Electrifying the High School Student Pipeline

Marc E. Herniter
Professor, RHIT

Thomas P. Foulkes
University of Illinois

- What do you love about power electronics?
  - Do high school students know this?
- Why is power electronics cool?
  - Do high school students know this?
- What is power electronics?
  - Has a high school student ever heard of it?
- Has a high school student heard of
  - Billions and billions of transistors on a chip?
  - A single giant transistor that can pass thousands of amps of current?
- We have a problem…..

Importance of tackling skills gap

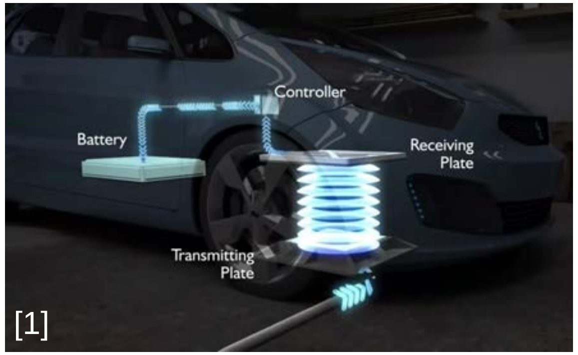
- Identified as one of the top risks to the U.S. transportation supply chain and modernization of the electric grid [1,2].
- Designing from a systems-perspective is a key skill requested by industry [3]
- Problem: High school students don't go into engineering.
  - High school students don't go into electrical engineering. (You can't take it apart…)
    - High school students have never heard of power electronics…
      - This is bad…..

[1] ARPA-E Summit, *Electrification of Vehicle Platforms Session*, 2019.
[2] Quadrennial Energy Report, *Transforming the Nation's Electricity System*, 2017.
[3] P. Krein, "Electric vehicle manufacturers need engineers with AI, robotic, and systems skills, *IEEE Spectrum,* July 2019

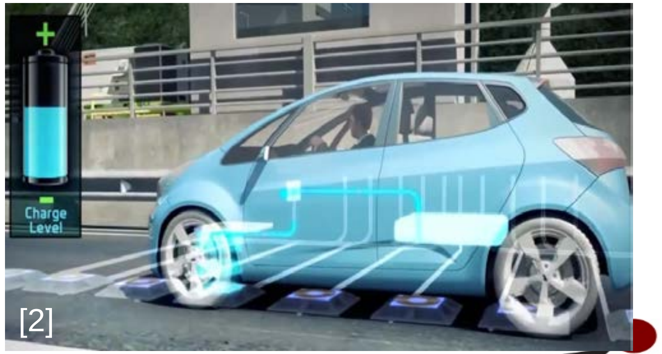
ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Introducing power electronics and system-thinking to address future need

- Goal 1: Making high school students aware of power electronics
  - Power electronics makes thing happen! This is not an mp3 player!
  - Things move, sometimes fast. Sometimes really, really fast….
  - Exciting things happen. Sometimes very, very exciting…
  - This is not your parent's transistor radio…
- Goal 2: Physics & energy modeling ("balance of plant") for battery charging and discharging
  - Increased number of sensors and processors become siphons for energy from the battery for autonomous electric vehicles



[1]

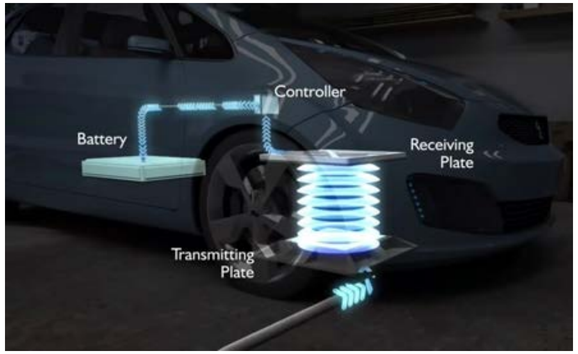


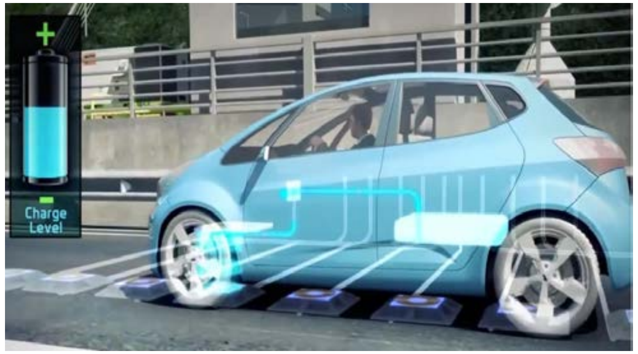
[2]

