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Exploring the Potential of V-Band for Satellite Communications

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Abstract: The current development in the scientific field indicates the ability to use v band in satellite communication. "This enhancement will enable the capacity of communication in GEO satellite system to be settled than before. During the last years, researches in geostationary telecommunication satellite systems had focused on the ability of satellite coverage for a wide area within broad banding context. This view had been changed under current investigations. Extended geostationary views in satellites had been challenged to remain able in the competitive context. This was due to its capacity, costs and supported services. The current situation showed its limited capacity, availability, flexibility, and inability to guarantee the required quality of service efficiently. These limitations expected to be resulted from the effects of radio-wave broadcast in atmospheric last layer. Lastly, "the attenuation and scintillation effects of atmospheric gas, clouds and rain become more severe by increasing the operating frequency.

Keywords: Rain Attenuation-Band Satellite Communication System, Fade Duration.

1. INTRODUCTION

There was a rapid development in GEO satellite systems round the world between 1970s and 1980s. This expansion cause a noticeable enhancement in telephone traffic and video distributions. The first band introduced in satellite communication system was C band. However, the demand for satellite system had been grew up to occupy C band spectrum mainly, but this development was accompanied with a leading to expansion to Ku band. This ensures rapid growth in video distribution, which enabled the fulfilment of Ku band. Another band named Ka-band in satellite system was required in order to contain the spreading out in

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digital traffic, particularly in the distribution of wide band that requires a high speed of internet in order to improve the communication capacity.

Multi-beam coverage is the first technique that should be considered when we intend to investigate the capacities in satellite communication. It requires high number of beams in order to permit the implication of a high degree of frequency. In addition, it may require to utilize higher frequency bands to increase capacity like, "Ka (20-30 GHz), Q/V (40-50 GHz) or EHF (20-45 GHz) bands." Respectively, "1 GHz, 3 GHz and 2 GHz allocated to fix satellite service". In terms of market use of satellite bands, the current transponder band is Ka-band. It had been predicted that satellite bands of low frequency overcrowding will allow new systems to adopt Ka-band and investigating in developing them to Q/V band. The expected developed form of Ka-Q/V satellite band can be described as two types of service within the access of broadband. It hed been nominated by a high irregular traffic which enables users to access by adopting part of Ka-band. While, the service of delivery will be implied in a wider Q/V bandwidth.

However, the attractive criterion of frequency that Ka and Q/V bands had as in the field of satellite communication, but it may encounter some vital limitation of usage during implementation process. In this case, a certain technique should be applied to system for insuring capacity, availability and the quality of service will not be guaranteed. In addition, the radio-wave propagation may be limited in the lowest layers of the atmosphere due to the reasons stated previously. The reduction and gleaming roles in the atmospheric elements like, gas, clouds and rain will be more effective in every time when operational frequency is increased [1]. Therefore, there is a necessity to involve more sophisticate system with a fixed limit, for ensuring the targeted objective of service minimum outage duration with linking availability.

Inadequacy of earth and space equipment accompanied with high costs of required materials stand in front of nominating fixed static borders, in order to recompense broadcast losses in high frequency bands. This enabled the process of fade mitigation techniques implementation to move forward [2]. "These techniques enable designing systems with small static margin and ability to overcome atmospheric challenges such as cloud attenuation and depolarization events." One of the techniques that attacked the interest of designers was adaptive modulation/coding. It was characterized with their ability to allow an optimized perform of individual links. Also, it was able to adapt a transmission characteristics of broadcast canal and achieving required package criteria for a specific connection. There is a promising future designed for adopting those techniques, especially in the service of point-to-point scenario. This paper aims to investigate the major issues in designing satellite communication systems, particularly (FMTs) for (Ka-Q/V) band. FMT physical layer concepts has been reviewed in the traditional framework of sitcom system.

A. Frequency Allocation

In the face of increasing congestion in the high-throughput satellite frequency bands, particularly with constellations like Starlink and One Web relying on Ku/Ka bands, it becomes challenging to make use of these frequencies. However, the Q/V band presents itself as a promising alternative for future high-throughput satellite feeder connections [3-4]. As a result, YINHE-1 opted to utilize the Q/V band for the feeder link and the Ka-band for the

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user link. To fully exploit the Ka-band resources for the user link, a four-color frequency reuse scheme with 16 user beams was implemented. This setup allows for a single polarization bandwidth of approximately 5 GHz at the gateway station, and when employing dual-polarization, the total bandwidth can reach around 10 GHz. Notably, frequency reuse involves using the same frequency for beams in different directions. This technology enhances frequency utilization and boosts the network's communication capacity without the need to expand the frequency bandwidth. The concept of signal polarization refers to the orientation in which the electric field component changes over time.

