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Using Virtual Instrument in Teaching Automatic Measurement Technology Course

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Abstract— **The use of an automatic measurement technology is highly important in current industries. The technology has been sued in various applications such as environment monitoring, quality control of production line, and medical disease analysis. Automatic measurement technology requires programming, facilities integration, control application, function innovation, and maintenance technology. Developing suitable teaching equipment that can satisfy the demand of industry-orientation Automatic Measurement Technology Course (AMTC) is a challenge. In this study, a virtual instrument is introduced to solve the problem. LabVIEW, which is utilized to design virtual instruments, provides powerful functions for instrument control and measurement. Therefore, in this proposed AMTC, a LabVIEW-based virtual instrument system is established as teaching equipment for undergraduate students in colleges of engineering or technology**

Index Terms— **virtual, instrument, LabVIEW, automatic, measurement**

I. Introduction

Virtual instrument technology, which comprises computer technology and instrument technology, has provided significant convenient modern technology and techniques. To undertake measurement and maintenance tasks in hospitals, laboratories, factories, and in outdoor works, many apparatuses, such as an ECG analyzer, oscilloscope, spectrum gauge, voltmeter, and spectrum analyzer are used. These instruments are costly, large in volume, and occupy considerable space, causing the reciprocal link to become troublesome [1]. Virtual instruments require a PC, a workshop, an instrument interface platform, and suitable software to accomplish the desired functions. Thus, advanced virtual instruments have taken the place of many classical instruments and equipment on hand. Virtual instruments possess advantages such as functions defined by users, diversity extensibility, open development, easy maintenance, quick technology update, and cheap price. Virtual instrument technology develops into minute trends of current virtual instruments. Virtual instruments provide the best active computer resource, can match with oneness constructive instrument hardware and proprietary software, and achieve all functions of the traditional instrument and some outstanding specific functions that cannot be carried out on traditional medical instruments. A virtual instrument is created by adding a set of software and hardware on a general-purpose computer. The user operates this computer similar to personally designed special traditional equipment. The virtual instrument technology breaks through the mode of traditional instrument is defined by manufacturer, and the user cannot change this mode. A user can design an instrument system to satisfy various application demands given the adequacy space to exert ability and imagination. Today the emphasis in engineering laboratories is toward implementing devices that provide graphical computer interfaces, a range of input/output devices, and the ability to record results, and feedback [2-3]. These devices provide a set of virtual instruments that are not only applicable to laboratory works but also in industrial applications as well [4-5]. Figure 1 shows the appearance of classical measurement and virtual instruments. A comparison of virtual instruments with classical instruments is show in Table 1.

Figure 1. Appearance of traditional measurement instrument and virtual one.

Table1. Comparison of virtual instrument and classical instrument.

	Virtual Instruments	Classical 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

Automatic measurement is the instantaneous and automatic measurements of the environment, system, and objects. Traditionally, automatic measurement is more often seen with physical instruments for industry, such as monitoring boiler

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temperatures, measuring humidity in a flower nursery, or sensing of the extent of shaking of a working machine. These measuring functions and applications are indispensable to monitor essential procedures or technical applications in product manufacturing processes or in the product itself for industry. For example, measurement was conducted using of diodes or transistors in the manufacturing process and quality management testing, as well as in fabricating a variety of sensing and measuring devices for up-to-date machines. Automatic measurements, aimed at measuring and storing values and instigating treatment and applications, are especially in demand.

In data acquisition, automatic measurement measures actual signal processes (such as a voltage) to transfer the signal to a computer to process, analyze, store or provide other treatments. In the real world, objects are based on physical or chemical phenomena, such as velocity, temperature, humidity, pressure, flow velocity, pH (i.e. power of Hydrogen ions) value, switch, radiation, luminosity, and so on. These phenomena could be subjects of measurement [6]. The transducer or sensor can bring forth physical phenomena to obtain proportional electrical signals. For instance, thermocouples can transform temperature into voltage magnitude, and afterwards the object can be measured by a D/A converter. Other transducers included a strain gauge, flow meter, manometer, and so on, which might gauge stress, flow velocity, and pressure separately.

LabVIEW is graphic program software developed by NI Company and include virtual instruments and the software development platform. For example, it could connect to the computer by way of GPIB, IEEE-488, RS-232 communication interface, or Local Area Network (LAN) to carry out signal measurement, analysis, data storage, and data acquisition functions, and to promote working efficiency and accuracy of the data [7-9]. The data acquisition process inputs the real-world physical signals into a computer for further signal processing and analysis [10]. NI USB-6009, which possesses a USB interface, is used as the data acquisition device in this study, as shown in Figure 2 [11]. Figure 3 shows the pin-out of USB-6009.

Figure 2. NI USB-6009

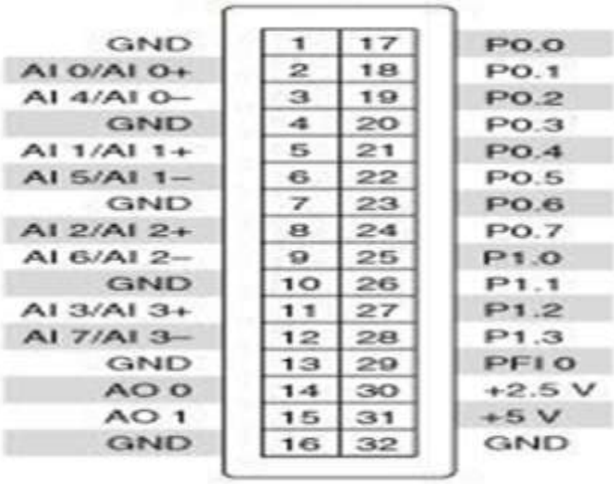


Figure 3. Pin-out of USB-6009

II. PPLICATION OF VIRTUAL INSTRUMENT IN AUTOMATIC MEASUREMENT TECHNOLOGY

The application of automatic measurement technology was considerably widespread. In the automobile industry, conventional manpower conducted the measurement and inspection of vehicles, which was extremely time-consuming in the past. However, the automotive end-of-line test systems aim that the system, automotive ECUs, and mechanical components proceed with simulation and measurement, and inspected the related functionality in LabVIEW technique at present. Therefore, LabVIEW was able to supply the testing products with some particular input or output state, chassis, and related controllers to integrate and strengthen the existing test systems through the combination of software and hardware for virtual instrument. Thus far, the export-import quarantine in agriculture must be developed. These examined agricultural products are sometimes wrong-headed under the conventional method. Thus, this situation cannot be judged easily. Some crops may have suffered from collision or insect pest. We were only dependent on our experienced judgment. Accordingly, LabVIEW technique was able to achieve acquisitively the X-ray and the visible light image of the testing products at once. Hence we obtained internal and external information of the cropper, which may have suffered from moth and external forces marked on the image to determine the injured parts. Therefore, LabVIEW technique was fast and accurate in providing some information for technologist reference. It also cuts down our time and labor costs as well as procedures compared with conventional quarantine methods. In terms of medical devices, patients may not stay in the hospital given the existence of home care. Nevertheless, the virtual instrument technique could develop a suit of compound monitoring and measurement platform. This diversified monitoring system conduct data combination. The information was stored by linking the network on the remote servers to allow the families of the patients to use the web interface to browse their status and requirements and the conditions of the patients are available anytime. This method eases care for disabled elderly and eliminates the need for them to visit a doctor when they need to use public transport and they have access to quality medical nursing. We fabricated some hardware equipment (e.g., DAQ interface card) for these computers in the multimedia classroom, and collocated fitting software, that is, it constituted a virtual instrument to replace general experimental instrument, such as digital oscilloscope, spectrum analyzer, voltage meter, and ammeter. Virtual instruments satisfy experimental instruction requirements for multimedia and allow students to perform advanced instrument and experimental techniques. These instruments shortened the distance between student knowledge and modern experimental technique, and enhanced the modernistic level of experimental instruction. [12-15].

III. METHODOLOGY

The established automatic measurement system includes hardware and software. The hardware includes a computer, USB-DAQ, approximately 20 kinds of sensors and measurement devices, which were chosen through expert consultation and literature investigation. The software contains a front panel and block diagram design.

