The DLR Facility for Testing of GNSS- Receivers with Controlled Reception Pattern Antennas (CRPA)

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Overview

- New concept for simulator with individual satellite baseband and RF-outputs
- Allows wavefront generation with additional digital matrix processor
- Application for array antenna (Controlled Reception Pattern Antenna) receiver development and testing
- Various multipath models
- Interference induction by signal generators
Modified Spirent GSS7790 & Wavefront Matrix (WFM)

- SimGEN
- IF Signal Generation
- Modified GSS7790
- GSS7790 RF-Up Converter
- Digital Matrix Processor
- Wavefront Generation
- Receiver Under Test

Signal Parameters

- Complex Weighting Coefficients
- Wave + Beamforming
- Matrix Coefficients
- 100 Hz

- 12 x L1 and 12 x L2 Satellite Signals
- Digital I/Q Baseband Signals (81.84 MHz)
- 12 Antenna Elements x 2 Frequencies (L1/L2)

- 12 x L1 IF Analogue IF Signals
- 12 x L2 IF Analogue RF Signals
- 12 x L1 RF Analogue RF Signals
- 12 x L2 RF Analogue RF Signals

- LOS
- Multipath
- Antenna Pattern
- Antenna Array

- Interference
Available Signals

- GPS L1 C/A code
- GPS L1 P-code (pseudo Y-code)
- GPS L2 C/A code
- GPS L2 P-code (pseudo Y-code)
- GPS L2C code (normally used with GPS L2 P-code)
- Galileo like BOC(1,1)-signal on L1, modulated with a navigation message in GPS format (as long as the Galileo message is not finally defined)
- GPS L5 baseband signal on L1 or L2
- Update to Galileo-Signals
Features of the Simulator

- L1/L1-Mode with 24 complex baseband signals at one frequency
- Combined L1/L2 RF output
- Multipath options:
  1. Ground plane model
  2. Vertical plane multipath model
  3. Reading of pre-processed data files
  4. Land mobile model (only for use with combined L1/L2 RF output)
- Replacement of SimGEN – Models (Orbit, Atmosphere,…) by pre-processed data files
Wavefront Matrix (WMF) Processor

IN

Board-to-Board-Connection

FPGAs (for weighting and combining)

OUT

Compact Flash Card

Control-FPGA

USB
Modified Spirent GSS7790 Simulator

- **Individual RF outputs**
- **Baseband Signals**
- **Combined RF output**
- **IF Signals**
Schedule of Availability

- GPS available at the moment
  
  *Synchronization software between WFM and Simulator still under test*

- Upgrade to Galileo signals in July 2006
  
  *Only GPS or Galileo possible*

- Upgrade to 48 complex baseband signals in January 2007
  
  *24 Galileo and 24 GPS signals*
Conditions of Usage

- Conditions are to be negotiated from case to case with DLR

- Approximate costs: 52 € per hour, 414 € per day

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Baseband Wavefront Generation, Narrowband Assumption

\[
\begin{bmatrix}
    x_0(kT) \\
    x_1(kT) \\
    \vdots \\
    x_{MN-1}(kT)
\end{bmatrix} =
\begin{bmatrix}
    a_{0,0} & a_{0,1} & \cdots & a_{0,Q-1} \\
    a_{1,0} & \ddots & & \vdots \\
    \vdots & & \ddots & \vdots \\
    a_{MN-1,0} & \cdots & a_{MN-1,Q-1}
\end{bmatrix} \cdot
\begin{bmatrix}
    s_0(kT) \\
    s_1(kT) \\
    \vdots \\
    s_{Q-1}(kT)
\end{bmatrix}
\]

\( x_{MN-1}(kT) \): sampled baseband signal at element \( i \)

\( s_q(kT) \): sampled satellite baseband signal

\( a_{i,q} = e^{j\Delta \phi_i(\theta_q, \varphi_q)} \)

complex coefficient

Carrier phase shift at element \( i \) relative to element 0:

\[\Delta \phi_i(\theta_q, \varphi_q) = -2\pi f \tau_i = -\frac{2\pi}{\lambda} \Delta r_i\]