the measured values and reproducing measured signal form stored data.

3. **Main Results.** The platform solar cell measurement function will be illustrated and other measurement results will be also demonstrated.

3.1. **Solar cells (photovoltaic cells).** Solar cells measurement platform is shown in Figure 6. Solar cells convert light radiation into a physical voltage directly. The solar cell measurement is displayed when the light illuminates the solar cells. When the illumination is increased the physical effect also increases. This also increases the output voltage.

In this measurement function, when the solar cells receive different illumination, strengths the solar cells will output different voltage. Different voltage strength of voltage displays different colors that show different illumination.

The block diagram of solar cell measurement function is shown in Figure 7. The DAQ card acquires physical signal and converts the signal into digital for computer analysis. A flow chart of the signal processing is shown in Figure 8. Because the external circuit output conversion rate is 1mV/1X, 1000 multiplication is used for clearer display. Moreover, the light intensity of output uses BCD to decoding the value and applies seven-segment display to showing the illumination strength value.

Figure 9 shows the solar cells measurement function. The darker color means receiving higher illumination and the lighter color means receiving lower illumination. The measured illumination is 1061Lx by lamp lighting on solar cells. The laboratory illumination was 121Lx without turning on the lamp.

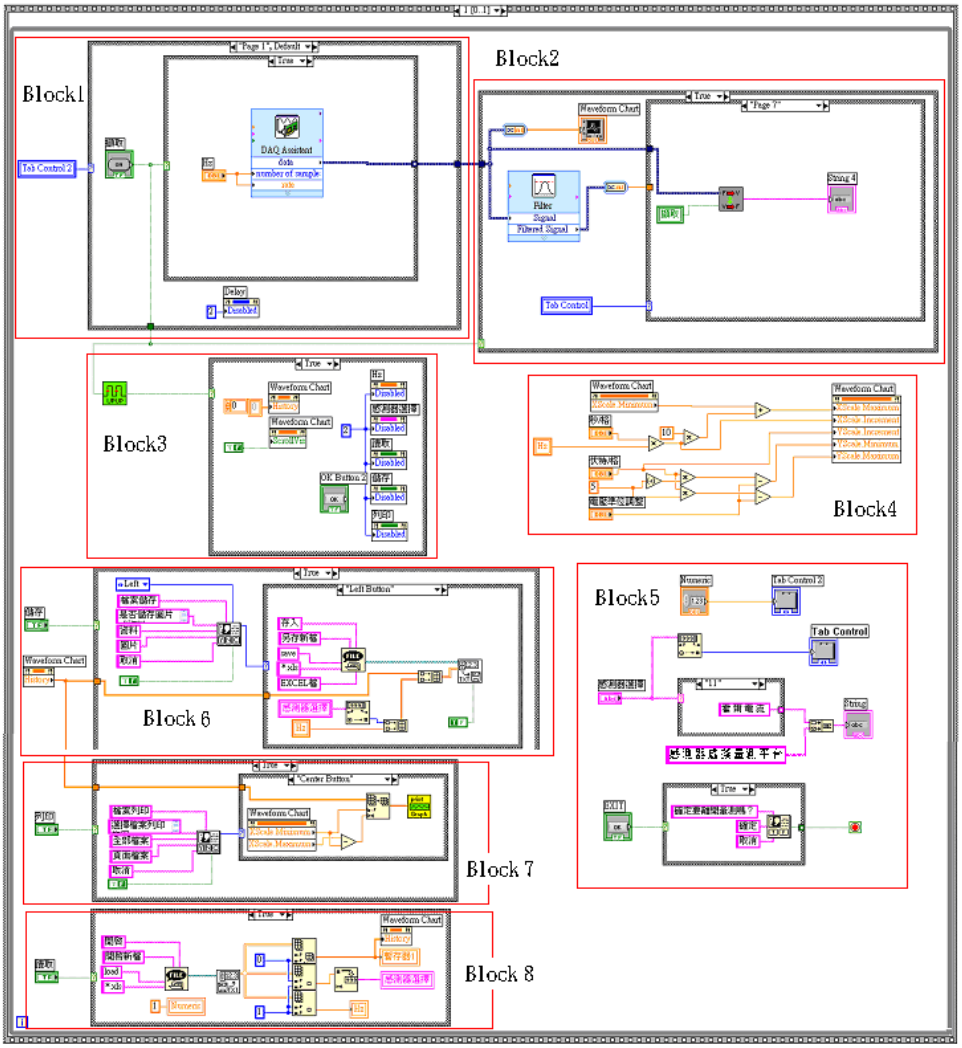


FIGURE 5. The block diagram of the multi-function automatic measurement platform for weight measurement

