Precise clock comparison by means of software-defined radio receiver

Yi-Jiun Huang and Huang-Tien Lin
National Time and Frequency Standard Lab., Chunghwa Telecom Labs.(TL), Taiwan
dongua@cht.com.tw, linht@cht.com.tw

The coordinated universal time (UTC) is a weighted average over an amount of atomic frequency sources, such as Hydrogen masers or Cesium clocks. The weighting of each source is depending on the frequency stability relative to the others [1]. To determine the stability, time difference measurements between two frequency sources are required. Because the locations of frequency sources spread worldwide, suitable comparison techniques over intercontinental baselines are important for the generation of UTC.

Two-way satellite time and frequency transfer (TWSTFT) is one of the most accurate methods to compare two frequency sources that are far apart. Two TWSTFT earth stations located at one laboratory and its counterpart separately and the local frequency sources to be compared are connected to them. The binary shift code keying (BPSK) signal synthesizing to the local frequency source will be generated by the time-transfer modem, and then transmit through earth station transmitter. The modem can also demodulate the signal transmitting from the counter-part station, and then get its time of arrival (TOA). To improve time comparison uncertainty, the signal propagation uncertainty should be reduced and the accuracy of TOA measurement should be ensured. TWSTFT is performed using the microwave communication on physical layer through geostationary satellites. According to the symmetrical property, (the propagation delays between two stations are regarded as the same) the microwave signal propagation from an earth station to a satellite and is identical to that from the satellite to the station. Taking this advantage, the TWSTFT can offer a precision of one nanosecond for time comparison between two clocks over an intercontinental distance.

The software-defined radio (SDR) method provides more computational resources and more flexible platform for digital signal processing (DSP) than existing analog modems. The key components of the SDR are an analog-to-digital (A/D) sampler, a signal generator, and DSP algorithms. The features that the A/D sampler has high sampling rate (50M samples per second) and the samples have uniform sampling interval could improve the accuracy of TOA measurement. We have developed a TWSTFT receiver based on SDR technique to measure TOA, and we have conducted several clock comparison activities among several institutes with the SDR receiver. As shown in Figure 1, the SDR receiver can provide higher precision than existing TWSTFT modem. Based on some encouraging results, the clock comparison by using TWSTFT with SDR receivers has been considered as an effective method for the UTC generation [2].

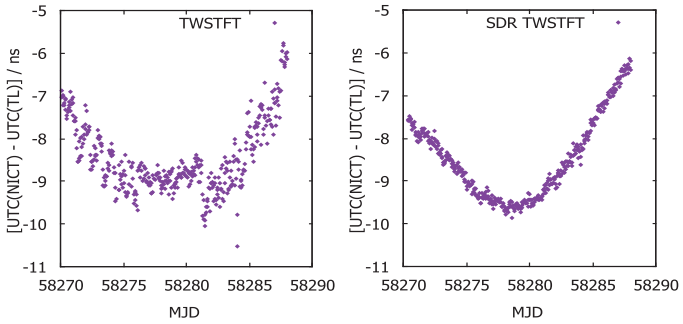

Figure 1. time differences between UTC(NICT) and UTC(TL) measured by traditional TWSTFT (left) and SDR TWSTFT (right)

Acknowledgement

We thank National Institute of Information and Communications Technology NICT, Japan, for agreeing us to use their measurement data.

Reference

[1] G. Panfilo, A. Harmegnies and L. Tisserand, A new weighting procedure for UTC, *Metrologia,* vol. 51, no. 3, pp. 285-292, 2014.

[2] Z. Jiang et al., "Use of software-defined radio receivers in two-way satellite time and frequency transfers for UTC computation", *Metrologia,* vol. 55, no. 5, pp. 685-98, Aug. 2018.