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Enhancing battery monitoring in eVTOL applications

By Ryan Smart, Vice President of Product, Harwin

Electrically powered vertical take-off and landing (eVTOL) aircraft are shaking up the aerospace industry. The trend is similar to the effect electric vehicles (EVs) have had on the automotive market. This article explores the requirements of eVTOL applications, focusing on battery management and power and signal connectivity. The area is of vital, as the aircraft need detailed data about the onboard battery/powertrain system to run safely.

According to McKinsey, eVTOL has attracted $12.8 billion in investment over the last 12 years. Currently, around 200 companies worldwide have development projects in the sector.

eVTOL is suitable for various applications, but the most popular one is urban transportation. Aerial taxis will offer faster, greener, and more efficient transfers from city locations, such as financial quarters, to airports. eVTOLs could replace the helicopter services currently used for the purpose.

eVTOL-based transportation will also be more cost-effective. Aviation fuel costs are constantly increasing, but most eVTOL aircraft don't require any fuel. There are also other commercial and logistical benefits. The first of these is noise: eVTOL will reduce noise pollution. At the moment, this is the main factor restricting helicopter operation at nighttime. With eVTOLs, however, commercial flights could potentially run 24/7. Replacing helicopters could also improve air quality in city centers, as eVTOLs don't generate air pollution.

Key engineering design considerations

Unlike conventional aircraft, eVTOL must deliver vertical and horizontal propulsion. The movement can be achieved with fixed vertical rotors for take-off/landing and horizontal ones for moving forward. Alternatively, the rotors can use actuators to move between vertical and horizontal flight configurations.

Powering the constituent electrical actuators is another critical function. These actuators control the aircraft roll moment by deflecting aileron surfaces and pitch moment by deflecting the elevator. Yaw moment is managed through rudder deflection and thrust force by changing the propeller speed. The aircraft designs must also incorporate the infrastructure for distributing power to electric-propulsion motors, positioning systems, tele-networking, and cockpit/mission systems.

As eVTOLs are smaller and lighter than conventional aircraft, they are also less stable. While traditional aircraft become lighter during flight as they burn fuel, eVTOLs don't. They remain the same weight throughout the flight, which puts more stress on the structure during landing. These requirements need to be built into the design. This means using robust materials in the airframes as well as electrical components.

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Importance of battery monitoring in eVTOL designs

eVTOL aircraft are powered by large Li-Ion batteries. Therefore, an effective battery management system (BMS) is essential. Data relating to current, voltage, temperature, and other parameters must be continuously available to ensure optimal performance and safety of the passengers. If a battery fault that should have been detected leads to an accident, the aircraft manufacturer or operator could damage their reputation beyond repair.

In an electric road vehicle, managing risks is more straightforward. The EV can automatically stop and alert the occupants if there is a risk of thermal runaway within the battery. For eVTOLs, it is not as simple. When a fault occurs, the aircraft could be thousands of meters up in the air. Likewise, if a cell malfunctions and goes offline, the effect might be severe. In a ground vehicle, it will mean a loss of traction. But for an eVTOL, a power failure could result in a sudden drop in altitude. That's why BMS monitoring of the cells needs increased scrutiny to identify and mitigate potential problems as quickly as possible.

What to look for in a connector

The connectors used in eVTOL BMS implementations need to be chosen carefully. Here is a summary of what engineers should consider:

- **Compactness** – eVTOLs are dependent on electrical propulsion, so the components need to be small. They must take up minimal board space and have low profiles.
- **Contact density** –eVTOLs' battery packs feature many Li-Ion cells. Compact connectors with dense contact arrangements help achieve data acquisition more easily.
- **Weight** – eVTOL designs have strict weight constraints, so the fuselage and hardware must be as light as possible. The same goes for the components used. Light construction helps maximize the number of passengers or the amount of cargo the aircraft can carry.
- **Reliability** – To guarantee passenger safety, the connectors must function over a prolonged operational life without failure.
- **Robustness** – The connectors must maintain continued operation in harsh working conditions. They will have to withstand shocks, vibrations, and extreme temperatures.
- **EMI susceptibility** – Due to proximity to electrical sources, the designs must consider electromagnetic interference (EMI). Overlooking the issue can result in poor data quality, which can affect the decisions made by the BMS.
- **Component expense** – As the eVTOL sector is very cost-sensitive, keeping the bill-of-materials (BoM) down is vital. This, combined with the low volume levels, means that custom-built components are not an option. Instead, companies must have access to off-the-shelf products to optimize their budgets.
- **Quality** – Complete output repeatability in the production process is paramount when supplying parts to the aerospace market. Any variation could have dire consequences. That's why it's essential to work with connector suppliers that conform to globally recognized quality standards.

