

## **ANALYSIS OF DIGITAL TELEVISION SIGNAL RECEPTION IN COMBINED TRANSMITTER ANTENNA SYSTEMS**

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### **ABSTRACT**

*The Indonesian broadcasting sector has undergone significant transformation with the implementation of the Analogue Switch Off (ASO) program. By July 2023, approximately 97.23% of television stations in Indonesia had migrated to digital broadcasting. However, this figure does not reflect an equitable distribution of normal broadcasts. Data from Transmission Station X indicate that 6.77% of broadcasts are blank, 12.24% experience freezing, and only 80.99% are classified as normal for channel X in the Jabodetabek region. These statistics suggest that the primary objective of the ASO program—providing an enhanced television viewing experience—has not yet been universally achieved. Therefore, efforts are required to ensure the equitable distribution of normal broadcasts. Transitioning from a lower transmitter antenna system to a combined transmitter antenna system is proposed as a potential solution. This study evaluates the Modulation Error Ratio (MER) values in the Jabodetabek region when channel X uses a combined transmitter antenna system. Measurements, conducted using the drive test method, reveal that 99.703% of MER data are above the threshold (normal broadcasts), 0.042% are at the threshold (freeze broadcasts), and 0.255% are below the threshold (blank broadcasts). These results demonstrate that adopting a combined transmitter antenna system can help address the uneven distribution of normal broadcasts in the Jabodetabek region.*

**Keywords:** ASO, MER, digital television signals.

### **I. INTRODUCTION**

**T**HE global transition to digital television broadcasting has revolutionized audiovisual technology, providing enhanced picture quality, increased channel capacity, and interactive features. This shift, commonly referred to as the Analog Switch-Off (ASO), has been implemented worldwide to optimize radio frequency spectrum utilization. Indonesia recently joined this trend, with 97.23% of its television stations migrating to digital broadcasting by July 2023. However, this progress highlights disparities in regional broadcast coverage. Monitoring data from the Jabodetabek region indicate significant gaps, with 6.77% blank broadcasts, 12.24% freeze broadcasts, and only 80.99% normal broadcasts for channel X.

This uneven reception of normal broadcasts suggests that the primary goal of ASO—to provide an improved television viewing experience—has not been fully realized across all regions [1], [2]. Telecommunications infrastructure availability and reliability are critical factors contributing to this disparity [3]. The readiness for ASO is not solely determined by the availability of multiplexers, the number of television stations transitioning to digital broadcasting, or the distribution of set-top boxes (STBs) to households. It also depends on optimizing transmitter device usage. Transitioning from a lower transmitter antenna system to a combined transmitter antenna system is a viable step toward addressing the issue of uneven normal broadcast reception.

Previous studies on digital television signal reception in Bali and Malaysia, conducted using the field strength method, have produced varied results. Pradnyana et al. reported adequate coverage in Bali [4], while Mansor et al. identified potential blank broadcasts in some areas of Malaysia [5]. Julianawati et al. highlighted the challenges of ensuring consistent digital television signal reception, especially in rural

TABLE 1  
MER THRESHOLD FOR X CHANNEL

| Channel | MER Above the Threshold (dB) | MER At the Threshold (dB) | MER Below the Threshold (dB) |
|---------|------------------------------|---------------------------|------------------------------|
| X       | <7.4                         | 7.4-8                     | >8                           |

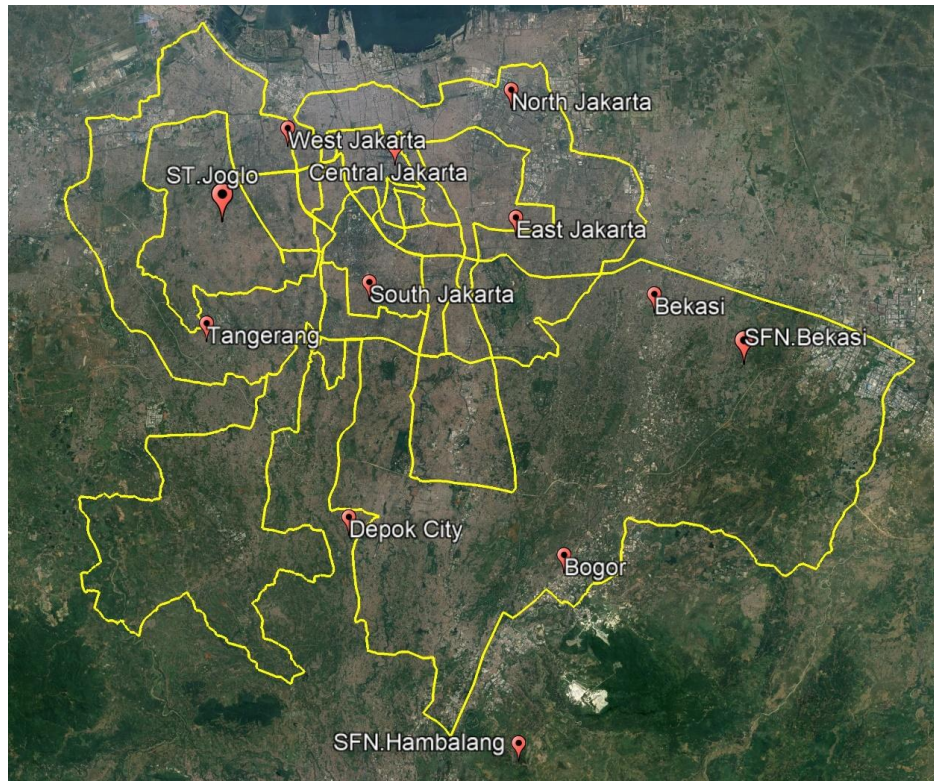


Figure 1. Drive test route

regions. Their findings revealed three urban locations and five rural locations experiencing blank broadcasts, necessitating efforts by transmission stations to enhance digital television signal quality [6].

