

# CONTROL SYSTEM CONFIGURATION



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## 5 CONTROL SYSTEM CONFIGURATION

### 5.1 FIRMWARE UPGRADES TO 2009 CONTROL SYSTEM COMPONENTS

The “as-shipped” Driver Station and cRIO require firmware upgrades before they can be used beyond the “benchtop test” configuration. This section details the procedure for upgrading the Driver Station and cRIO. Please update both Driver Station and cRIO as this is required for proper operation.

#### 5.1.1 Update Firmware on Driver Station

Note that the firmware update procedure can result in corruption of the Driver Station flash drive if the firmware update procedure is interrupted after the completion of step 6 below. Please ensure that the Driver Station will not be interfered with during this procedure.

1. Power on the Driver Station, wait for it to boot to the status screen (Shows “Team, Mode, System, and Battery” status).



2. Acquire the latest firmware for the Driver Station from [www.usfirst.org/frccontrolsystem](http://www.usfirst.org/frccontrolsystem) and save it on a USB flash drive, named “DSUD\_PKG.BIN” in the top-level directory on the flash drive. (Note that this file does not need to be the only file on the USB flash drive, however the flash drive should not have auto-run programs on it.)
3. Insert the USB flash drive containing the “DSUD\_PKG.BIN” file into the USB1 port on the Driver Station.
4. Hold down the left (up arrow) and center (down arrow) buttons middle button for approximately 7 seconds until the screen displays “\*FIRMWARE UPDATE Release buttons”



- The screen will display "Hold 'up' button" Within two seconds, press and hold the 'up' button until the display shows "Release buttons". Release the 'up' button



- The screen will display "Hold 'down' button" Within two seconds, press and hold the 'down' button until the display shows "Release buttons". Release the 'down' button
- The screen will display "Hold 'select' button". Within two seconds, press and hold the 'SELECT' button until the display shows "...". Release the 'select' button.
- The firmware upgrade will proceed automatically. Do NOT interrupt this process by cutting power to the Driver Station, inserting/removing any cables from the Driver Station, touching any of the I/O pins, etc. The firmware upgrade takes approximately 3 minutes to complete.



- The Driver Station will automatically reboot upon completion of the firmware upgrade.

## 5.1.2 Update Firmware on cRIO

The cRIO firmware is updated via a FIRST-specific cRIO imaging utility. This section describes the cRIO imaging procedure.

### 5.1.2.1 cRIO Ethernet Connection to Laptop

The cRIO has two Ethernet ports, labeled as “1” and “2” along the right side of the ports. Port 1 is intended for connection to either a wireless bridge or directly to the driver station. Port 2 is intended for connection to other Ethernet devices on the robot such as a camera.

The cRIO Ethernet ports are not “auto-sensing” so the correct Ethernet cable type must be used if the cRIO is not connected to an auto-sensing port. However, both of the driver station Ethernet ports are “auto-sensing” for connections to other devices – accordingly, in order to program the cRIO from a laptop in a cabled configuration, it is recommended that the cRIO be connected to one of the driver station Ethernet ports, and that the laptop be connected to the other driver station Ethernet port. In this way, no special Ethernet “crossover cables” are required.

### 5.1.2.2 Obtaining an Upgraded cRIO Image

The most recent cRIO Image is included in the upgrades to the software that can be found on [www.usfirst.org/frccontrolsystem](http://www.usfirst.org/frccontrolsystem). If you have not yet downloaded and installed these upgrades, you will need to do so in order to get the most recent cRIO Image. (See section 4.3.1)

