Performance Analysis of Digital Terrestrial Television (DTT) Services in The Central Region of Malaysia

ABSTRACT

Due to the increasing demand of services and content, Quality of Service (QoS) has become an important aspect in the broadcasting industry including Radio Televisyen Malaysia (RTM), especially with the implementation of Digital Terrestrial Television (DTT) in Malaysia. Thus, the performance of DTT in Malaysia should be investigated because there are areas which do not receive coverage due to the variety of terrain, or where some areas receive weak DTT signals. Apart from geological and topographic factors in Malaysia, the selection of DVB-T2 parameters is also an important factor in determining signal strength and coverage This research has proposed to study the performance analysis of DTT propagation for fixed reception in Malaysia's central region. The Field Strength Measurement (FSM) was set up to evaluate the QoS of DTT signal such as Field Strength (E), Modulation Error Ratio (MER), and Carrier to Noise Ratio (C/N) at specific test points across Malaysia's central region. The FSM was simulated at the designated test points using CHIRplus_BC software to evaluate the performance of Single Frequency Network (SFN) with three locations of transmitter. It can be concluded that the coverage of DTT is reduced with the increase in the distance of the measurement area to the transmitter. The findings also show that the field strength value obtained from FSM and simulation was comparable.

KEYWORDS

DTT, DVB-T2, QoS, fixed reception, Field Strength, MER, C/N, SFN, Modulation, FEC, CHIRplus_BC simulation

INTRODUCTION

A. RESEARCH BACKGROUNDS

Digital terrestrial television (DTT) is a terrestrial television technology in which land-based (terrestrial) television station's broadcast the television content in digital format via radio waves to television in consumers' residences. Compared to the previous, analogue television, DTT is a significant technical development that essentially replaces the analogue system, in common use since the middle of the 20th century.

The perks of shifting to DTT include effective usage of limited radio spectrum capacity, the availability of more television channels, better quality videos, and potentially lower operating costs for broadcasters. Different countries have adopted various standards for digital broadcasting.

The Digital Video Broadcasting - Second Generation Terrestrial (DVB-T2) standard has been chosen as the standard to substitute the analogue TV system in the growing demand for services and content by RTM as one of Content Application Service Provider (CASP) and has forced the DTT Central Integrated Infrastructure Provider (CIIP) in Malaysia to meet the QoS criteria while providing high bit rate information security and error protection. *Fig. 1* illustrates the Diagram of DTT services in Malaysia.

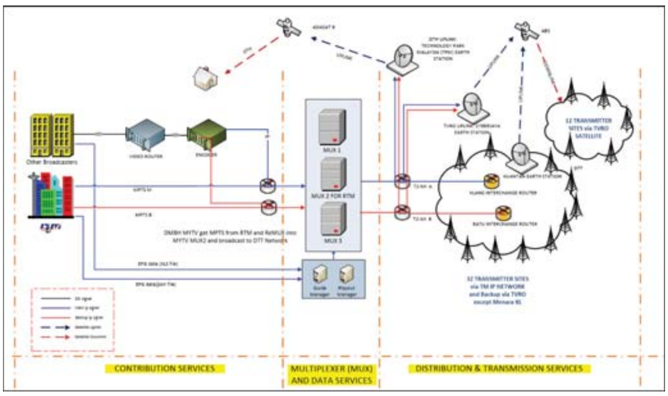

Fig. 1: DTT services in Malaysia

B. PROBLEMS STATEMENTS AND OBJECTIVES

Currently, signal coverage for DTT in Malaysia reaches 95.3% of the populated area, and the rest is supported by Direct to Home (DTH) broadcasting (DVB-S)[1]. However, the drawback of DTH broadcast is that the signal is susceptible to rain attenuation because it propagates using a high-frequency carrier. Furthermore, only designated areas have access to DTH coverage in Malaysia. DTT service providers, need to ensure the QoS of DTT, including signal strength and quality transmitted throughout the region. A total of 44 DTT transmitters in Malaysia, including in Sabah and Sarawak, have been built to transmit DTT broadcasts nationwide. Of these 44 transmitters, the data signal has been distributed according to six regions (northern region, central region, southern region, eastern region, Sabah region and Sarawak region). *Fig. 2* shows the DTT distribution by region in Malaysia.

In Selangor, 23 locations were identified as receiving weak DTT signals or no coverage. MYTV designates these areas as non-coverage areas and allows the residents to receive DTH instead of DTT. The DTH coverage information can be accessed through website www.mytvbroadcasting.my. Although the populated coverage is 95.3%, some areas received weak signals due to Malaysia's terrain. In addition to the effects of geological and landscape profiles in Malaysia, the selection of DVB-T2 transmission parameters is very important for good reception of the received signal. The QoS parameters that can be related to the operational of DVB-T2 transmission through measurement are Modulation Error Rate (MER), Bit Error Rate (BER), Carrier to Noise Ratio (C/N), Field Strength, and coverage range [3].

