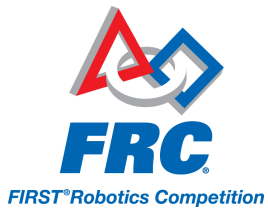
TROUBLESHOOTING



FRC
FIRST®Robotics Competition

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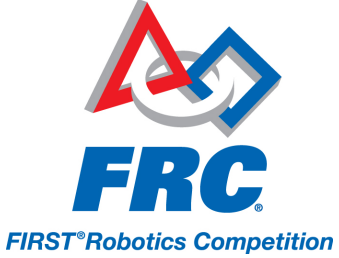


General Troubleshooting

Status Light Quick Reference

Many of the components of the FRC Control System have indicator lights that can be used to quickly diagnose problems with your robot. This guide shows each of the hardware components and describes the meaning of the indicators. Photos and information from Innovation FIRST and Cross the Road Electronics.

Robot Signal Light (RSL)

- Solid ON - Robot On and Disabled
- Blinking - Robot On and Enabled
- Off - Robot Off, roboRIO not powered or RSL not wired properly.

RoboRIO

Power

- Green - Power is good
- Amber - Brownout protection tripped, outputs disabled
- Red - Power fault, check user rails for short circuit

Status

- On while the controller is booting, then should turn off
- 2 blinks - Software error, reimage roboRIO
- 3 blinks - Safe Mode, restart roboRIO, reimage if not resolved
- 4 blinks - Software crashed twice without rebooting, reboot roboRIO, reimage if not resolved
- Constant flash or stays solid on - Unrecoverable error

Radio

Not currently implemented

Comm

- Off - No Communication
- Red Solid - Communication with DS, but no user code
- Red Blinking - E-stop
- Green Solid - Good communication with DS

Mode

- Off - Outputs disabled (robot in Disabled, brown-out, etc.)
- Amber/Orange - Autonomous Enabled
- Green - Teleop Enabled
- Red - Test Enabled

RSL

See above

Power Distribution Panel

LED Fault Table

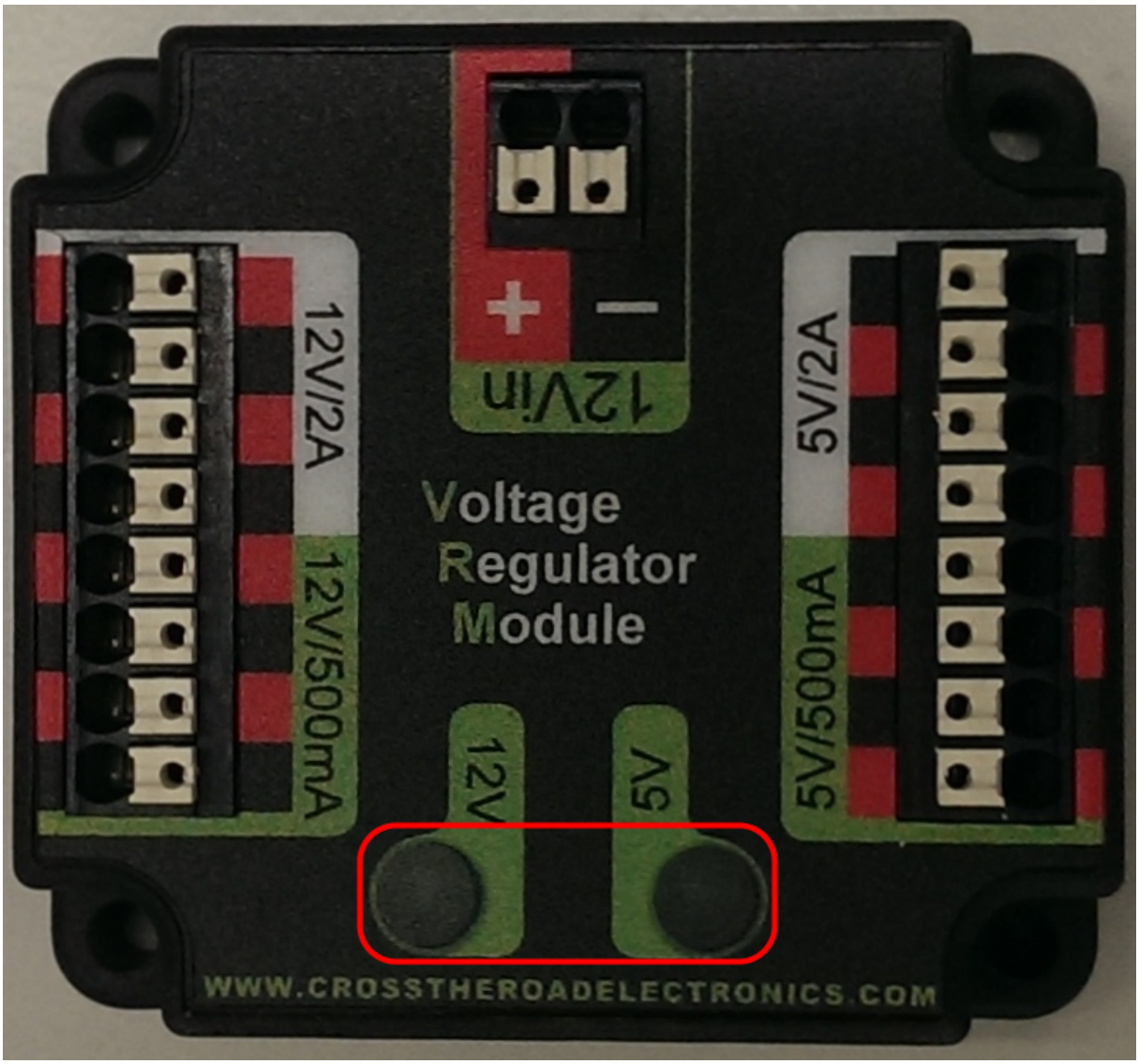
LED	Strobe	Slow	Long
Green	No Fault - Robot Enabled	No Fault - Robot Disabled	NA
Orange	NA	Sticky Fault	NA
Red	NA	No CAN Comm	NA

*If PCM LED contains more than one color, see LED Special States Table

LED Special States Table

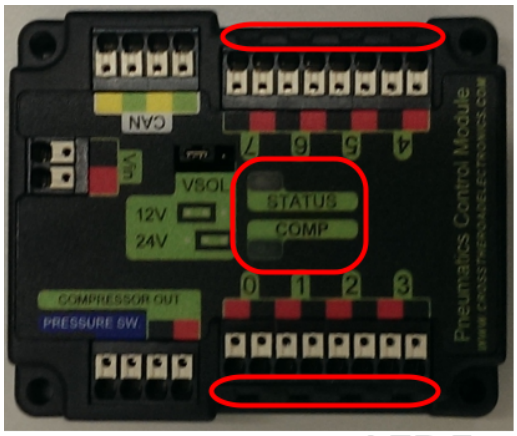
LED Colors	Problem
Red/ Orange	Damaged Hardware
Green/ Orange	In Bootloader
No LED	No Power / Incorrect Polarity

Voltage Regulator Module



The status LEDs on the VRM indicate the state of the two power supplies. If the supply is functioning properly the LED should be lit bright green. If the LED is not lit or is dim, the output may be shorted or drawing too much current.

Pneumatics Control Module



LED Fault Table

LED	Strobe	Slow	Long
Green	No Fault - Robot Enabled	No Fault - Robot Disabled	NA
Orange	NA	Sticky Fault	NA
Red	NA	No CAN Comm OR Solenoid Fault (Blinks Solenoid Index)	Compressor Fault

*If PCM LED contains more than one color, see LED Special States Table

LED Special States Table

LED Colors	Problem
Red/ Orange	Damaged Hardware
Green/ Orange	In Bootloader
No LED	No Power / Incorrect Polarity

Solenoid Channel LEDs - These LEDs are lit red if the Solenoid channel is enabled and not lit if it is disabled.

Comp - This is the Compressor LED. This LED is green when the compressor output is active (compressor is currently on) and off when the compressor output is not active.

Status - The status LED indicates device status as indicated by the two tables above. For more information on resolving PCM faults see the PCM User Manual. Note that the No CAN Comm fault will

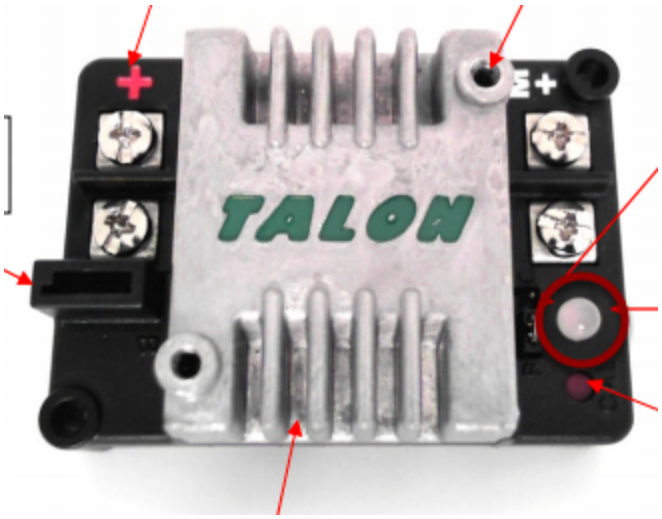
not occur only if the device cannot see communicate with any other device, if the PCM and PDP can communicate with each other, but not the roboRIO you will NOT see a No Can Comm fault.

Jaguar speed controllers

LED State	Module Status
Normal Operating Conditions	
Solid Yellow	Neutral (speed set to 0)
Fast Flashing Green	Forward
Fast Flashing Red	Reverse
Solid Green	Full-speed forward
Solid Red	Full-speed reverse
Fault Conditions	
Slow Flashing Yellow	Loss of servo or Network link
Fast Flashing Yellow	Invalid CAN ID
Slow Flashing Red	Voltage, Temperature, or Limit Switch fault condition
Slow Flashing Red and Yellow	Current fault condition

LED State	Module Status
Calibration Conditions	
Fast Flashing Red and Green	Calibration mode active
Fast Flashing Red and Yellow	Calibration mode failure
Slow Flashing Green and Yellow	Calibration mode success
Slow Flashing Red and Green	Calibration mode reset to factory default settings success
Other Conditions	
Slow Flashing Green	Waiting in CAN Assignment mode

Talon speed controllers



The LED is used to indicate the direction and percentage of throttle and state of calibration. The LED may be one of three colors; red, orange or green. A solid green LED indicates positive output voltage equal to the input voltage of the Talon. A solid Red LED indicates an output voltage that is equal to the input voltage multiplied by -1(input voltage = 12 volts, output equals -12 volts). The LED will blink it's corresponding color for any throttle less than 100% (red indicates negative polarity, green indicates positive). The rate at which the led blinks is proportional to the percent throttle. The faster the LED blinks the closer the output is to 100% in either polarity.

The LED will blink orange any time the Talon is in the disabled state. This will happen if the PWM input signal is lost, or in FRC, when the robot is disabled. If the Talon is in the enabled state and the throttle is within the 4% dead band, the LED will remain solid orange.

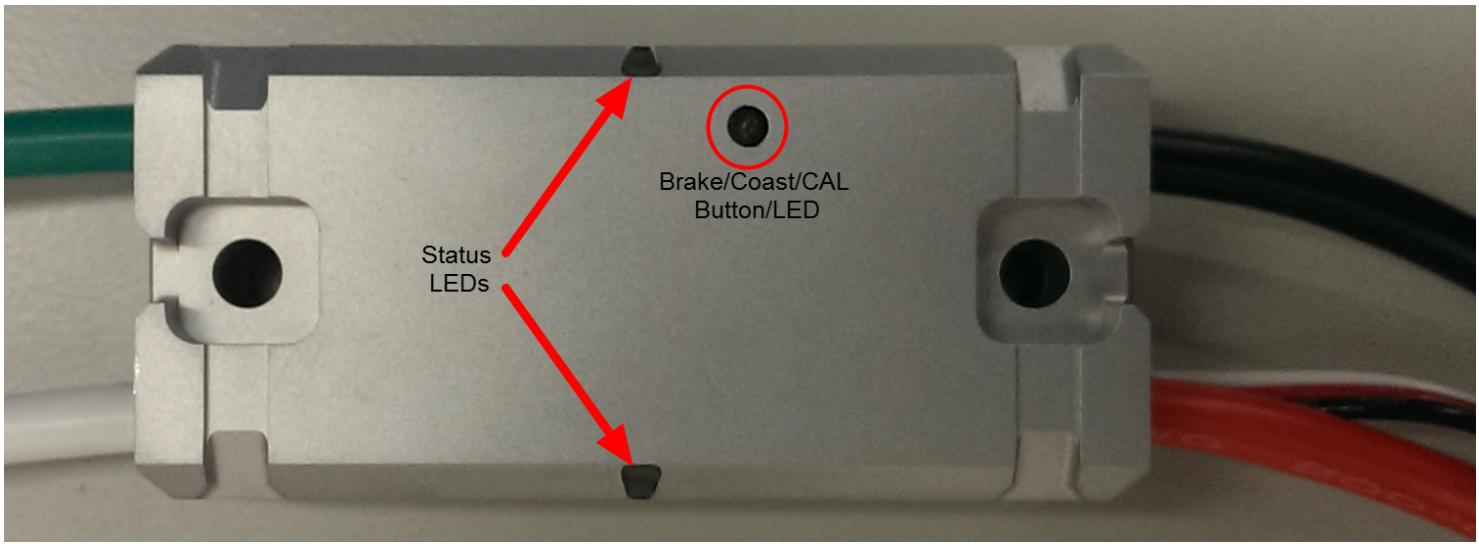
Flashing Red/Green indicate ready for calibration. Several green flashes indicates successful calibration, and red several times indicates unsuccessful calibration.

Victor speed controllers

LED Indicator Status:

Green - full forward
Orange - neutral / brake
Red - full reverse
Flashing orange - no PWM signal
Flashing red/green - calibration mode
Flashing green - successful calibration
Flashing red - unsuccessful calibration

Victor-SP speed controllers



Brake/Coast/Cal Button/LED - Red if the controller is in brake mode, off if the controller is in coast mode

Status

The Status LEDs are used to indicate the direction and percentage of throttle and state of calibration. The LEDs may be one of three colors; red, orange or green. Solid green LEDs indicate positive output voltage equal to the input voltage of the Victor-SP. Solid Red LEDs indicate an output voltage that is equal to the input voltage multiplied by -1(input voltage = 12 volts, output equals -12 volts). The LEDs will blink in the corresponding color for any throttle less than 100% (red indicates negative polarity, green indicates positive). The rate at which the LEDs blink is proportional to the percent throttle. The faster the LEDs blink the closer the output is to 100% in either polarity.

The LEDs will blink orange any time the Victor-SP is in the disabled state. This will happen if the PWM input signal is lost, or in FRC, when the robot is disabled. If the Victor-SP is in the enabled state and the throttle is within the 4% dead band, the LED will remain solid orange.

Flashing Red/Green indicate ready for calibration. Several green flashes indicates successful calibration, and red several times indicates unsuccessful calibration.

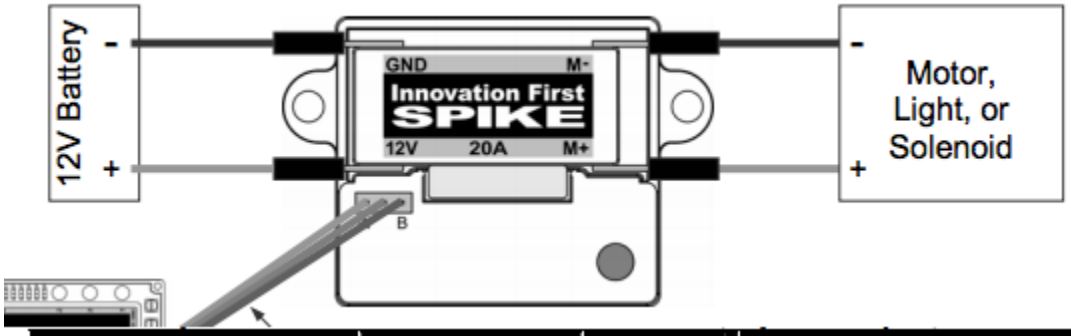
Talon-SRX speed controllers

Blink Codes During Calibration	
Status LEDs Blink Code	**Talon SRX State**
Flashing Red/Green	Calibration Mode
Blinking Green	Successful Calibration
Blinking Red	Failed Calibration

Blink Codes During Normal Operation		
LEDs	**Colors**	**Talon SRX State**
Both	Blinking Green	Forward throttle is applied. Blink rate is proportional to Duty Cycle
Both	Blinking Red	Reverse throttle is applied. Blink rate is proportional to Duty Cycle
None	None	No Power is being applied to Talon SRX
LEDs Alternate[1]	Off/Orange	CAN bus detected, robot disabled
LEDs Alternate[1]	Off/Slow Red	CAN bus/PWM is not detected
LEDs Alternate[1]	Off/Fast Red	Fault Detected
LEDs Alternate[1]	Red/Orange	Damaged Hardware
LEDs Strobe "towards" (M+)[2]	Off/Red	Forward Limit Switch or Forward Soft Limit
LEDs Strobe "towards" (M-)[2]	Off/Red	Reverse Limit Switch or Reverse Soft Limit
LED1 Only "closest" to M+/V+	Green/Orange	In Boot-loader

B/C CAL Blink Codes	
B/C CAL Button Color	**Talon SRX State**
Solid Red	Brake Mode
Off	Coast Mode

Spike relay configured as a motor, light, or solenoid switch

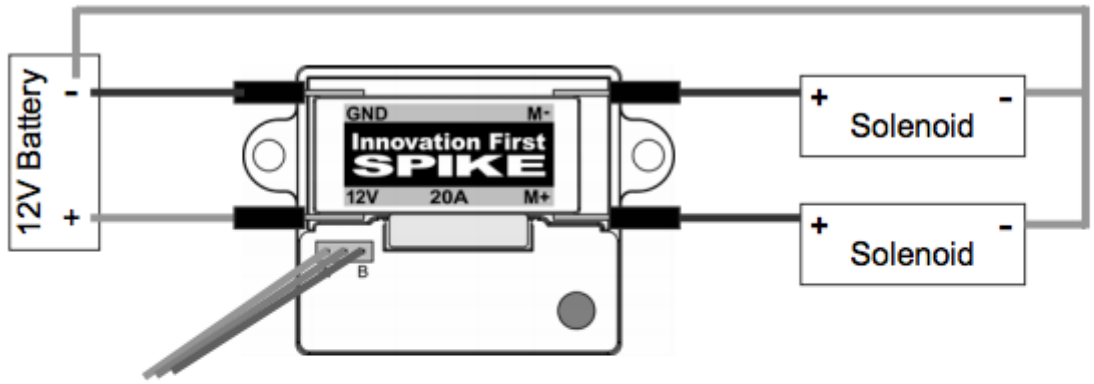


INPUTS		OUTPUTS			
Fwd(Wht)	**Rev(Red)**	**M+**	**M-**	**Indicator**	**Motor Function**
0	0	GND	GND	Orange	OFF / Brake Condition (default)
1	0	+12v	GND	Green	Motor rotates in one direction
0	1	GND	+12v	Red	Motor rotates in opposite direction
1	1	+12v	+12v	Off	OFF / Brake Condition

Notes:

1. 'Brake' refers to the dynamic stopping of the motor due to the shorting of the motor inputs. This condition is not optional when going to an off state.
2. The INPUT Fwd and Rev are defined as follows: 0 (Off) and 1 (On).

Spike relay configured as for one or two solenoids



INPUT		OUTPUTS			
Fwd(Wht)	Rev(Red)	M+	M-	Indicator	Solenoid Function
0	0	GND	GND	Orange	Both Solenoids OFF (default)
1	0	+12v	GND	Green	Solenoid connected to M+ is ON
0	1	GND	+12v	Red	Solenoid connected to M- is ON
1	1	+12v	+12v	Off	Both Solenoids ON

Note:

1. The INPUT Fwd and Rev are defined as follows: 0 (Off) and 1 (On).

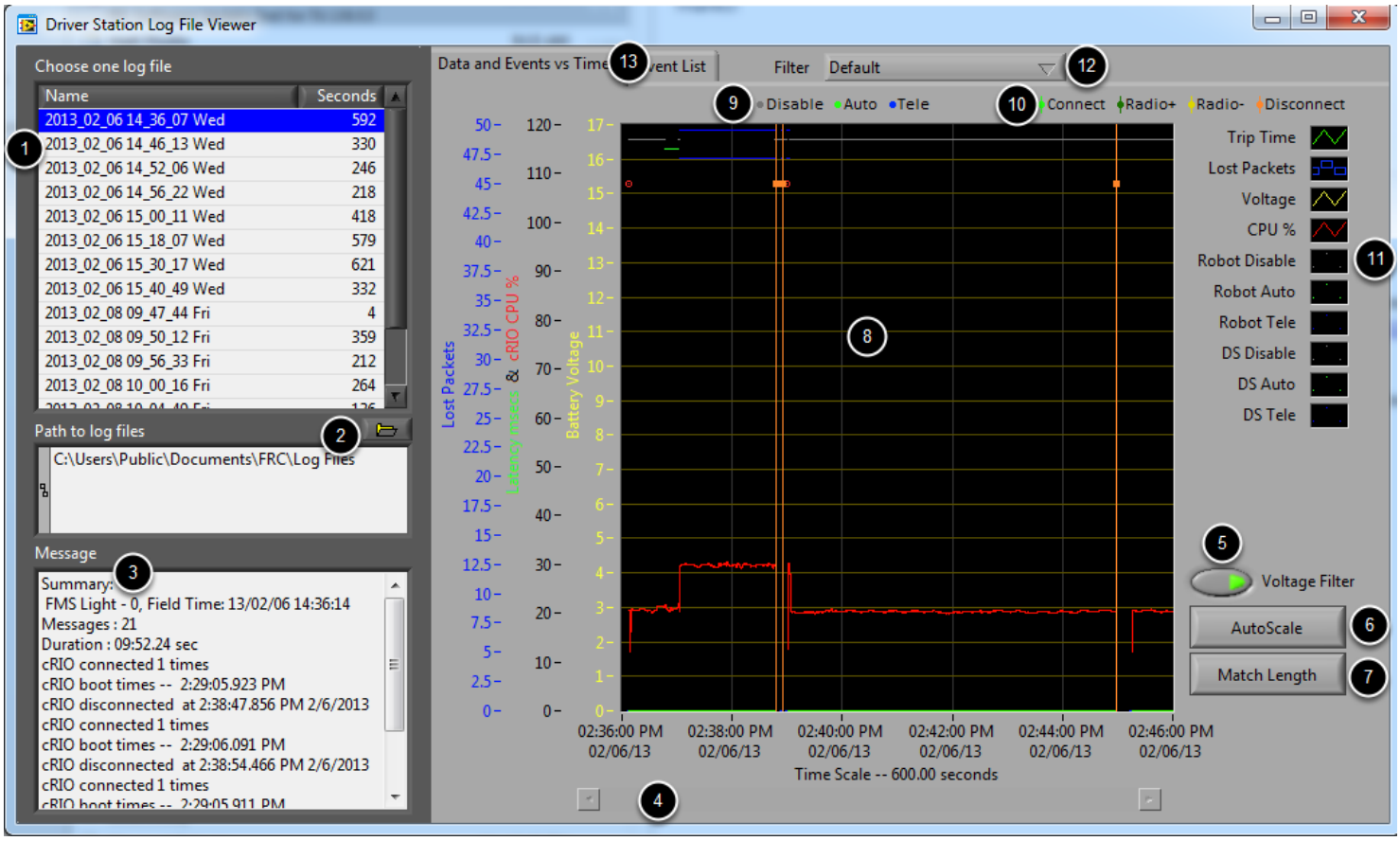
Driver Station Log File Viewer

In an effort to provide information to aid in debugging, the FRC Driver Station creates log files of important diagnostic data while running. These logs can be reviewed later using the FRC Driver Station Log Viewer. The Log Viewer can be found via the shortcut installed in the Start menu or in the FRC Driver Station folder in Program Files.

