# Mitigate Effects of Multipath Interference at GPS Using Separate Antennas

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**Abstract - Multipath is one of the contributing sources of errors that effect on the accuracy and reliability of the Global Positioning System (GPS). GPS multipath is caused by the reception of signals from satellites directly and indirectly reflected from the local objects. This paper investigates multipath errors at the GPS receiver antenna and the possibility to mitigate multipath interference effect by use two separate antennas model GA 25 MCX with one GPS receiver card (GARMIN GPS 25LP Series) are GPS sensor boards designed for a broad spectrum of OEM (Original Equipment Manufacturer) to improve accuracy and reliability of GPS. We used a specially designed simulator platform to simulate the movement and the reflection of GPS signals from the body of platform**.

**Keyword -** GPS, Antenna, Multipath, OEM, HDOP, NEMA

## I. Introduction

Position and attitude parameters are important information in the navigation, control and guidance of moving platforms. GPS can consistently provide accurate position, velocity and timing information under good satellite signal tracking environments. The main factor limiting the use of GPS is the requirement for line-of-sight between the receiver antenna and the satellites, which cannot always be met. Standard GPS position estimates can achieve accuracy on the order of meters to centimeters, depending on the measurements and methods employed. This high accuracy positioning capability is required by many applications such as automated vehicle position control sub-systems within an automated highway system (AHS).

The Global Positioning System consists of three separate elements: the space segment, the control segment and the user segment. For the space segment, the GPS constellation consists of 24 satellites arrange in 6 orbital planes with 4 satellites per plane. The system utilizes the concept of one way time of arrival (TOA) ranging. Satellite transmissions are referenced to highly accurate atomic frequency standards onboard the satellites. GPS satellites transmit two codes: the Precision or P-code and the Coarse Acquisition or C/A code. The control segment tracks the GPS satellite and provides them with periodic updates, correcting their ephemeris constant and clock-bias errors. The location of the stations is known with a high degree of accuracy and each station is equipped with a cesium atomic clock. Each satellite signals are read at least by four stations. Because the stations positions and time coordinates are known, the pseudo range measurements made by each station for a given satellite can be combined to create an inverted navigation solution to fix the location and time of that satellite. The GPS user segment consists of GPS receivers and their auxiliary equipment such as antenna.

Multipath is the effect a satellite-emitted signal arrives at the receiver via more than one path. Reflecting surfaces near the receiver mainly causes multipath. Secondary effects are reflections at the satellite during signal transmission. The satellite signal arrives at the receiver on different paths direct and indirect. The received signals have relative phase offsets and the phase differences are proportional to the differences of the path lengths there is no general model of the multipath effect because of the arbitrarily different geometric situations. The Multipath effects on carrier phases for relative positioning with short baselines, should generally not be greater than 1 cm (good satellite geometry and a reasonably long observation interval). But even in those cases, a simple change of the height of the receiver may increase the multipath and thus, deteriorate the results.

## II. GPS GARMIN-25LP SERIES

The GARMIN GPS 25LP Series are GPS sensor boards designed for a broad spectrum of OEM (Original Equipment Manufacturer) system application. The GPS 25LP will simultaneously track up to twelve satellites providing fast time-to-first-fix, one second navigation updates and low power consumption. Their far-reaching capability meets the sensitivity requirements of land navigation as well as the dynamic requirements of high performance aircraft.

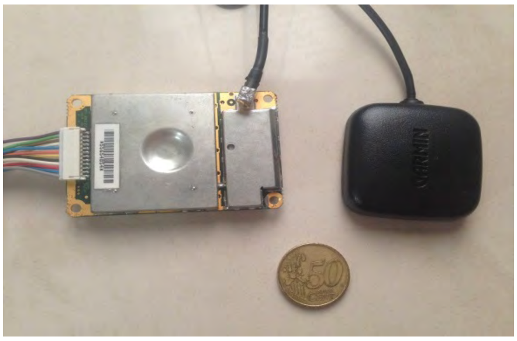

Figure 1. GPS Garmin 25LP Series

Figure 2. Separate GPS Antenna's GA 25 MCX

The GPS 25LP is designed to withstand rugged operation conditions, however it should be mounted in an enclosure as part of a larger system designed by an OEM or system integrator. The system may communicate with the board set via a choice of two CMOS/TTL or two RS-232 compatible bi-directional communication channels. A highly accurate one –pulse-per-second (PPS) output can be utilized in applications requiring precise timing measurements. An on-board memory rechargeable backup battery allows the sensor board to retain critical data such as satellite orbital parameters, last position, date and time. After the acquisition process is complete, the GPS 25LP will begin sending valid navigation information over its output channels. These data include: position (Latitude, Longitude, and Altitude), Velocity, Date/time, Error estimates and Satellite and Receiver status.