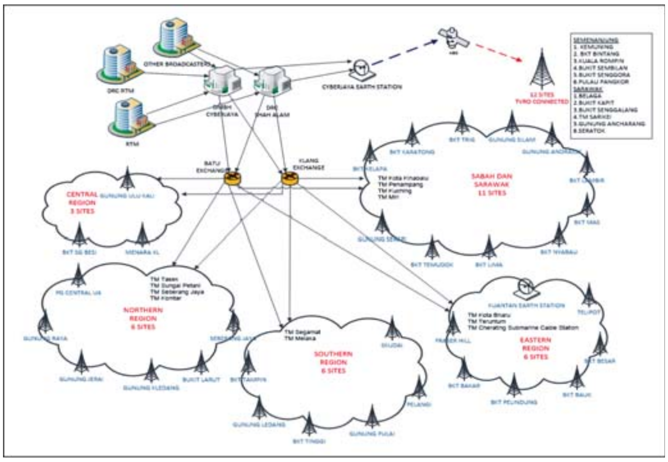

Fig. 2: DTT distribution by region in Malaysia

The objectives of this study are:

- To measure the Quality of Services (QoS) of DTT Single Frequency Network (SFN) signals in the designated test points for fixed reception by performing the Field Strength Measurement (FSM).
- To simulate the FSM at the designated test points using CHIRplus_BC software in order to obtain the coverage range.

C. DIGITAL VIDEO BROADCASTING – SECOND GENERATION TERRESTRIAL (DVB-T2)

The first edition of the DVB-T2 standard (ETSI EN 302 755 V1.1.1) was based on a DVB blue-book released by ETSI in September 2009 [4]. In launching the second generation, the goal of DVB was to incorporate the advances accomplished in signal processing after the first digital standards emerged in 1993. Spectral efficiency is becoming more important for DTT because some spectrum previously allocated for TV broadcasting is now being re-allocated to mobile communications systems, particularly 4G LTE [5]. Simultaneously, TV-quality levels are improving, and high-definition TV (HDTV) is a must for individuals who own large flat-screen displays. This high bandwidth demand streaming content should be able to provide digital broadcasting. DVB-T2 was developed to satisfy these criteria, increasing spectral performance and robustness in a modular way. It is possible to cover a range of reception situations for the same system by selecting the best available configuration choices.

Compared with the already successful DVB-T standard, the DVB-T2 specification incorporates the latest modulation and Forward Error Correction (FEC) development to increase the bit-rate capacity and improve signal robustness [4]. FEC code rate parameter defines the ratio between the number of data bits received and the total number transmitted. The higher the code rate the better error correction, increasing the robustness of the signal but decreasing the capacity. When compared to the DVB-T standard, which uses Reed-Solomon and convolutional coding, DVB-T2 introduces two additional code rates; Low-Density-Parity-Check (LDPC) and Bose-Chaudhuri-Hocquenghem (BCH)[4]. In DVB-T2, the additional modulation scheme 256-QAM is available. The choice of modulation determines the bit rate (capacity), but it also has a significant impact upon the system's robustness; higher order modulation schemes that offer more capacity are more fragile [4].

DVB-T2 also utiises Single Frequency Networks (SFN), which uses the same channel frequency for all transmitters in the network. In an SFN Network the required coverage is provided through the use of multiple transmitters operating on the same frequency and carrying the same programmes [5]. The issues that need to be considered for broadcasting in SFN transmission are to make sure that all the transmitters are transmitting the same data using the same frequency and are transmitting at the same time [6]. When deploying the SFN, delay adjustment is performed by fitting the launching time of each transmitter, so that the time difference of the incoming signals within the reception area falls into the Guard Interval (GI) duration [7]. The aim of SFN is spectrum efficiency. When compared to a Multi Frequency Network, SFN can exhibit network gain, where signals from several transmitters contribute to a higher received signal level and improved coverage [8]. *Fig. 3* shows the concept of an SFN network.

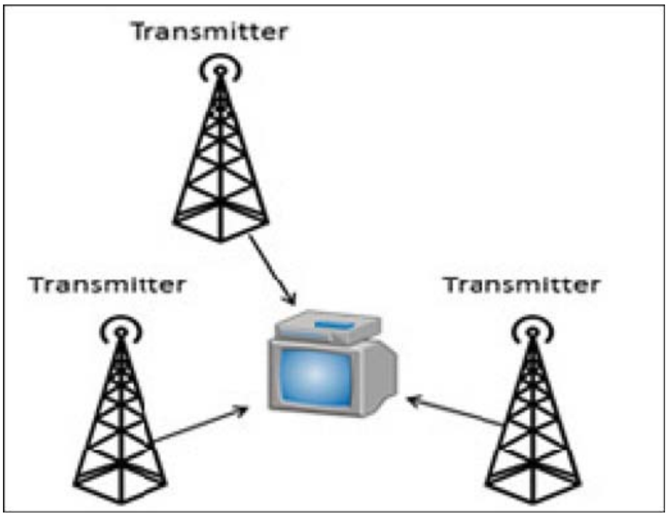

Fig. 3: Single Frequency Network (SFN)

