

# Glossary

## #

### **12 mode – Control Subsystem**

A Transmitter driving mode where axes 1 and 2 are used to control the primary navigation of the robot. Also called Arcade-style controls.

### **23 mode – Control Subsystem**

A Transmitter driving mode where axes 2 and 3 are used to control the primary navigation of the robot. Also called Tank-style controls.

### **4WD**

Short for Four-Wheel Drive. A four-wheel drive robot typically has four wheels, all of which are powered independently. This usage is analogous, but not identical, to the meaning of the term with respect to automobiles.

## A

### **Acceleration – Motion Subsystem**

In physics, acceleration is the change in velocity of an object over time. In robotics, acceleration usually refers to the ability of a robot to speed up or slow down quickly on demand.

### **Actuator – Motion Subsystem**

A term commonly used in industry to describe a mechanical device used for moving or triggering a mechanism.

### **Alkaline (Battery) – Power Subsystem**

A class of battery chemistries commonly used in disposable batteries. This type of battery is not suited for use in robotics applications.

### **Allen Wrench**

An L-shaped tool used to work with hex screws.

### **Analog Sensor – Sensor Subsystem**

Analog sensors communicate with the Microcontroller by sending an electrical voltage that varies between 0 and the maximum voltage.

### **Analog/Digital Port Bank – Logic Subsystem**

A group of ports on the Microcontroller used for analog and digital communication with other parts of the robot system.

### **Arcade-style Controls – Control Subsystem**

A Transmitter driving mode in which the robot is controlled with one joystick on the Transmitter, like an arcade game. Also called 12 mode because axes 1 and 2 are being used to drive the robot.

### **Attachment – Structure Subsystem**

Generally, any piece that is “attached” and not fundamentally part of the basic robot design. Usually refers to such pieces as arms or sensor modules, especially if they are removable.

### **Autonomous – Logic Subsystem**

Technically, a robot must be able to function entirely without human supervision to be considered fully autonomous. Almost all real-world robot systems are designed instead to work with partial autonomy under varying degrees of human supervision.

### **Autonomous Mode – Logic Subsystem**

The VEX robot has a simple pre-programmed autonomous mode that uses two bumper or limit switch sensors to detect obstacles as the robot wanders around a room or course.

### **Axis (Joystick) – Control Subsystem**

One of two axes (X and Y) along which a Transmitter joystick can move. Each axis on the joystick is associated with an onboard potentiometer that measures the joystick’s position along that axis.

### **Axis of Rotation – Motion Subsystem**

The imaginary line around which a spinning object rotates. This usually coincides with the axle for a wheel or gear.

### **Axle – Motion Subsystem**

A long, rigid piece through the rotational center of an object (like a gear or wheel). Axles serve two main purposes: to hold spinning bodies in place relative to the rest of the structure, and to transfer rotational motion from one spinning piece to another (as in the case of a motor axle turning a gear). Square bars are usually used as axles in the VEX system.

# Glossary

## B

### Back-driving – Motion Subsystem

A condition where torque is transferred backwards through a mechanical system, causing the driving element (typically a motor) to be driven instead. This can often be damaging to the mechanical system and/or the motor. A clutch can be used to disengage the motor if the back-driven force is strong enough to cause damage.

### Battery – Power Subsystem

Normally, any portable power source, such as the VEX battery packs. Technically, a battery is a collection of multiple cells, but single cells are often referred to as batteries in common usage.

### Battery Holder – Power Subsystem

The Battery Holder creates a 7.2V battery out of (6) 1.2V AA cells (by connecting them in series) or 9.6V out of (8) 1.2V AA cells. The Battery Holder also holds the AA cells in place on board the robot.

### Bearing – Structure Subsystem

A piece that is used to hold a moving piece (such as an axle) in place relative to the rest of the system.

### Bearing Flat – Motion Subsystem

A commonly used type of bearing in the VEX system. This bearing has three holes in a row. The bearing is secured to the chassis through two of the holes, and an axle is passed through the third, which allows it to spin freely but not move out of place relative to the chassis.

### Behavior – Sensor Subsystem, Logic Subsystem

In the context of robotics, a behavior is the pattern of actions a robot will enact when given certain inputs or commands.

### Bumper Switch Sensor – Sensor Subsystem

A high-durability sensor designed to detect physical contact. This is a digital sensor.

