2015-2016 *FIRST*® Tech Challenge
Robot Wiring Guide

FIRST TECH CHALLENGE





Volunteer Thank You

Thank you for taking the time to volunteer for a *FIRST* Tech Challenge Event. *FIRST* and FTC rely heavily on Volunteers to ensure Events run smoothly and are a fun experience for Teams and their families, which could not happen without people like you. With over 4,500 Teams competing annually, your dedication and commitment are paramount to the success of each Event and the FTC program. Thank you for your time and effort in supporting the mission of *FIRST*!

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Thank you to our generous sponsors for your continued support of the *FIRST* Tech Challenge!

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Revision History	
Date	**Description**
10/20/15	Initial Release
11/09/15	Added a reverse polarity warning
11/20/15	Links updated to www.firstinspires.org and Branding updates

Contents

Introduction

What is the FIRST Tech Challenge?

FIRST Tech Challenge is a student-centered activity that focuses on giving students a unique and stimulating experience. Each year, Teams participate in a new Game that requires them to design, build, test, and program autonomous and driver-operated Robots that must perform a series of tasks.

The Playing Field for the Game consists of the *FIRST* Tech Challenge Game Pieces set up on a foam-mat surface, surrounded by a metal and Lexan Field frame. Each Tournament features Alliances, which are comprised of two Teams, competing against one another on the Playing Field. Teams work to overcome obstacles and meet challenges, while learning from and interacting with their peers and adult Mentors. Students develop a greater appreciation of science and technology and how they might use that knowledge to impact the world around them in a positive manner. They also cultivate life skills such as:

***FTC is More Than Robots!* While competing, students develop personal and professional skills they will be able to rely on throughout their life.**

- Planning, brainstorming, and creative problem-solving.
- Research and technical skills.
- Collaboration and Teamwork.
- Appreciation of differences and respect for the ideas and contributions of others.

To learn more about FTC and other *FIRST* Robotics Competitions, visit www.firstinspires.org.

FIRST Tech Challenge (FTC) Core Values

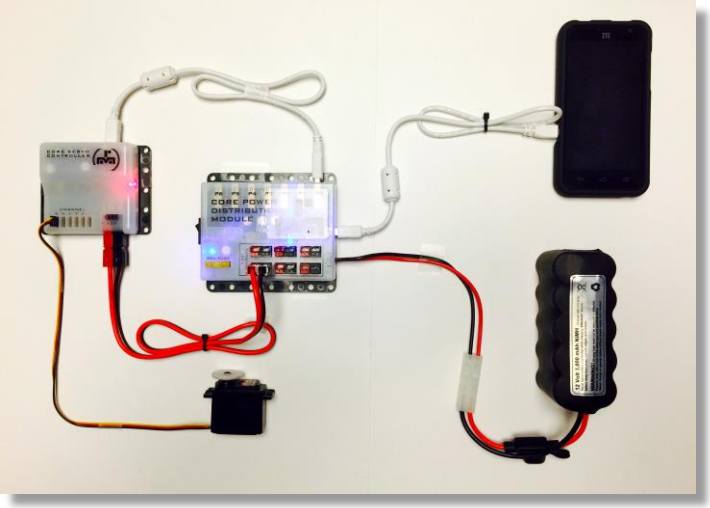
FIRST asks everyone who participates in FTC to uphold the following values:

- We display Gracious Professionalism with everyone we engage with and in everything we do.
- We act with integrity.
- We have fun.
- We are a welcoming community of students, Mentors, and volunteers.
- What we learn is more important than what we win.
- We respect each other and celebrate our diversity.
- Students and adults work together to find solutions to challenges.
- We honor the spirit of friendly Competition.
- We behave with courtesy and compassion for others at all times.
- We act as ambassadors for *FIRST* and the *FIRST* Tech Challenge.
- We inspire others to adopt these values.

What is the *FIRST* Tech Challenge Robot Wiring Guide?

The purpose of the *FIRST* Tech Challenge Robot Wiring Guide is to:

- Provide Teams detailed instructions for properly wiring their Robot for reliable performance.
- Provide Teams with tips and tricks to improve their wiring for improved Robot performance.
- Help Teams and mentors troubleshoot their Robot wiring. The guide focuses on the skills and concepts needed for the development of the following general goals:
    - Equip Teams with a complete list of Robot wiring tools and methods.
    - Provide clear instructions for improving basic Robot wiring.
    - Present instructions on troubleshooting wiring issues.



This Guide would not be possible without the contributions of time, ideas, and resources provided by the 2015 World Championship Inspire Award winning Team, #3595 Schrödinger's Hat.

Gracious Professionalism™

FIRST uses this term to describe the program's intent. This is one of the most important concepts that can be taught to a young person who is learning to get along in the work world. At *FIRST*, Team members help other Team members, but they also help other Teams.

Gracious Professionalism is not clearly defined for a reason. It can and should mean different things to everyone.

Some possible meanings of Gracious Professionalism include:

- Gracious attitudes and behaviors are win-win.
- Gracious folks respect others and let that respect show in their actions.
- Professionals possess special knowledge and are trusted by society to use that knowledge responsibly.
- Gracious Professionals make a valued contribution in a manner pleasing to others and to themselves.

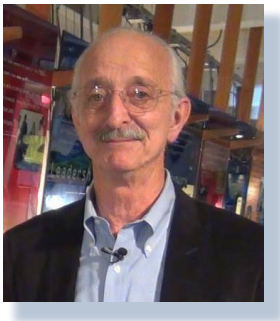
An example of Gracious Professionalism is patiently listening to a Team's question and providing support despite having several pressing things to do on the day of the Event.

In the context of *FIRST*, this means that all Teams and participants should:

- Learn to be strong competitors, but also treat one another with respect and kindness in the process.
- Avoid leaving anyone feeling as if they are excluded or unappreciated.
- Knowledge, pride and empathy should be comfortably and genuinely blended.

