ENHANCING SAFETY THROUGH TESTING AND DEVELOPMENT OF eVTOL POWER ELECTRONICS

At a glance

In pursuit of developing standardized testing methodology in electronics development, the HORYZN team at the Technical University of Munich integrated the R&S®RTO (with the R&S®RT-ZPR20 power rail probe) from Rohde&Schwarz into their prototyping design-loop and workflow. The increased accuracy compared to prior equipment enabled a thorough root-cause analysis to pinpoint voltage spikes in various COTS components in use. This expanded component testing possibilities within the avionics development cycle, leading to the discovery of a higher-than-expected output ripple of a DC/DC converter due to the initial in-rush current of other components in the architecture, to name one example.

Summary

- **Customer**: NEXT Prototype e.V., HORYZN, Mission Pulse
- **Task**: eVTOL voltage noise and ripple waveform analysis
- **Challenge**: Analyze and benchmark a different converter design integrated into the eVTOL
- **Product**: R&S®RTO (in conjunction with R&S®RT-ZPR20 power rail probe)
- **Key benefits**: High-performance oscilloscope (with power rail probe) for more accurate voltage ripple measurement

Case Study | Version 01.00

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About HORYZN

Recognizing a growing trend toward fully electric propulsion systems for UAVs capable of hovering, vertical take-off and landing, the HORYZN student initiative at the Technical University of Munich (TUM) was started in 2019 to create an eVTOL aircraft to solve real-world problems. After initial success with their SILENCIO Gamma prototype design, HORYZN announced the kick-off in 2021 of the Mission Pulse project aimed at the emergency medical services (EMS) industry.

In Germany, 75 000 patients experience sudden cardiac arrest every year and have a survival rate of just 11 %. A patient's chance of survival is directly correlated to ambulance response times and how quickly a defibrillator is used. In rural areas, ambulances often take a long time to arrive, averaging approximately 9 minutes. HORYZN's application takes advantage of the fact that eVTOLs are not limited by roadways and can lift off and land in remote, otherwise inaccessible areas with ease. This approach cuts the time it takes to deliver a defibrillator to approximately four minutes, roughly tripling the patient survival rate to 34 %. The project aims to build an eVTOL capable of reaching patients within a 6 km radius in five minutes. The UAV is controlled beyond the visual line of sight (BVLOS) by a pilot controlled ground station. Once on site, the defibrillator is lowered by winch and monitored via remote video.

A group of HORYZN team members with two prototypes

The task

One of the most critical parts of eVTOL design is power management efficiency, which directly correlates with the overall flight time, sustainability, endurance and parasitic weight. As a fully electric multicopter, HORYZN must address EM crosstalk, especially with the trapezoidal back EMF issues that come with BLDC motors, producing significant reverse current and voltage overshoot at the supply input. This can be a major issue due to the sensitivity of communications and control electronics integrated into the aircraft. To properly ensure safety and reliability in the system while supplying all of its components with the necessary power, a number of power conversion

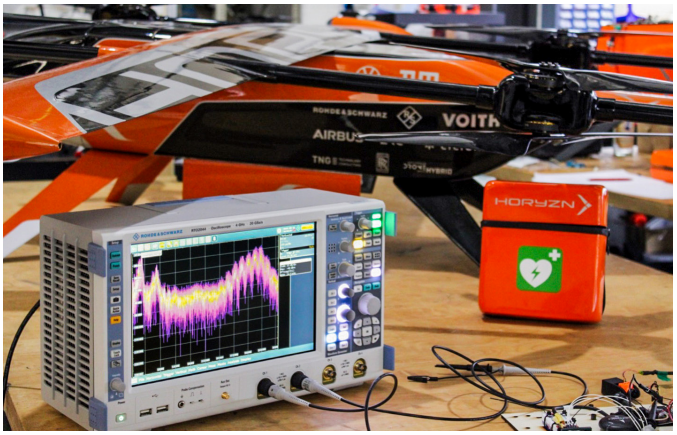
R&S®RTO oscilloscope

module designs have been proposed in the research and development process, ranging from highly efficient but noisy SMPS to more adjustable linear regulation for future device integration. All these solutions require a degree of benchmarking standardization.

Solution

Using components available in the workshop, the output voltage of several converters was measured with a fixed load and input voltage from a PSU to find the transient response. Then, similar measurements were done by varying the input voltage level to simulate the behavior of the 12S (2x6S) 12 000 mAh 25C LiPo battery. This test approach enabled a simulation of the hover propulsion system architecture, which also uses 60A 12S ESCs and eight KV100 BLDC motors.

In the final experimentation step, the team was able to observe both supply and load variation effects by connecting the batteries with the other propulsion components and mounting the 30 × 10.5 coaxial carbon hover propellers on the test bench. Once assured of the test flow at a higher voltage level, the next step of the process will be to test the viability of using a linear regulator to supply the aircraft's low-power electronics, such as the flight computer, NVIDIA Jetson Nano, telemetry transceivers and integrated sensors. This test will be carried out using telemetry functionality issue reports received for certain converter designs.



HORYZN's Mission Pulse "Frankenstein" eVTOL test bench incorporates the R&S®RTO oscilloscope to analyze voltage ripple waveform

Benefit

Following a sponsorship offer from Rohde&Schwarz to build a more reliable avionics workshop testing infrastructure for HORYZN, the parties agreed to find suitable instruments for test bench development. After research and feedback, HORYZN decided to use the R&S®RTO. The HORYZN team was won over by the legacy application notes on the Rohde&Schwarz website and its need for good bandwidth to avoid understating peak-to-peak voltage and missing the higher frequency content riding on the power rail.

R&S®RTO offers precise measurement results with its high sample rate and wide bandwidth. Currently, it is a crucial part of the testing environment for HORYZN's power electronics development.

R&S®RTO

- Bandwidth: 600 MHz to 6 GHz
- Maximum sample rate: 20 Gsample/s
- Maximum memory depth: 2 Gsample
- Up to 16-bit vertical resolution
- Mixed signal analysis (MSO):
  16 digital channels, optional, retrofittable

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Rohde&Schwarz

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- Energy efficiency and low emissions
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PD 3683.7890.32 | Version 01.00 | May 2023 (ch)
Enhancing safety through testing and development of eVTOL power electronics
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