TV White Spectrum for Wireless Broadband Internet Connectivity (WBIC)

A theoretical analysis of utilizing TV White Spectrum for Wireless Broadband Internet Connectivity (WBIC) on the basis of availability in the perspective of Bangladesh

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Abstract—**TV White Spectrum utilization has become a major concern in the field of communication sector throughout the world. This research paper focuses on utilizing the TV White Spectrum for Wireless Broadband Internet Connectivity (WBIC) on the basis of availability. For reference, a practical scenario has been considered. The scenario represents the TV White Spectrum of Bangladesh Television (National Television Channel of Bangladesh) and utilizes the unused bandwidth for Wireless Broadband Internet Connectivity (WBIC). Bangladesh government has allocated 56 MHz of Bandwidth among 200GHz of total bandwidth for communication purposes of Bangladesh for BTV (Bangladesh Television) broadcasting. But, BTV is using only 6 MHz of the available 50MHz frequency. So, the rest of the 50 MHz frequency remains unused. This paper, explains how this unused 50MHz frequency can be used for Wireless Broadband Internet Connectivity (WBIC). This paper also considers a case of using 6 MHz frequency for Sangsad Television (A live broadcasting TV Channel of Parliamentary Sessions). On the basis of availability of these two Television Channel (BTV and Sangsad TV) White TV Spectrum of 56 MHz have been explained and proposed. In this research a proposed model has been designed to use the unused bandwidth and simulation result proves that higher data rate can be achieved by using this white TV spectrum.**

Index Terms—**White TV Spectrum, Wireless Broad Band Internet Connectivity, Terrestrial Broadcasting.**

I. INTRODUCTION

Utilization of White TV Spectrum has become a major trending research topic among the communication engineers around the globe. Different countries are already using this unused bandwidth for mobile communication. Bangladesh is a country of 156.6 Million of people [] with the area of 1, 47,570 Square Kilometers. Only about 6.5 Percent of the total population has the access to the internet [World Bank]. As the internet is one of the most important factors for the digitization of the nation, the policy makers are focusing on increasing the rate of the internet users in Bangladesh. Rather than depending on the private organizations the government could utilize their potentials for providing wireless broadband internet connectivity to the mass people. Bangladesh Government has the allocation of 200GHz bandwidth for all of the nation's communication purposes [11]. Among these 200 GHz frequency, Bangladesh Television have the access to 56MHz for use to broadcast. But, Bangladesh Television only uses 6 MHz of the allocated 56 MHz frequency. The rest of the bandwidth remains unused, which can be used for providing wireless broadband internet connectivity. Besides Bangladesh Television, Sangsad Television (A live broadcasting Television Channel of Parliamentary Sessions) is also using 6 MHz of the rest 50 MHz bandwidth while the Parliamentary Sessions goeson. So, the authority has the access to all the 44 MHz of the bandwidth for utilization. In this research paper, all these scenarios have been briefed with flow chart and proper logical explanations.

II. RELATED STUDY

A. Television Broadcasting

Television Broadcasting system are encoding standards for the transmission and reception of terrestrial television signals. The television broadcasting system is mainly divided into two major categories one is analog television system and another one is digital television system. There are three main analog television systems in used around the world until late 2010s (expected) which are NTSC (National Television system committee), PAL (Phase Alternating Line) and SECAM (Sequential Color with Memory). These system were developed from 1940 to 1960s. In 1942 the federal communications commission adopted the recommendation of NTSC [1]. This committee developed a television channel which requires a bandwidth of 6 MHz to transmit the signals. The video signal is transmitted between 500 KHz and 5.45

