Measurement of Time Difference

Kuniyasu Imamura, Hiroyuki Itoh,
Noboru Kotake and Fumimaru Nakagawa

Outline

- Time Interval Counter
- DMTD method
  - Principle of DMTD
  - Measurement of Time Difference using DMTD system
  - Demonstration of DMTD system and comparison with a commercial time interval counter.
- Clock transportation
  - Method of Clock transportation
  - Practice of Clock transportation

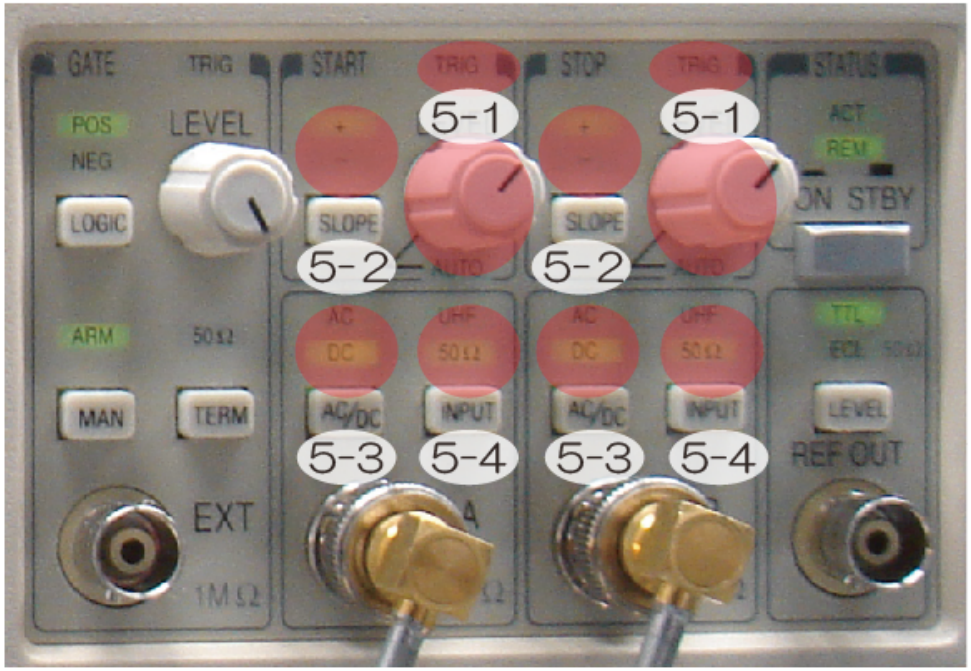
Procedure of Measurement of Time difference by SR620

①Turn on the switch.
②Connect Reference signal to
the rear connecter “10MHz in”
and check the red light at
“CONFIG - CLOCK” is clear.
(to measure using reference signal)
③Connect two signals to connecters.

④Set mesurement parameters.
(4-1) “MODE : TIME”
(4-2) “SOURCE : A”
(4-3) “GATE/ARM : +TIME”
(4-4) “SAMPLE SIZE : 1”
(4-5) “DISPLAY : TRIG”

