

بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِیْمِ

اقْرَأْ بِاسْمِ رَبِّكَ الَّذِي خَلَقَ (١) خَلَقَ الْإِنْسَانَ مِنْ عَلَقٍ (٢) اقْرَأْ وَرَبُّكَ الْأَكْرَمُ (٣) الَّذِي عَلَّمَ بِالْقَلَمِ (٤) عَلَّمَ الْإِنْسَانَ مَا لَمْ يَعْلَمْ

(٥).

(سورة العلق)

DEDICATION

This is dedicated to my father, mother and his soul

ACKNOWLEDGMENTS

First of all, I would like to express my gratitude towards my thesis supervisor Dr. Rashid Saeed ,whose highly professional suggestions and rigorous guidance helped me a lot

to succeed in my research work. In particular, I want to mention the support of my parents, sisters and my brother through this endeavor.

Also, without the strong and long term support from General Sudanese Corporation for radio and TV transmission including my colleagues in Earth-Station department my research could never have been realized.

I would like to thanks Meteorological Authority for the data that they gave me about the rain rate in several cities during the last four years.

المستخلص

النطاق KU يقدم عرض نطاق ترددي أكبر نسبياً ولكنه يتطلب قيمة EIRPs أعلى حتى يمكنه تعويض الفقد الذي تتعرض له الإشارة والذي هو أعلى من الفقد في النطاقات الترددية الأخرى، حيث أنه في النطاق C يكون الفقد طفيفاً ، وملحوظاً في النطاق KU ويمكن إستيعابه. ولكن في الترددات العالية مثال النطاق Ka والنطاق V يكون الفقد كبيراً بحيث لا يمكن تعويضه في مستوى توافر المتوقع عادة للترددات الأقل.

في هذا البحث تمت مناقشة تأثير الأمطار التي لها التأثير الأعلى في الفقد على الإشارة وكيفية حساب قيمة هذا الفقد ، ولإجراء هذه الدراسة تم أخذ 17 مدينة سودانية كعينات للقراءة ، وتم تحويل القراءات من معدل هطول المطر إلى حساب التوهين الناتج عن المطر في النطاق 21 قيقاهيرتز خلال أربعة سنوات متتالية.

التقنية التي تم إستخدامها في هذا البحث للتقليل من الفقد في الإشارة تحت تأثير المطر هي التحكم في توجيه هوائيات الإقمار الإصطناعية ، حيث تتم زيادة الطاقة المنتشرة في المناطق المتأثرة بالأمطار فقط دون المناطق الأخرى.

ABSTRACT

Ka-band offers relatively larger bandwidths but requires higher satellite EIRPs to compensate for higher link fading. At C-band the effects are minor and at Ku-band, while they are noticeable, can be accommodated. But at higher frequencies, such as Ka-band or V-band, the degradation can be so great that it simply cannot be compensated at the level of availability usually expected for lower frequencies.

In this thesis we discuss the effect of rain is that it attenuates the signal and how to calculate rain attenuation , in our research we took seventeen Sudanese cites as sample that we transform rainfall rate to rain attenuation in the 21-GHz band that it's suffers from during four years.

The techniques we used for mitigation rain fading is an adaptive satellite power control method in which the radiation power is increased locally in the area having heavy rainfall (“boosted” beam) while keeping the “nationwide” beam by using phased array antenna.

TABLE OF CONTENTS

	Page
آية	I
Dedication	II
Acknowledgments	III
المستخلص.....	IV
Abstract	V
Chapter One	
Introduction	
1.1 Preface.....	2
1.2 Problem Statement	2
1.3 Literature Review	3
1.4 Methodology	3
1.5 Aim and Objectives	4
1.6 Research Plan	4
Chapter two	
Literature Review	
2.1 Introduction.....	6
2.2 Basic Satellite System.....	6

2.3 Satellite Links.....	7
2.4 Satellite Frequency Allocation	8
2.5 Attenuations (AFS).....	9
2.5.1 Atmospheric Gaseous	10
2.5.2 Cloud Attenuation.....	10
2.5.3 Fog Attenuation	11
2.5.4 Worst Month Statistics	12
2.5.5 Rain Attenuation	13
2.6 Types of antenna	14
2.6.1 Wire antenna.....	15
2.6.2 Aperture antenna.....	15
2.6.3 Micro strip antenna.....	15
2.6.4 Reflector antenna.....	16
2.6.5 Lens antenna.....	16
2.6.6 Array antenna.....	16
2.7 Phased Array Architecture.....	19
2.7.1 Phased Array Based on feed net work design....	19
2.7.1.1 Parallel fed Array.....	20
2.7.1.2 Series fed Array.....	20
2.7.2 Phased Array Based on Phase Shift Stage.....	21
2.7.2.1 RF Phase Shifting.....	21
2.7.2.2 LO Phase Shifting.....	22
2.7.2.3 IF Phase Shifting.....	23
2.7.2.4 Digital Phase Shifting.....	23
2.8 Challenges in Design of Phased Array Antenna.....	24

