

# Calibration of geodetic-type receivers using the traveling BIPM Z12-T receiver

## Guidelines and operational procedures

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V2-e G. Petit, L. Tisserand April 2005  
V3 G. Petit, L. Tisserand May 2006

Version 2 described the calibration of Ashtech Z12-T receivers. Version 3 also includes the calibration of Septentrio PolaRx2.

### 1. Description of the equipment

Equipment supplied:

- Ashtech Z12-T serial number LP02944,
- Antenna Ashtech choke ring serial number CR15373,
- Frequency doubler (if 20 MHz is to be generated from 10 MHz),  
Frequency quadrupler (if 20 MHz is to be generated from 5 MHz) temporarily not available,
- DC Power supply, TTI EX752M, serial number 230378 (to be set to 12 or 13 Volts),
- Antenna cable (about 40m long),
- Portable PC TOSHIBA TECRA 8000 (serial number 98666265EPS17973).

Other non-supplied necessary equipment:

- Oscilloscope (for Z12T 20MHz input/PPS input phase measurement)
- Time Interval Counter (for PolaRx2 PPS input/output delay measurement)

### 2. General information

Software for data acquisition of the traveling receiver:

The GBSS version 3.0.up is used for the acquisition, with dongle (sentinel key).

Please check the annex 1 to properly configure GBSS before starting the acquisitions.

More details can be found on portable computer in path "D:\Docs"

Coordinates:

Coordinates for the phase centers of the two antennas should be provided. The relative positions should be known with an uncertainty of one cm [a few cm].

Hardware Connection :

#### 2.1 Ashtech Z12-T

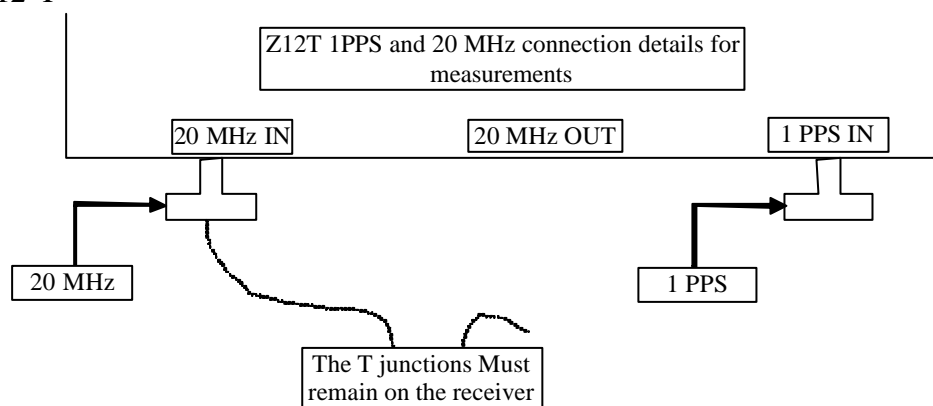


Figure A.1: Z12-T 1PPS and 20 MHz input and output close up.

## 2.2 Septentrio PolaRx2

No special requirement.

### 3. Relating the internal reference to the laboratory reference

The procedure to relate the internal reference to the laboratory reference is presented below. It should be carried out at the beginning and the end of the experiment (to check for stability and possible mistake), for the two systems.

#### 3.1 Ashtech Z12-T

See a more detailed description in annex 2.

3.1-0) Check the oscilloscope: one should obtain the same results when measuring a delay with different ranges (1V or 20 mV). Also when reversing channels.

3.1-1) Measure the delay between the laboratory reference 1PPS @ 1V and the 20 MHz in (inverted, positive zero crossing) (oscilloscope range 1V).

**Note: This measurement is a back-up measurement.** The measurement 3.1-3 will be used by default.

3.1-2) Measure the delay between the laboratory reference 1PPS @ 1V vs. 20 MHz out (positive zero crossing) (oscilloscope range 20 mV). **Note: 20 MHz out is not available on all systems.**  
[20 MHz out should trail inverted 20 MHz in by 18.2 ns]

3.1-3) Additional measurement: similar to 3.1-1) but connecting the cable of 20 MHz in and 1 PPS in directly to the oscilloscope. This should be performed before starting and after stopping operation.

**Note: This measurement will be used to compute the calibration results.**

3.1-4) Provide a plot of the oscilloscope screen (for all measurements for the two Z12-T systems).

#### 3.2 Septentrio PolaRx2

See a more detailed description in annex 3.