## C

### Calibrate (Sensor) – Sensor Subsystem

Calibrating a sensor is the process of matching sensor readings against known values to ensure that the sensor input is being interpreted correctly in the program. Simple sensors, like the Bumper and Limit Switches, typically do not need to be calibrated.

### Calibrate (Joysticks) – Control Subsystem

Calibrating the transmitter joysticks (also called “trimming” the sticks) is the process of adjusting trim values on the Transmitter to ensure that the sticks produce no motor movement when they are centered. A more thorough calibration process also includes setting the scaling and end points to ensure a full range of motion.

### Carrier Wave – Control Subsystem

The carrier wave for FM communication is a simple sine wave with a set frequency. It is then modified (modulated) by the desired signal wave to produce the final output wave that is sent to the receiver.

### Caster Wheel – Motion Subsystem

A free-swiveling wheel mounted on a robot to provide stability while producing a minimum of friction. The front wheels on a shopping cart are caster wheels; they support weight and stabilize the cart, but do not add significant amounts of friction like a skid would, nor do they change the maneuvering characteristics of the cart like an additional locked wheel would.

### CCW

Short for Counterclockwise.

### Cell – Power Subsystem

A single electrochemical unit producing a known voltage differential, such as a single NiCd AA battery, which has a voltage of 1.2V between the + and - terminals.

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## **Center of Gravity – Structure Subsystem**

The robot's center of gravity is the average position of all the mass on the robot (technically, this is the center of mass, but under terrestrial gravity conditions, they are the same). It is critical that the center of gravity be kept directly over the support polygon, or the robot will fall over.

## **Challenge – VEX System**

VEX Challenges are designed to give you a specific task to accomplish by building a robot, and to open possibilities for collaboration and competition with other robot designers.

## **Chassis – Structure Subsystem, Motion Subsystem**

A vehicle's basic structural frame, plus its locomotion systems. In the VEX system, this is generally the Structure Subsystem plus the Motion Subsystem, minus any attachments.

## **Circumference**

The distance around the edge of a circle. This quantity is equal to pi times the circle's diameter, or 2 times pi times the radius.

## **Clockwise**

A rotational "direction" that prescribes turning in the same direction as the hands on a clock normally turn.

## **Clutch – Motion Subsystem**

A detachable piece normally mounted to the VEX motors that protects them from shock loads. These should not be removed under most circumstances.

## **Collar – Structure Subsystem**

A type of spacer that can be set to remain stationary at any given point along an axle. These are often used to keep other components on the axle (or sometimes the axle itself) from sliding out of position.

## **Compound Gear – Motion Subsystem**

A system of gears involving several pairs of gears, some of which share axles with each other. When calculating gear ratio, this whole system of gears behaves as if it were a single gear pair with a gear ratio that might not otherwise be achievable.

## **Compound Gear Ratio – Motion Subsystem**

The overall equivalent gear ratio produced by a group of gears in a compound gear configuration. This can often be quite high or quite low, due to the multiplicative nature of gear ratios in a compound gear system.

## **Configuration (Transmitter) – Control Subsystem**

One of the 6 different control setups stored on the RF Transmitter. Each configuration saves the Transmitter menu settings that were set while using that configuration number.

## **Control Subsystem**

The subsystem responsible for collecting human operator input and communicating it to the Microcontroller.

## **Control Channel – Control Subsystem**

One of the 6 pathways for control information traveling from the Transmitter to the Microcontroller. The X-axis of the right joystick, for instance, sends its data over control channel 1 (that axis of the stick itself is sometimes referred to as Channel 1 as a result). Note that control channels are not the same as radio channels.

## **Counterclockwise**

A rotational "direction" that prescribes turning in the opposite direction from the way the hands on a clock normally turn.

## **Crystal (Radio Frequency) – Control Subsystem**

One of the crystals that determine the frequency on which the Transmitter and Receiver operate. The crystal used in the Transmitter Frequency Module must match the crystal used in the Receiver for controls to be sent and received properly.

## **CW**

Short for Clockwise.

# Glossary

## D

### Deep Cycling – Power Subsystem

Draining a battery down to very low power (below the normal cutoff levels) before recharging it. This will wear a rechargeable battery out very quickly, and should be avoided if possible.

