A PROPOSED IMPLEMENTATION OF DIGITAL TERRESTRIAL TELEVISION (DTT)

CASE STUDY: ASHANTI REGION-GHANA

BY

SIAW NTOW JERRY

A Project Submitted in partial fulfilment of the Requirements for the Masters of Science Degree in Telecommunication Engineering

Kwame Nkrumah University of Science and Technology

College of Engineering

Department of Electrical/Electronic Engineering

July, 2013

DECLARATION

This thesis is submitted as part fulfilment for the award of Master of Science (MSc.) in Telecommunication Engineering.

This work is the result of my investigations. All sections of this work which have been obtained from other sources are fully referenced. I understand that cheating and plagiarism constitute a breach of Kwame Nkrumah University of Science and Technology (KNUST), Kumasi.

Siaw Ntow Jerry, ID: PG 2653208 ………………… ……..………

(Student Name and ID) Signature Date

Dr. Emmanuel Kofi Akowuah ………………… ………………

Supervisor's Name Signature Date

………………… ………………… ………………

Head of Department Signature Date

DEDICATION

This thesis is dedicated to the Almighty God for his Guidance and Protection throughout my academic pursuit, May his name be praised both now and forever more, Amen. To my Soul mate, Mrs. Lydia Siaw for her love, support and encouragement, to my most treasure children Paa Joe, Sister Vanessa and Awura Akua and to my mother and father, brothers and sisters.

ACKNOWLEDMENT

I am most grateful to my Supervisor, Dr. Emmanuel Kofi Akowuah who supervised this work and offered all the necessary guidance, in fact he has helped in all diverse ways to make this work a success, without him, this work would not have been possible.

My special thanks go to the entire lecturers of MSc. (Telecommunication Engineering) who taught me in my academic ladder. My profound gratitude goes to my friends for their advice and support.

My wife, Mrs. Lydia Siaw, has enriched this work both spiritually and financially, my mother and father who have enriched this work both spiritually and financially, to my children, I owe all of you immeasurable gratitude.

Finally, my sincere thanks go to the Mr. Affum Emmanuel (Lecturer, Electrical Engineering Department, KNUST- Kumasi) and Mr. Sobeng Solomon (former student Telecommunication Engineering Department, KNUST- Kumasi) who have helped me in one way or the other.

ABSTRACT

Analog to digital television transmission is the transition from analog broadcasting to digital broadcasting. The International Telecommunication Union (ITU) has mandated every country to move from analog television to digital terrestrial television (DTT) by 2015. Ghana has chosen the Regional Rollout, where there is a move in phases through the regions. GBC (smart TV) has implemented a pilot project of the DTT in Kumasi and Accra.

This thesis proposes the implementation of DTT in Ashanti Region, using the pilot project by GBC (Smart TV) in Kumasi, with aim of proposing a DTT that would give a full coverage in the Ashanti Region. In order to propose a way to give a full coverage with a good quality of service in the region, Smart TV Set Top Box (STB) and Skyy TV STB were taken to various areas in Kumasi and its environs. Parameters such as Bit Error Rate (BER), Signal to Noise Ratio (SNR)and Signal Strength (SS) were recorded by Smart TV STB and Skyy TV STB at various distances from their respective transmitters and were investigated using MATLAB. The values recorded by Smart TV was used to simulate the different modulation scheme using MATLAB and predicted that 8PSK was the best modulation scheme to be used by Smart TV in Ashanti Region. The research further provides simulation in terms of measured signals and theoretical values of three propagation models. Based on that the Rec. ITU P.370 propagation model was proposed for the region by comparing to free space model and Okumura model, additional new sites were also proposed for the smooth transition in Ashanti Region.

TABLE OF CONTENTS

The final acts of the Regional Radio Communication Conference (RRC), 2006 in Geneva organized by the International Telecommunications Union (ITU), recommended the switch off of analog broadcasting services around 2015 and their replacement by digital broadcasting systems. As a result efforts are been made by various countries to meet the deadline. As such researches are being conducted to choose the best technology for convergence, and various surveys are being conducted to choose various sites for transmitters and receivers. Digital television (DTV) is the transmission of audio and video by digitally processed and multiplexed signal, in contrast to the totally analog and channel separated signals used by analog TV. Many countries are replacing broadcast analog television with digital television to allow other uses of the television radio spectrum. Several regions of the world are in different stages of adaptation and are implementing different broadcasting standards

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

As part of measures for Ghana to migrate from analog Television to digital television, the National Communications Authority (NCA) which is the frequency regulatory body in Ghana undertook re-planning of frequencies in the bands 174-230MHz and 470-862 MHz from 2004 to 2006 which was finalized at the ITU's Regional Radio communication Conference (RRC-06)[1]

The National Digital Migration Technical Committee (NDMTC) has set December, 2014 as the date of switchover from Analog Television to Digital Terrestrial Television (DTT) in Ghana to the Government of Ghana in their final report[2].

Statistics has shown that television viewing is on the rise in Ghana, with the reducing cost of Television sets [2].

Digital television is now an integral part of the information superhighway that is being built to deliver large amounts of information at very low cost compared to analogue technology and can be fully integrated into completely digital transmission networks. Digital television can deliver more programs than traditional analog television over one transmission channel and can be manipulated and treated in various ways which were never possible with analog television.

In addition, digital images can be stored on computers and discs and to be played continuously over digital networks without signal degradation until a certain threshold value is reached. Pictures can be modified, compressed, stored and transmitted. Another advantage of the digital format is that it can be integrated with telephone conversations as well as computer data and then transmitted from one network to other broadcast networks. Furthermore, any program can be stored on multimedia servers (movie, fillers and jingles, advert, songs) and retrieved instantly for broadcast to a single or multiple viewers on demand [3].

Bit Error Rate (BER), Signal to Noise Ratio (SNR), Signal strength(SS) e.t.c are studied to get a good quality of service for the receivers, by measuring signal reception quality at various areas in Ashanti Region for GTV and SKYY DTT transmission using Smart TV and Skyy TV Set top Boxes (STBs).This project seeks to establish how efficient and how best it can be optimized for a better signal reception during DTT era in Ashanti Region with the use of GPS and Decoders to take measurements.

1.2 Problem Statement

Ghana is switching from analog Television to digital Television so the need for measures to meet the deadline. Measures have to be put in place to take care of a more sophisticated multi-channel environment and also a larger number of separate processes and switching stages through which a radio or television signal will pass, since at any moment, one signal may fail or detrimentally affect the picture or sound quality. Hence, the opportunity for faults and failures occurring between the broadcaster and the consumer will increase. It will become more and more difficult for a broadcast engineer to know whether a signal, after passing through all these separate processes and transmission paths, will reach the consumer in a correct audio and picture format. This project seeks to investigate the parameters such as bit error rate (BER), signal to noise ratio (SNR), number of transmitters, T-R separation, and signal strength to compare three propagation models and to compare modulations schemes that need to be used to get a clear signal to the receivers in Ashanti-Region.

1.3 Scope of Study

Digital terrestrial television/transmission (DTT) systems are transmitted on three main platforms: terrestrial, satellite and cable. All transmission modes are currently being deployed in Ashanti Region, Ghana. The focus of this thesis will be on DTT broadcasting in Ashanti Region which includes carry out detailed measurements in the area of (Bit Error Rate(BER), signal strength(SS), signal to noise ratio (SNR), Coordinates) in selected areas. Analyzed the system capacity in bit per seconds and BER in terms of SNR and further make appropriate recommendation for system improvement. Also in the analysis of the recorded values, focus will be on the parameters to determine the quality of the service received, including the Signal Strength (SS), Signal-to-Noise Ratio (SNR), Bit Error Rate (BER), as well as the distance away from the respective transmitters.

1.4 Research Methodology

The GTV (Smart) and Skyy digital networks were used for the case study. The Smart and Skyy Set Top Boxes (STBs) were taken to a number of stations at various distances within Kumasi and its environs and the receiver information provided by the STBs system at an antenna height of 1.5m and 10m were recorded and tabulated. At the receiver terminal, several values were taken and distances from the transmitters as recorded by the decoder (values) are used to analyze (BER), modulation schemes and capacity analysis of multi-band orthogonal frequency division multiplexing (MB-OFDM), using MATLAB. Physical map of Ashanti-Region was used to propose the number of transmitters to give full coverage in the region and also to determine how signals will be transmitted from the transmitter to receiver. The theoretical and measured values of three propagation models were compared by using their respective equations and simulated using MATLAB.

1.5 Limitations

There are more Television stations in Kumasi but due to time constraint, various technical backgrounds of the stations and the cost involve in buying the various decoders, Smart TV and Skyy TV decoders were used. However, Smart TV covers a large coverage area there is the probability of it being used by many people. Also Smart TV is being operated by GTV. If problems are solved with the Smart TV more people are likely to get better quality of service in the region. Skyy TV was used in comparing some parameters with Smart TV so far as the quality of service is concerned.

1.6 Objectives of the project

The objectives of the thesis among other things will be to:

1. To propose the optimal location of transmitters for full coverage of Ashanti region using smart TV.
2. To propose an appropriate propagation model for wireless environment in Ashanti region
3. System performance analysis.

1.7 Relevance of Study

Ghana and part of the world has dramatic rise in the use of television (TV) sets and has even become part of everyday life. There is a rise over a short period of time without a corresponding development in the way to get a clear unobstructed image on TV sets. Again, the introduction of many operators and competitive technologies has driven prices downwards, thereby compelling more users across the social divide and ages to subscribe the services for different users such as advert and other financial transaction. This research would propose a quality of service with regards to DTT for clear images to the customers in the region.

This project aims to define the propagation model which would best fit this migration.

Taking Ashanti region as the case study, the ITU-R P.370 propagation prediction model, Okumura propagation prediction model and Free Space model were focused as the area of study. This project is meant to expose the model with minimal losses in its implementation in the region.

1.8 Organization of the Project

Following the current chapter is Chapter two which gives a comprehensive review of available technologies with regards to DTT. It provides a good basic concept of DTT and reviews some of the prominent works by other researchers in the area of DTT. Chapter three gives a background of tools and models employed in the analysis of the results.

Chapter four deals with the use of Tools, Models presented in chapter three for analysis of results of findings from the field test.

Finally chapter five concludes and makes appropriate recommendations

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The final acts of the Regional Radio Communication Conference (RRC), 2006 in Geneva organized by the International Telecommunications Union (ITU), recommended the switch off of analog broadcasting services around 2015 and their replacement by digital broadcasting systems. As a result efforts are been made by various countries to meet the deadline. As such researches are being conducted to choose the best technology for convergence, and various surveys are being conducted to choose various sites for transmitters and receivers. Digital television (DTV) is the transmission of audio and video by digitally processed and multiplexed signal, in contrast to the totally analog and channel separated signals used by analog TV. Many countries are replacing broadcast analog television with digital television to allow other uses of the television radio spectrum. Several regions of the world are in different stages of adaptation and are implementing different broadcasting standards [4]

In a bid to ensure Ghana's conformance to the GE06 Agreement, in January, 2010 the National Digital Broadcasting Migration Technical Committee (NDBMTC) was inaugurated [5]. Their report focuses on the migration from analogue to digital terrestrial television (DTT) since Satellite and cable TV in Ghana are already digitalized and most Ghanaians however depend on terrestrial TV (which is TV that uses a common aerial for signal reception) for information dissemination; education and entertainment**.**

There were some findings by the Committee, which identified that there is no single worldwide standard for digital broadcasting and different markets have developed or adopted different standards. Europe and Africa have adopted Digital Video Broadcasting (DVB). North America has adopted Advanced Television Systems Committee (ATSC) and the Japanese and some South American states have adopted Integrated Services Digital Broadcasting (ISDB) standards.

The Committee recommends the adoption of DVB-T (EN 300 744) for terrestrial digital television broadcasting, in accordance with the decisions taken at RRC-06 because it has been proven to deliver all the benefits expected from digital broadcasting. DVB-T has also been proven to deliver all the functionalities that ISDB, the Japanese standard, can offer. [5]

Table 2.1 The launching of DTT and the closing down of analogue television in some countries [4]

Country	**Official launch**	**Start of closedown**	**End of closedown**
Australia	Jan 1, 2001	Jun 30, 2010	Dec 10, 2013
Cambodia	2011(trial) 2012 (delayed)	2012	2020
France	Mar 31, 2005(FTA) Mar 1, 2006(Pay DTT)	Feb 4, 2009	Before Nov 30, 2011
Germany	Mar 2003	Mar 2003 (Regional Rollout)	Dec 2, 2008
Brazil	Jun 2006	2013	Jun 29, 2016
S. Africa	Mar 2006	Nov 1, 2008	Nov 1, 2011

It can be seen from the above that some countries have completely migrated fully to digital terrestrial television transmission and others in the process have different deadlines. The deadline for analogue switch-off in Ghana as designed by the committee is scheduled for December 2014. South African is the first African country to have migrated fully to digital terrestrial transmission by the ending of 2011. There are several approach adopted for the migration to Digital Terrestrial Transmission. The first being the Regional Rollout where there is a move in phases through regions, the second being digitizing of the transmission network between production studios and different broadcasting stations based on the transmission stations spread throughout the country and offering National digital terrestrial TV broadcasting Network to viewers throughout the country. Ghana has opted for the first approach, hence the relevance to this thesis to aid the deployment in Ashanti-Region. Some of the technical aspects of the DTT are being reviewed.

2.1 Digital Television

The DVB-T standard was produced in 1997 following several measurements and testing by various projects. Digital television is now an integral part of the information super high way that is being built to deliver large amount of information at very low cost compared to analogue technology and can be fully integrated into completely digital transmission networks[3]. Digital television can deliver more programs than traditional analog television over one transmission channel and can be manipulated and treated in various ways which were never possible with analog television. We can therefore store digital images on computers and discs and play them continuously over digital networks without signal degradation until a certain threshold value is reached. Pictures can be modified, compressed, stored and transmitted [3].One advantage of the digital format is that it can be integrated with telephone conversations as well as computer data and then transmitted from one network to other broadcast networks.

Furthermore, any program can be stored on multimedia servers (movie, fillers and jingles, advert, songs) and retrieved instantly for broadcast to a single or multiple viewers on demand [3].

However, having good Quality of Service and cheaper services do not mean that the problems of transmission and reception of digital signal broadcasting are completely solved [6]. A correctly-formatted DTV signal is exposed to various factors which can detriment the sound or picture quality before it reaches the intended customers [6].For that reasons, many organizations and researchers are working on various areas such as transmitter and antenna models, propagation and coverage failures, compression techniques and standards in order to overcome the implementation problems in view of setting frame works and standards for digital television implementation

Digital broadcasting refers to digital techniques i.e. the compression of the picture and the sound information before transmitting to viewers/listeners [6].

Digital TV broadcasting has a number of advantages compared to Analog TV broadcasting. It has a more robust signal, higher and consistent technical quality, increased flexibility, seamless integration into other applications and services. It improves user control over what and when one views or listens, and creates greater choice in content among others[6]. The analogue system of broadcasting utilizes one whole frequency channel of 7MHz or 8MHz to transmit program of one station.

However, on a digital broadcasting platform, about 4 to 16 TV program (representing 4 to 16 TV stations) can be transmitted over one frequency channel of 7 or 8 MHz. It also provides for the additional capacity of public transmission of audio broadcasting and other data communication services

The important features and benefits of Digital TV to the consumer are[6]:

i. Better Picture quality
ii. Clearer Sound (quality audio)
iii. No ghosting, reduced blurred images etc.
iv. More stations and therefore more choice.
v. More interactivity

Digital Terrestrial TV is the transmission of TV signal with land based antennas. The main difference between digital and analog TV signal is that the digital signal is compressed into bytes and sent as data to a receiver while the analog signal is carrying a recorded video feed. Digital Terrestrial Television (DTT) is therefore expected to be the most dominant digital TV platform [4].

As a result of its benefits the whole world is migrating to Digital Television Broadcasting. The International Telecommunications Union (ITU) is leading the way in order to make the transition from Analog Television Broadcasting to Digital Television

Broadcasting as smooth as possible. Countries such as Luxembourg, the Netherlands, Finland, Andorra, Sweden, Switzerland, Germany and the U.S.A have already made the full transition [4].

However, looking at the advantages of the digital TV as described in section 2.1, it will be very important for the people in Ashanti-Region to benefit from this migration so that the number of programs per channel can be increased for them to get more local programs, local advert e.t.c to ease the pressure from the national TV.

The technical aspects of a broadband digital transmission standard are quite suitable for providing multimedia video base services. Both the government and digital TV operators should pay special attention to maintaining and balance a development path between an ordinary public services and commercial path services. The cost of STBs to the receivers as well as the condition of future integration in TV sets should be considered very well in the transition. Digital TV signal like any other digital data has the potential to combine TV services with internet and telephony services to provide end users with an integrated entrainment and communication.

2.2 Basics of DVB-T

Rather than carrying the data on a single radio frequency (RF) carrier, OFDM (orthogonal frequency division multiplexing) works by splitting the digital data stream into a large number of slower digital streams, each of which digitally modulates a set of closely spaced adjacent carrier frequencies[7].

In the case of DVB-T, there are two choices for the number of carriers known as

2K-mode or 8K-mode. These are actually 1.705 or 6.817 carriers that are approximately 4 kHz or 1 kHz apart [8]. DVB-T offers three different modulation schemes (QPSK, 16QAM, 64QAM), whiles DVB-T2 has (QPSK, 16 QAM, 64QAM, 256 QAM [9].

DVB-T has been adopted or proposed for digital television broadcasting by many countries, using mainly VHF 7 MHz and UHF 8 MHz channels. DVB-T receivers are generally manufactured so that they can be set up to work with all these different systems without being made for specific countries or regions [8]. The DVB-T Standard is published as EN 300 744, Framing structure, channel coding and modulation for digital terrestrial television. Details of the DVB use of source coding methods for MPEG-2 and, more recently, H.264/MPEG-4 AVC as well as audio encoding systems have all outlined in the standard. Many countries that have adopted DVB-T have published standards for their implementation. These include the D-Book in the UK, the Italian DGTVi, the ETSI E-Book and Scandinavia Nor Dig [9].DVB-T has been further developed into newer standards such as DVB-H (Handheld), now in operation, and DVB-T2, which was recently finalized [9].

DVB-T as a digital transmission delivers data in a form of discrete blocks at the symbol rate. DVB-T is a COFDM transmission technique which includes the use of a Guard Interval. It allows single-frequency network (SFN) operation, where two or more transmitters carrying the same data operate on the same frequency. In such cases the signals from each transmitter in the SFN needs to be accurately time-aligned, which is done by synchronizing the information in the stream timing at each transmitter referenced to GPS(Global Positioning System) [9].

The length of the Guard Interval can be chosen. It is a trade off between data rate and SFN capability. The longer the guard interval the larger is the potential SFN area without creating Inter Symbol interference (ISI). It is possible to operate SFNs which do not fulfill the guard interval condition if the self-interference is properly planned and monitored [9]. The DVB technology uses COFDM (code orthogonal frequency division multiplex) which splits the digital streams into a large number of slower data streams making multiplexing easier and better than carrying the data on a single radio frequency carrier, hence the need to adopt DVB.

