

# Modelling an Efficient Gap Filler for DTT network using ADS Software

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**Abstract** - This paper proposes the modelling and simulation of a special gap filler intended to cover grey areas in the DTT network of Accra. This has become necessary due to the numerous areas of low signal coverage in the Accra DTT and the incapability of previous methods to efficiently address the problem. The ADS simulation consists of arrangements of components from the DBV-T library which consists of filters, amplifiers and a power source. This setup mimics a gap filler system with a better noise reduction implementation, several frequency values are being used for the simulation process. A significant increase in the output signal as in comparison to the input means the shaded areas will be properly covered. The results derived from the simulation of the ADS setup highly improved upon the output signal values, when compared to the ITU standard. Three (3) out of five (5) simulation results show values beyond the minimum signal level requirement. Also using MATLAB, the RF propagation toolbox which has the map tool feature was able to implement the gap fillers into the Accra area and gave a visual representation of the signal strength. Modelling a gap filler system which has better noise cancellation and which propagates better with a dipole antenna was achieved in this paper. The outcome of the paper shows that the gap filler modelling increase signals in grey areas.

**Index Terms** - Digital Terrestrial Television, Gap filler, Grey areas, MATLAB, Advanced Design System (ADS)

## I. INTRODUCTION

Gap filler are low-power signal repeaters which are deployed to resolve failures in shade areas as a result of either artificial or natural hindrances within the coverage area [1] In the current broadcasting system, the radio repeater or gap-filler as they are also referred to are used to provide signal rebroadcast in a radio dead zones such as underground city and tunnel space. Some of them can transmit broadband RF signal through optical fibre after a conversion is done from electric to optical signal. The gap-filler system then receives the signal on an antenna and retransmits it in dead zone coverage areas with radio over fibre (RoF) replay links.[2]

Analogue to digital television transmission is the transition from analogue broadcasting to digital broadcasting. Digital transmission has changed the way television channels are allocated and will result in new measures to enhance the optimization of service coverage. There was a mandate from the International Telecommunication Union (ITU) that every country to move from analogue television to digital terrestrial television (DTT) by 2015. [3] Ghana migrated from Analogue to Digital Terrestrial Broadcasting by March 2016, according to the Ministry of Communications.

Over the past 10 years, there has been a change in broadcasting which has been influenced by digitization. This migration led to the release of some valuable spectrum currently used for analogue television broadcasting for the provision of mobile broadband services. Migration from Analogue to Digital Broadcasting basically has to do with the process of TV stations moving from analogue network to a digital-based transmission.

Reference [4] modelled their Gap filler in this way. It consisted of an RF amplifier in the digital channel with a feedback cancellation filter. This prevented certain limits of the signal transmitted cancels itself at the receiver input. The technology used here does not make this an actual channel equalizer, although exists an adaptive filter, this makes this a limitation which should be worked upon in subsequent research.

Reference [5] tried to improve the indoor signal quality within a house. The optimum radiated power of a DVB-H gap filler for good indoor coverage at 514 MHz in different types of houses is determined. Proposed here is a new criterion for the Electric-field value and carrier-to-interference-plus-noise ratio corresponding with good reception. The study from this paper can assist broadcasters and operators to determine the optimal radiated power of indoor gap fillers for a specific coverage area requirement and to perform link budget calculations for indoor coverage because of the lognormal distribution of indoor penetration losses within the house and

the minimum Effective Radiated Power (ERP) to derive good indoor coverage is determined.

Another reference shows that the satellite digital multimedia broadcasting system shows that general coverage can be achieved by a combination of a geostationary satellite and a complementary terrestrial gap filler (GF) system was explained by [6]. The paper also states other issues which were investigated and efficient GF deployment is recommended. Investigates here is the trade-off between gap filler distance and receiver searching algorithm complexity.