METHODOLOGY

A. FIELD STRENGTH MEASUREMENT (FSM)

To conduct the Field Strength Measurement (FSM) of DTT propagation in central region of Malaysia requires several steps as shown in *Fig. 4*. The first step is to identify the test point of FSM in the central region. The second step is to perform Field Strength Measurement (FSM) at the designated test points. The data collected from the FSM were Field Strength (E), MER and C/N. The results obtained from FSM were compared with the results obtained from the CHIRplus_BC simulation.

The measurement tools used to perform the FSM are Field Strength Meter Promax Ranger Neo+, and Antenna Maspro Denkoh which is used as the antenna receiver. The antenna was raised 10 metres above ground level to ensure signal reception was optimised for a fixed reception method. *Fig. 5* shows the FSM setup.

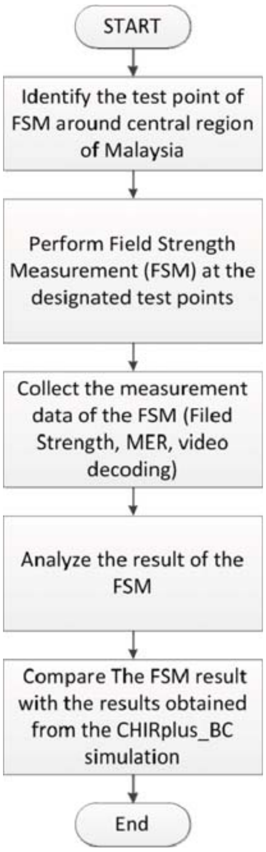

Fig. 4: Flow Chart of the FSM

Fig. 5: Field Strength Measurement (FSM) Setup

B. MEASUREMENT PARAMETERS

1) Field Strength (E)

Field Strength measures the power over the entire bandwidth of the channel. It is formed by the vector addition of the directly received signal component and reflections due to obstructions in the field [16]. Coverage area means a certain area is regarded as being covered by DVB-T/T2, when the median field strength for the particular receiving situation at a specified height above ground (often 10 m) [12]. The minimum median equivalent field strength (Emed) DVB-T2 8 MHz system at 650 MHz is 56 dBμV/m [13]. The antenna factor is used to calculate the field strength from the antenna output level. The calculation formula of field strength at the antenna is as follows:

$$E = U + K \quad (dB\mu V/m) \qquad (1)$$

$$U = P_s + 120 + 10\, log\,(Z_i) \quad (dB\mu V) \qquad (2)$$

$$P_s = C/N + P_n \quad (dBW) \qquad (3)$$

$$P_n = F + 10\log(k\, T_o\, B) \quad (dBW) \qquad (4)$$

where, U is the measured antenna output voltage, K is the antenna factor, P_s is the receiver signal input power, Z_i is the receiver input impedance (75 Ω), C/N is the carrier to noise ratio required by the system, P_n is the receiver noise input power, F is the receiver noise figure, B is the receiver noise bandwidth, k is Boltzmann's Constant = 1.38*10 – 23 Ws/K, and T_o is absolute temperature = 290 K

The antenna factor depends on frequency and gain according to the following formula:

$$K = 20\, Log(f\,) - Gi - 29.774 \qquad (5)$$

where f is the channel frequency and Gi is the antenna gain relative to an isotropic radiator.

2) Modulation Error Ratio (MER)

The modulation error ratio (MER) represents the ratio between the average power of the DVB-T2 constellation signal and the average noise power of the signal constellation. The sum of the squares of the magnitudes of the ideal symbol vectors (Ij , Qj) is divided by the sum of the squares of the magnitudes of the symbol error vectors (δIj , δQj) [3]. The result, expressed as a power ratio in dB, is defined as the Modulation Error Ratio (MER) and given by the formula:

$$MER = 10 \times \log_{10}\left\{\frac{\sum_{j=1}^{N}\left(I_j^2 + Q_j^2\right)}{\sum_{j=1}^{N}\left(\delta I_j^2 + \delta Q_j^2\right)}\right\} \qquad (6)$$

An error vector (δIj , δQj) is determined as distance between ideal and measured position of received symbol. In other words, a received vector ($I'j$, $Q'j$) is the sum of ideal vector (Ij , Qj)[12] and error vector as shown in *Fig. 6*.