Event Logs

A new addition to the Driver Station logging this year is the Event Log. The Driver Station now logs all messages sent to the Messages box on the Diagnostics tab (not the User Messages box on the Operation tab) into a new Event Log file. When viewing Log Files with the Driver Station Log File Viewer, the Event Log and DSLog files are overlaid in a single display.

Log Viewer UI



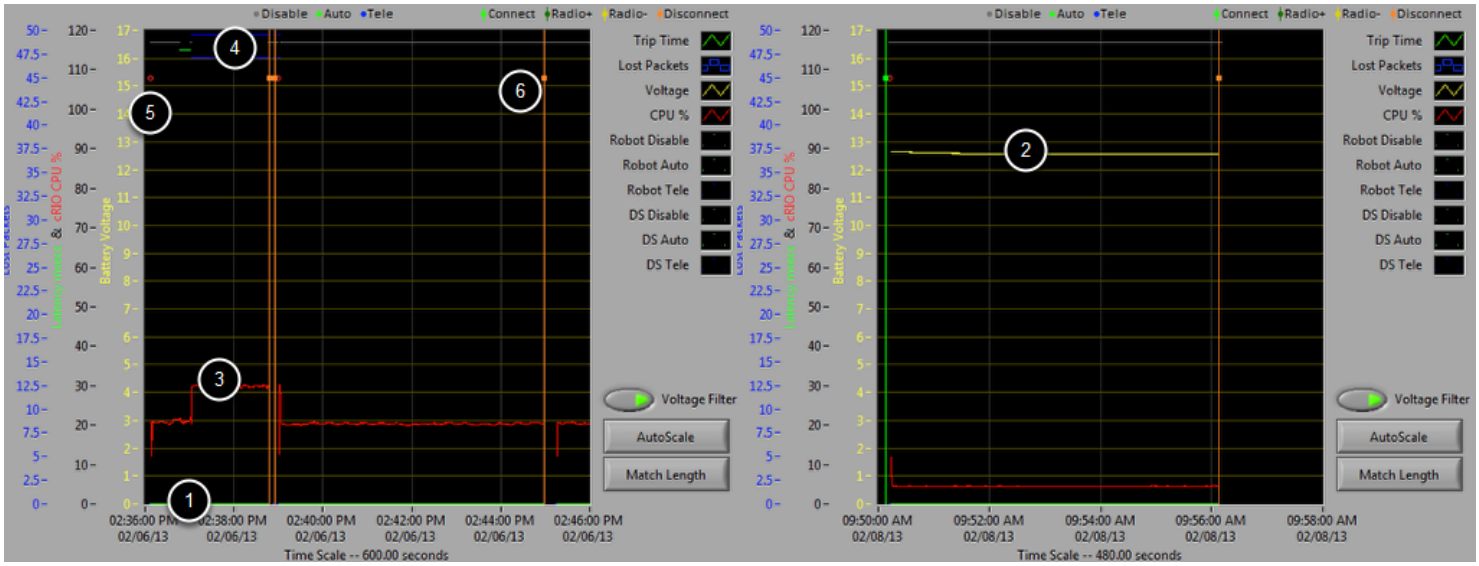
The Log Viewer contains a number of controls and displays to aid in the analysis of the Driver Station log files:

1. File Selection Box - This window displays all available log files in the currently selected folder. Click on a log file in the list to select it.
2. Path to Log Files - This box displays the current folder the viewer is looking in for log files. This defaults to the folder that the Driver Station stores log files in. Click the folder icon to browse to a different location.
3. Message Box - This box displays a summary of all messages from the Event Log. When hovering over an event on the graph this box changes to display the information for that event.
4. Scroll Bar - When the graph is zoomed in, this scroll bar allows for horizontal scrolling of the graph.
5. Voltage Filter - This control turns the Voltage Filter on and off (defaults to on). The Voltage Filter filters out data such as CPU %, robot mode and trip time when no Battery Voltage is received (indicating that the DS is not in communication with the cRIO). This does not filter out data when

the battery voltage being received is 0 due to a missing jumper on the Analog Module or no power provided to the Analog Module.

6. AutoScale - This button zooms the graph out to show all data in the log.
7. Match Length - This button scales the graph to approximately the length of an FRC match (2 minutes and 20 seconds shown). It does not automatically locate the start of the match, you will have to scroll using the scroll bar to locate the beginning of the Autonomous mode.
8. Graph - This display shows graph data from the DS Log file (voltage, trip time, cRIO CPU%, Lost Packets, and robot mode) as well as overlaid event data (shown as dots on the graph with select events showing as vertical lines across the entire graph). Hovering over event markers on the graph displays information about the event in the Messages window in the bottom left of the screen.
9. Robot Mode Key - Key for the Robot Mode displayed at the top of the screen
10. Major event key - Key for the major events, displayed as vertical lines on the graph
11. Graph key - Key for the graph data
12. Filter Control - Drop-down to select the filter mode (filter modes explained below)
13. Tab Control - Control to switch between the Graph (Data and Events vs. Time) and Event List displays.

Using the Graph Display



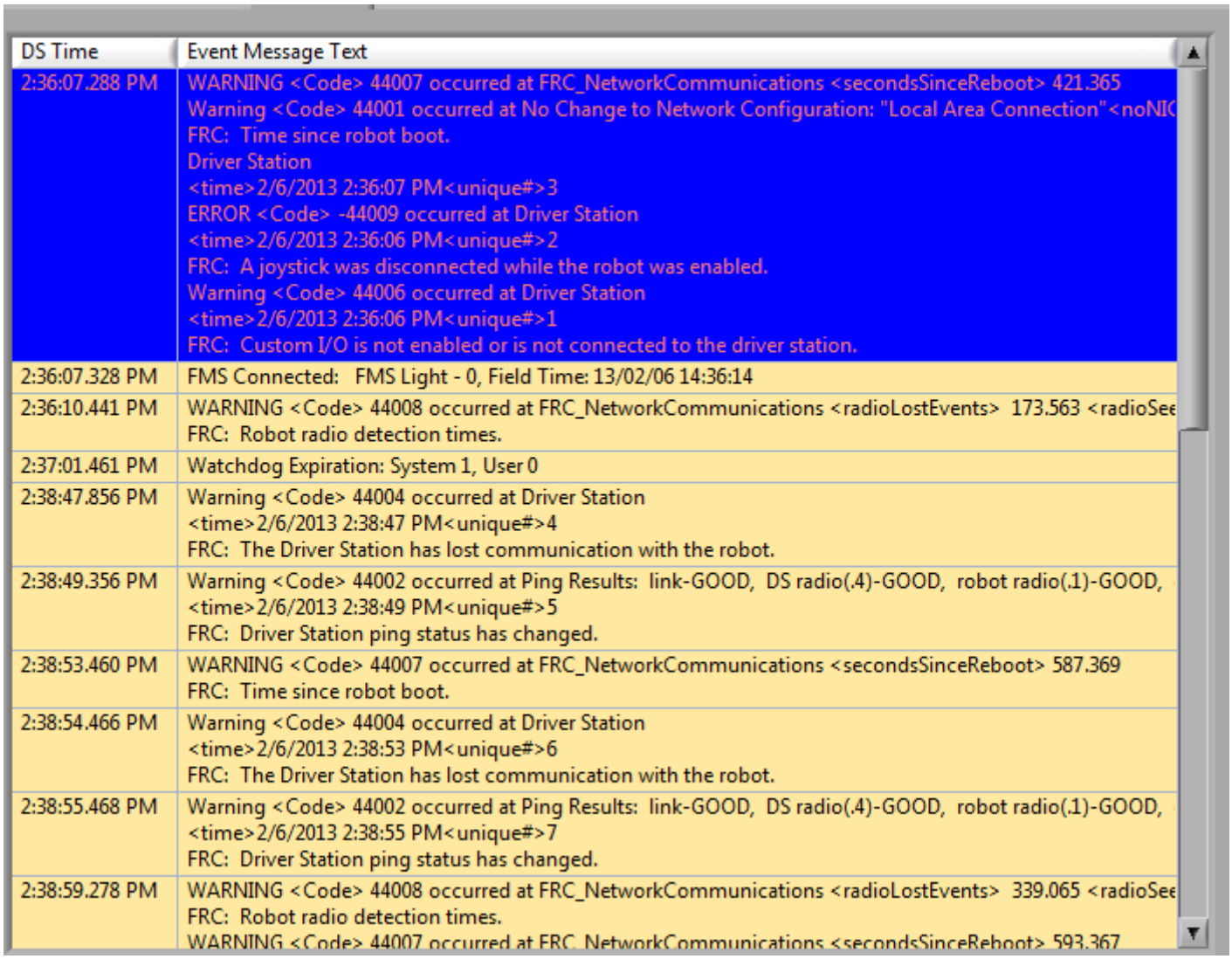
The Graph Display contains the following information:

1. Graphs of Trip Time in ms (green line) and Lost Packets per second (displayed as blue vertical bars). In these example images Trip Time is a flat green line at the bottom of the graph and there are no lost packets
2. Graph of Battery voltage displayed as a yellow line.

3. Graph of cRIO CPU % as a red line
4. Graph of robot mode and DS mode. The top set of the display shows the mode commanded by the Driver Station. The bottom set shows the mode reported by the robot code. In this example the robot is not reporting it's mode during the disabled and autonomous modes, but is reported during Teleop.
5. Event markers will be displayed on the graph indicating the time the event occurred. Errors will display in red; warnings will display in yellow. Hovering over an event marker will display information about the event in the Messages box at the bottom left of the screen.
6. Major events are shown as vertical lines across the graph display.

To zoom in on a portion of the graph, click and drag around the desired viewing area. You can only zoom the time axis, you cannot zoom vertically.

Event List



DS Time	Event Message Text
2:36:07.288 PM	WARNING <Code> 44007 occurred at FRC_NetworkCommunications <secondsSinceReboot> 421.365 Warning <Code> 44001 occurred at No Change to Network Configuration: "Local Area Connection" <noNIC FRC: Time since robot boot. Driver Station <time>2/6/2013 2:36:07 PM<unique#>3 ERROR <Code> -44009 occurred at Driver Station <time>2/6/2013 2:36:06 PM<unique#>2 FRC: A joystick was disconnected while the robot was enabled. Warning <Code> 44006 occurred at Driver Station <time>2/6/2013 2:36:06 PM<unique#>1 FRC: Custom I/O is not enabled or is not connected to the driver station.
2:36:07.328 PM	FMS Connected: FMS Light - 0, Field Time: 13/02/06 14:36:14
2:36:10.441 PM	WARNING <Code> 44008 occurred at FRC_NetworkCommunications <radioLostEvents> 173.563 <radioSee FRC: Robot radio detection times.
2:37:01.461 PM	Watchdog Expiration: System 1, User 0
2:38:47.856 PM	Warning <Code> 44004 occurred at Driver Station <time>2/6/2013 2:38:47 PM<unique#>4 FRC: The Driver Station has lost communication with the robot.
2:38:49.356 PM	Warning <Code> 44002 occurred at Ping Results: link-GOOD, DS radio(.4)-GOOD, robot radio(.1)-GOOD, <time>2/6/2013 2:38:49 PM<unique#>5 FRC: Driver Station ping status has changed.
2:38:53.460 PM	WARNING <Code> 44007 occurred at FRC_NetworkCommunications <secondsSinceReboot> 587.369 FRC: Time since robot boot.
2:38:54.466 PM	Warning <Code> 44004 occurred at Driver Station <time>2/6/2013 2:38:53 PM<unique#>6 FRC: The Driver Station has lost communication with the robot.
2:38:55.468 PM	Warning <Code> 44002 occurred at Ping Results: link-GOOD, DS radio(.4)-GOOD, robot radio(.1)-GOOD, <time>2/6/2013 2:38:55 PM<unique#>7 FRC: Driver Station ping status has changed.
2:38:59.278 PM	WARNING <Code> 44008 occurred at FRC_NetworkCommunications <radioLostEvents> 339.065 <radioSee FRC: Robot radio detection times. WARNING <Code> 44007 occurred at FRC_NetworkCommunications <secondsSinceReboot> 593.367

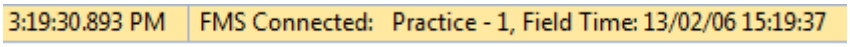
The Event List tab displays a list of events (warnings and errors) recorded by the Driver Station. The events and detail displayed are determined by the currently active filter (images shows "All Events, All Info" filter active).

Filters

Three filters are currently available in the Log Viewer:

1. Default: This filter filters out many of the errors and warnings produced by the Driver Station. This filter is useful for identifying errors thrown by the code on the Robot.
2. All Events and Time: This filter shows all events and the time they occured.
3. All Events, All Info: This filter shows all events and all recorded info. At this time the primary difference between this filter and "All Events and Time" is that this option shows the "unique" designator for the first occurrence of a particular message.

Identifying Logs from Matches



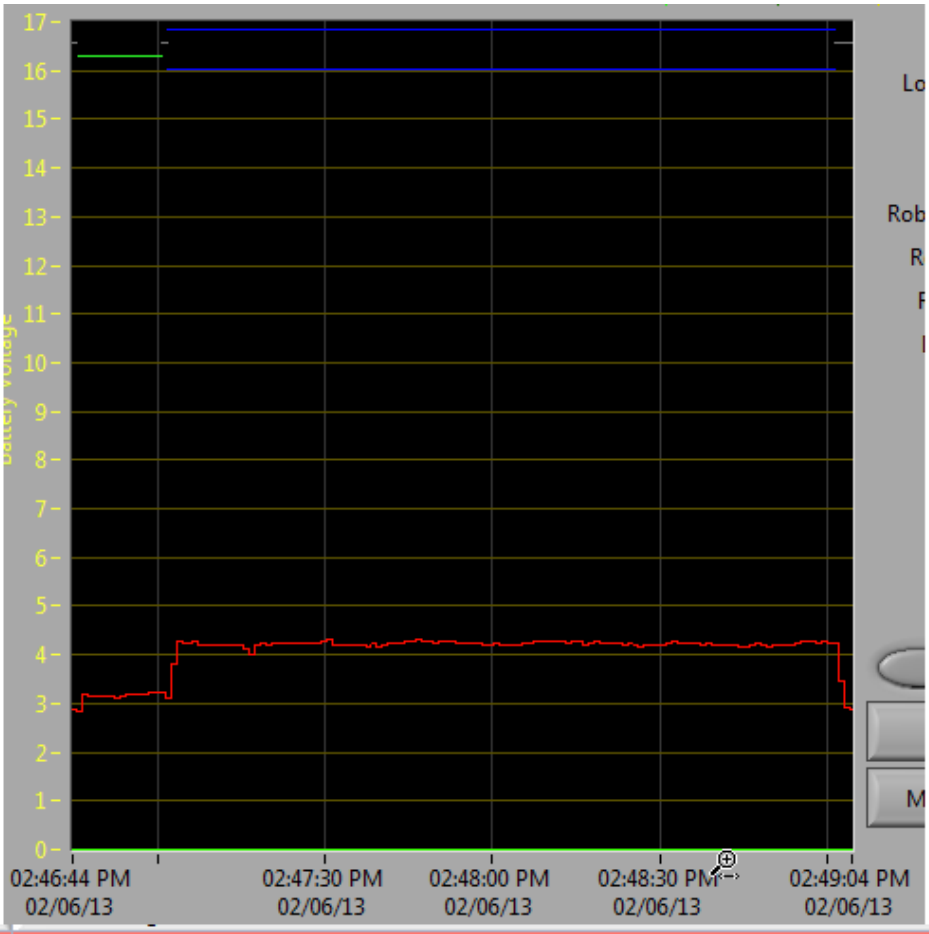
A common task when working with the Driver Station Logs is to identify which logs came from competition matches. Logs which were taken during a match can now be identified using the FMS Connected event which will display the match type (Practice, Qualification or Elimination), match number, and the current time according to the FMS server. In this example, you can see that the FMS server time and the time of the Driver Station computer are fairly close, approximately 7 seconds apart.

Identifying Common Connection Failures with the Log Viewer

When diagnosing robot issues, there is no substitute for thorough knowledge of the system and a methodical debugging approach. If you need assistance diagnosing a connection problem at your events it is strongly recommended to seek assistance from your FTA and/or CSA. The goal of this section is to familiarize teams with how some common failures can manifest themselves in the DS Log files. Please note that depending on a variety of conditions a particular failure show slightly differently in a log file.

Note that all log files shown in this section have been scaled to match length using the Match Length button and then scrolling to the beginning of the autonomous mode. Also, many of the logs do not contain battery voltage information, the platform used for log capture was not properly wired for reporting the battery voltage.

"Normal" Log

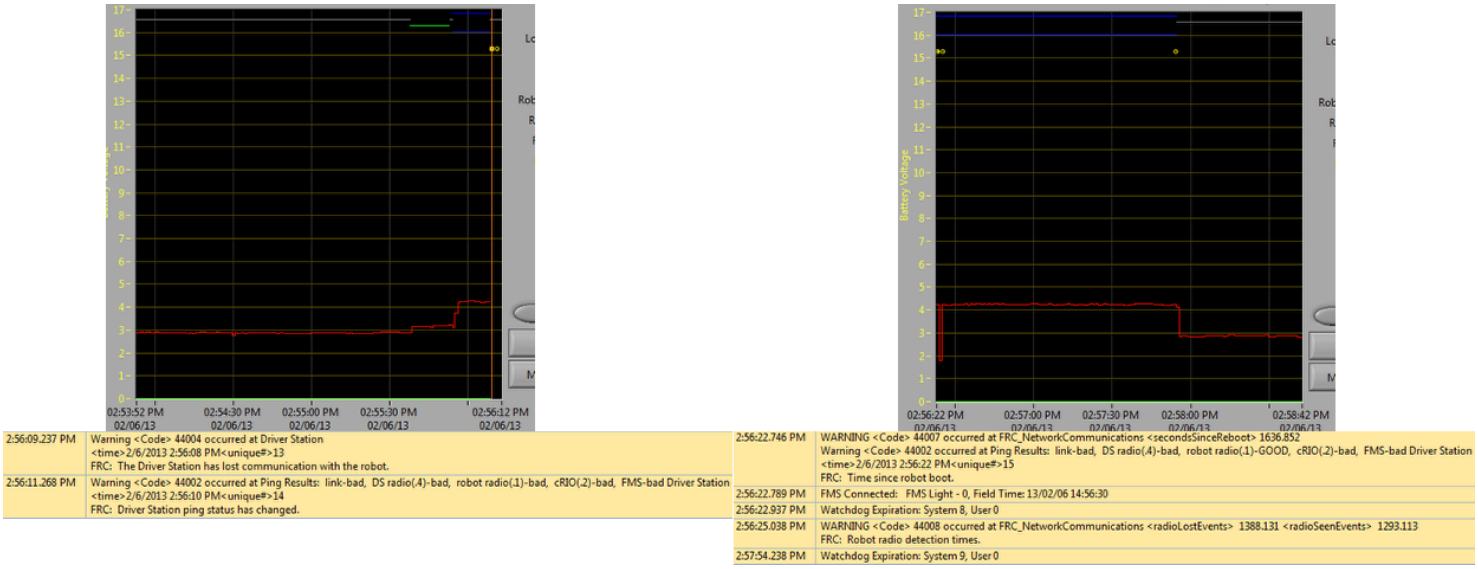


2:46:13.575 PM	WARNING <Code> 44007 occurred at FRC_NetworkCommunications <secondsSinceReboot> 1027.648 Warning <Code> 44001 occurred at No Change to Network Configuration: "Local Area Connection"<noNIC FRC: Time since robot boot. Driver Station <time>2/6/2013 2:46:13 PM<unique#>3 ERROR <Code> -44009 occurred at Driver Station <time>2/6/2013 2:46:13 PM<unique#>2 FRC: A joystick was disconnected while the robot was enabled. Warning <Code> 44006 occurred at Driver Station <time>2/6/2013 2:46:13 PM<unique#>1 FRC: Custom I/O is not enabled or is not connected to the driver station.
2:46:13.617 PM	FMS Connected: FMS Light - 0, Field Time: 13/02/06 14:46:21
2:46:16.471 PM	WARNING <Code> 44008 occurred at FRC_NetworkCommunications <radioLostEvents> 779.588 <radioSee FRC: Robot radio detection times.

