

Examples of allowed single degree of freedom parts:

- Linear Slide
- Single Sped (non-shifting) gearboxes
- Pulley
- Lazy Susan
- Lead screws

Examples of illegal multiple degrees of freedom parts:

- Gripper assemblies or kits
- Ratcheting wrenches

<RM03> Holonomic Wheels - Holonomic wheels (omni or mecanum) are allowed.

<RM04> Modifying Materials and COTS Parts - Allowed materials and legal COTS parts may be modified (that is, drilled, cut, painted, etc.), as long as no other rules are violated.

<RM05> Allowed Assembly Methods - Welding, brazing, soldering, and fasteners of any type are legal methods for assembling a *Robot*.

<RM06> Lubricant - Any type of COTS lubricant is allowed, if it doesn't contaminate the *Playing Field*, game elements, other *Robots*, etc.

8.3.3 Robot Electrical Parts and Materials Rules

There are many possible ways to build and wire a *Robot*. These rules provide specific requirements on what is and is not allowed. *Teams* must ensure that electrical and electronic devices are used consistently with manufacturer's requirements and specifications. *Teams* are encouraged to review the [FIRST Tech Challenge Robot Wiring Guide](#) for suggestions on how to build a *Robot* with safe and reliable wiring.

<RE01> Main Power Switch - The *Robot* Main Power Switch must control all power provided by the *Robot* main battery pack. *FIRST* requires *Teams* to use either the TETRIX (part # W39129), MATRIX (part # 50-0030), or REV (REV-31-1387) power switch. This is the safest method for *Teams* and field personnel to shut down a *Robot*.

The *Robot* main power switch **MUST** be mounted or positioned to be readily accessible and visible to competition personnel. A Main *Robot* Power label must be placed near the Main Power Switch of the *Robot*. Attach the image ("POWER BUTTON") to your *Robot* near the Main Power Switch. To be easily seen by field personnel the label should be at least 1 in x 2.63 in (2.54 cm x 6.68 cm, Avery Label # 5160) and placed on a flat surface (not wrapped around corners or cylinders).



The *Robot* Main Power Switch should be mounted on the *Robot* so it is protected from *Robot-to-Robot* contact to avoid inadvertent actuation or damage.

<RE02> Battery Mount - Batteries MUST be securely attached (for example, VELCRO, zip tie, rubber band) to the *Robot* in a location where they will not make direct contact with other *Robots* or the *Playing Field*.

<RE03> Robot Main Battery – All *Robot* power is provided by a single 12 V *Robot* main battery.

The only allowed *Robot* main power battery packs are:

- a. TETRIX (W39057, formally 739023) 12 VDC battery pack
- b. Modern Robotics/MATRIX (14-0014) 12 VDC battery pack
- c. REV Robotics (REV-31-1302) 12 VDC Slim Battery pack

Note: There are similar looking batteries available from multiple sources but the ONLY legal batteries are those listed above.

<RE04> Fuses - Where present, fuses must not be replaced with fuses of higher rating than originally installed or according to manufacturer's specifications; fuses may not be shorted out. Fuses must not exceed the rating of those closer to the battery; if necessary, a fuse may be replaced with a smaller rating. Fuses must be single use only, self-resetting fuses (breakers) are not allowed.

<RE05> Robot Power - *Robot* power is constrained by the following:

- a. Allowed electronic devices may only be powered by power ports on the *Core Power Distribution Module* or the *REV Expansion Hub* except as follows:
 - i. The *Core Power Distribution Module* or *REV Expansion Hub* is powered by the *Robot* main battery.
 - ii. *REV SPARK Mini Motor Controllers* are powered by the *Robot* main battery.
 - iii. Allowed sensors connected to the *Core Device Interface Module* and/or the *REV Expansion Hub*.
 - iv. Light sources per <RE12>.
 - v. Video cameras per <RE13>.
- b. The *Robot Controller* Android device must be powered by its own internal battery or by the built-in charging feature of the *REV Expansion Hub*; external power is not allowed.