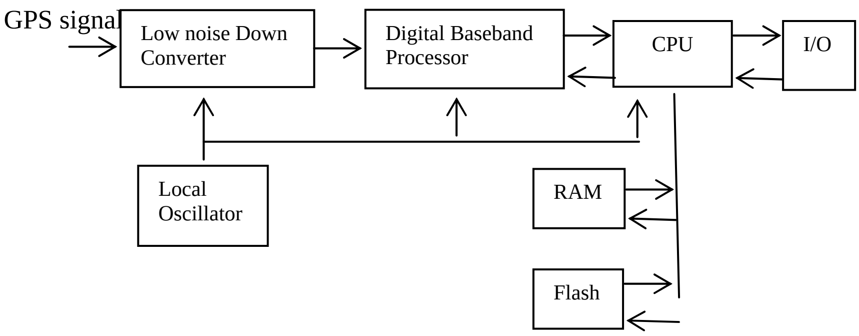


Figure 3. GPS 25 LP Block Diagram

The navigation message which is defined, (NMEA) The National Marine Electronics Association (NMEA) in the USA defines Input/output message format. It is the only standard Input/output message format in the GPS industry (both for GPS Hardware and for GPS Application Software). In domain of (NMEA) we use following 6 output messages most:

| **(NEMA) message** | **Description** |
|---|---|
| GGA | Global positioning system fixed data |
| GLL | Geographic position latitude / longitude |
| GSA | GNSS DOP and active satellite |
| GSV | GNSS satellite in view |
| RMC | Recommended minimum GNSS data |
| VTG | Course over ground and ground speed |

The BIOS of GPS Engine Board determines which NMEA output messages this GPS Engine Board should generate. We choose default of BIOS regarding NMEA output message is: GGA, GSA and RMC. The reason why GLL, GSV and VTG are not generated by our standard BIOS is as follows:

(a) All data of GLL is already included in GGA.

(b) The data of VTG and GSV is not so valuable for practical applications.

## III. EXPERIMENTAL WORK

For our experimental work, we chose a specially designed simulator platform made of metal and contain bascule cover as shown in figure (4), because the metal is a very good reflector for the GPS electromagnetic waves. The GPS antenna located on platform stand which is connected with OEM card and computer laptop.

