Remote Data Acquisition with NI WSN Gateways and Wireless Nodes

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1. Introduction

The objective of this project is to develop a lab station for a sensor network which would allow remote programming of sensor nodes. National Instruments' Wireless Sensor Network (NI-WSN) 9792 Ethernet gateway was selected for this purpose. The National Instruments Wireless Security Network (NI-WSN) 9792 gateway is a programmable Ethernet gateway that connects the NI-WSN nodes to a computer for data acquisition and control. The NI-WSN 3202 and the NI-WSN 3212 nodes are programmable wireless receivers housing several analog and digital inputs. These nodes can be connected to a variety of sensors including, but not limited to, ultrasonic sensors and infrared sensors. This way, data from various sensors can be transmitted via a wireless network to a computer running LabVIEW as well as allow the remote programming of the nodes via a remotely programmable Ethernet Gateway. To prove this concept, the security system from this group's previous project, will be adapted as a vehicle for experimentation [4].

2. Previous Accompolishments

2.1 Available Hardware

The devices used in this project include:

- NI WSN 9792 Ethernet Gateway: used to route the connection from the nodes to the host computer
- NI WSN 3202 Node: used to relay data gathered from analog or digital sensors to the host computer
- NI WSN 3212 Node: used to relay data obtained from thermocouples or digital sensors to the host computer
- Parallax PING Ultrasonic Sensor: a sonar sensor used to detect the proximity of an object.
- Parallax PIR Infrared Sensor: used to detect the proximity of an object using infrared signals
- Basic K-type Thermocouple: used to detect changes in temperature.

NI WSN 9792 Ethernet Gateway. The Ethernet gateway shown in Fig. 1 can essentially be thought of as the bridge between the wireless nodes and the host computer. It connects to the host computer via an Ethernet cable to receive instructions from LabVIEW 2010+ and broadcast them to the nodes. Alternatively, programming can be received over both a local area network and a wide area network. Each node is synchronized with the gateway via LabVIEW Measurement and Automation..

Fig. 1. NI WSN 9792 Ethernet Gateway

NI WSN 3202 Wireless Node. The NI WSN 3202 Wireless Node shown in Fig. 2 is a programmable wireless receiver that transmits data from a sensor to the gateway. This particular node contains 4 analog and 4 digital inputs.

Fig. 2. NI WSN 3202 Wireless Node

NI WSN 3212 Wireless Node. The NI WSN 3212 Wireless Node shown in Fig. 3 is a programmable wireless receiver that, like the 3202, transmits data from a sensor to the gateway. This particular node contains 4 thermocouple inputs and 4 digital inputs.

Fig. 3. NI WSN 3212 Wireless Node

National Instruments Remotely Programmable Ethernet Gateway. This gateway, which replaces the NI WSN 9791 Gateway in this project, allows for the programming of the wireless nodes from remote locations on a network.

Parallax PING Ultrasonic Sensor. The Parallax PING Ultrasonic Sensor shown in Fig. 4 utilizes ultrasonic audio chirps to detect motion. The sensor connects to the analog input of the NI WSN 3202 wireless node.

Fig. 4. Parallax PING UltraSonic Sensor

Infrared Sensor. The infrared sensor shown in Fig. 5, provides data about the temperature of an object. Like the PING sensor, it connects to an analog port on the NI WSN 3202 wireless node.

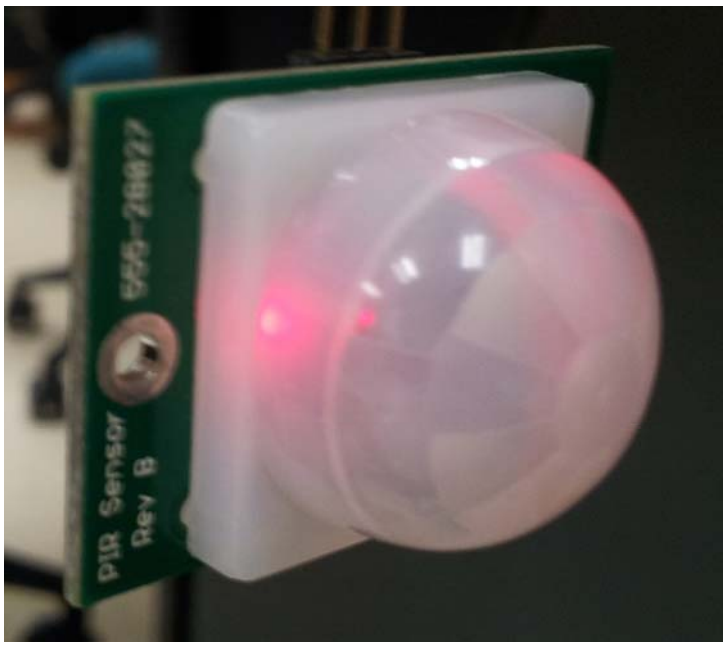


Fig. 5. Parallax PIR Infrared Sensor

2.2. Programming Logic

Each of the sensors is monitored via a LabVIEW 2010 programming. The logic to the program is fairly straight-forward and has been used in the previous experiment. The selected programming API is LabVIEW G, a high level graphical language with the ability to perform many of the same functions as Object Oriented Languages such as: Java, C, C++, and C#.

The ultrasonic sensor runs at a constant voltage of 0.5V when there is no motion detected. Once motion is detected, the voltage changes in either the positive or negative direction. Therefore, the pseudocode for the LabVIEW program at the time of writing this document would be:

```
if (detectedVoltage != 0.5){
activateLED();
}
```

Similar logic can be applied to the operation of the infrared sensor:

```
if(detectedVoltage != 0.5){
activateLED();
}
```

This same logic will be applied to the remote program. Very little to no actual programming logic should be required to transmit the program over the network.

To create the program in LabVIEW, the sensor nodes must be connected to the Ethernet gateway in software via NI Measurement and Automation Explorer. To do so, follow the following steps:

- Open NI Measurement and Automation Explorer.
- Expand the Remote Systems Tree.
- The NI WSN 9791 Ethernet Gateway should automatically be detected. Click it.
- On the screen that appears after clicking the gateway, click the nodes tab.
- Click add nodes.
- Enter the type of node and the serial number of the node.
- Repeat for each additional node.

Once the nodes are added to the gateway, the user can now create an empty LabVIEW project. Once the project is created in LabVIEW:

- Right click the project name.
- Select New >> Targets and Devices...
- Select Existing Targets or Devices
- Expand the WSN Gateway folder to choose the 9791 Ethernet Gateway configured in Measurement and Automation.
- The measurement nodes configured with the network are automatically added underneath the gateway in the LabVIEW Project, giving an instant access to their I/O variables and properties.
- Drag the AI0 from the 3202's I/O tree on the left hand side of the screen onto the block diagram and attach it to an indicator. Do the same for the TC0. More detailed information can be found in the User Manual section of this document. (see Appendix)

3. New Objectives

In the previous project, a running example consists of the graphs displaying the correct voltage of both the ultrasonic sensor and the infrared sensor. In addition to this, when the desired result is obtained (motion detected/temperature achieved), the program turns on the LED in LabVIEW, This experiment will be kept in the current project.

A new objective in this iteration of the project is that the security system's program will be sent to the wireless nodes and run on LabVIEW from a remote location on the network (Fig. 6). From there, it is only a matter of forwarding the correct ports in order to access the gateway over the Internet. A successful trial will be defined as one in which the wireless nodes correctly display the alarm status.