3.2-0) Synchronize the 1PPS output signal from the PolaRx2 receiver with the measurement latching epoch using the command:

“SetPPSPParameters 1 0 local” (or equivalently “spp 1 0 3”)

3.2-1) Measure the delay between the 1PPS-in and 1PPS-out. The result should be between 213.0 and 246.3 ns (+/- 2ns) for firmware version 2.3 and higher.

### 4. Measurements for differential calibration of total (internal + antenna) delay

The two systems are set-up independently (2 antennas). The input frequency (20 MHz for Z12T and 10 MHz for PolaRx2) and the 1 PPS in for the two systems are derived from the same reference.

Four days to one week of measurements are taken with a 30s data interval and stored in daily files (see annex 1 for the traveling Z12-T).

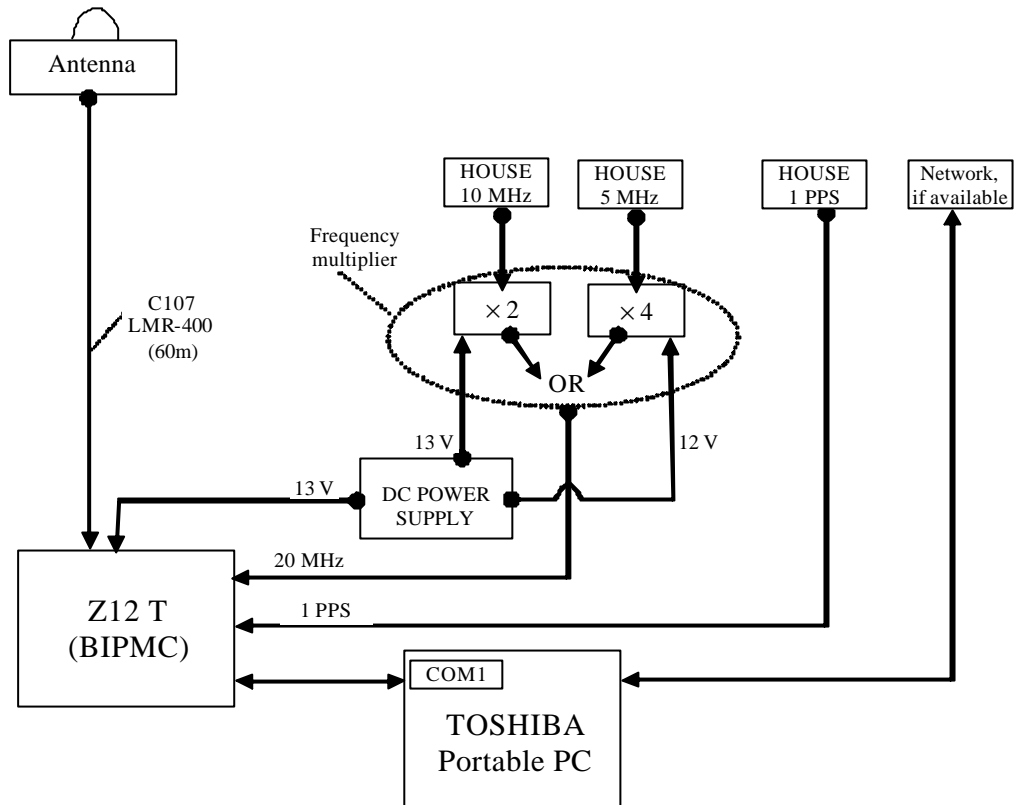


Figure B: short baseline set-up

## 5. Data report

Figure describing the actual set-up with indication of all measured delays.

Results of measurements described in section 3 (at the beginning and end of the experiment).

Coordinates of the phase center of the antennas

Log of events

The BIPM Z12-T data are stored on the traveling PC.

The data from the laboratory receiver are provided in daily RINEX files. They may also be stored on the traveling PC.

For safety reasons, all files should be recorded on an independent storage medium and kept by the laboratory until the end of the calibration trip. They should also be sent electronically to the BIPM (or made available on a server).

