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Research Article

Analyzing Troubleshooting of BTS Transmit Power and 4G LTE Coverage Area via VSWR Value Measurement

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A B S T R A C T

The Voltage Standing Wave Ratio (VSWR) serves as a comparative measure between transmitter and receiver voltages, impacting site transmit power. VSWR values at a Radio Base Station (RBS) are evident in feeder cable losses, jumpers, combiners, and radio antenna losses. This study aims to assess the impact of poor VSWR values on BTS transmit power and perform troubleshooting analysis on 4G signal quality and Coverage Area. The study commenced with a literature review and VSWR measurements in the Gurun Laweh Aia Pacah region. The process involved identifying VSWR issues at the BTS site, conducting a Drive Test using pocket Tems, and troubleshooting the VSWR problem. Drive Test findings encompassed areas with weak signals, BTS site data, and problematic spots. The analysis utilized applications like Tems Discovery and MapInfo Pro. Results along the Gurun Laweh Aia Pacah road showed signal strength affected by a high VSWR value of 1.6. RSRP data rated 50% in the good category, SINR at 31% in the good category, and throughput at 5% in the good category. Elevated VSWR values diminish signal range, subsequently impacting traffic metrics. Immediate VSWR troubleshooting becomes imperative; low VSWR promotes higher transmit power efficiency, while normal VSWR ensures optimal transmit power efficiency.

INTRODUCTION

With the rapid advancements in today's technology, especially in internet user accessibility, Aia Pacah (Gurun Laweh) emerged as a pivotal sub-district in Nanggalo, Padang, West Sumatra, Indonesia. Situated at latitude 100° 22'34.8"E and east longitude 0° 51'31.4" S, this area serves as an alternative route for car and motorcycle traffic, classifying it within the densely populated suburban category. Consequently, heightened social media activity is anticipated among residents. To optimize network performance for both upload and download, it becomes imperative to enhance the area's connectivity. However, this study specifically focuses on the upload method, with data transfer speeds reaching 50 Mbps, in contrast to the potential 100 Mbps achievable through the downlink [1]. These disparities significantly correlate with high and normal VSWR values. In 2021, the Naggalo sub-district boasted a population of 58,320, slightly reducing to 58,183 in 2022 [2].

LTE, an evolution of UMTS and HSDPA technology, represents the 4th generation network. The coverage provided by 4G technology significantly impacts the quality of the covered area. Improving telecommunications networks' quality, quantity, and coverage relies heavily on meticulous network planning and verification [3]. The collaboration between Indosat and Hutchison 3 Indonesia, forming IOH (MOCN/Multi Operator Core Network), reflects one such effort [4]. Telecommunication networks are susceptible to errors or issues, requiring site troubleshooting and repair actions. This includes installation teams rectifying issues followed by drive test analysis comparing pre- and post-repair data, essential in ensuring a high VSWR (Voltage Standing Wave Ratio) value.

VSWR, a crucial voltage comparison metric, profoundly affects transmitter quality at a site. This value is influenced by voltage comparisons between the transmitter and receiver at the Radio Base Station (RBS), encompassing feeder losses and losses within the jumper connected to the radio antenna [5]. Notably, the VSWR value in the antenna sector should not exceed 1.3 post-integration and site activation. Exceeding this value may result in various disruptions, such as sudden signal loss [6].

The optimization process involves driving test activities and capturing signal conditions for troubleshooting data before and after using Tems Pocket software. Improvements, like replacing the BTS combiner, aim to widen and enhance coverage. This study focuses on optimizing the VSWR value through before-and-after data comparisons between poor and normal VSWR conditions.

This study is crucial due to the limited scope of previous studies regarding BTS transmit power and 4G LTE coverage area based on VSWR value measurements, relying solely on previous data sampling with a few studied parameters. Additionally, previous studies lack discussion on data collection after repairs. Other

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study focuses on empirical VSWR and distance to fault (DTF) analyses on the 900 MHz GSM BTS feeder or primarily relies on drive test data for verification. There's a direct correlation between VSWR and coverage area enhancement in previous studies but with limitations in parameter comparisons and frequency exploration.

