Discuss Modulation System Used In Satellite Communication

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**Introduction**

A modulation system can be defined as the fundamental technique in the telecommunication and signal processing sector basically tailored to ensure the relay of information to and from ground stations to satellites in the orbits (Donghong et al., 2020). The modulation technique involves varying characteristics of a carrier signal that is high-frequency waves intended to encode and transmit information (Donghong et al., 2020), such as voice, data, or video, over a communication channel.

The concept of modulation is particularly purposed to take a low-frequency information carrier signal, also known as baseband signal and superimpose it onto a higher-frequency carrier signal, making it suitable for efficient and reliable transmission over long distances or through various mediums like air, space, or cables ("Satellite communication system," 2020). Normally carrier signals utilizes radio frequency for transmission which usually have less information in itself. To add speech or data, another additional wave has to be superimposed on the initial carrier wave hence changing the shape of the carrier signal wave, hence the essence of modulation (Donghong et al., 2020).

The modulation technique involves manipulating various characteristics of a carrier signal, hence the choice of the modulation scheme is dependent on; the design of the satellite system, the bandwidth available and the of course the desired data rate (Kumar et al., 2019). In this paper, I aim to discuss various modulation technique and how they ensure satellite communication.

**Modulation System**

Here are some of the pivotal modulation schemes employed in ensuring satellite communication is achieved and how they are working: First and foremost, is the Basic modulation system; this scheme of modulation involves three typical techniques as indicate below.

Carrier Signal Frequency; The modulation system involving varying the signal frequency is known as Frequency Modulation (FM). The frequency modulation technique refers to the process of varying the carrier signal frequency with respect to the existing information signal. The variations in the frequency indicate the information being transmitted from source to recipient (Kumar et al., 2019).

Carrier Signal Amplitude; The modulation system involving manipulating the signal amplitude concerning the information signal is known as Amplitude Modulation. The resultant modulated signal always harbours the information signal in its varied amplitude (Kumar et al., 2019).

Carrier Signal Phase; The modulation process involving alteration of the carrier signal phase in response to the information signal is known as Phase Modulation. In this modulation technique, the alterations in the signal’s phase have in it the encoded data that represent the information (Ohkawa et al., 2019).This technique can be further divided into two main form; Phase-shift keying (PSK) and Offset Quadrature phase-shift keying. For the Phase-shift keying form the process involves keying method altering the phase of the carrier signal to assume different data points. This form of modulation employ two distinct strategies; Binary phase shift keying which utilizes two phase shifts that is 0 and 180 degrees for two-bit data while Quadrature phase shift keying utilizes the four phase shifts that is 0, 90,180 and 270 degrees for probable higher data rates transmission (Kumar et al., 2019).

Besides the Offset Quadrature phase shift keying is typically a varied form of the Quadrature phase shift keying involving reduction of the phase transitions between symbols, making it more stronger in the presence of noisy environment. Additionally, there exist 8-phase shift keying and 16-quadrature amplitude modulation technique (Ohkawa et al., 2019). These modulation technique involves encoding more bits per data symbol by employing eight or sixteen disparate phase respectively. These techniques actually provide higher rates of data however,very sensitive they are to noise and any form of inteference. Finally digital modulation system also deploy Adaptive modulation technique. In Adpative modulation technique, the scheme is dynamically manipulated depended on the link situation (Chen et al., 2021). This enables optimal data rate and error performance in varying the signal-to-noise ratios.

Orthogonal frequency-division multiplexing; this modulation scheme is stronger in face of narrowband interference. The scheme is also suitable for the dispersive low delay indoor channels (Ohkawa et al., 2019). The scheme is however, sensitive to phase noise particularly when utilizing higher order modulations like quadrature amplitude modulation or PSK. Additionally, the technique is also sensitive to frequency offset errors and nonlinearities in the form of carrier signal compression(Kumar et al., 2019).

**Interference and Error Correction**

Interference in the communication system environment is inevitable hence satellite communication system as well has to contend with it. To mitigate the challenge the below techniques are applicable.

Inteference Mitigation technique; Normally various Satellite communication system must deal with several sources of inteference (Hasan et al., 2017). Some of which include terrestrial signals and noise from the environment. It takes stronger modulation and effective error correction coding techniques to ensure mitigation of interference from the sorrounding during the modulation process. Sources of noise interference could be natural sources of radiation situated in the sorrounding of the reception area of antenna and noise originating from components in the receiving equipment (Hasan et al., 2017).

Error Correction Coding technique; Besides modulation technique deployed,various error corrections measures are employed in satellite communication system to ensure reliably and efficient transmission of the information from end to end. Some of the popularly deployed correction mechanism are Reed-Solomon codes and Turbo codes (Hasan et al., 2017). To achieve the error correction expectation, these codes instigate additional redundancy to the transmitted data, thus enabling the various receiver station to rectify errors initiated through transmission process (Hasan et al., 2017).

Linked Budget Analysis; During the satellite communication link design, a detailed link budget analysis is factored in. Normally, the following factors are considered;path loss, transmitter power, receiver sensitivity and antenna gain. This therefore informs the modulation technique to be utilized in order to achive a particular data rate while everything is kept within the link budget constraints ("Link budget design for integrated 5G-LEO communication applications," 2021).

**Conclusion**

With high demands of faster and quick data throughput, satellite communication utilizes high-order modulation schemes to attain improvement in spectral efficiency. Nonetheless, satellite channel impairments like delay and path losses may lead to serious problem in the satellite communication network. To curb the challenges, modulation techniques employed in the satellite communication, are typically designed and developed to enable optimal transmission of data over long distances in space.

As indicated, several factors and condition must be considered when designing and developing the modulation strategies to ensure proper spectral efficiency, noise and interference resilience is attained which in turn will enable reliable and efficient transmission and relay of information over the satellite communication system. It is also notable that the choice of modulation system is indeed critical aspect of satellite communication system design and also depend on the specific requirements of the mission and the frequency band used.

**References**

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