### Diameter

The distance from one point on a circle to the point directly across from it. This quantity is equal to two times the radius, or it can be multiplied by pi to find the circumference of the circle.

### Digital Sensor – Sensor Subsystem

Digital sensors communicate with the Microcontroller by setting an electrical voltage in the system to one of two values: either a digital LOW equal to 0V, or a digital HIGH equal to the maximum voltage on that port.

### Discharge Cycle – Power Subsystem

Technically, any period during which power is drawn from the battery and then recharged. Usually used in one of two contexts: either when referring to the usage pattern of a battery (using a battery for a short time, then recharging it constitutes a pattern of short discharge cycles), or when battery chargers automatically drain the battery before recharging it (the charger performs a “discharge cycle” on the battery).

### Drive Train – Motion Subsystem

All the parts involved in the primary locomotion system of a robot, including the motors, gears, axles, and wheels.

### Driven Gear – Motion Subsystem

In a gear train, the last gear being turned. Usually, this gear shares an axle with a wheel.

### Driving Gear – Motion Subsystem

In a gear train, the gear that provides the energy to turn all the other gears and their connected components. This gear usually shares an axle with a motor.

### Driving Mode (Transmitter) – Control Subsystem

The driving mode selected on the Transmitter through the DRIVE menu, either “23 mode” or “12 mode.” This setting (together with Jumper 14 on the Microcontroller) determines which combination of joystick axes on the Transmitter will control the robot’s movement.

## E

### Electromagnetic Waves – Control Subsystem

Technically, a time-varying electric field that propagates through space at the speed of light, caused by the acceleration of a charged particle. More simply, an electronically controllable wave that travels at the speed of light and can carry information between two points through a variety of encoding techniques.

### End Points (Joystick) – Control Subsystem

End points control the percentage of the full power command that will be sent by the Transmitter when the joystick is pushed to the edge of its movement area.

### Exponential Scaling – Control Subsystem

A control scaling method that allows for “stiffening” or “softening” of the feel of the joystick controls by causing the output command value to increase faster or slower than it normally would as the joystick is moved away from the center of its movement area.

## F

### Fastener – Structure Subsystem

A general term for pieces (such as screws) whose primary purpose is to hold two or more other components together.

### Floating – Structure Subsystem

As opposed to “locked.” Moving freely, not held in one specific place. A collar floats freely on a square bar when the screw is not tightened (it slides easily up or down the bar).

### Flush – Structure Subsystem

As in “flush against another part.” Pushed up against something, leaving no space between them. A collar is flush against a bearing when it is pushed up against the bearing as far as it can go.

# Glossary

## Four Wheel Drive – Control Subsystem

A four-wheel drive robot typically has four wheels, all of which are powered independently. This usage is analogous, but not identical, to the meaning of the term with respect to automobiles.

## Frequency-Modulated Signals – Control Subsystem

Frequency-Modulated (FM) signals are used in the VEX system to encode data in radio transmissions. Radio waves are a form of electromagnetic wave with a very high frequency. The frequencies used by the VEX system all have a carrier frequency near 75MHz, which is part of the VHF (Very High Frequency) band of the electromagnetic spectrum. This carrier wave is then modulated by the signal wave to produce a third wave, which is transmitted through the air and received by the RF Receiver Module on the robot.

## Friction – Motion Subsystem

The force between two touching surfaces moving at different speeds that acts to slow their movement relative to each other. In robotics, this usually has one of three contexts: friction between wheels and ground that results in rolling wheels slowing down, friction between wheels and ground that allows wheels to “push off” and start moving to begin with (rather than spinning in place), and friction between any two components rubbing together in the robot that result in loss of energy.

## G

### Gear – Motion Subsystem

Essentially, gears are spinning discs with teeth that prevent them from slipping past each other. Gears are frequently used to transfer rotational motion from one piece to another, and to provide mechanical advantage while doing so. The number of teeth on a gear (assuming the same spacing between teeth on both gears, so their teeth mesh properly) is directly proportional to the gear disc’s circumference, thus the number of teeth can easily be used to calculate the gear ratios of gear trains.

### Gear Ratio – Motion Subsystem

The mechanical advantage, or “force multiplier” generated by a group of 2 or more gears turning together. For simple non-compound gear trains, this can be calculated as the number of teeth on the driven gear divided by the number of teeth on the driving gear.

