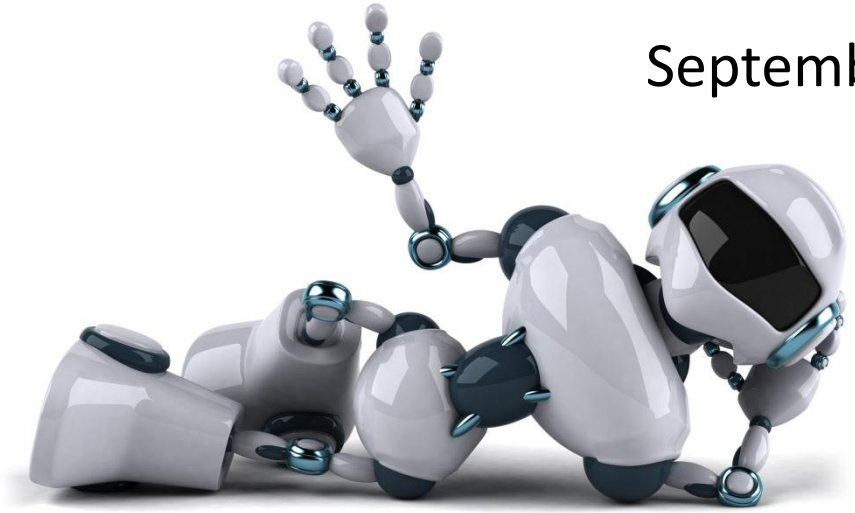
FTC Robots and ESD

Presented by Daniel Edwards

FTC Iowa Lead FTA

September, 2014



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Introduction

- ESD Overview
- FTC Official ESD Suggestions
- FTC Rules related to ESD
- Daniel's ESD Suggestions
- Colleen – Wiring Guide
- Resources

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What I am, and am not-

- Official FIRST Information vs. FTA Experience
- I am not authorized to interpret game rules ☺
  - Use the forums to submit official questions
- ESD is a complex topic!
- I don't know everything (sshhh… don't tell!)

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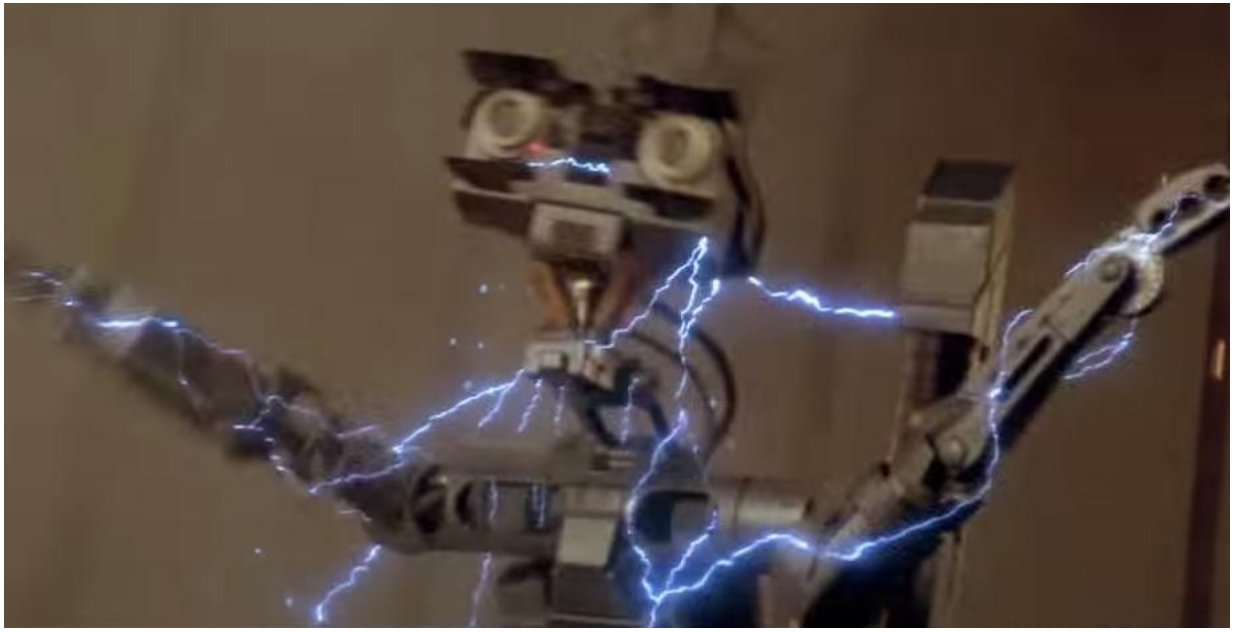
ESD Defined

