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Implementation of an omnidirectional antenna on a 4G repeater with a working frequency of 1800 MHZ

Ade Silvia Handayani [a,1], *Nasron* [a], *Rivaldo Arviando* [a], *Abu Hasan* [b], *Sopian Soim* [a]

[a]*Department of Telecommunications Engineering, Politeknik Negeri Sriwijaya, Jl. Srijaya Negara, Bukit Besar Kec. Ilir Barat I, Palembang City, South Sumatera 30139, Indonesia*

[b]*Department of Telecommunications Engineering, Politeknik Negeri Sriwijaya, Jl. Srijaya Negara, Bukit Besar Kec. Ilir Barat I, Palembang City, South Sumatera 30139, Indonesia*

[1]*E-mail:ade_silvia@polsri.ac.id*

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ABSTRACT

In this study, an omnidirectional antenna is used as a 4G signal amplifier with a frequency of 1800 Mhz. Omnidirectional antennas typically have a gain of about 3-12 dBi. The application of an omnidirectional antenna on a 4G signal amplifier repeater is used as a donor antenna facing the base transceiver station (BTS) source. Applying an omnidirectional antenna as a donor antenna will allow signal transmission from all directions to the BTS to be received from all directions. This antenna will serve or only emit signals in the vicinity of 360 degrees. While at the top of the antenna, there is no radiation signal. The voltage standing wave ratio (VSWR) test results with the MMANA test software get a reading of <1.5, with an impedance of 49 ohms and a gain of >6.5 dB. The radiation distribution pattern from the plotting results shows a circular spread of 360 degrees. This antenna is suitable for donor antennas that can receive signals from the BTS from all directions from the angle of incidence. From testing with an open signal application and comparing parameters before and after using a repeater, the download speed increased from 0.2 Mbps to 2.3 Mbps, and the latency increased from 159 ms to 73 ms. The scanning spectrum in auto mode gets a mid-frequency reading of 1867.20Mhz when the repeater is on. The results achieved in the service of this 4G signal booster tool are being able to understand 5th generation materials such as 5G technology. Several countries have started to study 5G technology by forming consortiums such as METIS, 5GNOW, and others.

ABSTRAK

Pada penelitian ini digunakan antena omnidirectional sebagai penguat sinyal 4G dengan frekuensi 1800Mhz. Antena omnidirectional biasanya memiliki penguatan sekitar 3-12 dBi. Penerapan antena omnidirectional pada repeater penguat sinyal 4G digunakan sebagai antena donor yang menghadap ke sumber base tranceiver station (BTS). Penerapan antena omnidirectional sebagai antena donor akan memungkinkan transmisi sinyal dari segala arah ke BTS dapat diterima dari segala arah. Antena ini akan melayani atau hanya memancarkan sinyal di sekitarnya atau 360 derajat. Sedangkan di bagian atas antena, tidak ada sinyal radiasi. Hasil pengujian voltage standing wave ratio (VSWR) dengan software uji MMANA mendapatkan pembacaan <1,5, dengan impedansi 49 ohm dan gain >6,5 dB. Pola sebaran radiasi dari hasil plotting menunjukkan penyebaran melingkar sebesar 360 derajat. Antena ini cocok untuk antena donor yang dapat menerima sinyal dari BTS dari segala arah dari sudut datang. Dari pengujian menggunakan aplikasi open signal, didapatkan perbandingan parameter sebelum dan sesudah menggunakan repeater, dari kecepatan download 0.2 Mbps menjadi 2.3 Mbps dan peningkatan latency dari 159 ms menjadi 73 ms. Spektrum pemindaian dalam mode otomatis mendapatkan pembacaan frekuensi tengah 1867.20Mhz saat repeater aktif. Hasil yang dicapai di pengabdian alat penguat sinyal 4G ini adalah dapat memahami materi generasi ke-5 seperti teknologi 5G. Seperti beberapa negara telah memulai mengkaji teknologi 5G dengan membentuk konsorsium seperti METIS, 5GNOW, dan lainnya.

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1. Introduction

Changes in cellular technology have accelerated from 2G to 5G now. The 4G network is the 4th generation (4G) that uses IP-based technology, which is a technology that is widely used today. The 4G network utilizes subjective radio, designed to operate at 1800 MHz frequency [1-2]. However, the 4G network in Indonesia is not evenly distributed. There is a connectivity gap between urban areas with a dense population and rural areas with an uneven population [3], which causes residents in rural areas to feel less of technology.