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MHz above the lower limit of the channel. Each sideband of 4.2 MHz wide. The upper sideband is transmitted and also 1.25 MHz of the lower sideband is transmitted which is known as vestigial sideband. The color subcarrier is 3.5795 MHz above the video carrier. The audio signal is frequency modulated and it broadcasted by FM (frequency Modulated) radio station in the range of 88 to 108 MHz bandwidth. To make the audio signal softer and efficient, audio carrier is 4.5 MHz above the video carrier. In Europe The SECAM system was developed in 1961[4]. It has two sub carriers, consisting of two simple FM signals at 4.41 MHz and 4.25MHz, which made this system more efficient respect to PAL and NTSC. Its also required the bandwidth of 6 MHz to broadcast the signals [5]. It is required to use no more bandwidth than the monochrome signal alone. The color signal has to be inserted into the monochrome signal without creating any problems. Though monochromes TV signal is not continuous, so it is possible to use the empty space for color signal. After few years varies color system was proposed among them PAL is one of the best system[2][3]PAL system use a quadrature amplitude modulation subcarrier which carry the chrominance information added to the luminance video signal to form a composed video baseband signal. For PAL, subcarrier uses a frequency of 4.4336187 MHz which is slight higher than NTSC which is also shown in the figure 1. Phase Alternating Line can be describe that the phase of part of the color information on the video signals is reversed with each line, which has the ability to automatically corrects phase errors in the transmission of the signal by cancelling them out, at the expense of the vertical frame color resolution.

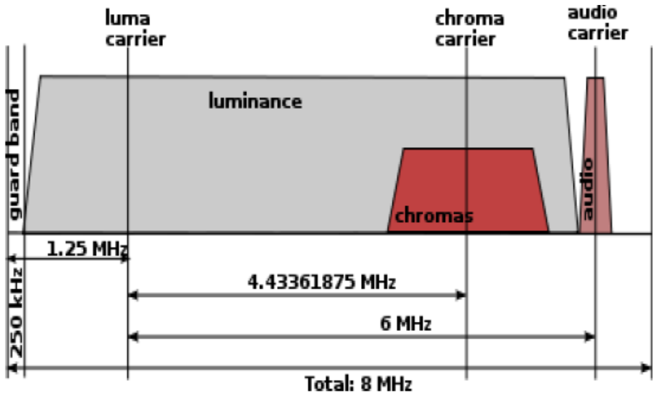

Figure1: Bandwidth allocation for terrestrial TV[6]

Before 1990, digital broadcast network was impractical due to the implementation cost. But the advance digital technology in both the algorithmic and hardware implementation side, the system was designed. The transition to digital technology results in an improved spectrum efficiency, where more program channel can be broadcast within the same bandwidth. The spectrum occupied by analogue TV can be used for new service, such as more broadcast channels or mobile communication [6]. For the digital television, it is important to design compression algorithms so that it does not damage human eyes or ears[7].At first in 1990, Advanced Television System Committee (ATSC) set a standard for digital television transmission over terrestrial, cable and satellite networks. If broadcasters use ATSC with an analog signal must broadcast on two separate channels because ATSC system requires an entire channel. ATSC system used Dolby Digital AC-3 as the audio codec and it is standardized as A/52. Five channels of sound with a sixth channel for low frequency effects can be used which is known worldwide as 5.1 configurations. MPEG-1 and MPEG-2 are used for the ATSC audio system. ATS signal are designed for 6 MHz bandwidth as analog television channel and terrestrial broadcast use 8VSB modulation that is capable of transferring data at a maximum rate of 19.93 Mbit/s which is more than sufficient for transferring audio and video signals. This data rate is much higher for the cable television which is 38.78 Mbit/s, using the same bandwidth 6 MHz channel. Digital video broadcasting (DVB) is one of the standard systems for digital television. This system is different mainly in the modulation schemes. It can use QPSK, QAM and even some cases it can combine QAM or QPSK with OFDM and can support hierarchical modulation. ISDB (Integrated Service Digital Broadcasting) and DTMB(Digital Terrestrial Multimedia Broadcast) broadcasting system has also been developed which are used by different country. Analog terrestrial broadcasting has few drawbacks which has been modified in the digital terrestrial television and more data can carry through this system. This system will develop the transmission of pictures quality dramatically and definitely the sound quality than the current one.

