GPS Sensor

Date – 14/04/24 Group - 3

1. Functioning of GPS

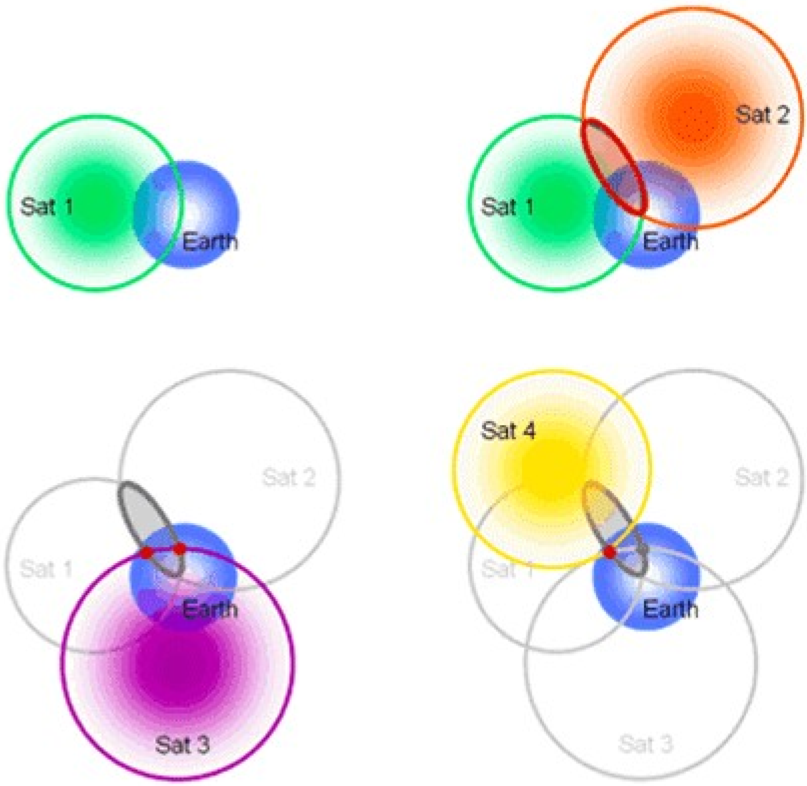
GPS (Global Positioning System) plays a crucial role in the functioning of rovers, particularly those used in space exploration or terrestrial exploration in remote areas. Here's how it works:

1. **Satellite Communication**: GPS relies on a network of satellites orbiting the Earth. These satellites continuously transmit signals containing their current position and the precise time the signals were sent.
2. **Triangulation**: A GPS receiver on the rover picks up signals from multiple satellites overhead. By measuring the time it takes for each signal to reach the receiver, the GPS can determine the distance between the rover and each satellite.
3. **Determining Position**: Once the distances to at least four satellites are known, the GPS receiver can calculate its own position using a process called trilateration. Trilateration involves intersecting spheres (or in this case, spheres represented by the distance from each satellite) to pinpoint the receiver's location.
4. **Accuracy Enhancement**: In addition to basic GPS, rovers may use techniques to enhance accuracy. Differential GPS (DGPS) is one such method. DGPS involves comparing the rover's position calculated from GPS signals with a known position (such as a base station). Any discrepancies can be used to correct the rover's position calculation, improving accuracy.
5. **Navigation and Guidance**: With its precise position known, the rover can navigate terrain, avoid obstacles, and execute its mission objectives. GPS data can be combined with other sensors and mapping data to create detailed maps of the rover's surroundings, aiding in navigation.
6. **Communication**: In some cases, GPS data may also be used for communication purposes, helping the rover relay its position back to a control center or coordinate with other vehicles or assets in the vicinity.

2. What is Trilateration?

Radio signals travel at the speed of light, and the delay between the time a signal is transmitted by a GPS satellite and the time the signal is received by a receiver is key to the operation of GPS.

- **Trilateration** is a technique where a GPS receiver uses the differences in delays between the signals along with 3-dimensional geometric calculations to determine the latitude, longitude and elevation of the receiver.
- While the *tri* part of *trilateration* implies three, and it is possible to calculate location from three GPS signals if the receiver has a high-precision clock, very few GPS receivers have such clocks, so almost all **GPS receivers need at least four signals to accurately calculate location**. Averaging using signals from additional receivers beyond the minimum four signals can improve accuracy.



