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Electric propulsion demonstrator

NASA and several partner firms led by Empirical Systems Aerospace have worked on the X-57 Maxwell electric propulsion demonstrator, which uses several CANopen networks.

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Technicians at Scaled Composites in Mojave (CA) install a wing designed for electric motors onto a Tecnam P2006T to form the X-57 Maxwell battery-powered plane (Photo: NASA)

The X-57 is an experimental aircraft designed to demonstrate improved aircraft efficiency with a 3,5-times aero-propulsive efficiency gain at a "high-speed cruise" flight condition for comparable general aviation aircraft. In the first testing, some battery issues were detected. After fixing them, NASA has now approved the final of four planned phases of the X-57 program. These will include mounting the high-aspect-ratio wing, installing the high-lift and cruise motors, and performing flight demonstrations by late 2018 and early 2019.

The X-57 CAN-based command network is used to control the electric motors and provides aircraft health and status information. The higher-layer protocol complies with CANopen. Some connected devices transmit proprietary messages (CAN layer-2 approach). The command flow consists of throttle encoders (TEs), which digitize the existing Tecnam throttle lever positions and the electric motor controllers, which use this position as a torque target.

The embedded CAN networks in the X-57 Maxwell battery-powered aircraft use fiber-optic cables to reduce the susceptibility radiated EMI from the traction power bus (Photo: NASA)

The NASA researchers selected the CAN protocol, because if offers various benefits including error detection, frame arbitration, multicast reception, and prioritization [1]. The configured CAN bit-rate is 1 Mbit/s. The CANopen application layer (CiA 301) was chosen because it enables the integration of CAN devices with proprietary messages.

The devices of the CANopen command network were selected based on robustness and interoperability. Because some devices use the CANopen application layer, precautions were taken to ensure the devices using proprietary messages do not interfere with the additional functionality of the CANopen devices. The CANopen protocol uses a portion of the ID field, four most significant bits of the 11-bit identifier, to indicate PDO and SDO protocols. By considering the PDO identifiers used by CANopen, and carefully selecting the IDs for proprietary messages, ID collisions were prevented.

Connected devices

The battery management system (BMS) is a custom solution built by Electric Power Systems (EPS). It uses the CANopen application layer with a customized profile to fit the X-57 CAN architecture. The BMS provides battery health and status information to the CANopen network, which can help convey relevant information to the pilot.

The CMC device is a custom solution provided by Joby Aviation (Santa Cruz, CA) and uses a CAN interface without CANopen. It controls the 10-kW lift motors and the 60-kW cruise motors. This distributed electric propulsion generates enough lift by blowing over the top of the wing to enable the airplane to take off. The motor controller communicates via CAN health and status information for itself and the motor, including torque, speed, and temperatures, that can be used to provide situational awareness to the pilot.

Motec's (Australia) synchronous versatile input module (SVIM) is an analog-to-digital converter that transmits the data on a CAN network. These modules collect data at high rates (5000 samples per second) and high resolution (15-bit) synchronously with other modules as needed. For the X-57 application, these modules are used to record the blade pitch angle and temperatures associated with the CMCs and the motors. The size and capability to transmit on the CAN network make these devices useful in an EMI environment research capacity.

The ACL logger communicates via CAN with multiple SVIM input modules (Photo: Motec)

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