Unit

4

Microcontroller and Transmitter Overview

In Unit 4: Microcontroller and Transmitter Overview, you learn about and use the various functions of the VEX Control Subsystem, specifically the Transmitter Microcontroller, as provided by the VEX default code.

Microcontrollers and transmitter technologies have countless applications. In STEM Connections, we use the Mars Pathfinder and Sojourner robotic probes as references to help you see how the concepts found in this unit can be used to solve some very challenging real-world problems.

Unit Objectives

After completing Unit 4: Microcontroller and Transmitter Overview, you will be able to:

- Demonstrate ways to wire a robot using the default setup, relate the controls on the Transmitter to the Motor Ports on the Microcontroller and utilize the Arcade Style Drive Configuration.
- Activate Tank-Style Control (23 Mode).
- Drive a robot with Tank-Style Control (23 Mode).

Prerequisites and Resources

Related resources for Unit 4: Microcontroller and Transmitter Overview are:

- Unit 1: Introduction to VEX and Robotics.
- Unit 3: Building Protobot.

Key Terms and Definitions

The following key terms are used in Unit 4: Microcontroller and Transmitter Overview.

Term	Definition
Arcade Style Drive	A one-joystick robot drive code that uses the X and Y axes for locomotion, enabling the operator to operate a robot drive system much like a one-joystick arcade/video game.
Channel	Refers to any of the six labeled origins of input on the VEX Transmitter.
Default Code	Factory initial control program code loaded into the VEX (or other) Microcontroller.
Microcontroller	Uses logic (programming software) to receive commands and interpret signals from the Transmitter and/or sensors that control a robot's movement and functions.
Motor Port	Refers to any of the eight ports for connecting Motors and/or Servo Motors to the VEX Microcontroller.
Receiver	A device that passes signals from the Transmitter to the Microcontroller for interpretation.
Tank Style Drive	A two-joystick robot drive code that typically uses the y-axis (up and down) only for locomotion. Each joystick controls a single side of the robot drive system.
Transmitter	Primary input device used for tele-operation of a VEX (or other) robot.

Required Supplies and Software

The following supplies are used in Unit 4: Microcontroller and Transmitter Overview:

Supplies
VEX Classroom Kit
Notebook and pen
One assembled Protobot from Unit 3: Building a Protobot > Build Phase
Work surface
Small storage container for loose parts
One VEX Jumper
12'x12' of open space

Academic Standards

The following national academic standards are supported in Unit 4: Microcontroller and Transmitter Overview.

Phase	Academic Standard
Think	**Science (NSES)** *Unifying Concepts and Processes*: Form and Function *Physical Science*: Transfer of Energy *Science and Technology*: Abilities of Technological Design **Technology (ITEA)** 5.8: The Attributes of Design 6.12: Use and Maintain Technological Products and Systems **Mathematics (NCTM)** *Connections* Recognize and apply mathematics in contexts outside of mathematics.
Build	**Science (NSES)** *Unifying Concepts and Processes*: Form and Function *Physical Science*: Transfer of Energy *Science and Technology*: Abilities of Technological Design **Technology (ITEA)** 5.8: The Attributes of Design 6.12: Use and Maintain Technological Products and Systems **Mathematics (NCTM)** *Connections* Recognize and apply mathematics in contexts outside of mathematics.
Amaze	**Science (NSES)** *Unifying Concepts and Processes*: Form and Function *Physical Science*: Transfer of Energy *Science and Technology*: Abilities of Technological Design **Technology (ITEA)** 5.8: The Attributes of Design 6.12: Use and Maintain Technological Products and Systems **Mathematics (NCTM)** *Connections* Recognize and apply mathematics in contexts outside of mathematics.

Think Phase

Overview

This phase explains the various functions of the VEX Control Subsystem, specifically the Microcontroller and Transmitter, as provided by the VEX default code.

Phase Objectives

After completing this phase, you will be able to:

- Demonstrate different ways to wire a robot using the default setup.
- Relate the controls on the Transmitter to the Motor Ports on the Microcontroller.
- Use the Arcade Style Drive Configuration.

Prerequisites

Related phase resources are:

- Completed Unit 1: Introduction to VEX and Robotics.
- Completed Unit 3: Building Protobot.