In the end, Gracious Professionalism is part of pursuing a meaningful life. When professionals use knowledge in a gracious manner and individuals act with integrity and sensitivity, everyone wins, and society benefits.

Watch Dr. Woodie Flowers explain Gracious Professionalism in this short video.



"The FIRST spirit encourages doing high-quality, well-informed work in a manner that leaves everyone feeling valued. Gracious Professionalism seems to be a good descriptor for part of the ethos of FIRST. It is part of what makes FIRST different and wonderful."

- Dr. Woodie Flowers, National Advisor for ***FIRST***

Youth Protection Program

The purpose of the FIRST Youth Protection Program (FIRST YPP) is to provide coaches, mentors, volunteers, employees, others working in FIRST programs, Team members, parents, and guardians of Team members with information, guidelines, and procedures to create safe environments for everyone participating in FIRST programs.

The FIRST YPP sets minimum standards recommended for all FIRST activities. Adults working in FIRST programs must be knowledgeable of the standards set by the FIRST YPP, as well as those set by the school or organization hosting their Team.

Youth Protection Expectations and Guidelines

Coaches and Mentors are expected to read and follow elements in the FIRST Youth Protection Program guide that are labeled as required. These are mandatory in the United States and Canada, and may not be waived without the approval of the *FIRST* Youth Protection Department.

FIRST recommends that the standards set forth in the FIRST Youth Protection Program guide be applied outside of the United States and Canada to the extent possible. At a minimum, local regulations regarding youth protection must be complied with.

Everyone working with FIRST Teams should be familiar with the *FIRST* YPP policies.

Forms are available here: http://www.firstinspires.org/resource-library/youth-protection-policy

Information on the US Screening process is available here: http://www.firstinspires.org/sites/default/files/uploads/about/US-Screening-Screen-Shots.pdf

Information on the Canadian Screening process is available here: http://vimeo.com/30137373

You can find FAQ and additional information about the *FIRST* Youth Protection Program on the *FIRST* website at: http://www.firstinspires.org/resource-library/youth-protection-policy

NOTICE OF NON-DISCRIMINATION

United States Foundation for Inspiration and Recognition of Science and Technology (*FIRST*®) does not discriminate on the basis of race, color, national origin, sex, disability, or age in its programs and activities. The following person has been designated to handle inquiries regarding the non-discrimination policies: Lee Doucette, Youth Protection Program Manager, 200 Bedford Street, Manchester, NH 03101, 603-666-3906, Ext. 250.

Introduction to Robot Wiring

Wiring is one of the most important components of a Robot. However, wiring often does not receive the same care and attention as the rest of the Robot. Good wiring allows Teams to create tight connections and to better troubleshoot problems as they occur. Such wiring takes a lot of patience and practice, and Teams should budget time accordingly.

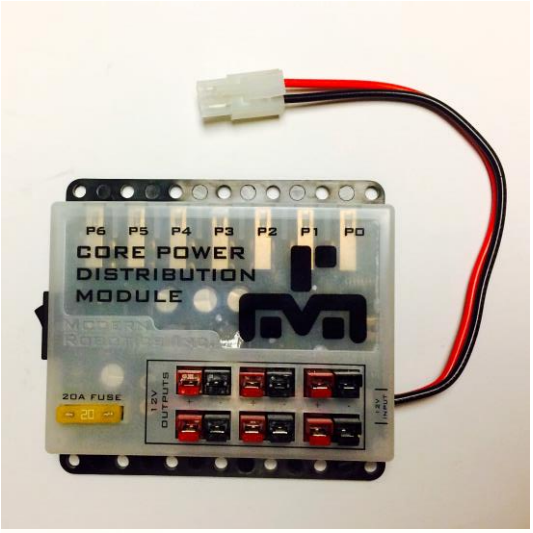


Figure 1: Power Distribution Module

Figure 2: Core Servo Controller

Figure 3: Core Device Interface

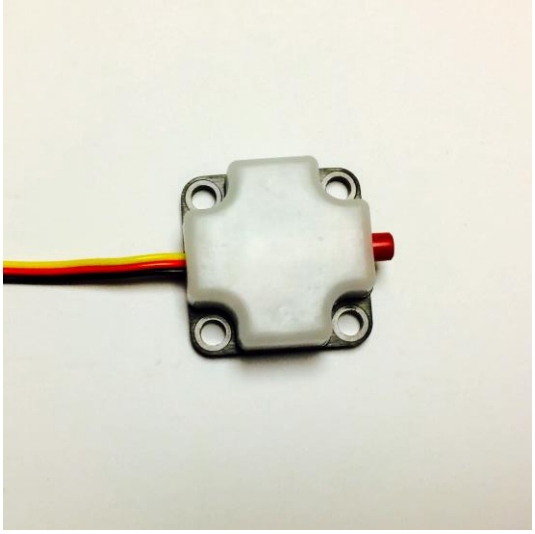


Figure 4: Modern Robotics Touch Sensor

In this Guide, Teams will learn how to properly wire their Robot, how to improve wiring reliability, and how to deal with hardware issues associated with the Legacy Technology.

- Section 1 of this document covers the new technology.
- Section 2 of this document discusses common wiring problems and their solutions.
- Section 3 provides tips for wire management.
- Section 4 contains links to additional resources and wiring fundamentals.

Section 1

Suggested Alterations to the Core Modules

This section will cover optional changes and additions that Teams may wish to make as they wire their Robot. For an overview of the new electronics, please visit the Modern Robotics site or watch one of FIRST's videos on the subject.

Note: *It is required that Teams follow the rules detailed in the Game Manuals. For a list of rules for the 2015-2016 season regarding Robot wiring, see rule <RE05> in the Game Manual Part I.*

Warning!

