GPS signal tracking loop design for a satellite launcher

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ABSTRACT

This paper describes GPS signal tracking loop design for applying to the space system. The satellite launcher is operated in the harsh environment such as high dynamics, high vibrations, high shocks, severe thermal changes with vacuum, high humidity and electromagnetic interferences. Therefore, the GPS receiver adopted in a satellite launcher must be designed to operate in these harsh environments. Normally, the main design factors on the signal tracking loops are dynamic characteristics and navigation solution accuracy. In the space application, the error caused by high vibrations and severe thermal changes should be considered as well. For solving these problems, it is important not only to the hardware design but also to the software design such as a signal tracking loop. First of all, for the GPS signal tracking loop design adopted in a satellite launcher, it must be designed to choose the proper bandwidth in high dynamics and high vibrations and not to fail to do a signal tracking in high vibrations. Among the loop filter design, a Carrier tracking loop filter has a FLL(Frequency Lock Loop), PLL(Phase Lock Loop), and FLL-assisted-PLL mixing a FLL and a PLL. Figure 1 presents a block diagram of a GPS receiver carrier tracking loop.

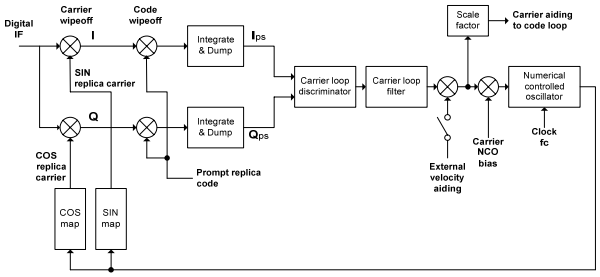

Figure 1 Generic GPS receiver carrier tracking loop block diagram.

Figure 2 is a block diagram of two novel FLL-assisted-PLL designs. This tracking loop is insensitive to constant velocity stress but is sensitive to acceleration stress. This paper uses the design in Figure 2, which is a second order FLL assisting a third order PLL. This design is insensitive to constant acceleration stress.

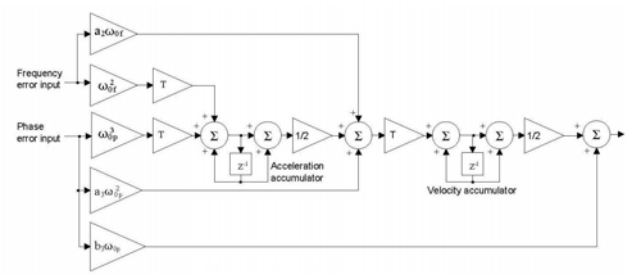

Figure 2 third order PLL with second order FLL assist.

The dominant sources of phase error in a PLL are phase jitter and dynamic stress error. Dynamic stress error is a 3-sigma effect. The phase jitter is the RSS of every source of uncorrelated phase error, such as thermal noise and oscillator noise

$$\sigma_{PLL} = \sqrt{\sigma_t^2 + \sigma_v^2 + \theta_A^2} + \frac{\theta_e}{3} \le 15[\text{deg}]$$

The dominant sources of frequency error in a FLL are frequency jitter because of thermal noise and dynamic stress error. The general rule of thumb for FLL tracking threshold is :

$$3\sigma_{FLL} = 3\sigma_{tFLL} + f_e \le 1/4T[Hz]$$

When a bandwidth range substitutes these equations for the value about high vibrations standard, a bandwidth range can be decided in high vibrations.

This paper proposes the design of GPS signal tracking loops with considering satellite launcher dynamic and harsh environment. For certifying the performance of a signal tracking loop in harsh environment, we try to the test about high dynamics and high vibrations and shows the test result.