B. Terrestrial Broadcasting

In Terrestrial broadcasting signal is transmitted by radio waves to the receiver from a terrestrial transmitter and received with an antenna and when this system is implemented for broadcasting television then this system is named as terrestrial television. Terrestrial broadcasting was first implemented in USA in 1927. To make it more efficient digital terrestrial modulation has been started using in some of the developed count

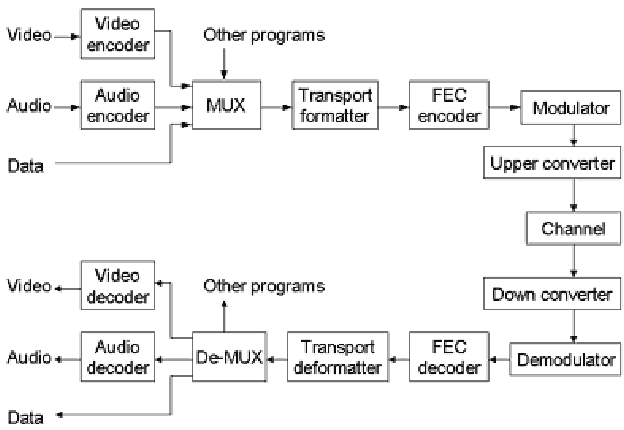

Figure2: Modulation scheme for Digital terrestrial broadcasting[12]

Digital terrestrial television broadcasting system (DTTB) has been shown in the figure2. Video, audio and other data are compressed and multiplexed to form elementary streams. Then streams may be multiplexed with the source data from other programs to from the MPEG-2 transport stream. Transport packets that are 188 bytes in length is considered as a transport stream. The FEC encoder takes preventive measures to protect the transport streams from errors caused by noise and interference in the transmission channels. It also includes convolutional coding Reed-Solomon coding, and outer interleaving which is also known as Viterbi. After that modulator converts the FEC protected transport packets into digital symbols that are suitable for transmission in the terrestrial channels. It involves Quadrature amplitude modulation (QAM) and OFDM in DVB-T and ISDB-T systems, or PAM and VSB in ATSC-T. Then the final stage comes to an action which is the upper converter, which converts the digital modulated signal into the appropriate RF channel. The operation in the receiver end as the same as transmitter end but the sequence of operations is in the reverse order of the operations. The total system required a bandwidth of 6 MHz but it can use more effectively compare to analog terrestrial television. Interactive communication can be performed in terrestrial television.

C. Bandwidth

Bandwidth is a range of frequencies within a given band in particular that used for transmitting a signal. The higher data rate can be achieved by increase the bandwidth of the system. Bangladesh has 200Gbps of bandwidth and only 16% of them is being used. The bandwidth is mainly used for terrestrial television broadcasting, Satellite Television Broadcasting, FM Radio Broadcasting and Community Radio Broadcasting.

Methods of Broadcasting	Bandwidth per Channel	Total Number of Channel	Allocated Bandwidth
TTB	6 MHz	2	174-230 MHz
STB	6 MHz	28	5.85-6.425GHz
FMRB	200 KHz	12	87.5-108 MHz

Table 1: Bandwidth per channel in Bangladesh.

For terrestrial television broadcasting (TTB) 6 MHz bandwidth is required. But satellite television broadcasting (STB) are using 6, 9 or 12 MHz uplink frequency from 5.85-6.425 GHz band. FM radio broadcasting(FMRB) using around 200KHz of bandwidth while communication radio broadcasting(CRB) channel has been using the three spectrum which are 98.40 MHz, 98.80 MHz and 99.20 MHz

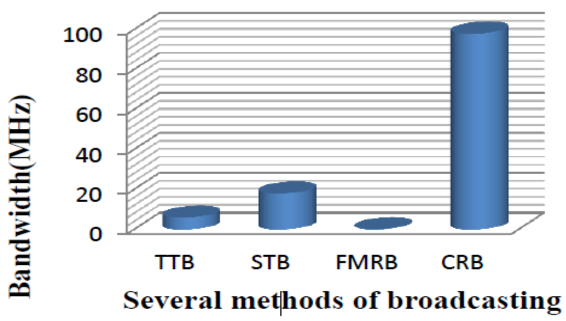

Figure 3: Different types of broadcasting methods in Bangladesh

Terrestrial broadcasting is using 174-230 MHz spectrum in VHF band for this transmission and 522-698 MHz spectrum is reserved for digital terrestrial broadcasting in near future. Satellite television use uplink frequency from 5.85-6.425 GHz band while Radio communication uplink from 87.5 to 108 MHz