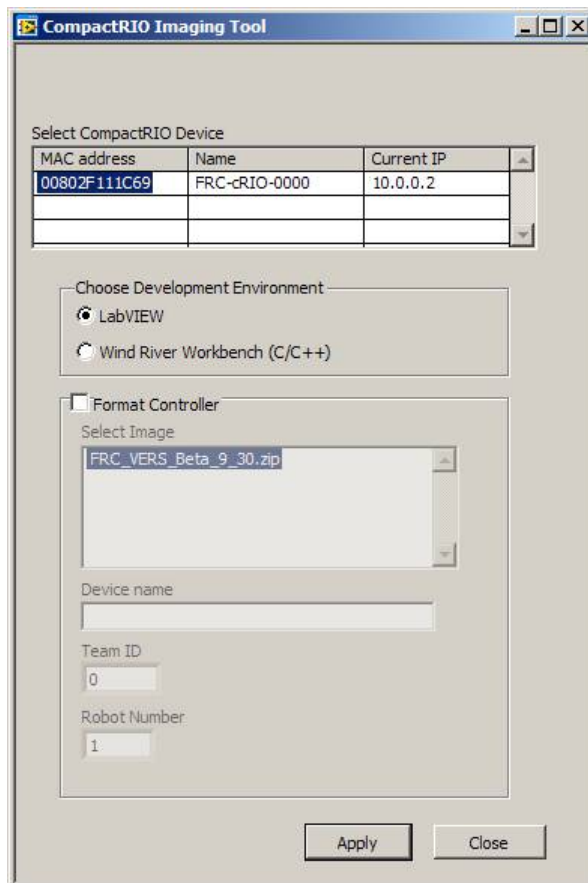
### 5.1.2.3 IP Addressing of cRIO and Laptop

As described in section 5.3, the IP addresses to be used by the cRIO, Driver Station, and Laptop are dependent upon team number. The default “as shipped” configuration of the cRIO and Driver Station are for team #0. In order to have a laptop communicate with the “as shipped” cRIO, the laptop’s IP address should be set to 10.0.0.6 with a subnet mask of 255.0.0.0. If the team number has been set on the cRIO, the appropriate IP number should be used for the laptop, according to section 5.2.

### 5.1.2.4 Installation of an Upgraded cRIO Image

To install an upgraded cRIO image, follow the instructions below:

1. Start the cRIO Imaging tool by clicking on “Start -> All Programs -> National Instruments -> LabVIEW 8.5 -> FRC cRIO Imaging Tool” in the Windows Start Menu.  
If a dialog window appears with the message “No CompactRIO devices were found. Verify the network connection,” there was a problem connecting to the cRIO. Check power to the cRIO and ensure the Ethernet cables are connected.
2. The cRIO Imaging tool will be launched and a window will be displayed titled “CompactRIO Imaging Tool.” The top of the window will show information on any cRIO devices which were found on the network. Select the MAC address of the cRIO you would like to re-image. (Note: The cRIO MAC address is printed on a label on the back of the CRIO next to the bar code.)
3. Select the development environment you would like to use by clicking the radio button next to



either “LabVIEW” or “Wind River Workbench (C/C++)”.

4. Select the checkbox next to “Format Controller” to install a new image onto the cRIO.
5. Select the image to be used from those in the list. (As of 1 October 2008, the most recent image is FRC\_VERS\_Beta\_9\_30.zip)
6. In the text box under “Device name” enter the desired name for your cRIO device. (e.g. for team 1234, use “FRC-cRIO-1234”)
7. In the text box under “Team ID” enter your team number. The IP address and subnet mask for the cRIO will be derived from the team number as described in section 5.2.
8. Downloading a complete image to the cRIO requires about 5 minutes, during which time the laptop and cRIO **must not be interrupted** by resetting the power or interfering with the network connection. When ready to proceed, select the “Download Image” button to commence imaging of the cRIO.
9. A “Reconfiguring Device” window should appear showing current status of the imaging procedure. The text window will sequence through the following messages:
  - a. Extracting CompactRIO Image...
  - b. Connecting to CompactRIO device...
  - c. Formatting CompactRIO device...
  - d. Assigning IP address...
  - e. Updating CompactRIO Image...
  - f. Configuring secondary Ethernet port...
10. The imaging process should complete within approximately 5 minutes. When the imaging process is complete, the message “The CompactRIO image was successfully updated. The IP address of the CompactRIO device is 10.xx.yy.2.” (where xxyy come from your team number)
11. Select “Close” to close the “Reconfiguring Device” window. Then select “Close” to close the “CompactRIO Imaging Tool” window and exit the cRIO Imaging Tool.



