TELECOMMAND SIGNAL INTEGRITY ENHANCEMENT VIA SPECTRAL MINIMAL VARIANCE IN SOFTWARE DEFINED RADIO SYSTEMS

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***Abstract*:**

This paper primary focus is on using software defined radio to design and create an energy-efficient telecommand subsystem. One of the main issues when implementing a telecommand subsystem is energy optimization. Numerous algorithms and optimization strategies have been used to optimize energy, but none of them have been able to achieve the needed level of performance. Spectral Minimal Variance Method using Different Window approach is an optimization approach that we will employ in conjunction with Software Defined Radio (SDR) in this implementation. In addition to reaching the intended level, the approach works well in various SNR settings. The Bit-Error Rate (BER) and Signal to Noise Ratio (SNR) will be used to validate the method's effectiveness. This paper main objective is to design and develop an energy-efficient software-defined radio-based telecommand subsystem. Energy optimization is a major concern when putting a telecommand subsystem into place. Energy efficiency has been increased using a variety of algorithms and optimization techniques, but none of them have been able to reach the required level. Therefore, in order to optimize this approach, we will combine the Spectral Covariance Method using Different Window Technique with Software Defined Radio (SDR). The method will outperform different SNR settings in addition to achieving the desired level. The Bit-Error Rate (BER) and Signal to Noise Ratio (SNR) are used to confirm the method's efficacy.

Keywords: Tele Command Subsystem (TCSS), Energy Efficient, Software Defined Radio (SDR), Bit-Error Rate (BER) and Signal to Noise Ratio (SNR).

1. INTRODUCTION

Software Defined Radio (SDR) devices have significantly improved communication networks by cutting down on the time and expense of developing radio frequency (RF) solutions. Programmers were given access to Software Defined Radio, which allowed them to expand the capabilities of these readily manipulable systems. A radio communication platform called Software Defined Radio (SDR) uses software in an embedded system to enable more computing power. Several hardware components in conventional goods are fundamentally replaced by software functions and protocols found in embedded systems. Historically, software-defined radio, or SDR, has been employed in many different terrestrial applications. However, SDRs have progressively gained traction in the space industry due to the growing need for high processing power on-board satellites and space equipment. Since the advent of high-throughput satellites (HTS) in the last ten years, the upstream satellite business has experienced significant changes. Non-Geostationary Satellite Orbit (NGSO) satellite operators are starting to use HTS systems more widely, even though many Geostationary Earth Orbit (GEO) satellite operators have historically used them. This is especially true as Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) applications are fueling new expansion in the sector. The high processing power needed for improved transmission and signal reception in the form of data and bandwidth requirements is one of the most crucial elements of HTS systems. The significant acceleration provided by Software Defined Radio platforms is very helpful to systems such as HTS, ultimately increasing the processing capacity of the satellites. Ground-space communication systems, on-orbit servicing, and satellite-satellite communication are just a few of the space industry's numerous applications for SDRs. For example, in response to the growing need for more processing power, Earth Observation (EO) and communication satellites are increasingly utilizing Software Defined Radio technology.

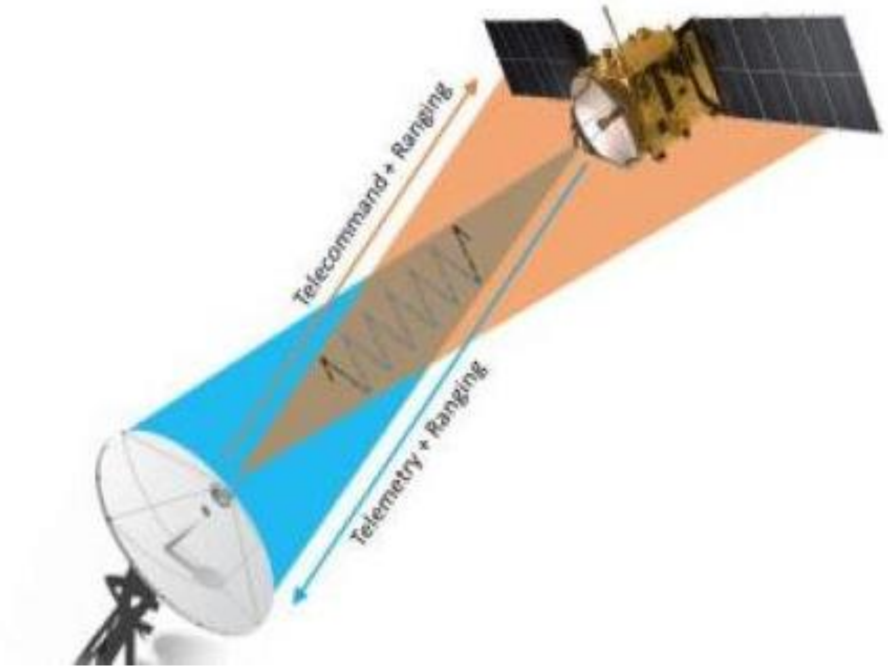

Figure 1: Software Defined Radios (SDRs) for Satellite Subsystem

2. LITERATURE REVIEW

Augustus Ehiremen Ibhaze al in [1], have talked about creating new communication technologies to overcome RF communication systems' shortcomings. An appropriate energy-efficiency plan aids in preventing unnecessary energy use in wireless communication. Selecting the most energy-efficient equipment to reduce energy costs and reduce the energy consumption of particular network elements without compromising their distinctive features is made easier by choosing the best energy-efficiency plan.

