SECS Senior Design
Available Projects – Winter 2022

Development of a lifetime testing rig for electromechanical actuators – Ewellix

Project contact: Michael Ridley (michael.ridley@ewellix.com)

Ewellix, formerly SKF Motion Technologies, is an innovator and manufacturer of linear motion components with a global footprint. Key industries include medical, mobile machinery and assembly automation. X-ray tables, baby incubators, hamburger grills or riveting actuators are only some of the applications we move. At our site in Armada, MI we design and manufacture actuators and ball & roller screws for the North American market. We have a range of exciting engineering projects and can offer a fun work environment for aspiring mechatronics engineers.

Do you want to be part of a team that sent a roller screw to mars?

Project description:

To support our product development and testing teams, we need to develop a new lifetime testing rig for electromechanical actuators. Test rigs are used to do in house testing of our products or prototypes in development before sending them out to a customer. The testing rig will need to meet the following criteria:

- Ability to mount an electromechanical actuator minimum of 100 mm retracted length to total extended length of 600 mm.
- Provide a resistance in “push” and/or “pull” with adjustable force up to 5 KN max. The force should be independently adjustable. Example, 5 KN push, 2 KN pull.
- Total test rig footprint cannot exceed 2 m^2.
- Target mechanical assembly cost $5k USD.

- Weight adjustment procedure needs to safe and ergonomic for the operator of the equipment

Electromechanical actuators and controls to drive the actuators will be provided by Ewellix. Ewellix has multiple working designs available for inspiration of a new design. Interest and skills in mechanical, electrical and/or software design are needed to tackle this project.

NOTE: Confidentiality and assignment agreements are required before students can begin work on this project

Active Aerodynamics on rear wing of Formula SAE vehicle

Project contact: Adam Polosky anpolosky@oakland.edu

Project Overview

Like most known sports, the success of a team relies not only in the hands of the athlete(s) which participate in the game or activity. Unique to motorsport though, is the dependence on mechanical ingenuity to create an advantage for a team to succeed. Formula SAE works as a playground in which students are able to stretch their engineering limbs to solve unique problems and create that competitive advantage among opponents.

During the 2021 Formula SAE dynamics competition, the Oakland University challenger, GR21, found significant struggle in two of the four events. The acceleration event and the endurance event both proved to be problematic for the team as times were considerably noncompetitive. It was found that the amount of drag created by the aerodynamic elements of the vehicle were a significant factor in the sub-standard times for these two events.

GR22 is comprised of 4 main aerodynamic components which in unison are designed to create downforce at speed so that the vehicle can maintain grip among all four tires and navigate corners quickly without adding significant weight to the vehicle. The four aerodynamic component groups on the vehicle are as follows: front wing, sidepods, undertray/diffuser, and rear wing. The production of downforce rather than adding additional weight, allow for the vehicle to maintain a low body roll moment, as well as a low center of gravity and the ability to map center of pressure.

Within this project, the rear wing will be the area of focus, with the goal to decrease drag force produced by the tertiary and quaternary elements of the wing. Upon command, the two wing elements will have their angle of attack decreased to an angle that roughly eliminates the drag produced by them when in default state.

The wing elements will be actuated by a servo motor housed within the elements themselves and will be triggered by several signals. The engage signals will be as

follows; manual button is triggered, vehicle reaches specific speed given rear tire slip below specified threshold. The disengagement signals will be as follows; manual button is triggered, brake pressure is applied, vehicle speed less than specified value.

Mechanical Design:
The design of the rear wing elements will be amended to introduce and integrate the servo motors which will be used for changing element angles. They are constructed entirely of carbon fiber and house 3 internal structures which assist in maintaining shape and rigidity under load. Wiring will be mounted within the honeycomb structure of the rear wing end plates so that they are hidden from view and do not create any aerodynamic disturbance.

Electrical Design:
The 2022 Grizzlies Racing vehicle utilized a CAN system through which all data is transmitted. The wiring of the servo motors will be integrated into this CAN system so that the signals required for activation and deactivation of the rear wings can be readily available. The signals of interest will be: a button located on the steering wheel, brake pressure sensor, wheel speed sensor, and wheel slip values which are calculated within the main ECU.