- ESD = Electrostatic Discharge

ESD and FTC

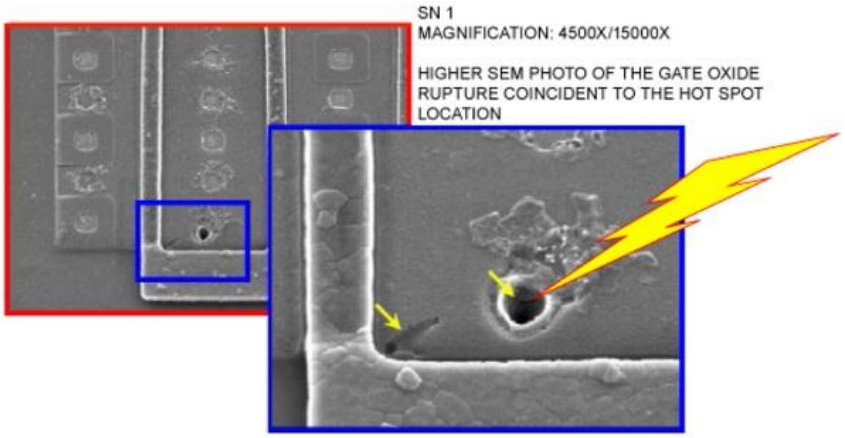
- “zorch” = zap + scorch, v. tr. To destroy or render unusable, esp. with electrical current of improper or fatal voltage or current.

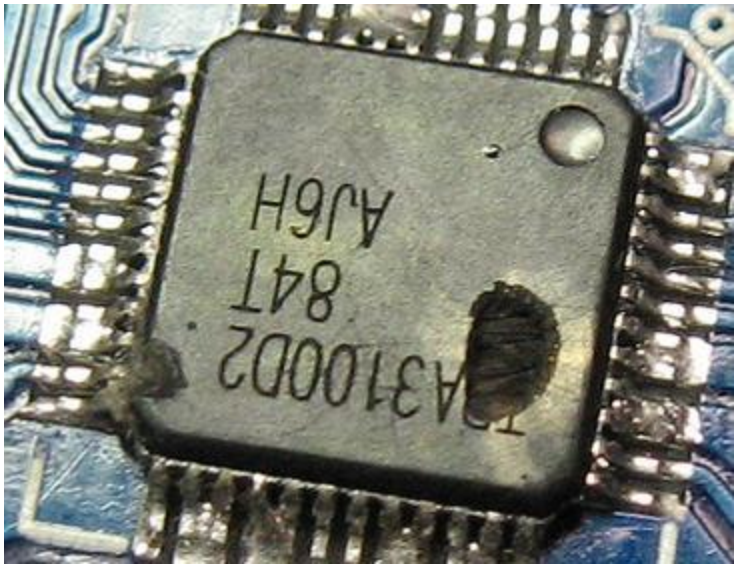
Source: (Urbandictionary.com)



Effects of ESD

ESD causes physical damage to electronic components.





Effects of ESD and FTC

- The typical effect of ESD experienced in FTC is a NXT “brick lock”.
- Typically the only way to un-lock a brick is to remove the NXT power source momentarily.
- An untimely brick-lock can decisively impact the outcome of a match!

The Trouble With the Triboelectric Effect.

- Tribble-electric what?