### Gear Train – Motion Subsystem

In general, a group of gears that turn together to transmit motion from one point to another on the robot, often providing mechanical advantage along the way.

### Gripper

An attachment designed to pick up or hold an object, often by “gripping” it with claw-like appendages.

### Gusset – Structure Subsystem

A piece used to strengthen an angled joint.

## H

### HIGH (Digital value) – Sensor Subsystem

One of two possible values in a digital system (the other is LOW). The voltage used to indicate HIGH usually corresponds to the maximum voltage of the system.

### Hub – Motion Subsystem

With wheels, the hub is the center portion of the wheel that joins to the axle.

## I

### Idler Gear – Motion Subsystem

A gear in a gear train that is neither the driven nor the driving gear, and does not share an axle with another gear in the train (i.e. does not form a compound gear). Each idler gear in the train reverses the direction of spin once, but never affects the gear ratio.

# Glossary

## **Interrupt Port Bank – Logic Subsystem**

A port bank on the Microcontroller used primarily for advanced programming functions.

## **J**

### **Jumper – Control Subsystem, Logic Subsystem**

A metal wire contained in a plastic housing that can be placed (and removed) by hand to complete (make) an electrical connection. These are most often used to “set” options on the Microcontroller by placing them in ports in the Analog/Digital Port Bank. Placing a jumper in one of these ports closes a circuit, setting the voltage for that port’s input value, just like closing a limit switch sensor would.

## **K**

### **Keys Nut – Structure Subsystem**

A variant of the standard nut that includes a toothed “crown” designed to bite into a mounting surface and prevent the nut from slipping. Nuts are used to allow a screw to function as a fastener when the actual component being fastened does not include its own threading.

### **Keying (connectors) – Logic Subsystem**

An intentionally asymmetrical construction of a connector to prevent backwards insertion. The power port on the VEX Microcontroller is keyed (the two plastic shapes in the middle are not the same), for instance, so that the power plug cannot be inserted upside-down. Keyed connectors are sometimes called polarized connectors.

## **L**

### **Lever – Structure Subsystem**

One of the six “simple machines” that provides a mechanical advantage. There are three main classes of levers with subtle differences, but in general, long pieces that rotate around any point on their length will function as levers and can provide mechanical advantage.

### **Limit Switch Sensor – Sensor Subsystem**

A small, contact-sensitive sensor that is most often used for internal regulation of movement, and should not be exposed to high-impact conditions. This is a digital sensor.

### **Linear Scaling – Control Subsystem**

A control scaling method that allows for control of the overall range of motion and sensitivity of the joysticks on the Transmitter.

### **Logic Subsystem**

The subsystem responsible for onboard robot operation, allocation of power, processing sensor feedback, and interpretation of human operator control.

### **LOW (Digital value) – Sensor Subsystem**

One of two possible values in a digital system (the other is HIGH). The voltage used to indicate LOW usually corresponds to the zero (ground) voltage of the system.

## **M**

### **Master Channel – Control Subsystem**

In a Programmable Mix, the Master Channel is the control channel that, when manipulated by the operator, will also affect the value on the designated slave channel.

### **Mechanical Advantage – Structure Subsystem, Motion Subsystem**

The ratio of the force a machine can exert to the amount of force that is put in. Mechanical advantage can also be thought of as the “force multiplier” factor that a mechanical system provides.

# Glossary

## **Memory Effect – Power Subsystem**

Technically, the phenomenon where a rechargeable battery that is repeatedly discharged to the exact same level and then recharged will develop a permanently diminished capacity. True memory effect is observed only under laboratory conditions and on board solar-powered satellites in space. The more common usage of the term is incorrect, and is frequently used mistakenly to refer to voltage drop.

## **Microcontroller – Logic Subsystem**

The “brain” of the robot. The Microcontroller contains the robot’s program and processes all signals received from both human operators and onboard sensor systems. It also manages power allocation on board the robot, and directly controls the motors.

## **Miscalibrated – Control Subsystem**

A condition where two values which should be the same do not, in fact, match each other. This occurs frequently with the joysticks on the Transmitter, which should produce a neutral motor state when centered, but will often cause motors to turn slowly instead when the sticks are released. Sensors that indicate things like distances can also become miscalibrated, and report values that do not reflect the actual physical situation.