Expected Outcomes:
The overall goal of this project is to reduce the amount of drag produced by the rear wing's tertiary and quaternary elements via electromechanical actuation of the elements to change their aerodynamic angles of attack. After performing computational fluid dynamic simulations at different speeds, the expected outcome of the integration of this technology will be that at speeds above 30 miles/hour, the drag coefficient of the rear wing is substantially lower when engaged versus when disengaged. Following multiple validation tests, it is also expected that the wing elements will "open" and "shut" accurately upon signal activation or deactivation.

Development of Remanufactured Functional Test and Hysteresis Test for Smart Remote Actuator (SRA) – BorgWarner Corp

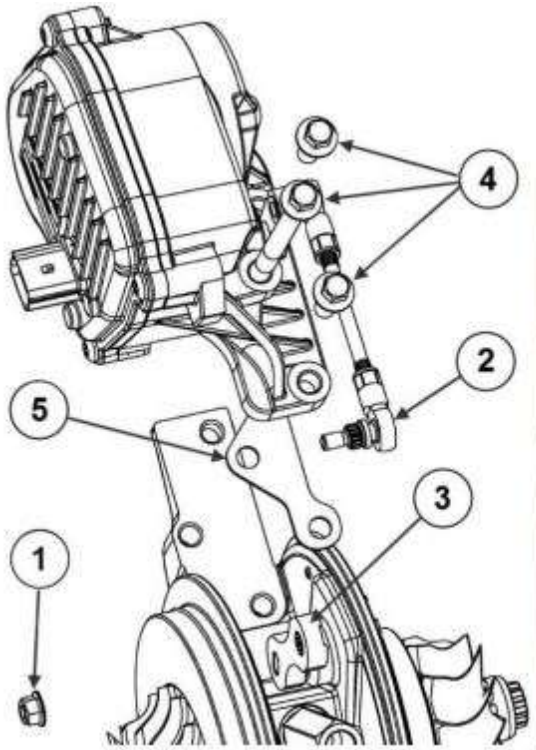
Project contacts: Yeshwant Bhoskar (ybhoskar@borgwarner.com), Dave Pierce (dpierce@borgwarner.com)

The automotive industry and their suppliers continue on the path to being "greener". The Remanufacturing path continues to grow from the traditional electrical / hydraulic components to reuse the emission controls components.

Most diesel engines incorporate a turbo to assist in the flow of air into the combustion chamber. To improve the compression of the air in the intake side, in the past decade or more; turbo manufactures have introduced the variable geometry turbocharger (VGT) to help "map" the demands of air supplied to the intake system. To control the VGT vanes, an electronic control device (SRA) is fitted. The SRA receives commands from the electronic control unit (ECU) via either Universal Asynchronous

Receiver/Transmitter (UART) or Control Area Network (CAN) communication protocols to move a driveshaft / linkage or gear drive to move vanes within the compressor side of the turbo. Position data from the SRA is then sent back to the ECU.

BorgWarner's - Delphi Technologies Remanufacturing is in the development stages of reverse engineering a reman strategy for the Continental Automotive SRA fitted to the BorgWarner V2S turbo system fitted to the Ford 6.4L Power Stoke or Navistar V-134 6.4L engine.



The proposed testing methods would be adapted to the current production test rig at the plant using CAN communications within LabView language. Included, in the project is any test machine fixturing to hold and support the SRA on the current test stand while being commanded from the test software

The expected outputs of this project are not limited to but should include the following:

- Establish a project timing plan
- Establishment and execution of a test plan using LabView
- Establishment a project budget
- Commercial cost assessment of proposed solutions
- Renderings of proposed solutions using a 3D CAD software
- Creation of DFMEA (Design Failure Mode and Effect Analysis) document(s)
- Development and documentation of required electrical interfaces (schematics)

- Gathering and processing of physical test data
- Make a substantiated design recommendation from which BorgWarner can further develop its remanufacturing process

If requested BorgWarner will schedule time or Oakland University students to review the production test stand that will be used for this project.

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Wire Harness Electrical Continuity Check – Lear Corp

Project Contact: Neil Martinuzzi (NMartinuzzi@lear.com)