<RE06> Android Devices - The following Android devices are allowed:

- ZTE Speed
- Motorola Moto G 2nd Generation
- Motorola Moto G 3rd Generation
- Motorola Moto G4 Play
- Motorola Moto G5
- Motorola Moto E4

- Google Nexus 5*
- Samsung Galaxy S5*
 - a. No other devices may be used as *Robot Controllers* or in *Driver Stations*. See Rule <RS03> for the approved list of Android Operating System versions.
 - b. Exactly one (1) Android device must be used as the *Robot Controller* and the USB interface may only connect to the *Core Power Distribution Module*, a *REV Expansion Hub*, or a non-powered USB hub.
 - c. The *Robot Controller* Android device must be powered by its own internal battery or by the built-in charging feature of the *REV Expansion Hub*; external power is not allowed.

<RE07> Control Module Quantities - *Robot* control module quantities are constrained as follows:

- a. Exactly one (1) *Core Power Distribution Module* is required for *Teams* using any *Modern Robotics Core Control Modules*.
- b. No more than two (2) *Core Device Interface Modules* are allowed.
- c. Any quantity of *Core Motor*, or *Core Servo Controllers* are allowed.
- d. Any quantity of *REV Servo Power Modules* is allowed.
- e. No more than two (2) *REV Expansion Hubs* are allowed.
- f. Any quantity of *REV SPARK Mini Motor Controllers* are allowed.
- g. The *REV Control Hub* is not allowed.
- h. The *Core Legacy Module* is not allowed.

<RE08> Motor and Servo Controllers - Motor and Servo Controllers are allowed in the following configuration.

- a. *Core Motor Controllers*, *Core Servo Controllers*, *REV Expansion Hub*, *REV Servo Power Module*, and *REV SPARK Mini Motor Controllers* in any combination.

<RE09> DC Motors – A maximum of eight (8) DC motors are allowed. The only allowed motors are:

- a. TETRIX 12V DC Motor
- b. AndyMark NeveRest series 12V DC Motors
- c. Modern Robotics/MATRIX 12V DC Motors
- d. REV Robotics HD Hex 12V DC Motor
- e. REV Robotics Core Hex 12V DC Motor

No other DC motors are allowed.

* Does not support Wi-Fi Direct channel changing through the Robot Controller app.

<RE10> Servos – A maximum of twelve (12) servos are allowed. Any servo that is compatible with the attached servo controller is allowed. Servos may only be controlled and powered by an allowed Servo Controller, *REV Expansion Hub* or *REV Servo Power Module* (when used with an allowed Servo Controller or *REV Expansion Hub*). Servos may be rotary or linear but are limited to 6V or less and must have the three-wire servo connector.

Teams should be prepared during *Robot* inspection to show documentation confirming that the servos individually and together on the same servo controller do not exceed the manufacturer specifications for the controller.

The VEX EDR 393 motor is considered a servo and it is subject to the overall total maximum of twelve (12) servos. *Core Servo Controllers* may control up to two (2) VEX EDR 393 Motors per module. A VEX Motor Controller 29 must be used between a servo module and each VEX EDR 393 motor. *REV Expansion Hubs* must use a *REV Servo Power Module* between the *REV Expansion Hub* and the VEX Motor Controller 29. A maximum of two (2) VEX EDR 393 Motors may be controlled/powered per *REV Servo Power Module*.

<RE11> Sensors - Sensors are subject to the following constraints:

- a. Compatible sensors from any manufacturer may be connected to the *Core Device Interface Module* or *REV Expansion Hub*.
- b. Compatible sensors from any manufacturer may be connected to the *Logic Level Converter and/or the I²C Sensor Adapter Cable*. Refer to Rule <RE14.k> for details on the use of *Logic Level Converter* and the *I²C Sensor Adapter Cable*.
- c. Passive electronics may be used as recommended by sensor manufacturers at the interfaces to the sensors.
- d. Voltage sensors are allowed; except on an output port of a motor or servo controller.
- e. Current sensors are allowed; except on an output port of a motor or servo controller.
- f. Simple I²C multiplexers are allowed and they may only be connected to and powered from the I²C connections available on the *Core Device Interface Module* or the *REV Expansion Hub*.
- g. Voltage and/or current sensors are also allowed to connect between the battery pack and the *REV Expansion Hub* or *Core Power Distribution Module*.