This paper makes an attempt to improve the noise cancellation using improved ADS techniques which shows positive and better signal output. Dipole antennas was used in the gap filler system which shows considerable signal boost improvement in the gap filler system. It is recommended that gap fillers are placed to increase signal quality in the Accra Environs. A receiver should possess an access system to allow for encryption of signal services coming from the different multiplex. Also, a better replacement policy should be instituted when the T2 transmission begins. The regulation body/bodies should ensure that such replacements are made as at when due

## II BACKGROUND

### A. Single Frequency Network (SFN)

In this network, a source of constant supply provides the digital signal to two co-channel transmitters, these transmitters send out the same content synchronously. A single frequency network is required to transmit the same signals over the same frequency, and at the same time. The modulation scheme determines the precision of synchronization which is being used to broadcast content. If the accuracy of synchronization is on nanosecond range, it is said to be more accurate. (The more accurate the synchronization between the transmitters, the better the receiving conditions). To enable such synchronous transmission, a common transport stream is provided by a content source. This transport stream includes a multiplexer or an IP encapsulator in the case of an IP Datacast.

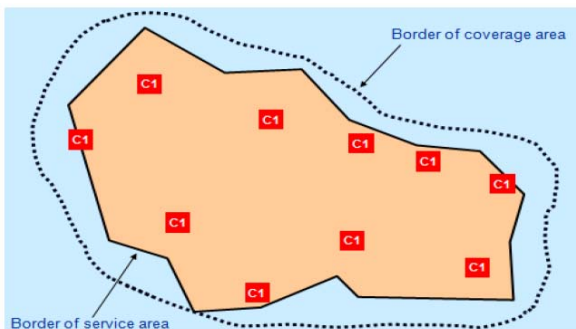


Figure 1: Single Frequency Network Architecture.

### B. Multiple Frequency Network (MFN)

A multi-frequency network (MFN) is a network in which multiple/various radio frequencies (RFs) are used to broadcast media content (*EBU Technical Report on Digital Video*, 1999). A planned DVB-T network includes different transmitters with different separate programs signals and with individual frequencies.

A Multi-Frequency Network is a network of transmitting stations that all use their own frequency. The main reason to use different frequencies for the stations is to prevent co-channel interference between the transmitters. Frequencies can only be re-used after a certain separation distance between the stations using the same frequency.

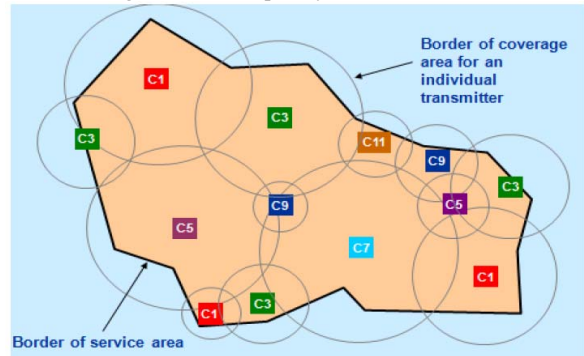


Figure 2: Multiple Frequency Network.

### C. Overview of Gap Filler Technology

Gap-fillers or on-channel repeaters as they are also called are systems that retransmit the digital signal so as to effectively boost the quality of service and increase coverage area in shadowed areas, which cannot be reached by the original transmitters. [8]. When Digital Terrestrial Television (DTT) Transmitters are non-effective in areas which are obstructed due to either man-made structures or natural topography, this is where Gap Fillers are deployed for retransmission for effective coverage. [9]

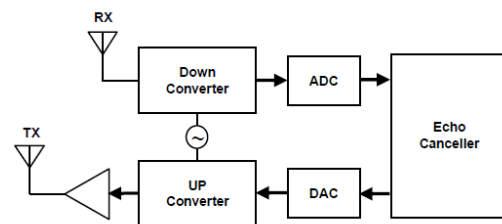


Figure 3: Architecture of conventional gap filler

Figure 3 depicts the architecture of a conventional Gap Filler [1], which includes a high-gain receiving antenna, along with a processing what selects the desired channel and retransmits it via a directional antenna. One important feature of the processing is the echo cancellation, which reduces the interference due to the relayed signal that comes back to the

receiving antenna. In this setup, the transmitted power can be adjusted manually to derive satisfactory coverage in the grey/shaded area.