Therefore, this study aims to bridge these gaps by comprehensively comparing pre- and post-repair data, specifically focusing on VSWR values across all frequencies and a standardized bandwidth of 10 MHz. Furthermore, it incorporates an analysis of PUCH Throughput parameters on the uplink channel side. Ultimately, this study intends to enhance optimal signal quality and improve the user experience for network users in the Nanggalo Gurun Laweh sub-district area. The data collection process involves drive tests to obtain actual field-uploaded data for analyzing differences in VSWR values before and after troubleshooting.

RESEARCH METHODS

The methodology employed in this study involves qualitative measurement of transmit power and signal strength at the BTS site before and after VSWR troubleshooting via a driving test. The Drive Test method assesses signal strength emitted by the nearest BTS, capturing BTS network data in real time. Its purpose is to gather actual network information in the field, evaluate network performance, and determine throughput values (upload and download speeds) [7].

Equipment utilized includes a laptop, dongle, Tems Pocket, and Tems Discovery 11.10, instrumental in plotting and analyzing data results in line with the operators' Key Performance Indicators (KPIs). Google Earth and Mapinfo software aid in visualizing Earth's 3D representation based on satellite imagery. Google Earth overlays various image types onto the Earth's surface, assisting in planning test drive paths [6]. Mapinfo also serves as a site display, showcasing PCI for each problematic sector, enabling detailed examination and display of parameters on the drive test route [8]. Additionally, VSWR space checks are conducted with support from Nokia's Web Element Manager. The technology employed is 4G LTE with a 10 MHz bandwidth. Logfile data is analyzed to measure VSWR values before and after data collection.

Parameters assessed include Reference Signal Recovered Power (RSRP), indicating signal strength received by the user (UE) at a specific frequency. Signal to Interference Noise Ratio (SINR) measures the ratio of signal power or interference power and received noise by service users [7]. Throughput evaluates effective data transfer speed measured in bits per second (bps) from the UE to the eNodeB in real-time internet usage for both uploading and downloading. PCI assigns a unique code to each transmitter, ensuring specific cell user information isn't used by other cells within the LTE network [9].

The study commenced with interviews with field engineers regarding sites experiencing VSWR issues. Test routes were designed in the Gurun Laweh site to study high VSWR values (1.6) and compare them with normal VSWR values (1.1). Subsequently, drive test equipment preparation involved smartphones equipped with TEMS Pocket and SIM cards, alongside TEMS Discovery for study parameter needs to be installed in the Campus Lab. Once data met requirements, the parameters were analyzed, comparing data before and after VSWR troubleshooting. The study flowchart is outlined in Figure 1 below.

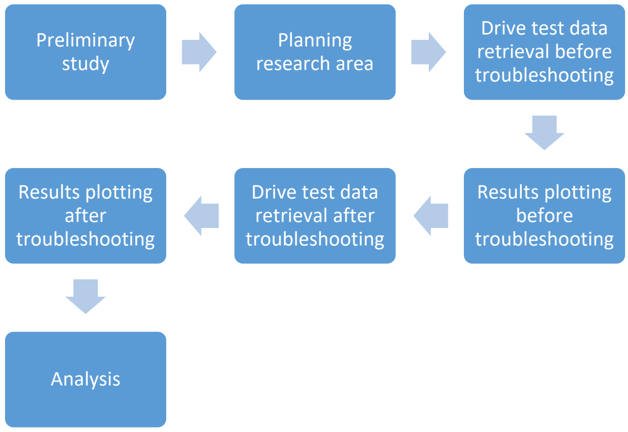

Figure 1. Study flowchart

This study relies on the 4G LTE network of Hutchison Tri Indonesia, part of the IOH network following the collaboration between Tri and Indosat. The predefined drive test route is depicted in Figure 2.

Figure 2. Drive Test Route

RESULTS AND DISCUSSION

In this study, the spaciousness of VSWR values is measured before and after troubleshooting using the web element manager. Additionally, actual data regarding spaciousness is collected through the drive test method, both before and after VSWR troubleshooting. This section also scrutinizes various drive test parameters, including RSRP, SINR, PCI, and Throughput. Data collection involves the upload method and eNodeB cell information, encompassing the Gurun Laweh area during the drive test action.

