UNC CHARLOTTE
The WILLIAM STATES LEE COLLEGE *of* ENGINEERING

Senior Design Project Description

Company Name	Rail Propulsion Systems	**Date Submitted**	May 21, 2018
Project Title	Wireless Power Transfer (WPT) System for Fixed Guideway Vehicles Phase II**:** Invariable Dynamic Wireless Power Transfer (IDWPT) (RAIL_WIRE2)	**Planned Semester**	Fall 2018

Personnel

Typical teams will have 4-6 students, with engineering disciplines assigned based on the anticipated Scope of the Project. 250 hours are expected per person. Complete the following table if this information is known, otherwise the Senior Design Committee will develop based on the project scope:

Discipline	**Number**	**Discipline**	**Number**
Mechanical	2	Electrical	3
Computer		Systems	
Other ( )			

Project Overview:

With the advent of increasing environmental awareness, new technologies such as hybrid battery/electric vehicles have emerged as viable alternatives to traditional diesel engines. Many battery/electric on-road vehicles are commercially available, and the technology is beginning to cross over into off-road vehicles. One emerging area of interest for application of battery/electric propulsion technology is locomotives, specifically those units that serve passenger rail systems. Diesel-electric passenger service locomotives are common throughout the United States; these units use a large, significantly polluting diesel engine to power an electric generator to provide propulsion power. This technology is largely unchanged from its implementation in the mid-1900s. Passenger service locomotives are a preferred choice for replacement of diesel/electric engines with battery electric propulsion systems, as these vehicles commonly travel through densely populated urban areas that are indicated as EPA non-attainment for one or more types of air pollution. Battery technology has matured to the point that the use of a battery bank as a replacement for the diesel engine is viable and should be pursued as it offers a pollution-free, zero emissions alternative to traditional diesel/electric locomotive engines.

Concurrent with implementation of battery/electric propulsion for locomotives is improved battery charging technology, specifically wireless power transfer (WPT). Traditionally, connecting a locomotive to ground power is a cumbersome process that involves connecting large, heavy high voltage/amperage cables to a wayside station. Wireless power transfer provides a more efficient charging option – a locomotive can be parked over a transmitter mat embedded in the ground between the rails, and electricity travels through an air gap from the transmitter to a receiver that is installed

on the locomotive and wired directly to the batteries. WPT systems are in use on some light duty mass transit vehicles such as busses and trams; bringing this technology to the passenger rail industry would represent a significant technological leap forward, and additionally bring time savings and increased worker safety as they would preclude the need for traditional ground power connections.

Additionally, WPT systems have historically required close physical alignment between the transmitter and receiver for sufficient charging efficiency. Implementation of WPT in a railroad environment offers the added benefit of designing a system that eliminates the need for this precise alignment between the transmitter and receiver, known as invariable dynamic WPT (IDWPT). Locomotives are difficult to consistently park in an exact spot due to their size and momentum, thus IDWPT offers a user-friendly solution that accomplishes the desired wireless recharging – the train must simply be parked in proximity to the transmitter rather than precisely over it. The goal of this senior design project is to develop a prototype IDWPT system that would enable wireless charging of locomotive battery systems. The IDWPT technology could be proven conceptually on the UNCC on-site demo train, then subsequently the system could be installed and tested on a local commercial passenger rail agency, for example the NC Transportation Museum excursion train or the NCDOT Piedmont service. The IDWPT system would be installed at locations where the locomotive was parked for an extended amount of time, i.e. several hours, such as mid-route turnaround points or overnight layovers. In the future as the technology becomes accepted in the industry it could additionally be installed in route at station stops to allow for ongoing battery charging while the train is in service.

WPT in fixed guideway applications, such as rail, have both a challenge and opportunity for building systems that eliminates the need for alignment between the WPT transmitters and receivers. The rails provide lateral alignment, but the mass of the train creates a challenge for stopping at an exact location for longitudinal alignment. The invariable dynamic (ID) WPT system increases the number of transmitters and sequences their activations allowing the train to charge at any point along the length of transmitters. For passenger rail vehicles this would allow both simple stationary charging and dynamic charging as the vehicle slowed to a stop at a station, loiters for transferring passengers, and then when while it was accelerating out of the station.

