AIR-COUPLED GPR SYSTEM USER GUIDE

Subsurface Sensing Lab
Electrical and Computer Engineering
University of Houston
4800 Calhoun Road
Houston, TX 77004
Phone: (713)743-4421
Fax: (713)743-4444
http://www2.egr.uh.edu/~elee52c/

Safety Instructions

- This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.
- **Warning**: Changes or modifications to this device not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC RF Exposure Compliance

This GPR device has been tested and complies with the Federal Communications Commission (FCC) RF exposure limits for the General Population/Uncontrolled exposure environment.

Table of Contents

Table of Figures

1. INTRODUCTION

The GPR technique is based on measurement of travel time and reflection amplitude of a short electromagnetic pulse wave that transmits through a medium. It provides continuous and nondestructive measurement compared to traditional highway detection methods, and is widely applied in thickness measurement, crack detection and pavement moisture content measurement.

1.1 Measurement principle

A GPR system is mainly composed of six parts: a transmitter, a transmitting antenna, a receiver, a receiving antenna, a control/circuit unit (including controlling, sampling, filtering and amplifying functions), and a laptop computer with data acquisition card, used to control the GPR system and process sampled data. When the control unit receives a command from the computer, it triggers transmitter to emit a short pulse wave into space via the transmitting antenna. At the same time, the control unit also sends a command to the sampling unit to get the unit ready for the coming reflected signals. The transmitted wave from the transmitting antenna will propagate in all directions in space, and part of it will penetrate into pavement. When the penetrated wave encounters any subsurface interfaces or rebars, it will be reflected back and be picked up by the receiving antenna. There is also a another part of the transmitted wave propagating directly from the transmitting antenna to the receiving antenna or from the transmitting antenna to pavement surface and then bouncing back to the receiving antenna, which is called direct wave. The received signal is then transferred to the laptop by the sampling unit and data acquisition card. By processing the received signals, the thickness, dielectric constant and rebar information of the pavement can be obtained.

1.2 System block diagram

The block diagram of the radar thickness measurement system is shown in Fig. 1.1.

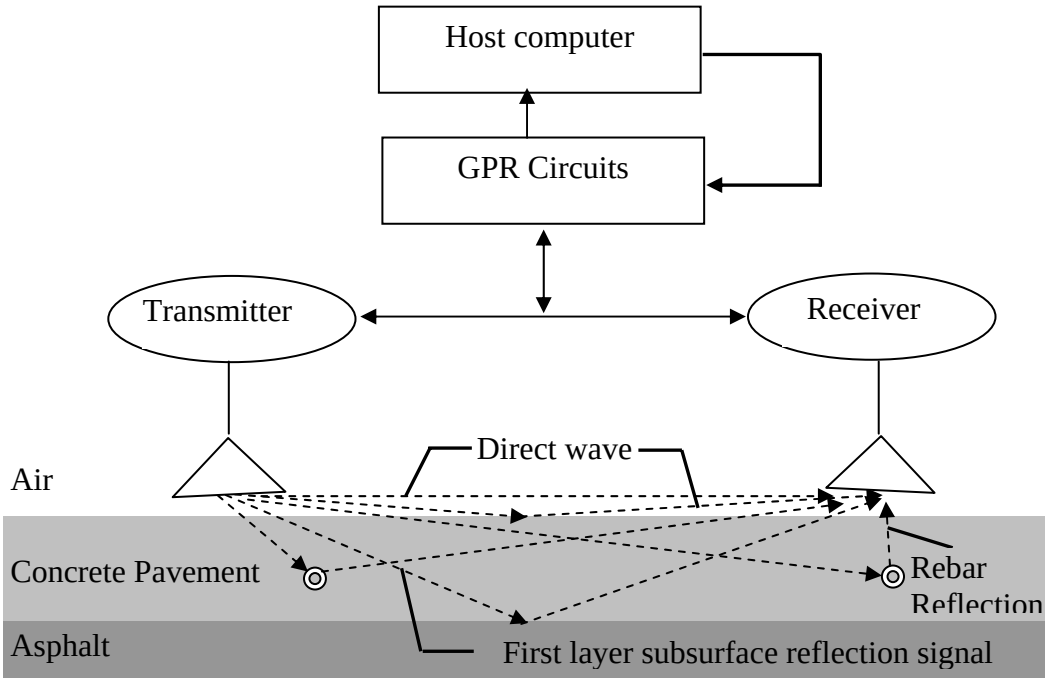

Figure 1-1 Block diagram of the GPR system

1.3 Performance description

The GPR system developed in this project is shown in Figure 1.2. On the cart is installed the encoder, which is used for distance calculation. Inside the black box just above the ground, there are a transmitting antenna and a receiving antenna. The other black box on the cart contains the control/circuit unit, the rechargeable battery and the charger. On the back, there are connection sockets to the encoder, transmitter, and receiver and the power for charging the battery. The output signal is digitized and displayed in the laptop computer.

Figure 1-2 GPR system mounted on a vehicle for measurements

The system main parameters are as follows:

1) Center frequency 400MHz;
2) Repeat rate of pulse radiation: 50kHz;
3) Transmitter pulse amplitude 16 - 100 Vp-p;
4) Maximum Penetration Depth: 4 meters in dry soil;
5) Transmit Pulse Width: 1.25 ns;
6) Receiver's Time Window: 20 – 60 ns adjustable;
7) System Clock: 25 kHz;
8) Digitization Resolution: 12 bits;

9) Antenna Type: Bowtie antenna;

10) Power Consumption: 0.37 A at 12 VDC. This is the total power consumed by the GPR system;

11) Maximum recorded trace number for each continuous measurement: 10240;

12) Maximum trace number in one page for multi-trace display: 512, total maximum 20 pages=10240/512;

13) With the software, you can either start a new measurement, save results, or open saved files. Friendly software interface provides a multi-trace map display, single trace display, thickness results and statistical results. From the multi-trace map, the colorful underground information is displayed, and detailed trace information can be obtained from a single trace display. Also, convenient buttons and menus are easily operated. You can also obtain the thickness profiles from the saved results.

2. HARDWARE INSTALLATION

2.1 GPR device

Figure 2.1 shows the developed GPR device. The white GPR box contains a transmitter, a receiver, a transmitting antenna and a receiving antenna. A 5-core cable is used to transfer data from and provide power to the GPR device.

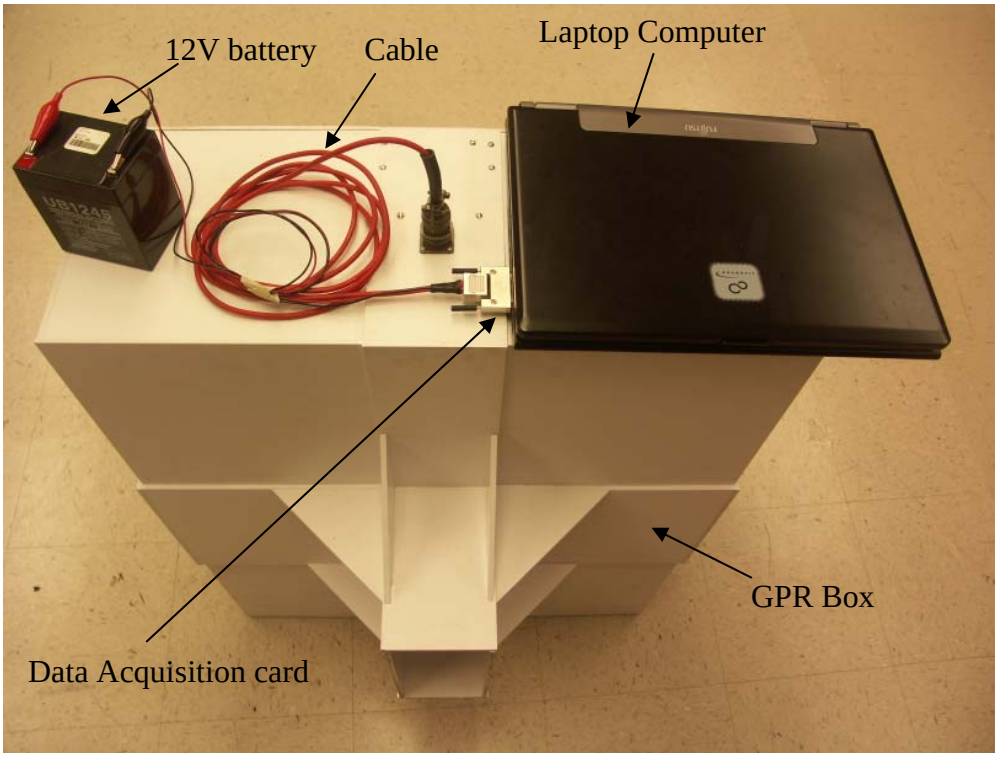

Figure 2-1 Developed GPR

2.2 Physical connection of GPR system

Figure 2.1 also shows physical connections of the GPR system. The GPR device and laptop computer are physically connected through a red cable, and two crocodile clippers hook to a 12V battery. Once the power is supplied, the GPR is working and the GPR data can be acquired and stored to the computer using installed software.