VSWR Value Before Troubleshooting

At the Gurun Laweh site, the problematic VSWR value was obtained, caused by a damaged combiner on the site, the VSWR data before that was obtained at the Gurun Laweh site in this study using the assistance of cooperation with PT. Putra Mulia

Telekomunikasi (PT.PMT) Padang City. Following are the results of the data before the VSWR value for the Gurun Laweh site: Display of the problematic sector which can be seen in Figure 3 Display of the problematic VSWR port in the FXED section (4G channel) on sector 1 on the ANT port 2, with PCI 376 with eNodeB azimuth direction of 70 degrees.

The next problem is also in the FRGU (3G channel) which has problems in sector 1 and sector 2 on the ANT2 and ANT4 ports with an azimuth direction of 200 degrees. The VSWR value for these two problems is 1.6. This results in the VSWR value on the 4G sector 1 channel and 3G sector 1 and 2 channels being too high as shown in Figure 4. Sector 1 only moves in band 3 (1800), sector 2 moves in band 1 (2100). Then, in sector 3 it moves in band 3 (1800). The cell technology used is FDD (Frequency Division Duplexing) with a bandwidth of 10 Mhz.

Cells have problems resulting in less than optimal serving or coverage area resulting in poor antenna transmit power resulting in low traffic in the area. This is indicated by the results obtained in the Element Manager web application to get a serving area that has not been repaired against VSWR, which is 75% of 100% serving which can be seen in Figure 5.