Required Supplies and Software

The following supplies are used in this phase:

Supplies
Notebook and pen
Work surface
One assembled Protobot from Unit 3: Building a Protobot > Build Phase

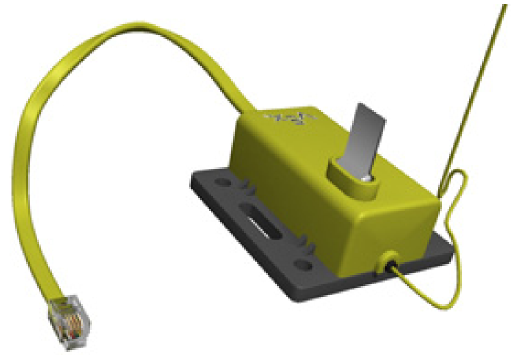
Research and Activity

Microcontroller and Transmitter Overview

When designing robots, it is important to understand how they will be controlled. Some robots utilize software and logic to run fully autonomously, without any human input. Other robots use some sort of input device so that they can be controlled by a human driver.

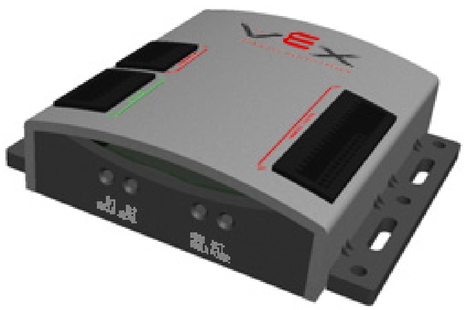
In VEX, the Control Subsystem provides the link between the robot and the human operator. The Transmitter is the primary input device used. This Transmitter (or TX) has two (2) joysticks, which can each be moved in the X and Y axis (up/down & left/right). The TX also has two (2) pairs of buttons on its back. These are called *channels*; there are six (6) total channels on the TX and each one is labeled.

Transmitter (TX)

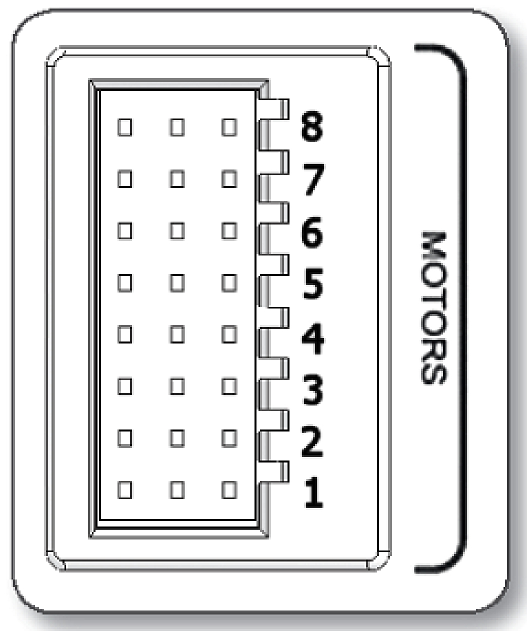


Receiver (RX)

The Transmitter wireless communicates signals to the Receiver Module (RX), which is located on the robot. The RX passes these signals to the Microcontroller, which uses logic (programming software) to interpret them. The Microcontroller then sends signals to the motors, which move. The Microcontroller has eight (8) Motor Ports individually labeled 1–8.



Microcontroller



Motor Ports

On the Protobot, when you press forward on the right joystick of the Transmitter, the right drive motors move forward. When you press forward on the left joystick of the Transmitter, the left drive motors move forward. Why does this happen? Simple—the default configuration of the Microcontroller and Transmitter is for a tank-style drive. The basic setup directly maps Motor Ports on the Microcontroller to Channels on the Transmitter. For example, a Motor or Servo plugged into Motor Port #1 is controlled by Transmitter Channel #1.

So if you want to control a motor by using the buttons of Channel 5, you simply plug that motor into Motor Port #5.

Since there are eight (8) Motor Ports on the Microcontroller, but only six (6) Channels on the Transmitter, some Channels control more than one Motor Port at the same time.