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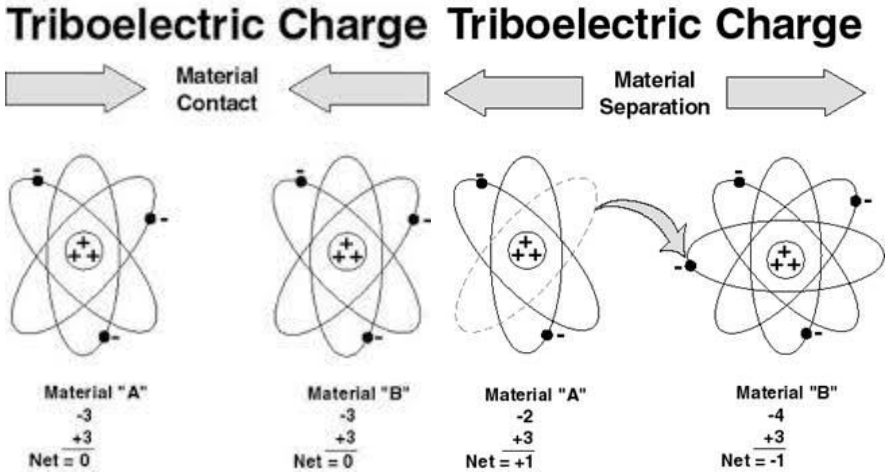
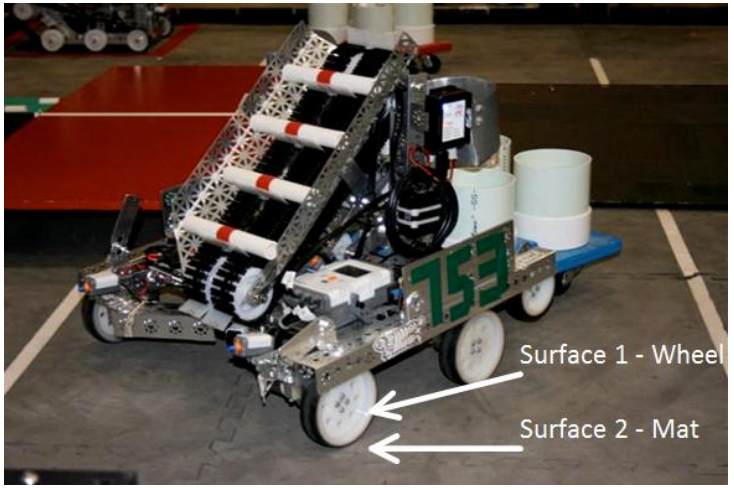
Triboelectric Effect & FTC

EVA foam mat tiles + nylon wheels:

FTC Robots are basically little static generators!





ESD is NOT the Only Cause of Lockups

- Faulty USB Cable
- Lose / unsupported USB cable
- Faulty I2C cable (black Lego cables)
- NXT physical abuse (e.g. batteries get disconnected momentarily after a direct hit)
- Power sags – loose Tamiya Connector

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What are the Factors?

- Humidity
- Field Mat Conductivity
- Robot Wheel Material
- Robot Wiring Practices
- NXT USB Surge Suppression & Chokes
- Insulation

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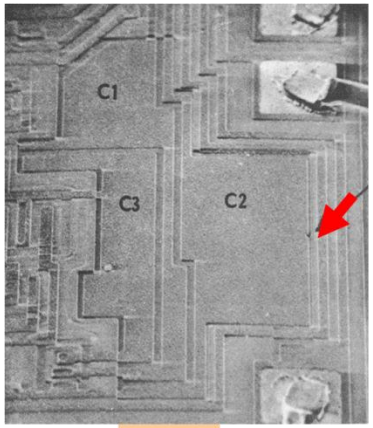
The effect of ESD is cumulative!

- ESD Damage is cumulative, and can cause irreversible damage to electronic components.
- Are you managing ESD at home?



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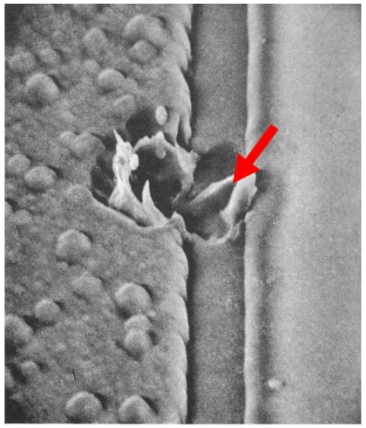
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Official FIRST ESD Techniques

- "Addressing NXT Lockups" from FIRST
  - The most sensitive element is the length and placement of the USB cable between the NXT and Samantha Module. Running a cable along the chassis, or having excess cable lengths make the NXT very susceptible to lockup.
  - FIRST allows a USB surge protector as well as chokes this year. The surge protector used in the ESD guide costs $18 and made a significant reduction in lockups. Chokes cost around $1.
  - Reduce Rapid Discharges: Insulate your robot from other robots, insulate the control system from the robot frame.