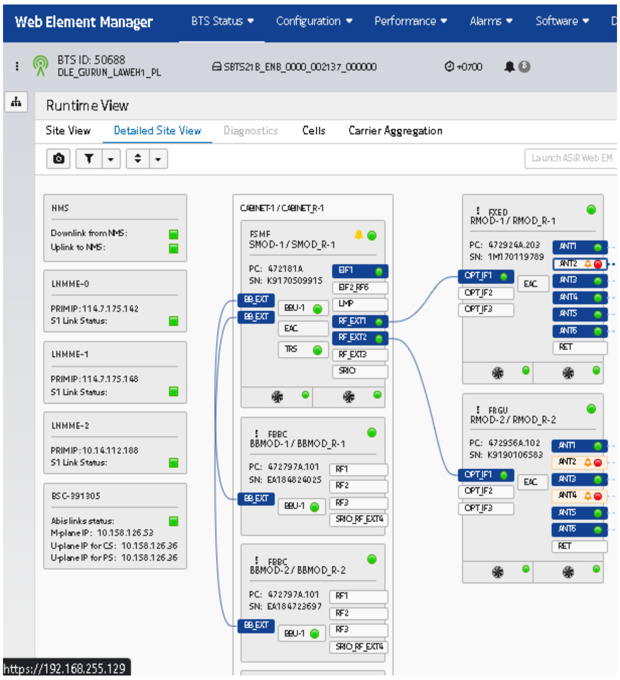

Figure 3. VSWR Display Alarm

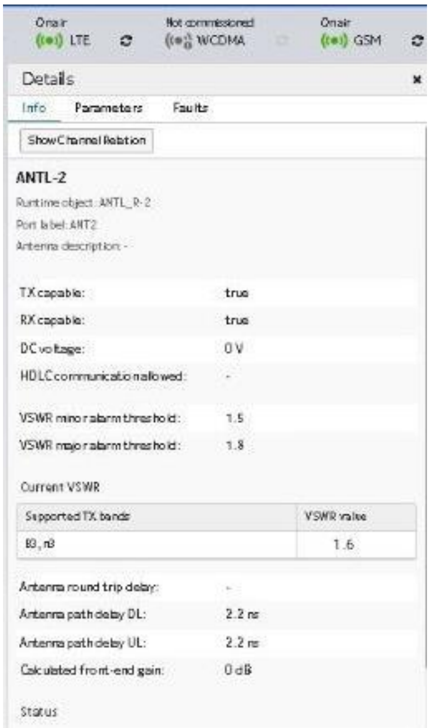

Figure 4. VSWR Value

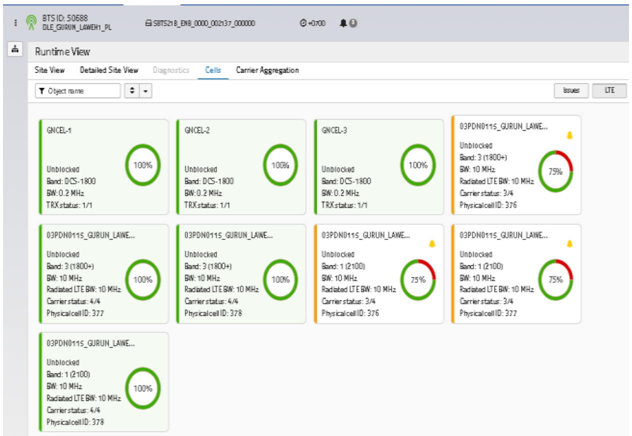

Figure 5. Serving Cell Before

To compare the VSWR value before troubleshooting between measurements and calculations, the following equations are used:

$$\text{Reflection Coefficient} = \frac{VSWR-1}{VSWR+1} \quad (1)$$

Using the measured VSWR value of 1.6, the VSWR value of the reflection coefficient is 0.2307 or 23.07% of the problem area.

Drive Test Data Results Before Troubleshooting

The next stage is carrying out actual data collection activities to a field called the Drive Test activity for data retrieval before using the Upload method for the results of the serving coverage area on the site, by analyzing several parameters, namely PCI, RSRP, SINR, and Throughput. The following parameters will be analyzed in this final project:

PCI

In the plotting results of the driving test assisted by Tems Discovery software, the IOH desert site is in its PCI identity for sector 1 (376) serving area with a percentage of 10.83% with an azimuth direction of 70 degrees, sector 2 (377) serving area with a percentage of 23.67% with an azimuth direction of 200 degrees and 378 (378) serving area with a percentage of 34.67% with an direction azimuth seen in Figure 6.

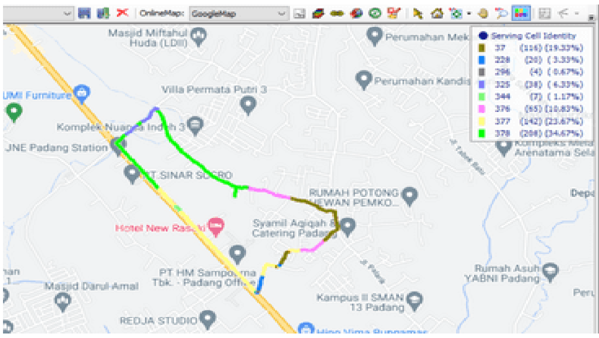

Figure 6. Physical Cell Identity

RSRP

The logfile plot of the Gurun Laweh site on the RSRP parameter is more dominant in green. With a good signal strength category in the range of -80 to 0 dBm with a percentage of 10% with 82 samples. Meanwhile, the signal strength category with bad spots is in the range of -140 to -110 dbm at a percentage of 0.23% with 2 samples. The data can be seen in Figure 7 which is the plot of the RSRP site Gurun Laweh.

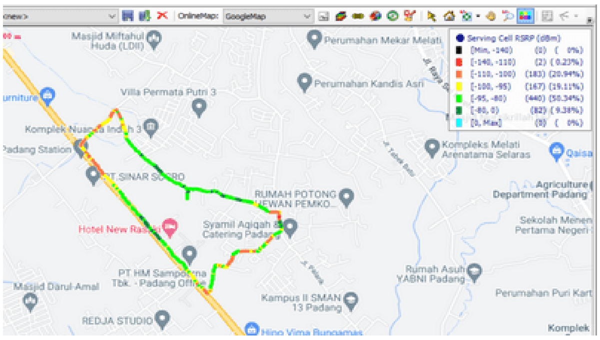

Figure 7. RSRP Plot

Besides being seen in Table 1, is the filtered data from the serving cell RSRP measurement value, a range of signal strength tables is needed, namely the RSSI table before which serves the maximum and minimum RSRP values in the path area.