In the default configuration, Motor Port #7 is driven by Channel 5 and Motor Port #8 is driven by Channel 6. This enables you to double up motors on some mechanisms and have them be driven by the same Transmitter Channel.

The Default Control Configuration is as shown:

Transmitter in "23 mode", Jumper 15 set on Micro Controller

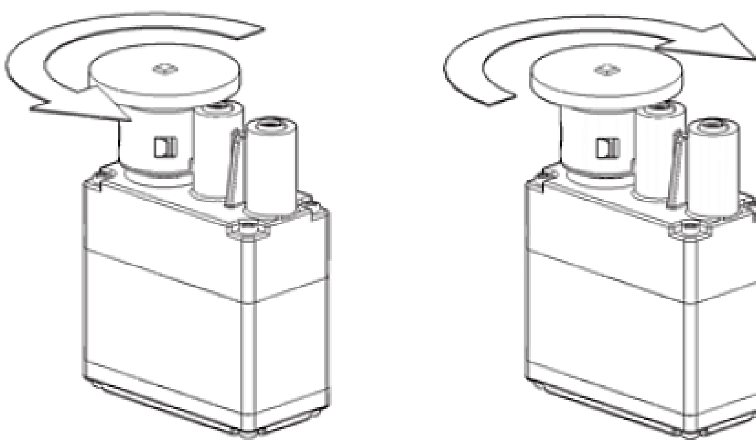
CW= clockwise
CCW = counter-clockwise

	Motor 1	Motor 2	Motor 3	Motor 4	Motor 5	Motor 6	Motor 7	Motor 8
Channel 1								
Stick Left	CCW							
Stick Right	CW							
Channel 2								
Stick Up		CCW					CCW	
Stick Down		CW					CW	
Channel 3								
Stick Up			CW					CW
Stick Down			CCW					CCW
Channel 4								
Stick Left				CCW				
Stick Right				CW				
Channel 5								
Top Button					CCW			
Bottom Button					CW			
Channel 6								
Top Button						CCW		
Bottom Button						CW		

The directions listed in this table indicate the direction of spin for a standard Vex Motor Module. Vex Servo Modules will turn in the opposite direction.

Note the direction of rotation for the motors as shown.

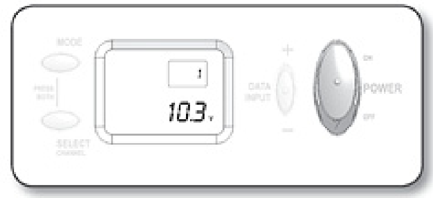
What happens if you press the joystick forward, but the robot goes backwards? In this situation the robot design is such that the Motor or Servo needs to have its motion reversed. The Transmitter has a method of doing this built into it.



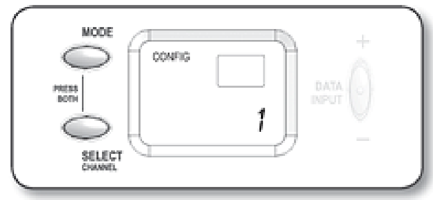
CCW MOTOR ROTATION **CW MOTOR ROTATION**

To reverse (or un-reverse) an axis:

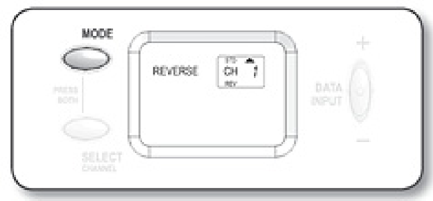
1. Turn on the Transmitter by pushing the power switch to the ON position.



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

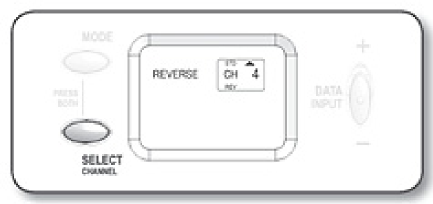


3. Push Mode until the word REVERSE appears on the left-hand side of the display.

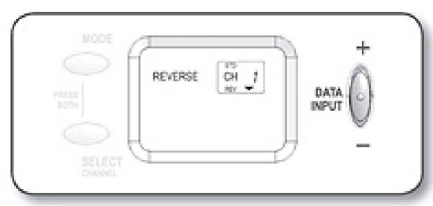


The number in the upper-right indicates which control channel (axis) you are currently viewing. The small arrow to the left of the number indicates whether the axis is currently set to operate with standard (STD) or reversed (REV) directions.

