

IMPLEMENTATION OF ADAPTIVE CODE MODULATION TECHNIQUE FOR RAIN ATTENUATION

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Abstract: Extending demand and proceeding interest for satellite applications that demand high speed operation has inevitably made standard frequency bands to become crowded and tightly packed. There is never ending need that provokes moving towards higher frequencies and investigate them as they have huge dealing capability. Systems which are being operated above 10 GHz frequencies ought to be thoroughly observed and scrutinised considering all possible propagation impairments. Rain, a major conceivable impairment corrupts the radio signal through absorption, causing link performance degradation. There is a requirement for transmission link to respond suitably and adaptively under inevitable environmental conditions. Adaptive modulation, a reliable, versatile adaptation scheme is employed to combat for bit error rate. This technique lessens probability of occurring bit errors and mitigates fade. Altering the scheme of modulation employed and code rate in accordance with randomly changing channel conditions, adaptation promisingly gives better performance in terms of bit error probability and throughput.

Keywords: Rain attenuation, Adaptive Code Modulation, Bit error probability.

1. Introduction

In Telecommunications, equipping a satellite is the only means of providing a connection among different earth stations. High speed satellite applications and high data rate services are very much prevailing now-a-days and will surely continue in the near future also. It is need worthy and essential to have additional bandwidth for the

delivery of data at an appreciable speed. A satellite communication system first operated in the C-band but as the GEO orbit is fully congested with satellites using this band, new satellites have been built for next higher bands like K_u and K_a bands. So as to allocate for many new services, there is a proceeding interest for even more additional spectrum and effective usage. Although these high frequency bands are appreciable in terms of bandwidth but on the other hand they have some limitations and inevitable potential risks. Until and unless some specific techniques are used these bands cannot guarantee the desired quality of service and availability [1]. The major limitation comes into picture when the radio signal passes through the lower layers of atmosphere. When the operating frequency is increased, the effect of scintillations and attenuations because of cloud, rain and atmospheric gases will seriously degrade the link performance and eventually decreases the transmission efficiency [2].

2. Propagation Effects and Impact on Satellite-Earth Links

i) Rain Attenuation

Rainfall is one of the most frequent real issues noticed amongst channel hindrances, which are usually seen particularly while dealing at frequencies much greater than 10 GHz. Rain fundamentally incorporates change of polarization in the signal. Vital portion of signal energy will be lost during this phenomenon and prompts the reduction in signal strength. This degradation in the signal strength is called rain attenuation. Once this

fade is identified, link budget can be computed effortlessly which can be used to estimate the power losses in the midst of the transmission. The abnormal variations in the rain rate [3] tend to cease the signal in reaching with the expected signal strength. Readings have been recorded at KL University in Vaddeswaram region.

ii) Cloud Attenuation

A serious threat in regards to the modelling of cloud attenuation is that there can be of many sorts of clouds and even they can likewise be at different levels. The content of water-vapor varies with every cloud and the ice crystals predominantly seen in them are known to cause weakening of the signal. But this debilitation is most seen at higher frequencies. A formal degradation of 1dB or 2 dB will happen. This additionally prompts to deterioration of the signal polarization causing serious degradation.

iii) Atmospheric Absorption

Resonant absorption of the signal during the path because of the molecules present with in the atmosphere is the main reason behind the losses due to atmospheric- absorption. However, this loss could be nearly to a nominal 2 or 3 dB .Strong depolarization of the signal will also be occurred because of the absorptions present in the atmosphere surroundings. The amount of the absorption that would occur is chiefly dependent on frequency and climatic conditions furthermore.

iv) Tropospheric Scintillations

Solar energy received from the sun make the earth to get heated up. This eventually creates variations in the refractive index along the path in which the signal is ought to travel. These variations will lead to fluctuations in the signal strength of the received signal [4].

v) Low Angle Fading

Another serious propagation impairment that becomes significant at lower elevation angles is low angle fading. This usually occurs at elevation angles below 10 degrees .This phenomenon is more or less similar to multipath fading which is most commonly seen in terrestrial links. Because of this, the signal may arrive at the receiving earth station antenna with multiple phase shifts and there after causing attenuation of signal level when compared

to signal level under clear sky.