This document provides some suggested alterations that users can make to their Modern Robotics Core Modules. These suggested alterations can provide some benefit towards improving the overall reliability of the system. Users should be advised, however, that these alterations are not without risk and altering the Modern Robotics Core Modules **will void the manufacturer's warranty**. If these alterations are not done properly, users can damage their Modern Robotics hardware. Also, before any alterations are made to their hardware, users should carefully test their hardware to verify that their hardware is working properly. Once a module has been altered, the factory warranty will be voided.

Power Switch

Rule <RG04> requires that the power switch is easily accessible. Because the power switch is built into the Core Power Distribution Module, module placement may become difficult or be situated in a vulnerable location. As a solution, FIRST recommends the use of an external TETRIX or MATRIX power switch. Teams should be aware that TETRIX power switches come with blade connectors that are crimped onto tinned wire. Over time this solder will creep (or flow), leading to a poor connection that may cause intermittent power interruptions. The simplest way to fix this problem is to cut off the tinned section of the wire and replace it with a new blade connector (Figure 5).

Figure 5: Blade connectors and power switch.

Replacing Tinned Wire

1. Cut the blade connector off of the wire, as close to the edge of the connector as possible, so as not to waste wire (Figure 7).
2. Strip the end of the wire to the required length (Figure 8).
3. Insert the stripped wire into a replacement connector. Make sure that all of the strands of the wire make it inside the connector. They should not bend or otherwise miss the opening.
4. Crimp the necessary section of the connector onto the wire (Figure 9).
5. Attach the connector to the switch (Figure 10).
6. Repeat as necessary.

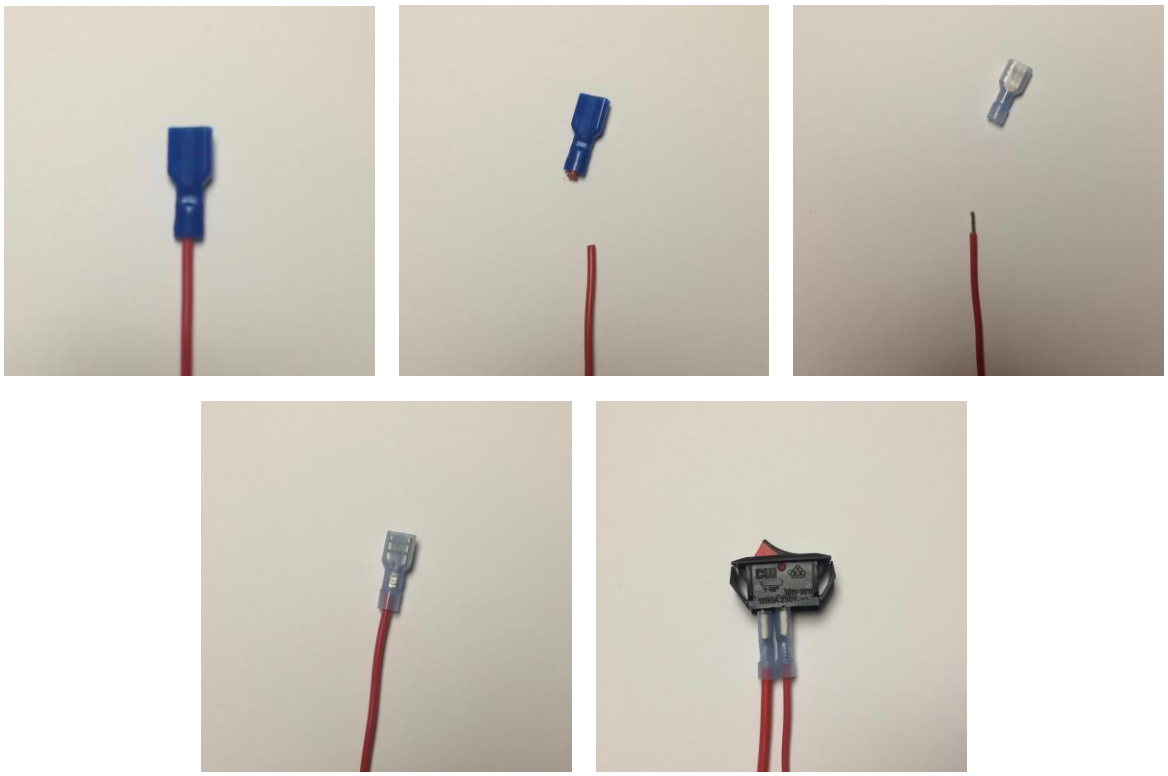


Figure 6: The original wire.

Figure 7: The wire with the tinned end removed.

Figure 8: The stripped wire with a new connector.

Figure 9: The wire with the connector crimped on.

Figure 10: The switch with the new connectors.

Battery Connections

The batteries that come with the standard part kits are outfitted with Tamiya connectors (Figure 11). Tamiya connectors provide a quick and easy way to change a battery but are only reliable for a few dozen cycles and may wear out during an FTC season.

Figure 11: Tamiya connector.

An extremely reliable alternative to Tamiya connectors are the Anderson PowerPoles used elsewhere on the core modules. If Teams wish to make the change, they will need to modify their core power module, battery, and battery charger as detailed below.

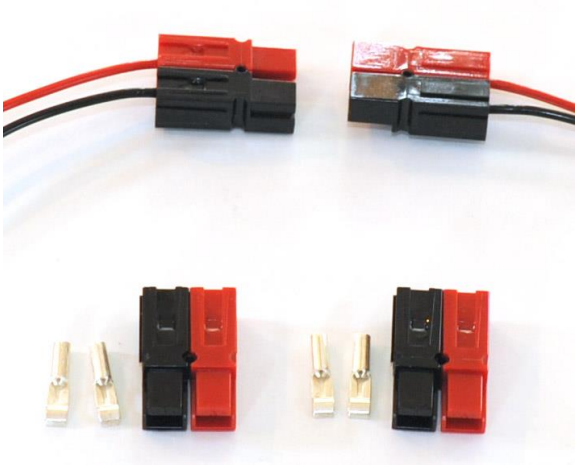


Figure 12: Anderson PowerPoles.