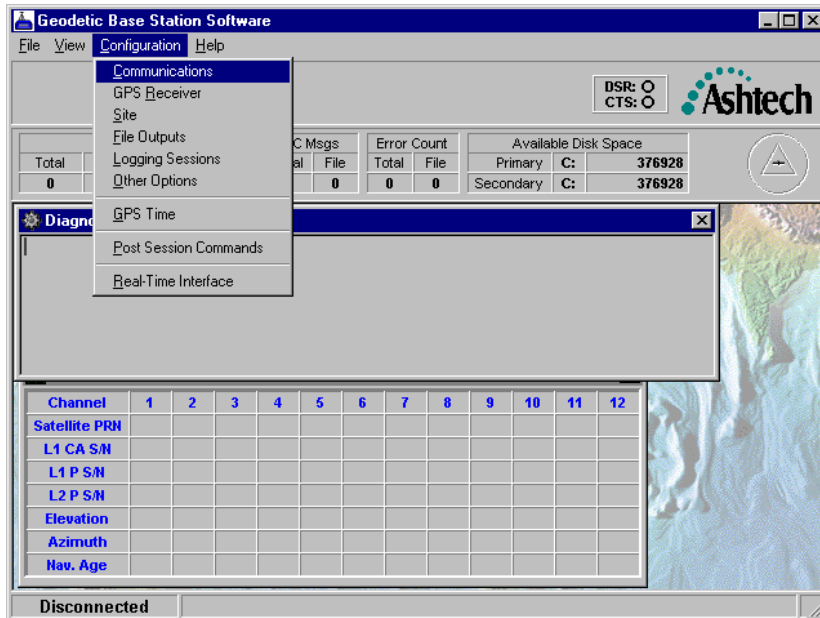
# ANNEX 1

## GBSS configuration

Launch the GBSS software by double-clicking on this icon situated on the desktop of the Toshiba.



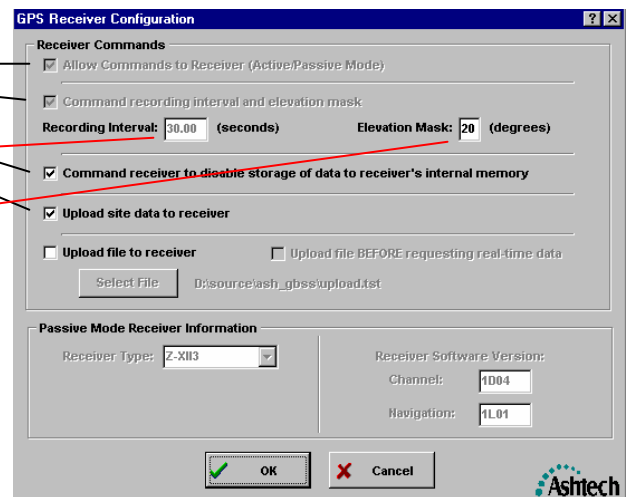
This screen should appear on the screen.



In the configuration Menu, start by checking the “GPS Receiver”.

On this screen, make sure :

1. The 4 four first check box are ticked.
2. The recording interval is 30 seconds
3. The elevation mask is 20 degrees



Press OK.

Then go to the Site configuration screen

1. Leave BIPC as site name.
2. Update the coordinates with the ones corresponding to your site

Press OK

Then go to the File Outputs screen

- On the data files page:
1. Update the primary and secondary output path names. Choose in D:\BIPMC the directory named after your laboratory and affect it to both primary and secondary path.
  2. Make sure these three check box are ticked.
  3. Make sure the file duration is 24 hours.
  4. It is best to leave a 60 seconds re-open rate and to disable epoch filtering
  5. Do not use the ashtech subdirectory structure

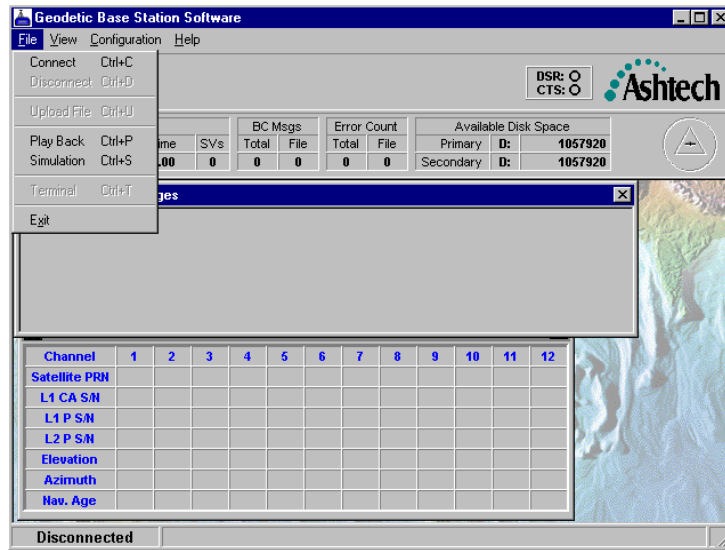
Then on this screen click on the Configure RINEX command button.