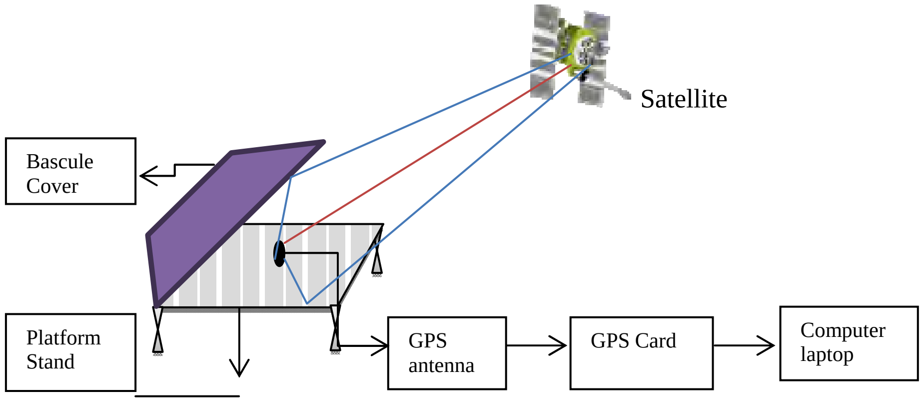


Figure 4. Specially Designed Simulator Platform

### A. TESTING OF USING ONE ANTENNA

In this test, we made tested measurements for detecting multipath signal by used one antenna model GA25MCX with one GPS receiver card (GARMIN GPS 25LP Series). Initially the GPS antenna is covered completely by bascule cover, then the cover is raised gradually reduced by step of (5) degree up to (90) degree, during each change of angles we recorded the parameters such as, reception time, horizontal dilution of precision (HDOP) and in addition to the number of satellite in used. The results obtained with these test are given in figures (5&6). The satellite signal can received in angle of sight (10 degree) with very high of the reception time (32 second). We can deduce from this figure that there is an inverse relationship, so that whenever increased angle of sight result in reception time is decrease that’s mean mitigate of multipath interference but still there is error. We found it when the angle of sight reach to (75 degree) the reception time becomes constant.

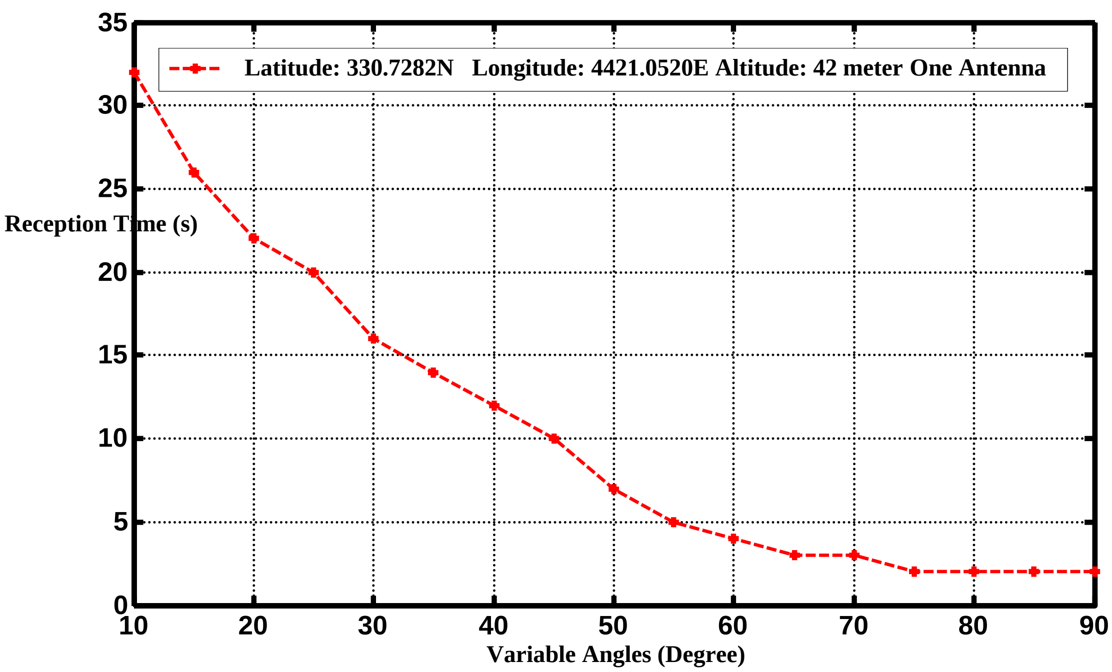


Figure 5. variable angle with reception time using one GPS Antenna

The relation between variable angles of sight with (HDOP) is shown in figure (6) We can observe from this figure that the Horizontal Dilution of Precision (HDOP) is decrease when the angle of sight is increase. If the angle of sight equal (60) degree or more the (HDOP) becomes constant with never change. We can see in this figure the changing in HDOP depend of multipath that affect on angle of sight.