This is an example of a normal match log. The errors and warnings contained in the first box are from when the DS first started and can be ignored. This is confirmed by observing that these events occurred prior to the "FMS Connected:" event. The last event shown can also be ignored, it is also from the robot

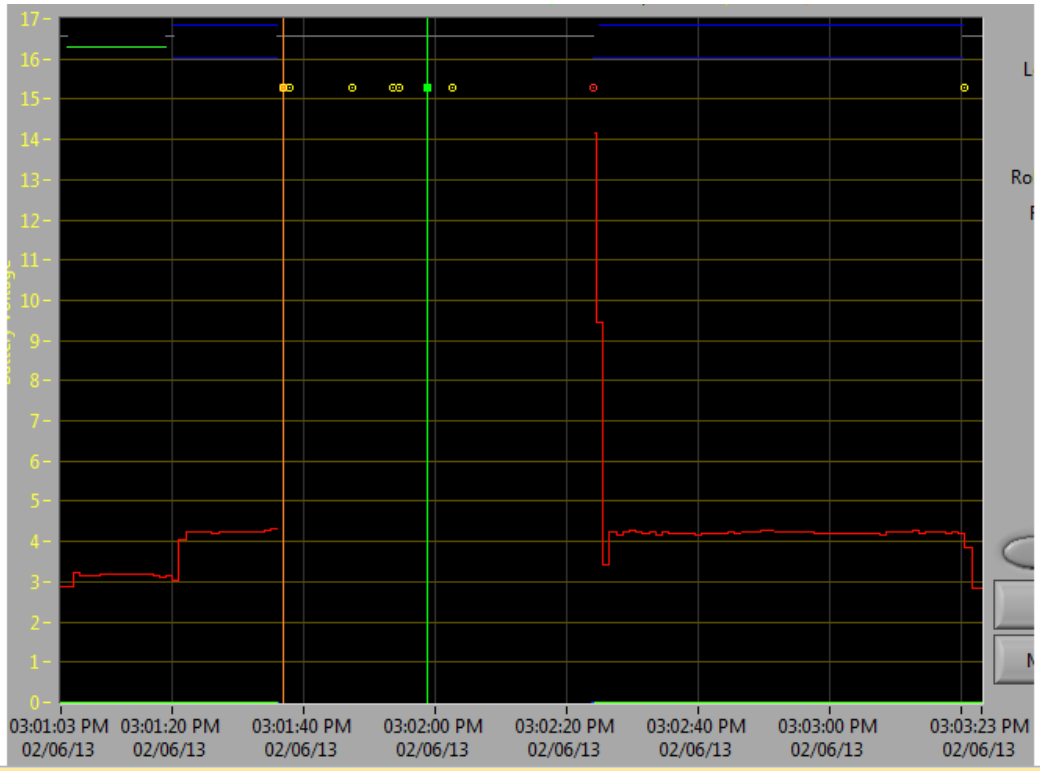
first connecting to the DS (it occurs 3 seconds after connecting to FMS) and occurs roughly 30 seconds before the match started.

Disconnected from FMS



When the DS disconnects from FMS, and therefore the robot, during the match it may segment the log into pieces. The key indicators to this failure are the last event of the first log, indicating that the connection to FMS is now "bad" and the second event from the 2nd log which is a new FMS connected message followed by the DS immediately transitioning into Teleop Enabled. The most common cause of this type of failure is an ethernet cable with no latching tab or a damaged ethernet port on the DS computer.

cRIo Reboot

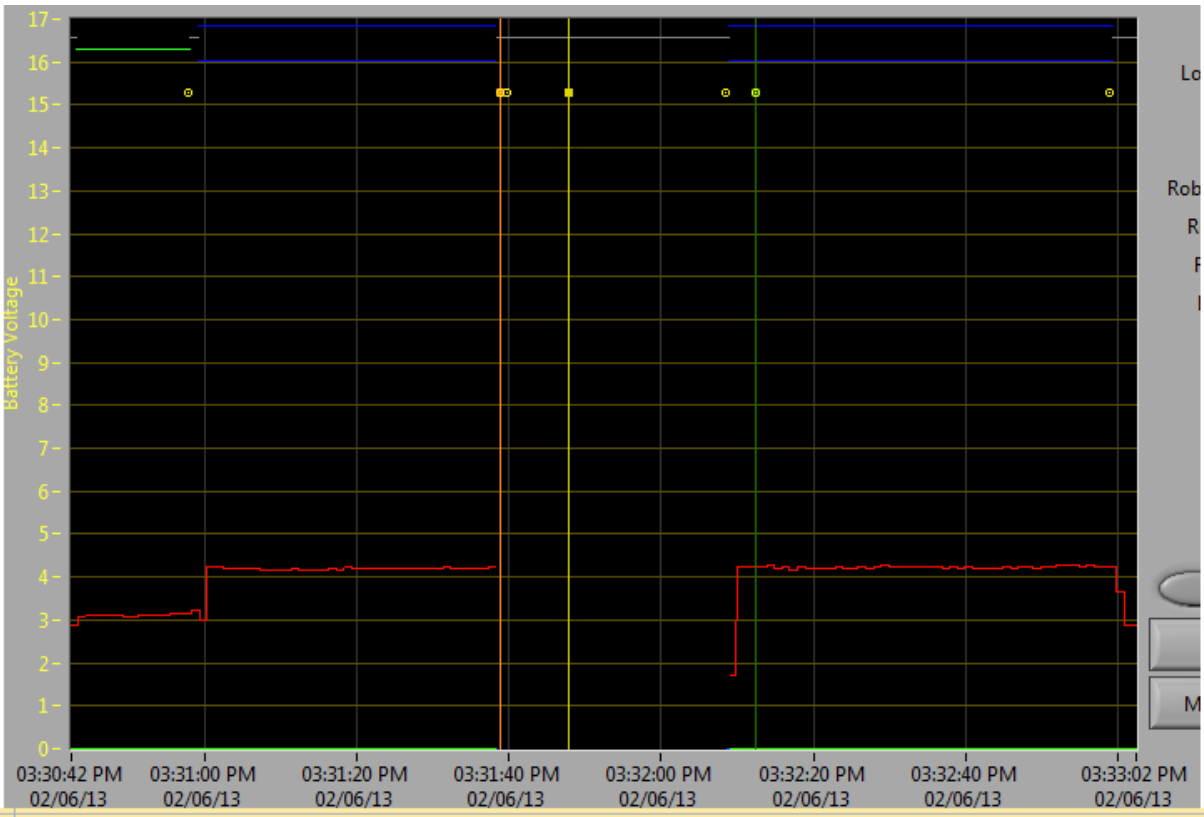


3:01:36.869 PM	Warning <Code> 44004 occurred at Driver Station <time>2/6/2013 3:01:36 PM<unique#>4 FRC: The Driver Station has lost communication with the robot.
3:01:37.871 PM	Warning <Code> 44002 occurred at Ping Results: link-GOOD, DS radio(.4)-GOOD, robot radio(.1)-GOOD, cRIO(.2)-bad, FMS-GOOD Driver Station <time>2/6/2013 3:01:37 PM<unique#>5 FRC: Driver Station ping status has changed.
3:01:47.281 PM	Warning <Code> 44002 occurred at Ping Results: link-GOOD, DS radio(.4)-GOOD, robot radio(.1)-GOOD, cRIO(.2)-GOOD, FMS-GOOD Driver Station <time>2/6/2013 3:01:46 PM<unique#>6 FRC: Driver Station ping status has changed.
3:01:53.689 PM	Warning <Code> 44002 occurred at Ping Results: link-GOOD, DS radio(.4)-GOOD, robot radio(.1)-GOOD, cRIO(.2)-bad, FMS-GOOD Driver Station <time>2/6/2013 3:01:52 PM<unique#>7 FRC: Driver Station ping status has changed.
3:01:54.490 PM	Warning <Code> 44002 occurred at Ping Results: link-GOOD, DS radio(.4)-GOOD, robot radio(.1)-GOOD, cRIO(.2)-GOOD, FMS-GOOD Driver Station <time>2/6/2013 3:01:53 PM<unique#>8 FRC: Driver Station ping status has changed.
3:02:02.512 PM	WARNING <Code> 44007 occurred at FRC_NetworkCommunications <secondsSinceReboot> 3.682 FRC: Time since robot boot.
3:02:24.128 PM	ERROR <Code> -44003 occurred at WPI_CameraIssue HTTP Request with Authentication.vi>>WPI_CameraIssue Get.vi>>WPI_CameraGet Image Appea <time>21:30:35 02/06/2013 FRC: Operation failed due to a communication failure with the camera.
3:02:24.151 PM	Warning <Code> 44003 occurred at Driver Station <time>2/6/2013 3:02:24 PM<unique#>9 FRC: No robot code is currently running.

The "Time since robot boot" message is the primary indicator in a connection failure caused by the cRIO rebooting. In this log the DS loses connection with the cRIO at 3:01:36 as indicated by the first event. The second event indicates that the ping initiated after the connection failed was successful to all

devices other than the cRIO. At 3:01:47 the cRIO begins responding to pings again, one additional ping fails at 3:01:52. At 3:02:02 the Driver Station connects to the cRIO and the cRIO reports that it has been up for 3.682 seconds. This is a clear indicator that the cRIO has rebooted. The code continues to load and at 3:02:24 the code reports an error communicating with the camera. A warning is also reported indicating that no robot code is running right before the code finishes starting up.

Ethernet cable issue on robot

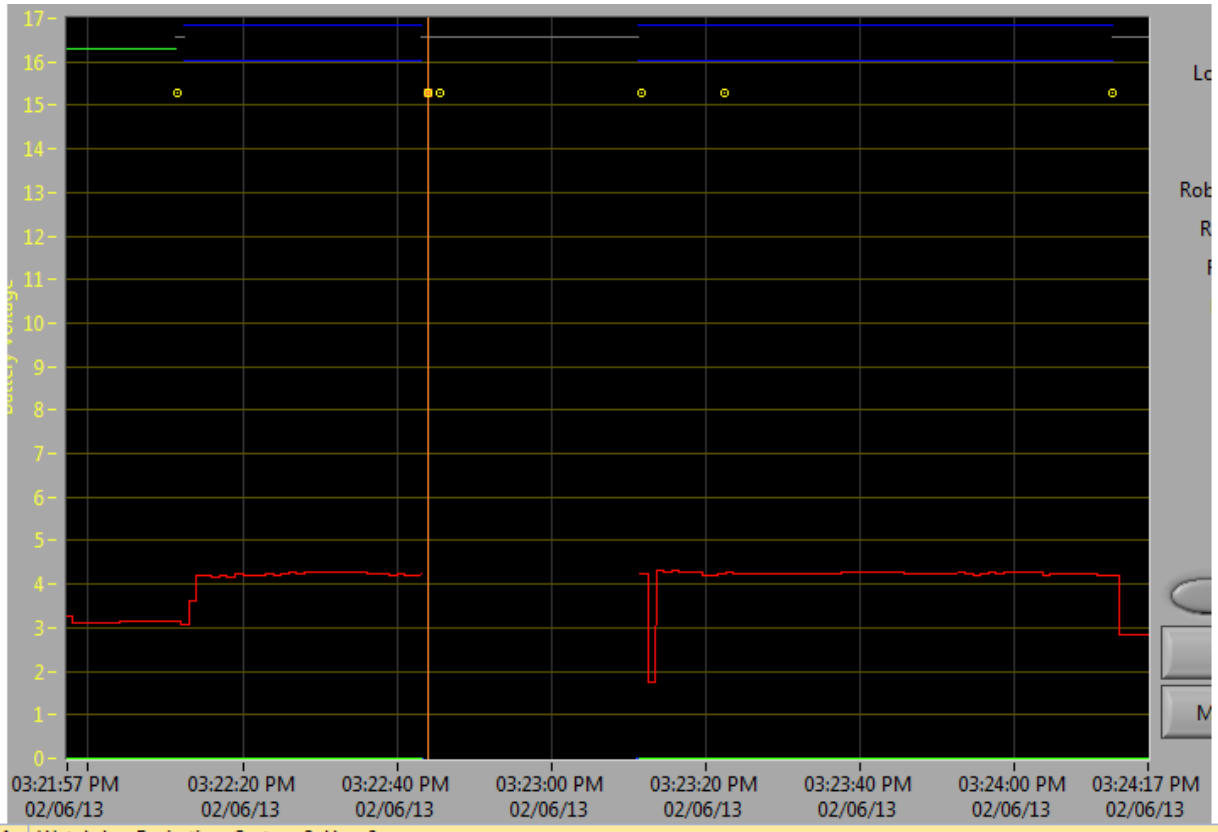


3:30:57.799 PM	Watchdog Expiration: System 5, User 0
3:31:38.800 PM	Warning <Code> 44004 occurred at Driver Station <time>2/6/2013 3:31:38 PM<unique#>10 FRC: The Driver Station has lost communication with the robot.
3:31:39.801 PM	Warning <Code> 44002 occurred at Ping Results: link-GOOD, DS radio(.4)-GOOD, robot radio(.1)-GOOD, cRIO(.2)-bad, FMS-GOOD Driver Station <time>2/6/2013 3:31:39 PM<unique#>11 FRC: Driver Station ping status has changed.
3:32:08.449 PM	WARNING <Code> 44007 occurred at FRC_NetworkCommunications <secondsSinceReboot> 1809.393 FRC: Time since robot boot.
3:32:12.399 PM	WARNING <Code> 44008 occurred at FRC_NetworkCommunications <radioLostEvents> 24.505,1492.752 <radioSeenEvents> 0.000,260.086 FRC: Robot radio detection times.
3:32:59.018 PM	Watchdog Expiration: System 7, User 0

An issue with the ethernet cable on the robot is primarily indicated by the ping to the cRIO going to bad and Radio Lost and Radio Seen events when the cRIO reconnects. The "Time since robot boot" message when the cRIO reconnects will also indicate that the cRIO has not rebooted. In this example,

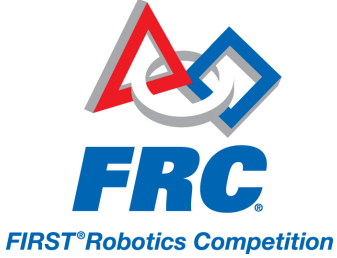
the robot Ethernet cable was disconnected at 3:31:38. The ping status indicates that the D-Link radio is still connected. When the robot reconnects at 3:32:08 the "Tim since robot boot" is 1809 seconds indicating that the cRIO clearly did not reboot. At 3:32:12 the robot indicates that it lost the radio 24.505 seconds ago and it returned 0.000 seconds ago. These points are plotted as vertical lines on the graph, yellow for radio lost and green for radio seen. Note that the times are slightly offset from the actual events as shown via the disconnection and connection, but help to provide additional information about what is occurring.

Radio reboot



3:22:11.489 PM	Watchdog Expiration: System 2, User 0
3:22:44.030 PM	Warning <Code> 44004 occurred at Driver Station <time>2/6/2013 3:22:43 PM<unique#>6 FRC: The Driver Station has lost communication with the robot.
3:22:45.531 PM	Warning <Code> 44002 occurred at Ping Results: link-GOOD, DS radio(.4)-GOOD, robot radio(.1)-bad, cRIO(.2)-bad, FMS-GOOD Driver Station <time>2/6/2013 3:22:45 PM<unique#>7 FRC: Driver Station ping status has changed.
3:23:11.620 PM	WARNING <Code> 44007 occurred at FRC_NetworkCommunications <secondsSinceReboot> 1272.775 FRC: Time since robot boot.
3:23:11.690 PM	Watchdog Expiration: System 3, User 0

A reboot of the robot radio is typically characterized by a loss of connection to the radio for ~25-30 seconds. In this example, the radio briefly lost power at 3:22:44, causing it to start rebooting. The event at 3:22:45 indicates that the ping to the radio failed. At 3:23:11, the DS regains communication with the cRIO and the cRIO indicates it gas been up for 1272.775 seconds, ruling out a cRIO reboot. Note that the network switch on the radio comes back up very quickly so a momentary power loss may not result in a "radio lost"/"radio seen" event pair. A longer disturbance may result in radio events being logged by the DS. In that case, the distinguishing factor which points towards a radio reboot is the ping status of the radio from the DS. If the radio resets, the radio will be unreachable. If the issue is a cabling or connection issue on the robot, the radio ping should remain "GOOD".



Support Resources

In addition to the documentation here, there are a variety of other resources available to FRC teams to help understand the Control System and software.

Other Documentation

In addition to this site there are a few other places teams may check for documentation:

- NI FRC Community Documents Section
- USFIRST.org Technical Resources Page
- VEXPro Jaguar Page

Forums

Stuck? Have a question not answered by the documentation? Official Support is provided on these forums:

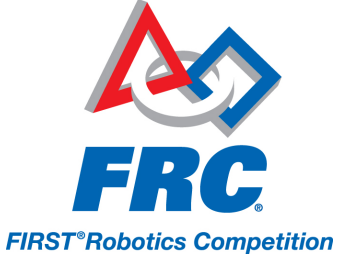
- NI FRC Community Discussion Section (roboRIO, LabVIEW and Driver Station software questions)
- USFIRST.org Control System Forum (wiring, hardware and Driver Station questions)
- USFIRST.org Programming Forum (programming questions for C++, Java, or LabVIEW)

NI Phone Support

Have a LabVIEW, roboRIO, or Driver Station question? NI provides phone support for FRC teams during the build season **Update for 2015**

Bug Reporting

Found a bug? Let us know by reporting it on the WPILib Bug Tracker. Note that you will have to create a TeamForge account if you do not already have one, but **you do not need** to apply for project membership.



Specific Issues

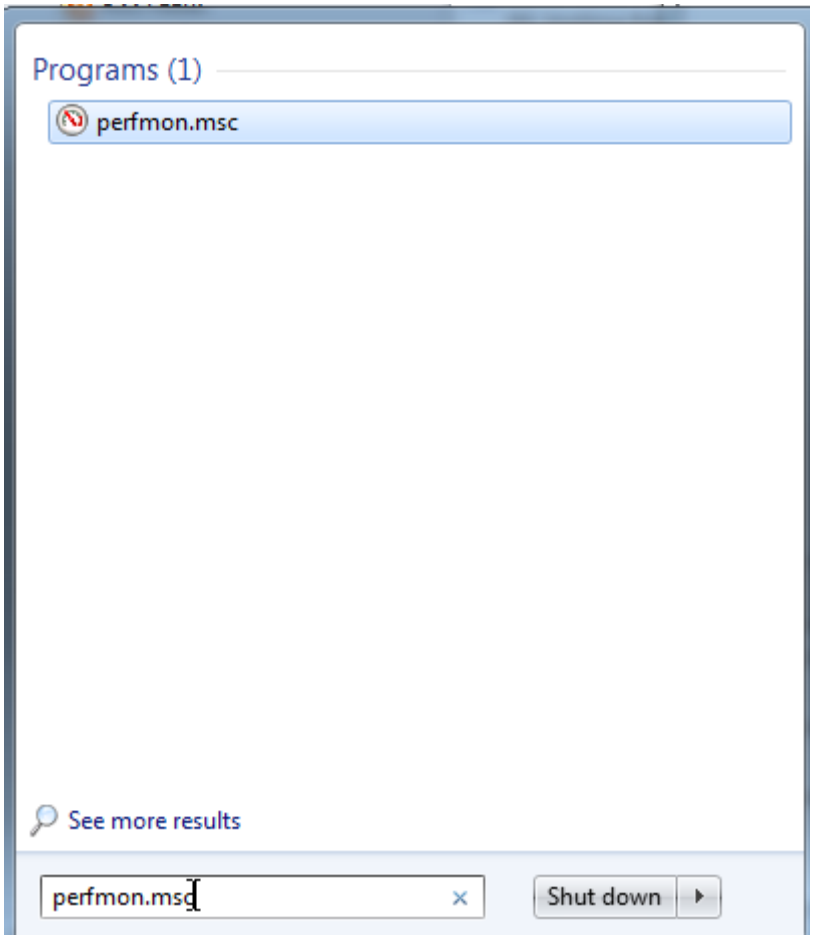
Measuring Bandwidth Usage

On the 2013 FRC Field (and at home when the DAP-1522 is configured using the FRC Bridge Configuration Utility) each team is limited to 7Mb/s of network traffic (see the FMS Whitepaper for more details). The FMS Whitepaper provides information on determining the bandwidth usage of the Axis camera, but some teams may wish to measure their overall bandwidth consumption. This document details how to make that measurement.

Measuring Bandwidth Using the Perfomance Monitor (Win 7 only)

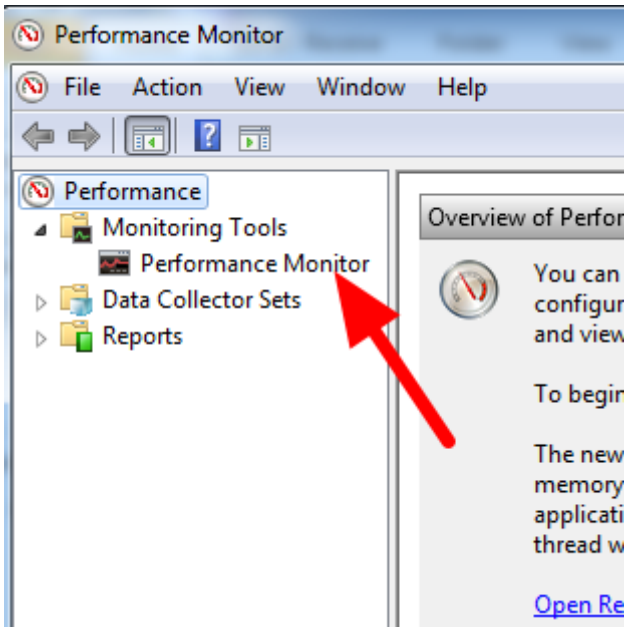
Windows 7 contains a built-in tool called the Performance Monitor that can be used to monitor the bandwidth usage over a network interface.

