Section 2

BENCHTOP TEST

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2 BENCHTOP TEST INTRODUCTION

2.1 GOALS OF THE BENCHTOP TEST OF THE 2009 FRC CONTROL SYSTEM

The initial "Benchtop Test" configuration does not require use of a PC to program the control system components. The Benchtop Test uses the pre-loaded software on the Driver Station and cRIO allowing for quick set up and easy verification that the control system components are all functioning properly.

2.2 BENCHTOP TEST SETUP PROCEDURE

This document is a "pointing" document. Many steps will send you to another location, where you will find the information you need to complete that step. To avoid errors it is worth your time to read the referenced documents and become familiar with the components. You will need to make reference to the following documents:

- FRC Control System Manual, Chapter 3, Component Datasheets
- FRC Control System Manual, Chapter 5, Configuration

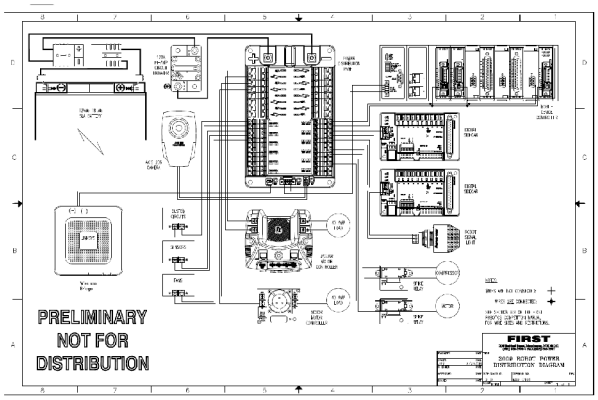
2.2.1 Special Note for Teams Receiving the "Early Control System Shipment"

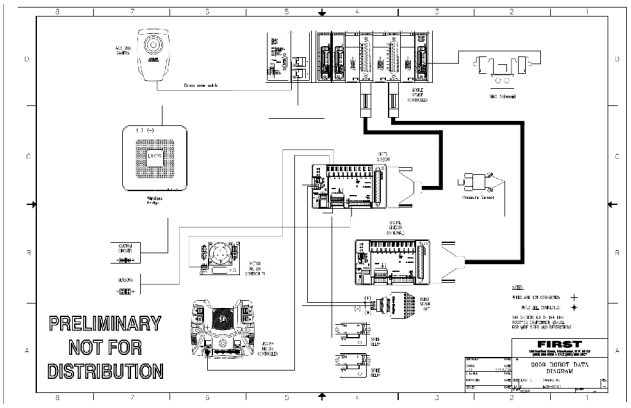
Teams receiving an "early control system shipment" are requested to carefully follow the steps below, recording any deficiencies, confusing points, errors, and/or possible improvements to the setup procedures so that this document can be improved for the use by all teams. Please post your detailed suggestions in the appropriate discussion on the FIRST Control System forum

2.2.2 Identify and Inventory All Control System Components

1. **Control System Inventory** - Print the "Controls Kit of Parts Checklist" (see www.usfirst.org/frccontrolsystem to inventory the control system kit of parts that you received. Identify each of the components through the use of the descriptions and photos. Record the quantities that you have received on your printed checklist. <Q: How to address inconsistencies with the controls kit of parts?> Report any inconsistencies within 3 days of receiving your controls kit to frcparts@usfirst.org

2. **Wiring Diagrams** - Print out the "2009 Robot Power Distribution Diagram" http://www.usfirst.org/uploadedFiles/2009%20Power%20distribution%20diargam.pdf and the "2009 Robot Data Connectivity Diagram" http://www.usfirst.org/uploadedFiles/2009%20Data%20diagram.pdf so that these are available for reference when assembling the benchtop control system.