A. Hardware parts:

The multi-functional device measurement platform provides more than 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 interfaced easily with the corresponding function. It contains the following: (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 / Fume concentration sensor; (22) Alcohol sensor.

B. Software part:

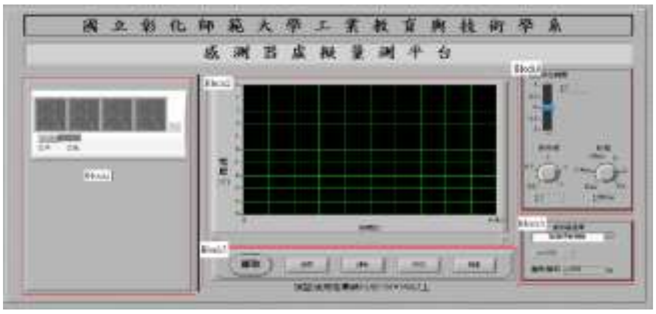
In the measurement platform, NI LabVIEW is applied to design the front panel and block diagram for different kinds of measurement sensors and devices. This platform was developed to be user-friendly and therefore, every measurement function is designed considering this aspect. For example, the metal detection panel was designed to detect substances in close proximity to metal, the alcohol detection panel was designed to detect alcoholic liquids, and the solar cell measurement panel was designed for different types of illumination by causing color changes in the display window.

IV. MAIN RESULTS

The design of the multi-function automatic measurement front platform is shown in Figure 4(a) and shows that the weight measurement function is selected. Figure 5 shows a block diagram of Figure 4.

In Figure 4(a), Block 1 shows the display window of the measured weight. Block 2 represents the measured signal obtained by the computer through the DAQ card. Block 3 contains function buttons, including the leave, read, print, save, and data acquisition buttons. Block 4 highlights the voltage adjustment in X scale, time adjustment in Y scale, and off-set adjustment. Block 5 shows the panel selection, list selection, and sampling rate setting.

Figure 5 shows the design for Block 1, which contains data acquisition and analog to digital data transformation. Block 2 is designed to filter the signals for further use. Block 3 is used to lock the function list selection to avoid platform malfunction. Block 4 controls the adjustment knobs for the signal display window. Block 5 allows the selection of the required measuring devices or functions. Block 6 shows how the measured data, including values and images, can be saved. Block 8 represents the print function and designed to store the measured values and reproduce the measured signal from stored data.



(a)

(b)

Figure 4. (a) Front panel of the multi-function automatic measurement platform for weight measurement (b) Measurement function panel selection list of the multi-function automatic measurement platform embedded in Block 5.

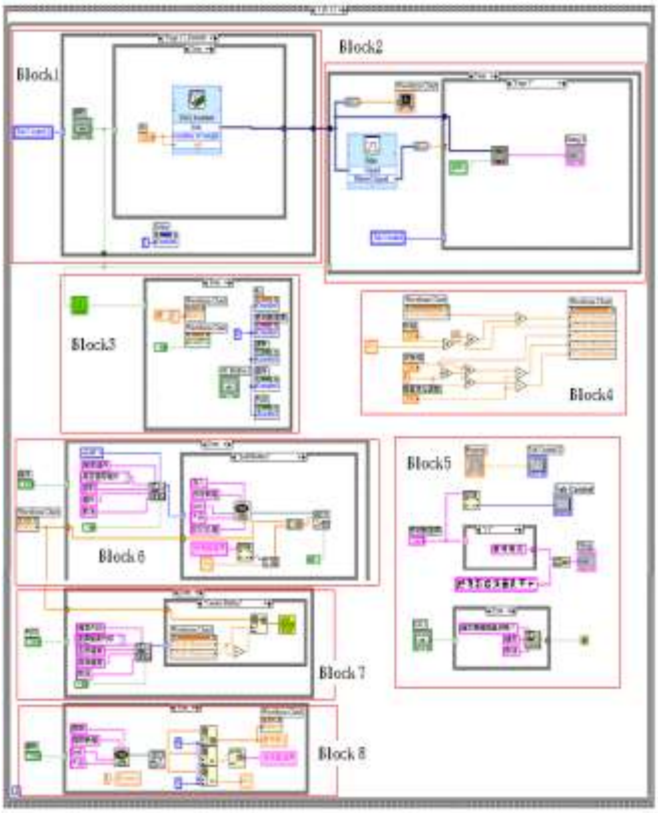


Figure 5. Block diagram of the multi-function automatic measurement platform for weight measurementThe platform solar cell measurement function and other measurement results will also be illustrated and demonstrated.

A. Solar cells (Photovoltaic cells)

Figure 6 shows the solar cell measurement platform. In this platform, the solar cells directly convert light radiation into a physical voltage. The solar cell measurement is displayed when the light illuminates the solar cells. When illumination is increased, the physical effect also increases, thereby increasing the output voltage. In this measurement function, when the solar cells receive different illumination strengths and the solar cells will have different voltages. Different voltage strengths display different colors that exhibit different illuminations.

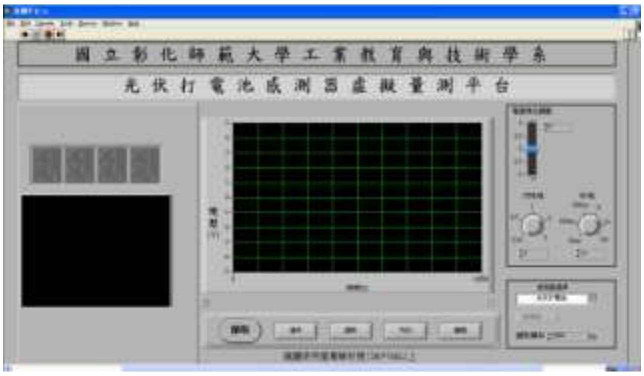


Figure 6. Front panel of solar cell measurement function

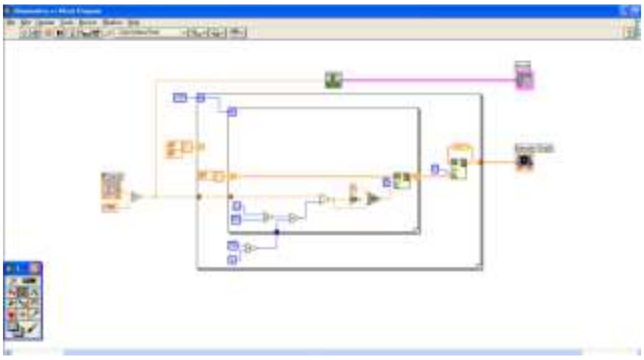


Figure 7. Block diagram of solar cell measurement function

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

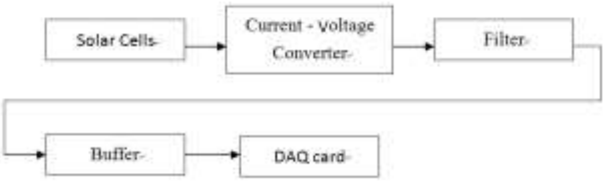


Figure 8. Flow chart of signal processing from solar cells to DAQ card

Figure 9 shows the solar cell measurement function. The darker color indicates that the cells have measured higher illumination while the lighter it has received lower illumination. The measured illumination from lamp lighting on solar cells is 1061Lx. The laboratory illumination without turning on the lamp is 121Lx.

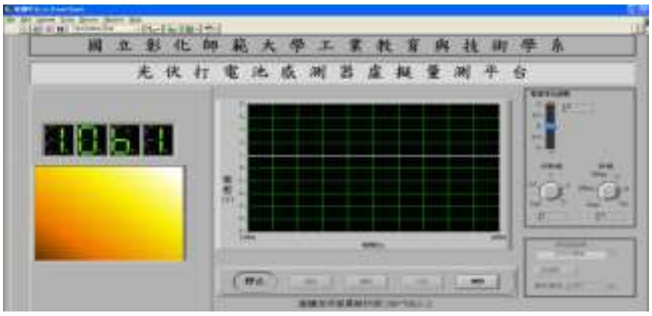


Figure 9. Demonstration of solar cell measurement function

This platform can save experiment data as shown in Figure 10. The saved data can be seen in Figures 11 and 12. The measured data can also be printed out as shown in Figure 13.