[1] O. Onar, "Oak Ridge National Laboratory Wireless Charging of Electric Vehicles – CRADA Report," 2016.
[2] O. Onar et al, "A novel wireless power transfer system for in-motion EV/PHEV charging." IEEE APEC March 17-21; Long Beach, CA. 2013.

Introducing power electronics and system-thinking to address future need

- Goal 3: Introduce students to soldering/debugging and circuit waveforms for car-side and track-side power electronics for in-motion wireless charging
  - Ability to charge while driving or facilitate fast-charging will require compact, lightweight on-board power electronics [1-4]
- Goal 4: Getting young people/high school students interested in power electronics.
  - It is not very often a high school student can participate in a project that shows them that they could be the people to make it happen in the future.
    - It does not exist now… It will exist… Someone has to do it… They will be the ones to make it happen…
    - This is not making a better toaster!

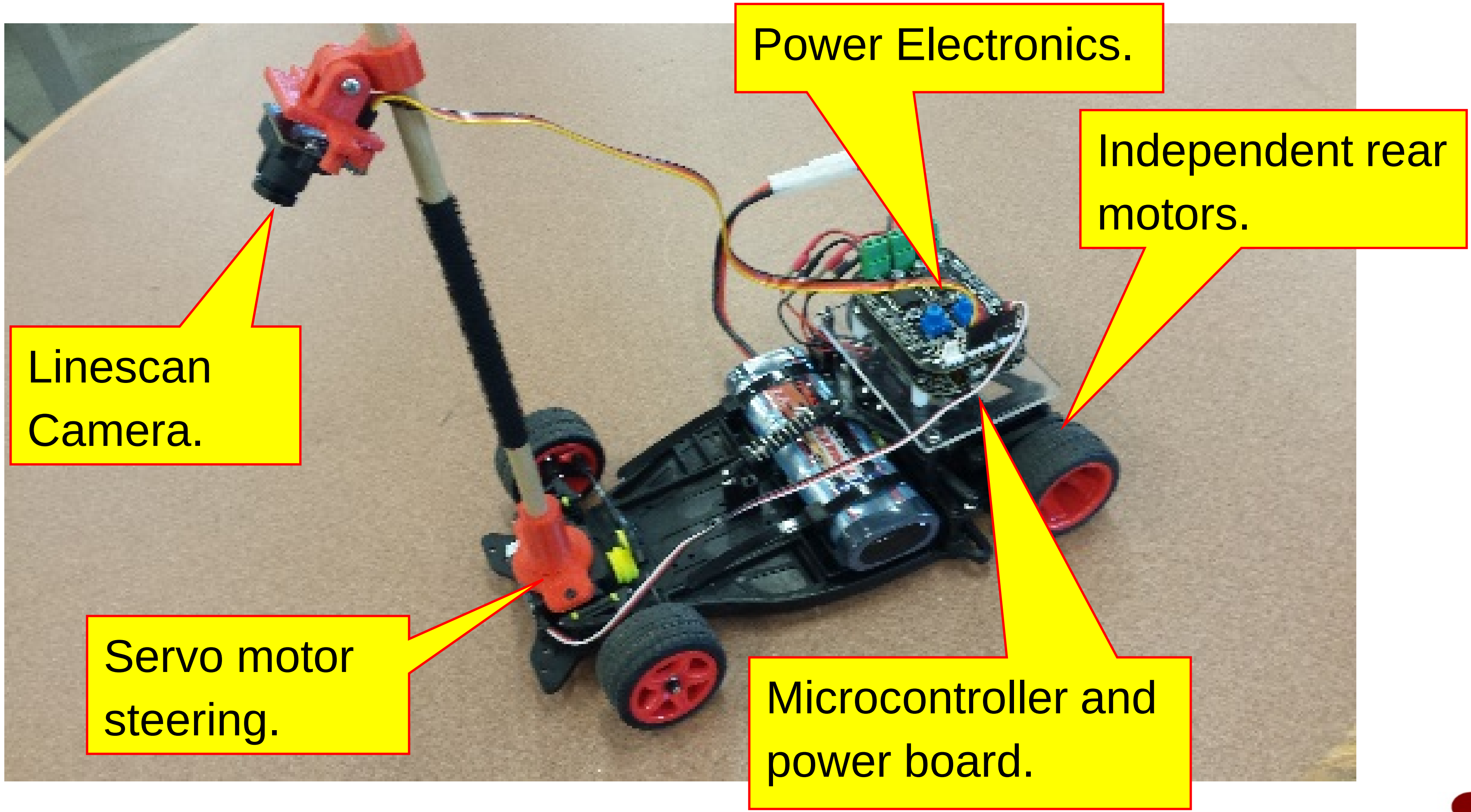




[1] O. Onar, “Oak Ridge National Laboratory Wireless Charging of Electric Vehicles – CRADA Report,” 2016.
[2] O. Onar et al, “A novel wireless power transfer system for in-motion EV/PHEV charging.” IEEE APEC March 17-21; Long Beach, CA. 2013.
[3] K. Afridi, “Wireless Charging of Electric Vehicles,” Frontiers of Engineering: Reports on Leading-Edge Engineering from the 2017 Symposium
[4] R. Bosshard & J. Kolar, “All-SiC 9.5 kW/dm3 on-board power electronics for 50 kW/85 kHz automotive IPT system.” IEEE JESTPE 5 (1), 2016

Autonomous Vehicle Challenge
ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Working to Meet Goals with High School Autonomous Vehicle Challenge