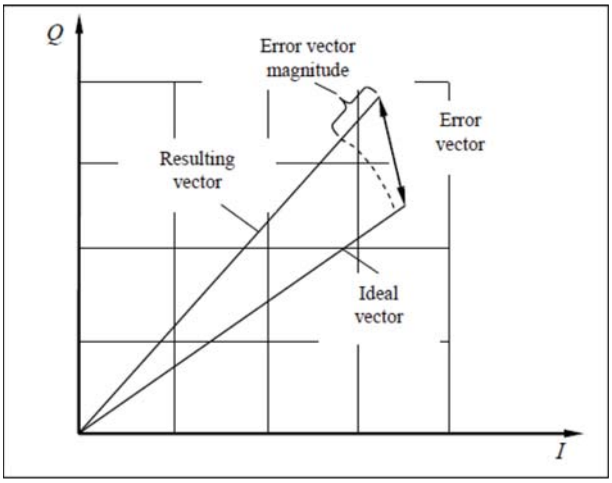

Fig. 6: Error vector calculation [12]

3) Carrier To Noise Ratio (C/N)

The Carrier-to-noise ratio (C/N) is a ratio of the strength of the received carrier to the strength of the received noise. High C/N ratios provide greater reception quality and communications accuracy and reliability. The minimum C/N required by DVB-T2 system with 8 MHz bandwidth at 650 MHz is 20 dB [13]. The carrier-to-noise ratio, C/N, in dB is given by the formula:

$$C/N = 10\ \log_{10}(\,P_c/P_n)\,dB \qquad (7)$$

where P_c is the carrier strength in μW and P_n is the noise level in μW.

C. STUDY AREA

This study focused on Malaysia's central region in the area of Klang Valley, Selangor, and some areas in Pahang with the coverage of 19,800 km^2. 111 test points were set up in this area. These test points involved populated areas such as residential areas, schools, mosques, petrol stations, multi-purpose hall stadiums, villages and rural areas. *Fig. 7* shows the study area and the test point locations.

The DTT signal received was from three transmitters, which were Menara KL transmitter (3.15289, 101.70382), Gunung Ulu Kali transmitter (3.42775, 101.78899) and Bukit Sungai Besi transmitter (3.07031, 101.72949). These transmitters were set to transmit as a single frequency network (SFN).

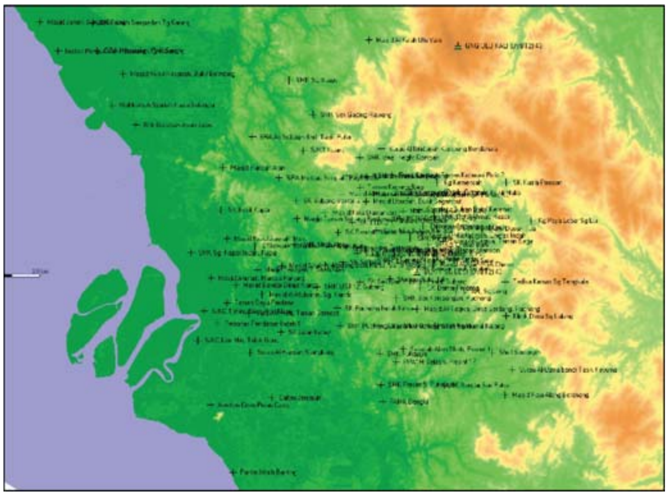

Fig. 7: Study area and 111 test points set in test point databased CHIRplus_BC

D. DVB-T2 PARAMETER SET UP IN CHIRPLUS_BC SOFTWARE

The parameters as shown in **Table II** were configured in the CHIRplus_BC software.

TABLE II : CURRENT DVB-T2 STANDARD PARAMETERS IN MALAYSIA [14]

III. DVB-T2 Parameters for UHF CH 43 (650MHz)	
IV. Channels	V. UHF CH 43 (650 MHz)
VI. Bandwidth	VII. 8 MHz
VIII. Modulation	IX. COFDM
X. Carrier Modulation	XI. 256-QAM
XII. FEC Code Rate	XIII. 2/3
XIV. Guard Interval	XV. 19/256
XVI. FFT Size	XVII. 32k Extended
XVIII. Pilot Pattern	XIX. PP2

Broadcasting network planning involves setting of the transmitter parameters in order to provide good QoS in the intended coverage area. The parameters for the three transmitters were configured into the CHIRplus_BC working database as shown in **Table III**.

TABLE III : TRANSMITTER PARAMETERS FOR SIMULATION

Transmitter Parameters			
Transmitter	ERP (dBW)	Height (m)	Freq (MHz)
Menara KL	51	543	650
Ulu Kali	50	1786	650
Sungai Besi	50	291	650

RESULT AND ANALYSIS

The results of 111 test points of Field Strength Measurement (FSM) and simulation from CHIRplus_BC are introduced in this section. The results obtained were analyzed and compared.