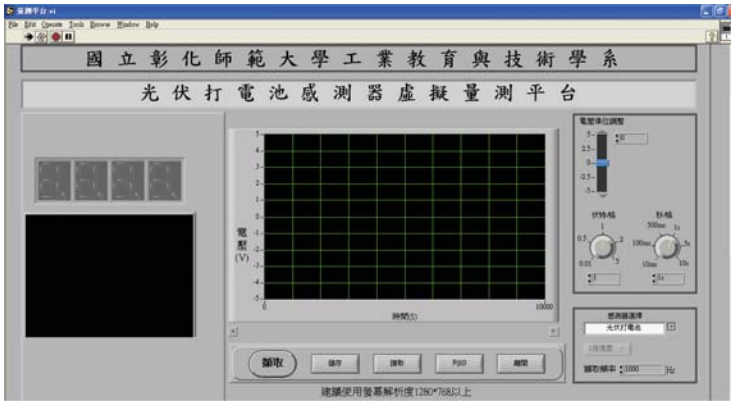


FIGURE 6. The front panel of solar cells measurement function

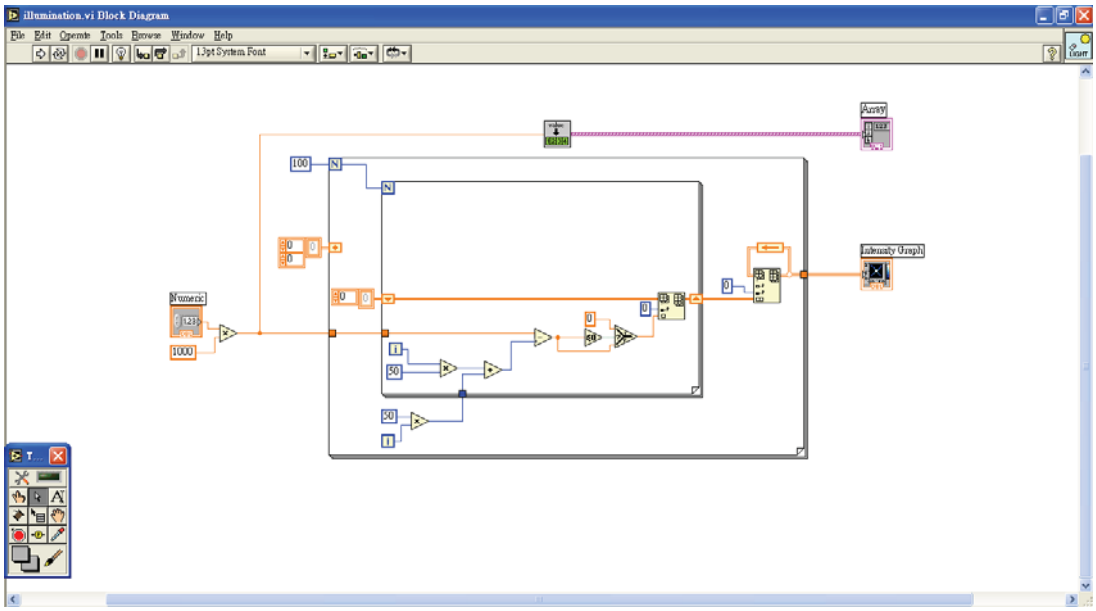


FIGURE 7. The block diagram of solar cells measurement function

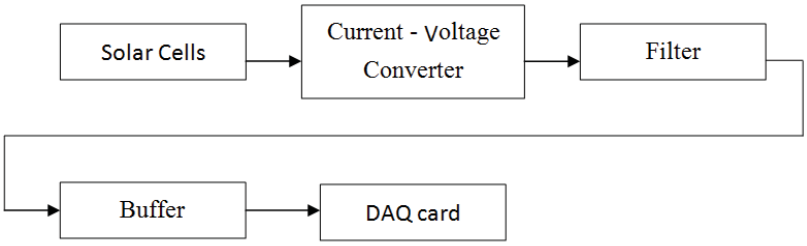


FIGURE 8. The flow chart of signal processing from solar cells to DAQ card

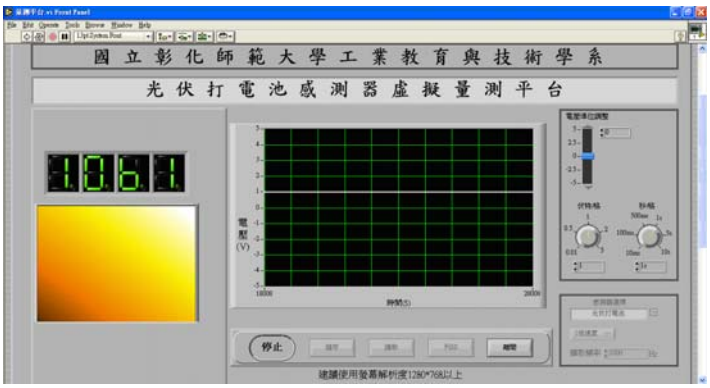


FIGURE 9. The demonstration of solar cells measurement function

This platform can save experiment data such as picture in Figure 10. The saved data can be read as Figure 11 and Figure 12. The measured data can be also printed out as Figure 13.

3.2. **Other measurement functions.** This section will focus on other measurement illustration and present the experimental results. Other measurement displays for the multi-function measurement platforms are shown in Figures 14 to 50.

1. Infrared joules switch

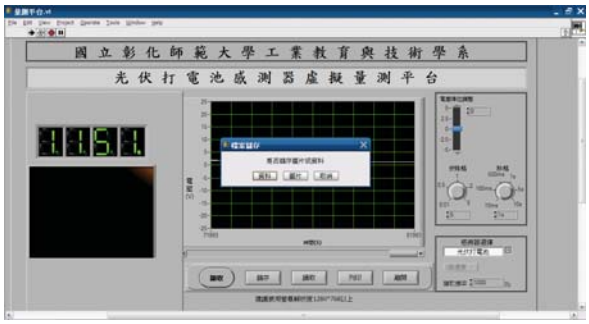


FIGURE 10. Saving the measured data and picture

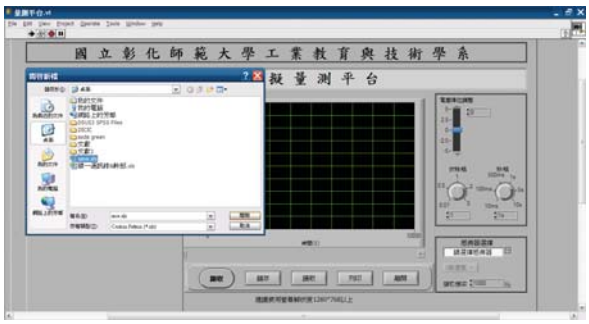


FIGURE 11. Reading existing saved data

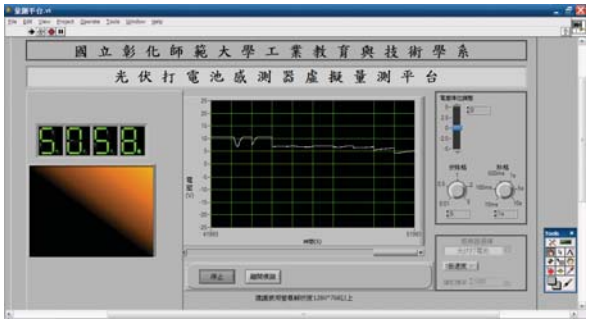


FIGURE 12. Analyzing existing saved data

FIGURE 13. Printing measured data

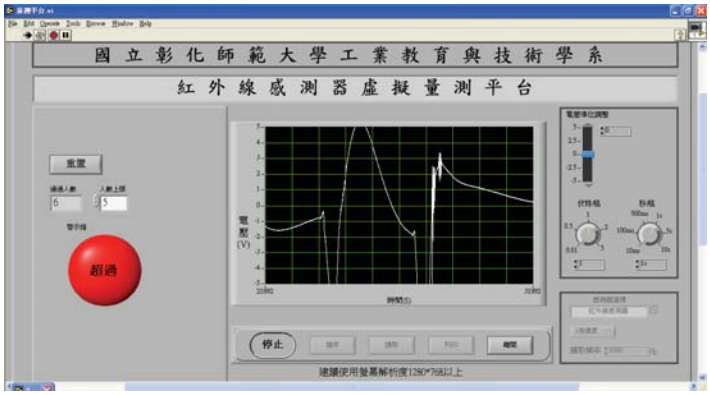


FIGURE 14. Operation of infrared joules switch

The measuring status of infrared joules switch is shown in Figure 14. The LED is used to alert the counting time exceeding of setting number. There is also a button on the screen to reset the measurement.

