Tektronix + Elektro-Automatik

Reprinted From
EE POWER
June 13, 2023

Examining Electric Aircraft Fuel-Cell-Hardware Simulation Challenges

Blue hydrogen-filled H2 airplane. *Image used courtesy of Adobe Stock*

As one of the largest contributors to carbon emissions, the transportation industry has seen many companies pledge to lower their carbon footprints. While the auto industry's EVs catch most of the headlines, airlines and manufacturers are hard at work bringing electrification and alternative fuels to the world of aviation.

Jarod Todd, EA Elektro-Automatik | June 13, 2023

One of the most promising options for clean energy in aviation is the hydrogen fuel cell.

Seen in cars, buses, and even NASA's space shuttle, it's only a matter of time before fuel cells are part of the status quo. Before this happens, though, there must be rigorous engineering, testing, and simulation to ensure the safety of this new wave of aircraft.

H2/PEM Fuel Cell Benefits

Let's first get into why there is so much excitement surrounding hydrogen and proton exchange membrane (PEM) fuel cells.

One major benefit of PEM fuel cells is that the only byproduct of hydrogen consumption in a fuel cell is water, meaning no carbon emissions.

Hydrogen is a small, energy-dense molecule, giving it a high energy capacity at a low weight. The majority of our hydrogen supply is synthesized out of natural gas. However, there is a clear path to producing green hydrogen available through solar energy to power the electrolysis of water.

Some significant advantages of a fuel cell versus a conventional lithium-ion battery are:

- Refueling time for fuel cells is exceptionally shorter.
- Fuel cells store fuel externally, while batteries must take t ime to recharge to store fuel internally.
- PEMFCs operate with higher efficiency.
- With no combustion in a fuel cell, less energy is lost to heat, so fuel cells can also run at lower operating temperatures.

Initial use cases in aviation include unmanned aerial vehicles (UAVs), small and regional aircraft, and drones. With success, hydrogen will spread to more aircraft and scale to larger applications.

An eVTOL concept that can utilize PEM fuel cells. *Image used courtesy of Adobe Stock*

Tel. +1 858-836-1300 . sales@elektroautomatik.com . www.EApowered.com

The Importance of Hardware Simulation

As the industry pushes harder to make fuel cell-based electric aviation a reality, the importance of hardware simulation has become increasingly apparent.

As is the nature of innovation, these are first-of-their-kind systems, and simulation and testing are essential to prove the concept. Before a pilot can ever sit in the cockpit, the fuel cells must be tested to ensure their performance, reliability, and safety throughout all stages of flight.

However, without hardware simulation, the only way to test a fuel cell would be physically producing and testing it in real-world conditions, bringing time-to-market and cost challenges since fuel cell manufacturing is expensive and time-consuming.

Instead, simulation allows designers to accurately test their designs without having a physical device in hand, meaning more rapid iteration of designs should a problem be found and cuts down on the product development life cycle. Simulation is a crucial aspect of passing commercial and military standards as well as performance guidelines.

Simulation Challenges

Despite the benefits of simulation, there are undoubtedly many obstacles.

One challenge is that, since electric aircraft are just emerging, there are no previous standards for testing systems. The lack of maturity in the field means it does not benefit from economies of scale. For this reason, the industry is mostly limited to using robust and expensive equipment. Even with this equipment, it is difficult to replicate extreme conditions that can be experienced in a real-world, field-deployed aircraft.

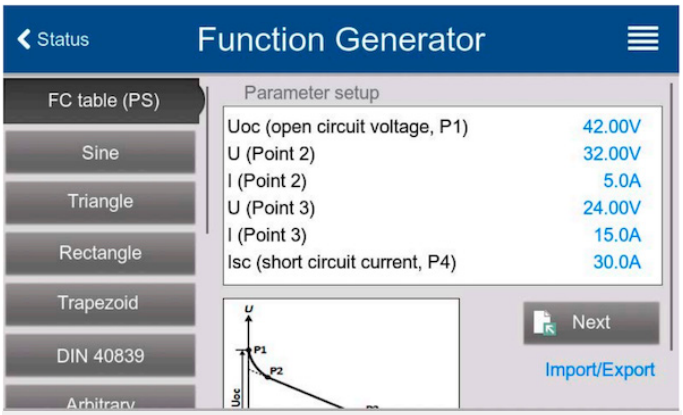
In the current state of testing, a separate power supply, load, and external signal generator are needed. These systems must produce high voltages and currents to the point that cooling systems are needed to prevent overheating. The power and thermal limitations that come here make scaling fuel cells very difficult, often requiring a parallel operation to achieve higher total power output.