#### D. Accra DTT Network

[10] explains the Accra DTT network regarding the challenges of transition from analogue to digital Transmission which explains that there are four sites currently used by existing DVB-T broadcasters serving Accra and Tema environs. They are located at McCarty Hill, Adjangote, Sakumono and GIMPA Legon campus. The study showed that signals received from the two DVB-T transmissions broadcast by the two operators during the study period were slightly above the minimum required level with others below the level set by the ITU for the DV-T reception. The recommendations of this paper were that a gap filler system integrated into the network will boost reception and minimize cost for viewers and also that co-location of transmitters should be done.

### III. METHODOLOGY

This design consists of developing an ADS model made of a number of components connected in a special manner to form the gap filler with justification.

The power source component is first added having a single frequency which is then connected to the noise oscillator phase noise. The oscillator inherently produces high levels of phase noise. These noises are at different frequencies as shown in the model (Figure 4). A mixer is attached having a function of being used to shift signals from one frequency to another. Next are two Butterworth filters connected with an amplifier in between them. A Butterworth filter can be explained as a signal processing filter designed to operate at a frequency response as flat as possible. They are referred to as flat magnitude filters. The amplifier's purpose is to boost the signal's power, to raise it to a reasonable level for transmission.

#### A. ADS Simulation setup

The signal passes through a number of components interconnected. Noise is added through the noise phase oscillator and it is passed through the mixer. The signal passes through a Butterworth filter, a series of amplifiers and filters before ending up at the output terminal. The components are set at specific values in order to achieve results and all are specified in the simulation design.

The following are the variable parameters in this simulation worthy of note;

#### Butterworth filter:

F center = IFfreq1  
 BW pass = 20MH  
 Apass = 1.2dB(-1)  
 BWstop=60MHz

Astop=20 dB

#### Amplifier

S21 = dbpolar (IFAGC, 0)  
 S11 = dbpolar (-12, 0)  
 S22 = dbpolar (-15, 180)  
 S12 = 0

The Harmonic simulator has the following parameters:

TRfreq =1910  
 IFfreq1=186 MHz  
 LOfreq2=1761MHz  
 FreqBase = 40 MHz  
 Base Power = -90watts  
 IFAGC=15  
 LO freq1= 148MHz

The frequency base (FreqBase) of the baseband signal was varied from 20MH to 60 MHz for this simulation. The values of this simulation were taken in comparison with the south American standard.

### IV RESULTS AND INTERPRETATION

This section presents simulation results (Figure 5 to 10) obtained from different simulations scenarios with the ADS software at various initial baseband frequencies ranging from 20MHz to 60MHz