In times of a pandemic like this, many schools conduct online learning. However, many people complain of a weak signal in areas far from urban areas. Several methods have been developed to enhance the signal that has been delivered so that the general public can properly receive it, one of which is the use of a repeater [4]. A repeater is a device that supports 4G networks. The 4G signal received using the internal repeater antenna is not optimal in some areas [5]. An external antenna in the form of a transmitting antenna is required to enhance the signal received by the repeater. In general, the transmitting antenna used in 4G signal amplifier applications is an antenna that has an omnidirectional radiation pattern because the signal beam that radiates in all directions can reach the entire room. Areas that receive poor 4G signal require a repeater [6-7].

The antenna that is suitable to complete these needs is an omnidirectional biquad. The Biquad antenna is a double square loop dipole wire antenna with the reflector in a flat panel with a slightly longer side width than the dipole circuit. The main function of this Omni antenna is to receive and forward signals from the nearest BTS. The radiation pattern suitable for the antenna is to radiate in all directions or 360 degrees [8]. There are two types of antennas for this 4G signal booster. The first is the Omni-vertical antenna and the biquad antenna. In this study, the investigated omnidirectional antenna is made of an N-type connector, and the impedance is close to 50 ohms [9]. An Omni antenna can also be an SMA type connector, with the characteristic that the more efficient the power beam is close to 100%, the better it is used for internet networks [10-12]. To produce a wide coverage area, the gain of an omnidirectional antenna must focus its power horizontally. In addition, the advantage of using an omnidirectional antenna is that it can be operated at several frequencies [13].

Thus, the advantage of using this type of omnidirectional antenna is that it can serve a larger number of users and a wider area [14]. Disadvantages of using the antenna are the allocation of frequencies for each cell that has the potential for interference. Most of these omnidirectional antennas have perpendicular polarization. Based on the nature and advantages of this omnidirectional antenna, the Omni-vertical antenna with a radius of 360 degrees is very suitable for application as a donor antenna on BTS devices tasked with dealing with BTS towers. The choice of an omnidirectional antenna that has an even distribution pattern in all directions is intended so that 4G signal reception from all angles can be received with the same signal strength on the repeater so that the repeater can redistribute 4G signals to the maximum.

Table 1. Specification of measurement results using Mmana-Gal.

Specification	Measurement results
Frekuensi Antenna	1800 Mhz
Gain	Min 9.06 dB and max 9.16 dB
SWR	< 1.1 - 2
Bandwidth	40000 KHz (1780 Mhz – 1820 Mhz)
Dimensi Antenna	16 x 8 cm

2. Research Methodology

2.1. Materials and Tools

The materials and tools used in this research are:

1. Receiver antenna. This tool converts electrical signals into electromagnetic signals, then transmits 4G signals from the nearest BTS tower. The antenna used in the receiving section is an omnidirectional biquad type so that the reception from the signal source can be maximized.
2. Repeater booster. Repeaters are used to extend the range of the signal. If the signal is weak, the range will be narrower, while the range will be wider when the signal is strong. The block is used as a radio bridge that bridges the exchange of information between users and the BTS tower that will repeat itself.
3. Splitters. This tool is located on one part of the repeater component. It is used to divide the addition of the antenna to the repeater, if needed or not needed.
4. Omnidirectional Antenna. The antenna has a pattern of transmitting signals in all directions with the same power forming a circle (360 degrees). This antenna is in charge of conveying information exchange between the user and the repeater bridge
5. Power-In. This tool is used as a supply of the electric current source needed by the repeater circuit
6. Step down. This tool is used to lower the electric voltage according to the working voltage value of the repeater device
7. Power regulator. This tool is used to regulate the voltage value required by the repeater circuit to make it more stable
8. Current booster. This tool ensures that the current flow to the repeater device is maintained at the nominal current value as needed.

The test steps are as follows:

1. Prepare all the equipment needed in this testing process, such as sockets, spectrum analyzers, cellphones, and power supplies already available in the series of tools.
2. Then, check that the power supply is correctly placed in the series of tools to prevent problems such as a short in the circuit.
3. After the circuit is securely installed, connect the circuit to an electric current source and turn on the MCB.
4. Then, the DC comes out to the 220-volt power supply.
5. Then, the contactor or Stepdown changes the current according to the working voltage value of the repeater device to 37.06 volts.

