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Signal-To-Noise-Ratio of Signal Acquisition In Global Navigation Satellite System Receiver

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Abstract:
This paper presents a measurement of signal-to noise ratio (SNR) for some global navigation systems, and making a comparison between such ratios. This ratio is an important measure to the quality of the signal as SNR increases the quality increases and vice versa. A new ratio is developed here, that is (noise to signal ration)NSR, it is found that as the value of NSR increases the quality decreases. The effects of both bit time and bit error rate on both SNR and NSR is studied. Both bit time and bit error rate effects on SNR, as such quantities increases SNR decreases.
Keywords: signal-to-noise ratio, global navigation system, signal acquisition.

1. Introduction

Signal to noise ratio is an important quantity that defines the quality of the communication system and networks. As the noise to signal ratio increases the quality decreases which makes weak signal acquisition, and long-time issue in radio astronomy. Increasing the sensitivity of the acquisition of weak signals is a critical problem. Receivers use the squares of the real and imaginary components in the detection process, but the convenience of using the absolute values of the real and imaginary components suggests an analysis to evaluate if increased sensitivity (lower probability of false positive) for weak signal acquisition results. Hereafter, a weak signal is considered to be considered as sinusoidal signal with amplitude from one to five times the noise levels, [1,2,3].
Such signal to noise effects appears in many applications like Global Navigation Satellite Systems (GNSS) which cannot always be relied upon, particularly indoors or in challenging signal environments. This situation affects signal acquisition more than the tracking process, as it is relatively less immune to the received noise and interference. [3,4,5].

Luke W. et al. 2004, investigated NASA Goddard Space Flight Center (GSFC) which is developing a new space-borne GPS receiver that can operate effectively in the full range of Earth orbiting missions from Low Earth Orbit (LEO) to geostationary and beyond. Navigator is designed to be a fully space flight qualified GPS receiver optimized for fast signal acquisition and weak signal tracking. The fast acquisition capabilities provide exceptional time to first fix performance (TTFF) with no a priori receiver state or GPS almanac information, even in the presence of high Doppler shifts present in LEO (or near perigee in highly eccentric orbits). The fast acquisition capability also makes it feasible to implement extended correlation intervals and therefore significantly reduce Navigator’s acquisition threshold. This greatly improves GPS observability when the receiver is above the GPS constellation (and satellites must be tracked from the opposite side of the Earth) by providing at least 10 dB of increased acquisition sensitivity. Fast acquisition and weak signal tracking algorithms have been implemented and validated on a hardware development board.[1].

Grace X.,2009, two test satellites of the European Galileo and one satellite from the Chinese Compass have been launched. The new satellites and new signals create a great opportunity for GNSS receivers to gain more redundancy and accuracy. On the other hand, the new GNSS signals could interfere with each other since their frequency bands overlap. Moreover, when the satellites were put into orbit, the signal specifications were not available to the public. This mystery made it impossible for GNSS receivers to acquire and track the new satellites. It was also impossible to analyze the interference among GNSS satellites. Thus, there was an urgent and great need for discovering the unknown signal characteristics. The contribution of this work is to design algorithms for deciphering all the new test satellite signals from the Galileo and Compass satellite programs. He reveal the spread spectrum codes for all the signals on the prototype satellites listed above. In addition, the writer also derived the underlying code generators based on a modification of the Berlekamp-Massey algorithm for solving systems of equations over finite fields. [2]

Faisal A. et al. 2011, proposed four algorithms that offer improved signal acquisition in challenging situations and evaluates the performance of these algorithms in detail using real Locata signals. First, appreciating the complexity involved in the non-coherent acquisition of Locata signals, an algorithm is presented that exploits the inherent characteristics of the Locata gating sequence and offers receiver sensitivity improvement of around 1.3dB each time the integration duration is doubled. A concept of assisted acquisition is then introduced. It is shown that acquisition of any one signal can assist acquisition of the rest allowing reduction in mean acquisition time (MAT) and computational load and offering a further improvement of 1.7dB over previous algorithms. Next the use of long replica codes is suggested so as to allow for coherent integration. It is shown that this offers comparable sensitivity improvement and doesn't require any assistance. Finally an integrated scheme is described that employs the above-mentioned algorithms, and offers a signal acquisition approach better than the conventional one. [5].

This paper constructs a formula to measure both the signal-to noise and noise –to -signal rations and studied the effects of bit error rate and bit time in signal systems on them.

