

squarebot radio subsystem
The radio provides the
control link between a
human operator and the
squarebot. Commands are
sent through a pair of
switches and buttons on
the Radio Transmitter,
sent via radio signal
to the Radio Receiver on
the squarebot. In this way, the
squarebot can be controlled
from a safe location of
operator and all dangerous

radio

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squarebot radio subsystem parts & assembly

The Radio Subsystem provides the link between the robot and the human operator. Commands are entered through the joysticks and buttons on the Radio Transmitter, and sent through the air via FM radio waves to the Radio Receiver mounted on the robot.

- 1 Collect and identify the parts from the list of materials below:

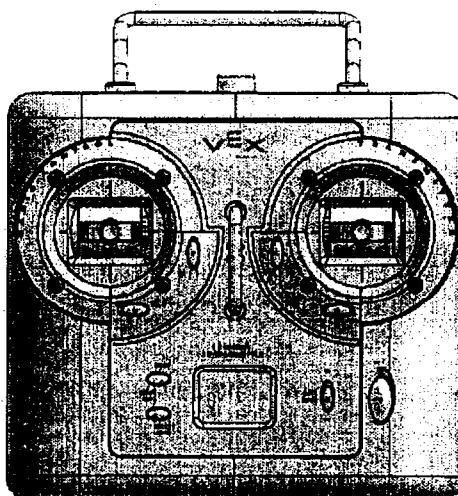
materials	qty
radio transmitter	1
transmitter antenna	1
radio receiver	1
receiver crystal (75MHz)	1
8-32 hex screw, $\frac{1}{4}$ "	4
keps nut	4

Refer to full-size illustrations of all of the components on the following page

squarebot assembly

squarebot radio subsystem parts & assembly, continued

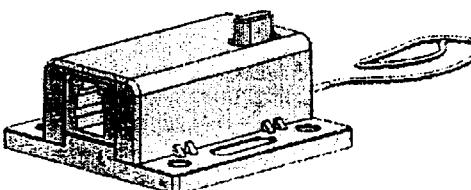
transmitter x 1



transmitter antenna x 1



receiver x 1



8-32 hex screw, $\frac{1}{4}$ " x 4



keps nut x 4

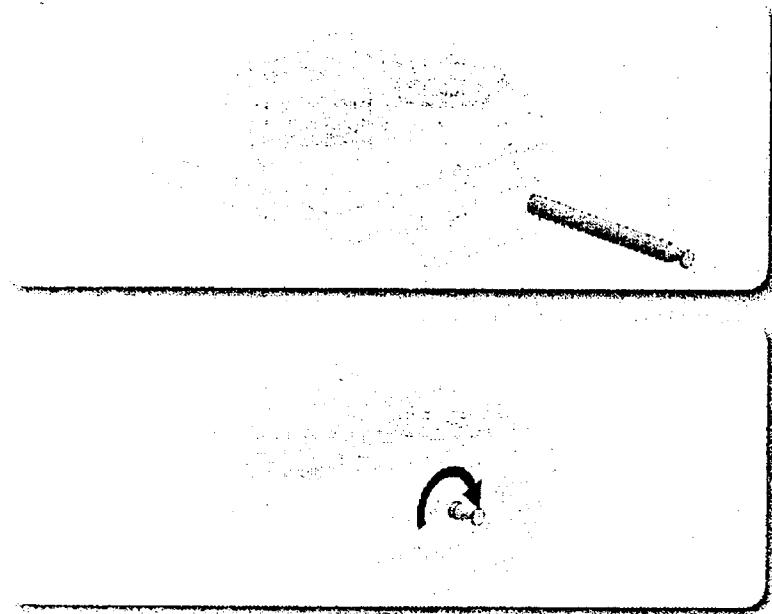


squarebot assembly

squarebot radio subsystem parts & assembly, continued

2 Attach the antenna to the Transmitter:

Insert the antenna into the hole on the top of the Transmitter body. There is a screw inside the Transmitter housing (at the bottom of the hole), and a threaded screw hole at the base of the antenna. Push the antenna in until you feel the antenna come into contact with the screw, then start twisting the base of the antenna clockwise until it is firmly locked in position. Twist only the bottom most segment of the antenna, as the others will spin freely and not actually screw the antenna in properly.

