# Development of a new TWSTFT modem at NICT

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## 1. Introduction

Two-Way Satellite Time and Frequency Transfer (TWSTFT) is one of the time and frequency transfer methods configuring the international network for TAI generation. The accuracy and stability have not progressed well from the point of view of the limited onboard frequency bandwidth, in other words, the low chip rate. To break the barrier, National Institute of Information and Communications Technology (NICT) has developed a Two-Way Carrier-Phase Satellite Frequency Transfer (TWCP) and demonstrated its high measurement precision at the $10^{-13}$ level [1]. The experiments have been done aiming stable frequency transfer in links connecting some laboratories: NICT-PTB, PTB-OP, NICT-Osaka University [2] and NICT-KRISS until now. The combination of an arbitrary waveform generator and an AD sampler has been applied for signal generation and carrier-phase detection, respectively.

## 2. A new modem

To widely disseminate the TWCP technique, NICT has started the development of a new modem which enables both time and frequency transfers. It is a FPGA based modem for cost effectiveness and re-program. It generates a signal with a chip rate of 1 MHz at a frequency of 70 MHz and it is designed in consideration of internal delay calibration for time transfer as well as frequency transfer. We have achieved the expected measurement precision by the laboratory test.

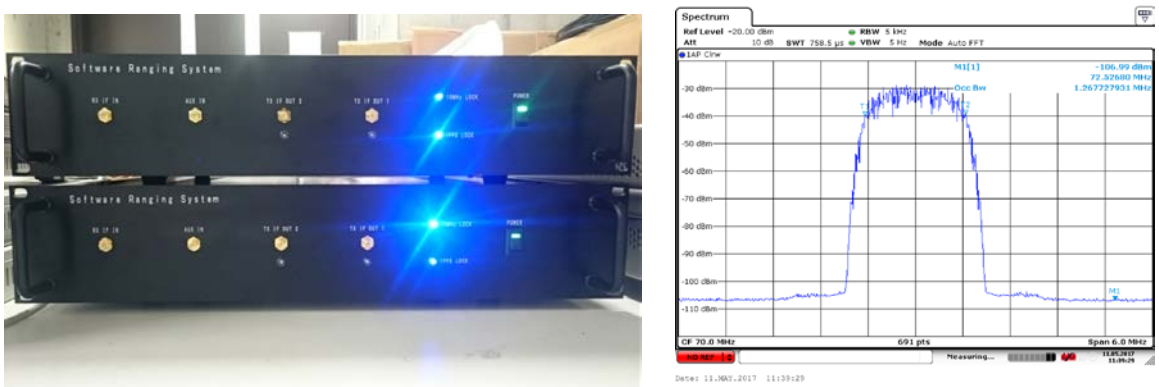


**Fig. 1.** (Left) Appearance of the modem, (Right) the output signal at 70 MHz.

## 3. Summary

We introduce the newly developed TWSTFT modem. By application of the modem, we can expect the improvement of the TWSTFT stability. Additionally, it will pave the way for comparison of optical frequency standards over satellite-based links.

[1] M. Fujieda et al., Metrologia, 51, 253-262 (2014).
[2] M. Fujieda et al., IEEE TUFFC, 63, 12, 2231-2236 (2016).