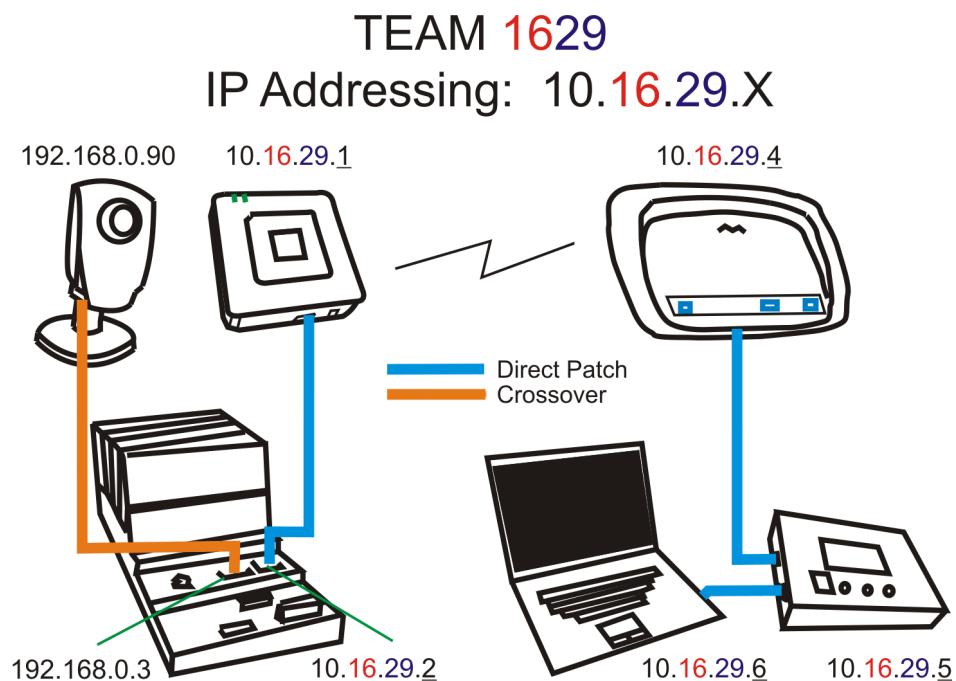
Power cycle the cRIO to have the new FPGA image loaded automatically.

## 5.2 NETWORK IP ADDRESSES

The team network is set with static IP addresses. The center two bytes in the IP number are based on the team number. The following table shows the default IP addresses and how teams will be expected to configure their network. The subnet mask is set to 255.0.0.0 for all components on the primary robot network.

Component	Default IP (Team 0)	Team Config	Example: Team 40	Example: Team 190	Example: Team 1629
Wireless Bridge (on Robot)	-	10.xx.yy.1	10.0.40.1	10.1.90.1	10.16.29.1
CRIO, port #1	10.0.0.2	10.xx.yy.2	10.0.40.2	10.1.90.2	10.16.29.2
CRIO, port #2	Not enabled	192.168.0.3	No change	No change	No change
DS Wireless	-	10.xx.yy.4	10.0.40.4	10.1.90.4	10.16.29.4
DS	10.0.0.5	10.xx.yy.5	10.0.40.5	10.1.90.5	10.16.29.5
PC	-	10.xx.yy.6	10.0.40.6	10.1.90.6	10.16.29.6
Camera	192.168.0.90	No change	No change	No change	No change

The following diagram shows the installed network configuration for an individual team (1629):



2009 FRC: Example IP address allocation.

## 5.3 DRIVER STATION CONFIGURATION

This section describes configuration procedures for the driver station.

### 5.3.1 Driver Station Connection to Laptop

In order to connect the Driver Station (DS) to a laptop, use a standard 10BaseT Ethernet cable with RJ45 connections on each end. The Driver Station Ethernet ports are auto-sensing for connections to either network hubs or other network client devices, so either a standard or “crossover” network cable can be used.

### 5.3.2 Set Team Number on Driver Station

To change team number:

- 1) Turn on Driver Station, wait for it to boot to the status screen (Shows “Team, Mode, System, and Battery” status).
- 2) Hold down the middle button for approximately 4 seconds until the screen changes to display “SET TEAM NUMBER”. While in this mode, controls are as follows. (Note that each button must be held for approximately one second before it responds.)
  - 3a) Left button (up arrow): increments the selected (highlighted) digit
  - 3b) Center button (down arrow): moves the selection cursor to the next digit
  - 3c) Right button (SEL): sets the team number to the displayed number
- 4) After setting the team number, the Driver Station will display “UPDATE COMPLETE CLOSING SYSTEM” and reboot. The new team number should be displayed on the status screen

## 5.4 CRIO CONFIGURATION

### 5.4.1 cRIO Console Serial Connection to Laptop

This is an optional connection that is nice to have to monitor status on the cRIO. In order to connect the cRIO console to a laptop, use a cable with female connectors on both ends, plus a null modem cable. (An IFI tether cable with a RadioShack null modem works fine.)