Official FTC Rules – ESD

- T1 (c) Team members are not allowed onto the playing field for any reason other than to place or retrieve their robots.
  - This means that if your robot locks up, you are **not** allowed to power cycle it! ☹
- <G15> At the conclusion of the *Autonomous Period*, … Power to the *Robot* may also be reset under supervision of the Field Technical Advisor as long as the *Match* is not extraordinarily delayed. If the *Robot* cannot be controlled after attempts to get it working with the field, it will be *Disabled* for the remainder of the *Match*.
  - During the pause between autonomous and tele-op ONLY, the FTA may cycle the power on your robot ONLY IF: The NXT battery is easily accessible, and they can do it without delaying the match.
  - If you change the default NXT display, the FTA may not be able to tell that your robot is locked!
  - If you think that your robot is locked, ask the FTA to reset your robot. ☺

Official FTC Rules – ESD

- <RG03> The following types of mechanisms and components are not allowed:
  - b. Those that could potentially damage or flip other competing Robots. (ESD may not be used as a weapon!)
  - i. Those that are designed to electrically ground the Robot frame to the floor.
- <RG07>
  - a. The NXT battery MUST be easily removable with minimal disassembly of the Robot
  - The NXT Controller and Samantha Wi-Fi Communication Module shall be mounted such that they are protected from contact with the Playing Field elements or other Robots. These and other electrical components (batteries, motor and servo controllers, switches, etc.) make poor bumpers and are unlikely to survive the rigors of game play when attached in a Robot-to-Robot contact area.

Official FTC Rules – ESD

- <G14> Matches are replayed at the discretion of the Head Referee and only under the following circumstances:
  - a. Failure of a Field Element that was likely to have impacted which Alliance won the Match.
  - b. Loss of control of a Robot due to a VERIFIABLE failure of the tournament-supplied FCS computer, FCS software, USB Hub, or Gamepad that was likely to have impacted which Alliance won the Match.
  - c. Loss of control of all four Robots due to a failure of the Field's wireless router that was likely to have impacted which Alliance won the Match.
  - Unexpected Robot behavior in itself will not result in a Match replay. Team-induced failures, such as low battery conditions, processor sleep time-outs, Robot mechanical/electrical/software failures, Robot communication failures, etc. are NOT valid justifications for a re-Match.
- <T1> b. Any questions for the referees must be brought forward by one student drive team member per team within the time period of two (2) matches following the disputed match. Students are required to support their questions by referencing specific rules or posts to the Q&A section of the official FTC Forum. Team members are required to ask their questions in a gracious and respectful manner.

Official FTC Rules – ESD

- 4-13-2014 Forum Ruling for 2013-2014 season: “The use of copper tape as any sort of a conductive media is not allowed. This type of ground strap concept was addressed … and is not allowed.
- …The technique described increases the total capacitance across the robot, providing for the potential of larger and more frequent static discharges to other robots. The same is true (by observation across multiple events) of the use of ground straps, hence their prohibition as well.

Pop Quiz

During a match, three out of the four robots stopped responding to the Field Control System. At the conclusion of the match, the FTA told me that he checked my robot and the NXT was locked up. What should I do?

a) It was clearly a field control failure; send one student to the question box and request a match replay from the head ref.

b) Consider implementing one or more additional ESD management techniques. All teams are subject to the same operating environment, and it is their responsibility to employ good ESD management.

c) Complain to the Tournament organizer that they need to apply more anti-static spray to the field surface.

d) Give up. There is nothing you can do because ESD cannot be eliminated.

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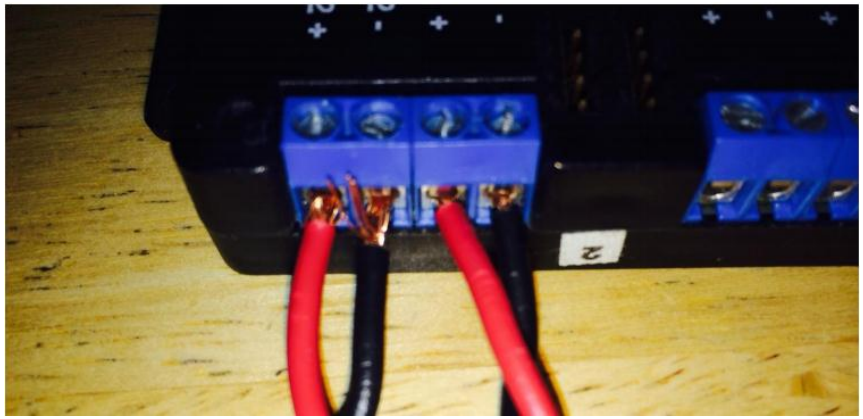
Unofficial FTA Observations

