Multipath Mitigation Performance Comparison of Strobe Correlators in GNSS Receivers

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ABSTRACT

This paper introduces effective methods of decreasing multipath errors by utilizing strobe correlators designed for GPS coarse-acquisition (C/A) code for future modernized signals including the BOC (n,n) modulation used for GPS L1C, Galileo E1 and the GLONASS new CDMA signal. The implementation and performance of different types of strobes are compared and discussed. The strobe concept is especially investigated for BOC (n,n), in order to identify a suitable locally generated tailored reference code to produce an unambiguous discriminator function for the receiver Delay Locked Loop. The new strobe correlators produce significant multipath resistance (especially to the medium-delayed multipath interference) and false tracking event elimination. The multipath rejection and tracking performance are quantitatively analyzed and discussed by utilizing a proposed methodology, so the best performing strobe for a particular application can be selected.

INTRODUCTION

To improve the positioning accuracy with respect to multipath and narrowband interference resistance, the binary offset carrier (BOC) (n, n) has been selected by three GNSS providers, GPS, Galileo and GLONASS, as the future modernized GNSS Code Division Multiple Access (CDMA) signal modulation scheme (Gibbons, 2008; EU/US agreement, 2004). However, multipath interference remains a major error source for current GPS positioning, even though the overall multipath error for new GNSS signal is reduced (Hein, Irsigler, Rodriguez, & Pany, 2004; Irsigler, Rodrıguez, & Hein, 2005).

The multipath errors include carrier phase multipath error generated in the carrier tracking loop and ranging error produced inside the code tracking loop. The existing multipath mitigation techniques can be grouped into 2 major categories, carrier phase multipath mitigation and reference waveform based code ranging multipath error mitigation.

Code ranging multipath error mitigation is currently the most commonly used methodology. It uses shaping techniques (i.e. the discriminator shaping and correlation shaping (Braasch, 2001)) in the Delay Lock Loop (DLL). The basic principle of DLL tracking relies on the correlation process (Dempster, 2006) between the receiving signal and the locally generated reference signal (denoted as LS). The discriminator shaping techniques include the Narrow Correlator and Pulse Aperture Correlator (PAC), where the desired discriminators are generated through linear combinations of several correlator outputs; while in the correlation shaping mechanism, the desired correlation output is produced by despreading the received signal with specially tailored LS. The later shaping technique includes the strobe correlator and High Resolution Correlator (HRC) (Veitsel, Zhdanov, & Zhodzicshky, 1998; McGraw & Braasch, 1999). In general, since correlation is a linear process, different shaping techniques can be summarized as the linear combination (i.e. addition or subtraction) of the results of the correlation processes between the received signal and several different specially tailored LSs. This methodology will be investigated in detail throughout this paper.

Moreover, in the light of new GNSS signals, adopting the BOC(n,n) signal as the receiving spreading code also brings a potential challenge in the DLL design. Generating the ambiguous discriminator function (DF) during DLL tracking is problematic. The ambiguity of the DLL discriminator can cause problems in the presence of strong inference (Hollreiser, et al., 2007; Wu & Dempster, 2008a). Hence according to the realization of tailored reference code-based shaping techniques, the objective of this paper is to design an unambiguous DF generated with a novel method. The new unambiguous DF "looks like" the HRC for C/A code and the "shaping correlator" (Garin, 2005) for BOC (n,n) except that the DF is represented in a much simpler way. The corresponding code ranging multipath error mitigation performance is provided and discussed.

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