Launching the Performance Monitor



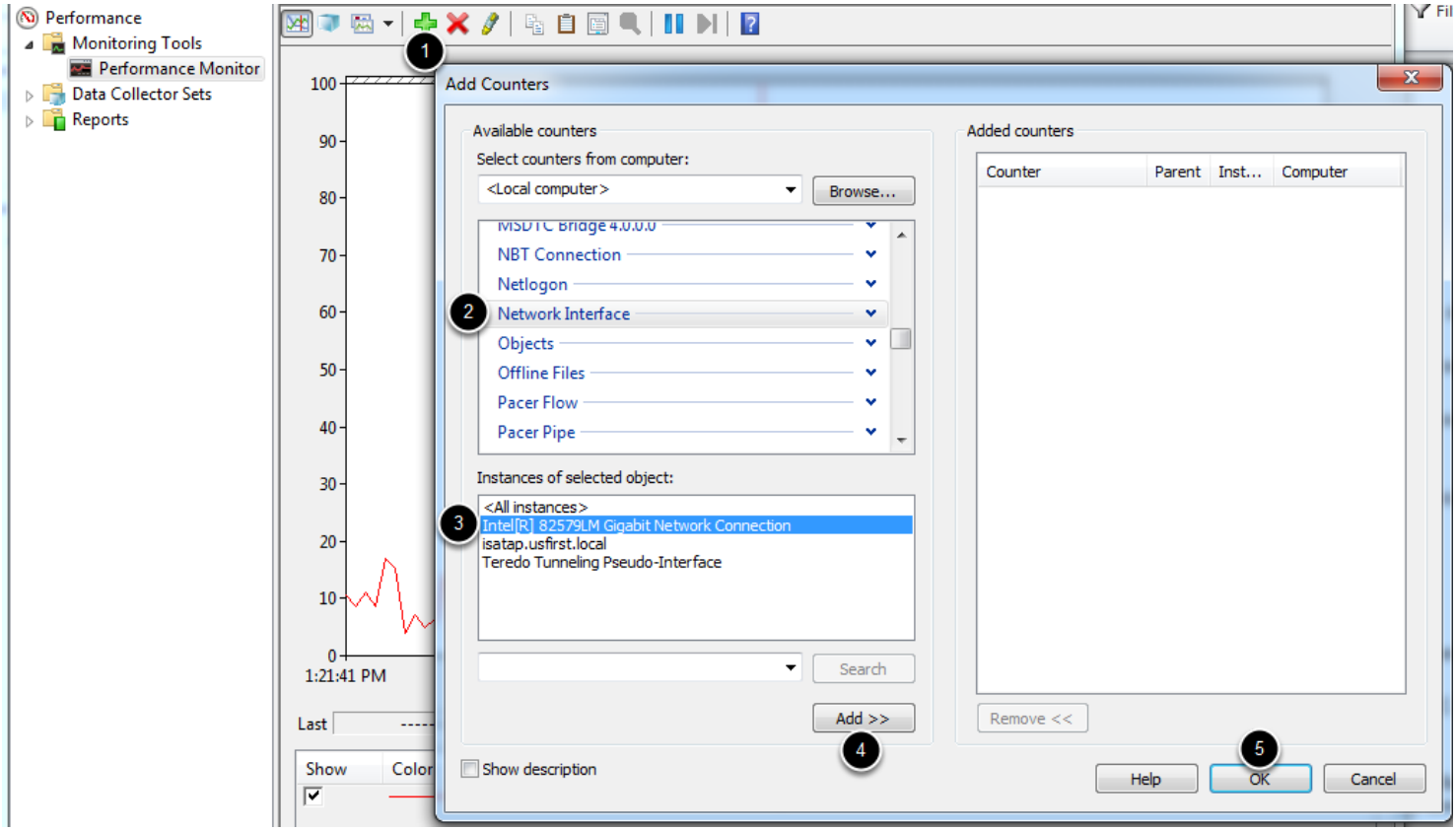
Click **Start** and in the search box, type **perfmon.msc** and press Enter.

Open Real-Time Monitor



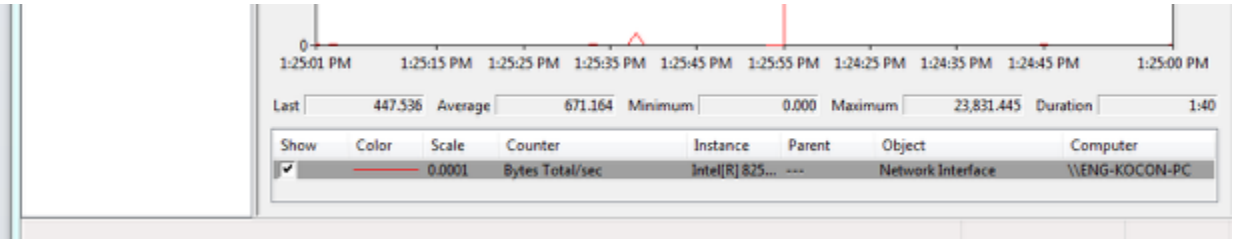
In the left pane, click Performance Monitor to display the real-time monitor.

Add Network Counter



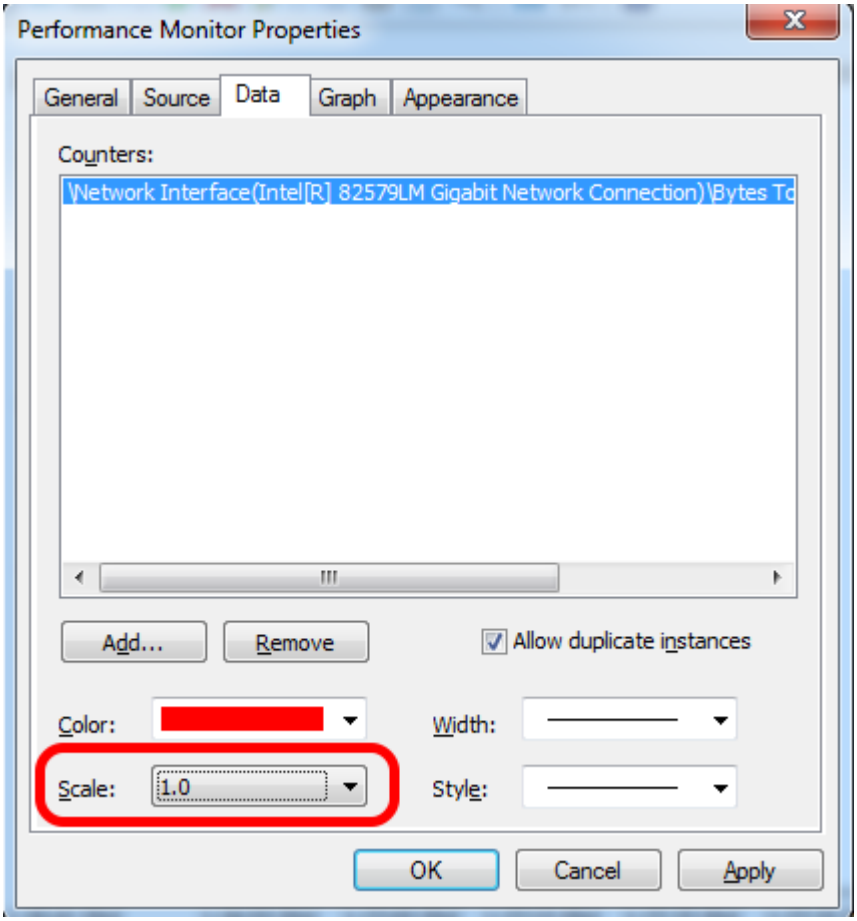
1. Click the green plus near the top of the screen to add a counter
2. In the top left pane, locate and click on **Network Interface** to select it
3. In the bottom left pane, locate the desired network interface (or use All instances to monitor all interfaces)
4. Click **Add>>** to add the counter to the right pane.
5. Click **OK** to add the counters to the graph.

Remove extra counters



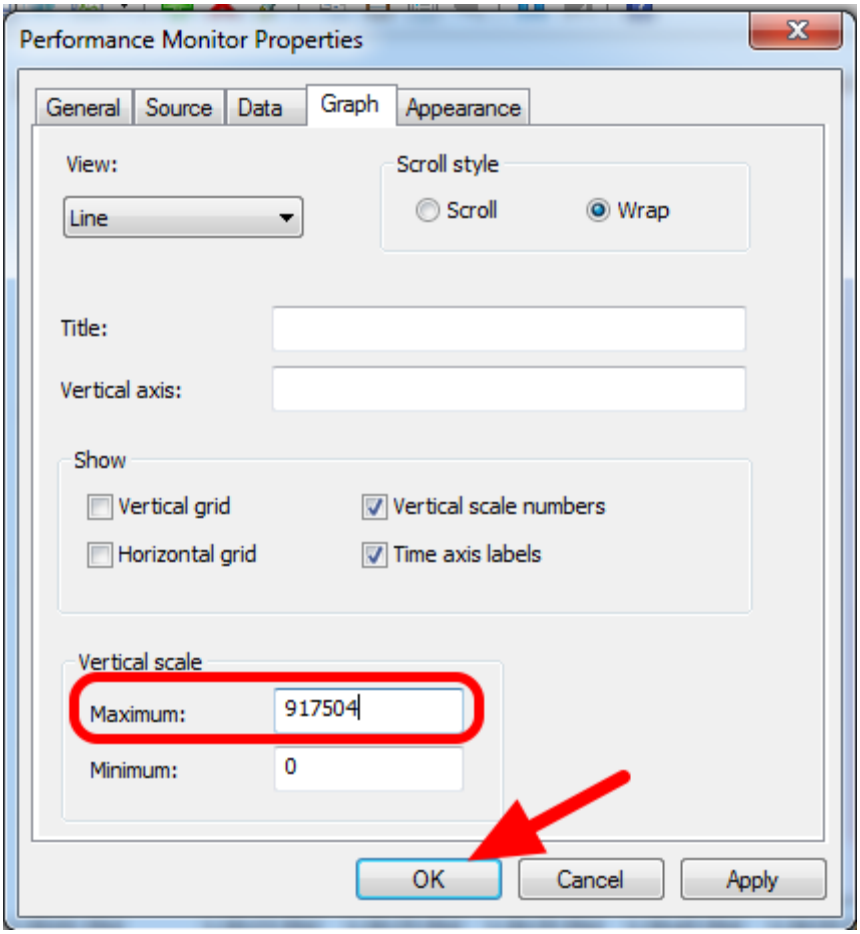
In the bottom pane, select each counter other than **Bytes Total/sec** and press the **Delete** key. The **Bytes Total/sec** entry should be the only entry remaining in the pane.

Configure Data Properties



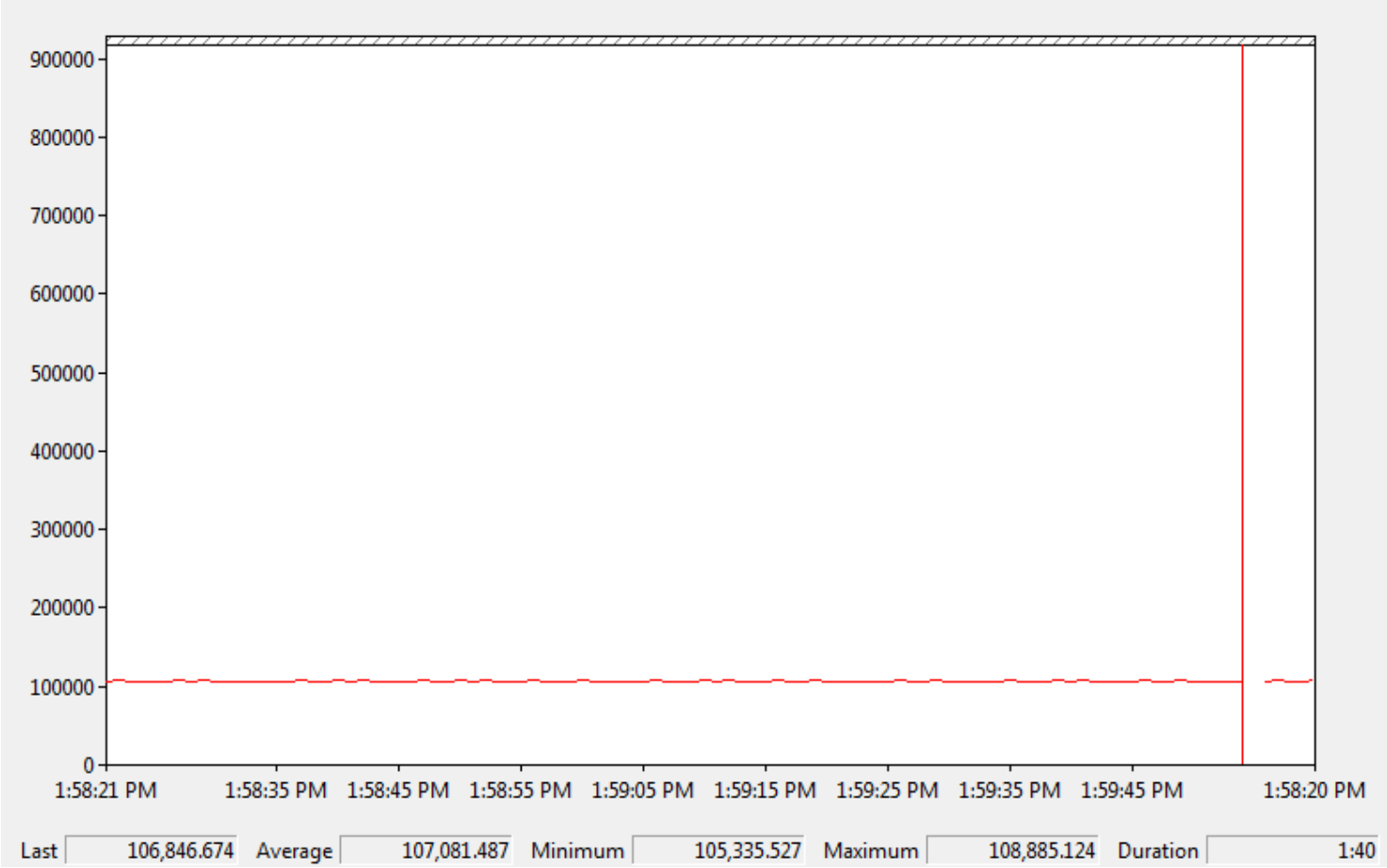
Press **Ctrl+Q** to bring up the Properties window. Click on the dropdown next to **Scale** and select **1.0**. Then click on the **Graph** tab.

Configure Graph Properties



In the **Maximum Box** under **Vertical Scale** enter 917504 (this is 7Megabits converted to Bytes). If desired, turn on the horizontal grid by checking the box. The click **OK** to close the dialog.

Viewing Bandwidth Usage

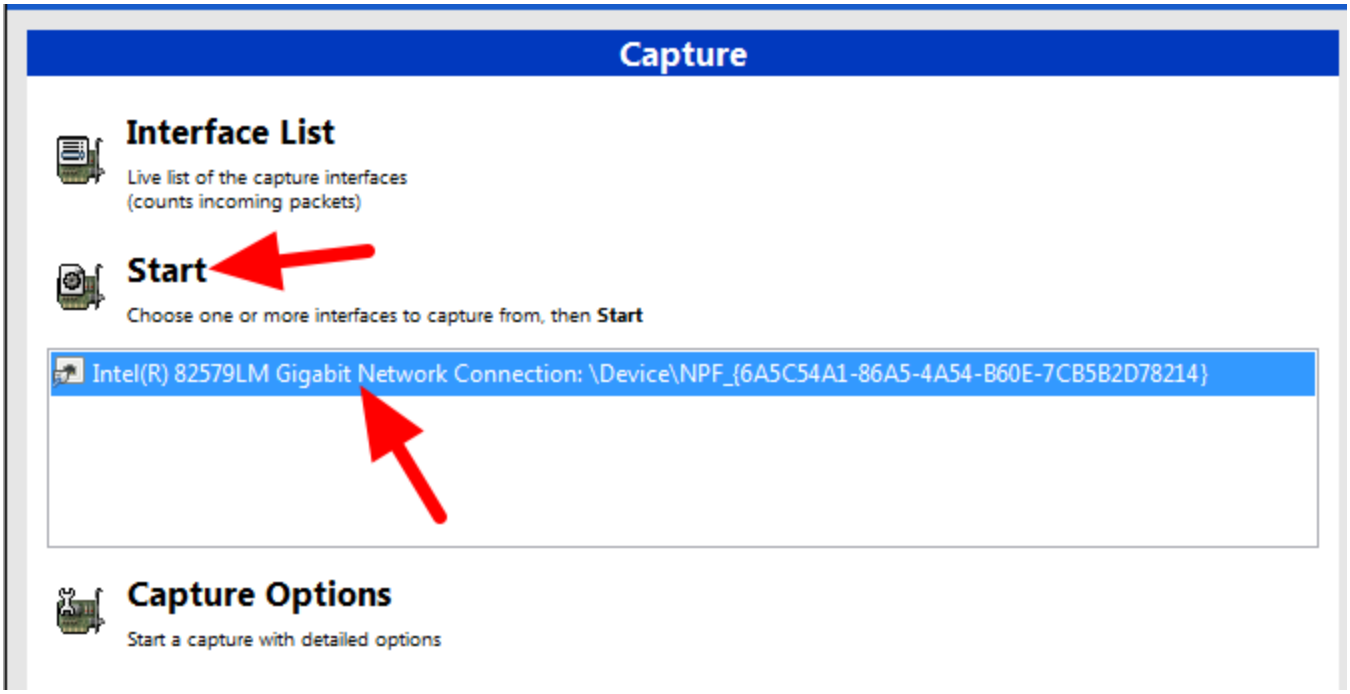


You may now connect to your robot as normal over the selected interface (if you haven't done so already). The graph will show the total bandwidth usage of the connection, with the bandwidth cap at the top of the graph. The Last, Average, Min and Max values are also displayed at the bottom of the graph. Note that these values are in Bytes/Second meaning the cap is 917,504. With just the Driver Station open you should see a flat line at ~100000 Bytes/Second.

Measuring Bandwidth Usage using Wireshark

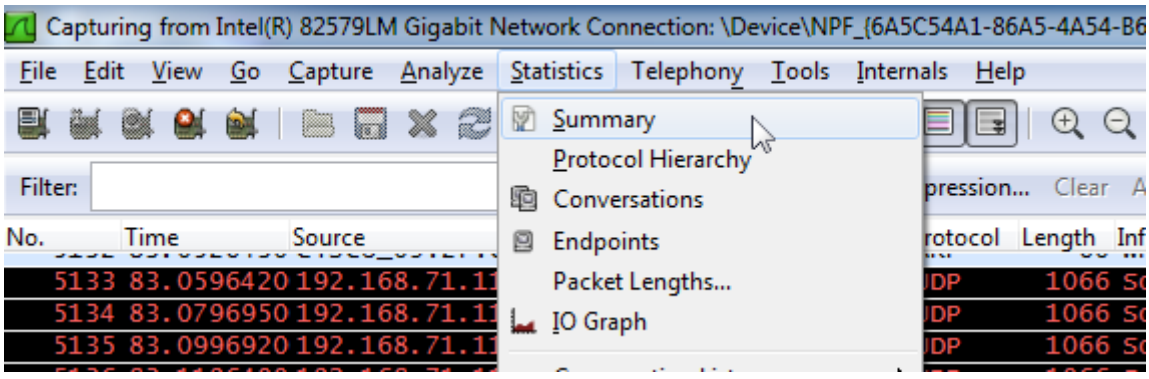
If you are not using Windows 7, you will need to install a 3rd party program to monitor bandwidth usage. One program that can be used for this purpose is Wireshark. Download and install the latest version of Wireshark for your version of Windows. After installation is complete, locate and open Wireshark. Connect your computer to your robot, open the Driver Station and any Dashboard or custom programs you may be using.

Select the interface and Start capture



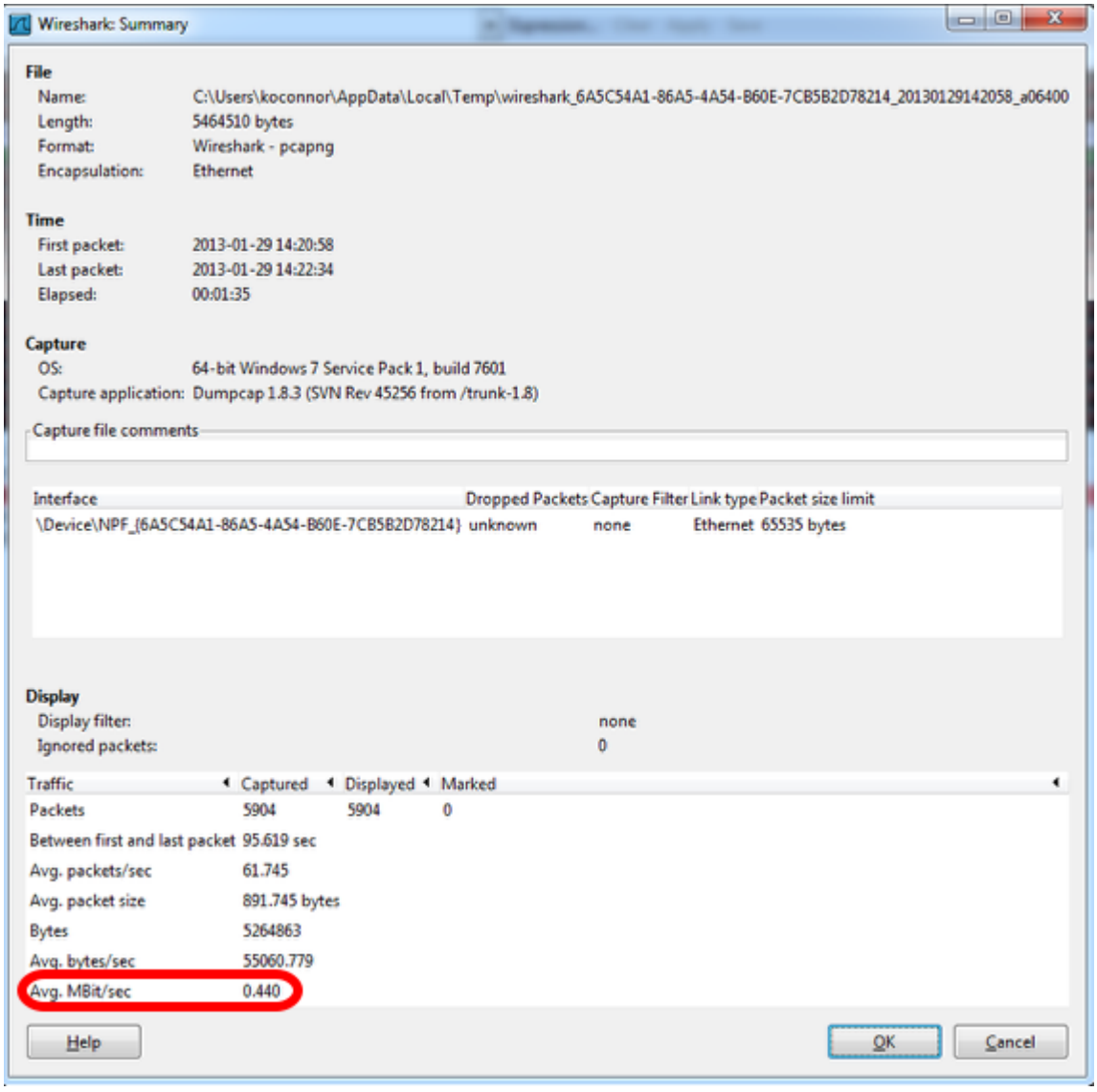
In the Wireshark program on the left side, select the interface you are using to connect to the robot and click **Start.**

Open Statistics Summary



Let the capture run for at least 1 minute, then click **Statistics>>Summary**.