A. FSM RESULTS

1) Field Strength (E)

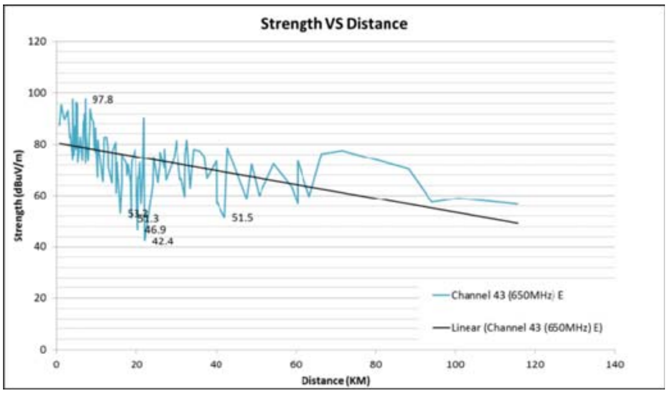

Fig. 8: Field Strength Vs Distance at 111 FSM test points

Fig. 8 shows the field strength of the received signal. It is observed that when the distance increases, the signal strength is reduced. The highest field strength is 97.8 dBµV/m at a distance of 7.1 km from the nearest transmitter, Bukit Sungai Besi. Five test point locations were identified as receiving signal strengths of less than 56 dBµV/m. which is the minimum threshold. The locations were Kg. Paya Lebar, Sg. Lui, SK Kuala Pomson, Masjid Al-Makmur, Felda Gedangsa, Masjid Nurul Husna, Felda Sg. Tengi Selatan and Tadika KEMAS Sg. Tekala. The lowest signal strength is 42.4 dBµV/m, at a distance of 22.1 km from the nearest transmitter, which is Bukit Sungai Besi. It can also be concluded that even when the distance between the transmitter and the area is short, the field strength can be low. This is due to the obstructions and signal reflections caused by hilly terrain, plantation trees, or tall buildings around the measurement area.

2) Modulation Error Ratio (MER)

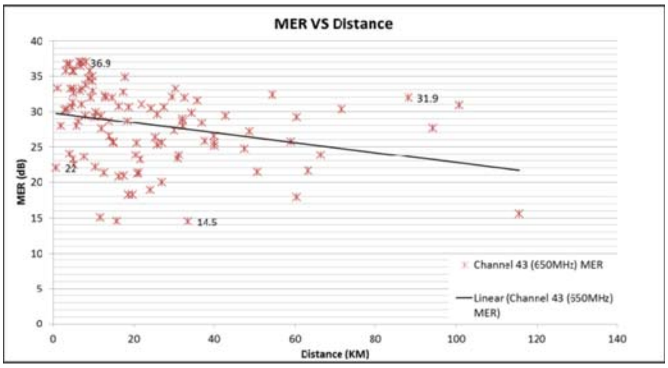

Fig. 9: MER Vs Distance

The result of MER is presented in *Fig. 9*. It is demonstrated that as the distance increases, the MER decreases. The highest MER is 36.9 dB from the test point location with a distance of 7.1 km from the nearest transmitter, Bukit Sungai Besi. The MER reading for five test point locations cannot be obtained and the video channel could not decode the signal. There were cases where the MER reading obtained were higher from the test point located farthest from the transmitter. For instance, at the test point, where the distance to the transmitter was 88 km, the MER was 31.9 dB, while at the test point of 0.75 km, the MER was 22.4 dB. This is because the location of the distant test point had no interference or obstruction from hills and tall buildings, unlike the area closer to the transmitter. Transmission delay time caused by obstruction will cause noise power of signal modulation to increase. The noise power changes when phase (I) and amplitude (Q) of QAM modulation is shifted. The longer the delay time, the higher the noise power, contributing to lower MER readings.

3) Carrier-To-Noise ratio (C/N)

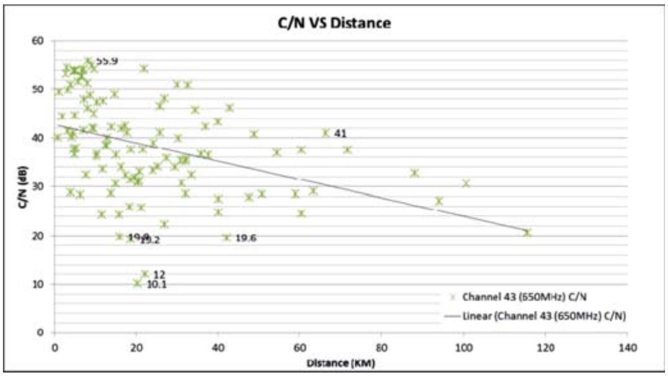

Fig. 10: C/N Vs Distance

Fig. 10 shows the result of C/N. The C/N decreased as the distance decreases. The highest C/N is 55.9 dB at a distance of 8.2 km from the nearest transmitter, Bukit Sungai Besi. There are five test point locations with C/N less than 20 dB. There are also cases where the C/N obtained from the test point farthest from the transmitter is higher than the C/N obtained from the test site near to the transmitter. For example, the C/N of 10.1 dB was measured at the test location where the distance to the transmitter was 20.3 km, while the C/N was 41 dB at the test point where the distance to the transmitter was 66 km. This is because of the obstruction and interference cause by hills and tall buildings at the test point even though the distance to the transmitter was closer.

