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ESTIMATION OF SIGNAL PROPAGATION TIME DELAY FROM SPREAD SPECTRUM BINARY PHASE SHIFT KEYING MODULATED RANGING SIGNALS FOR SPACE WEATHER APPLICATIONS

Abstract

Signal propagation through space is greatly affected by regular and irregular rapid ionosphere scintillations and atmospheric water vapor. As a result, satellite communication systems suffer from signal time delay which leads to poor data transmission, and huge packet losses. Based on the principles of radio sensing of the atmosphere, predicting atmospheric geophysical parameters such as total electron content (TEC) and total atmospheric vapor content (TWVC) depends on the signal propagation time delay through space. These atmospheric geophysical parameters greatly influence climate change, and they lead to disruptive space weather patterns such as floods, storms, tornados, heatwaves and droughts which threatens infrastructure,humans, and other living species. This paper presents ground test results from an implemented method that detects signal time delay due to atmospheric water vapor and ionosphere electron density between a low-Earth orbiting satellite and terrestrial ground stations. The time delay is computed based on the satellite position as well as the time of signal transmission from the ground and reception at the satellite side. Multiple spread-spectrum ranging signals modulated with binary phase shift keying (SS-BPSK) are transmitted from a network of ground stations to the satellite. The signal transmission and reception are facilitated by software-defined radio (SDR) hardware, and satellite location and time are given by a Global Positioning System (GPS) onboard the satellite. A radio frequency transistor-based (RF) switch was utilised to insert one pulse per second of GPS signal onto the received signal in order to synchronize ground and satellite time. The test results demonstrated that this method can be used to detect time delay due to atmospheric geophysical parameters in space weather applications.

Keywords: Time delay, GPS, SS-BPSK, SDR, climate change, space weather