Table 1. RSSI Before Troubleshooting

Range	Value	Indicator
Maximum	-72.1 dBm	Very good
Average	-91.2886 dBm	Good
Minimum	-107.9 dBm	Pretty good

To see the results of measurements and calculations generated by the RSRP parameters, the following calculations are generated by the parameters RSRP:

$$RSRP = RSSI - 10 * \log(20 * N) \quad (2)$$

By using RSSI value of 72.1 dBm, hence RSRP value is obtained at -102.1 dBm.

SINR

The logfile plot in Figure 8 shows that the dominant SINR parameters fall into the yellow and green categories. The total serving of SINR parameters for data upload before serving the area is 600 samples, with the signal strength category valued at 20 to 30 dBm at a percentage of 4% with 24 samples and the worst signal strength category is at -20 to 0 dB at a percentage of 21.33%.

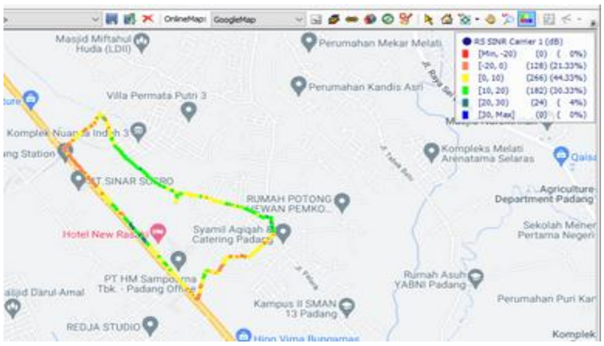

Figure 8. SINR Plot

Throughput

The results of the dominant Throuhgput parameter plot are in the black and red categories. As seen in Figure 9, the total serving of the throughput parameter is 570 samples. in a good range, namely in 31 samples in the value range of 10000 to 20000 kbps at a percentage of 5.44%. Then the Bad Spot signal strength is in 212 samples in the range < 512 kbps with a percentage of 37.19%.

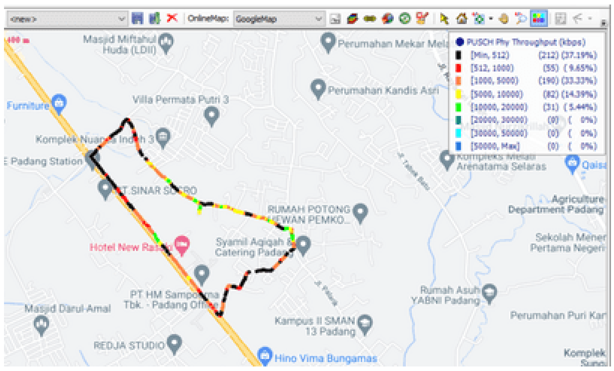

Figure 9. Throuhput Plot

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VSWR Value After Troubleshooting

After Troubleshooting the combiner device replacement, as shown in Figure 10, the VSWR value stabilized to (1.1) as shown in Figure 11, which is the VSWR value that has been measured using the element manager web application. This VSWR value uses the help of cooperation with PT. Putra Mulia Telekomunikasi (PT. PMT) located in Padang city.

The improved sector display which can be seen in Figure 12 is the change in the VSWR value before and after troubleshooting, the difference is very visible. Port V display The SWR that has a problem in the FXED section (4G channel) in sector 1 on the ANT2 port, with PCI 376 with an azimuth eNodeB direction of 70 degrees is sector 1.1. The next problem is also in FRGU (3G channel) which has problems in sector 1 and sector 2 on the ANT2 and ANT4 ports to 1.1. Checking the value of the VSWR LTE cells turns yellow to green.

Troubleshooting against the Gurun Laweh serving cell site can be filled to 100%. In Figure 13 sector 1 in PCI 376 band 3 (1800), 10 Mhz bandwidth with the serving area of the sector becomes 100% on the 4G channel. Meanwhile, on the 3G sector 1 channel on PCI 376 and PCI 377 band 1 (2100) the bandwidth is 10 Mhz with the sector serving area being 100%.

