E-Stop Design

ILLINOIS ROBOTICS IN SPACE

AE 199 IRS – NOVEMBER 3, 2014

JOSH RABINOWITZ

Review of Electrical Sub-teams

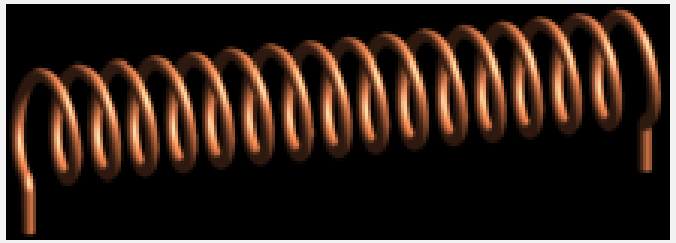
Team:	Purpose:	Responsible for:
Power Team	Promise reliable power to all systems	Battery selection, recharge management, power conditioning, power integrity, etc.
Electro-mechanics Team	Give muscles to the mechanical skeleton	Motors, linear actuators, servos, and other electro-mechanical systems
Integration Team	Ensure safety for design, engineering, and operation of the robot via system integration (interconnectivity, critical requirements and housing).	Emergency stop, signal and power integrity monitoring and design, wire harness, PCB design, 3D printed enclosures, Electrostatic discharge (ESD) protection, lab safety, etc.

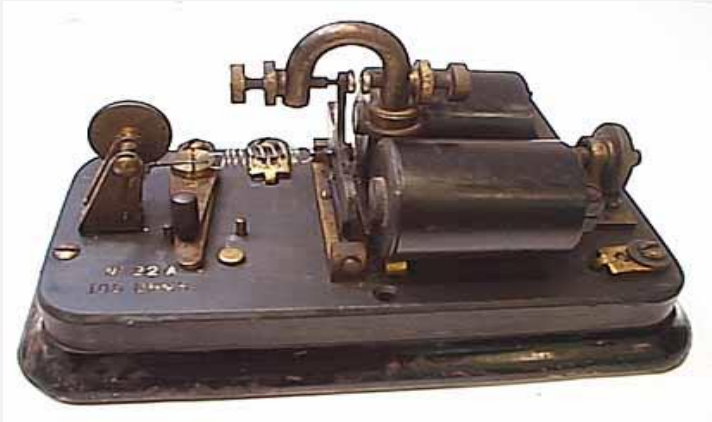
Emergency Stop Button

- NASA requires the robot to have a button which can completely cut power to the machine in an emergency
- Emergency Stop can't handle large current; therefore, charging circuit consists of relay, small battery and the red E-stop button
- It's important the e-stop system can not only cut power to the robot, but can also dissipate the accumulated charge within the circuits
  - (This is often done by adding a 'large' resistor in parallel with the e-stop system, as well as adding diodes in parallel to the inductive loads and motors)
- According to other IRIS members (this is my first year) the electrical team failed to discharge the circuit in a previous competition and the still-live electronics MELTED A SCREWDRIVER…
- Very dangerous with no E-stop and no ESD Protection (electrostatic discharge)!!

Designing the E-Stop

- The most crucial part of the e-stop design is what's known as the "solenoid"- a tight, helical coil of wire usually wrapped around a metallic core
- The concept used is induction: a small, separately attached battery (NOT to be confused with the large battery powering the robot, the power from which must be cut by this small system) sends a current through the coil and induces a magnetic field within
- This magnetic field forces the magnet inside the coil to move, usually opening/closing a circuit (opens in this case)
- This type of electrically induced switch is known as a "relay"- a device used commonly in EE since the invention of the telegraph





High Voltage Contactors

(Small, handheld contactors)

- Some relays are specifically designed for use with handling higher voltages
- (i.e. the variations used in large motor vehicles)
- These types of relays are referred to as “Contactors”
- Usually the threshold is about 15 amps/a few kilowatts
- The size of a contactor may vary…

(large, industrial-sized Contactors)

Choosing the Contactor

- Must take into account:
  - Contact voltage (must handle >50v)
  - Current rating (~20-30A cont.)
  - Coil voltage- possibly uses 3AA batteries (won't be over ~12V)
  - Weight- NASA requires entire robot weigh **less than 80kg** (excluding comm. Equipment not attached to robot)
  - Must consider not only weight of contactor, but weight of voltage source that charges it!