Warning: The Core Power Distribution Module is not reverse-polarity protected. If the wires are inadvertently reversed (red to black, black to red as in Figure 13), the Core Power Distribution Module will be damaged. Additionally, the battery should never be plugged into the distribution ports (Figure 14). Altering the Core Power Distribution Module will void the manufacturer's warranty. An alternate to modifying the Core Power Distribution Module is to create an adapter that can be used to connect the Tamiya connector of the Core Power Distribution Module to the Anderson PowerPole connector of the battery. Using such an adapter allows the user to connect/disconnect to/from the battery quickly using the PowerPole interface, but does not require any alterations to the Core Power Distribution Module. Using such an adapter also can help reduce the risk of the Tamiya adapter from being worn out from repeated connect/disconnect cycles.

Figure 13: Reversed power wires.

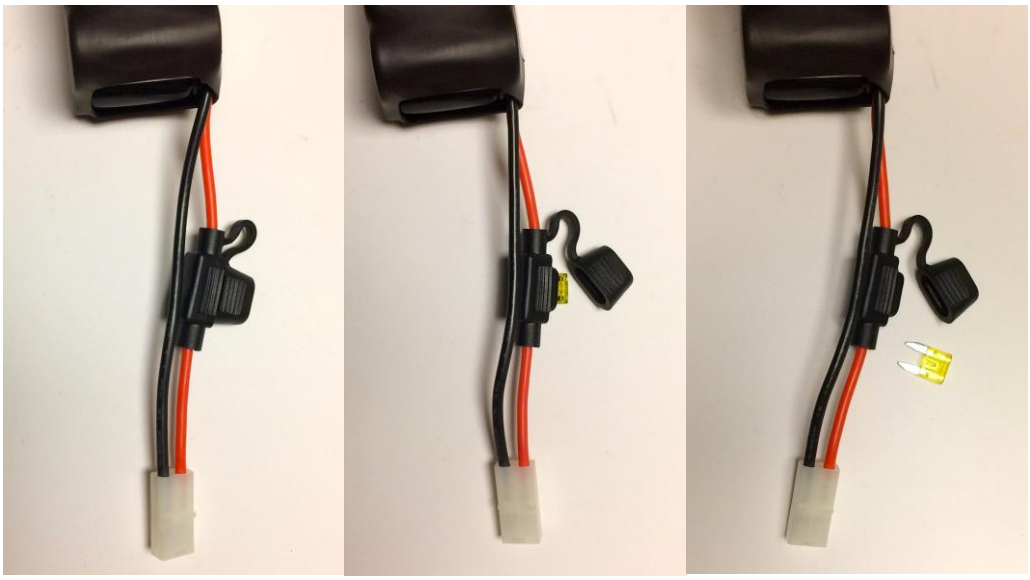
Figure 14: Battery plugged into wrong port.

Installing Anderson PowerPoles

The following sequence of steps explains how to install Anderson PowerPoles on a battery:

Note: Under no circumstances should there be exposed ends on both battery wires. MATRIX batteries have no built-in fuse. Bare wires that touch will short out the battery and may create a fire hazard.

1. With TETRIX batteries, remove the fuse from the battery. For Matrix batteries skip this step.



Figures 15, 16, 17: Remove the fuse.

2. Cut <u>one</u> of the wires close to the attached Tamiya connector. Do not cut too close to the battery or the fuse housing as that will make installation difficult or impossible.
3. Strip the wire to the Anderson PowerPole specs (Figure 18).

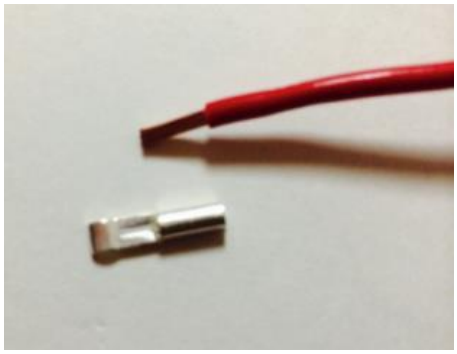


Figure 18: Strip the wires.

4. Crimp the connector on. (Make sure that the wire is in the proper orientation before doing this -- the PowerPoles need to be able to interface.) (Figure 19).

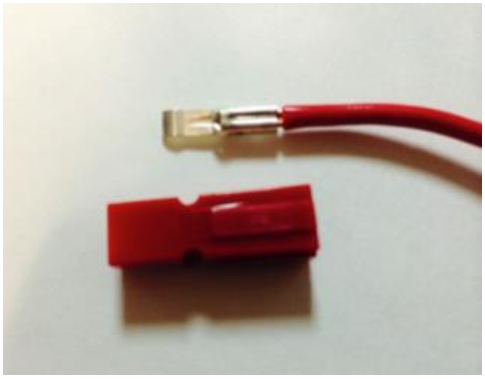


Figure 19: Crimp connector onto wire.

5. Snap on the plastic housing. (Note colors, making sure that the red housing is attached to the red wire, and the black housing is attached to the black wire.)
6. Repeat steps 2 through 5 on the remaining wire.
7. Snap the red and black housing pieces together as shown (Figure 20). This vertical configuration makes it physically impossible for the battery to be plugged into the wrong port.

Figure 20: Stacked Anderson PowerPole housing.

8. If the battery is made by TETRIX, re-insert the fuse.
9. Repeat the procedure on the Core Power Distribution Module.
10. Repeat the procedure on the battery charger.

