International Journal of Electronics Communication and Computer Engineering
Volume 3, Issue 3, ISSN 2249 –071X

Electronic and Satellite Navigation

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***Abstract* — In simple terms navigation is a method of getting from one known point to some distant point. Piloting, celestial navigation, radio navigation and satellite navigation. Are most commonly used methods. In radio navigation components among them is electronics navigation. Navigation is a important means without which every transfer becomes almost impossible. It has been helping making ever since the necessity of travelling from one place to another place has raised. If at all the idea of navigation has not originated in different places and people located globally may not be in synchronization. The navigations are plotted in MATLAB.**

***Keywords* — Loran, Omega, SINS, GPS, DGPS, NNSS, NAVSTAR GPS**

I. INTRODUCTION

Navigation:

Navigation is the determination of the position and velocity of a moving vehicle on land, at sea, in the air or in space. Surveyors are beginning to use the same sensors as navigators but are achieving higher accuracy as a result of longer periods of observation, a fixed location and more complex, non real time data reduction.

This paper deal with electronic and satellite navigation. Simple, but electronic navigation is in the form of piloting. Piloting is a branch of navigation in which ships position is determined by referring to landmarks with known position on the earth. The referring points and to its ranges are determined by electronic means.

A satellite navigation system is a system of satellites that provides autonomous geo-spatial positioning with global coverage. It allows small electronic receivers to determine their location (longitude, latitude and altitude) to within a few meters using time signals transmitted along a line-of-sight by radio from satellites.

II. ELECTRONIC NAVIGATION

Position in electronic navigation is determined in practically the same way as piloting though there is one important difference the landmark from which the ship's position is determined do not have to be visible from ship. These reference points may be bearings and distance to a single object, cross bearings on two or more objects or two bearings on the same object with a time interval in between. Instead, their bearings and ranges are obtained by electronic means.[1]

Fig.1. Electronic navigation display

Since electronic navigation is the primary form of today's navigation and the role played by the following system.

1. Long range aid to navigation (LORAN).
2. VLF radio navigation (OMEGA)
3. Ship Inertia Navigation System (SINS).

III. LORAN

LORAN is a long distance navigation system used by ships at sea to obtain a position fix. System is based on the differences in the transit time required for pulsed radio signals to arrive at the LORAN receiver from multiple, synchronized, unidirectional ashore transmitter. LORAN also takes the advantage of the constant velocity of the radio signals to use the time lapse between the arrival of two signals to measure the differences in distance from the transmitting to the point of reception, which is provided with direct reading in micro seconds.[2]

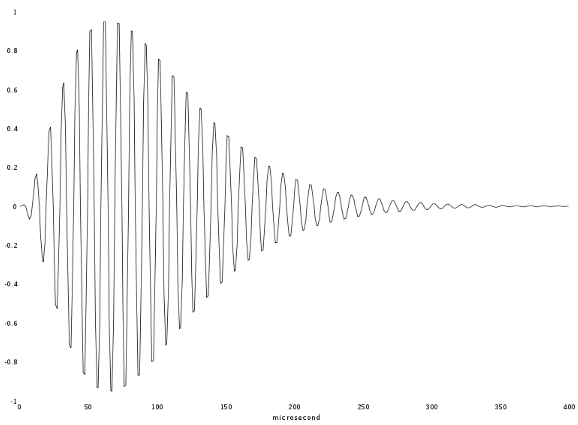

Fig.2. Graph of difference in distance.

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IV. OMEGA

OMEGA is a hyperbolic phase – difference measurement system. Hyperbolic navigation involves comparing the phase angles of two or more radio signals that can be synchronized to a common time base by moving the OMEGA receiver (by ships movement) and giving the transmitter station on frequency with a constant difference in time and phase, the system can measure the relative phase relationship between two stations to determine a line of position (LOP) for the ship[4]. The relative phase angle measure between paired transmitting stations depends upon the distance of the receiver from each transmitter.[5]

Fig.3. OMEGA Transmitter

Three or four transmitters are necessary to obtain accurate fix. One way around this problem is to receiver oscillators as a third or “phantom” transmitter [3]. By setting the receiver oscillators to the frequency transmitted by each of two OMEGA transmitters, the operator can compare the actual transmitted frequencies of two received signals which provides two phase angles. These two phase angles are compared to determine third phase angle which yields accurate fix.

