Analysis of Digital Television Signal System Based on Gain and Information in Malang City Area

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***Abstract*— The transition to digital terrestrial television (DTT) broadcasting necessitates rigorous signal quality assessment to ensure reliable service. This study presents a field measurement and analysis of DTT signal characteristics in the Malang City area, focusing on critical parameters such as gain, signal-to-noise ratio (SNR), and bit error rate (BER). Measurements were conducted using a Signal Hound USB-SA44B spectrum analyzer coupled with a calibrated measurement antenna. The Spike software platform facilitated real-time spectrum analysis and data capture across allocated DTT channels. Results indicate significant variation in signal integrity across different locations. The average measured signal gain was -65 dBm, with SNR values ranging from 18 dB to 25 dB depending on topography and obstructions. A strong correlation was observed between suboptimal gain values (< -70 dBm) and increased BER, leading to pixelation and service dropouts. Furthermore, spectrum analysis revealed the presence of adjacent channel interference in congested urban zones. The study concludes that while core urban areas in Malang generally meet minimum reception thresholds, fringe and obstructed areas suffer from degraded signal quality. These findings underscore the importance of strategic transmitter placement and the potential need for signal repeaters to achieve comprehensive coverage, providing actionable insights for network planners and broadcast engineers.**

Keywords—Digital Terrestrial Television (DTT), Signal-to-Noise Ratio (SNR), Bit Error Rate (BER), Signal Hound, Coverage Analysis.

I. INTRODUCTION

The global transition from analog to digital terrestrial television (DTT) broadcasting represents a fundamental shift in telecommunications infrastructure, driven by the imperative for spectral efficiency, enhanced service quality, and greater data capacity. This migration, often termed the Analog Switch-Off (ASO), liberates substantial segments of the Very High Frequency (VHF) and Ultra High Frequency (UHF) spectrum, enabling its reallocation for next-generation mobile broadband services while simultaneously improving broadcast robustness and content diversity [1], [2]. In Indonesia, this digital transformation has been a protracted national policy initiative, with its full realization and the subsequent analog sunset presenting ongoing technical and implementation challenges [3], [4].

Digital Video Broadcasting - Second Generation Terrestrial (DVB-T2) has emerged as the predominant standard for DTT due to its superior spectral efficiency and resilience compared to its predecessor, DVB-T [5]. The system's performance is governed by a suite of configurable parameters, including modulation order (e.g., 16-QAM, 64-QAM), Forward Error Correction (FEC) coding rates, and the Fast Fourier Transform (FFT) size, which collectively determine the trade-off between data throughput and reception reliability under varying channel conditions [6], [7]. Consequently, empirical evaluation of the received signal quality is critical for broadcasters, regulators, and network planners to ensure service coverage complies with design specifications and user experience expectations.

The quality of service (QoS) in DTT networks is intrinsically linked to the received signal strength and the signal-to-noise ratio (SNR) at the viewer's location [8]. These metrics are profoundly influenced by a confluence of factors, including transmitter power, geographical topology, environmental clutter (urban vs. rural), and the performance characteristics of the receiving antenna, such as its gain, radiation pattern, and placement [9], [10]. In urban environments like Malang City, multipath propagation caused by signal reflection from buildings and other structures can lead to fading and inter-symbol interference, which DVB-T2's Orthogonal Frequency Division Multiplexing (OFDM) and guard interval are designed to mitigate [11], [12]. Therefore, a location-specific analysis that measures the actual, delivered signal parameters is indispensable.

While prior studies have broadly addressed Indonesia's digital migration policy [3], [4] and simulated DVB-T2 performance [6], [7], there is a discernible research gap concerning detailed, empirical measurements of broadcast signal integrity in specific urban areas post-ASO. Previous works often rely on theoretical models or subjective quality assessment (e.g., SINPO codes) [13], rather than objective, instrument-based analysis of signal gain and spectral occupancy. This study aims to address this gap by conducting a field measurement campaign in the Malang City area. The primary objective is to analyze the digital television signal system by quantitatively measuring signal gain and characterizing the spectral information across the allocated VHF (47-230 MHz) and UHF (470-870 MHz) bands. Utilizing a high-resolution Spectrum Analyzer (Signal Hound), this research will capture and analyze the amplitude response of broadcast signals to evaluate conformity with technical standards, identify potential interference, and assess the effective coverage quality. The findings are expected to provide actionable data for optimizing broadcast network performance and ensuring the promised benefits of the digital dividend are fully realized for end-users in the region.