Research on the reception of digital television broadcasts has yet to be conducted in the Jabodetabek area. This is notable given that, as highlighted by the Director General of PPI KOMINFO, Ismail, the Jabodetabek region is the primary focus for the implementation of the ASO program and plays a critical role in its success. Employing the drive test method, This study aims to measure the Modulation Error Ratio (MER) value for channel X using a combined transmitter antenna system in the Jabodetabek area. The drive test method provides a comprehensive and realistic assessment of DVB-T2 signal reception quality across the entire service area of a transmission station, as opposed to the field strength method, which only measures specific points within a service area. MER is a key parameter that reflects total signal degradation from the receiver side. The MER threshold values used for Channel X are presented in Table 1.

MER values above the threshold indicate normal broadcasts, values at the threshold indicate freezing broadcasts, and values below the threshold indicate blank broadcasts. The primary research question for this study is: What is the performance of measured MER on the SCM channel in the Jabodetabek area when using a combined transmitter antenna system? The findings are expected to provide insights into addressing the uneven DVB-T2 signal reception in the Jabodetabek area.

## II. RESEARCH METHOD

### A. Route Planning

The process of determining the route for the drive test is known as route plotting [7]. Route plotting identifies the area to be covered during measurements and allows for estimating the measurement duration. The route is designed using Google Earth, which provides a realistic depiction of field conditions. The planned route for measuring Channel X signal reception in the Jabodetabek region is illustrated in Figure 1.

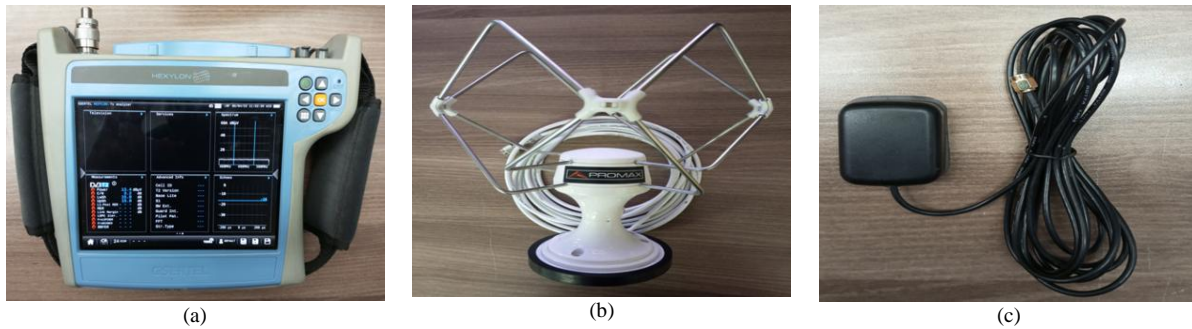


Figure 2. Drive test primary tools

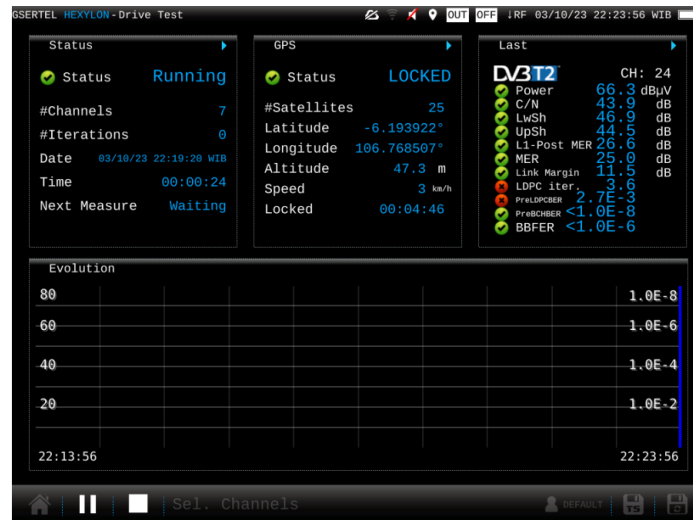


Figure 3. Indication of configuration success

### B. Equipment Preparation

The primary tool for the drive test include a TV analyzer, receiving antennas, and a GPS antenna, as shown sequentially in Figure 2: (a), (b), and (c). The TV analyzer used is the Gsertel Hexylon, a portable, high-precision measuring device designed for professional use. Hexylon is commonly utilized by television stations and technicians to measure and diagnose radio and TV signals in real time. During the measurements, the Hexylon device displays MER values.

A receiver antenna will be mounted on top of the vehicle during measurements. The antenna used is a Promax AM060BES01, a portable omnidirectional model capable of receiving signals from multiple directions. The GPS antenna serves as a satellite signal receiver, providing positional and time-related information. If the GPS antenna is not connected, the route measurement data will be interrupted, and the Hexylon device will be unable to capture the quality of signal reception.