6. Then, the current goes to the repeater power supply terminal and acts as a supply of the electric current needed by the repeater circuit. The current booster regulator regulates the voltage value required by the repeater circuit to make it more stable.
7. The receiver antenna converts the electrical signal into an electromagnetic signal, then receives and transmits the 4G signal from the nearest BTS tower. The antenna used on the receiver is an omnidirectional type, which has a pattern of transmitting signals in all directions with the same power that forms a circle (360 degrees).
8. Then, the current goes to the RG58 Coaxial cable, whose signal range is expanded by the Repeater booster. If the signal is weak, the range will be narrower, while the range will be wider when the signal is strong. This block functions as a radio bridge that bridges the exchange of information between the user and the BTS tower that will be repeated.
9. Splitter serves as a repeater component, used to divide the additional antenna on the repeater if needed, connected by a coaxial cable to the balun to get to the transmitting antenna.
10. Transceiver antenna in the form of a biquad antenna is tasked with conveying information exchange between the user and the repeater bridge. This type of biquad with a sectoral antenna can receive the maximum signal with a longer range.
11. After the signal has been amplified and received by the user, open the open signal application and turn on the spectrum analyzer. Do a test with the app.
12. Turn on the spectrum analyzer, then test the device.
13. Use a different distance using a spectrum analyzer when there is activity/user used by 4G service users, which is reinforced by repeater devices.
14. The open signal application is used to measure the signal strength obtained before using the repeater and after using the repeater.

The system can be activated when the input power is connected to a 220V power source which is then forwarded to step-down transformers as a voltage level adjustment from 220V AC to DC voltage. Furthermore, the process is continued by managing the voltage through a power regulator circuit that functions to adjust the DC voltage level according to the needs of the repeater device, which is 5V DC. The power regulator works supported by a series of booster circuits that function as a stabilizer to make the current generated by the regulator management process more stable.

After the repeater booster device gets a pgc power supply, the system starts to be ready to work. There is a receiver antenna that faces directly with the closest repeater transmitter source on the input side. The antenna design used in this tool is an omnidirectional antenna, then the signal receiver input from the repeater can be focused in the specified direction only so that the antenna gain can be optimized to receive a potential 4G signal. The captured signal goes to the repeater booster connector through the 50ohm coaxial cable feeder channel, namely RG58.

Installation of the receiving antenna is done outdoors, facing a source with a 4G signal. There is a signal processing process in the repeater booster by increasing the resulting amplitude value without changing the frequency. After passing through the stages of strengthening by the repeater booster, the current is then directed to the splitter circuit and omnidirectional antenna, which serves to redistribute the 4G signal that the repeater booster circuit has successfully issued. The distribution of this signal is carried out via a 50-ohm coaxial cable type RG58 through the output connector of the booster repeater device.

2.2. Software Design

The characteristics of the parameter device to be generated are as follows: it has a working frequency of 1800MHz, the largest VSWR is 1.5, the smallest gain is 6.5, the maximum return loss is -10dB, and the radiation pattern is omnidirectional. The choice of antenna material uses metal coated with enamel to prevent and avoid corrosion of the antenna elements. Determination of the dimensions of the antenna based on the simulation design that has been made, with the size calculated using the formula for making a 5/8 lambda vertical antenna. The stages of the antenna design process, namely:

1. Measuring and cutting the antenna element material used, the required dimensions are 29.67 cm,
2. Prepare the loading coil as a phase inverter. The size of the loading coil used is lambda x metal velocity factor. = 7.91cm.
3. Combining a 3 x 5/8 lambda antenna element with a loading coil.
4. Installing the antenna connector cable, the connector used on the coaxial line is the N connector type.
5. Ensure that the antenna connector installed must not be short because it can cause damage to the 4G radio repeater used.