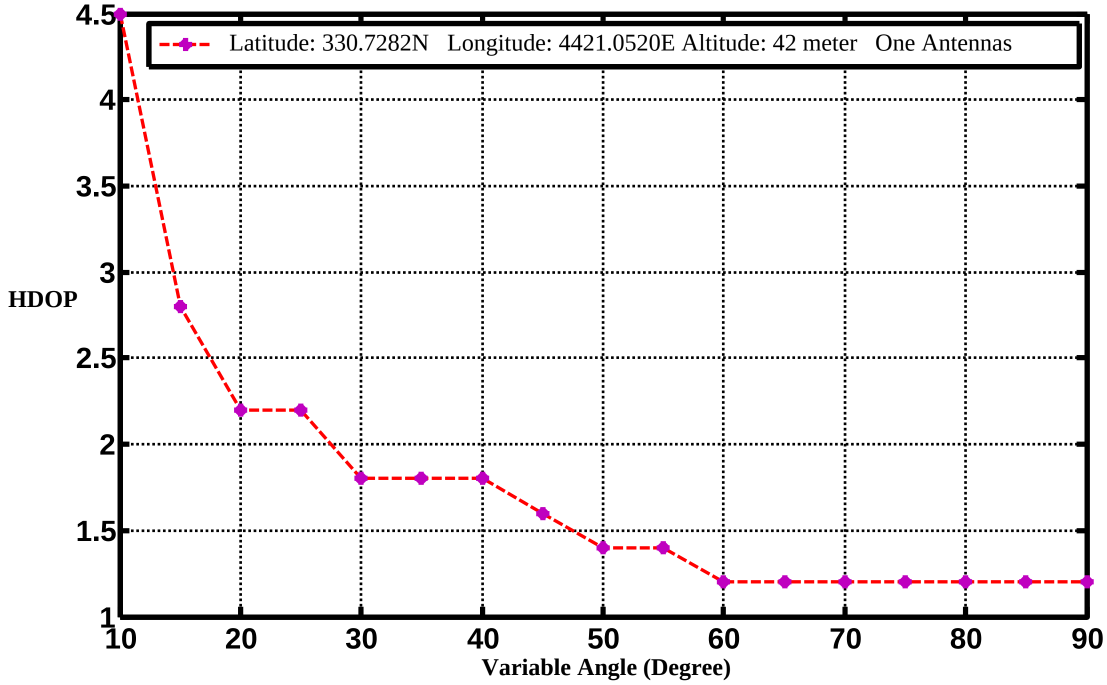


Figure 6. variable angle with HDOP using one GPS Antenna

B. TESTING OF USING TWO ANTENNAS

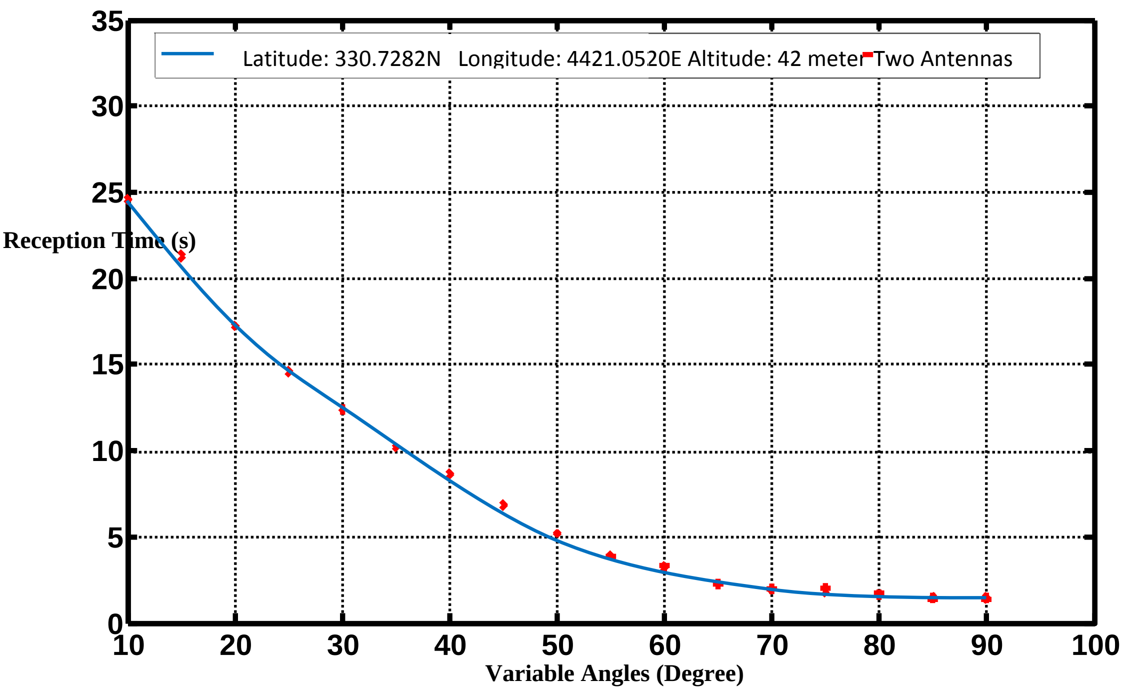


**Figure 7. variable angle with reception time using two GPS Antennas**

In the second test were the same first test but by using two antennas model GA 25 MCX with one GPS receiver card. The results have been different and more accurate as shown in Figures (7&8).

