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AN ULTRA STABLE OSCILLATOR FOR THE 3GM INVESTIGATION OF ESA'S "JUICE" MISSION TO THE JOVIAN SYSTEM

Abstract

The 3GM (Gravity and Geophysics of Jupiter and the Galilean Moons) experiment of ESA's JUICE mission will use radio tracking from ground to map the gravity fields of Jupiter's icy moons Ganymede, Callisto and Europa, and to reveal internal oceans on two of them (Ganymede and Callisto). 3GM will use a one-way (space to ground) radio link in X and Ka band (8.4 and 32.5 GHz) to investigate the structure of the neutral atmospheres and ionospheres of Jupiter and its moons. AccuBeat Ltd is developing an Ultra Stable Oscillator (USO) enabling the 3GM microwave link for radio occultations. The USO is a compact Ultra Stable Oscillator based on quartz crystal resonator, however exhibiting outstanding short term stability of parts per 10^{13} for averaging times of 1s to 1000s. These stabilities are comparable or superior to those of some commercial atomic clocks such as Rubidium and Cesium. This paper briefly reviews the oscillator design and the critical issues to be tackled. We analyse the design using the quartz resonator key parameters: its quality factor (Q) and its internal noise. We use the Leeson model which provides the transfer function of the sustaining amplifier flicker noise to the oscillator output. Another key issue is the temperature stabilization of the crystal resonator and its sustaining electronics. We use a double oven design to maintain temperature stability in the sub mK range at the relevant time constants of 1 to 1000s. The output frequency of the USO is achieved by multiplying the oscillator frequency in a manner which provides a minimal effect of temperature induced phase variations on the output stability. Key environmental space requirements to address are operation under thermal vacuum, irradiation at the level of 50krad, and hardened structural design to withstand vibrations and shock during the launch phase. The variation of the strong Jupiter magnetic field during a radio occultation was evaluated and its effects on the oscillator stability have been assessed.