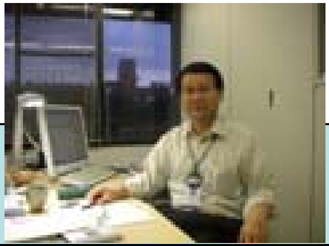
TWSTFT Activities in NMIJ, AIST

National Metrology Institute of Japan (NMIJ)

Tomonari SUZUYAMA

Members of our section



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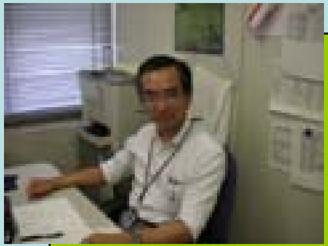

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Time Standards Section

Wavelength Standards Section

Time keeping at NMIJ

- Seven Cs atomic clocks (four clocks are reported to BIPM)
- Four Hydrogen Masers, three of them are made by Anritsu(RH401A), one is CH1-75A made by Kvartz.
- UTC(NMIJ) has been generated by using an AOG since June, 2004.
A HROG is used for back up now.
- The source oscillator for the AOG is one of the Hydrogen Masers since March, 2006

Time transfer at NMIJ

- **JCSAT-1B link among Pacific-rim region NMIs**
  This station's operation was interrupted due to the SSPA trouble since August 24, 2007. We will replace a new transceiver as soon as possible.
- **Preparation for another link**
  A new earth station with 2.4 m dish antenna for PAS-4 was installed at NMIJ at last.
- **Two NICT modems and one SATRE modem**
- **Precise time and frequency transfer**
  Development of TWSTFT carrier phase system has been started to realize highly precise time and frequency transfer, such as 10^{-16} level.

UTC(NMIJ) measurement system

TWSTFT system at NMIJ

- 1.8 m antenna (4 W) for JCSAT-1B among Pacific-rim region NMIs.
- New earth station with 2.4 m antenna (10 W) for PAS-4.

Calibration between NMIJ and NICT

- **February 19 and 20, 2007.**

Many thanks to NICT TW members.

Portable station

New earth station

air-conditioned storehouse

chamber

Up&Down converter SSPA will be inside

It connects by wave guide tube between a radiation part and SSPA.

A radio station license is already issued, and UAT will be performed on next Friday.

Carrier Phase TWSTFT development

TWSTFT using PN code phase

time transfer	~ 0.1 ns
frequency transfer	10^{-10} @1 s

TWSTFT using carrier phase

time transfer	~ 0.1 ps
frequency transfer	10^{-12} @1 s
	10^{-16} - 10^{-17} @1 day

Concept of Carrier-Phase TWSTFT method

The signal carrier phase of bidirectional transmission is used.

resolution	0.1 ~ 1 ps (If a sub-carrier is assumed to be 10GHz, it will measure by the resolution of 1/100 – 1/1000 of the one cycle..)
time transfer Accuracy	$<$ 1ps
frequency transfer Accuracy	$< 10^{-12}$ @1 s