<RE12> Light Sources - Functional and/or decorative light sources (including LEDs) are allowed with the following constraints:

- a. Focused or directed light sources (for example: lasers and mirrors) are not allowed except for the REV Robotics 2m Distance sensor (REV-31-1505).
- b. Light source control by compatible ports on the REV Expansion Hub and Modern Robotics Core Control Modules is allowed.
- c. Commercial off the Shelf interface modules (without user programmable microprocessors) are allowed between the light source and the components listed in <RE12>b.
- d. The only approved power sources for lights are as follows:
 - i. Internal (as supplied by the Commercial off the Shelf manufacturer) battery pack or battery holder.

- ii. Power ports on the *Core Power Distribution Module*.
- iii. Motor-control ports on the *Core Motor Controller Module*.
- iv. REV Expansion Hub Motor-control ports, spare XT30 ports, 5V auxiliary power ports, and I2C sensor ports.

<RE13> Video Cameras

- a. Self-contained video recording devices (GoPro or similar) are allowed providing they are used only for non-functional post-match viewing and the wireless capability is turned off. Approved self-contained video cameras must be powered by an internal (as supplied by the manufacturer) battery.
- b. *UVC Compatible Cameras* are allowed for computer vision-related tasks. *UVC Compatible Cameras* should be powered by the *Robot Controller* through a non-powered USB hub that is connected to the *Robot Controller* through an OTG adapter.

<RE14> Robot Wiring - Robot wiring is constrained as follows:

- a. USB Surge Protectors connected to USB cables are allowed.
- b. Ferrite chokes (beads) on wires and cables are allowed.
- c. A *Mini USB to OTG (On-The-Go) Micro Cable* or any combination of a *Mini USB cable*, a *non-powered USB hub*, and an *OTG Micro Adapter* may be used to connect the *Robot Controller* Android device to the *Robot* electronics. These devices may connect to the *Robot* electronics in the following ways:
 - i. Built-in USB input port of the *Core Power Distribution Module*, or
 - ii. Built-in USB input port of the *REV Expansion Hub*, or
 - iii. A non-powered USB hub that connects to the built-in USB input port of the *REV Expansion Hub*.
- d. Non-powered USB hubs connected to the *Core Power Distribution Module* are allowed.
- e. Anderson PowerPole, and similar crimp or quick connect style connectors are required to connect downstream electronics with the *Core Power Distribution Module* and are recommended for joining electrical wires throughout the *Robot*. Power distribution splitters are recommended where appropriate to reduce wiring congestion. All connectors and distribution splitters should be appropriately insulated.
- f. Installed connectors (such as battery-pack connectors, battery charger connectors, and *Core Power Distribution Module* power input connectors) may be replaced with Anderson PowerPole or any compatible connector.
- g. Power and motor control wires must use consistent color coding with different colors used for the positive (red, white, brown, or black with a stripe) and negative/common (black or blue) wires.
- h. Wire and cable management products of any type are permitted (for example, cable ties, cord clips, sleeving, etc.).
- i. Wire insulation materials of any type are permitted when used to insulate electrical wires or secure motor control wires to motors (for example, electrical tape, heat shrink, etc.).
- j. Power, motor control, servo, encoder, and sensor wires and their connectors may be extended,

modified, custom made, or COTS subject to the following constraints:

- i. Power wires are 18 AWG or larger.
- ii. Motor control wires as follows:
 - ii 22 AWG or larger for TETRIX Max 12V DC motors and REV Robotics Core Hex (REV-41-1300) 12V DC motors
 - ii 18 AWG or larger for all other 12V DC motors
- iii. PWM (servo) wires are 20 AWG or 22 AWG.
- iv. Sensor wires should be the same size or larger than the original wiring.

Teams should be prepared during Robot inspection to show documentation confirming the wire gauges used; particularly for multi-conductor cables.