II. METHOD

A. Research Stages

The overall research stages are illustrated in Fig. 1.

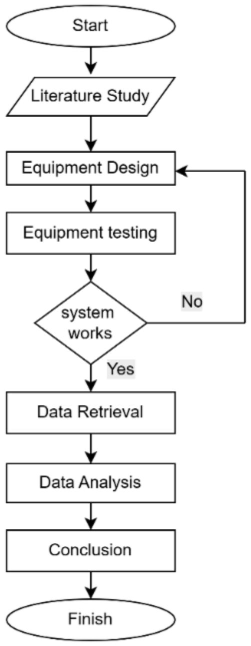

Figure 1. Flowchart of research stages

The research stages are structured to systematically analyze the digital television signal system using a spectrum analyzer. These stages are designed to ensure that each process, from system preparation to data analysis, is conducted in an organized and sequential manner.

The first stage involves a literature study related to digital television broadcasting, modulation techniques, spectrum analysis, and antenna characteristics. This stage aims to provide a theoretical foundation for understanding the parameters and performance indicators of digital TV signals.

The second stage focuses on system setup and hardware preparation, including the installation of a digital television, a digital antenna, and the Signal Hound spectrum analyzer. The antenna is positioned in both indoor and outdoor environments to observe variations in signal reception and spectrum characteristics.

The third stage is the measurement and data acquisition process, where digital TV signals are captured and analyzed using the Signal Hound device. Spectrum parameters such as carrier frequency, signal amplitude, and spectral shape are recorded using the Spike Spectrum Analyzer software.

The final stage involves data analysis and interpretation. The measured spectrum data are evaluated to assess signal quality, frequency utilization, and the impact of antenna placement on reception performance.

B. Electronics Design

Figure 2. System block diagram

Electronic circuit that will be implemented in the Modulation System Implementation on Digital TV using a Spectrum Analyzer (Signal Hound). This testing starts from a digital antenna that functions to receive signals in the form of electromagnetic waves, which are then transmitted to a digital television. This television is equipped with a tuner capable of capturing and decoding digital TV signals. After decoding, the television displays the images and sounds produced from the signal.

The digital TV signal, which has been decoded by the television, is then sent to the Signal Hound to obtain results such as frequency, amplitude, and waveform shape. The data obtained by the Signal Hound is sent to a laptop, which acts as a controller and data processor equipped with the Spike Spectrum Analyzer application, which is software that displays the spectrum analysis results.

C. Tool Design Flowchart

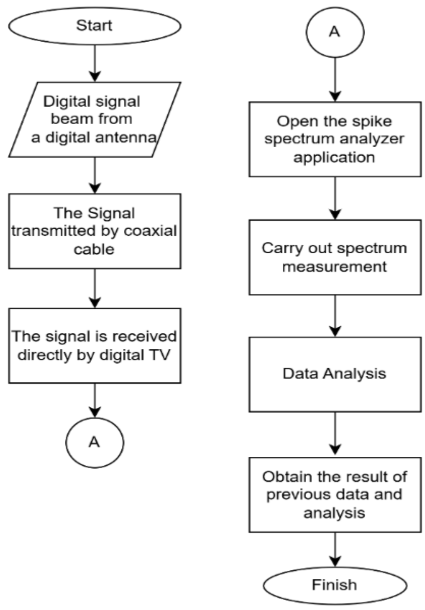

Figure 3. Tools design flowchart

The tool design flowchart illustrates the operational sequence of the digital television signal analysis system using the Signal Hound spectrum analyzer, as shown in Fig. 3. This flowchart describes the steps required to obtain and analyze spectrum data from digital TV broadcasts. The process begins with system initialization, including the setup of the digital antenna, digital television, Signal Hound device, and laptop. After initialization, the measurement parameters are configured by selecting the desired center frequency and frequency span according to the broadcast channel being analyzed.

Next, the resolution bandwidth is adjusted to obtain clearer and more accurate spectrum measurements. Once the configuration is completed, the spectrum data are captured in real time using the Signal Hound device and displayed through the Spike Spectrum Analyzer software.

The final step involves analyzing and interpreting the spectrum results by observing frequency peaks, signal amplitude levels, and spectral characteristics. This analysis is used to evaluate signal quality and frequency utilization in the digital television broadcasting system.