A video demonstration of this process can be seen in the *Gear Up with FTC!* Robot Wiring Troubleshooting Video. (Skip to 10:10 in the video.) Additional details can be found at:

http://www.powerwerx.com/assembly.asp

Teams using AndyMark NeveRest or TETRIX motors from earlier seasons will also need to install PowerPoles on their motors. When using PowerPoles on motor wires, do not stack them as detailed above. Instead make sure that they properly interface with the connectors on the motor controllers.

Mounting the Android Phone

When attaching the Android Phone to the robot, there are many things to keep in mind.

1. It is imperative that the phone is protected from robot-to-robot contact.
2. Avoid burying the phone in metal. If it is mounted at the bottom of a robot and surrounded by metal, the metal can interfere with the phone's WI-FI connection.
3. Make sure that the phone is easily accessible for charging, programming, and emergencies.
4. Make sure that all wires connected to the phone are securely mounted and are not in danger of being bumped, damaged, or disconnected. It is essential that there is no chance of stress being placed on the wire that connects to the phone. If the wire is stressed, the phone port could be ruined. Wires should be tied down, and there should be no movement around the port. Phone mounts are available from a variety of different sources for FTC.

Figure 21: The cable is not supported and is easily damaged or disconnected.

Figure 22: The cable is supported and secured in place. It is still easy to unplug it for charging, but it will be difficult to accidentally unplug it.

Note: Every wire connection is a possible point of failure. This applies not only to the phone, but also to all electronics. In general, all USB connections should be properly secured and strain relieved. Wires should be tied down/secured near their ends to prevent them from moving or shaking loose during a match. If you notice that your robot controller (Android phone) is having connection problems with the USB devices during a match, then it could be that your cables are not properly secured and that these cables are momentarily being shaken/jolted loose during the match. In particular, the USB connection to the Micro USB port on the phone should be properly secured. This Micro USB connection tends to be more susceptible to being shaken or jolted loose if the USB cable is not properly secured.

Section 2

Common Problems

Hardware Problems and Their Solutions

There are several potential issues that can arise with the legacy electronics. This section will detail these issues and offer solutions

Legacy Controller Connections

Problem: Legacy Motor and Servo Controllers use screw terminals for the power and motor connection wires. These terminals hold onto the wires using compression. Unfortunately, the wires that come with kits are tinned and, because the solder creeps when compressed, the grip on the wires can loosen over time and cause the Robot to experience intermittent failures.

Additionally, stripping a wire and inserting it into the Motor Controller often results in stray strands of wire (Figure 23). These loose strands of wire are problematic and make it easy to inadvertently create a short circuit.

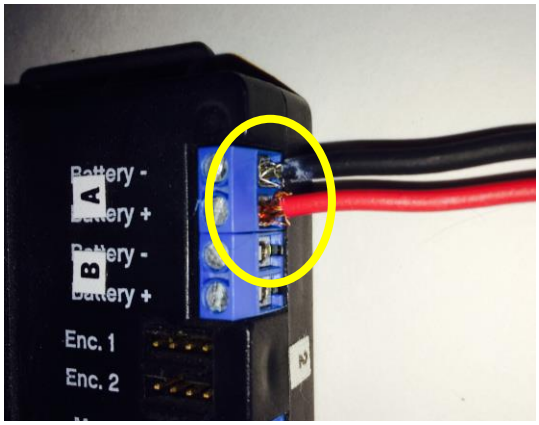


Figure 23: Try to avoid stray strands of wire when connecting to the Motor Controller.

Solution: Ferrules, also called “end sleeves”, are a simple way to avoid many of the potential problems with the Motor and Servo Controller connections (Figure 24). Ferrules are the industry standard for providing a robust connection in a screw terminal, and they are inexpensive and easy to install.

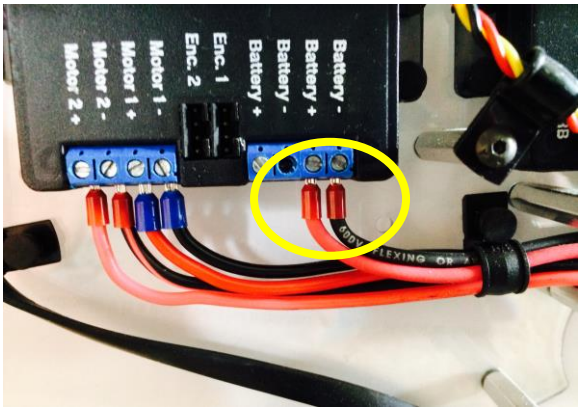


Figure 24: Ferrules or End Sleeves.

Installing Ferrules

1. Cut wire to proper length:

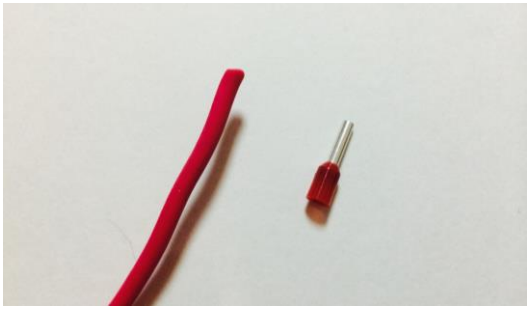


Figure 25: Wire and Ferrule.

2. Strip off the end of the wire insulation:

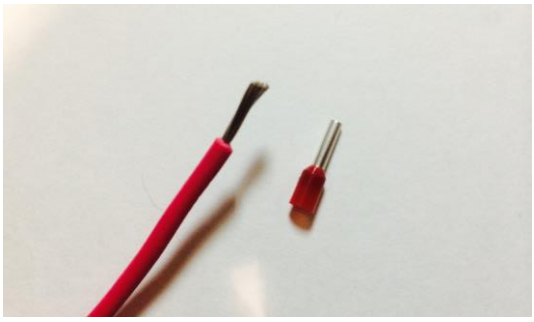


Figure 26: Strip the wire.