### C. Device Configuration

The Hexylon TV analyzer is configured by selecting the 'Drive Test' mode for data acquisition in this study. Next, the 'TV Analyzer' mode is activated, and the 'Ultrafast Autolock' feature is enabled. The device is connected to a GPS antenna and a receiving antenna using the provided cables. Successful configuration is indicated by the 'Running' status and a 'Locked' GPS status, as shown in Figure 3.

### D. Performing Drive Test

Measurements are conducted over six days along the predetermined route. The measurements are performed between 10:00 PM and 5:00 AM, covering the required distance.

### E. Data Processing

Microsoft Excel 2021 and Google Earth are used for data processing in this study. Data cleaning and statistical processing are performed in Microsoft Excel, while data visualization is conducted using Google Earth.

TABLE 2  
MER PERCENTAGE IN JABODETABEK

| Region      | MER Above the Threshold | MER At the Threshold | MER Below the Threshold |
|-------------|-------------------------|----------------------|-------------------------|
| Jabodetabek | 99.703%                 | 0.042%               | 0.255%                  |

TABLE 3  
MER RESULTS IN NORTH JAKARTA

| Region        | MER Above the Threshold | MER At the Threshold | MER Below the Threshold |
|---------------|-------------------------|----------------------|-------------------------|
| North Jakarta | 98.81%                  | 0.60%                | 0.60%                   |

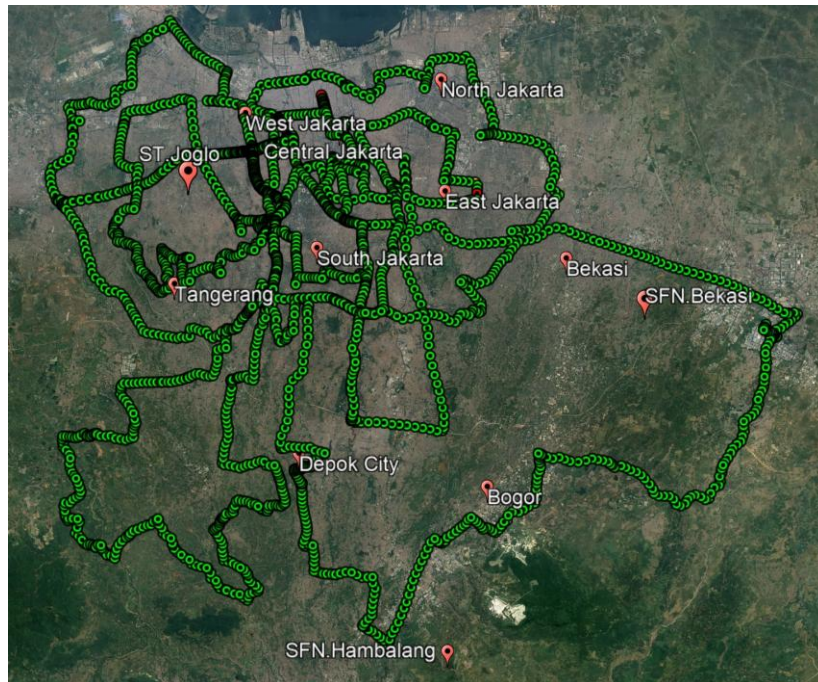


Figure 4. MER mapping results in Jabodetabek

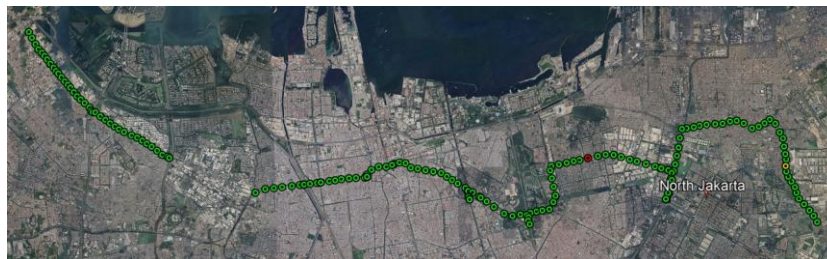


Figure 5. MER mapping results in North Jakarta

### III. RESULTS AND DISCUSSION

#### A. Result of MER in Combined Transmitter Antenna Systems

Table 2 provides the percentage distribution of MER values measured for channel X in the Jabodetabek area. Table 2 demonstrates that the implementation of a combined transmitter antenna system for channel X achieves a 99.703% MER above the threshold (normal broadcasts), 0.042% MER at the threshold (freeze broadcasts), and 0.255% MER below the threshold (blank broadcasts) in the Jabodetabek area. Figure 4 depicts the spatial distribution of normal, freeze, and blank broadcasts in the Jabodetabek region.

In Figure 4, green points represent MER values above the threshold, yellow points indicate MER values at the threshold, and red points signify MER values below the threshold. The map clearly shows that normal broadcasts dominate the measurement results, as indicated by the extensive distribution of green points compared to the limited occurrences of yellow and red points. This dominance highlights the effectiveness of the combined transmitter antenna system in ensuring normal broadcast reception across the Jabodetabek area.

