Volunteer Thank You

Thank you for taking the time to volunteer for a FIRST® Tech Challenge event. FIRST® and FIRST Tech Challenge 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 4,600 Teams competing annually, your dedication and commitment are paramount to the success of each event and the FIRST Tech Challenge program. Thank you for your time and effort in supporting the mission of FIRST!

Sponsor Thank You

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

What is 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 polycarbonate 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:

- 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 FIRST Tech Challenge and other FIRST Programs, visit www.firstinspires.org.

FIRST Tech Challenge Core Values
Volunteers are integral to the FIRST community. FIRST Tech Challenge relies on Volunteers to run the program at many levels, from managing a region to Mentoring an individual Team. Our Affiliate Partners coordinate the program in each region or state. These Affiliate Partners fundraise, run Tournaments, hold workshops and demonstrations, market FIRST Tech Challenge locally, handle public relations, and recruit Volunteers and Teams. They are a tremendous resource for Mentors and FIRST would not exist without them.

FIRST asks everyone who participates in FIRST Tech Challenge 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 FIRST Tech Challenge.
- We inspire others to adopt these values.

Gracious Professionalism® - “Doing your best work while treating others with respect and kindess - It’s what makes FIRST, first.”
**Gracious Professionalism®**

*FIRST* uses this term to describe our programs’ 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.

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*

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**Gracious Professionalism® for Volunteers**

It is a good idea to spend time going over this concept with Volunteers. Provide Volunteers with real-life examples of *Gracious Professionalism* in practice before, during, and after the event and recognize great *Gracious Professionalism* when you see it in action!
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 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.

Forms are available here: [http://www.firstinspires.org/sites/default/files/uploads/about/FORMS.zip](http://www.firstinspires.org/sites/default/files/uploads/about/FORMS.zip)


Information on the Canadian Screening process is available here: [http://vimeo.com/30137373](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](http://www.firstinspires.org/resource-library/youth-protection-policy)

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

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.

Gracious Professionalism® - “Doing your best work while treating others with respect and kindess - It’s what makes FIRST, first.”
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.

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
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 2016-2017 season regarding Robot wiring, see rule <RE01> 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).

![Blade connectors and power switch.](image)

**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.

![The original wire.](image)

![The wire with the tinned end removed.](image)

![The stripped wire with a new connector.](image)

**Figure 6: The original wire.**

**Figure 7: The wire with the tinned end removed.**

**Figure 8: The stripped wire with a new connector.**
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 FIRST Tech Challenge season.

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.
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 (page 28). 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.
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. Early 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 and current Matrix batteries, remove the fuse from the battery. For early Matrix batteries skip this step.

![Figures 15, 16, 17: Remove the fuse.](image)

2. Cut one 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.](image)
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.](image)

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.](image)

8. If applicable, 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. The phone should be mounted such that it is not in contact with any metal components on the Robot. If it is in contact with metal, the phone becomes susceptible to Electro Static Discharge.
3. Similarly, teams should 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.
4. Make sure that the phone is easily accessible for charging, programming, and emergencies.
5. 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 FIRST Tech Challenge teams.

![Figure 21: The cable is not supported and is easily damaged or disconnected. The phone is also in direct contact with metal.](image1)

![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.](image2)

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 both the new and legacy electronics. This section will detail these issues and offer solutions

Connection Issues
Note: Before wiring a Robot make sure to inspect the ports on all of the modules. It is possible for the pins in the module ports to be damaged. **If this is the case do not use the module.** It should be sent back to the manufacturer for repairs.

Problem: It is common for teams to experience connection issues with the new technology. There are a number of tricks teams can implement to reduce these issues.

Mitigation: The most important and effective solution is for teams to take great care in supporting every single one of their wiring connections. Using 3D-printed supports for the USB connections where they plug into the core modules has proven to greatly reduce connection issues. Zip-tying the USB cords to these supports adds even more strain relief. There are a variety of designs already available for teams online.

![Figure 23: Make sure every connection to and from the modules are supported.](image)

Mitigation: Isolating electronics from metal components of the robot also cuts down on connection issues. Mounting the electronic components on plastic areas of the robot helps to isolate them and cuts down on the effect of Electro Static Discharge.