D. Long Term Evolution(LTE)

In Europe development of 4th Generation technology has been branded by Long Term Evolution or LTE by 3GPP (*3rd Generation Partnership Project) on the contrary in North America this effort is branded as* UMB (Ultra-Mobile Broadband) by 3GPP2 [13]. Orthogonal Frequency Division Multiple Access (OFDMA) has been used by LTE. For multi-antenna (2x2) multiple-input multiple outputs (MIMO) the download rate is 150 Mbps for the category terminal which is highest. For the available channel spectrum having channel bandwidth ranging between 1.25 Megahertz (MHz) to 20MHz very efficient use of this spectrum has been made by LTE. LTE has "slice" which is flexible. As a result of this LTE can easily be implemented in countries having 5MHz as the amount of spectrum which is commonly allocated [14]. One of the features of LTE is Carrier Aggregation. It is introduced by 3GPP so that they can fulfill IMT-Advanced requirements of peak data rates which is upto 1 Gbit/s in the DL and also in UL it is 500 Mbit/s[15-16]. Apart from increasing the peak data rate the benefit that is achieved from CA is that there's a chance of aggregating fragmented spectrum for the operators. As an UE in LTE Advanced CE has cells which are aggregated, load balancing which is fast can be achieved. On these aggregated cells traffic schedule is based on Transmission Time Interval (TTI) [17]. Continuous as well as non-continuous component carriers (CCs) can be scheduled by using the technology of carrier aggregation [18]. Not only LTE-A users but also LTE users can be supported by the LTE-A system [19]. At the layer which is termed as medium access control (MAC) layer the transmission blocks of the components are aggregated so that the backward compatibility can be provided [20].

E. TV White Space

TV white space refers to frequencies allocated to a broadcasting service but not used locally. Normally TV spectrum is not used totally specially in the rural region and for that reason developed country have already using this spectrum for other important use like mobile communication or internet[8][9]. The analysis carried out here builds on the knowledge of the properties of the TV transmitters in a region of interest. The i_{th}transmitter's location by x_i, its power by P_i, its height by h_i, and its operating frequency by f_i.

$$I\,(t,f,x) = \begin{cases} 0, when\; x \in U, f = fA(t) \\ 1, otherwise \end{cases} \quad .....1$$

Where t, f, and x denote time, frequency and space respectively. The white space label depend on this three main aspect. In particularly, for the second label

$$I'(t,f,x) = \begin{cases} 0, when\ x \in U, f = fA(t)U \\ 1, otherwise \end{cases} \quad \ldots\ldots 2$$

Where $B_{in}(t)$ is the adjacent-channel no-talk region of the i_{th}TV transmitter at time t. In this definition, the white space label of a frequency bin f also accounts for TV transmitters operating on adjacent channels f-Δf and f+Δf.

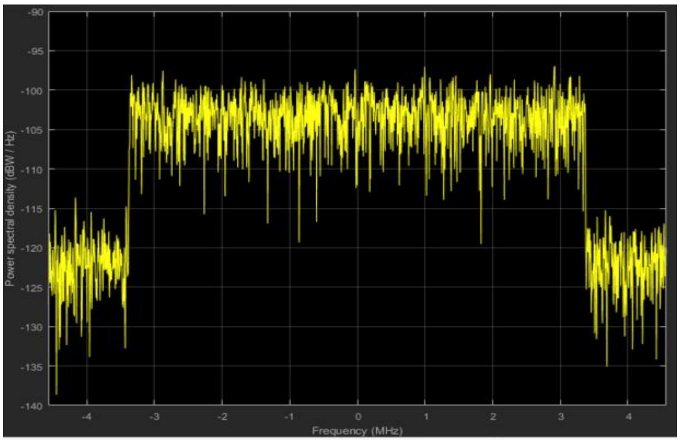

Figure 5: TV spectrum for terrestrial broadcasting [5]