Figure 10. Combiner Site Devices

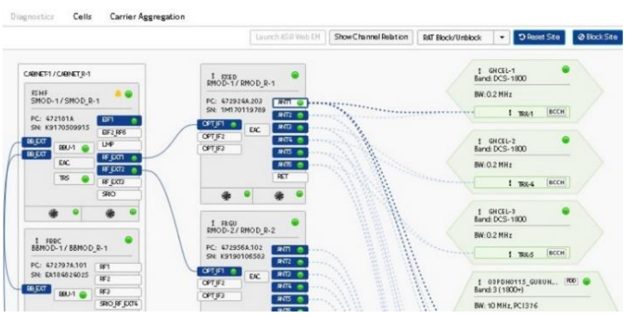
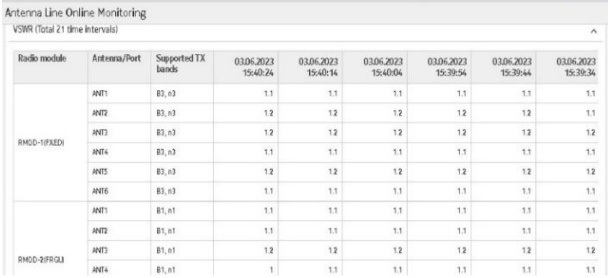


Figure 11. VSWR Alarm Display Details After



Antenna Line Online Monitoring

VSWR (Total 21 time intervals)

Radio module	Antenna/Port	Supported TX bands	03.06.2023 15:40:24	03.06.2023 15:40:14	03.06.2023 15:40:04	03.06.2023 15:39:54	03.06.2023 15:39:44	03.06.2023 15:39:34
RMOD-1(FXED)	ANT1	B3, n3	1.1	1.1	1.1	1.1	1.1	1.1
	ANT2	B3, n3	1.2	1.2	1.2	1.2	1.2	1.1
	ANT3	B3, n3	1.2	1.2	1.2	1.2	1.2	1.2
	ANT4	B3, n3	1.1	1.1	1.1	1.1	1.1	1.1
	ANT5	B3, n3	1.2	1.2	1.2	1.2	1.2	1.2
	ANT6	B3, n3	1.1	1.1	1.1	1.1	1.1	1.1
RMOD-2(FRGU)	ANT1	B1, n1	1.1	1.1	1.1	1.1	1.1	1.1
	ANT2	B1, n1	1.1	1.1	1.1	1.1	1.1	1.1
	ANT3	B1, n1	1.2	1.2	1.2	1.2	1.2	1.2
	ANT4	B1, n1	1	1.1	1.1	1.1	1.1	1.1

Figure 12. VSWR Value After

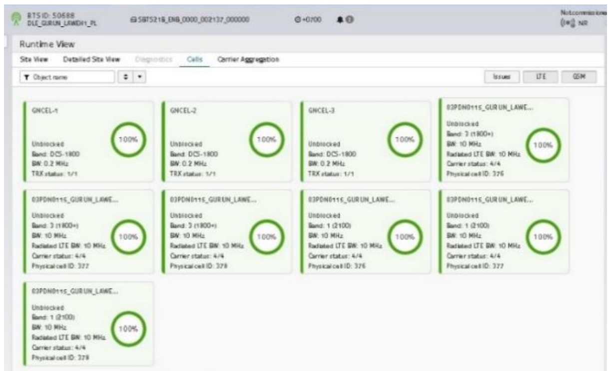


Figure 13. Serving Cell After

Drive Test Data Results After Troubleshooting

After the troubleshooting site was carried out, the VSWR value was checked to show normal numbers, namely 1.1 and 1.2, the next stage the author carried out the action of taking after drive test data in the Laweh desert area. The following parameters will be analyzed in this study.

PCI

In the results of the drive test plot by Tems Discovery, the IOH desert site is in its PCI identity for sector 1 (376) serving area with a percentage of 10.83% with an azimuth direction of 70 degrees, while sector 2 (377) serving area with a percentage of 23.67% with an azimuth direction of 200 degrees and 378 (378) serving area with a percentage of 34.67% with an azimuth direction. Figure 14 is a plot for the Physical Cell Identity at the Gurun Laweh site.

