Guide to Electrical

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Electrical

Planning Electrical System

- Plan, create drawings just like mechanical systems
- Create a test bed early
- Use test bed to test all systems before integrating
- Communicate effectively with the mechanical sub-teams early and often
- Document everything
- Think ahead to as to the function of the robot systems in a real world example.
    - What actually will take place on your robot
    - Perhaps what is taking place on your robot today.

Layout Tips

- Label and/or Colour Code Everything
- Secure wire so a hit from another robot doesn't stretch the wiring to a breaking point or pull a terminal out of a breaker, victor or spike
- When in doubt, insulate
- Secure the battery so it doesn't fall out
- Leave some slack in wire to allow for swapping of parts
- Be careful when running wiring through frame members so that mech heads don't drill into it at some point down the road
- Check every crimp to make sure the wires do not move or turn when pulled
- Use the correct tool for the job
- Solder all critical joints
- Shorten the length of your wires (also helps in keeping things neat and traceable)

Before You Start

1) Know your robot system

- It is essential to know the list of requirements for the system before you begin.
- It is essential to have an grasp on the location of mechanical parts and needed clearance.
- Must work with mechanical designer to place major components in a central location, i.e.battery, main breaker, fuse panels.

2) Know how many motors will be used

- How many and what type of motors for drive and where located.
- How many motors for actuators, are they required to be speed controlled or operated by relay.
- How many motors for steering.
- How many servo motors.
- Where will all these be located on the robot?

3) Know if you will be using sensors

- Light Sensors
- Gear Tooth Sensor
- Accelerometer
- Current Sense
- Custom Sensor
- Camera

4) Do the sensors need power?

- What sensors need 5 volts, what need 12 volts?
- Will the power be provided by a Custom Circuit, RC or Breaker?

5) Know what electrical hardware you will be using

- How many Victors and how many Spikes will be needed?
- Will you be using the SLU or crimp connectors for the mains wiring?
- How do I attach cable to the battery terminals?

- Do I need to use insulated or non insulated terminals?
- Do we need to solder?

6) Know the installation failure modes of all devices.

- How should it react when powered?
- Does it have indicators and what do they mean?

7) Know the correct handling of all devices.

- What component is best for terminations?
- What are the mechanical stresses due to mounting and termination?
- What happens if you drop the device?
- What is the correct wiring polarity?
- How should it be electrically protected?
- Is there a common mistake when installing?

8) Know the mechanical layout of the robot.

- Work with the mechanical designer to position electrical parts. Keep in mind shortest wire runs, protection of electronic components and try to balance out the distribution of loads equally
- Establish mounting areas for:
  - Main battery, low and near the centre of robot.
  - Main circuit breaker, accessible but not vulnerable.
  - Location of the Terminal Blocks to minimize wire length and allow easy connection of 40 amp returns.
  - Location of circuit breaker panels to minimize wire from terminal block
  - Location of Speed Controllers and Spikes
  - Wire runs and tie down points
  - Sensors
  - Custom Circuit Board
  - Special needs, i.e. moving assemblies, removable modules, optional motors, multiple configurations.

Mounting Your Electrical Components

Be prepared to change with mechanical design changes!

1) Battery

- Mount so that heat generated within the device can escape.
- Mount near centre of robot for better balance.
- Mount so that it will not move when the robot is struck.
- Mount so that it will not contact metal parts when installed or removed.
- Insulate all exposed metal, both terminals, please.

2) Main Breaker

- Position the breaker so it is easy to get at from outside the robot!
- Mount breaker on a flat surface so that the body of the breaker cannot be stressed or cracked.
- Mount where the breaker will complete the shortest run from battery disconnect to first distribution block.
- Mount so that mechanical systems cannot move against the terminals and other robots cannot push the reset button.

3) Power Distribution Panel (PDP)

- Near main breaker to minimize wire run.
- In a visible spot on the robot so you can see that all breakers are installed and wiring is correct gauge.
- Mount away from high temperature components, i.e. away from drive motors. Heat will affect the trip point on circuit breakers.
- Do not mount upside down. Breakers will loosen and fall out.

4) Terminal Blocks

- The terminal blocks should be close to the main circuit breaker and battery negative wire.
- Blocks should be close to the Maxi-block fuse holders.

- Blocks should be centrally located within the robot for balanced wire runs to drive motors.
- Blocks may be mounted in any position but need access to screws for securing wires.

5) Speed Controllers

- Do not confine or cover the controller.
- Mount so that it is easy to replace.
- Mount so that it is between the breaker panel and the motor in a nearly direct line.
- Mount so you can check hardware, check PWM cable, have access to brake jumper and see the indicator.
- Mount so you can calibrate!

Common Mistakes

- **Long wire runs**
  - Adds resistance and lowers available current to motors.
  - Difficult to troubleshoot.
  - Needs wire management.
  - Worse case when using smaller than optimal wire gauge (#12 or #14).