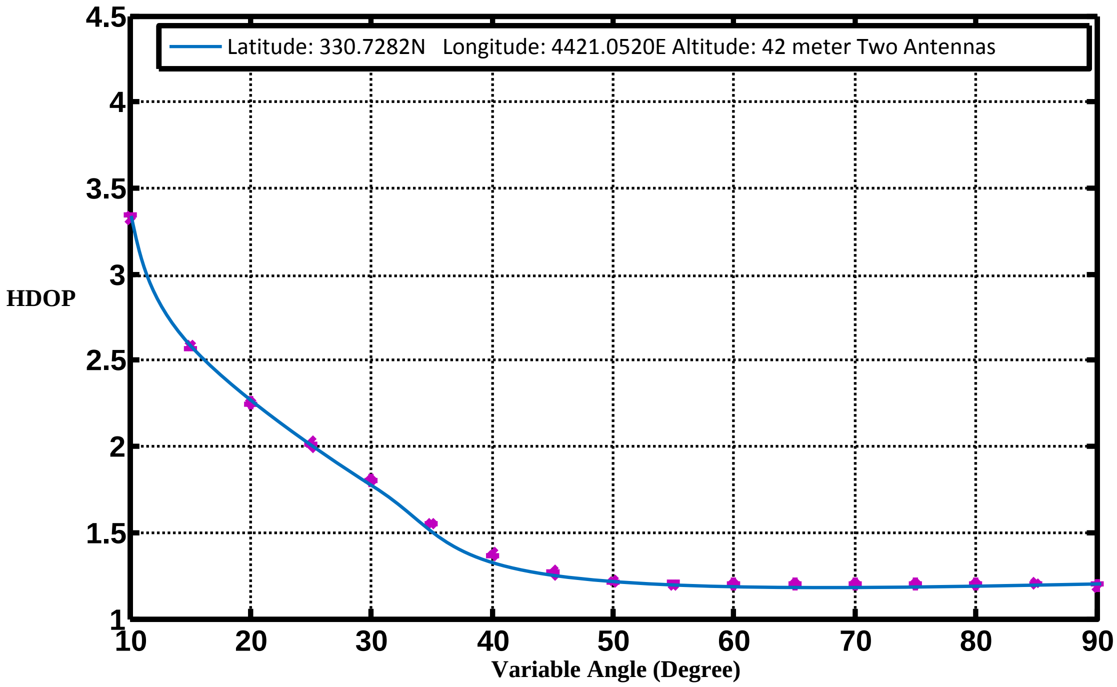


Figure 8. variable angle with HDOP using two GPS Antennas

We can see that the satellite signal can received start in the reception time (24.5 second) we conclude that the multipath interference is mitigated and when the angle of sight reach to (65 degree) the reception time becomes constant. In figure (8) shown HDOP start from 3.4 in 10 degree then coming down whenever increasing the angle until the angle of sight equal (45) degree or more the (HDOP) becomes constant with never change, so the effect of multipath interference is dropped significantly and the measurements of GPS now is high accuracy.

## IV. CONCLUSION

In this paper we conclude that using two separate GPS antennas in different locations with one GPS receiver card it will have a positive effective on the accuracy of the system work because mitigate the effects resulting from multipath interference it will be able to receive direct and indirect the signals from satellites with high quality. The correct selection of GPS antenna location on the objects to be visible to the satellites and unimpeded it will be helped the system to receive the signals clearly without multipath interference. Choose the type of GPS system which is used on multi applications in land, sea and air will have impact in improving the performance of GPS system and the reliability and to mitigate the effects of multipath interference then reduce the proportion of error in the measurements of the system, thus an increase in accuracy is achieved by using the receiver which is works with two antennas or more that can be installed in different locations for the purpose of ensure a signal received from highest number of satellites every time.

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