B. CHIRPLUS_BC SIMULATION RESULTS

In this section, the field strength simulation results obtained from the three transmitters, Menara KL, Gunung Ulu Kali and Bukit Sungai Besi were analysed using scatter graph to observe the correlation between the received signal strength and the distance from the transmitter. Then, the received signal strength readings obtained from the FSM were compared to the simulation results and analysed.

1) Field Strength from Menara KL Transmitter

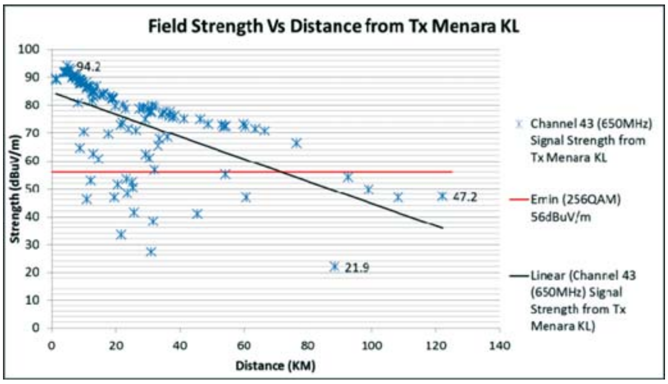

Fig. 11: Simulation of Field Strength Vs Distance from Menara KL Transmitter

Fig. 11 shows the field strength simulation results. A scatter graph was plotted to see the relationship between the received signal strength and the distance of 111 test points to the Menara KL transmitter. It is demonstrated that when the distance increases, the signal strength reduces. The highest strength is 94.2 dBµV/m at a measurement distance of 4.62 km. Out of 111 test points, 95 had signal strength greater than 56 dBµV/m of the minimum thresholds, resulting in 89.2% coverage. The lowest strength is 21.9 dBµV/m at 88.4 km distance from Menara KL. Lower signal coverage will however be supported by higher signal transmitted from the other two transmitters. This being one of the advantages of SFN in DVB-T2 transmission. There were some test point locations where the strength was very low even though the distance to the transmitter was less. This was due to the obstruction and interference caused by the hilly terrain and tall buildings in this measurement area.

Fig. 12 shows the simulation of the coverage area from the Menara KL transmitter. The transmission of the DTT signal from the Menara KL transmitter focuses on the urban areas with high population density in the Klang Valley. The signal from Menara KL could not however cover the state of Pahang and the north of Selangor. This being due to the distance of the transmitter as well as obstruction from the hilly area of the Banjaran

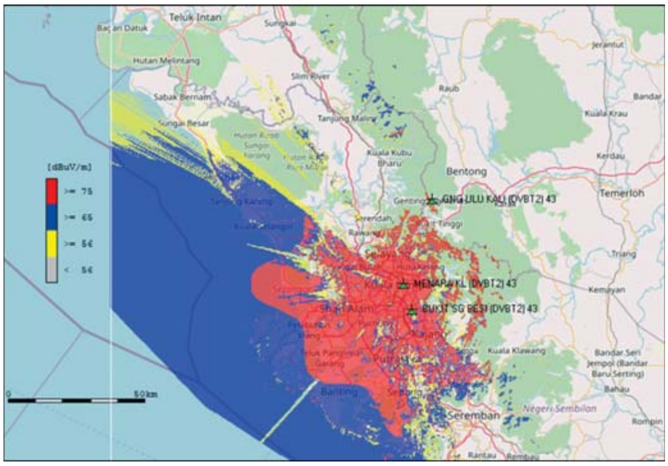

Fig. 12: Simulation of coverage area from Menara KL Transmitter

Titiwangsa, which is the longest range in Peninsular Malaysia. The Menara KL transmitter works as part of an SFN network. Thus, contributing to the increase in signal gain and further improvement in coverage around the central region of Malaysia, especially in urban areas.

2) Field Strength from Gunung Ulu kali Transmitter

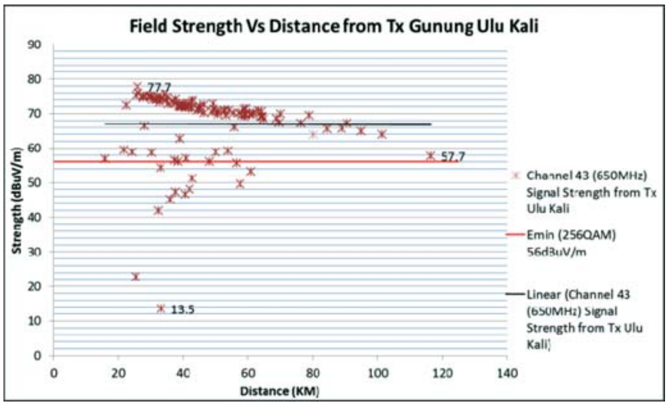

Fig. 13: Simulation of Field Strength Vs Distance from Gunung Ulu Kali Transmitter