2. AD590

In the front panel of AD590 measurement platform, three statuses are shown in the following demonstration. Figure 15 shows the measurement status for a low temperature. Figure 16 shows the measurement status for a normal temperature environment. Figure 17 shows the measurement status for an overheated environment. The temperature limits of the measurement platform are defined by users, and the upper and lower limit values can be changed any time.

3. PT100

PT100 measurement status is shown in Figure 18. Insert PT100 into hot water and measure the temperature change. The water temperature increases. The output voltage will also follow up. Figure 18 displays the measurement result when the temperature is 72.4350C.

4. Humidity sensor

Humidity sensor measurement status is shown in Figure 19. The front panel indicates the measured relative humidity is 63.92% which is shown by digital display and gauge.

5. V/F and F/V converter

V/F and F/V converter platform is shown in Figure 20. When using power supply input DC voltage signal, the signal, 0.762V, can be seen in the display window and the

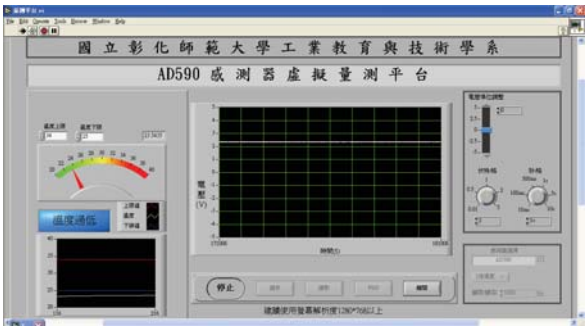


FIGURE 15. Temperature is too low

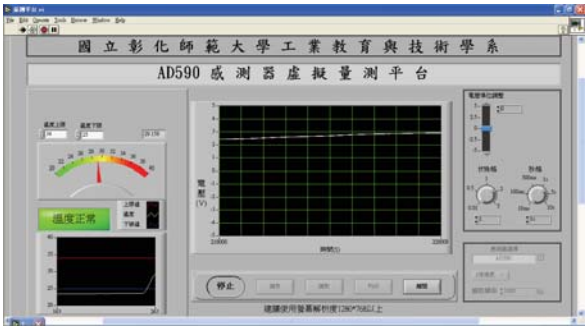


FIGURE 16. Temperature is normal

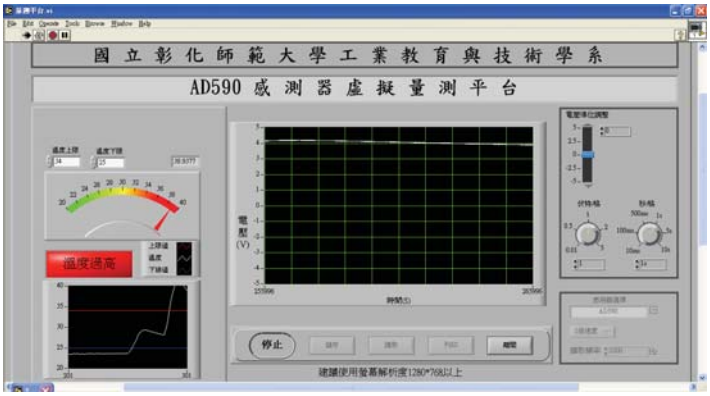


FIGURE 17. Temperature overheated

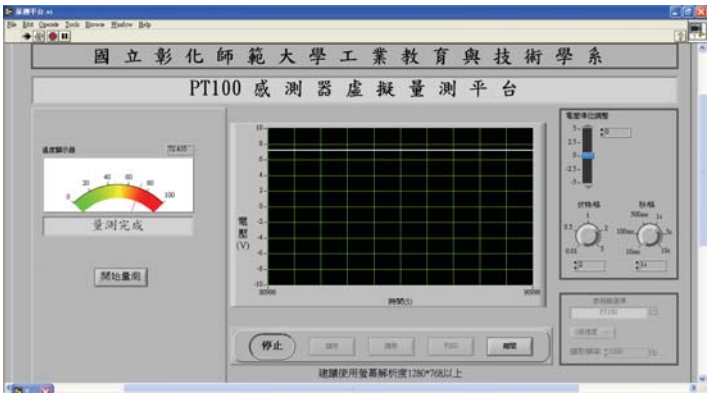


FIGURE 18. PT100 temperature sensor

converted frequency of 381.071Hz. When using the wave 1.404KHz signal, the output voltage is 1.404V shown in Figure 21.

6. Pressure sensor

Pressure measurement platform is shown in Figure 22. The front panel shows the measurement result, 516mmHg, when the sensor measures the pressure. The measurement system will also convert the value into different units including mmHg, Psi and Kg/cm^2.

7. LVDT (Linear Variable Differential Transformer)

LVDT measurement platform is shown in Figure 23. In the front panel design, the displacement measurement result of LVTD is shown in two ways that are sliding bar and dot matrix display.