4. Use Select to cycle through channels (axes).

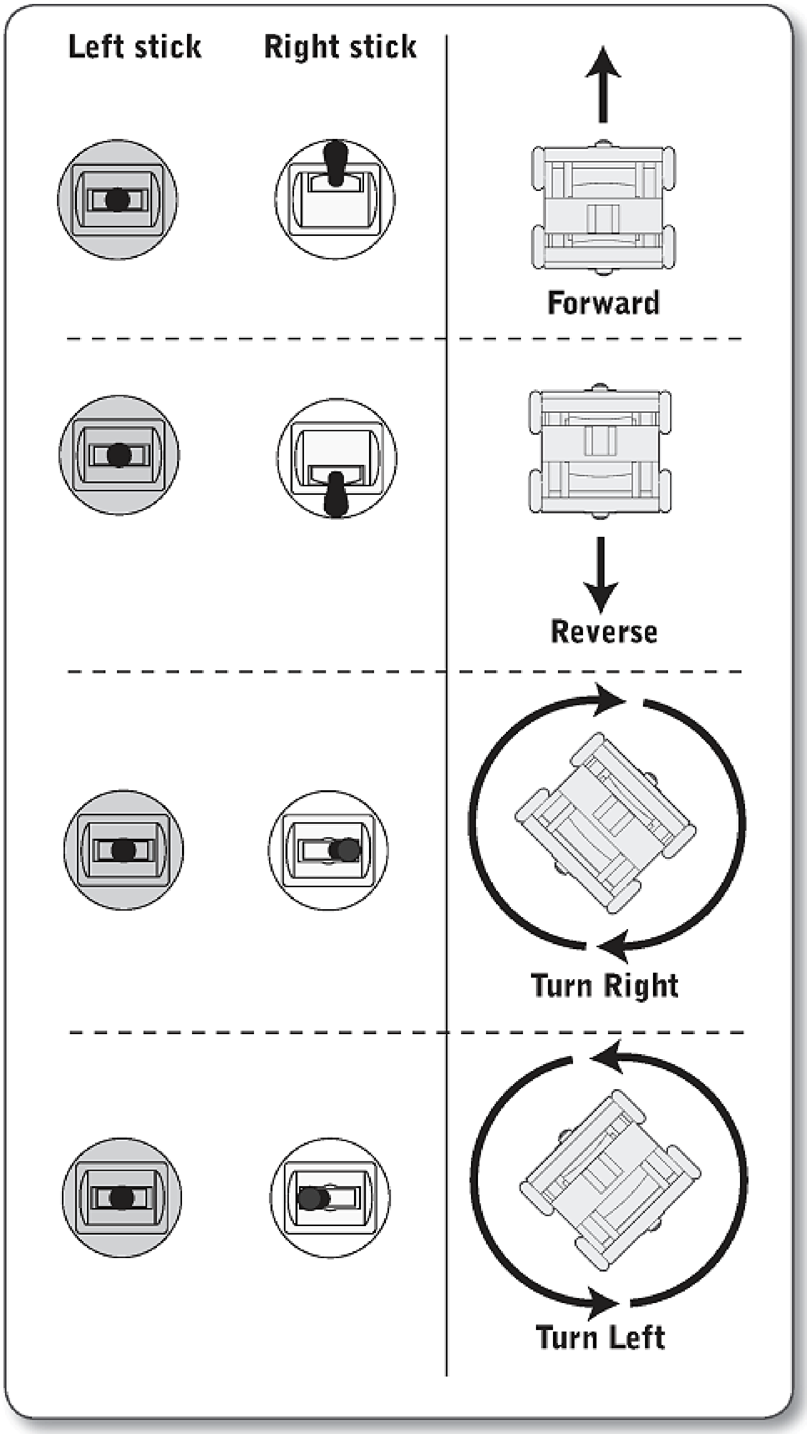


5. Use + and – on the Data Input button to the right of the display screen to switch between standard or reversed directional controls for the displayed axis.