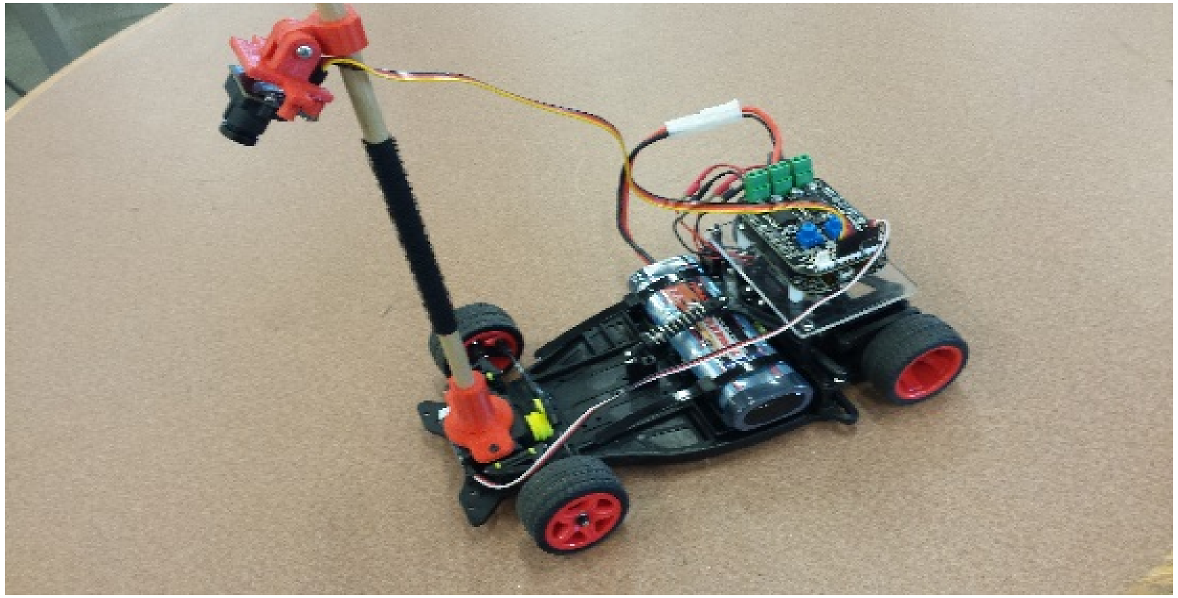


Autonomous Vehicle Challenge

ROSE-HULMAN INSTITUTE OF TECHNOLOGY

History

- Over the last five years over 500 students from 24 different schools have participated.