2. Signal-to noise ratio

Calculating signal to noise ratio (SNR) is very important to determine the signal quality in any communication, signal acquisition, and any network signal systems, the following formulas are applied to determine SNR or C/N0:

$$P_e = 0.5\, erfc\left(\sqrt{SNR.T_b}\right) \quad (1)$$

where: P_e: is the theoretical probability of bit error, T_b: is the bits time, and

$$erfc(x) = 1.128 * \int_{t=x}^{\infty} e^{-t^2}\, dt \quad (2)$$

Depending on calculus relations (Silverman R. , 1985, pp:430-431) SNR can be written as:

$$SNR = -\frac{1}{T_b}\ln\left(\frac{P_e}{0.5}\right) \quad (3)$$

3.Results and discussion

The value of both SNR and NSR is calculated. The performance metric is the Bit-error-rate, BER or Pe, which will be estimated by as a theoretical probability of bit error Pe. On the GPS L1 frequency, data is transmitted at a rate of 50bits/second (Tb = 20ms) and the C/A chipping rate is 1.023 MHz with a period of 1023 chips. The period of the pre-detection integration is assumed to be equal to the period of the code (TS = 1ms). Pe for the normal demodulation, Pe is given by: $P_e = 0.5\, erfc\left(\sqrt{SNR.T_b}\right)$, where $erfc(x) = 1.128 * \int_{t=x}^{\infty} e^{-t^2}\, dt$.

So by applying last data for some system and assuming the following data for the suggested system:

Case 1: Take Tb is constant as (20 ms) and Pe has the following values: Pe={0.05, 0.1 0.2 0.3 0.35, 0.4, 0.45, 0.5}, then figure (1) represents the relation between SNR and theoretical probability of bit error, or bit-error-rate, Pe. It can be noticed that as the bit-error-rate increases the SNR decreases.

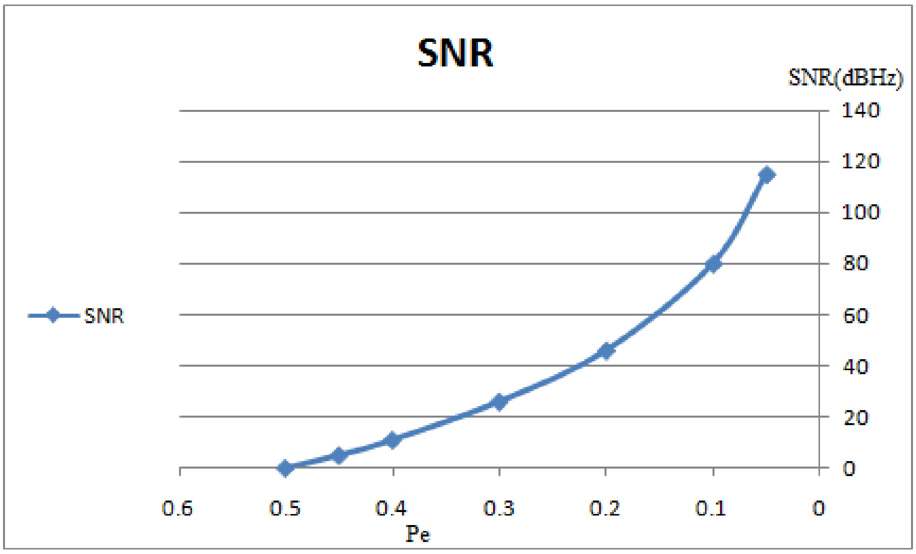

Figure (1) SNR as a relation with bit error rate.

Case 2: Take Pe as constant value at 0.1, and Tb={20, 40, 60, 80, 100, 200, 1000, 2000} ms, the relation between SNR and Tb is represented in figure 2.

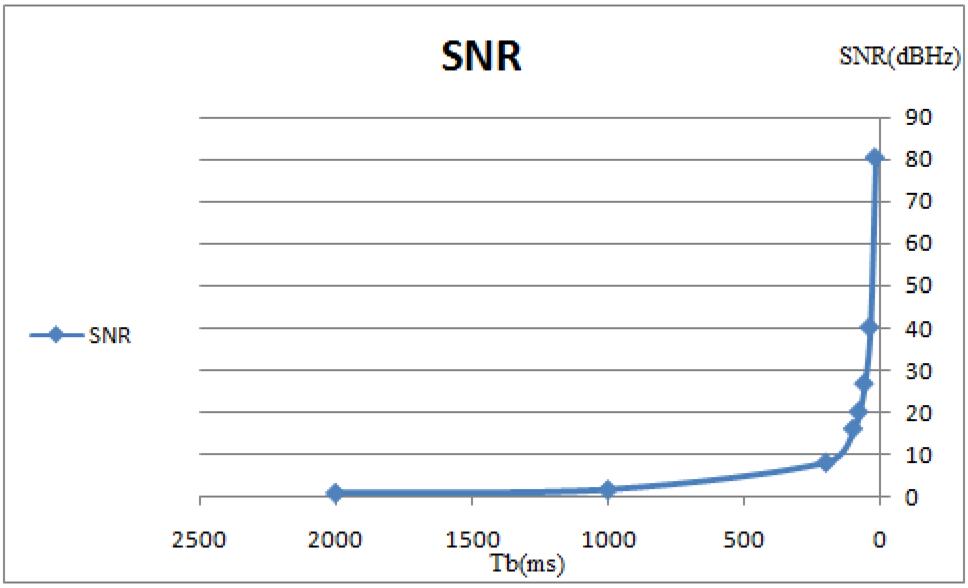

Figure (2) SNR vs. bit time.