You should get this screen:

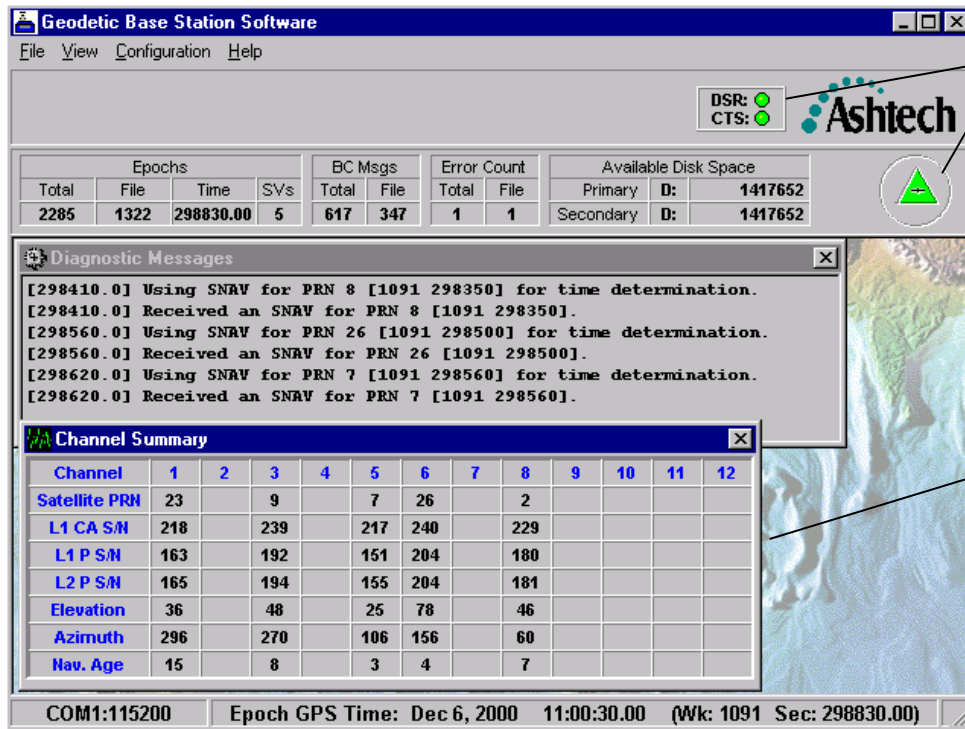
1. Update these three fields
2. Add any comments you think necessary
3. Do not change these three options

Press OK

Then go to the File menu and click on Connect



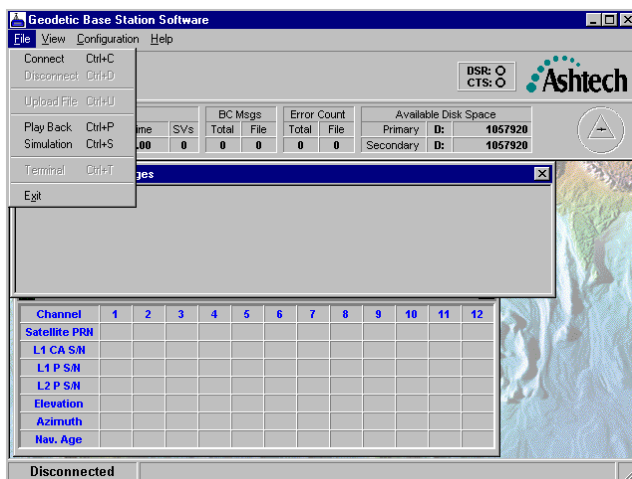
You should then get something like this screen:



Please note these green lights. They mean the receiver is connected.

Satellites tracking parameters should then appear in this box.

At the end of the stay in your laboratory just disconnect from the File menu.



At all times files except the one of the current day are accessible and transferable from the directory selected in the File outputs configuration screen.

## ANNEX 2

### Z12T Measurement detailed procedure

Measurements 3.1-1 and 3.1-2 do not affect the receiver operation. Measurements 3.1-3 should be performed before starting the operation and after ending operation.

Please note the use of two phase matched external cables (cable A and cable B).

They are provided but, if for any reason you are using other cables, please make sure they are phased matched at the level of 0.1 ns.