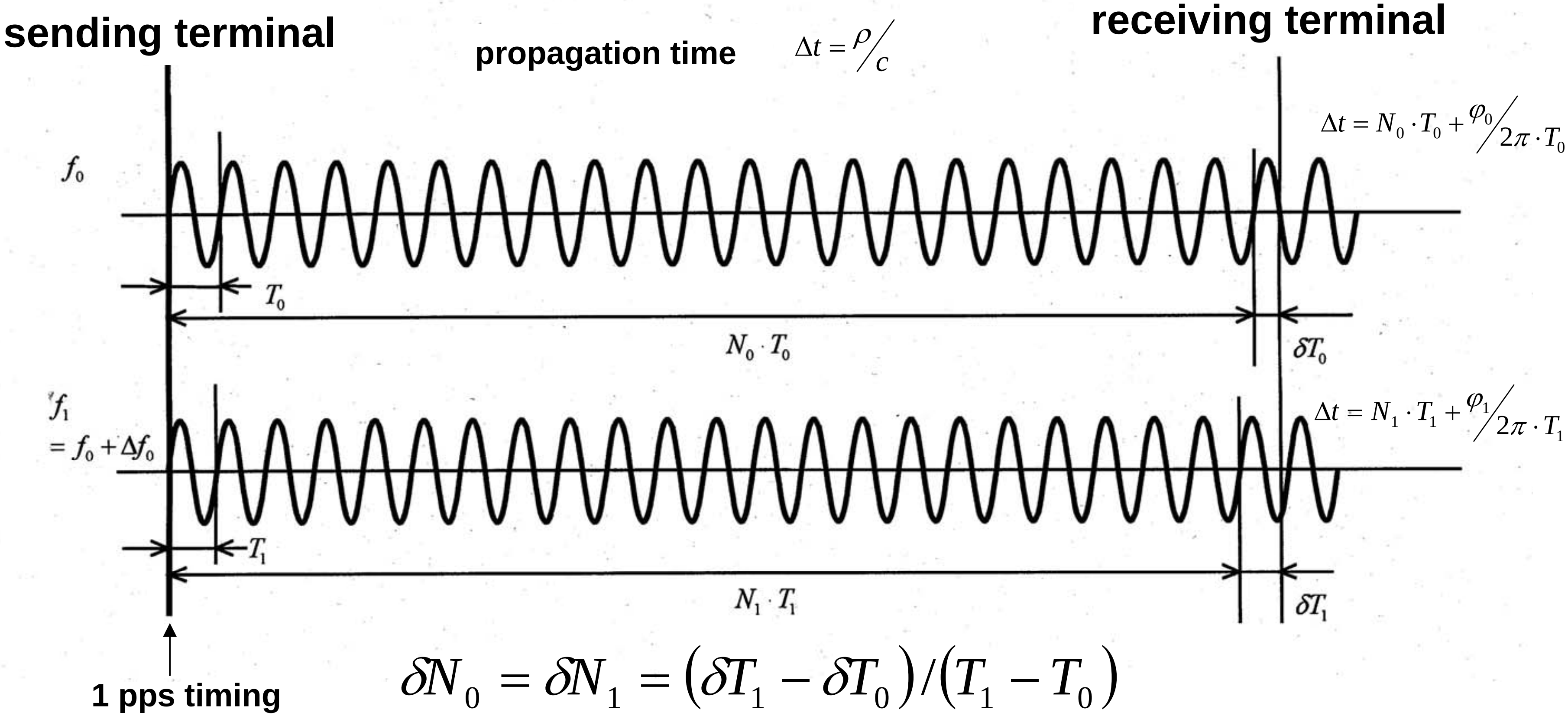
using several PN codes, and it compares simultaneously at many points.

problem to be solved

1. solving the ambiguity of carrier phase
2. correction of ionosphere delay effect caused by the frequency difference between the up-link frequency and the down-link one
3. compensation of phase fluctuation in the ground station devices caused by mainly temperature variation

