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Glasgow College, UESTC Coursework Assignment

A Satellite Communications System for Poor Quality Satellite Communication Channels

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COURSEWORK ASSIGNMENT changgang zheng 1 November 22, 2019 contents 1Glasgow College, University of Electronic Science and Technology of China, ChengDu, China

 1 abstract For satellite communication, channel conditions are generally poor, how to use appropriate methods to establish a satellite and the ground to establish a stable, high-quality link is a problem. This test USES MATLAB/ Simulink simulation to realize TDMA, FDMA, and CDMA in the simulated channel conditions

through the relay satellite and the ground base station to establish a connection, and the result performance is proved acceptable.

2 introduction 1 2 introduction Satellite communication is a tough task due to its distance as well as undesir- able and undetectable environment [1, 2]. Due to that, challenges for satellite communication, including Network Layers, for which, the undesired channel introduced in above results in long delays, packet losses, and sometimes inter- mittent connectivity and link disruptions are introduced in [3]. And, for Physical layers, establishing line-of-sight (LOS) limit its usage. Besides, potentially high density of users with requirements of high data rate requires the satellite com- munication to have a high throughput [4]. In this Coursework Assignment, data would be generated, then, passing through a Transmitter block. After this, antenna saw is added. Then signal passing through the channel. The receiver and received antenna is applied. Finally, proper calculation or scope is applied to evaluate the system. All the principles of techniques are illustrated and explained before the description of the system. For the Implementation, the state of art Design and Implement of Satellite Com- munications System for Poor Quality Satellite Communication Channels would not be mentioned. The report would mainly focus on the most general prob- lems of the communication between satellites. The communication system is designed and implemented to overcome these challenges and realize an accept- able link. The Multiple Access, Multiplexing, Antennas design Orbits design, and other techniques are used in the system for a better communication quality. Also, the performance of the designed system would be evaluated. 2.1 Environment Impairments 2.1.1 Media Impairments There are mainly three types of impairments, which are sources or nature of other impairments. Noise is one of the most common impairments. The Noise is additive to the signal. Which is always generated by the components due to its thermal temper- ature and its physical property. It is usually added in both channel and TX or RX. components. Distortion is formed by the channel and the transmitter. For the channel, there be a transfer function of it other than the impulse function. And, there is no ideal transmitter can generate Sinc or rectangular shape signal. Thus, distortion and ISI can easily happen due to the above two reasons.

environment impairments 2 Attenuation is happened because the amplitude of the signal would transfer to thermal heat when passing through channel and media. So, the superconducting could minimize the attenuation, which would be great helpful for the power transformation and communication. The attenuation has a direct link with the orbit and the distance. 2.1.2 Impairments In Satellite Communication The distance between the a and the ground base station is large, and the attenua- tion when it is passing through the air includes Ionospheric Error, Tropospheric Error, Multipath effect results in Intersymbol Interference (ISI) and finally gener- ates a Rayleigh fading channel mainly. Ionospheric Error Tropospheric Error Multipath Effect Antenna Phase Center Satellite Orbital Error Satellite Antenna Phase Center Satellite Clock Error Building or Other Obstacles Figure 1: Possible Impairments In Satellite Communication System There are also common Sources of Signal Loss and Noise like Band- LimitingLoss, Local Oscillator Phase Noise, AM/PM Conversion (Amplitude variations), Lim- iter Loss or Enhancement, Multiple-carrier Intermodulation Products (non-linear devices), Modulation Loss (message content power), Antenna Efficiency, Radom- LossandNoise, PointingLoss, Polarisation Loss, Atmospheric Loss and Noise, Space Loss, Adjacent Channel