- k. *Logic Level Converters* – *Logic Level Converters* that are used to connect a *REV Expansion Hub* to a 5V-compatible I²C sensor or a 5V-compatible digital sensor are allowed. Exactly one *Logic Level Converter* per I²C device and one *Logic Level Converter* per digital sensor are allowed. A *Logic Level Converter* should only draw power from the *REV Expansion Hub*.
- l. Electrically grounding the Control System electronics to the frame of the *Robot* is only permitted using a *FIRST*-approved, commercially manufactured Resistive Grounding Strap. The only Resistive Grounding Strap approved for use is the REV Robotics Resistive Grounding Strap (REV-31-1269). Teams that have electronics with Powerpole-style connectors may also use the REV Robotics Anderson Powerpole to XT30 Adapter (REV-31-1385) in conjunction with the REV Robotics Resistive Grounding Strap. No other grounding straps or adapters are permitted. For additional details on installation of the grounding strap or adapter, please see the [Robot Wiring Guide](#).”

<RE15> Modifying Electronics - Approved electrical and electronic devices may be modified to make them more usable; they may not be modified internally or in any way that affects their safety.

Examples of modifications that are allowed:

- Shortening or extending wires
- Replacing or adding connectors on wires
- Shortening motor shafts
- Replacing gearboxes and/or changing gears

Examples of modifications that are **not** allowed:

- Replacing an H-Bridge in a motor controller
- Rewinding a motor
- Replacing a fuse with a higher value than specified by the manufacturer
- Shorting out a fuse

<RE16> Driver Station Constraints – Teams provide their own *Driver Station* and it must comply with the following constraints:

- a. The *Driver's Station* must consist only of:
 - i. One (1) Android device
 - ii. One (1) OTG Cable
 - iii. No more than one (1) USB hub
 - iv. No more than two (2) gamepads
 - v. Any components used to hold the above listed legal devices.
- b. The *Driver Station* Android device USB interface may only connect to either:
 - i. A Mini *USB to OTG* (On-The-Go) cable or combination of cables connected to a non-powered USB Hub, or
 - ii. One (1) gamepad and an OTG Micro Adapter.
- c. One optional COTS USB external battery connected to the USB Hub to charge the Android device is allowed.
- d. The only allowed gamepads are listed below. They may be used in any combination.
 - i. Logitech F310 gamepad (Part# 940-00010)
 - ii. Xbox 360 Controller for Windows (Part# 52A-00004)
- e. The touch display screen of the *Driver Station* must be accessible and visible by competition personnel.

Important Note: The *Driver Station* is a wireless device with a built-in wireless radio. During a match, the *Driver Station* should not be obscured by metal or other material that could block or absorb the radio signals from the *Driver Station*.

<RE17> Additional Electronics – Electronic devices that are not specifically addressed in the preceding rules are not allowed. A partial list of electronics that are not allowed includes: Arduino boards, Raspberry Pi, relays, and custom circuits.

8.3.4 Robot Software Rules

<RS01> Android Device Names - Each *Team* MUST “name” their *Robot Controller* with their official *FIRST* Tech Challenge *Team* number and –RC (for example, “12345-RC”). Each *Team* MUST “name” their *Driver Station* with their official *Team* number and –DS (for example, 12345-DS). Spare Android devices should be named with the *Team* number followed by a hyphen then a letter designation beginning with “B” (for example, “12345-B-RC”, “12345-C-RC”).

<RS02> Recommended Programming Language - *Java* and the Blocks Development Tool are the recommended programming languages for the *FIRST* Tech Challenge. The minimum allowed app version number is 4.0. Programming must be done using one of the following applications:

- a. FTC Blocks Development tool – a visual, blocks-based programming tool hosted by the *Robot*

Controller.

- b. Android Studio – a text-based integrated development environment.
- c. Java Native Interface (JNI) & Android Native Development Kit (NDK) – *Teams* can incorporate native code libraries into their apps using the JNI framework and the Android NDK.
- d. FTC OnBot Java Programming tool – a text-based integrated development environment hosted by the Robot Controller.

If mandatory updates are announced by *FIRST* later in the season, *Teams* must install them before the time of competition. Additionally, beta versions of the software are allowed at official tournaments.