For software connection with the serial port, you can use any “terminal emulation program” on your PC. Two excellent options are to use the “Terminal” within Wind River Workbench or the Windows “Hyperterminal” program.

In order to enable console usage of the serial port, the “Console Out” switch needs to be turned “on” from its default position of “off”.

#### 5.4.1.1 Configuration of Wind River Workbench “Terminal”

The Wind River Workbench “Terminal” normally appears as a tab on the lower center pane. If there is not already a “Terminal” tab in your Workbench perspective, select (in Workbench) “Window->Show View->Terminal” to create a terminal tab on the lower center pane. Select the “Terminal” tab to display it. Click the “settings” icon in the upper right of the pane to set terminal settings:

- Connection Type: Serial
- Port: <the appropriate serial port> (in in-house trials, the USB to Serial Converter becomes COM10.)
- 9600 baud, 8 data bits, 1 stop bit, parity none, flow control none
- The appropriate serial port.

#### 5.4.1.2 Configuration of Windows “Hyperterminal”

The Windows “Hyperterminal” program’s default location is ”Start -> All Programs -> Accessories -> Communications -> Hyperterminal”. Use the following settings:

- 9600 baud, 8 data bits, no parity, 1 stop bit, no flow control

The appropriate serial port. (in in-house trials, the USB to Serial Converter became COM10.)

#### 5.4.1.3 Configuration of the cRIO for “Console Out”

The cRIO needs to have the console output enabled by setting the cRIO DIP Switch #2 (labeled “CONSOLE OUT”) to the “ON” position. In order for changes to the DIPswitch to take effect, the cRIO needs to be power-cycled.

When resetting the cRIO, one should see text similar to the following on the terminal:

---

```
cRIO-907x Boot

Copyright 2007 National Instruments Corp.

Bootrom version: 2.4.7
Creation date: Jul  9 2007, 00:45:07
...
```

---

Note that about the 30<sup>th</sup> line of the boot messages will include lines such as the following:

---

```
Initializing network...
Device 1 - MAC address: 00:80:2F:10:F9:84 - 192.168.0.1 (primary)
Device 2 - MAC address: 00:80:2F:10:F9:85 - 0.0.0.0 (secondary)
```

---

As indicated by the lines above, the cRIO used in in-house trials has a primary MAC address of “00:80:2F:10:F9:84” and a primary IP address of “192.168.0.1” The primary IP address, in particular, is needed in order to establish a network connection with the cRIO from the laptop in order to program the cRIO.

Particularly useful commands that may be entered from the console:

- > i (monitor processes)
- > sp taskname (spawn a task)
- > reboot (reboot the cRIO)

## 5.5 CAMERA CONFIGURATION

The camera comes with a network address of 192.168.0.90 and a root password of "pass". The IP address is kept but the password for root must be updated to "admin" to work with the camera access software.

### 5.5.1 Manual Configuration of the Camera

The username/password combinations that work with the default code are shown in the table below. As long as at least one of these users is configured, the camera initialization software will work.

User name	Password
root	pass (Axis default)
root	admin
FRC	FRC

To change passwords:

1. Connect your computer to the camera using a crossover Ethernet cable.
2. Open up "http://portforward.com/networking/staticip.htm" in your web browser.
3. Select your operating system and read about how to set a static ip address.
4. Set your IP address to 192.168.0.XX where XX is something not in use (1-255)
5. Close the window and wait while it configures the network card.
  
6. Navigate your web browser to <http://192.168.0.90/>.
7. If a "Configure Root Password" dialog box pops up, enter the username "root" and the password "pass".
8. If a login dialog pops up, enter the username "root" and the password "pass" (this is the default password).
9. In the top right, click "Setup"
10. On the left, click "Users"
11. Click "root" and click "Modify"
12. Enter the desired password twice in the password box.
13. Click OK, then Save.