Interference, Co-channel Interference, Intermod- ulation Noise, Galactic or Cosmic, Star and Terrestrial Noise, Feeder Line Loss, Receiver Noise, Implementation Loss, Imperfect Synchronisation are all possible loss may happen during communication, which are illustrate by [5]. The Link- Power Budget Equation of the loss is described in [6], which is shown in the equation. [LOSSES] = [FSL] + [RFL] + [AML] + [AA] + [PL] (1) Where FSL means free-space spreading loss, RFL means receiver feeder loss, AM means antenna misalignment loss, AA means atmospheric absorption loss, and

orbit element and satellites' position 3 PL means polarisation mismatch loss. These are the most common losses in the link. 2.2 Orbit Element and Satellites' Position The orbit of the satellite would severely influence the performance of the satel- lite communication [7]. The Impairment, especially attenuation, would very a lot following the distance between two end machines. Also, the area of coverage, the signal strength, including other essential factors, would be influenced by the orbit. The orbit of the satellite can not be designed for achieving theoretical performance as it may cost too much fuel for the satellite. So the design of the satellite orbit is a kind of tradeoff. Calculate the average angular velocity, we can use, = r a 3 (2) Calculate the mean anomaly, we can use, M = (t - t p) (3) Solver for Eccentric anomaly, we have, M = E - e sin(E) (4) Calculate the polar coordinates, we use, r 0 = a[1 - ecos(E)] (5) 0 = cos -1 " a * 1 - e 2 - r 0 er 0 # (6) Fined the rectangular coordinates, we can apply, x 0 = r 0 cos(0) y 0 = r 0 sin(0) (7) In the celestial coordinate system, we have the following equations [8]. r = 2 4 X Y Z 3 5 = a(cosE - e) 2 4 P x P y P z 3 5 + a p 1 - e 2 sinE 2 4 Q x Q y Q z 3 5 (8) The coordinate weight of the position vector r of the satellite and the unit vec- tors P and Q in the coordinate system of the flat celestial sphere are (X,Y,Z), (Q x ,Q y ,Q z) and (P x ,P y ,P z) respectively. And unit vectors Q is shown as follow. P = 2 4 P x P x P z 3 5 = 2 4 cos! cos - sin! sin cosi cos! sin + sin! cos cosi sin! sini 3 5 (9)

choice of orbit 4 Unit vectors P is shown as follow. Q = 2 4 Q x Q y Q z 3 5 = 2 4 - sin! cos - cos! sin cosi - sin! sin + cos! cos cosi cos! sini 3 5 (10) Solver for Eccentric anomaly, E 1 = M + e sinE 0 E 2 = M + e sinE 1 (11) It can also be approximated by series expansion. E = M + e - e 3 8 sinM + 1 2 e 2 sin2M + 3 8 e 3 sin3M + (12) According to the above formula, the position of satellite in inertial space at any time can be calculated from the root number of satellite orbit. 2.3 Choice of Orbit Now, there are two main types of orbit used for satellite communication: one is geostationary orbit, such as Inmarsat satellite communication system; The other is low-earth orbit, for example, iridium communications systems. 2.3.1 Geostationary Earth Orbit (GEO) Semi-long axis of the orbit is selected so that the satellite rotates around the cen- ter of mass of the earth at the same period as the earth rotates, and the orbit is round and in the equatorial plane. At this point, the satellite appears to be stationary above the earth's equator relative to users on the ground. According to Kepler's third law, the orbit radius of GEO satellite is, r S = 4 2 1 3 T 2 3 = 42164.17km (13) Where, T is an average sidereal day. The geostationary orbit satellite has a large coverage area and a fixed coverage area, which is the most used orbit for communication satellites. However, the problem of large space path attenuation and long transmission time delay caused by distance should be overcome. At the same time, because GEO satellites are over the equator and cannot cover the north and south poles, it is not suitable for high latitude users to use satellite communications.

free space path loss 5 2.3.2 Low-Earth orbit (LEO) Generally, it refers to the satellite orbit with a height of 160km 2500km from the ground. Due to the low altitude of the orbit, the space path between the user and the ground has little attenuation, and the transmission time delay is short. Moreover, the coverage of the high latitude area can be realized by selecting the inclination Angle of the orbit. However, LEO orbit also has significant disadvantages, that is, the coverage area is small, and the coverage area moves on the ground with the movement of the satellite. If a user in a given area wants continuous communication coverage, it must be achieved by a constellation of LEO satellites. 2.4 Free Space Path Loss All radio signals propagating in free space have free space path loss. For distance r in km and frequency f in GHz, the path attenuation expressed in dB is: L FS (dB) = 20 lg(f) + 20 lg(r) + 92.44 (14) For GEO orbit, when the communication frequency of 6GHz is adopted, the path attenuation is about 199dB. For LEO satellites, the path attenuation is about 148db-172db. 2.5 Channel 2.5.1 Gaussian Channel The most fundamental channel is an RF communication channel that contains characteristics of specific noise spectral density at various frequencies. So, actu- ally, the gaussian channel means the additive noise, which named as Additive white Gaussian noise (AWGN), has a random jitter around its mean value, where any sufficient length of signal would have a zero average. Plus, the variance of these noise follows the normal distribution. AWGN has mainly three properties. Firstly, the variance of AWGN is its power. AWGN is one of two primary sources of signal deterioration (the other source is attenuation). The transmitting signal would not change its power after passing through an AWGN channel, which reduces the SNR of the transmitting signal. 2.5.2 Rayleigh fading channel For wireless transmission, especially satellite communication, the multipath phe- nomenon is common. For each transmission path, the signal amplitude is ran- domly fading so that the whole envelope obeys Rayleigh distribution. This channel can well describe the ionospheric and tropospheric reflection short-wave channels and any areas where multipath phenomena are serious.

