Exploring and Measuring of Regulatory Influence DVB-T2 on Broadcasting Service Quality: A Technical Perspective

Solichah Larasati [1,2*], Zein Hanni Pradana [1,2], and Shinta Romadhona [1,2]

[1] Department of Electrical Engineering, Institut Teknologi Telkom Purwokerto, Central Java, Indonesia
[2] Department of Electrical Engineering, Telkom University, Central Java, Indonesia
Email: solichahl@telkomuniversity.ac.id (S.L.); zeinhp@telkomuniversity.ac.id (Z.H.P.); shintaromadhona@telkomuniversity.ac.id (S.R.)
*Corresponding author

***Abstract*—The transition from analog to digital television broadcasting in Indonesia began in 2018 and ended in 2024. This transition requires industry players, regulatory bodies, and the public to adapt to the new regulations. The regulatory body issued regulations on DVB-T2 through the Minister of Communications and Informatics Regulation No. 6 of 2019, with a minimum field strength limit of 47.4 dBµV/m. With this regulation, broadcasts are expected to reach the public with good signal quality by analysing the BER, MER, C/N, and field strength values. The methods used to analyse digital TV signals include measurements test points and predictions. The predicted average minimum field strength obtained is 42.1 dBµV/m, while the measured value is 43.11 dBµV/m, with the highest field strength recorded at 56.7 dBµV/m. Digital TV broadcasts can still be received with field strength lower below regulation. However, for field strengths below 33.3 dBµV/m, the broadcast quality degraded to poor quality until the signal was lost at 19.6 dBµV/m. This prediction and measurement model provides accurate estimates of DVB-T2 signal strength, ensuring efficiency in line with established regulatory standards.**

***Keywords*—BER, C/N, DVB-T2, field strength, regulation**

I. Introduction

Digital Video Broadcasting–Second Generation Terrestrial (DVB-T2) is a digital television broadcasting standard issued by the European Telecommunications Standards Institute (ETSI). DVB-T2 enhances coding and modulation schemes by efficiently using the frequency spectrum for delivering services. The DVB-T2 standard in Indonesia is regulated by to Ministerial Regulation No. 05/PER/M.KOMINFO/2/2012 [1].

In this research, the performance of the DVB-T2 system was recommended by the International Telecommunication Union (ITU). ITU-R BT.2468-0 provides guidelines for selecting system parameters for implementation of the DVB-T2 system. Terrestrial television refers to digital television broadcasting with a channel bandwidth of 8 MHz and can transmit up to 8 television programmes [2]. DVB-T2 adopts various techniques to address the limitations of its predecessor DVB-T, including Fast Fourier Transform (FFT) sizes of 1k, 4k, 16k, and 32k with guard interval (GI) values of 1/128, 19/256, and 19/128. In DVB-T2, the maximum distance between the transmitters is approximately 160 km [3, 4].

Digital television broadcasting began in around 2002, but the ITU targeted the end of the transition from analogue to digital by 2015. However, the Indonesian government only began the nationwide shutdown of analogue broadcasts in 2018. This prompted industry, regulators, and the public to begin preparing for the digital TV broadcasting era. The roadmap for digital TV broadcasting in Indonesia is divided into three phases: Phase 1 from 2009 to 2013 focused on field trials. Phase II from 2014 to 2017 focused on local industry to produce decoders and accelerate licencing in less developed economic areas. Phase III, from 2018 to the present, involves the cessation of analogue broadcasts across all Indonesian regions [5]. Digital television broadcasting in Indonesia is regulated by Ministerial Regulation No. 22/PER/M.KOMINFO/11/2011 on the implementation of terrestrial digital television broadcasting [6].