DVB-T provides sufficient bandwidth for multimedia information which can serve large number of users.

Architecture of DVB-T2 Network

The architectural illustration of how DVB-T2 network is implemented is shown in Figure 2.1 [7]. The difference in the DVB-T andDVB-T2 networks is addition of new network nodes (T2 Gateway), a change in the modulator/transmitter to T2 modulator and implementation of the transmission link in T2 (T2-MI (Modulator interface)) can be both in ASI or IP whilst that in T is strictly ASI [7]. Based on the architecture of DVB-T2 transmissions, three additional nodes need to be added to that of the T1 network: T2 gateway, T2 modulator (transmitter) and a new interface for transmission.

Below are the key features needed for DVB-T2 implementation [7]; T2-MI, SFN MISO, with seamless switch, Multi-PLP support and TFS (optional).

A DVB-T2 is an MPEG-2 Transport Stream with a bit rate as specified in ETS 302 755 (for DVB-T2 standard), and ending with the power output of the DVB-T2 signal after the output filter. All transmitters shall be capable to operate in a Single Frequency Network and/or Multiple Frequency Network as appropriate depending on the Network design [18]. The general requirements for DVB-T2 transmitter should take into account; the noise requirements, connector types, local interface, remote interface, Web GUI, SNMP interface and the event log. Details of these specifications for Ghana are outlined in the Bidding document for DTT network of Ghana [10].

The technologies employed by the various working parts of the DVB-T2 transmitters the standards Ghana intends adopting has the following parts[10]

- Modulator (Input Signal and Test Signal)
- Working frequency (Frequency Range, IF, External Reference)
- Synchronization (Frequency and time reference, Stability, Internal Reference, Behavior In case of GPS Failure, SFN Propagation Delay Compensation, Dynamic Delay Compensation, Static Delay Compensation),
- Transmitter power (Output power, Nominal Power, Power consumption, Stability, Return loss, Efficiency),
- Outage stage, measurement/test point (transport stream, RF test point and isolation point),

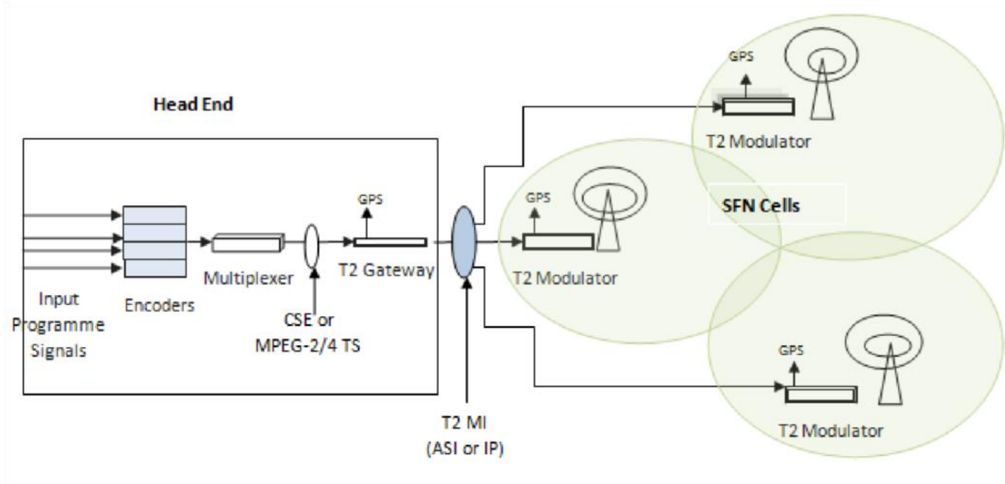

Figure 2.1;

DVB-T2: Typical Architecture [7]

Generally, digital television transmitter networks consist of the following parts [10]: The Head End that is made up of Central multiplex center and central monitoring and operations center. The Transmission Link thus the (Multiplex-to-Transmitter Link) made of the radio relay, fiber optic or satellite) and Distribution links making up the radio relay [Main and Fill-In Transmitters], satellite or cable

Table 2.2 Useful bitrate (Mbits) for all combinations of code rate, FEC etc. for non-hierarchical systems for 8MHz channels (irrespective of the transmission modes) for DVB-T/T2[11]

Modulation	Code rate	Absolute maximum bitrates				
		Bitrates/Mbit/s	**Frame length**	**FEC block per frame**	**Bitrates/ Mbit/s**	**Frame length**
QPSK	½	7.48255			7.444273	
	3/5	9.00374			8.9457325	
	2/3	10.0186	62	52	9.9541201	60
	¾	11.27054			11.197922	
	4/5	12.02614			11.948651	
	5/5	12.53733			12.456553	
16-QAM	½	15.03743			15.03712	
	3/5	18.07038			18.67038	
	2/3	20.10732	60	101	20.107323	60
	¾	22.6198			22.619802	
	4/5	22.13628			24.136236	
	5/5	25.16224			25.162236	
64-QAM	½	22.51994			22.481705	
	3/5	27.11257			27.016112	
	2/3	30.11257	46	116	30.061443	60
	¾	33.87524			33.817724	
	4/5	36.1463			36.084927	
	5/5	37.68277			37.618789	
256-QAM	½	30.08728			30. 074863	
	3/5	36.15568	68	229	36.140759	60
	2/3	40.23124			40. 214645	
	¾	45.25828			45. 239604	
	4/5	48.29248			48. 272552	
	5/6	50.34524			50. 324472	

However, the DVB-T2 has some advantages such as T2 node, 256-QAM, 16k, 64k which will help increase coverage, giving a better quality of service compared with the DVB-T. It also has more channels per frequency than DVB-T. Although GOtv has launched DVB-T2 in Ghana, Smart TV (GTV) is yet to deploy DVB-T2 in Ghana,

hence the need to pay attention since it is a national TV station.

2.3 Visible High Frequency (VHF) and Ultra- violet High Frequency (UHF) Propagation

Propagation in the VHF and UHF is mainly by space waves since surface wave is rapidly attenuated at VHF and UHF [12]. In the VHF band, diffraction allows short-range reception into build-up areas. However, in the UHF band, signals tend to diffract only slightly around hills and mountains compared to VHF band. Thus, diffraction loss around hills is less in VHF Band than UHF Band [12]. It is therefore very easy to predict the transmitter service area at UHF, once the terrain data is available together with the transmitter location, Effective Radiated Power (ERP), and aerial height [12].

Band II 87.5- 108 MHz is used for FM radio while Band III, 174—230 MHz includes channels 5, 6, 7, 8, 9, 11 and 12. During the 1960s, most countries in Europe wanted to start a second channel. Since the national TV stations had a monopoly in almost all European countries, the development of private TV was restricted and the number of channels was small. It took some time before the UHF frequency bands were brought into operation. In the UHF frequency bands, 470 - 862 MHz, there are much more bandwidth including channels 21- 69 [13].

However, distributing TV at these higher frequencies is much more dependent on a free line of sight between the transmitter and the receiver than is the case in the VHF frequency ranges. Wider bandwidth per channels per waveband is attractive for television, as well as higher gain antennas [12].

2.4 Multipath

As radio waves are reflected, refracted, diffracted or scattered by trees, hills and mountains, buildings and other obstacles, they establish various transmission paths from the transmitter to the receive antennas[3].

A typical multipath scenario is one in which direct signals are received at the same time as indirect ones which arrive at the antenna via scattering from nearby trees, utility poles, other structures, the side of a mountain, or a nearby water body. The sum total of received signals may add constructively or destructively resulting in signal enhancement or fade. An example scenario is illustrated figure 2.2. The received power is a manifestation of the phasor sum of the direct transmission and the combined indirect voltage levels. These depend upon the scattering cross sections of the multipath reflectors, their number, and their relative distances to the antenna and the received field [3].

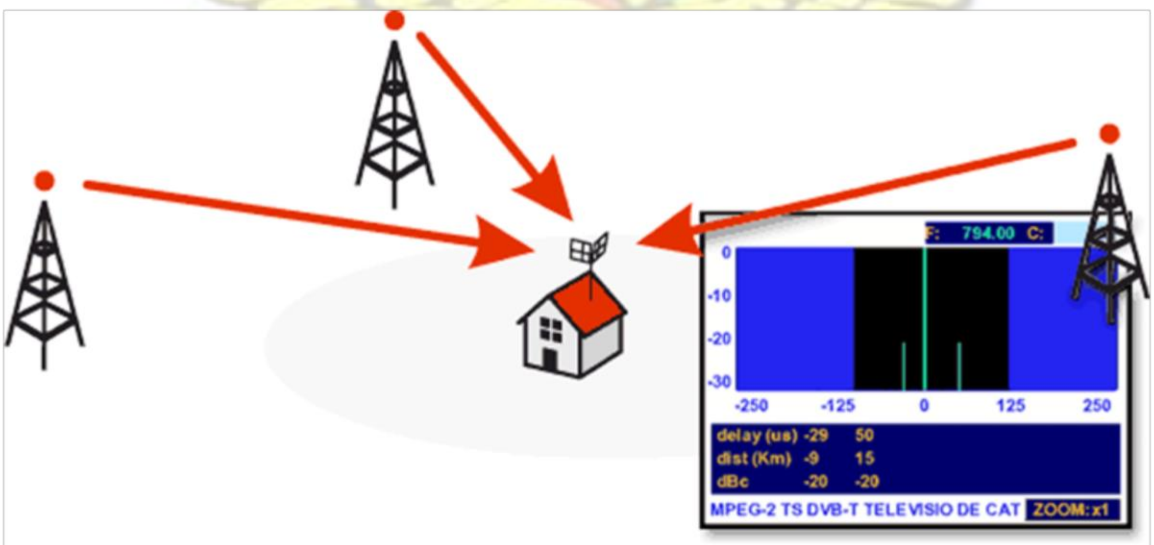

Figure 2.2: Multipath with SFN [14]

A Single Frequency Network (SFN) is a broadcast transmitter network consisting of transmitters with overlapping coverage areas that transmit the same program in the same frequency channel at the same time Consequently, the same signal can arrive at a receiver antenna from different SFN transmitters, each with its own delay, which is related to the distance between receiver and transmitter [14]. The receiver can deal with this effect in the same way as it deals with multipath propagation: the signals arriving from distant transmitters are considered as echoes from the signal arriving from the nearby transmitter. In conventional analog transmission schemes(as PAL television) multipath reception results in ghost images. So SFNs were traditionally not possible [14].

However, since OFDM systems with guard intervals are inherently capable of handling multipath, SFNs become practical in DTTB. Since SFNs improve the efficiency of spectrum usage considerably, the SFN-feature is an important advantage of OFDM systems over analog and single carrier digital systems. The difference between[14]

- local SFNs, consisting of a single main transmitter and a few gap-fillers to cover shielded areas, and
- Nation-wide SFNs, consist of a large number of main transmitters.

Haneda and et al, 2013[15] did work on the method of estimating spatial degrees of freedom (DoF) from measured multipath propagation channels in the multiple-input single-output regime and predicted that the DoF on the Tx side of the considered multipath channels reveals larger values when the antenna aperture size is increased at a fixed frequency, when the frequency increases for a fixed antenna aperture size. Also for a fixed frequency, increasing the antenna aperture size is more effective in observing extra DoF in the obstructed and non-line-of-sight channels than in the line-of-sight channels. Furthermore, for a fixed antenna aperture size, the use of the higher frequency brings larger DoFs in many propagation scenarios. It also predicted that electrically smaller antennas are more efficient in observing the DoF.

Aling Lu and et al, 1997 [16] studied how multi-beam antennas at the cell-site can be used to increase the system capacity and improve the quality of service and predicted that the use of antenna pattern may have an effect on the channel's characteristics in the multipath propagation environments and the use of a sectorized antenna pattern tends to reduce the multipath diversity since a portion of multipath components are suppressed to a certain extent. The investigation of the effect of the antenna pattern on the mobile
RAKE receiver was also studied and predicted that a higher SNR is required for RAKE reception in a multipath fading environment to guarantee an acceptable bit-error-rate performance and at a given BER, the excess SNR requirements depend on the beam width and side lobe levels of the sectorized antenna, as well as the characteristics of the propagation environment. In a multipath scenario, although the adjacent beams have a relatively high correlation in the channel's impulse response, the RAKE receiver at the mobile can take advantage of the soft-handoff from beam to beam to greatly improve the RAKE reception in fast fading channels.

2.5 The mode of Transmission of DTT

The mode of transmission of DTT can be link by microwave, fiber optic or satellite.

2.5.1 Microwave

It is a kind of electromagnetic wave which ranges from 300MHz to 300GHz. It is a plane wave with electric and magnetic fields, which exist at vertical direction of the plane wave. It is called transverse electric and magnetic field wave; it is line of sight communication. Being a line-of-sight system limited by the horizon, the height of the antenna above the earth plays an important role in determining the transmission distance in microwave communication. Microwave are usually bent or refracted beyond the optical horizon, i.e. the horizon visible to our eyes. Hence, the radio horizon is generally further away from the optical horizon. However, the distance to the radio horizon varies with the atmospheric refractive changes and can be even less than the optical horizon at times [17].

2.5.2 Satellite communication

Early satellites were designed with single spatial beam providing wide earth coverage. Theoretically, three such satellites properly placed in synchronous orbit could provide 100% coverage of the earth as shown in Figure2.7. Typically, these satellites had an EIRP of 20 to 28 dBW, requiring large earth station antennas (10 – 30m) for operation in C band. Technological advancements have brought about the use of multiple directional antennas on the present day satellites, each antenna providing a narrow spot beam, covering a small geographical area and an EIRP of 35 to 50 dBW. These satellites can operate with considerably smaller sized antennas of 3 to 6m [17].

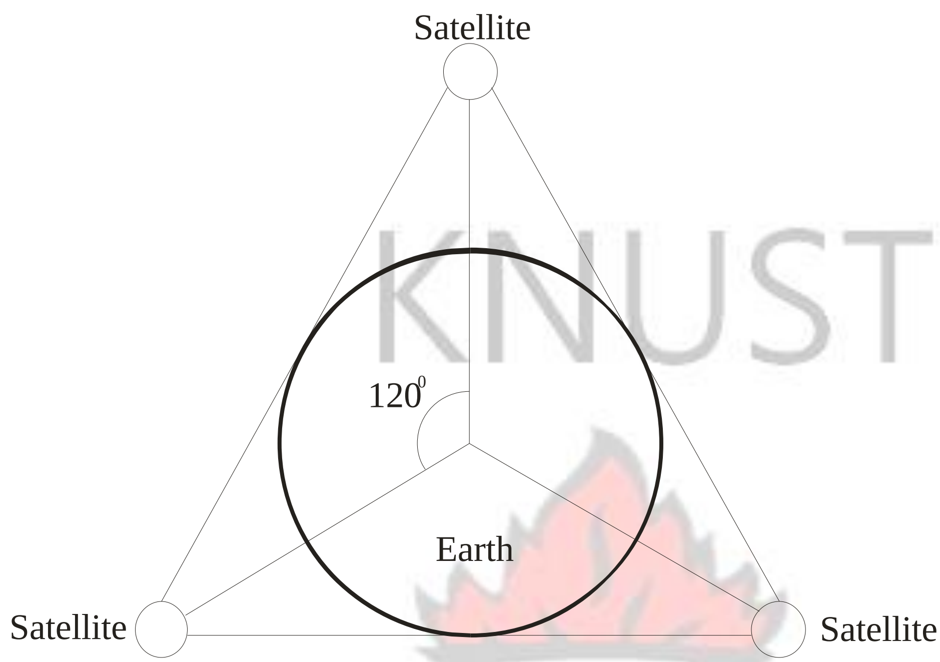

Figure 2.3: Satellite Positioning for 100% Earth Coverage

Spot beams give an added advantage of spectrum reuse. Same frequencies can be used for different geographical areas, thus achieving more effective bandwidth. Frequency reuse can also be achieved by using different polarizations in the beams. INTELSAT V reuses the 500-MHz C band four times and its successor INTELSAT VI is designed to reuse the spectrum six times. (INTELSAT) is an international organization set up in 1964 to establish and manage a global satellite communication system). Multiple beams, however, tend to isolate communities of earth stations removing the advantage of worldwide connectivity of geostationary satellite [17].

2.5.3 Fiber optic communication

Optical fiber network are characterized by [17]

1. High speed operation (typically 100 Mbps or more)

2. Ability to span large distance (100 – 200km)
3. Ability to support a moderate number of stations; typically 10 to a few hundred stations are supported with a maximum limit around 1000.

These characteristics make the fiber optic networks suitable for high speed LANs and MANs with a limited number of stations. Fiber networks may be configured around a star, ring or bus structure. The number of stations that can be supported in a star or a bus structure is relatively low compared to that in a ring configuration [17]. Optical fibers are inherently unidirectional and this influences the way in which the network structures are realized, and the consideration for medium access. Some of medium access considerations discussed in the context of MANs is also applicable to fiber optic networks (FONs) [17]

2.6 DVB-T2 mode for SFNs

One approach for selecting a mode for SFN operation would be to select the length of the guard interval according to the physical size of the SFN or the SFN's intra transmitter separation distances, noting of course that it may be possible to have larger transmitter separations than the guard interval depending on practical considerations such as terrain, propagation and system robustness etc. Additionally, optimization of coverage by modification of antenna diagrams, transmitter powers, antenna heights, transmitter timing etc, may allow larger transmitter distances in the SFN than the guard interval [8].

However in such cases detailed coverage simulations need to be made. The choice of modulation determines the bit rate (capacity), but it also has a large impact upon the robustness of the system. Higher order modulation schemes that offer more capacity are more fragile. It should, however, be noted that due to the more efficient channel coding, rotated constellation etc. used in DVB-T2, compared with DVB-T, 256-QAM will require C/N values in the same order of magnitude as those previously required for 64-QAM, that is, values in the order of 17 – 20 dB depending on the code rate used[8].

Tormos and et al, 2011 [18] studied how to evaluate and compare the performances of different network combinations from the usage of coded MISO (Multiple Input Single Output) in a Single Frequency Network (SFN) forDVB-T2. They also addressed classical SFN and different MISO-SFN network combinations and predicted that the number of combinations depends on the number of transmitters. They also proposed an additional table of these combinations in the T2-Gateway. They also predicted that the performances of the received signals depend on the network combinations and the difference can be higher than 2 dB.

According to Yang [19] and et al, 2011 a new positioning system using transmitter signature waveforms of DVB-T2 in Single Frequency Networks (SFNs) was proposed and predicted that, due to the wide coverage of the SFN and extremely high transmission power of digital television (DTV) transmitting stations, positioning based on DTV SFN can be considered as a promising complementary to remedy the poor coverage of the Global Positioning System (GPS) in dense multipath propagation environments. The proposed positioning system is fully compatible with the current DVB-T2 standard and therefore, no dedicated hardware modification is required. The performance of the proposed positioning system is evaluated through computer simulations under different signal propagation scenarios and compared with existing methods. Simulation results show that very high accuracy can be obtained with the proposed positioning system.

Planning A DTT Network

Two important factors to consider in planning a DTT network [20] are

- Protection Ratio
- Minimum Field Strength

Protection Ratio

Protection ratio specifies the extent to which unwanted field strength must be less than wanted field strength. It is the minimum ratio of the power of the wanted signal to the power of the unwanted signal measured at a receiver. Protection-ratio values depend on the type of service for both the wanted and unwanted signals, and also on whether the interfering signal is at the same frequency as the wanted service (co-channel), or at a given frequency difference (adjacent channels)[20].