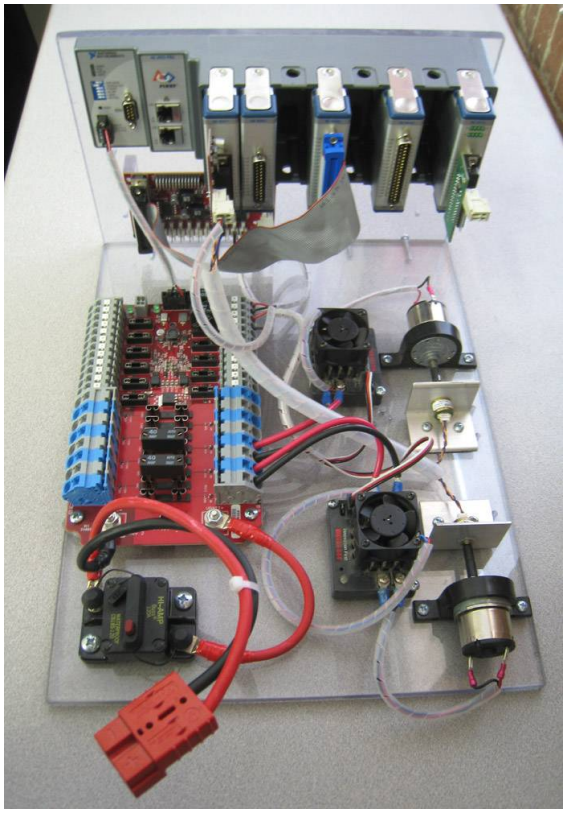
2.2.3 Benchtop Hardware Setup

Setup the hardware for the benchtop test as follows.

2.2.3.1 Hardware Layout Planning

Locate the following control system components and layout their locations on an appropriate non-conductive surface (e.g. plywood or lexan) to permit wiring connections between the below components as shown in the power distribution diagram. Plan the positions of the components to leave space to access the various connectors.

- Kit Materials:
  - Power Distribution Board
  - cRIO with modules (2x NI 9201 in slots 1,2; 2x NI 9403 in slots 4,6; NI 9472 in slot 8)
  - Analog Breakout (to be installed with the NI 9201 module in slot 1)
  - Digital Sidecar (to be connected to the NI 9403 module in slot 4)
  - Solenoid Breakout (to be installed with the NI 9472 module)
  - Wireless bridge, WGA600N
- Team-Provided Materials:
  - 120-amp circuit breaker
  - Victor 884 speed controllers, qty 2
  - 12V DC motors, qty 2
  - 6 AWG wire and ring terminal connectors
  - 22 AWG wire
  - appropriate wire for size of motors
  - circuit breakers
- Tools Required:
  - M6 nut driver (10mm socket)
  - Jeweler's flat-head screwdriver
  - Wire cutters, strippers, and crimpers



An example of a completed benchtop setup (excluding the wireless adapter) is shown at right.

2.2.3.2 Electrical Connections for Control System Components

1. **Power Distribution Board** – Make each of the following connections. Refer to the Power Distribution Board datasheet for additional detailed information (Section 3.2).
   - 12V Power connection to the Power Distribution Board from the 120-Amp circuit Breaker
     - (WARNING: the shanks on the 2009 PD use metric M6 nuts. Use of ¼" nuts will strip the studs on the PD board.)
     - NOTE: Do not connect a battery to the PD until after all other connections are established and double-checked.
   - 24V Power connection to the cRIO (See the FAQ on the PD Datasheet for information on making this cable.)
   - Power connections to the Analog Breakout, Digital Sidecar, and Solenoid Breakout. (See the FAQ on the PD Datasheet for information on making these cables.)

- Power connection to the Victor 884 Speed Controllers from either the Maxi Breaker outputs (for 40A circuits) or the VB3 Breaker outputs (for 20A or 30A circuits)
- Install appropriately-sized circuit breakers in the needed locations

2. **cRIO** – Make each of the following connections. Refer to the cRIO manual for additional detailed information.
    - CRIO Module Positions for Beta Test
        - Slot 1: 9201 (with Analog Breakout)
        - Slot 2: 9201
        - Slot 3: Empty
        - Slot 4: 9403 (connected to Digital Sidecar)
        - Slot 5: Empty
        - Slot 6: 9403
        - Slot 7: Empty
        - Slot 8: 9472 (connected to Solenoid Breakout)
    - Power connection from the Power Distribution Board (Note that a spare black cRIO power connector (Part No CTF040V8) will have shipped attached to the cRIO. You can remove this connector and should save it as a spare.)
    - Ethernet cable from network port 1 to the Driver Station
    - (Optional connection: parts not supplied in kit) Console Serial Port to Personal Computer to be used for viewing "console output" from the cRIO on a PC; see section 5.5.1, "cRIO Console Serial Connection to Laptop" for additional details.

3. **Analog Breakout** – Make each of the following connections. Refer to the Analog Breakout datasheet for additional detailed information (Section 3.4).
    - Connect the Analog Breakout to the NI 9201 module installed in slot 1 of the cRIO
    - Power connection to Power Distribution Board
    - Jumper installed on the Analog Breakout's "Battery Selection Jumper" in accordance with the Analog Breakout Datasheet to enable battery monitoring

4. **Digital Sidecar** – Make each of the following connections. Refer to the Digital Sidecar datasheet for additional detailed information (Section 3.5).
    - Connect the Digital Sidecar to the NI 9403 module installed in slot 4 of the cRIO with the supplied DB-37 cable.
    - Power connection to Power Distribution Board
    - PWM cables to Victor 884 Speed Controllers (PWM #1 to Victor #1; PWM #2 to Victor #2).