The frequency spectrum is a limited resource; therefore, developing ways to increase the spectrum efficiency and capacity [7–9]. The transition from analog to digital transmission requires regulatory mechanisms to allocate a small portion of the available spectrum for transmission while ensuring high-quality transmission and reception across all regions. The evaluation process related to the established DVB-T2 regulations is a critical step in supporting the equitable implementation of digital television broadcasting in Indonesia. The journey of broadcasting digitalization in Indonesia has entered a new phase driven, by regulatory policy urgency [10, 11], infrastructure [12], and economic factors. The quality of

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digital TV services has also begun to improve in terms of both coverage [13–15] and capacity [16].

The evaluation process related to the effectiveness of DVB-T2 regulations is highly relevant to current developments in digital broadcasting technology. The results of this evaluation will provide recommendations for DVB-T2 regulatory policies. Terrestrial broadcasting regulations must consider the interests of various stakeholders, such as broadcasting license holders, device manufacturers, network operators, and consumers. Crafting balanced regulations requires a deep understanding of societal, market, and technological dynamics. The findings of this study indicate an urgency to address the challenges and effectiveness of DVB-T2 regulations in the face of technological advancements. These findings encourage further research on DVB-T2 regulatory recommendations based on direct field studies.

The field strength measurements of DVB-T2 can verify the signal quality at a specific location. These measurements were conducted according to the minimum standards of the Ministerial Regulation KOMINFO No. 6 of 2019, with a minimum field strength limit of 47.4 dBµV/m. Based on the measurements helps in optimizing the network efficiently without compromising signal quality.

The contributions of this paper are summarized as follows: (i) the field strength threshold that can still receive a signal with good quality is measured above and below 47.4 dBµV/m (ii) the effectiveness of DVB-T2 regulation is determined based on field study results (iii) comparison of signal quality is conducted based on measurement results and calculations.

II. Methodology

The signal measurements in the DVB-T2 system must comply with the ITU and ETSI standards, which include the following:

- The average measured field strength must meet the protection requirements or be accurately recalculated.
- Bit Error Rate (BER) and Modulation Error Ratio (MER) must be assessed with the quality of the carrier frequency using Orthogonal Frequency Division Multiplexing (OFDM).
- The BER should be < 0.0002 and MER should be >20-22 dB.

The modulation error ratio (MER) is a performance metric for modulation quality in digital television standards. The MER is measured from a radio frequency (RF) test port on transmitter or broadcast receiver [17]. The measured of MER can be displayed as amplitude and phase errors on a constellation diagram.

Field strength measurements are crucial for ensuring availability, reliability, and optimal quality. The methods used to achieve the objectives of this research are described in the following flowchart in Fig. 1.

According to the Ministerial Regulation KOMINFO No. 6 of 2019, the minimum field strength limit is 47.4 dBµV/m. This research aimed to determine the field strength values in a specific area in accordance with the existing regulatory standards. This study involved direct measurements based on quantitative data. Measurements were conducted at test points with field strength values below and above 47.4 dBµV/m. A total of 20 test points were measured using the field strength to obtain empirical data related to signal intensity. The data is then analyzed and input into a field strength prediction model. This prediction model uses technical parameters such as frequency, transmission power, geographic conditions, and environmental factors. The model can provide accurate estimates of DVB-T2 signal strength and network optimization for digital broadcasting. The evaluation and analysis results are aligned with DVB-T2 regulations regarding the effectiveness of broadcasting service quality.

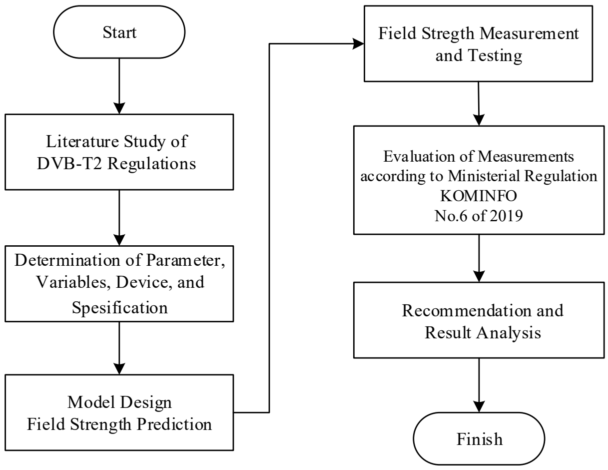

Fig. 1. Flowchart system.