2.9 Literature Review	26
2.9.1 Fixed allocation of EIRP to rainy area.....	26
2.9.2 Hierarchical transmission	28
2.9.3 Site diversity	28
Chapter Summary.....	29

Chapter Three

Methodology

3.1 Introduction	31
3.2 Rain fade Calculation.....	31
3.3 N-element Linear Array	35
3.3.1 Broad Side Array	36
3.3.2 Ordinary-End fire Array.....	38
3.3.3 Phased(Scanning) Array	38
3.3.4 Calculating Antenna Gain in Phased Array	40
3.3.5 Radiation Pattern	41
3.3.6 Directivity	42
Chapter Summary	43

Chapter Four

Numerical Results and Dissection

4.1 Rain fade calculation	46
4.2 Array factor	51
4.3 Phased array antenna	
Radiation pattern and array configuration	55
4.4 results	62

Chapter Five

Conclusions and Recommendation

5.1 Conclusions	64
5.2 Recommendation	66

References

Appendix A

Appendix B

LIST OF FIGURES

	Page
Figure (2-1) satellite communication converge area	6
Figure (2-2) Three geostationary satellite	7
Figure (2-3) Spectrum satellite communication	9
Figure (2-4) Control the direction and shape of the beam Radiated by the array with element spacing d	19
Figure (2-5) Parallel-fed array	20
Figure (2-6) Series-fed array	21
Figure (2-7) Plan view of site diversity system	28
Figure (3-1) Drain parameters	32
Figure (4-1) Rain attenuation at Ka band and Ku band	47
Figure (4-2) Rain attenuation with availability 99.9%&99.7%&99%	48
Figure (4-3a) Rain attenuation at 12GHZ (V) & (H)	48
Figure (4-3b) Rain attenuation at 20GHZ (V) & (H)	49
Figure (4-4a) Array Factor when N=5 and d=dmax	50
Figure (4-4b) Array Factor when N=10 and d=dmax	51
Figure (4-4c) Array Factor when N=20 and d=dmax	51
Figure (4-4d) Array Factor when N=60 and d =dmax	52
Figure (4-5) Array Factor when d=dmax ,N=5,10,20,60	53
Figure (4-6) Array Factor when d=dmax/2, N=5,10,20	54
Figure (4-7a) Ratio between distance and wave length $d/\lambda=0.1$	55
Figure (4-7b) Ratio between distance and wave length $d/\lambda=0.5$	55
Figure (4-7c) Ratio between distance and wave length $d/\lambda=1$	56
Figure (4-7d) Ratio between distance and wave length $d/\lambda=2$	56
Figure (4-7e) Ratio between distance and wave length $d/\lambda=5$	56

Figure (4-8a)	Number of antenna elements =4 & $d/\lambda=0.5$	57
Figure (4-8b)	Number of antenna elements =16 & $d/\lambda=0.5$	57
Figure (4-8c)	Number of antenna elements =60 & $d/\lambda=0.5$	58
Figure (4-8d)	Number of antenna elements =100 & $d/\lambda=0.5$	58
Figure (4-8e)	Number of antenna elements =180 & $d/\lambda=0.5$	59
Figure (4-9)	Radiation pattern change	59

LIST OF TABLES

S/N	Table	Description	Page
1	3-1	World Regions	33
2	3-2	Worlds Zones	33
3	3-3	K and α Values	34
4	4-1	Rain Attenuation in Sudanese Cities	46

LIST OF ABBRIVIATIONS

ADC	Analog-to-Digital Converter
AF	Array Factor
AFS	Attenuation with respect to Free Space
BPSK	Binary Phase Shift Keying
BSS	Broadcasting Satellite Service
C/N	Carrier-to-Noise ratio
DAR	Digital Audio Radio Service
Db	Decibel
DSP	Digital Signal Processing
E_b/N_0	Energy per bit Noise density ratio
EHRP	Extremely High Resolution Imagery
EIRP	Equivalent Isotropic ally Radiated Power
FSS	Fixed Satellite Services
GHZ	Giga Hertz
HD	High Definition
IEEE	Institute of Electrical and Electronics Engineers
IF	Intermediate Frequency
ITU	International Telecommunications Union
LMOS	Local Multichannel Distribution Service
LO	Local Oscillator
MIMO	Multiple-Input Multiple-Output

MSS	Mobile Satellite Service
PSK	Phase Shift Keying
RF	Radio Frequency
SVC	Scalable Video Coding
T/R	Transmit/Receive
UHD	Ultra High Definition
UHF	Ultra High Frequency
VCM	Variable Coding and Modulator