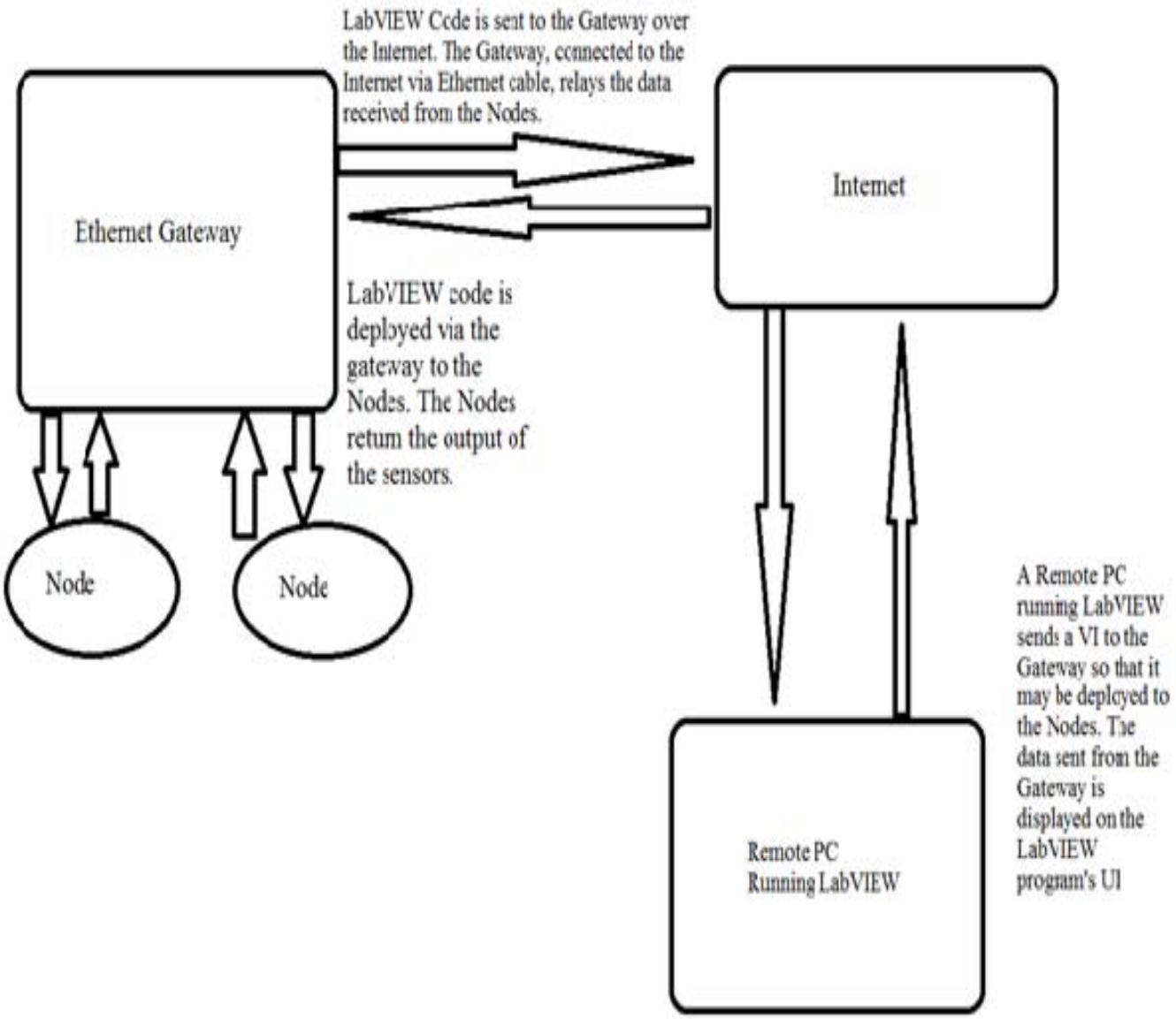


Fig. 6: Diagram depicting the way in which the hardware interacts.

4. Conclusion

The current status of the project is that the gateway is able to be programmed remotely from any computer on the FGCU public, wired network. The gateway can also be programmed over the Internet, provided that the network hosting the gateway has the ports 3580, 3581, and 8080 open. Since this project dealt solely with analog sensors, future projects should expand the LabVIEW program to read and process data from digital sensors.

5. References

[1] Parallax PING Ultrasonic Sensor Documentation, URL:

http://www.parallax.com/Portals/0/Downloads/docs/prod/acc/28015-PING-v1.6.pdf

[2] Parallax PIR Sensor Documentation, URL:

http://www.parallax.com/dl/docs/prod/audiovis/pirsensor-v1.2.pdf

[3] Getting Started with NI Wireless Sensor Networks, URL:

http://zone.ni.com/devzone/cda/tut/p/id/8890

[4] Data Acquisition with NI WSN Gateway and Nodes, URL:
http://itech.fgcu.edu/faculty/zalewski/projects/files/Wireless_Sensor_Network.pdf

Appendix

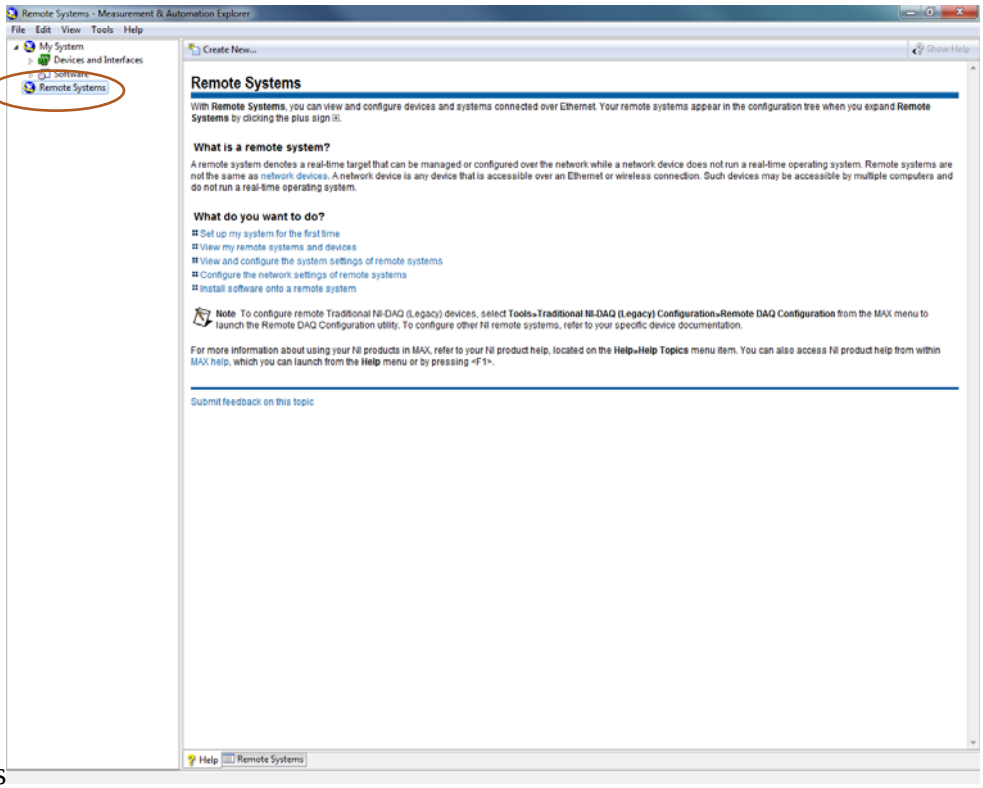
User Manual

The purpose of this document is to guide the user step by step through the process of: (1) controlling the sensor nodes remotely with Labview, and (2) updating sensor node software through the gateway. Both can be done in two ways:

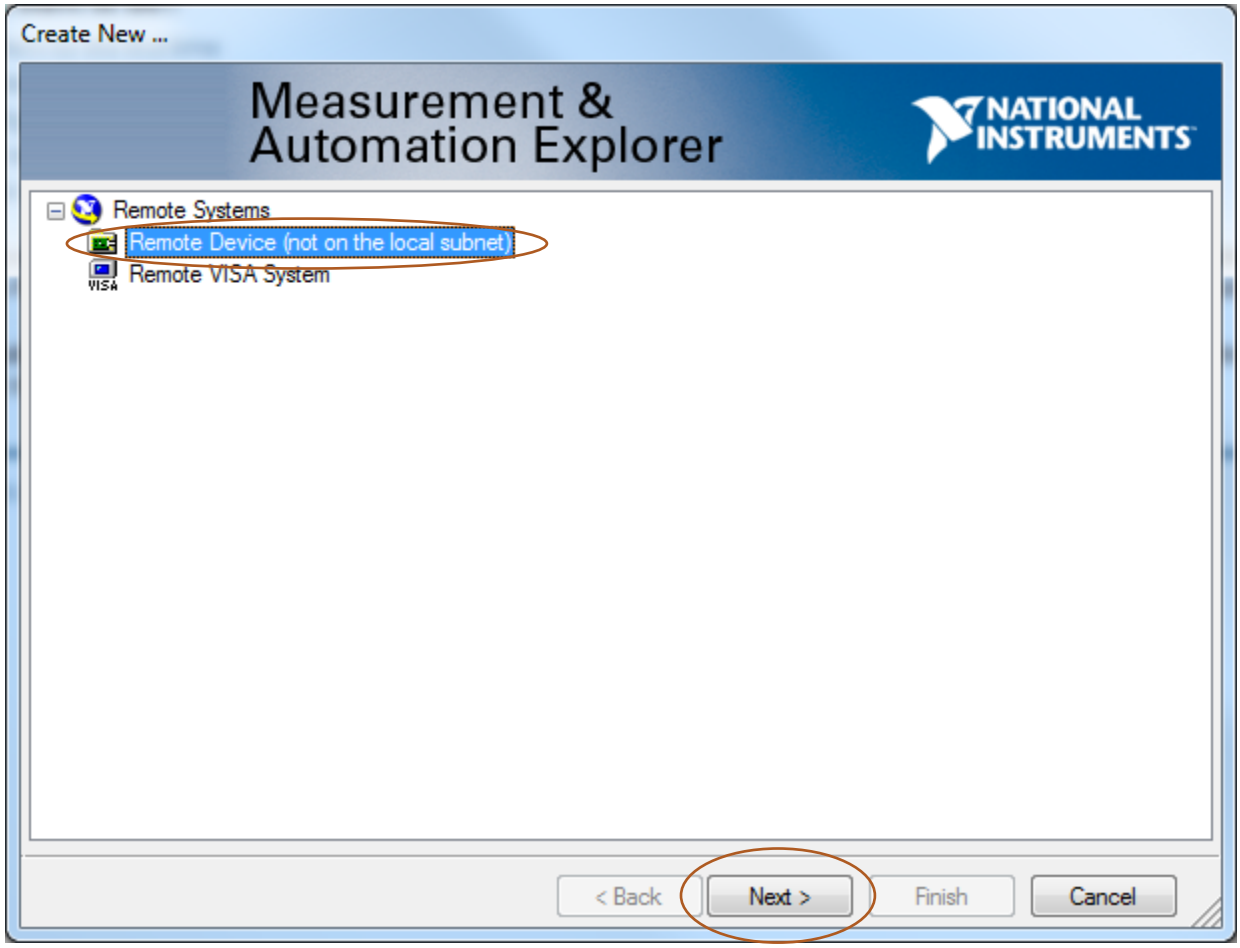
1. On the FGCU network using 172.28.xx.yy addresses.
2. From any network using ports 3580 and 3581, once they are open (assuming port 8080 is already open).