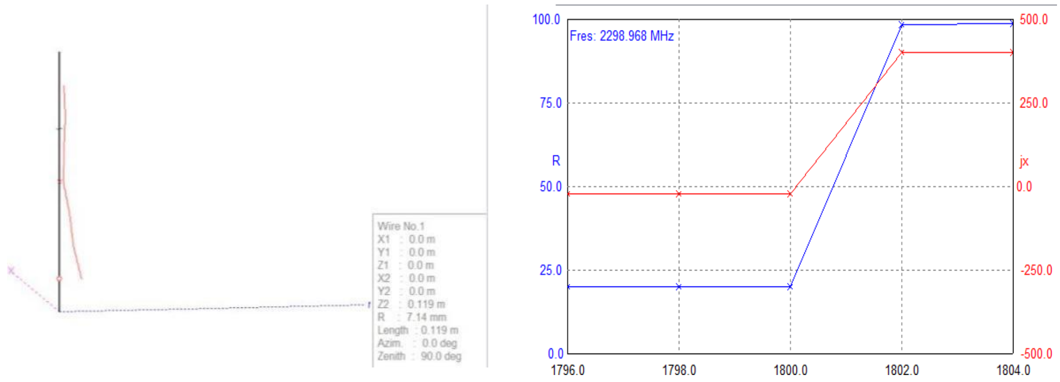
Analysis of the frequency spectrum using test software in radio definition software. The biquad type unidirectional antenna is used as a 4G signal receiver to forward the current to the receiver device. The use of this type of unidirectional biquad antenna can maximize 4G signal capture concentratedly from the direction of the 4G signal source originating from the nearest repeater and testing the performance and ability of the tool in improving the quality of 4G signal reception using direct observation, namely field testing. The test was carried out with the help of a vector network analyzer instrument to analyze the antenna efficiency by plotting data on the Smith chart [15-17]. The test results get valid data in the form of signal amplification parameters before and after the addition of the repeater booster device.

3. Result and discussion

3.1. Software Design Results

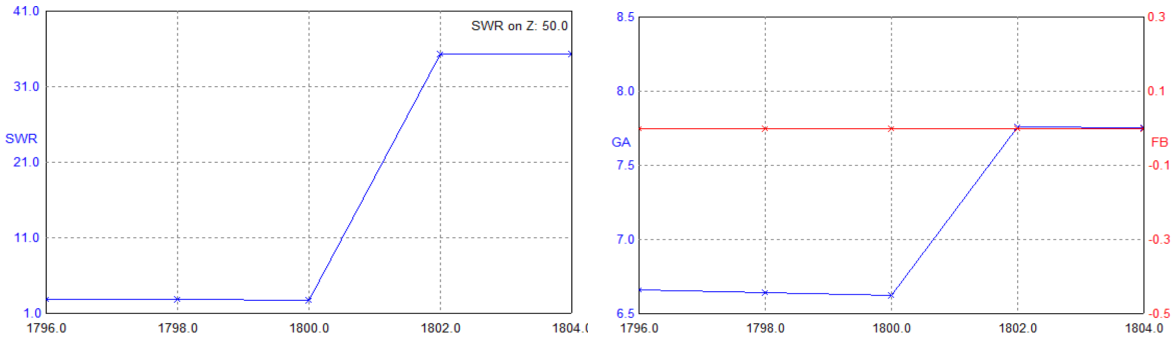
Figure 1(a) illustrates an omnidirectional antenna with an upright position so that it can transmit signals to the BTS easily. The physical form of an omnidirectional antenna looks at the front, consisting of a main driven element mounted vertically and equipped with a reflector that functions to increase the antenna's directivity so that it has a more directional and distant transceiver (transmitter-receiver) capability. Figure 1(b) is the result of impedance measurement. The test is carried out to determine the characteristic impedance value of the antenna load. The ideal value of the line is 50 ohms, but the test results obtained are 49 ohms. The X-Axis is the Horizontal Bid, and the Y-Axis is the Vertical Bid.

The VSWR test with the results shown in Figure 2(a) was obtained <1.5. Determination of the antenna's specifications is matched with the radiofrequency device used by testing the SWR value on the antenna. The red dot is the feed point, and the blue dot is the ground place. Gain test results can be seen in Figure 2(b). The value is >6.5 dB. Antenna gain testing using MMANA software by getting a reading value of >6.5 dB. The antenna's gain value will determine the quality of the gain that can be produced. Testing of the gain value using MMANA-GAL software with Gain/FB plotting mode.



