International Journal For Technological Research In Engineering
Volume 3, Issue 3, November-2014 ISSN (Online): 2347 - 4718

AN ITERATIVE APPROACH TO IMPROVE GNSS SIGNAL OBSERVABILITY

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ABSTRACT: Signal Quality Monitoring (SQM) in GNSS is about monitoring the signal deformation. There are many sources of error which affects waveforms of satellite navigation, i.e. multipath, thermal noise etc. These sources of error are generally called noise. Even if these type of noise do not affect the signals, then also received signal is somewhat corrupted because of hardware at transmitter and receiver side. Signal quality monitoring in satellite navigation is generally performed by High gain antenna. If we use Survey grade antenna then because of its Low gain, signal waveforms are more corrupted with noise. So signal quality monitoring become improper. If we want proper signal quality monitoring then we have to go for either high gain antenna or appropriate signal processing techniques. This paper describes a new approach to enhance observability based on signal processing named as 'Iterative approach'. This paper presents how this technique reduces the noise allowing better signal quality monitoring by using survey grade antenna. Result clearly shows reduction in the noise floor with the help of iterative approach.
Index terms: GNSS, Signal Quality Monitoring, noise, Signal Processing, MATLAB.

I. INTRODUCTION

Global Navigation Satellite System (GNSS) is a satellite system that allows small electronic receivers to determine their location (longitude, latitude, and altitude) to high precision (within a few meters) using time signals transmitted along a line of sight by radio from satellites. At satellite side digital data is first modulated so that data can be easily transmitted from satellite to the receiver on the earth. Each satellite transmits coded signals at precise intervals. At receiver side we demodulate the navigation data and recover the signal information into position, velocity, and time estimates. GNSS satellites operate at geo stationary and medium earth orbit. When using a survey grade traditional antenna, the received signal at a ground based navigation receiver is obscured by noise such as thermal noise and multipath. Although several error sources obscure the receiver's measurements and are problematic to mitigate (e.g., thermal noise and multipath), for high performance applications it is critical that any signal structure deviation from ideal be quantified to establish error budgets and also enable detection of minor distortions of the underlying structure from satellite-induced hardware errors. GNSS signal observation is becoming predominantly important because it will warn the operators in case the position error exceeds a predefined threshold. A valid way to examine and test the signal structure is to use a high gain antenna and perform measurements. An alternate approach is to use the conventional antennas and receiver hardware and implement a signal processing technique which allows for improving the signal observability.

A. Related work done

Many studies have been made on GNSS signal deformation monitoring. A paper is published on enhancing observability of GNSS signal. In which they have used sampling strategy named dithered sampling. The dithered sampling frequency allows for a high resolution of the time domain signal in post processing. Considering repetitive signals, it is possible to superimpose the samples of several epochs and obtain a resulting period represented by an increased number of samples [3].A very interesting set of papers have been published by Stanford University, mostly focusing on the time deformation of the signal [4].

B. Proposed work

In this paper we have proposed Iterative approach and successfully reduce the noise, so that we can improve the GNSS signal observability.

C. Organization of rest of the paper

In section II iterative approach is explained in brief. In section III we have discussed the measurement results as well simulation results we have derived through the Iterative approach. Section IV concludes the paper.

II. ITERATIVE APPROACH FOR QUALITY MONITORING

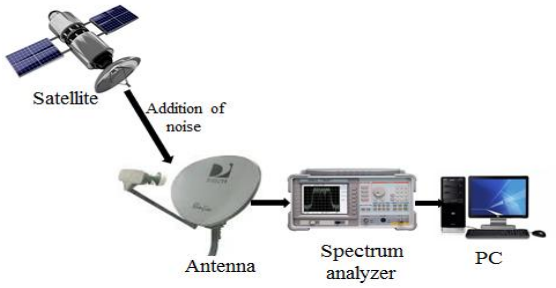

Fig. 1 General block diagram of system used to acquire the data.

This section describes an iterative approach for reduction of noise. GNSS data is sent from satellite and received in antenna on the earth. General block diagram of system used to collect data is shown in fig.1.Noise such as multipath and thermal noise is added in the transmission path. Due to the addition of noise, transmitted data becomes corrupted from its original shape when we receive it.

