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A Literature Study of Various Satellite Navigation Systems with Reference to Their Signaling Scheme

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***Abstract*—The concept of satellite navigation has started from 1973 with the very first introduction of GPS, as the time passes; in 1995 GPS navigation system becomes the very first global navigation system. There are various other systems for navigation, some are global navigation systems and some are regional navigation systems. This paper presents a literature study on various navigation systems and the signal scheme and modulation format which evolves through the time with special description for IRNSS**

***Keywords*— GPS, IRNSS, Galileo, QZSS, Compass, BPSK, BOC, MBOC**

I. INTRODUCTION

In 1970s US military's Department of Defense (DOD) brings the concept of satellite navigation system. In the mid of 1990s, they started the world's first navigation system known as the global navigation system. For a long time there hadn't been any other navigation systemavailable, but recently in 2010 Russia has launched their GLONASS global navigation system and the only other alternative for GPS. With the advancement in technology and need of positioning and tracking services of civil users various other countries has joined the race for their navigation system. Some systems are the global systems and some become regional navigation systems i.e. monitoring, tracking only a particular geographical region [1]. The different navigation systems available or in talks today are USA's GPS, Russia's GLONASS, Europe's Galileo Navigation System, India's IRNSS, Japan's QZSS, China's Compass [2][3]. In the later sections, we will discuss these navigation systems and their signaling structure in detail.

II. GLOBAL POSITIONING SYSTEM

In 1973, the development of GPS systems began with the aim to empower the military operations. Requirements for developing the GPS systems from thesignaling point of view are as follows [2]:

- Multiple access capabilities so that no interference in the GPS signals from other satellites should take place.
- Avoiding some amount of multipath interference.
- Minimization of interference from jamming, spoofing of signal etc up to a certain level.
- Low power signal so that it should not interfere with the microwave line of sight communication signals.

So, there requirements were fulfilled by using DS-SS (Direct Sequence Spread Spectrum) implementation of CDMA as it can distinguish signals from other satellites as well. Also BPSK modulation is used in NRZ format which gives simple signal structure possessing a constant envelope and can be easily transmitted with High Performance Amplifiers as used by GPS satellite transmitters [2].

The system uses 3 signals, 2 high performance signals with long spreading codes and fast code rates and is known as P or Precise spreading codes broadcasting in L1 and L2 bands at the frequency range 1575.42 MHz and 1227.6 MHz respectively. These P codes are encoded by classified Y codes so that unauthorized users cannot access the signal. Recently P codes signals are replaced by M codes signals which are used in military purposes as they provide much better jamming resistance, authentication and confidentiality. The third signal is known as Coarse/Acquisition signals, transmitting on L1 band and is not encoded or encrypted. This is the signals civil users use for their tracking and positioning services. GPS signals uses CDMA Gold codes of 1023 bit, it provides good correlation properties with the code rate of 1.023 MHz For M codes, GPS now uses BOC modulation scheme in L1 and L2 bands both and M BOC modulation in time multiplexed fashion in L1C band [2][3].

III. GLONASS

The Russian navigation system, GLONASS as an acronym of Global Navigation Satellite System is operated by Russian federation govt. by Russian space forces. The ground segment of Glonass located within the former Soviet Union territory which results in inferior performance in the stability and predictability as compare to GPS where the ground segment is spreaded all over the world. GLONASS uses FDMA or frequency Division Multiple Access to transmit its signal. This allows two GLONASS Satellites to transmit their navigation system at their own carrier frequency. It uses BPSK modulation scheme for C/A and P codes at L1 band, L3 band and L2 band all [4].

GLONASS satellite transmitstwo different types of signals: Standard Precision (SP) and High Precision (HP) in both the L1 and L2 bands. The GLONASS standard accuracy signal, also known as C/A Code with the clock rate 0.511 MHz and is designed for use by civil users worldwide while the high accuracy signal [5]. (P Code) has a clock rate of 5.11 MHz which is onlyavailable to users authorized by the Ministry of Defense.

IV. GALILEO

Galileo navigation system is the European navigation satellite system or ENSS and which provides a highlyaccurate, guaranteed global positioning service for civil users. According to [Galileo SIS ICD, 2008], this system will be interoperable with USA's GPS and to someextent with GLONASS, the only two global satellitenavigation systems available to us today [6].The fully deployed Galileo system will consist of 30 satellites in which 27 will be operational and 3 satellites will be for redundancy.