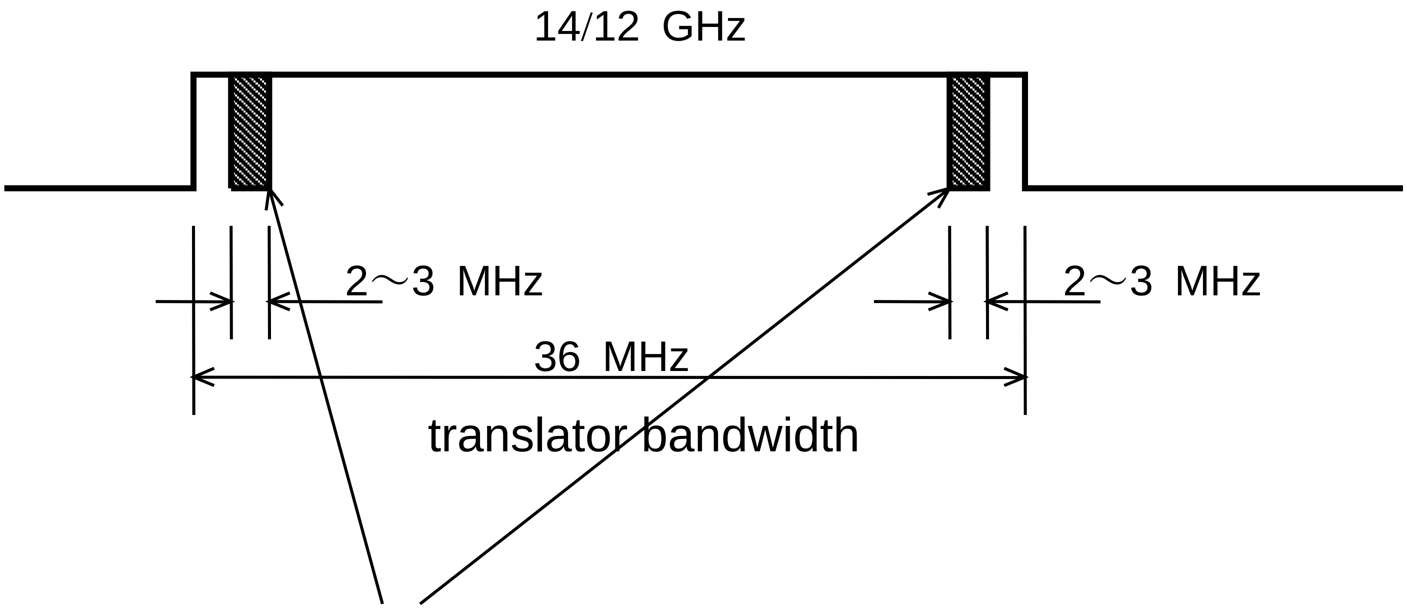
Ambiguity of carrier phase

Using main carrier and coherent subcarrier which frequency separated Δf, ambiguity is removed from the approximate value of transmission time (using code phase of data), the main carrier phase and a subcarrier one and the propagation time are decided.



$$\delta N_0 = \delta N_1 = (\delta T_1 - \delta T_0)/(T_1 - T_0)$$

Ionosphere delay effect