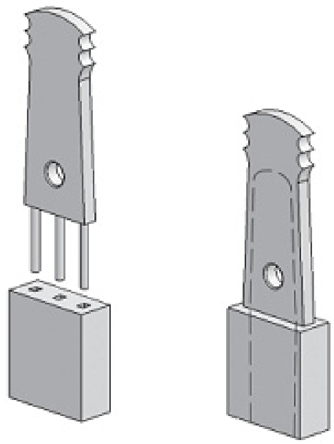
Your changes take effect immediately. You do not have to confirm your selection with an Enter command. You can turn on your robot and test your changes now to see if they have fixed the problem.

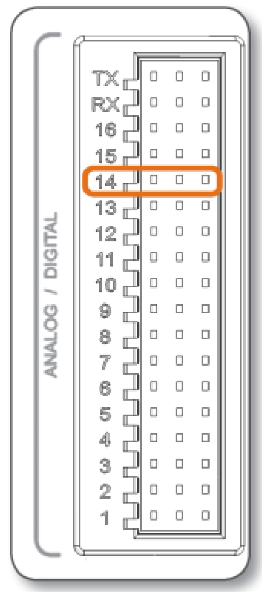
The Default Program, which is loaded into every Microcontroller has some special features that can be activated. One commonly used special feature is the Arcade-style drive configuration. In this setup, the Drivetrain of the robot can be controlled using only the right joystick of the Transmitter, as seen below:



This setup requires the RIGHT drive motor be plugged into Motor Port #2 and the LEFT drive motor be plugged into Motor Port #3.

To activate the special code to use this Arcade-style drive, you need to insert a Jumper Clip into I/O Port # 14. This jumper provides a signal to the Microcontroller, which tells it to run the Arcade drive code.





Once activated, the Arcade Style Drive Code will change the Control Configuration as follows:

Transmitter in "23 mode", Jumper 15 set on Micro Controller

CW= clockwise
CCW = counter-clockwise

	Motor 1	Motor 2	Motor 3	Motor 4	Motor 5	Motor 6	Motor 7	Motor 8
Channel 1								
Stick Left	CCW							
Stick Right	CW							
Channel 2								
Stick Up		CCW					CCW	
Stick Down		CW					CW	
Channel 3								
Stick Up			CW					CW
Stick Down			CCW					CCW
Channel 4								
Stick Left				CCW				
Stick Right				CW				
Channel 5								
Top Button					CCW			
Bottom Button					CW			
Channel 6								
Top Button						CCW		
Bottom Button						CW		

The directions listed in this table indicate the direction of spin for a standard Vex Motor Module.
Vex Servo Modules will turn in the opposite direction.

Now that the Drivetrain can be entirely controlled by the right joystick, the left joystick is now fully available to control other robot functions. This is useful when trying to control more complex designs.

NOTE: The Microcontroller and Transmitter each have a number of other advanced options. For instruction on how to use these features, refer to the chapters and appendices on "Control" and "Logic" in the VEX Inventor's Guide.

Build Phase

Overview

In this phase, you will enable two different types of drive style control.

Phase Objectives

After completing this phase, you will be able to:

- Activate Tank-Style Control (23 Mode).
- Activate Arcade-Style Control (Software 12 Mix).

Prerequisites and Resources

Before starting this phase, you must have:

- Completed the Unit 4: Microcontroller and Transmitter Overview > Think Phase.
- Have one assembled Protobot from Unit 3: Building a Protobot.

Related phase resources are:

- Unit 1: Introduction to VEX and Robotics.
- Unit 3: Building Protobot.

