

ANthem

BRakes

Project Proposal

Electronic Actuated Braking system

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Road Map

- Project Background
- Market Placement
- Risk Analysis
- Standards and Regulations
- Project Overview
- Cost Analysis Results
- Current Schedule
- Meta Analysis
- Future Plans
- Conclusion

The Anthem Brakes Solution

1. Background/Current Hydraulic Solutions

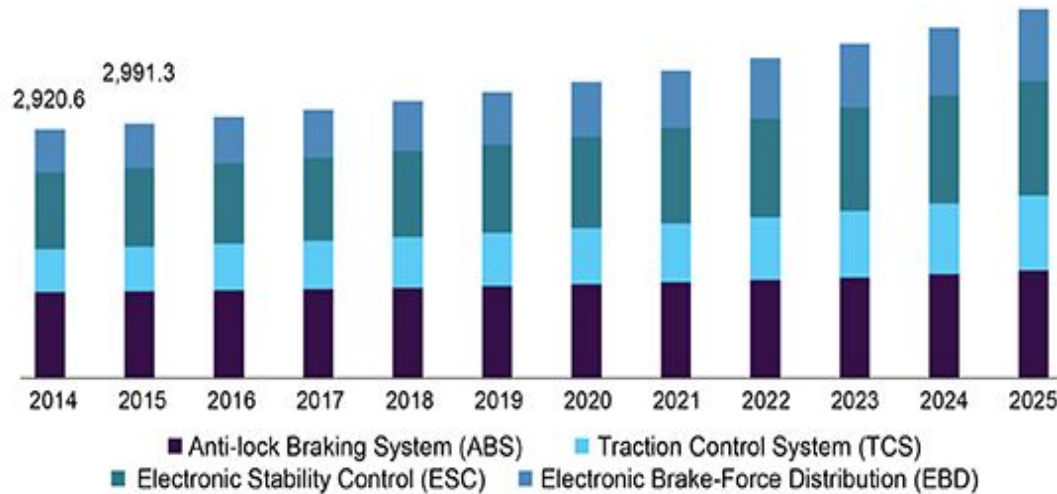
- a. Slower than electronically actuated brakes [1]
- b. Requires constant maintenance [2], [3]
- c. Wasted energy

2. Our Solution

- a. Increases safety
- b. Ease of integration with current expanding EV market
- c. No brake fluids

Market Placement

U.S. automotive brake systems market, by technology, 2014 - 2025 (USD Million)



Automotive brakes estimated growth [4]

Brake Type

- Disc
- Drum

Vehicle Type

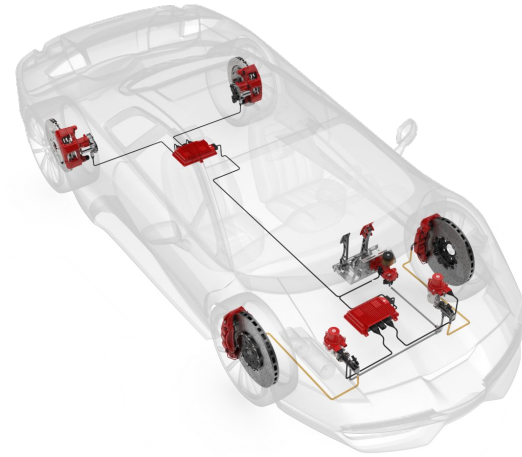
- Passenger Cars
- Commercial Vehicles

Technology

- Anti-lock Brake System (ABS)
- traction control system (TCS)
- Electronic stability control (ESC)
- Electronic Brake Force Distribution (EBFD)

Current Market

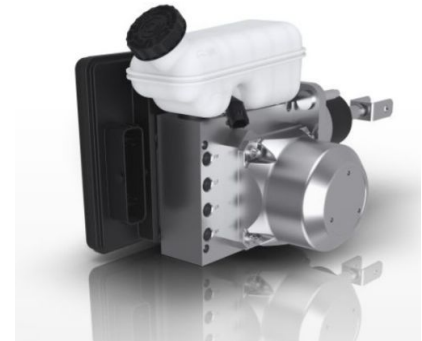
- Compounded annual growth rate (CAGR) of roughly 3.3% in the braking market
- By 2023, braking systems alone brings up to 7060 million USD worldwide
- Brake-by-wire and integrated brake controls from **Brembo**, **ZF TRW**, and **Continental**



