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PROGRESS ON CESIUM ATOMIC CLOCK WITH MAGNETIC STATE SELECTION FOR SPACE APPLICATION

Abstract

The paper introduces our development work of compact cesium atomic clock for space application during the last ten years. Our product of compact cesium atomic clock is composed with cesium beam tube (CBT) with magnetic state selection and frequency standard electronics unit (FSEU). In the CBT, an atomic Cs beam is manipulated with a pair of magnetic state selectors. The clock transition is |3, 0> to |4, 0> in the Ramsey cavity. The detection for the Cs atoms is accomplished by a hot-wire detector and electron multiplier with dynodes. A great deal of research work has been performed in order to accommodate the space application, which includes optimization of beam optics, development of long-life electron multiplier, design of microwave source with low phase noise and servo optimization of operational parameters. The positions of all components of beam optics are optimized with Monte Carlo simulation. With the method of magnetron sputtering, the life of electron multiplier has been prolonged to 10 years for the operational voltage increases 0.2V per day. The high vacuum in the tube is maintained down to 5.0E-5Pa with vacuum bake in the middle temperature for several days and a 0.5 l/s ion pump connected to 3.5kV high voltage power supply. The FSEU is designed with digital technology, which includes power supply for CBT, microwave link and DSP based servo loop. The 9.2GHz microwave module with low phase noise is acquired with technologies of direct digital synthesis (DDS), phase lock loop (PLL) and VXCO. Various operational parameters realize real-time control with servo software, such as oven temperature, microwave power, strength of C-field and voltage of electron multiplier. A first preliminary design for space use has been accomplished. The present short-term stability of our compact cesium atomic clock is $\sigma y(\tau)$=1.2E-11/$\sqrt{\tau}$. A great deal of work should be performed in order to adapt space environment and improve the long-term stability of the clock later.