View Bandwidth Usage



Average bandwidth usage, in Megabits/Second is displayed near the bottom of the summary window. The bandwidth cap on the field is 7 Megabits/second.

RoboRIO Network Troubleshooting

The roboRIO and the 2015 FRC tools use dynamic IPs (DHCP) for network connectivity. This article describes steps for troubleshooting networking connectivity between your PC and your roboRIO

Ping roboRIO

The first step to identifying roboRIO networking issues is to isolate if it is an application issue or a general network issue. To do this, click Start->type **cmd**->press Enter to open the command prompt. Type **ping roboRIO-####.local** where #### is your team number (with no leading zeroes) and press enter. If the ping succeeds, the issue is likely with the specific application, verify your team number configuration in the application, and check your firewall configuration.

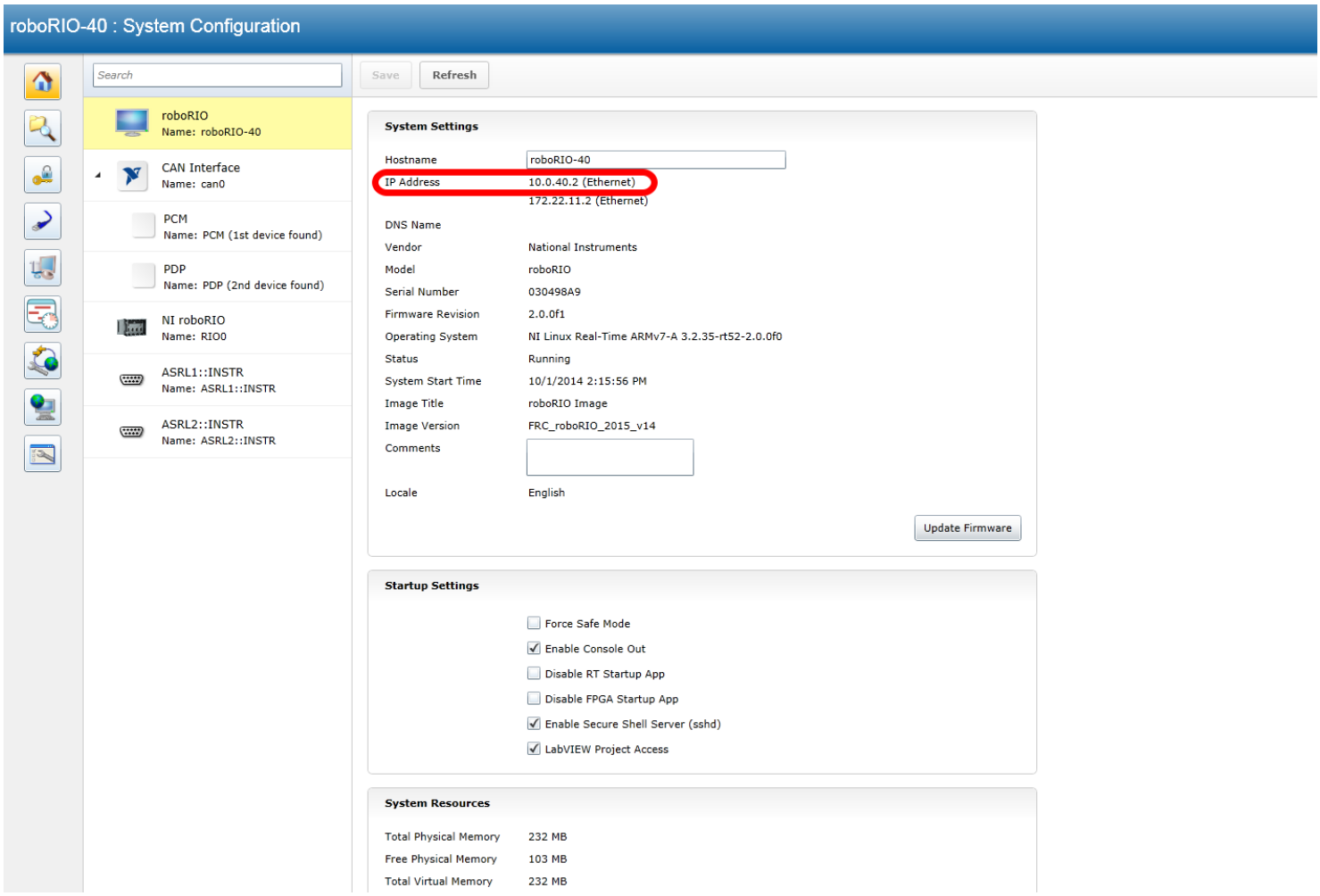
USB Connection Troubleshooting

If you are attempting to troubleshoot the USB connection, try pinging the roboRIO's IP. As long as there is only one roboRIO connected to the PC, it should be configured as 172.22.11.2. If this ping fails, make sure you have the roboRIO connected and powered, and that you have installed the NI FRC Update Suite. This update installs the roboRIO drivers needed for the USB connection.

If this ping suceeds, but the .local ping fails, it is likely that either the roboRIO hostname is configured incorrectly,, or you are connected to a DNS server which is attempting to resolve the .local address.

- Verify that your roboRIO has been imaged for your team number. This sets the hostname used by mDNS.
- Disconnect your computer from all other networks including Ethernet and WiFi. It is possible that one of these networks contains a DNS server that is attempting to resolve the .local address.

Ethernet Connection



If you are troubleshooting an Ethernet connection, it may be helpful to first make sure that you can connect to the roboRIO using the USB connection. Using the USB connection, open the roboRIO webdashboard and verify that the roboRIO has an IP on the ethernet interface. If you are tethering to the roboRIO directly this should be a self-assigned 169.*.*.* address, if you are connected to the D-Link, it should be an address of the form 10.TE.AM.XX where TEAM is your four digit FRC team number. If the only IP here is the USB address, verify the roboRIO ethernet connection.

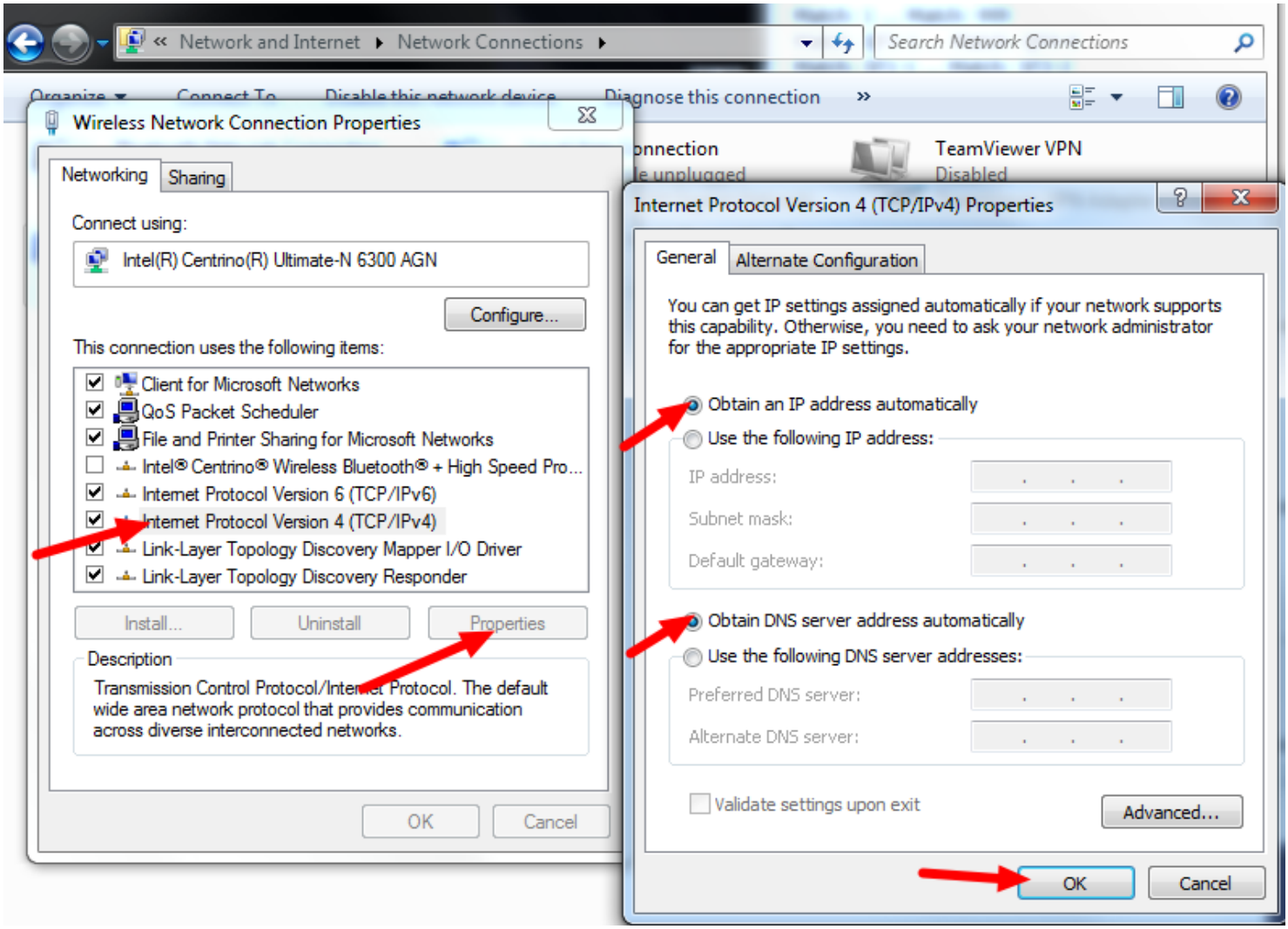
Ping the roboRIO IP

If there is an IP in the step above, try pinging this IP using the command prompt as described above. If this works, you have an issue resolving the mDNS address on your PC. The two most common causes

are not having an mDNS resolver installed on the system and a DNS server on the network that is trying to resolve the .local address using regular DNS.

- Verify that you have an mDNS resolver installed on your system. On Windows, this is typically fulfilled by the NI FRC Update Suite. For more information on mDNS resolvers, see the RoboRIO Networking article.
- Disconnect your computer from any other networks and make sure you have the D-Link configured as an access point, using the FRC Bridge Configuration Utility. Removing any other routers from the system will help verify that there is not a DNS server causing the issue.

Ping fails



If pinging the IP directly fails, you may have an issue with the network configuration of the PC. The PC should be configured to Obtain an Address Automatically (also known as DHCP). To check this, click Start->Control Panel->Network Connections->Change adapter settings, then right click on the appropriate interface (usually Local Area Connection for Ethernet or Wireless Network Connection for wireless) and select Properties. Click Internet PRotocol Version 4, then click Properties. Make sure both radio buttons are set to Obtain automatically.

Other things to check

Other possibilities that may cause issues include:

- Proxies. Having a proxy enabled may cause issues with the roboRIO networking.

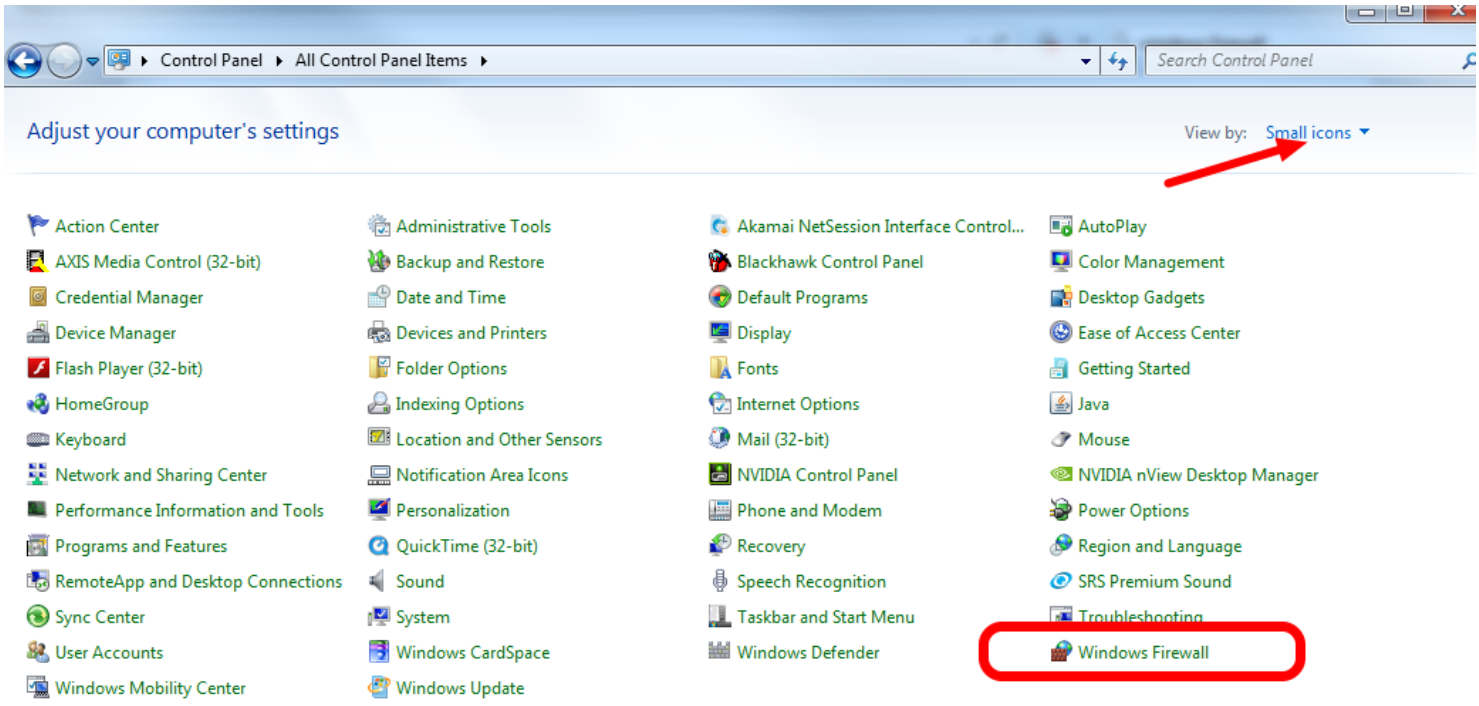
Windows Firewall Configuration

Many of the programming tools used in FRC need network access for various reasons. Depending on the exact configuration, the Windows Firewall may potentially interfere with this access for one or more of these programs. This document describes procedures for Windows 7, but Windows 8 should be similar.

Disabling Windows Firewall

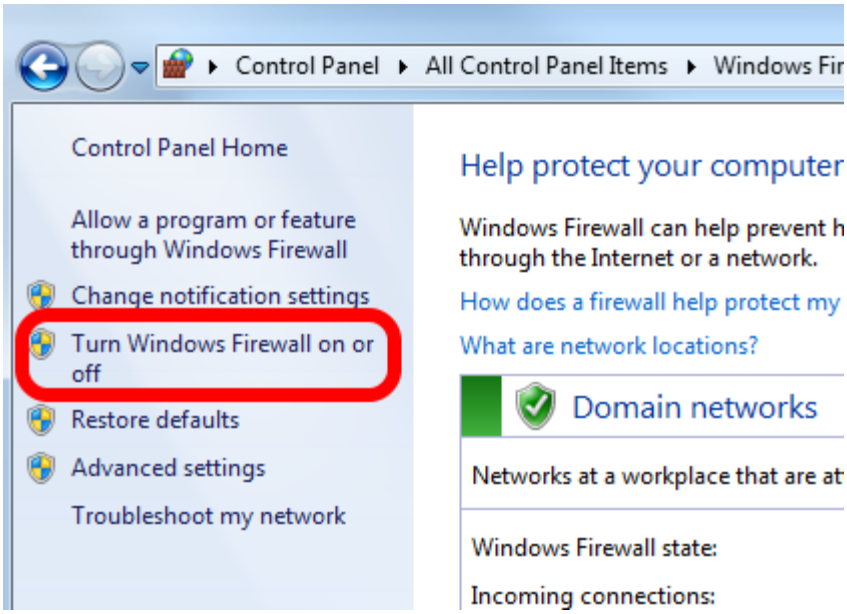
The easiest solution is to disable the Windows Firewall. Teams should beware that this does make the PC potentially more vulnerable to malware attacks if connecting to the internet.

Control Panel



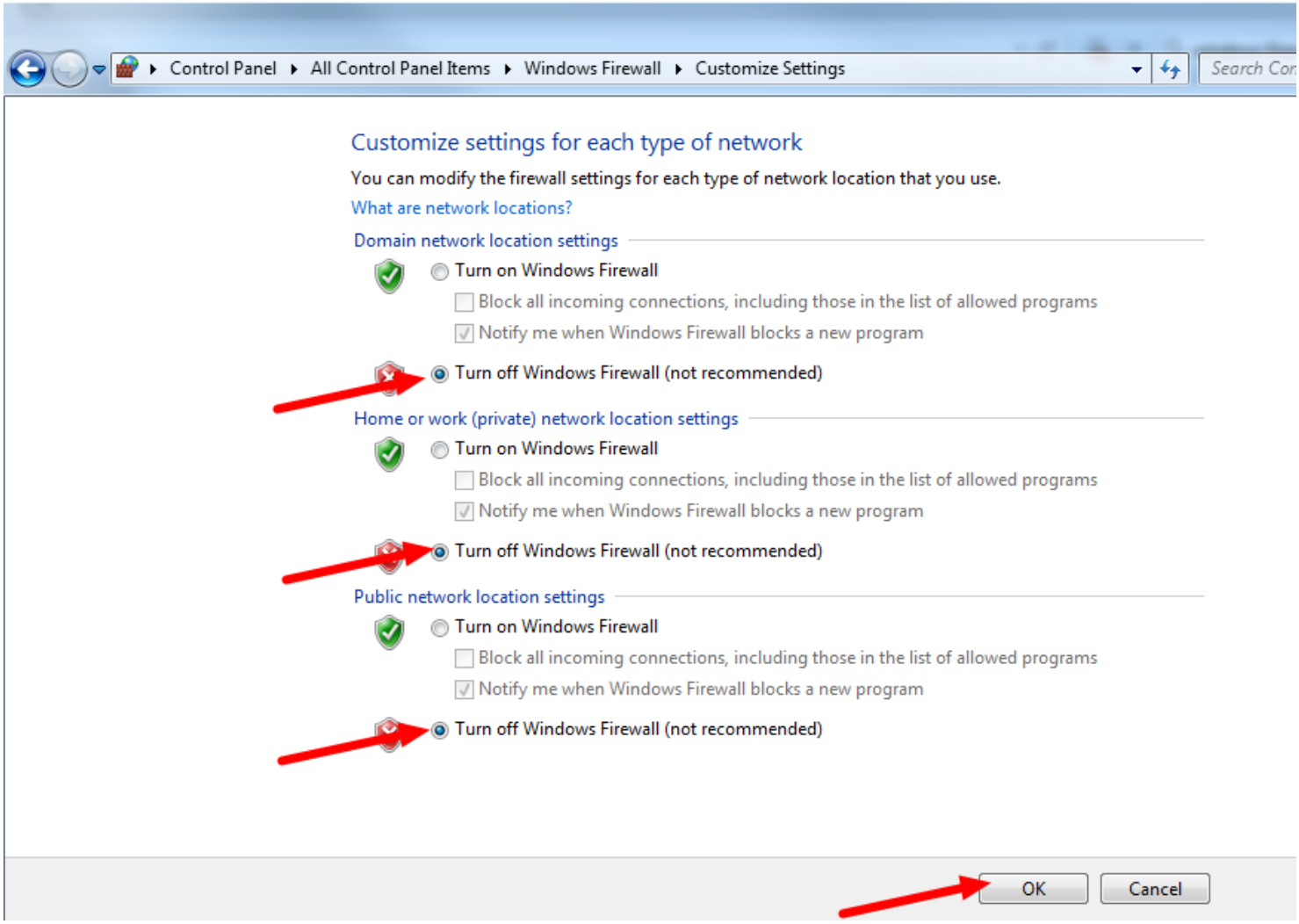
Click Start->Control Panel to open the Control Panel. Click the dropdown next to **View by:** and select **Small icons** then click **Windows Firewall**.

Turn Windows Firewall on or off



In the left pane, click **Turn Windows Firewall on or off,** and click yes or enter your Administrator password if a dialog appears.