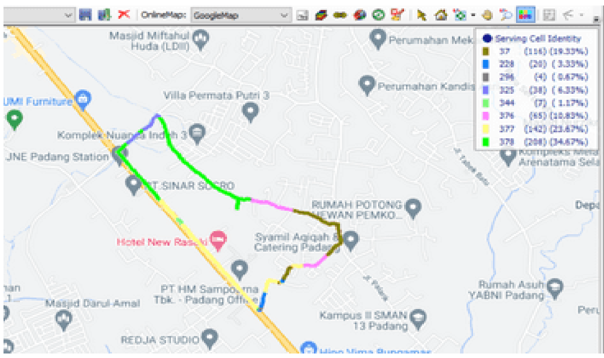


Figure 14. Physical Cell Identity After

RSRP

Seen in Figure 15 is the logfile plot of the Gurun Laweh site on the RSRP parameter which is more dominant in green. The total serving of RSRP parameters serving the area is 874 samples with a percentage of 100%, with a good signal strength category in the range of -80 to 0 dBm with a percentage of 13%. Meanwhile, the signal strength category with bad spots is in the range of -140 to -110 dbm at a percentage of 0.17% with 1 sample.

Figure 15. RSRP After Plot

To see the measurement and calculation results generated by the RSRP parameters, the following calculations are generated by the RSRP parameters: Then look at the filter coverage area table results which can be seen in Table 2.

Tabel 2. RSSI After Troubleshooting

Range	Value	Indicator
Maximum	-74.1 dBm	Very good
Average	-85.7068 dBm	Good
Minimum	-93.1 dBm	Pretty good

RSRP is obtained using equation (2), which is around -100.1 dBm.

SINR

In the plotting of the SINR data seen in Figure 16. SINR is dominantly in the green and yellow categories. The total serving of SINR parameters for data upload before serving the area was 873 samples, with the signal strength category being rated 20 to 30 dBm at a percentage of 8.82% with 77 samples and the worst signal strength category being at -20 to 0 dB at a percentage of 23.14%.

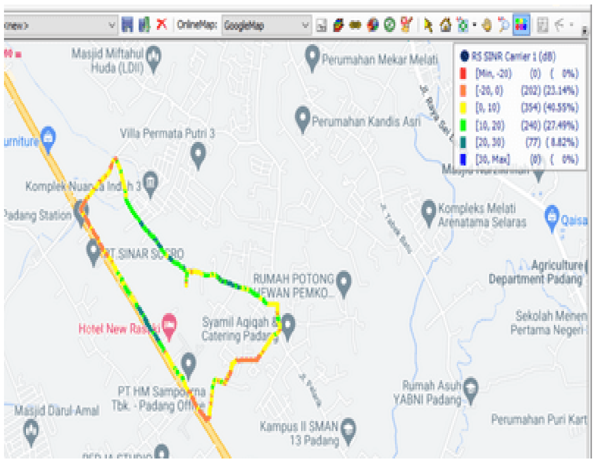


Figure 16. SINR Plot

Throuhgput

The results of the dominant Throuhgput parameter plot are in the yellow and green categories, which can be seen in Figure 17. The total serving of the throughput parameter is 733 samples. In the good range, 121 samples range in value from 10000 to 20000 kbps at a percentage of 16.51%. Then the Bad Spot signal strength is in 127 samples in the range < 512 kbps with a percentage of 17.33%.