#### MEASUREMENT 3.1-1:

Set-up your oscilloscope as stated on the following figure. The trigger level is not critical.

Use a time base of 10ns/div, the signals will then be easier to identify.

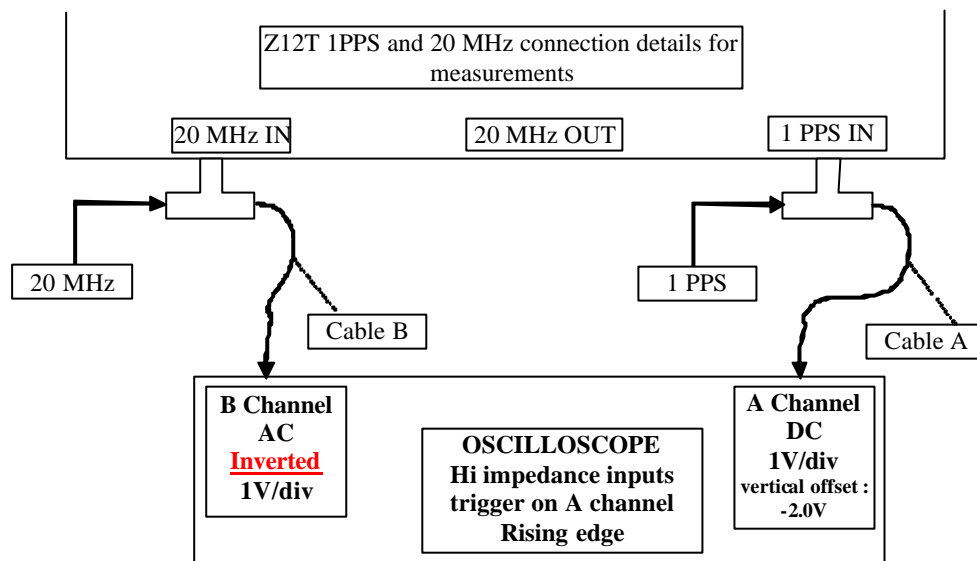


Figure 1: measurement (3.1-1) set-up

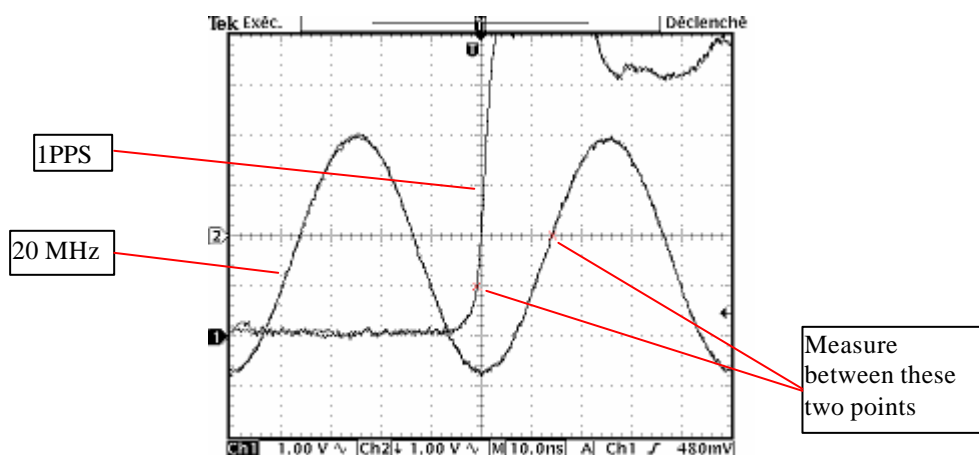


Figure 2: example of oscilloscope display using this set-up

Measure the phase difference between the 1PPS 1V crossing and the following inverted 20 MHz RISING EDGE ZERO crossing as shown on figure 2.



This first measurement is important because you can check if the configuration correspond to the receiver setup.

For a receiver in “rising edge sampling”, the measurement value should be between 5 and 20 ns. For a receiver in “falling edge sampling”, the measurement value should be between 30 and 45 ns. If the measurement value is not in the indicate range, add a delay line in the 20Mhz line to force this first measurement in this range.

Examples below are for “rising edge sampling”, which is the usual setup of a receiver.