Minimum Field Strength (Signal Level)

This is the lowest value of wanted field strength for which protection can be claimed.

In defining coverage it is indicated that due to the very rapid transition from near perfect to no reception at all, it is necessary that (at least) the minimum required signal level is achieved at a high percentage of locations. These percentages have been set at 95% for “good” and 70% for “acceptable” reception [20].The main factors that determine the feasibility of DTT on a channel are [20]. Interference coming from the existing analogue television services is a key issue for determining the suitability of potential channels. DTT does not cause interference to the existing analogue services and DTT not causing interference to other DTT services within the same or adjacent coverage [20].

Liang Yin and et al [21], 2012 presented work on digital dividend (DD) spectrum capacity gain brought about by switching from analogue terrestrial television (ATT) to digital terrestrial television (**DTT**) which is now ongoing in China and predicted that spectrum measurement is the most effective method to evaluate the capacity. They also predicted that during the transition period, introducing **DTT** to rural areas tends to provide less spectrum compared with purely ATT broadcasting, hence rural areas have less DD capacity compared with urban. They also provided spectrum measurement methodology and findings which are applicable to spectrum **planning** and spectrum regulations, especially for developing countries that are in **DTT** transition periods.

2.8 Location Coverage Probability

The natural statistical variation of field strengths with location is described by the quantity location coverage probability which is a measure for the coverage quality. Normally, to achieve satisfactory coverage, a location coverage probability of 95% is required for fixed and portable reception and 99% for mobile reception. Sometimes the value of 70% is requested for a lower coverage quality target [22]

2.9 Guard Interval

The purpose of the guard interval is to introduce immunity to propagation delays, echoes and reflections, to which digital data is normally very sensitive [23]. In both the 2k and 8k systems, each symbol (set of bits) is transmitted for a bit longer than is really necessary to keep the bitrate at the desired speed. This extra time is called the guard interval, and it provides extra time for the receiver to identify the symbol while the same symbol is available in the directly received signal as well as in the reflected signal [13].

Large service area SFNs need a large guard interval of 1/4 of the useful symbol time in order to cope with the large delay times in a large scale SFN.

According to Lacroix and et al, 2001[24] there is OFDM modulation using a guard interval, denoted OFDM/QAM which is well known for its robustness to multipath time varying propagation channels, and therefore used in several broadcasting and high data rate radio LAN standards. OFDM/OQAM modulation is an alternative to it, which has the advantage not to require the use of a guard interval. This leads to a gain in spectral efficiency.

Khambeker and et al, 2007[5] did work on how Spectrum sensing is crucial for dynamic spectrum management systems and proposed a scheme that utilizes the guard interval of OFDM symbol at the transmitter for spectrum sensing. They also predicted that the scheme can be implemented with no impact on the BER under various channel conditions, and detection of incumbent DTV signal is possible in the OFDM guard interval.

2.10 2k/8k/16k/64k Transmission Mode

Using the 2k system, the distance between the transmission sites can be up to 17 km (11 miles) in order to get SFN to work. However, with the 8k system, the distance between the SFN transmission sites increases to a maximum of 68 km (42 miles). Everything is four times slower in 8k than in 2k, making the 8k system capable of handling reflections that are four times longer than in the 2k system. If an interfering signal is regarded as a reflection, the allowed distance between two interfering stations must be four times larger for an 8k system than a 2k system [26].

From a receiver point of view, the selection between the 2k and 8k systems does not matter anymore since most receivers nowadays are equipped to receive both systems.

The table below summarizes the various DVB-T planning configuration parameters [20].

Table 2.3: Differences between DVB-T and DVB-T2 [26]

	DVB-T	**DVB-T2**
Modulation (Max)	QPSK, 16QAM, 64 QAM	QPSK, 16QAM, 64QAM, 256-QAM
FTT Size (Max)	8k	32k
Guard Interval	1/4, 1/8, 1/16, 1/32	1/4, **19/256**, 1/8, **19/128**, 1/16,1/32, **1/128**
FTT Size	2k, 8k	**1k**, 2k, **4k**, 8k, **16k**, **32k**
FEC	2/3CC +RS	3/5LDPC +BCH
Scattered Pilot	8.3%	4.2 %
Continual Pilot	2.0%	0.38 %
Carrier Mode	Standard	Extended
Capacity	32.21 Mbps	50.32 Mbps

2.11 Digital TV Measurements on STB

The possibility to perform many different types of measurements on either the digital bit stream to modulation, or on the modulated signal itself exists in DTV transmission [22]. Signal Level (SL) of the received signals, Bit Error Rate (BER) of the received and decoded signal, Signal-to-Noise ratio (SRN) of the modulated signal and the Modulation Error Rate (MER) are among the most common measurements performed in digital television broadcast system that can employ the services of the STB which can be done either using SFN or MFN [22].

Single Frequency Network (SFN)/Multi Frequency Network (MFN)

The transmitters can be operated as Multi Frequency Network (MFN) or as Single Frequency Network (SFN) or as a Hybrid Network (combination of both MFN and SFN).

Multi Frequency Network (MFN)

A multi-frequency network (MFN) is a network in which multiple radio frequencies (RFs) (or if channels) are used to transmit media content [20].A planned DVB-T networks consist of transmitters with independent program signals and with individual radio frequencies. For configuration, in order to cover large areas with one DVB-T signal a certain number of frequency channels are needed to be assigned to each transmitter [27].

Single Frequency Network (SFN)

A single frequency network or SFN is a broadcast network where several transmitters simultaneously send the same signal over the same frequency channel [28].Analogue FM and AM radio broadcast networks as well as digital broadcast networks can operate in this manner. SFNs are not generally compatible with analog television transmission. The SFN results in ghosting due to echoes of the same signal [28].The aim of SFNs is efficient utilization of the radio spectrum, allowing a higher number of radio and TV programs in comparison to traditional multi-frequency network (MFN) transmission. A SFN may also increase the coverage area and decrease the outage probability in comparison to MFN, since the total received signal strength may increase to Positions midway between the transmitters [28].

According to Egli and Et al, 2012[29] the problem of maximizing Single Frequency Network (SFN) coverage for digital terrestrial television (DTT) based on the ISDB-T standard was studied and predicted that the optimization-based approach introduces directive receiving antennas along with transmitting sector antennas to make the network more realistic.

According to Plets and Et al, 2011[30]for broadcast networks, the Single-Frequency Net work (SFN) mode is an alternative to the well-known Multi Frequency Network (MFN) mode, where instead of transmitters operating at different frequencies, all base stations use the same frequency. Besides an expected improvement of the quality of service due to the more homogeneous distribution of received signal strength, some areas will also show a degraded quality caused by the SFN echoes.

Although multipath can bring about echoes, reflections among others which affect the quality of service. But if is it directed well, in combination of SFN, it can increase reception quality and also bring about increase in frequency spectrum

However, following the review of some technical aspect of the DTT, researchers have also done work in various ways to aid in the convergence from analogue to digital. The prominent research works among them are discussed as follows;

Schreiber Et al.1995 [31] did work on the discussion of the requirements that must be met by a new television broadcasting system to maximize its acceptability to the various stakeholders, including broadcasters, equipment manufacturers, program producers, regulatory authorities, and viewers and techniques that may permit meeting these requirements and concluded that the system provides extended coverage at lower quality than currently proposed all-digital systems, and equal or higher quality than such systems in much of their service area. It also realized that self-optimization at each receiver depends on signal quality and receiver characteristics, and facilitates the design of receivers of lower cost and performance for less-critical applications.

Collins Et al, 2001[32] did work on the transmitter and transmission line and how the antenna and its performance characteristics play an important role with regard to digital television system performance. They predicted that antenna power rating must be consistent with these requirements and the antenna wind load contributes significantly to tower loading and cost. Antenna impedance, pattern bandwidth, and associated frequency response are important components of overall system response. Other antenna characteristics affecting system performance include tower mounting and channel combining strategies.

Jintao Wang, 2004 [33] studied how high spectrum efficiency and high coverage on the SFN (single frequency network) has been used more and more widely and explains the basic concepts and technical features of SFN. It also introduces the SFN of the three main DTTB (digital television terrestrial broadcasting) standards (the modulation system developed by ATSC, DVB-T and ISDB-T). A new implementation of SFN is also proposed based on DMB-T (digital multimedia broadcasting for terrestrial).

According to Jintao Wang, 2004[33], the propagation of digital TV signals is identical to that of their analog counterparts. However, an important difference is the signal bandwidth; the broad continuous spectrum of digital television brings special concern for the effect of multipath on frequency response. Beyond this concern, consideration of digital TV propagation gives the opportunity to review the factors that affect the terrestrial channel, compare theoretical concepts with measured data, and assess the effectiveness of various prediction methods.

According to Ying-Wen Bai, 2005 [34] how rapid digitalization of television broadcasting, the conventional television media is gradually merging with the related information and communication technologies to form a completely new and enormous digital television industry was studied. A set-top box (STB) was designed to receive the television signal, run the interactive applications and transfer the digital TV signal to the TV. A design and implementation of a DVB-T (digital video broadcasting-terrestrial) system set-top box by utilizing a high integration chip solution was proposed.

Successfully, a whole hardware of the set-top box was designed and also implemented a testing procedure to verify the system's performance as in a common specification.

Jain Song, 2007 [35] studied the technical details of the Chinese Digital Terrestrial Television Broadcasting Standard which defines the physical layer transmission protocol. These included the frame structure, channel coding and modulation schemes and the major differences between Chinese DTV standard in multi-carrier working mode and DVB-T standard, all occupying the same 8 MHz baseband bandwidth. The measurement results of several working modes showed satisfactory receiving performance of high and standard definition TV signals under both indoor and outdoor environments for the fixed and mobile reception were also presented.

Jae-Young lee, 2008[36] studied the transmitter identification (TxID) signal analyzer for the ATSC terrestrial digital TV system in single frequency networks (SFNs) and the structure of the TxID signal analyzer and its practical use in SFN environment were presented and a theoretical approach of the performance measurement was also studied. He concluded that the proposed TxID signal analyzer showed robustness at low carrier to noise ratio (CNR), and improvement of analyzing performance using ensemble averaging scheme.

According to Samuel Afoakwah, 2011 [37] work was done on multiplexing and content in Ghana and predicted that Drop and Add services should be taken into consideration when planning the digital network to ensure efficiency and effectiveness, the provision of Conditional Access (CA), Middleware on multiplex and Set-Top-Box (STB) were necessary to regulate digital signal reception and also used it for valued added services such as e-government.

Eric Frempong Gyamfi, 2011 [38] studied the technical challenges of the transition from analog to digital Television and established that, poor sitting of existing DVB-T transmitting stations has affected quality reception of the DTT transmissions at certain locations in Accra and Tema, especially areas between the two transmitters. Evaluation of STBs distributed by present service operators was carried out and was established that DVB-T STBs are currently available to meet the specifications for the variant of DTT network (DVB-T2) recommended in the Bidding document for DTT network in Ghana.

However, Ghana is migrating to digital TV based on regional bases. Ashanti Region being the region with highest population needs to be studied carefully to ensure that better quality reception is available to consumers.

CHAPTER THREE

3.0 SYSTEM MODELING AND IMPLEMENTAION

Data was taken from Skyy TV at Adum, Kumasi and Smart TV at Dadieso-Aba, Kumasi using two Set Top Boxes (STBs). The free space model was as a reference model and was compared to two empirical models i.e. Okumura model and Rec. ITU P.370 model, theoretical and measured values were simulated with MATLAB for each of the model. Analytically, calculations were performed per the models using equations and comparison was drawn-out of the results.

Also different modulation schemes were compared using their respective equations using MATLAB simulation by imputing SNR taken from field test to analyze the BER.

3.1 Space Wave Propagation Models Overview

The common approaches to propagation modeling include:

3.1.1 Physical models

Physical models of path loss make use of physical radio waves principles such as free space transmission, reflection or diffraction [3].

3.1.2 Empirical models

Empirical models use measurement data to model a path loss equation. Examples of empirical propagation models include the ITU-R and the Hata models. Empirical models use what are known as predictors or specify in general statistical modeling theory [3].

3.1.3 Applications of Propagation models

The prediction techniques or models described in this study are most often implemented for practical planning within computer software. The development of such software has been motivated by a number of factors [3]:

i. The enormous increase in the need to plan digital broadcast systems for TV services and cellular systems accurately and quickly ii. The development of fast and affordable resources iii. The development of graphical information systems, which index data of terrain, clutter and land usage in an easily accessible and manipulated form giving better frequency management.

Free Space path loss model and two empirical propagation models i.e. the ITU-R P.370 prediction propagation model and the Okumura propagation model were compared using their respective theories and the values taken from the field test in Ashanti Region.

3.1.3.1 Free space propagation model

The free space propagation model is used to predict received signal strength when the transmitter and receiver have a clear, unobstructed line-of-sight path between them. As with most large-scale radio wave propagation models, the free space model predicts that received power decays as a function of the Transmitter-Receiver separation distance raised to some power (i.e. a power law function).

The free space power transmitter antenna by a distanced, is given by the Friis free space equation [3]

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi d)^2} \qquad (3.1)$$

Where P_r is the received power in watts P_t is the transmitted power in watts G_t is the transmitter antenna gain in dB G_r is the received antenna gain in dB λ is the wavelength in meters d is the Transmitter-Receiver separation distance in meters

The path loss $P(L)$ which represent signal attenuations as positive quantity is measured in dB is different between the effective transmitted power and received power is given by [39]

$$P_L(dB) = 10^{log_{10}\frac{P_t}{P_r}} \quad (3.2)$$

$P_L(dB)$ is Path loss

P_t is Transmitted power

P_r is Received power

$$P_L(dB) = -10log_{10}\left[\frac{G_t G_r \lambda^2}{(4\pi)^2 d^2}\right] \quad (3.3)$$

When the isotropic antenna is used gain G=1, then the path loss equation becomes

$$P_L(dB) = -10log_{10}\left[\frac{\lambda^2}{(4\pi)^2 d^2}\right] \quad (3.4)$$

Where;

$P_L(dB)$ is path loss

d^2 is Separation distance in meters

λ^2 is Antenna wavelength in meters

From equation (3.2) and (3.3) by applying logarithm law, the total path loss for free space when antenna gain is included is given by

$$P_L(dB) = -10log_{10}(G_t) - 10log_{10}(G_r) - 20log_{10}\left[\frac{(C^*10^{-3})}{4\pi^*f^*10^6}\right] - 20log_{10}\left(\frac{1}{d}\right) \qquad (3.5)$$

Where; C is the speed of light ($3*10^{-8}ms^{-1}$)

$$P_L(dB) = -G(dB) - G_r(dB) + 32.44 + 20log_{10}(d/_{km}) + 20log_{10}\left(\frac{f}{MHZ}\right) \qquad (3.6)$$

Total path loss for free space is given as [39]

$$P_L(dB) = -G_t - G_r + 32.44 + 20log_{10}(d) + 20log_{10}(f) \qquad (3.7)$$

3.1.3.2 Okumura propagation model

Okumura propagation model is model based upon an extensive series of measurements made around Tokyo between 200MHz to 2Ghz. Prediction are made via a series of graphs. The thoroughness of the work has made the model the most widely used macro cell prediction model and is often regarded as a standard against which researchers can benchmark new approaches [3].

This Okumura's propagation developed an extensive measurements using vertical Omni-directional antenna at both the base station and mobile station. However, it used to determine path loss which is the signal attenuation between transmitter and receiver distance. Hence, to determine the path loss using Okumura's propagation model, the free space path loss between the points of strong signal strength is first determined and the value of median attenuation $A_{mu}(d, f)$ is added to it along with correction factors to account for the type of terrain [40].

To plot the function of frequency in the range of 200MHZ to 2GHZ as the function of distance from base station is in the range of 1km to 100km is considered. The Okumura's model is wholly base on the measured data and does not provide analytical resolution situation [40].

For many situations, extrapolations of the derived curve can be made to obtain values outside extrapolations depends on the circumstances and the smoothness of the curves.

Okumura's propagation model is considered to be the simplest and best in terms of accuracy in path loss predictions for cellular and mobile radio and TV transmission system in the cluttered environments [40].

Some of the important terrain related parameters are the terrain undulated height which is isolated ridge height, average slope of the terrain and mixed land-sea parameters. Whenever, the terrain parameters are calculated, the necessary correction factors can be added or subtracted as required value. All these correction factors are also available as Okumura curves.

Okumura derived empirical correction factors related to terrain which also developed and improve the model accuracy.

The empirical path loss formula of Okumura at a distance d parameterized by a carrier frequency fc is given as [40]

$$L_{50}(dB) = L_F + A_{mu}(d,f) - G(h_{te}) - G(h_{re}) - G_{AREA} \qquad (3.8)$$

$L_{50}(dB)$ is the 50th percentile value of propagation path loss

L_F is the free space propagation loss

$A_{mu}(d,f)$ is the median attenuation relative to free space

$G(h_{te})$ is the base station antenna height gain factor

$G(h_{re})$ is the mobile antenna height gain factor

G_{AREA} is the gain due to the type of environment

Okumura found that $G(h_{te})$ varies at a rate of 20dB and $G(h_{re})$ varies at a rate of 10dB/decade for height less than 3m [41].

3.1.3.3 Rec. ITU-R P.370 propagation prediction method

The ITU model being an empirical approach means it is based on its own set of fitting curves or analytical expressions that recreate a set of measured data. This further aids in interpolation and extrapolation of data. This model is a commonly agreed field strength method for broadcasting services. The propagation curves given in this recommendation represent field strength values in the VHF and UHF bands as a function of various

parameters. The power received at a distance *d*, P_r is given by [42]:

$$P_r = \frac{|E|^2}{120\pi} A_e \tag{3.10}$$

Taken P_r into (dB) and applying logarithm law the equation becomes;

$$P_r(dB) = 20log_{10}E - 10log_{10}(120\pi) + 10log_{10}A_e \tag{3.11}$$

$$P_r(dB) = 2E_{min} - 10log_{10}(20\pi)\Omega + A_e(dBm^2) \quad (3.12)$$

Where;

E_{min} is the equivalent minimum field strength at receiving place

A_e is the effective antenna aperture (dBm^2)

(120π) is the value of intrinsic impedance of free space (ohms)

However, the above equation relates electric field (with units of V/m) to received power (with units of watts). Often, this equation is used to relate the received power level to a receiver input voltage, as well as to an induced electric field at the receiver antenna. In situations where practical values of field strengths are available in $dB\mu V/m$ from measurements, the corresponding path loss in dB can be calculated as follows if the values for transmitted power and effective receiver antenna aperture are known [42]:

The total path loss of Rec. ITU-R P.370 is given as

$$P_L(dB) = P_t(dB) - P_r(dB) \quad (3.13)$$

$$P_L(dB) = P_t(dB) - E_{min} + A_e(dB) + 10log_{10}(120\pi) \quad (3.14)$$

$$P_L(dB) = P_t(dB) - E_{min}(dB\mu/m) + 240 - A_e(dB) + 10log_{10}(120\pi) \quad (3.15)$$

Where;

$E_{min} = E_{min}(dB\mu/m) - 120$

3.2 BER Analysis of Modulation Schemes based on Gaussian noise channel with OFDM

Different modulation schemes were compared using their respective equations under Gaussian noise channel and the result simulated with MATLAB using the SNR results obtained from the field test to predict which modulation scheme would be the appropriate for transmission of DTT in Ashanti Region.