Disable the Firewall

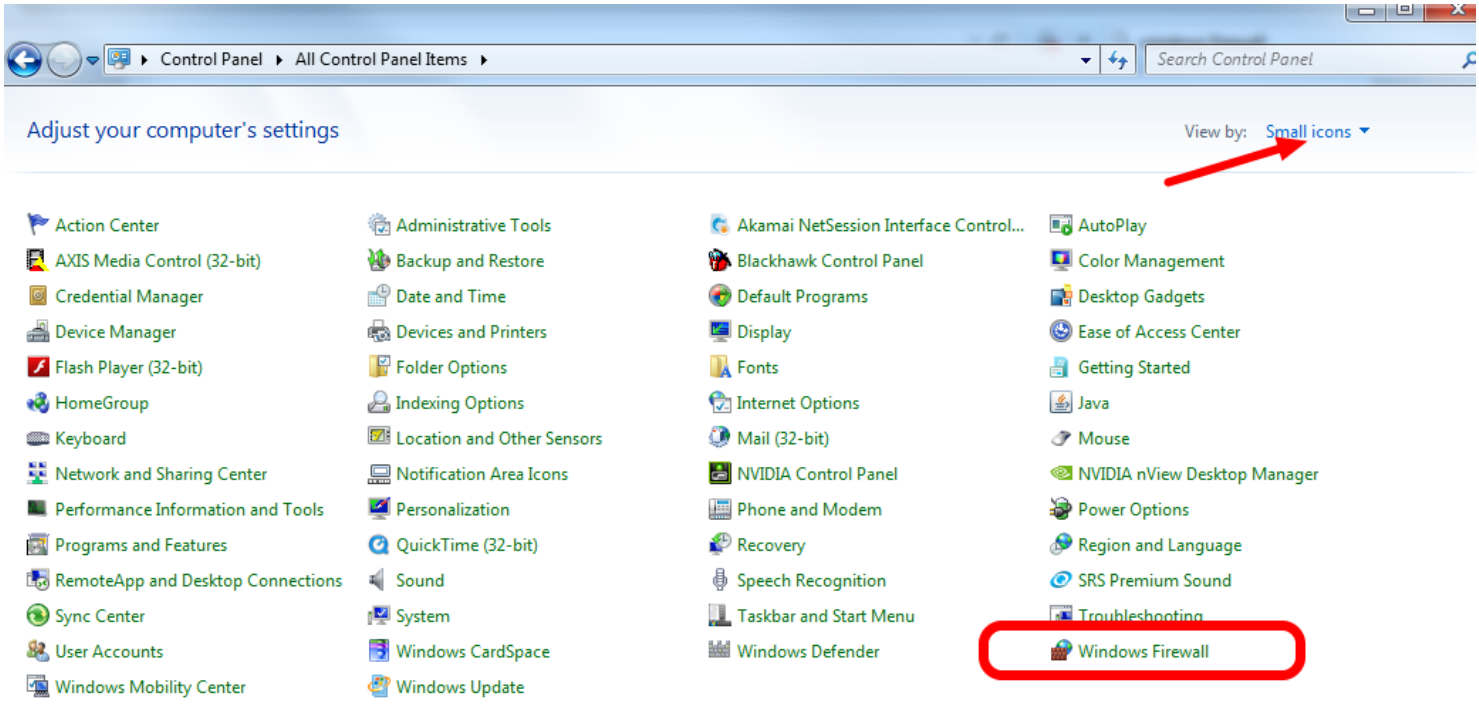


For each category, select the radio button to **Turn off Windows Firewall**. Then click **OK.**

Configure the firewall

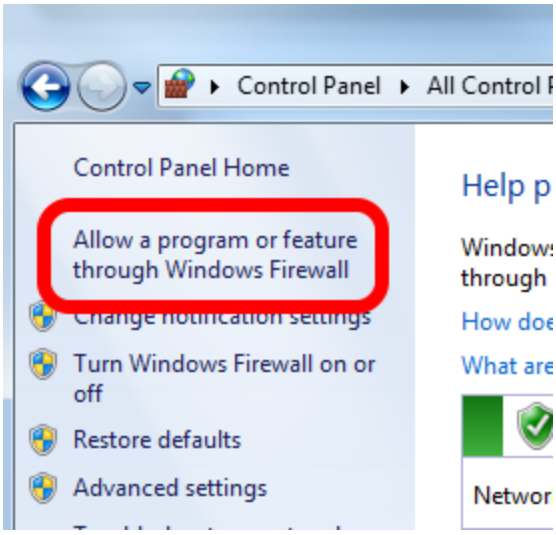
Alternatively, you can add exceptions to the Firewall for any FRC programs you are having issues with.

Control Panel



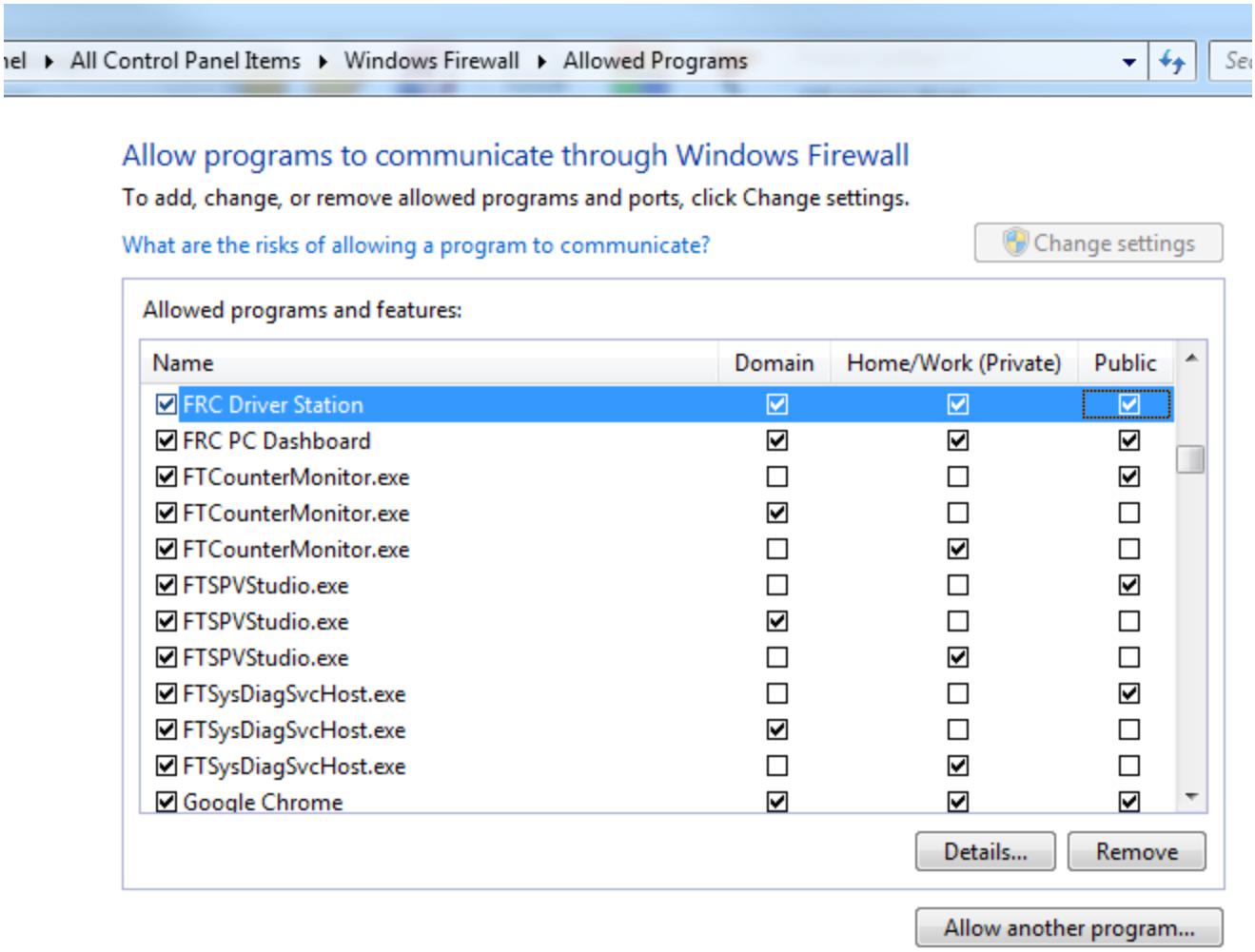
Click Start->Control Panel to open the Control Panel. Click the dropdown next to **View by:** and select **Small icons** then click **Windows Firewall**.

Allow a program...



In the left pane, click **Allow a program or feature through Windows Firewall**

Allowed Programs

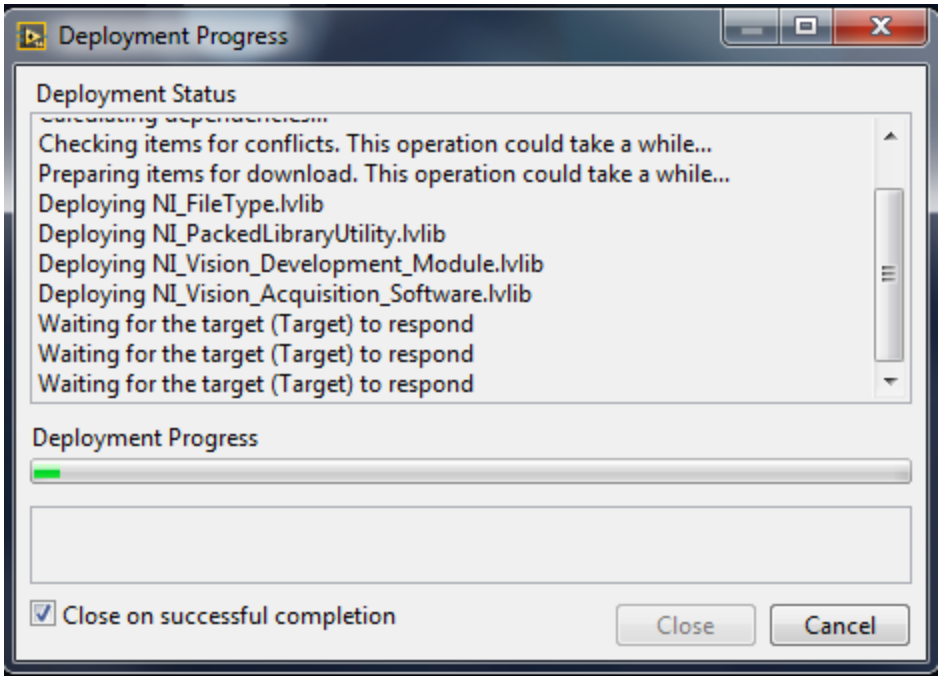


For each FRC program you are having an issue with, make sure that it appears in the list and that it has a check in each of the 3 columns. If you need to change a setting, you made need to click the **Change settings** button in the top right before changing the settings. If the program is not in the list at all, click the **Allow another program...** button and browse to the location of the program to add it.

Waiting for Target to Respond - Recovering from bad loops

If you download LabVIEW code which contains an unconstrained loop (a loop with no delay) it is possible to get the roboRIO into a state where LabVIEW is unable to connect to download new code. This document explains the process required to load new, fixed, code to recover from this state.

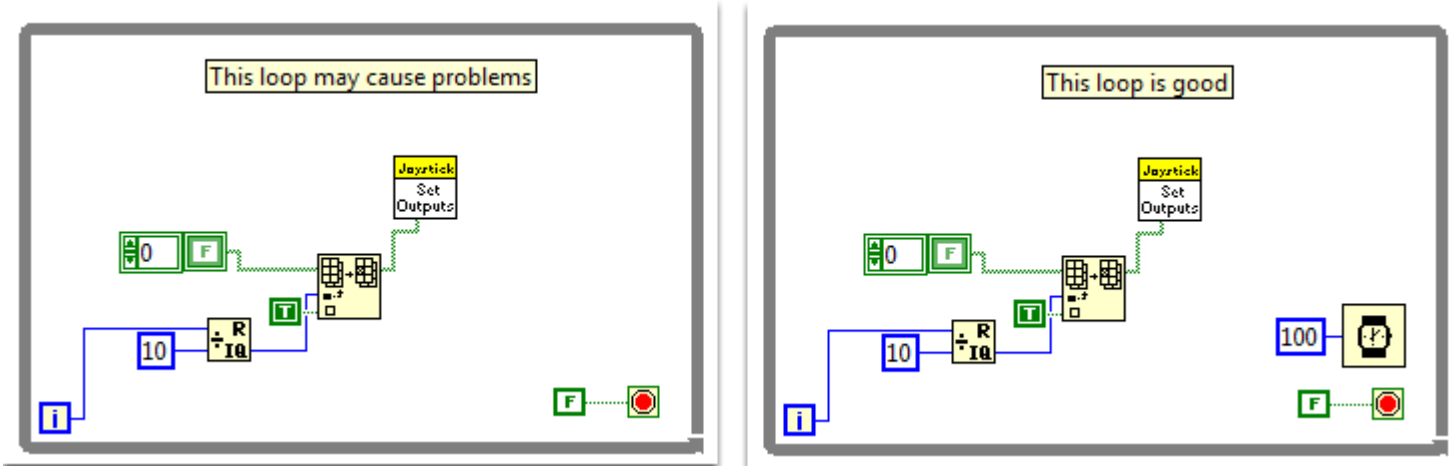
The Symptom



The primary symptom of this issue is attempts to download new robot code hang at the "Waiting for the target (Target) to respond" step as shown above. Note that there are other possible causes of this symptom (such as switching from a C++\Java program to LabVIEW program) but the steps described here should resolve most or all of them.

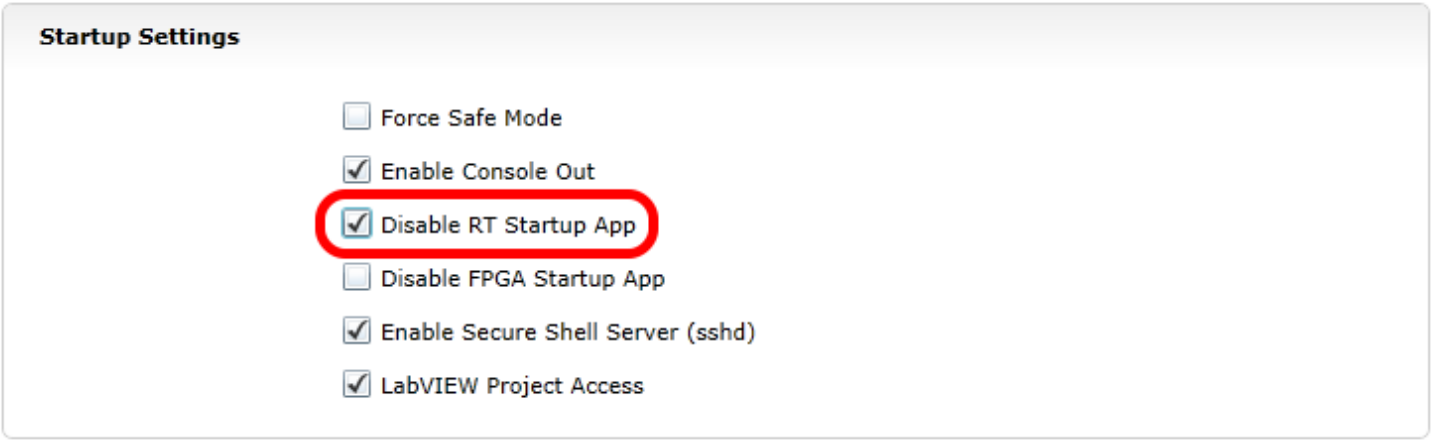
Click Cancel to close the download dialog.

The Problem



One common source of this issue is unconstrained loops in your LabVIEW code. An unconstrained loop is a loop which does not contain any delay element (such as the one on the left). If you are unsure where to begin looking, Disabled.VI, Periodic Tasks.VI and Vision Processing.VI are the common locations for this type of loop. To fix the issue with the code, add a delay element such as the Wait (ms) VI from the Timing palette, found in the right loop.

Set No App

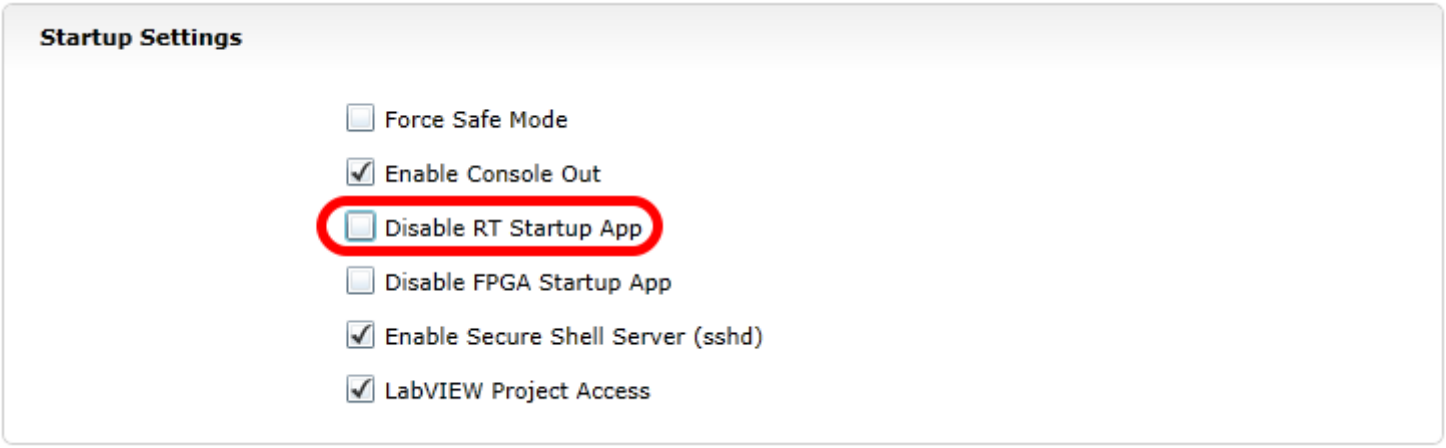


Using the roboRIO webserver (see the article RoboRIO Webdashboard for more details). Check the box to "Disable RT Startup App".

Reboot

Reboot the roboRIO, either using the Reset button on the device or by click Restart in the top right corner of the webpage.

Clear No App



Using the roboRIO webserver (see the article RoboRIO Webdashboard for more details). Uncheck the box to "Disable RT Startup App".

Load LabVIEW Code

Load LabVIEW code (either using the Run button or Run as Startup). Make sure to set LabVIEW code to Run as Startup before rebooting the roboRIO or you will need to follow the instructions above again.

Recovering a roboRIO using Safe Mode

Occasionally a roboRIO may become corrupted to the point that it cannot be recovered using the normal boot and imaging process. Booting the roboRIO into Safe Mode may allow the device to be successfully re-imaged.

Booting into Safe Mode

To boot the roboRIO into Safe Mode:

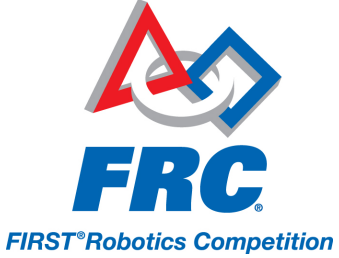
1. Apply power to the roboRIO
2. Press and hold the Reset button until the Status LED lights (~5 seconds) then release the Reset button
3. The roboRIO will boot in Safe Mode (indicated by the Status LED flashing in groups of 3)

Recovering the roboRIO

The roboRIO can now be imaged by using the roboRIO Imaging Tool as described in Imaging your roboRIO.

About Safe Mode

In Safe Mode, the roboRIO boots a separate copy of the operating system into a RAM Disk. This allows you to recover the roboRIO even if the normal copy of the OS is corrupted. While in Safe Mode, any changes made to the OS (such as changes made by accessing the device via SSH or Serial) will not persist to the normal copy of the OS stored on disk.



At The Event

Preparing your Control System for Competition

This article outlines a number of Control System related items a team can do to prepare for running their robot connected to the field at an event. These tips and tricks should help ensure a smooth experience when bringing your robot to the field and connecting the Field Management System.

Verify all software is up to date

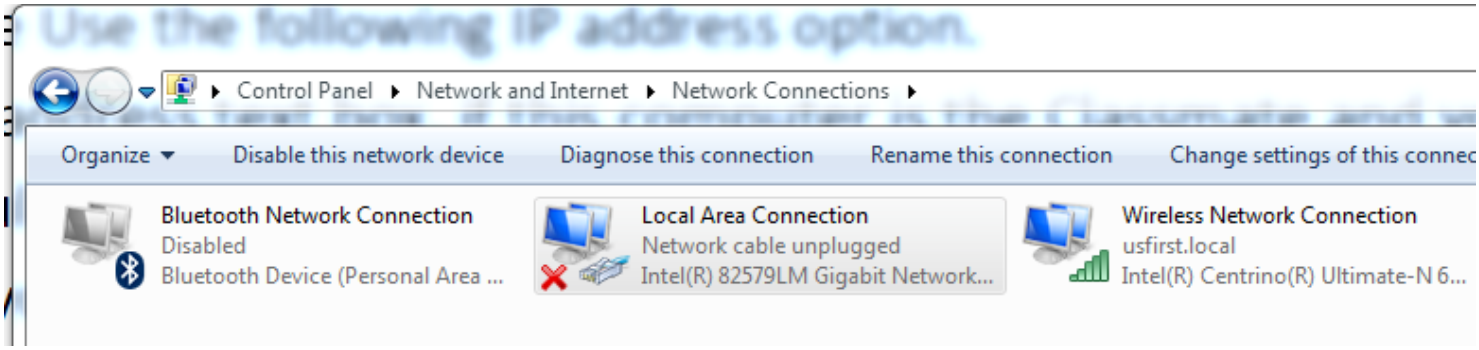
Check to make sure all your software is up to date. The latest versions of each piece of software are:

- Driver Station - Update 3 (2.12.13.00)
- LabVIEW - Update 5.10
- C++ - Midseason Update 2 (rev3615)
- Java - Midseason Update 2 (2013.0.429) Also downloadable from inside Netbeans
- SmartDashboard Vision Installer - 1.0.5

Check Driver Station Network Settings

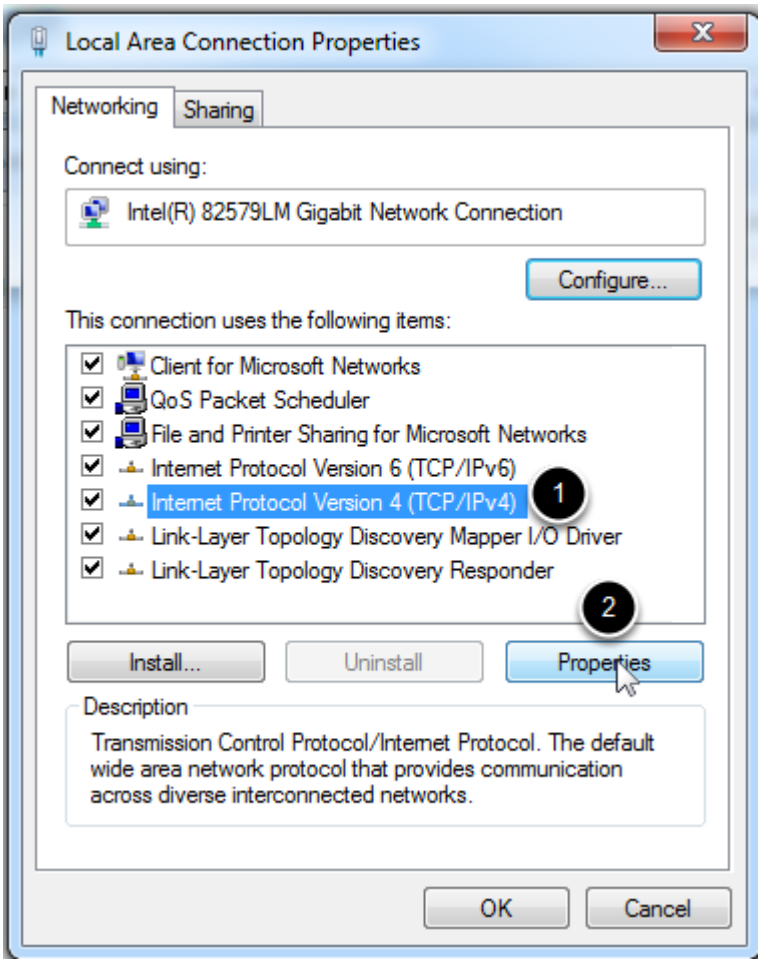
When operating at home, everything will work fine with the Driver Station set to a subnet mask of 255.255.255.0 and any IP in the 10.TE.AM.ZZ range. At the competition, the **DS IP must be 10.TE.AM.5 and the subnet mask must be set to 255.0.0.0 to work properly with FMS.** To check the IP and subnet mask of your Driver Station PC, follow the steps below.