3. Link Budget Analysis

Link budget analysis is one of main thrusts in studying the satellite links [5]. This is the most frequently used method in estimating the value of received power taking into account all the parameters involved in the transmission. Now-a-days many tools have come into being to estimate the link budget most of the times for an end-to-end link. However there are customary routine methods also to figure out the link budget.

The formula for calculating the received power through link budget equation is given as

$$P_{RX}=P_{TX}+G_{TX}+G_{RX}-L_{TX}-L_{RX}-L_{FS}-L_M(1)$$

From this eq.(1), it can be clearly understood that as transmitting antenna's power, gain are constant values, the value of the receiving power is clearly depending on the losses that are induced during the propagation through path. By knowing the value of noise power for a specific channel that is in use, one can easily arrive at obtaining the values of signal-to-noise ratio which is obtained by dividing the signal power by channel noise power. Free space losses can be computed by knowing the distance of observation station from satellite and operating wavelength. Apart from these, it is required to have a sound knowledge regarding the amount of losses that occur because of rain, fog and cloud.

4.Adaptive Coding and Modulation

All of the channel impediments which are discussed in the earlier segment usually vary abnormally and behave stochastically and hence show an anomalous behaviour which cannot be predictable both in time and space in contrast to the deterministic factors like free space losses. Availability and accessibility of the link is the promising factor in determining the reliability of the transmission of the signal in satellite systems. A link is said to be available if the bit error rate is lower than the predetermined threshold levels of the bit error ratio. This adaptive scheme can also be inferred as link adaptation technique. It is one of the prominently used fade mitigating technique [6].Adaptation has to be done dynamically by recording the values of SNR and switching the modulation or code rate based on the obtained SNR and some predetermined thresholds [7].

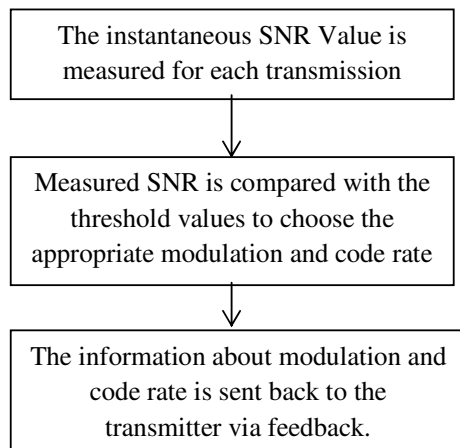


Figure 1.Flow chart for Adaptation Procedure.

The choosing of appropriate coding rate and suitable modulation is dependent upon state information about the physical channel present. Suppressing the bit errors and increasing the throughput in any fading channel particularly in tropical regions is the key goal of any adaptation technique [8].

4. Results

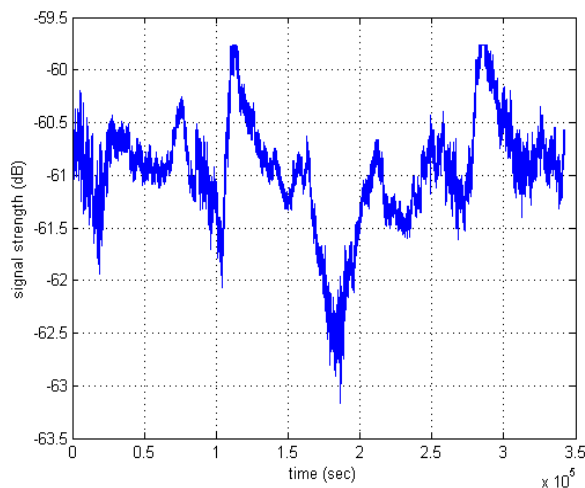


Figure 2.Plot of received signal power Vs time for the signal received.