1. Importing the Gateway into Measurement and Automation 5.1

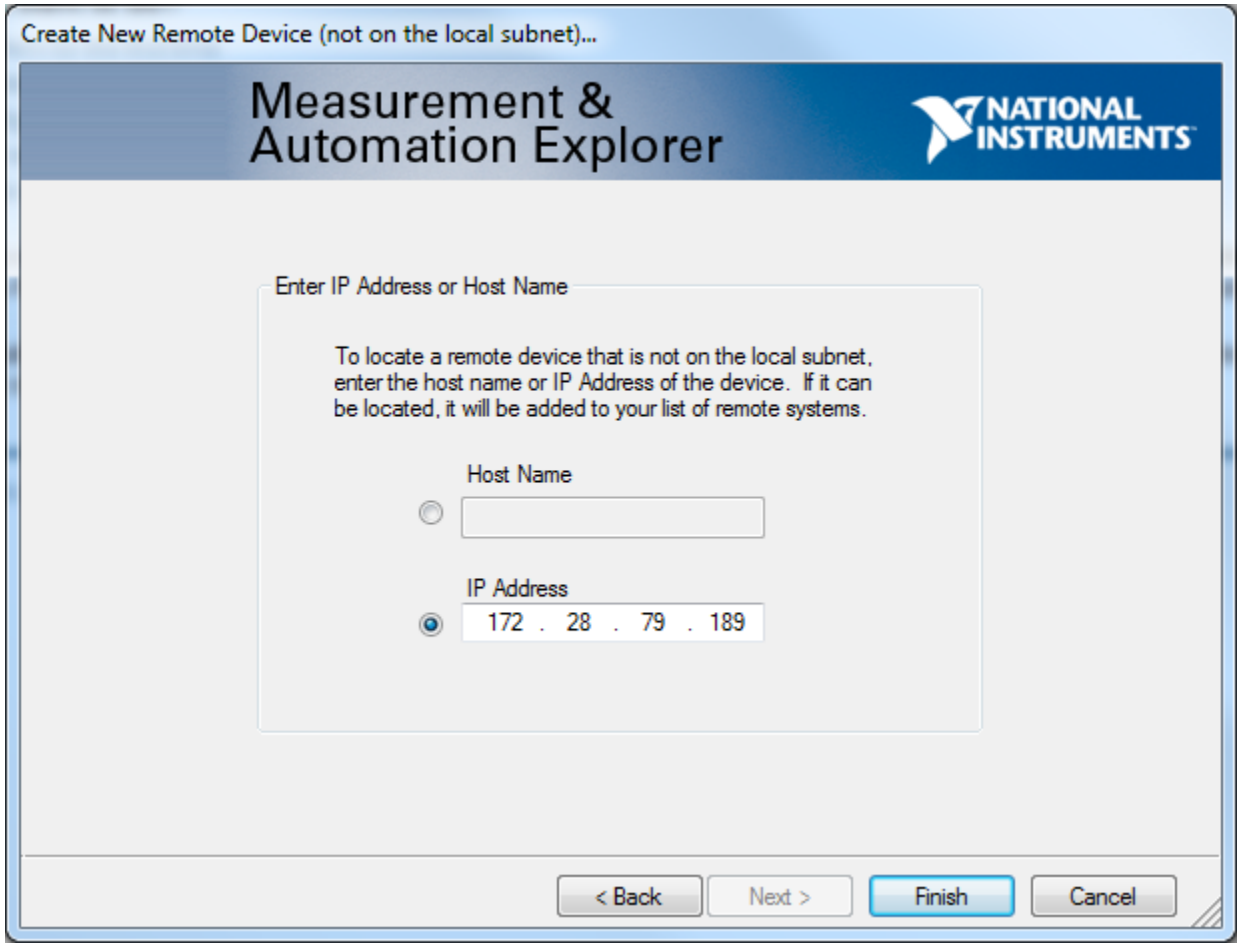
1.1. Open Measurement and Automation 5.1. In the screen that appears, click Remote Systems



1.2. Right click Remote Systems and click Create New. In the window that appears, click Remote Device (not on the local subnet) and click Next.

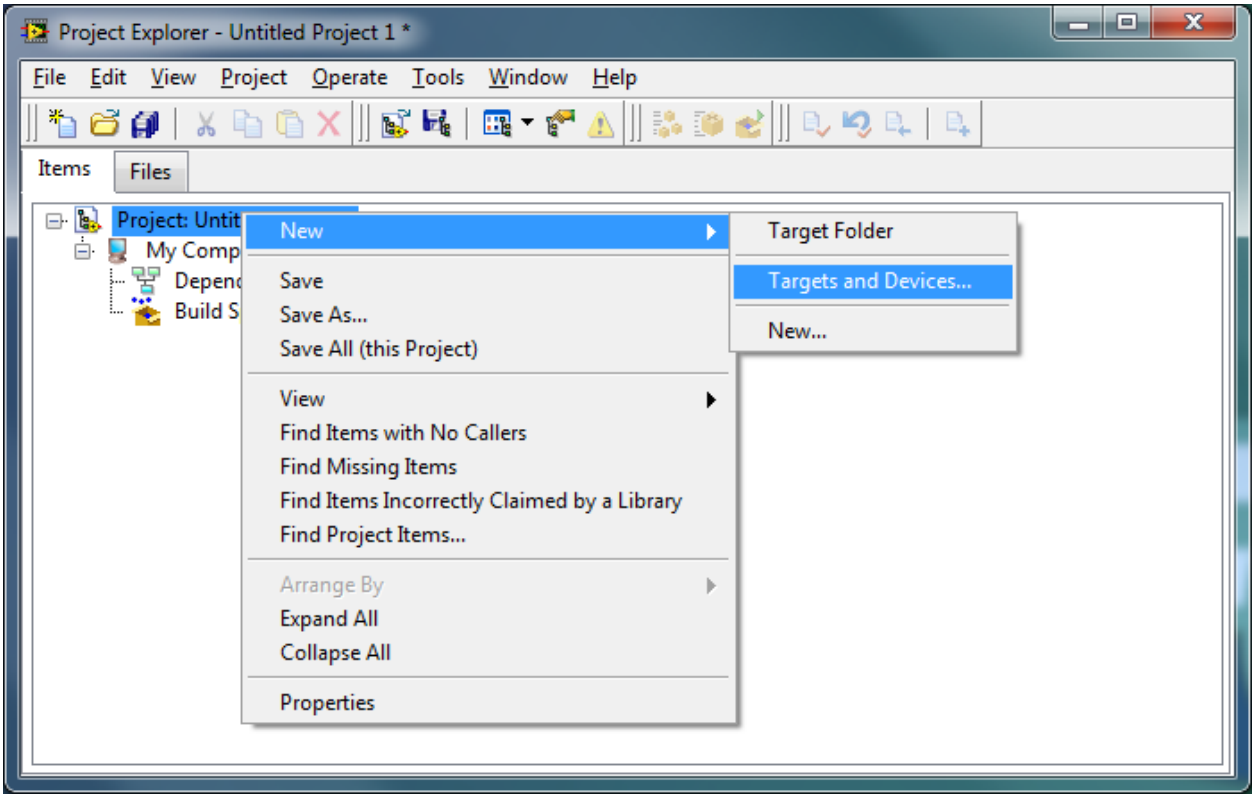


1.3. In the next screen, tick the IP Address Radio Button. Type in the following IP Address: 172.28.79.189 and click Finish.

