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PRESENT AND FUTURE OF LEONARDO ATOMIC CLOCKS FOR SPACE AND GROUND APPLICATIONS

Abstract

In this paper, we report an overview of Leonardo atomic clocks focusing on their technological aspects and application fields.

Leonardo flagship product is the Passive Hydrogen Maser (PHM) that represents the state-of-art for space atomic clocks. PHM is the master clock of the Galileo GNSS constellation and embeds the high-achieved accuracy reaching a time error of one second every three million years, which leads to on ground position error of about 30 cm. PHM is a space qualified clock designed to operate for more than 12 years providing an output frequency of 10 MHz with a drift less than $8x10^{-15}/day$.

With this performance, PHM is already on board of Galileo Navigation Satellite System (GNSS) with more than 40 units. In the last few years, Leonardo started to work on the design and development of PHM of the second generation (PHM2). PHM2 is the evolution of the PHM atomic clock aiming at a further consolidation of its performance. Part of Leonardo atomic clocks products is also a miniaturized version of the PHM, called mini-PHM, which guarantees same performances of the PHM with reduced Size Weight and Power (SWaP) .

Leonardo is also working for the industrialization of the Rubidium Pulsed Optical Pumping (Rb POP) atomic clock in partnership with the Italian National Metrology Institute (INRiM) and under the supervision of the European Space Agency (ESA). The objective is the realization of the Rb POP space qualified product for future use in Galileo GNSS constellation. Rb POP is one of the most promising technology for the next generation of high performances space clocks. Despite using hot atoms held in a vapour cell, this technology has demonstrated short-term stability comparable to a Hydrogen maser with reduced SWaP.

Taking advantage from the new technological developments in the field of optical frequency metrology, Leonardo recently started a collaboration with INRiM and with the Italian Space Agency (ASI) for the

realization of a new product: a high accuracy transportable Optical clock based on cold atoms targeting an accuracy at the level of 10^{-18}.