III. Experimental System of DVB-T2

In technical terms, before measurements and testing are conducted, the technical parameters of the DVB-T2 system must be determined. The area is adjusted based on population and topography, by varying distances and directions in each region. In addition, changes in topology affect the established quality standards. Environmental conditions, such as electromagnetic interference, topology changes, and urban development, also influence the field strength. Any increase or decrease in the field strength below the established minimum limit will affect the characteristics of DVB-T2.

A. Measurement Parameter System of DVB-T2

1) Bandwidth with channel capacity

DVB-T2 offers system performance close to the Shannon Limit, which represents the theoretical maximum efficiency of digital communication relevant to Eq. (1).

$$C = B\ log_2 \frac{P}{N} \tag{1}$$

where, B is bandwidth (Hz), C channel capacity (bit/s), and $\frac{P}{N}$ is signal-to-noise ratio.

2) Guard interval and maximum distance

The implementation of the Guard Interval (GI) affects the interval distance in a Single Frequency Network (SFN) system. Where, cs is carrier spacing calculated using Eq (2):

$$cs = \frac{B}{Number\ of\ carriers} \quad (2)$$

To calculate the maximum distance, the symbol duration and Guard Interval (GI) are used in Eq. (3).

$$Tu = \frac{1}{cs},$$
$$Gi\mu s = Tu \times Gi \quad (3)$$

Tu is the total symbol duration, $Gi\mu s$ is the guard interval in microseconds, and the velocity of light is denoted V_o. The maximum distance is used in Eq. (4) [18]:

$$Distance = Gi \times V_o \quad (4)$$

The magnetic field strength H can be calculated using Eq. (5) [18]:

$$H = \sqrt{\frac{S}{Z_0}} \quad (5)$$

Power flux density and characteristic vacuum impedance are denoted in S and Z_0, respectively. By substituting the calculated value of $H_{max,DVB-T2}$into Eq. (6) [18]:

$$E = Z_0 \times H \quad (6)$$

Finally, the magnetic flux density B was calculated using Eq. (7) [18]:

$$B = \mu_0 \times \mu_r \times H \quad (7)$$

Where, the vacuum permeability is$\mu_0 = 1.257$ N/A^2 and the relative permeability for air are $\mu_r = 1$ [18]. The DVB-T2 system parameters based on the established standards used in this study are detailed in Table 1.

TABLE I. TECHNICAL PARAMETERS OF DVB-T2

Variable	Value
Frequency Band	UHF
Constellation Mode	64 QAM
Code Rate	4/5
FFT	32k
GI	1/16
Channel Bandwidth	8 MHz
Video Decoder	MPEG-4 AVC (H.256)
Resolution Source Video	HDTV 1920/1080i,

B. Field Strength Prediction Model

TABLE II. EQUIVALENT MINIMUM FIELD STRENGTH PREDICTION

Variable	Value
Location	Bulupitu
Coordinat	7.69758 LS 109.72041 BT
Address	Bukit Bulupitu, Dukuh Panunjang Desa Tunjungseto, Kecamatan Kutowinangun, Kab. Kebumen 54393
High level of Location	262 MDPL
Tower High	Triangel, 60 metre
Power Transmit	650 watt
Panel Antenna	8 panel
Gain Antenna	17 dBi
Loss Feeder	24.3 dB/km
Antenna Polarisation	Horizontal
Feeder Cable	70 metre

For the technical calculation of the field strength from each transmitter at various test points, the standards recommended by ITU-R P.1546-6 are followed [19]. The technical parameters for calculating the minimum field strength can are listed in Table II and Table III.