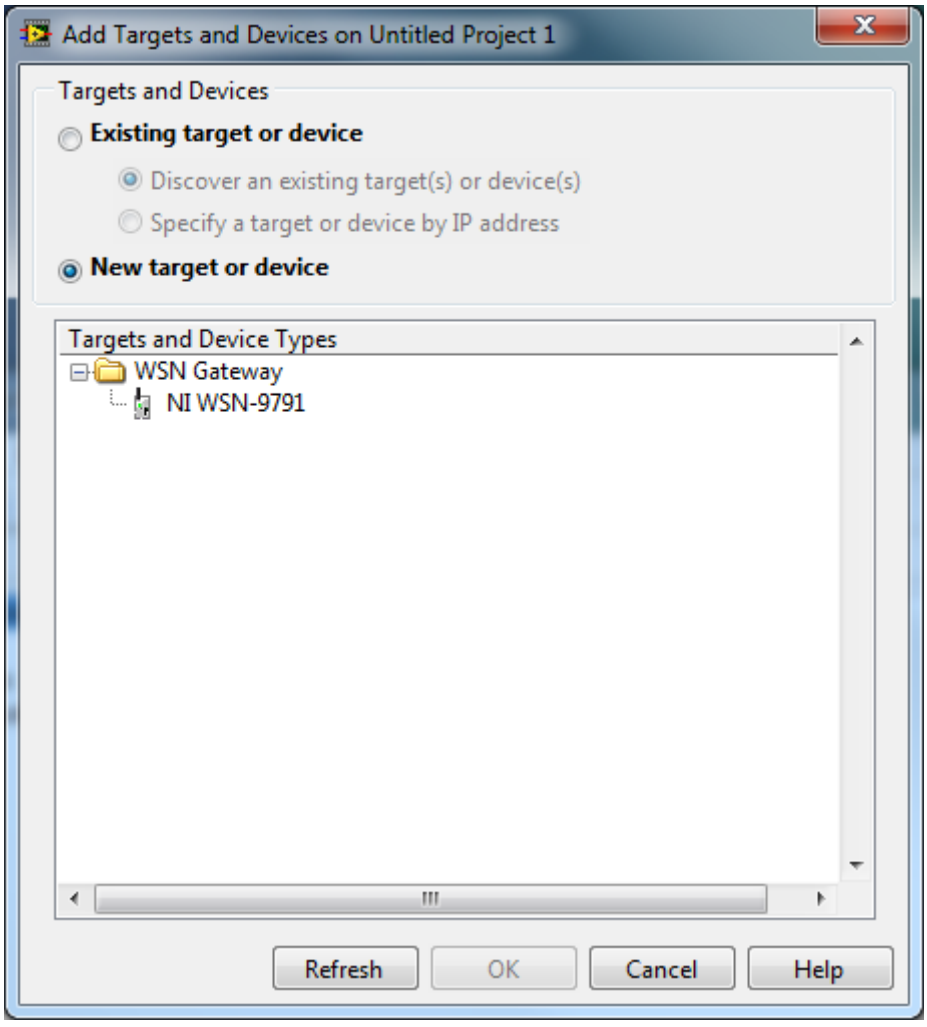


2. Using the Nodes in LabVIEW 2011

2.1. Open LabVIEW 2011 and create a new project. In the project explorer, right click Project: <Your Project Name>. Hover over New and click Targets and Devices.



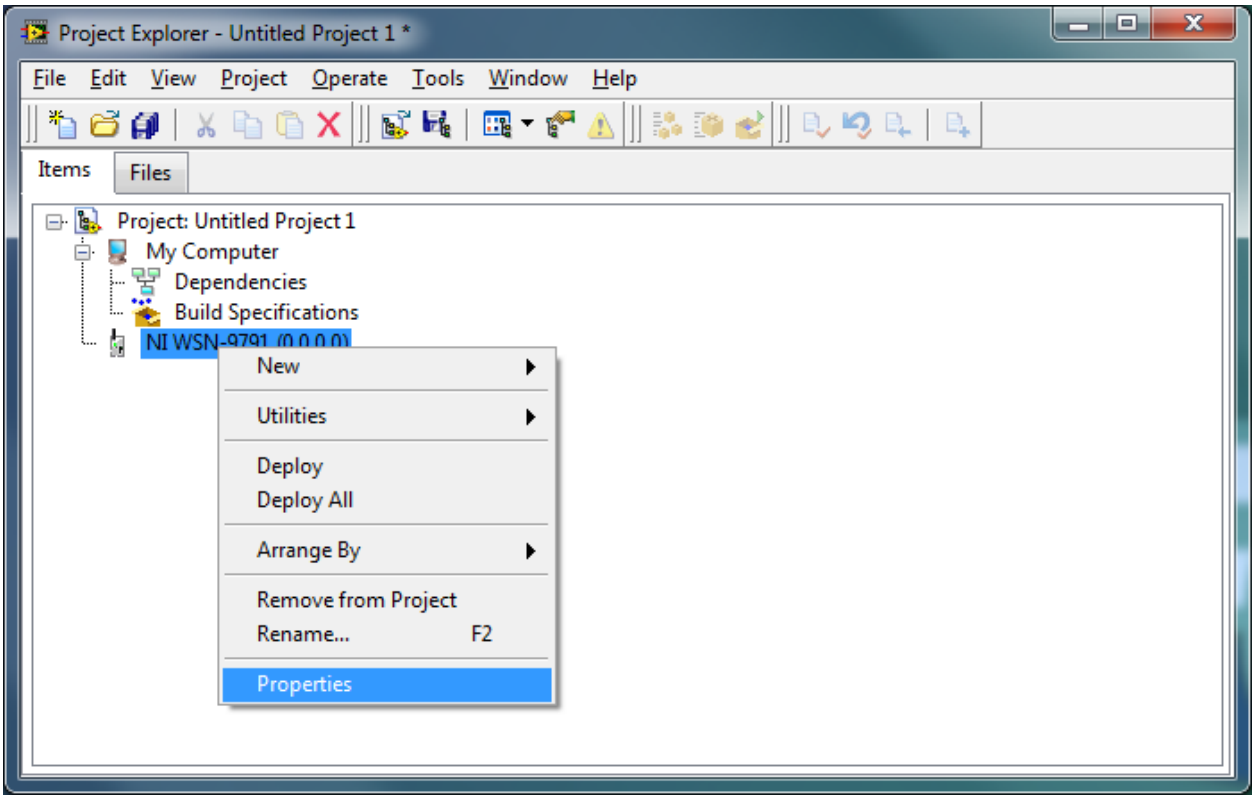
2.2. Check the New target or device radio button and expand the folder labeled WSN Gateway. Click NI WSN-9791 and click Ok



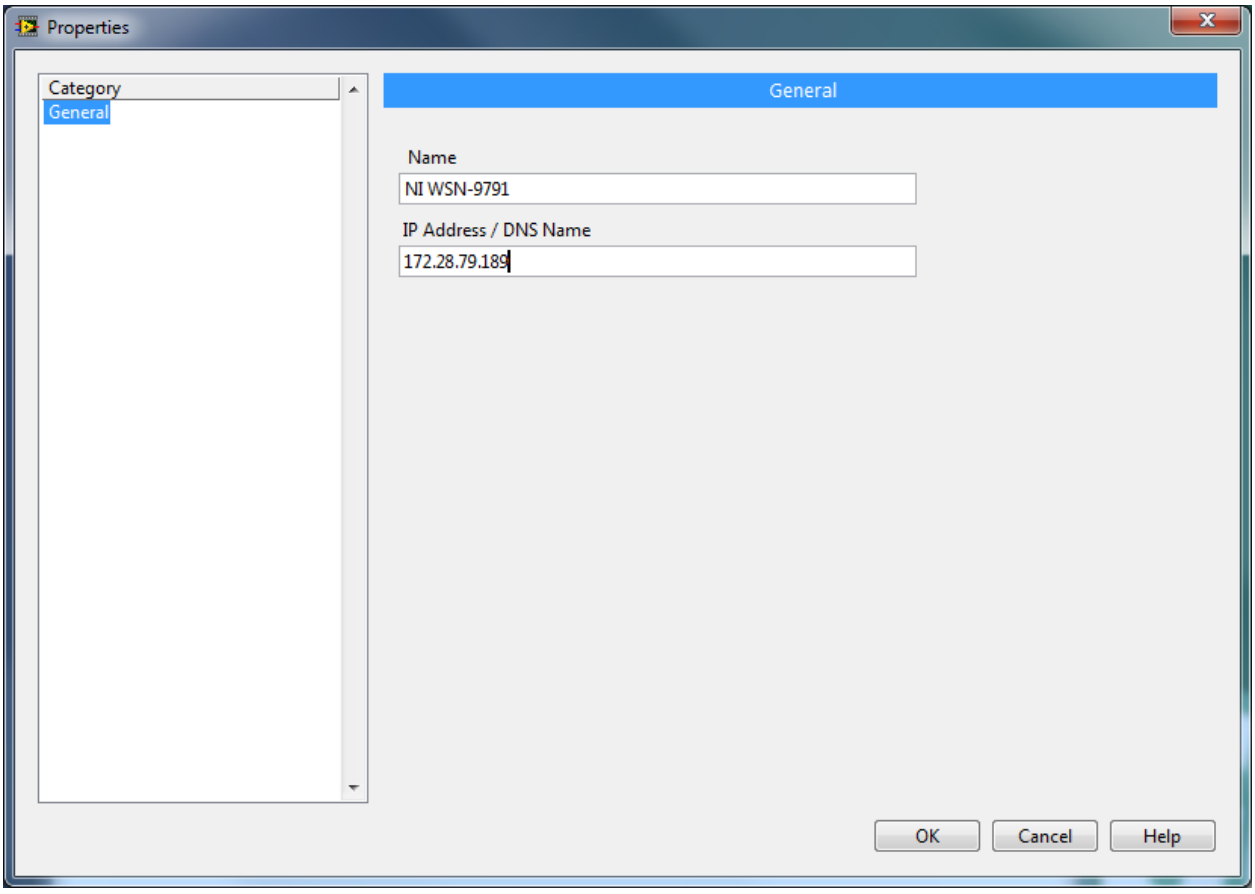
The Gateway should be imported into LabVIEW 2011.

