Industrialisation approach of the POP atomic clock for application to GNSS

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Since 2007 Selex ES, in collaboration with INRIM, has been studying the possibility to develop a Pulsed Optically Pumped (POP) clock suitable for the needs of future Navigation Systems, such as high frequency stability, low failure rate for more than 10 years mission time, ability to withstand space radiation, low sensitivity to environmental perturbations, reduced mass and power consumption.

The POP clock is a vapour cell frequency standard operating in pulsed regime at the Rb ground-state hyperfine frequency (6834 MHz). Selex ES' interest in this technology relies on the possibility to implement a compact device, with improvement in terms of mass, size and power consumption compared to a passive hydrogen maser (PHM), but with a similar frequency stability and less operation constraints.

A first feasibility study [1] (under an ASI contract) based on the maser approach was concluded in 2009 and led to a preliminary design for space use (mass 10.8 kg max, power consumption 45 W max). Further studies, carried out at INRIM under an ESA contract and with the partnership of Selex-ES, demonstrated that the optical detection improves the frequency stability performances, reducing at the same time the complexity of the clock design. Specifically, a frequency stability of 1.7×10^{-13} at 1s and 5×10^{-15} until 50000 s has been demonstrated [2] (drift $<10^{-14}$/day), a result fully compliant to the GALILEO PHM specifications. Moreover, the design simplification leads to further reduction in terms of mass (< 9 kg), size and power consumption (< 40 W).

This paper intends to present the Selex ES industrialization approach required to pass from a laboratory successful prototype to a POP engineering model designed to sustain space environment and life time requirements, but at the same time offering clock performances at the state of the art in terms of frequency stability, mass, power consumption and cost. The first step of the development plan will address the realisation of electronic and optical units based on commercial components with either space heritage or ability to be space qualified.

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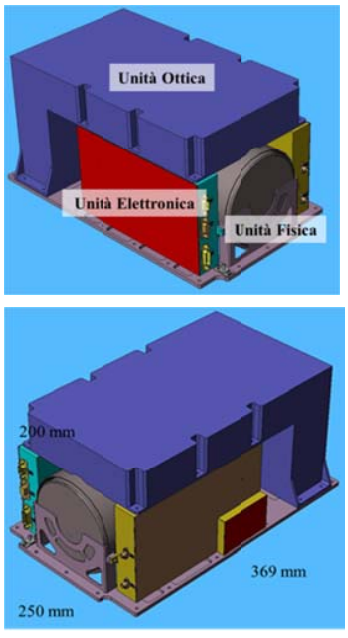

Fig. 1. Engineering model unit layout.

[1] M. Belloni et al., A space rubidium pulsed optical pumped clock – Current Status and future activities, PTTI 2009

[2] S. Micalizio et al., Metrological characterisation of the pulsed Rb clock with optical detection, Metrologia vol. 49, pp.425-436, 2012