TABLE III. PARAMETER OF THE TRANSMITTER AND RECEIVER

Variable	Value
Channel	33
Frequency	570 MHz
TX Power	650 watt
TX Antenna Gain	17 dBi
TX Feeder Loss	1.701 dB
RX Noise Figure	6 dB
RX C/N Ratio	20 dB
RX Antenna Gain	12 dB
RX Feeder Loss	2 dB
Man-Made Noise	5 dB
Location Correction	9 dB
Tower Height	8 metre
Site Attitude	95 metre

The minimum field strength and minimum media equivalent field strength values are calculated using the following Eq. (8).

1) *Receiver Noise Input Power [19]*

$$P_n = F + 10\log(kT_oB) \quad (8)$$
$$T_o = 290^oK$$

where $P_n$is receiver noise input power ((dBW) with noise figure F(dB), Boltzmann constant $k = 1.38 \times 10^{-23} J/K$, receiver noise bandwidth (B) and absolute temperature $T_o = 290^oK$. From the calculated result, the value of the receiver noise input power is -128.946 dBW.

2) *The minimum receiver input power can be calculated using Eq.(9) [19]:*

$$P_{smin} = \frac{C}{N} + P_n \quad (9)$$

In the calculation result, we have the minimum receiver input power of -108.946 dBW, with $\frac{C}{N}$ is the RF S/N at the receiver input required by the system (dB).

1) *Effective Antenna Aperture*

Effective Antenna Aperture determines the capability of an antenna to capture the power of an incoming electromagnetic wave, which directly influences the effectiveness and performance of the antenna in receiving signals. We calculate the effective antenna aperture with Eq. (10) [19].

$$A_a = G + 10\log\left(\frac{1.64\,\lambda^2}{4\pi}\right) \quad (10)$$

where, G antenna gain is related to the half dipole (dB) and λ is the wavelength of the signal (metres). From the prediction calculations at a frequency of 570 MHz and a wavelength of 0.52 metres, an effective antenna gain of 2.4165 dBm² was obtained.

2) *Minimum Power Flux Density in the Receiver*

The minimum power flux density at the receiver is calculated by considering the effective antenna gain (A_a) and feeder loss (L_f). The equation flux density calculation is given in Eq. (11) [19].

$$\varphi_{min} = P_{smin} - A_a + L_f \quad (11)$$

Prediction result for the minimum power flux density -104.529 dBW/m^2.

3) The Field Strength Equivalent Minimum and Field Strength Equivalent Median Minimum can be calculated as Eq.(12) [19].

$$E_{min} = \varphi_{min} + 120 + 10\log\,(120\pi) \quad (12)$$

$$E_{med} = E_{min} + P_{mmn} + C_1,$$

(for rooftop fixed reception)

$$E_{med} = E_{min} + P_{mmn} + C_1 + L_h,$$

(for portable outdoor and mobile reception)

$$E_{med} = E_{min} + P_{mmn} + C_1 + L_h + L_b \quad (13)$$

(for portable indoor and mobile hand-held reception)

where,

E_{min} = equivalent minimum field strength at receiving place (dB(μV/m)

E_{med} = minimum median equivalent field strength, planning value (dB(μV/m)

P_{mmn} = allowance for man-made noise (dB)

L_h = height loss (reception point at 1.5 m above level (dB)

L_b = building or vehicle entry loss (dB)

C_1 = location correction factor (dB)

Based on the prediction result of the field strength, the field strength equivalent minimum is 41.27 dBμV/m and Field Strength Equivalent Median Minimum value is 56.77 dBμV/m.

