Development of the Optical Space Cs Clock

A.Douahi[1], R.Schmeissner[1], P.Dufreche[1], A.Brechenmacher[1], F.Chastellain[2], A.Romer[2], C.Roth[2], W.W.Coppoolse[2], N.Mestre[1], M.Baldy[1]

[1]Thales Electron Devices, Vélizy, France
[2]RUAG AG, Zurich, Swizerland

Email: Michel.Baldy@thalesgroup.com

The optical pumping of the Cs hyperfine state was identified many years ago as a suitable technology candidate for an atomic clock to operate in GNSS, and in particular in Galileo. Related industrial activities currently develop this technology with focus on ground applications [1, 2]. Based on their heritage in the domains of Cs clock development and space electronics, Thales Electron Devices and RUAG develop the engineering model (EM) of the Optical Space Cs Clock (OSCC) [3]. The current project phase started in 2015 and will end in 2017.

In the previous phase, a short-term Allan Deviation frequency stability of $3E\text{-}12\tau^{-1/2}$ was demonstrated. The target of the present phase is $1E\text{-}12\tau^{-1/2}$. In addition, new design constraints are taken into account: 12 liter volume, 10kg mass, 30W power consumption and 12 years lifetime in medium earth orbit.

After a presentation of the main activity objectives, an overview of the preliminary engineering model clock design will be given. Indeed, numerous different technologies are applied: a high vacuum Cs tube containing a high quality RF cavity and optical elements, an optics subsystem and an electronics package designed for harsh space environment. Emphasis will be put on Cs vacuum tube manufacturing constraints and technologies. The presentation will also address technological risks arising from the application of semiconductor laser, optics and optoelectronics in vacuum and under ionizing radiation.

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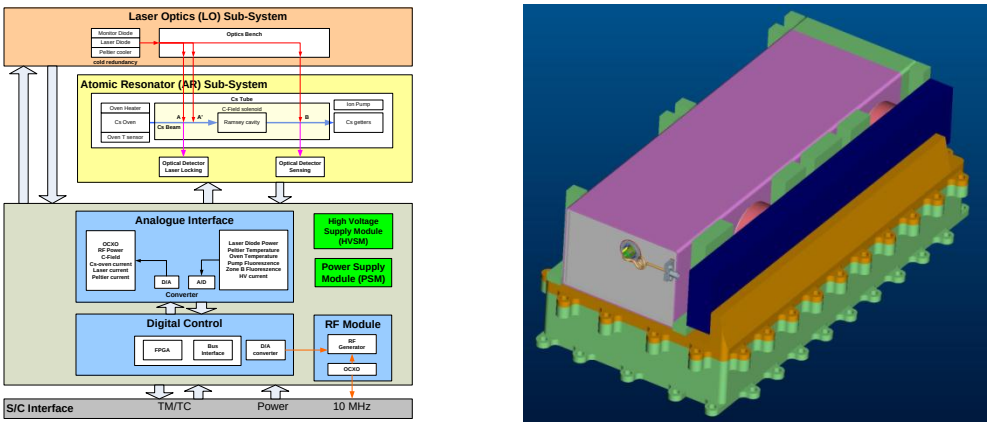

Figure 1: *Left:* Functional architecture of the OSCC EM. *Right:* Preliminary design of the physical implementation.

[1] Progress in the Development of Commercial Optically Pumped Cs Atomic Clock, Yuanhong Cao, et al., International Frequency Control Symposium IFCS 2014

[2] Dev. of a transportable optically pumped atomic Cs beam clock, P.Berthoud et al., European Frequency and Time Forum 2015

[3] Towards Engineering Model of the Optical Space Cs clock, R.Schmeissner et al., European Frequency and Time Forum 2016