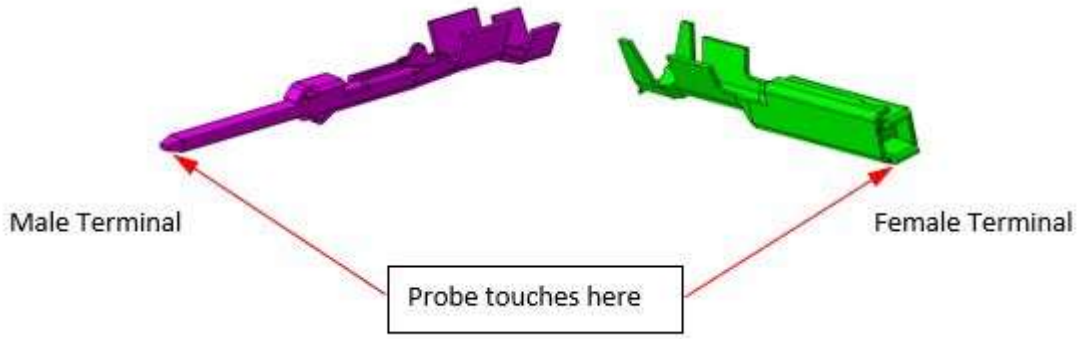
Every wire harness must successfully pass a electrical continuity check before it can receive a barcode and be shipped to the customer.

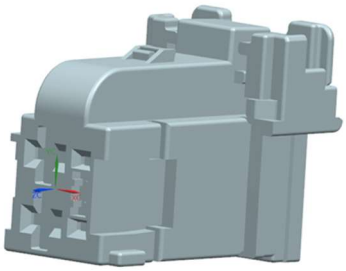
In the current process finished harnesses are placed on a test fixture, called an Offline Test Table (OLTT) or End of Line (EOL) tester. The harness is placed on the OLTT and every connector is inserted into a receptacle on the test fixture, the harness is now, 'locked' into the test fixture.

A program is run that causes test probes to come into contact with the terminals in all of the connecters, electrical current is run through probes, to the terminals and wires, if there is continuity in all wires, a bar code is printed and applied to the harness, the connectors are 'unlocked' and the wire harness is taken off the fixture, packaged and shipped to the customer.

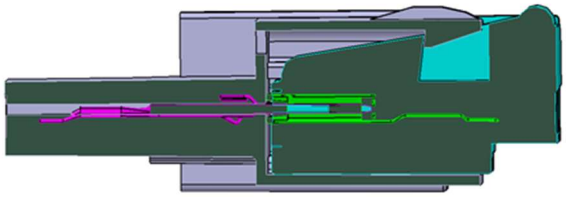
Designing the OLTT always includes a finished harness so the probes can be exactly positioned to touch the terminals. Waiting for a finished harness is too late in the process to be efficient. We have CAD Geometry of the terminals, connectors, and wire harness. There is not sufficient CAD detail in the connector models to accurately position the terminal in the connector.

-***If the test probes are incorrectly positioned, they could damage the terminals!*** -





Connector



Section through a connector showing insufficient CAD detail
to accurately position the terminals

Objective:
Create a method for a continuity check before the finished harness is available.

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Comprehensive Alerting Technology for Scooters (CATS) – Razor USA

Project Contact: Dan Champoux (dchampoux14@googlemail.com)

A suite of technology features designed to improve the overall micro-mobility experience. Each project team will:

Identify

- Learn about concerns with electric scooters: safety, usage rules, theft/abuse
- Review existing solutions related to your topic
- Develop a test plan to evaluate concept solutions provided
- Test concept solutions utilizing prototype vehicles
- Evaluate concept solutions in terms of effectiveness and feasibility (cost/benefit analysis)

Design/Create

- Develop low cost/high benefit solution for your topic
- Develop a system configuration app for calibration and demonstration needs
- Develop a “proof of concept” prototype of your solution

Iterate

- Develop a fully functional prototype of your solution suitable for “real world” functional testing
- Test, evaluate, and improve on your design
- Develop a “First article” sample of your solution suitable for customer evaluation
- Work with local suppliers to develop a short run manufacturing plan

CATS Team 1: Asset loss prevention - Detect and mitigate theft/abuse through alarms, IOT notifications, and countermeasures

- Unauthorized deck removal
- Battery kill switch
- Hardened deck lid (pry resistant)
- Unauthorized movement/abuse
- Battery removal/disconnect detection
- LMU removal/disconnect

CATS Team 2: Compliance with usage rules- Detect and mitigate improper usage through alarms, IOT notifications, and countermeasures

- Sidewalk riding (accelerometer, vision)
- Reckless riding
- Fall/accident detection
- Downed scooter detection (sidewalk clutter)

CATS Team 3: Active safety- Detect and mitigate riding hazards through improved situational awareness

- Front hazard detection (bell sound)
- Side approaching hazard detection
- Pot hole/curb detection