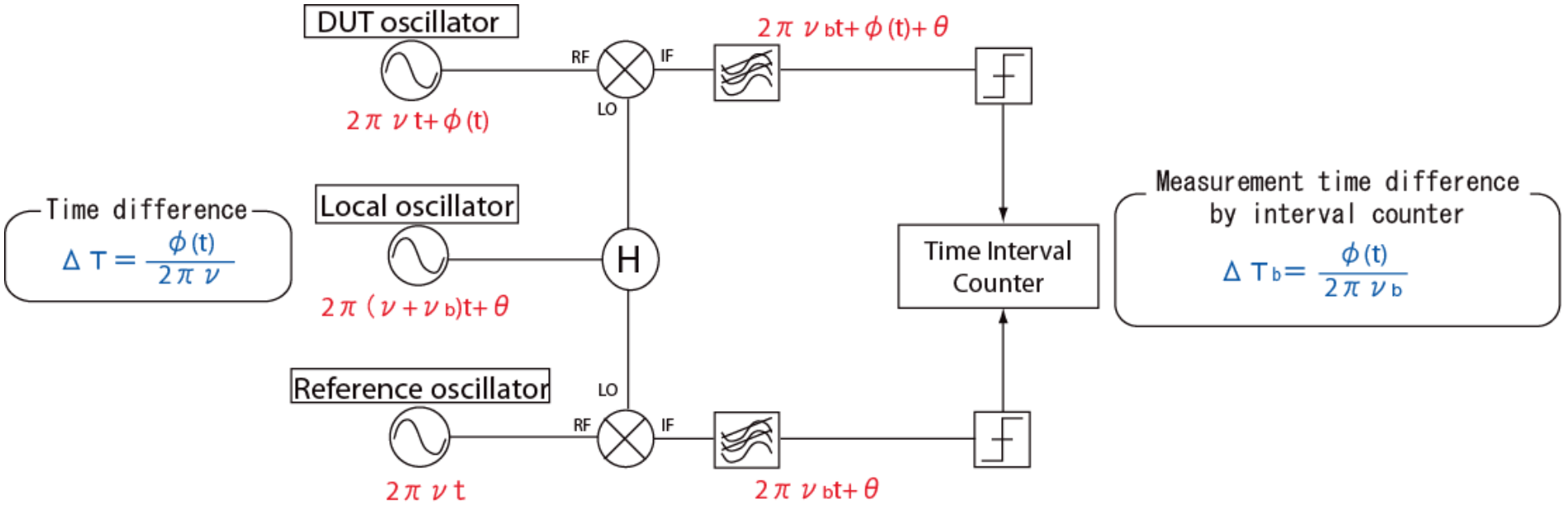
Procedure of Measurement of Time difference by SR620

⑤Set both “START” and “STOP” Trigger parameters
(Each parameter is adapted to input signals.)
(5-1) “LEVEL : 1.0V” and check flashing “TRIG light”
(5-2) “SLOPE : +”
(5-3) “AC/DC : DC”
(5-4) “INPUT : 50Ω”
⑥Set mesurement parameters “DISPLAY : MEAN”



Dual Mixer Time Difference (DMTD)

- Using two double balanced mixer, both a reference signal and a DUT signal are down-converted by the same local signal.
- Before and after the down-convert, a phase difference between Reference and DUT dose not change, but frequency is decreased.
- As a result, a time difference measured by TIC is amplified and a measurement precision of time difference is improved.



- A reference signal and a Device Under the test (DUT) signal are down-converted to ν_b by a local signal.
- Time difference (ΔTb) between two down-converted signals is measured by time interval counter.
- Time difference ΔT is calculated, as $\Delta T = \Delta Tb \times \nu_b / \nu$.
- The accuracy of measurement is improved by a factor (ν / ν_b).

Demonstration of DMTD

- Frequency stability of TIC(SR-620)
- Frequency stability of DMTD system
- Measurement of Cesium atomic clock by TIC
- Measurement of Cesium atomic clock by DMTD system

Measurement of Time Difference

- Using Time Interval Counter

  * Measurement of absolute value (using 1pps)