TABLE 4  
MER RESULTS IN EAST JAKARTA

| Region       | MER Above the Threshold | MER At the Threshold | MER Below the Threshold |
|--------------|-------------------------|----------------------|-------------------------|
| East Jakarta | 98.25%                  | 0.25%                | 1.50%                   |

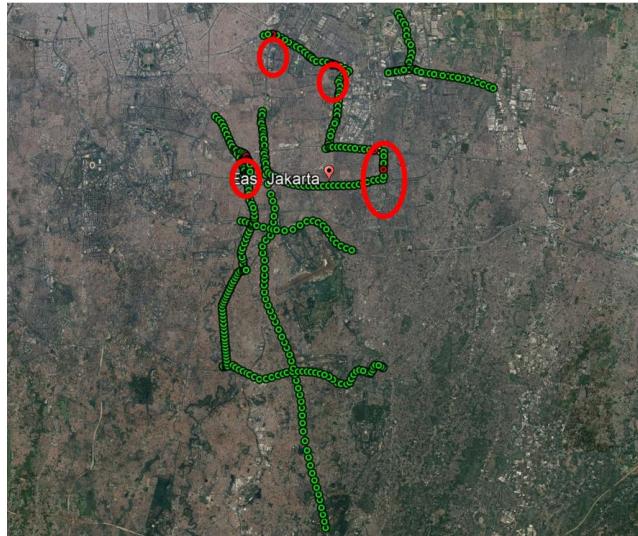


Figure 6. MER mapping results in East Jakarta

### B. Results of MER in Each Region

Measurements were conducted in the Jabodetabek region, covering North Jakarta, East Jakarta, South Jakarta, West Jakarta, Central Jakarta, Bogor, Depok, Tangerang, and Bekasi. The MER results for each region are presented below.

#### 1) North Jakarta

The MER values measured in North Jakarta are summarized in Table 3, with the corresponding spatial distribution illustrated in Figure 5. Table 3 indicates that 98.81% of the data corresponds to normal broadcasts, while 0.60% represents freeze broadcasts, and another 0.60% corresponds to blank broadcasts in North Jakarta. Figure 5 highlights a single freeze frame instance, marked by a yellow dot near Jalan Tipar Cakung, occurring approximately 0.52 km from PT Golden Garmen Indonesia. Additionally, one blank broadcast instance, represented by a red dot, was detected near Jalan Danau Sunter Utara, approximately 0.32 km from Mal Sunter. Both freeze and blank broadcast data points are located 3.2 km and 4.7 km, respectively, from Tanjung Priok Port. Despite these instances, the data show that disruptions to channel X broadcasts in North Jakarta are minimal, with 98.81% of broadcasts classified as normal. This indicates a high level of broadcast stability in the region.

#### 2) East Jakarta

The percentage of MER measurement results for the East Jakarta area is presented in Table 4, while Figure 6 illustrates the MER mapping results in East Jakarta. Table 4 shows that 98.25% of the data corresponds to normal broadcasts, 0.25% to freeze broadcasts, and 1.50% to blank broadcasts. Figure 6 highlights the locations of freeze and blank broadcast data points. On Jalan Jenderal Ahmad Yani, the data points are approximately 0.21 km from ITC Cempaka Mas Mall and Lippo Tower Village. Data collected on Jalan Perintis Kemerdekaan indicates proximity to Premier Oak Apartments and Gading Icon Apartments, at a distance of 0.12 km. Additional data from Jalan I Gusti Ngurah Rai is located 0.58 km from Plaza Buaran, while data collected on Jalan Radin Inten II is 0.35 km from Plaza Buaran.

#### 3) South Jakarta

The MER measurement results for the South Jakarta area are detailed in Table 5, with the corresponding mapping shown in Figure 7. Table 5 indicates that 100% of broadcasts in South Jakarta are classified as normal, with no instances of freeze or blank broadcasts recorded for the X channel when the combined transmitter antenna system is used. Figure 7 corroborates these results, showing no red or yellow points. Despite the presence of shopping malls and tall apartment buildings in South Jakarta, which are typically prone to signal reflection and interference, the MER values for the X channel remain stable and well-received.

TABLE 5  
MER RESULTS IN SOUTH JAKARTA

| Region        | MER Above the Threshold | MER At the Threshold | MER Below the Threshold |
|---------------|-------------------------|----------------------|-------------------------|
| South Jakarta | 100%                    | 0%                   | 0%                      |

TABLE 6  
MER RESULTS IN WEST JAKARTA

| Region       | MER Above the Threshold | MER At the Threshold | MER Below the Threshold |
|--------------|-------------------------|----------------------|-------------------------|
| West Jakarta | 99.60%                  | 0%                   | 0.40%                   |