## **Mix (Transmitter) – Control Subsystem**

A control setup where inputting commands on one control channel influences the commands being sent on other control channels.

## **Motion Subsystem**

The subsystem responsible for the generation and transmission of physical motion on the robot. This includes motors, gears, wheels, and many others.

## **Motor (Electric) – Motion Subsystem**

An electromechanical device that converts electrical energy into kinetic (physical) energy on demand. The motion generated by a motor is almost always rotational in nature, and may need to be mechanically redirected before it can be used to produce the desired effect.

## **Motor Port Bank – Logic Subsystem**

The port bank on the Microcontroller where the motors or servos are plugged in. The motors/servos receive both commands and power through these ports.

## **Motor Shaft – Structure Subsystem, Motion Subsystem**

A carried-over term from automotive engineering, this usually refers to the axle (square bar) that is directly driven by the motor.

## **Mounting Point – Structure Subsystem**

Any place where a component can be conveniently attached. An open spot on the front bumper, for instance, may serve as a good mounting point for a forward-facing sensor.

## **N**

### **NiCd (Nickel-Cadmium) – Power Subsystem**

The preferred battery chemistry for the VEX Robotics Design System for performance reasons. A NiCd (pronounced Nai-kad) battery is an electrochemical cell which uses Nickel metal as its cathode material, and Cadmium metal as its anode material. Cadmium is highly toxic, and should not be disposed of in the trash (call 1-800-8-BATTERY).

### **Nut – Structure Subsystem**

Nuts are used to allow a screw to function as a fastener when the actual component being fastened does not include its own threading. A screw and a nut “sandwich” the parts that are being fastened, and hold them together. The nut provides threading for the screw to lock into when none is present otherwise.

## **O**

### **Overcharging – Power Subsystem**

Continuing to apply a charging voltage to the battery after it has reached full capacity. This is very likely to damage your battery, and can be dangerous, as the battery will heat up rapidly while being overcharged, and may even explode if it gets too hot. Be sure your charger has the appropriate safeguards so that it will not attempt to overcharge your batteries.

# Glossary

## P

### **Parallel (Batteries) – Power Subsystem**

A battery arrangement where multiple battery cells are hooked up so that they provide the same voltage as a single cell, but drain power evenly across all the cells, thus behaving similarly to a single cell with a very large capacity.

### **Pivot – Structure Subsystem**

A structural component that provides a mounting point for another component, but rather than locking it in place, the pivot allows the attached component to swivel or turn along a specific arc.

### **Potentiometer – Sensor Subsystem**

An analog sensor which measures angular position.

### **Power Subsystem**

The subsystem responsible for storing and delivering electrical energy to the robot systems.

### **Programmable Mix – Control Subsystem**

A feature of the Transmitter that allows the operator to designate one master channel and one slave channel to be used in a configurable control mix.

## R

### **Radio Channel – Control Subsystem**

A shortened name for a radio frequency. Radio frequencies often have long names, so they are given "channel" designations to be used as shorthand. 75.410MHz, for instance, is referred to as Channel 61.

### **Radio Frequency – Control Subsystem**

A designated carrier frequency for radio transmission. Each transmitter-receiver pair should operate on its own radio frequency, and hence transmit data that will not interfere with other signals in the air. The radio frequency for a transmitter-receiver pair is determined by the frequency crystals installed in both devices.

### **Radius**

The distance from the center of a circle to the edge. This quantity is equal to half the diameter, or it can be multiplied by two times pi to find the circumference of the circle.

### **RBRC – Power Subsystem**

Rechargeable Battery Recycling Corporation. A non-profit organization that facilitates the collection of rechargeable batteries for recycling, because rechargeable battery chemicals (such as the cadmium in NiCd batteries) tend to be very harmful to the environment when thrown in the trash.  
<http://www.rbrc.org>

### **RF Receiver Module – Control Subsystem**

The Control Subsystem component that receives and decodes FM radio signals that are sent by the Transmitter. After decoding the signals, they are passed on to the Microcontroller.

### **RF – Control Subsystem**

Short for Radio Frequency, but often used to refer to any system or component that deals with radio transmission in any way (e.g. RF Receiver).