V. SIN

The ship’s inertial navigation system (SINS) is a navigation system that continuously computes the latitude and longitude of the ship by sensing acceleration. This is in contrast to OMEGA and LORAN, which fix the ship’s position by measuring position relative to some known object.

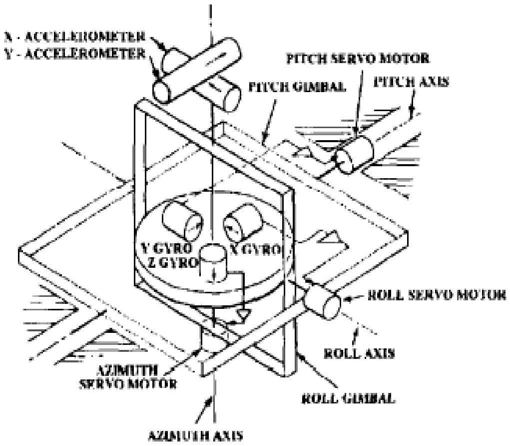

Fig.4. SINS

The basic components of an inertial navigation system are accelerometers, gyroscopes, servo systems and the computers. Accelerometers measure changes in speed or direction along the access in which they lie. High performance servo systems keep the platform stabilized to the desired accuracy.[6]

Advantages

SINS have a major security advantage over other types of navigation systems because it is completely independent of celestial, sight and radio navigation aids.

SINS has the following advantages

1. It is self contained.
2. It cannot be jammed
3. It does not radiate energy and cannot be detectable by enemy sensors.
4. It is not affected by adverse weather conditions.

Advantages of electronic navigation

The advantages of electronic navigation are obvious. A ship’s position may be fixed electronically in fog or heavy weather that makes it impossible to take visual fixes. Also, an electronic fix can be based on stations far beyond the range of any local bad weather.

VI. Satellite Navigation Systems

A satellite navigation system is a system of satellites that provide autonomous geo-spatial positioning with global coverage. Receivers calculate the precise time as well as position, which can be used as a reference for scientific experiments. They noticed a shift in the received radio frequency signal as a satellite passed by. This shift, known as the Doppler effect, is an apparent change in a received frequency by relative motion between a transmitter and receiver. [7]

In satellite navigation, the first successful satellite launch is from U.S Navy Navigation Satellite System (NNSS) became operational.

VII. NNSS

Navy navigation satellite system is an all-weather, highly accurate navigation aid. NNSS also explains Doppler principles, system accuracy. Looking at figure we can observe the NNSS consists of earth-orbiting satellites, tracking stations, injection stations, computing center and shipboard navigation equipment.

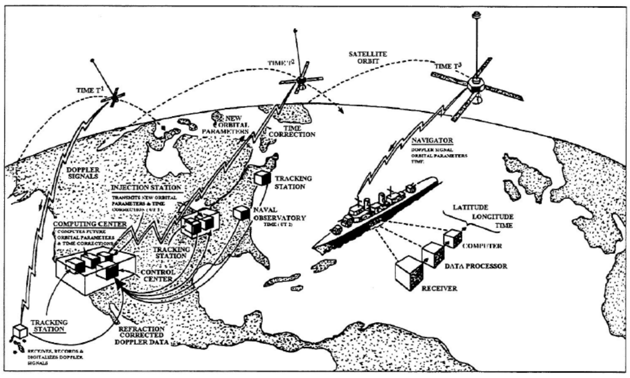

Fig.5. NNSS

Orbiting satellites

Each satellite orbit in approximately 107 minutes, continually transmitting phase-modulated data every two minutes on two RF carriers. This data includes time synchronization signals, a 400 Hz tone, and fixed and variable parameters that describe the satellite's orbit.

Tracking stations

As each satellite passes within radio line of sight (LOS) of each tracking station, it is tracked to accurately determine its present and future orbits. Just before predicted satellite acquisition, the tracking station's antenna is pointed towards the satellite to acquire its signals.

The Doppler tracking signal is digitized and sent with the satellite time measurement to the computing center.