- Program a 1/18th scale vehicle to follow a random track autonomously as fast as possible.



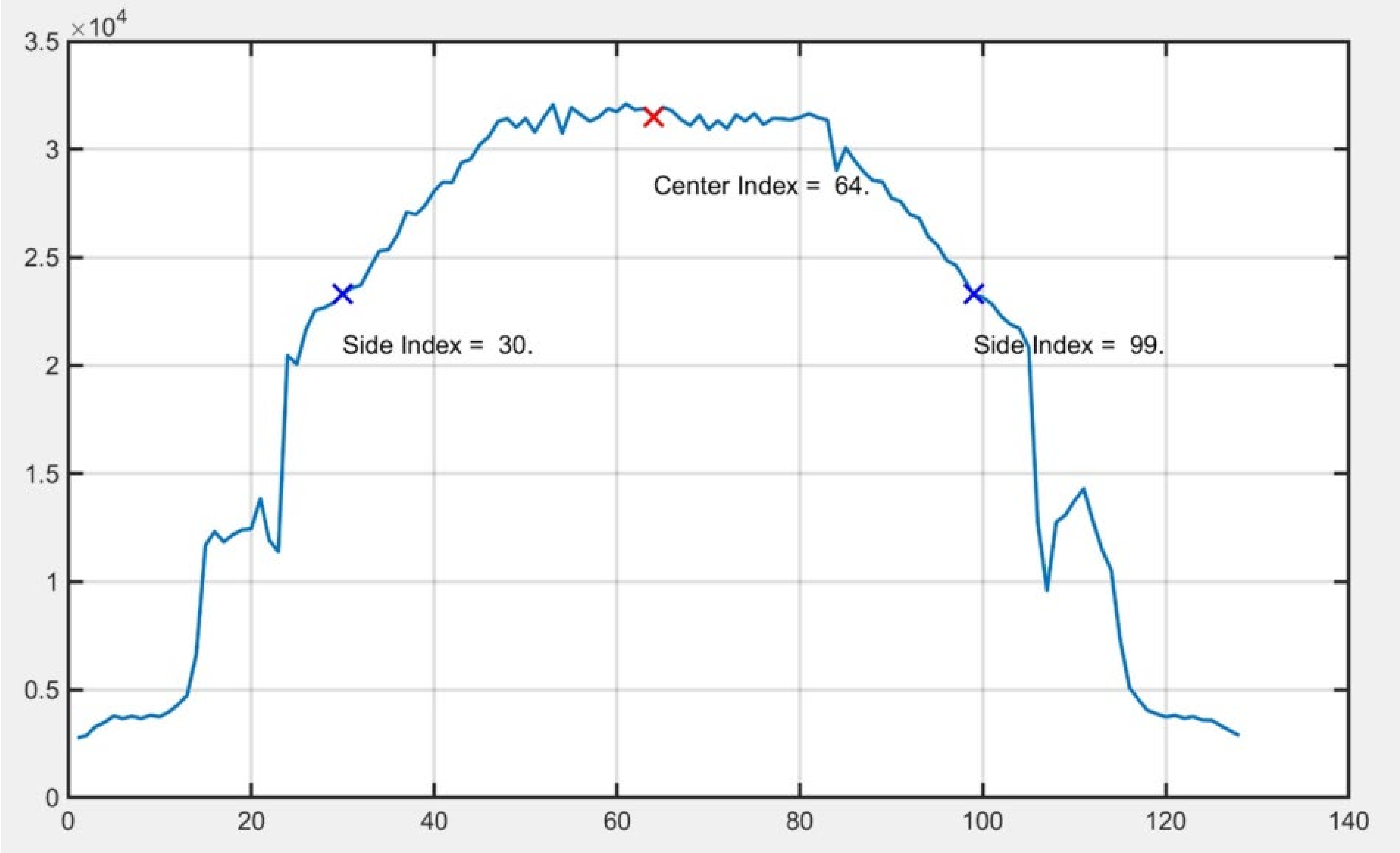
- Wouldn't it be cool if those 500 students knew what power electronics existed!