L.-X. Jiang al in [2], have outlined a design project for microsatellite on-board computers that includes a parallel system and spare system in accordance with the strict specifications for dependability and real-time performance. The design project's reliability is modeled and computed using Markov chains and computer system reliability theory.

Joseph N. Pelton al in [3], have developing new systems or capabilities that might complete important technical tasks or provide services with a tolerable level of dependability and proficiency while operating within more constrained mass, volume, and, frequently, cost constraints has been the main and continuous challenge of small satellites.

QinetiQ al in [4], have examined the assessment of software-defined radio. One major factor contributing to the received deteriorated signals in wireless communication is channel fading. Several temporal and space domain strategies can be used to reduce the impact of fading. However, because of their benefits, space domain approaches are chosen above the others.

3. PROPOSED METHODOLOGY FOR SOFTWARE DEFINED RADIO USING SATELLITE SUBSYSTEM BY SPECTRAL MINIMAL VARIANCE OPTIMIZATION

The implementation of Cognitive Radio necessitates a variety of arrangements, including hardware, software, and network interface ports; as a result, the combination of these arrangements is referred to as software define radio, or SDR. Conventional communication technology, such as manual analog operation, has limited usefulness. In order to comprehend the requirements of parameter changes, an advanced set of arrangements that can function over a broad frequency range (about 2-3 MHz range and above) was introduced, leading to the creation of SDR. In this case, it is evident that the SDR uses software to convey the execution. As a result, the OSI model is essential to spectrum sensing since it allows for physical implementation through terminal interfaces via physical layers, data connection layers, and some network layers. Software Defined Radio doesn't work with any other layers save these three. When building a bridge for the real-time interface of an existing signal for spectrum sensing, these three layers are quite helpful. It offers incredibly clever flexibility in controlling and executing the many properties of cognitive radio, allowing for the necessary modification of operating frequency, current power, signal modulation, and available bandwidth. Software Defined Radio provides a flexible form of radio characteristics to circumvent the need for intricate analog equipment. The cognitive radio is essentially a Software Defined Radio that can automatically rearrange itself and is clever enough to understand the state of its surroundings.

Our motto is to improve the spectrum sensing technique's performance. When the windows are chosen properly, it may be measured more precisely. The many windows that are appropriate for our investigation are explained in this section. Only the intended output features will satisfy our expectations if we use the appropriate windows approach during CR analysis. Windows are crucial to spectral analysis because they include zero values outside of any band and determine the time period for any band-limited signal. Many window functions are being used to simulate signal analysis for various features in order to produce the desired output. However, due to performance constraints in cognitive radio environments, it is typically not viable to allow all windows for spectrum analysis. A select few of the windows have been selected to assess our performance.

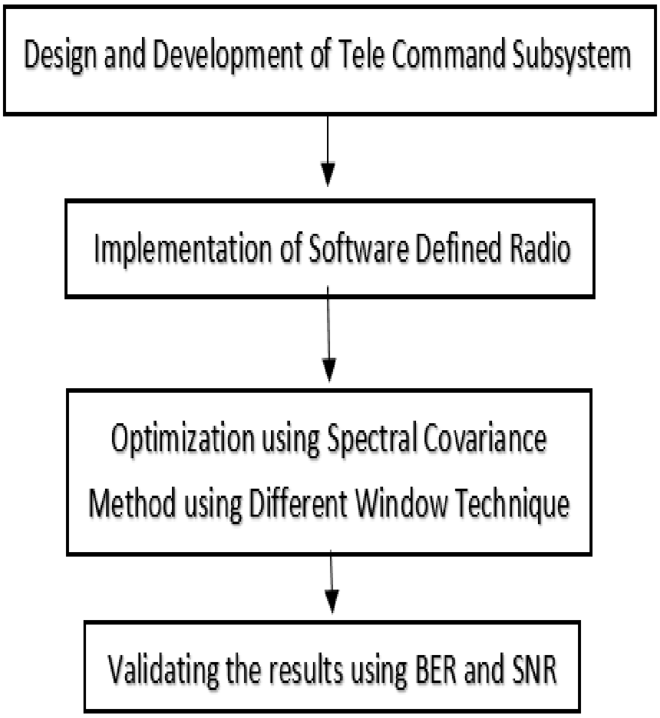

Figure.2: Flow of Proposed Method

Assuming that either one or no primary transmitter is accessible for detection, a secondary node could be located anywhere from the inner corner to the outer corner of the primary cell position. Under the two categories of hypotheses listed below, the assumption output problem can then be resolved by evaluation based on binary outcomes, such as zero or one:

$$H0: z(n) = w(n),$$
$$H1: z(n) = s(n) + w(n)$$

In order to determine the spectrum sensing result based on parameter comparison, the equation indicates hypothesis testing. Whereas s(n) is just a signal component that was received as samples, and w(n) indicates the noise component present in the received signal, z(n) in the above represents any baseband signal. For convenience, each stage's associated whole description section has been summarized here with the appropriate mathematical expression: The available received signal s(t) must first be down-converted to the appropriate baseband signal component in the very first step.

$$y(t) = x(t)e^{-j2\pi fct}$$

Following the first step, a Low Pass Filter (LPF) is used to down sample y(t) and pass low frequency components. By setting the sampling rate (1/Ts) appropriately, a z(n) sample function is produced [13,14]. Following that, a spectrogram will be used to define z(n). This is not immediately calculable. The short-time Fourier transform (STFT) is used to derive it as

$$Z\tau(k) = \frac{1}{\mathrm{N}}\left|\sum_{\mathrm{n}=0}^{\mathrm{N}-1} \mathrm{z}(\mathrm{n}+\tau\mathrm{N})\, \mathrm{e}^{-\mathrm{j}2\pi\mathrm{nk}/\mathrm{N}}\right|^2$$

The index of the sensing window is represented by $\tau \in \{0, 1, \ldots, Nd - 1\}$, while N displays the FFT points. In the same way, $k \in \{-N/2, \ldots, 0, \ldots, N/2 - 1\}$ represents the range of frequency index, while the term Nd indicates the number of sensing windows. It is now possible to count the correct DC value as a matrix of M with dimensions N*N.

$$M = \begin{bmatrix} Z_o(-K) & \cdots & Z_{Nd-1}(-K) \\ \vdots & \ddots & \vdots \\ Z_o(K) & \cdots & Z_{Nd-1}(K) \end{bmatrix}$$

The index for LPF with cut off frequency (Bf) of FFT is defined by K in the preceding matrix, which is K = [N・Bf/Fs]. A low pass filter, which describes the spectral features of the primary signal and lowers noise power, is the cause of this matrix's size decrease. By taking the covariance of matrix M, we can now obtain the sample covariance of that matrix.

$$\bar{C} = \mathrm{cov}(M)$$

It is now possible to generate the test statistic T = T1/T2, where T1 and T2 are the testing parameters that are compared to the threshold value to determine the simulation's result. The last step, where we compare T with decision threshold values to get various hypothesis findings. This test statistic is still being used to compare the output for the range of SNR versus decision accuracy, as well as the various windows utilized for analysis, such as the rectangular, hamming, and Hann windows. The analytical method ultimately reaches the highest decision accuracy in the intended output after a number of iterations. We are currently attempting to assess the effectiveness of the SCS-based spectrum sensing technique following this execution. For this, we're taking into account a percentage of roughly 0.7 and a false alert rate of roughly 0.001.The first output of this project, which must be determined by axial parameters, will be provided by the simulation result. The standard graphical representation of output one is shown below.

4. RESULTS & DISSCUSSION

The satellite subsystem's SNR optimization utilizing software-defined radio is depicted in Figure 3. The process of increasing a system's signal-to-noise ratio (SNR) is known as SNR optimization. Either boosting the signal strength or cutting down on noise can accomplish this. Telecommand subsystems can benefit from the usage of software-defined radio (SDR) devices to maximize signal-to-noise ratio (SNR). This may contribute to the system's increased efficiency.

The use of software-defined radio for satellite BER optimization is depicted in Figure 4. The technique of lowering the quantity of errors in data transmission is known as bit error rate (BER) optimization. Error correction codes, a robust modulation technique, or increased signal intensity can all help achieve this. The BER can be increased by applying channel coding techniques such redundant forward error correction codes, selecting a slow and robust modulation scheme or line coding scheme, and selecting a strong signal strength (unless this results in cross-talk and extra bit errors). By lowering the frequency of data transmission mistakes, bit error rate (BER) optimization of an energy-efficient telecommand subsystem employing software defined radio (SDR) enhances signal quality.