Computing center

The central computing center continually accepts satellite data input from the tracking stations. Periodically to obtain fixed orbital parameters for a satellite, the central computing center computes an orbit for each satellite the best fits the Doppler curves obtained from all tracking stations. These various data input are supplied to injection stations.[8]

Injection stations

The injection stations, after receiving and verifying the incoming message from the control center, stores the message until it is needed for transmission to the satellite. Transmission to the satellite is at the high bit rate so injection is completed about 15 seconds.

The message transmitted by the satellite contains a mix of old and new data, the injection station compares a read back of newly injected data with the data the satellite should be transmitting as a check for errors.

Doppler principles

Look at the figure stable oscillator frequencies radiating from a satellite coming towards the receiver are received (T1) at a higher frequency than transmitted ,because of the velocity of the approaching satellite .The satellite's velocity produces according –like compression effects that squeeze the radio signals as the intervening distance shortens. As the satellite nears its closest point of approach, these compression effects lessen rapidly, until, at the moment of closest approach (T2), the cycle count of the received frequency exactly matches those which are generated. As the satellite passes beyond this point and travels away from the receiver (T3), expansion effects the received frequencies to drop below the frequencies proportionally to the widening distance and the speed of the receding.[10]

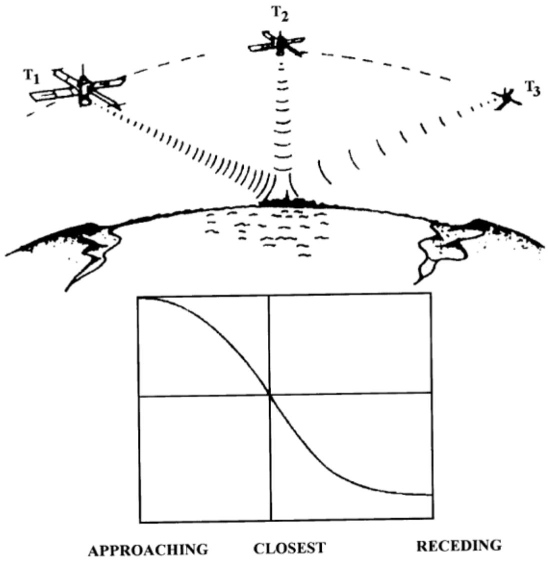

Fig.6. Doppler principle

Factors effecting accuracy:

Electrically charged particles in the ionospheric layer cause refraction of these transmissions. To solve this problem, the satellites are designed to broadcast on two frequencies (150 and 400MHz).

The most serious problems effecting accuracy is the effect of uncertainty in the vessel's velocity computational problems are inherent in the system.

VIII. GPS

GPS is the pioneer and forerunner of GNSS technology and is the only fully functional GNSS system in operation. GPS and GNSS are often used interchangeably, although GPS specifically refers to NAVASTAR GPS.[11]

Description of the entire system

The GPS system is comprised of three functional segments.

1. The space segment (all operating satellites).
2. The control segment (all ground stations involved in the monitoring of the system).
3. The user segment (all civilian and military users).

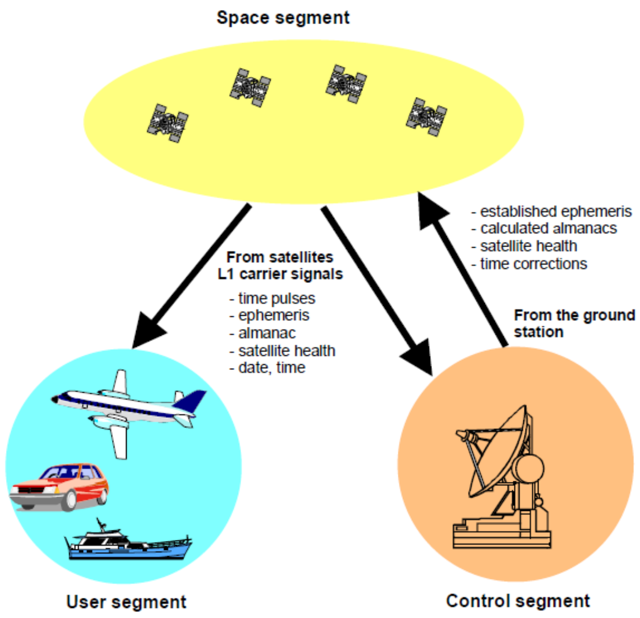

Fig.7. GPS

Space segment

The space segment of the GPS system consists of up to 32 operational satellites orbiting the earth on 6 different orbital planes. They orbit at a height of 20,180 km above earth surface and are inclined at 55 degrees to the equator. Any one satellite completes its orbit in around 12 hours. Due to the rotation of the earth, a satellite will be at its initial starting position.

