Calibration of IT01 station for non-UTC links – 2022

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Summary

Calibration values to be used for non-UTC links with IT01 are, as of 18/05/2022:

* CAL	585 TYPE	E: TCC		MJD:	59639	EST.	UNCERT.:	1.800 ns
* CAL	586 TYPE	E: TCC	, ,	MJD:	59639	EST.	UNCERT.:	1.700 ns
* CAL	587 TYPE	E: TCC		MJD:	59639	EST.	UNCERT.:	1.900 ns
* CAL	588 TYPE	E: TCC		MJD:	59639	EST.	UNCERT.:	1.700 ns
* CAL	589 TYPE	E: TCC		MJD:	59639	EST.	UNCERT.:	1.900 ns
* CAL	590 TYPE	E: TCC		MJD:	59639	EST.	UNCERT.:	2.100 ns
* CAL	591 TYPE	E: TCC		MJD:	59639	EST.	UNCERT.:	1.600 ns
* CAL	592 TYPE	E: TCC		MJD:	59639	EST.	UNCERT.:	1.900 ns
LOC	REM	CIS	CALR	ESDVAR	ESIG			
IT01	OP01	585 1	7123.900	0.000	0.000			
OP01	IT01	585 1	-7123.900	0.000	0.000			
IT01	ROA01	586 1	-36.300	0.000	0.000			
ROA01	ITO1	586 1	36.300	0.000	0.000			
ITO1	SP01	587 1	-11.900	0.000	0.000			
SP01	ITO1	587 1	11.900	0.000	0.000			
ITO1	VSL01	588 1	-12.300	0.000	0.000			
VSL01	IT01	588 1	12.300	0.000	0.000			
IT01	NPL02	589 1	-738.700	0.000	0.000			
NPL02	IT01	589 1	738.700	0.000	0.000			
IT01	NIST01	590 1	-290.000	0.000	0.000			
NIST01	IT01	590 1	290.000	0.000	0.000			
IT01	USNO01	591 1	-221.300	0.000	0.000			
USNO01	IT01	591 1	221.300	0.000	0.000			
IT01	CH01	592 1	-7.400	0.000	0.000			
CH01	IT01	592 1	7.400	0.000	0.000			

Motivation

Nominal station switching from IT02 to IT01, given the previously estimated CALR for link IT01 – PTB05 we estimate the other non-UTC links from/to IT01.

Method

Calibration of link IT01 – UTC(k) by triangle closure via PTB05 (CI 584 approved in February 2021, applied from 28th February 2022 MJD 59638 10 UTC), using the following quantities:

(1) [IT01 – PTB05]_{calibrated}

(2) [UTCk - PTB05]_{calibrated}

(3) [IT01 – UTCk]_{uncalibrated} (setting previous CALR and ESDVAR values to 999999999)

The new CALR value for each link IT01 – UTC(k) is then calculated as follows:

$$0 = [(1) - (2)] - (3 + CALR_{new})$$

Quantities (2) and (3) are aligned in time to (1) by interpolation since they all have different time tags due to the TWSTFT nominal schedule: for each time tag of (1) as reference, measurements of (2) and (3) are calculated by interpolating from a linear fit of 2 closest available points.

The uncertainty values are estimated as square root of the quadratic sum of the uncertainties of (1) and (2), and the standard deviation of the closure.

Results

The following figures show the triangle closure / CALR values estimated by the method described above; all time series exhibit a standard deviation of about 150-200 ps over the analyzed period (1 month, 01 March 2022 – 31 March 2022, MJD 59639 – 59669).



Figure 1 Triangle closures for IT01 and other UTC(k) via PTB05

Table 1 summarizes the results by taking the mean value of each triangle closure as the proposed CALR values, and the associated uncertainty estimations. Figure 2 shows the triangle closures computed by applying the proposed CALR values, which are zero-mean as expected after INRiM station change on 28^{th} February 2022 MJD 59638 (represented by the vertical bar). It can be noted that the closures before such date for the two transatlantic links (IT02-PTB05-NIST01 and IT02-PTB05-USN001) have an offset of about 1 ns. This induces a more visible discontinuity on the UTC(IT) – UTC(NIST) and UTC(IT) – UTC(USNO) baselines with respect to other UTC(IT) – UTC(k) links (Figure 3). Nevertheless, they are all within the estimated calibration uncertainties.

			Proposed u _{cal} components					
Proposed Cl	LOC	REM	Proposed CALR	Proposed u _{cal}	LOC - PTB05 links		TC σ	IT01 - PTB05 CI 584 ucal
					CI	U _{cal}		
585	OP01	IT01	-7123.900	1.800	545	1.100	0.150	1.400
586	ROA01	IT01	36.300	1.700	540	1.000	0.150	1.400
587	SP01	IT01	11.900	1.900	541	1.200	0.200	1.400
588	VSL01	IT01	12.300	1.700	542	1.000	0.200	1.400
589	NPL02	IT01	738.700	1.900	550	1.200	0.150	1.400
590	NIST01	IT01	290.000	2.100	533	1.600	0.200	1.400
591	USNO01	IT01	221.300	1.600	534	0.800	0.200	1.400
592	CH01	IT01	7.400	1.900	542	1.200	0.150	1.400

Table 1 Summary of estimated CALR values and associated uncertainty estimations
Image: Comparison of the state of t

The REFDELAY value of the IT01 station was also measured again with a SR620 TIC and found to be in agreement within uncertainty with the previously measured value and the one currently reported in ITU files i.e. 835.3 ns.



Figure 2 Triangle closures with PTB05 as pivot, before and after switch from IT02 to IT01



UTC(IT) - UTC(k) TWSTFT

Figure 3 UTC(IT) - UTC(k) via TWSTFT, before and after switch from IT02 to IT01