From the figure5 it can be observed that the TV required only 6 MHz bandwidth to send the data but normally it has quite more than the requirement. To use TV white space, FCC regulations require that white space devices will be able to sense, at levels as low as −114 dBm, licensed incumbent signals such as TV signals (both digital and analog), different wireless microphone signals, and signals of other services that operate in the TV bands on intermittent basis [10]. Noise power in a 6 MHz TV channel under normal temperature is about −96 dBm assuming that the noise figure of a sensing device is around 10 dB, The sensing requirement set by FCC is about −18 dB in terms of signalto- noise power ratio (SNR), which is a rather difficult task to handle. For Bangladesh Television (BTV)

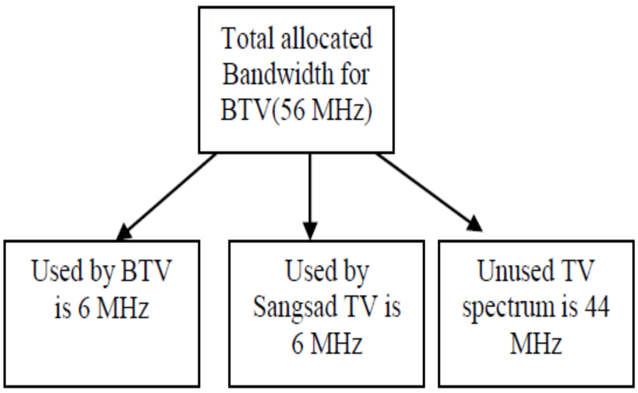

Figure 7: Block diagram of BTV bandwidth allocation.

This block diagram shows the used and unused spectrum for BTV and Sangsad TV which is on air only for 2 hours in a day.

III. PROPOSED MODEL

A model has been designed to use the TV white spectrum for wireless internet connection which will provide internet connection especially in the rural areas. This flow chart in figure8 has been designed to show the available bandwidth in the terrestrial television broadcasting system. Bangladesh government has been allocated 56 MHz of bandwidth from the total of 200 GHz. At first this flow chart will check that BTV is on air or off air, if BTV is on air then it will use the bandwidth of 6 MHz and remain 50 MHz can be used for wireless internet connection. After that it will check that Sangsad TV is broadcasting or not. If this channel is on air then another 6 MHz of bandwidth will be used for this channel and remaining 44MHz bandwidth will be available for internet connection and if both the channel is off line then total of 56 MHz bandwidth will be used for internet connection. As it is known that only a 5MHz of bandwidth is needed to supply a wireless broadband internet in Mbit/s range and 1.25 MHz to 20 MHz bandwidth is quite enough to broadcast internet for those areas made by LTE. As far BTV has 44 MHz of bandwidth even the period when both the channel are on air. Even for those deprived people it is important to get internet connection rather than high speed internet.