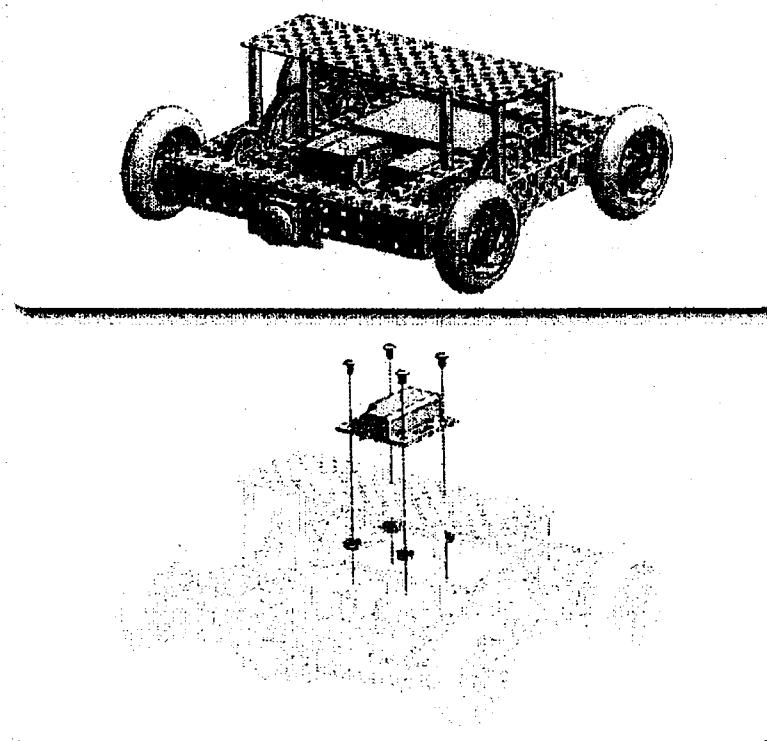


squarebot assembly

squarebot radio subsystem parts & assembly, continued

3 Attach the Radio Receiver Module to the robot:

Position the receiver module on top of the the SquareBot deck, and secure it with four $\frac{3}{4}$ " screws and keps nuts.

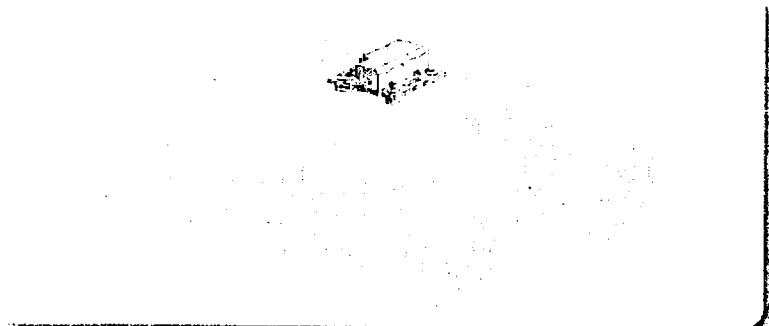


squarebot assembly

squarebot radio subsystem parts & assembly, continued

3 For receiver assembly, continued:

The installed receiver module should look like this:

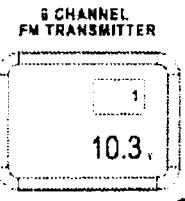


radio subsystem

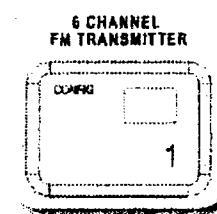
Basic Controller Operation

The Radio Transmitter joysticks can be configured to work in two basic configurations. To check or switch between configurations, follow these instructions:

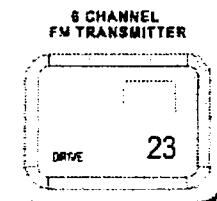
1. Turn on the Transmitter by pushing the power switch to the ON position.



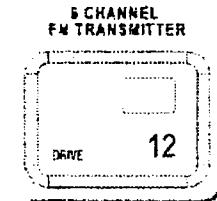
2. Enter the menu on the transmitter by holding down both the Mode and Select buttons next to the LCD until the menu opens.



3. Enter "DRIV" mode by pressing the Mode button until DRIV is displayed on the left side (it's the last mode).



4. The current driving mode is displayed. This will be either "23" or "12". Press either the + or - on the data input button on the right side of the LCD to switch between these two modes. The two modes are explained on the following pages.



radio subsystem, continued

Configuration 1:

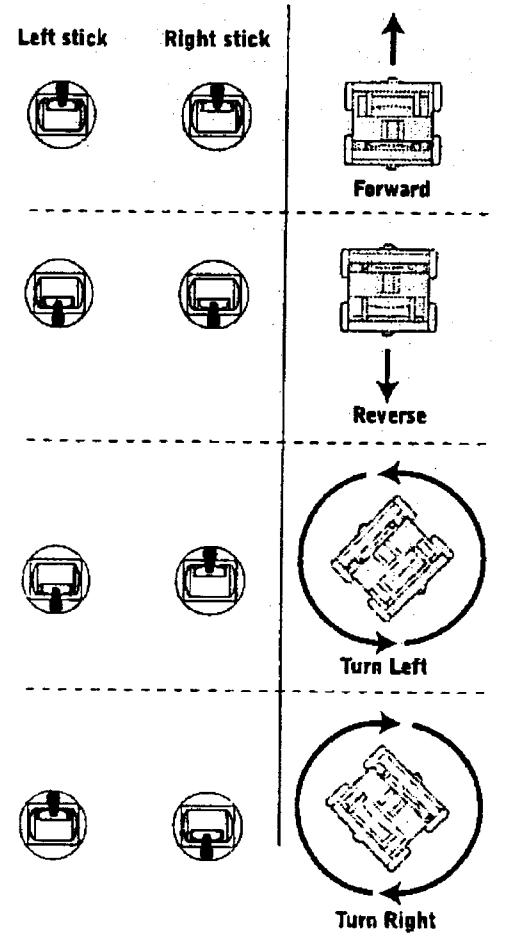
Tank-style control ("23" mode – default)

Note: Make sure there are no jumper clips on Analog/Digital Parts 13, 14, 15, or 16 on the Robot Controller, otherwise your robot's controls will be different from what is listed here in this section. For details on how to use these jumpers to configure advanced control features, visit the Logic and Control Subsystem chapter.

This control configuration uses the vertical axes of both sticks to control the two motors independently. The name "23 mode" comes from the fact that the vertical axis of the right stick is "Control Channel 2", and the vertical axis of the left stick is "Control Channel 3", hence axes 2 and 3 ("23") are being used to drive.

In this configuration, the left stick controls the motor attached to Motor Port 3, and the right stick controls the motor attached to Motor Port 2.

Warning: Always make sure the transmitter is turned on and functioning before turning on the robot! If the transmitter is not on when the receiver is activated, the receiver may accidentally interpret other radio waves in the air as commands and cause the robot to move unexpectedly!



radio subsystem, continued

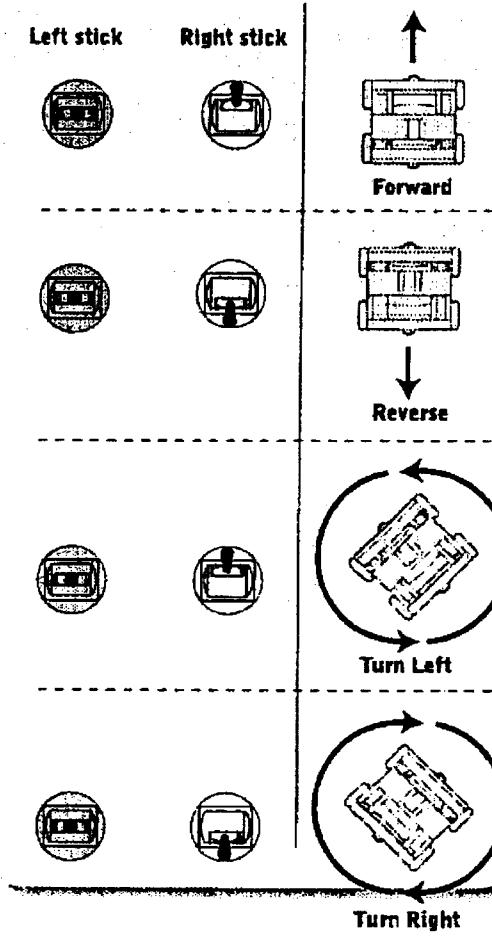
Configuration 2:

Arcade-style control ("12" mode)

Note: Make sure there are no jumper clips on Analog/Digital Parts 13, 14, 15, or 16 on the Robot Controller, otherwise your robot's controls will be different from what is listed here in this section. For details on how to use these jumpers to configure advanced control features, visit the Logic and Control Subsystem chapter.