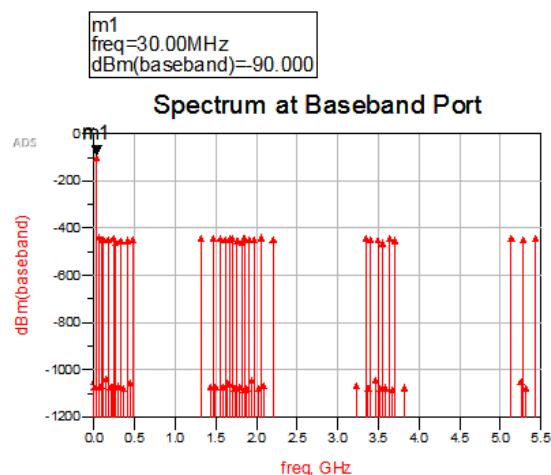


Figure 5: Graph of Spectrum at Baseband port at frequency 30 MHz

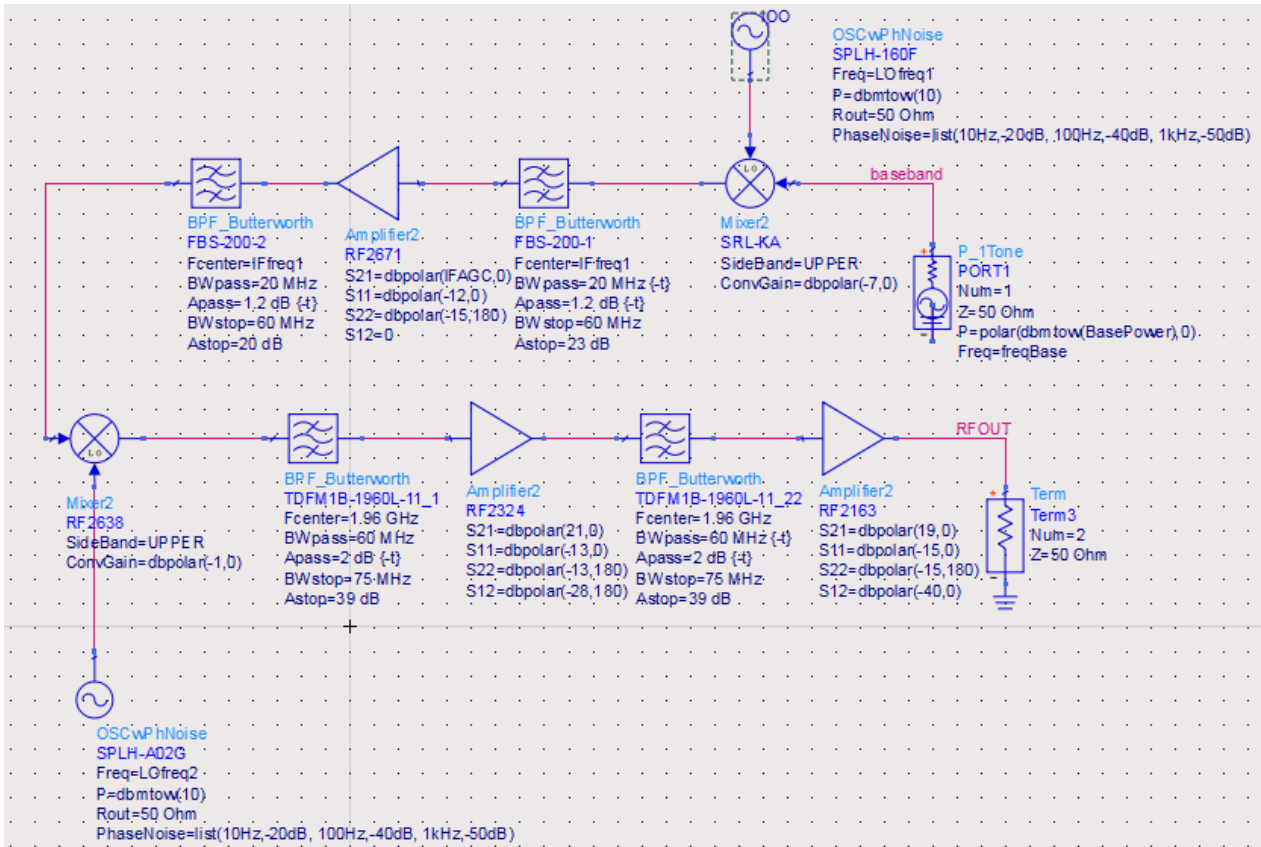


Figure 4: System Schematic of the Gap filler system.