communication system 6 2.6 Communication System 2.6.1 Multiple Access Time-division multiplexing Access aims to divide the time and allocate them to different users or simply use a different time slot to transform data. The trans- mission happens along the same channel [9]. Frequency division multiple access (FDMA) divides its possible spectrum for users. For every user, it will be allocated with a frequency. That user's data would be modulated and transformed on that channel only. Code division multiple access (CDMA) is different from the previous two meth- ods. Every user can use every channel at any time if the capacity of the channel is large enough. This method uses orthogonal bits to encode and finally decode the data. 2.6.2 Modulation Amplitude Shift Key (ASK) is the most simple modulation techniques. It has the advantage of simple, but

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it is very susceptible to noise interference because noise affects the amplitude [10].

This now mainly used when data Transmit over optical fiber. Frequency Shift Key (FSK) is a little bit more difficult than the ASK. All the data bits are embedded in the frequency, which closed 2-time spectrum as ASK, which means the bandwidth is 4 times as original signal. Phase Shift Key (PSK) is used more than communication techniques. All the data bits are embedded in the phase, which has the same spectrum as ASK. However, when the signal M is bigger than 16, OSK can not meet the high re- quirements. [10] Quadrature Amplitude Modulation (QAM) has the best performance compared with the previous examples. 2.6.3 Pulse Shaping Filter Inter Symbol Interference (ISI), a type of signal impairment, can be caused by various reasons, the not ideal Signal generator, for example. The not be ideally rectangular signal spectrum will finally result in ISI. For dealing with these ef- fects, the system can use the idea of Pulse Shaping Filter (PS Filter) [11], which let the total transfer function of the first three blocks of the following blocks to be a PS Filter. Thus, the signal would not have the ISI before the detector.

communication system 7 PS Filter (RCC Filter) Match Filter Detector Channel s(t) ŝ(t) x(t) y(t) z(t) !(t) h(t) c(t) = 1 Figure 2: Communication System model of RX and TX and Channel In this system, we suppose that the channel is equal to 1, which ingore the effect and influence of channel. Then we can get x(t) = y(t). x(t) = s(t) (t) (15) In frequency domain, the Z(f) and get from the mutiplication of input signal and tramsfor functions of each blocks. F[z(t)] = F[y(t) h(t)] = F[s (t) (t) h(t)] (16) After the Fourier Transform, we can get. Z(f) = S(f)R(f)H(f) (17) Secause S(f) is a constant value in the frequency domain. So R(f) = H (f) due to the match filter H(f). H e (f) = R(f) H(f) (18) Then, combine with the above formula, we can get the following equations. H e (f) = H (f)H (f)) H(f) = p H e (f) (19) Thus, the defined RRC function is shown, H(f) = 8 < < < > < < < : T 0 6 jfj 6 1- 2T T 2

1 + cos h T jfj - 1- 2T i 1- 2T 6 jfj 6 1+ 2T 0 jfj < 1+ 2T (20) By using the Fourier transfer, we can get the Raised Cosine Pulse Shaping filter is defined by [12]. h(t) = sin t=T t=T cos t=T 1 - (4 2 t 2 =T 2) (21) Square root in the frequency domain, the Raised Cosine Filter can become the Root Raised Cosine rolloff Pulse Shaping filter and we can use inverse Fourier transfer to get its time domain representation [11]. h(t) = 2 p T cos[(1 +) t=T] + sin[(1-) t=T] 4 t=T 1 - (4 t=T) 2 (22) So, if possible, the Root Raised Cosine roll-off Pulse Shaping filter will be used as a signal generator and matched filter to make sure that the system would have ISI due to the not idea signal generator.