Note: If the Gateway is imported with an IP Address of 0.0.0.0, follow the steps below.

2.3. Right click the gateway and click Properties.

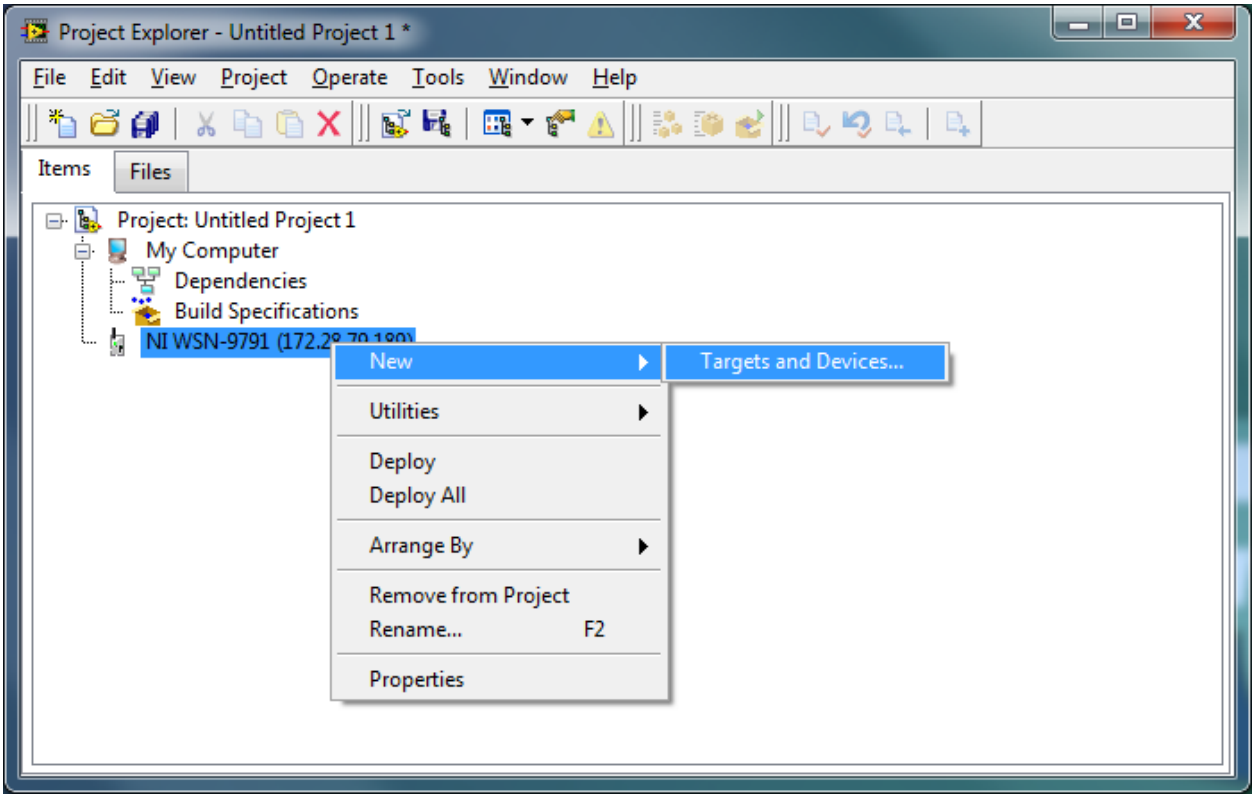


2.4. In the screen that appears, type the following IP Address into the IP Address/DNS Name Field: 172.28.79.189 and click Ok.