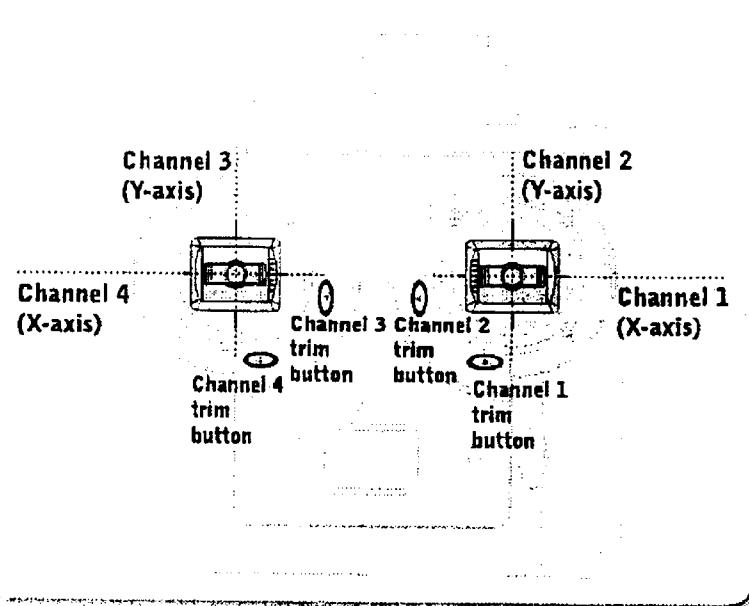
This control configuration uses only the right joystick to control both forward/back motion and turning motion. The name "12 mode" comes from the fact that the horizontal axis of the right stick is "Control Channel 1", and the vertical axis is "Control Channel 2", hence axes 1 and 2 ("12") are being used to drive.

In this configuration, the right stick controls both throttle and turning.



radio subsystem, continued

Controller Trim



Because the sticks on the transmitter are analog electromechanical devices that operate directly on circuit voltage, there is the distinct possibility that the sticks will become miscalibrated. This happens when the sticks start delivering different voltages than what the controller expects for a given position.

In order to counteract this problem, there are manual adjustment buttons on the transmitter that allow you to recalibrate or "recenter" the controller. These can be adjusted so that the voltages match up correctly again on the stick.

Note that each stick's position actually breaks down into two separate measurements. One of them indicates how far left and right the stick is (the horizontal, or "X", axis), and the other measures where it is with respect to the vertical, or "Y", axis. These four axes (two axes times two sticks) can become miscalibrated separately, so you may need to adjust each of them independently.

Conveniently, each axis is assigned a number (which corresponds with the "control channel" that it works on), so there should be no confusion between about which axis or stick is which.

radio subsystem, continued

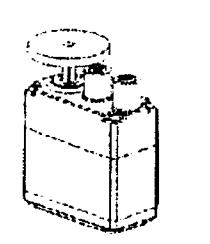
Controller Trim, continued

To calibrate the sticks:

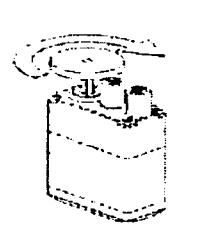
1. Release both control sticks so they return to their neutral positions.



2. Hold the robot (or just the motors, if they are not mounted) up in the air so you can see whether the motors are turning or not, and whether the servomotors are in the centered positions or not.

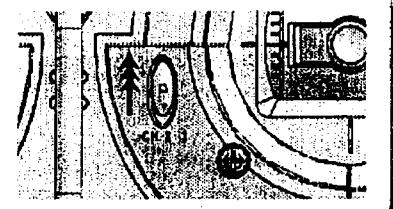


3. If you see a motor turning or a servomotor not centered, follow the wire back to the Robot Controller to see which port it is plugged into.



4. Consult the Joystick Mappings section to see which controller axis controls that particular port (this will depend on the Driving mode you are in).

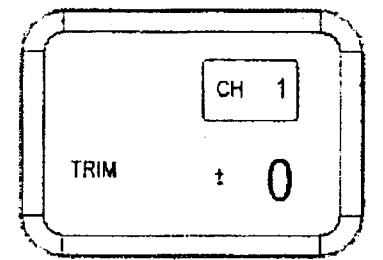
5. Push either direction on the Trim Button for that axis to try and correct the problem.



6. Check if the motors slowed down or got closer to center. If they did, then keep pushing the button in that direction until they are stopped/centered; if they get faster or farther from center, push the other way on the trim button instead.

7. If you cannot get the motors to stop because the "stop" position seems to be in between two trim settings, finer adjustments are available. Go into the menu (hold both the Select and Mode buttons for one second), and adjust the appropriate channel from the TRIM menu (push Mode until TRIM is displayed, then Select until the channel you want is displayed, then use the Data Input lever on the right to make adjustments).

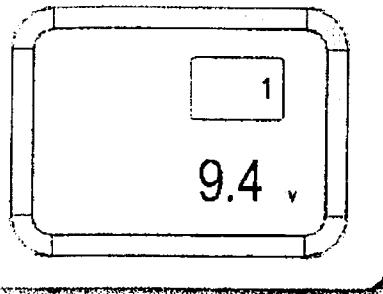
6 CHANNEL FM TRANSMITTER



radio subsystem, continued

Transmitter Battery Voltage

6 CHANNEL FM TRANSMITTER



In normal operation, the transmitter displays two numbers on the LCD screen: the configuration number (see Appendix G), and the battery voltage on the transmitter. Note that this screen only displays the battery power left on the transmitter, and not the robot! There is no way to monitor the robot's battery voltage using this display, so you will need to watch separately for problems arising from low robot battery power.