error coding 8 2.6.4 Channel equalization For signal passing through the air and the magnetic field, Multipath Effect can cause ISI. The signal can be reflected between the cloud and the earth and finally reach the receiver or either satellite or base station. Tx Equalizer Channel ŝ(t) s(t) r(t) h(t) = 1 Rx Figure 3: Channel Equalizer The idea of channel Equalizer aims to compensate the effect of channel which can be generally be present as, ˆs(t) = s(t) h(t) c(t) + n (t) c(t) (23) By applying FT, In frequency domain, we can get, ˆ S(f) = S(f)H(f)C(f) (24) So the target changes to let the channel equalizer to compensate the channel in frequency domain, H(f)C(f) = 1 (25) So, we can conclude that the design of the block should follow, C(f) = 1 H(f) (26) 2.7 Error Coding Coding theory is a branch of mathematics and computer science dealing with the error tendency in transmitting data in noisy channels. According to coding the- ory, better methods are used for data transmission to correct a large number of errors during transmission. There are two types of coding: source coding (data compression [also known as data compression]) and channel coding (forward error correction). 2.7.1 Huffman coding Huffman coding algorithm is based on a binary tree to build coding compression structure, which is a classic algorithm in data compression. The algorithm reen- codes the characters according to the frequency of text characters. To shorten the length of the code, we naturally want words with higher frequency to encode shorter, so as to finally maximize the compression of the space to store text data.

3 system design 9 2.7.2 Shannon coding Shannon coding theorem is also a common theorem. It is a variable-length cod- ing. In this method, code length depends on the cumulative probability. The codeword depends on its own probability. Technically speaking, Shannon cod- ing is not the best coding method, it just assigns the code by using the cumulative probability. For Shannon coding, there are advantages as follows. The first is that we do not need to care about the dummy leave in order to meet the formula D+D(K-1). The second is that it is easier to calculate and implement. The disadvantage also exists as it may not be the best coding method. Shannon coding is not the optimal code in the strict sense. It uses the cumulative probability distribution function of the source symbol to allocate the code word. 2.7.3 Fanon coding This method dates from the year 1949. It was published by Claude Elwood Shannon (he is designated as the father of the theory of information) with War- ren Weaver and by Robert Mario Fano independently. Similar to Huffman-tree, fano coding also uses a binary Tree to encode characters. However, in practice, fano coding is not of great use. This is because it has lower coding efficiency compared with Huffman coding (or the average codeword of fano algorithm is larger), but its basic ideas can be referred. Fanon coding algorithm is based on dividing nodes by even probability, and it is a classic algorithm in data compression. The algorithm reencodes the characters according to the frequency of text characters. To shorten the length of the code, we naturally want words with higher frequency to encode shorter, so as to finally maximize the compression of the space to store text data. 3 system design 3.1 Transmitter, Receiver Antenna and Channel 3.1.1 Channel with a Retranslator Satellite Embed Inside Usually, for satellites, it can not directly communicate with the ground station. So a Retranslator Satellite is needed for helping it to communication. For the worst case, we consider the channel under the help of a Retranslator Satellite. As shown in the figure, channel is constructed by the concrete connection of the blocks of Free Space Path Loss, Praraboloidal Reflector Antennas, Receiver

transmitter, receiver antenna and channel 10 Downlink Path Satellite Downlink Receiver Antenna Satellite Downlink Transmitter Antenna Free Space Path Loss 199 dB 17.3371 dB (54.1644) Praraboloidal Reflector Antennas1 Noise Temperature 300.6 K Receiver System Noise Temperature1 22.934 dB (196.515) Praraboloidal Reflector Antennas2 Free Space Path Loss 196 dB 57.2669 dB (532959) Praraboloidal Reflector Antennas 44.6442 dB (29135.1) Praraboloidal Reflector Antennas3 Noise Temperature 150.6 K Receiver System Noise Temperature2 Magnitude AGC Select AGC (with a retranslator satellite embed inside) Figure 4: Model of the Designed Channel System Noise Temperature, Mixer, Amplifier, Paraboloidal reflector antennas of a retranslator satellite and