  *The precision is a few 10ps

  → ～10s averaging time for Cs clock

  → ～10000s averaging time for HM clock

- Using DMTD method

  *Measurement with high precision

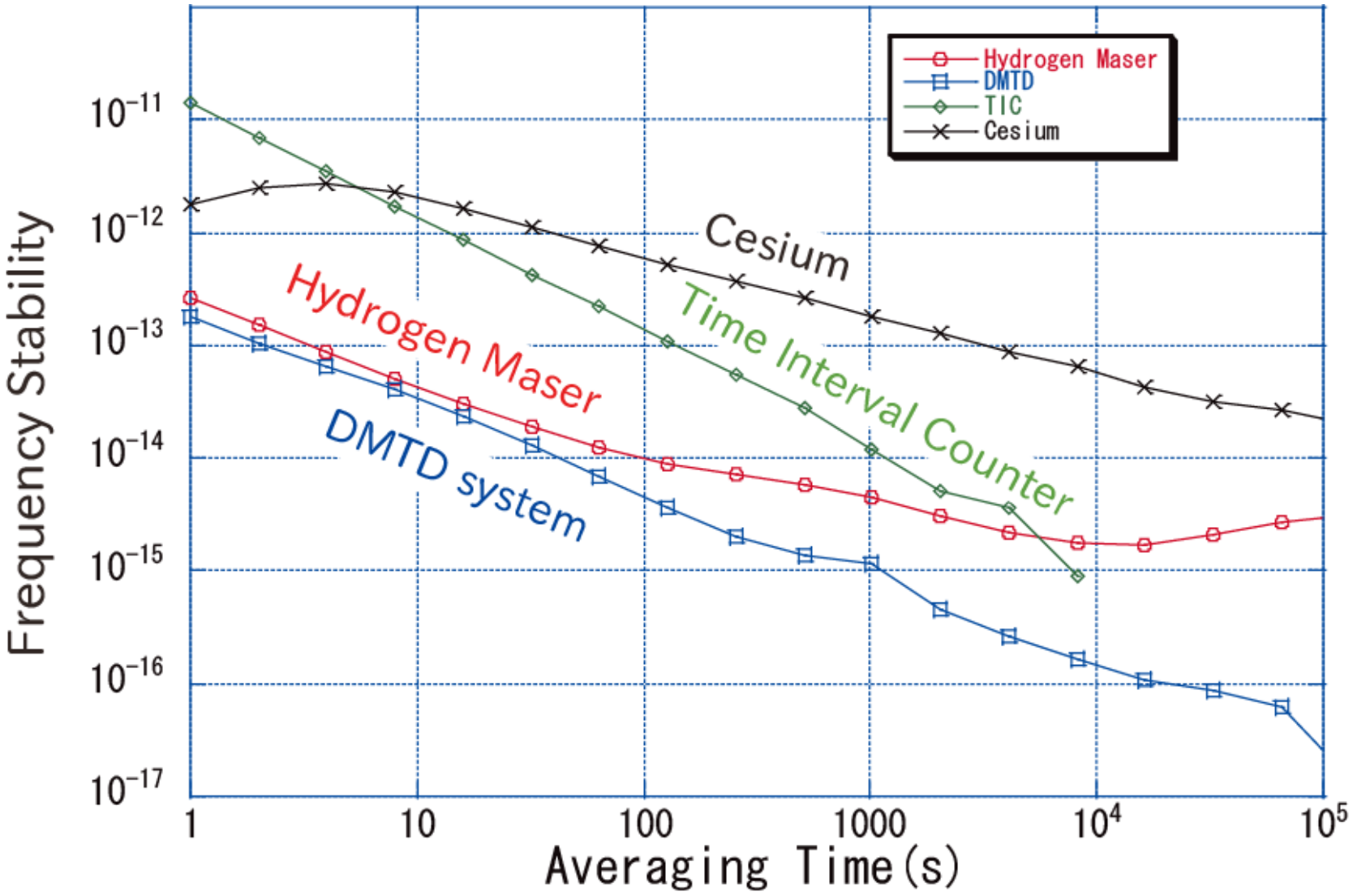
  *Only measurement of relative value is possible.

  *Using carrier signal (ex. 5Mhz)

  *The precision is below a few 0.1ps

  → We can measure the frequencies both Cs and HM from 1s averaging time.