Control segments

The GPS control segment(operational control system(OCS) consists of a master control station located in the state of Colorado, five monitor stations, and three ground control stations transmitting information to the satellite.

- Observing the movement of the satellites and computing orbital data.
- Monitoring the satellite clocks and predicting their behavior.
- Synchronizing onboard satellite time.
- Relaying precise orbital data received from satellites.
- Relaying the approximate orbital data of all satellites.
- Relaying future information, including satellite health, clock errors etc.

User segment

The radio signals transmitted by the GPS satellites take approximately 67 million seconds to reach a receiver on earth. As the signals travel at a constant speed, their travel time determines the exact distance between the satellite and the user. Speed of light is however a function of the medium.

Four different signals are generated in the receiver each having the same structure as the signals received from the four satellites. By synchronizing the signals generated in the receiver with those from the satellites, the signal time shifts delta T of the four satellite are measured as a time mark, these time shifts multiplied by the speed of light are called pseudo ranges.

NAVASTAR GPS

NAVASTAR GPS is a space-based, ratio navigation system that provides continuous extremely accurate three-dimensional position, velocity and timing signals to users world-wide. It consists basically of ground control, satellite and user equipment.

Satellite ranging

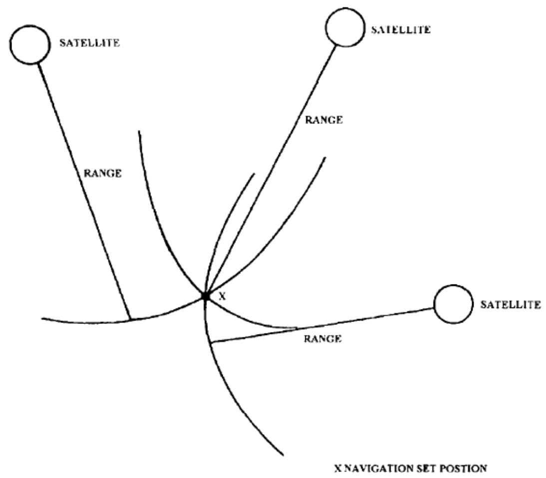

Fig.8. Satellite ranging

GPS Navigation is based on the principle of satellite ranging. Satellite ranging involves measuring the time it takes the satellite signals to travels from the satellite to the navigation set. By dividing the travel time by the speed of light, the distance between the navigation set and the satellite is known. By ranging three satellite, a three dimensional picture.

GPS system is accurate to within 30 meters which is equal to or better than any other radio navigation system available today is DGPS.

IX. DGPS

DIFFERENTIAL GLOBAL POSITIONING SYSTEM (DGPS) is a method of increasing the accuracy of positions derived from GPS receivers. With DGPS receivers position accuracy is improved going from 30 meters to better than 10 meter.[12]

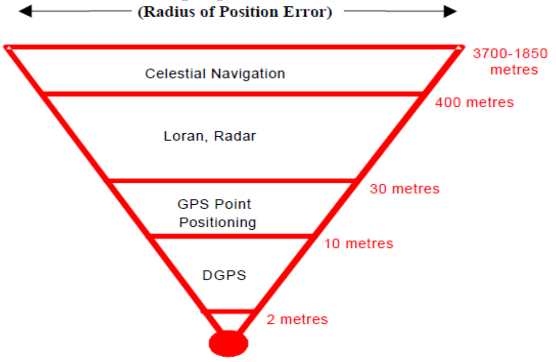

Fig.9. Global Positioning Systems

Advantages of DGPS:

- Accuracy to 10 meters, 95% of the time.
- Signal availability 99.0% of the time.
- Broadcast reliability 99.8% of the time.
- Integrity monitoring warning within 10 seconds.