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Free Space Path Loss. Free Space Path Loss: Simulate the signal loss when it is passing through the space which Reduce the amplitude of the input signal by the amount specified. Praraboloidal Reflector Antennas: This simulate the property of the antenna, with setting its parameters Carrier frequency to 6000 (MHz), Transmit Frequency to 6 (GHz), Antennas Caliber/Diameter to 0.14 (m) and Gain factor to 0.7. Receiver System Noise Temperature: This simulate the signal passing through a noise, which have set the parameter of Sky Temperature to 10 K, Surface Tem- perature to 300 K, Beam Efficiency to 0.72 and The Noise Temperature of Re- ceiver Facility to 250 K. Mixer: For the Complex baseband model, the mixer add the

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phase noise to it — the phase noise of this block characterized by a 1/f slope. The level of the spectrum is specified by the noise power contained in a one-hertz bandwidth offset from the carrier by a certain frequency.

Amplifier: This amplifier amplifies the signal as well as adds noise to it. So,

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in addition to Linear amplifier, this block has five different methods to model the nonlinear amplifier.

Paraboloidal reflector antennas of a retranslator satellite: This simulates the property of the antenna, which has a similar function with the previous antenna. 3.1.2 Transmitter and Receiver Antenna As shown in the figure, RX is constructed by the connection of the blocks of Mixer, Amplifier, and Paraboloidal reflector antennas. And TX is constructed by the connection of the blocks of Mixer, Magnitude AGC, Receiver system noise temperature and Paraboloidal reflector antennas.

frequency division multiple access 11 Downlink Path Satellite Downlink Receiver Antenna Satellite Downlink Transmitter Antenna Free Space Path Loss 199 dB 17.3371 dB (54.1644) Praraboloidal Reflector Antennas1 Noise Temperature 300.6 K Receiver System Noise Temperature1 22.934 dB (196.515) Praraboloidal Reflector Antennas2 Free Space Path Loss 196 dB 57.2669 dB (532959) Praraboloidal Reflector Antennas 44.6442 dB (29135.1) Praraboloidal Reflector Antennas3 Noise Temperature 150.6 K Receiver System Noise Temperature2 Magnitude AGC Select AGC Figure 5: Model of the Designed RX and RX System with Antenna Paraboloidal reflector antennas, Mixer, Amplifier and Receiver system noise temperature in this system, is very similar to the blocks in the channel. So I would not do further introduction to it. Magnitude AGC: Automatic gain control in the RX is used to control and adjust its gain automatically to compensate for the impairment during the RX, RX, or the channel. 3.2 Frequency Division Multiple Access Frequency Division Multiple Access divide the frequency spectrum to users, and each user can use one small slot of the spectrum. The key idea of the FDMA is to move the baseband spectrum to the allocated passband spectrum. For this Transmitter Block Receiver Block Power Scope BER Calculator Data Generator Satellite Downlink Receiver Antenna Downlink Path Satellite Downlink Transmitter Antenna Bernoulli Binary QPSK Square root 57.2669 dB (532959) Praraboloidal Reflector Antennas Free Space

Path Loss 199 dB 17.3371 dB (54.1644) Praraboloidal Reflector Antennas1 Noise Temperature 300.6 K Receiver System Noise Temperature1 22.934 dB (196.515) Praraboloidal Reflector Antennas2 Test Power Free Space Path Loss 196 dB 44.6442 dB (29135.1) Praraboloidal Reflector Antennas3 Test Power Noise Temperature 150.6 K Receiver System Noise Temperature2 Magnitude AGC Select AGC Square root Power Spectrum QPSK Error Rate Calculation Tx Rx sRef sDel delay Find Delay 16 9.493e-05 61 6.426e+05 1.881e-15 -147.3 2.353 3.715 Test Power 4.895e+10 106.9 Bernoulli Binary QPSK Square root FDMA FDMA at Transmitter FDMA FDMA at Receiver1 Square root QPSK Error Rate Calculation Tx Rx 0 0 3.213e+05 sRef sDel delay Find Delay 42 Convolutional Encoder Viterbi Decoder Figure 6: FDMA Overall System system, the Transmitter, Receiver Antenna and Channel are constructed in fig- ure, which is the same are the previous explained.