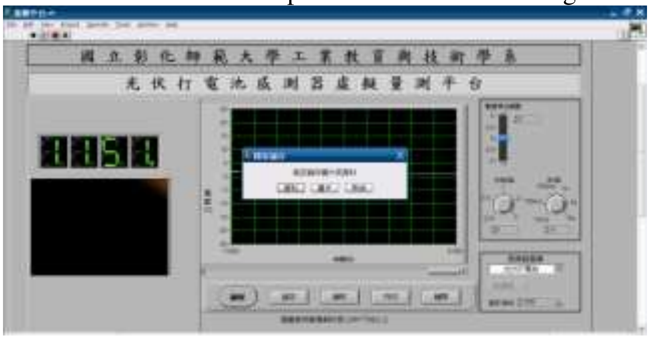


Figure 10. Photo of the saved measured data

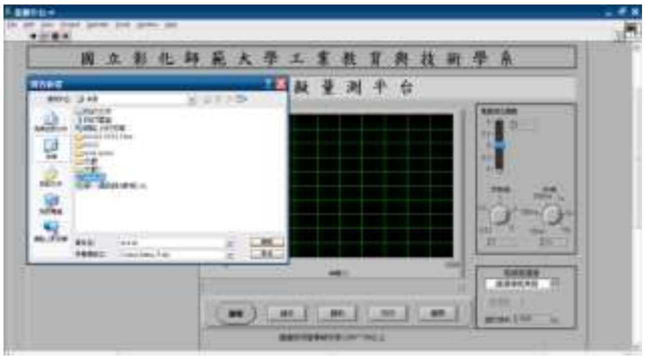


Figure 11. Reading the saved data

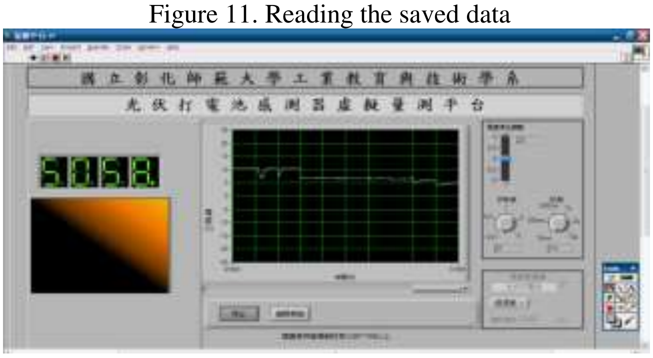


Figure 12. Analysis of the saved data

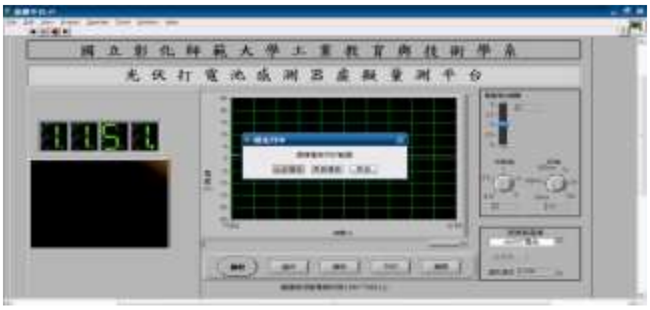


Figure 13. Printing the measured data

B. Other measurement functions

This section focuses on the other measurement illustrations and presents the experimental results. Figures 14 to 50 show the measurement displays for the multi-function measurement platforms.

1. Infrared joules switch

The measurement status of the infrared joules switch can be observed in Figure 14. The LED is used to alert the counting time that exceeds the set number. A button on the screen can reset the measurement.

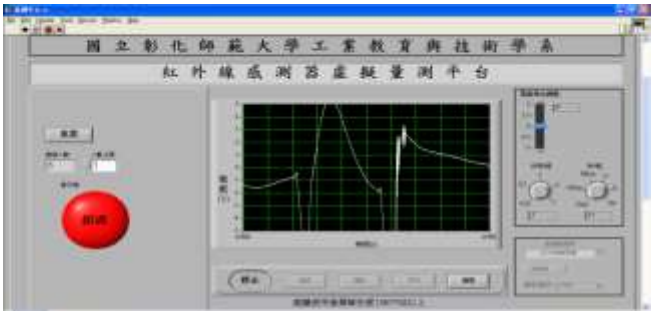


Figure14. Operation of Infrared joules switch

2. AD590

In the following demonstration, three statuses can be observed in the front panel of AD590 measurement platform. Figure 15 shows the measurement status for 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 the users, and the upper and lower limit values can be changed any time.

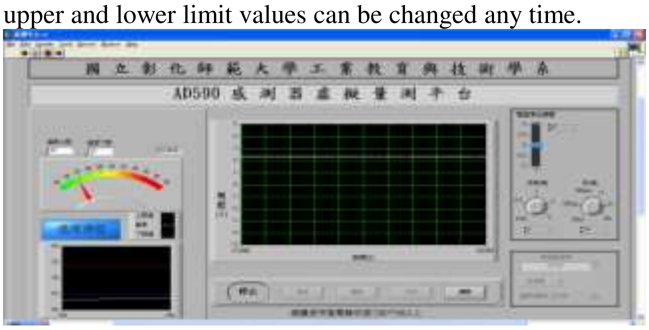


Figure 15. Extremely low temperature

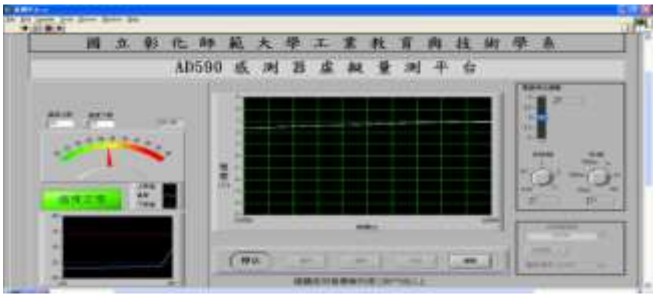


Figure 16. Normal temperature

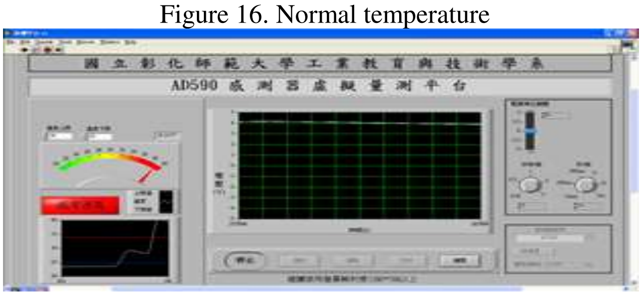


Figure17. Overheated temperature

3. PT100

PT100 measurement status is shown in Figure 18. The PT100 is placed in hot water, and the temperature change measured. The water temperature increases and the output voltage will also increase. Figure 18 displays the measurement results when the temperature is 72.4350 °C.

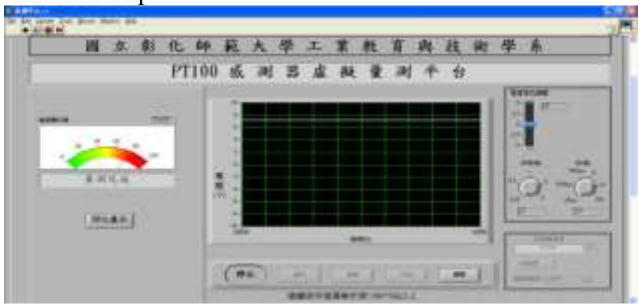


Figure 18. PT100 temperature sensor

4. Humidity sensor

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

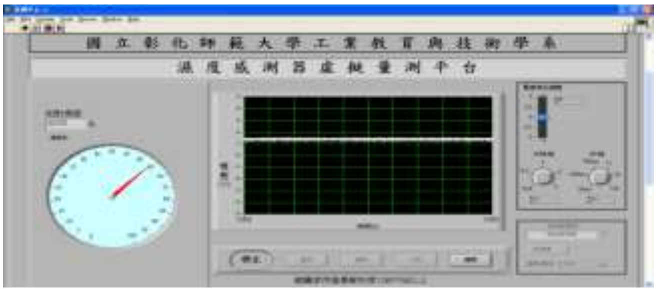


Figure19. Humidity sensor operation

5. V/F and F/V converter

The V/F and F/V converter platform is shown in Figure 20. When the power supply input DC voltage signal is used, the signal, 0.762V and the converted frequency of 381.071Hz can be observed in the display window. When the wave 1.404KHz signal is used, the output voltage is 1.404V as shown in Figure 21.