- [High School Autonomous Vehicle Challenge]
- [Micro Mouse Competition at APEC]

Autonomous Vehicle Challenge
ROSE-HULMAN INSTITUTE OF TECHNOLOGY

What Students Learn

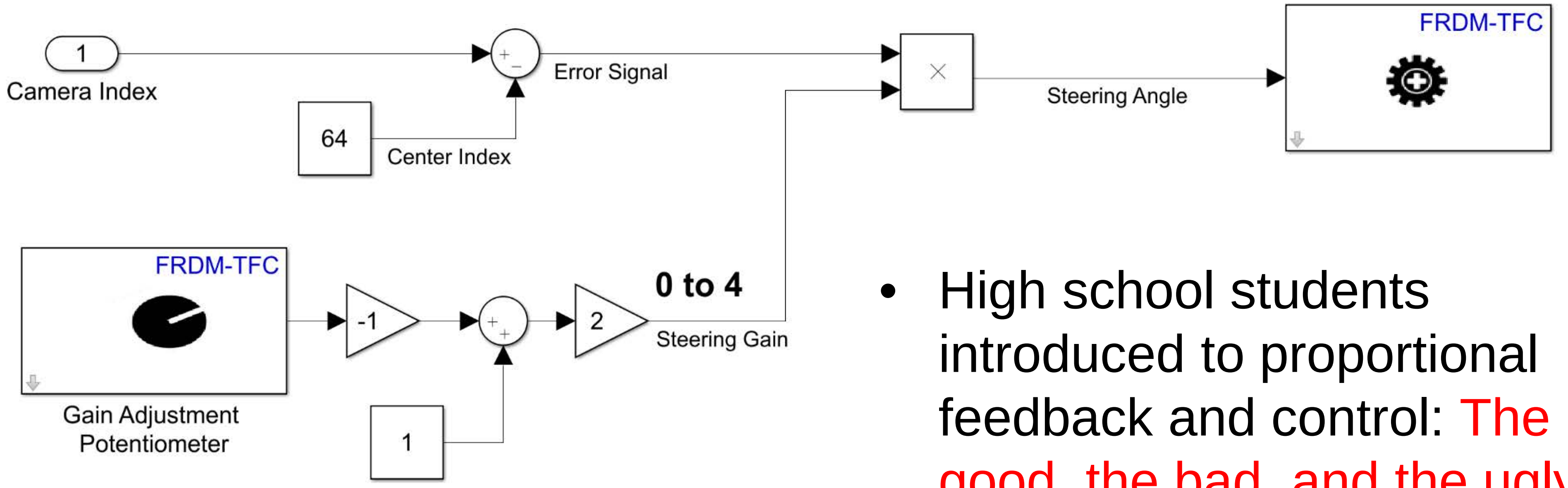
- Graphs? What do graphs have to do with the real world?
- Visualization – How do we follow a line given this information?



- y=mx+b
- Slope
- Y-Intercept
- Who really cares!?