In choosing digital modulation scheme the following factors should be taken into consideration: high data rate, high spectral efficiency (minimum bandwidth occupancy), high power efficiency (minimum required transmitter power) and robustness to channel impairments (minimum probability of bit error) [43].

The choice of modulation scheme is based on technique to achieve the best trade the best trade-off between these requirements [43].

Digital modulation can be additive white Gaussian noise (AWGN) or flat- fading. Two criteria of interest: the probability of error relative to either symbol or bit error and outage probability defined by the probability the instantaneous SNR falls below a given threshold are considered. For an outage probability for a digital voice the probability of error $P_b = 10^{-3}$. For a fast fading the performance is the same as the AWGN [43].

AWGN for terrestrial path modelling is commonly used to simulate a background noise of the channel under study in addition to multipath, terrain blocking, interference and self interference that modern radio encounter in terrestrial operation [43].

When MB-OFDM (Multi-Band Orthogonal Frequency Division Multiplexing) carrier modulation comprises of Gaussian noise, its equation is given by [45];

$$Q(a) = \int_a^{\infty} \frac{e^{-x^2/2}}{\sqrt{2\pi}} dx \qquad (3.16)$$

Where Q(a) is a Gaussian Q-function or the complementary probability distribution function for Gaussian distribution. In the Gaussian Q-function, the complementary **error function** (erfc) is related to the BER and the SNR for the different modulation schemes as follows [45];

For BPSK

$$BER = 0.5erfc\sqrt{E_b/N_o} \qquad (3.17)$$

For QPSK

$$BER = o.5erfc1.477\sqrt{E_b/N_o} \qquad (3.18)$$

For 8PSK

$$BER = 0.5erfc2.2155\sqrt{E_b/N_o} \qquad (3.19)$$

For 16PSK

$$BER = 0.75erfc1.0833\sqrt{E_b/N_o} \qquad (3.20)$$

For 64-QAM

$$BER = 0.5833 erfc 0.211 \sqrt{E_b/N_o} \quad (3.21)$$

3.3 Physical map of Ashanti Region

The physical map of Ashanti Region in **Fig 3.1** from survey department Accra was drawn using CorelDraw Graphics Suite X4 to identify the physical features in the Region so as to propose the number of transmitter sites, the gap fillers where necessary and to calculate the distances from the various proposed sites to Kumasi

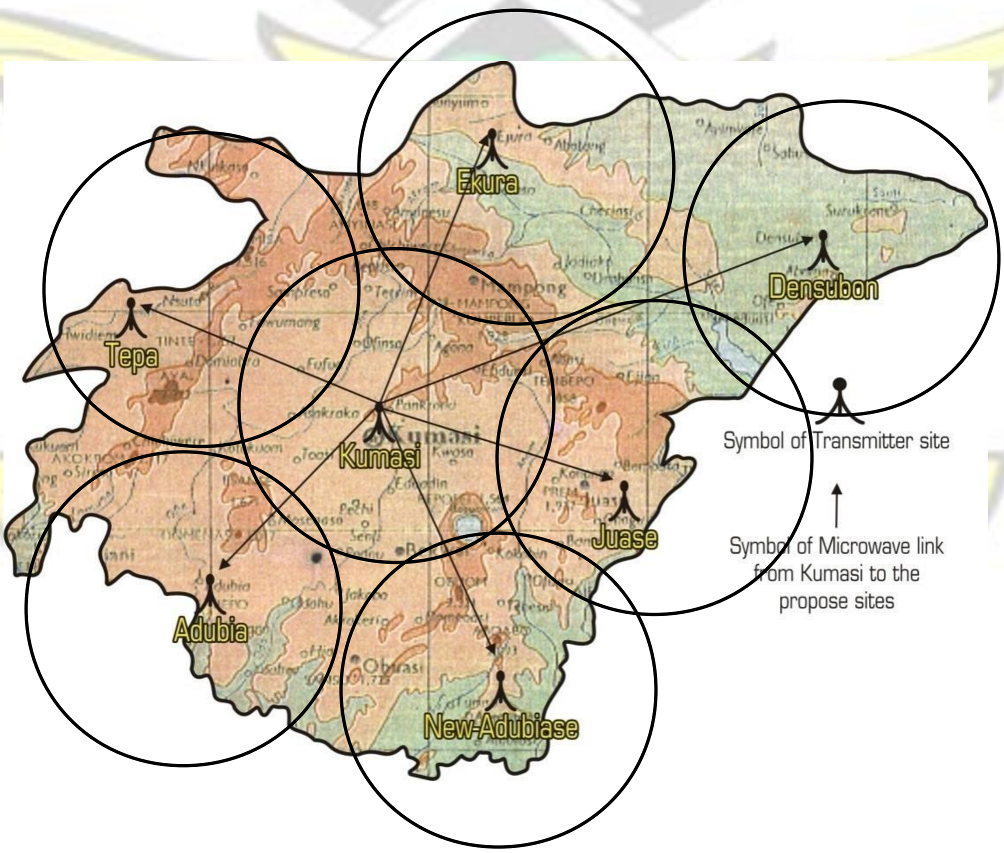

Figure 3.1: Physical map of Ashanti

CHAPTER FOUR

4.0 PRESENTATION AND ANALYSIS OF RESULTS

Distances were measured from the Smart TV (GTV) transmitter at Dadieso- Aba, Kumasi and Skyy TV transmitter at Adum, Kumasi. Other factors were studied to propose a way of implementing the DTT to give a full coverage in Ashanti-Region

Table 4.1 Location of GTV and Skyy DTT transmitter in Kumasi [46] [47]

	DVB-T Transmitter	
	GTV	SKYY
Transmitter location	Dadieso-Aba –Kumasi	Adum-Vodafone Tower
Elevation of transmitter Sites/m	260	282
Height of Transmitting sites Antenna above average terrain/m	93	150
Transmitter power /kW	2	1
Signal Range/km	=50	=28
Cable loss/dB	0.1dB/100m =0.12dB for 120m cable length	0.1dB/100m =0.18dB for 180m cable length
Antenna Gain/dB	12	12
Effective Radiated Power(ERP)	=31kW(45dB)	=15kW(42dB)

4.1 Sites Presently Used by GTV and Skyy Transmitters in Kumasi

Currently two transmitters (Channels 22 operating at 482MHz and 23 operating at 490MHz) are serving the Ashanti-Region (Kumasi and its environs) by Smart TV Skyy digital transmit antennas (located on the Vodafone lower at Adum, Kumasi), operating at 625MHz (channel 40) serve subscribers within the Kumasi and its environs.

The various frequencies for the various channels were used in the analysis.

4.1.1 Sitting of antennas in Kumasi

The two transmitters are not co-located, as it is with current analog television infrastructure. It is however worth noting that each of the two transmitters shares the towers with other providers.GTV tower at Dadieso-Aba is for example co-located with Vodafone transmitters, as well as the analog television systems.

4.2 System Parameters for GTV and Skyy Transmitters in Kumasi

Table 4.2 Modulation Parameters for GTV Digital System [47]

Modulation Parameters	Modulation Scheme – 64-QAM Transmission Mode - 8k Guard interval - 1/8 Code rate HP - 2/3 Bandwidth - 8MHz
Multiplex Capacity	22.12Mbps

Table 4.3 Modulation Parameters for Skyy Digital System [46]

Modulation Parameters	Modulation Scheme – 64-QAM Transmission Mode - 8k Guard interval - 1/32 Code rate HP - 5/6 Bandwidth - 8MHz
Multiplex Capacity	30.16Mbps

Looking at Table 4.2, it supports a bit rate up to 22.12Mbps,approximately 2Mbps of 22.12Mbps is in providing Electronic Program Guide (EPG) services leaving about 20Mbps for audio and video broadcasting signals for channels 22 and 23. The bit rates for individual channels are dynamically based on the program being transmitted and the bit rate demand of that program. Football matches require more bits rate than most of the broadcast for transmission for example news.

Table 4.3 shows that the choice of 1/32 of guide interval for skyy TV means OFDM signals from Skyy TV will be less protected against interference than GTV systems using 1/8.FEC of 5/6 code rate for Skyy and 2/3 for GTV means GTV uses more redundant bits for error correction than Skyy providers at expense of data rate i.e Skyy providers has less error protection than GTV. The higher net data rate for Skyy makes room for more programs to be packed in their channel. Skyy TV opted for ¾ code rate which offered a more robust signal and useful data rate of approximately 27.14Mbps but in order to add more programs to satisfy customers and attract more customers, code rate of 5/6 with 30.16Mdps of Guard Interval (GI) of 1/32 at the expense of a more robust DTT signal is possible by configuring the modulator.

4.3 Quality of Service with the Map of Ashanti Region

A physical map of Ashanti Region was used to study how a better quality of service will be available for the consumers in Ashanti Region.

4.3.1 Linking of transmitter sites in Ashanti Region-Ghana

Most areas in Ashanti Region, Ghana are situated on highlands as shown in Figure 4.1 with most the areas between 500 and 1000ft above sea level whiles few areas are situated on plains. Some towns are selected in order to have a better received regional coverage of the DTT. The GBC tower at Dadieso-Aba, Kumasi at a height of 93m and signal range of 50km as shown in Table 4.1 were used to propose the transmitting sites, from Table 4.4 and Figure 4.1, the various towns were proposed in order to have a clear image for the receiver. They include Tepa, Ejura, Densubon,Juaso, Adubia and NewAdubiase for GTV at Dadieso-Aba.

Table 4.4 A proposed transmitter sites in Ashanti Region and their distances away from Kumasi was calculated from Figure 4.1

Towns	**Distance away from Kumasi (km)**
Tepa	68.0
Ejura	78.0
Densubon	126.0
New adubiase	74.0
Chrenso	112.0
Seriso	56.0
Akumadan	82.0
Obuasi	59.0
Juaso	58.0

4.3.1.1 The already existing GBC (DTT) tower in Kumasi and it's propose maximum coverage in Ashanti-Region

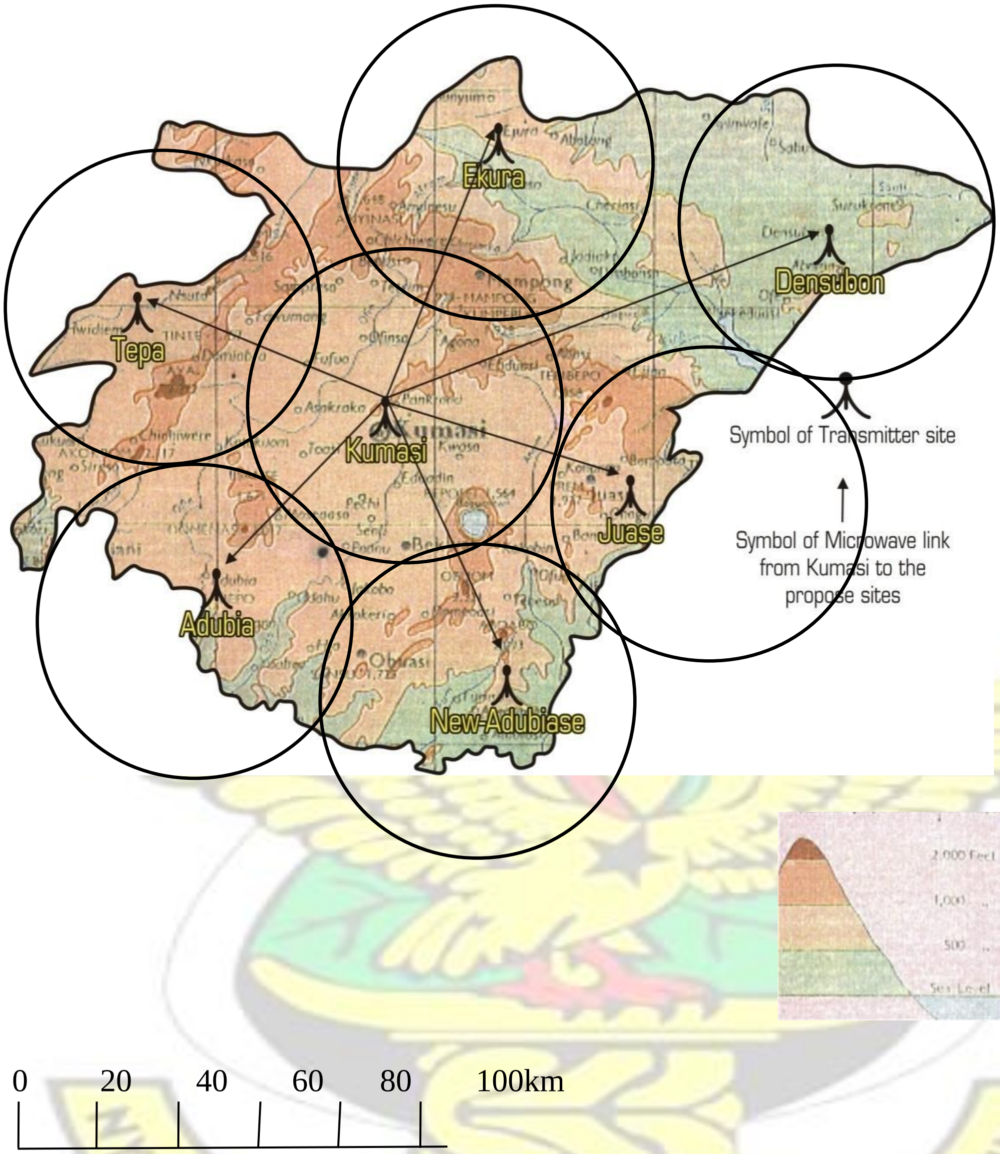

Figure 4.1: Map of Ashanti-Region Showing the Proposed Regional Coverage Using the Existing GBC (DTT) Coverage with the Transmitter in Dadieso-Aba, Kumasi Using a Transmitter Antenna Height of 93m above the Ground.

There is overlapping of coverage of the transmitters of the proposed sites except Densubon. Gap filers should be placed between Kumasi and Densubon, Tepa and Ejura to give a full coverage in Ashanti- Region.

4.3.1.1.1 Optimal location of transmitting antennas in Ashanti-

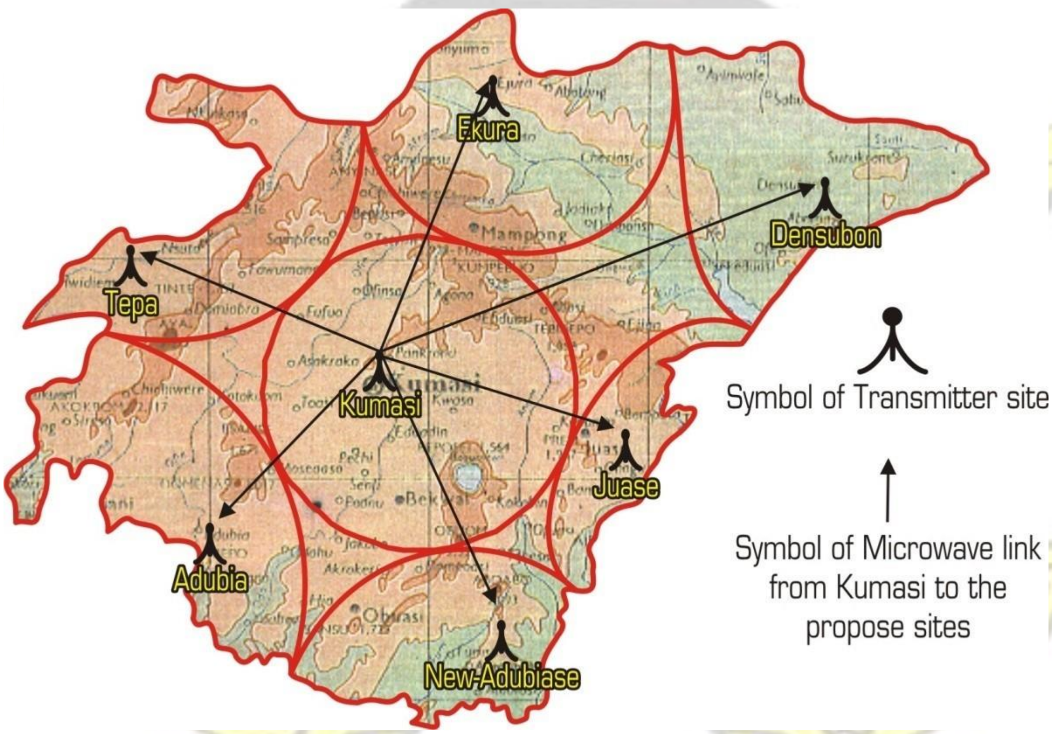

Figure 4.2: Map of Ashanti-Region Showing the Proposed Regional Coverage Using the Existing GBC (DTT) Coverage of the Transmitter in Dadieso-Aba, Kumasi so as to reduced Cost through the Maximize Used of Power

For the transmitters in Kumasi and Juaso, there was overlap of coverage of the two transmitters there by wasting the ERP. It makes efficient use of the Effective Radiated Power (ERP), the transmitter in Juaso should be reshaped by reducing the transmitter power to about half the original transmitter power and maintain the rest of the parameters such as antenna gain, Height Above Average Terrain (HAAT), cable loss etc. constant for transmitter in Juaso to give a full coverage of the area.

For Transmitters in Densubon) (C3 , New- Adubiase (C4) , Adubia (C5) , Tepa (C6) and Ejura (C7), for the ERP not be wasted the C3 coverage should be reshape by reducing the transmitter power to about 3/4th for C3, C4, C5, C6 and C7 for the original transmitter power and maintain the rest of the parameters such as antenna gain, HAAT, cable loss etc. constant for them to give a full coverage of the area as shown in Figure.4.1 and Figure 4.2

Gap filers should be placed between C1 and all the rest of the transmitters except Juaso where there is no bigger obstacle.

The technical aspect of the mode of transmission was very important however the economic aspect of it has to be also taken into consideration.

4.3.1.2 Cost of fiber optic and microwave for about a typical 30km link

Fiber optic with SDH over DWDM [48]

Parameter	Cost($)
Fiber laying	480,000
Equipment	120,000
Services	12,000
Total	610,000

Microwave with SDH over 2 X 2-STM-1 [48]

Parameter	**Cost($)**
Installation of Equipment for a hop	45,000
Services	6,000
Total	51,000

The cost of transmission for 30km for the fiber optic is far higher than the microwave. Also in fiber optic transmission a place should be dug before the cable is used, hence there are some parts of Kumasi which are either somebody's private land or there is existing building which will be difficult to install the fiber but microwave needs a small piece of land to install the towers hence applicable in some areas. Although microwave is a line of site transmission to hop two microwave antennas between Kumasi and Tepa, New Adubiase, Densubo, and Ejura, line of sight is possible through hub, where by a microwave tower is placed at a certain place so as to link the hop sites or the tower is made longer than any obstacle to get line of sight. Using a microwave with SDH (Synchronous Digital Hierarchy) of 2xSynchronous Transport Module (2xSTM) or 2xSTM-1that is capacity of about 310Mb/s can serve so many people in Ashanti-Region. However fiber has more capacity to take care of future use. Also in Figure 4.2 from Kumasi to Tepa, New- Adubiase, Ejura, and Densubon highlands are in between so hub is done so that microwave antennas are put at such areas to have a line of sight, for the installation of microwave to become easier.