3. Slide the Ferrule over the end of the wire. Be sure that the ends of the wire are flush with the end of the Ferrule.

4. Insert the Ferrule/wire combination into the proper slot on the crimping tool:

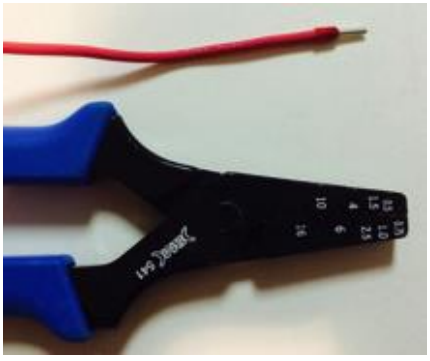


Figure 27: Ferrule crimping tool.

5. Crimp:

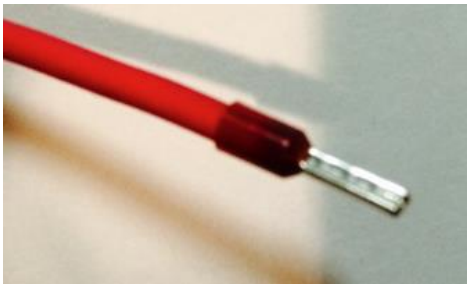


Figure 28: Crimped Ferrule.

Common Pitfalls and Their Solutions

The following pitfalls are common when wiring. Being able to recognize and avoid them will lead to much more reliable and resilient wiring.

Haphazard Wiring

Pitfall: It is not unusual to quickly wire a Robot for testing purposes and then let that "temporary" wiring become permanent. When all of the wires in a Robot are jumbled together and not properly tied down, a variety of problems can arise, including:

- Faulty Connections
- Broken Wires
- Difficulties with Troubleshooting
- Maintenance Issues

Solution: If enough time is allotted for wiring, this should not be an issue. Wire management techniques that are described in Section 3 of this document also help prevent this "rat's nest" wiring.

Loose USB Cables

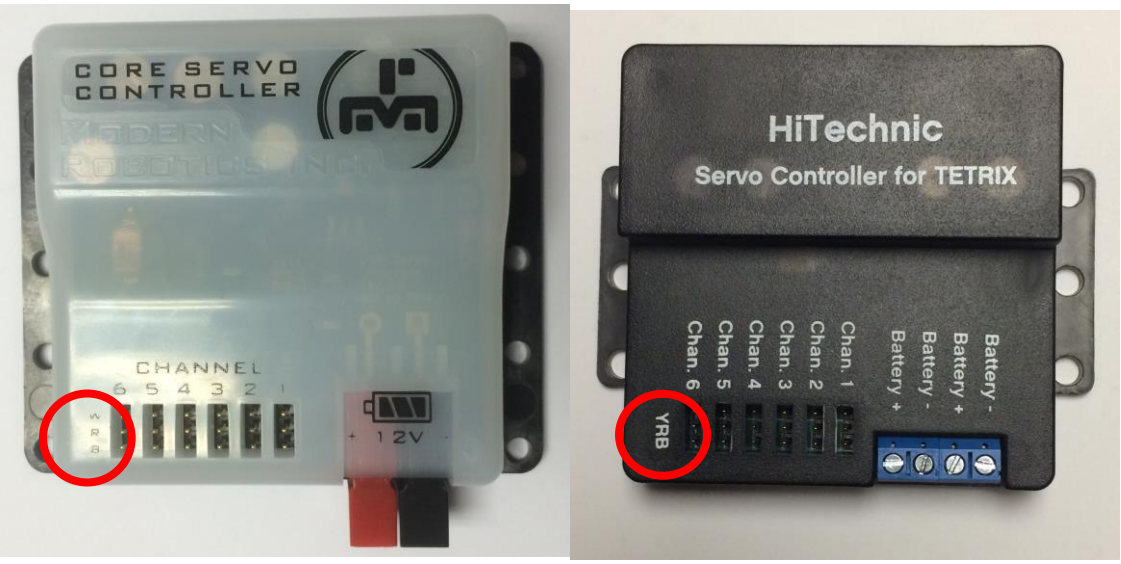
Pitfall: If the USB cables connecting the devices are not properly secured and strain relieved, they could shake loose during a match and cause the robot to stop working properly.

Solution: Make sure your wires are properly secured so that they do not vibrate or jolt loose during a match. Securing the wires to the frame or some rigid structure near the ends of the cable help prevent them from shaking loose during normal operation.

Reversed Servo Wire

Pitfall: The Legacy servo Controllers are marked with "YRB," and the Core Servo Controllers are marked with "WRB" as shown in Figures 29 and 30. YRB stands for "Yellow Red Black." WRB stands for White Red Black and indicates the orientation of the Servo wire. The black wire must line up with the "B." The other colors do not matter. It is easy to reverse the connection and then misidentify the problem as a software issue. This same mistake can be made if using servo extensions or splitters.

Solution: Be mindful of this common problem and you can easily avoid it (see Figures 29 and 30).



Figures 29 and 30: YRB and WRB Markings on the Servo Controllers.

Daisy Chaining Legacy Wiring Components

Pitfall: Daisy chaining is one way of powering several different units. Multiple components are wired together, with each unit being powered by the one before it in the chain. It is common for Teams to daisy chain the power terminals on the Motor and Servo Controllers. In a haphazardly-wired Robot, daisy chaining can cause many issues. If one connection in the middle of the chain comes loose, the power to the remaining Controllers will be lost.

Solution: Rather than daisy chaining legacy components, plug each one into the Core Distribution module.