the ionospheric effect can actually be measured using two slots of the time transfer signal located at near both edges of the satellite transponder.

numbers of electrons (A to sat.) : N_{tA}
numbers of electrons (B to sat.) : N_{tB}

Station A to B

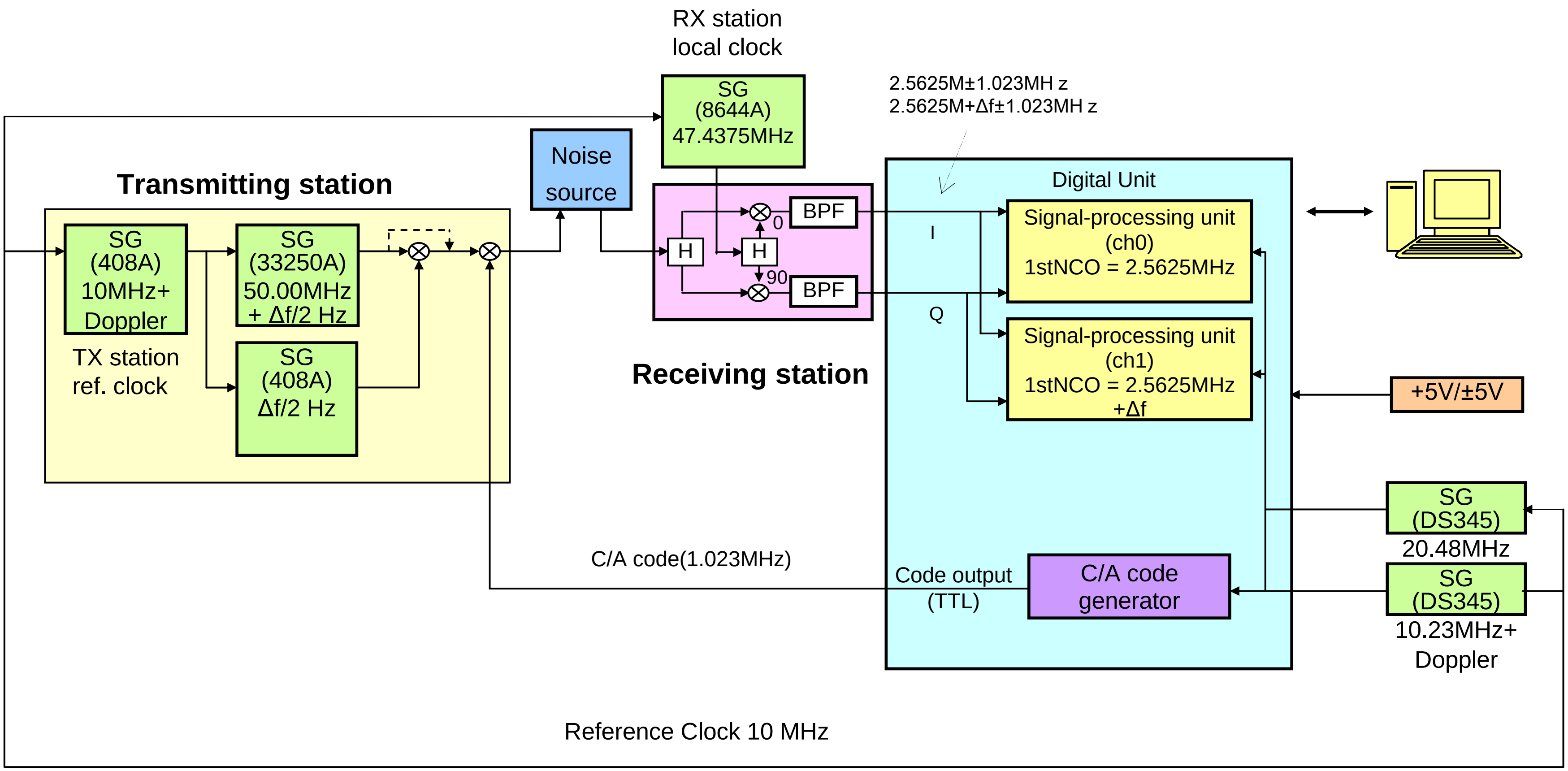
$$\Delta T^{ion}_{A-B} = T^{ion}_{h,A-B} - T^{ion}_{l,A-B} = 40.5 \times \left(\frac{1}{c f_{uh}^2} - \frac{1}{c f_{ul}^2} \right) \times N_{tA} + 40.5 \times \left(\frac{1}{c f_{dh}^2} - \frac{1}{c f_{dl}^2} \right) \times N_{tB}$$