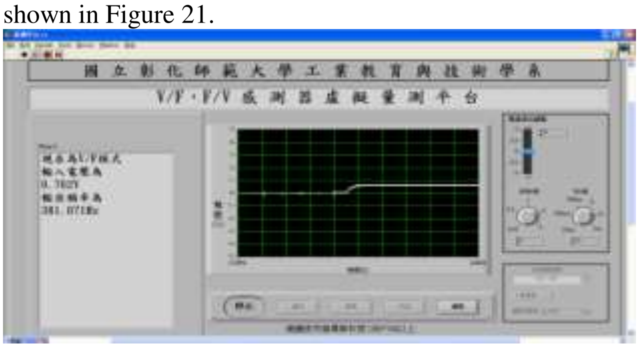


Figure 20. V/F mode conversion

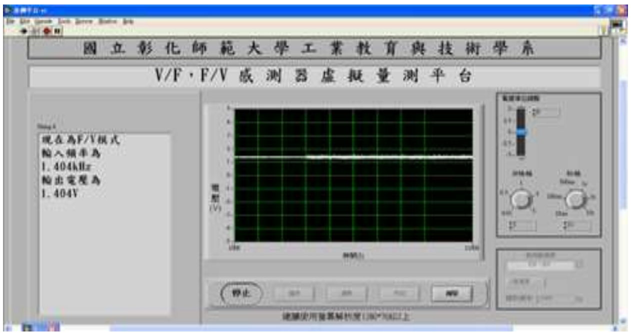


Figure21. F/V mode conversion

6. Pressure sensor

The pressure measurement platform is shown in Figure 22. The front panel shows the measurement results, which is 516mmHg, when the sensor measures the pressure. The measurement system will also convert the value into different units including mmHg, Psi, and Kg/cm2.

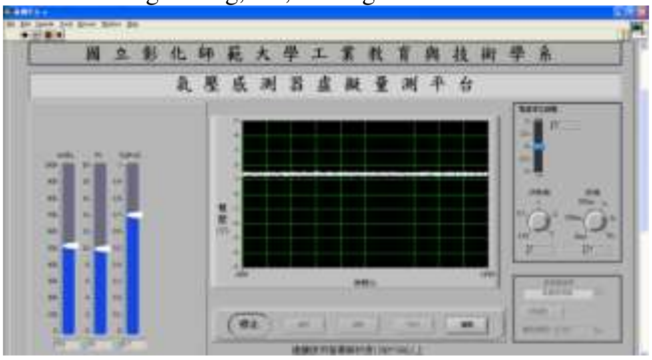


Figure 22. Pressure sensors operation

7. Linear Variable Differential Transformer ((LVDT)

The LVDT measurement platform is shown in Figure 23. In the front panel design, the displacement measurement results of LVTD are shown as a sliding bar and a dot matrix display.

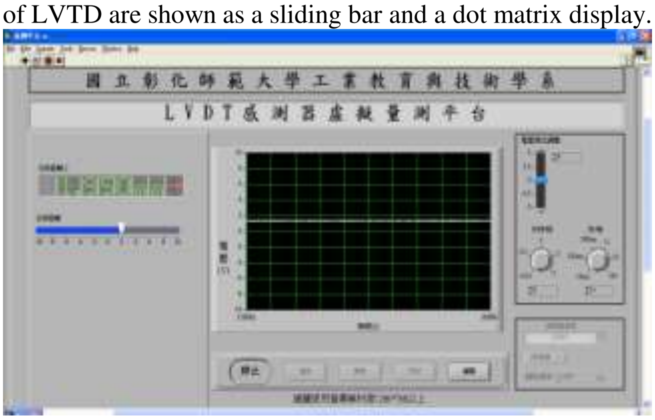


Figure23. Operation of the relative distance of LVDT displacement

8. Rotation angle measurement

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

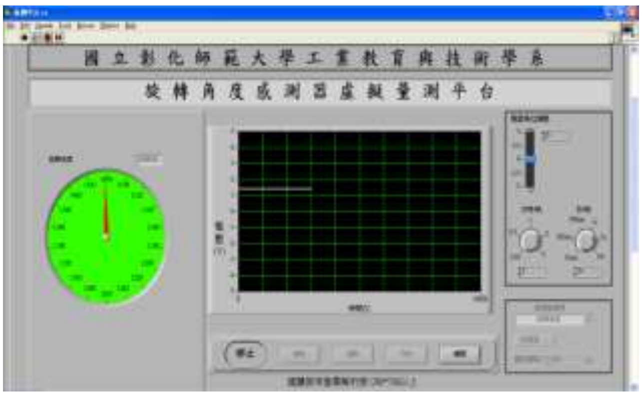


Figure24. Degree angle is 1438.03

9. Hall current sensor

The hall current sensor measurement platform is shown in Figure 25. In the measurement simulation, Figure 25 shows the measured current while Figure 26 shows the measured current status that has exceeded the setting current 3A.

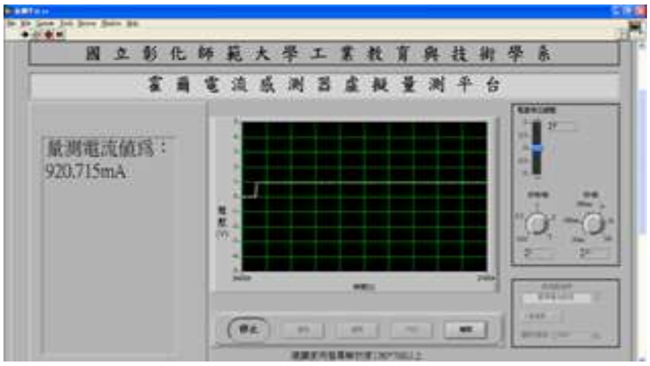


Figure 25. The current is less than 3A

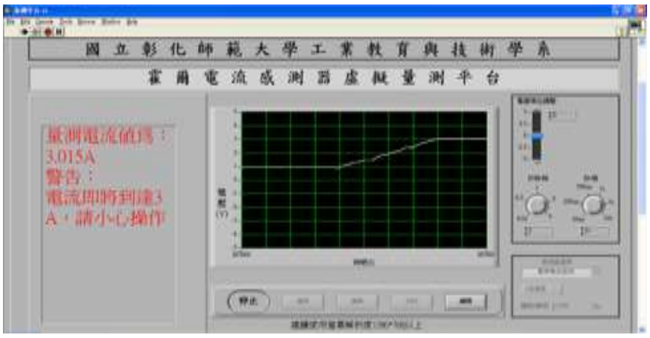


Figure 26. The current is larger than 3A

11. Light type switches

This measurement platform includes phototransistor, optical interrupter, optical fiber transmission, and infrared sensing. Figure 27 shows the measurement status when a phototransistor is chosen. When the waveform changes, the on-off state is switched when the accumulation time reaches setting time and the LED will light up. Figure 28 shows the optical interrupter action status, Figure 29 shows the optical fiber transmission action status, and Figure 30 shows the infrared sensor action status.

