Accord Software & Systems Pvt. Ltd.

Why so many GNSS satellite Constellations?

Why Multi-constellation and Multi-frequency Receiver is needed?

Abstract

This paper discusses the benefits of having so many Global Navigation Satellite System (GNSS) constellations and the need for a multi-frequency receiver.

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Introduction

The use of GNSS in the day-to-day applications is increasing significantly and it has already become very hard to imagine a world without GNSS, as it is the all-weather and absolute global positioning system. Because of this popularity, there is a continuous addition and modernization of navigation satellite systems to improve the robustness and accuracy of the positioning. These developments demand that the receiver manufacturers keep a steady pace updating their receivers to match the addition of new constellations and new signals at existing and new carrier frequencies.

GNSS Status and Signal Characteristics

The current and future satellite signals, carrier frequencies and modulation schemes are discussed below.

Constellations	Typical no. of satellites	Operational satellites
GPS	24	31
Galileo	30	17
GLONASS	24	24
IRNSS / NavIC	IGSO - 4 GEO - 3	IGSO - 4 GEO - 3
BeiDou	MEO-27 IGSO-3 GEO-5	MEO-3 IGSO-6 GEO-6
QZSS	IGSO-3 GEO-1	IGSO-3 GEO-1

Table 1: Table depicting the GNSS status

Table 1 lists the various constellations and the satellites in each constellation. The complete list of signals transmitted (or to be transmitted) by each constellation are given below.

- GPS L1/L2/L5
  - L1 C/A and L1C (data and pilot)
  - L2-CM & CL
  - L5 data and pilot
- Galileo E1/E5a/E5b/E5 AltBoC/E6
- GLONASS L1/L2/L3OC/L5OC
- BEIDOU B1/B2/B3
- QZSS* L1/L2/L5/L1-SAIF
  - SAIF: Submeter-Class Augmentation with Integrity Function
- IRNSS L5/S
- SBAS L1/L5
  - L1: WAAS, EGNOS, MSAS, GAGAN, SDCM, SNAS
  - L5:WAAS, GAGAN
  - DFMC (Dual Frequency Multi Constellation)

Signal	Carrier Frequency (MHz)
L1/L1C/E1	1575.42
B1	1561.098
GLONASS L1	1602
L2	1227.6
GLONASS L3 Future	1202.025
E5b/B2	1207.14
GLONASS L2	1246
GLONASS L2 Future	1248.06
B3	1268.52
E6	1278.75
L5/E5a/GLONASS L5 Future	1176.45
S	2492.028

Table 2: The GNSS carrier frequencies for current and future signals

The Table 2 list the carrier frequencies of the current and upcoming GNSS signals. The following modulations schemes are adopted by various signals to modulate the carrier before transmitting the signals from the carrier using PRN (pseudo-random noise) code and the data bits. The PRN code chipping rate varies from 0.511MHz to 10.23MHz and transmitted data rate varies from 50 bps to 2000 bps.

- BPSK up to 32.736 MHz chipping rate
- Time multiplexed BPSK with programmable chipping rate: Example L2CM and L2CL
- BOC(1, 1)
- Time Multiplexed BOC: BOC(1, 1) & BOC(6, 1)
- CBOC(6, 1, 1)
- BOC(5, 2.5)
- AltBOC(15, 10)

Advantages of Multi-constellation and Multi-frequency GNSS Receiver

A multi-constellation and multi-frequency GNSS receiver, that can receive signals from multiple constellation and at least two carrier frequencies, is a must for providing a better navigation solution to the user.

The newer and the modernized signals with higher chipping rate and wider bandwidth (bandwidth is at least twice the chipping rate) help reduce the effect of multipath signals significantly, improving the accuracy of the position and timing solutions.

The benefit of multi-frequency processing is that is helps remove 99% ionosphere induced errors. This is possible by exploiting frequency dispersive nature of the ionosphere; that is the ionosphere induced error varies with carrier frequency, so it affects, for example, L1 and L2 signals differently. So, by comparing the delay measured at L1 and L2 carriers of a GNSS signal the receiver can correct the ionosphere induced errors.

Figure 1: Single constellation - visible and masked satellites

Apart from the benefits of better multipath mitigation and ionosphere error reduction, there are many other benefits of processing a greater number of satellites signals from multi-constellation. As shown in Figure 1 and Figure 2, the number of satellite visible for multi-constellation satellite in a challenging environments such as urban canyons or dense foliage, is higher as compared to the single constellation receiver. Availability of a greater number of satellites offers significant improvement in the following:

- Availability (percentage of the time navigation system is usable)
- Continuity (percentage of the time the navigation system is usable without interruption)

Figure 2: Multi-constellation - visible and masked satellites

- Integrity (measure of trust on the correctness of the outputs of the navigation system)
- Accuracy (degree of conformance of the position output, from the navigation system, with the true position) as DOP (dilution of precision) is reduced significantly
- Robustness against interference / jamming / spoofing as all constellation signals at all the different carrier frequencies may not be affected at the same time
- Speed up of operation performance (faster TTFF in urban canyons)

Accord's MGNSS receiver SoC built around the MGNSS RTL IP is geared to support dual-frequency and multi-constellation receiver applications in commercial, automotive, defence, avionics and space segments. Along with these, the SoC also supports precise positioning using carrier phase measurements in RTK or PPP modes. There is a dedicated hardware channel to support reception of PPP corrections from L-band satellites from various service providers.

If you want to integrate a MGNSS IP into your own custom SoC, the silicon proven RTL (VHDL) IP is available.

Check out:

http://accord-soft.com/accord_MGNSS_IP.html

About the Author

Naveen GS, has been associated with Accord since 2005 and he has been at the core of GNSS receiver design, development and testing.

He has a PhD degree from PLAN group of Geomatics Engineering, University of Calgary.

About Accord Software & Systems

Accord Software & Systems designs and manufactures innovative solutions to help customers maintain a competitive advantage in their markets and achieve their business goals. We provide cutting-edge Positioning, Navigation and Timing products and solutions to industry leaders in the Defence, Commercial and Semiconductors Business areas.

Accord has developed a vertically integrated GPS/GNSS portfolio consisting of Semiconductor ICs, Modules and solutions that cater to a variety of applications like Avionics, Automotive, Industrial, IoT, Marine, Telecommunications.

Contact Us

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Rev 1.0
Mar 2019

Accord Software & Systems Private Limited

No 72 & 73, K.R. Colony, Domlur Layout,
Bangalore - 560 071. INDIA.
Tel: +91 - 80 2535 0105   Fax: +91 - 80 2535 2723
Email: ibd@accord-soft.com
Web: www.accord-soft.com