Known Points: Trilateration requires at least three known points with their respective positions accurately known. In the case of GPS, these known points are the satellites orbiting the Earth, each transmitting signals with their precise locations.

Distance Measurement: The unknown point (the position to be determined) measures its distance from each of the known points. In the case of GPS, the unknown point is your GPS receiver (such as a rover), and the known points are the satellites. The distances are calculated based on the time it takes for signals to travel from the satellites to the receiver.

Sphere Intersection: Trilateration involves creating spheres around each known point with a radius equal to the measured distance to the unknown point. The unknown point is somewhere on the surface of each of these spheres.

Intersection Point: Where these spheres intersect, there's only one point in space that satisfies the measured distances from all three known points. This point is the location of the unknown point (the receiver in GPS).

Calculation: Trilateration calculates the coordinates of this intersection point, giving the precise position of the unknown point.

In GPS systems, trilateration is slightly more complex because it involves four satellites instead of three to get an accurate 3D position (latitude, longitude, and altitude). This is because a three-dimensional fix requires a minimum of four known points (satellites) to solve for the three unknowns (x, y, and z coordinates).

2. Implementation steps to integrate GPS into a rover :-

Hardware Integration:

Selecting the appropriate components is crucial for a successful GPS integration. This involves researching and selecting a GPS receiver module that aligns with the rover's requirements, considering factors such as accuracy, update rate, sensitivity, size, power consumption, and cost. Once the module is chosen, it needs to be physically integrated into the rover's hardware setup. This includes securely mounting the GPS receiver module onto the rover's chassis or electronics platform and ensuring the proper orientation of the GPS antenna for optimal signal reception. Connections between the GPS module, onboard computer/microcontroller, and power supply are established using appropriate cables and connectors, ensuring compatibility and reliability throughout the integration process.

Software Development:

Software development involves setting up communication with the GPS receiver module and processing the received data. The first step is installing any necessary drivers or libraries required to communicate with the chosen GPS receiver module. This ensures compatibility with the onboard computer/microcontroller's operating system. Next, the communication protocol used by the GPS module (e.g., NMEA 0183, UART) needs to be determined, and code is developed to establish communication with the module over the chosen protocol. Subsequently, code is implemented to receive raw GPS data streams from the module and parse the received data to extract relevant information such as latitude, longitude, altitude, speed, and time. Proper error handling mechanisms are also implemented to manage data parsing errors and exceptions gracefully.

Data Processing and Integration:

Once the GPS data is received and parsed, it needs to be processed and integrated into the rover's control system. This involves converting GPS coordinates from the WGS84 format to the desired coordinate system, if necessary, and applying filtering and smoothing techniques to reduce noise and improve accuracy. Techniques such as Kalman filtering and moving average filtering are commonly used for this purpose. Processed GPS data is then integrated with the rover's control system to determine the rover's position, orientation, and velocity. Algorithms for waypoint navigation, obstacle avoidance, and path planning are developed based on GPS data, enabling the rover to navigate its environment effectively.

Error Handling and Safety Measures:

Error handling and safety measures are essential to ensure reliable operation of the GPS-enabled rover. Mechanisms are implemented to detect and handle situations where GPS signal is lost or weak, such as switching to alternative navigation modes or relying on other sensors. Accuracy monitoring is also conducted to assess the reliability of GPS data, with recalibration or error correction procedures triggered if accuracy falls below acceptable thresholds. Fail-safe mechanisms are developed to ensure safe rover operation in case of GPS failure or anomalies, including emergency stop procedures or return-to-base algorithms to prevent accidents or loss of control.

Testing and Calibration:

Functional testing of the GPS-enabled rover is conducted to verify its accuracy, reliability, and performance under various environmental conditions and scenarios. This involves rigorous field tests and simulations to validate the GPS system's capabilities. Additionally, calibration of the GPS system is performed to optimize accuracy and consistency. Fine-tuning of sensor parameters, such as antenna position and satellite constellation selection, is based on calibration data and performance feedback, ensuring that the GPS system operates at peak efficiency.