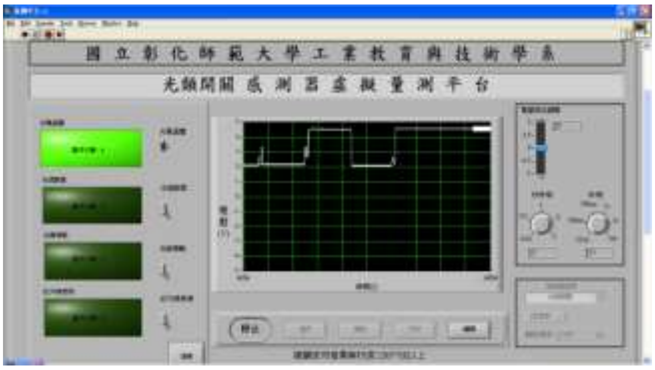


Figure 27. Phototransistor measuring status

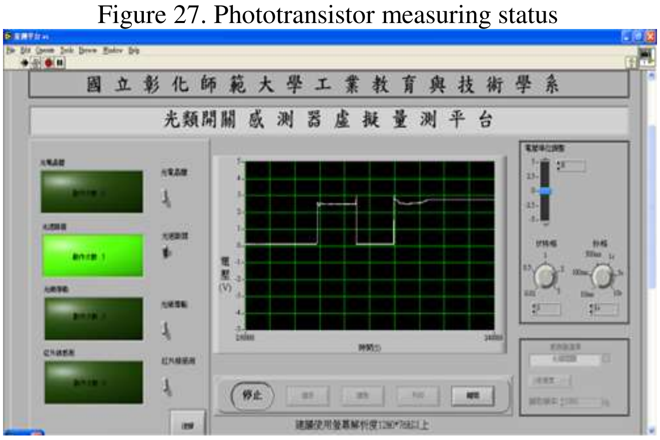


Figure 28. Optical interrupter measuring status

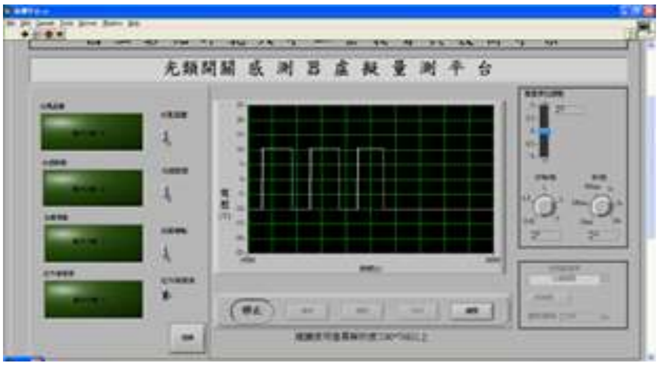


Figure29. Optical fiber transmission measuring status

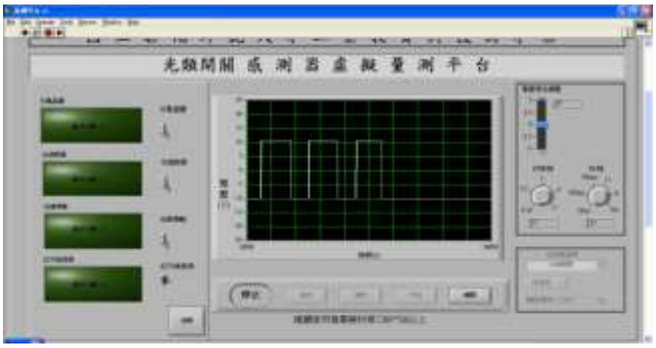


Figure 30. Infrared sensor measuring status

12. 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. Each sensor is triggered at a certain time, and the corresponding LED will light up. Figure 31 shows the magnetic red switch action status. Figure 32 indicates the status of the limit switch action. Figure 33 shows the mercury switch action status and Figure 34 shows the vibration switch action status.