B. Satellite Propulsion System

The satellite platform's electric propulsion subsystem generates thrust with support from the power supply, applying the required impulse to the satellite's center of mass. The Hall electric propulsion subsystem encompasses several key components, including the Hall thruster, storage and supply unit, power processing and control unit, and more [5,6]. The thruster serves as the central component of the Hall electric propulsion subsystem, responsible for thrust generation. The Power Processing Control Unit (PPCU) plays a pivotal role in converting the primary bus power supply into various power supplies necessary for thruster operation, alongside providing control and status detection interfaces. The storage-supply unit, under the PPCU's guidance, depressurizes xenon gas in the high-pressure cylinder and regulates its flow rate through the flow control module to meet the thruster ignition requirements. The PPCU handles remote control commands, manages the timing and logic control of the electric propulsion subsystem, oversees the switching control of power supply modules, valve and flow control of the storage and supply system, and collects telemetry data.

Band of Satellite

The field of satellite technology is rapidly advancing, leading to a growing range of applications. Satellites are no longer limited to radio communications; they now find utility in areas such as astronomy, weather forecasting, broadcasting, mapping, and numerous other fields. To facilitate easy reference, various designations have been established for the different satellite frequency bands available. Higher frequency bands typically provide access to broader bandwidths, but they are also more vulnerable to signal degradation caused by 'rain fade'—the absorption of radio signals by atmospheric rain, snow, or ice. The increased utilization and proliferation of satellites have given rise to congestion issues in the lower frequency bands. Consequently, ongoing research is exploring new technologies to make use of higher frequency bands.

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Table.1: The frequency band classification.

Band	Frequency range
L Band	1 to 2 GHz
S Band	2 to 4 GHz
C Band	4 to 8 GHz
X Band	8 to 12 GHz
Ku Band	12 to 18 GHz
K Band	18 to 27 GHz
Ka Band	27 to 40 GHz
V Band	40 to 75 GHz
W Band	75 to 110 GHz

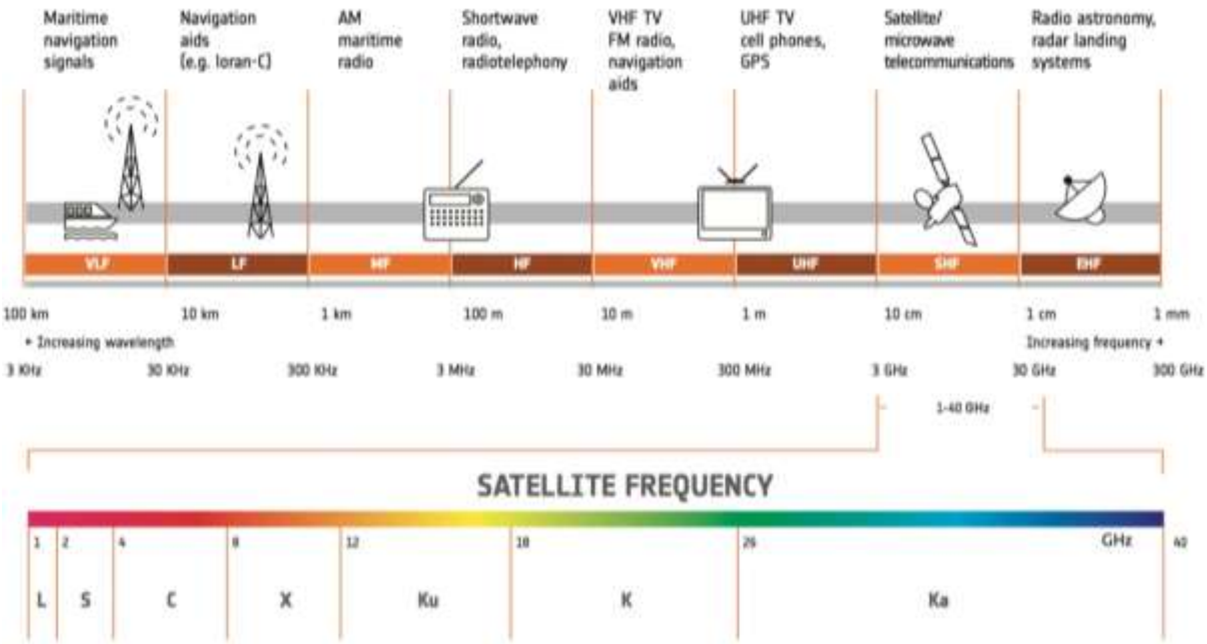

Figure.1: Satellite frequency

A. C-Band

There are a number of benefits that accompanied adopting C-Band frequencies in industry during the last era. Resistance to rain degradations was the major one of those benefits. A regularity direction factor required to every transmitting ground station in order to initiate the process of sharing bands with terrestrial microwave facilities. The existence of evolutional potential interference made it as the main factor for founding locations for C-Band ground stations. A typical size of C-Band is very small (2.4) meters to aperture terminal (VSAT) antenna. Thus, industry was not in favor for using it due to high costs of frequency coordination and shielding high volume C-Band (VSAT) networks where (VSAT) placed on the premises of the end user.

The scholars investigate a lot to solve this problem. They implement various approaches to it. One of these solutions was implementing a spread spectrum technique to decrease the interference by spreading. Technically, a spread spectrum technique can be implemented in a

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certain condition, when the coming interference is relatively narrow banded to satellite signals. Normally, this case cannot apply in microwave band. This explains lack of success for Equatorial. Although, the limitations that C-Band encounters on large (VSAT) networks, but it still useful band till modern days because of it does not affected by rain. In addition, cable industry since 1970s believed that the head end of C-Band earth stations systems is able to delivery programming for thousands of cable subscriber without necessity to build another C-Band earth station.