The distribution of population in the region by district will help in giving preference to a particular area before a full coverage of the region.

Table 4.5 Districts in Ashanti–Region and their respective population [49]

DISTRIBUTION OF POPULATION BY DISTRICT, ASHANTI-REGION, 2010 Number Total All Districts	4,780,380
Atwima Mponua	119,180
Amansie West	134,331
Amansie Central	90,741
Adansi South	115,378
Obuasi Municipal	168,641
Adansi North	107,091
Bekwai Municipal	118,024
Bosome Freho	60,397
Asante Akim South	117,245
Asante Akim Municipal	140,694
Ejusu Juaben Municipal	143.762
Bosumtwi	93,910
Atwima Kwanwoma	90,634
Kumasi Metropolis	2,035,064
Atwima Nwabiagya	149,025
Ahafo Ano South	121,659
Ahafo Ano North	94,285
Offinso Municipal	76,895
Afigya Kwabre	136,140
Kwabre East	115,556
Afigya Sekyere	94,009
Mampong Municipal	88,051
Sekyere East	62,172
Sekyere Afram Plains	93,937
Sekyere Central	71,232
Ejura Sekye Odumasi	85,446
Ofinso North	56,881

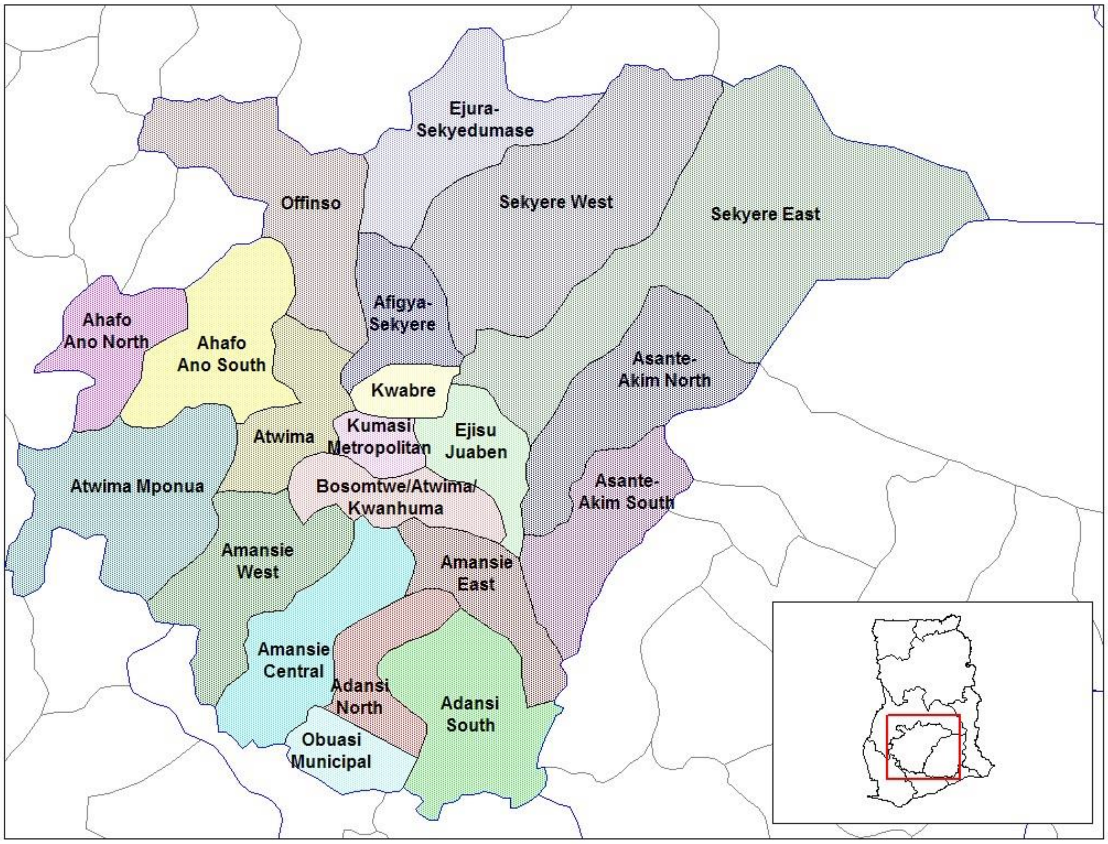

Figure 4.3: Map of Districts in Ashanti-Region, 2010 [50]

The total population of Ghana is 24,658,823 with population of Ashanti-Region being 4,780,380 representing 19.4% of the total population in Ghana [49]. The proposed DTT coverage in Ashanti-Region should be very important since it is the highest populated region in Ghana. However, Kumasi metropolis is densely populated with a population of 2,035,064 in Table 4.7 representing 42.6% of the entire population Ashanti-Region. Extra care should be taken when implementing the DTT in Kumasi to provide a clear image to the receivers. With some storey buildings in Kumasi, repeaters (microwave) through hub should be used to get a clear line of sight of hop where applicable.

Table 4.6 Regional Distribution of Population in Ghana [49]

Upper East	1,046,545

Ashanti Region	4,780,380
Greater Accra	4,010,054
Volta Region	2,118,252
Western Region	2,376,O21
Central Region	2,201,863
Upper West	702,110
Brong-Ahafo	2,310,983
Northern Region	2,479,461
Eastern Region	2,633,154

4.4 Measured field strength for DTT reception in Ashanti-Region (Kumasi and its environs)

Two set-ups were used to assess the reception quality based on three parameters (Bit error rate (BER), Signal Strength (SS), Signal to Noise Ratio (SNR) as whereas distances from the respective antennas using GPS in a selected areas in (Kumasi and its environs)

4.4.1 Selected Sites

Some sites selected for GTV, in which several readings were recorded at each site at distances of 1km,2km,……10km from the transmitting antenna at Dadieso-Aba, Kumasi usad GPS and the reception qualities were recorded. Three sites were recorded for Skyy at distance of 2,3 and 4km. Some of the values recorded are listed in Tables (appendix C) and values recorded were used for the analysis of the results.

4.5 Analysis of data recorded by both Smart and Skyy DTT

Data recorded by the two decoders were used for the analysis of result taken from the field test

4.5.1 Theoretical Power and Measured received Power analysis for GTV and Skyy TV for free space model

The tables in appendix D were used for analyzing the measured received power and theoretical received power using MATLAB (Appendix A).

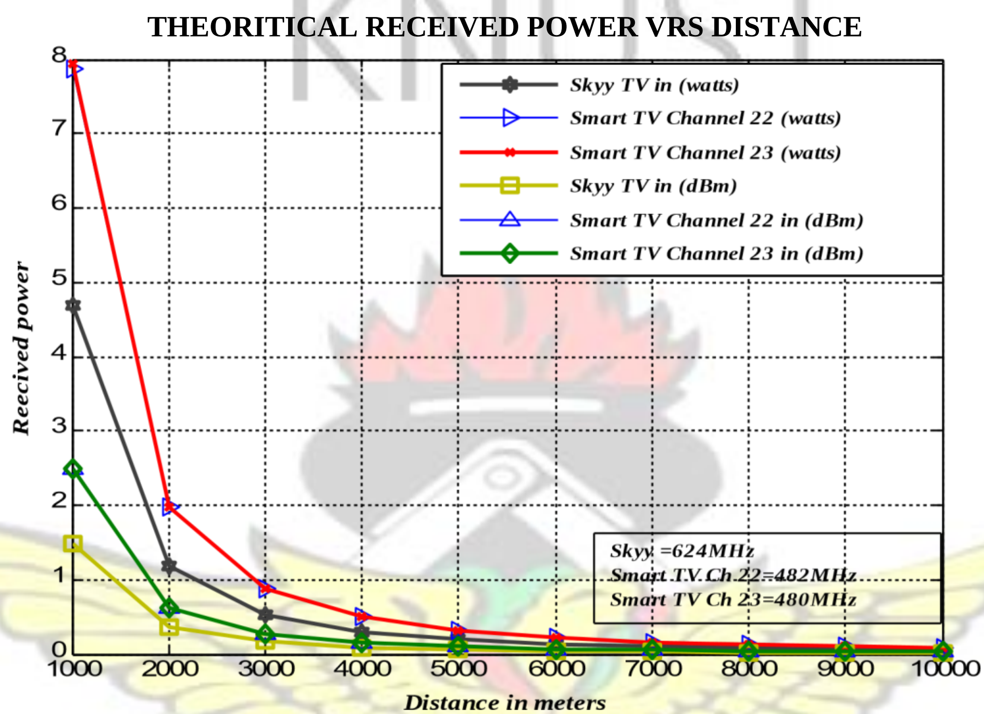

Figure 4.4: The Theoritical power versus Distance in dBm and in watt

In figure 4.5, it is observed that the received power reduces as the distance from the transmitter increases. Frequencies for Smart TV channels 22 and 23 as well as that of SKYY TV were used to plot the graphs. This is the expected behavior as akin to most propagation models since the Free Space model assumes that there is no obstacle to impede transmission.

MEASURED RECEIVED POWER VRS DISTANCE

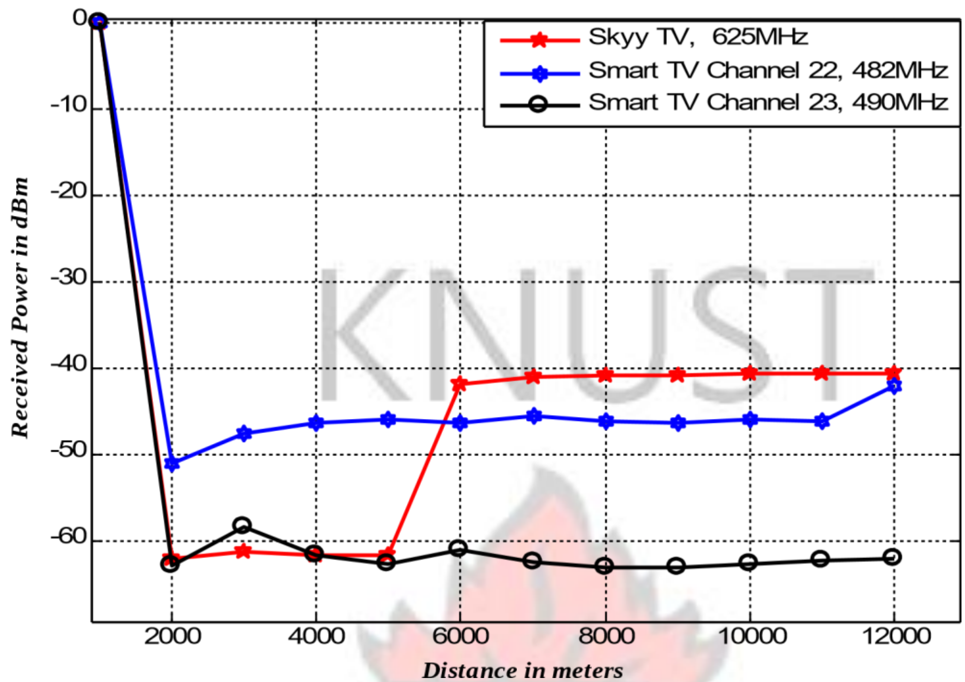

Figure 4.5: The Measured Received Power versus Distance

Figure 4.5 shows field measured signal strength which was measured using the STB. Theoretically it is expected that the signal strength decreases with increasing distance. It is worth noting that as the distance increases from the transmitting antenna the signal rises and falls but decreases more rapidly at 600 m for Skyy TV, this is due to the topology of the land and the obstacles between T-R separation, since it is a non-uniform surface causing the signal strength to rise and fall.

The free space model was treated separately here because it was used as reference model based on Smart TV and Skyy TV parameters and were compare to Okumura and Rec.

ITU P.370 models in the section of the work.

4.5.2 Theoretical graphs and discussions

Theoretically the same arbitrary values transmitter power, distances and frequency were used to compare three propagation models i.e. free space model (3.7), Okumura model

(3.8) and the Rec. ITU P.370 (3.15) considering their path loss using MATLAB. The same values were used so as to make comparison easy.

4.5.2.1 Free space propagation model

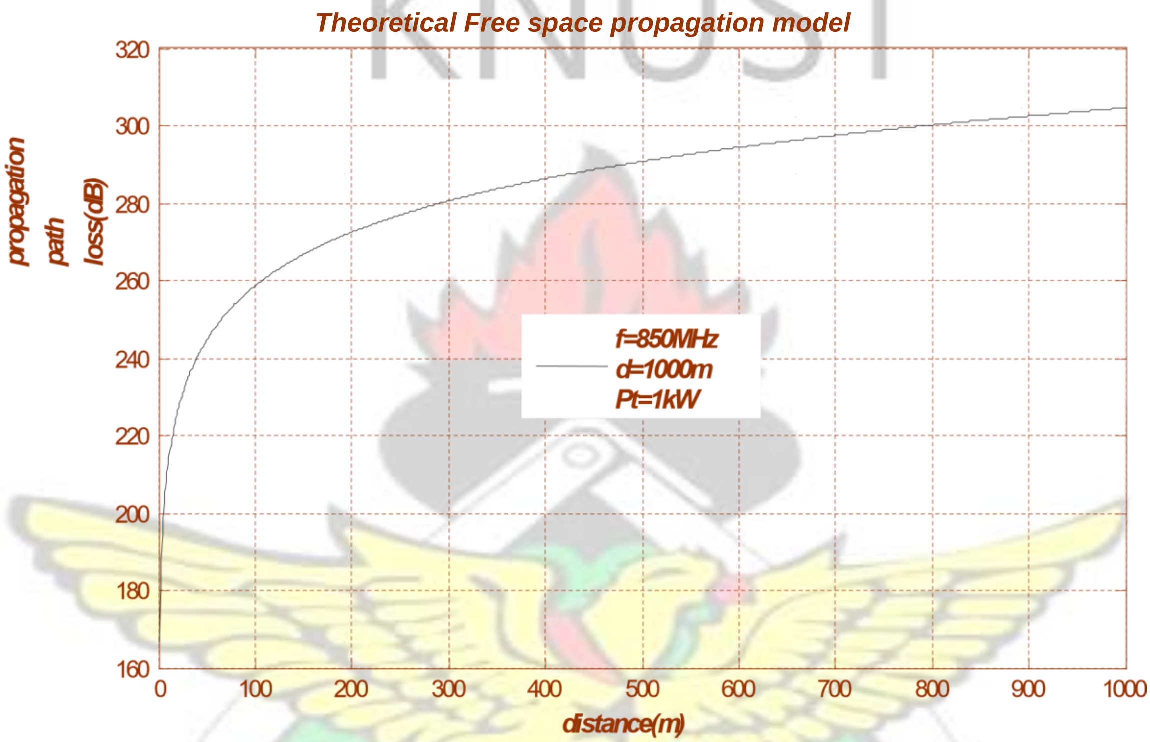

Figure 4.6a: Theoretical graph of path loss against distance for free space model.

In the figure 4.6a, it is observed that the path loss reduces as the distance from the transmitter decreases. An arbitrary frequency, distances and transmitter power were used to plot the graph. This is the expected behavior from the Free Space model, as it assumes that there is no obstacle to impede transmission.

However, at a distance of 200m, the path loss recorded is approximately 275dB.When the distance is increased in an interval of 100m, the path loss recorded at 1000m is approximately 307dB.

4.5.2.2 Okumura propagation model

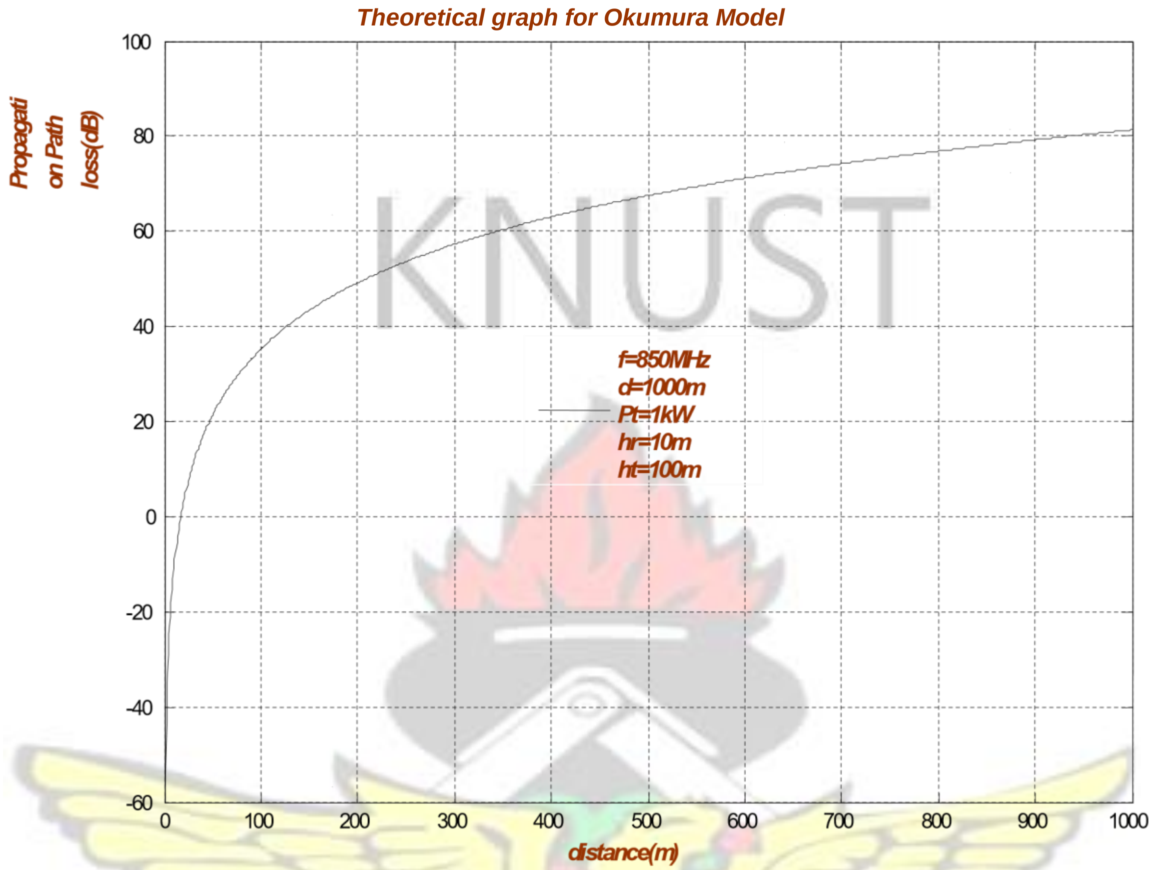

Figure 4.6b: Theoretical graph of path loss against distance for Okumura model.