The transmitter's power begins to decrease at approximately 9.4V on the display. If you are at 9.4V or less, consider stopping and recharging the transmitter batteries. If the voltage reaches 8.9V, you have about 10 minutes left before you hit low voltage, so you should stop if possible. The transmitter hits low voltage at 8.5V on the display. At this point, you will hear a beeping sound, a low battery indicator will appear, and performance will begin to degrade significantly. You should stop and recharge the batteries at this point.

Note that if you continue to run the battery down to a very low voltage, you risk damage to the battery pack (or rechargeable AA cells). See the Power Subsystem Background Information for details.

9.4V	Batteries somewhat low. You will need to stop soon.
8.9V	Batteries very low (10 minutes or less remaining), stop unless absolutely necessary.
8.5V (Low battery indicator comes on, controller sounds warning beep)	Batteries depleted. Stop now.

radio subsystem, continued

Stick Mode

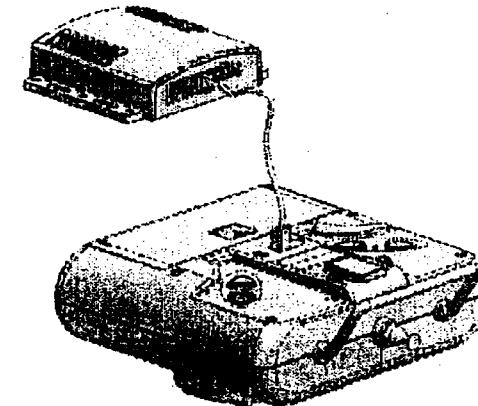
Stick Mode configuration is accessed differently from the other menus. To access this mode, you must hold down Mode and Select while turning the controller on, rather than pressing them once it is already on.

The only option you can change is the Stick Mode, between "2" and "1". 2 is the default, and you should leave it this way unless you have a specific reason for changing it. Setting the Stick Mode to 1 will swap axes 2 and 3, so the vertical axis of the left stick becomes channel 2, and the vertical axis of the right stick becomes channel 3. Unless you have a good reason to change this, you should leave the Stick Mode on 2.

Tether Port

Sometimes for diagnostic purposes, it may be useful to plug the transmitter directly into the robot controller, and eliminate the need for the Radio Receiver and radio wave transmission. This would help you determine, for instance, whether radio interference is at fault for your robot behaving strangely, or if some other factor is to blame.

In order to use the tether feature, you will need to purchase a cable. Any telephone handset extension cable should work (the cable that goes from the handset to the base of a corded phone, not the cable that goes from the phone to the wall).

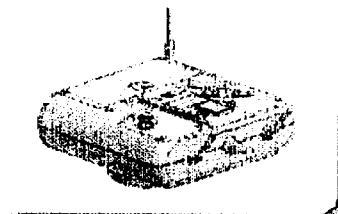


radio subsystem, continued

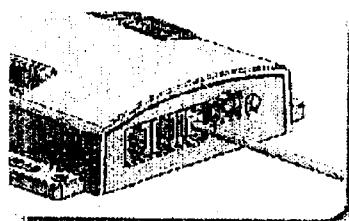
Tether Port, continued

To use the tether feature:

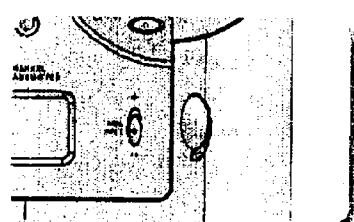
1. Hook up one end of the cable to the back of your Radio Transmitter, in the port marked "Tether Port".



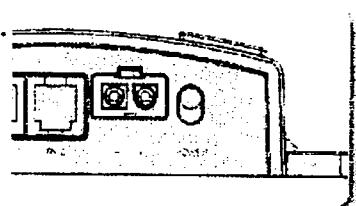
2. Plug the other end directly into the Rx1 port of your Robot Controller.