frequency division multiple access 12 3.2.1 Transmitter For transmitter, as shown in the figure, it is constructed by the connection of the blocks of Bernoulli Binary Generator, Convolutional Encoder, QPSK: M-PSK Modulator Baseband, Square Root: Raised Cosine Transmit Filter and FDMA. Bernoulli Binary Generator: It generate a Bernoulli random binary number. As the parameter Probability of a zero equals to 0.5, the probability of 1 and 0 is the same. Other parameters like frequency are also set properly. Convolutional Encoder: This is one time of coding block to implement channel coding; the coding method is Convolutional Code. It convolutionally encodes the binary input data, Which uses the poly2trellis function to create a trellis us- ing

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the constraint length, code generator (octal), and feedback connection (octal).

QPSK: M-PSK

Modulator Baseband: It

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modulate the input signal using the phase-shift keying method.

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Square Root:

Raised Cosine Transmit Filter: Upsample and filter the input signal using a normal or square root raised cosine FIR filter.

The

other benefits by using this type of filter is also mentioned above, which helps to reduce the ISI. Transmitter Block Receiver Block BER Calculator Satellite Downlink Transmitter Antenna Satellite Downlink Receiver Antenna Downlink Path Scopes Data Generator 57.2669 dB

(532959) Praraboloidal Reflector Antennas Free Space Path Loss 199 dB 17.3371 dB (54.1644) Praraboloidal Reflector Antennas1 Noise Temperature 300.6 K Receiver System Noise Temperature1 22.934 dB (196.515) Praraboloidal Reflector Antennas2 Test Power Free Space Path Loss 196 dB 44.6442 dB (29135.1) Praraboloidal Reflector Antennas3 Test Power Noise Temperature 150.6 K Receiver System Noise Temperature2 Magnitude AGC Select AGC 9.453e-16 -150.2 1.182 0.7267 Test Power 2.46e+10 103.9 Bernoulli Binary QPSK Square root Square root Power Spectrum QPSK Error Rate Calculation Tx Rx sRef sDel delay Find Delay 8 0.4535 1.387e+04 3.058e+04 Bernoulli Binary QPSK Square root Square root QPSK Error Rate Calculation Tx Rx 0.5016 7653 1.526e+04 sRef sDel delay Find Delay 188 Convolutional Encoder Viterbi Decoder In1 In2 Out1 Out2 Multiplex In1 In2 Out1 Out2 Demultiplex Figure 7: TDMA Overall System FDMA: For this block, it uses different carrier frequencies to shift the spectrum of the input signal to the proper place of passband spectrum.

time division multiple access 13 3.2.2 Receiver For transmitter, as shown in the figure, it is constructed by the connection of the blocks of FDMA: FDMA at Receiver, Square Root: Raised Cosine Transmit Filter, Viterbi Decoder1and Error Rate Calculation. These blocks firstly move the expected signal to the baseband, then demodulate and decode it. Besides, the BER is calculated. 3.3 Time Division Multiple Access The TDMA is very similar to the FDMA, and the main difference between these two systems is changing the modulation techniques from frequency division to time division. Receiver Block BER Calculator Data Generator Transmitter Block Satellite Downlink Transmitter Antenna Downlink Path Satellite Downlink Receiver Antenna Power Scope Bernoulli Binary QPSK Square root Square root Power Spectrum Error Rate Calculation Tx Rx sRef sDel delay Find Delay 0 0.5005 2.041e+04 4.078e+04 Bernoulli Binary QPSK Square root Square root Error Rate Calculation Tx Rx 0.4966 1.011e+04 2.036e+04 sRef sDel delay Find Delay 0 Convolutional Encoder Viterbi Decoder Filter Designer Filter Designer QPSK QPSK PN Sequence Generator Z -3 Integer Delay1 Z -4 Integer Delay 57.2669 dB (532959) Praraboloidal Reflector Antennas Free Space Path Loss 199 dB 17.3371 dB (54.1644) Praraboloidal Reflector Antennas1 Noise Temperature 300.6 K Receiver System Noise Temperature1 22.934 dB (196.515) Praraboloidal Reflector Antennas2 Test Power Free Space Path Loss 196 dB 44.6442 dB (29135.1) Praraboloidal Reflector Antennas3 Test Power Noise Temperature 150.6 K Receiver System Noise Temperature2 Magnitude AGC Select AGC 3.67e-15 -144.4 4.589 6.617 Test Power 9.548e+10 109.8 Figure 8: CDMA Overall System 3.3.1 Transmitter and Receiver For transmitter, as shown in the figure, it is constructed by the connection of the blocks of Bernoulli Binary Generator, Convolutional Encoder, QPSK: M-PSK Modulator Baseband, Square Root: Raised Cosine Transmit Filter, Multiplex and