After calculating the of minimum field strength and the minimum media equivalent field strength, we calculated the power factor using Eq. (14) and (15) [19].

$$P_{ERP} = P_{TX} + Antenna\ Gain\ Tx + Cable\ Loss\ Tx \quad (14)$$

$$P_{factor} = P_{ERP} - 1kW_{ERP} \quad (15)$$

where, P_{ERP} is the power transmitted and $1kW_{ERP}$ the same as 30 dB. Next, the field strength prediction for test point area follows Eq.(16) [19].

$$F_s = F_s 1kW - Antenna\ Gain\ Deviation + P_{factor} \quad (16)$$

s F_s1Kw the predicted field strength obtained from the ITU-R P.1546-1 recommendations and the antenna gain deviation based on company data sources. Based on the calculations, a power factor of 43.42 dB and a transmitter field strength of 60.828 dB were obtained.

C. Carrier-to-Noise Ratio (C/N)

C/N is the ratio of carrier power to noise power in a communication system. C/N is used to measure signal quality, with higher C/N values indicating better signal quality. The C/N ratio can be calculated using the following Eq. (17) [20].

$$\frac{C}{N} = \frac{P_{smin}}{P_n} = \frac{P_{smin}}{F \times k \times T_o \times B} \quad (17)$$

D. Bit Error Rate (BER)

The ratio of the number of erroneous bits in a transmission system to the total number of sent bit is referred to as the bit error rate (BER). The BER can be calculated using the formula in the following Eq. (18) [20].

$$BER = \left(\frac{\sqrt{M-1}}{Mlog_2\sqrt{M}}\right) erfc\left(\sqrt{\frac{2^{\sqrt{N}}-1*3log_2M}{2^{\sqrt{N-1}}-2(M-1)}SNR}\right) \quad (18)$$

where, $m = log_2M$ for M-QAM where for the case of DVB-T2 in this research is M=64.

IV. Measurement Result

Based on the measurements and calculations, the received signal level was within the optimal range. The measurement results from the 20 test points are shown in Table IV. The measurements were conducted by taking into account environmental factors that affect signal strength to reduce the likelihood of interference in signal reception.

TABLE IV. BIT ERROR RATE OF MEASUREMENT

Test Point	Field Strength (dBμV/m)	C/N (dB)	BER	MER	Classification
1	19.6	–3.2	1.0 E-1	0.0	No Signal
2	33.3	10.4	3.60E-02	16	Excellent
3	35	12	3.50E-02	16.2	Excellent
4	35.1	12.1	4.00E-02	11.7	Excellent
5	37.3	17.1	7.90E-03	20.2	Excellent
6	37.4	17.2	9.10E-03	20.1	Excellent
7	37.5	17.3	7.40E-03	20.1	Excellent
8	37.7	17.1	7.90E-03	20.2	Excellent
9	37.7	17.5	8.00E-03	20.1	Excellent
10	37.8	17.7	6.10E-03	20	Excellent
11	38.3	15.4	2.70E-02	14.7	Excellent
12	38.9	16	2.30E-02	15.1	Excellent
13	39.5	16.5	1.00E-02	18.3	Excellent
14	40.1	17.2	1.00E-02	18.3	Excellent
15	48.2	24.8	8.40E-03	20.5	Excellent
16	48.2	25.1	3.60E-04	25.2	Excellent
17	56.1	33	9.00E-06	30.8	Excellent
18	56.3	33.1	9.90E-06	31	Excellent
19	56.6	33.3	7.90E-06	30.4	Excellent
20	56.7	33.3	7.30E-06	30.6	Excellent

1) Comparison of Minimum Field Strength Graphs from Predictions and Measurements.

Analysis of the field strength measurements in the designated area shows that the received signal strength meets the established regulatory standards. The measurement results indicate consistent signal distribution within the set limits which ensures reliable and high-quality DVB-T2 reception. According to regulatory standards, the minimum field strength value is 47.4 dBμV/m, while the predicted average minimum field strength value obtained is 42.1 dBμV/m, and the measured value is 43.11 dBμV/m, as shown in Fig. 2.

Adherence to established regulatory standards will ensure that digital broadcasting can be optimally accessed by region-specific users.