One way to implement this system is to install it onto a pushcart as illustrated in Fig. 1.2. The operation of the system will be explained in next section.

Warning: when hook to the battery, make sure the red clipper goes to positive pole and the black clipper goes to the negative pole of the battery. Otherwise may cause damage to the device.

3. SOFTWARE OPERATION AND DATA INTERPRETATION

3.1 Interface description

Figure 3.1 shows the interface of GPRView software on the laptop computer for GPR application.

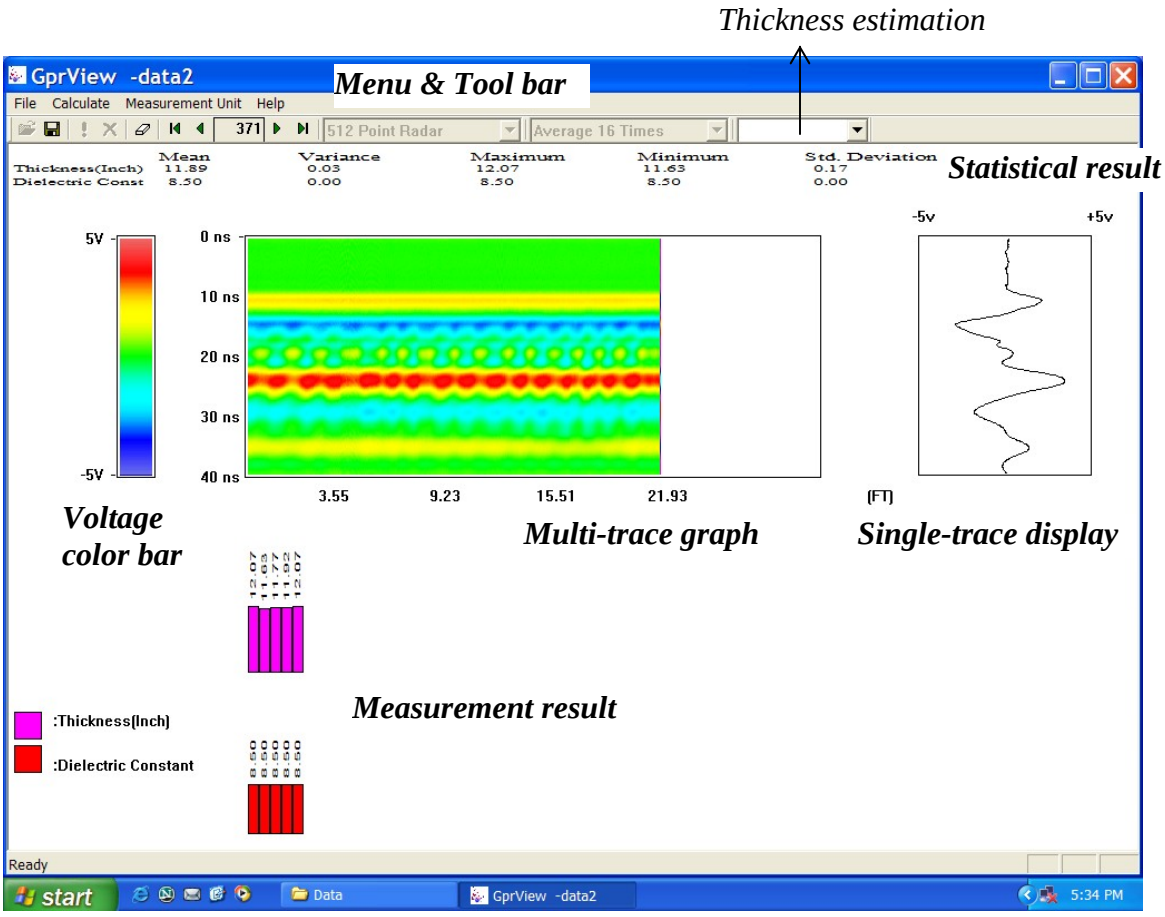

Figure 3-1 The interface for the GPRView software

There are several partitions in the interface. From the top are,

Menu and tool bar: function menu and icons. The **toolbar buttons** are, from left to right:

- **Open,** open a saved file, Multi-trace graph, Single-trace display. Measurement result and Statistical result will be updated respectively, and then you can press **Previous page trace**, **Previous trace, Next trace**, and **Next page trace** to see trace detail, or **Erase**
- **Save,** save current measurement result
- **Start,** start a new measurement
- **Stop,** stop the current measurement, then you can review the results, or press **Previous page trace**, **Previous trace, Next trace**, and **Next page trace** to see trace detail, or **Save**, or **Erase**
- **Erase,** erase the current result, then you can press **Start** for a new measurement or **Open** for a saved file
- **Previous page trace,** change the current trace to the corresponding trace on the previous page, if the current trace is on the first page, it will change to the first trace
- **Previous trace,** change the current trace to the trace just before it

  Current trace index (display only)
- **Next trace,** change the current trace to the trace just after it
- **Next page trace,** change the current trace to the correspondent trace on next page, if the current trace is on the last page, it will change to the last trace

  Radar type (display only)

  Stacking number (display only)

  Thickness estimation drop box, in which 7 selections are listed: 6-8, 8-10, 10-12, 12-14, 14-16, 16-18, and 18-20. It is recommended that you select the estimated thickness range before measurement; the default is10-12 inches if there is no selection. The estimated range provides a guide for the software to search the best-matching result around it, which does not confine the GPR result within the estimated range.

For the menus:

File, include the open file menu and save file menu, which provide the same functions as those by clicking the icons  and  respectively

Calculate, un-accessible, for algorithm debug only

Measurement unit: English or Metrics; default English

Statistical result: statistical analysis of the measurement result.

Color bar: relationship between color and signal value for the Multi-trace bar.

Multi-trace graph: a three-dimensional chart. The x-axis means moving distance. When you move the radar on the ground, the traces and their distances are displayed from left to right. The y-axis actually means the propagation time, the same meaning as y-axis in the single-trace chart. The color means value indicated in the color bar.

Single-trace display: also current trace chart (the trace index is shown on the current trace index display of the toolbar). The x-axis means signal value, the y-axis means propagation time.

Measurement result: the thickness and dielectric constant information. Each bar provides the result of one measurement cycle, not of one trace, because the algorithm needs several traces (one measurement cycle) to locate the rebar location and cancel its effect. Since several traces cover at least one time distance between adjacent rebars, we set it at approximately 4 feet.

3.2 Software operation

Note:

When you want to start the measurements in a different folder, copy GPRview.exe together with wavelet.dat to the new folder.

3.2.1 Start a new measurement

1. Double click the GPRView.exe on desktop
2. Select the estimated thickness range and preferred measurement unit (optional)
3. Click the **Start** to start a new measurement
4. Move the cart slowly; the interface will update as the cart moves forward
5. Click the **Stop** to stop the measurement
6. See the results or click **Previous page trace**, **Previous trace, Next trace**, and **Next page trace** for trace detail
7. If useful, **Save** the result
8. **Erase** the result, then go to I.2 for a new measurement or II.2 to open a new file

3.2.2 Open a saved file

1. Double click the GPRView.exe on desktop
2. Click **Open** to look for the saved file; the interface will update according to the saved file
3. See the results or click **Previous page trace**, **Previous trace, Next trace**, and **Next page trace** for trace detail
4. **Erase** the result, then go to I.2 for a new measurement or II.2 to open a new file

Tips: Except for 3.2.1 and 3.2.2 to see the trace detail, you can also click the mouse at your interested parts in the multi-trace chart. The current trace will change to the trace, which you click, and at the same time a horizontal line and a vertical line will appear for reference; then you can move around by **UP**, **DOWN**, **LEFT** and **RIGHT** on the keyboard for details. If you press outside the multi-trace chart, the horizontal line and the vertical line disappear and the multi-trace chart is updated.