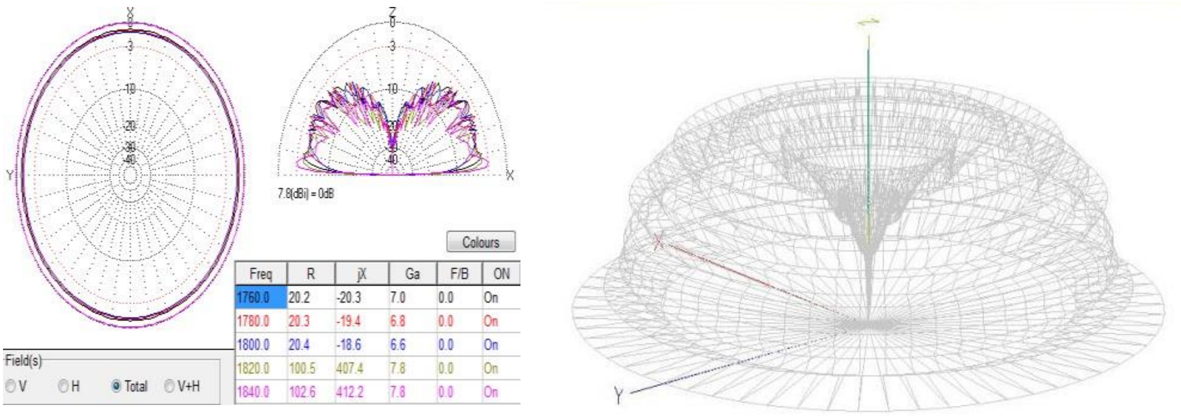
(a) (b)

Figure 1. (a) Omnidirectional antenna (b) Impedance measurement.



(a) (b)

Figure 2. (a) VSWR measurement curve (b) Gain value results.



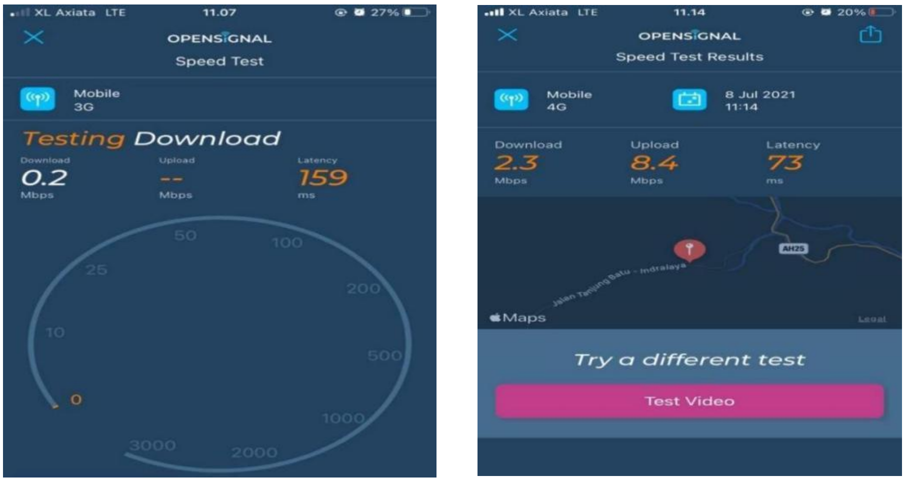
(a) (b)

Figure 3. (a) Radiation pattern results (b) 3-dimensional omnidirectional antenna.

Figure 3(a) is the result of testing the gain value and testing the radiation pattern of the Omni antenna. The test results with MMANA software get plotting results in a vertical, horizontal, and 3-dimensional perspective. The X-axis is the feed point, and the Y-axis is the ground place. The radiation pattern vertically and horizontally forms a pattern according to the characteristics of the antenna distribution. Figure 3(b) shows the Omni signal direction perpendicular to the z-axis. The resulting distribution pattern is 360 degrees uniformly.

3.2. Speed Test Results with Open Signal

The test was carried out in two conditions, namely when using a repeater and without the help of a repeater. The open signal software has a map feature to check the nearest BTS to the device. Figure 4(a) shows the signal bar has only one provider network and has a download speed of 0.2 Mbps. Figure 4(b) shows a full bar with a download speed of 2.3Mbps, an upload speed of 8.4Mbps, and a latency of 73ms.



