GPS calibration of DLR, METAS, VSL, BEV equipment with respect to PTB G1 (1012-2016)

Summary

In Spring 2016, the PTB conducted a trip to calibrate GNSS equipment owned by DLR, METAS, VSL and BEV. The trip started and finished at PTB, providing closure with respect to PTB Group1 reference receiver PT02. The operations and report of measurements are described in the report by PTB.

In October 2017, the METAS conducted a transfer of calibration from the receiver CH03, part of the original trip, to a new receiver. The operations and report of measurements are described in the report by METAS.

- **Final results for the equipment calibrated in the original trip**

The INTDLY values given in Table 1 have been computed by PTB using INTDLY values of PT02 available at the time of the calibration. They should not be updated to reflect later changes in the conventional INTDLY values of PT02.
For a P3/PPP UTC link A-B involving any Group 1 and any receiver in this trip, the uncertainty resulting from the calibration, U_B(A-B), is computed as

$$U_B(A\text{-}B) = (U_{CAL0}^2 + \Delta U_{CAL}(A)^2 + \Delta U_{CAL}(B)^2)^{1/2} \quad (1)$$

where U_{CAL0} = 2.5 ns at the time of calibration, as given conventionally to Group 2, and where ΔU_{CAL} (generally zero) is specified for each system.

Changes in the set-up of the receivers after the calibration must be accounted for as described in section A.3.6 of the Calibration guidelines v3.2 in ftp://ftp2.bipm.org/pub/tai/publication/gnss-calibration/guidelines/.

Table 1. Final P1/P2 INTDLY values from the 1012-2016 trip. Values of REFDLY and CABDLY during the calibration and the resulting P3 Total delay TOTDLY are also indicated for reference (all values in ns).

System	BIPM	Date	INTDLY P1	INTDLY P2	REFDLY	CABDLY	Note	TOTDLY P3	ΔU_{CAL}
OBET	DL05	2016.3	**57.8**	**56.1**	160.6	521.8	(1)	421.6	0.0
UTC1	DL01	2016.3	**201.6**	**200.9**	245.8	524.0	(1)	480.9	0.0
UTC2	DL02	2016.3	**205.6**	**197.8**	244.9	525.8	(1)	498.6	0.0
UTC3	DL03	2016.3	**208.2**	**198.1**	242.7	525.9	(4)	507.0	1.8
UTC4	DL04	2016.3	**58.3**	**56.7**	139.7	525.9	(1)	447.0	0.0
WAB1	CH03	2016.4	**50.7**	**53.3**	206.4	220.1	(1,5)	60.4	0.0
WAB2	CH02	2016.4	**298.9**	**315.6**	44.2	213.4	(1,5)	442.3	0.0
VSLF	VS06	2016.4	**52.5**	**61.1**	187.3	124.7	(1,2)	-23.4	0.0
VSLG	VS07	2016.4	**-51.1**	**-50.2**	36.2	124.8	(1,2)	36.1	0.0
BE1_	BE1_	2016.5	**-25.8**	**-28.0**	15.4	404	(1,3)	366.2	0.0
BE3_	BE3_	2016.5	**-37.7**	**-36.6**	15.3	262.1	(1)	207.4	0.0

Notes:
(1) REFDLY value corresponding to the calibration setup and measured during the calibration.
(2) INTDLY and REFDLY values of VSL receivers correspond to the receivers housed in a 19" box, with redefined input and output connectors, see the report.
(3) The REFDLY value of BE_1 has not been measured in full accordance with the Annex 1 of the calibration guidelines, see the report. Results are expressed as INTDLY for consistency with the CGGTTS V2 format but **care should be taken if the set-up is changed**: Only the "Total delay" (TOTDLY = INTDLY + CABDLY – REFDLY) is a strictly meaningful result.

(4) The REFDLY value of DL03, used to compute the calibration results, has been found inconsistent by 1.8 ns with the measurements taken during the calibration. The value of ΔU_{CAL} reflects this.
(5) The BIPM code was changed in version 2.0 of this report: CH03 was originally reported as CH00 and CH02 was originally reported as CH01.

- **Transfer of calibration performed by METAS in October 2017**

The INTDLY values given in Table 2 have been computed by METAS using INTDLY values for the receiver CH03 taken in Table 1.

Table 2. Final P1/P2 INTDLY values for CH04. Values of REFDLY (with respect to the indicated REF) and of CABDLY during the calibration are also indicated for reference. "Meas. Date" refers to the first day of the differential calibration, to which the calibration results can be applied. "Impl. Date" is the MJD when the results were implemented in the receiver.

System	BIPM	Meas. date	INTDLY P1	INTDLY P2	REF	REFDLY	CABDLY	Note	ΔU_{CAL}	Impl. date
WAB2	CH04	2017/09/26	**28.2**	**25.5**	UTC(CH)	25.2	208.9		0.6	58022

Notes:

- **Transfer of calibration performed by METAS in December 2021**

In December 2021, METAS conducted a Transfer of Calibration form its receiver CH04 (see preceding section) to a new receiver CH05, see the report by METAS.
The INTDLY values given in Table 3 have been computed by METAS using INTDLY values for the receiver CH04 taken in Table 2.

For a P3/PPP UTC link between CH05 and any Group 1 receiver, the uncertainty resulting from the calibration, U_B(A-B), is computed as in equation (1)

where U_{CAL0} = 2.8 ns is composed of the conventional Group 2 value (2.5 ns) and the uncertainty of the composed transfers from CH03 to CH04 (0.6 ns), then CH04 to CH05 (1.0 ns), and where ΔU_{CAL} (generally zero) is specified for each system. For UTC use, the ageing uncertainty will be based on the date of original calibration of CH03 i.e. 2016.4.

Table 3. Final P1/P2 INTDLY values for CH05. "Meas. Date" refers to the first day of the differential calibration, to which the calibration results can be applied. "Impl. Date" is the MJD when the results were implemented in the receiver.

System	BIPM	Meas. date	INTDLY P1	INTDLY P2	REF	REFDLY	CABDLY	Note	ΔU_{CAL}	Impl. date
WAB1	CH05	2021/12/18	**25.7**	**24.4**	UTC(CH)	9.2	220.0		0.0	59568

Notes:

Version history
V1.1 2016/09/14: Final results from V1.1 of the PTB Calibration report, to be implemented in G2 receivers. DL03 results to be confirmed.
V1.2 2016/10/07: Corresponds to V1.2 of the PTB Calibration report, with DL03 results.

V2.0 2018/03/16: New BIPM code designation for the METAS receivers; Added the transfer of calibration from CH03 to CH04 performed by METAS, see the report by METAS.
V2.1 2021/12/23: Transfer of calibration from CH04 to a new receiver CH05 performed by METAS, see the report by METAS.