What Students Learn

- Proportional Feedback

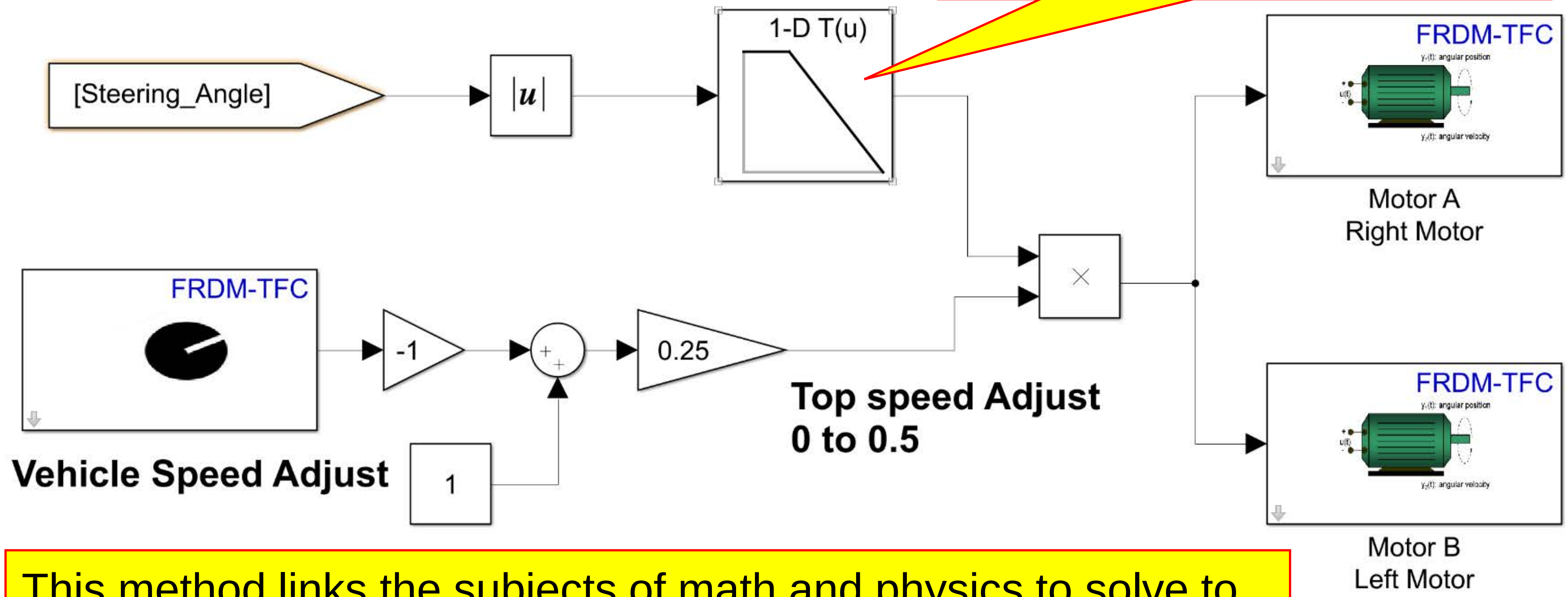


- High school students introduced to proportional feedback and control: The good, the bad, and the ugly.

What Students Learn

- Application of Algebra/Graphs/Visualization

Lookup table.
Graph → Physical Response



This method links the subjects of math and physics to solve to a contemporary problem. Students know autonomous and electric vehicles are the future.