CATS Team 4: Visibility and audio - Improve night visibility and audio functions

- Smart running lights
- Turn signals

- Multi-use audio system
- Bluetooth speaker integration

CATS Team 5: Electronic cable lock - integrated anti-theft system tethers the scooter to a bike rack when not in use

- "Bolt on" universal "lock-to"
- Fully integrated "lock-to"
- Consider "fail-safe" circuit protection
- Include a manual disconnect
- Feedback and IOT notifications

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Next Generation Control System (NGC)

Project Contact: Dan Champoux (dchampoux14@googlemail.com)
Develop a complete control system for a Light Electric Vehicle. Each project team will:

Identify

- Learn about electric scooter control systems and their limitations
- Review existing research related to your topic
- Review COTS solutions related to your topic
- Evaluate potential solutions in terms of effectiveness and feasibility (cost/benefit analysis)

Design/Create

- Develop low cost/high benefit solution for your topic
- Develop a "proof of concept" prototype of your solution

Iterate

- Develop a bench prototype of your solution suitable for functional testing
- Test, evaluate, and improve on your design

NGC Team 1: Power Management - Battery and power distribution modules

- Battery Management System communications
- Power distribution (Full time: 12v, 5v, On demand: 36v, 12v, 5v)
- Battery "kill switch" (anti-theft)

NGC Team 2: Motor control - Three-phase, brushless, hub motor control module

- 3-phase induction control hardware
- Control software
- Calibration system: motor size, application, dual motor

NGC Team 3: Vehicle control - Manage functional subsystems (listed in priority order)

- Module communications
- IOT interaction

- Throttle interaction
- Audio interaction
- Lights interaction
- Brake interaction
- New Instrumentation panel: Speed & SOC
- New configuration/calibration system: application specific
- New CATS module interaction
- New OTA updates

NOTE: Confidentiality and assignment agreements are required before students can begin work on this project

Afreecar Solar Cart

Project Contact: Christopher Borroni-Bird (chris@afreecar.org)

The essence is to modify an existing commercial product (a power-assisted wheelbarrow, PAW - see attached photo) with the solar panel and power electronics that are currently on the current solar cart (see attached photo), so that the solar cart would be cannibalized for parts.

The following are changes that would be requested:

- Attachment of the solar panel to the PAW frame (creating a roof structure)
- Attachment of net/fence to side of frame to prevent goods from falling out
- Enabling the solar panel to charge the PAW's battery (so that the PAW can be either solar or mains powered or even both at same time)
- Enabling the PAW to have water-protected electrical outlets for charging of smartphones and 110V appliances (corn grinder, water pump)

Given more resources of time, the following changes would be desirable as well:

- Enabling a mechanical power take off (one or both wheels may need to be lifted
- off ground for this operation to occur)
- Enabling remote control operation of the PAW

By using a commercial product as basis for the solar powered cart, it is expected to be easier to test the operation of finished solar cart more easily and safely. Testing would involve measuring total vehicle mass, payload, range and speeds under varying “road” conditions (surface type and grade), solar panel efficiency in different weather conditions, etc.

The goal is to take this solar powered cart at the end of Winter semester and to test it on a local urban farm in Spring 2022 to demonstrate its utility and potential application to rural Africa.

NOTE: Confidentiality and assignment agreements are required before students can begin work on this project

OU Immersive VR Experience

Project contact: Khalid Mirza, PhD (mirza@oakland.edu)

Several years ago, a group of faculty and students from across campus (Art/Art History, SECS, others), supported by industry partners have committed to design and build a two-seat mechanical motion-controlled platform that will interface with visual triggers supplied by an interactive movie, creating a VR immersive experience. Nabtesco Motion Control is funding the project along with support from Rave Computers, Epic Games, Autoliv and Roush Entertainment.

This platform is to be a portable, flexible test bed for VR experiences. During the Fall 2018, Winter 2019 and Fall 2021 semesters, teams of ECE and ME seniors designed the actuator base using input from Nabtesco and Roush engineers. As a proof of concept, they produced two small-scale models and implemented rudimentary control system. The Fall 2021 group went through the complete system, modified it for more safety and portability, and finalized the controls and power requirements. With the

recent establishment of the Augmented Reality Center, construction of the full-scale platform can begin.

Construction of an Actuator Base for the OU Immersive VR Experience
In the Winter 2022 semester, teams of ME and ECE students, consulting with industry partners, will thoroughly review the present design, make changes where necessary, and construct and test the resulting motion-controlled system.