Fuel cell simulation can also be cumbersome, requiring multiple disparate software programs to operate together. For example, many fuel-cell-simulation test suites have the function generator and the fuel-cell simulation as two different tools, requiring the designer to purchase additional software and find ways to make them interoperable, which adds time, money, and complexity to the fuel-cell simulation process.

Solutions for Testing Aircraft-Rated Fuel Cells and Circuits

To overcome many of the challenges associated with fuel cell simulation, companies like Elektro-Automatik (EA) put forth a range of solutions for testing fuel cells and DC circuitry.

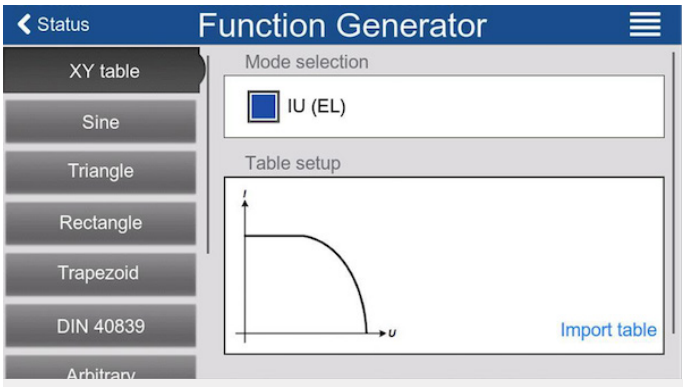
One of the most important of EA's offerings is its fuel cell (FC) table function mode (shown below).



Depiction of FC table configuration on the HMI.
Image used courtesy of EA-Elektro Automatik

As available in EA products with PSI and PSB supplies, FC table mode can accurately simulate a fuel cell's output over various conditions. By matching the fuel cell output characteristic, FC table mode allows users to test the load circuit to ensure it can appropriately operate under varying fuel cell output characteristics.

The XY table function is another valuable feature of EA's equipment (shown below). This table and the arbitrary signal generator can be used to test the fuel cell and the conditions it will face by matching the characteristic of the load. The waveform generator is a component of EA's regenerative load, so it is one less component that needs to be purchased and one more spot on the rack for another instrument.



In the XY table function, the user can define different discharge currents subject to varying voltages by loading this IV table to the unit. Image used courtesy of EA Elektro-Automatik

Additionally, built-in function generation and auto-ranging give flexibility to users for quick and effective testing. For example, EA's PSB 10000 series devices offer bidirectional power supplies that can act as a power supply and regenerative electronic load and include the function generator as part of the tool. These devices are also 96% efficient when acting as a load, which reduces energy use and cooling cost.

EA's products meet the high-power demands of modern fuel cells. Not only do products like EA's PSI 10000 and PSB 10000 series offer significantly higher voltage options than competitors (up to 2000Vdc) and higher power ratings (up to 30kW), but they also have the ability to be parallel for higher total outputs (currently up to 1.92MW).

These enhanced specifications enable engineers to simulate and test fuel cell systems more accurately, ensuring a more realistic representation of real-world operating conditions.

The Future of Fuel Cell Hardware Simulation

Testing fuel cell performance and lifetime can be easy with the right simulation tools. With the chase to net zero underway, the prevalence of fuel cells is increasing, as is the need for robust equipment to test them quickly, sustainably, and cost-effectively. Elektro-Automatik provides high-quality instruments making the transition to electrically powered aircraft possible. ■