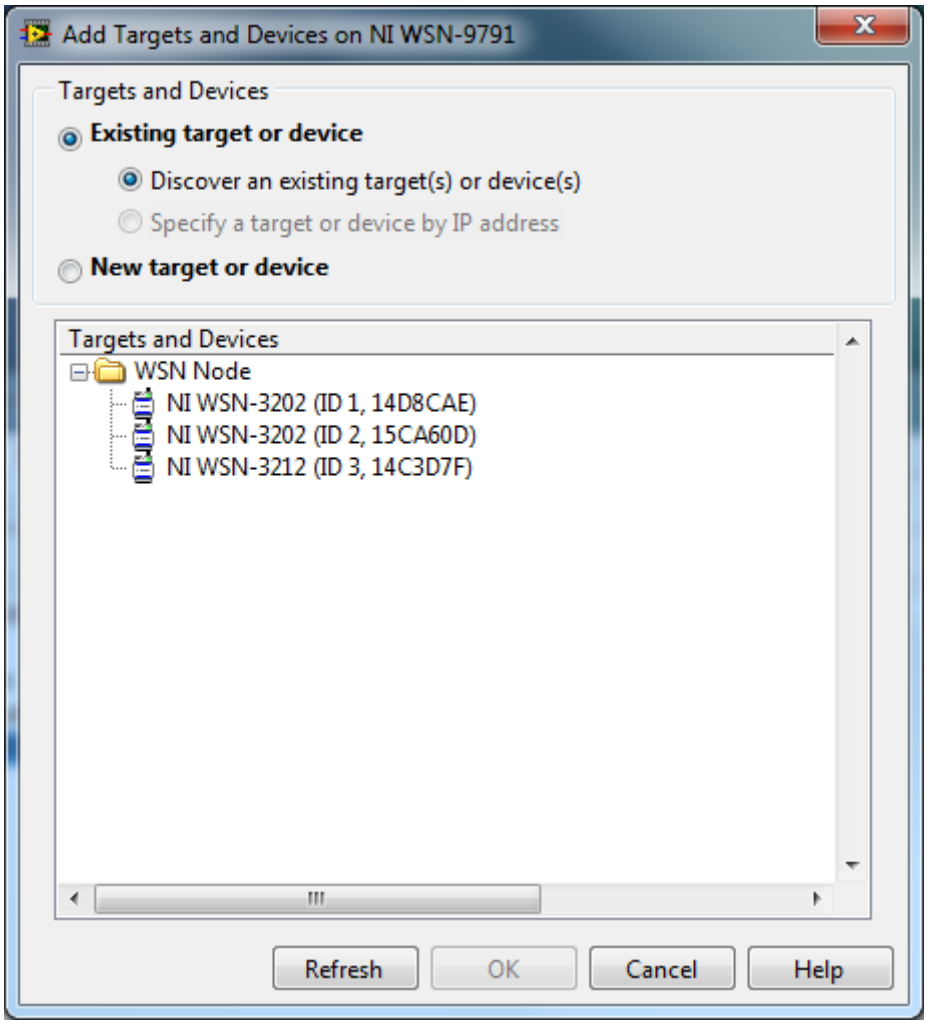


3. Adding Nodes to the Project

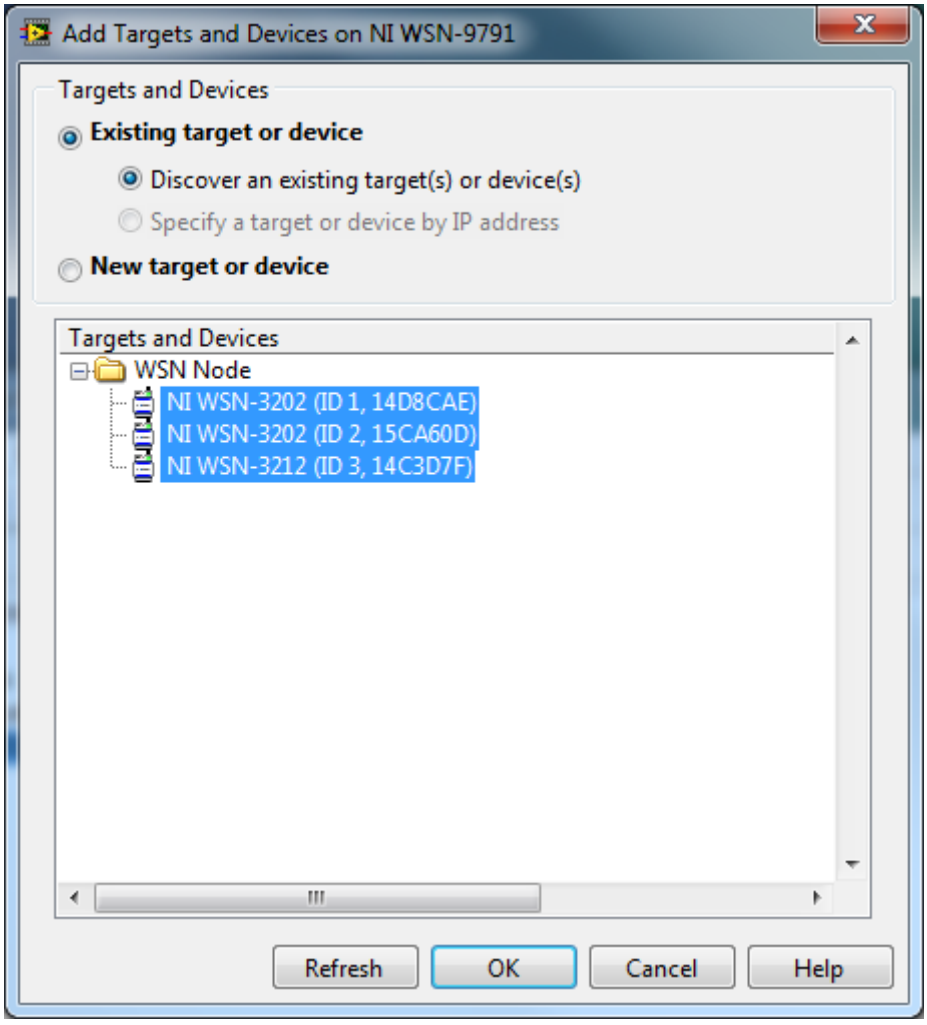
3.1. Right click the gateway, hover over New and click Targets and Devices



3.2. Tick the Existing target or device radio box and Expand the WSN Node Folder.



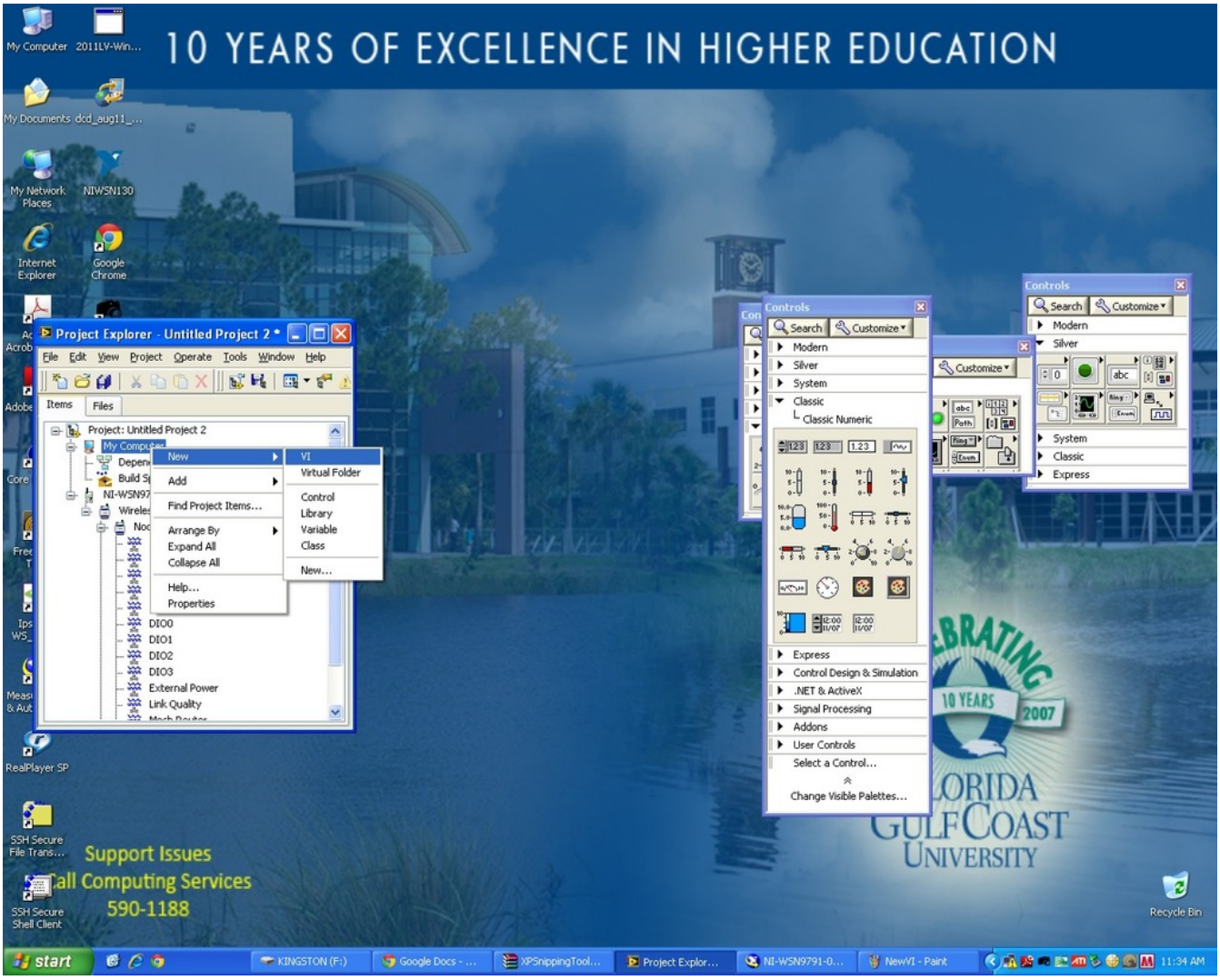
3.3. Click on a Node to select it. Alternatively Ctrl-Click Nodes to select more than one. Click Ok.



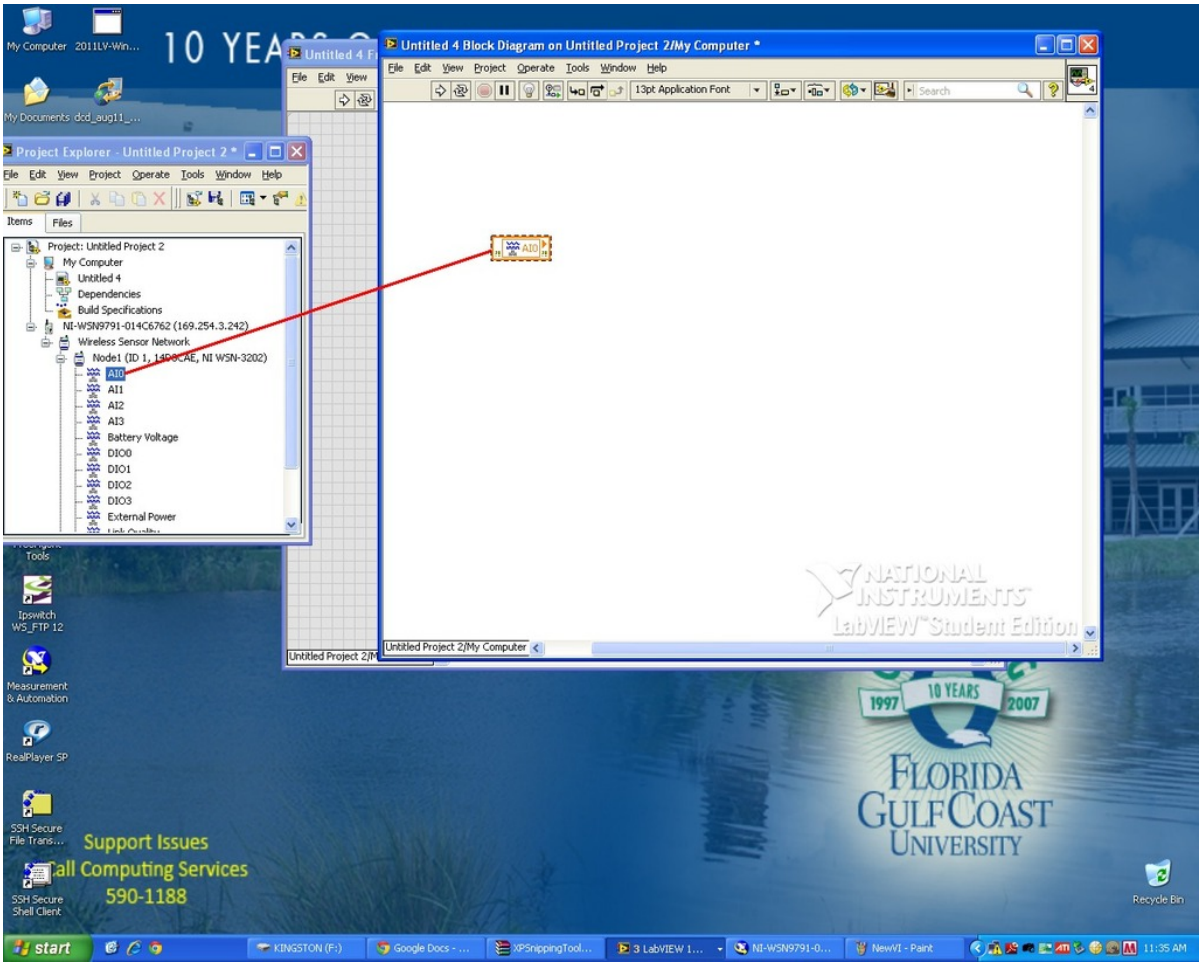
The nodes should be imported into LabVIEW successfully.