### 5.5.2 Camera tools and documentation

Vendor information about the Axis 206 camera can be obtained at the web site:

([http://www.axis.com/products/cam\\_206/index.htm](http://www.axis.com/products/cam_206/index.htm))

An installation and management tool from Axis is available from this site that is can be used to set the camera configuration. ([http://www.axis.com/products/cam\\_mgmt\\_software/index.htm](http://www.axis.com/products/cam_mgmt_software/index.htm))

## **5.6 WIRELESS ADAPTER CONFIGURATION**

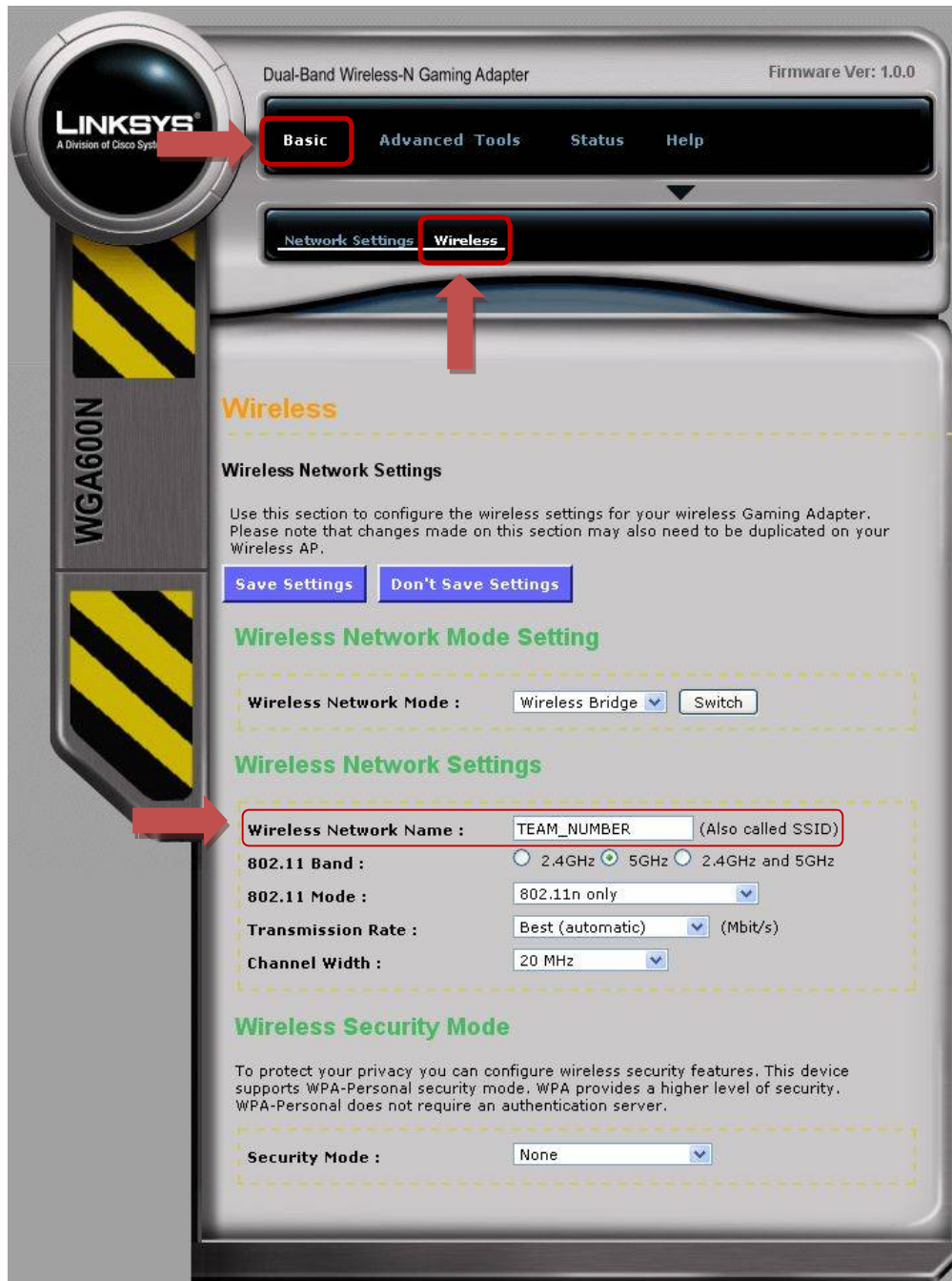
The default (i.e. out-of-box) configuration of the Linksys WRT610N and WGA600N radios require a few changes in order to operate properly within the FRC defined network architecture. Refer to section 5.2 for a review of the FRC IP address definitions.