5. **Solenoid Breakout** – Make each of the following connections. Refer to the Solenoid Breakout datasheet for additional detailed information (Section 3.6).
    - Connect the Solenoid Breakout to the NI 9472 module installed in slot 8 of the cRIO
    - Power connection to Power Distribution Board

6. **120-Amp Circuit Breaker** – Make each of the following connections:
    - Connect the "BAT" terminal to the "+" terminal of an Anderson connector
    - Connect the "AUX" terminal to the "+" terminal on the PD board.

7. **Victor 884 Speed Controllers and 12VDC Motors** – Make each of the following connections for each of the two Victor speed controllers and associated 12VDC motors:
    - Connect the “V-” terminal to the “-” output of either a Maxi or VB3 breaker on the PD board
    - Connect the “V+” terminal to the “+” output of the same Maxi or VB3 breaker on the PD board
    - Connect the “M-“ terminal to one of the motor input leads
    - Connect the “M+” terminal to the other motor input lead of the same motor

8. **Wireless Bridge (WGA600N)** – Make each of the following connections:
    - Connect the 12V / 1A power supply included with the WGA600N wireless bridge to a wall outlet and to the bridge. The bridge can alternatively be powered from the robot using the 12V supply included on the PD board. (See the FAQ on the PD Datasheet for more details on this connection.)
    - NOTE: Do not yet connect the Ethernet cable between the bridge and the cRIO. The first benchtop test will utilize “tethered” operation. Only after completing the test with tethered operation will the bridge be used for a wireless connection to the Driver Station.

2.2.3.3 Confirmation of Wiring of Control System Components

At this point, your electrical wiring for the “robot” portion of the benchtop test should be complete. Before turning the benchtop system on, ensure that all power connections are connected with the proper polarity and that any power cables you manufactured are correct. Applying reversed power will permanently damage many of the control system components (e.g. the wireless adapters and Victor speed controllers).

Leave the “benchtop” test setup turned off at this time while configuring the Driver Station as described in the next section.

2.2.4 Driver Station Setup

Set up the Driver Station as follows:

1. **Joystick Setup** - Connect the two Logitech Attack 3 joysticks to USB1 and USB2.
2. **Enable/Disable Dongle Setup** – Connect the enable/disable dongle to “Competition Port”.
3. **Ethernet Connection to cRIO** – Connect a standard 100-BaseT network cable from either of the Driver Station Ethernet ports to Port 1 on the cRIO
4. **Driver Station Power-On** - Attach the Driver Station to the appropriate Driver Station power adapter and plug the adapter in to a 120 VAC receptable.
    - The Driver Station screen should light up immediately; the “POWER” and “+5VDC” LEDs should both be lit.
    - After about two seconds, the “KwikByte” logo should be displayed and remain onscreen for approximately five seconds before the screen is blanked.

- The screen will remain blank with only a cursor visible in the upper left for approximately 30 seconds before being replaced with the Driver Station status display.

- The Driver Station status display should display the status of the Team Number (currently “00000”), Mode (Teleoperated or Autonomous depending upon the position of the AUTO/TELEOP switch), System (Disabled / Enabled), Battery voltage (“N/A” when not connected to a robot), and “OTB” for the software image version.

5. **Driver Station Power-Off** – Turn off the Driver Station by unplugging the power connector.
6. **For more information** - See Section 3.1.

2.3 BENCHTOP OPERATION AND TESTING

2.3.1 Power-On and Verification of Tethered Operation

At this point, the Driver Station and the "benchtop" system should be ready to be powered on. Before powering on the "benchtop" system, ensure that the motors are located in such a way that if they were to become immediately operational, they would not pose a safety hazard. Follow the instructions below to confirm the operation of your control system components:

2.3.1.1 Confirmation of LED Status on Control System Components while Disabled

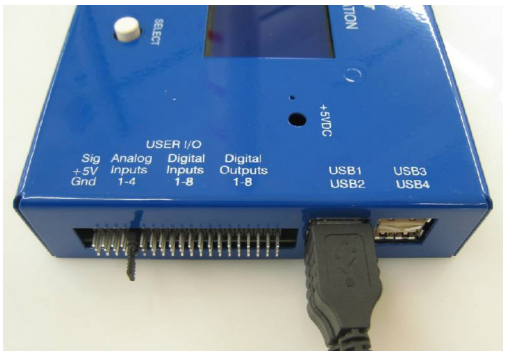
1. Turn on the Driver Station by connecting the power connector. Wait for the Driver Station to boot to the status screen.
2. Set the "Auto / Teleop" switch on the Driver Station to "Teleop". Ensure that the Driver Station display reads "Mode: Teleoperated."
3. Set the Enable/Disable switch on the Competition Port dongle of the Driver Station so that the Driver Station display reads "System: Disabled."
4. Connect a battery to the Anderson connector of the "benchtop test" setup. Turn on the power to the "benchtop test" setup at the Hi-Amp 120A circuit breaker.
5. Immediately after turning on the power, confirm that each of the items below is operating correctly:
    a. On the Power Distribution Board, three green LEDs should be lit: +5V supply, +24V supply, and +12V supply
    b. On the Digital Sidecar, three green LEDs should be lit: "Power Input," +5V, and +6V
    c. On the Analog Breakout, one green LED should be lit.
    d. On the Solenoid Breakout, one green LED should be lit
    e. The Victor 884 LEDs should be flashing orange.
    f. Note that the Driver Station display will continue to read "Battery: N/A". (Battery voltage display will not be active until after upgrading the firmware in the Driver Station and cRIO.)

2.3.1.2 Confirmation of "Tank Drive" Control System Component Operation while Enabled

1. Before enabling the "benchtop" system, ensure that no safety hazards exist if the motors are to suddenly become operational. Also ensure that the joysticks plugged in to the Driver Station are "centered."
2. Set the Enable/Disable switch on the Competition Port dongle of the Driver Station so that the Driver Station display reads "System: Enabled."
3. When enabled, the Victor LEDs should be solid orange (assuming that the joystick inputs are centered.)
4. The "benchtop" system is now configured so that the two joysticks should give "tank drive" behavior:
    a. Move the joystick connected to USB #2 all the way forward. The Victor connected to PWM #1 should have its LED change color to solid green and the motor connected to that Victor should turn at full speed forward.
    b. Move the joystick connected to USB #2 all the way backward. The Victor connected to PWM #1 should have its LED change color to solid red and the motor connected to that Victor should turn at full speed in reverse.
    c. Joystick on USB #1 full forward should result in Victor on PWM #2 having a solid red LED and the motor turning at full reverse.
    d. Joystick on USB #1 full backward should result in Victor on PWM #2 having a solid green LED and the motor turning at full forward.

2.3.1.3 Confirmation of "Arcade Drive" Control System Component Operation while Enabled

1. Set the Enable/Disable switch on the Competition Port dongle of the Driver Station so that the Driver Station display reads "System: Disabled."
2. Turn off the Driver Station by disconnecting the power connector.
3. Connect a 2-pin jumper to the top two pins of Driver Station Digital Input #1 (to connect the signal pin to +5V) as shown in the photo at right. Digital Input #1 is the fifth set of pins from the left. (Sets #1 through #4 are the analog inputs.) NOTE: Be careful when connecting this jumper to NOT CONNECT the lower two pins, as this shorts the +5V and GND pins together, which will prevent the Driver Station from booting.



4. Turn on the Driver Station by connecting the power connector. Wait approximately 35 seconds for the Driver Station to boot to the status screen.
5. Set the Enable/Disable switch on the Competition Port dongle of the Driver Station so that the Driver Station display reads "System: Enabled."
6. The "benchtop" system is now configured so that the joystick connected to USB#1 should give "arcade drive" behavior:
    a. Move the joystick connected to USB #1 all the way forward while keeping the joystick centered from right to left. The Victor connected to PWM #1 should have its LED switch to solid green and the motor connected to that Victor should turn at full speed forward; meanwhile, the Victor connected to PWM #2 should have its LED switch to solid red and the motor connected to that Victor should turn at full speed in reverse.
    b. Move the joystick connected to USB #1 all the way backward while keeping the joystick centered from right to left. The Victor connected to PWM #1 should have its LED switch to solid red and the motor connected to that Victor should turn at full speed backward; meanwhile, the Victor connected to PWM #2 should have its LED switch to solid green and the motor connected to that Victor should turn at full speed forward.
    c. Move the joystick to each of the four "corners" – when completely in each "corner" only one motor should turn. (This would implement "pivot" turns on a typical FRC robot.)
    d. While holding down button 2 of the joystick, move the joystick from side to side. Both motors should turn with rates proportional to the distance the joystick is moved away from center. This would implement "spin" turns on a typical FRC robot. (Note: in the "Out of the Box" code installed on the robot, button 2 activates the spins. Later versions of the code using WPILib use the trigger button for this functionality.)
    e. Experiment with moving the joystick to different positions, noting that different output behaviors take effect depending upon the position of the joystick.
7. Turn off the "benchtop" system by firmly pressing the red button on the Hi-Amp 120A circuit breaker.
8. Turn off the Driver Station by unplugging the power connector.