III. RESULTS AND DISCUSSION

A. The result of the device circuit

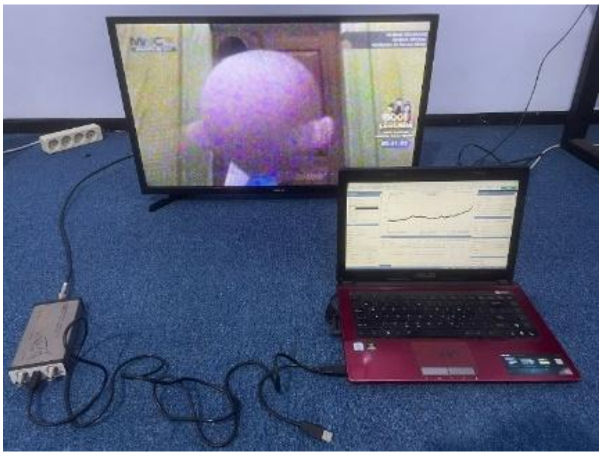

Figure 4. result of the device circuit

Fig. 4 shows the complete implementation of the digital television signal analysis system. The system consists of a digital television, a Signal Hound spectrum analyzer, and a laptop that are interconnected to observe and analyze RF spectrum characteristics in real time.

In this configuration, the digital antenna receives broadcast signals and forwards them to the digital television for decoding. The decoded RF signal output is then connected to the Signal Hound device, which measures spectrum parameters such as carrier frequency, signal amplitude, and spectral shape.

The measurement results obtained by the Signal Hound are transmitted to a laptop equipped with the Spike Spectrum Analyzer software. This setup enables real-time visualization and analysis of the digital TV signal spectrum, allowing evaluation of signal quality and system performance under different measurement conditions.

Figure 5. Indoor antenna

Fig. 5 presents the indoor placement of the digital antenna, which is installed near the window inside the building so that it can still receive reflected and direct signals from nearby transmitters. This indoor position is used to evaluate how wall attenuation and room layout affect the received signal strength, which will later be reflected in the spectrum analyzer readings and the visual quality of the television image.

Fig. 6 shows the same type of digital antenna positioned in an outdoor area, placed on a stair landing close to open space to minimize obstructions. The outdoor placement is expected to provide stronger and more stable reception because the antenna has a clearer line-of-sight to the transmitter, allowing comparison of gain, interference level, and overall signal quality between indoor and outdoor conditions.

Figure 6. Outdoor antenna

B. Experiment Results on Indoor ANTV Channel

Fig. 7 displays the RF spectrum of the ANTV indoor video modulator, with the picture carrier located at approximately 503.73 MHz and the span covering about 197–217 MHz. The trace shows the overall power distribution of the ANTV channel for this indoor antenna condition, providing a compact baseline to locate the picture carrier region and compare its signal level with other measurement settings.

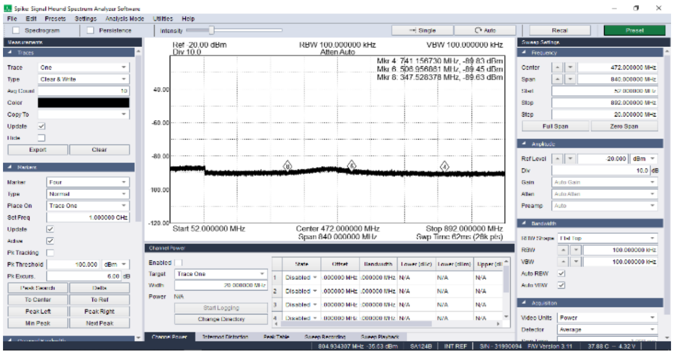

Figure 7. ANTV indoor video modulator

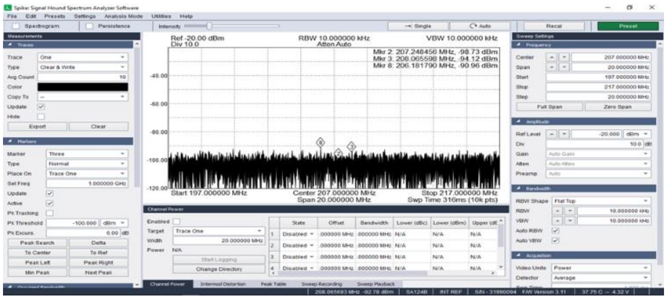

Figure 8. ANTV indoor video modulator span width is narrowed

Fig. 8 shows the ANTV indoor video modulator with the analyzer span narrowed around the channel, allowing a more detailed view near the picture carrier at about 503.73MHz. In this mode, the carrier components and their level differences appear more clearly, simplifying identification of the picture carrier and assessment of ANTV RF signal quality.

