Characterization of lightweight GPS Disciplined Oscillators for distributed UAV measurement applications

Julia Beuster[1], Carsten Andrich[1], Sebastian Giehl[1]

[1]Technische Universität Ilmenau, Institute for Information Technology, Ilmenau, Germany

Email: julia.beuster@tu-ilmenau.de

With the increasing variety of measurement applications using sensing nodes deployed at unmanned aerial vehicles (UAV) and requiring high timing and frequency precision, global positioning system (GPS) disciplined oscillators (GPSDO) are an appealing solution for wireless inter-device synchronization by providing 1 pulse per second (1 PPS) and 10 MHz reference signals for measurement instruments in a distributed network. Typically, the performance of these oscillators is assessed by analyzing the 1 PPS and 10 MHz reference signal stability under constant laboratory conditions in a live-sky scenario with a fixed antenna position. Unfortunately, this test method disregards effects arising from the operation in a mobile, aerial measurement scenario.

In this paper, we characterize and evaluate lightweight, commercial-off-the-shelf (COTS) GPSDO models selected with regard to the strict weight and space constraints of UAVs regarding their suitability for the specific use case of flight operation. We use a measurement system[1] based on software-defined-radios (SDR) and digital signal processing (DSP) to analyze the 1 PPS and 10 MHz reference signal stability provided by the GPSDOs under test in a laboratory setup. As shown in a GPSDO testbed[2] for vehicular measurement applications, controlled GPS signal reception loss is used to characterize the expectable performance in alternating operation modes, as free-run, disciplined, and holdover mode for later estimation of measurement precision loss due to GPS signal impairments caused by obstacles. Further, we characterize the behavior of the GPSDOs in conditions outlined in the standard[3] for payload devices at UAVs by measuring the reference signal stability in presence of vibrations and accelerations typical for air turbulences and steering maneuvers during flight, as well as the impact caused by operating the UAV, for instance in form of electromagnetic field changes and interferences in the power supply caused by running rotors.

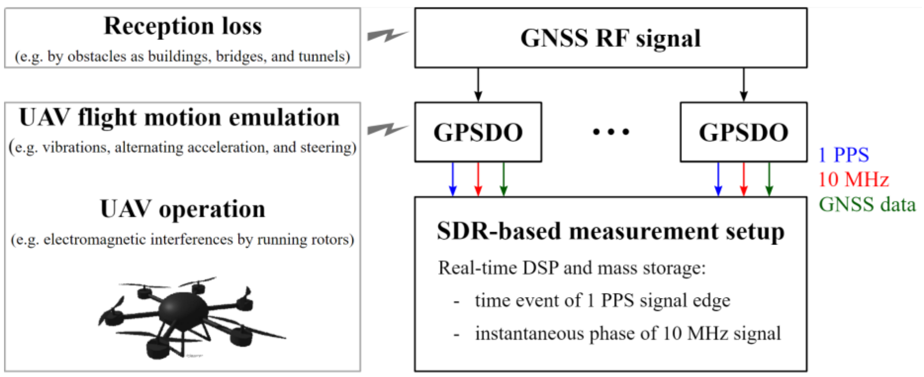

Fig. 1: SDR-based GPSDO testbed to analyze the 1 PPS and 10 MHz reference signal stability for UAV scenarios.

[1] C. Andrich et al., "Comparison of Software-Defined Radios for Performance Evaluation of High Precision Clocks," 2018 IEEE International Symposium on Precision Clock Synchronization for Measurement, Control, and Communications (ISPCS), Geneva, 2018, pp. 1-6

[2] J. Bauer et al., , "Characterizing GPS Disciplined Oscillators for Distributed Vehicle-to-X Measurement Applications," 2020 Joint Conference of the IEEE International Frequency Control Symposium and International Symposium on Applications of Ferroelectrics (IFCS-ISAF), Keystone, CO, USA, 2020

[3] "IEEE Standard Interface Requirements and Performance Characteristics of Payload Devices in Drones," in IEEE Std 1937.1-2020 , vol., no., pp.1-30, 12 Feb. 2021, doi: 10.1109/IEEESTD.2021.9354136.