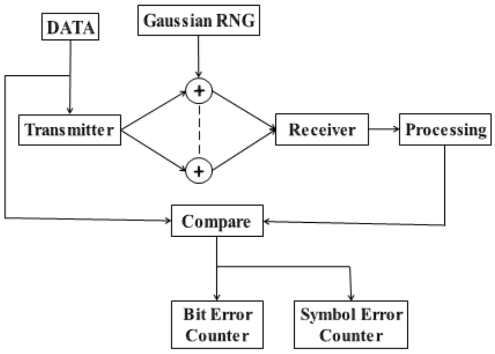

Fig. 2 Block diagram of an iterative approach for simulation

Addition of noise in transmitted data is a random process, means amount of noise added in data is different at every point. Idea behind iterative approach is that, if same data is transmitted many times then the noise corrupts data every time but amount of corruption in each turn is not same at every point. Simply speaking if in one transmission, noise corrupt some portion of the transmitted data then there is strong possibility that in another transmission, noise does not affect that portion in same manner. Fig 2 represents block diagram of an iterative approach for simulation. In iterative approach we are transmitting same data many times and receiving it, processing on it and stores it.

III. RESULTS

A. Measurement result

In the observation of Quality of signal, C/N0is an important factor. C/N0is career to noise power of signal per hertz bandwidth.

C/N0 = EIRP + Path loss + G/T – k

Where,

1) EIRP = Effective isotropic radiated power of satellite;

2) Path loss = $(\lambda / 4 \Pi R)^2$, R = Distance from satellite, λ = wavelength;

3) Antenna Gain (G) = $\eta \times (\Pi d / \lambda)^2$, η = Efficiency of antenna, d = Diameter of antenna;

4) Antenna Temperature (T) = A parameter that describes how much noise anantenna produce in given environment;

5) k = Boltzmann constant (1.3806 x 10-23J K-1);

In above equation all parameters except antenna gain are constant. Antenna gain is proportional to square of diameter of the antenna. So C/N0is directly proportional to square of diameter of the receiving antenna.Larger the diameter of the antenna, higher the C/N0of receiving signal and vice versa.

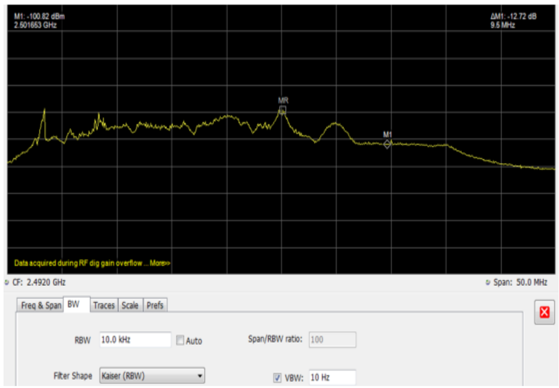

Fig. 3 Spectral plot of 1m antenna

Some spectral plots of satellite signal from different satellite with different diameter of antenna are taken from spectrum analyzer and shown here. Fig. 3 shows spectral plot of 1m diameter receiver antenna, which has difference between career power and Noise floor power is 12.72 dB.

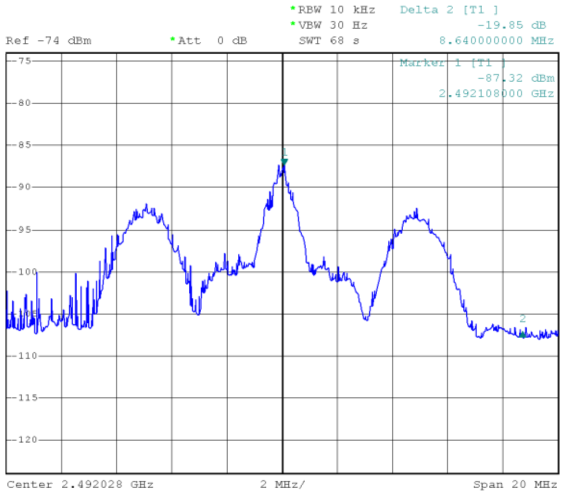

Fig. 4 Spectral plot of 3.8m antenna

Fig. 4 shows spectral plot of 3.8m diameter receiver antenna, which has difference between career power and Noise floor power is 19.85 dB..Higher the difference in power, better the quality of signal and vice versa. From given plots we can clearly see that difference in power of signal increases with increase in diameter. We can increase C/N0 by either improvingcareer power (C) or reducing noise floor (N0) of the signal. We have seen the first option now we will see the second option by simulation results.