B. Ku-Band

The first Ku- satellite band was launched in 1980. It took a long time to be developed in accordance to markets' needs and became the dominant adopted band in the industry. This step was not in favor of SBS that went into bankruptcy. This was due to the main criterion of local bands had "(11.7-12.2 GHz) / (14.0-14.5 GHz)" as well as it do not require frequency coordination. The existence of blanket licensing in Ku band (VSAT) stations was so helpful in this area. Currently, there are thousands of these stations in serves because of the favor for rain resistance criterion in comparison to C-Band links. The antenna size is smaller which range between 1m. to 1.8 m. in diameter.

C. Ka-Band

FCC band grown faster in the industry to be dependable band unlike Ku-band that took long time to be adopted. Ka-Band 8 (17.7-20.2 GHz) / (27.5-30.0 GHz) had been set aside in satellite communication in 1996, whereas, first orbit assignment was in 1997. The pick of using Ka-band was in 2003 when it became a popular band for its pointy output with a smaller beams' spot, dynamic bandwidth division and small size of antennas. It was prominent factor in Ka-band system for performing better service. Currently, a high internet service offered by (Wild Blue Company). It is able to supply up to 1.5 Mbps and upload speed 256 Kbps by adopting Ka-band technology. In 1998, the FCC preliminary allocated Q\V-band for better technological development. In 2003, the following frequencies had been finalized; Various terms had been used to refer to Q-Band and V-Band. Generally, V-Band had been used to refer for the uplink bands, while the Q-Band used for the downlink bands. However, many researchers refers to FCC as a V-Band. This band had some limitations such as an effect of broadcasting radio-wave in the low atmospheric layers. Increasing the number of operational frequencies will results a strong scintillation effects of gas, clouds and rain in the atmospheric. Fade Mitigation Techniques technology has to be implemented for utilizing V-band in those conditions.

The one solution to avoid the time cloud attenuation of rain as well as scintillation by designing a system is able to avoid this problem. .the one technology that could use is the adoptive modulation using coding technique.in addition, the one condition should be achieve is transmission characteristics synchronize with propagation channel conditions. The Q_V band could use in future with star network feeder links as well as backbone applications.

However, above mentioned details for the effects of rainfall on satellite signals, but it still limited in such frequencies in tropical regions. Additionally, more data required to be collected and investigated for real experiments and investigations in order to get a closer sight

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to this issue. In particular the outcomes collected from a microwave link have to present an initial sight for the criteria of V-band during the absence of satellite-Earth link.

Page Styl Fade Mitigation Technique

Fade Mitigation Techniques involves the adaption of a time link plan to the circulation circumstances in certain precise bounds like power, coding and data rating. It will effect in both carrier-to-noise ratios as well as interference ratios in upper layers. Those aspects demand detailed study in a further consideration. There are a lot of researches had been written and published in this area [7-14]. A well-prepared review for FMTs has been set in (COST 255) framework. FMT layer classified into four types;

A. Power Management: Adjusting the transmission power to accommodate propagation challenges.
B. Dynamic Waveform: Efficient modulation and coding schemes used to counteract signal fading.
C. Redundancy: Preventing signal fading by utilizing an alternative, less affected connection.
D. The purpose for implementing FMT in layer 2 level is retransmission of a message more than modifying a fade event. There are two techniques can be carried out in layer 2 which are; Automatic Repeat Request and Time Diversity. The first technique (ARQ) sends the message regularly until it delivered to the receiver. “This technique can be used as alternate solution in random or predefined time repetition protocol.

Forthcoming implementation of V-Band in satellite communication by time diversity technique aims to re-send the information when the state of the broadcast channel allows interaction. Generally, it refers for unnecessary for receiving data file in the real time. According to users’ point of view, it is acceptable to wait for the end of transmission event (tens of minutes) or until the traffic will decrease. This technique assisted by the use of broadcast mid-term prediction model in order to calculate the appropriate time for re-sending the message without repetition in request.

2. CONCLUSIONS

This work had reviewed Q/V bands role in satellite communication. It shows that V-Band implementation will enable the capacity of communication to increase rapidly. Also, it will enable networks to provide wide coverage over terrestrial and tropical regions as well as providing well communication to marine, flying and various industrial communications. “The major challenging issue for providing a good communication is the effects of atmosphere lowest layers in radio-wave propagation. These atmospheric effects of attenuation and scintillation caused by gas, clouds and rain become more severe during increased operational frequencies. There are some techniques that had been created for decreasing those atmospheric effects like, (Fade Mitigation Technique). This technique dealt with power control, adaptive waveform, diversity and layer 2. However, those techniques differ in their values, but it considered as a complementary part of (FMT). It could be concluded that the mutual use of various (FMT) considered as a major necessity for

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decreasing high impairments. Finally, it will participate in improving system availability, control the interference and increase system capacity.

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