Picking the most applicable products

Harwin has a long history of providing aerospace OEMs with high-reliability (Hi-Rel) connectors. Committed to quality engineering, its manufacturing facility is certified per EN9100D/AS9100D quality standards. When working with the eVTOL sector, the Harwin team benefits from experience with unmanned aerial vehicle (UAV) projects. Regarding size, weight, and robustness, the connectors used in UAVs have similar requirements to those used in eVTOLs.

Optimized for use in various eVTOL systems, the 1.25mm-pitch Gecko connectors deliver powerful performance and reliability. The lightweight and compact components have 2A-rated contacts made from a durable Beryllium-Copper. The patented 4-finger design means that interconnections remain unaffected by even the most intense shocks and vibrations.

Some applications, such as eVTOL BMS installation, require a larger number of contacts and large signal currents. Here, Harwin's Datamate 2mm-pitch Hi-Rel connectors offer significant advantages. They are available in single, dual, and triple-row configurations. Like the Gecko series, they provide industry-leading resilience to harsh environments. This means withstanding shocks of up to 100G. Their contacts can carry 3A of current (3.3A on an individual contact). A choice of latching mechanisms makes it easy to find the best match for the available space or the operating conditions.

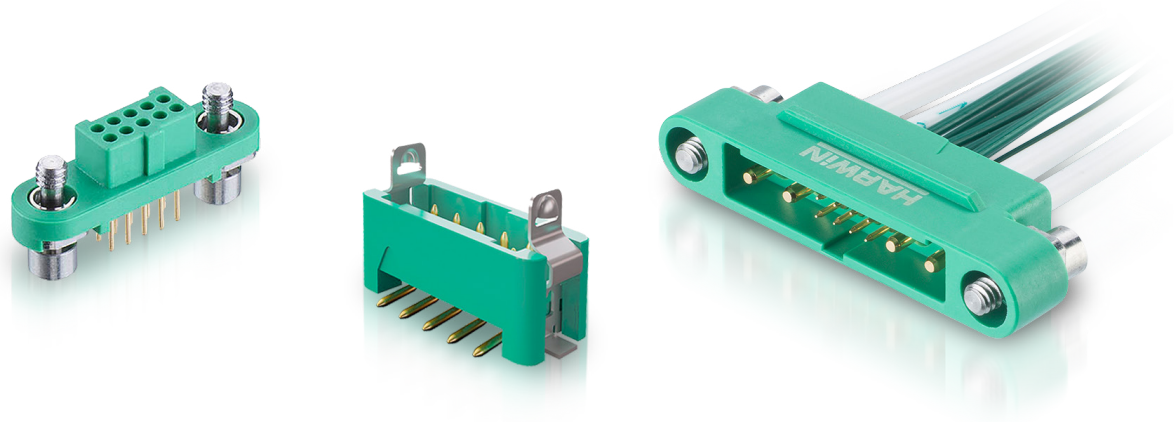

Figure 1: Harwin's Gecko connectors are well suited to space/weight-constrained eVTOL designs.

Gecko and Datamate connectors can come with integrated back shells to combat EMI issues. Cable assemblies are also available to accompany them. They are available in any length and configuration, even for small quantities. Harwin also offers Mix-Tek versions of both connector series. These devices make it possible to address power and data signals with just one component, saving space and simplifying design layouts.

Figure 2: Harwin's Datamate connectors, widely used by the avionics industry.

Conclusion

eVTOL will offer an environmentally friendly and more economical way of providing short-hop flights. The lower costs and 24/7 operation could make it accessible to more people.

The battery reserve and performance will be central to eVTOL services. It will also provide manufacturers with a way to differentiate their models in a competitive market. Recharging speed and the distance the aircraft can travel before recharging will be key differentiators. These requirements highlight the role of the BMS function in boosting battery performance and extending its longevity. Finally, having superior BMS interconnects means that accurate data is always available. This helps maintain optimal safety in eVTOL aircraft.