4. Creating a Basic LabVIEW Program with the Nodes

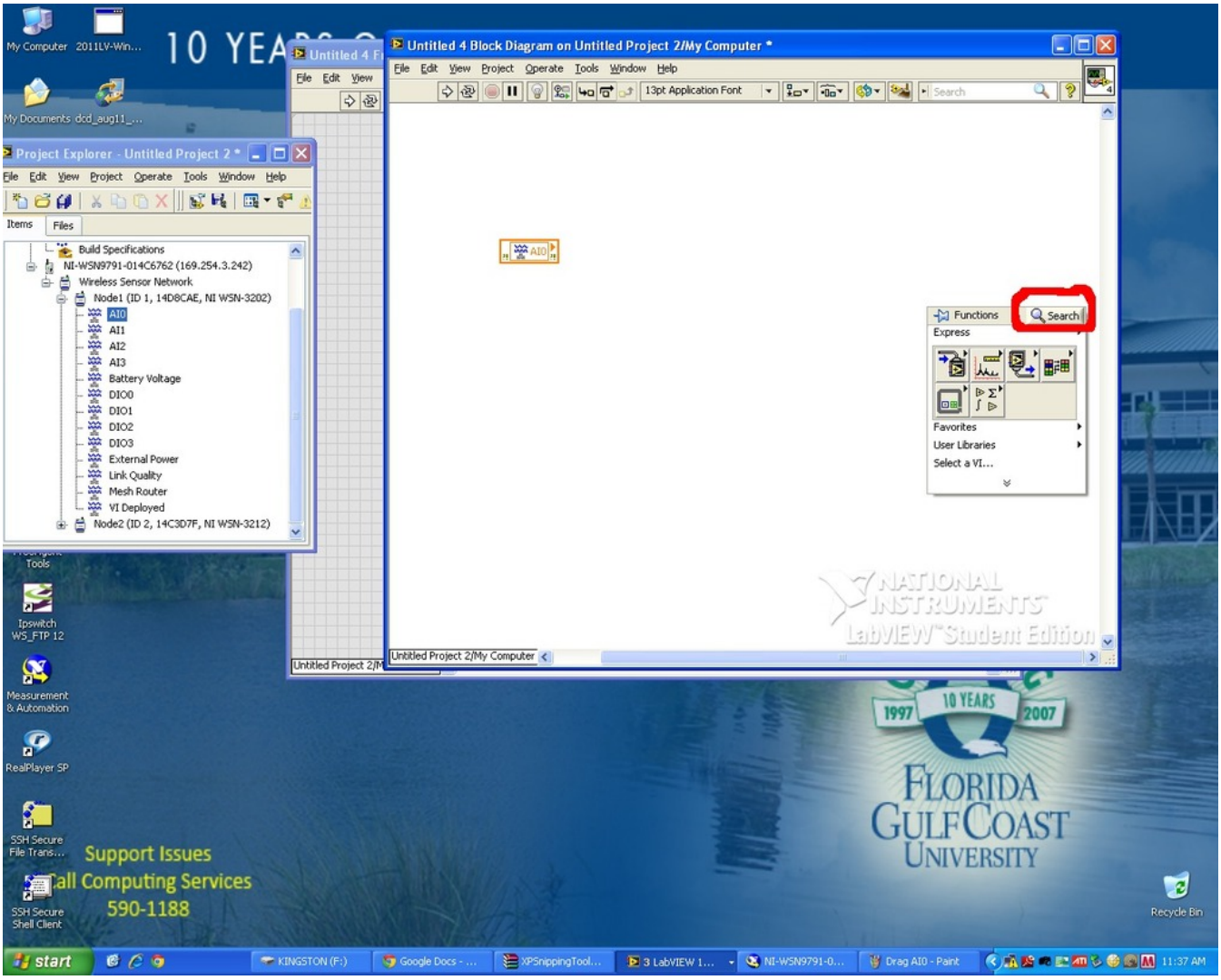
4.1. The two nodes will automatically be imported into your LabVIEW program. Next, right click My Computer (in the Project Explorer Window) and click New >> VI.



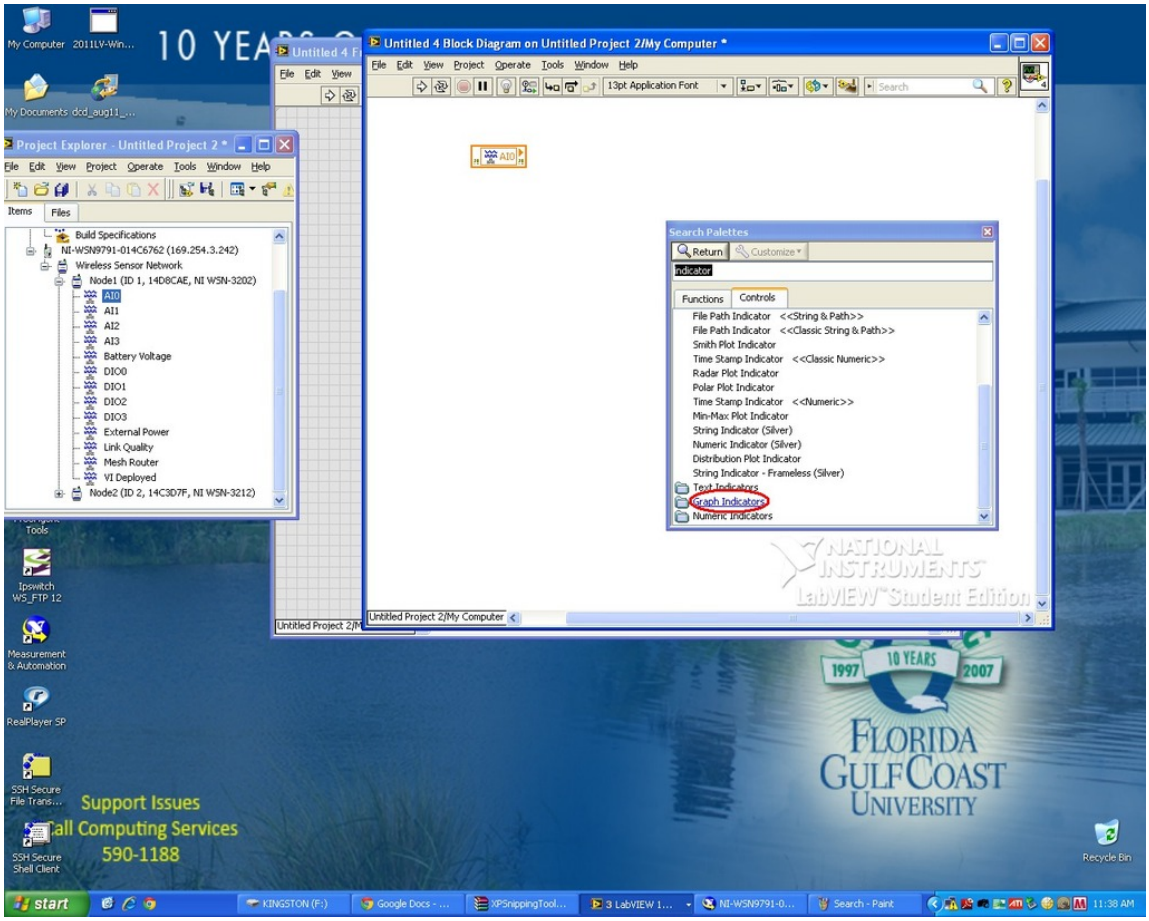
4.2. Expand node 1 (1st input should be: AI0). Drag AI0 (Or Analog input that the Ultrasonic sensor is attached to) onto the block diagram.



