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AUTONOMOUS NAVIGATION OF LEO AND GEO SATELLITES USING GPS

Abstract

The GPS code ranging measurements are inherently too noisy in nature for high fidelity users. On the other hand, the carrier phase measurements are very accurate but ambiguous and can be rectified only through a computation intensive algorithm. This paper describes a method to combine the advantages of both to achieve an accuracy level higher than that possible only through code ranging measurements but avoiding the complexities of ambiguity removal. A linear Kalman filter is applied on the carrier and the code measurements with increasing consecutive weights given to the former for a particular set of visible satellites. The weights are reset for a satellite on an event of its dropping out of the visibility region and reappearance. This smoothing algorithm is applied to a LEO and a GEO satellite and the accuracy obtained is compared to that obtained using coarse pseudorange measurements. The GEO satellites receive only the 'spilled' energy of the GPS signals, their orbits being above that of the GPS satellites. All conventional receivers detect only the main lobe of the GPS signal and hence observe a visibility of less than four satellites. 'Navigator', a receiver designed by NASA can detect the side lobes as well and thus ensures a visibility of four GPS satellites most of the time.

The simulations are done assuming Navigator as the receiver being used on board the GEO satellite. The environmental model is simulated by considering gravitational perturbation effects up to fourth order and the GPS orbits from the navigation data containing perturbed Keplerian elements. The velocity is calculated using both Doppler and carrier measurements. An orbit extrapolation model is used to propagate the position and velocity values in cases of high Dilution of Precision (DOP) values or number of visible GPS satellites being less than four. The position and velocity accuracy for various cases of DOP and limiting Kalman weight is analyzed.