Note:

When you want to save the results, the file name should not include the dot(.); for example, **FebResult.** Then four files are created to save the results: **FebResult, FebResult.dis, FebResult.cle, FebResultthickness.dat**.

The next time you want to open the file by GPRview.exe, open the one with the exact name such as **FebResult,** with no suffix, no appended characters.

Among the four files**,** the **FebResultthickness.dat** file provides you with the measurement results like thickness, dielectric constant, start distance and end distance, from which you can get the thickness profile through Excel.

If you want to move the saved file to another folder, move the four files together.

3.3 Data interpretation

Multi-trace chart: visual information of measured trace. In Fig 4.1, the periodicity represents the periodical existence of rebar underground. You can also get the approximate horizontal position of rebar with this chart as well as a

vertical location by combing with the **Single-trace charts** for the subsurface reflection.

Single-trace chart: detailed information for current trace

Measurement result: the thickness and dielectric constant information of one measurement cycle, which are obtained from several traces covering at least one time distance between adjacent rebar.

Statistical result: statistical analysis of the measurement result.

Later, rebar locations can also be added into the measurement results after the new algorithm is mature.

Thickness profile:

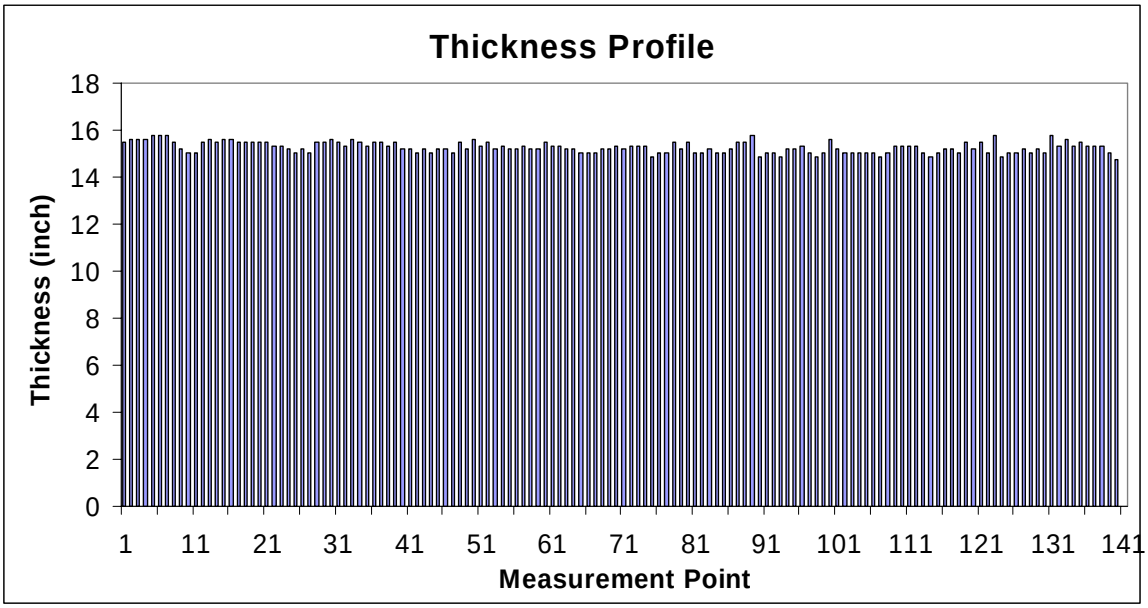

Figure 3-2 GPR thickness over 1000 FT I-45 N. Conroe, Site 1091-1081

4. TROUBLESHOOTING

In the case a problem occurs, refer to the following contents for possible solutions.

Table 4-1 List of possible errors and solutions

Problems	Causes	Solutions
No signal or wrong information when you just start a measurement	Power off or Connection problem	1. Check battery capacity; 2. Check if the power is on; 3. Check the encoder cable; 4. Check PCMCIA cable's connection status.
File open error	Wrong files	1. Make sure opened the right file name; 2. no appended characters; 3. if files are moved to a new folder;
Too less traces after a certain distance	Speed is too fast	Slow down GPR cart speed
No error in old folder, but error appears when GPRview.exe is copied into a new folder	Forget the calibration data file Metal-ref.dat	When you want to start the measurements in a different folder, copy GPRview.exe together with **Metal-ref.dat** to the new folder.

Note: When you want to disconnect the PCMCIA cable, do it after you shut down the computer in case you disconnect the PCMCIA card unintentionally. And if the PCMCIA card is moved out, re-insert it before you power on the computer. When you start a new measurement, there is an error like no signal, follow the next tip.

Tips: After complete the solution table above, you still can not obtain any signal, you need to check if the PCMCIA card works correctly. Follow the following procedures.

From "**All Programs" button in Windows' start menu,** click **Measurement and Automation** and a window shown in Figure 4-1 will appear. Expand **Devices and Interfaces;** the device number **DAQCard 6062E** should be in the list.

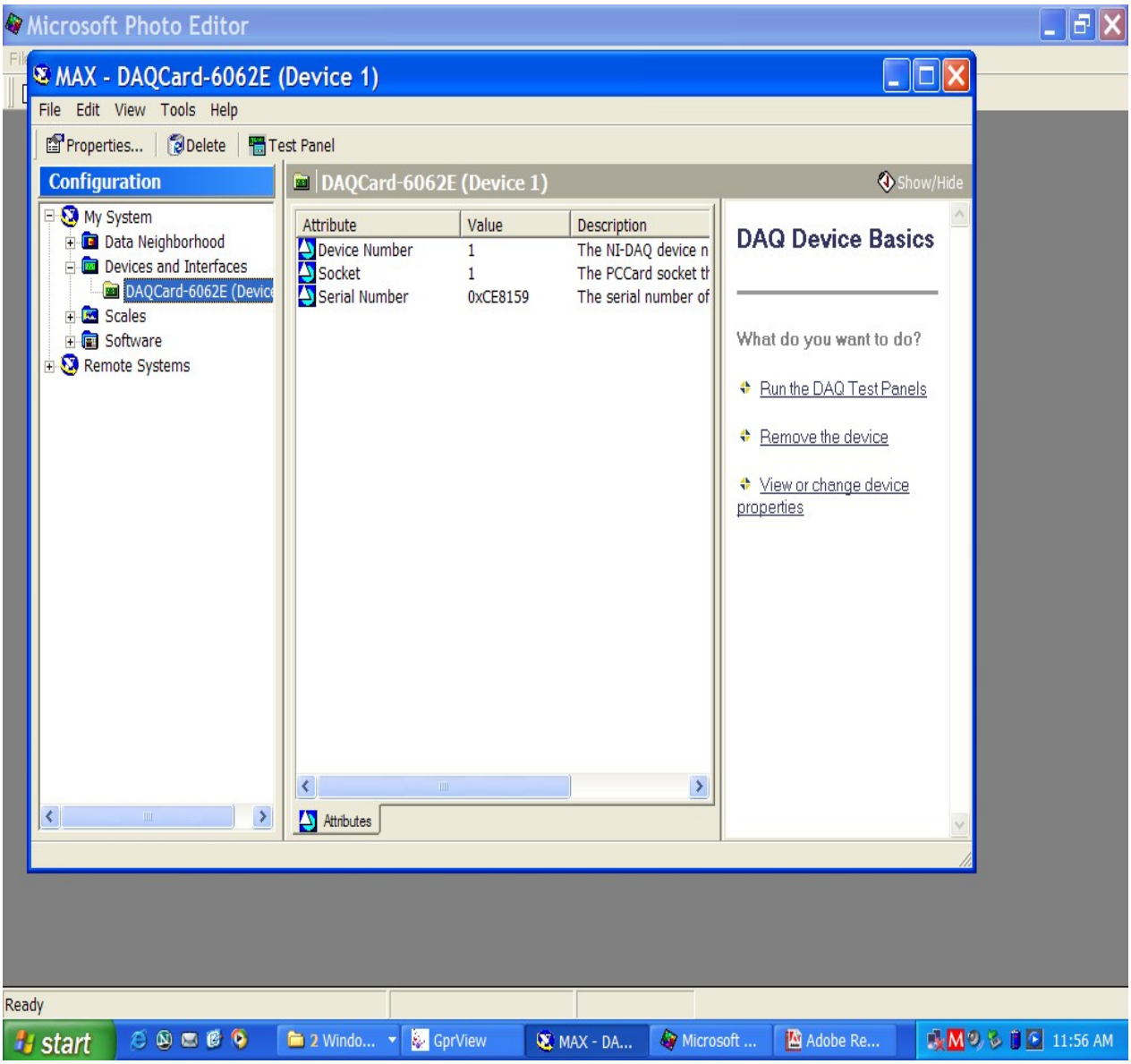

Figure 4-1 Data acquisition card interface

Right click on **DAQCard 6062E** bar**,** a dropdown window will show a few item like "Test panel", "Delete", and "Properties" as given in Figure 4-2. Press the "**Test panel"** menu, if an error message pops up as shown in Figure 4-3, the DAQ card is not working. At this moment, click yes to continue, then go to Figure 4-4.