8. Rotation angel measurement

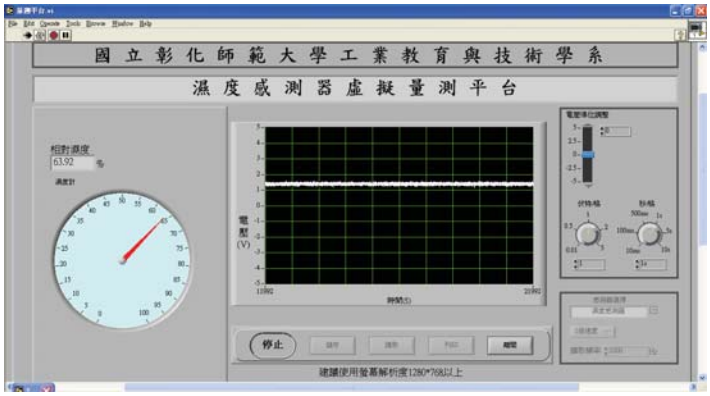


FIGURE 19. Humidity sensor operation

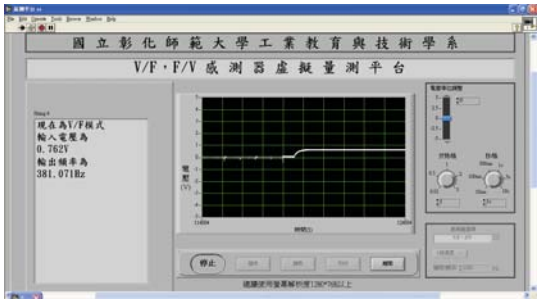


FIGURE 20. V/F mode conversion

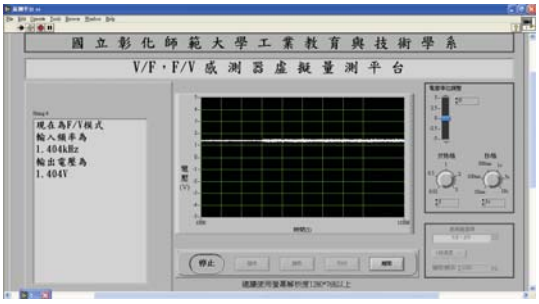


FIGURE 21. F/V mode conversion

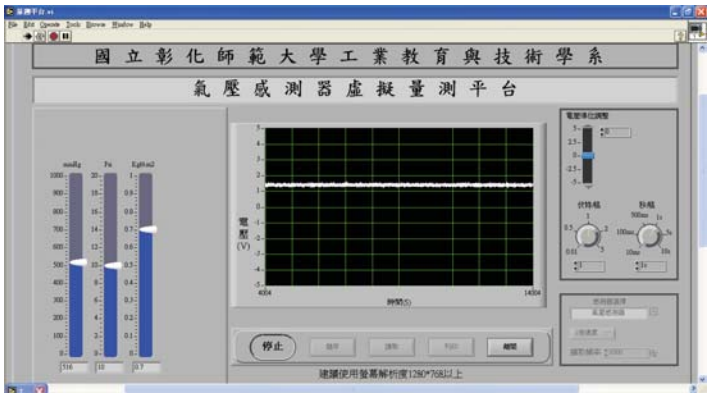


FIGURE 22. Pressure sensors operation

Rotation angel measurement platform is shown in Figure 24. The actual rotation angle will be displayed on the gauge and digital display.

9. Hall current sensor

Hall current sensor measurement platform is shown in Figure 25. In the measurement simulation, Figure 25 shows the measured current and Figure 26 shows the measured current status exceeding the setting current 3A.

10. Light type switches

This measurement platform includes phototransistor, optical interrupter, optical fiber transmission and infrared sensing. Figure 27 is measuring status when phototransistor

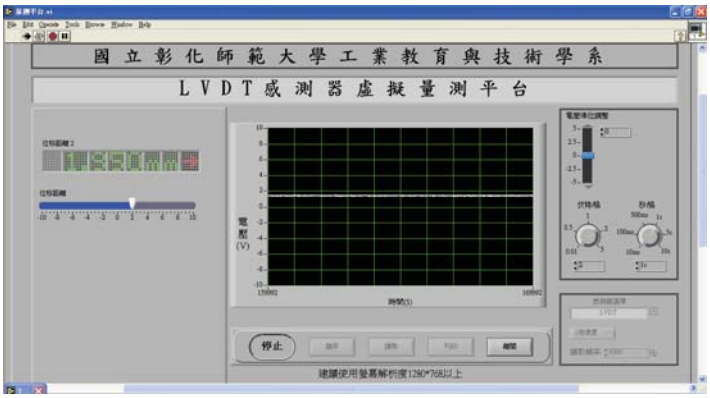


FIGURE 23. Operation of the relative distance of LVDT displacement

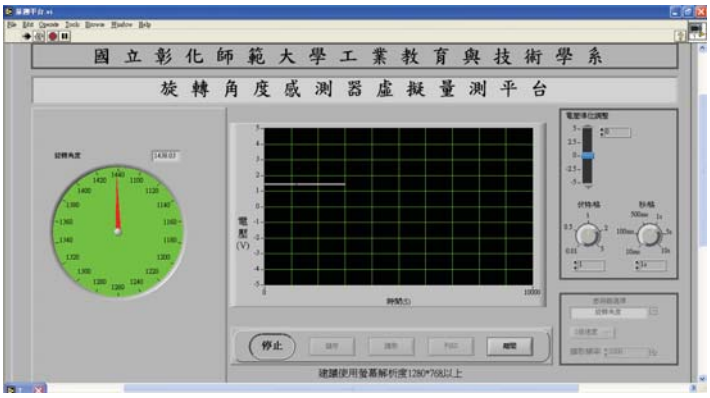


FIGURE 24. Degree angle is 1438.03

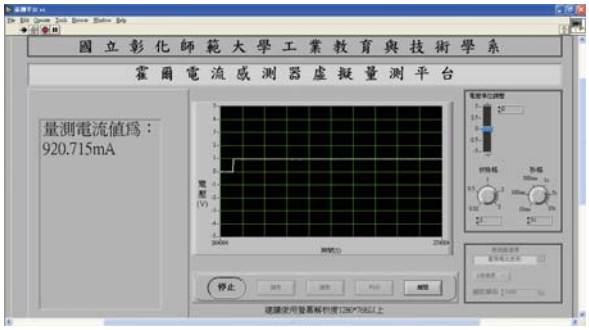


FIGURE 25. Current is less than 3A

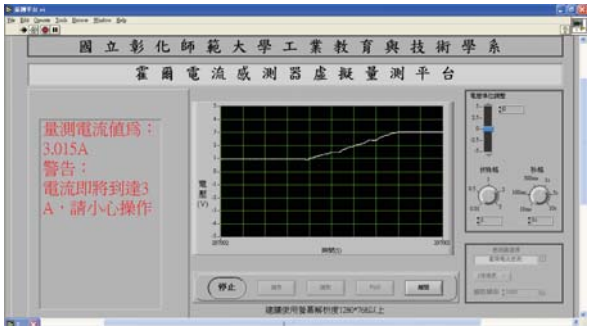


FIGURE 26. Current is larger than 3A

is chosen. Every time, when the waveform changes, on-off state is switched when accumulation time reaches the setting time, the LED will light-up. Figure 28 is the optical interrupter action status. Figure 29 is the optical fiber transmission action status. Figure 30 is the infrared sensor action status.