Fig. 13 shows the simulation result of the received signal strength of the 111 test points from the Gunung Ulu Kali transmitter. It is shown that when the distance increases, the signal strength is slightly reduced. The highest strength is 77.7 dBuV/m at a measurement distance of 25.9 km. Out of 111 test points, 99 had signal strength greater than the 56 dBµV/m minimum threshold, resulting in 89.2% coverage. The lowest was 13.5 dBµV/m at a location 33.17 km from the Gunung Ulu Kali transmitter. It is observed that six test points which were located more than 80 kilometers from the transmitter still received excellent signal strength, greater than 65 dBµV/m.=, demonstrating that the Gunung Ulu Kali transmitter could transmit DTT signals over a relatively long distances due to the location of the transmitter in a mountainous area, thus reducing the probability of obstruction.

Fig. 14 shows the coverage area of the Gunung Ulu Kali transmitter. The transmission of the DTT signal from the Gunung Ulu Kali transmitter provides a very

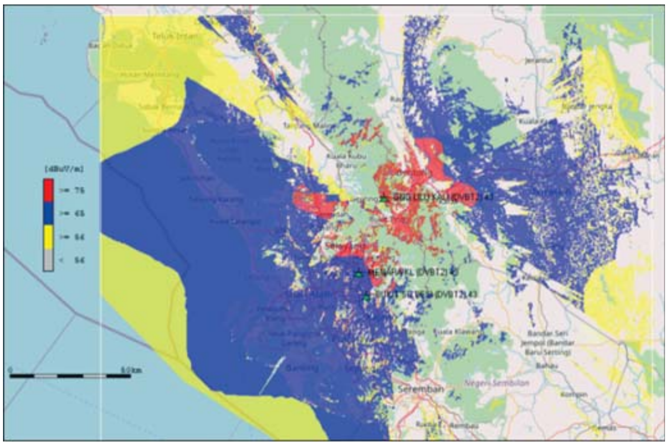

Fig. 14: Simulation of coverage area from Gunung Ulu Kali Transmitter

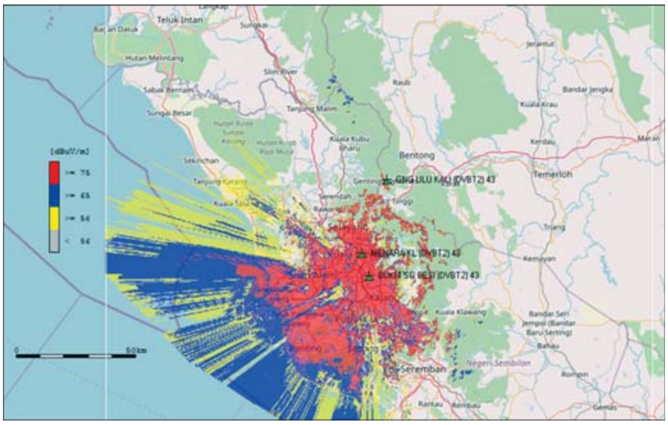

Fig. 16: Simulation of coverage area from Tx Bukit Sungai Besi

long transmission range, covering most areas in the central region of Malaysia, including some area in the state of Pahang excluding the hilly range. Transmission from Gunung Ulu Kali transmitter could also reach the north and south of Selangor, which is not covered by Menara KL and Bukit Sungai Besi transmitters. This shows that Gunung Ulu Kali transmitter could transmit DTT signals over relatively long distance due to the position of the transmitter which is installed in a mountainous area. The Gunung Ulu Kali transmitter also works within an SFN. It contributes to the increase in signal gain and further improves coverage around the central region of Malaysia.

3) Field Strength from Bukit Sg. Besi Transmitter

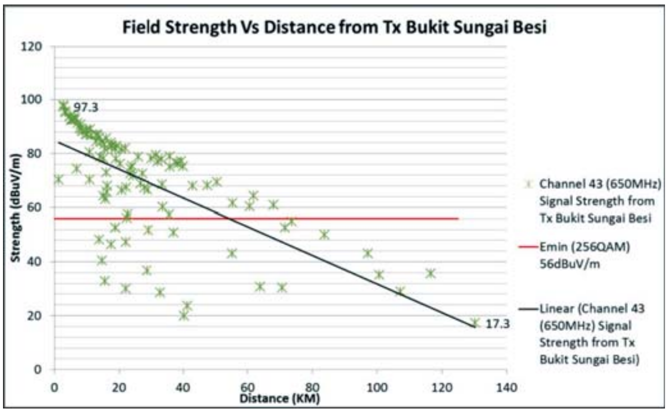

Fig. 15: Simulation of Field Strength Vs Distance from Bukit Sungai Besi Transmitter

Fig. 15 shows the simulation result of received signal strength from the 111 test points to the Bukit Sungai Besi transmitter. The trend line shows that as the distance to the transmitter increases, the signal strength decreases. At a distance of 2.88 km, the strongest signal is 97.3 dBμV/m. Out of 111 test points, only 87 had a signal strength greater than the 56 dBμV/m minimum threshold, resulting in 78.4% coverage. The received signal strength drops to 17.3 dBμV/m at a distance of 130.35 km from the transmitter. Even though the distance of test location to the transmitter is near, there were some test point locations where the signal strength was very low. This is due to the mountainous terrain and the density of tall buildings obstructing and interfering the signal at this location. The height of this transmitter is only 291 metres, which is the lowest among all the transmitters. resulting in small coverage.

