Space Rubidium Atomic Frequency Standard for BeiDou Navigation Satellite System

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In this talk, we outline development of the BeiDou system and its space primary frequency standard, the rubidium atomic frequency standard.

China's navigation satellite system BeiDou is developed according to a three step strategy [1]. The first step construction begun in 1994 and ended in 2000, as the BeiDou Navigation Demonstration System, as known as BeiDou I, provided radio determination satellite service (RDSS). The second step covers from 2004 to 2012, and is to construct the BeiDou navigation satellite System (BDS, also called BeiDou II sometimes), providing radio navigation satellite service (RNSS) for users in China and nearby regions. The third step involves functional enhancement of the system, making the BDS system able to provide high precision RNSS service for the worldwide users in 2020. As result of the second step construction, the current BDS system consists 16 satellites, including 5 MEO, 6 GEO and 5 IGSO satellites, and could provide the service with positioning precision of 10m in both horizontal and height, velocity measurement precision of 0.2m/s, and timing precision of 50ns. The service has covered the whole Asia Pacific region.

The rubidium atomic frequency standard (RAFS) is the only one type of space clock employed so far in BDS satellites. As one of the three domestic space RAFS suppliers, Wuhan Institute of Physics and Mathematics (WIPM), Chinese Academy of Sciences has been engaging in research of space RAFS since the late 1990's. Earlier work focused on realization of performance and adaptability for space environment. In the work, main attention was paid to developing a new structure slotted tube microwave cavity [2] with mode similar to TE_{011}, designing a high SNR physics package [3], verifying that the rubidium spectral lamp is of long operation time and ability to work in vacuum environment, optimizing operational parameters of the RAFS unit, and so on. To avoid element failure in space, no digital frequency synthesizing technique was used in the electronics. A test model was built in 2005, and the product was space qualified in 2006. Since then, the performance of the RAFS has been improved further [4]. 10 space RAFS products were used in the BDS satellites. Statistics obtained on ground showed that the key performance of the RAFS, the frequency stability per day, is within $2.0\sim5.0\times10^{-14}$ in Hadamard deviation, comparable with those used in GPS Block IIR[5] and Galileo satellites.

To meet the needs of the third step construction of the BDS system, further improvement of the RAFS is being performed at WIPM.

[1] "Report on the Development of BeiDou (COMPASS) Navigation Satellite System", http://www.beidou.gov.cn/

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