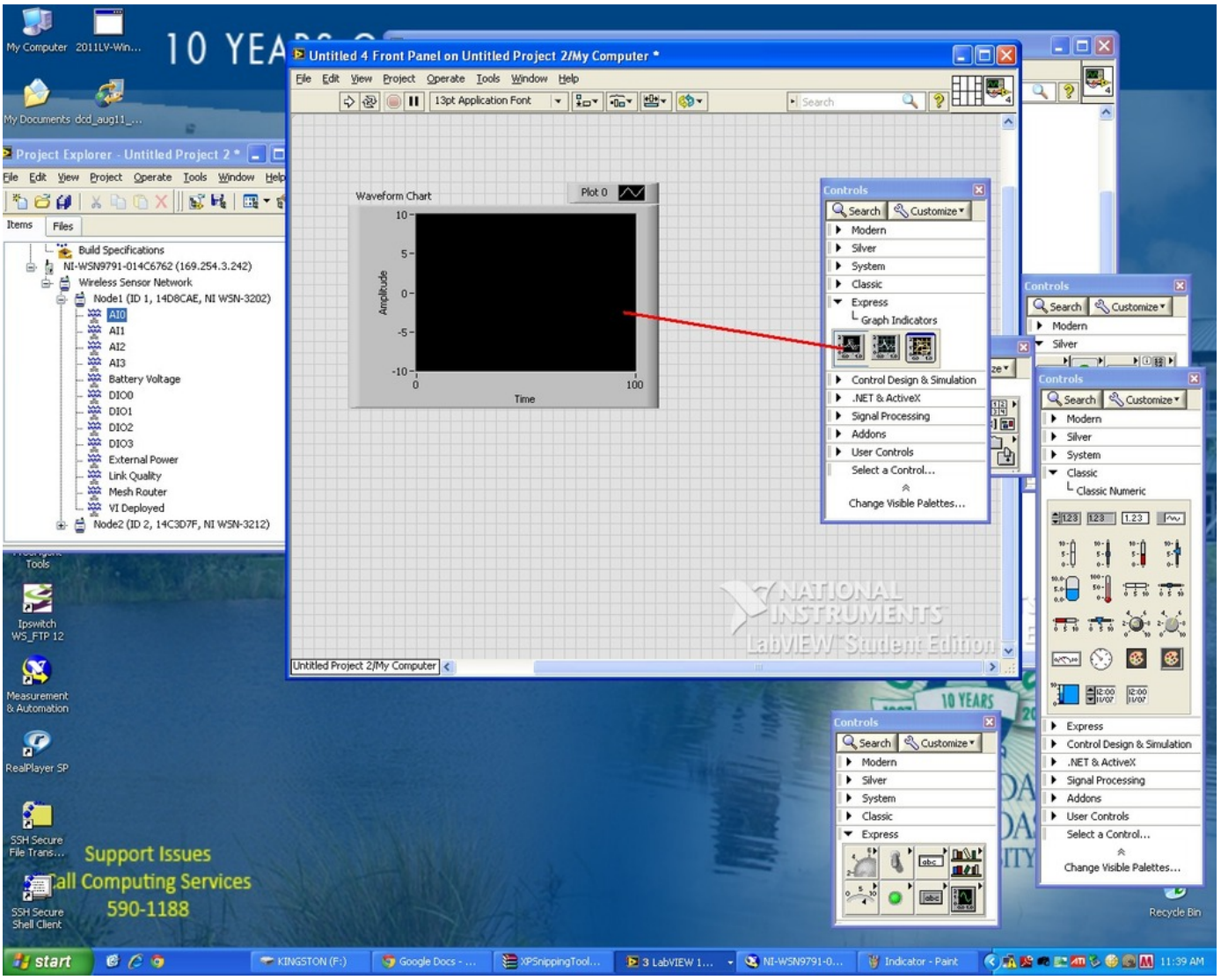
4.3. Next, on the Front Panel, right click and click the search button.



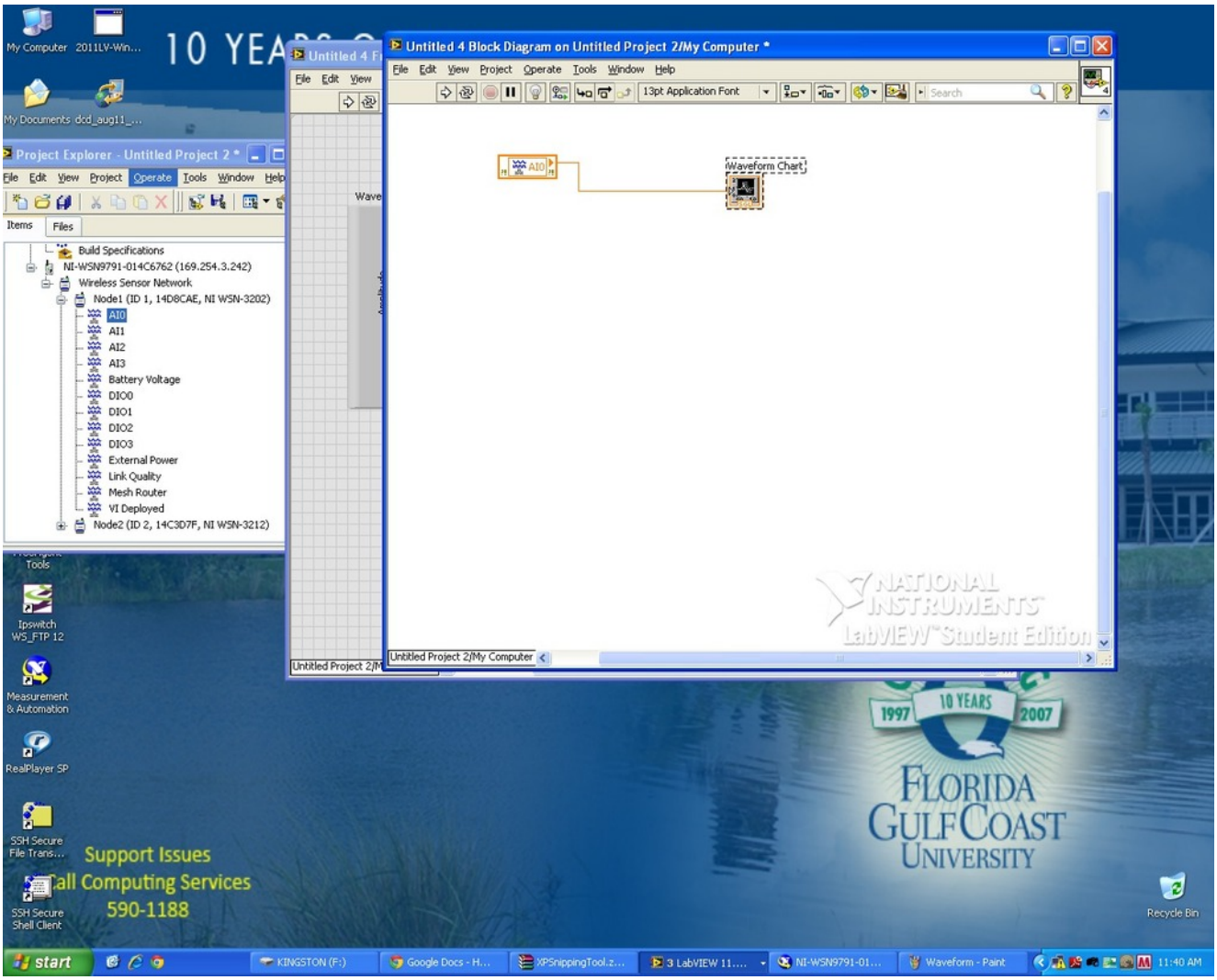
4.4. Type in indicator. Double click the folder labeled Graph Indicators. A new group of items will be added to the Express Menu.



4.5. Choose a Waveform Graph and drag it into the Front Panel.



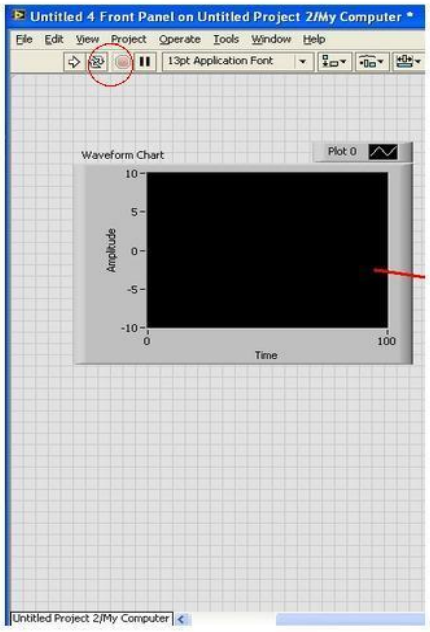
4.6. Returning to the block diagram, create a wire between AI0 and the Waveform Indicator.



The program is now ready to display the signals transmitted to the gateway via the wireless nodes.

5. Running the LabVIEW Program:

5.1. In the Front Panel, click the symbol of two arrows in a loop. This will cause the program to run until the stop button (orange octagon) is pressed.



6. Troubleshooting:

If the program does not work, make sure of the following:

- All wires are correctly connected. (Both securely and in the right ports)
- All LabVIEW wires are properly connected (No red X's)
- The ethernet gateway is connected and detected in both LabVIEW and Measurement and Automation.
- The wireless nodes have fresh, charged batteries.

For more help, visit: http://www.ni.com/support/