

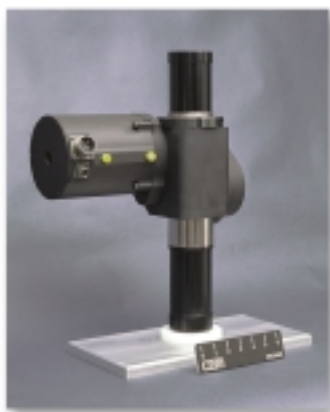
Development of Advanced Technologies for a Hybrid Electric Transit Bus

Project Objective

Under this project the University of Texas Center for Electromechanics (CEM-UT) developed and/or integrated four advanced technologies onto an Advanced Technology Transit Bus (ATTB) originally developed by Northrop Grumman. Those technologies are the: CEM-UT Flywheel Battery; Unique Mobility Wheel Motors; CEM-UT Active Suspension; and PEI Vehicle Management System.

Team Members

- University of Texas at Austin Center for Electromechanics
- UQM Technologies (formerly Unique Mobility)
- PEI Electronics Inc.
- Center for Transportation and the Environment (CTE)



project overview

Under the Advanced Technology Program, four specific technologies were developed, integrated and tested on the ATTB. The technologies were:

Flywheel Battery

CEM-UT developed an advanced flywheel energy storage system, specifically sized for power averaging on the ATTB. The system utilizes a 2 kWhr composite flywheel, low-loss magnetic bearings, a high efficiency 150 kW permanent magnet motor, and full space-vector controlled power electronics package. CEM also developed a gimbal and vibration isolation system and an advanced containment system to ensure safety in the unlikely event of a flywheel burst. The flywheel enables improved performance by capturing energy normally lost during braking and using it for high power acceleration events.

Wheel Motors

Unique Mobility designed, fabricated and tested a pair of 100 kW wheel motors and controllers for the ATTB. As replacements for the original ATTB wheel motors (manufactured by Kaman EML), the new motors were developed to improve performance, and efficiency by providing higher power capability in a smaller package providing additional space required by the active suspension actuators.

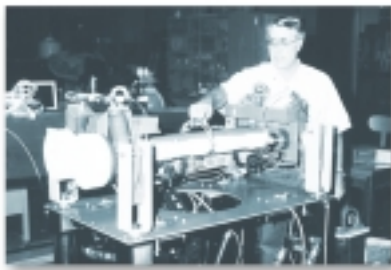
Project overview cont'd

Active Suspension

CEM-UT developed an active suspension system to improve ride quality and handling on the ATTB. The new suspension provides the bus with a smooth "soft" ride desired by passengers while virtually eliminating the roll and pitch motion normally associated with a transit bus. This is accomplished by replacing the original ATTB vehicle springs and shock absorbers with softer passive springs (to support vehicle static weight) and controlled electromechanical force actuators, for a fully active suspension system. An added benefit of this system is that it can maintain the desired static height of the bus under changing load conditions, such as the loading and unloading of passengers.

Vehicle Management Controller

PEI developed a vehicle management system controller and control strategy for managing energy on the ATTB. This system controls a number of preexisting (Northrop Grumman) component controllers already in place on the ATTB and several new controllers installed on this program for the flywheel, wheel motors and active suspension. The goal of this system is to manage the power flow into and out of all of the components on the ATTB in the most efficient manner while improving overall system performance over a wide range of operating scenarios.



each year. Due to the complexity of the control system and its reliance on other components on the ATTB, additional development will likely be required to market the controls or some variant of the existing system. Based on the successes to date it seems prudent to complete additional testing and tuning to optimize the existing system to verify the benefits predicted during modeling and determine any shortfalls in this technology.

Project Results

All four component technologies have been fully tested in the laboratory and during initial field testing of each subsystem. Field testing of the fully integrated system, with all four technologies operating in parallel, on the ATTB is now underway. Testing completed to date is summarized in the following paragraphs.

Flywheel Battery

CEM's flywheel battery system has been assembled and tested in the lab with a titanium flywheel up to 42,000 RPM (five percent over operating speed) and at a continuous duty power of 80 kW (20-40kW average required on ATTB) and peak power of 140 kW. The system was also subjected to shock and vibration testing in the lab in excess of what the ATTB is expected to generate under normal driving conditions. Following lab testing, the flywheel system with a composite flywheel, gimbal mount and containment was integrated onto the transit bus along with the required power electronics and auxiliaries for field testing. Initial testing of the system is now underway and the flywheel is successfully storing excess energy generated by the wheel motors during braking and using that stored energy during high power acceleration events.

Wheel Motor

The Unique Wheel motors were bench tested at Unique Mobility and after installation on the ATTB. Field testing of the motors has been completed successfully.

Active Suspension

Following completion of the active suspension integration, and wheel motor testing with the PEI control system, performance testing of the active suspension system was conducted on the ATTB. Ride quality was greatly increased under all scenarios and pitch and roll during braking and lane change testing was virtually eliminated.

Vehicle Management System

Following integration of the active suspension, wheel motors, and flywheel battery, the PEI vehicle management hardware and software was tested both in the laboratory and during initial field testing. The system is performing as designed and demonstrating improved performance in the areas of acceleration and braking.

Next Steps

All of the component technologies, and the complete system utilized under this program, are candidates for further development and commercialization. Specifically, negotiations to license the active suspension system to Northrop Grumman for military use are nearing completion and the possibility of a license for commercial use is also under consideration. The wheel motors are available commercially and the flywheel battery also has good commercialization potential as the market for large hybrid electric vehicles improves