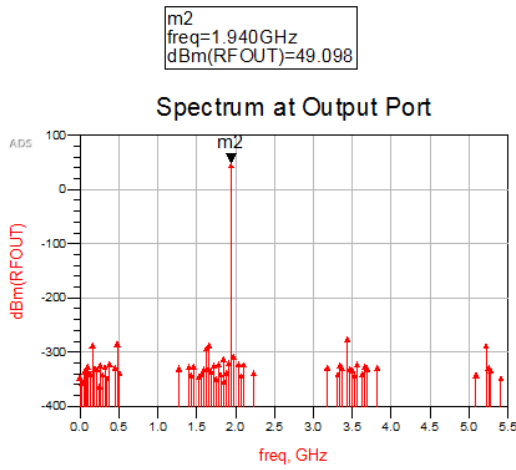


Figure 6: Graph of Spectrum at Output port at frequency 30 MHz

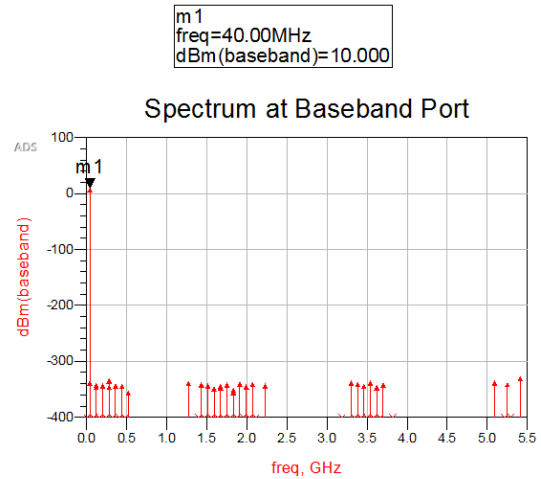


Figure 7: Graph of Spectrum at Baseband port at frequency 40 MHz

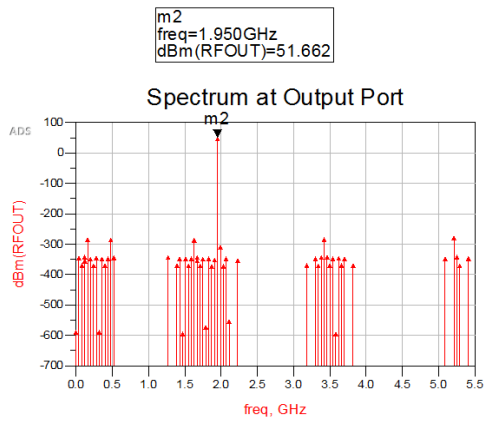


Figure 8: Graph of Spectrum at Output port at frequency 40 MHz

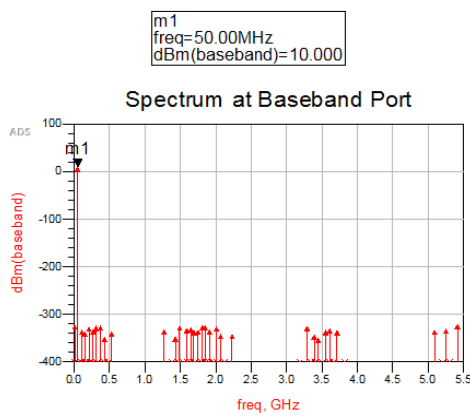


Figure 9: Graph of Spectrum at Baseband port at frequency 50 MHz

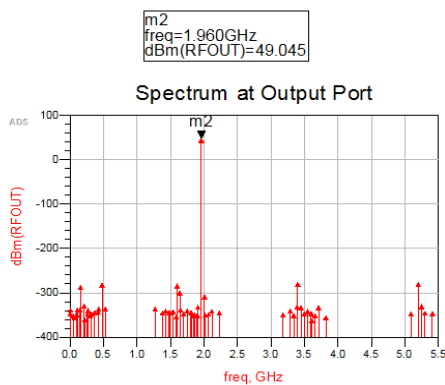


Figure 10: Graph of Spectrum at Output port at frequency 50 MHz

Table 1 below shows the summary of results illustrated in the previous graphs (Figure 5 to 10). The RF output signal in dBm as well as signal level in dB $\mu$ V/m have been provided for all the simulated scenarios.

TABLE 1: SUMMARY OF SIMULATION RESULTS.

Baseband Frequency (MHz)	Baseband signal (dBm)	Output frequency (GHz)	RF Output signal (dBm)	Signal level (dB $\mu$ V/m)
20	-90	1.929	-73.444	33.56
30	-90	1.939	-43.865	63.13
40	-90	1.949	-43.288	63.71
50	-90	1.959	-49.174	57.83
60	-90	1.969	-72.644	34.36

#### A. Comparing with standard

Information gathered in Accra metropolis earlier proved that the signal level is slightly lower than the ITU standard requirement for most locations. The measurements taken by [10] showed that the signal level received by SKYY Digital and GTV's DTT transmission was slightly below the International Telecommunication Union Standard. However, with the results obtained from the gap filler simulation, better coverage has been realized. This is the ITU-R (International Telecommunication sector for Radio communication) standard for the reception of DVB-T for fixed reception in band V; 64 QAM and code rate of 2/3: the minimum signal level set by the ITU-R is 48dB $\mu$ V/m. [11] [12]. This has been largely met with reference to Table 1.

