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ON THE LOW-COST ASYNCHRONOUS ONE-WAY RANGE MEASUREMENT METHOD AND THE DEVICE FOR MICRO TO NANO DEEP SPACE PROBES

Abstract

Current spread of micro to nano satellites activities will extend and lead to the moon and the interplanetary missions soon. In most cases, the navigation for the spacecraft on the low earth orbit usually rely on the GNSS (Global Navigation Satellite System) (GPS (Global Navigation System)) navigation services, and the operation for them are not restricted. However, as to the missions beyond the cis-lunar space, the GNSS(GPS) becomes hardly usable, and the agency-based range measurement facilities need to be combined with the specialized onboard radio transponders. Simply the GNSS(GPS) positioning is never practical in deep space owing to the degraded dilution of precision. This results in the heavy reliance on the agency resources and will prevent autonomous operation by the start-ups, universities and small organizations. This difficulty is circumvented by devising the new range measurement method which this paper provides. As in the GNSS(GPS), the method utilizes the two pseudo range measurements obtained and exchanged at both the ground station and the spacecraft asynchronously. Similar to the GNSS(GPS), the data received at both sides retrieve the transmission and reception time information together with the pseudo range measurement. This process eliminates the onboard clock uncertainty owing to its instability. The method concludes not only the range data but also the clock difference information. And the clock aboard the spacecraft is synchronized with the clock on the ground. Since the GNSS(GPS) based clock information is available on the ground, this method practically provides the clock synchronization service to the spacecraft in the end. The method was implemented on the SDR (Software Defined Radio) and Linux system last year, and the method was successfully verified to work actually. Even the propagation delay corresponding to 100 million km distance was correctly processed. Both the range measurement and the clock synchronization were accomplished. After the completion of the demonstration of the scheme, currently the flight hardware device is under development toward the flight demonstration in 2024 by putting the device aboard a 3U class satellite. This paper presents not only the method itself but also the demonstration results obtained so far, as well as the hardware development status. The method will alleviate the navigation work load significantly and opens the autonomous capability of operating micro to nano space probes flying beyond cis-lunar space independent of the agency resources.