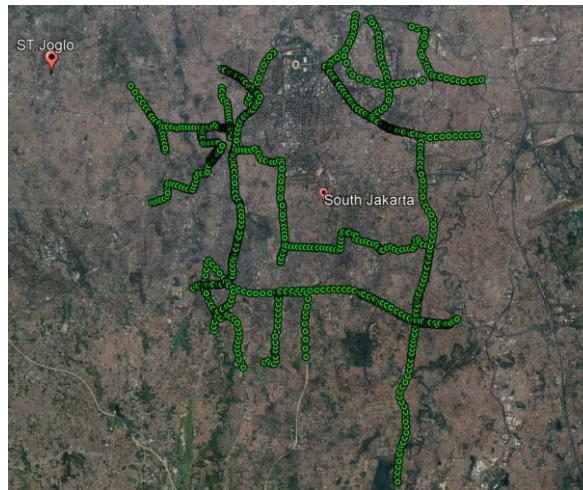


Figure 7. MER Mapping Results in South Jakarta

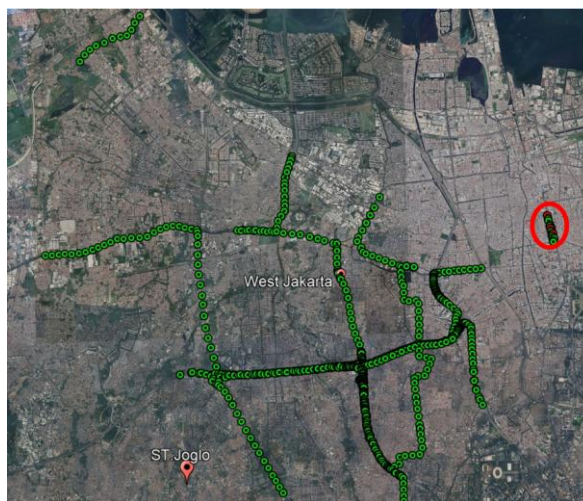


Figure 8. MER mapping results in West Jakarta

#### 4) West Jakarta

The MER measurement results for the West Jakarta area are detailed in Table 6, with the corresponding mapping shown in Figure 8. Table 6 indicates that 99.60% of broadcasts in West Jakarta are classified as normal, 0% as freeze broadcasts, and 0.40% as blank broadcasts when the combined transmitter antenna system is used. Figure 8 shows that the blank broadcast data point is located on Jalan Gadjah Mada Taman Sari. This area is surrounded by tall buildings, including Mal Paragon, Plaza Hayam Wuruk, and Hayam Wuruk Apartments, which may contribute to signal interference.

#### 5) Central Jakarta

The MER measurement results for the Central Jakarta area are summarized in Table 7, with the corresponding mapping illustrated in Figure 9. Table 7 reveals that 99.57% of the broadcasts in Central Jakarta are classified as normal, with 0% as freeze broadcasts and 0.43% as blank broadcasts for the X channel. Figure 9 shows that the blank broadcast data point is located on Jalan Gadjah Mada Gambir, approximately 0.20 km from Plaza Gadjah Mada. This location suggests that environmental factors, such as nearby tall structures, might contribute to the observed signal disruption.

TABLE 7  
MER RESULTS IN CENTRAL JAKARTA

| Region          | MER Above the Threshold | MER At the Threshold | MER Below the Threshold |
|-----------------|-------------------------|----------------------|-------------------------|
| Central Jakarta | 99.57%                  | 0%                   | 0.43%                   |

TABLE 8  
MER RESULTS IN BOGOR

| Region | MER Above the Threshold | MER At the Threshold | MER Below the Threshold |
|--------|-------------------------|----------------------|-------------------------|
| Bogor  | 100%                    | 0%                   | 0%                      |



Figure 9. MER Mapping Results in Central Jakarta

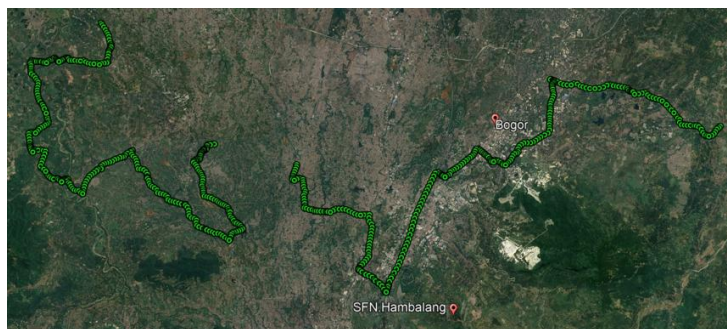


Figure 10. MER mapping results in Bogor

6) Bogor

The MER measurement results for the Bogor region, focusing on the X channel, are presented in Table 8, with the corresponding mapping shown in Figure 10. Table 8 shows that all measurement data in the Bogor region indicate normal broadcasts, with 100% of the MER values above the threshold and no occurrences of freeze or blank broadcasts. Figure 10 corroborates this, as no measurement points are represented in red or yellow. These results demonstrate that the combined transmitter antenna system used for the X channel ensures excellent MER reception values in the Bogor region. Furthermore, the presence of a Single Frequency Network (SFN) in the Bogor area may contribute to the stability and quality of the signal reception.

7) Depok

The MER measurement results for the Depok region are summarized in Table 9, with the mapping displayed in Figure 11. Table 9 indicates that 100% of the measurement data in the Depok area corresponds to normal broadcasts, with no freeze or blank broadcasts observed. Figure 11 validates this, as no measurement points are marked in red or yellow. The findings suggest that the combined transmitter antenna system used for the X channel provides optimal MER reception in the Depok area. Additionally, similar to Bogor, Depok has fewer tall buildings compared to the Jakarta area, which may reduce the likelihood of signal reflection and interference, further enhancing signal quality.