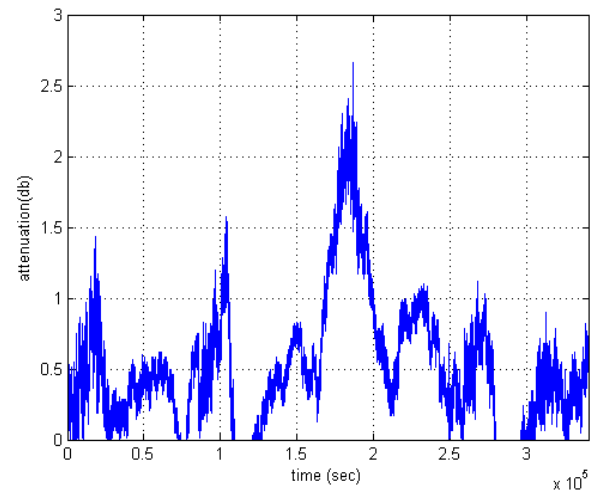


Figure 3.Plot of attenuation Vs time for the signal received for an observed event.

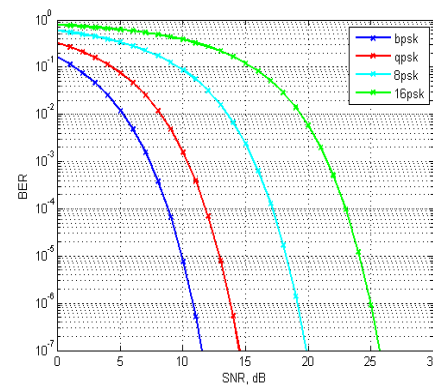


Figure 4.BER Vs SNR performance curves for various modulation schemes.

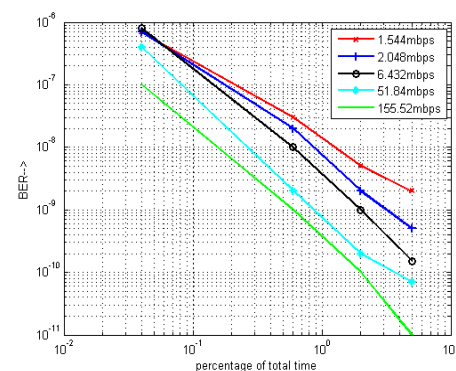


Figure 5.Variation of BER as a function of % of total time for various code rates.

5. Result Analysis

From Figure 4 it is evidently obvious that when there is more amount of degradation that means when the signal to noise ratio is low (when the link is experiencing serious degradation) it is preferable to use lower order modulation schemes such as binary phase shift keying, quadrature phase shift keying as they have lower bit error rates when compared to higher modulation schemes. When the signal strength is quite good that means when the SNR values are above 20 dB range, it is quite preferable to implement higher modulation schemes such as 8 PSK, 16 PSK etc. Based on the switching thresholds and for a given value of received SNR, for every modulation scheme, it is decided by the transmitter to choose which modulation for the next transmission. For accomplishing this, the receiver must send the instantaneous SNR values to the transmitter via a feedback path. Transmitter must be made aware of the channel state information. It can also be understood in another point of view that for any specified target value of bit error rate (threshold), SNR required to meet the target value is minimum in the case of BPSK and QPSK.

Figure 5 clearly illustrates the variation of probability of bit error with respect to various code rates, further more at different percentage of total times. Bit error rate ought to be low for any efficient and effective end-to-end transmission.

The graph clearly demonstrates the fact that using higher code rates is certainly worthy as they show significant reduction in number of bit errors. Hence, varying the code rates has a serious impact on bit error rates. According to the figure 4 switching thresholds for the modulations can be inferred as below:

Table1. Switching thresholds for MPSK transmissions.

S. No	Modulation	Switching thresholds
1.	BPSK	$\text{SNR} < 11.3 \text{ dB}$
2.	QPSK	$11.3 \text{ dB} < \text{SNR} < 15 \text{ dB}$
3.	8 PSK	$15 \text{ dB} < \text{SNR} < 20.5 \text{ dB}$
4.	16 PSK	$20.5 \text{ dB} < \text{SNR} < 25.6 \text{ dB}$
5.	32 PSK	$\text{SNR} > 25.6 \text{ dB}$

6. Conclusion

When the signal undergoes serious disturbances (at low SNR), lower modulation schemes can be employed to have better bit error probability. When the channel impediments are quite low (at high SNR), higher modulation techniques can be better employed to meet the target values of BER. Incrementing the code rate with which the data transfers causes decrease in the bit error rate which is primarily desired in long distance transmissions.

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