code division multiple access 14 Merge. For this system, the main idea is to control the time. To check which user can use the channel at that time. If the time is for the specific user, them, it will use the whole spectrum to do the transmission. 3.4 Code Division Multiple Access The TDMA is very similar to the TDMA, and the main difference between these two systems is changing the modulation techniques from time-division to code division. 3.4.1 Transmitter and Receiver For transmitter, as shown in the figure, it is constructed by the connection of the blocks of Bernoulli Binary Generator, Convolutional Encoder, Relayer, Product, QPSK, Square Root: Raised Cosine Transmit Filter and Add. For this system, the main idea is to calculate and find the orthogonal code, which can be used to product with the signal to implement CDMA.

The only reason why we can use it is because all the code words are orthogonal with each other. Thus, it can be decoded successfully. 4 experiment After all the blocks are properly set, as mentioned in previous sections, the over- all system is simulated. In this report, Only the FDMA is tested as the report can not be infinite length. Transmitter Transmitter Channel Receiver Figure 9: Constellation Diagrams in FDMA The constellation diagrams of the system in each part of the channel is captured and presented as above. As we can see in the receiver part constellation, the

5 conclusion 15 diagram looks acceptable, which is expected to have a low BER. Besides, performance comparison between these three satellite communication system Based on the BER is also be made, as shown in Table 10. Figure 10: TDMA Overall System BER Overall Without Coding No Noise CDMA system 8.90 10 -5 2.47 10 -4 0 TDMA system 1.20 10 -4 4.20 10 -4 0 FDMA system 9.20 10 -5 2.30 10 -4 0 Table 1: BER Comparison Between CDMA, TDMA, and FDMA From the table, we can conclude that the CDMA system the best performance. Then, compare with TDMA, FDMA performs better. 5 conclusion All of CDMA, TDMA, and FDMA communication system can be implemented via MATLAB/Simulink. The complexity of these systems can be varied when implementing communication in different environment.

6 acknowledgements 16 When dealing with signal impairment, coding methods, channel equalizer, Raised Cosine Transmit Filter, matched filter, Automatic gain controller are used to make sure the acceptable received signal quality. Besides, signal impairment is acceptable in the satellite communication when all the losses are acceptable, and all of these three systems have an acceptable performance. 6 acknowledgements First and foremost, thanks to everyone who helps me with this project. In partic- ular, Glasgow College, UESTC, who offers me this project. Institute of Science and Management of the School League Committee offer the place to discuss. Furthermore, I would like to thank Dr. Liyan Zhang and Dr. Jinjun Zheng for explaining the orbit design for me. And I would also like to thank Ph.D. candidate Yang Xu for discussing and guiding me to design the overall system. Thanks for all of these kindnesses and help. references [1] Leroy

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the constraint length, code generator (octal), and feedback connection (octal).	

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modulate the input signal using the phase-shift keying method.		Modulate the input signal using the phase shift keying method.(	

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Square Root: Raised Cosine Transmit Filter: Upsample and filter the input signal using a normal or square root raised cosine FIR filter.		Square Root:Raised Cosine Transmit filter-Upsample and filter the input signal using a normal or square root raised cosine FIR filter.	

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Free Space Path Loss. Free Space Path Loss: Simulate the signal loss when it is passing through the space which Reduce the amplitude of the input signal by the amount	Free Space Path Loss- The Free Space Path Loss block simulates the loss of signal power due to the distance between transmitter and receiver. The block reduces the amplitude of the input signal by an amount

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it is very susceptible to noise interference because noise affects the amplitude [10].	it is very susceptible to noise interference since noise affects the amplitude.

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