Performance Evaluation of Tracking Loops in a Galileo BOC (1, 1) Receiver

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INTRODUCTION
The new generation of the Global Navigation Satellite Systems (GNSS) such as Galileo and the modernized GPS has lead to a new signal design. After researches for designing and selecting the best modulation consistent with the existing GPS BPSK modulation, the Binary Offset Carrier (BOC) Modulation was postulated to be the new signal modulation. For this new BOC modulation, the spreading symbols are not simple rectangles but rather segments of a square wave. This modulation multiplies a spreading code with a square wave called sub-carrier whose frequency is a multiple of the spreading code frequency. This BOC modulation may cause such a potential problem that its natural autocorrelation function is ambiguous. That is, the autocorrelation function of BOC modulated signal shows multiple peaks. As a result of this ambiguity problem, the use of the conventional early minus late correlator may result in a false tracking state. This ambiguity must be initially resolved and continuously maintained. This paper proposes a new discriminator function that can remove this ambiguity and evaluates its performance comparing with previous methods.

GPS AND GALILEO SIGNAL CHARACTERISTICS
The GPS C/A code is a Binary Phase Shift Keying (BPSK) signal with a chipping rate of 1.023MHz. The Galileo Open Service signal on L1 will use a BOC modulated signal. For BOC signals, the spreading code is mixed with a square wave of a given subcarrier frequency. The notation BOC \( (f_s, f_c) \) is used, where \( f_s \) represents the square wave subcarrier frequency in units of 1.023MHz and \( f_c \) represents the chipping rate in units of 1.023MHz. The square wave subcarrier modulation used with BOC (1, 1) results in the autocorrelation function having a sharp main peak and two smaller negative side peaks. The sharp main peak will result in improved code tracking performance for the BOC (1, 1) signal as well as improved multipath mitigation performance while the side peaks can cause false tracking.

DESIGN OF TRACKING LOOPS
Due to the structural similarity of Galileo and GPS signal, the high-level architecture of Galileo receivers is similar to that of GPS receivers. The essential new element of Galileo receivers is a generic channel which is able to track the signals of all the possible modulation schemes including GPS BPSK (1) and Galileo BOC (1, 1). WDELP (Weighted Double Early minus Late Power) discriminator algorithm is implemented in a Galileo software receiver through this paper following our previous result [1]. Other methods such as the bump-jump algorithm, the de-convolution correlator technique and the GARDA correlator technique are also implemented to compare the performance with that of WDELP algorithm [2].

PERFORMANCE EVALUATION
Some experiments are done to evaluate and compare the effectiveness of the proposed tracking loop in a Galileo software receiver. Using the signals of the software based GNSS signal generator, the accuracy of signal tracking and navigation is examined, and the noise performance of the tracking loop is analyzed.

CONCLUSIONS
The ambiguity problem of the BOC modulated signal has been reformulated in terms of a signal acquisition and tracking, and a tracking loop in Galileo receiver has been designed. In order to perform a performance evaluation, a software based Galileo receiver with various tracking loops has been implemented. The tracking and navigation accuracy have been evaluated.

REFERENCES