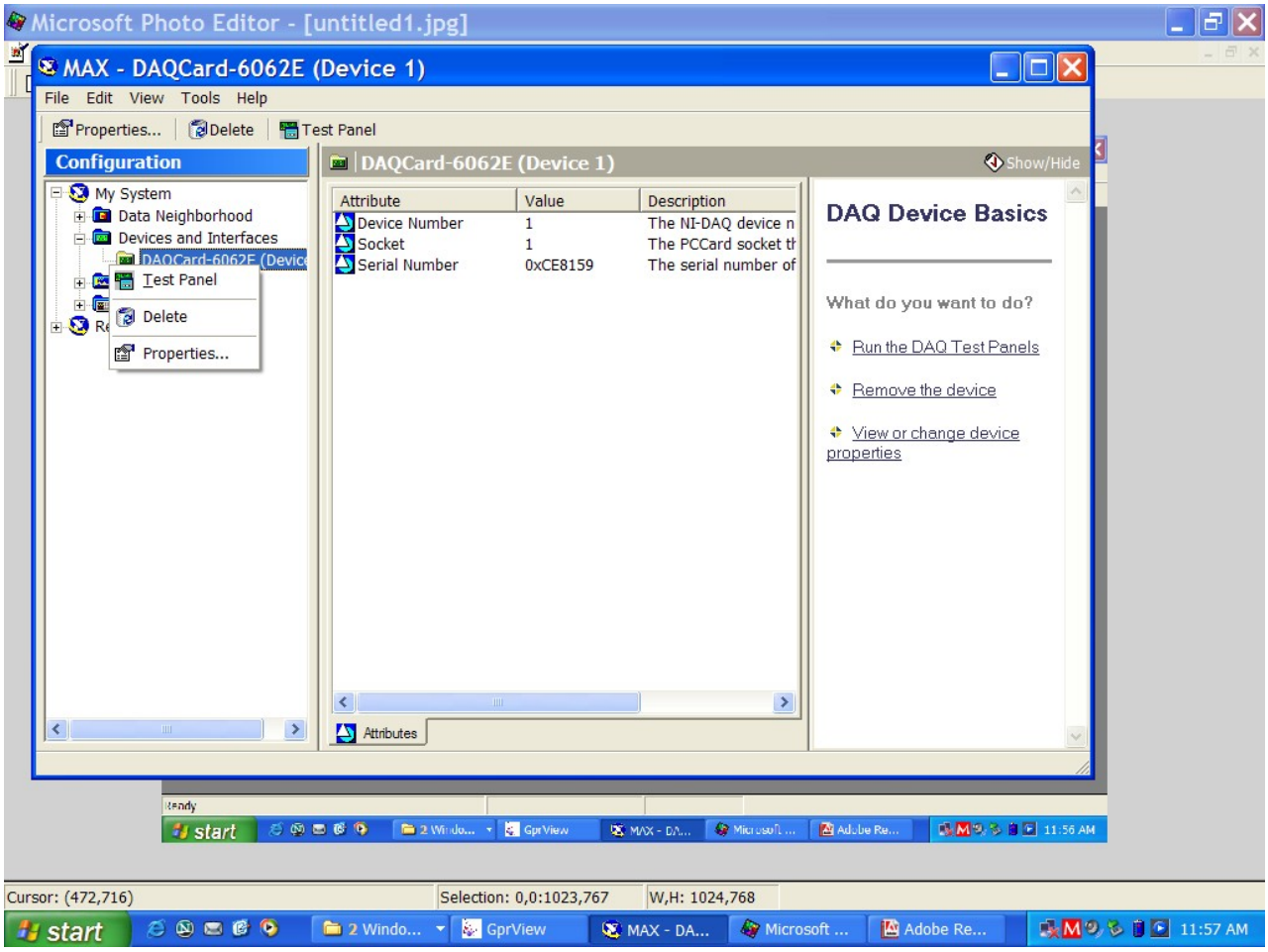

Figure 4-2 Contents in the dropdown window

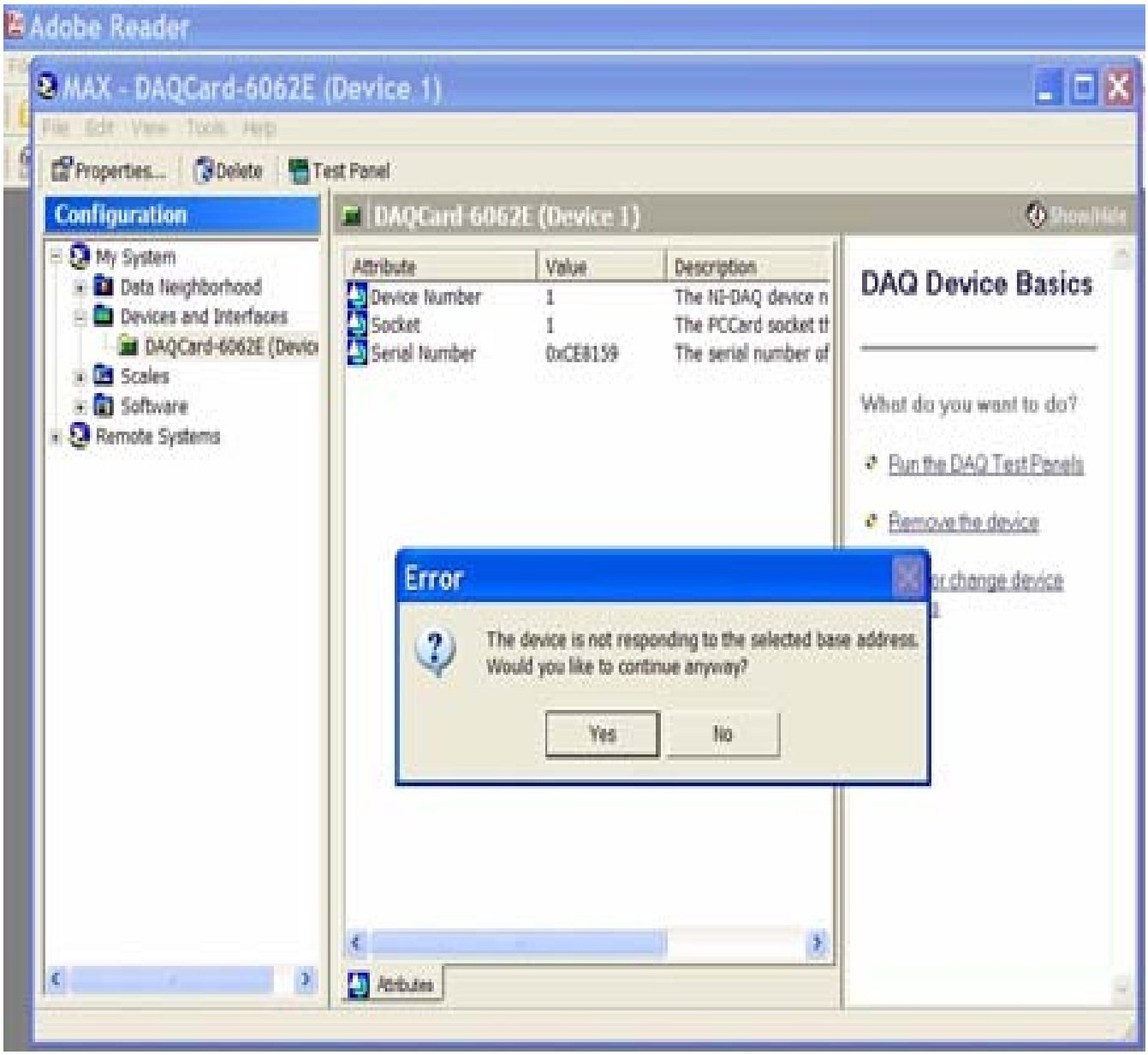

Figure 4-3 Error message pops out when the DAQ card is not working

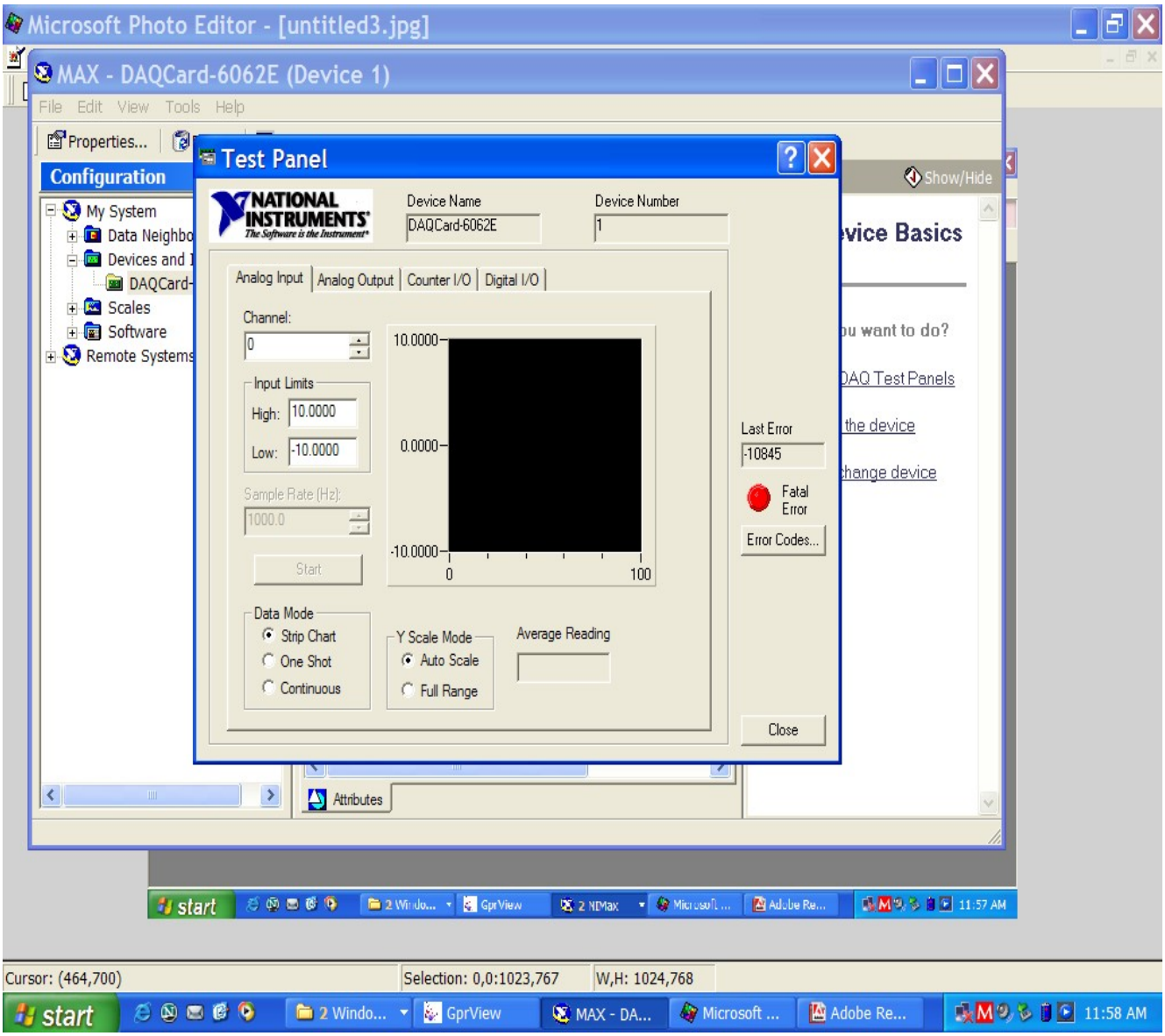

Figure 4-4 Error indicator of the DAQ card

If the error indicator is **red** in Figure 4-4, which means the problem is caused by the data acquisition card