Fig. 9 shows the right audio spectrum of the ANTV indoor channel, where the trace indicates the RF power distribution around the audio subcarrier at approximately 565.81MHz. From this display, the carrier's frequency and amplitude can be read, so its offset of about 62.09 MHz from the 503.73 MHz picture carrier can be calculated and the resulting audio signal quality evaluated.

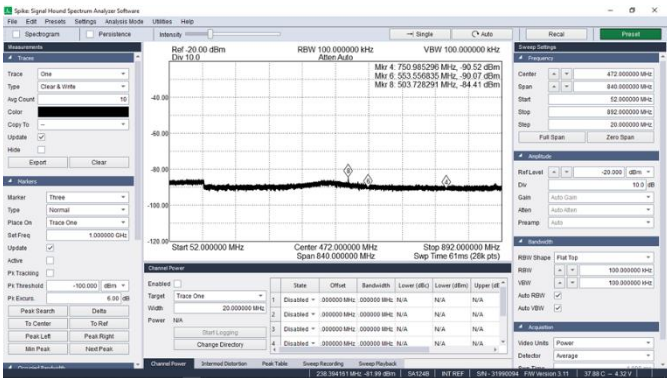

Figure 9. Audio right output from ANTV indoor channel using spectrum analyzer

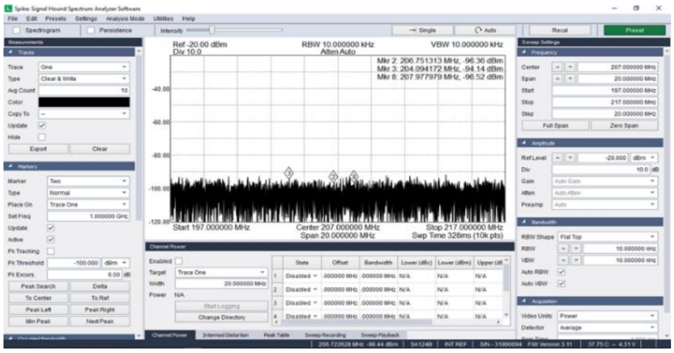

Figure 10. Audio right ANTV indoor span width is narrowed

In Fig. 10, it can be seen that the Spike Spectrum Analyzer displays the RF spectrum around 207 MHz with relatively low and uniform signal levels close to the noise floor, without any dominant carrier present. The markers are placed on small peaks above the noise to indicate weak signal components within the 197–217 MHz frequency range. This spectrum condition serves as a baseline for comparing power level and spectrum quality changes when the antenna configuration or broadcast channel is modified in the digital TV system under test.

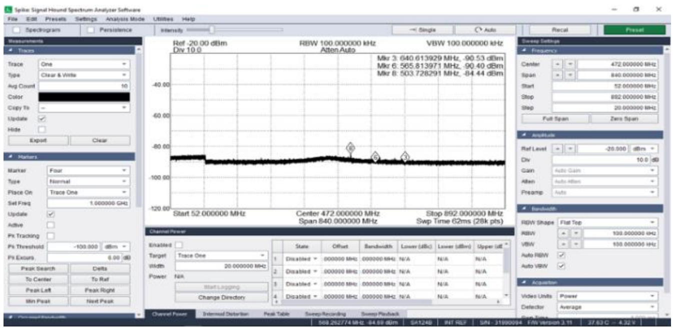

Figure 11. Audio left output from ANTV indoor channel using spectrum analyzer

Fig. 11 shows the ANTV indoor left audio output when the spectrum analyzer span has been narrowed to 452–492 MHz, so the frequency range around the audio carrier can be observed in more detail. With this narrower span, the small rises along the trace between approximately 465–480 MHz become clearer, making it easier to see that the signal level remains close to the noise floor and to evaluate the uniformity of the low-level audio RF components.

Fig. 12 shows the left audio spectrum of the ANTV indoor channel with the analyzer span narrowed around the channel, so the frequency region near the left audio subcarrier can be examined in more detail. In this narrower span, the small peaks standing slightly above the noise floor become clearer, making it easier to locate the left audio carrier, estimate its frequency offset from the 503.73 MHz picture carrier, and evaluate the uniformity of the low-level audio signal.