Required Supplies and Software

The following supplies are used in Unit 4: Microcontroller and Transmitter Overview:

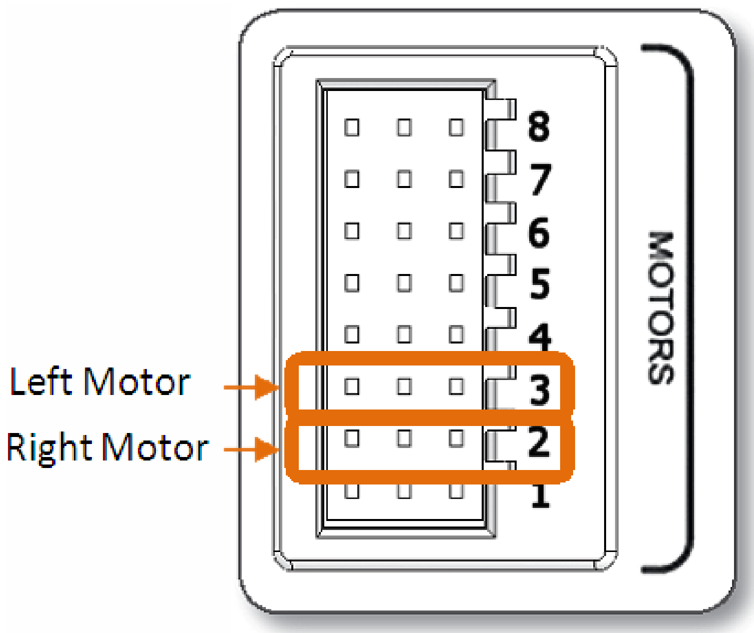
Supplies
VEX Classroom Lab Kit
One assembled Protobot from Unit 3: Building a Protobot
Notebook and pen
Work surface
Small storage container for loose parts
One VEX Jumper

Activity

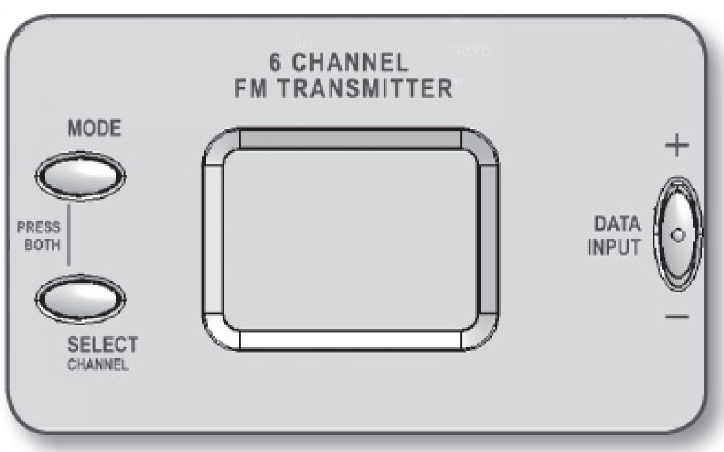
Activating Tank-Style Control (23 Mode) Instructions

This is the default configuration that the Protobot should already be in. To verify this, follow these steps.

1. Verify that your right drive motor is plugged into motor port 2, and your left drive motor is plugged into motor port 3.

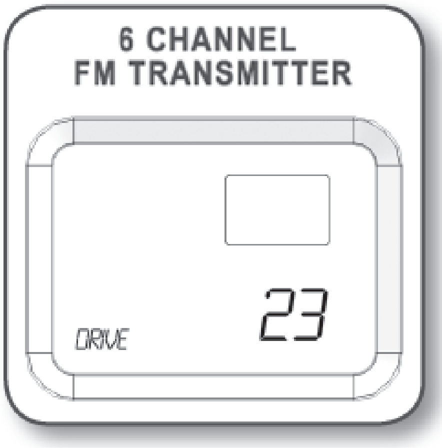


2. Next, you need to verify the mode that your Transmitter is in. Turn the Transmitter on.
3. Enter the menu on the Transmitter by holding down both the Mode and Select buttons (next to the LCD) at the same time until the menu opens.



4. Enter the Driving Mode Adjustment menu by pressing Mode until DRIVE is displayed on the left side (the last menu). You pass over the following advanced menus: CONFIG, REVERSE, SCALE, EDITPT, TRIM, and PMIX.

5. The current driving mode is displayed. This should be 23. If 12 is displayed, push either the + or – on the Data Input button on the right side of the LCD to switch to 23.