3. Turn the Transmitter on by pushing the power switch on the Transmitter to the ON position.



4. Turn the Robot Controller on by flipping the power switch on the Robot Controller to the ON position.



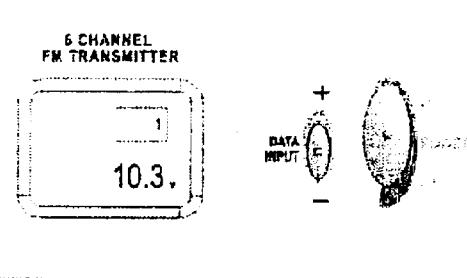
5. Test your robot. The controls should operate exactly as they would remotely over radio, but without the possibility of radio interference or other similar issues.

radio

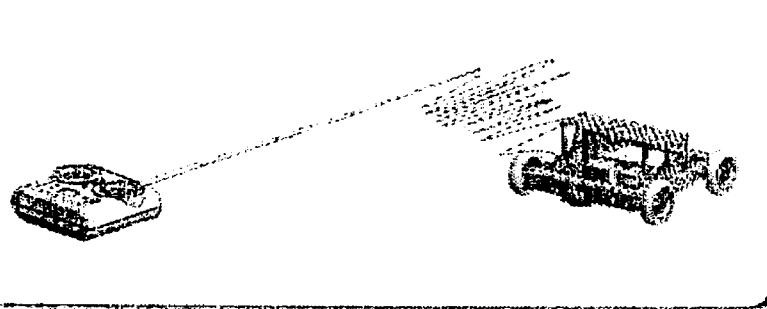
radio subsystem, continued

Tips

Always turn the Transmitter on before powering up the robot. If the transmitter is not on when the receiver is activated, the receiver may accidentally interpret other radio waves in the air as commands and cause the robot to move unexpectedly!



Radio waves radiate out from the sides of the transmitter antenna, not from the tip. For this reason, you will get the best range and performance from your transmitter if you don't point it directly at your robot.

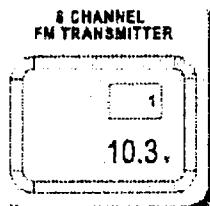


radio subsystem, continued

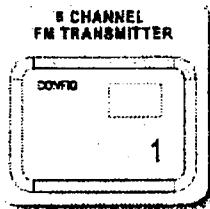
Tips, continued

If you accidentally change a setting on your controller that you didn't want to change, you can reset the controls through the CONFIG menu.

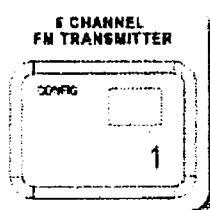
1. Turn the transmitter on by pushing the power switch into the ON position.



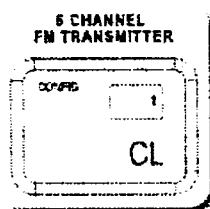
2. Hold down the Mode and Select buttons for two seconds until the menu appears. CONFIG should be selected by default.



3. If you wish to reset the data for a different robot configuration, press the + button on the Data Input button until the configuration number you want is displayed. If you are not using multiple configurations (see Appendix G), then ignore this step.



4. Press the Select button. The letters CL (for "clear") should appear.



5. Hold either the + or - on the Data Input button for 2 seconds to reset the controls for the selected config number. The Transmitter will beep when the configuration is reset.

radio

radio subsystem, continued

Tips, continued

Remember that the transmitter does not monitor robot battery voltage, only its own transmitter battery. Watch the robot to see if it seems to be low on power.

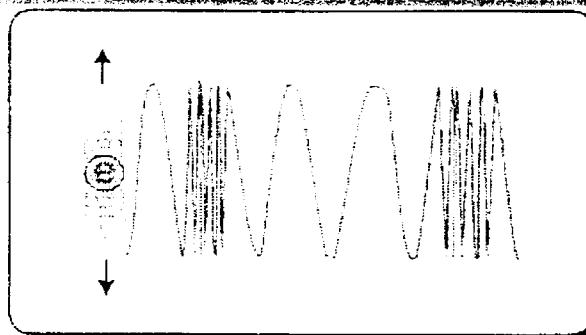
If more than one robot is operating in the same area, be sure that the robots are operating on different frequencies or their commands will interfere with each other (see Frequency Crystals in Background Information in this chapter).

If you own more than one set of frequency crystals, be sure that the crystal in your transmitter matches the crystal in your receiver (see Frequency Crystals in Background Information in this chapter).

Concepts to understand, continue

Electromagnetic Waves

When electrons accelerate, they radiate an electromagnetic signal that moves at the speed of light. By accelerating and decelerating electrons in a controlled pattern, a wave pattern can be generated in the radiated electromagnetic field. These are called electromagnetic waves. Electromagnetic waves move at the speed of light, and are therefore very good at carrying information quickly from one place to another.