Use this configuration to check your oscilloscope measurement:

Change the range of both channels to 20mV. Make sure to apply a vertical offset of -1.0 V on channel A (the PPS channel) This will put the 1.0V level in the middle of the screen. Use the cursors to check where the 1.0V level is. You should get a display like this one:

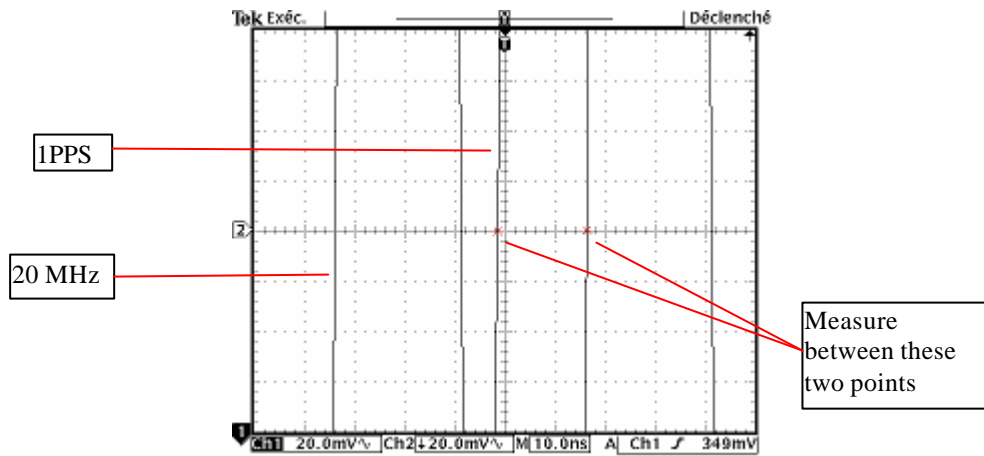


Figure 3: example of oscilloscope display using 20 mV range

Measure the same delay, The result should be the same (within the cursor uncertainty) as the one using the 1V/div range. If you don't measure the same value try to use another oscilloscope.

There is still a set-up to try to validate the oscilloscope measurements.

Set the vertical range back to 1V/div. remove vertical offset values

Interchange the channels and measure again

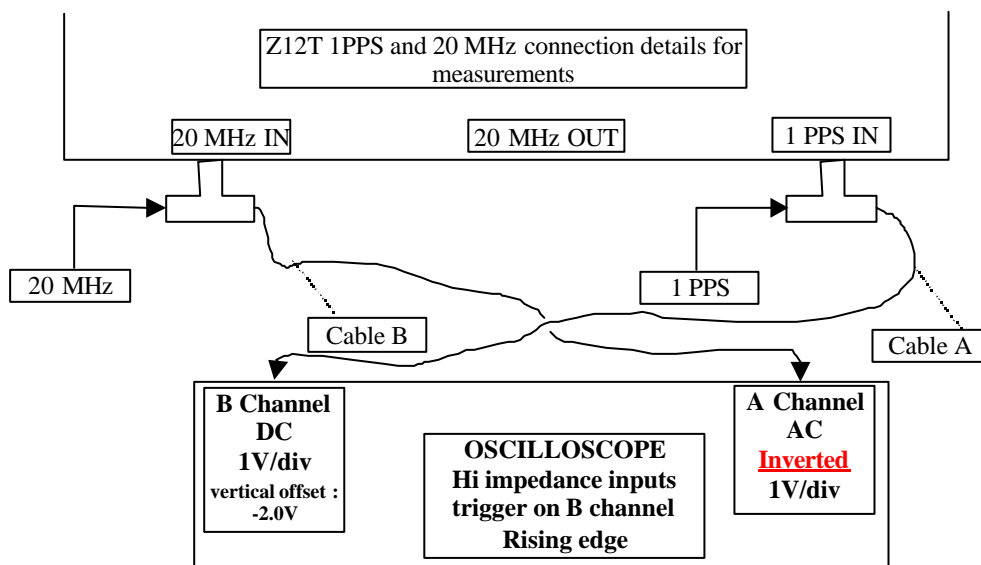


Figure 4: exchanged channel set-up

With this setup, you should get a plot equivalent to the figure 2  
 The measurement should give the same value as the others (within cursor uncertainty).  
 If not, take the average between this value and the one measured at the same range before exchanging channels.

**MEASUREMENT 3.1-2:**

Set-up your oscilloscope as stated on the following figure. The trigger level is not critical.  
 Use a time base of 10ns/div, the signals will then be easier to identify.