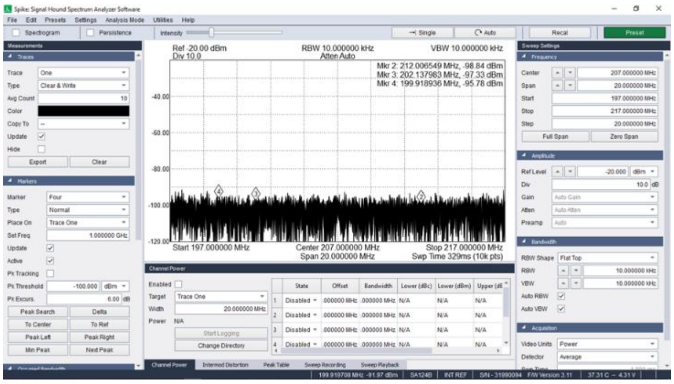

Figure 12 ANTV indoor audio left span width is narrowed

C. Quality Result of ANTV Indoor Image.

Figure 13. Image quality of ANTV when the antenna is indoors

Fig. 13 shows the image quality of the ANTV broadcast when the digital antenna is placed indoors and connected to the digital television, where the program content is still displayed with relatively clear colors and motion. This condition indicates that, despite indoor placement and potential attenuation from walls, the received signal remains strong enough to avoid severe pixelation or loss of audio-video synchronization.

At the same time, the laptop running Spike Spectrum Analyzer is connected to the system, enabling direct correlation between the visual quality on the TV screen and the RF spectrum characteristics measured during the test.

D. Experiment Results on Trans TV HD Channel Indoor.

Fig. 14 shows the RF output spectrum of the Trans TV HD indoor video modulator measured using the Spike Spectrum Analyzer, with the picture carrier located at approximately 502.04MHz. The trace illustrates how the signal power is distributed around this carrier when received indoors, providing a reference to assess carrier level and overall Trans TV HD channel quality under the indoor antenna condition.

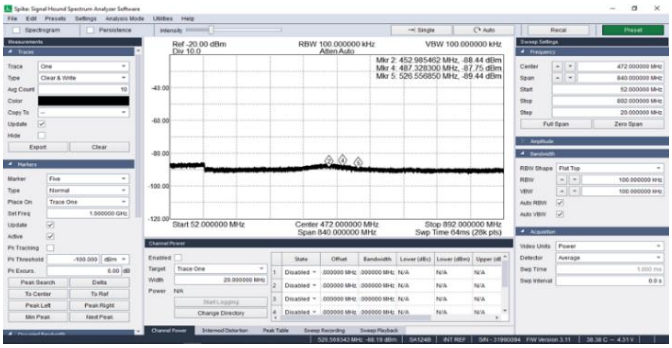

Figure 14. Video modulator (RF) output of Trans TV HD indoor using spectrum analyzer

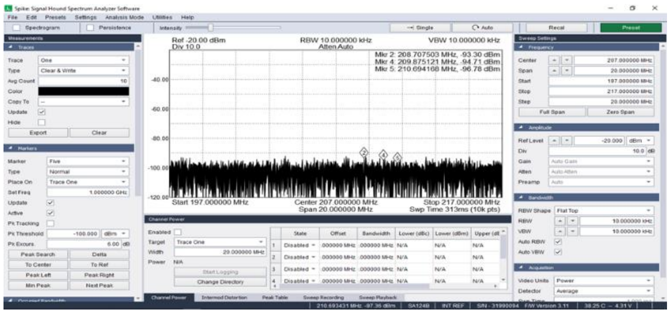

Figure 15. Trans TV HD indoor video modulator span width is narrowed

Fig. 15 shows the Trans TV HD indoor video modulator signal with the spectrum analyzer span narrowed around the channel so that the frequency region near the picture carrier at about 502.04 MHz can be inspected in more detail. In this narrower span, the individual carrier components and their small level variations become clearer, simplifying identification of the picture carrier and evaluation of the Trans TV HD RF signal quality under indoor conditions.

