GPS Receiver

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ABSTRACT

The Global Positioning System is widely used. Here we propose a simpler method which helps in better receiver design. We achieve better accuracy in measurement of position and speed.

1.0 INTRODUCTION

The Global Positioning System (GPS) is operational for civilian users since December 1993[1]. Twenty years have passed, the basic principle for measuring Vehicular position and speed has remained unchanged. Recently, there is an investigation on Optimum detection of signal under noise. Here, the author proposes a spread spectrum based receiver with higher noise immunity in carrier recovery, as well as, in demodulation.

We use a method of double integration of received signal. Once as we transmit differentially encoded signal and second time as we send spread spectrum signal coded with Manchester code.

2.0 THE MATHEMATICS BEHIND THE GPS

Normal global positioning system uses transmitted signal from the handset to three satellites (geo-synchronous and their locations are known) at three different frequencies and receive the retransmitted signals back to the transmitter with three different delays. The receiver measures the delays and calculates the distances. Then it finds the location of the hand set at the cross point of the spheres drawn from the locations of satellites as their centers. It requires number of frequency bands equal to the number of satellites and hence in the receiver we need that many PLLs to lock and find the delays. Moreover we need satellites to respond to the need of individual handset. This method will fail to respond if many users try to get their locations simultaneously. In our case we need four frequency bands, one from handset to base station and others from satellites to handset. Here we get the starting point from base station (BS). The BS gets the starting point from the satellite and because its location is known to itself. The main base station (MBS) transmits to the three satellites and three satellites retransmit the signal to earth (MBS is at the center of equilateral triangle with satellites at the vertex at a height, x) all the time. Also we get the amplitudes and the delays from satellites to handset using three PLLs and three synchronizers.

2.1 PROPOSED MODEL

The previous paragraph explains the basic operation of synchronized transmission from satellites in three bands and a band of frequency to transmit from MBS to satellites. All the satellites and MBSs are synchronized. Here we try to design the receiver for stationary and moving handset.

2.2 RECEIVED SIGNAL FOR STATIONARY HANDSET

The received signals will be

$$x_{r1}(t) = a_1 a(t - T_1) cos(w_{c1} t + \theta_1) + N_1$$

$$x_{r2}(t) = a_2 a(t - T_2) cos(w_{c2} t + \theta_2) + N_2$$

$$x_{r3}(t) = a_3 a(t - T_3) cos(w_{c3} t + \theta_3) + N_3$$

where, a(t) is a pseudo random number (PRN); a1, a2 and a3 are their amplitudes; wc1, wc2, wc3 are three carriers with phases and N1, N2, N3 are AWGN noise. After mixer and LPF we get the signal,

$$x_r(t) = 0.5 * a_1 a(t - T_1) + noise$$

and so on. We recover the carrier and the Tc clock using PLL-DPLL circuit. Then we synchronized the PRN sequence and integrate the signal. This is the way we get the delay times and amplitudes.

2.3 RECEIVED SIGNAL FOR MOVING HANDSET

For moving handset, the received signals will be

$$x_{r1}'(t) = a_1 a'(t - T_1) cos(w_{c1} t + w_{n1} t + \theta_1) + N_1$$

$$x_{r2}(t) = a_2 a'(t - T_2) cos(w_{c2} t + w_{n2} t + \theta_2) + N_2$$

$$x_{r3}(t) = a_3 a'(t - T_3) cos(w_{c3} t + w_{n3} t + \theta_3) + N_3$$

Where, w_{n1}, w_{n2}, w_{n3} are their Doppler frequencies due to their respective velocity components. After mixer and LPF we get the signal

$$x_r(t) = 0.5 * a_1 a'(t - T_1) + noise$$

and so on. Here a'(t-T_n) is for data shrinkage. We use three different Phase locked loops for locking to different carrier frequencies and recover the data clocks which is shrunk automatically.

We know the velocity of the vehicle and from rough idea of location. Hence we know the velocity components in the satellites' direction. So the correction will be v_n*□t/c, where c is the speed of light. Thus after few iterations we find the actual location and also the velocity components.