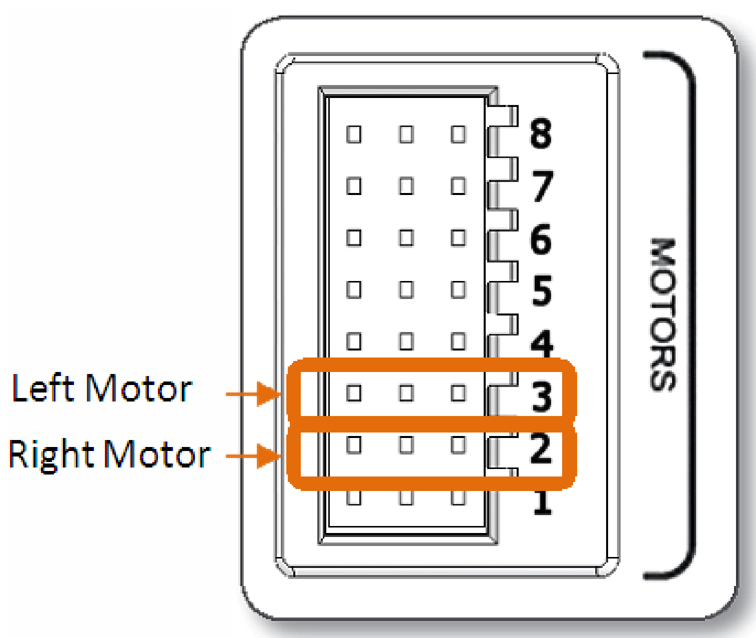
Your robot is now in set for Tank-Style Control (23 Mode). The Protobot will now respond to commands from the Transmitter as shown in the chart in the Unit 4 Think Phase. For more information on Tank-Style Control, please see Appendix D – Control Configurations in the Inventor's Guide.

Activating Arcade-Style Control (Software 12 Mix) Instructions

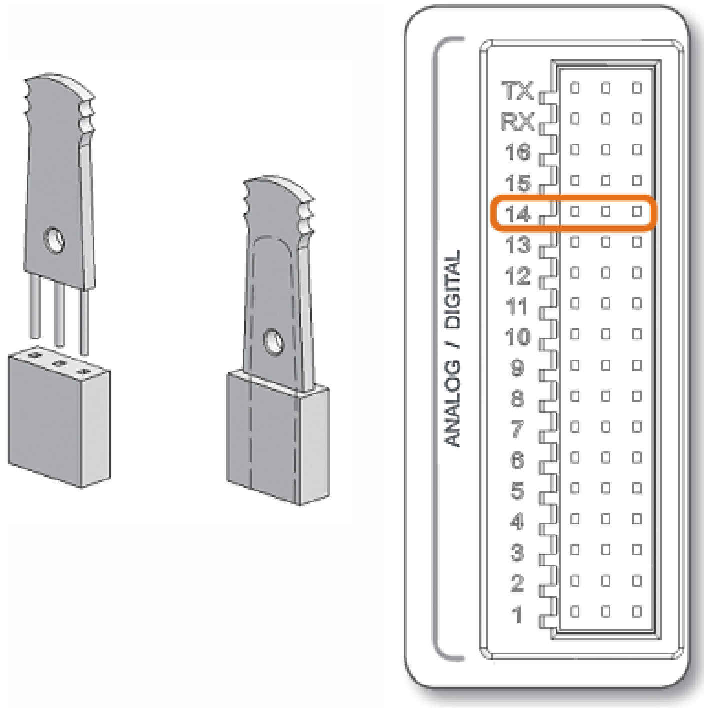
In this activity, you learn how to switch between the two most common drive styles for VEX robots. These modes enable you to control your robot in different ways, each providing its own set of advantages and disadvantages.

To activate arcade-style control, follow these steps.

1. Verify that your right drive motor is plugged into motor port 2, and your left drive motor is plugged into motor port 3.



2. Insert a Jumper clip into I/O Port 14. Insert the jumper such that the metal pins go into the three holes, and the jumper itself sits securely in position.



Your robot is now in set for Arcade-Style Control (Software 12 Mix). The Protobot will now respond to commands from the Transmitter as shown in the chart in the Unit 4 Think Phase. For more information on Arcade-Style Control, please see Appendix D – Control Configurations in the Inventor’s Guide.