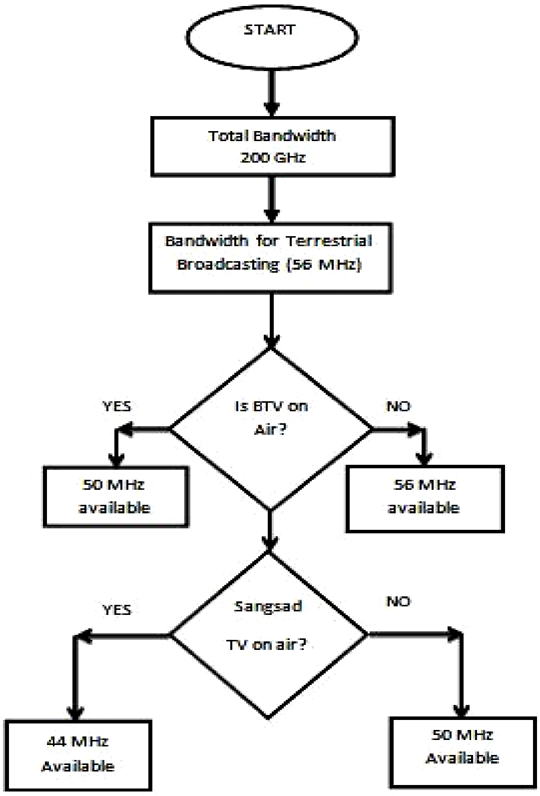

Figure 8: Flow chart to use white spectrum for wireless Broadband internet connection in Bangladesh

Bangladesh Television (BTV) is the only terrestrial television in our country. For terrestrial television broadcasting, Bangladesh government has allocated 56 MHz bandwidth but only 6 MHz of bandwidth is required to broadcast this channel. Sangsad TV which is broadcast for only 2 hours in a day and this channel use the bandwidth of BTV but still a lot of bandwidth is unused. However a wireless broadband connection can be provided through this bandwidth. If only BTV is on air from 6.00 AM to 12.00 AM, around 50 MHZ of its bandwidth can be used in this certain period. Sangsad TV only broadcast from 4.00 PM to 6.00 PM, in that period another 6 MHz bandwidth is required from the total bandwidth of 56 MHZ still 44 MHz bandwidth will be available for the internet connection. After 12.00 AM, the whole bandwidth can be used for internet connection because both of this TV channel are switched off. Internet connection is one of the most important requirements for both rural and urban area. It is quite easy to access internet in urban area but still it is like dream in rural area. There is no good news for the huge number of population in the rural area in terms of internet connection. In that case if this bandwidth can be used for internet connection in the rural areas, it could be very helpful to develop their daily life quite easily.

IV. SIMULATION and RESULTS

This simulation has been done to observe the white spectrum bandwidth available in the Bangladesh Television (BTV) and the possible data rate which can be transmitted through this unused bandwidth.

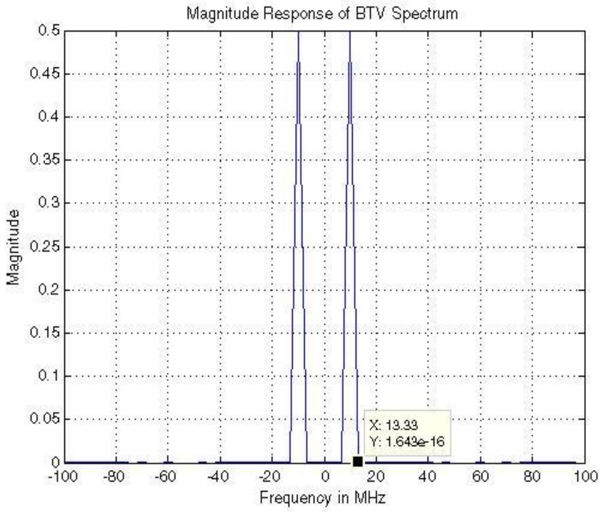

Figure 9: Magnitude Spectrum of BTV.

In fig 9, the bandwidth used for BTV has been observed; it is clear from the result that the BTV uses only 6 MHz bandwidth for video transmitted among 56 MHz bandwidth allocated for BTV.