Station B to A

$$\Delta T^{ion}_{B-A} = T^{ion}_{h,B-A} - T^{ion}_{l,B-A} = 40.5 \times \left(\frac{1}{c f_{uh}^2} - \frac{1}{c f_{ul}^2} \right) \times N_{tB} + 40.5 \times \left(\frac{1}{c f_{dh}^2} - \frac{1}{c f_{dl}^2} \right) \times N_{tA}$$

Carrier-Phase TWSTFT Experiment system (Phase1)

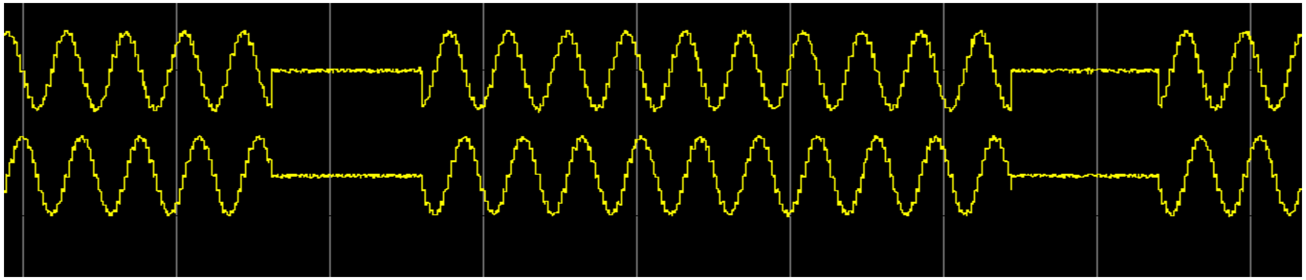
evaluate basic system & simulation

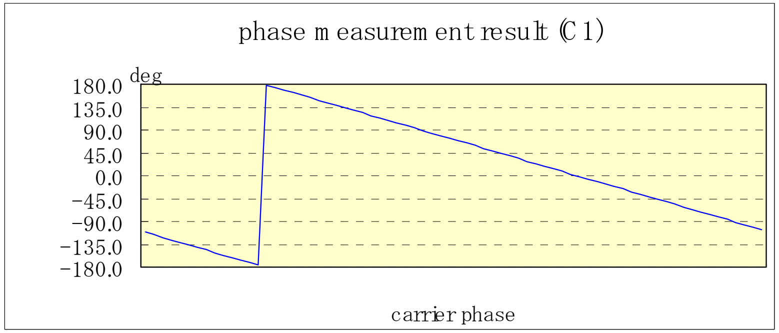


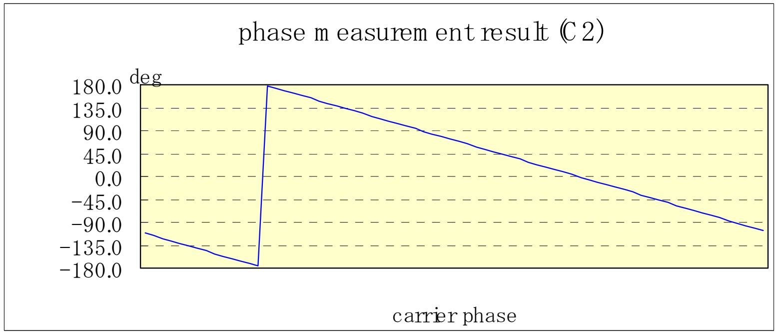
We are planning to solve the ambiguity comparatively easily by using a sub-carrier signal which is generated coherently with the main carrier signal.

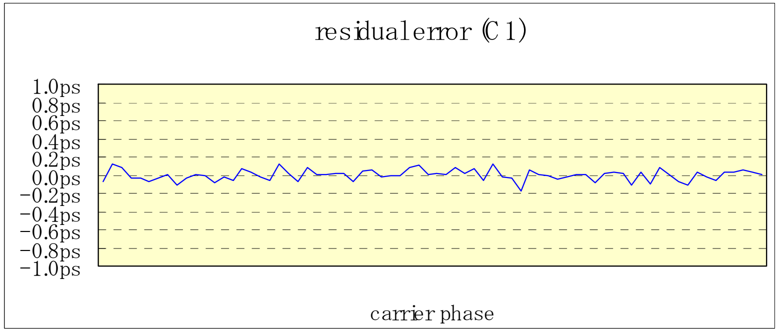
Simulation result (CN_0= 90 dBHz)

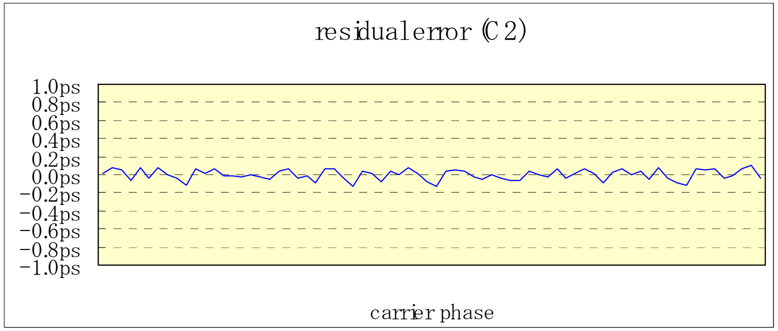
carrier wave pattern (upper:C1, lower:C2)





