Galileo Time Receivers

by

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Workshop "T&F Services with Galileo"
5/6 December 2005
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Company Profile – PPM GmbH

The company:

PPM GmbH (ltd.) is a trading, consulting and servicing company founded in 1998, with it’s head office at Penzberg, located near Munich, Germany.

Our team of sales and service professionals, coming from leading GPS and communication manufacturers, combines experience and flexibility to serve our customers in the best possible way.

Long time experience in the field of GPS-OEM integration, deformation monitoring, navigation and surveying is distinguishing our company.
Company Profile – PPM GmbH

Our Scope of Services:

- Distribution of GPS hard- and software for industry, science and research customers. We distribute products from AeroAntenna, GPS Networking, Septentrio, Thales Navigation (Ashtech) and Waypoint Consulting.
- Consulting and services for GPS system integration, positioning, timing and surveying.
- Repair service for Ashtech/Thales GPS receivers up to board level. For Ashtech Z12 products PPM is exclusive on a worldwide basis.
- Installation and operation of precise deformation monitoring systems. We do monitor displacements of slopes, dams, buildings or other large structures in real-time with millimeter accuracy.
GNSS Time Receiver
Applications

GNSS (GPS) Time receivers are used in a wide spread of applications such as:

- Time and frequency synchronisation in large communication networks like:
  - GSM, UMTS, DAB, DVB, CDMA base stations

- Network Synchronization with NTP time servers

- Precise atomic clocks time transfer
• During the early GSTB-V2 phase the Galileo satellites will transmit no ephemeris data - Hence standard GNSS timing techniques will not work with Galileo only.
• The only time application during this phase is, to measure the Galileo satellite clock drift by comparing it with precise reference clocks. Which is in reverse to what most users want to do.
• Currently there are only scientific general purpose Galileo – GNSS receivers from Novatel and Septentrio available.
• As soon as the Galileo satellites transmit ephemeris data, these receivers will be able to determine a Galileo time, with similar techniques as currently used for GPS.
Galileo – GNSS Receivers

At the moment there are 2 manufacturers offering Galileo – GNSS receivers:

- NovAtel Inc., based in Calgary, Canada
- Septentrio Satellite Navigation NV, based in Leuven Belgium
GNSS - Galileo Receivers

Novatel GTR Receiver (Galileo Test Receiver)
- FPGA based receiver design
- 16 channel dual constellation, dual frequency receiver
- tracks any combination of:
  - Galileo: L1, E5a
  - GPS: L1, L5
  - WAAS: L1, L5
- designed to operate with GSTB-V2 and IOV signals
- receiver can be extended with a GPS L1/L2 card
GNSS - Galileo Receivers

Septentrio GeNeRx1 Receiver

- FPGA based receiver design
- 72 channel dual constellation, multi frequency receiver
- tracks any combination of:
  - Galileo: L1, E5a, E5b, E5 (altBOC), E6
  - GPS: L1, L2, L5
  - WAAS/EGNOS/MSAS: L1
- designed to operate with GSTB-V2 and IOV signals
- receiver consists of Galileo all signal and frequency card and GPS L1/L2 card
Septentrio GeNeRx receiver architecture

RF Splitter + Clock Distribution

E5 Frontend

E5 Baseband

E6 Frontend

E6 Baseband

L1 Frontend

L1 Baseband

L2 Frontend

L2 Baseband

Receiver Control

Input/Output

Power Supply Distribution

RF IN

AUX IN

REF IN

MAINS

ETH

COM

PPS
GeNeRx
FPGA Board Features

• Supported signals:
  – All signals in GSTB-V2 SISICD
  – All non-PRS signals in Galileo SISICD (iss. 10), including AltBOC.
• 4 generic channels (+ 1 altBOC and 9 GPS L1/L2)
• Full signal flexibility:
  – BOC sine/cosine
  – QPSK/Interplex
  – Pilot or Data tracking
• Real-time correlation peak probing
• IF samples logging
GeNeRx Outputs

5 types of output files:

<table>
<thead>
<tr>
<th>Log file type</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meas</td>
<td>all measurements (pseudoranges, Carrier phase, Doppler, C/N0, locktime and epoch time)</td>
</tr>
<tr>
<td>Nav</td>
<td>raw symbols and decoded navigation pages, including CRC/Viterbi diagnostics</td>
</tr>
<tr>
<td>Corr</td>
<td>Correlation peak samples</td>
</tr>
<tr>
<td>Log</td>
<td>Activity log (user commands, warning reports, etc).</td>
</tr>
<tr>
<td>IFSamples</td>
<td>16Mbytes of IF samples, covering 150ms</td>
</tr>
</tbody>
</table>
Real-Time Correlation Peak Monitoring
IF Samples Processing

Chip shape analysis:

![Graph showing chip shape analysis]
By definition, the pseudorange is the difference between the receive time and the transmit time, where the receive time is measured in the receiver time scale, and the transmit time is measured in the satellite time scale.

The following slides explain how the GeNeRx receiver computes the transmit and receive time.
In GNSS receivers, the transmit time (also referred to as “code phase”) is generally recovered from three pieces of information:

1. The tracking of the PRN code provides the code phase with high accuracy, but with an ambiguity equal to the period of the PRN code. For Galileo/GSTB-V2, this ambiguity ranges from ten to hundred milliseconds depending on the signal band.

2. The detection of the navigation frame boundaries (i.e. the identification of the synchronization field, confirmed by a valid CRC) allows to extend the ambiguity to the period of one navigation frame “T_FR”. For Galileo/GSTB-V2, this ambiguity ranges from 1 to 10 seconds.

3. The decoding of the time-tag fields in the navigation frames (especially the FRMCNT, WN and TOW fields) allows to completely fix the ambiguity, and hence to obtain an absolute value of the transmit time.
Transmit (satellite) time

To sustain the GSTB-V2 early validation phase, the GeNeRx purposely ignores the contents of the navigation frame, such that the ambiguity fixing in the 3rd step above must be performed by other means.

In the GeNeRx, this is done by using the time tag provided by the GPS satellites.

The algorithm provides unambiguous recovery of the transmit time if the clock bias onboard the GSTB-V2 satellites is smaller than half the navigation frame duration.
Receive (receiver) time

- In the early phases, there will not be enough Galileo/GSTB-V2 satellites to compute a Galileo-based PVT fix, and as the GeNeRx should function even when invalid or no ephemeris parameters are sent by the Galileo/GSTB-V2 satellites.
- The receiver time cannot be deduced from the Galileo/GSTB-V2 constellation, and is therefore solely derived from the GPS constellation.
- To be specific, the GeNeRx will keep its local time close to GPS time, with a deviation never larger than 0.6ms.
Galileo/GNSS Time Receivers

Conclusion:

– As soon as the Galileo satellites transmit valid ephemeris data, Galileo time applications can be conducted with the existing Galileo-GNSS Receivers

– Dual system GPS/Galileo receivers will have significant advantages over GPS only receivers:
  • Significantly increased availability due to a more then doubled number of satellites.
  • Improved time integrity due to the Galileo signal structure and the redundant satellite system
  • Improved time accuracy due to the increased number of satellites and the superior Galileo system time.

– Once Galileo becomes operational there will be a wide choice of commercial Galileo/GNSS time receivers
Thank you very much for your attention