#### V. DISCUSSION

The results from table 1 show varying output signal values depending on the baseband frequency set. This shows that the highest signal value at -43.288 dBm is gotten at a baseband frequency of 40 MHz. The RF output signal level decreases with an increase in the baseband frequency from 40 to 60 MHz. A decrease in the output signal is also observed as the frequency reduces from 40 to 20 MHz i.e. from -43.288 dBm to -73.444 dBm. This gap filler simulation model, when adopted into the Ghana DVB-T system, will boost signal reception in the grey areas of the coverage area and will be able to conveniently meet the ITU standard. The signal power has considerably increased which becomes beneficial to the end users.

The yellow bar in Figure 11 shows the minimum signal level set by the ITU-R (International Telecommunication sector for Radio communication) for the reception of DVB-T to fixed reception in band V using 64 QAM and code rate of 2/3. The minimum signal level set by the ITU-R is 48dB $\mu$ V/m [11] [12].

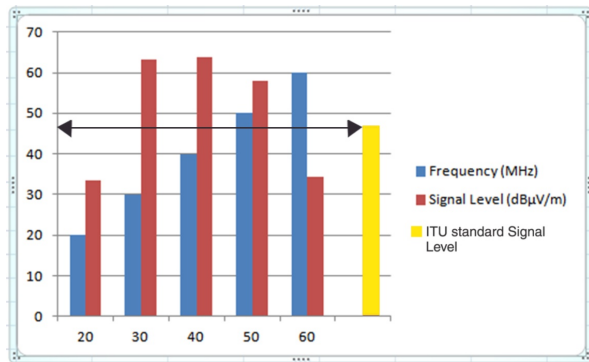


Figure 11: Simulation results compared to the ITU-R standard.

Working with the frequency range of 20MHz to 60MHz for this simulation, it can be said that three of the simulation results are sufficiently above the ITU-R standard that is set for the reception of a fixed reception in the band V. This simulation model seems to be ideal in dealing with the low coverage problem, and should be integrated into the Accra DDT system to improve reception.

The problems encountered in the review of the Accra DTT network system were mostly fading of the transmission signal and multipath propagation due to high-rise buildings and other obstacles in the Accra metropolis. Introducing the gap filler system will reduce signal fading significantly with an increase in the signal output at the receiver.

#### VI CONCLUSION

This paper proposes a new technique using ADS simulation that improves the output signals of a transmitter with the use of specially designed filters and amplifiers. The signal coverage has been extended over the grey areas with a significant signal level in comparison to the ITU minimum signal level requirement of 48dBµV/m. This extension of signal coverage will lead a better user satisfaction and experience with regard to the DTT migration in Ghana.

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#### APPENDIX

##### APPENDIX A: STANDARD US FREQUENCY OFFSET.

Band	Frequency Range (MHz)	Offset	Notes
10m Ham (repeater subband)	29.5-29.7	-100 kHz	1
VHF Low Band	30-50	No standard offset	
6m Ham	50-54	-500 kHz or -1 MHz	1
VHF High Band	138-174	No standard offset	2
2m Ham	144-148	+600 kHz or -600 kHz	1
220 MHz	220-222	+1 MHz	
1.25m Ham	222-225	-1.6 MHz	1
380 MHz Federal LMR	380-400	+10 MHz	
Federal UHF	406.1-420	+9 MHz	3
70cm Ham (repeater subband)	440-450	+5 MHz or -5 MHz	1
UHF Canadian border area	420-430	+5 MHz	
UHF	450-470	+5 MHz	
UHF T	470-512	+3 MHz	4
Lower 700 MHz	698-746	+30 MHz	5
Upper 700 MHz	746-806	+30 MHz	
800 MHz	806-896	-45 MHz	
900 MHz	896-940	-39 MHz	6