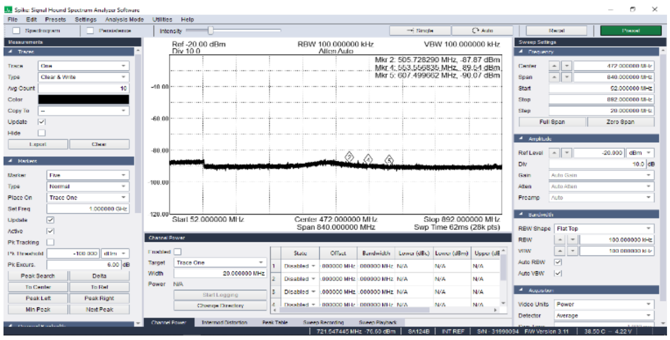

Figure 16. Audio right output from Trans TV HD channel using spectrum analyzer

Fig. 16 shows the right audio spectrum of the Trans TV HD indoor channel, with the trace representing the RF power distribution around the right audio subcarrier at approximately 563.36MHz. From this display, the carrier's frequency and amplitude can be identified, enabling calculation of its offset of about 61.31 MHz from the 502.04 MHz picture carrier and evaluation of the resulting audio signal quality.

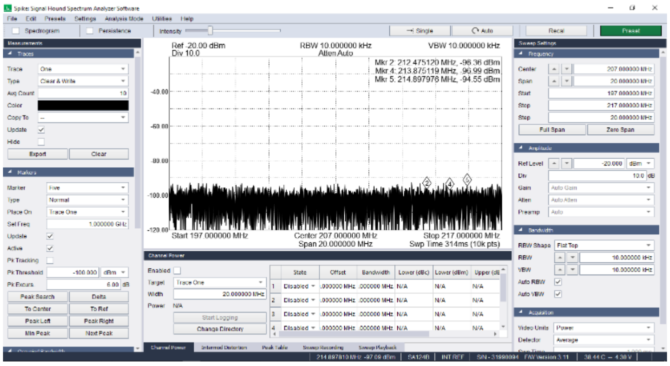

Figure 17. Audio right Trans TV HD indoor span width is narrowed

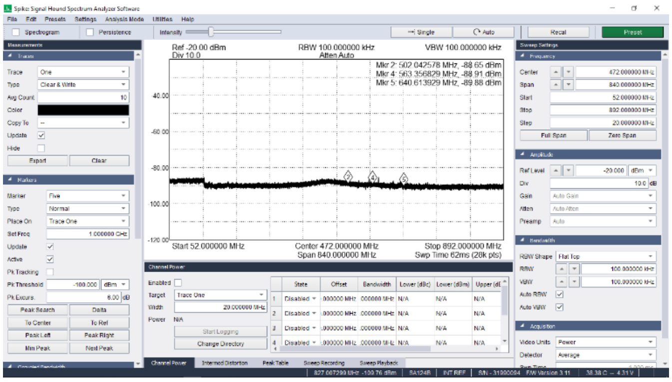

Figure 18. Audio left output from Trans TV HD indoor channel using spectrum analyzer

Fig. 18 shows the left audio spectrum of the Trans TV HD indoor channel, with the trace representing the RF power distribution around the left audio subcarrier at approximately 640.61MHz. From this measurement, the carrier's frequency and amplitude can be determined, enabling calculation of its offset of about 138.57 MHz from the 502.04 MHz picture carrier and evaluation of the left audio signal quality.

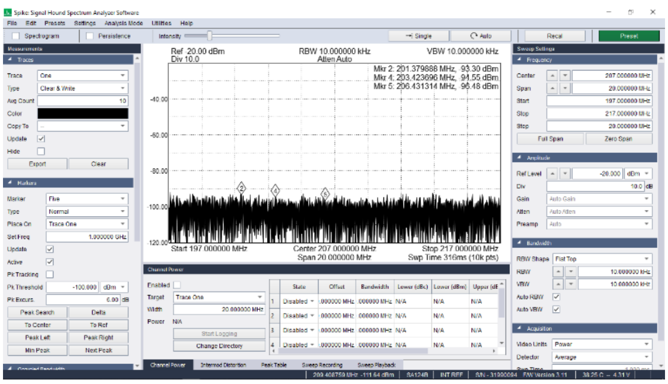

Figure 19. Trans TV HD audio left span width is narrowed

Fig. 19 shows the left audio spectrum of the Trans TV HD indoor channel with the analyzer span narrowed around the channel so the region near the 640.61 MHz audio subcarrier can be examined in more detail. In this narrower span, the small peaks above the noise floor are more distinguishable, making it easier to identify the left audio carrier, confirm its offset of about 138.57 MHz from the 502.04 MHz picture carrier, and evaluate the audio signal quality.