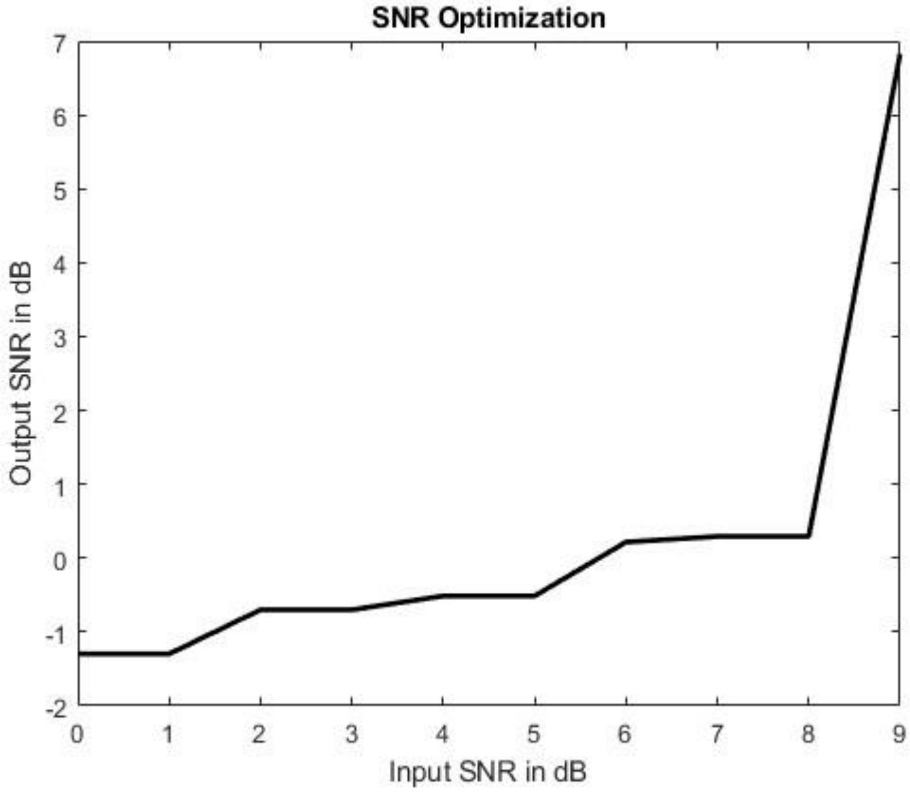

Figure.3: SNR Optimization of Satellite Subsystem using Software defined Radio

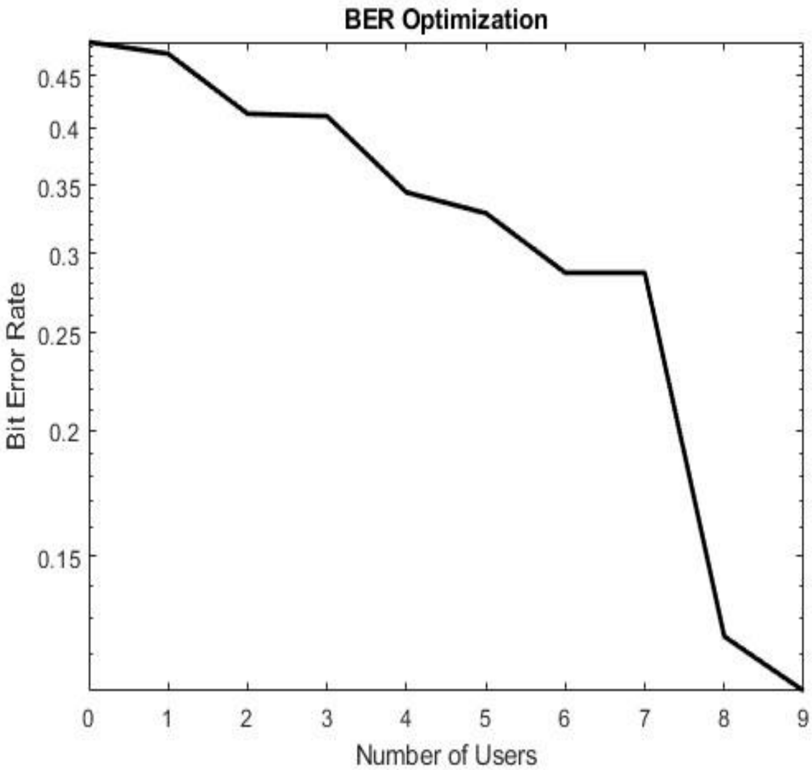

Figure.4: BER Optimization of Satellite Subsystem using Software defined Radio

5. CONCLUSION

This paper finally proposes the design of an energy-efficient telemetry and telecommand (TTC) subsystem and analyzes the subsystem's dependability using the Software Defined Radio scheme. We can finally say that, after implementing spectral covariance-based energy optimization for the TTCS subsystem, the energy optimization outperformed the current approaches. Even in conditions with low SNR, the implementation held up. Better Bit Error Rate (BER) and Signal to Noise Ratio (SNR) were achieved in the construction of the TTCS subsystem, which is energy optimized with windowing.

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