Unofficial FTA Observations

- Mounting control system components on a good insulator can make a real difference.
  - For instance: The screw heads on the bottom of the motor controllers make it easy for ESD to jump into the motor controller itself in an unintended way.
- A solid power distribution bus can make a big difference in surviving ESD events. Use Anderson Poweroles if possible. Use the correct gauge wire – heavier is better, so long as it fits correctly in the terminals. Do NOT daisy-chain using the motor controller terminals!
- Avoid running power cables right next to data cables when possible. Keep all cables as short as possible.

Unofficial Observations

- ESD likes to jump off of small points!
  - A frayed wire makes it easy for ESD to jump, or can even cause a short! Strongly consider bootlace ferrules. Do NOT tin your wires when using screw terminals.



Robot Wiring and ESD

- Colleen Johnson, Team #3595, Schrödinger's Hat, Alaska

Food for Thought

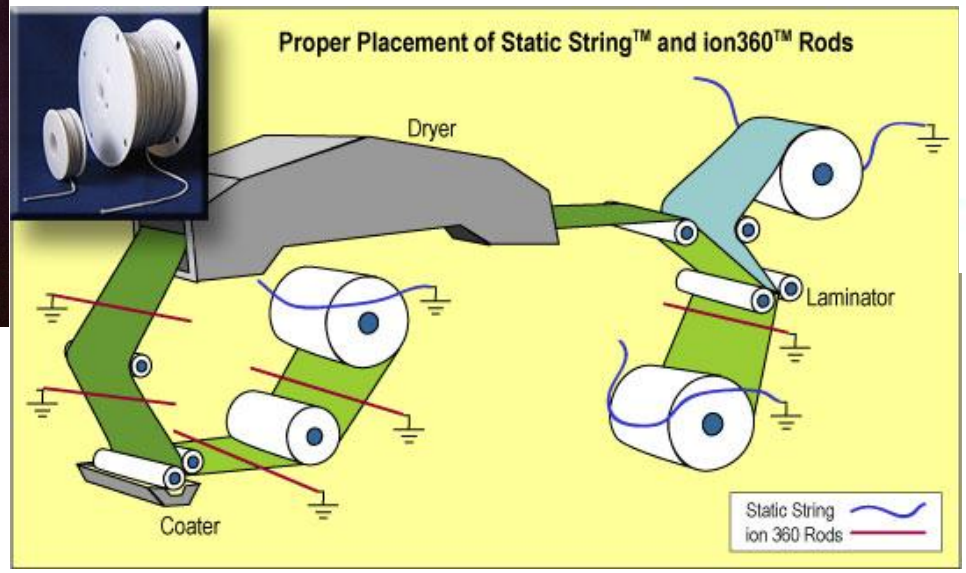
- What is the resistance from the exterior of your motor controller to the motor controller power wires? What might the impact of this be when your robot takes an ESD hit?
- What is the electrostatic charge affinity of the materials you have chosen for your wheels and the matt? How might you minimize the triboelectric effect with careful choice of materials? (materials science and engineering)
- How might you help limit the rate of charge transfers from other robots or field perimeter / elements? Insulating bumpers? Powder Coating? Conformal Coating? Gaffer's tape?

Food for Thought

What solutions have been developed in industry to effectively handle static buildup and ESD tolerance?

Corona Discharge

Might there be other ways to reduce static buildup without grounding to the floor?



Reference Materials

- http://www.usfirst.org/roboticsprograms/ftc/team-resources
- http://en.wikipedia.org/wiki/Triboelectric_effect
- http://en.wikipedia.org/wiki/Static_discharger
- http://en.wikipedia.org/wiki/Corona_discharge
- http://www.esda.org/fundamentalsp1.html
- http://www.esda.org/esd_fundamentals.html
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