### **5.6.1 Configuration of Wireless Adapter for Robot (WGA600N)**

The Robot radio, WGA600N, needs a few changes to the default settings in order to work correctly with the WRT610N. Follow the steps below to make these changes:

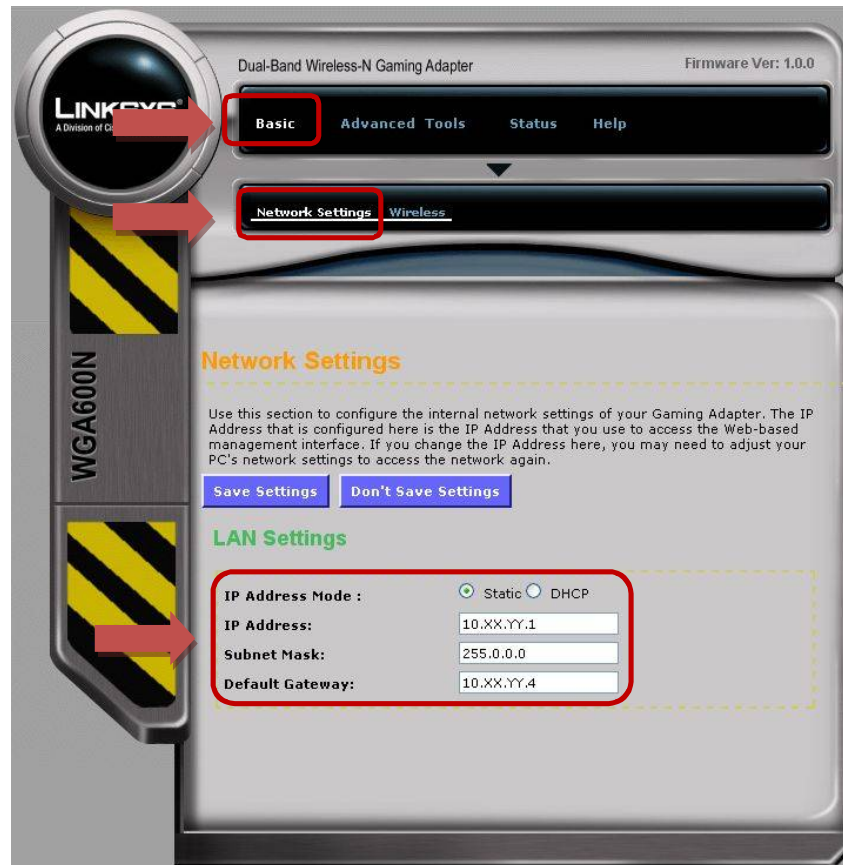
1. Set your computer to receive it's IP via DHCP
2. Connect the computer's Ethernet port to one of the Ethernet ports on the Driver Station using a standard 100-BaseT Ethernet cable.
3. Connect the other Ethernet port on the Driver Station to any of the 4 Ethernet ports on the WRT610N using a standard 100-BaseT Ethernet cable.
4. Connect the WGA600N to any of the remaining 3 Ethernet ports on the WRT610N using a standard 100-BaseT Ethernet cable.
5. Open a web browser and navigate to the IP of the WGA600N, the default settings are:
  - a. IP: 192.168.1.250
  - b. Username: admin
  - c. Password: admin
6. Select "Basic" from the menu across the top of the webpage.

7. Select "Wireless" to open the configuration page for the wireless settings. The configuration page is shown below:



8. Change the "Wireless Network Name" to your FRC Team Number, no quotation marks.
9. Configure all other settings to match those shown above.
10. Click "Save Settings"
11. When asked to reboot now or later, choose "Reboot Now"
12. Login again.
  - a. Username: admin
  - b. Password: admin

13. Select "Basic" from the menu across the top of the webpage.
14. Select "Network Settings" to open the configuration page for the wireless settings. The configuration page is shown below:



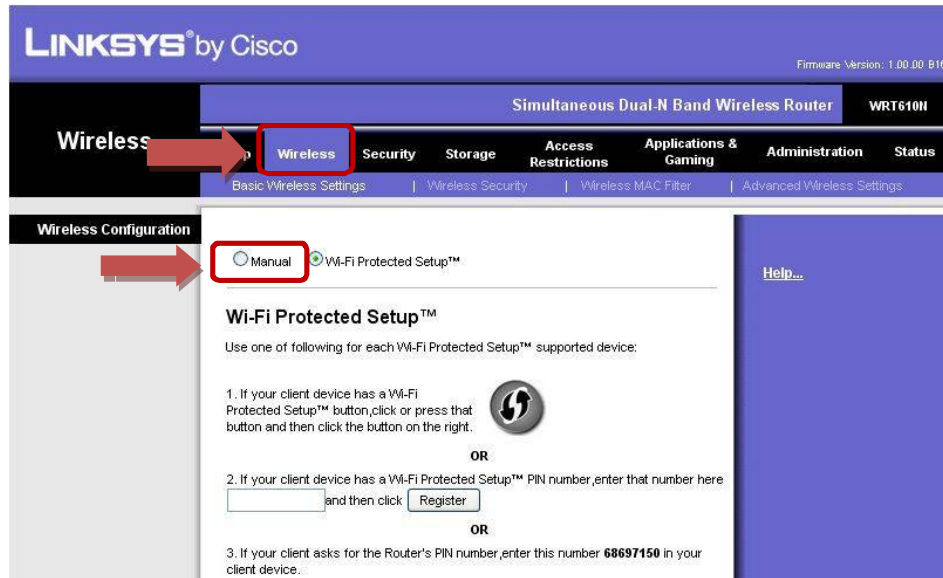
- d. Configure the LAN Settings to match those shown above. In the IP Address and Default Gateway lines, replace "XX.YY" with your FRC Team Number.
15. Click the "Save Settings"
  16. When asked to reboot now or later, choose "Reboot Now". The login page will not reload at this point due to the IP address mismatch of the PC and WGA600N.

### 5.6.2 Configuration of Wireless Adapter for Driver Station (WRT610N)

The Driver Station radio, WRT610N, needs a few changes to the default settings in order to work correctly with the WGA600N. Follow the steps below to make these changes:

1. Set your computer to receive its IP via DHCP
2. Connect the computer's Ethernet port to one of the Ethernet ports on the Driver Station using a standard 100-BaseT Ethernet cable.
3. Connect the other Ethernet port on the Driver Station to any of the 4 Ethernet ports on the WRT610N using a standard 100-BaseT Ethernet cable.
4. Open a web browser and navigate to the web configuration tool of the WRT610N, the default settings are:
  - a. IP: 192.168.1.1
  - b. Username: leave this space blank
  - c. Password: admin

5. Select the “Wireless” tab, the default screen should look like the screen below.



a. Check the “Manual” option

6. Change the settings on the new page to match those shown below.

The screenshot displays the Linksys WRT610N wireless configuration interface. The top navigation bar includes 'Setup', 'Wireless', 'Security', 'Storage', 'Access Restrictions', 'Applications & Gaming', 'Administration', and 'Status'. The 'Wireless' section is active, showing 'Basic Wireless Settings'. The '5GHz Wireless Settings' section is highlighted with a red arrow pointing to the 'Network Name (SSID)' field, which contains 'TEAM\_NUMBER'. The '2.4GHz Wireless Settings' section is also visible. The 'Save Settings' and 'Cancel Changes' buttons are at the bottom.

- Enter your FRC Team Number in the SSID field, i.e. if your team number is 9999, enter 9999 in the field.
- Disconnect the Ethernet cable between the WGA600N and WRT610N.
- Click "Save Settings"
- The "Settings are Successful" screen should now be displayed. Click "Continue". If the web page does not reload, change the IP in the status bar to 192.168.1.1

7. Select the “Setup” Tab.

8. Under “Basic Setup”, Make the following changes to in the “Network Setup” area of the page

The screenshot shows the Linksys WRT610N Setup page. The top navigation bar includes 'Setup', 'Wireless', 'Security', 'Storage', 'Access Restrictions', 'Applications & Gaming', 'Administration', and 'Status'. The 'Setup' tab is selected, and the 'Basic Setup' sub-tab is active. The 'Network Setup' section is highlighted with a red box. Within this section, the 'Router Address' fields are set to IP Address: 10.XX.YY.4, Subnet Mask: 255.255.255.0, and URL Address: http://WRT610N.com. The 'DHCP Server' is set to 'Enabled'. The 'Start IP Address' is 10.0.0.1. The 'Adjust clock for daylight saving changes' checkbox is checked. Red arrows point to the 'Setup' tab, the 'Basic Setup' sub-tab, the 'Network Setup' section, the 'Router Address' fields, the 'DHCP Server' checkbox, and the 'Adjust clock for daylight saving changes' checkbox.

