Subject Name: GPS
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Year and Sem, Department:IV& II SEM, ECE

Unit – I: GLOBAL POSITIONING SYSTEM

Important Points / Definitions:

- The Global Positioning System (GPS) is part of a satellite-based navigation system developed by the U.S. Department of Defense under its NAVSTAR satellite program
- The fully operational GPS includes 24 or more (28 in March 2006) active satellites approximately uniformly dispersed around six circular orbits with four or more satellites each.
- Each GPS satellite transmits two spread spectrum, L-band carrier signals—an L1 signal with carrier frequency 1575.42 MHz and an L2 signal with carrier frequency 1227.6 MHz
- Selective availability (SA) is a combination of methods available to the U.S. Department of Defense to deliberately derating the accuracy of GPS for "nonauthorized" (i.e., non-U.S. military) users during periods of perceived threat.
- A second configuration for global positioning is the Global Orbiting Navigation Satellite System (GLONASS), placed in orbit by the former Soviet Union, and now maintained by the Russian Republic.
- The Galileo system is the third satellite-based navigation system currently under development. Its frequency structure and signal design is being developed by the European Commission's Galileo Signal Task Force (STF), which was established by the European Commission (EC) in March 2001.
- GPS satellites occupy six orbital planes inclined 55◦ from the equatorial plane.
- Coordinated Universal Time (UTC) is the timescale based on the atomic second, but occasionally corrected by the insertion of leap seconds, so as to keep it approximately synchronized with the earth's rotation.
- A critical constraint on the GPS constellation is that it must provide a minimum of fourfold coverage at all times.
- GPS system time is also a paper time scale; it is based on statistically processed readings from the atomic clocks in the satellites and at various ground control segment components.

QUESTIONS:

1. How many satellites and orbit planes exist for GPS, GLONASS, and Galileo? What are the respective orbit plane inclinations?
2. List the differences in signal characteristics between GPS, GLONASS, and Galileo.
3. Explain briefly about GPS Time.
4. List out the features of GPS constellation
5. Explain the principle of GAGAN with neat diagram.
6. How did the NAVSTAR GPS originate?
7. Write the equation for GPS satellite transmitted signal.
8. What are the other Global Navigation Satellite systems and how does they different from the GPS system in terms of constellations and services provide by them?
9. Describe the various GPS system segments.
10. Write the basic equations for finding the user position.

Fill in the blanks / choose the Best:

1. Which of the following coordinate systems is not rotating?
   (a) North–east–down (NED)
   (b) East–north–up (ENU)
   (c) Earth-centered, earth-fixed (ECEF)
   (d) Earth-centered inertial (ECI)
   (e) Moon-centered, moon-fixed

2. What is the minimum number of two-axis gyroscopes (i.e., gyroscopes with two, independent, orthogonal input axes) required for inertial navigation?
   (a) 1
   (b) 2
   (c) 3
   (d) Not determined
3. What is the minimum number of gimbal axes required for gimbaled inertial navigators in fully maneuverable host vehicles? Explain your answer.
   (a) 1
   (b) 2

(c) 3

(d) 4

4. An inertial sensor assembly (ISA) operating at a fixed location on the surface of the earth would measure FUNDAMENTALS OF SATELLITE AND INERTIAL NAVIGATION

(a) No acceleration

(b) 1 *g* acceleration downward

(c) 1 *g* acceleration upward

5. The *inertial* rotation rate of the earth is

(a) 1 revolution per day

(b) 15 degrees per hour

(c) 15 arc-seconds per second

(d) ≈ 15.0411 arc-seconds per second

6. The CEP rate for a *medium accuracy* INS is in the order of

(a) 2 meters per second (m/s)

(b) 200 meters per hour (m/h)

(c) 2000 m/h

(d) 20 km/h

7. Rank VDOP, HDOP and PDOP from smallest (best) to largest (worst) under normal conditions:

(a) VDOP ≤ HDOP≤PDOP

(b) VDOP≤PDOP≤HDOP

(c) HDOP≤VDOP≤PDOP

(d) HDOP≤PDOP≤VDOP

(e) PDOP≤HDOP≤VDOP

(f) PDOP≤VDOP≤HDOP

8. UTC time and the GPS time are offset by an integer number of seconds (e.g., 14 s as of January 1, 2006) as well as a fraction of a second. The fractional part is approximately:

(a) 0.1–0.5 s

(b) 1–2 ms

(c) 100–200 ns

(d) 10–20 ns

Unit –II: Signal Characteristics

Important Points / Definitions:

- *Satellite Almanac Data.* Each satellite transmits orbital data called the *almanac*, which enables the user to calculate the approximate location of every satellite in the GPS constellation at any given time.
- Almanac data are not accurate enough for determining position but can be stored in a receiver where they remain valid for many months. They are used primarily to determine which satellites are visible at a given location so that the receiver can search for those satellites when it is first turned on.
- *Satellite Ephemeris Data.* Ephemeris data are similar to almanac data but enable a much more accurate determination of satellite position needed to convert signal propagation delay into an estimate of user position.
- The *zero state* is defined to be that week that started with the $X1$ epoch occurring at approximately midnight on the night of January 5, 1980/morning of January 6, 1980.
- The interface between the GPS space and user segments consists of two radiofrequency (RF) links, L1 and L2.
- The ephemeris parameters and algorithms used for computing satellite positions.
- The problem of determining satellite position from these data and equations is called the *Kepler problem*
- The hardest part of the Kepler problem, is the problem of determining true anomaly as a function of time. This problem was eventually solved by introducing two intermediate "anomaly" variables **E**, the *eccentric anomaly* **M**, the *mean anomaly*
- The ephemeris data permit the position and velocity of each satellite to be computedat the signal transmission time

Questions

1. Discuss briefly about the GPS signal structure?
2. What are the advantages of Galileo signal structure over GPS
3. What do you understand by the terms spoofing and Antispoofing?
4. Differentiate between GPS and GALILEO satellite construction
5. Describe how the time of travel (from satellite to receiver) of the GPS signal is determine

Fill in the blanks / choose the Best:

1. The relativistic effect in a GPS satellite clock which is compensated by a deliberate clock offset is about
    a. 4.5 parts per million
    b. 4.5 parts per 100 million
    c. 4.5 parts per 10 billion
    d. 4.5 parts per trillion
2. The following component of the ephemeris error contributes the most to the range error:
    a. Along-track error
    b. Cross-track error
    c. Both along-track and cross-track error
    d. Radial error
3. The differences between pseudorange and carrier phase observations are
    a. Integer ambiguity, multipath errors, and receiver noise
    b. Satellite clock, integer ambiguity, multipath errors, and receiver noise
    c. Integer ambiguity, ionospheric errors, multipath errors, and receiver Noise
    d.Satellite clock, integer ambiguity, ionospheric errors, multipath errors,and receiver noise
4. GPS week number started incrementing from zero at
    a. Midnight of Jan. 5–6, 1980
    b. Midnight of. Jan. 5–6, 1995
    c. Midnight of Dec. 31–Jan. 1, 1994–1995
    d. Midnight of Dec. 31–Jan. 1, 1999–2000

5. The complete set of satellite ephemeris data comes once in every
   a. 6 s
   b. 30 s
   c. 12.5 s
   d. 12 s

6. For high accuracy of the carrier phase measurements, the most suitable carrier tracking loop will be
   a. PLL with low loop bandwidth
   b. FLL with low loop bandwidth
   c. PLL with high loop bandwidth
   d. FLL with high loop bandwidth
7. Which of the following actions does *not* reduce the receiver noise (code)?
   a. Reducing the loop bandwidth
   b. Decreasing the predetection integration time
   c. Spacing the early–late correlators closer
   d. Increasing the signal strength

8. Before bit synchronization can occur, the <u>PLL</u> must be locked to the GPS signal

9. Some receivers avoid the conflicting demands of the need for a small bandwidth and a large capture range in the PLL by using a <u>frequency-lock loop.</u>

10. For highdynamics applications, such as missile platforms, loop bandwidths might be on the order of <u>10 Hz or larger</u>.