The GRANADA Bit-True Simulator recreates the Galileo and GPS signal-in-space and the receiver signal processing chain using a sampled-based simulation approach. Developed in MATLAB/Simulink to provide high modularity, it targets receiver experts in development and analysis of receiver core technologies. The tool enables analyses and simulations of the receiver critical algorithms and architecture design, such as acquisition and tracking, AltBOC performance, multipath and interference analysis. GRANADA can be used as a receiver design test bench that includes the possibility to integrate and analyse user defined algorithms.

GNSS signal generation. The tool simulates all the Galileo and GPS channels at the selected carrier frequency. It includes ranging codes generation, data and sub-carrier modulation, IF upconversion and filter design. The transmitter module includes E5 AltBOC modulation scheme, MBOC signals, and the new GPS open service and commercial channels.

Environment model. The propagation channel receiver allows the simulation of different environmental effects, including AWGN, multipath delay, external interference and system dynamics. The multipath model consists of the sum of a direct ray and several indirect paths affected by a random fading component. Interference modelling includes band-limited Gaussian noise. The relative dynamics between the receiver and the satellite is considered including both code and carrier Doppler shifts in the transmitted signal.

Receiver simulation. The receiver is modelled both in floating and fixed-point designs. It includes RF modelling, IF downconversion, ADC, code acquisition, code and carrier tracking, data detection and C/N_0 estimation. The receiver architecture is capable of simulating any possible sampling frequency or chip spacing.

The simulator modular design allows the modification of the default Simulink model and the insertion of user-defined algorithms, receiver architectures and environment perturbations.

Graphical user interface

GRANADA bit-true simulator includes a user interface that allows the configuration of all system parameters and the visualisation of simulation raw outputs and statistics. The user can obtain Ccompiled versions of the Simulink models using autocoding techniques, achieving a 100% performance improvement.

Requirements:

Single PC under Windows: Pentium IV with 512 Mbytes of RAM or higher
Matlab/Simulink, with Signal Processing Toolbox and Signal Processing Blockset.

● General characteristics

- Single-satellite Galileo/GPS signal simulation
- Bit-true simulation at IF of the complete signal processing chain: transmitter, propagation channel and receiver
- Implemented in Matlab/Simulink. Signal Processing toolbox and blockset required
- Highest modularity: user configurable models and algorithms
- Floating-point and fixed-point data types
- GNSS Receiver Toolbox (automatically installed in the user Simulink library)

● Transmitter

- IF signal generation of Galileo E5, E6, E1 and GPS L5, L2, and L1 (support for BPSK, BOC, MBOC, CBOC, TMBOC and AltBOC modulations). Selectable ranging codes.
- Configurable IF upconversion and transmitter filter
- Configurable sampling frequency

● Propagation Channel

- User-defined carrier-to-noise density ratio (C/N_0)
- Multipath model:
  - Diffuse component and several reflected rays
  - Configurable delay, relative power, and Doppler bandwidth
  - Rice and Rayleigh power distribution
- External interference:
  - Configurable C/I_0, interference bandwidth and centre frequency
  - Time interval of the interference

● Receiver

- Bi-channel receiver architecture
- BPSK, BOC, MBOC, CBOC, TMBOC and AltBOC demodulation
- Analog-to Digital converter model
- Configurable receiver filter
- IF downconversion
- Configurable narrow correlator
- Code Acquisition: configurable matched-filter acquisition strategy
- Code Tracking: configurable DLL discriminator, early-late spacing, and loop bandwidth
- Carrier Phase and Frequency Tracking: configurable PLL/FLL discriminators damping factors and loop bandwidth
- User Dynamics: coherent code and carrier Doppler shift
- C/N_0 estimator
- Floating-point and configurable fixed-point data types

● Outputs

- Acquisition outputs, data detection, code and carrier phase errors, Doppler shift estimation, C/N_0 estimation
- Statistics and Histograms
- Text and mat-files containing the outputs of the simulations

● Other features

- Automatic Real-Time Workshop compilation of the Simulink model
- Graphical user interface to control all the simulator capabilities
- Configurable simulation time
- Two simulation modes: IF band-pass signals, and complex low-pass model
- File Management: possibility to run on-the-fly simulations or to load and save intermediate signal from files

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