Also a new value can be derived here represent what is called noise to signal ration, NSR which can be defined as the inverse of the SNR, figure (3) to (4) represents the NSR as a function of both bit-error-rate, Pe, and bit time, Tb.

Figure 3 and 4 show the relation between the NSR with both bit-error-ratio and bit time it is clear that NSR increases as both Pe and Tb increase.

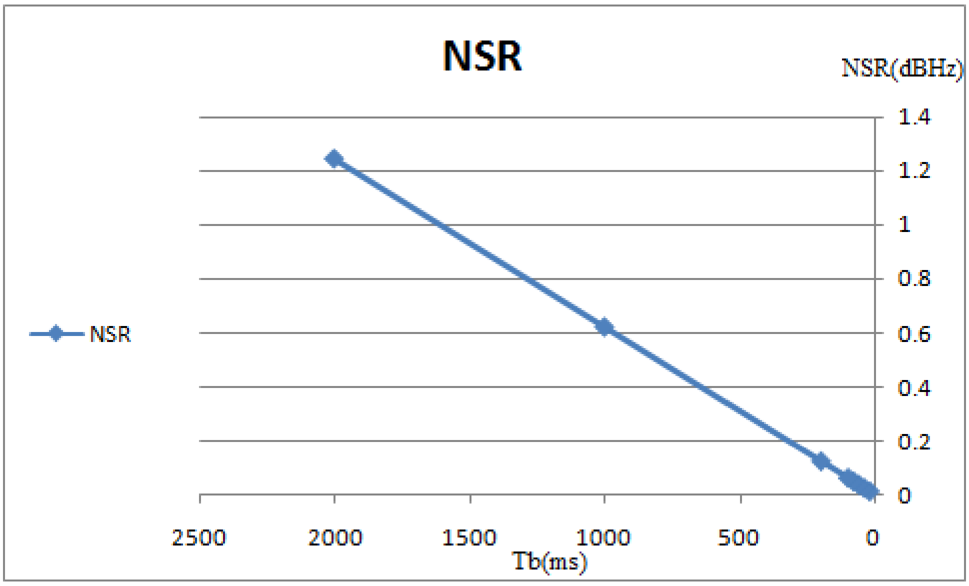

Figure (3) NSR vs. Tb

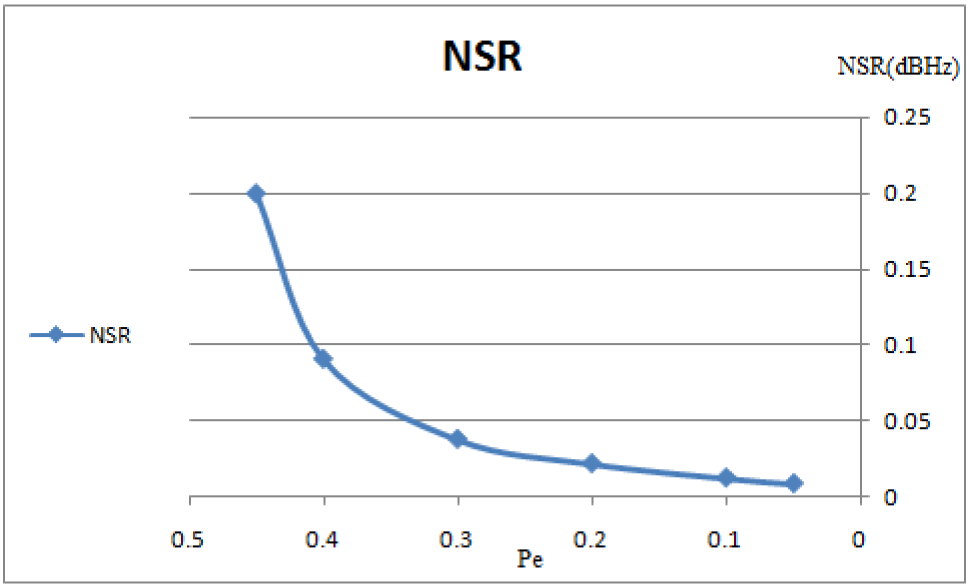

Figure (4) NSR vs. Pe.

4. Conclusions

It is clear that the quality of signals in any communication or networks systems depends mainly on both bit time and bit error ratio. Both values SNR and NSR are a measure for the performance of the signal systems.

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