Requirements (Multiple Subsystems)

Requirement ID	Requirement	Subteams affected
R1	Shall compete on site at NASA Kennedy Space Center on May 18-23, 2015	M, E, A
R2	Shall perform two competition runs	M, E, A
R7	Shall weigh less than 80kg (not including communication equipment separate from robot)	M, E, A
R20	Shall include a manual operation mode as a backup	E, A
R21	Shall be capable of restoring manual control at any time during operation	E, A
R27	Shall deposit collected BP-1 and gravel into collection bin	M, A
R28	Shall be capable of operation regardless of initial orientation and position	M, A
R31	Shall move across obstacle area to mining area and back to start area to deposit regolith	M, A
R32	Shall be placed in start area and set up within 10 minutes, compete for 10 minutes, and be removed from pit within 5 minutes.	M, E, A
R33	Shall end operation immediately once power-off command is sent	E, A
R36	Shall deposit into Collection Bin placed adjacent to side wall, no gap, about 0.5m +/- .2m above regolith surface, 1.65x0.48m in dimension.	M, A
R47	Shall avoid 3 randomly-placed, 10-30cm diameter obstacles and 2 random craters with width and depth up to 30cm	M, A
R48	Shall not exit the Mining Arena during the competition attempt	M, A
R51	May separate at any time, but all parts of robot must be under control at all times	M, A
R52	Shall not ram a wall in the mining arena	M, A
R54	Shall not use walls as support or way to push/scoop regolith to accumulate for mining	M, A
R56	Shall be prepared to encounter airborne dust from either team during competition	M, E, A
R58	Shall have onboard power	E, A
R59	Shall have an easily accessible red emergency stop button	M, E, A
R85	May deploy or expand beyond 1.5 m x .75 m height after the start of the competition attempt	M, E, A
R89	Shall not exceed volumetric requirements in the case that a multiple robot design is implemented	M, E, A
R90	Shall not use physical processes, gases, fluids, or consumables that would not work in a martian environment	M, E
R92	Shall not use GPS, rubber pneumatic tires, air/foam filled tires, open or closed cell foam, ultrasonic proximity sensors, or hydraulics	M, E, A
R98	Shall not intentionally harm another robot. This includes network interference, BP-1 manipulation, physically colliding with another robot, or other offensive actions as determined by judges	M, E, A
R99	Shall fit inside the rear of a Chevy Suburban for Transport to Kennedy Space Center	M, E, A

And the last consideration…

(Continued)

- Price depends on manufacturer as well as design and operating principle
- Some contactors used slightly different internal designs to serve their purpose
- Ex. Some use multiple poles, or points of contact
- Previous IRIS teams used the

'Kilovac LEV100 Series 900V DC Contactor'

(pictured right)

Lastly: The Trade Study

			Alternatives						
		Weights	Kilovac LEV 100	Gigavac GX 11	Albright SW 200	Nanfeng Reversing	TE-Connectivity PRD	Omron General G7Z	
Measures	Cost	14.29%	16.66667	16.66667	13.88889	8.333333	25	19.44444	0
	Concact voltage	14.29%	35.55556	26.66667	6.666667	13.33333	8.888889	8.888889	0
	coil voltage	17.86%	15.15152	15.15152	15.15152	15.15152	24.24242	15.15152	0
	current rating	17.86%	15.90909	18.18182	21.59091	21.59091	10.22727	12.5	0
	weight	35.71%	23.37662	15.58442	9.090909	12.98701	20.77922	18.18182	0
		0.00%	0	0	0	0	0	0	0
		0.00%	0	0	0	0	0	0	0
		100.00%	**21.35565**	**17.70872**	**12.74441**	**14.2946**	**18.41772**	**15.4789**	**0**

(Most likely won't be re-using last year's contactor!)