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CARRIER TRACKING SYSTEM DESIGN FOR LEO SATELLITE ON BOARD COMMAND RECEIVERS

Abstract

Command receiver is one the most critical among on board satellite units. In Low Earth Orbit (LEO) satellite missions, carrier frequency transmitted from the ground station to satellite, and vice versa is continuously deviated due to Doppler shifts phenomenon (as relative motion of the satellite varies with respect to ground station). As consequence, on board command receiver down converts deviated frequency rather than the desired receive frequency, which can cause many problems like loss of carrier synchronization in demodulator, higher bit error rate (BER), or complete data loss etc.

The purpose of this paper is to present a complete system design, and introduce procedural methodology to implement carrier tracking, using conventional double conversion super heterodyne command receiver scheme.

Whenever there is any Doppler shift (plus/minus)fd in the carrier, it is linearly translated as variation in both intermediate frequencies. The system is designed to maintain 2nd intermediate frequency (IF) always at fixed frequency f2 Hz. This is done by using Voltage Controlled Temperature Compensated Crystal Oscillator (VCTCXO) as highly stable reference fref for the two local oscillators, LO1 and LO2 in a phase locked carrier tracking loop. This Doppler shift (plus/minus)fd causes the input RF frequency to vary in the range fRF(plus/minus)fd resulting 2nd IF to change as f2 (plus/minus)fd. The phase of this dynamically varying IF signal is then compared with a fixed frequency Temperature Compensated Crystal Oscillator (TCXO). The phase comparator outputs an R.M.S. error voltage, ve, which is proportional to the error fd, between its two input frequencies. This voltage signal is low pass filtered and linearly mapped to produce control voltage for VCTCXO. By applying the control voltage to the VCTCXO, the two LOs are shifted in such a way that the final IF returns back to f2 Hz, thus abolishing the effect of Doppler shifts.

Prototype Carrier Tracking System is developed for proof of concept with following steps; Requirements Analysis, System Design and Simulations, Hardware Design, Integration, and, Testing.

The PCBs designed, developed and tested are VCTCXO, 1st LO, 2nd LO, Down Conversion Board (For Both IF Stages), Phase Frequency Detector and Filter Board, and TCXO.

The complete prototype hardware is successfully integrated and tested. This work provides a systematic methodology for carrier tracking, with reliable implementation using traditional receiver hardware.