Haphazard Battery and Controller Placement

Pitfall: When the placement of the battery and controllers is not incorporated into the initial Robot design, the components may be attached to the Robot as an afterthought. The controllers may then be placed in locations that are difficult to reach and/or that can be damaged by other Robots during competition. The battery may be attached towards the top of the Robot, leading to a high center of gravity and an unstable Robot.

Solution: Take the battery and controllers into consideration while building.

- Ensure that there are no sharp edges that can cut into the battery.
- Ensure that the battery and controllers will be protected during matches.
- Ensure that all connections are secure and cannot be jostled or otherwise disturbed during matches.
- Ensure that the battery is properly secured to the robot, and cannot disconnect during a match.
- The battery is often one of the heaviest components on the robot and its placement can have a dramatic effect on drivability and stability. A good rule of thumb is to place the battery as low as possible.

Problem: The signals that pass between the Android phone and the controllers are sensitive to interference. If a motor power wire or servo wire is routed adjacent to a USB cable, it is possible to induce a stray signal that can lead to intermittent problems.

Solutions:

Wiring Placement

Try to keep power wires away from motor wires and motor wire away from USB cables. Use the shortest possible cable at all times. Coiling a 6' USB cable inside a robot may cause data errors on the USB bus. 12" or 18" cables are an inexpensive alternative.

Ferrite Chokes

Ferrite chokes electronically isolate signal cables from the power network. Use a high-quality shielded USB cable with built-in or external Ferrite chokes to help reduce interference on the line from the Motors and to help reduce the effects of electro-static discharge.

Section 3

Wire Management Tips

In addition to building a great Robot and wiring it using the recommendations made in Sections 1 and 2, there are best practices for general wiring of the Robot – good habits to start as soon as possible and then maintain every season.

Conduct Proper Maintenance

To help a Robot perform better during a competition, teams should:

- Double-check that the wiring is tightened down;
- Check battery voltages and connections; and
- Check wiring insulation for imperfections.

Using a checklist with written reminders to conduct this maintenance between matches can ensure that each of these details is attended to throughout the tournament.

Keep It Neat

There are a lot of parts on a Competition Robot, and a neatly-wired Robot is not only more aesthetically pleasing but also less likely to run into problems. A Robot with disorganized wiring is more likely to have connection issues.

Neat wiring will be:

- Easier to follow, thus aiding in troubleshooting;
- Easier to fix;
- Less likely to get caught in moving parts; and
- Less likely to become entangled in other robots.

Use Proper Wire Management

Perhaps the most important step towards neat wiring is the implementation of proper wire management. Wire management involves bundling and routing wires along a defined path to the various electrical components. Keeping the following tips in mind will ensure neater, more robust wiring:

- Keep the wiring stationary.
- Protect the wiring.
- Make sure all cables are the correct length.

- Use wire management hardware (Figures 31 - 34.)
  - Zip ties allow teams to quickly tie down wiring.
  - Wire loom allows teams to quickly protect at-risk wiring.
  - Self-adhesive cable tie mounts allow teams to attach wires to surfaces without holes.
  - Grommets protect wire from damage when it is passed through a hole with sharp edges.

Figures 31, 32, 33, 34: from left to right: zip ties, wire loom, self-adhesive cable tie mounts, grommets.

Tie Down All Wiring

It is best to run wires along stationary components of a Robot as much as possible. Properly tying down wiring will:

- Prevent wires from moving into pinch points (e.g., between two gears or into a movable mechanism);
- Prevent entanglement with other Robots;
- Prevent strain on wiring components; and
- Provide easier access for maintenance.

Teams should keep the end cap securely attached to the TETRIX DC Motor. One method is to use electrical tape to fasten the end cap (Figure 35).

Figure 35: Securely fastened end cap.

Dealing with Moving Parts

In some cases teams will need to run wires over and around moving pieces to get them to a required location. When doing this, teams should use extreme caution. Avoid pinch points whenever possible, and make sure that there is always enough slack so that wires are never put under unnecessary stress. Protect wires that will be prone to chaffing and rubbing with wire loom and routinely check them during the course of the season. Make sure that wires will not end up twisted around any moving parts, which could cause damage both to the wiring and to the part.

Make Wiring Diagrams

Wiring diagrams show what components are wired together at a glance (Figure 36). These diagrams are relatively simple to create and are useful for the following reasons:

- They ease troubleshooting;
- They ease programming; and
- They become a valuable reference when included in the Engineering Notebook.

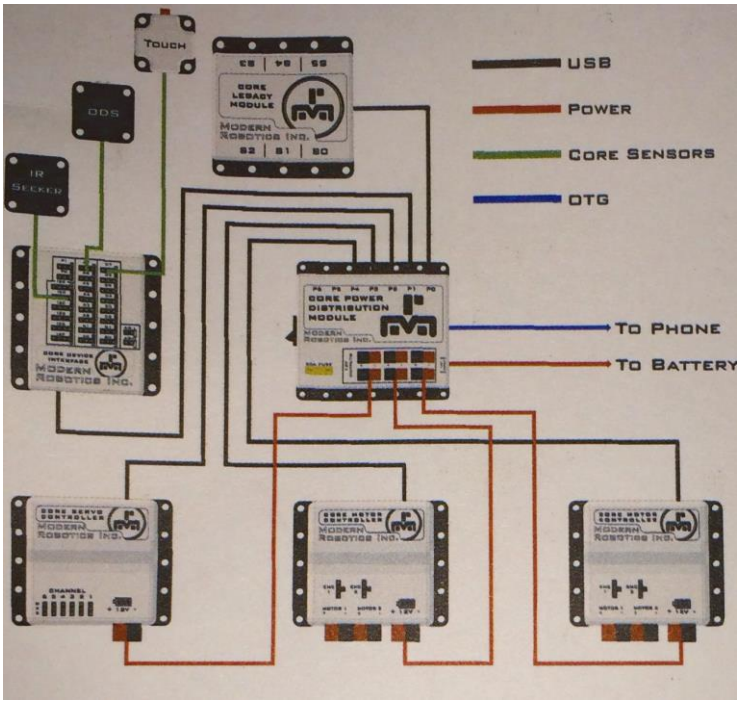


Figure 36: A simple wiring diagram.