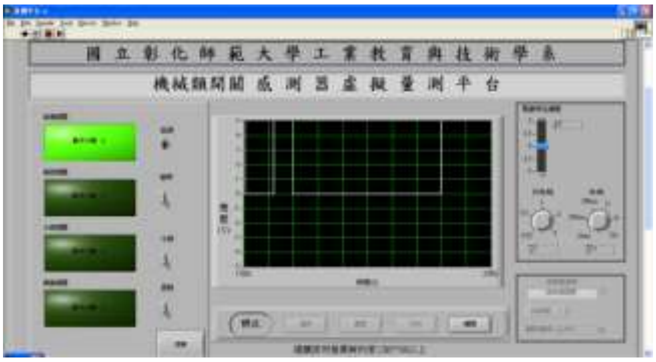


Figure31. Magnetic reed switch measurement status

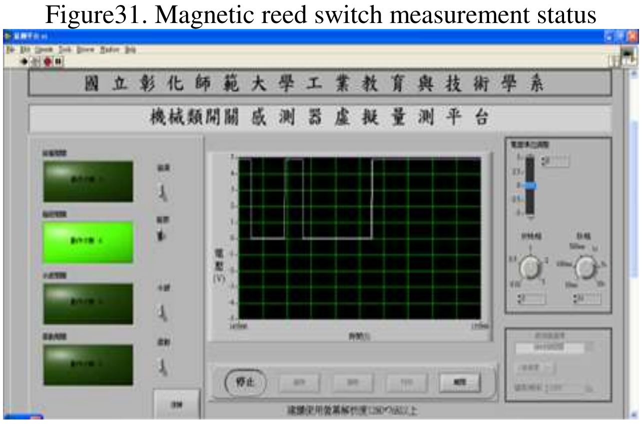


Figure32. Limit switch

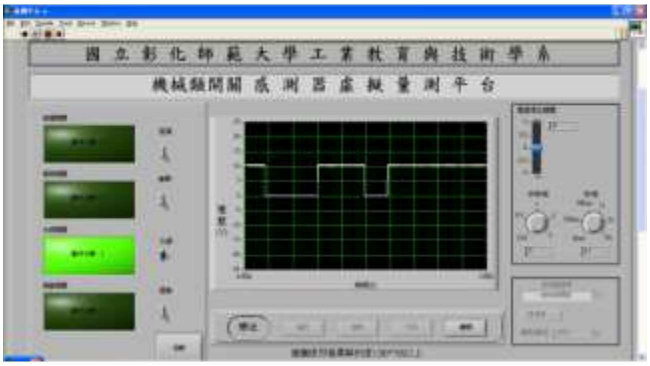


Figure 33. Mercury switch measurement status

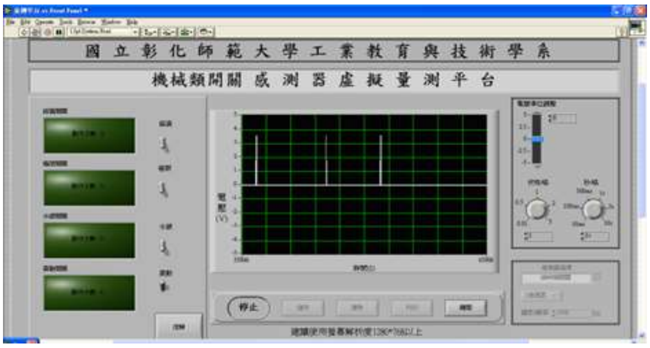


Figure34. Vibration switch measurement status

13. Ultrasonic sensor

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

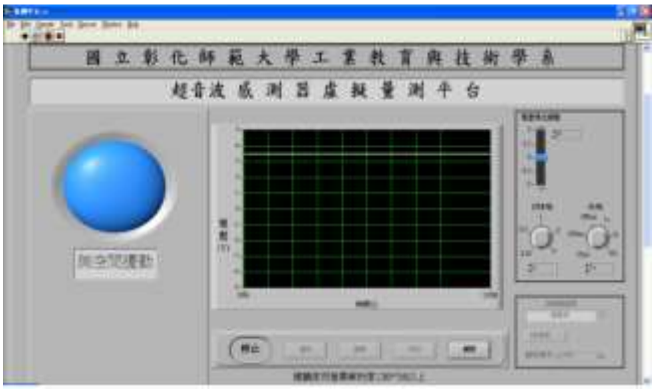


Figure 35. Measurement status when no object is blocking the path

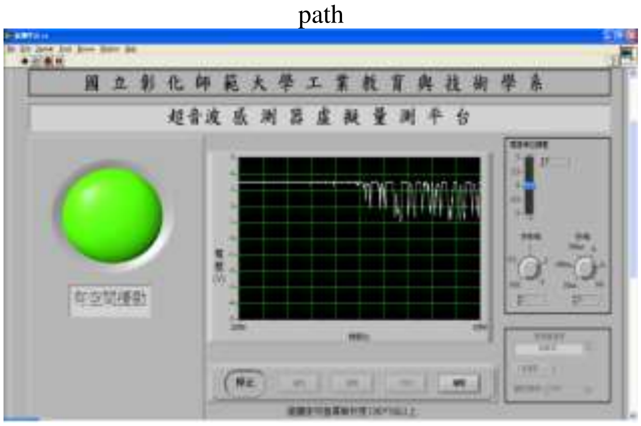


Figure36. Measurement status when an object is passing the path

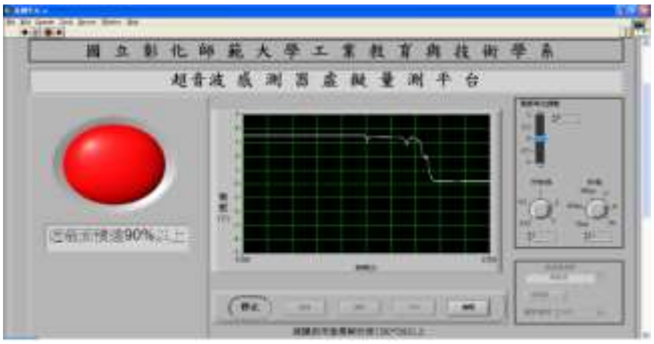


Figure 37. Blocked transmission path

14. Metal sensor

The metal sensor measuring demonstration can be observed in Figures 38 to 40. Figure 38 shows the measurement status when no metal is near the sensor. Figure 39 shows the measurement status when metal is near the sensor. Figure 40 shows when the metal is very close to the sensor. In the front panel design, different LED colors represent how close the metal is to the sensor. The panel will light up with red colored LED when metal is located close to the sensor. The panel will light up with blue colored LED when no metal is located near the sensor.

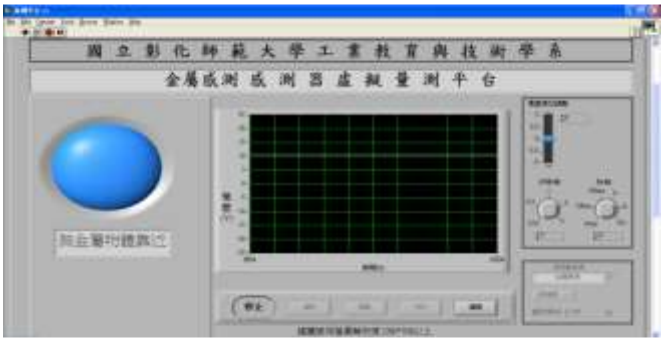


Figure 38. Measurement status when no metal near the sensor

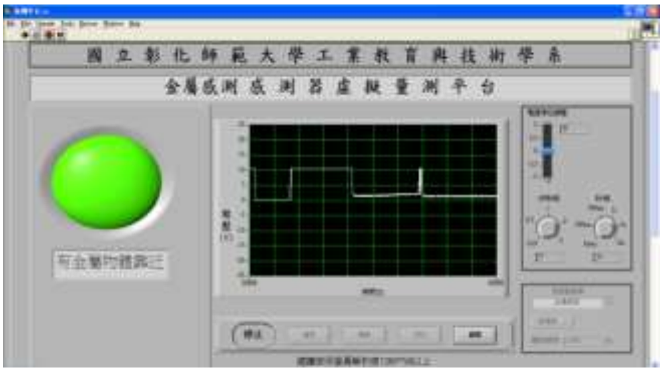


Figure 39. Measurement status when metal is near the sensor

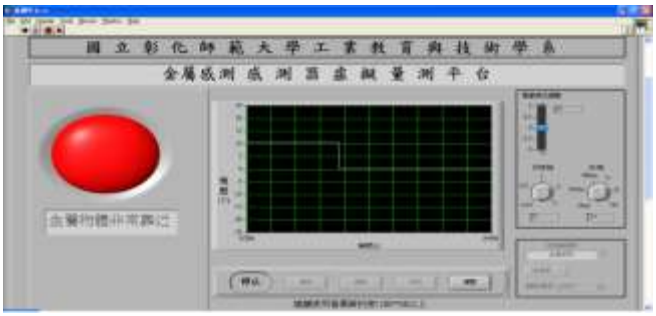


Figure 40. Measurement status when metal is located very close to the sensor

15. Magnetic sensor

The magnetic sensor measurement platform is shown in Figures 41 and 42. Figure 41 shows the measurement status when no magnetic material is near the sensor. Figure 42 shows the measurement status when magnetic material is close to the sensor, which triggered the change in color in the LED.

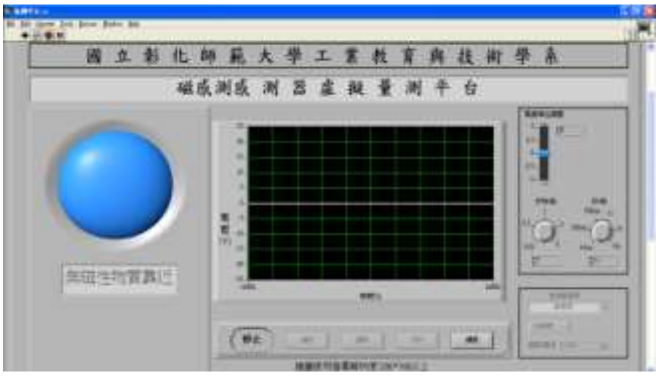


Figure 41. Measurement status when no magnetic material is near the sensor

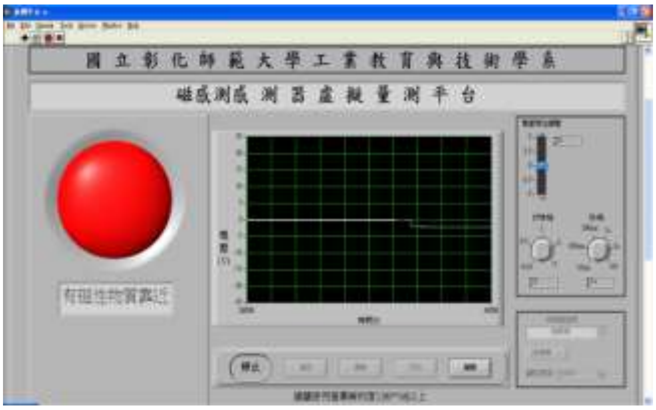


Figure 42. Measurement status when the magnetic material is close to the sensor

16. 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 indicate sensor resistance and voltage change status. Figures 43 and 44 show the photo resister measurement status. Figure 43 shows the absence of resistance change in the photo resister, and Figure 44 shows the resistance change in the photo resistor.

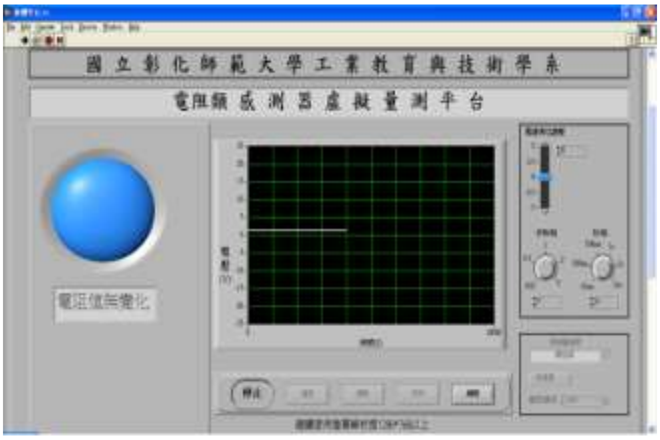


Figure 43. Panel indicating no change in resistance

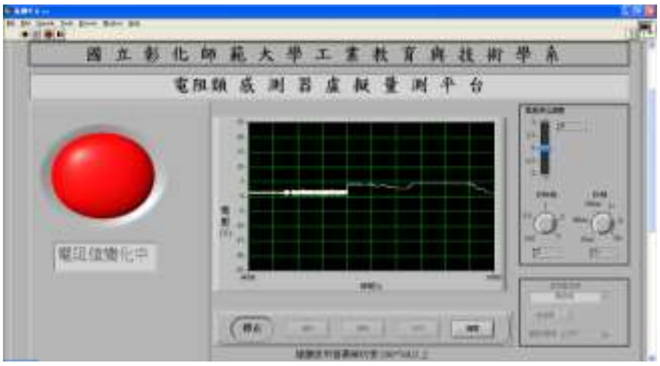


Figure 44. Panel showing change in resistance

17. Microphone

The microphone measurement platform is shown in Figure 45. The capacitance inside the microphone will change when audio is inputted.