TABLE 9  
MER RESULTS IN DEPOK

| Region | MER Above the Threshold | MER At the Threshold | MER Below the Threshold |
|--------|-------------------------|----------------------|-------------------------|
| Depok  | 100%                    | 0%                   | 0%                      |

TABLE 10  
MER RESULTS IN TANGERANG

| Region    | MER Above the Threshold | MER At the Threshold | MER Below the Threshold |
|-----------|-------------------------|----------------------|-------------------------|
| Tangerang | 100%                    | 0%                   | 0%                      |

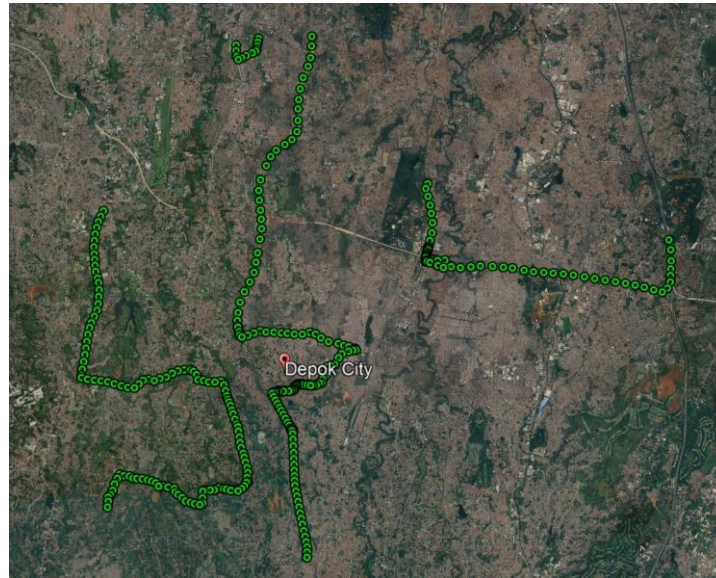


Figure 11. MER mapping results in Depok

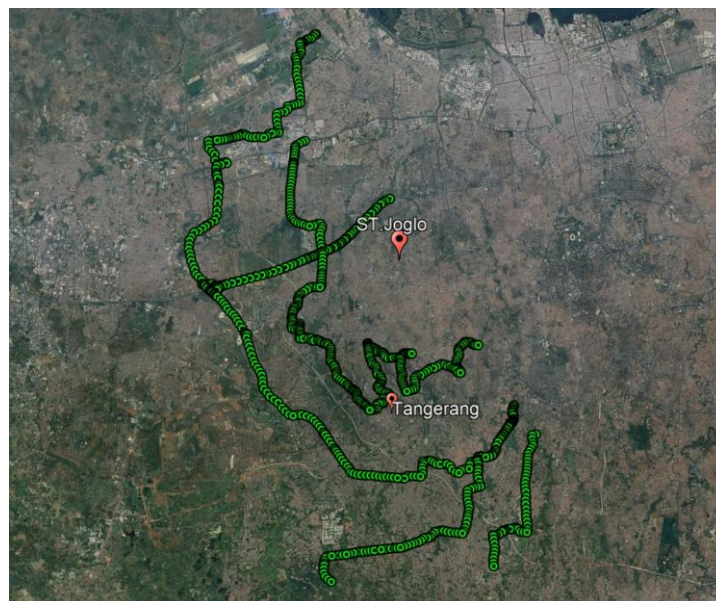


Figure 12. MER mapping results in Tangerang

#### 8) Tangerang

The MER measurement results for the Tangerang area are summarized in Table 10, with the corresponding mapping displayed in Figure 12. Based on Table 10 and Figure 12, the measurement results indicate that 100% of the data corresponds to normal broadcasts, with no instances of freeze or blank broadcasts. This suggests that the signal reception for the X channel in Tangerang is optimal when using a combined transmitter antenna system. From a topographical perspective, the Tangerang area features low-lying terrain with a relatively flat topography, characterized by slopes averaging 0–3%. This geographical attribute may contribute to the stable and consistent signal reception observed in the area.

TABLE 11  
MER RESULTS IN BEKASI

| Region | MER Above the Threshold | MER At the Threshold | MER Below the Threshold |
|--------|-------------------------|----------------------|-------------------------|
| Bekasi | 99.74%                  | 0%                   | 0.26%                   |