Galileo signals in E1 band known as E1 OS (open service) signals uses Composite form of MBOC Modulation or Multiplexed binary offset carrier modulation scheme with Code Division Multiple Access and PRS signals with BOC modulation scheme in which the code rate for the former is 1.023 MHz and later is 15.345 MHz in E6 band, the system uses BPSK modulation for CS or commercial service signals and BOC modulation for PRS. In E6 band, Galileo system uses Alt BOC modulation with the clock rate of 15.345 MHz [7].

V. COMPASS

Compass is the Global navigation satellite system of China with Beidou as its Regional navigation satellite version. It will consist of a constellation of 30 Non-Geostationary satellites. Each satellite will transmit the same four carrier frequencies for navigational signals, where B1 and B1-2 are counted as separate bands. These navigational signals are modulated with a predetermined bit stream, containing coded ephemeris data and time [8]. The current frequency filings according to the compass ITU filling for radio bands made by China to the International Telecommunications Union (ITU) indicate that it would overlay both the Galileo Public Regulated Service (PRS) and the military GPS M-code at E1/L1, as well as in the L2 band. Compass will use QPSK modulation scheme with CDMA as multiple access in B1, B2 and B3 bands[8] .

VI. QZSS

QZSS is the regional navigation system of JAPAN. This will consist of three satellite constellations inclined in elliptic orbits and passes over the same ground track. QZSS was designed in a way that at any moment of time, at least one of its three satellites is close to the zenith over Japan. It will be fully interoperable with GPS navigation system [9].
QZSS and GPS will be fully interoperable. It will provide C/A services with BPSK modulation, L1C services with BOC modulation and SAIF services with BPSK modulation. All the services will use CDMA access technique and use Gold codes with BPSK modulations and Weil codes with BOC modulation [9].

VII. IRNSS

IRNSS or the Indian Regional Navigation Satellite System is a seven satellite constellation that will be built and operated by India. This system may be compatible with other satellite navigation system. Out of its seven satellites, three satellites will be geostationary satellites and together will be known as GAGAN and the remaining four satellites will be geo synchronous satellites. The designated positions for GAGAN satellites are 34^{o}E, 83^{o}E and 132o E and for geo synchronous satellites, two satellites will have equatorial crossings at 55o E and the other two satellites will 111^0 E with the relative phasing of 56^o and inclination of 29^o[10][11].

A. Services IRNSS will provide two kinds of services:

- SPS or the special positioning services.
- PS or the precision Service

Both of these services will be carried on L5 band and S band at the frequency range of 1176.45 MHz and 2492.08 MHz respectively. The navigation signals would be transmitted in the S-band frequency which is 2 GHz to 4 GHz and broadcast through a phased array antenna so that required coverage and signal strength can be maintained.

The expected performances of the IRNSS system are: accuracy in position around 20 m over the Indian Ocean Regionand less than 10 m accuracy over India and adjacent countries [10].

B. Opportunities

IRNSS will explore whole new opportunities with some of them including, elementary terrestrial, aerial and marine navigation that can be used by the defense establishments for the country's safety and strength. The civil applications like fleet management and vehicle tracking.The solution to such sea-based border issues like along the coastline of Kerala and Tamil Naidu, fisherman can trace their locations and make sure that they won't cross the border. The civil users would have access to finding routes within India and traveling by self would become more safe and comfortable. Another is an accurate tracking systemfor the defense equipments that will help them during the militaryoperations [11].

C. Challenges

The IRNSS system will operates on the minimum number of satellite constellation as required from the navigation point of view. Having 3 geo stationary satellites and 4 geo synchronous satellites, the system cannot afford to lose any one of those satellites. The system needs to call for redundancy or redundant satellites [11].

VIII. SUMMARY

A. GPS

- Satellite Constellation: 32 Satellites(initially run on 21 active and 3 redundant satellites)
- Multiple Access: CDMA
- Modulation schemes used: BPSK (1), BPSK (5), BPSK (10), BOC_{sin} (10,5), TMBOC(6,1,1/11).
- Center Frequency: 1575.42 MHz, 1227.60 MHz, 1176.45 MHz
- Frequency Bands: L1, L2 and L5.