An Overview of Brembo's Brake-By-Wire Architecture [5]

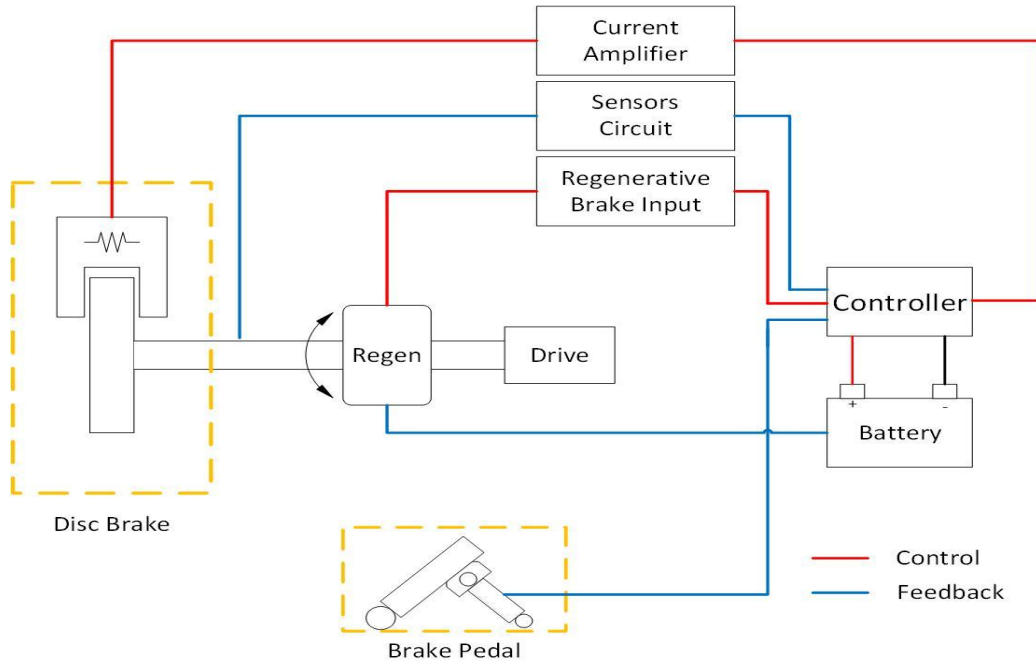


One Box Brake-By-Wire System [6]



Integrated Brake Control [7]

Project Outline



High Level Project Layout

Test Bench:

- Bench Frame
- Axle Assembly

Hardware:

- Power Supply
- Data Acquisition Sensors

Software:

- Control
- User Interface

Supplementary Braking:

- Motor
- Battery

Electromagnet Friction Brake:

- Electromagnet
- Rocker Arm

Project Cost Estimate

Costs to date: \$555.40

Future Costs: \$1277.83

Contingency: \$300.00

Total: \$2133.23

Example Cost Items:

12V Deep Cycle Battery

Test Stand

Sensors

AC Motors

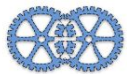
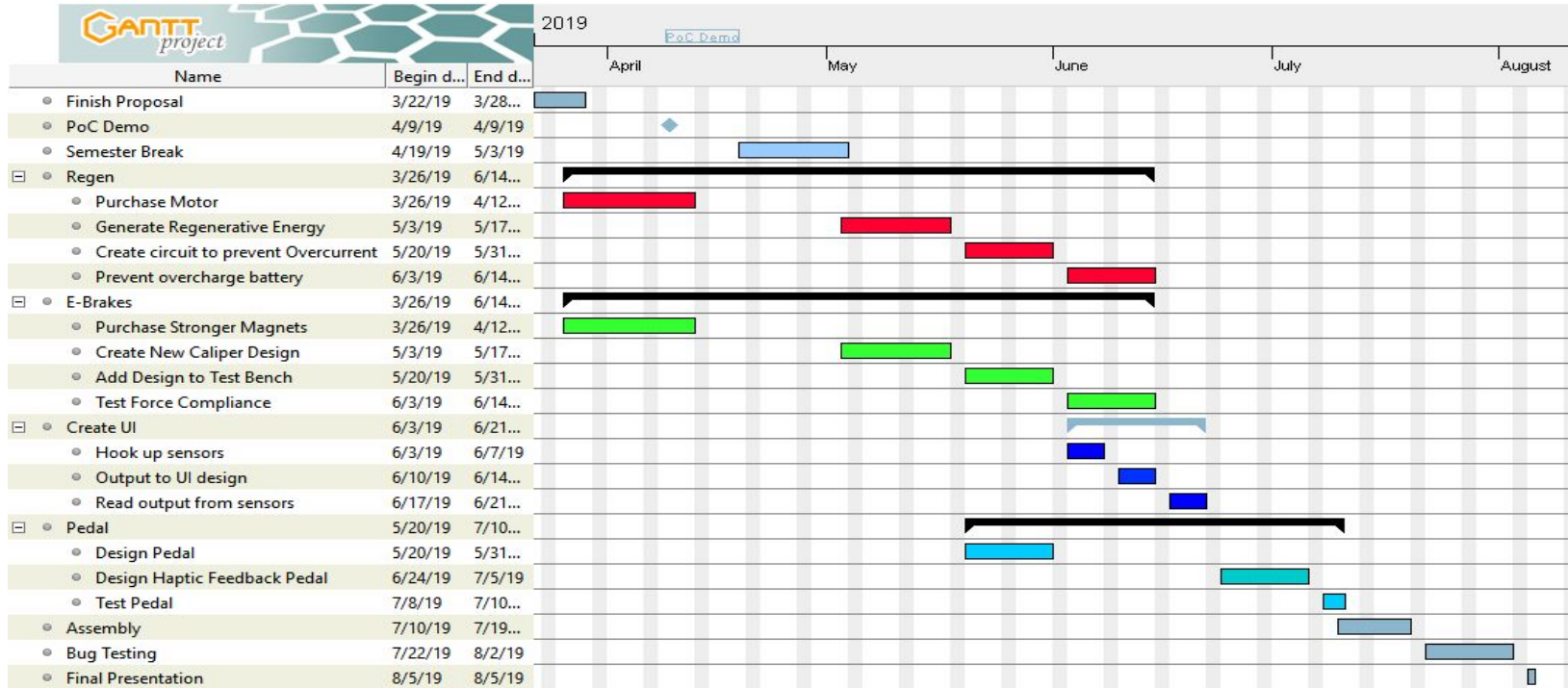
Variable Frequency Drive

Inverter

Brake Pads

Electromagnets

Project Schedule



Risk Analysis

Limited Braking Force

The electromagnet friction brake must provide adequate stopping power to meet current industry standards.

Industry Acceptance

Currently, most companies are still using traditional hydraulics. The market only began to accept electric/hydraulic brake-by-wire systems recently.

Haptic Pedal Feedback

There may be unforeseen difficulties in replicating the “feel” of a traditional hydraulic system.

Safety Standards

Redundancies and safety nets will need to be in place for this system to get industry approval.

Servicing

Service may initially need to be done only at dealerships or approved shops.

Standards and Regulations

ISO 26262

Safety standard for automotive software development: includes passive systems, active systems, by-wire systems, and electronic stability control throughout the automotive industry [3]

Transport Canada TSD 105

Section on hydraulic and electric brake systems from Transport Canada's Motor Vehicle Safety Regulations [4]

ISO 15118-3:2015

The requirements for controller and sensors to have a physical data link that exchanges information with higher level communication [5]

B.C. Reg. 26/58

Motor Vehicle Act Regulations provide some characteristics of brake systems for on-road vehicles [6]

Progress Considerations

1. Points of Reflection

- a. Theory is very different from real world results
- b. Managing time constraints and planning ahead is critical
- c. Funding/resource constraints play a key role in project development
- d. Safety

2. Lessons Learned

- a. Allocate plenty of time for assembly, as well as finding compatible parts at reasonable prices
- b. Look for alternative parts and have a “plan B” in case time or funding run out
- c. Safeguard in place in case of emergency

Plan for ENSC 440

1. Electromagnetic Brakes

- a. Improve the braking force by implementing stronger electromagnets
- b. Use a dual caliper setup (such that friction is applied to both sides of the rotor)

2. Software/Controllers

- a. Implement safety features using software such as ABS, and traction control to modulate amount of braking to the rotor
- b. Implement feedback control

3. Supplemental Brakes Using AC Motor

- a. Implement AC motor for regenerative braking and circuitry to capture energy
- b. Utilize controller to modulate amount of regenerative braking
- c. Attempt to implement different forms of braking using AC Motor such as dynamic and plugging braking

Conclusion

**This has been a fun project, and we look forward to
getting our hands dirty in 440!**

References & Acknowledgements

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