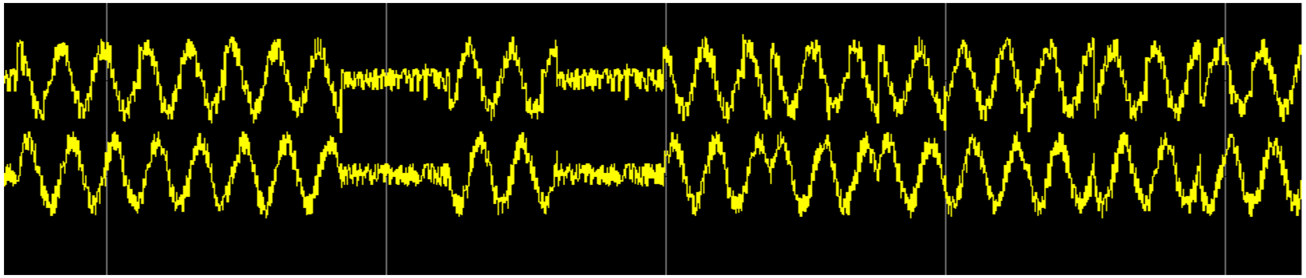


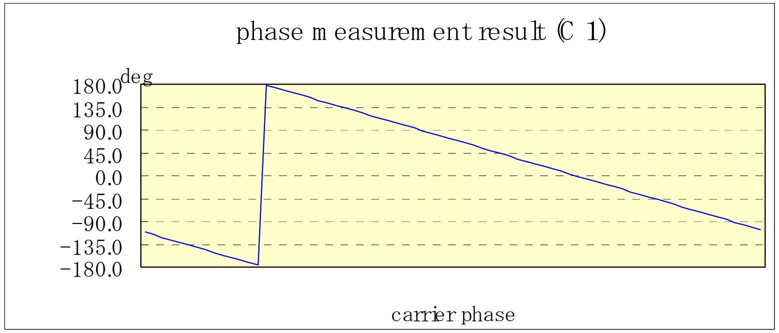


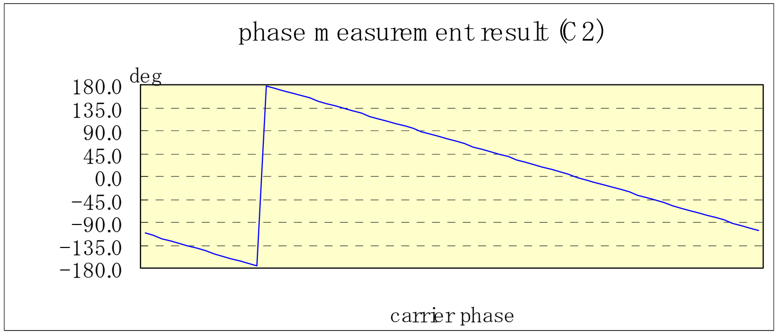


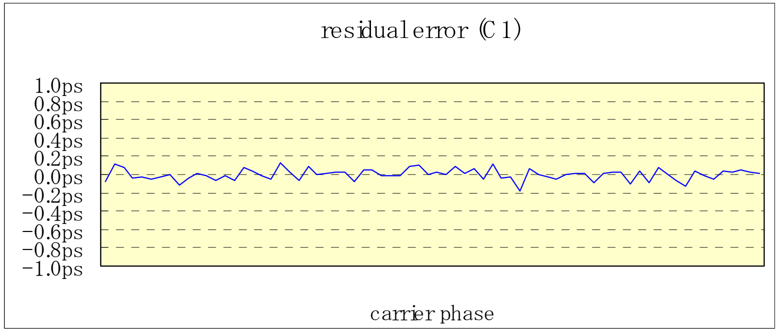
Simulation result (CN_0= 70 dBHz)

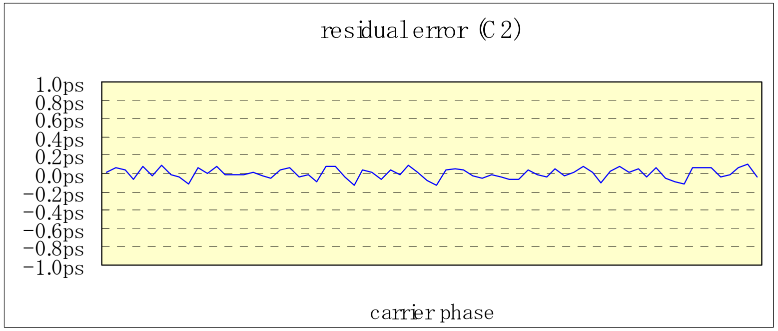
carrier wave pattern (upper:C1, lower:C2)





