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Carrier Phase Time Transfer using NavIC

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NavIC System time is generated and maintained at its two Precise Timing Facilities geographically situated apart. The time offset between the timescale systems at the two laboratories is continuously monitored using the precise time transfer methods namely Two Way Satellite Time and Frequency Transfer (TWSTFT), GNSS and NavIC All-In-View (AV) time transfer providing an accuracy of ~1 ns and ~5ns respectively.
The time transfer receiver, in general, generates two types of measurements, namely, the code pseudorange measurements and the carrier phase measurements. Of the two types of measurements, the carrier measurements have better precision but are ambiguous due to the unknown number of cycles between receiver and satellite while the code measurements are unambiguous but are less precise as compared to carrier phase measurements.
Carrier phase measurements are precise due to the following reasons:
1) The effect of multipath on carrier phase measurements is much less as compared to that on the code range measurements 2) The effect of thermal noise on carrier phase measurements is an order of magnitude lesser as compared to code range measurements. However, both the observations are subject to many common error sources, such as atmospheric delays, orbital error, clock biases, and measurement noise. To compute the offset between the local reference time and constellation reference time using code range measurements, it is required to model/estimate all the errors/delays involved in the measurements and remove it from the code range measurements [1, 2]. Whereas to compute the offset using carrier phase measurements, it is required to compute additionally the integer number of cycles along with all above errors. The integer ambiguity can be resolved with different methods by using the combination of dual frequency code and carrier phase measurements.
An attempt has been made to estimate the time offset between the two timescale systems using both code and carrier phase measurements provided by the NavIC receivers at the two timing facilities and to study the improvement achieved using carrier phase measurements. This paper provides the first cut results of the carrier phase time transfer using NavIC signals in comparison to the standard code based time transfer method. The comparison of the results obtained using two methods for both zero-baseline (two timescales situated at the same location) and long-baseline (two timescales geographically separated by approximately 2000 km) is shown in Figure 1 and Figure 2 respectively. The results demonstrate that time transfer accuracy using carrier phase based time transfer is better than 1 ns as compared to 5 ns obtained from code-based time transfer techniques.

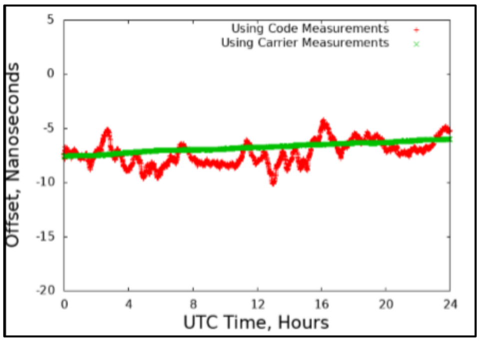

Figure 1: Comparison between Code and Carrier based time transfer at zero-baseline

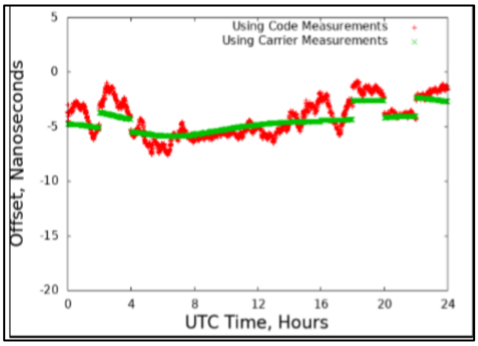

Figure 2: Comparison between Code and Carrier based time transfer at long-baseline

1. Gerard Petit and Claudine Thomas, GPS Frequency Transfer using Carrier Phase Measurements, Proceedings of 1996 IEEE International Frequency Control Symposium, doi: 10.1109/FREQ.1996.560307.
2. Kristine M. Larson and Judah Levine, Carrier-Phase Time Transfer, IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control, Vol. 46, No. 4, July 1999.