driver. Then select **DAQCard 6062E** tab, and press **Delete** on the keyboard. A window will pop out to let you make sure that you want to delete the DAQ card like shown in Figure 4-5.

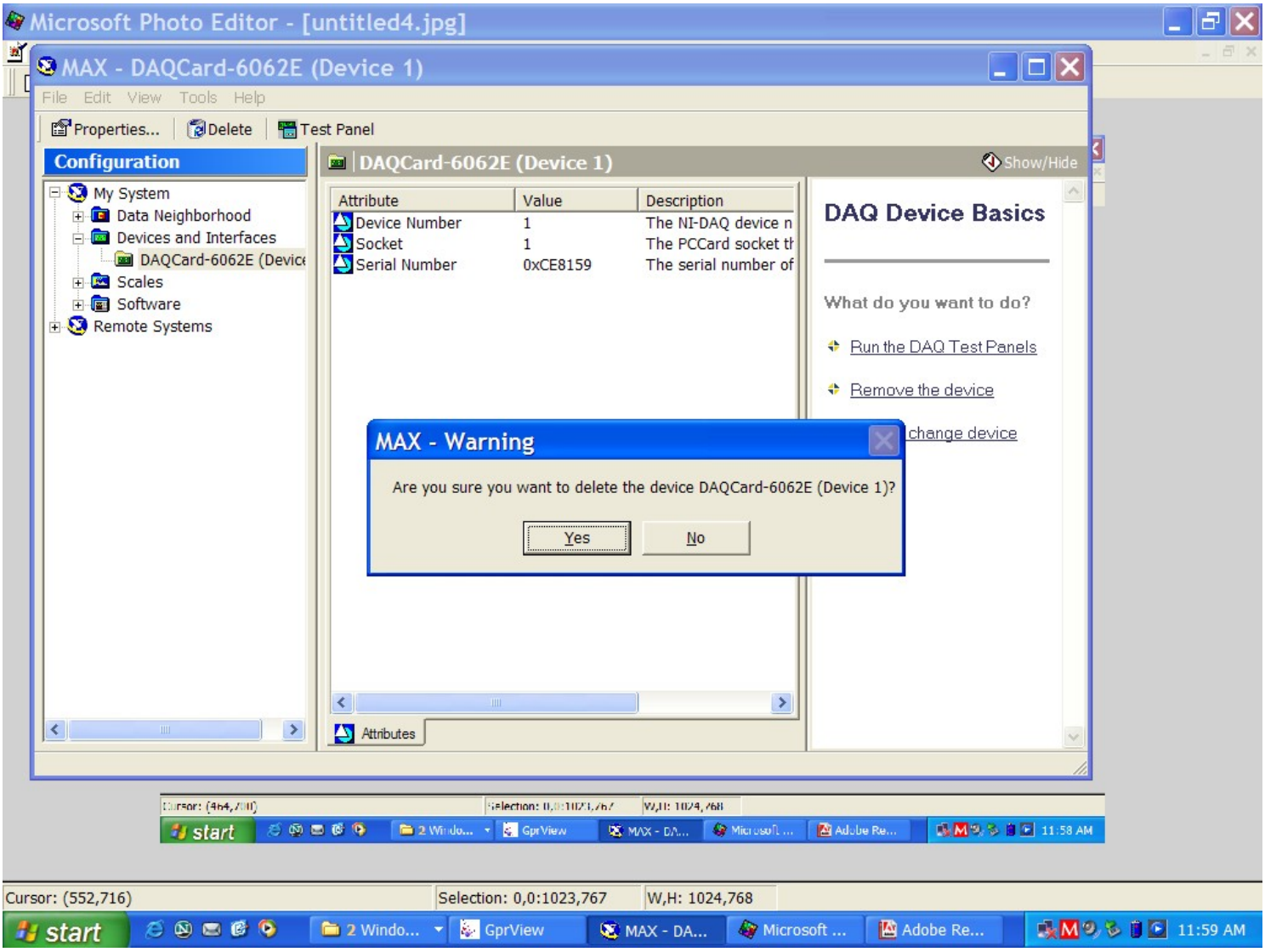

Figure 4-5 make sure to delete the DAQ card

After click “yes” in Figure 4-5, the card information will disappear from the device list in the interface as shown in Figure 4-6.