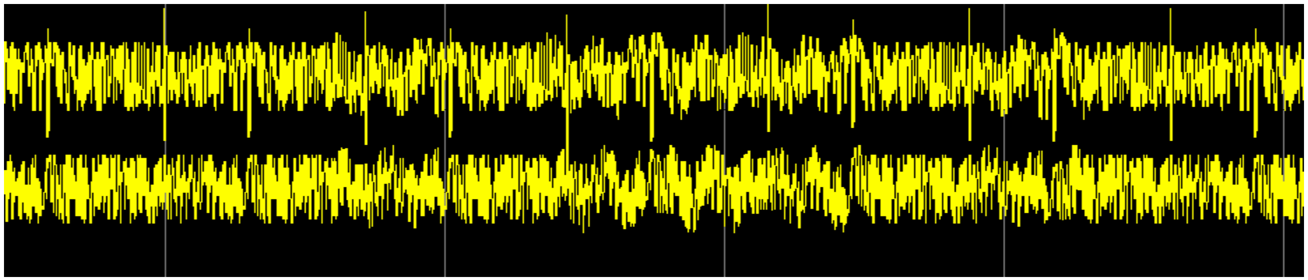


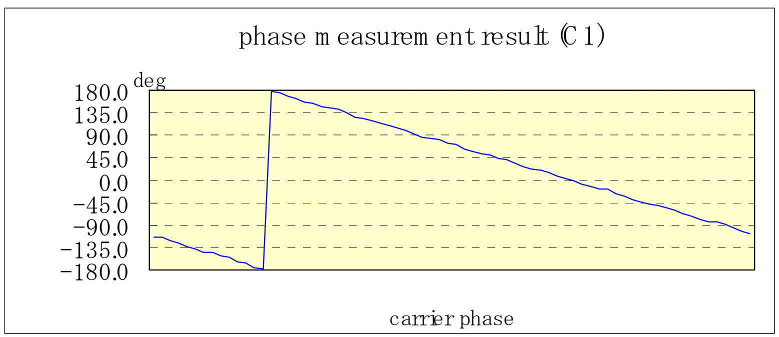


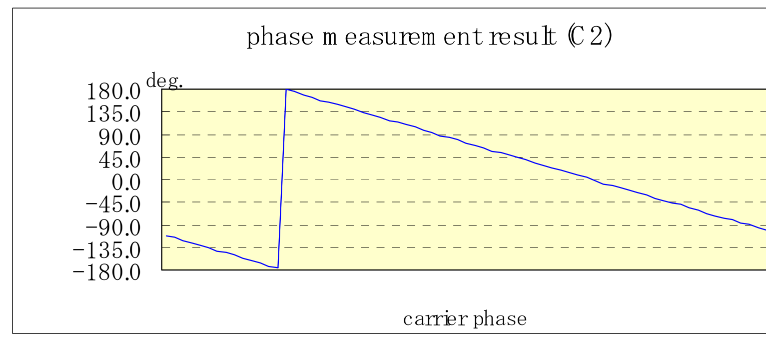


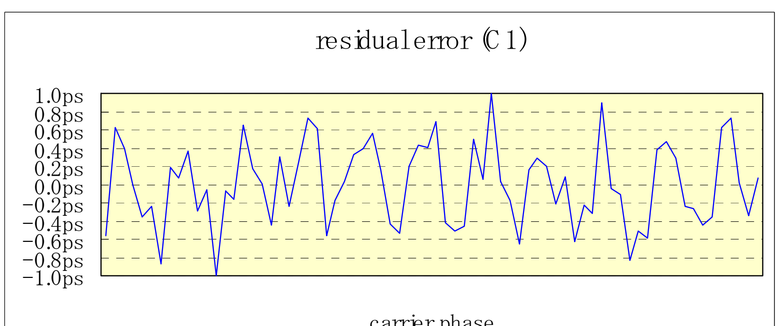
Simulation result (CN_0= 50 dBHz)

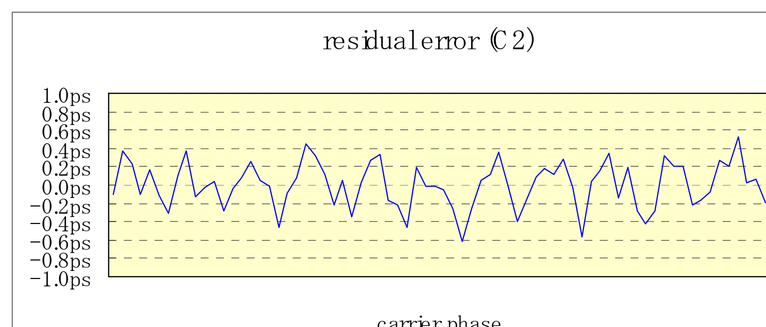
carrier wave pattern (upper:C1, lower:C2)











present status

- The simulation results show a possibility that the accuracy of 0.3 ps for solving ambiguity can be attained. (It improves by multi-bits quantization. *etc.*)

- The detailed technical specification of a prototype machine’s hardware and software are under creation, and the RX parts will be completed soon.

- The evaluation test also including the TX parts is due to be started from the second half in the current fiscal year.