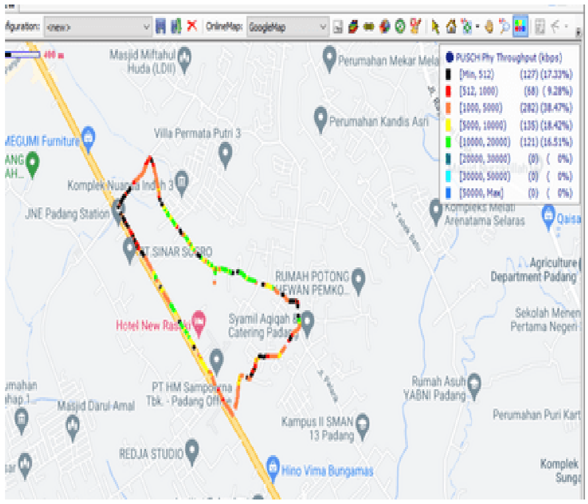


Figure 17. Throughput Plotting

Apart from that, to make it easier to see in comparison between the RSRP, SINR and Throughput parameters, it can be seen in the graphical diagram of the comparison of drive test data on the data before and after VSWR data. RSRP parameters are seen in Figure 18, SINR seen in Figure 19 and Throughput in Figure 20.

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Figure 18. RSRP data comparison before and after troubleshooting

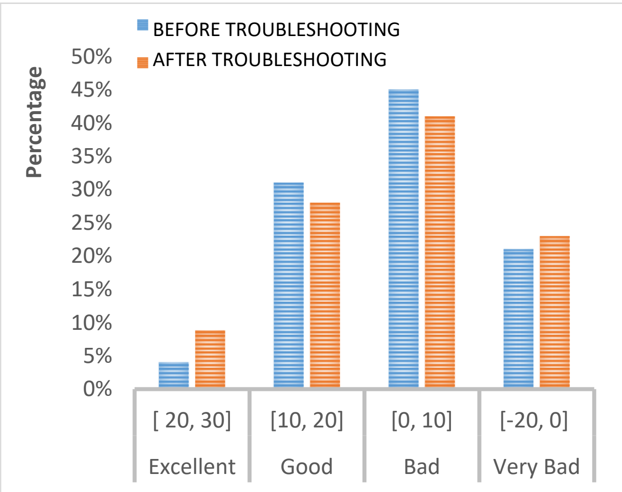

Figure 19. Comparison Graph of SINR data Before and After Troubleshooting

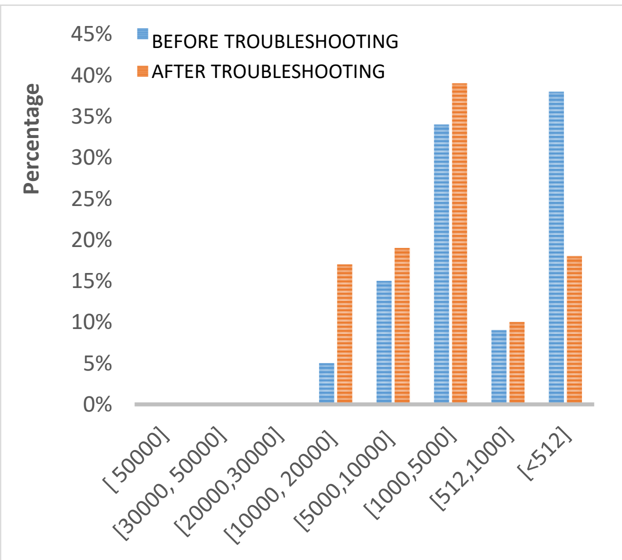

Figure 20. Data Throughput Parameters Before and After Troubleshooting

CONCLUSION

Based on the signal strength measurements conducted on Jalan Gurun Laweh, Aia Pacah, Lubuk Minturun, Padang City, it is evident that a high VSWR value of 1.6 significantly impacted the transmit power of BTS ID 030408E in Laweh Desert, Panjang City, Ikua Koto, before the drive test data was executed. This impact is supported by the RSRP parameter, which showed a shift from 50% to 54% in the good category before and after the data collection. Similarly, the SINR parameter changed from 31% to 28% in the good category, and the Throughput parameter improved from 5% to 17% in the good category after the VSWR troubleshooting. A high VSWR value leads to signal range reduction, consequently affecting traffic volume. This decline in traffic could potentially decrease the revenue of telecommunication service providers (operators). Hence, immediate VSWR troubleshooting becomes crucial. Lower VSWR values result in enhanced transmit power efficiency, while maintaining a normal VSWR ensures optimal transmit power efficiency.

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