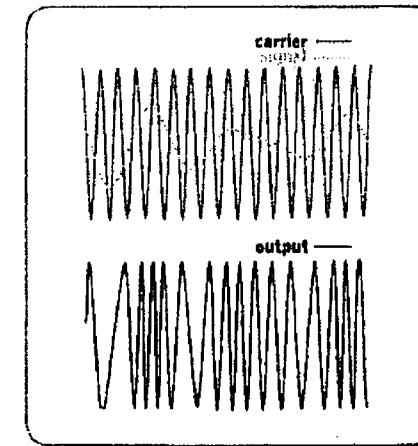
Frequency-Modulated Signals

The Vex Radio Transmitter uses an electromagnetic wave with a certain frequency to transmit data to the radio control receiver. Frequency modulation (FM) is a way of encoding information in wave patterns such as these.



Waves have several basic properties, including amplitude and frequency. In frequency modulation, the frequency of the basic ("carrier") wave is modified by combining it with another ("signal", or "modulating") wave, producing a final wave that looks irregular, but is really carrying the data from the signal wave on top of the carrier wave.

FM is less susceptible to interference than other methods, such as amplitude modulation (AM) or direct transmission of the signal wave.



Vex starter kit

The FCC Wants You to Know

This equipment has been tested and found to comply with the limits for radio controlled devices, pursuant to Part 15 and Part 43 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Relocate or reorient the receiving antenna.
- Increase the separation between the equipment and receiver.
- Consult your local electronics store or an experienced radio/TV technician for help.
- If you cannot eliminate the interference, the FCC requires that you limit using your R/C transmitter.

Warning: Changes or modifications made without approved by Innovation Doc may cause inoperability and void the star's authority to operate the equipment. Only use authorized systems designed for use with the Vex Robotics Design System.



Important: The EPA certified RBRC® Battery Recycling Seal on the nickel-cadmium (Ni-Cd) battery indicates Innovation One voluntarily participates in an industry program that collects and recycles NiCd batteries at the end of their useful life, when taken out of service in the United States or Canada. The RBRC program provides a convenient alternative to placing used Ni-Cd batteries into the trash or the municipal waste stream, which may be illegal in your area. Please call 1-800-8-Battery for information on Ni-Cd battery recycling and disposal laws/restrictions in your area. Innovation One's commitment to this program is part of the company's commitment to preserving our environment and conserving our natural resources.

Unconditional Warranty

This product is warranted by **Imagination One** against manufacturing defects in material and craftsmanship under normal use for ninety (90) days from the date of purchase from authorized **Imagination One** dealers. For complete warranty details and restrictions, check with your dealer.

Imperial Oil, Inc.
350 North Henderson Street
Fort Worth, TX 76102

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Inventor's Guide



Admire ROC curve_tuned_2

1975 4 00 PM

A color calibration target card featuring a grid of color patches (black, white, grey, red, green, blue, cyan, magenta, yellow, and various CMYK combinations), a central registration mark with 'Y', '@', and 'W', and a ruler scale at the bottom.

Vex starter kit

The FCC Wants You to Know

This equipment has been tested and found to comply with the limits for radio controlled devices, pursuant to Part 15 and Part 95 of the *FCC Rules*. These limits are designed to provide reasonable protection against harmful interference. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

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Limited 90-day Warranty

This product is warranted by Innovation One against manufacturing defects in material and workmanship under normal use for ninety (90) days from the date of purchase from authorized Innovation One dealers. For complete warranty details and exclusions, check with your dealer.

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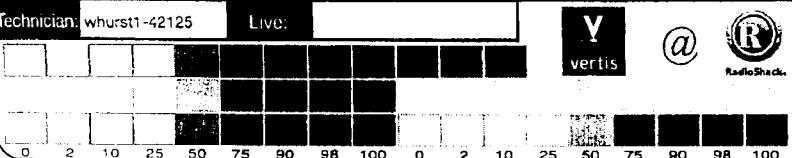
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The actual product may vary from images depicted in this Inventor's Guide.

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Inventor's Guide



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Filename	Master TOC color_r1.indd	Trim:	(8.5 in, 11 in)	Date:	1/19/05 4:08 PM	VEX_1C_K_sm.apa, RBRC_Icon_bw [Converted].apa	<input checked="" type="checkbox"/> Process Black <input checked="" type="checkbox"/> Process Magenta <input checked="" type="checkbox"/> Process Yellow <input checked="" type="checkbox"/> Process Cyan
Technician:	whurst1-42125	Live:				 	
							
							

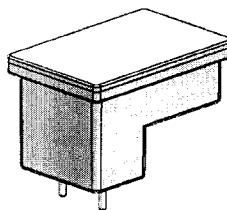
additional crystal set #2

The **Vex Robotics Design System** is designed to be usable in competition settings with multiple robots on the field together at the same time. In order for each robot to be able to tell which radio commands are intended for it, every robot needs to be listening for commands on a different radio channel (see Radio Subsystem background information).