- IP Address: 10.XX.YY.4, where “XX.YY” is the FRC team number.
- Subnet Mask: 255.255.255.0
- Change the DHCP “Start IP Address” field to 10
- Click “Save Settings”
- The “Settings are Successful” screen should now be displayed. Click “Continue”. The web page will not reload due to the IP mismatch between the PC and the WRT610N.

9. Configure your PC with a static IP address according to section 5.3

- IP Address: 10.XX.YY.1
- Subnet Mask: 255.0.0.0
- Gateway: 10.XX.YY.4

10. Open a web browser and navigate to the WRT610N’s newly configured address, 10.XX.YY.4 to confirm that it has been set correctly.

11. Ensure the WGA600N is powered on, but not connected to the WRT610N. Open a web browser and navigate to 10.XX.YY.1 to confirm that the WGA600N’s IP address has been set correctly.

12. Connect all network cables to match the diagram shown in section 5.3 to confirm wireless control of the robot.

## 5.7 TROUBLESHOOTING

### 5.7.1 Wind River Workbench

**Very slow startup** – The first time the workbench starts, it takes longer because it is initializing the workspace. After that it scans the workspace every time it starts. If your workspace is set to the **C:** drive instead of **C:/workbench/workspace**, this scan can take a long time. We have also encountered an issue with the antivirus Sophos that slowed the startup significantly.

#### 5.7.1.1 License Issues

**“System Time has changed”** – On startup, WindRiver checks every file in the workspace to see if the creation or last modified date of each file and folder is later than the current date.

To fix this error, you can delete all files and folders with a creation date later than the current date or get a program that can modify the creation date.

For files with a last modified date later than the current date, you can open the file then save it. For folders with a last modified date later than the current date, you can create a folder inside the offending folder then delete it.

Another possible solution is to run Workbench in a virtual machine. This should also increase the startup time of Workbench, as it would only check the files in the virtual machine. (We didn't try this).

**“License not found”** – we are investigating this issue

### 5.7.2 Driver Station

**Mode and System say, “INVALID”** – Your team number is not set in the DS software. See the “Initial Configuration” section.

## 5.8 ACRONYMS RELATED TO THE NEW CONTROL SYSTEM

You may see these acronyms in FIRST or vendor related documentation describing the control system.

ASIC – Application-specific Integrated Circuit  
BFL – Big Fancy Light or Big Flashing Light (colloquial terms for the Robot Signal Light)  
CAD – Computer Aided Design  
CLB – Configurable-Logic Blocks (FPGA architecture building block)  
cRIO – Compact Reconfigurable Input/Output (real-time embedded controller from NI)  
DMA – Direct Memory Access  
DS – Driver Station (replaces 2008 Operator Interface)  
DSC – Digital SideCar (generally written as Digital Sidecar)  
FAQ – Frequently Asked Questions  
FC – Field Controller  
FIR – Finite Impulse Response (digital filter type)  
FMS – Field Management System  
FPGA – Field Programmable Gate Array  
FRC – FIRST Robotics Competition  
GPIO – General Purpose Input/Output  
HDL – Hardware Description Language  
HID – Human Interface Device  
HSL – Image type (Hue, Saturation, Luminance)  
I<sup>2</sup>C – (I squared C) – Inter Integrated Circuit  
IFI – Innovation First, Inc.  
KOP – kit of parts  
LabVIEW - Laboratory Virtual Instrument Engineering Workbench  
MDC – Mobile Device Controller  
OCR – Optical Character Recognition  
NI – National Instruments  
PD – Power Distribution (or PDB for “Power Distribution Board”)  
PID – Proportional-Integral-Derivative (control loop feedback mechanism)  
PWM – Pulse Width Modulation  
RGB – Image type (Red, Green, Blue)  
RSL – Robot Signal Light  
SVN – Subversion (configuration control software)  
TBD – To be determined  
TCP/IP – Transmission Control Protocol / Internet Protocol  
UART – Universal Asynchronous Receiver/Transmitter  
UDP – User Datagram Protocol  
USB – Universal Serial Bus  
VHSIC – Very High Speed Integrated Circuit  
VI – Virtual Instrument (module in LabVIEW)  
WPI - Worcester Polytechnic Institute