11. Mechanical type switches

This measurement platform includes magnetic reed switch, limit switch, mercury switch and vibration switch. This measurement platform design is similar to the light type switch measurement platform. When each sensor is triggered at a certain time, the corresponding LED will light-up. Figure 31 shows the magnetic red switch action status. Figure 32 is the limit switch action status. Figure 33 is a mercury switch action status. Figure 34 is a vibration switch action status.

12. Ultrasonic sensor

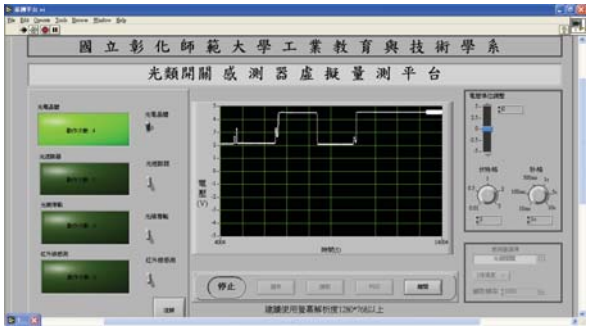


FIGURE 27. Phototransistor measuring status

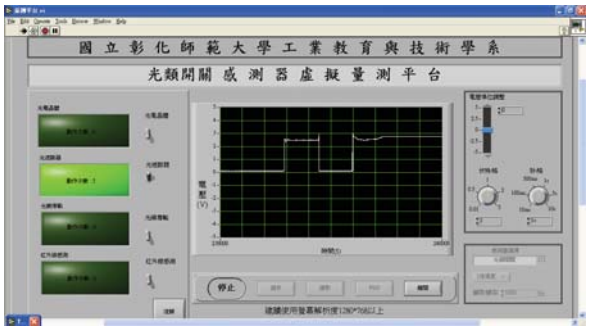


FIGURE 28. Optical interrupter measuring status

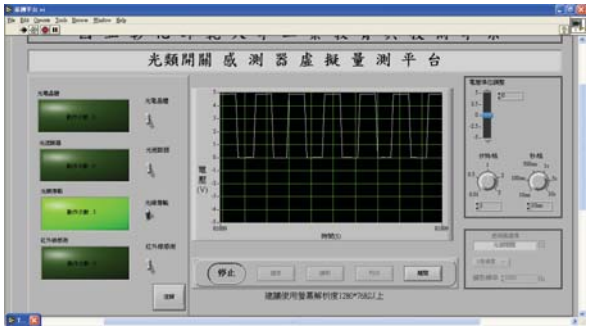


FIGURE 29. Optical fiber transmission measuring status

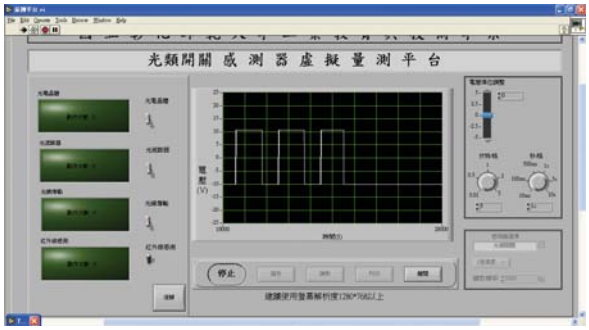


FIGURE 30. Infrared sensor measuring status

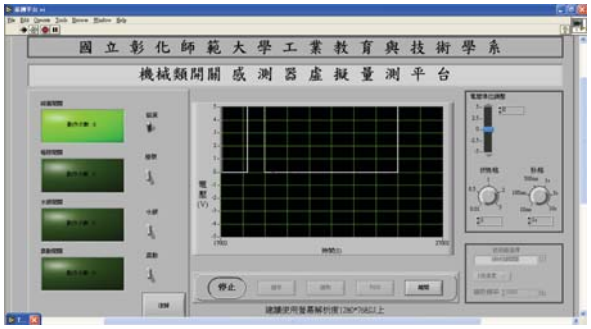


FIGURE 31. Magnetic reed switch measuring status

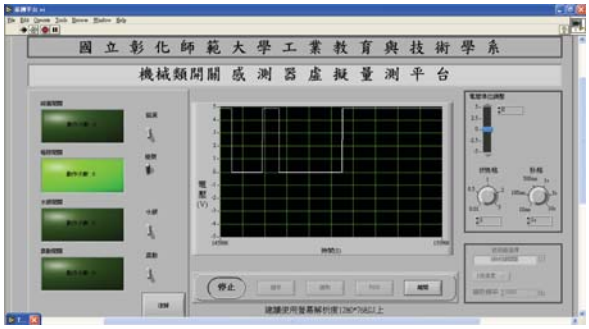


FIGURE 32. Limit switch

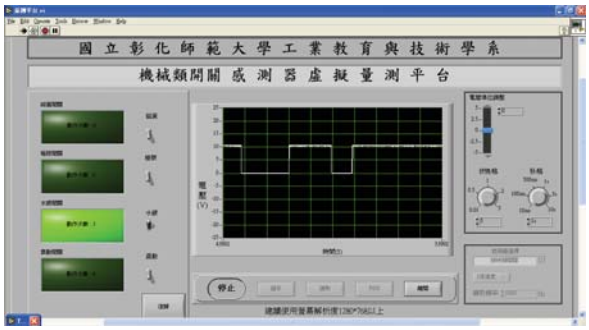


FIGURE 33. Mercury switch measuring status

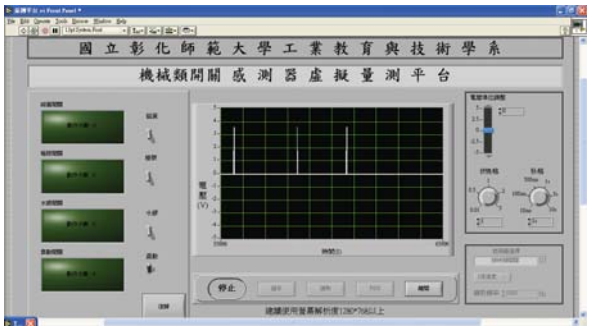


FIGURE 34. Vibration switch measuring status

The ultrasonic sensor measurement platform is shown in Figures 35 to 37. Figure 35 shows the measurement status when no object is blocking the transmission path. Figure 36 shows the measurement status when an object is passing through the transmission path. Figure 37 shows the measurement status with an object blocking the transmission path.

