A Brief Introduction To GPS Technology

Watson Industries, Inc. 2014

The Global Positioning System (GPS) was put in place by the U.S. Department of Defense during the 1980s and 1990s. GPS is composed of a group of satellites in orbit around the earth. The system was originally conceived as having 24 satellites, but now there are at least 30 operating or serving as backups. The GPS satellites transmit a coded radio signal back to earth that a GPS receiver can use to calculate its exact position.

Since the U.S. developed the GPS system, several other countries have fielded or are developing their own satellite-based positioning systems: Russian GLONASS, Europe's Galileo, India's IRNASS, and China's BDS.

Initially, GPS was intended for military purposes. The United States intentionally degraded the signals from the GPS satellites to make commercial GPS devices less accurate. This was called Selective Availability. By 2000, the accuracy of commercial GPS receivers had improved using differential GPS technology and the U.S. government decided to do away with Selective Availability.

The concept behind GPS can be complicated, but described in simple terms it works in this way: Each GPS satellite is outfitted with an extremely accurate atomic clock. The satellite is also programmed with precise information about its orbit. The GPS satellite transmits the time and orbital data as coded radio signals.

A GPS receiver does just what its name indicates. It receives the signals from GPS satellites. The GPS receiver also has the accuracy of the satellite's atomic clocks, so it knows what time it is to extremely accurate precision. Even though the radio signals travel from the GPS satellites at the speed of light, it takes a small amount of time for them to reach the GPS receiver. This is the key to GPS: the receiver compares the time the satellite sent the data to the time when the data was received. This information, along with the satellite's orbital data allows the receiver device to calculate exactly how far away it is from the satellite. At this point, the position of the receiver device can be imagined to be located anywhere on the surface of an imaginary sphere with a radius equal to the calculated distance.

Once this calculation is made using the signals from at least three GPS satellites, the GPS receiver now has three imaginary spheres that all define the receiver's position. Where all these spheres intersect defines the geographic location of the receiver (latitude and longitude). This process is called trilateration. If the receiver can get data from at least 4 satellites, it can also calculate altitude. The more satellites a GPS receiver can get data from, the more accurately it can calculate its position.

As was written above, the GPS receiver needs to know the exact time extremely accurately. Even a small timing error can cause large variations in the location calculations. Putting an atomic clock inside each GPS receiver would be extremely expensive however, so the GPS receiver device uses the time signals from the GPS satellites to correct its own clock. When the receiver acquires data from four or more satellites, the positional spheres (see above) must share a common intersection point – this is the GPS receiver's location. If they do not intersect exactly, there must be a small error in the receiver's clock. The GPS receiver can calculate what clock correction is required to make the positional spheres intersect. The GPS receiver can be used as an atomic clock – as long as it is receiving GPS signals.

Sometimes, GPS signals can bounce off of large obstacles or be delayed by atmospheric patterns. This causes an error in the position calculations since it takes the signal longer than it should to travel from the satellite to the GPS receiver. Differential GPS (DGPS) can help to solve these issues.

DGPS works by placing a separate receiver that remains at a particular stationary, known location. The DGPS transmitter sends its own data to the receivers. This gives them accurate local reference data to use for error correction.

Another method of providing corrections for GPS signals is a Space-Based Augmentation System (SBAS). This system is composed of networks of "base stations" like DGPS. The difference is that these stations transmit their information to a series of satellites in geostationary orbit. Then these satellites transmit the information back to receivers on the ground to apply the corrections. This allows for a much wider coverage area for the correction signals.

References

1. Global Positioning System (2014). Retrieved from http://en.m.wikipedia.org/wiki/Global_Positioning_System
2. Zahradnik, F. (2014). How GPS Works. Retrieved from http://gps.about.com/od/beforeyoubuy/a/howgpsworks.htm
3. Brain, M. and Harris, T. (2011). How GPS Receivers Work. Retrieved from http://electronics.howstuffworks.com/gadgets/travel/gps.htm
4. What is GPS? (2014). Retrieved from http://www8.garmin.com/about/GPS/
5. How does GPS work? (2014). Retrieved from http://www.physics.org/article-questions.asp?id=55
6. About GPS Technology (2013). Retrieved from http://www.hemispheregps.com/AboutUs/AboutGPSTechnology/tabid/517/Default.aspx