Network Adapter Properties



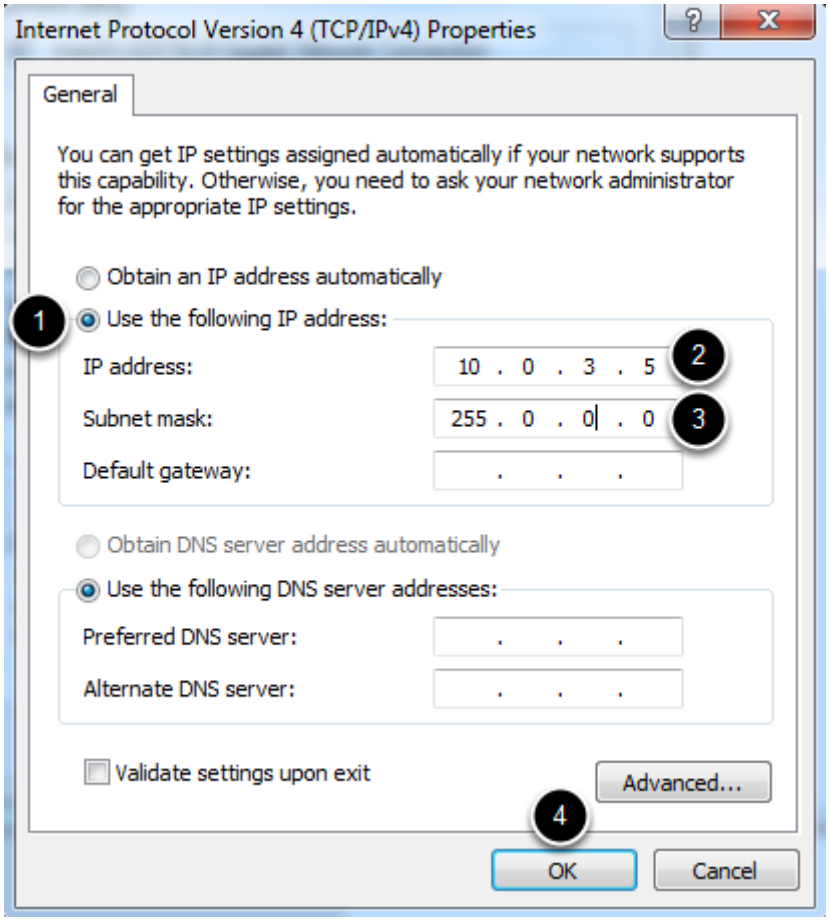
To set the IP address, click on **Start > Control Panel > View Network Status and Tasks > Change Adapter Settings,** then double-click on **Local Area Connection** to display the Local Area Connection Properties dialog.

TCP/IP Properties



Click on **Internet Protocol Version 4 (TCP/IPv4)** to highlight it, then click **Properties**.

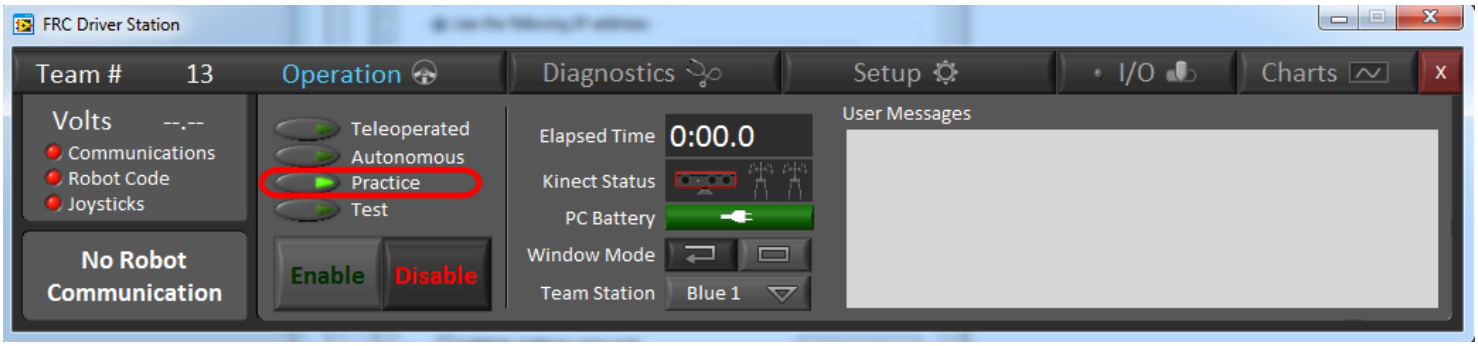
Set IP address



On the TCP/IP properties page:

1. Click the bubble next to **Use the following IP address**
2. Enter your **10.xx.yy.5** or .6 address into the **IP address box**
3. Change the **Subnet mask** to **255.0.0.0**
4. Click **OK.** Then click **Close** on the Local Area Connection Properties dialog box.

Run the Robot in Practice Mode



During a match on the official playing field, the robot state will transition from Disabled->Autonomous->Disabled->Teleop->Disabled. To make sure your code works properly with this sequence, you should run at least one complete match using the Practice mode on the DS. To run a match in Practice mode, put the Driver Station in Practice mode, as shown above, then enable the robot. The Driver Station will have a 5 second countdown, then run the robot through the sequence it will experience during a match. Testing in this manner will help catch potential issues with the code transitioning between the states or with variables not being properly reset when changing modes.

Have Multiple Copies of Code

Make sure to have multiple copies of your final robot code (and Dashboard code if customized). At least one copy should be on a computer you are bringing to the event and it is recommended to have at least one copy on a USB Flash drive. You may also wish to make sure that at least two people on the team have a copy of the latest code.

Charge Batteries

Make sure both your Robot and Driver Station Computer batteries are fully charged. Also make sure to have a plan for ensuring batteries are charged throughout the event and keeping track of which batteries are charged and which are depleted. This will help prevent running into any power issues during a match.

Train your Drivers

Make sure the team members who will be going out to field each match know:

- How to turn the robot on and off
- Where Ethernet cables go if unplugged
- Where the wireless bridge is located and which position the mode switch should be in
- How to test which joysticks are in which position in the Driver Station software and rearrange if necessary
- Any applicable Administrator passwords that may be required to change network or firewall settings on the Driver Station computer

At the Event

After arriving at the event, there are a few things you can get done early to help things run as smooth as possible when coming to the field:

Program Robot Radio

After arriving at the competition, make sure to get the D-Link DAP-1522 Rev B. radio programmed at one of the official event programming kiosks. The radio will need to be placed into Bridge mode for programming and should stay in bridge mode for the entire event, all connections to the radio at the event, but outside the official field should be tethered. It is not necessary to reset the radio prior to programming, only reset the radio if instructed to do so by the programming kiosk and follow the instructions on screen to do so.

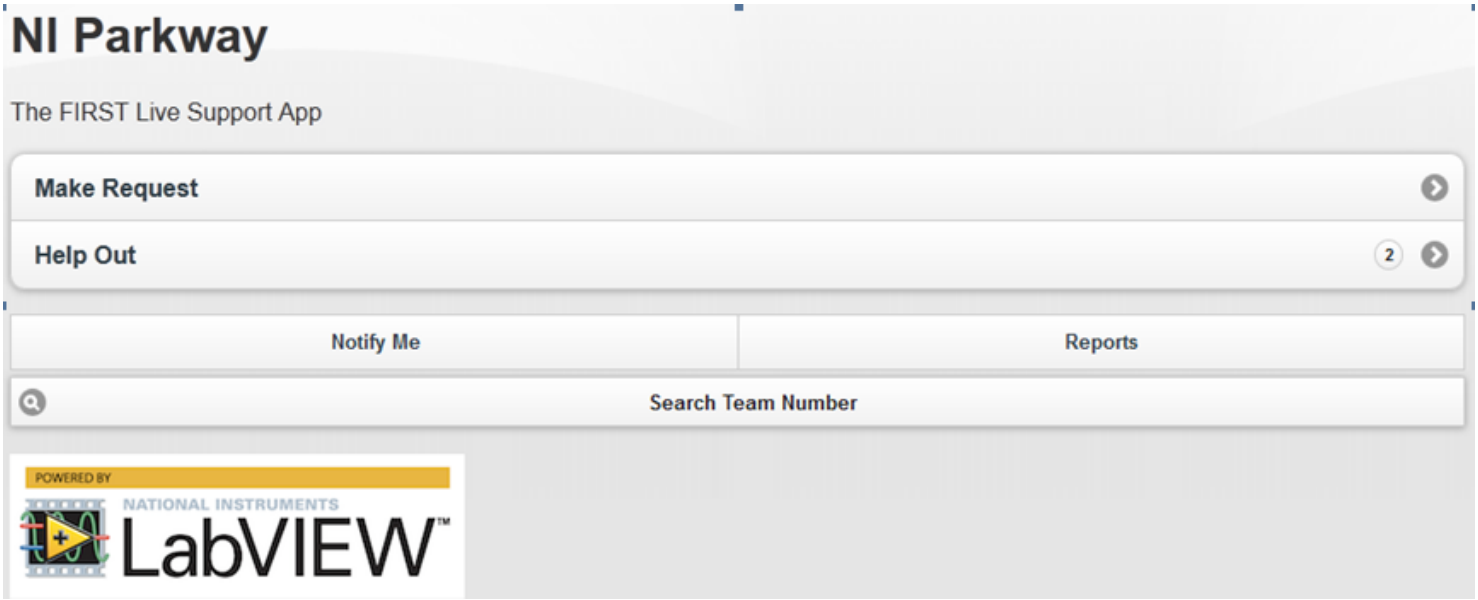
Connect to the Field on Practice Day

Even if your robot is not inspected, or ready to fully compete in the match, make sure to attend at least one practice match to verify that your Driver Station and Robot can connect properly to the field. If you do not make it to the field for any of your Practice Matches, check with your FTA to see if they are having all teams whom have not yet connected come out to the field on Thursday evening to verify that they are able to connect.

Using the NI Parkway System for Help at an Event

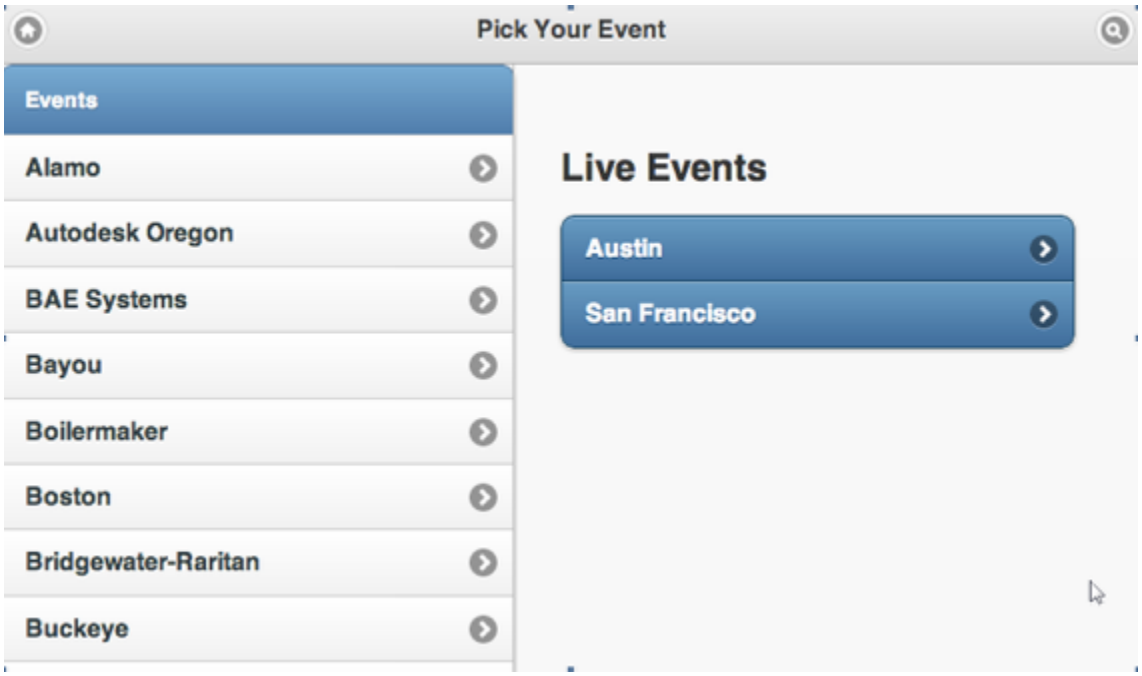
If you have any Control System issue at your event that you need assistance with, each event has at least one Control System Advisor who is there to help. This year FRC will be using the NI Parkway system to help teams connect with the CSA and indicate they have an issue. The Parkway System can be accessed using the Parkway Kiosk found at your event (ask Pit Admin if you can't locate it) or via a mobile device.

Getting to Parkway



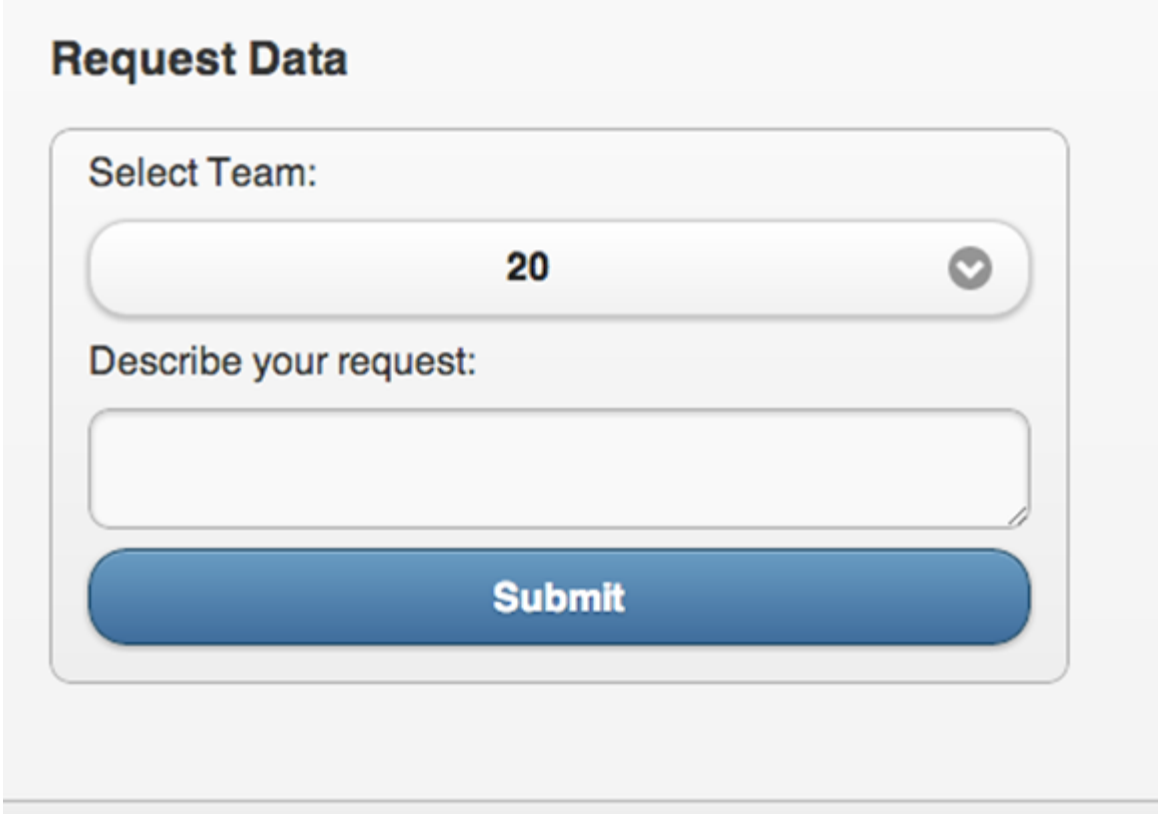
If using the Parkway Kiosk, you should already be on the Parkway homepage, if not you can press Alt+Home or Alt+Back until you reach the home page. If accessing Parkway from a mobile device enter www.niparkway.com in your web browser.

Make a Request



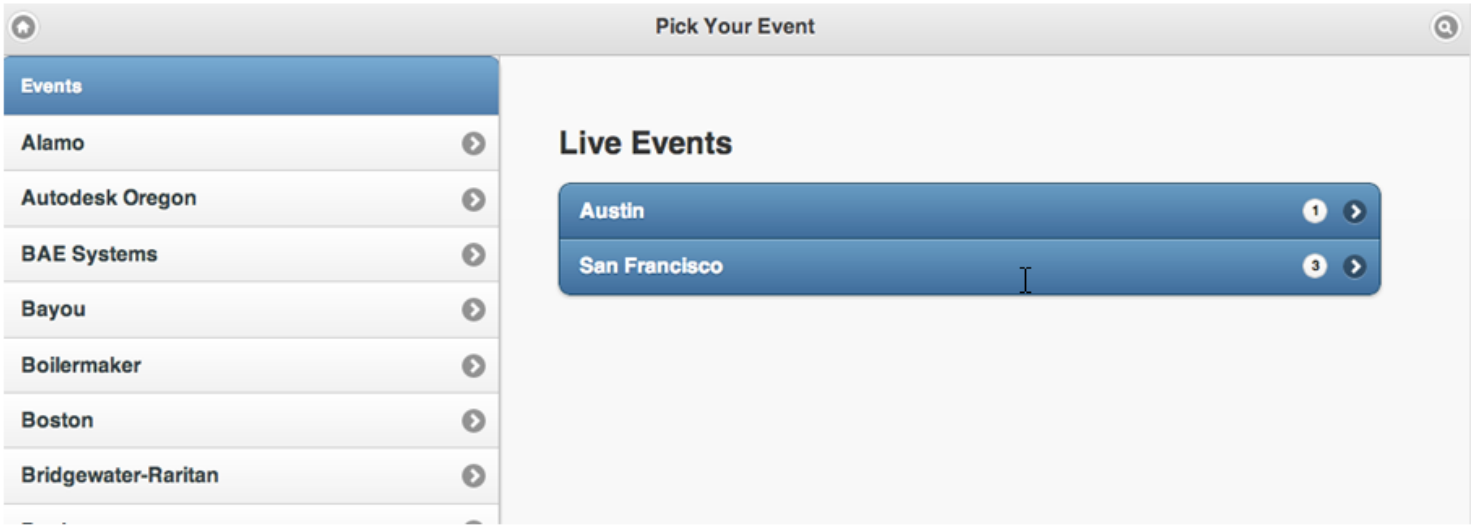
To enter a request for assistance, click on the Make Request button, you will be shown a list of Live events in the right pane. Click on the appropriate event from the list of Live Events.

Select Team Number



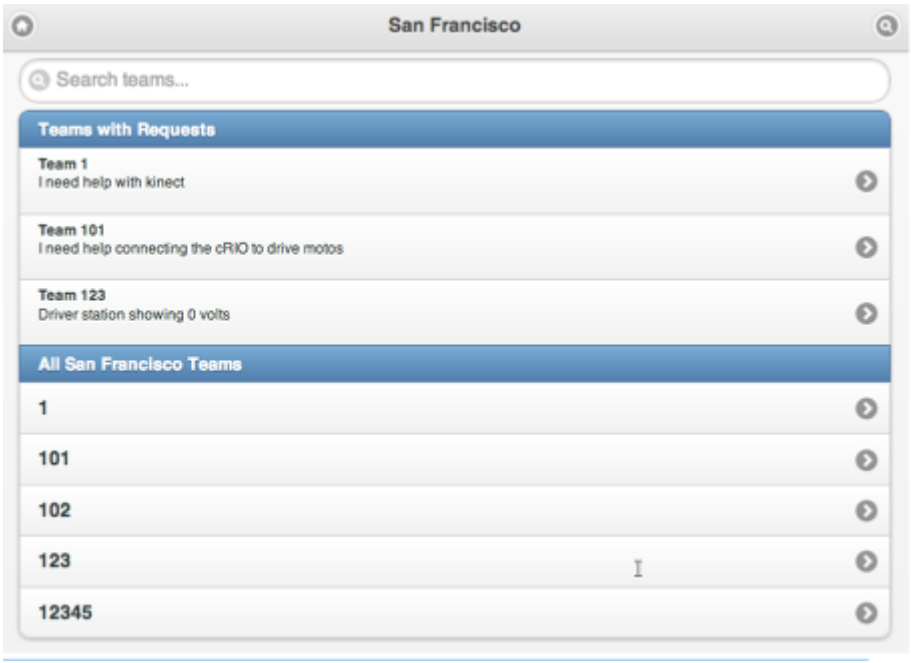
Click on the Select Team dropdown and pick the appropriate Team Number from the list. Enter a description of the request/issue in the box, and then click **Submit**.

Viewing Requests



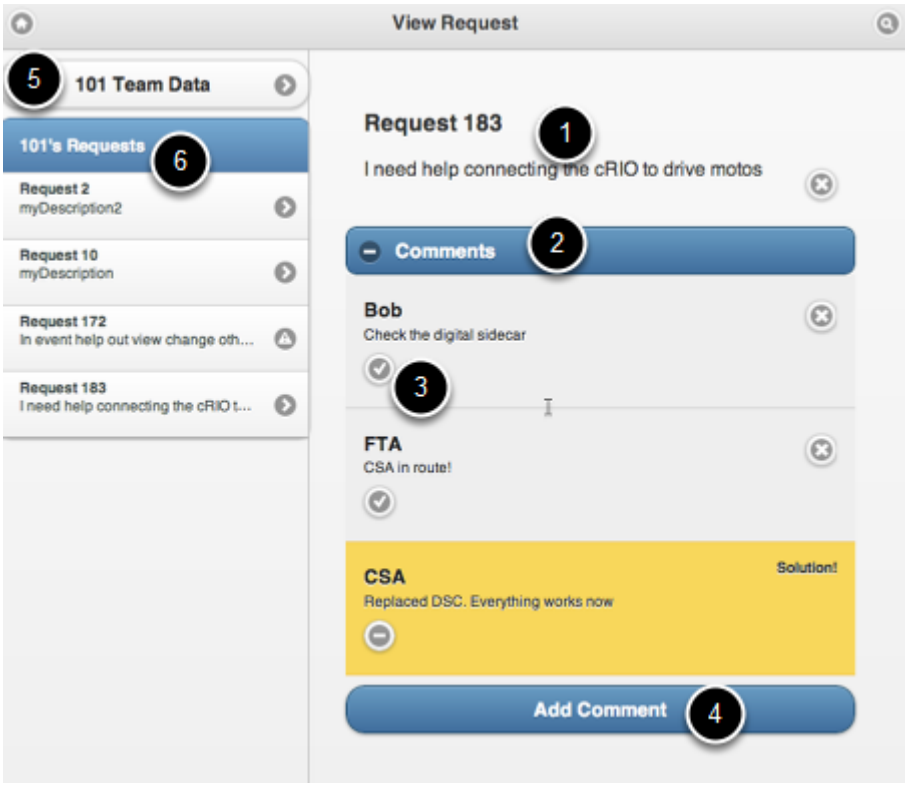
To view or respond to a request (including leaving a comment or closing a request) click the Help Out button on the NI Parkway home page. Click on the appropriate event from the list of Live Events in the right pane. Numbers listed next to the event describe the number of open requests.