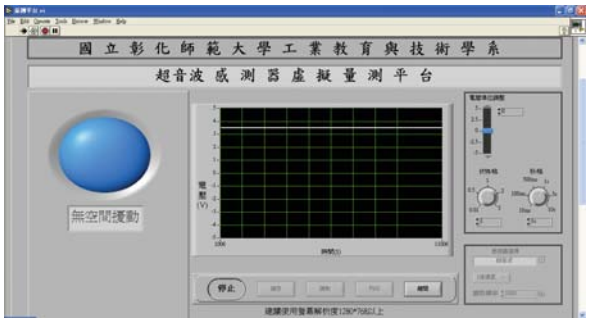


FIGURE 35. The measuring status of no object blocking

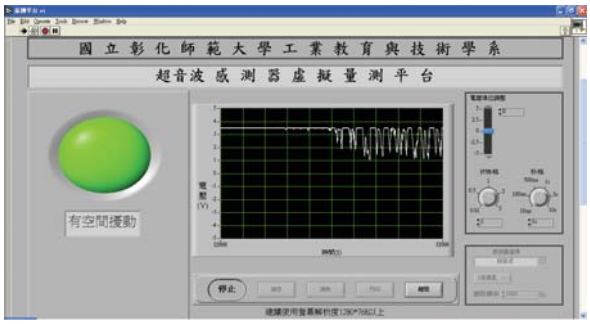


FIGURE 36. The measuring status when object passing

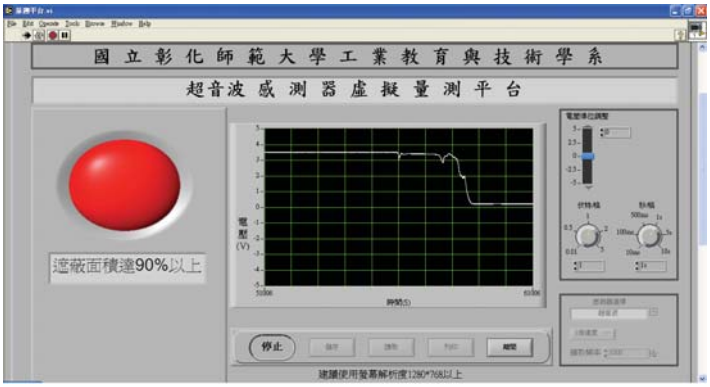


FIGURE 37. The transmission path is blocked

13. Metal sensor

Metal sensor measuring demonstration is shown in Figures 38 to 40. Figure 38 shows the measuring status when no metal is nearby. Figure 39 shows the measurement status when metal is nearby. Figure 40 shows that metal is very close to the sensor. In the front panel design, different LED colors represent how close the metal is to the sensor. When