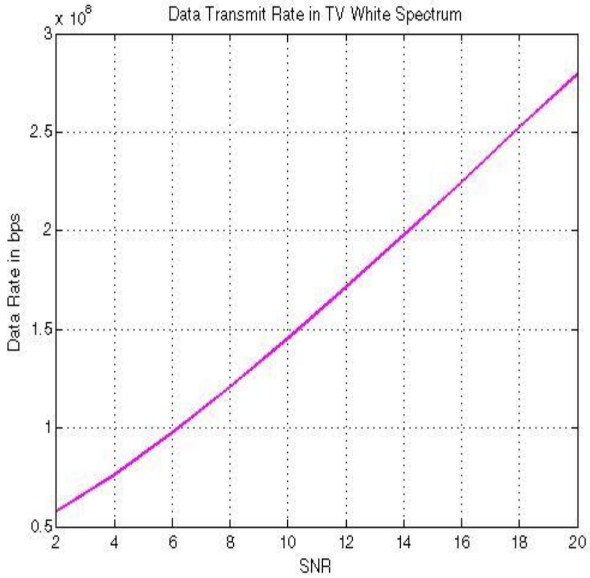

Figure 10: Data Transmit Rate in TV White Spectrum when BTV is on air.

The available white spectrum is 50 MHz when only BTV on air and in fig 10 shows that the unused bandwidth can transmit data at 2.8e8 bps which has been observed in terms of signal to noise ratio (SNR). The results has been calculated from Shannon capacity.

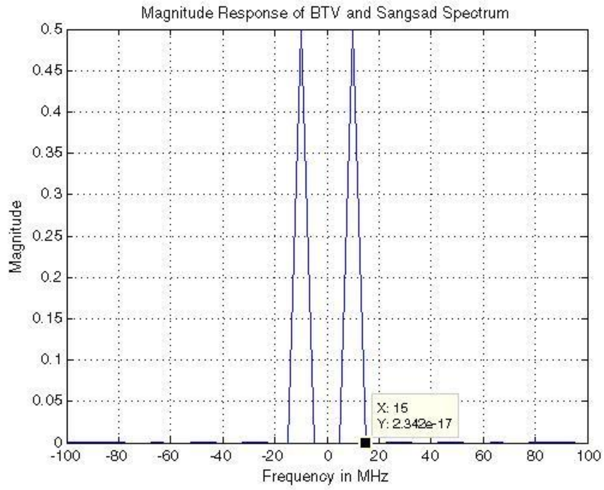

Figure 11:Magnitude Spectrum of BTV and Sangsad TV

In fig 11, the bandwidth used for BTV and Sangsad TV is 12 MHz and the remain 44 MHz bandwidth can be used for wireless internet connection.

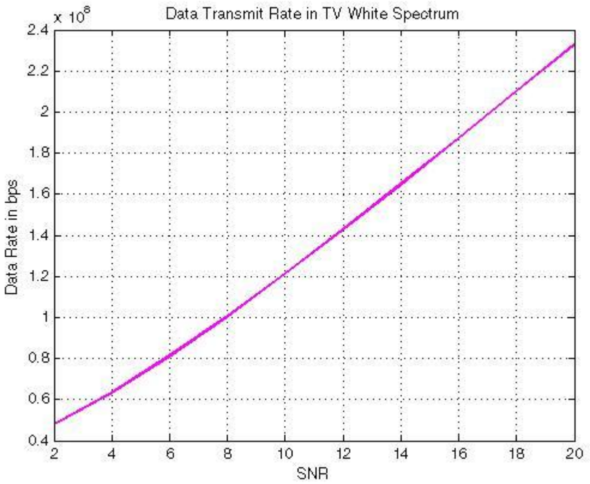

Figure 12: Data Transmit Rate in TV White Spectrum when both BTV and Sangsad TV are on air.

The available white spectrum is 44 MHz when both BTV and Sangsad TV are on air and in fig 12 shows that the unused bandwidth can transmit data at 2.3e8 bps.

V. CONCLUSION

The importance of utilizing TV White Spectrum for Wireless Broadband Internet Connectivity (WBIC) has been considered as a great way of providing internet connectivity throughout the world. The research paper describes the way of utilizing this white TV Spectrum for a practical case scenario of Bangladesh (Bangladesh Television & Sangsad Television) and logically explains how to use the unused spectrum. This work has more significance considering the fact that, within the end of 2016 Bangladesh Government has decided to use digital terrestrial transmission for Bangladesh Television which will have much more allocation of Bandwidth [11]. However the simulation results show that the higher data rate can be achieved by using the unused bandwidth allocated for BTV.

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