X. Simulation Results

Simulations are carried out on implementation of different techniques and obtained results for them in MATLAB.

In MATLAB simulation are done for different techniques those are Electronic Navigation and Satellite Navigation.

The navigation techniques from the far field is observed by taking different plane of axis, as taking reference of electric and magnetic field. This figure describes the magnetic field of line source excitation.

The figure gives us information about the signal variation with according magnetic field.

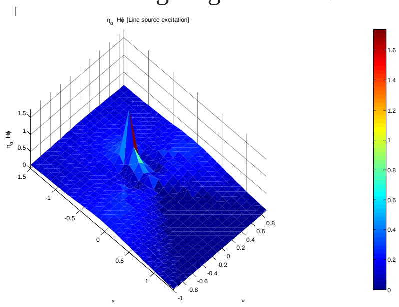

Fig.10. Signal variation in accordance with magnetic field.

This figure demonstrates the Ez plane of far field, of radiation pattern with the simulation of the matlab

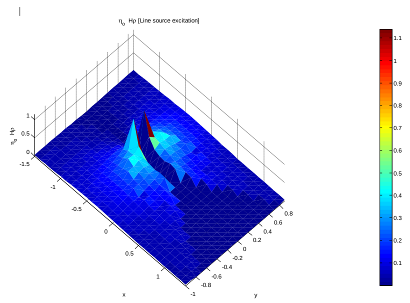

Fig.11. Ez plane of far field,of radiation pattern

The plane wave excitation is observed in magnetic field from the near field of matlab simulation of the electronic and satellite navigation.

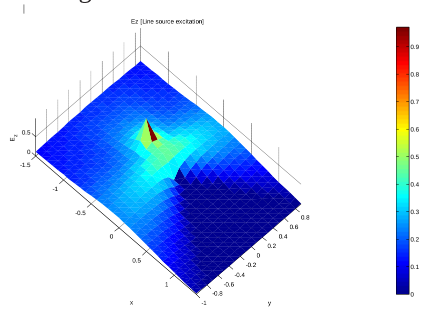

Fig.12. The plane wave excitation is observed in magnetic field from the near field

The simulation of radiation pattern from the near field is observed in accordance with magnetic field of plane wave excitation.

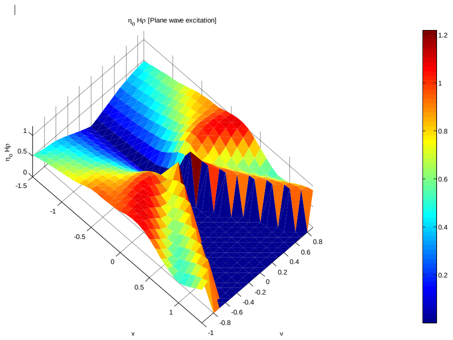

Fig.13. radiation pattern from the near field in accordance with magnetic field of plane wave excitation.

The simulation results of the navigation radiation pattern of electrical field of near field ,plane wave excitation.

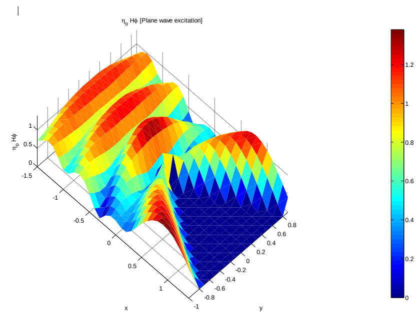

Fig.14. navigation radiation pattern of electrical field of near field ,plane wave excitation

The simulation results of the navigation radiation pattern of electrical field of far field ,plane wave excitation.

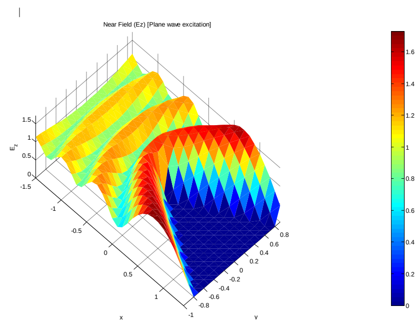

Fig.15. navigation radiation pattern of electrical field of far field, plane wave excitation.

Acknowledgment

The author likes to thank his parents and sister for giving financial support in publishing this paper

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