2.3.1.4 Confirmation of "Autonomous" Control System Component Operation

1. Turn on the Driver Station by connecting the power connector. Wait approximately 15 seconds for the Driver Station to boot to the status screen.
2. Set the Enable/Disable switch on the Competition Port dongle of the Driver Station so that the Driver Station display reads "System: Disabled."
3. Set the Auto/Teleop switch of the Driver Station so that Driver Station display reads "Mode: Autonomous."
4. Turn off the Driver Station by disconnecting the power connector.

5. Connect a 2-pin jumper to the top two pins of Driver Station Digital Input #2 (to connect the signal pin to +5V) as shown in the photo below at right. Digital Input #2 is the sixth set of pins from the left. (Sets #1 through #4 are the analog inputs.) (NOTE: Be careful when connecting this jumper to NOT CONNECT the lower two pins, as this shorts the +5V and GND pins together, which will prevent the Driver Station from booting.)

6. Turn on the Driver Station by connecting the power connector. Wait approximately 35 seconds for the Driver Station to boot to the status screen. Confirm that the screen reads “System: Disabled” and “Mode: Autonomous.”
7. Before enabling the “benchtop” system, ensure that no safety hazards exist if the motors are to suddenly become operational. Turn on the power to the “benchtop” system and wait fifteen seconds for the cRIO to boot.
8. Set the Enable/Disable switch on the Competition Port dongle of the Driver Station so that the Driver Station display reads “System: Enabled.”
9. Immediately upon enabling the system, the motors connected to PWM#1 and PWM#2 should both be activated for exactly two seconds. The motor connected to PWM #1 should turn forward at about half speed, and the motor connected to PWM #2 should turn backward at about half speed.
10. Toggle the Enable/Disable switch to “System: Disabled” to disable the benchtop system.
11. Toggle the “Teleop / Autonomous” switch so that “Mode: Teleoperated” is shown on the Driver Station display.
12. Toggle the Enable/Disable switch to “System: Enabled” to re-enable the benchtop system with teleoperated control. Check that the motors move in accordance with the joystick(s).
13. Turn off the “benchtop” system by firmly pressing the red button on the Hi-Amp 120A circuit breaker.
14. Turn off the Driver Station by unplugging the power connector.

2.3.2 Configuration of Wireless Components

There are two wireless components in the control system:

- Linksys WRT610N Wireless Router – This wireless device is to be physically connected to the Driver Station to provide wireless communication to the robot when not on a competition field. Throughout the remainder of the documentation, this device will be referred to as the “wireless router” or simply “router.”
- Linksys WGA600N Wireless Gaming Adapter / Bridge – This wireless device is to be physically connected to the cRIO and reside on the robot. Throughout the remainder of the documentation, this device will be referred to as the “wireless bridge” or simply “bridge.”

Further information on configuring these devices can be found in section 5.7 of the FRC Control System Manual.

2.3.2.1 Physical Connectivity of Wireless Router for Driver Station (WRT610N)

1. Disconnect the Ethernet cable from Port 1 of the Driver Station that was used to “tether” the Driver Station directly to the cRIO.
2. Connect an Ethernet cable from Port 1 of the Driver Station to port “Ethernet 1” of the WRT610N router.
3. Connect the router to 120VAC power via the supplied power adapter.

2.3.2.2 Physical Connectivity of Wireless Bridge for Robot (WGA600N)

1. Disconnect the Ethernet cable from Port 1 of the cRIO that was used to “tether” the cRIO directly to the Driver Station.
2. Connect an Ethernet cable from Port 1 of the cRIO to the “Ethernet” port on the WGA600N bridge.
3. Supply power to the bridge via either the supplied 120VAC power adapter or via the Power Distribution Board. (See the FAQ on the PD Datasheet for more details on the power connection.)

2.3.3 Verification of Wireless Operation

Repeat the tests described in section 2.3.1 with the “benchtop” system now being wirelessly connected to the Driver Station.

Information on configuring the wireless devices can be found in section 5.7 of the FRC Control System Manual.