NOTE: Arcade-Style Control can also be enabled by using the menus on the Transmitter. This requires switching the motor ports, and selecting 12 Mode on the Transmitter. Transmitter 12 Mix behaves slightly differently than Software 12 Mix. Transmitter 12 Mix mode drives only 60% of full speed forward, but is more responsive in turns. Software 12 Mix is faster in straight lines, but slows down in turns. For more information, please see the Logic section in the Inventor’s Guide.

Amaze Phase

Overview

In this phase, you experiment with two different types of drive style control.

Phase Objectives

After completing this phase, you will be able to:

- Drive a robot with Tank-Style Control (23 Mode).
- Drive a robot with Arcade-Style Control (Software 12 Mix).

Prerequisites

Before starting this phase, you must have:

- Completed Unit 4: Microcontroller and Transmitter Overview > Think Phase.
- Completed Unit 4: Microcontroller and Transmitter Overview > Build Phase.
- Have one assembled Protobot from Unit 3: Building a Protobot.

Related phase resources are:

- Unit 1: Introduction to VEX and Robotics.
- Unit 3: Building a Protobot.

Required Supplies and Software

The following supplies are used in Unit 4: Microcontroller and Transmitter Overview:

Supplies
VEX Classroom Lab Kit
One assembled Protobot from Unit 3: Building a Protobot
Notebook and pen
12’x12’ of open space
One VEX Jumper

Evaluation

Challenge

In this activity, you switch between the two most common drive styles for VEX robots, and experiment with the controls.

Instructions
1. Active Tank-Style Control (23 Mode) by following the instructions in the Unit 4: Microcontroller and Transmitter Overview > Build Phase.
2. Drive the robot around your open space. Pay specific attention to how the robot handles in turns. Does it corner well? How easy is it to drive in an arc? A complete circle?
3. Activate Arcade-Style Control (12 Mode) by following the instructions in the Unit 4: Microcontroller and Transmitter Overview > Build Phase.
4. Drive the robot around your open space. Pay specific attention to how the robot handles in turns. Does it corner well? How easy is it to drive in an arc? A complete circle?

Engineering Notebook

- Write an analysis comparing the two different types of drive control. In your analysis answer the following questions:
  - What are the advantages of both styles of drive?
  - What are the disadvantages of both styles of drive?
  - Which style do you prefer, and why?
  - Which style is it easier to drive straight with? Why?
  - Which style is it easier to turn with? Why?
  - Which style is easier to learn? Which was more intuitive when you first started?
- List some real life driving applications that would benefit from either style of drive.
- What are some other drive styles that are common in the real world?

Presentation

Present your findings on the different styles of drive to the class.

STEM Connections

Sojourner sampling a large rock formation on the Martian surface. (Image courtesy of NASA)

Background

In 2006, a NASA lander called the Mars Pathfinder set foot on the surface of Mars and deployed a small robotic probe, the Sojourner, to explore the environment and perform tests on samples. Since the technology to send a person to Mars does not yet exist, the lander and the rover were remotely operated, like the robot you construct in this unit.

Science

Because Mars is so far away (when its orbit brings it closest to the Earth, it is still 35 million miles away), the commands given to the robot from its operators took several minutes to reach the probe.

1. How does this limitation affect the operation of the probe?
2. If you were controlling a robot that was on the other side of the earth, would you have this problem?
3. Would the VEX robot work if you put it on Mars and tried to control it from Earth?

Technology

Advanced computers on the Mars Pathfinder enabled it to recognize minor obstacles such as rocks and move around them on its own without directions from Earth.

1. Why would that be particularly helpful to a robot on Mars?
2. Can you think of any disadvantages to a system like this?

Engineering

The Mars Pathfinder was designed to land on the surface of Mars and bounce several times, cushioned by balloon-like airbags on the outside of the lander. Because the descent was so rapid, both the lander and the probe had to be designed to withstand the impacts.

1. How do you protect fragile equipment like the receiver and transmitter from breaking?

Math

In 2003, Earth and Mars were about 55 million km apart, the closest they have been in over 50,000 years.

1. If you were to transmit instructions at light speed (300,000 km/s), how long would it take for your instructions to travel 55 million km?