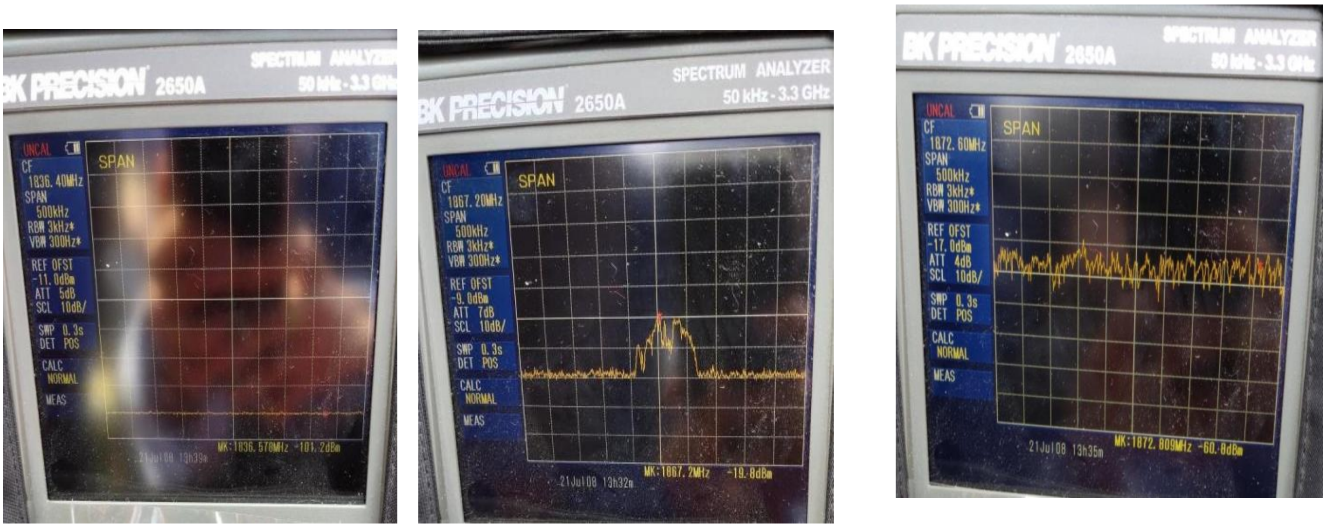
(a) **(b)**

Figure 4. (a) Signal before the test (b) Signal after the test.

3.3. Testing Using a Spectrum Analyzer

Tests with a spectrum analyzer were carried out to observe the spectrum measuring instrument's response to the repeater device's activity [18]. The test is carried out in two conditions: when the repeater is off and when the repeater is active. Tests using a spectrum analyzer were carried out to observe whether the repeater device could forward the 4G signal from the BTS tower to the mobile phone device. Testing is carried out starting with testing when the repeater device is off, followed by the condition of the repeater device on, and finally when there is data traffic in the 4G working frequency range used. The following are the results of the spectrum analyzer test.

Figure 5(a) shows the spectrum reading in the repeater off condition, namely the almost flat noise floor condition. The image shows no radio frequency emission generated by the repeater in the off state. Figure 5(b) shows the condition of the repeater when it is active, and activity occurs on the spectrum with a center frequency of 1867.2 Mhz with auto-scan mode. The test results show that the function of the repeater device has worked as planned. Figure 5(c) shows the test results when the repeater device is on, shows an interaction between the user and the repeater device, the tracking mode is on auto, and the center obtained is 1872,909 Mhz. Spectrum readings almost increase on all bandwidths used, indicating that the repeater device that we use has a bandwidth response capability capable of broadband at all 4G working frequencies so that this repeater is suitable to be applied as a signal amplifier.



(a) **(b)** **(c)**

Figure 5. (1) Initial view of the spectrum analyzer before activity (b) Initial view after activity (c) Display of activity after a certain period of time.

3.4. Mechanical Device Design Results

Figure 6(a) shows a complete set consisting of a power supply, repeater, Omni-vertical antenna, biquad antenna, and RG58 coaxial cable. All components in the block diagram are arranged compactly in one shelter that contains all the needs of repeater devices. The shelter used is an iron box measuring 48 x 60 x 90 cm3. On the backside of the box, a pole serves to place the antenna so that it can reach good reception from the nearest BTS beam. Figure 6(b) shows the diagonal view of the created shelter box. Table 1 shows a significant difference from the download test results obtained that have a very large difference and the latency value obtained. Before the tool was activated, the download speed only had 0.2 Mbps, while after the tool was activated, it had a download speed of 2.3 Mbps, and so did the latency and upload speed.