<RS03> Allowed Android Operating Systems - The only allowed operating systems for the *Robot Controller* and *Driver Station* Android devices are:

- a. ZTE Speed: 4.4 or higher (Kit Kat)
- b. Motorola Moto E4: 7.1 or higher (Nougat)
- c. Motorola Moto G 2nd Generation, Motorola Moto G 3rd Generation, Google Nexus 5, Samsung Galaxy S5: 6.0 or higher (Marshmallow)
- d. Motorola Moto G4 Play: 6.0.1 or higher (Marshmallow)
- e. Motorola Moto G5: 7.0 or higher (Nougat)

IMPORTANT: Rules <RS02> or <RS03> do not require that *Teams* upgrade to the latest version of the software. A mandatory upgrade would only be required if *FIRST* determined there was a critical software fix that must be adopted by *Teams*. Mandatory upgrades will be communicated in the following ways:

- Via [Team Blast](#) – The mandatory upgrade and version number will be communicated to *Teams* on the *Team Blast*, which will also show the date the required upgrade must be made.
- Online – the minimally required software will be listed on our [Technology Resources](#) page, with the date *Teams* are required to make the mandatory software upgrade.
- Forum – The minimally required software will be listed in the [Technology Forum](#) page, with the date *Teams* are required to make the mandatory software upgrade.

Templates for all programming choices are available through the links located at <http://www.firstinspires.org/node/5181>.

<RS04> Autonomous to Driver-Controlled Transition - *Teams* that expect to operate their *Robot* during the Autonomous period must demonstrate during Field Inspection the *Driver Station* switches the *Robot Controller* between Autonomous mode and Driver-Controlled mode.

<RS05> Robot Controller App - The *Robot Controller* must have a designated “FTC *Robot Controller*” app that is the default application for the *Core Robot modules* (*Servo, Motor, and Device Interface*) or the *REV Expansion Hub*.

<RS06> Driver Station App - *Teams* must install the official “FTC *Driver Station*” app onto their *Driver Station* Android Device and use this app to control their *Robot* during a match. The *Driver Station* software version number must match the version number of the *Robot Controller* app.

<RS07> Android Device Operating System Settings - The *Robot Controller* and *Driver Station* must be set to airplane mode, and Bluetooth must be turned off.

<RS08> Wi-Fi Direct Channel Changing App - The *Robot Controller* must have the *FIRST Tech Challenge* “Wi-Fi Direct Channel Changing” App installed (ZTE Speed ONLY).

<RS9> Software Modification - *Teams* are not allowed to modify the *FIRST Tech Challenge Driver Station* application or *Robot Controller* SDK in any fashion.

<RS10> Driver Station Communication - Communication between the *Robot* and *Driver Station* is only allowed via the *Robot Controller* and *Driver Station* applications.

Communication between the *Robot Controller* and the *Driver Station* is limited to the unmodified mechanisms provided by the official *FIRST Tech Challenge* (FTC) software, which consists of the official FTC Software Development Kit (SDK), the FTC *Robot Controller* app, and the FTC *Driver Station* app. *Teams* are not permitted to stream audio, video or other data using third party software or modified versions of the FTC software. *Teams* may only use the unmodified telemetry feature included with the FTC software to transfer additional data between the *Robot Controller* and the *Driver Station*. Software that is preinstalled by an approved phone’s manufacturer and cannot be disabled is exempt from this constraint.

During a Match a *Team’s Robot Controller* and a *Team’s Driver Station* are not allowed to be connected wirelessly to any other device besides each other.

8.4 Team Marker Rules

The Team Marker is a new, game specific scoring element that will be used in the ROVER RUCKUSSM Presented by Qualcomm® game. The Team Marker must pass Inspection before it allowed to be used in a Match.

<TM01> Material Constraints - The Team Marker is subject to the *Robot Mechanical Parts and Materials* Rules in section 8.3.2.

<TM02> Size Constraints - The maximum size of the *Team Marker* is 4 inches (10.16 cm) by 4 inches (10.16 cm) by 8 inches (20.32 cm). The minimum size of the *Team Marker* is 3 inches (7.62 cm) by 3 inches (7.62 cm) by 4 inches (10.16cm).

<TM03> Team Number - Team Markers must be labeled with their *Team* number (numerals only, for example “12345”) The letters must be legible when viewed from a distance of 12 inches away. The Team number needs to appear only once on the Team Marker.

<TM04> Illegal Parts - The following types of mechanisms and parts are not allowed:

- a. Electronics.
- b. Any other part or material that violates *Robot* construction rules outlined in section 8.3.