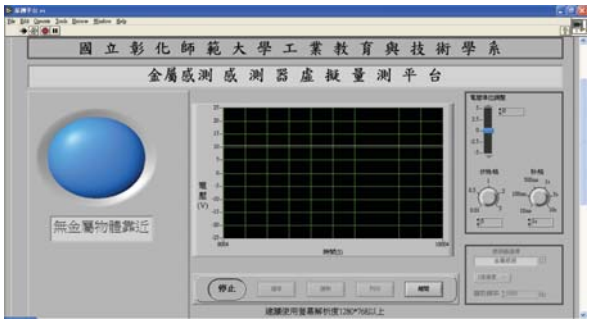


FIGURE 38. There is no metal nearby

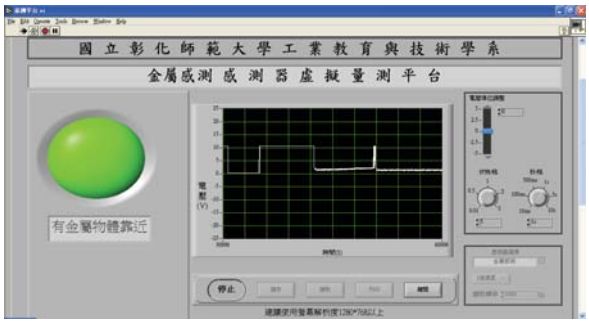


FIGURE 39. There is metal nearby

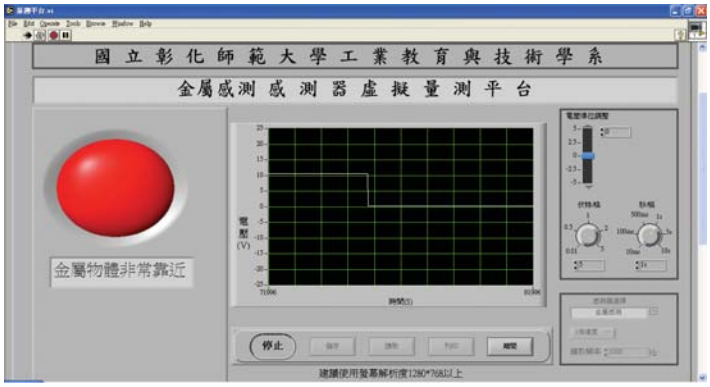


FIGURE 40. There is metal very close

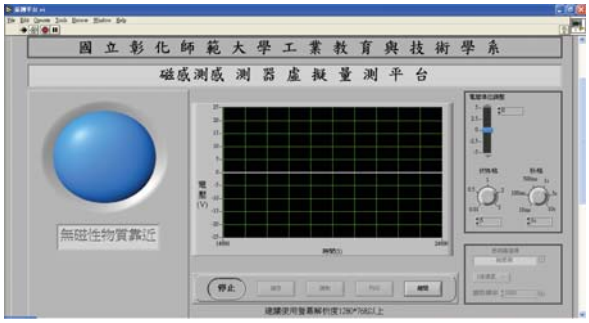


FIGURE 41. There is no magnetic material nearby

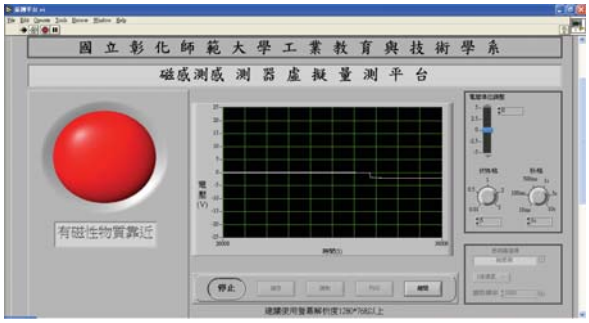


FIGURE 42. The material is close to the sensor

the metal is very close, the color is designed to show red. If there is no metal around, The LED color of LED is designed to show blue.

14. Magnetic sensor

Magnetic sensor measurement platform is shown in Figures 41 and 42. Figure 41 shows the measurement status when no magnetic material is nearby. Figure 42 shows the measurement status when magnetic material is close to the sensor and triggers the LED to change color.

15. Resistance type sensor

This measurement platform can be used for any resistance type sensors such as photo resister and thermistor. In the front panel, the LED will show the sensor resistance and voltage change status. Figures 43 and 44 show the photo resister measurement status.

Figure 43 shows no resistance change in photo resister and Figure 44 shows resistance change in the photo resistor.

16. Microphone

The microphone measurement platform is shown in Figure 45. The capacitance inside the microphone will change, when audio is input. The demonstration is shown below.

17. Liquid level controller

Liquid level controller controls the pump motor. When the pump motor is activated, the LED light will alert the user and a tip dialog will be shown in the bottom. Figure 46 shows the measurement status when the pump motor is running and Figure 47 shows the status that motor is not running.