Figure 4-6 Empty device list at the interface

Restart the computer. A "Found new hardware" wizard appears as in Figure 4-7. Choose the recommended installation, then go to Figure 4-8 and 4-9.

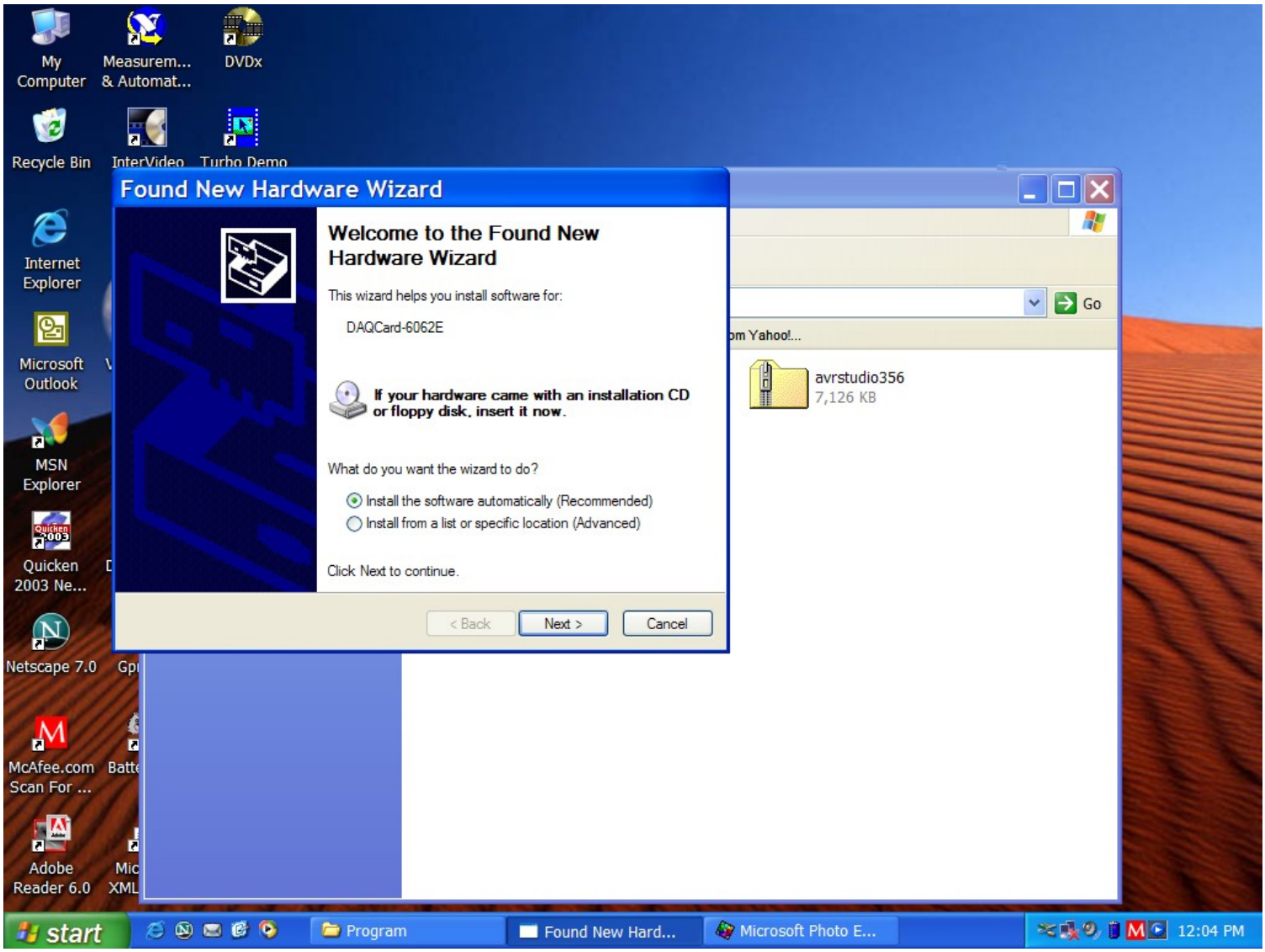

Figure 4-7 "Found New Hardware" wizard

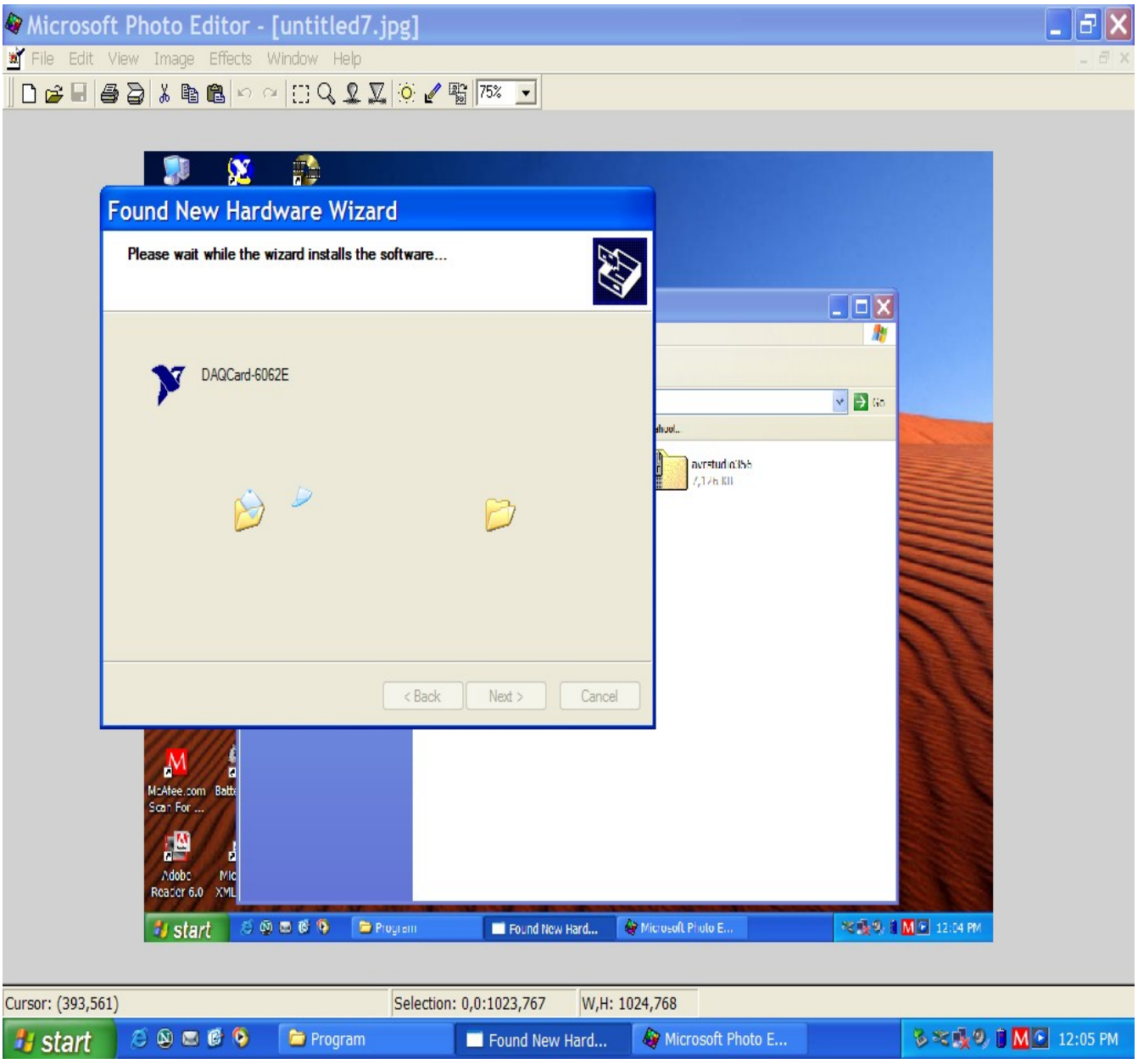