Frequency stabilities of measurement systems and atomic clocks

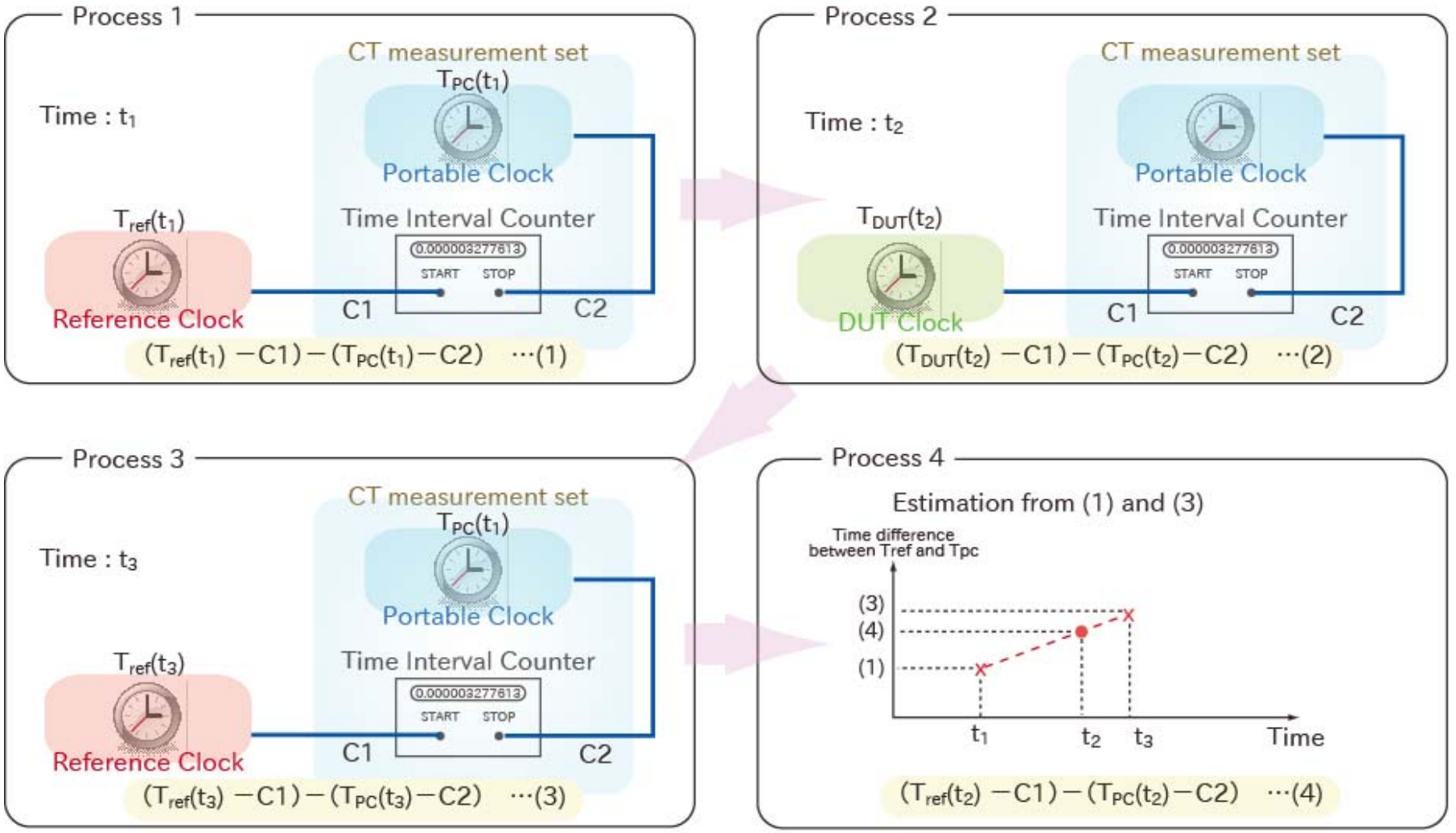


Measurement of Time Difference and Cable Delay using Clock Transportation

(1)Measurement of time difference