B. Simulation result

In this section we are discussing the results we got by the simulation in MATLAB. For finding out the effectiveness of iterative approach we have to test it with known data. So we have generated sequence of symbol having two bits each randomly. Then we are adding the Gaussian noise with some mean and standard deviation so that it can corrupt the original data sources. By changing value of mean we can change the amount of added noise. Here we have shown some results with different values of mean.

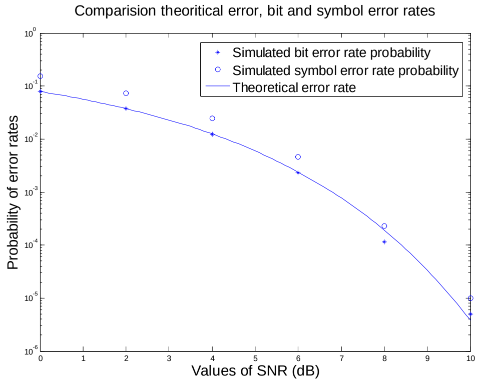

Fig. 5 Simulation results for normal receiving with noise added to the signal having mean=0

Fig. 5 shows normal receiving with noise added to the signal having mean=0. Probability error rates of Bit and symbol are almost same to the theoretical error because noise is of very low value.

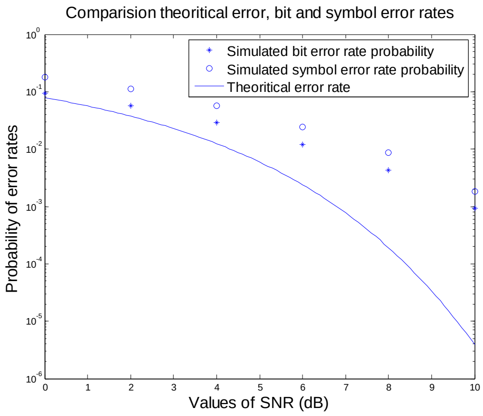

Fig. 6 Simulation results for normal receiving with noise added to the signal having mean=0.2

Fig. 6shows normal receiving with noise added to the signal having mean=0.2. Here we have added higher value of noise. Probability error rates of Bit and symbol are above than theoretical error. Fig. 7 shows reduction in probability error rates of bit and symbol near to the theoretical error by using iterative approach having 3 iterations.

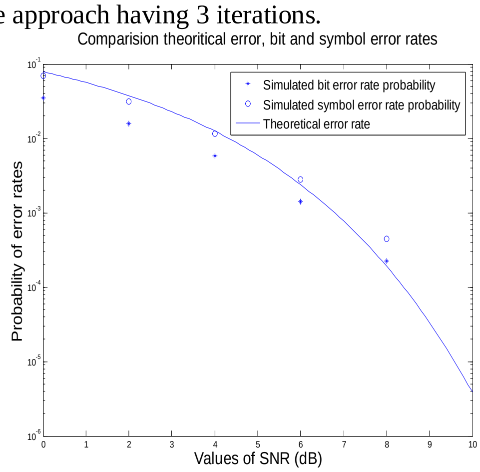

Fig. 7 Simulation results for 3 iterations with noise added to the signal having mean=0.2

IV. CONCLUSION

In this paper, we have proposed and analyzed technique named ‘Iterative approach’ in order to increase C/N0.To increase C/N0either we have to increase C or reduce N0. From results we can see that we have reduced amount of noise. With reduction in amount of noise, C/N0increases. As we know that C/N0is an important factor in signal quality monitoring, so by increasing C/N0we have improved quality monitoring of signal in GNSS.

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