CANopen controls helicopter drone rotor

The TD220 unmanned aerial vehicle (UAV) uses Hornet CANopen servo drives from Elmo (Israel).

The Chinese UAV implements Hornet servo drives with CANopen interfaces (Source: Elmo)

When the ZHZ (Zhong-Hang-Zhi) Chinese company set out to design an improved helicopter drone, they wanted to replace traditional mechanical control assemblies with electromechanical technology. To accomplish that goal, they servo drives tough enough to survive the vibration and harsh operating conditions of diesel-driven flight. The Chinese engineers selected the ExtrIQ Hornet servo drives from Elmo Motion Control. These drives are specifically designed for harsh environments.

Like fixed-wing aircraft, helicopters can be adjusted in pitch (rotation around the y axis), roll (rotation about the x axis), and yaw (rotation about the z axis). To change the tilt and roll of the aircraft, the entire plane of rotation of the rotor needs to be angled as a whole. The process requires continuous and independent repositioning of each blade as it cycles around the center mount of the rotor. This is known as cyclic control. Adjusting the position of the aircraft in yaw typically involves the tail assembly.

Blade control in a helicopter is quite complex. Conventional helicopters use mechanical linkages to control the blades. Though effective, these designs are complex, bulky, and heavy. They require regular maintenance and are prone to wear and failure. To produce a smaller and lighter rotary UAV with higher power efficiency, as well as improved reliability and lifetime, the ZHZ design team replaced the mechanical assemblies with motion control.

The ZHZ TD220 has two air screws, or rotors. Each rotor is fitted with two blades and controlled by three motor-drive assemblies. A motor-drive assembly consists of a small DC motor and a servo drive, along with a resolver for robust, high-resolution position feedback. One motor-drive assembly performs collective control (ascent/descent). The other two motor-drives perform cyclic control (tilt and roll). Having a second rotor helps stabilizing the aircraft in yaw, eliminating the need for a tail rotor.

Blade positioning for adjustments in tilt and roll is not typically distinct. Many moves are a combination of the tilt and roll or a rapid transition from one into the other. As a result, the controls structure can be complicated. In response, the ZHZ design team developed a three-level control architecture. The attitude and position are part of the same controls loop. The velocity loop is separate and significantly faster.

As mentioned above, the helicopter drone uses resolvers for position feedback. Resolvers are tolerant of harsh environments.

The TD220 uses a nested control architecture, separating out collective control (position control and velocity control) from cyclic control (attitude control) (Source: Elmo)

One of the drive features is that it can convert the analog signal into a high-resolution absolute position. They also allow resetting the zero point of the feedback device on first use. This is essentially a homing method to establish the starting position for absolute feedback.

The Hornet drive provides CANopen connectivity. This enables the rapid adjustment of blade positions, for example during takeoff/ascend or landing/descent. The controller interrogates the drives via CANopen to get position and velocity data, and then sends back the motion commands. With a cycle time of 5 ms, the drives maximize the performance and maneuverability of the aircraft.

Although helicopters can be landed safely without engine power, the techniques used depend upon collective and cyclic control of the blades. As a result, reliability of the blade control systems is absolutely essential.

The UAV environment exposes the servo drives to punishing conditions that can damage sensitive electronics. The diesel engines used to turn the rotors generate large amounts of continuous vibration at 10 Hz. The aircraft may also undergo periodic shock events of up to 4 g during landing. As with any equipment used outdoors, components will be subjected to temperature swings, wind, and precipitation. If used in coastal applications, they will also suffer the negative effects of corrosive salt air. ZHZ came to Elmo to find equipment that could take a beating and continue functioning.

The Hornet drives are part of Elmo’s ExtrIQ product line, which is designed to survive tough environments such as those found in military and aerospace applications. Hornet drives are rated for temperatures from -40 °C to +70 °C and for vibrations of up to 14 g (RMS). G.Y. Tian, general manager of ZHZ, pointed to the environmental toughness of the drives as one of the top reasons for choosing them. “The diesel engine can cause very high vibration,” he said. “The Hornet drives ensure the system can work very well in these harsh conditions.”

Battery output changes over the duration of a flight charge, the overall lifetime of the battery, and even from unit to unit. Hornet drives are built to tolerate variations in input voltage, over a range from 12 VDC to 95 VDC. This eliminates the need for an external shunt. “Due to the battery, the voltage range of the TD220 is very wide,” said Tian. “The Elmo drives ensure that the system can operate over such a wide voltage-range without any malfunction.”

Multifunctional unmanned aerial vehicle (UAV)

Zhong-Hang-Zhi (ZHZ) Science and Technology has developed on the basis of the drone by the Kamov Russian aircraft company the TD220 helicopter drone. The UAV can be used to carry out tasks related to reconnaissance, observation, patrol, and monitoring flights, to be used for aerial photography and aerial surveying, to be used for security on a given perimeter and territories, etc. However, it is important to take into account that because of the rather high cost, this air vehicle could not get much popularity, and its use is limited mainly to governmental organizations and departments, especially military purposes.

The UAV is made in a helicopter-type configuration, which allows the drones to take off and land in almost any conditions. It is represented by a single piston petrol engine with an output of 48 kW, which allows the device to fly at speeds of up to 120 km/h, and the maximum range is 42 km.

Finally, the servo drive is capable of generating up to 25 A of current from a 55 mm x 15 mm x 46.5 mm package that weighs 50 g. “The small form factor is very important and significant to shrink the size of cabinet and weight, as well,” said Tian. The drone has a total weight of 140 kg and can carry payloads of up to 100 kg. Its cruising speed is 100 km/h.

The Elmo team worked closely with ZHZ in the implementation of the project. The applications engineers, both local and from Elmo headquarters, helped with customizing the firmware of the drive in order to make it 99.6 % efficient. Tian stated: “We are very satisfied with Elmo’s after-sales service, the applications engineers gave us very powerful help in a short timeframe.” To date, the helicopter drone has been thoroughly tested and has moved into production.

hz