## S

### **Screw, Hex – Structure Subsystem**

A screw with a hexagon-shaped hole in the head, allowing the screw to be tightened or loosened with a hex L wrench.

### **Sensor Subsystem**

The "eyes and ears" of the robot. Electromechanical devices that can detect specific things about the robot and its environment, and communicate that information to the Microcontroller through an electrical signal.

### **Series (Batteries) – Power Subsystem**

A battery arrangement where multiple battery cells are hooked up so that their voltages are added together, thus behaving similarly to a single battery with a much higher voltage.

# Glossary

## **Servomotor – Motion Subsystem**

An electromechanical device that converts electrical energy into kinetic (physical) energy on demand. The difference between a standard motor and a servomotor is the way they respond to joystick commands. A motor will spin continuously in one direction or the other, whereas a servomotor will turn to face a specific direction within a limited arc.

## **Signal Wave – Control Subsystem**

In radio transmission, the signal wave represents the data that is being sent, converted into a wave form in order to be included in an FM transmission.

## **Skid – Motion Subsystem**

A non-wheel piece which rests on the ground and provides support for the robot, but is intended to slide when the robot moves. Skids provide support and stability without fundamentally altering the way the robot maneuvers, but they can cause significant friction, and often wear out quickly. Caster wheels are the preferred alternative in most cases.

## **Slave Channel – Control Subsystem**

In a Programmable Mix, the Slave Channel is the control channel that is partly or completely controlled by the Master Channel.

## **Software 12 Mix – Control Subsystem, Logic Subsystem**

A version of the “12 mix” arcade style controls where the control mixing takes place in software on the Microcontroller, rather than in hardware on the Transmitter. The software implementation of the controls also performs a few of the calculation differently, resulting in a somewhat different feel for the driver. This mode is activated by placing a jumper clip on top of Analog/Digital Port 14 on the Microcontroller.

## **Spacer – Structure Subsystem, Motion Subsystem**

There are several plastic spacers which are designed to slide onto square bar axles between other parts (or between parts and rails) to keep them from moving too close together. They can also be used like collars if enough spacers are added to keep the other parts from moving at all.

## **SPDT switch – Sensor Subsystem**

Short for “Single Pole, Double Throw.” A switch that is activated by a single contact (single pole), but changes the state of two outputs at once (double throw). The Limit Switch Sensor is an SPDT switch, but one of the two outputs is hidden, making it function effectively as an SPST switch.

## **Speed – Motion Subsystem**

Technically, speed is the magnitude of velocity (i.e. velocity, but without indicating direction). It is most commonly used to mean the rate of movement of a vehicle. By extension, it can also mean the rate of rotation of a gear or wheel. It is also sometimes used to refer to a vehicle’s potential maximum speed, as opposed to its acceleration capability.

## **SPST switch – Sensor Subsystem**

Short for “Single Pole, Single Throw.” A switch that is activated by a single contact (single pole) and changes the state of a single output (single throw). The Bumper Switch Sensor is an SPST switch.

## **Stability – Structure Subsystem**

The ability of a robot to remain upright and steady while moving over terrain and traversing obstacles.

## **Stall (Motor) – Motion Subsystem**

A condition where a motor encounters so much resistance that it cannot turn. It is damaging for the motor to be in this condition. The motor can get hot and can stop functioning.

## **Stick Mode – Control Subsystem**

An advanced feature of the Transmitter that allows control channels 2 and 3 to trade places on the joysticks (2 becomes the right stick’s vertical axis and 3 becomes the left stick’s vertical axis). The default mode is 2, and should not be changed under most circumstances.

## **Stress (Structural) – Structure Subsystem**

Physical forces acting on an object constitute mechanical stress. Too much stress concentrated on a small area can cause parts to bend or break.

# Glossary

## Structure Subsystem

The subsystem responsible for holding the rest of the subsystems together and in place, and for protecting them from physical harm.

## Subsystem

A subdivision of a system that helps to organize the system into convenient compartmentalized functions. The lines between subsystems are not always perfectly clear (for example, a wheel's axle is both a motion-transferring device and a physical support), but they work to give a general idea of purpose for the components in a system.

## Support – Structure Subsystem

The degree of physical stability a piece has, owing to the strength of the foundation provided by the other pieces which are holding it in place. A piece which provides a physical brace or foundation for another piece is also called a support.

