

# A Cyclostationary Bayesian Approach For GPS Signals Delay and Frequency Offset Estimation

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## Abstract

Frequency offset and delay estimation are typically required in the reception of GPS signals. The frequency of the incoming signal can differ from that of the local oscillator frequency due to propagation, Doppler effects and mismatch between the satellites transmitter and the receiver. The delay estimation allows the computation of the distance between the user and the satellite, and with at least four estimates from the different emitters, the positioning can be realized. In GPS applications, conventional positioning techniques are based on the characteristics of the pseudorandom code autocorrelation function. They don't take into account the eventuality presence of interference, multipath reflections and high level non-Gaussian noise. These undesired signals may greatly disturb the measures of the usual Early-Late method [3]. Several techniques has been proposed in the GPS literature to mitigate separately the interference or multipath effect but there is no synchronization method robust to both of them.

Since we have shown in [1, 2] that the cyclostationarity property of the GPS signal can be exploited to improve the synchronization parameters estimation, we propose in this paper a novel method based on the second order cyclic statistics. By considering the sample cyclic autocorrelation function of the GPS signal and the probability distribution of the estimation error, a general linear model formulation of the problem is derived from which the parameters are estimated using the Maximum A Posteriori (MAP) estimator in a Bayesian framework. This approach require only knowledge of the frequency that characterizes the underlying periodicity exhibited by the GPS signal, namely the cycle frequency. Thus we avoid the need for a priori knowledge of interference and noise characteristics (e.g. no gaussianity assumption is needed).

The results demonstrate analytically and also by simulations that greatly improved jammer and interference rejection is achievable by exploiting properly the signal-selectivity properties of the cyclic autocorrelation function of the cyclostationary GPS signals. The proposed method can perform well for multipath signals severely corruptive by noise and interference that exhibit no cyclostationarity with the same cycle frequency.

## References:

- [1] William A. Gardner (Editor), Cyclostationarity in Communications and Signal Processing, IEEE PESS 1994.
- [2] M. Sahmoudi and M. G. Amin, "Unitary Cyclic MUSIC for Direction Finding in GPS Receivers", submitted to the IEEE International Conference SAM 2006.
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**Key Words:** GPS, Delay estimation, Interference, Multipath, Cyclostationarity.