B. GLONASS

- Satellite Constellation: 24 Satellites (21 Active + 3 Redundant)
- Multiple Access: FDMA
- Modulation Schemes used: BPSK(0.511), BPSK(5.11), BPSK(4), BPSK(2), BPSK(8)
- Center Frequency: 1598.0625 MHz-1605.375 MHz, 1242.9375 MHz-1248.625 MHz, 1201 MHz
- Frequency Bands: L1, L2 and L3

C. Galileo
- Satellite Constellation: 30 Satellite (27 active +3 redundant).
- Multiple Accesses: CDMA.
- Modulation Scheme : CBOC(6,11,1/11), BOC(15,2.5), BPSK(5), BOC_{cos}(10,5), AltBOC (15,10).
- Center Frequency: 1575.42 MHz, 1278.75 MHz, 1191.795MHz
- Frequency Bands: E1, E6 and E5

D. Compass
- Constellation: 30 Non geo Stationary Satellites with(3 IGO and 27 MEO) and 5 Geostationary satellites
- Multiple Access: CDMA
- Modulation Scheme: QPSK (2), QPSK (1), QPSK (10).
- Center Frequency: 1561.098 MHz, 1589.742 MHz, 1207.14 MHz, 1268.52 MHz
- Frequency Bands: B1, B2 and B3.

E. QZSS
- Constellation: 3 Geo Stationary Satellites
- Multiple Access: CDMA
- Modulation Scheme: BPSK (1), BPSK (5), BPSK (10), BOC_{sin} (1, 1).
- Center frequency: 1575.42 MHz, 1227.60 MHz, 1176.45 MHz, 1278.75 MHz.
- Frequency Bands: L1, L2, L5 and E6.

F. IRNSS
- Constellation: 3 Geostationary Satellites and 4 Geo Synchronous satellites.
- Multiple Access: CDMA
- Modulation Scheme: BPSK(10), BOC_{sin}(5,2)
- Center Frequency: 1191.795 MHz
- Frequency Bands: L5A, L5B, L5C and S

IX. Conclusion

The paper has presented all the satellite navigation systems available or in process today. Every system from GPS to IRNSS has been properly introduced and signaling schemes and modulation schemes are studied. Satellite navigation now days are what every country desire to have to become on great power as most importantly it serves military applications and rescue operations. The next generation of satellite navigation are giving services to the civil users and hence a very good market for commercial point of view. But this brings an important question to seek for further study and research, would it be possible to have so many systems coexisting without affecting or degrading the performance of each other.

References

[1] Misra, P., Enge P. Global Positioning System: Signals, Measurements, and Performance. Ganga-Jamuna Press, Lincoln, Mass., 2011.

[2] UNITED NATIONS. Current and planned global and regional navigation satellite systems and satellite-based augmentations systems. In *International Committee on Global Navigation Satellite Systems Provider's Forum*. New York, June 2010, p. 35-40.

[3] J.W. Betz, *Binary Offset Carrier Modulations for Radionavigation*, NAVIGATION: Journal of The Institute of Navigation Vol. 48, No. 4, Winter 2001/02.

[4] GlonasOverview,[http://www.novatel.com/assets/Documents/Papers/GLONASSOverview.pdf],accessed on 15 feb 2014.

[5] GLONASS[http://gauss.gge.unb.ca/GLONASS.ICD-98.pdf], accessed om 15 feb, 2014

[6] "Galileo Joint Undertaking - Galileo Open Service, Signal in space interface control document (OS SIS ICD)." GJU webpages.

[7] Avellone G, Frazzetto M, Messina E. On the acquisition ambiguity for Galileo BOC(m,n) modulated signals. In: IEEE International Conference, ICC '07 Communications. Glasgow: IEEE, 2007. 4438–4443.

[8] Chong Cao, Guifei Jing, Ming Luo, "COMPASS Satellite Navigation System Development', [http://scpnt.stanford.edu/pnt/PNT08/Presentations/8_Cao-Jing-Luo_PNT_2008.pdf].

[9] "Quasi-Zenith Satellite System", Office of National Space Policy, Cabinet Office, Government of Japan, [http://www.oosa.unvienna.org/pdf/pres/stsc2013/tech-39E.pdf]

[10] Parimal Majithiya et. Al. "Indian regional Navigation Satellite System", [http://www.insidegnss.com/auto/IGM_janfeb11-IRNSS.pdf]

[11] Singh, A.K., A.K. Sisodia, and V. Garg (2008) "Modulation Designs For Indian Regional Navigation Satellite Systems," in *International Aeronautical Federation.*