- **Components mounted where convenient not where practical for lowest loss or replacement**
  - Adds to wire length.
  - Requires longer control PWM wiring.
  - May put components out of sight.

- **High currents shared in same wire**
  - Currents add together reducing available voltage.
  - Currents shared by same terminals.
  - Add to wire and breaker heating.

- **Bad crimp-on solderless connectors. (either bad crimp or loose/spread contacts.)**

- Raises effective resistance of circuit.
- Causes localized heating at connector.
- Heat causes higher resistance of contact, domino effect leads to failure

- **Low values for breakers**
  - Using a 30 amp breaker instead of a 40 amp does not limit the current on CIM and FP motors.
  - Early tripping of breaker.
  - Breaker overheats and trips at less than specified current.

- **Using smaller wire gauge to save weight**
  - Smaller gauge limits available current.
  - Chalupas and FP motors run better with #10 or larger.
  - Robot wire gauge rules do not follow National Electrical Code. Ampacity is increased because the heating time is short and wire is in open air.
  - Crimp on connectors (on #12 or #14) are under sized for actual current. This causes voltage drops and high heat. At breaker panel(s) this will result in breaker heating.
  - Small wire does not fit the Maxi block insert points.

- **Using the supplied alligator clips on the battery charger to connect to the Anderson Connector**
  - This causes scratching of the Anderson contact surface. The scratches create high spots which reduce the contact area and therefore increase the resistance of the contact. This causes extreme heating during high current peaks. Early connector failure is almost always the result.
  - The high heat in turn is conducted through the wire into the main breaker which lowers the point at which it trips.
  - No way to effectively insulate the supplied clips.

- **Loose connections**
  - Loose hardware on battery, main breaker or breaker panels causes heating and voltage loss.

- When using the maxi blocks, improper termination of the #6 wire reduces the effective connection to that of a #10 or even a #14 wire.
- Loose connections on Victors cause intermittent operation. Stutter drive motion of a robot is generally a result of loose hardware.

Common Fixes

- Keep wire runs short, especially those that share currents (#6 primary wiring).
- Mount components in practical locations for short wire runs and easy access.
- Be sure of crimp on connectors by using a ratchet style crimper and/or solder all crimp connections.
- Use 40 amp breakers for Chalupas (large and small) and FP when used for drive.
- Use #10 wire for high current loads. The weight saving of #12 does not justify the loss (almost double that of #10)
- Add a 50 amp Anderson Connector to your battery chargers. It prevents scratching and reverse polarity. The charger may only supply 6 amps but the battery more than 500. This will weld wires in the event of a short.
- Use lock washers between the battery terminals and the wire terminals to prevent terminals from twisting and causing loose hardware.
- When using the Maxi block, terminate the #6 by stripping back 3⁄4 to 1” of insulation and folding the wire back on itself. This causes the wire to be the diameter of a #2 wire which is the largest wire designed for that block.
- Solder KPA4C connectors after you have tightened the clamp screw so they don’t loosen up. These connectors are meant for a non vibrational environment. Heat terminal then apply solder to the end of the wire and inside terminal. Do not allow solder to wick under the insulation. This reduces the flexibility of the wire.

Some Rules of Thumb

- Wire Foot(WF)
  - Equivalent to loss in 1 foot of #10 wire.
  - At stall current of the three large motors, about 100 amps, this is equivalent to 0.1 volt/wire foot(WF).
  - 1 ft. of #6 wire =0.5 WF
  - 1 ft. of #10 wire=1 WF
  - 1 ft. of # 12 = 2 WF
  - Battery Internal Resistance=11 WF
  - Victor Series Resistance=6 WF
  - Bad crimps=1-3 WF each
  - Remember, there are two wires in every circuit, positive and negative.

- Murphy's Law
  - Anything that can go wrong will...at the worst possible time.
  - Robot postulate...It will go wrong in the last match of the finals on Einstein.
  - My favourite is Murphy's Law of selective gravitation. A dropped tool will fall where it will do the most damage.

Links

- How to setup the 2015 RoboRIO and control systems
  - https://wpilib.screenstepslive.com/s/4485/m/24166/l/144971-wiring-the-2015-frc-control-system

- FRC Pneumatics Manual
  - https://rps01.usfirst.org/frc/manual/2015/2015FRCPneumaticsManual.pdf

- How to wire 2015 Pneumatics
  - https://wpilib.screenstepslive.com/s/4485/m/24166/l/290495-wiring-pneumatics-in-the-2015-system

WORKS CITED

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- Electrical Tips: http://www.firstnemo.org/PDF/electrical_tips.pdf

- Electrical ThinkTank Articles: http://thinktank.wpi.edu/tag/3

- Electrical design and technique: http://thinktank.wpi.edu/article/149

- Electrical and Control System: http://thinktank.wpi.edu/article/37

- Electrical Design: http://thinktank.wpi.edu/article/37

- Wiring the FRC Robot: http://thinktank.wpi.edu/article/68