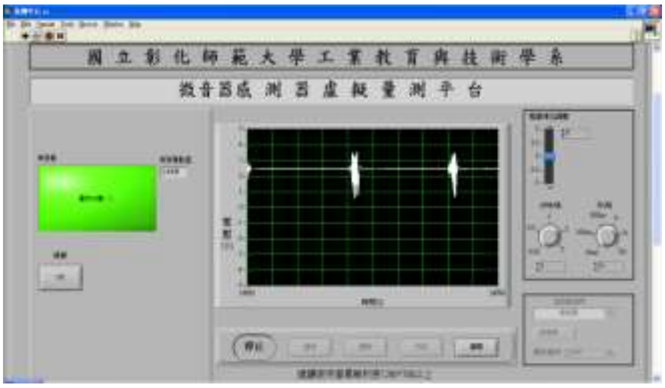


Figure 45. Microphone measurement status

18. Liquid level controller

The 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 appear at the bottom. Figure 46 shows the measurement status when the pump motor is operating while Figure 47 shows the status when the motor is not operating.

Figure 46. Operating pump motor

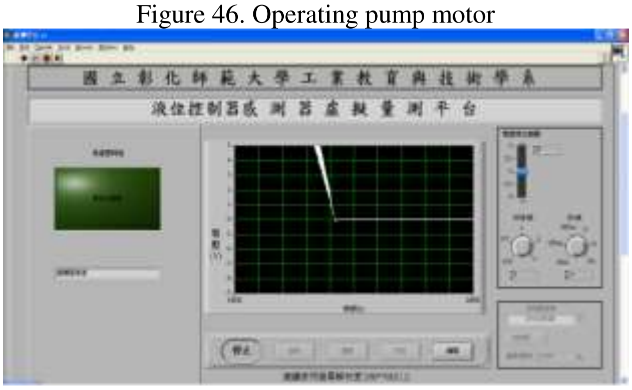


Figure 47. Non-operating pump motor

19. Alcohol / Gas concentration sensor

The alcohol and gas concentration measurement platform can be observed in Figures 48 to 51. Figure 50 shows the measurement status when alcohol and gas conversion is normal in the air. Figure 49 shows the alcohol concentration sensor when it has measured high level alcohol concentration. Figure 50 shows the gas concentration sensor when it has measured high level gas concentration.

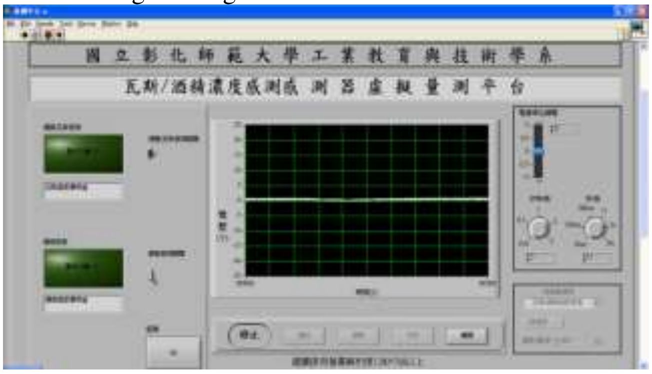


Figure 48. Normal Alcohol/Gas concentration sensors

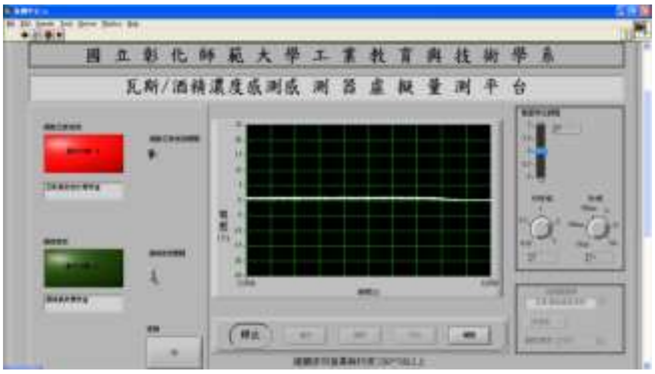


Figure 49. Working Alcohol concentration sensor

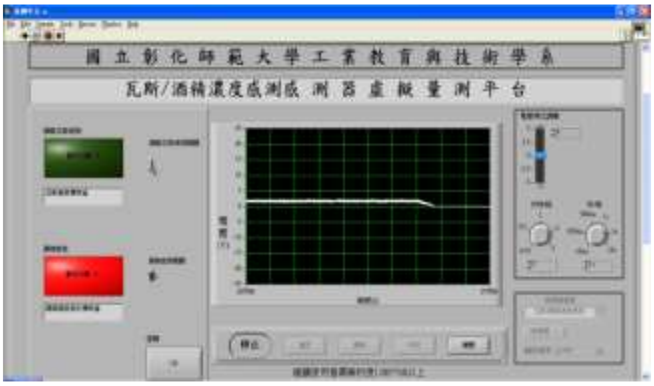


Figure 50. Working Gas concentration sensor

V. DISCUSSION

5-1. Experimental class implementation

The experimental class is offered as a requirement in Fall 2014 and Spring 2015 semesters in the Department of Industrial Education and Technology, National Changhua University of Education, Taiwan. This course is called Automatic Measurement Technology and is taught for three hours and has 3 credits. A total of 40 students were enrolled.

5-2. Experimental class evaluation

A quasi-experimental design is applied in the teaching experiment because of the newly developed teaching materials and equipment. Pre-test and post-test design methods were used in this course evaluation [16]. B. S.

Bloom proposed taxonomy for educational objectives in 1956 [17]. According to this theory, the evaluation involved three domains. In this study, the developed and designed evaluation forms included cognitive test, affective scale form, and psychomotor scale form. Figure 51 shows the schedule for the formal evaluation of the three domains. The three evaluation tools were designed and developed during the Develop and Implementation phases.

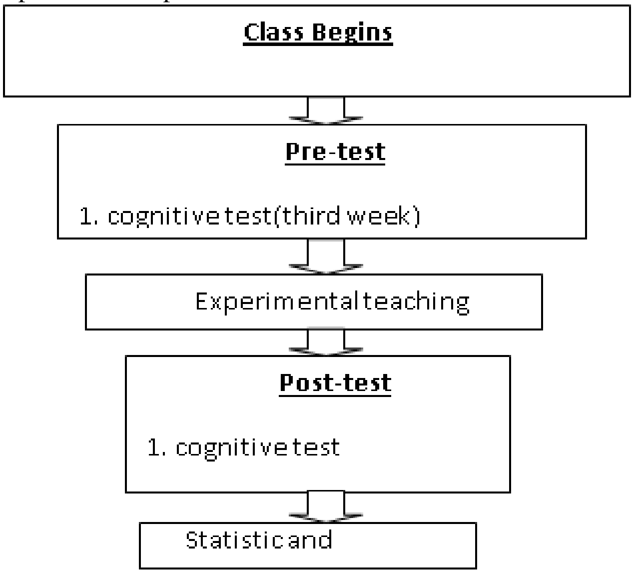


Figure 51. The schedule of formal evaluation of the three domains.

Following the time schedule in Figure 51, the cognitive, psychomotor, and affective scale tests were conducted. The results are shown below.