between two clocks with some distance

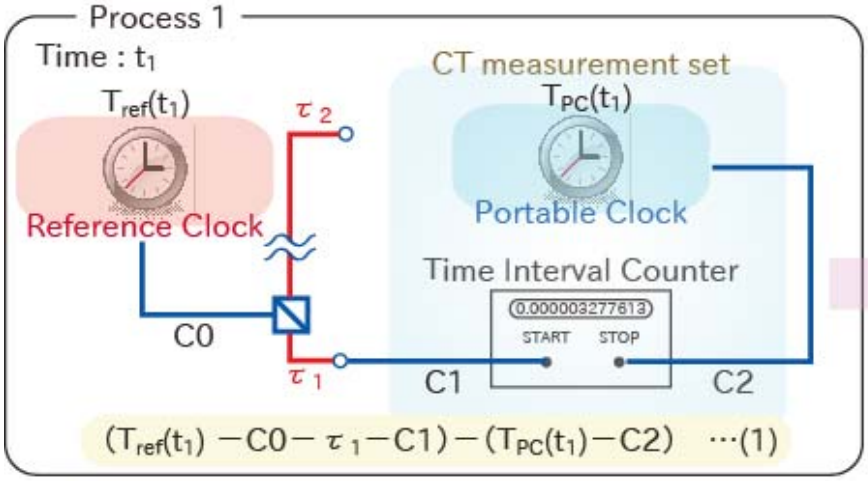
(2)Measurement of cable delay

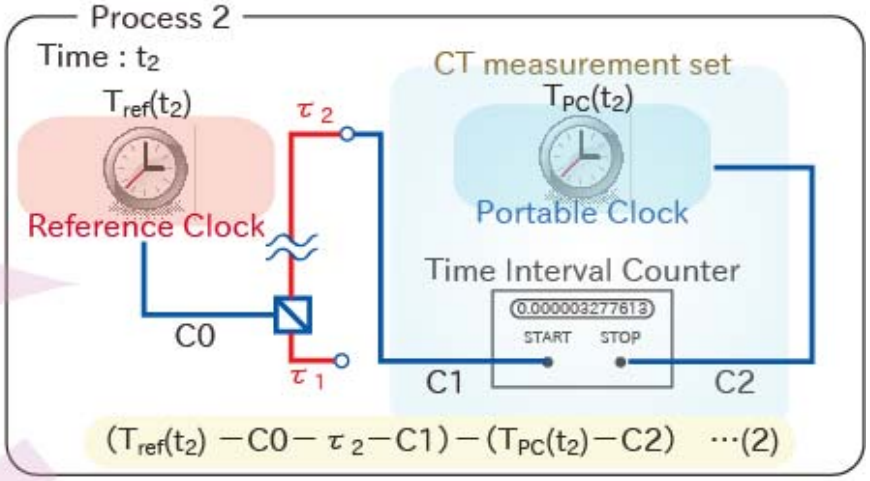
Measurement of time difference between two clocks far from each other.