Use the Proper Tools

Proper tools ease the implementation of wiring (see Figures 37 - 41). Tools like the Anderson PowerPole crimping tool and small nippers will greatly aid in clean wiring.

Figure 37: Wire strippers.

Figure 41: Anderson PowerPole crimpers.

Figure 38: Small screwdriver for tightening screw terminals on Legacy modules.

Figure 39: Small nippers for cutting zip ties.

Figure 40: Ferrule crimpers.

Label Wires

Properly wire labeling quickly solves many problems (Figures 42 and 43). It helps in the creation of a wiring document and also cuts down on time devoted to maintenance and troubleshooting.

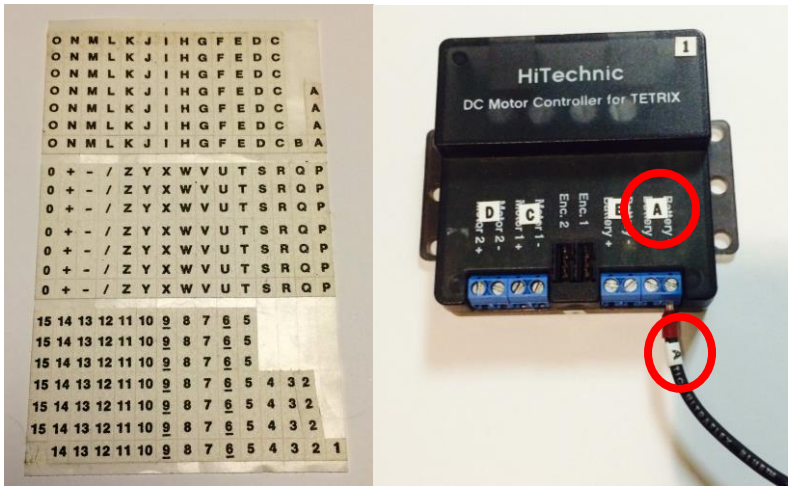


Figure 42, 43: Wire labels.

Make a Tamiya/PowerPole Adapter

Teams that replace Tamiya connectors with Anderson PowerPoles may be concerned that they cannot share batteries and battery chargers with other Teams during a Tournament. In order to maintain compatibility with both styles of connectors, Teams can make an adapter (Figure 44).

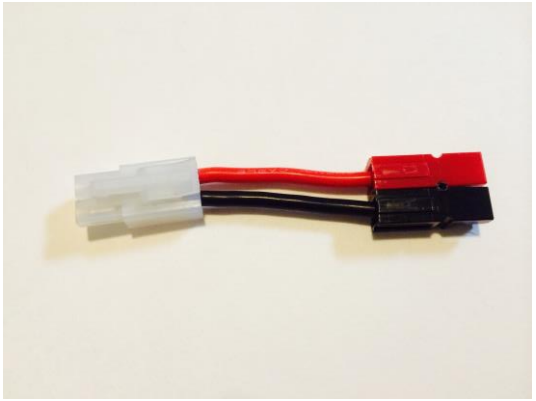


Figure 44: Tamiya/PowerPole Adapter.

Making an Adapter

1. When removing the Tamiya connectors from the battery, do not cut the wires flush with the end of the Tamiya connector. Instead, leave a 1/2” length of wire attached to the Tamiya connector.
2. Install Anderson PowerPoles on the free end of the 1/2” length of wire.
3. Velcro or otherwise attach this adapter to the Robot to ensure that it is available when needed.
4. Attach additional adaptors to battery chargers, toolboxes, etc. if desired.

Section 4

Additional Resources

Careful incorporation of the solutions and wire management tips in the previous three sections should ensure more robust wiring and increase Robot reliability. For Teams looking to further increase their wiring knowledge, the following resources may be useful:

- NASA Guide to Crimping, Interconnecting cables, Harnesses, and Wiring
- Gear Up With FTC Presentation: Robot Wiring Troubleshooting
- Basic wiring instructions:
  - Provided with TETRIX kits.
  - Provided with MATRIX kits.
  - Provided by Carnegie Mellon Robotics Academy.

FIRST also has a number of resources for teams looking for more information on the Android Based technology: http://www.firstinspires.org/node/5291

Modern Robotics also has descriptions of the new technology: http://www.modernroboticsinc.com

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Robot Wiring Guide

Appendices

Appendix A - Resources

Game Forum Q&A - ***http://ftcforum.usfirst.org/forum.php***

FTC Game Manuals – Part I and II - http://www.firstinspires.org/node/4271

FIRST Headquarters Support

Phone: 603-666-3906

Email: FTCTeams@firstinspires.org

FIRSTINSPIRES.ORG

FIRST Tech Challenge (FTC) Page – For everything FTC.

FTC Volunteer Resources – To access public Volunteer Manuals.

FTC Event Schedule – Find FTC events in your area.

FIRST Tech Challenge Social Media

FTC Twitter Feed - If you are on Twitter, follow the FTC twitter feed for news updates.

FTC Facebook page - If you are on Facebook, follow the FTC page for news updates.

FTC YouTube Channel – Contains training videos, Game animations, news clips, and more.

FTC Blog – Weekly articles for the FTC community, including Outstanding Volunteer Recognition!

FTC Team Email Blasts – contain the most recent FTC news for Teams.

FTC Google+ community - If you are on Google+, follow the FTC community for news updates.

Feedback

We strive to create support materials that are the best they can be. If you have feedback regarding this manual, please email ftcteams@firstinspires.org. Thank you!