The Present Competition

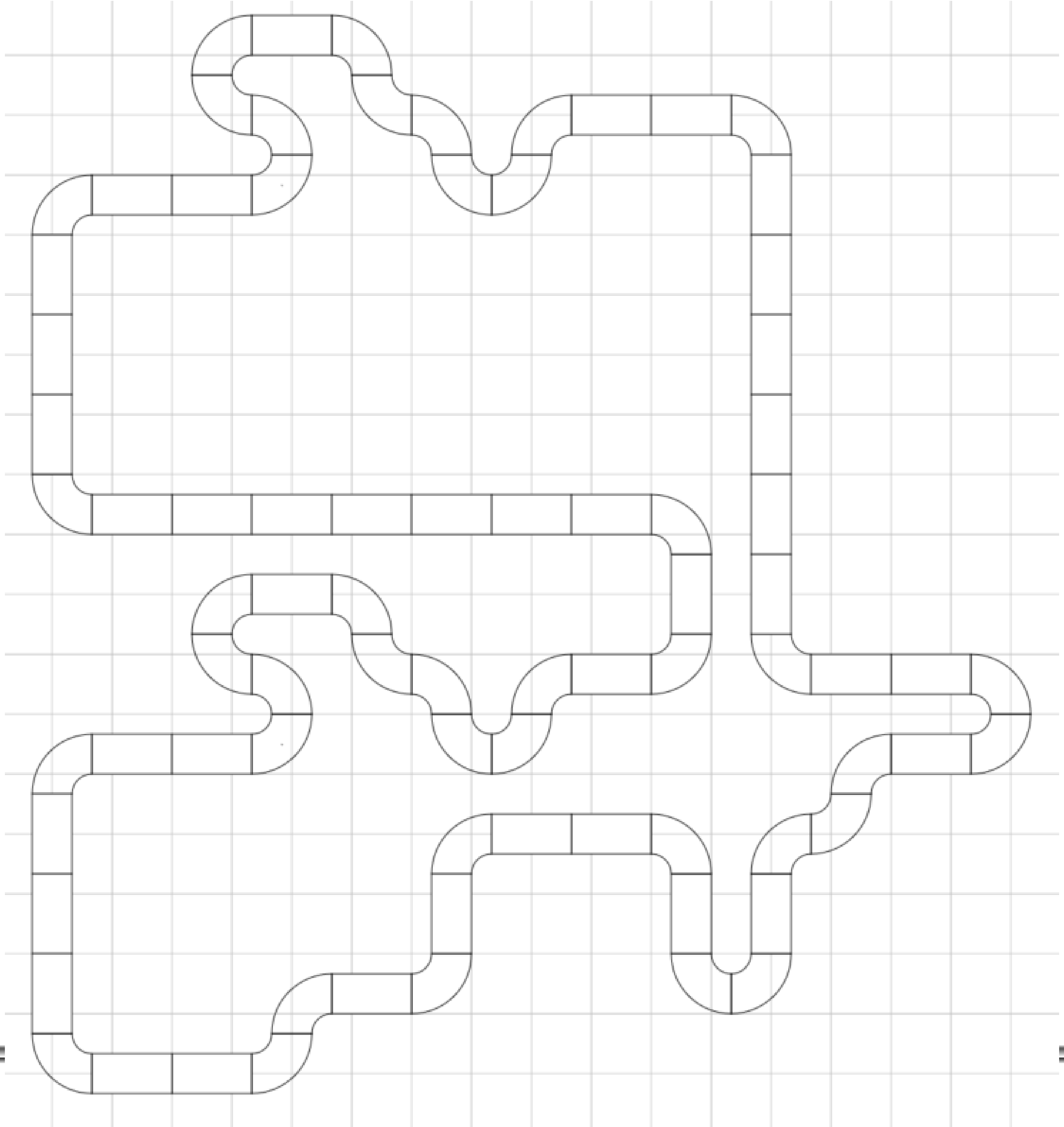
- What Teams Get (Free)
  - – Car Kit
  - – Laptop with Software Installed (MATLAB and Simulink)
  - – Oval Practice Track
  - – Technical Support from Rose-Hulman
- What Teams Must Do (Work)
  - – Program in Simulink
  - – Optimize cars for the following tracks:
    - Long Oval, Clover, Random

ROSE-HULMAN INSTITUTE OF TECHNOLOGY

What Students Learn

- Proportional Feedback Control
- Rear-wheel Differential Steering
- Slowing Down in a Curve
  - (Counter intuitive to a high schooler….)
- Accelerate out of a curve
- Memory Lock for Tight Curve
- Image Analysis and Processing
- Real-time programming