In the figure 4.6b, it is observed that the path loss reduces as the distance from the transmitter decreases. The same arbitrary frequency, distances and transmitter power used by free space model were used to plot the graph so as to make comparison easy. At a distance of 200m, the path loss recorded is approximately 51 dB. When the distance is increased in an interval of 100m, the path loss recorded at 1000m is approximately 84.

4.5.2.3 Rec. ITU P.370 model

Rec.itu p370 model analysis

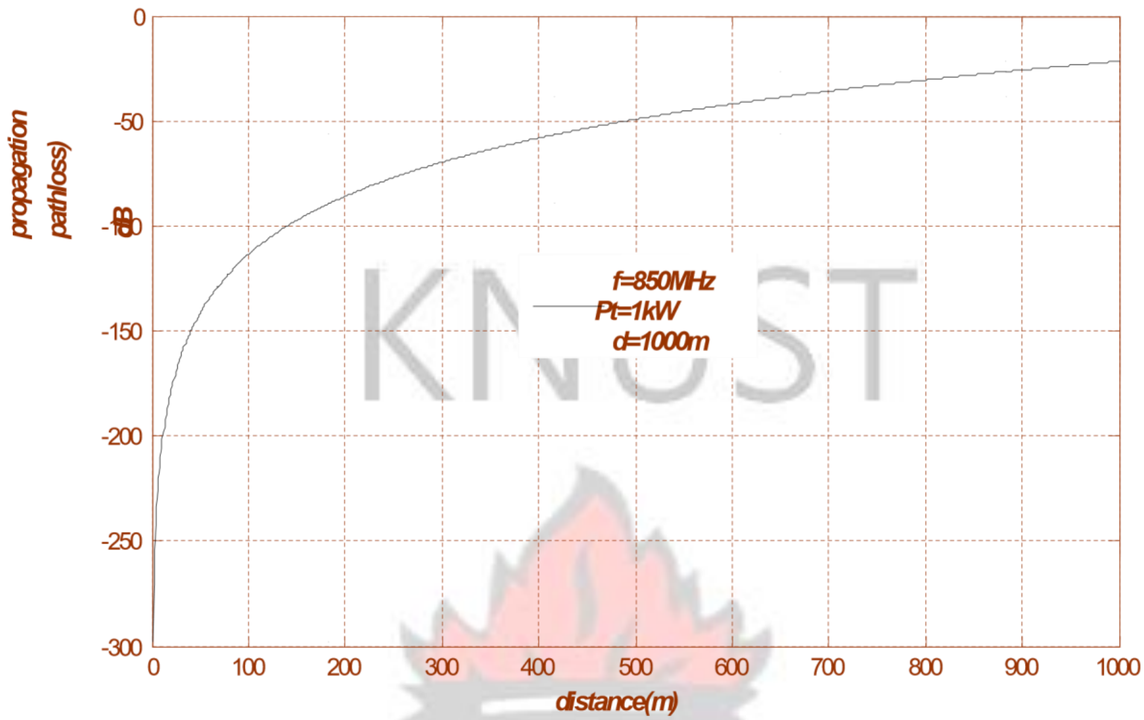

Figure 4.6c: Theoretical graph of path loss against distance for Rec.ITU P.370 model

In the figure 4.7c, it is observed that the path loss reduces as the distance from the transmitter decreases. The same arbitrary frequency, distances and transmitter power used by free space model were used to plot the graph so as to make comparison easy.

It is also observed that, at a distance of 200 m, the path loss recorded is approximately -72 dB. When the distance is increased in an interval of 100m, the path loss recorded at 1000 m is approximately -26 dB

4.5.3 Received signal strength against distance for the three models

The received signal strength from the field test with respect to distances for three propagation models i.e. free space model (3.1), Okumura model (3.1) and the Rec. ITU P.370 (3.10) were compared using their respective equations and simulated using MATLAB.

4.5.3.1 Free space propagation model

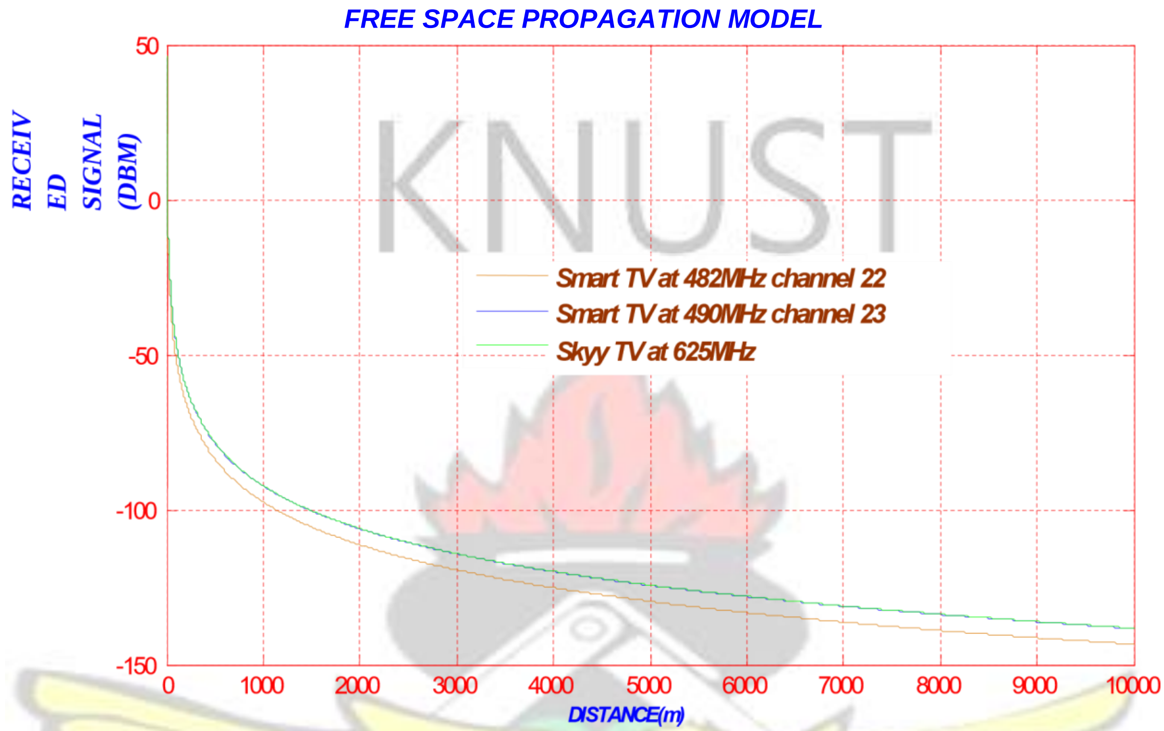

Figure 4.7a: A graph of received signal strength against distance for free space model.

In figure 4.7a, the two stations show different curves due their different frequencies. However the two channels for smart TV show almost the same curve since their frequencies are nearly equal.

It is seen that, at a distance of 10000 m, the signal strength for the 625 MHz is about -145MHz which is higher than the other two different frequencies Smart TV is -147MHz.

4.5.3.2 Okumura propagation model

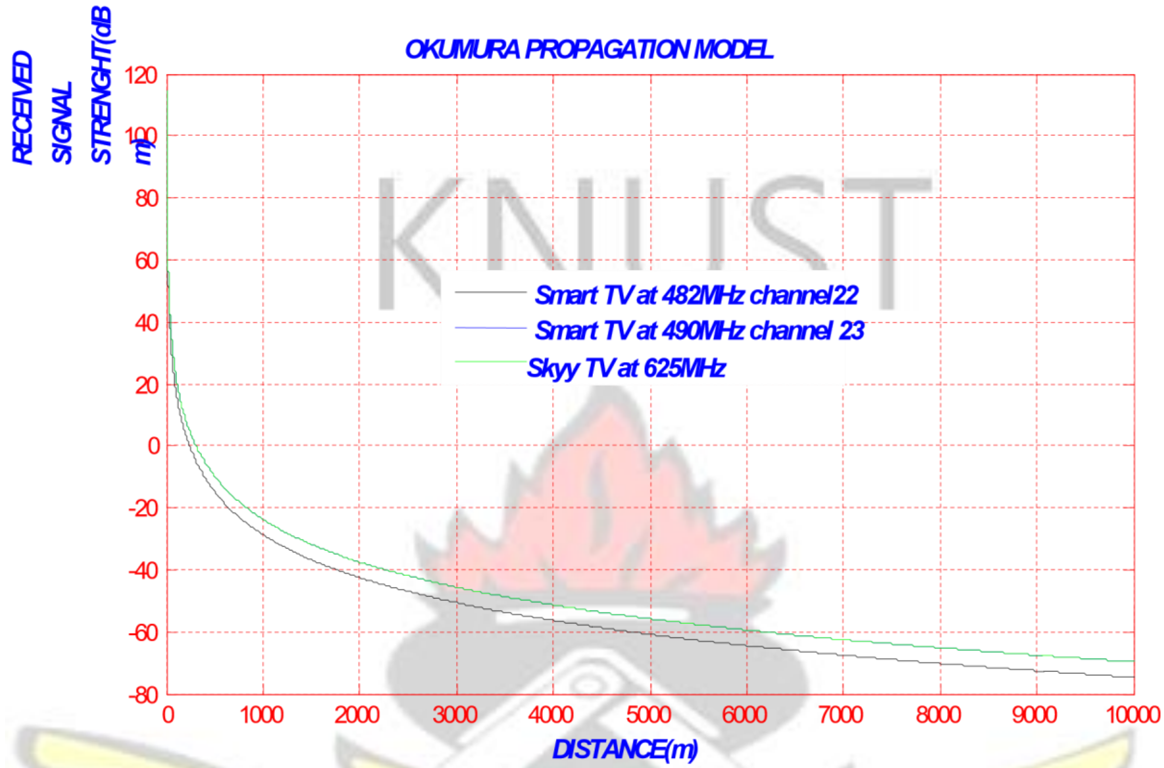

Figure 4.7b: A graph of received signal strength against distance for Okumura model.

Figure 4.7b shows that the two stations show different curves due their frequencies. However the two channels for Smart TV show almost the same curve since their frequencies are nearly equal.

It is seen that, at a distance of 10000m, the signal strength for the 625MHz is -65dB which is higher than the other two different frequencies for Smart TV which is about -67dB. It is also observed that the signal strength of the two stations for Okumura model is higher than that of free space propagation model.

4.5.3.3 Rec. ITU P.370 model

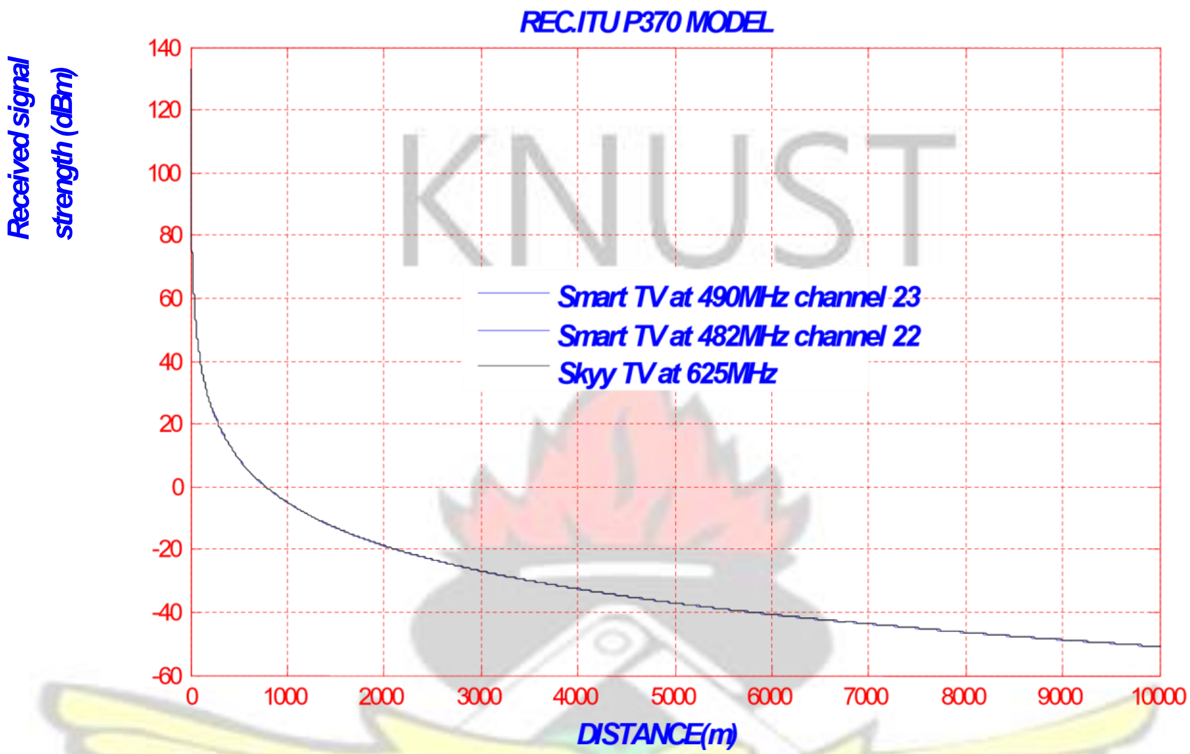

Figure 4.7c: A graph of received signal strength against distance for Rec.ITU P.370 model.

In Figure 4.7c, the two stations show different curves due their effective antenna aperture. However the two channels for Smart TV show almost the same curve since their effective antenna aperture will be nearly equal.

It is seen that, at a distance of 10000m, the signal strength for the 625MHz is infinitesimally higher than the other two different frequencies due to effective antenna aperture of the two stations.

It is observed from figure 4.7a, figure 4.7b and figure 4.7c that the signal strength at 625MHz, 482MHz and 490MHz for Rec.ITU P.370 model is higher than that of free space propagation model as well as the Okumura propagation model when the distance is the same for the three models.

4.5.4 Path loss against distance from the field test for the three models

The path loss with respect to distances from the values taken from the field test for the free space model (3.7), Okumura model (3.8) and Rec. ITU P.370 (3.15) were compared using their respective equations and simulated using MATLAB.

4.5.4.1 Free space propagation model

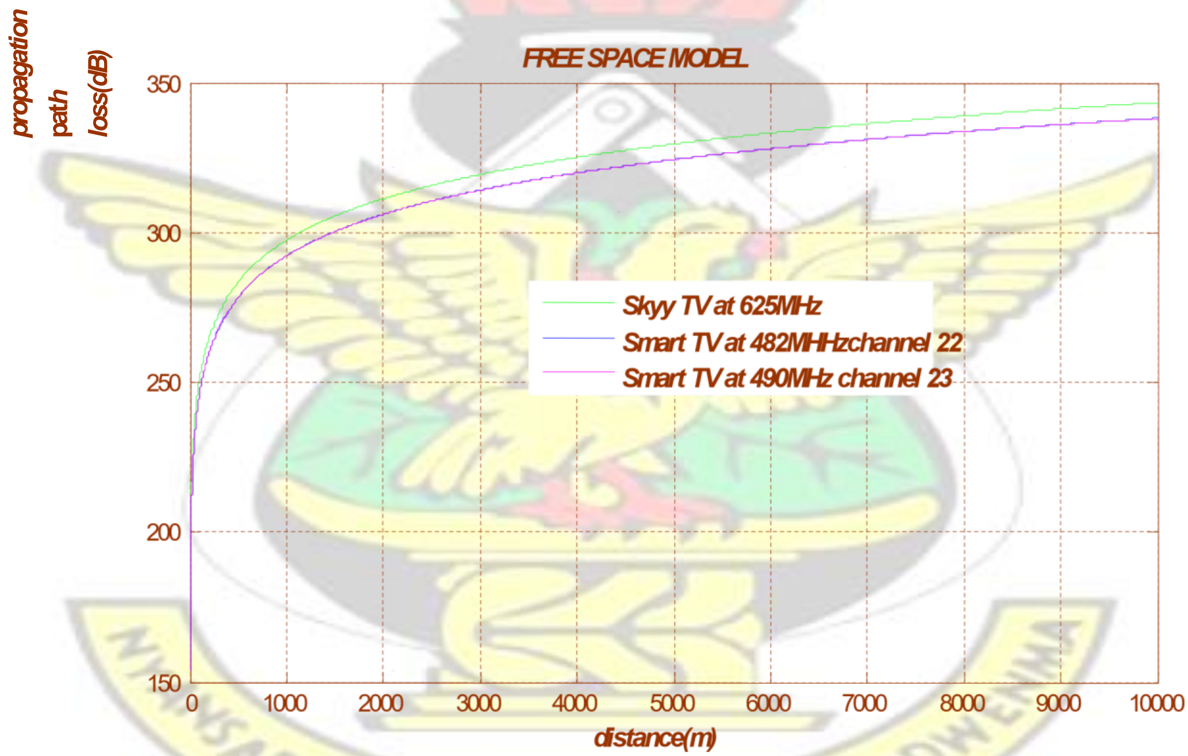

Figure 4.7d: A graph of path loss against distance from the field test for free space model

From figure 4.7d, the two stations show different curves due their different frequencies. However the two channels for Smart TV show almost the same curve since their frequencies are nearly equal.

It is also observed that, the path loss curve for Skyy TV at a frequency of 625 MHz is higher as compared to the other frequencies. The path los for Smart TV and Skyy TV is about 335dB and 340 dB which is high due to fact that this was done in free space which is based on a line of sight.