Fig. 16 is the coverage area of the Bukit Sungai Besi transmitter. The transmission of the DTT signal from the Bukit Sungai Besi transmitter is also targeted for the high-density urban area in Klang Valley. Apart from improving coverage of the urban area, Bukit Sungai Besi transmitter provides DTT signal to affected areas if the Menara KL transmitter is faulty. The signal from the Menara KL could not cover Pahang and north of Selangor. This is due to the distance of the Bukit Sungai Besi transmitter and the hills that run across the Banjaran Titiwangsa, which is Peninsular Malaysia's longest range.

4) Comparison of Actual FSM and Simulation

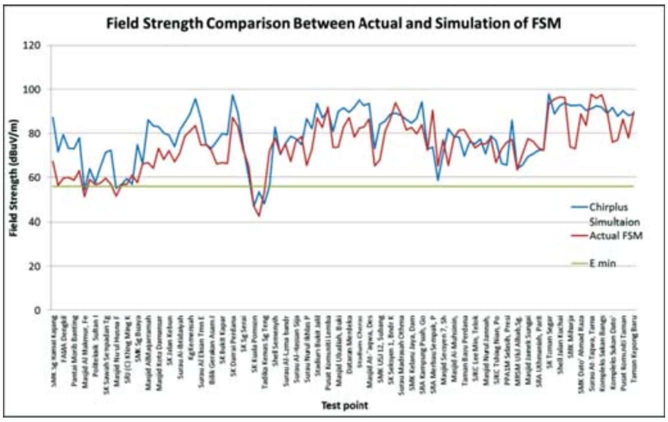

Fig. 17: Comparison of field strength value betwen FSM and CHIRplus_BC simulation

The comparison of the field strength value obtained from the FSM and simulation is shown in *Fig. 17*. From this graph, it is found that the measured field strength and the simulation value is within the same range, although there were slight deviations. It indicates the measurement accuracy of the FSM. The difference in the field strength readings between the FSM and simulation may be due to the transmitter parameters set up in the CHIRplus_BC database, such as ERP, or the antenna pattern, not being equivalent to the actual transmitter. In addition, obstructions and interference from tall building and hilly terrain in the measurement area can cause the field strength value of FSM to be lower than the simulation. However, five test point locations which show the lowest Field Strength readings, less than the threshold of 56dBμV/m remained the same for both FSM and simulated results. The location of the test points were Kg. Paya Lebar, Sg. Lui, SK Kuala Pomson, Masjid Al-Makmur, Felda Gedangsa, Masjid

Nurul Husna, Felda Sg. Tengi Selatan and Tadika KEMAS Sg. Tekala. The results of this simulation also show that the overall coverage at the test points reached 95.5, indicating that with the SFN function, all three transmitters have successfully increased the coverage of the central region of Malaysia.

CONCLUSION

It can be concluded that the objectives of this study have been achieved. The FSM performed on 111 test points in the central region of Malaysia shows that there were areas which are not covered by DTT particularly the areas that are close to hills and ranges due to geographical terrain factors. In addition, the coverage of DTT is reduced with the increase in the distance of the measurement area to the transmitter. Furthermore, obstruction from tall buildings and hills in the measurement area also caused the DTT coverage to deteriorate. Simulation of coverage area conducted for three transmitters; Menara KL, Gunung Ulu Kali and Bukit Sungai Besi, demonstrated the DTT transmission performance of these three transmitters. The advantage of the Single Frequency Network (SFN) approach for DVB-T2 transmission is shown in this simulation, where the three transmitters provide good coverage across the central region of Malaysia. SFN can exhibit network gain, where signals from the three transmitters contribute to a higher received signal level and improved coverage of the region. Moreover, the field strength results obtained from the FSM and the simulation is almost in the same range, although there are slight deviations. It indicates the measurement accuracy of the FSM.

RECOMMENDATIONS

There are several recommendations to improve this study:

- The performance analysis can be extended to other areas that are recorded to have a low percentage of coverage due to geographical factors, such as the rural areas of Sabah and Sarawak. It can also be extended to the whole country of Malaysia.
- In future, the analysis of indoor and mobile reception of DVB-T2 propagation can be considered because until now, it has never been studied in Malaysia.

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