2018 Random Track



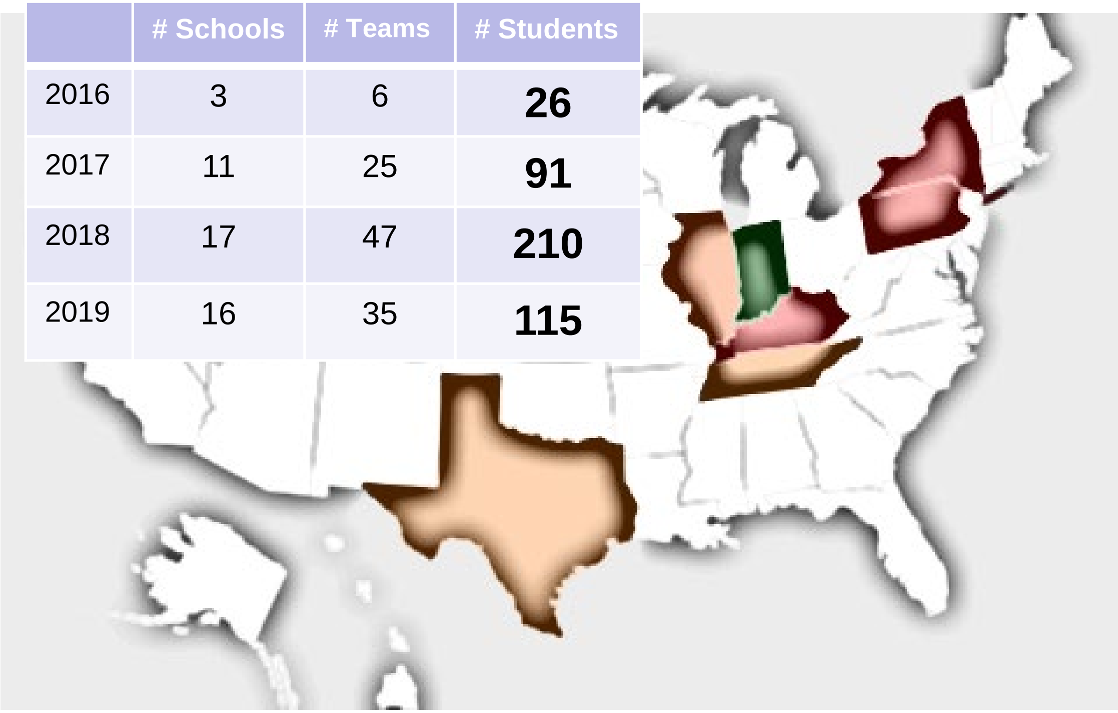
2019 Random Track

- One square = 3 Feet.

Impact

PSMA

	# Schools	# Teams	# Students
2016	3	6	**26**
2017	11	25	**91**
2018	17	47	**210**
2019	16	35	**115**



Teams from 7 states have participated

30% female participants

- Students are successful.
- We have yet to have a team that did not complete at least one event successfully.

The Future

- We have created a model that:
  - Is Inexpensive for schools to adopt
  - Is easy for teachers to incorporate into existing classes
  - Allows self learning by students
  - Can be expanded nationally and technically
- Expand the Scope of the Competition
  - Advanced manufacturing learning outcomes with 3-D printed chassis and accessories
  - Image recognition and deep learning modules
  - Power electronics learning outcomes with charging and solar powered vehicle activities

The Future

3-D Model of Vehicle
Equivalent to The Vehicle Now but Modular
Allows Expansion of Competition in Multiple Directions

Electrical
- Heathkit Type Modules
- New Sensors
- Lights
- Sound/Audio Amplifier
- Battery Charger
- Off-Line Charger
- Energy Monitor
- PV Panels

Control
- 2/4 wheel steering
- Create new 3-D parts
- Crash Avoidance
- Auto Stop
- Right Turn/Left Turn
- Vehicle Following

Mechanical Engineering
- Modify Components in the Vehicle
- Create new 3-D parts
- 2-Wheel Steering
- 4-Wheel Steering
- Center of Gravity
- Weighting
- Vehicle Floatation Device

Physics
- Energy Storage
- Coast Down
- Friction
- Vehicle Model
- Solar Power
- Cap Energy Storage
- Inductive Charging
- Water Thrust Motor

Computer
- Image Recognition
- Deep Learning

Thank You!

Questions?

For More Information:

Contact: Marc.Herniter@ieee.org

www: www.rose-hulman.edu/avc