Figure 4-8 Install DAQ card driver

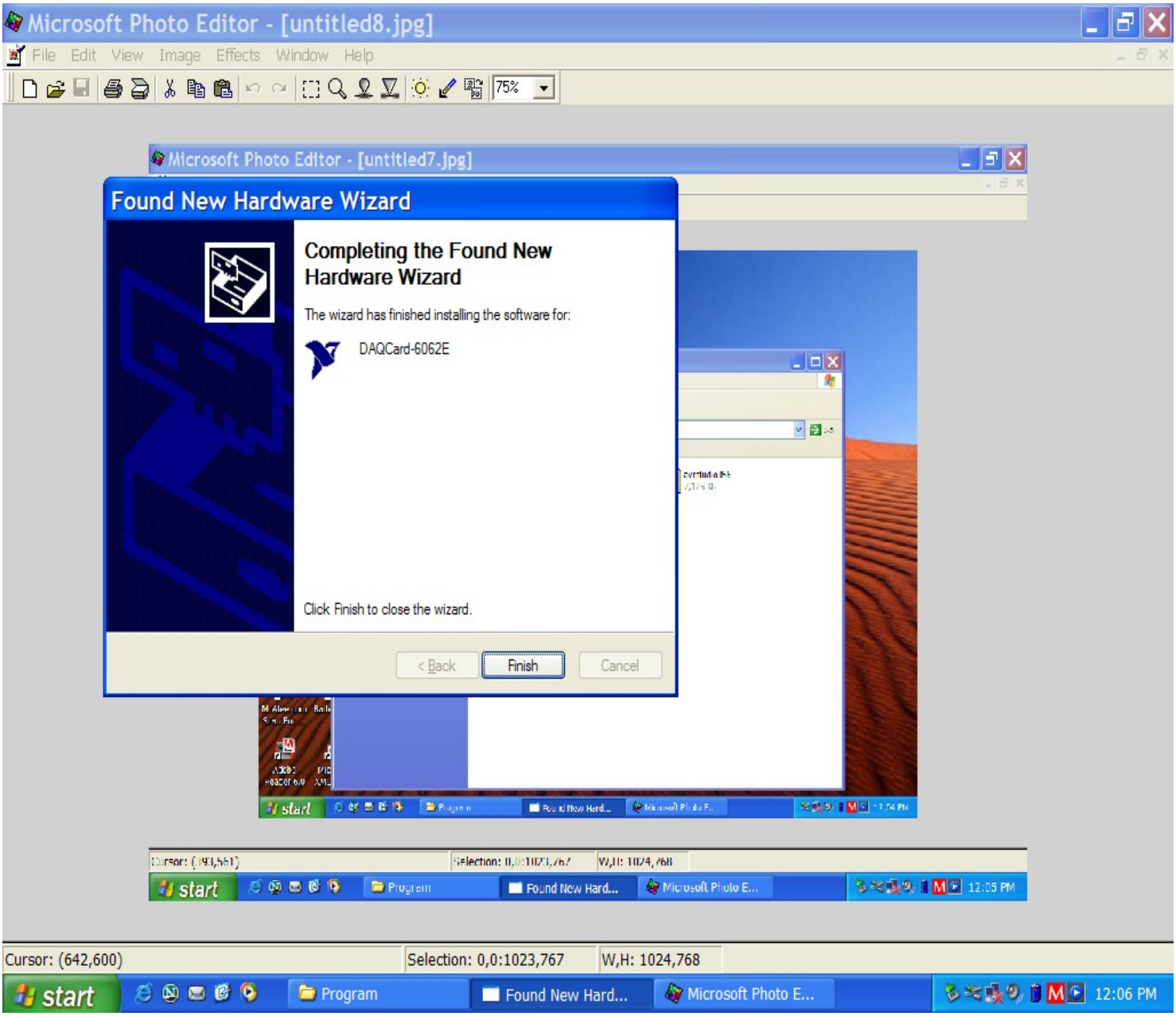

Figure 4-9 Finish driver installaion

Open **Measurement and Automation,** click menu **View->Refresh.** The device of **DAQCard 6062E** will appear under **Devices and Interfaces** as in Figure 4-10 and Figure 4-11.

