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Multi-Frequency
GNSS Antennas

Do you know the difference between a GPS (Global Position System) antenna and a multi-frequency GNSS (Global Navigation Satellite Systems) antenna? A single frequency GPS antenna only receives signals from one satellite. GPS antennas systems in phones, cars, and other consumer devices typically use GPS single frequency (L1). A dual-frequency antenna receives two signals from each satellite system. A multi-frequency GNSS antenna receive signals from the GNSS which is a constellation of satellites systems from all over the world. These satellites broadcast signals from outer space with positioning and timing information (see table 1). These signals are picked up by multi-frequency GNSS antennas attached to multi-frequency GNSS receivers that then use this information to calculate geographic (longitude, latitude, and height) location.

Multi-frequency GNSS antennas are used in many industries such as unmanned autonomous vehicles, trains, and agricultural applications that require accurate positioning at centimeter levels. Antennas used for these applications receive GNSS signals that transmit positioning and timing data to multi-frequency receivers from outer space. The receivers then use this data to calculate extremely accurate location. GNNS antennas that can receive the most satellite signals offer the best positioning availability, accuracy, and high performance even in dense locations. These antennas will also receive signals from up-and-coming services that will be available through existing GNSS frequencies. Some of these services include anti-spoofing like Galileo's OSNMA and GPS's Chimera and high accuracy services like Galileo's HAS, QZSS CLAS, and BeiDou's HAS – detailed description of these technologies is beyond the scope of this article.

System	Owner	Frequency	Satellite QTY	Coverage
GPS	USA	1.563–1.587 GHz (L1) 1.215–1.2396 GHz (L2) 1.164–1.189 GHz (L5)	32	Global
GLONASS	Russia	1.593–1.610 GHz (G1) 1.237–1.254 GHz (G2) 1.189–1.214 GHz (G3)	24	Global
Galileo	Europe	1.559–1.592 GHz (E1) 1.164–1.215 GHz (E5a/b) 1.260–1.300 GHz (E6)	26+	Global
BeiDou	China	1.561098 GHz (B1) 1.589742 GHz (B1-2) 1.20714 GHz (B2) 1.26852 GHz (B3)	25+	Global
QZSS	Japan	1.57542 GHz (L1c/a, L1c, L1S) 1.22760 GHz (L2c) 1.17645 GHz (L5, L5s) 1.27875 GHz (L6)	4+	Regional
NavIC	India	1.17645 GHz(L5) 2.492028 GHz (S)	7+	Regional

Table 1: *GNSS owner, frequency, number of satellites, and coverage*

Each GNSS satellite uses one or more signals to transmit positioning, timing, and navigation data. These signals vary in terms of their dependability and availability. The more signals a multi-frequency antenna receives, the more information it collects from other satellites the more accurate and reliable the calculated location will be. Navigation GPS in phones, cars, and other consumer devices usually use GPS or GNSS signals on one frequency (L1). Multi-frequency antennas and receivers, on the other hand, receive signals from multiple GNSS system. Today's multi-frequency receivers are pushing the limits of GNSS technology to achieve the most accurate, reliable, and robust positioning possible.

Up-and-coming GNSS Technology

Engineers around the world are currently developing new technologies that will add valuable services to existing satellite systems. These technologies include high security and high-accuracy positioning techniques (see table 2). These up-and-coming technologies will be available through existing GNSS frequencies. Using future-proof multi-frequency GNSS antennas allows users to take advantage of upcoming technology when they become available.

Service	**Technology**	**System**	**Signal**	**Coverage**
Chimera	Anti-spoofing	GPS	L1c	Global
OSNMA	Anti-spoofing	Galileo	E1b	Global
CAS	Anti-spoofing	Galileo	E6	Global
HAS	High accuracy	Galileo	E6	Global
CLAS	High accuracy	QZSS	L6	Japan
SLAS	High accuracy	QZSS	L1s	Japan
PPB2b	High accuracy	BeiDou	B2b	China

Table 2: *Up-and-coming GNSS technology*

When a multi-frequency GNSS antenna receives signals from at least 4 GNSS satellites, the multi-frequency receiver then calculates position (longitude, latitude, height). These receivers utilize RTK (Real Time Kinematics) technology to calculate position accuracy to centimeter level. GNNS antennas that can receive the most satellite signals offer the best positioning availability, accuracy, and high performance even in dense urban or dense rural environments.

In dense urban and rural environments, the number of usable satellites significantly drops because the field of view is often obstructed by buildings or trees. Multi-frequency GNSS antennas attached to GNSS receivers are ideal for these environments because they can pick up signals from all GNSS satellites in the vicinity.

In addition to high reliability in dense and urban environments there are other benefits of receiving multifrequency GNSS signals. Some of these benefits include removal of ionospheric errors, better multipath rejection, system redundancy, and less radio frequency interference.

Removal of ionospheric errors: A major difference between single and multi-frequency antennas is that high accuracy can be achieved when ionospheric errors are removed. Charged particles in the ionosphere disturb and delay GNSS signals. Multi-frequency receivers are able remove ionospheric errors when it has access to two or more signals from the same satellite. This brings accuracy from several meters down to a single meter.

Better multipath rejection: The L1 signal, which is used in single frequency receivers is susceptible to multipath rejection. Multipath rejection is the distortion of direct line-of-sight signals as they are contaminated by identical signals reflected from objects such as buildings, cars, or trees.

System redundancy: multi-frequency receiver has built in redundancy because they can receive signals from other satellites. Having the ability to receive signals from other satellites also means signal acquisition time is reduced. When a signal from one satellite is blocked due to an obstruction, the antenna simply picks up a signal from another satellite to ensure system continuity.

Less radio frequency interference: radio interference happens when other signals on the same frequency overpower GNSS signals. Interference can be caused by radio amateurs or by neighboring electronic devices and it usually effects one of the GNSS frequencies at a time. Using signals on multiple frequencies allows the receiver to switch to another frequency if interference on one frequency is detected.

In conclusion, there are many benefits multi-frequency GNSS antennas offer over a single or dual frequency GPS antennas. This is because GPS satellites collaborate with other satellites in the GNSS. This collaboration enables higher signal availability, accuracy, and high performance even in dense urban or dense rural environments because multi-frequency GNSS antennas can pick up signals from other GNSS satellites. This capability enables receivers to calculate extremely accurate location anywhere in the world. It's important to keep in mind that GNSS and GPS are part of same constellation system; however, the main difference of multi-frequency GNSS antennas is that they can pick up satellite signals from other networks beyond the GPS system and more satellites means increased positional accuracy and reliability. All GNSS antennas are compatible with GPS; however, GPS antennas are not necessarily compatible with multi-frequency GNSS receivers.

Jaime Duran,
Product Manager