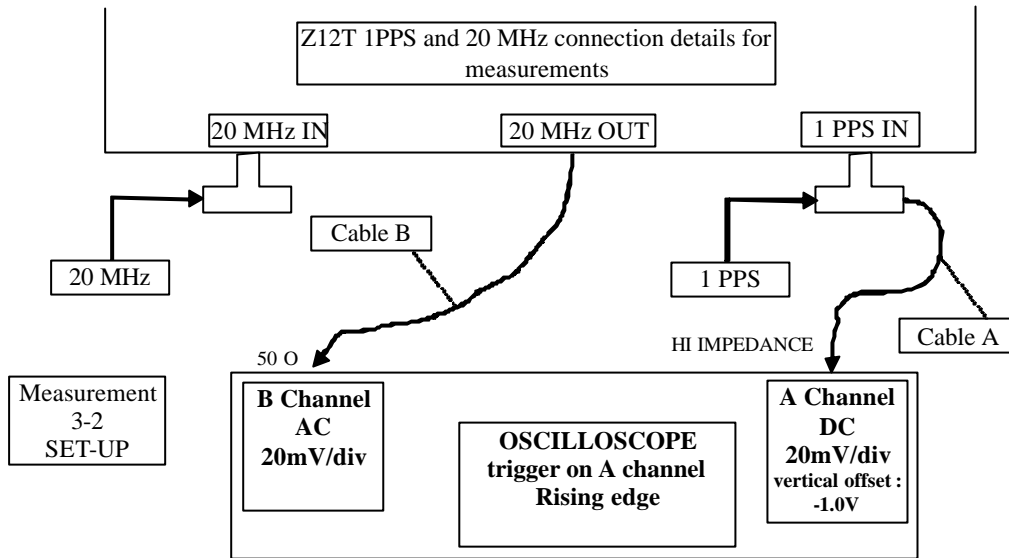


Figure 5: measurement (3.1-2) set-up

You should obtain a result like the figure 6.

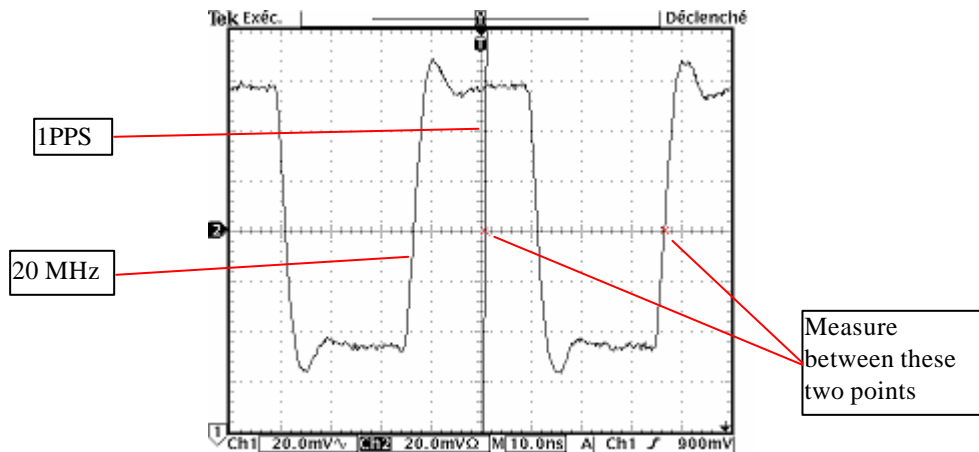


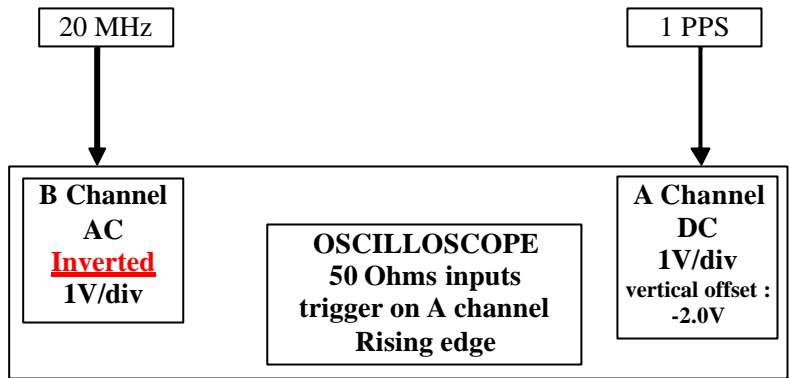
Figure 6: example of oscilloscope display

Measure the phase difference between the 1PPS 1V crossing and the following 20 MHz RISING EDGE ZERO crossing as shown on figure 6.  
 Do a measurement with exchanged channels if necessary.