Figure 13. MER mapping results in Bekasi

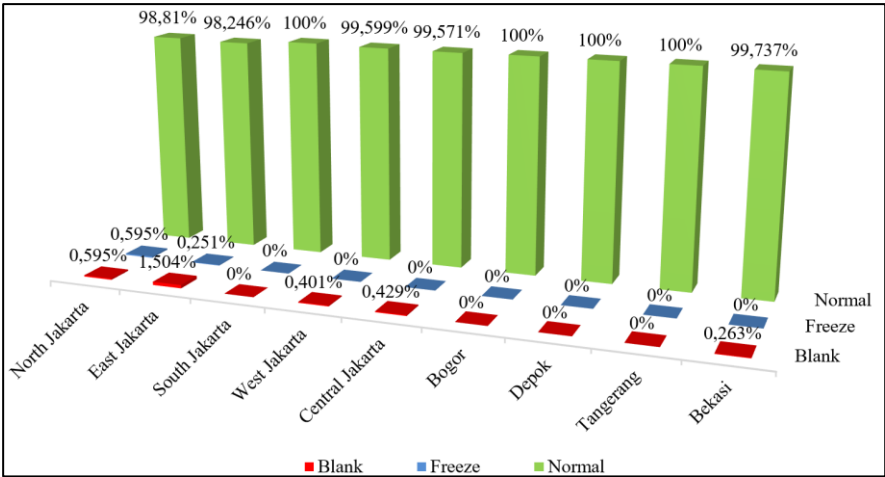


Figure 14. Comparison of MER results for each region

9) Bekasi

The MER measurement results for the Bekasi area are presented in Table 11, with the distribution visualized in Figure 13. Table 11 indicates that 99.74% of the measurement data in Bekasi corresponds to normal broadcasts, with no freeze broadcasts and 0.26% blank broadcasts. The blank broadcast data is concentrated in the Serang Baru area, as shown in Figure 13. The blank broadcast point is located approximately 62 meters from a cement supplier's office, an area frequently traversed by large trucks. The passage of these heavy vehicles may contribute to signal weakening at this location. Despite this, the Bekasi area is predominantly characterized by normal broadcasts, which account for 99.74% of the total data. The presence of a Single Frequency Network (SFN) tower in the Bekasi area also enhances signal stability, ensuring that normal broadcasts dominate despite occasional disruptions.

C. Comparison of MER Results for Each Region

A comparison of MER scores across all regions is illustrated in Figure 14. As shown in Figure 14, certain areas—North Jakarta, West Jakarta, East Jakarta, Central Jakarta, and Bekasi—experienced instances of freezing or blank broadcasts even after transitioning from a lower to a combined transmitter antenna system. As noted in previous sections, these occurrences are primarily observed near obstacles such as tall buildings, apartments, and shopping malls. On the other hand, Figure 14 highlights four

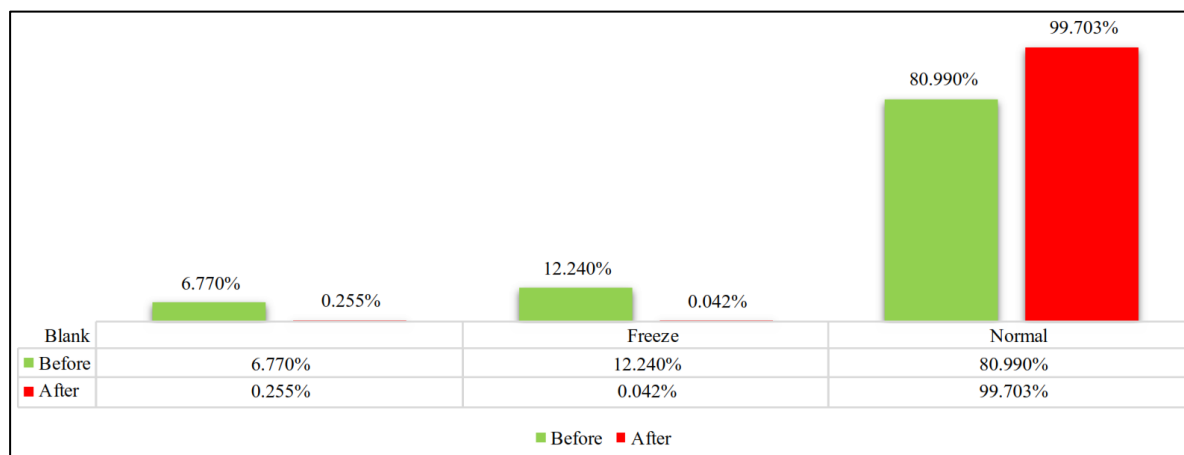


Figure 15. Comparison of MER values for lower and combined systems

regions—South Jakarta, Bogor, Depok, and Tangerang—where MER values consistently indicate perfectly normal broadcasts, reflecting the effectiveness of the combined transmitter antenna system in these areas.

#### *D. Comparison of MER Values Before and After the Transition of the Transmitter Antenna System*

The changes in MER values before and after transitioning from the lower transmitter antenna system to a combined system are depicted in Figure 15. Figure 15 demonstrates a significant improvement in MER values following the transition to the combined transmitter antenna system. The percentage of blank broadcasts decreased dramatically, from 6.770% to 0.255%, while freeze broadcasts dropped from 12.240% to a negligible 0.042%. This improvement led to a substantial increase in normal broadcasts, rising from 81.99% to 99.703%. These findings underscore the effectiveness of the combined transmitter antenna system in enhancing the overall quality and stability of digital television broadcasts.

#### *E. Discussion*

After conducting measurements, it can be observed that the environmental conditions around the measurement points can affect signal reception at those points. This is evidenced by the measurement results showing that blank and freeze broadcast data occurred at points located near obstacles. These obstacles may include tall buildings, such as apartments or malls, and large vehicles, such as trucks. These obstacles clearly impact signal reception in the surrounding areas. Physical obstacles can interfere with the electromagnetic waves transmitting the signal from the transmitter to the receiver [8].