Rail Propulsion Systems, LLC (RPS) of Fullerton, CA and McDowell Engineers & Associates (MEA) of Raleigh, NC are the project leads. RPS will act as the engineering and technical lead for this project, and MEA will act as the on-site project overseer and provide engineering support.

Initial Project Requirements:

Project team will explore the aspects of IDWPT system design for an axial strip of transmitters spaced under a long receiver. The long receiver will be designed and tuned to receive power from quantity “n” transmitters and will be physically long enough to cover “n+1” transmitters.

The system will function by activating exactly n transmitters at one time as they are under the receiver. As the receiver is in motion, the control system will deactivate the transmitter that is about to leave the space under the receivers as it turns on the transmitter that is now fully under the receiver. In this manner, the system does not have a defined axial alignment requirement for the vehicle and can continuously transmit power as the vehicle moves along the guideway. The sequencing of the fixed number of transmitters under the moving receiver act as a virtual moving fixed transmitter that follows the train staying in perfect resonance with continuous and invariable power transfer.

Team will explore ways of synchronizing and controlling transmitter activation along with methods of determining relative location of vehicle on the guideway.

The size of the system is to be defined by the hardware and functional aspects that will result in a complete functional demonstration of a receiver and corresponding set of transmitters.

Expected Deliverables/Results:

The following are defined in order of priority over the two semesters and must be completed as such. A project plan with specific milestones and dates shall be generated by the team, approved by the sponsor and managed by the faculty advisor. Milestones and dates shall be selected with allowance for issues such as lead times for materials, troubleshooting, and periodic assessment by the project sponsors. Any modifications to the scope and/or schedule of this project require written approval from the sponsors.

Semester 1: The team shall design and build a scale IDWPT antenna set sized and configured for possible installation on the UNCC baby train. The antenna system should follow the architecture developed in phase one of this project consisting of four transmitters and one receiver to investigate the above alignment free concept.

- Expectation is design, construction and static demonstration of 4 transmitter, single receiver set with a minimum of 65% energy transfer efficiency
- Minimum criteria for passing grade is completion of design of said antenna set

Semester 2: The team shall design and develop the necessary hardware and software to demonstrate IDWPT using the antenna set constructed in semester one.

- Expectation is a dynamic demonstration of the system on the UNCC baby train. The team will explore ways of controlling transmitter activation along with methods of determining relative location of vehicle on the guideway.
- Minimum criteria for passing grade is construction and static demonstration of 4 transmitter, single receiver set with a minimum of 80% energy transfer efficiency

Disposition of Deliverables at the End of the Project:

Hardware, Software and Solutions developed under this project would be used for RPS to promote rail electrification programs to gain future grant opportunities in partnership with UNCC.

Knowledge of IDWPT systems gained from this project is expected to be applied on a similar IDWPT pilot projects planned by RPS, MEA, and UNCC.

List here any specific skills, requirements, knowledge needed or suggested (If none please

state none):

Requirements for UNCC students in this senior design team:

- Electrical Engineering:
  - Should be able to complete calculations and circuit simulation using Matlab/Simulink or equivalent simulation software. Must also design, build and test power electronics converters with guidance.
  - Experience with power electronics converter design in class, hands-on circuit testing ability is preferred.
  - Understanding of transformers and electromagnetic field. Ability to use electromagnetic FEA tools is highly preferred.
  - Ability to create printed circuit boards (PCBs)
  - Ability to assist with programming as needed

- Mechanical Engineering Majors:
  - Should be able to create 3-D Models through Computer-Aided Design (CAD).
  - Understanding of heat dissipating elements
  - Practical experience with design, fabrication and assembly of mechanical systems.
  - Creativity in structural design for aesthetics
  - Familiarity with 3d printing