4.5.4.2 Okumura propagation model

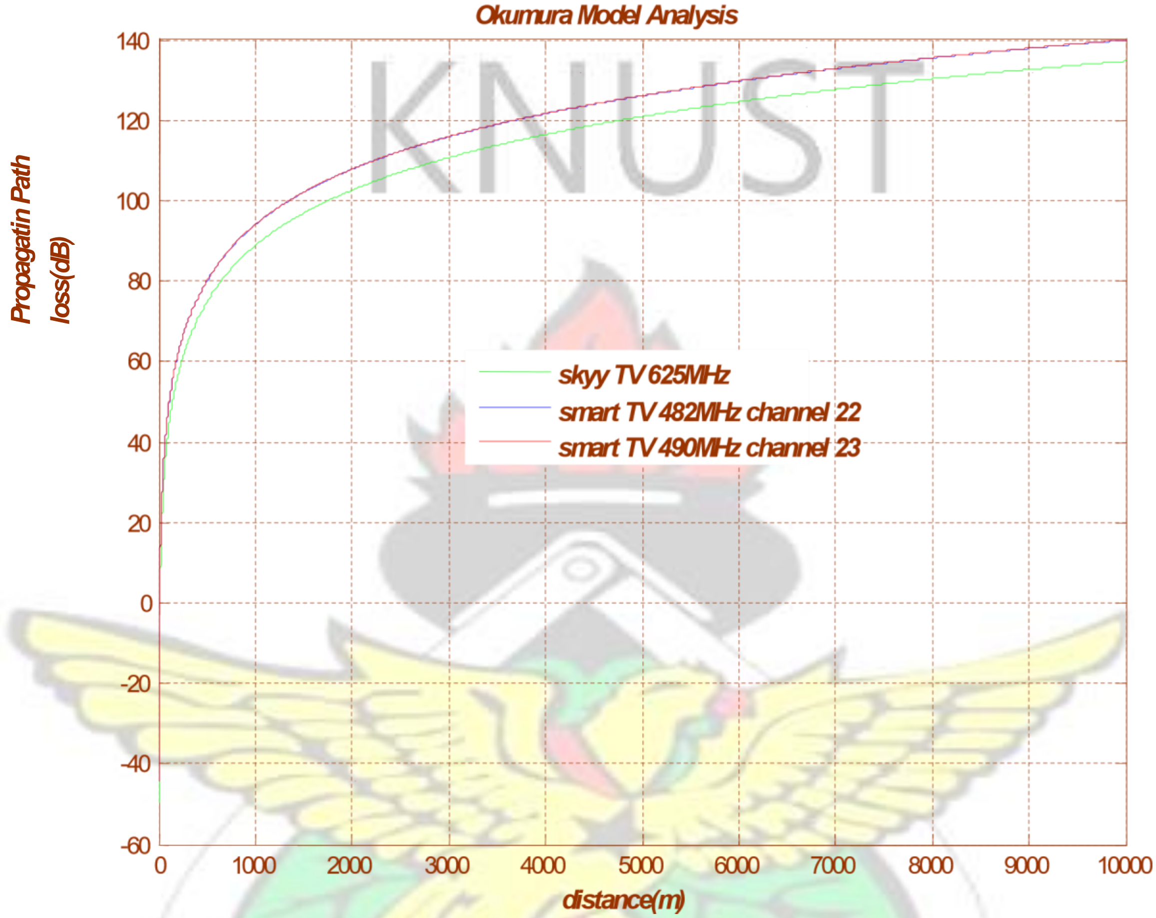

Figure 4.7e: A graph of path loss against distance from the field test for Okumura model

In figure 4.7e, the two stations show different curves due their different frequencies. However the two channels for smart TV show almost the same curve since their frequencies are nearly equal. At 1000m the path loss is about 140dB and 135dB for Smart

TV and Skyy TV respectively because in Okumura model, apart from the free space other correction factors were taken added in order to improve the quality of signal from the T-R separation hence reduction in path loss as compared to the free space model.

4.5.4.3 Rec. ITU P.370 model

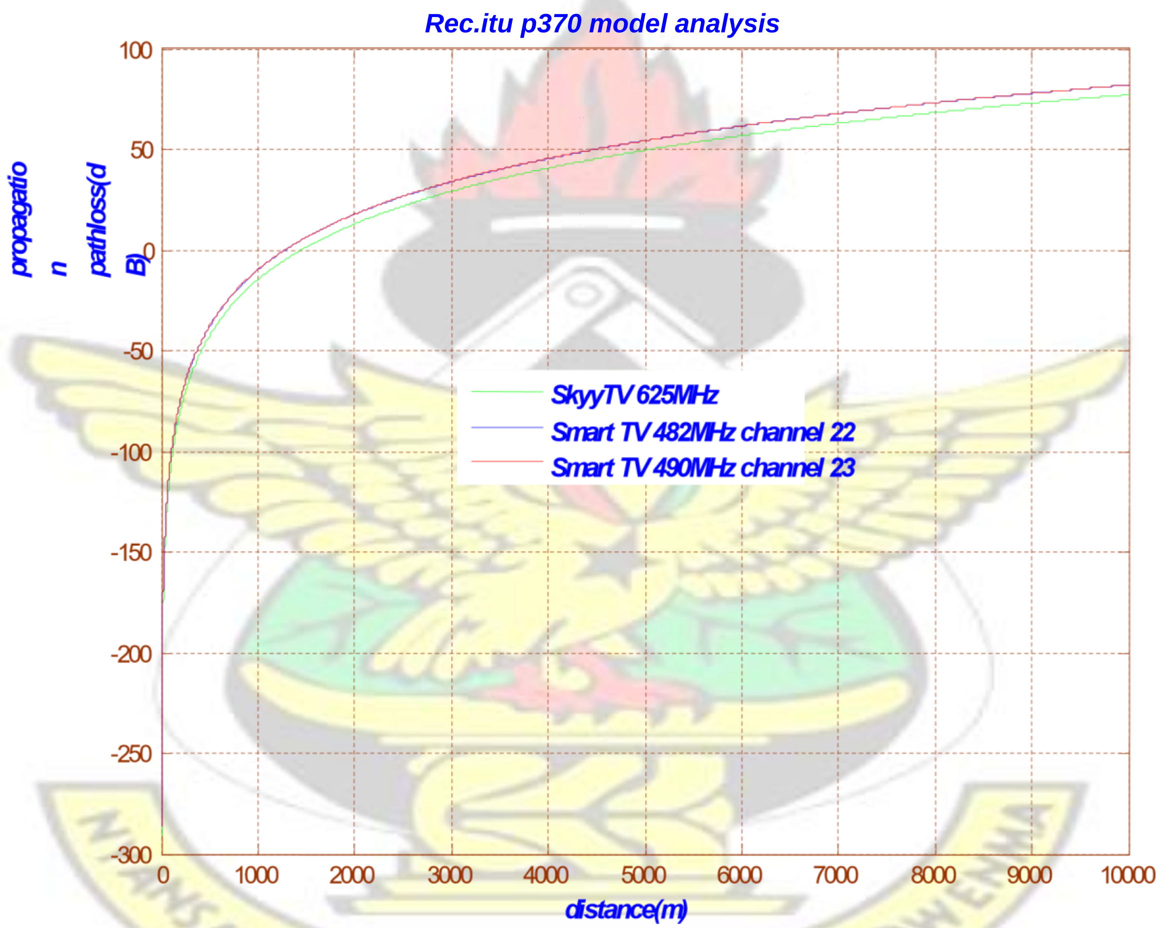

Figure 4.7f: A graph of path loss against distance from the field test for Rec. ITU P.370

model

Figure 4.7f shows that the two stations show different curves due their different effective antenna aperture. However the two channels for smart TV show almost the same curve since their frequencies are nearly equal. At 10000m the path loss recorded by Smart TV and Skyy TV are about 78 dB and 75dB for Smart TV and Skyy TV respectively which shows the minimum path loss due to fact the parameters used by Rec. ITU P.370 is better for the Kumasi and its environs where the field test was done.

4.5.4.4 Theoretical comparison of the three models

THEORETICAL GRAPH COMPARISON

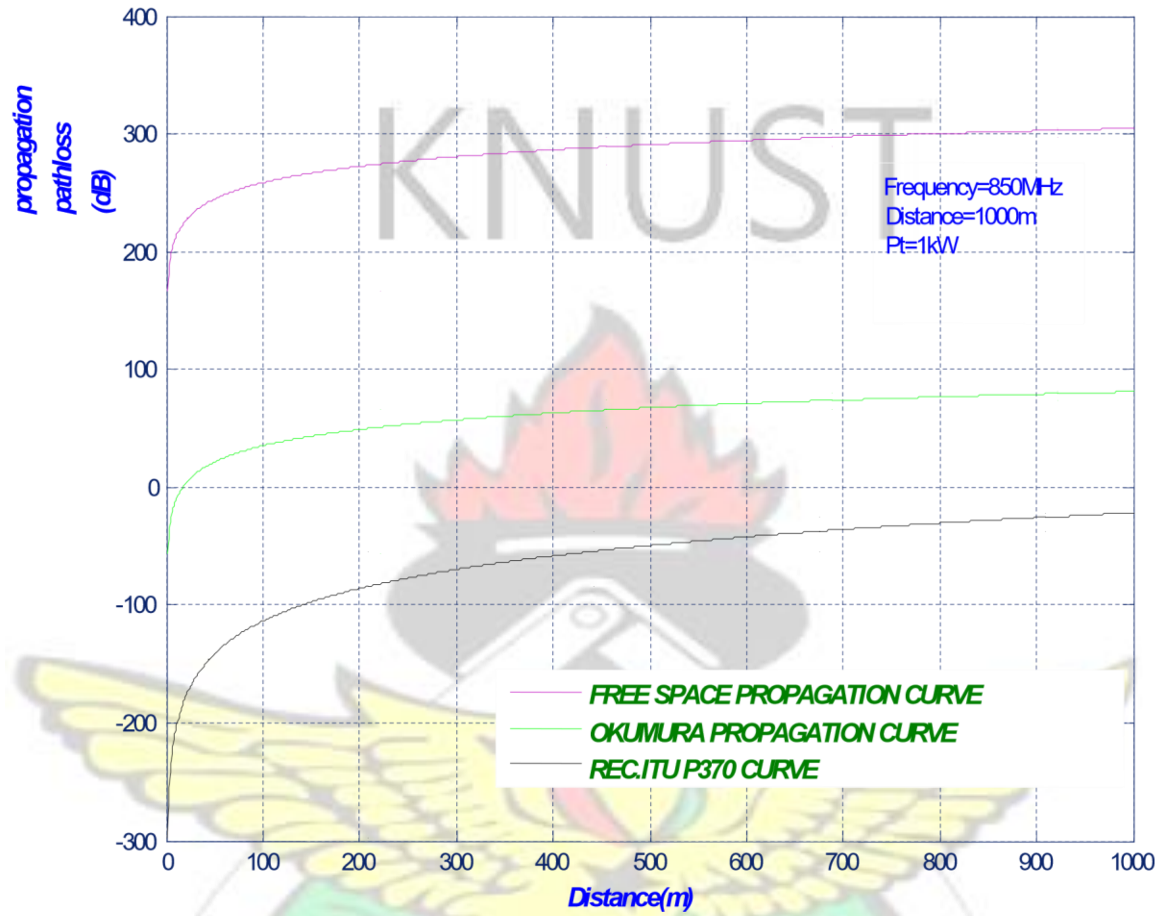

Figure 4.7g: Theoretical graph of path loss against distance for the three models.

From Fig.4.7g, a comparison between the models has been made based on the theoretical analysis. It can be observed that Okumura model as compared to free space model has the less path loss. However the Rec. ITU P.370 model shows the minimum path loss compared to the free space and Okumura models.

4.5.4.5 Path loss against distance from the field test for the three models in one graph

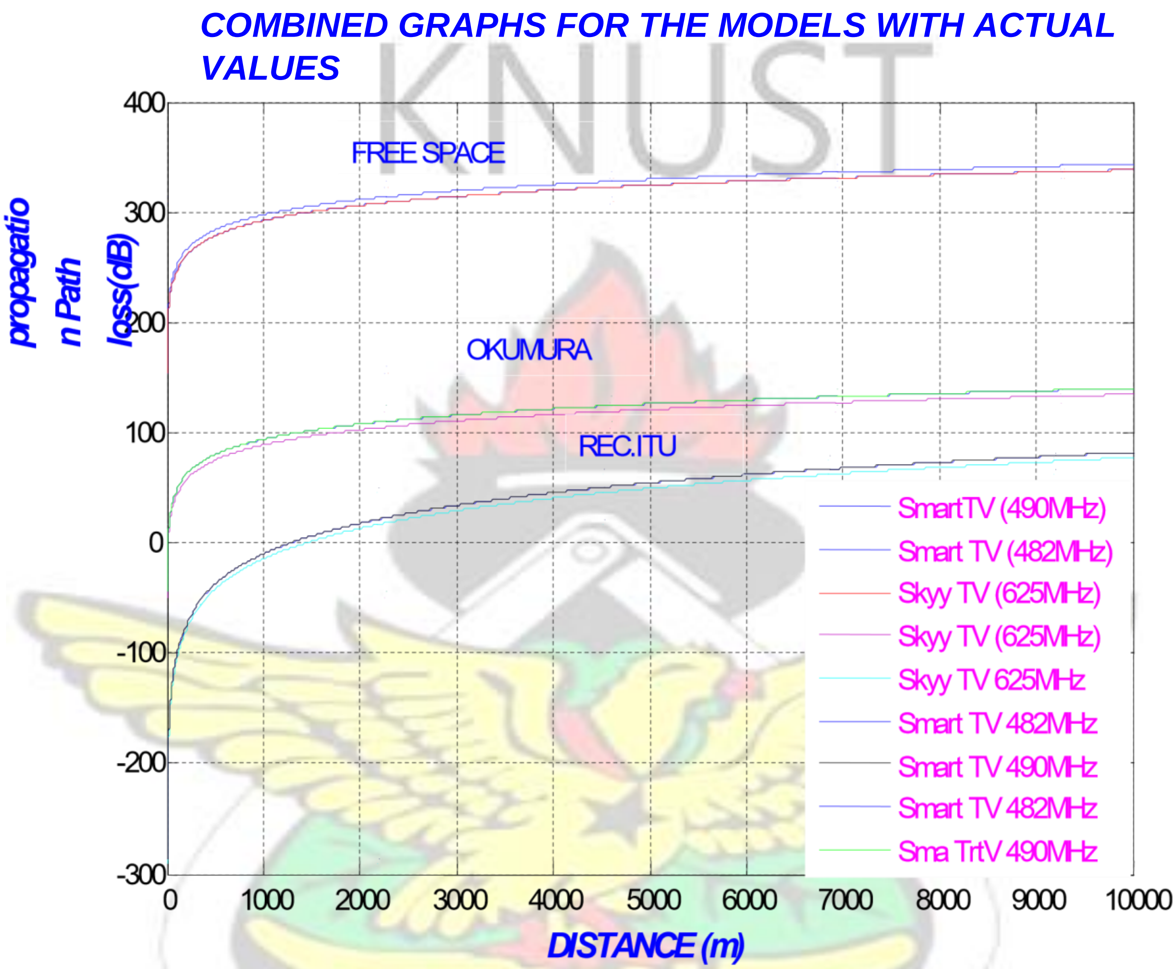

Figure.4.7h A graph of path loss against distance from the field test for three models

From Figure 4.4h, a comparison between the models has been made based on the actual (field values) analysis. It can be observed that Okumura model as compared to free space model has a less path loss. However the Rec.ITU P.370 model has the least path loss compared to the free space model and Okumura model, Rec. ITU P.370 can therefore give a better performance. Therefore it can be proposed based on the field values that the Rec. ITU P.370 model is recommended for DTT in Ashanti Region.

4.5.5 BER Analysis of Modulation Schemes based on Gaussian noise channel with OFDM

Different modulation schemes were compared using their respective equations (3.17), (3.18), (3.19), (3.20) and (3.21) under Gaussian noise channel and the result simulated with MATLAB using the SNR values obtained from the field test to predict which modulation scheme would be the appropriate for transmission of DTT in Ashanti Region. However the minimum BER of each modulation scheme was compared to the minimum BER from NDBMTC.

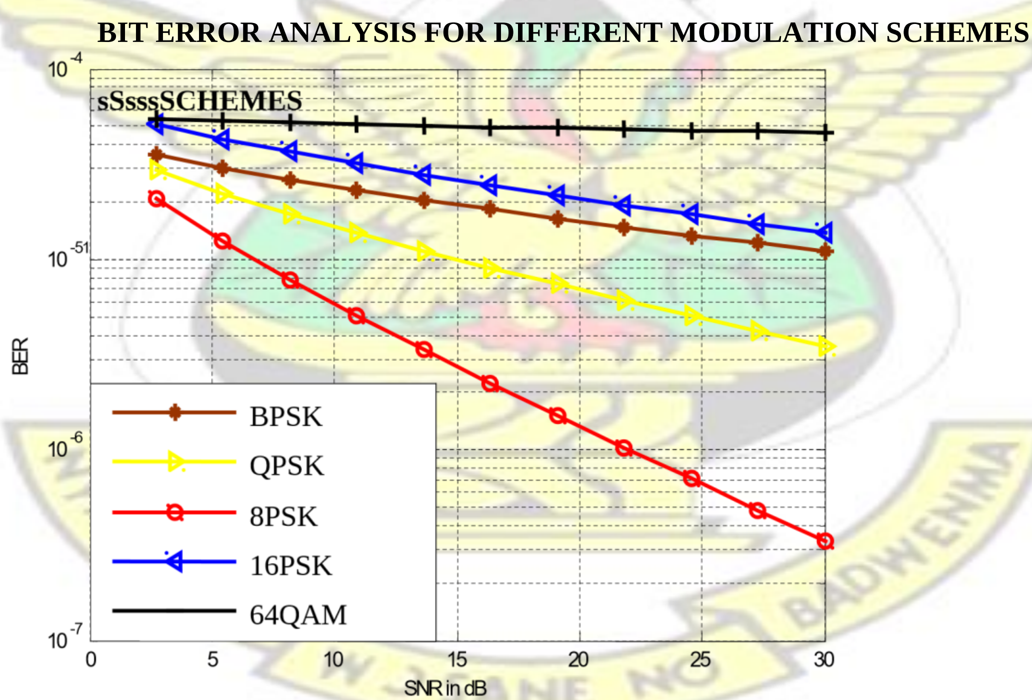

Figure 4.8: Bit Error Analysis for Different Modulation Schemes

From Figure 4.8 the different modulation schemes was analyzed using BER and SNR, the 64-QAM shows the maximum BER whiles 8PSK shows the minimum BER which could be due to interference and the robustness of the modulations schemes. As the SNR decreases BER increases because whenever SNR is high, received power is also high therefore reduction in path loss due fading.

Modulation scheme	Minimum BER at 30dB	Maximum BER at about 2.5dB
64-QAM	$1 \times 10^{-4.3}$	$1 \times 10^{-4.2}$
16PSK	$1 \times 10^{-4.8}$	$1 \times 10^{-4.2}$
QPSK	$1 \times 10^{-5.5}$	$1 \times 10^{-4.6}$
8PSK	$1 \times 10^{-6.7}$	$1 \times 10^{-4.7}$
BPSK	$1 \times 10^{-4.7}$	$1 \times 10^{-4.5}$

CHAPTER FIVE

5.1 Conclusion

The aim of this project work was to propose how DTT can be implemented in Ashanti Region to get a quality of services for the people in the region. The proposed implementation is in conjunction with Ghana's plans to undertake a migration to Digital Television Broadcasting by December, 2014.

The already existing transmitter by Smart TV in Kumasi and the physical map of the region were used to propose other new sites so as to give a full coverage of the region. The Smart TV transmitter in Kumasi is covering an area of 50km which was used to propose other new sites by measuring the distances from the proposed sites to Kumasi. However, three propagation models were compared to predict the minimum path loss so as to maximize the transmitter power. Also modulation schemes are compared to obtain the minimum BER so as to maximize power for optimal transmission.

Free space model was used as reference model and the theoretical values and measured values taken from the field test (field values) using two STBs one for Smart TV at Dadieso-Aba, Kumasi and the other for Skyy TV at Adum, Kumasi were analyzed using the equation of the free space model (3.1) and MATLAB was used for the simulation. There was difference in the theoretical graph and the graph of the measured values, since the free space model is a line of sight which is not applicable in Kumasi. However Smart TV shows different graph of measured values from Skyy TV due to the topology of the land and the obstacles between Transmitting-Receiving (T-R) separations.

The free space model was compared with two empirical models i.e. Okumura model and

Rec. ITU P.370 model using their respective equation and simulated using MATLAB by considering the theoretical graph, graph of measured signals and graph of the path loss of the three models so as to propose an appropriate propagation model to be used in Ashanti Region to enhance the quality of service. The signal received by Rec. ITU P.370 was the maximum with free space model being the minimum considering the same parameters for the three models. The path loss for free space model was the maximum while that of Rec. ITU P.370 was the minimum.