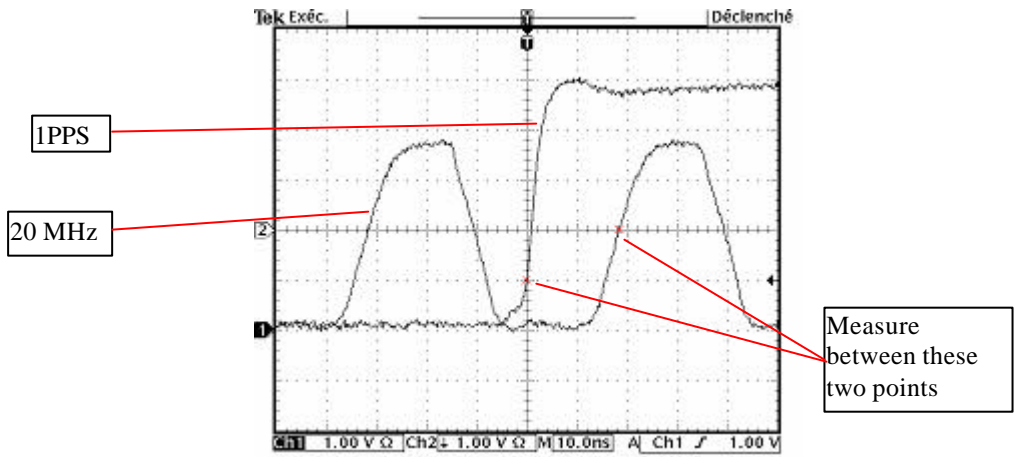
The difference between measurement (3.1-1) and (3.1-2) should be 18.2 ns (within combined cursor measurement uncertainties).

**MEASUREMENT 3.1-3:**

Set-up your oscilloscope as stated on the following figure. The trigger level is not critical. Use a time base of 10ns/div, the signals will then be easier to identify.



**Figure 7:** measurement (3-3) set-up



**Figure 8:** example of oscilloscope display using this set-up

# ANNEX 3

## PolaRx2 Measurement detailed procedure

### MEASUREMENT 3.2-1:

In order to avoid disturbing the equipment during operation, one solution is to perform a tare of your set-up without PolaRx2 receiver before starting the operation and after ending operation.

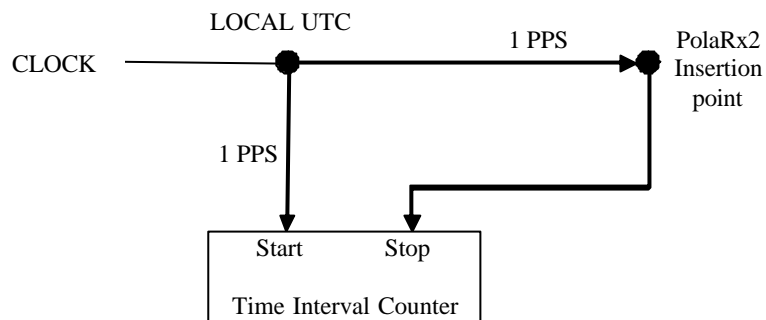


Figure 1: example of tare measurement set-up before and after operation

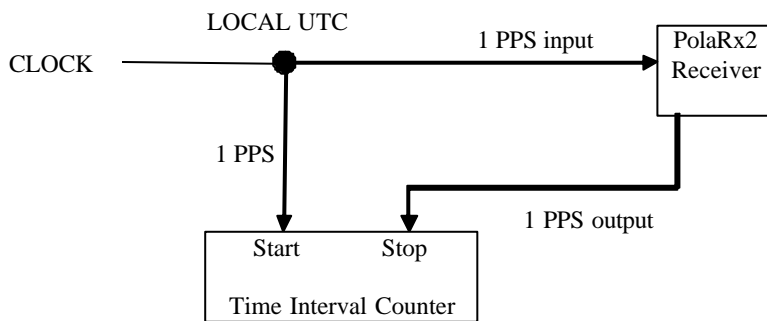


Figure 2: example of delay measurement set-up during operation

The delay between 1 PPS input and 1 PPS output is equivalent to the delay measured in the second set-up (see figure 2) minus the tare delay (average of the initial tare and the final tare, see figure 1) and should be between 213.0 and 246.3 ns (+/- 2ns) for firmware version 2.3 and higher.