18. Alcohol/Gas concentration sensor

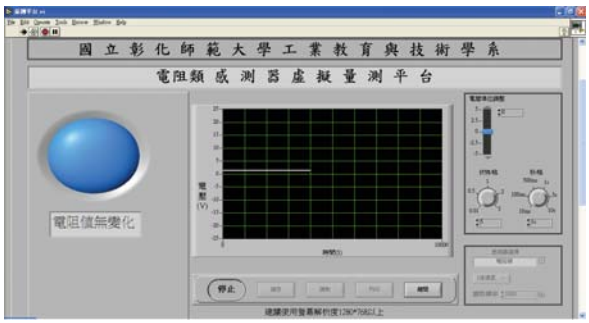


FIGURE 43. There is no change in resistance

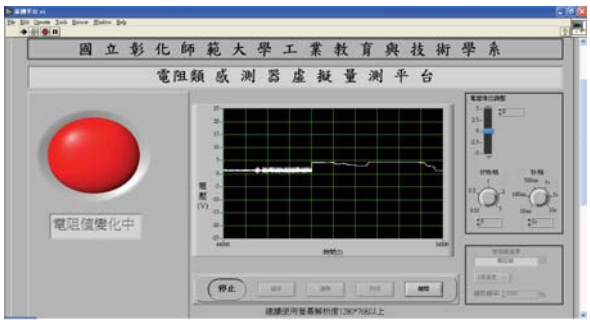


FIGURE 44. There is change in resistance

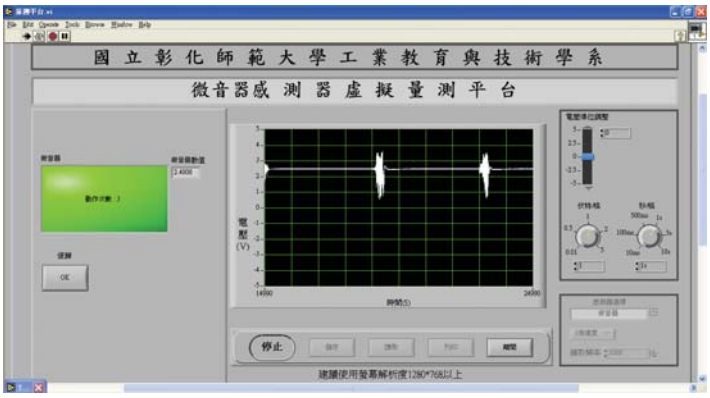


FIGURE 45. Microphone measurement status

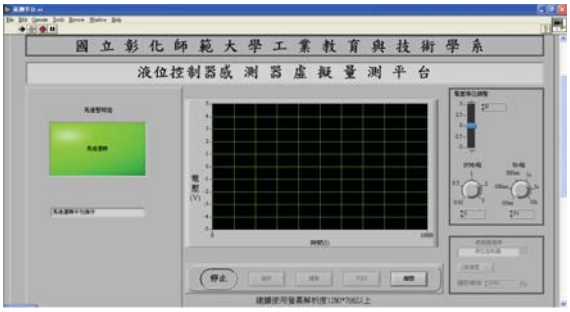


FIGURE 46. Pump motor is running

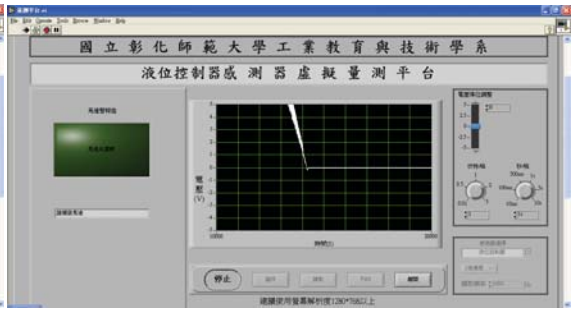


FIGURE 47. Pump motor is not running

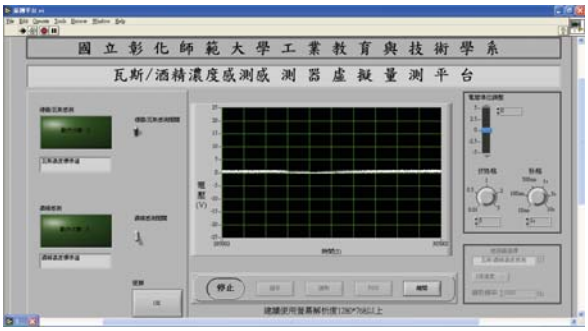


FIGURE 48. Alcohol/Gas concentration sensors are normal

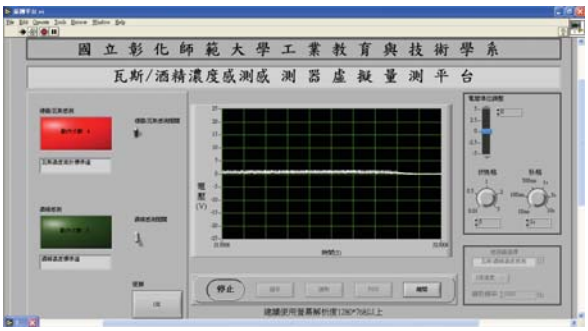


FIGURE 49. Alcohol concentration sensor is working

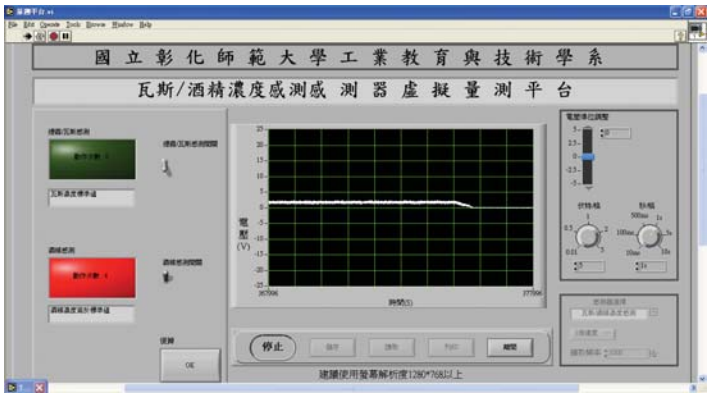


FIGURE 50. Gas concentration sensor is working

The alcohol and gas concentration measurement platform is shown in Figures 48 to 50. Figure 48 shows the measurement status when alcohol and gas conversion is normal in the air. Figure 49 shows the alcohol concentration sensor has measured a high level alcohol concentration. Figure 50 shows the gas concentration sensor has measured high level gas concentration.

4. **Conclusions.** Automatic measurement means the environment, systems or devices can be measured automatically. This paper, presented an industry-oriented automatic measurement platform has to be developed by applying a virtual instrument. When concerned with capability, automatic measurement possesses instant data measurement acquisition and also is able to save data for further processing and application. In automatic measurement technology, programmable features, equipment integration, control applications, cost, function and maintenance are all more efficient.

In this article, the LabVIEW platform was used to develop a multi-function automatic measurement platform. Compared with using other software, this graphical design tool is more user-friendly and powerful for the designer. The programmable features allow users to adjust the measurement function any time.

This developed platform will be an effective teaching aid for training people in the automatic measurement field. This research work integrates basic technology sensors and measurement devices applications, advanced technology, virtual instrument and industry-oriented integrated technology into comprehensive automatic measurement technology.

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REFERENCES

[1] K.-C. Yao, C.-H. Lai and J.-S. Fang, The study of practical competence indicator analysis and establishment for automatic measurement technology course, *World Transactions on Education and Technology Education*, vol.9, no.3, pp.161-166, 2011.

[2] L. Wang, C. Chen, L. Ma and J. Shen, Development of multi-functional virtual oscilloscope based on soundcard, *Proc. of the 3rd International Conference on Measuring Technology and Mechatronics Automation*, pp.1056-1059, 2011.

[3] B. Tang, A. Yin and C. Zhou, Research on developing platform of virtual instrument based on Qin's model, *China Mechanical Engineering*, vol.15, no.11, pp.1018-1021, 2004.

[4] Z. Deng, J. Qi, G. Li et al., Constructing virtual instrument system based on LabVIEW, *Journal of North China aerospace industry college*, vol.11, no.3, pp.10-17, 2001.

[5] K.-C. Yao, Virtual digital writers and virtual digital readers design and implementation, *Information Education and Technological Application Conference*, CD CS97002, 2008.

[6] L. Wang, Y. Liu and Y. Huang, Virtual signal generator and oscilloscope design based on the LabVIEW, *Journal of North China Institute of Water Conservancy and Hydroelectric Power*, no.3, pp.57-59, 2010.

[7] K.-C. Yao, Single input virtual digital multi-meter design and implementation, *International Journal of Innovative Computing, Information and Control*, vol.4, no.12, pp.3101-3110, 2008.

[8] K.-C. Yao, W.-J. Shyr and D.-F. Chen, Course development and evaluation strategy of a new technology – Programmable physiological signal measurement technology, *The International Conference on e-Commerce, e-Administration, e-Society, e-Education, and e-Technology*, Macau, 2010.

[9] B. Gu, Q. Lu and Y. Liu, A DAQ board based logic analyzer design, *International Conference on Electrical and Control Engineering*, pp.4594-4597, 2010.

[10] USB-6008/6009 user guide and specifications, *National Instruments User Manual*, 2008.

[11] A. Abu-aisheh and F. Farahmand, Lab VIEW-based integrated virtual learning platform, *Proc. of the 10th IEEE International Conference on Advanced Learning Technologies*, pp.403-405, 2011.

[12] K.-C. Yao, Computer robust control of discrete-time decentralized stochastic singularly perturbed systems, *International Journal of Innovative Computing, Information and Control*, vol.4, no.7, pp.1771-1782, 2008.

[13] K.-C. Yao and C.-H. Hsu, Robust optimal stabilizing observer-based control design of decentralized stochastic singularly-perturbed computer controlled systems with multiple time-varying delays, *International Journal of Innovative Computing, Information and Control*, vol.5, no.2, pp.467-477, 2009.

[14] K.-C. Yao, D.-F. Chen and W.-T. Huang, Digital control design of decentralized stochastic singularly-perturbed large-scale actuator type systems with multiple time-varying delays, *International Journal of Innovative Computing, Information and Control*, vol.5, no.10(B), pp.3303-3311, 2009.