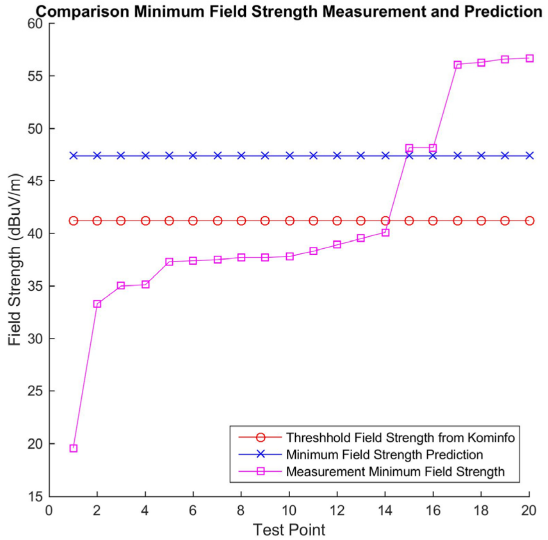

Fig. 2. Comparison minimum field strength measurement and prediction.

2) Comparison of Minimum Median Equivalent Field Strength Graphs from Predictions and Measurements.

The minimum median equivalent field strength indicates that most majority of the area meets or exceeds the required threshold for receiving DVB-T2 signals.

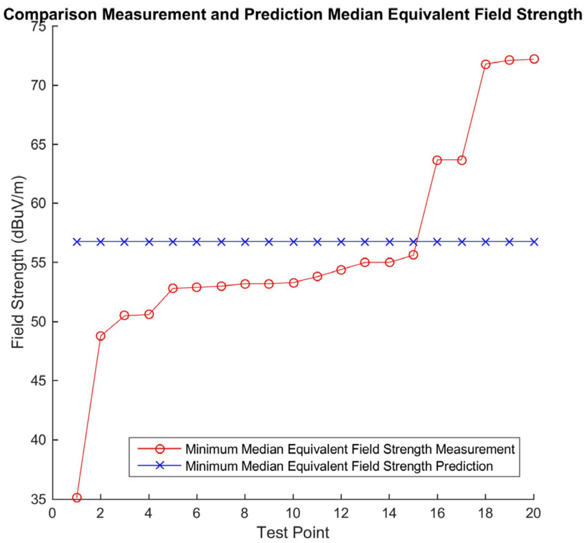

Fig. 3. Comparison median equivalent field strength prediction and measurement.

Based on Fig. 3, the threshold median equivalent field strength from the predictions is 56.7 dBμV/m, and the median equivalent field strength from the measurements is 58.6 dBμV/m. The measurement and prediction results are in good agreement. These values are important to ensure that digital broadcasting services can be effectively received by users and comply with applicable regulatory standards.

3) Graphic Carrier-to-Noise-Ratio (C/N) versus Power Received Input

The increase in the receiver input power will be directly proportional to the increase in the C/N value. As shown in Fig. 4, as the received signal power, the transmission quality improves, resulting in clearer and more stable signal reception. Achieving the optimal reception requires an increase in the signal power to achieve an adequate C/N ratio.

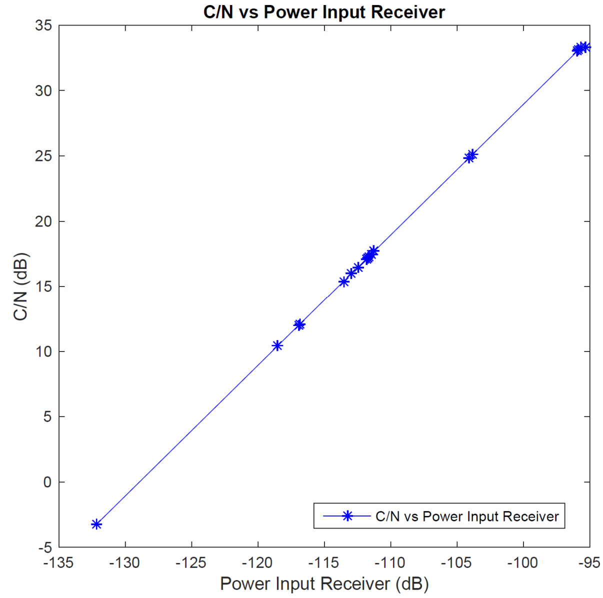

Fig. 4. C/N vs power receiver input.