A. Cognitive Test Differential Analysis

The basic automatic measurement technology concept is introduced at the beginning of the course. The cognitive examination pre-test is also given. The post-test is given during the final week. Table 2 shows the paired-sample cognitive t-test results. Table 3 shows the difference between the two tests and the t-test results. The differential mean value of the two tests is M = -29.8. Moreover, t = -41.244, df = 39, and reaches .001 significance level. Therefore, after taking this class, the cognitive ability of the students became significantly enhanced.

Table 2. The paired-sample cognitive t-test statistical results

Paired variables	N	M	SD	SE	t
Pre-test	40	54.45	9.82	1.55	-41.244***
Post-test	40	84.25	9.50	1.50	

***p < .001

Table 3. Paired-sample t-test

Item		Paired difference					t	df
		M	SD	SE	95% CI UL	95% CI LL		
Paired Sample	Pre-test Post-test	-30	4.6	0.7	-31.3	-28.3	-41.244***	39

remark ：CI=Confidence Interval ；UL=Upper Limit ；LL=Lower Limit

***p < .001

B. Differential Analysis of Skill Performance

Pre- and post-tests are given to obtain the difference using the paired-sample t-test to determine the effectiveness of the developed teaching material and equipment that enhanced the skill performance of the students. In the psychomotor scale form, the full score is 50 points and lowest score is 10 points. Table 4 shows the statistical results of the paired-sample t-test for skill performance. Table 5 shows the difference between the two tests and the t-test results. It shows that the differential mean value of the two tests M = -21.83. Moreover, t = -39.222, df = 39, and reaches .001 significance level. Thus, after taking this class, the students demonstrated significantly enhanced skill performance.

Table 4. The paired-sample cognitive t-test results

Paired variables	N	M	SD	SE	t
Pre-test	40	19.10	2.22	.35	-41.244***
Post-test	40	40.93	4.26	.67	

***p < .001

Table 5. Paired-sample t-test

Item		Paired ifference					t	df
		M	SD	SE	95% CI UL	95% CI LL		
Paired Sample	Pre-test Post-test	-21.8	3.5	0.6	-23	-21	-39.111***	39

remark ：CI=Confidence Interval ；UL=Upper Limit ；LL=Lower Limit

***p < .001。

C. Affective Scale Test

Students were asked to fill out an affective scale form to understand their reactions and thoughts. The affective scale was developed by literature research and expert consultation, and contains four dimensions: learning demand, cognitive development, skills performance, and self-exploration dimension. The affective scale form was designed as a five-point Likert scale that ranked the contents as strongly agree, tend to agree, neither agree nor disagree, tend to disagree, and strongly disagree. The pilot test indicated that the developed affective scale form has reliability of α = .928. In the final week of the class, the form distributed to the students. The statistical results are shown below.

1. Learning Demand Dimension

Table 6. Mean value and standard deviation in the learning demand dimension

No.	N	M	SD
1. The teaching material content is correct and easy to read	40	4.45	.60
2. The amount and difficulty of the content are appropriate	40	4.25	.59
3. The teaching material content is logical and well organized	40	4.30	.76
4. The teaching material has good connection with the teaching	40	4.20	.65
5. The teaching material contains sufficient knowledge and practices	40	4.33	.69
6. The experimental parts of the teaching material can clearly explain the experimental process	40	4.13	.56
7. The teaching material can integrate other related professional knowledge to solve the problems	40	4.18	.68

2. Dimension of Cognitive Development

Table 7. Mean value and standard deviation in the cognitive development dimension

No.	N	M	SD
1. The goal of each chapter clearly expresses the key points of learning points	40	4.45	.64
2. The teaching material can help me to learn more new professional concepts in this field	40	4.18	.64
3. The quiz provides a proper assessment of learning	40	4.18	.78
4. The teaching material can enhance my application ability	40	4.18	.68
5. The teaching material and experimental equipment stimulate personal learning motivation and interest	40	4.15	.86
6. The teaching material corresponds with the experimental Equipment	40	4.43	.67
7. The teaching material and experimental equipment inspire me to develop new products	40	4.35	.70

3. Skill Performance Dimension

Table 8. Mean value and standard deviation in dimension of skill performance

No.	N	M	SD
1. The course helps to increase LabVIEW programming and analysis ability	40	4.25	.71
2. The course and teaching materials excite me to apply myself to LabVIEW programming	40	4.40	.63
3. The course promotes personal knowledge and skills in understanding the computer measurement instrument structure	40	4.38	.54
4. This course and teaching materials can improve practical skills on circuit failure detection and removal	40	4.15	.92
5. This course promotes personal innovative ability in this profession	40	4.10	.81
6. The teaching material and experimental equipment provide an opportunity to learn a different technical profession	40	4.20	.79
7. This course promotes personal multi-dimensional professional skills	40	4.03	.70

4. Self-Exploration Dimension

Table 9. Mean value and standard deviation in the exploration dimension

No.	N	M	SD
1. The skill training in this course matches industry needs	40	4.25	.90
2. This course contains professional skills and knowledge on automatic measurement technology	40	4.25	.63
3. This skills training in this course matches the skill needs of industry automatic measurement technology	40	4.35	.74
4. This course can assist me in understanding the current trends in industry automatic measurement technology	40	4.20	.65
5. This course helps me understand whether I am fit for this professional field.	40	3.88	.88
6. This course increases my practical experience in automatic measurement technology.	40	4.05	.90
7. The course offers a personal professional advantage for future jobs	40	4.45	.96

Table 10 shows the mean value and standard deviation of the four dimensions. The mean values are 4.26, 4.27, 4.21, and 4.13. The results indicate that the four dimensions tend to agree, reaching an average of 4.22.

Table 10. The mean value and standard deviation of four dimensions

Dimension	Question Numbers	N	M	SD
1.Learning Demand	7	40	4.26	.37
2.Cognitive Development	7	40	4.27	.47
3.Skill Performance	7	40	4.21	.50
4.Self-Exploration	7	40	4.13	.58
Total	28	40	4.22	.44

The three domains are discussed further as follows.

1. Professional cognitive domain

In the cognitive post-test performance, the post-test for the constructive teaching material yielded better results than the pre-test. The t-test results indicated that the developed teaching material and teaching equipment assisted the students in performing well in the cognitive test. The analysis results indicated an evident difference between the pre-test and the post-test.

2. Skill performance domain

In the psychomotor post-test performance, the post-test using the developed teaching material and training equipment that included constructive teaching strategy yielded better results than the pre-test. The results of the t-test indicated that the constructive teaching strategy aided the students in performing well in the psychomotor test. The analysis results highlighted an evident difference between the pre-test and the post-test.

3. Affective domain

(1) In terms of the learning demand dimension, the teaching material content was accurate and easy to read. The material was well-organized and logically arranged, providing sufficient knowledge and practices. The experimental parts of the teaching material clearly explained the experimental process.

(2) In terms of the cognitive development dimension, the goal of each chapter clearly expressed the key learning points. The teaching material corresponded with the experimental equipment, thereby inspiring the development of new products.

(3) In terms of the skill performance dimension, the course and teaching material contributed to the excitement to learn Labview programming, and promote knowledge and skills in understanding the structure of the computer measurement instrument.

(4) In terms of the self-exploration dimension, most students who enrolled in the course opined that the course contained professional automatic measurement technology skills training. This course matched the skill requirements of the automatic measurement technology industry. The course also offers a personal professional advantage for future jobs.

VI. CONCLUSION

In this paper, an industry-oriented automatic measurement platform has been developed by applying the virtual instrument and used in the Automatic Technology Course as teaching equipment. The automatic measurement technology has instant data measurement acquisition and can save data for further processing and application. The automatic measurement system has efficient programmable features, equipment integration, control applications, cost, function, and maintenance. In this research, the LabVIEW platform is used to develop the multi-function automatic measurement platform. Compared with other software, this graphical design tool is more powerful and user-friendly. The programmable features allow users to adjust the measurement function at any time. The results of the experiment course and evaluation indicated that this developed platform can be an effective teaching aid to train people in the field of automatic measurement technology. This research work integrates basic technology sensors and measurement device applications, advanced technology, virtual instrument, and industry-oriented integrated technology into a comprehensive automatic measurement technology.

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