Different modulation schemes were analyzed using their respective equations and simulated using MATLAB. BER and SNR were used for the analysis, it was found that as the SNR increases BER decreases for the different modulation. However at 30dB, 8PSK was having the minimum error whiles 64-QAM was having the maximum error. All the modulation schemes have an error which is below the threshold value for digital voice to be heard.

The following conclusions were drawn:

- It was established that the variation between the theoretical and measured values of the free space model is due to the fact that the free space model uses line of sight, which is not applicable in Kumasi and its environs and also the difference between the Skyy TV and Smart TV curves was due to topology of the land and obstacles between the T-R separation of the respective stations.
- It was realized that the Rec. ITU P.370 model was approaching the measured values more than the two models from the received signal curves and the path loss curves, therefore the Rec. ITU P.370 propagation model is proposed in this work

to be used in Ashanti-region which will help engineers implementing the migration process from analog to digital TV.

- 8PSK has the minimum BER hence it received the maximum signal power after transmission, however 64-QAM has higher data rate and high spectral efficiency and the falls within the recommended value by NDBMTC, 2010 for the migration process.

5.2 Summary of Recommendation

- The Rec. ITU P.370 model is recommended in Ashanti-Region.
- In future works, other propagation models can be compared to Rec. ITU P.370 to determine if better results could be obtained from the other models that were not discussed in this thesis.
- 64-QAM is recommended for people in the region, however 256-QAM could be studied in future.
- Ashanti-Region being the second region which has a larger coverage of Electricity and highest population in Ghana, the DTT in that region would be very important.

REFRENCES

[1] Digital Television Transmission in Ghana, http://www.myskyyonline.com/SKYY_NEWS/Entries/2008/6/1_Entry_1.html.
(16/02/10)

[2] NDBMTC "Report to the Government of Ghana on the migration from analogue toDigital broadcasting in Ghana, final version" 2010.

[3] J.S. Chitode, "Information Coding, Techniques" First Edition, Technical PublicationPune, Anna Nager, chennel, 2008.

[4] http://www.nca.org.gh/documents/digital broadcasting/EXECUTIVE %20SUMM-Digital%20broadcasting%20report.pdf (11/03/2011)

[5] http://en.wikipedia.org/wiki/Digital_television(23/05/2011)

[6]"Digital Broadcasting Switchover", available of http/www/nca.gor.gh/index.php? Option=com content & view = article &id = 88&itemid = 87 (12/02/2010)

[7] Emmanuel Jacques, "DVB-T2: The New Story", Bangkok,2010,pp 9-11

[8] EBU Tech 3348 Frequency and Network Planning Aspects of DVB-T2.

[9] DVB-T (online); Available; http//en.wikipedia.org/wiki) DVB-T (15/11/2010). [10] DigiTAG Report, "Network in Evolution", Making Changes to the digital terrestrial television platform" ,May 2008,p 20.

[11] hppt://tech.ebu.ch/docs/tech/tech3348.pdf (1/12/2012)

[12] M.P.M. Hall, L. W. Barclay and M. T. Hewitt "Propagation of Radio Waves", published by institution of Electrical Engineers 1996, p 376.

13] Lairs – Ingemar Lundstrom, "Digital TV, by Terrestrial transmitters", in Understanding Digital Television, An introduction to systems with satellite, cable, Broadband and Terrestrial TV, Burlington, Elsevier, 2006 Ch 6,pp4-5.

[14] Paul G.M. de Bot, Flavio Daffara, 1993, 1995 JPL's, Wireless Communication Reference Website.

[15] Haneda and Etal, "Measurement-Based analysis of spatial degree of freedom inmultipath propagation" SMARAD Centre of Excellence, Aalto Univ., Espoo, Finland

[16] Aling Lu and Etal, "Effect of transmit antenna pattern of RAKE reception in

multipath fading channels" Commun. Res antenna lab, McMaster Univ., Hatrilton, Ont, Canada

[17] Thiagarajan Viswanathan, "Telecommunication Switching Systems and Networks", Eastern Economy Edition,pp 337-345,349,466-471.

[18] Tormos and Etal, "Performance evaluation for different MISO-SFN network for DVB-T2 standards" TDF-C2R. Metz, France

[19] Yang and Etal, "A new position system using DVB-T2 transmitter signature wavein SFNs Elect. and comp. eng. Dept. Univ. of Western Ontario, Canada

[20] DVB "Implementation Guideline for DVB-T Service", Transmission Aspects"1997, p. 46

[21] Liang Yin and Etal, "Digital dividend capacity in China, a developing country casestudy" Beijing Univ. of Posts & Telecom, Beijing, China.

[22] Steamus O'Leary," Understanding Digital Terrestrial Television Broadcasting "ARTECH BOUSE, INC, 2000, pp 149.

[23] "Guard Interval" [online]. Available: http://en.wiki/Guard_interval(15/11/2011).

[24] Lacroix and Etal, "OFDM with guard interval versus OFDM/off set QAM for high data rate UMTS downlink transmission" DMR/DDH Lab, France Telecom R&D, Cesson-Sevigne, France.

[25] Khambekar and Etal, "Utilizing OFDM guard interval for Spectrum sensing" Dept.of comp. sci., Wayne State Univ., Detroit, MI.

[26] DVB-T2_Handbook.pdf-Foxit Reader (2/10/2012)

[27]."Multi-Frequency network" (online). Available: http://en.wikipedia.org/wiki/Multi- frequency network(5/9/11)

[28] “Single frequency network” (online) Available http//en.wikipedia.org/wiki/ single

[29] Egli and Etal, “Maximizing coverage of SFN for digital TV Services” Univ. of Concepcion (UDEG), Concepcion, China.

[30] Plets and Etal, “SFN gain in broadcast network” Dept. of Technology, ChentUniversity Belgium.

[31] Schreiber, W. , “Advanced television systems for terrestrial broadcasting: Some problems and some proposed solutions”, Res. Lab. of Electron, MIT, Cambridge, MA, USA, Jun 1995

[32] Collins, G., “Fundamentals of Digital Television Transmission”,Wiley-IEEE Press, 1st Edition, 2001

[33] Jintao Wang, “A new implementation of single frequency network based on DMB-TV”, State Key Lab. on Microwave &Digital Commun., Tsinghua Univ., China, June 2004

[34] Ying-Wen Bai , “Design and implementation of set-top box of DVB-T system by a high integration chip solution”, Dept. of Electron. Eng., Fu Jen Catholic Univ., Taipei, Taiwan, June 2005

[35] Jian Song , “Technical Review on Chinese Digital Terrestrial Television Broadcasting Standard and Measurements on Some Working Modes”, Tsinghua Univ., Beijing, March 2007

[36] Jae-Young Lee, “implementation of transmitter identification signal analyzer in single frequency network”, Electron &Telecommun. Res. Inst., Daejeon, Jan. 2008

[37]Samuel Afoakwah, “Evaluation of analog/digital broadcast value chain implementation in Ghana: case study of content and multiplexing components”, KNUST-Kumasi, Ghana, September, 2011

[38] Eric Frempong Gyamfi, “Technical challenges of the transition from analog to digital television transmission in Ghana (2015): Case study: digital and terrestrial analogue television transmission in Accra and Tema environs”, KNUST-Kumasi, Ghana, September, 2011

[39] Amoogum. V, soyjaudah.K.M.S, Fogarty.T and Mohamudally. N, ‘comparativestudy of path loss suing Existing model for Digital Television Broadcasting for summer season. proceedings of third advanced IEEE international conference on

telecommunication, Mauritius vol. 4, pp34-38, may 2007.

[40] A.Medeisis and A.kajackas, propagation prediction model in rural areas; Vehiculartechnology conference proceedings, VTC tohyo vol. 3 pp1815-1818, may 2000.

[41] Wireless communication chapter 3 by T. S Rappaport.

[42] H. R. Anderson, “Fixed Broadband Wireless System Design”. John Wiley & Co. 2003

[43] Andrea Goldsmith, ”Wireless Communications”, Stanford University, 2004

[44] Mclaning, Kelvin “Radio Receiver Design” Noble Publishing Cooperation, 2007

[45] G. Poroakis “Digital Communication” Fourth Edition, Irwin/McGraw-Hill, imprint of the McGraw-Hill companies, Inc. New York, USA, 2000.

[46] Questionnaire Prepared to SKYY Digital TV, 2011 by Solomon Sobeng ofTelecom Department, KNUST, Kumasi, Ghana, 2011.

[47] Questionnaire Prepared to GTV Digital TV, 2011 by Solomon Sobeng of Telecom Department KNUST, Kumasi, Ghana, 2011.

[48] MTN Ghana- Network Group

[49] Statistical Department, Ghana

[50] http://wikipedia.org/wiki/file:Ashantidistrict.png (11/2/2011)

[51] hppt://energycenter.knust.edu.gh/downloads/5/51124.pdf (11/12/2010)

[52] hppt://www.microvolt.com/table.html (1/12/2012)

APPENDICES

APPENDIX A PROGRAMS/CODINGS

```
clc; clear
all; close
all;
%distance from base station antenna
d=0:1:1000; %carrier frequency
f=900; %speed of light c=3*10.^8;
%wavelenght lamda=c/(f*10.^6);
%Gain of the base station antenna
Gt=1;
%Gain of the receiver antenna
Gr=1; %propagation path loss
pl=32.44+20*log(d)+20*log(f)-Gt-Gr;
display('propagation path loss is:');
disp(pl); plot(d,pl);
xlabel('distance(m)');
ylabel('propagation path loss');
grid on; clc; clear all; close
all;
```

```
d=1:1000;

Hre=input('Enter the receiver antenna height 3m<hre<10m : ');          % Mobile Antenna
Height

Hte =100;

f=900; c=3*10^8;

lamda=(c)/(f*10^6);

Lf = 10*log((lamda.^2)/((4.*pi).^2)*d.^2); %   Free Space Propagation Loss

Amu = 35;       % Median Attenuation Relative to Free Space (900 MHz and 30 Km)

Garea = 9;      % Gain due to the Type of Environment (Suburban Area)

Ghte = 20*log(Hte/200); % Base Station Antenna Height Gain Factor

if(Hre>3)

Ghre    =    20*log(Hre/3);

else

Ghre    =    10*log(Hre/3);

end

%Propagation Path Loss
L50 = Lf+Amu-Ghte-Ghre-Garea;

display('Propagation pathloss is : ');

disp(L50); plot(d,L50);

title('Okumura Model Analysis');

xlabel('distance');

ylabel('Propagation Path loss(dB)');

grid on;
```

```
clc; clear
all; close
all;
%base station antenna height(m)       ht=100;
%distance from base station(m)
d=[100,200,300,400,500,600,700,800,900,1000];
%receiving antenna height(m) hr=10; %carrier
frequency f=900; c=3*10.^8; lamda=c/(f*10.^6);
pi=3.142;
Pt=(2*10.^3);
G=1;%gain
Emin=(88*(Pt)^(1/2)*ht*hr)./(lamda*d.^2);
Ae=((lamda^2)*G)/(4*pi);
%propagation path loss
PL=Pt-2*Emin+240-Ae+10*log(120*pi);
display('propagation path loss is:');
disp(PL); plot(d,PL); title('rec.itu
p370 model analysis');
xlabel('distance(m)');
ylabel('propagation pathloss'); grid
on;


%snr=10.^(snrdB/10);
```

```
%============================================================
=============

sn=[0 21.2 21.3 21.4 21.5 26.6 27.1 27.3 27.5 27.8 28 28.1];      % Measured SNR

%============================================================
=============

x=[0 -62.2 -61.2 -61.8 -61.7 -41.9 -41.1 -40.9 -40.8 -40.7 -40.7 -40.6]; %
Measured signal strength in dBm

%============================================================
=============

P=10.^(x-30)/10; % Measured signal in watts

%============================================================
=============


%Probability of Error Estimation

%============================================================
=============

px=0.5*erfc(snr.*sigma/sqrt(2));              %BPSK


x1=0.5*erfc((1.477*snr.*sigma)/sqrt(2));       %QPSK


x2=0.5*erfc((2.2155*snr.*sigma)/sqrt(2));      %8PSK


x3=0.75*erfc((1.0833*snr.*sigma)/sqrt(2));     %16PSK
```

```
x4=0.5833*erfc((0.211*snr.*sigma)/sqrt(2));    %64QAM
%============================================================
=============

%============================================================
=============

%Capacity estimation

%============================================================
=============

k=1+snr;

C_sm=B_sm*log2(k);

C_sma=B_sm*log2(k);

C_sk=B_sk*log2(k);

%============================================================
============

%Graphics(BER)

%============================================================
=============

figure(1) semilogy(snr,px,'-*')

%BPSK hold on semilogy(snr,x1,'-

>')          %QPSK hold on

semilogy(snr,x2,'-o')          %8PSK

hold on

semilogy(snr,x3,'-<')          %16PSK

hold on semilogy(snr,x4,'-+')
```

```
%64QAM ylabel('BER') xlabel('SNR
in dB')
title('BIT ERROR ANALYSIS FOR DIFFERNT MODUALTION SCHEMES')
%==============================================================
=============
```

APPENDIX B

Ghana - Electricity coverage, on Regional basis, as on 1/2/2010[50]:

1. Ashanti 80.70%
2. Brong-Ahafo 62.53%
3. Central 70.16%
4. Eastern 61.56%
5. Greater Accra 95.77%
6. Northern 43.62%
7. Upper East 30.43%
8. Upper West 31.95%
9. Volta 58.35%
10. Western 59.43%

APPENDIX C

Table C1 values recorded by smart decoder at 9km away from the transmitting antenna at receiving antenna height of 1.5m

Date: 6/1/2012 **Coordinate: N 06**°40.226 *W* 001° 33.751

Signal Strength	BER	Signal to noise Ratio
-48.1dBm	3.3E-05	18.8dB
-48.1dBm	3.3E-05	18.8dB
-48.1dBm	2.8E-05	18.6`dB
-47.4dBm	2.8E-05	18.9dB
-48.1dBm	2.7E-05	20.3dB
-48.8dBm	2.7E-05	19.4dB
-48.7dBm	6.7E-05	20.5dB
-48.3dBm	5.1E-05	20.7dB
-48.2dBm	6.7E-05	19.0dB
-48.3dBm	5.1E-05	20.2dB
-48.2dBm	5.5E-05	18.7dB
-48.6dBm	5.2E-05	19.7dB
-48.8dBm	1.7E-04	19.1dB
-48.8dBm	3.7E-05	18.4dB

Table C2 values recorded by smart decoder at 6km away from the transmitting antenna at receiving antenna height of 10m

Date:6/1/2012 **Coordinate: N 06**°41.336 *W* 001°34.395

Signal Strength	BER	Signal to noise Ratio
-42.0dBm	0.0E+00	27.0dB
-43.7dBm	0.0E+00	26.6dB
-43.5dBm	0.0E+00	26.6dB
-43.6dBm	0.0E+00	26.6dB
-43.5dBm	0.0E+00	26.7dB
-43.4dBm	0.0E+00	27.6dB
-43.4dBm	0.0E+00	26.5dB
-42.0dBm	0.0E+00	27.0dB
-43.7dBm	0.0E+00	26.6dB
-43.5dBm	0.0E+00	26.6dB
-43.6dBm	0.0E+00	26.6dB

-43.5dBm	0.0E+00	26.7dB
-43.4dBm	0.0E+00	27.6dB
-43.4dBm	0.0E+00	26.7dB
-43.7dBm	0.0E+00	26.6dB

Table C3 values recorded by smart decoder at 4km away from the transmitting antenna at receiving antenna height of 10m

Date:6/1/2012 Coordinate: N 06°42.986 *W* 001°28.372

Date:7/1/2012Coordinate: N 06°43.335 *W* 001°13.866

Signal Strength	BER	Signal to noise Ratio
-41.1dBm	0.0E+00	27.1dB
-41.9dBm	0.0E+00	26.6dB
-40.8dBm	0.0E+00	27.5dB
-43.6dBm	0.0E+00	28.1dB
-40.8dBm	0.0E+00	28.0dB
-40.6dBm	0.0E+00	28.1dB
-41.7dBm	0.0E+00	28.0dB
-42.2dBm	0.0E+00	21.3dB
-42.7dBm	3.9E-05	21.4dB

Table C4 values recorded by smart decoder at 4km away from the transmitting antenna at receiving antenna height of 1.5m

Date:7/1/2012Coordinate: N 06°43.335 *W* 001°13.866

Signal Strength	BER	Signal to noise Ratio
-41.1dBm	0.0E+00	27.1dB
-41.9dBm	0.0E+00	26.6dB
-40.8dBm	0.0E+00	27.5dB
-40.6dBm	0.0E+00	28.1dB
-40.8dBm	0.0E+00	28.0dB
-40.6dBm	0.0E+00	28.1dB
-40.7dBm	0.0E+00	28.0dB
-41.2dBm	0.0E+00	21.3dB
-41.7dBm	3.9E-05	21.4dB

Table C5 values recorded by smart decoder at 5km away from the transmitting antenna at receiving antenna height of 1.5m

Date:7/1/2012Coordinate: N 06$^{\circ}41.348\ W\ 001^{\circ}34.286$

Signal Strength	BER	Signal to noise Ratio
-47.8dBm	0.0E+00	27.1dB
-47.5dBm	0.0E+00	25.6dB
-46.4dBm	0.0E+00	27.5dB
-45.9dBm	0.0E+00	28.1dB
-45.5dBm	0.0E+00	27.0dB
-46.2dBm	0.0E+00	25.1dB
-46.3dBm	0.0E+00	28.0dB
-46.0dBm	0.0E+00	22.3dB
-46.1dBm	3.9E-05	21.4dB
-42.1dBm	3.7E-05	22.2dB
-42.2dBm	4.9E-05	23.2dB
-42.2dBm	4.2E-05	24.2dB
-41.1dBm	4.2E-04	21.4dB
-40.2dBm	3.9E-05	21.4dB

Converting of dBμV/m to dBm

The Skyy TV decoder presented readings of Signal Strength in dBμV/m and therefore needed to be converted to dBm so that all the recordings have the same unit.

The formula for conversion:

$dBm = dB\mu\,V/m - 107dB$ [52] (8)

Table C6 values recorded by Skyy decoder (channel 40) at 4km away from the transmitting antenna at receiving antenna height of 1.5m

Date:7/1/2012 **Coordinate: N 06°42.218 W 001°34.733**

Signal Strength	BER	SNR
-48.9dBm	0.0E+00	27.1dB
-48.4dBm	0.0E+00	25.6dB
-41.8dBm	0.0E+00	22.5dB
-42.6dBm	0.0E+00	28.1dB
-42.8dBm	0.0E+00	28.0dB
-41.7dBm	0.0E+00	26.1dB
-41.6dBm	0.0E+00	28.0dB
-43.1dBm	0.0E+00	23.3dB
-41.7dBm	3.9E-05	21.4dB
-42.7dBm	3.7E-05	23.2dB
-43.2dBm	4.2E-05	2132dB
-42.2dBm	4.1E-05	21.2dB
-41.1dBm	1.2E-03	23.4dB
-40.2dBm	2.1E-02	22.4dB