Select a Request



A list of teams with Open Requests will be shown at the top of the page (with a summary of the latest request below the team number). A list of all teams at the event will be immediately below it. To search for team or request use the search box at the top. To view a team's request(s) click on the team number.

Request Page



The View Request page has the following buttons/information:

1. Request Info The Request number and Summary are displayed at the top of right pane
2. Comments All comments on the request are displayed in the collapsible element under the request summary
3. Mark/Unmark as solution Each comment has a check or minus underneath which allows you to mark or unmark the comment as the solution. Marking comment as a solution will close the request. Unmarking a comment as the solution will re-open the request. To close a request there must be at least one comment to be marked as the solution
4. Add Comment Press this button to display the Add Comment dialog. Enter the name you want displayed above the comment and the comment text, and then click Submit.
5. XXXX Team Data button Click to view or update the team data page (contains information such as software language and usage of advanced features such as vision)
6. Other Requests Shows any other requests this team has made, including requests that have been closed. This data is persistent across events so if a team has been to a previous event, their requests from that event will also display here.
    - An “!” next to a request shows the request is open.

FIRST®Robotics Competition

FMS Whitepaper

Overview

The Field Management System (FMS) is the electronics core of a *FIRST* Robotics Competition (FRC) playing field. It encompasses all the controls for the field electronics, team robots, and is used to manage the event by creating match schedules, managing all field hardware during a match (timers, team lights, estops, etc.), scoring the matches in real-time, posting information to the Audience screen, and uploading results data to the Internet.

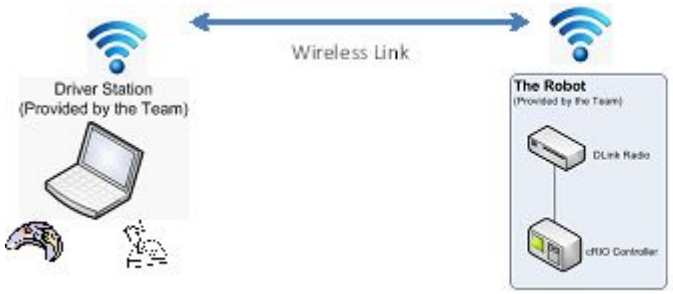
FMS is based on Ethernet architecture. Components such as the Driver Station, or the touchscreens used by the referees, integrate with FMS through direct wired Ethernet interfaces. Devices like the ball counters used in *Breakaway* and *Rebound Rumble*, or the Estops and Stack Lights mounted in each Player Station, interface through Ethernet-based Input/Output (I/O) modules that are donated to *FIRST* by Rockwell Automation. The lights used to illuminate the tower bases in *Logo Motion* and the bridges in *Rebound Rumble* are controlled via Ethernet-enabled power supplies donated to *FIRST* by Philips Color Kinetics. The weight sensors used in *Ultimate Accen*t are read by a National Instruments cRIO-FRC II and interfaces over the Ethernet network to a Rockwell Automation PLC module.

This white paper focuses on the electronics infrastructure needed to control the robots on the playing field. Specific details on the FMS software used during each season can be found in the Field Management System User Guide, publically available on the FRC Scorekeeper Forum.

Frequently Asked Questions about the Field Management System and recommended best practices when operating on the competition field appear at the end of this document.

This document was written using the 2013 FRC Robot Control System and Field Management System as the model platform, however with only minor differences, this system topology has remained the same since 2009.

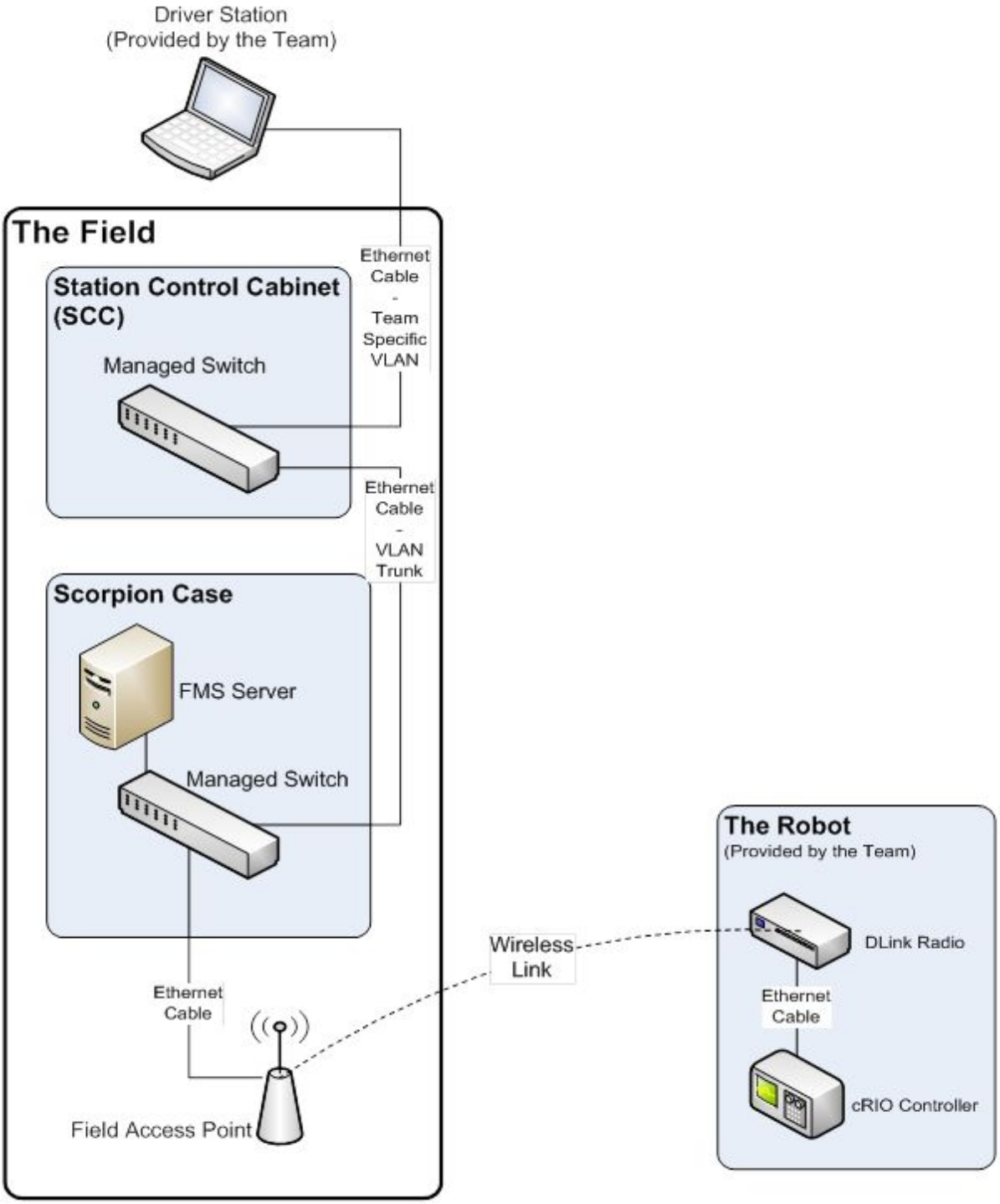
Driver Station <-> Robot Communications - The Basics



The standard configuration for controlling an FRC robot is two core components, the robot itself with a cRIO controller installed, and a netbook/ ultrabook/ laptop etc. running the FRC Driver Station (DS) software. The FRC Robot Control System is built such that the DS is the master controller, i.e. the status and actions of the robot are determined by commands from the DS.

Communication packets from the DS are broadcast wirelessly via the integrated radio in the DS or a separate radio (like the WRT610N provided in previous seasons), or through a tether (i.e wired Ethernet.) The DLink radio on the Robot receives the command packets from the DS and forwards them to the cRIO robot controller. Status packets from the cRIO are sent to the DS after each received command packet.

On-Field Communications Path for a Single Team



Driver Station - Robot Communications

Communication packets from a Driver Station are routed through the managed switches in the Station Control Cabinet and Scorpion Case to the Field Access Point, which then transmits the packets wirelessly to the appropriate Robot.

The DLink Radio on the Robot receives the wireless transmissions from the Field AP, and forwards the packets to the cRIO robot controller. Status packets from the cRIO are sent to the DS after each received command packet.

Field Management System (FMS) Role

The FMS software (running on the FMS Server) communicates with each Driver Station via the managed switches in the Scorpion Case and Station Control Cabinets. This communication employs team-specific virtual local area networks (VLANs) which serve to isolate each teams data traffic.

The FMS software does not communicate with the robots directly. Instead, FMS gathers data from the Driver Station about the Robot's status, and tells the Driver Station which state (enabled/ disabled/ e-stopped) and mode (autonomous/ teleoperated) the robot should be in, as well as the player station and alliance color.

The FMS software configures the managed switches and Access Point before each match to ensure the data and communications for each team is kept separate from others..

Frequently Asked Questions

Does FMS control the robot?

No, FMS does not communicate with the Robots directly. On the playing field, FMS communicates exclusively with each DS, sending it commands for enable/disable, auto/teleop, Estop, player station number and alliance color. The DS then sends this data to the Robot.

What does the flashing Player Station light mean?

The flashing light in the Player Station indicates that FMS does not think your DS has a connection to your robot. There are two main ways for this condition to occur: the DS is not communicating with FMS, or the DS is telling FMS it cannot communicate with the robot.

What information does FMS log?

FMS combines the status data from each DS along with the data that is monitored from the field components and stores this data in log files. The following data is logged every 500ms for each of the six robots on the playing field during each match:

- Timestamp (local time)
- Match Number
- Team Number
- Match Time
- Alliance
- Mode (Auto/Teleop)
- DS in FMS Mode (yes/no)
- Robot Mode (enable/disable)
- Estop state (on/off)
- Robot Link
- Average packet trip time between DS and Robot
- Number of missed packets between DS and Robot
- Total number of packets sent by DS to Robot
- Robot Battery Voltage
- Blue SCC connected (yes/no)
- Red SCC connected (yes/no)
- Blue Scoring I/O connected (yes/no)
- Red Scoring I/O connected (yes/no)

Can one team's DS control another team's Robot?

The FRC competition field is configured such that each team has its own virtual local area network (VLAN) within which all data is passed. The characteristics of a VLAN ensure that the command packets from one team's DS do not cause a response on another team's robot. These VLANs exist on both the wired and wireless side of the playing field's network; this is why for example, it's necessary for a team in Blue Player Station #1 to connect their DS into the corresponding cable for that station. On the wireless side of the network, the VLANs are configured in the field access point by broadcasting an individual network (SSID) for each of the six teams on the field, each with its own encryption passkey. These VLANs are configured prior to the start of each match so that only the six teams assigned in FMS may operate on the field.

What happens when you plug your DS into the competition field?

Once the process of setting up all the VLANs on the competition field is complete, through a process FRC calls “match prestart”, the FMS starts sending out command packets to the six DS’s. When a team plugs their DS into the Ethernet cable for their assigned Player Station, the DS receives these commands packets from FMS and switches over into FMS Mode. It’s at this point “FMS Connected” is displayed on the DS “Operation” tab. When in FMS Mode, the DS continues to serve as the master controller for the Robot, but state (enable/disable/estop) and mode (auto/teleop) are dictated by the FMS. The FMS tells the DS what to do, and the DS then tells the Robot.

Is Practice Mode on the DS different from FMS mode?

Yes, the two modes do have some differences, but the majority of the functions are identical. Both operating modes step through the same states, the order is:

1. Autonomous Disable state prior to match start
2. Autonomous Enable Autonomous period
3. Autonomous Disable end of Autonomous period
4. Teleop Disable end of Autonomous period, prior to start of Teleop period
5. Teleop Enable Teleop period
6. Teleop Disable end of Teleop/match end

Joysticks are handled a bit differently between the two modes. In Practice Mode unplugging a joystick will result in the robot being switched to Disabled. This is designed to be a safety feature, as the robot may be running in a variety of environments that might not be equipped with barriers to safely contain the robot.

Unplugging a joystick in FMS Mode will not result in the robot being disabled. If a joystick becomes disconnected, simply plugging it back in will not result in it returning to normal operation. The user must press F1 on the DS to manually rescan the USB interface to redetect the joystick.

Finally, the network port used by the DS to send command packets to the Robot is different in Practice Mode than the one used when in FMS Mode.

Why do I need to press F1 when a joystick is disconnected in FMS Mode?

While in Disable, the DS software periodically polls the USB interface for the presence of devices and adds/removes them from the list of joysticks on the DS “Setup” tab automatically. This polling is only done in Disable as it is computationally expensive and could compromise control of an enabled robot.

In FMS Mode, the DS's Enable/Disable state is dictated by FMS. When a joystick is disconnected during a match the robot is not disabled because FMS is continuously telling the DS to be enabled, and when the DS state is Enable, it does not poll the USB interface for device changes. Pressing F1 on the DS manually rescans the USB interface to redetect the change in joystick devices. If a joystick has disconnected from the DS or is otherwise unresponsive the recommended procedure is:

1. Unplug the joystick device's USB connector from the DS
2. Plug in the joystick device
3. Press F1 to rescan the USB devices

Is there anything different about the practice field vs. the competition field?

Yes. The practice field uses a different field access point, it does not employ the port filtering, bandwidth limits, or Quality-of-Service priorities used on the competition field, nor does it employ VLANs.

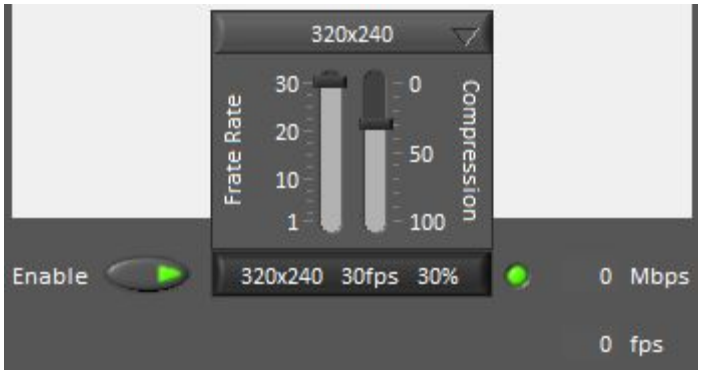
Are there any bandwidth limits on the playing field?

Yes, each team VLAN is limited to 7 megabits/second (Mbps). The bandwidth consumed by control packets sent from the DS to the robot, and the status packets sent from the robot to the DS are each ~450kilobits/second (kbps), or approximately 900kbps total. This leaves just over 6Mbps remaining for camera traffic, NetworkTables variables, and/or any other data traffic a team chooses to employ on their VLAN. In most cases, the camera data traffic will consume the majority of the available bandwidth between the DS and the robot.

The chart below shows the bandwidth consumption for some typical camera resolutions and frame rates. This data was captured using an Axis 1011, but the data is also applicable to the Axis 206.

			Peak Data Rate - Mbps	
Stream Type	Image Size	Frame Rate	Compression = 0	Compression = 30
MJPEG	640x480	30	34	14
MJPEG	640x480	24	25.5	11.1
MJPEG	640x480	15	15.5	6.1
MJPEG	640x480	10	11	4.3
MJPEG	320x240	30	8	3.7
MJPEG	320x240	24	7.5	2.9
MJPEG	320x240	15	4.2	2.1
MJPEG	320x240	10	2.8	1.2
MJPEG	160x120	30	2.9	1
MJPEG	160x120	24	2	0.9
MJPEG	160x120	15	1.1	0.6
MJPEG	160x120	10	0.8	0.4

The Dashboard can be used to monitor the bandwidth consumed by the camera stream from the robot. The default LabVIEW Dashboard includes controls and indicators to assist the user in selecting the preferred camera stream and display the resulting bandwidth consumption.



The default SmartDashboard does not include integrated controls like those provided in the LabVIEW Dashboard, but provisions are available to display the bandwidth consumption of the camera stream. Including the "#b" option in the *Overlay settings/Include Text* field in the Axis camera to will overlay a bandwidth measurement (in kbps) on the camera stream. This option also works for the LabVIEW Dashboard.

What are the recommended settings for the Axis Camera?

- Image Resolution: 320x240
- Compression: 30
- Overlay settings/Include Text: #b
    - This setting will overlay a bandwidth measurement (in kbps) onto the camera stream as shown above.

What is Quality of Service (QoS)? Are there any QoS priorities on the competition field?

Typically, networks operate on a best-effort delivery basis, which means that all packet traffic has equal priority and an equal chance of being delivered in a timely manner. When congestion occurs, all traffic has an equal chance of being dropped.

Configuring QoS on the field network allows for the selection of specific network traffic, placing a priority level on it, and using congestion-management and congestion-avoidance techniques to provide preferential treatment. This makes network performance more predictable and bandwidth utilization more effective.

The FMS does have a QoS policy in place for the 2013 FRC season. The policy increases the priority of all control and status packets between to the DS and robot to the same level as voice data, while keeping the priority of video data at the best-effort (or lowest priority) level. The “voice” level is the highest priority level packets can be set to without impacting the core functionality of the network.

Prioritizing control and status packets at the same level used for voice data was chosen because the desired performance is similar in both applications. In order for Voice-Over-IP (VoIP) to be a realistic replacement for standard public switched telephone network (PSTN) telephony services, customers need to receive the same quality of voice transmission they receive with basic telephone servicesmeaning consistently high-quality voice transmissions. Like other real-time applications (e.g. controlling an FRC robot), VoIP is extremely bandwidth- and delay-sensitive. For VoIP transmissions to be intelligible to the receiver, voice packets should not be dropped, excessively delayed, or suffer varying delay.

Which network ports are open on the competition field?

The ports that the teams are able to access on the competition field are as follows:

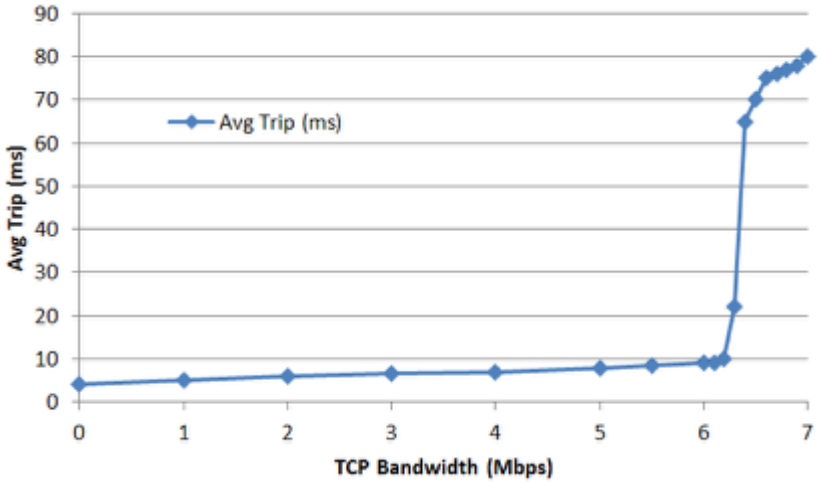
- TCP 1180: This port is typically used for camera data from the robot to the DS when the camera is connected to port 2 on the 8-slot cRIO. This port is bidirectional on the field.
- TCP 1735: SmartDashboard, bidirectional
- UDP 1130: Dashboard-to-Robot control data, directional
- UDP 1140: Robot-to-Dashboard status data, directional
- HTTP 80: Camera connected via switch on the robot, bidirectional
- HTTP 443: Camera connected via switch on the robot, bidirectional

All these ports are open on the competition field, so a team can use them as they wish if they choose not to employ them as outlined above (i.e. TCP 1180 can be used to pass data back and forth between the robot and the DS if the team chooses not to use the camera on port 2 of the 8-slot cRIO)

What is the significance of Trip time?

Trip time is the roundtrip time required for a control packet to be delivered from the DS to the robot and a corresponding status packet to be sent from the robot to the DS. It's similar to a network ping, but it's built into the communications protocol.

The DS computes the average trip time of the last 10 packets, logs it, as well as forwards the most current average value in each status packet sent to the FMS, which occurs every 100ms. Typical trip times are under 10ms, but can increase due to network congestion as a result of high bandwidth usage, addition processing in the DS, or inefficient code on the robot. Trip times are monitored during each match by the FTA.



The figure above shows how Average Trip time of the DS-Robot packets increases as the total bandwidth on the VLAN is consumed. A significant increase in Average Trip Time occurs just above 6Mbps of data because there is already ~900Kbits/sec being consumed by the DS-Robot packets alone. Network congestion increases as you approach the 7Mbps limit of the VLAN and as a result the Average Trip Time increases. The QoS policy described above works to prioritize control and status packets specifically to allow for some reasonable level of robot control to be available under such conditions, but performance cannot be guaranteed.

If you are experiencing high trip times, the first place to look should be the settings of your camera stream from the robot to the DS.

- For teams using the LabVIEW Dashboard: Increasing the compression value, or reducing the image size or frame rate should result in the average trip time value decreasing.

For teams using the SmartDashboard: Check the settings in the Axis camera. The SmartDashboard implementation requests a MJPEG stream using the default camera settings. If they have not been

manually configured, they are 640x480 @30fps with a compression value of 30. Under these conditions the camera stream alone requires ~14Mbps of bandwidth, which is twice (2X) the available limit on the competition field. Change the camera settings to match the recommended values at the bottom of page 6 to determine if performance improves.