3.0 THE SCHEMATIC DIAGRAM FOR PROPOSED GPS

The schematic diagram is given in Figure 1.

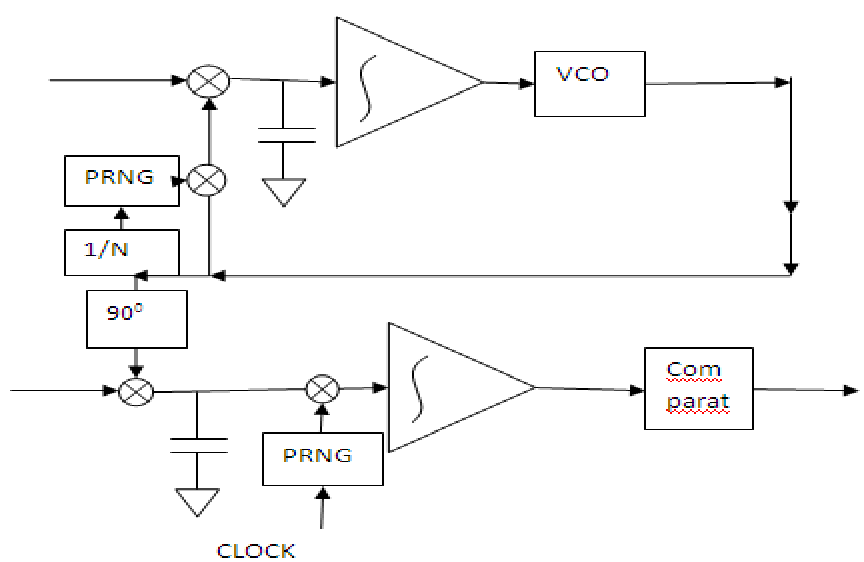

Figure 1. The receiver for Global Positioning System. We also can use Hadamard Code.

Here we recover the carriers and the data clocks using three PLL circuits. These carrier plus the velocity dependent frequencies are used to demodulate the signals. The data clock is used to synchronize and generate the Hadamard sequence also an additional square wave. Then we get the distance from time delay and the attenuation. Also we demodulate the Hadamard coded sequence to get additional information.

4.0 THE RECEIVER CIRCUIT FOR PROPOSED GPS

The operation of phase locked loop and data recovery phase locked loop together is known [2][3]. Following the demodulation we integrate the signal which gets rid of the higher frequency terms. If the noise in demodulated signal is AWGN then its PSD No/2 and the integrator has a response of 1/jw. So the output of the integrator will have a PSD of $1/w^2$. And the variance will be a integration of that. Hence,

$$S_{yN}(w) = 1/w^2$$

and

$$\sigma^2 = R(0) = \int_{10}^{\infty} \frac{1}{w^2} e^{jw\tau} dw$$

We put a zero at 10 Hz and take the integration over 10Hz to infinity and get No/10 (-10dB) as the variance of the output of integrator.

We correlate the output of the high pass filter and integrate it after high pass filtering it. Hence the noise variance reduces by 35dB ($1/3w_o^3$, where w_o is corner frequency of HPF) if we reject 0 to 10 Hz by high pass filter.

Here we achieve a SNR improvement of 35 dB for differential encoding in addition to the processing gain associated to PRN of length N. In the differential encoding the bits are chip(n)-chip(n-1) where they are after the chips are modulated by bit sequence. The bits are Manchester coded. For synchronization we use a additional signal with T_b duration.

CONCLUSION

Here a modification in GPS system is made in system level so that a communication is possible to the handset from the satellites as well as finding the location. The differential encoding of chip sequence made the communication possible at greater distance. The next step will be to use magnetic resonance antenna at the handset.

REFERENCES

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[2]. R.E. Ziemer and W. H. Tranter, “Principle of Communications Systems Modulation and Noise,” 5th Edn., John Wiley & Sons
[3]. F.M. Gardner, “Phaselock Techniques,” 2nd Edn., John Wiley & Sons