E. Image Quality Results of Trans TV HD Indoors

Figure 20. Image quality of Trans TV when the antenna is indoors

In Fig. 20, it shows the image quality of Trans TV HD broadcasting when the digital antenna is placed indoors on a Digital Television.

F. The Frequency Results obtained for ANTV channel with the digital antenna positioned indoors (Indoor)

1) For the calculation of the subcarrier frequency of the left audio on ANTV Indoor, the following steps are taken:

= Color subcarrier frequency - Picture carrier frequency
= 640.61329 MHz - 503.72891 MHz
= 136.88438 MHz

2) For the calculation of the subcarrier frequency of the left audio on ANTV Indoor, the following steps are taken:

= Audio carrier frequency - Picture carrier frequency
= 565.813971 MHz - 503.72891 MHz
= 62.08506 MHz

The initial span value before narrowing down is 840 MHz, ranging from 52 MHz to 892MHz. This frequency range falls below and above the channel frequency limits, allowing us to determine at which frequency the Digital Television operates.

The picture carrier frequency is 503.72891 MHz, the color subcarrier frequency is 211.871311 MHz, and the audio subcarrier frequency is 640.61329MHz. These frequencies can be used on television channel 32 within the broadcast channel range of 202 - 209MHz.

The color subcarrier frequency of 136.88438 MHz and the audio subcarrier frequency of 62.08506 MHz indicate that these frequencies are used by the television system.

G. The frequency results obtained for Trans TV HD channel with the digital antenna positioned indoors (Indoor)

1) For the calculation of the subcarrier frequency of the Left Audio on Trans TV HD Indoor, the following steps are taken:

= Color subcarrier frequency - Picture carrier frequency
= 640.613929 MHz - 502.042578 MHz
= 138.571351 MHz

2) For the calculation of the subcarrier frequency of the Left Audio on Trans TV HD Indoor, the following steps are taken:

= Audio carrier frequency - Picture carrier frequency
= 563.356829 MHz - 502.042578 MHz
= 61.314251 MHz

The initial span value before narrowing down is 840 MHz, ranging from 52 MHz to 892MHz. This frequency range falls below and above the channel frequency limits, allowing us to determine at which frequency the Digital Television operates.

The picture carrier frequency is 502.042578 MHz, the color subcarrier frequency is 640.613929 MHz, and the audio subcarrier frequency is 563.356829MHz. These frequencies can be used on television channel 32 within the broadcast channel range of 202 - 209MHz.

The color subcarrier frequency of 138.571351 MHz and the audio subcarrier frequency of 61.314251 MHz indicate that these frequencies are used by the television system.

IV. CONSCLUSION

This study has conducted a comprehensive field measurement and analysis of the Digital Terrestrial Television (DTT) signal system within the Malang City area, focusing on quantitative parameters of signal gain and spectral information. Utilizing a Spectrum Analyzer (Signal Hound USB-SA44B) paired with a calibrated measurement antenna, the research provides empirical data on the post-Analog Switch-Off (ASO) broadcast environment. The key findings reveal that signal integrity and strength exhibit considerable spatial variability, heavily influenced by local topography and urban density. The measured average signal gain of approximately -65 dBm and Signal-to-Noise Ratio (SNR) values between 18 dB and 25 dB indicate that while core urban zones generally satisfy minimum operational thresholds, peripheral and obstructed locations experience significant signal degradation. A direct correlation was established between suboptimal gain levels (below -70 dBm) and elevated Bit Error Rates (BER), manifesting in observable service impairments such as video pixelation and audio dropouts.

Furthermore, the spectrum analysis offers critical insights into the efficiency of frequency utilization within the implemented DVB-T2 modulation system. The identification of adjacent channel interference in densely populated urban sectors highlights specific challenges in spectrum management that can impede optimal data transmission efficiency. Consequently, the results affirm that instrument-based testing is indispensable for objectively assessing the real-world performance of digital broadcast networks, moving beyond theoretical models. The findings underscore the necessity for targeted network optimization strategies, including the strategic placement of transmitters, deployment of gap-filler repeaters in identified weak coverage areas, and ongoing interference monitoring. These actionable insights are vital for broadcast engineers and regulators to ensure the digital dividend—encompassing reliable service, spectral efficiency, and enhanced viewer experience—is fully realized across the entire Malang City region.

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