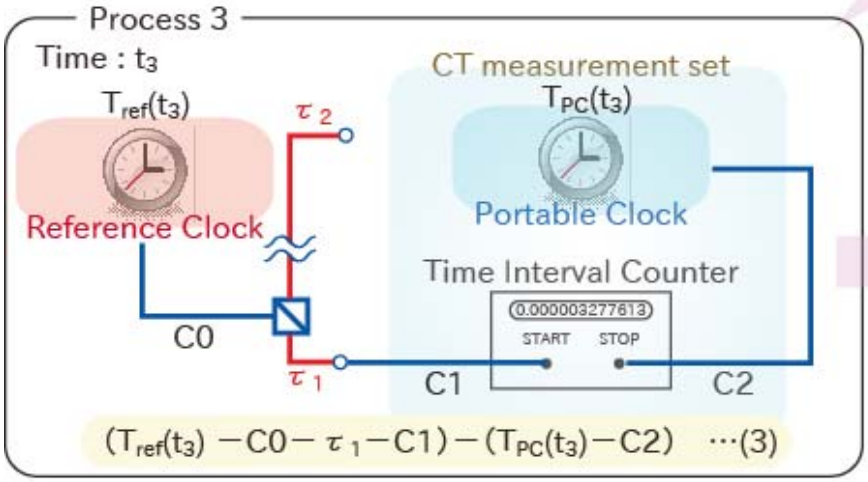


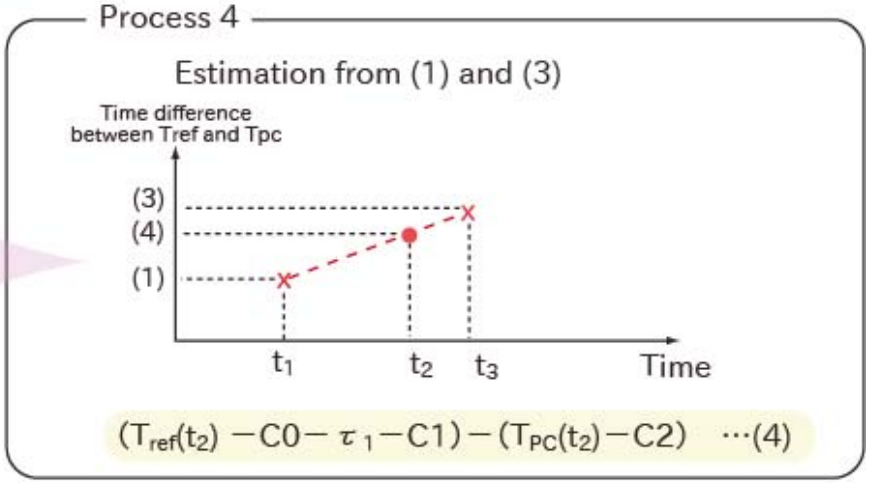
$(4) - (2) \rightarrow T_{ref}(t_2) - T_{DUT}(t_2)$

Measurement of cable delay.







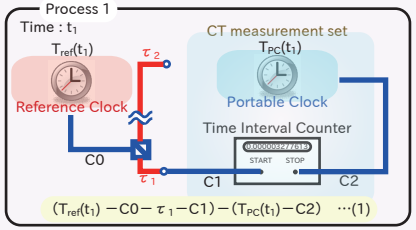


$(4)-(2) \rightarrow \tau_2(t_2)-\tau_1(t_2)$

Let's practice Clock transportation !!
(measurement of cable delay)

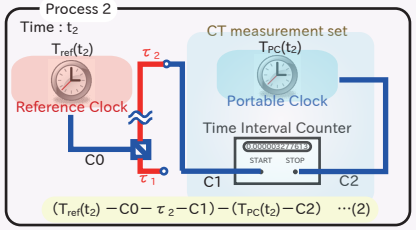
●Check TIC parameter at each measurement
- Reference signal
- Trigger parameter (level, impedance, slope…)

Impedance	☐50Ω	☐High
Slope	☐positive	☐negative
Trigger level	_____V	



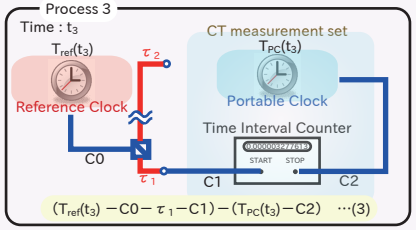
①Measurement-1
- Connect a reference cable to input-A of TIC.
- Set parameters of TIC
- Measure a time difference three times and record a value and time

①	Time	Time diff	Jitter
1st	_____	_____	_____
2nd	_____	_____	_____
3rd	_____	_____	_____
Avg.	_____	_____	_____



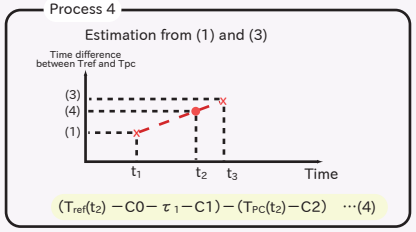
②Measurement-2
- Connect a DUT cable to input-A of TIC.
- Set parameters of TIC
- Measure a time difference three times and record a value and time

②	Time	Time diff	Jitter
1st	_____	_____	_____
2nd	_____	_____	_____
3rd	_____	_____	_____
Avg.	_____	_____	_____



③Measurement-3
- Connect a reference cable to input-A of TIC.
- Set parameters of TIC
- Measure a time difference three times and record a value and time

③	Time	Time diff	Jitter
1st	_____	_____	_____
2nd	_____	_____	_____
3rd	_____	_____	_____
Avg.	_____	_____	_____



④Estimation
- Estimate the time difference between the reference point and the portable clock at ② using linear fitting

④	Time	Time diff
①	_____	_____
③	_____	_____
④	_____	_____

⑤Calculation
- Calculate the cable delay from ② and ④.

④	−	②		Cable delay
_____	−	_____	=	_____