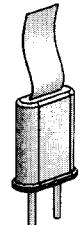
The radio channel is set by the crystal that is installed in every radio transmitter and receiver. A receiver will hear only commands sent by transmitters using the same frequency of crystal, so your transmitter and receiver must match for you to be able to control your robot. However, a robot will also hear commands sent by ALL transmitters on that frequency, so you need to make sure that nobody else is using the same frequency as you.

INSERT THESE PAGES
at the **back of the**
radio chapter in your
Vex inventor's guide.

transmitter crystal x 4
(different frequencies)



receiver crystal x 4
(different frequencies)

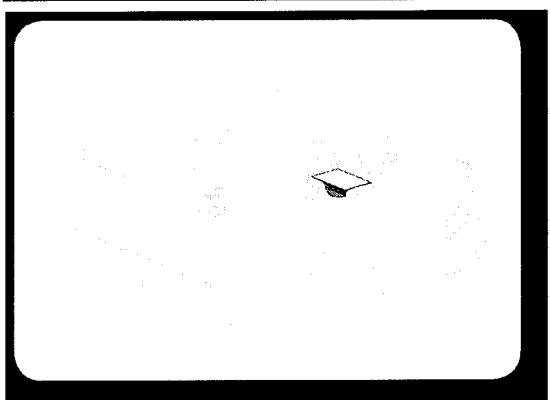
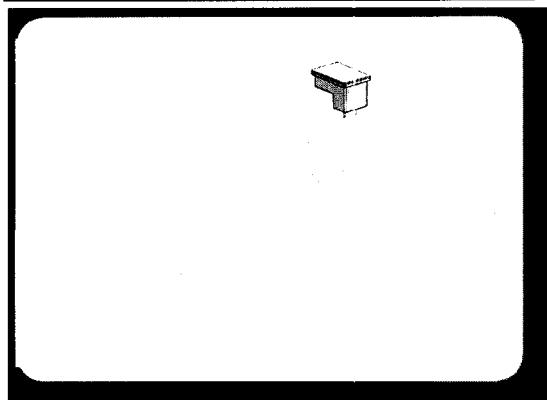
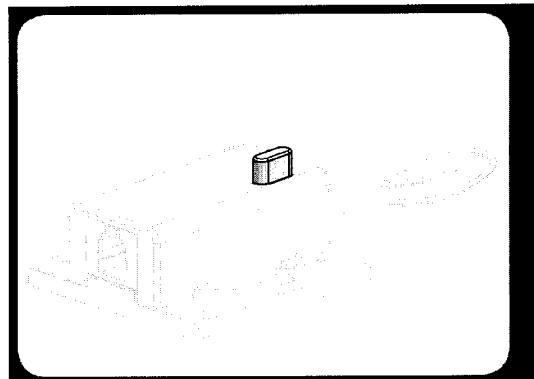
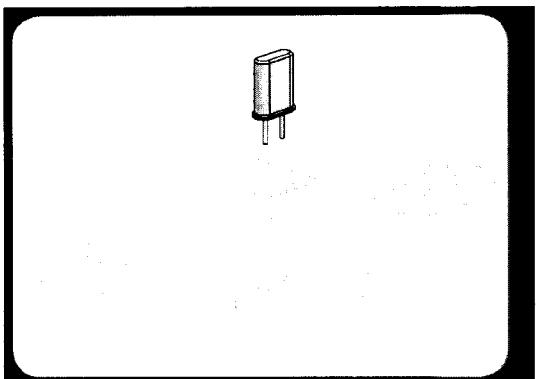


additional crystal set #2, continued

1 Installing the crystals

Remove the old crystals from both the receiver and the transmitter, and store them safely for later use. Select a new receiver crystal and a new transmitter crystal, and be sure that they have the same frequency number!

Insert the new crystals carefully into the vacant slots carefully. Do not use force, or you may bend or break the pins.



Crystals available for use with the Vex Robotics Design System

Starter kit 276-2151	Ch. 61 - 75.410MHz
Additional Transmitter and Receiver 276-2153	Ch. 89 - 75.970MHz
Additional Crystal Set #1 276-2171	Ch. 65, 69, 81, 85 - 75.490, 75.570, 75.810, 75.890MHz
(This kit) Additional Crystal Set #2 276-2160	Ch. 63, 67, 83, 87 - 75.450, 75.530, 75.850, 75.930MHz