Mitigation: Make sure that the USB cords are high quality and plug snugly into the modules. Cords that allow the plug to wobble at the connection to the module can contribute to connection issues. Cords with built-in ferrite chokes should be used, as they decrease the effects of Electro Static Discharge. Flexible cords also allow for ease in routing and cut down on wear and tear.
Mitigation: The wheels used on the Robot can play a big part in connection issues due to Electro Static Discharge. Before making a decision on wheels, Teams should research the pros and cons of the particular model and make a decision accordingly.

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 24). These loose strands of wire are problematic and make it easy to inadvertently create a short circuit.

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 25). Ferrules are the industry standard for providing a robust connection in a screw terminal, and they are inexpensive and easy to install.

Installing Ferrules

1. Cut wire to proper length:
2. Strip off the end of the wire insulation:

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:

5. Crimp:
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, it is common for a temporary disconnection to occur. Depending on the cable that comes loose this can cause the Robot to disconnect for the remainder of the match.

**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 30 and 31: YRB and WRB Markings on the Servo Controllers.](image)

**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 help suppress interference 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. The cords included with the Modern Robotics electronics come with built-in ferrite chokes.

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 32 - 35.)
  o Zip ties allow teams to quickly tie down wiring.
  o Wire loom allows teams to quickly protect at-risk wiring.
  o Self-adhesive cable tie mounts allow teams to attach wires to surfaces without holes.
  o Grommets protect wire from damage when it is passed through a hole with sharp edges.

![Figure 32, 33, 34, 35: 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:

- Minimize connection errors with the Android phone
- 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 36).

![Figure 36: 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 37). 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 37: A simple wiring diagram.

Use the Proper Tools
Proper tools ease the implementation of wiring (see Figures 38 - 42). Tools like the Anderson PowerPole crimping tool and small nippers will greatly aid in clean wiring.

Figure 38: Wire strippers.
Figure 39: Small screwdriver for tightening screw terminals on Legacy modules.
Figure 40: Small nippers for cutting zip ties.
Figure 41: Ferrule crimpers.
**Label Wires**
Properly wire labeling quickly solves many problems (Figures 43 and 44). It helps in the creation of a wiring document and also cuts down on time devoted to maintenance and troubleshooting.

**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 45).
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](http://www.firstinspires.org/node/5291)

Modern Robotics also has descriptions of the new technology: [http://www.modernroboticsinc.com](http://www.modernroboticsinc.com)
2016-2017 FIRST® Tech Challenge
Robot Wiring Guide

Appendices
Appendix A: Resources

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

Anyone may view questions and answers within the FIRST® Tech Challenge Game Q&A forum without a password. In order to submit a new question, you must have a unique Q&A System User Name and Password for your team.

**FIRST Tech Challenge Game Manuals**
Part 1 and 2 - [http://www.firstinspires.org/node/4271](http://www.firstinspires.org/node/4271)

**FIRST® Headquarters Pre-Event Support**
Phone: 603-666-3906
Mon – Fri
8:30am – 5:00pm
Email: FTCTeams@firstinspires.org

**FIRST Website: firstinspires.org**
- [FIRST Tech Challenge Page](http://www.firstinspires.org) – For everything FIRST Tech Challenge.
- [FIRST Tech Challenge Volunteer Resources](http://www.firstinspires.org) – To access public Volunteer Manuals.
- [FIRST Tech Challenge Event Schedule](http://www.firstinspires.org) – Find FIRST Tech Challenge events in your area.

**FIRST Tech Challenge Social Media**
- [FIRST Tech Challenge Twitter Feed](http://www.twitter.com) - If you are on Twitter, follow the FIRST Tech Challenge twitter feed for news updates.
- [FIRST Tech Challenge Facebook page](http://www.facebook.com) - If you are on Facebook, follow the FIRST Tech Challenge page for news updates.
- [FIRST Tech Challenge YouTube Channel](http://www.youtube.com) – Contains training videos, Game animations, news clips, and more.
- [FIRST Tech Challenge Blog](http://www.firstinspires.org) – Weekly articles for the FIRST Tech Challenge community, including Outstanding Volunteer Recognition!
- [FIRST Tech Challenge Team Email Blasts](http://www.firstinspires.org) – contain the most recent FIRST Tech Challenge news for Teams.
- [FIRST Tech Challenge Google+](http://www.google.com) community - If you are on Google+, follow the FIRST Tech Challenge 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!