## Support Polygon – Structure Subsystem

The imaginary polygon formed by connecting all the points at which the robot touches the ground. In cases where the arrangement of ground contact points is complex, the support polygon is the largest convex polygon that can be formed by those points. If the center of mass of the robot is not directly over the support polygon (i.e. projecting a line straight down from the center of gravity would not intersect the support polygon) at all times, the robot will fall over.

## T

### Tank-style Controls – Control Subsystem

A Transmitter driving mode in which the robot is controlled with only the vertical axes of the joysticks. Each joystick controls the motion of one side of the robot, like an old tank. Also called 23 mode because axes 2 and 3 are being used to drive the robot.

## Tether – Control Subsystem

A cable used to connect the Transmitter directly to the Microcontroller. Using a tether allows you to control the robot by sending signals through the cable rather than through the air, eliminating the possibility of radio interference. You can use any telephone handset cable (the one that goes from the base to the handset of a corded phone) as a tether.

## Threaded – Structure Subsystem

A threaded piece has threading on or in it, which allows a screw to be fastened into it. Threading is the tiny spiraling texture on the outside of a screw or the inside of a nut (for example) that allows a screw to be locked into place.

## Torque – Motion Subsystem

Angular ("spinning") force. Torque can be converted into linear ("pushing") force where a wheel comes in contact with the ground.

## Traction – Motion Subsystem

An overall measure of how well a tire is able to grip the ground. Many factors (texture, size, material, etc.) must be taken into account when evaluating a tire's traction on different surfaces.

## Transmitter – Control Subsystem

The primary user interface device for the human operator of the robot. The Transmitter gathers input from its two joysticks and four buttons, and transmits them via FM radio wave to the RF Receiver mounted on the robot.

## Transmitter Battery Holder – Power Subsystem

The battery container for the Transmitter. The battery holder contains the 8 NiCd AA batteries in place required to operate the Transmitter. If you wish to use the 9.6V battery pack, the Battery Box can be easily removed to make room for the 9.6V pack.

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## **Transmitter Frequency Crystal – Control Subsystem**

The swappable module in back of the Transmitter that designates the radio frequency that the Transmitter will use to communicate with the RF Receiver Module. The frequency of the Transmitter Frequency Module must match the frequency of the crystal installed in the RF Receiver Module on the robot in order for them to communicate. All VEX Systems come with the same Transmitter Frequency Module. Additional modules on different frequencies are available for purchase separately.

## **Trickle Charge – Power Subsystem**

A very low-power charge that is applied to full batteries in order to keep them full. A trickle charge counteracts a battery's natural loss of charge over time, so that the battery can be left on the charger, and still always maintain a full charge.

## **Trim – Control Subsystem**

The calibration setting for the joysticks on the Transmitter. Also, the name of the menu on the Transmitter that allows for fine tuning of these settings.

## **V**

### **Voltage (Battery) – Power Subsystem**

The electrical voltage difference between the + and – terminals on a battery. Different batteries and battery packs have different starting voltages. Voltage falls (though not all the way to 0) as the battery's power is used up, and can be used as a rough indicator of the amount of capacity remaining on a battery.

### **Voltage (Electrical) – Power Subsystem**

The difference in electrical potential between two points in a circuit or electrical field. An electron or other charged particle has more energy at one of the two points, and will tend to move toward the other point.

### **Voltage Drop – Power Subsystem**

A phenomenon exhibited by rechargeable batteries where a battery that is frequently "shallow discharged" (discharged only a little between recharges) will begin to experience reduced performance. This can be reversed by discharging the batteries to a nearly-empty safe level (when the robot automatically turns off, for example—NOT by shorting them or draining them to 0V by external means!) and then recharging them to full capacity. Repeating the drain-charge cycle a few times should restore the batteries to full performance.

## **W**

### **Washer – Structure Subsystem**

A round metal or plastic disc placed between a screw head or nut and the surface to which it is mounted. The washer gives the screw a secure surface to brace against, and prevents the screw head from bending the metal surrounding the hole and popping all the way through. Steel washers should be used with screws that are not meant to move at all. Delrin (white plastic) washers should be used when the entire screw-nut assembly is meant to turn together (e.g. the screw at the pivot of a movable arm attachment).

# User Glossary Notes

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