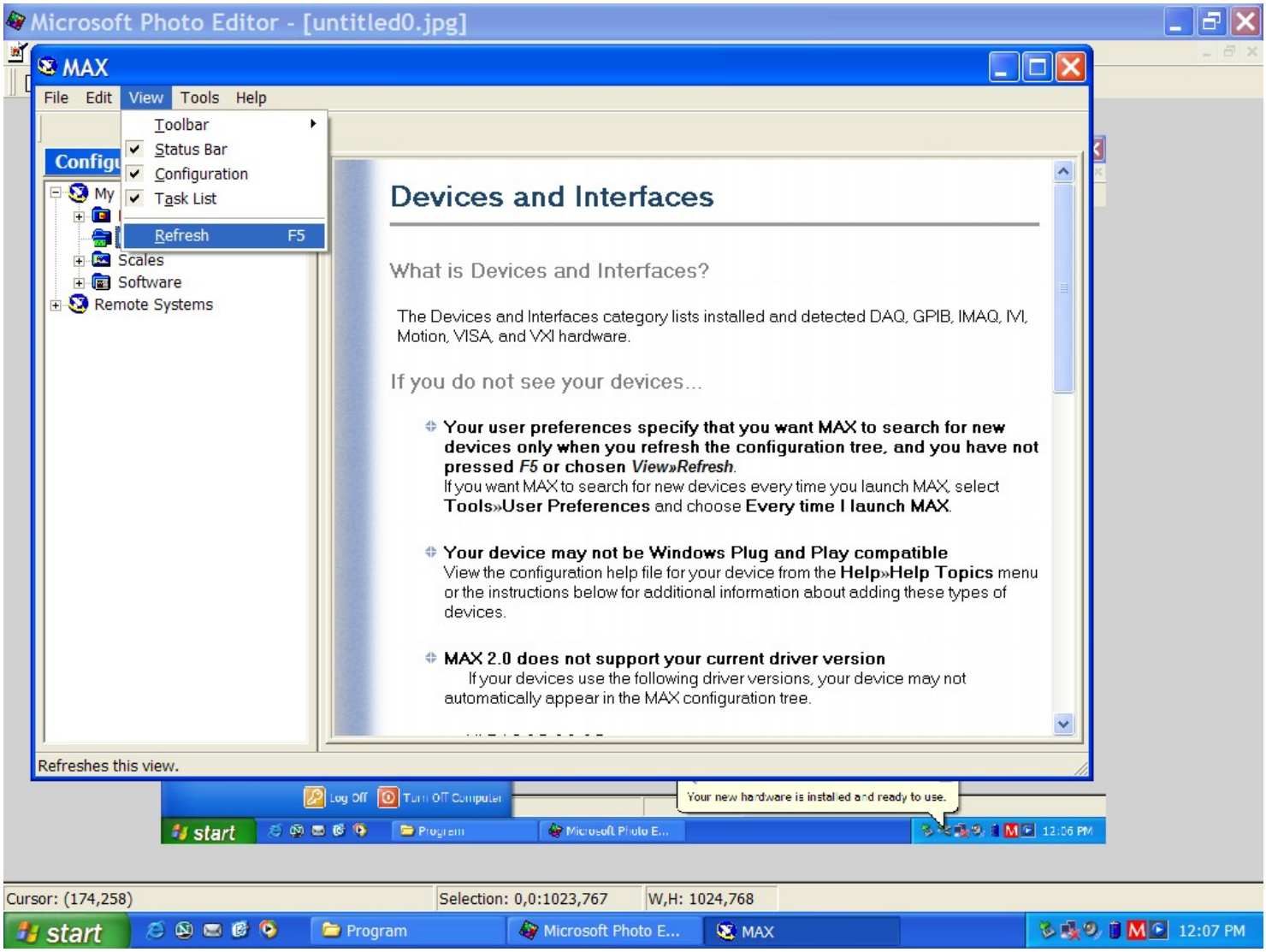

Figure 4-10 Refresh the DAQ device

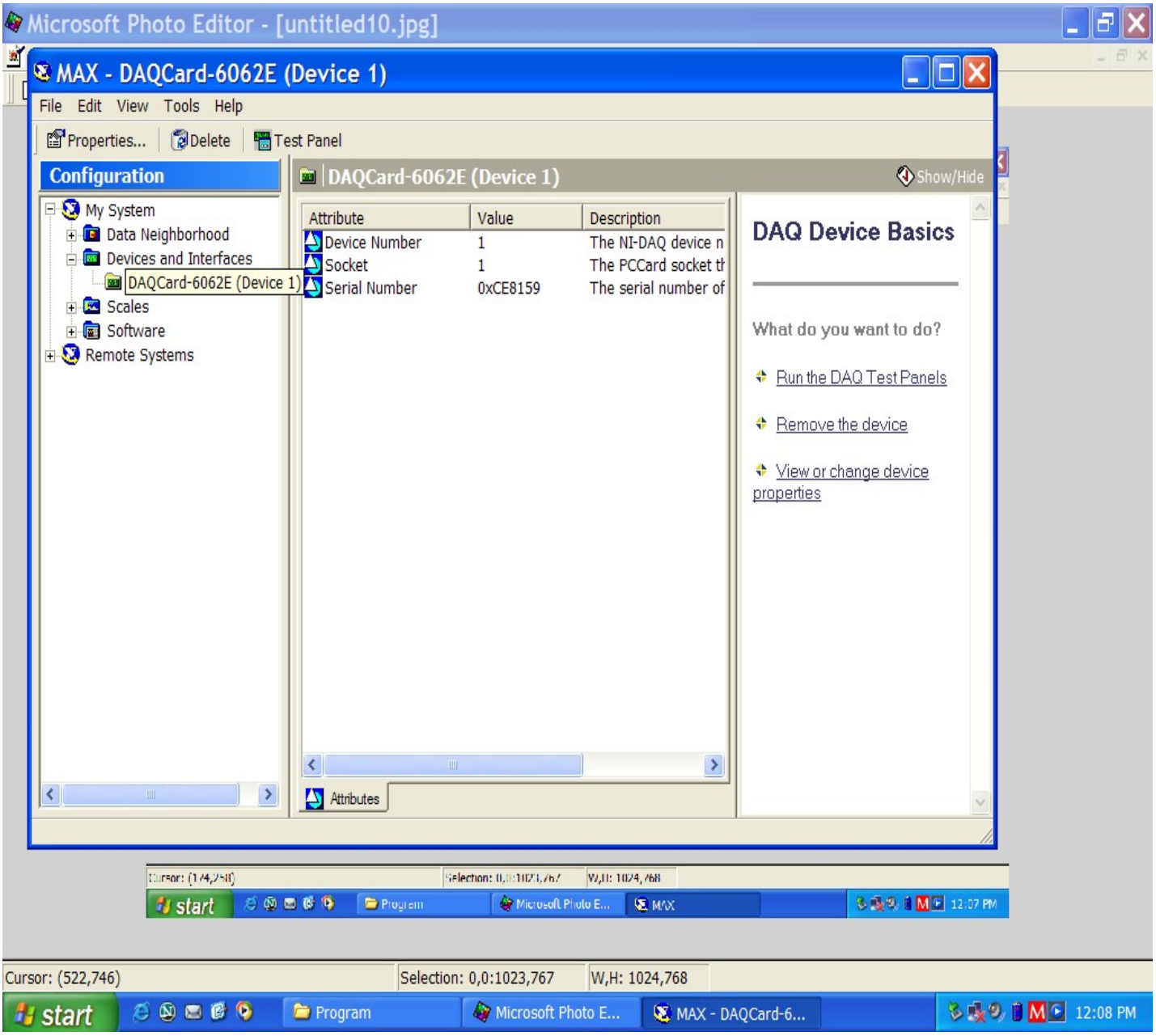

Figure 4-11 DAQ device driver being reinstalled

Open the **test panel,** the red light turns off as in Figure 4-12 and signals show up.

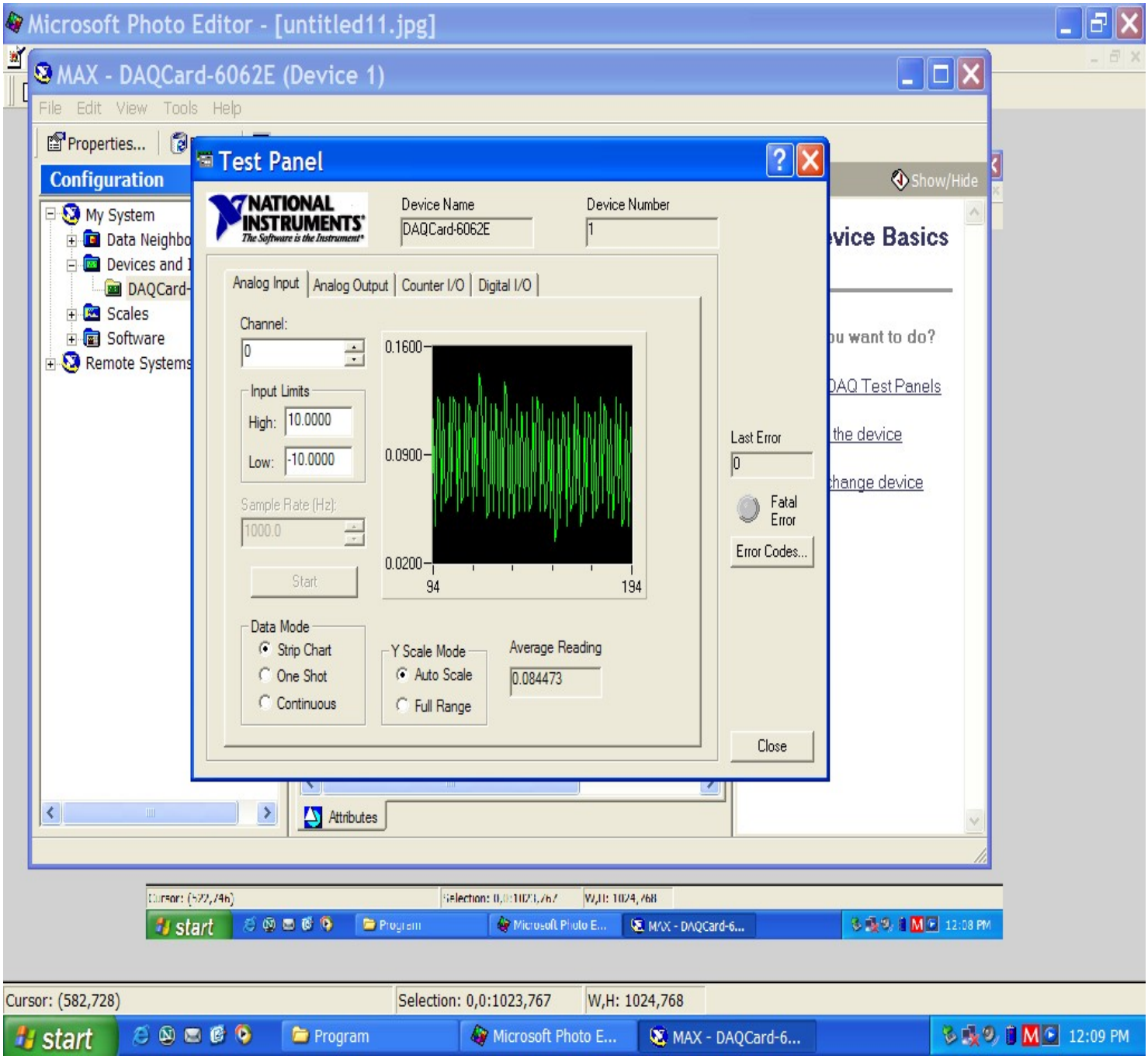

Figure 4-12 DAQ device working properly

Then close the above NIDAQ interface and **start** the GPRView.exe. GPR software should work properly.