4) Graphic BER versus MER

MER is one of the main indicators of the quality of digital TV signals. The MER test results show the capability of the digital signal receiver, a higher MER value indicates better signal quality. The threshold MER value according to the established standard was greater than 20 dB, where the average MER value obtained from the tests was 22.33 dB, as shown in Fig. 5. BER is the bits error rate against the total number of bits transmitted. The lower the BER, the better. According to regulatory standards, the BER value should be <0.0002, while the average BER value obtained from the measurements is 0.011 dB.

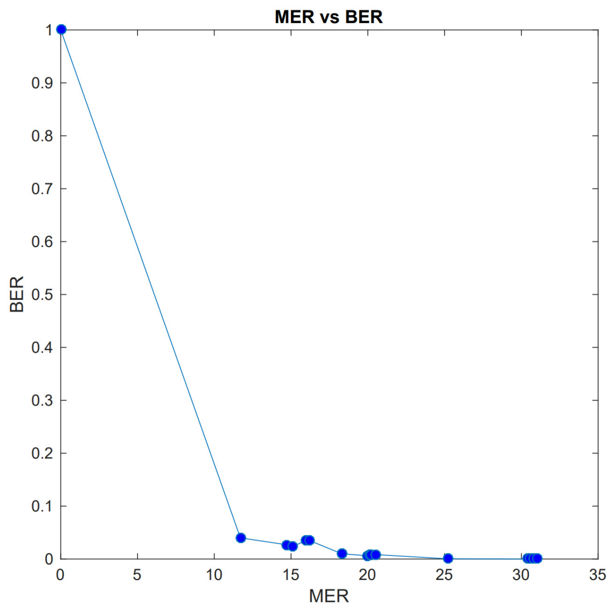

Fig. 5. BER vs MER.

The comparison of the MER and BER values in the DVB-T2 system shows a negative correlation. This indicates that as the MER increases, the BER decreases. This can be analyzed to show that the quality of the signal modulation contributes to reducing the number of bit errors. Based on Fig. 5, it can be concluded that a significant increase in the MER value reduced the BER value to almost zero. This ensures that the received signal is good.

V. Conclusion

In this paper, we present experiments based on measurement and prediction using actual transmitters in broadcasting. The technical parameters are recommended based on regulatory standards 8-MHz bandwidth, 32K FFT size, a guard interval of 1/16, and 64-QAM modulation technique. This research demonstrates that the implementation of these regulations can significantly enhance the quality of broadcasting services, with the average measured field strength reaching 43.11 dBμV/m. According to the Ministerial Regulation KOMINFO No. 6 of 2019, the recommended minimum field strength is 47.4 dBμV/m. The measurement results indicate that the received signal strength complied with the established regulatory standards. The measurements show that the maximum achievable field strength is 56.7 dBμV/m, while the minimum field strength is 33.3 dBμV/m. The technical testing parameters yielded a BER of 0.011, an MER of 22.33 dB, and a C/N ratio of 19.145 dB. The comparison of the measurement, prediction, and regulation results showed a good correlation. Adherence to the established regulatory standards will ensure that digital broadcasting can be optimally accessed by users in the region.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Solichah Larasati contributed to the entire research process, including data collection, planning, and article writing. Shinta Romadhona contributed by performing measurements and analyzing the prediction data. Zein Hanni contributed to the writing and editing of the article.

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