Interference can occur due to reflection, refraction, and attenuation when electromagnetic waves encounter obstacles [9]. Reflection happens because of signal bouncing off obstacles, causing changes in transmission direction. On the other hand, different signal paths may occur due to signals passing through different media, from air to solid objects like buildings, which is referred to as refraction. Additionally, attenuation occurs due to the absorption of electromagnetic wave energy by materials such as concrete and metal [10]. Reflection, refraction, and attenuation result in multipath effects and path loss in the signal transmission process. Multipath occurs due to refraction, reflection, and attenuation causing the signal to take different paths, which can lead to interference at the receiver end [11]. Conversely, path loss happens due to the weakening of the signal strength during transmission.

Furthermore, the presence of ports also affects signal reception in the surrounding areas [12]. Measurement data indicate that blank and freeze broadcast data were found around ports, as seen in the North Jakarta area. Regions around ports are generally more susceptible to signal interference. In addition to the consistently busy port area, the use of various electronic devices, such as communication, navigation, and security equipment used in ports, also contributes to signal interference [13]. Interference can degrade broadcast quality at the receiver end, indicated by a decrease in MER values.

Topographic conditions also affect signal reception in a region [14]. Lowlands tend to receive more stable and even stronger signals compared to highlands. This occurs because electromagnetic waves can propagate more freely without obstacles such as mountains or hills, especially when the lowland areas

are not surrounded by tall buildings or other obstacles [15]. This can be observed in the MER measurement results in the Depok and Tangerang areas, which show 100% above the threshold. In this case, Depok and Tangerang feature lowland topography and have fewer buildings compared to their surrounding areas, namely South Jakarta and West Jakarta. The reduction in obstacles enhances signal reception in lowland areas because the effects of multipath and path loss can be avoided.

As discussed, tall buildings and geographical features are the primary factors influencing MER values. These findings align with the research of Mansor et al., who attributed blank and freeze frames to distance from the transmitter, geographical conditions, and tall buildings [5]. A similar finding was reported by Igbonoba & Omoifo in their study on DVB-T2 signal strength in Jos, Nigeria, where they emphasized the significant role of geography in signal reception [16].

On the other hand, the presence of SFN also plays a significant role in digital television signal reception [17], [18]. Measurement data indicate that areas with SFNs tower have a percentage of normal broadcasts that almost reaches the maximum. In fact, South Jakarta and Bogor have a normal broadcast percentage of 100%. Although South Jakarta is surrounded by numerous tall buildings and Bogor is a highland area, signal reception can be optimized due to the construction of SFNs in these regions. SFNs operate by 'shooting' signals specifically to areas prone to blank spots from multiple towers simultaneously on the same frequency [19]. Thus, previously weak signals are strengthened by the 'shooting' from multiple SFN towers. With SFNs, signals can reach areas that are difficult to cover by a single transmitter alone [20].

Subsequent measurements indicate that the use of combined transmitter antenna systems can provide more uniform normal broadcasts compared to the use of lower systems. In fact, the percentage of normal broadcasts when using the combined system nearly reaches a perfect figure, at 99.703%, compared to only 80.990% with the lower transmitter antenna system. This difference is primarily due to the increased number of transmitter antenna arrays used. The combined transmitter antenna system utilizes all 64 antenna arrays available, whereas the lower transmitter antenna system uses only 32 arrays.

The increased number of antenna arrays in the combined system has been a significant contributing factor to the higher percentage of normal broadcasts. The number of antenna arrays used is a key factor influencing the Half Power Beam Width (HPBW) angle. The HPBW parameter indicates the angular width between two points that separate the main lobe in the power pattern. In this context, the pattern formed by the HPBW angle will determine the characteristics of the antenna used. The more antenna arrays used, the narrower the resulting HPBW angle. A narrower HPBW angle enhances the performance of the transmitter antenna by focusing the transmitted power more precisely on the target point. In other words, a narrower HPBW increases the antenna's directivity, thereby strengthening the received signal [21], [22].

When viewers receive stronger signals, the modulation error ratio decreases, resulting in a reduction in the percentage of blank and freeze broadcasts and an increase in the percentage of normal broadcasts. Ideally, digital television transmission stations should provide interference-free reception to their users. However, in practice, this is unattainable for all service areas, as various sources of noise and interference will always impair the signal.

This study successfully calculated the MER values for channel X when using the combined transmitter antenna system. It was found that the conditions around the measurement points, regional topography, and the presence of Single Frequency Networks (SFNs) affect digital television signal reception. Moreover, the use of the combined transmitter antenna system offers a higher percentage of normal broadcasts compared to the previous lower system.

#### IV. CONCLUSION

This research has successfully conducted MER measurements in the Jabodetabek area on channel X when the combined transmitter antenna system is utilized. Through drive test methodology, the measurement results reveal that the combined transmitter antenna system can achieve 99.703% normal broadcast data, 0.042% broadcast data freeze, and 0.255% broadcast data blank. These figures demonstrate that the combined transmitter antenna system can serve as one of the methods to address the uneven distribution of normal broadcasts in the Jabodetabek area. Based on the findings of this research, it is recommended that the government not only regulate the standardization of digital TV parameters but also establish specific policies regarding the standardization of transmitting antennas. This approach is expected to ensure equitable coverage and accessibility of digital television services. Additionally, it is

recommended that future research focus on measuring digital television signal reception in isolated island environments, such as the Kepulauan Seribu, to quantify the impact of distance and water attenuation on signal reception for digital television.

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