(a) (b)

Figure 6. (a) Overall hardware design results (b) Overall mechanical device results.

Table 1. Comparison of test results before and after using Omni**.**

Test	Download speed	Latency	Upload
Before using omni	0.2 Mbps	159 ms	0 Mbps
After using omni	2.3 Mbps	73 ms	8.4 Mbps

4. Conclusion

Based on the design results, the design of this tool uses an antenna as high as 6 meters and a cable length of 5.83 meters. When the hardware is off, the download is around 0.2 Mbps, and the latency is 159 ms, while in the on state, the download is 2.3 Mbps, and the latency is 159 ms. The Omni vertical antenna must also transmit to the nearest BTS and the sectoral biquad cover to the service area. This mechanical device must also have a transmitting mast that is higher than buildings or other obstructions. The results of the antenna SWR test of <1.5 using the Mmana-Gal software show that the antenna made is good enough to use. When testing the antenna, the Z value obtained is close to 50 ohms, so it can be concluded that it is following the required value of the coaxial impedance used. Testing the gain value starting from 0 dB while testing the biquad antenna produces a gain value of 9.06 dB. The next test uses a spectrum analyzer at a frequency of 1800 Mhz, with a repeater as a 4G signal amplifier that can forward the signal from the BTS tower to the user's mobile phone.

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References

[1] Nixon, B., & Purnomo, R. W. (2019). Rancang bangun antena octaquad sebagai pemancar repeater untuk aplikasi penguat sinyal 4G pada frekuensi 1800 MHz. *Seminar Nasional Teknik Elektro*, vol. 4, no. 1, pp. 31-36.

[2] Kavipriya, P., Jebarani, M. E., Jegan, G., Chitra, P., & Lakshmi, S. (2020). 4G signal booster. *IOP Conference Series: Materials Science and Engineering*, vol. 906, no. 1, pp. 012031-1-9.

[3] Kridawan, W. A., & Rahmat, R. (2020, January). Rancang bangun antena mikrostrip patch swastika untuk penguat sinyal 4G indoor pada frekuensi 1,8 GHz. *Seminar Nasional Teknik Elektro*, vol. 5, no. 2, pp. 315-322.

[4] Rajendar, S., Chandrasekhar, P., Rani, M. A., & Naresh, R. (2015). Performance analysis of alternate repeaters for on-chip interconnections in nanometer technologies. *Procedia Materials Science*, vol. 10, pp. 344-352.

[5] Agung, H., & Hakim, L. (2017). Analisis perbandingan pemakaian bahan wajan bolic dan provider telekomunikasi terhadap daya penerimaan sinyal di Desa Cibuntu. *Jurnal Muara Sains, Teknologi, Kedokteran dan Ilmu Kesehatan*, vol. 1, no. 1, pp. 91-100.

[6] Achmad, A. D., Achmad, A., & Anggreni, D. R. (2016). Perancangan antena mikrotrip untuk repeater jaringan 4G yang beroperasi pada frekuensi 1800 Mhz. *Prosiding Seminar Teknik Elektro & Informatika*, no. 2, pp. 24-30.

[7] Tiwery, J., & Corputty, R. (2018). Antena penguat sinyal handphone dengan frekuensi 1800 menggunakan repeater RF. *Mustek Anim HA*, vol. 7, no. 2, pp. 149-159.

[8] Muthiah, A., Nugroho, B. S., & Wahyu, Y. (2018). Antena omnidirectional ultra wide band (UWB) untuk aplikasi electronic support measure (ESM). *Prosiding Semnastek*, pp. 1-9.

[9] Zhang, Y., Li, Y., Zhang, W., Zhang, Z., & Feng, Z. (2020). Omnidirectional antenna diversity system for high-speed onboard communication. *Engineering*, pp. 1-11.

[10] Zeng, H. Y., An, J., Yu, Z. W., & Wang, S. Q. (2019). Implementation Method for Circularly Polarized Omnidirectional Antenna. *Procedia Computer Science*, vol. 154, pp. 477-480.

[11] Murugan, H. A., & Damodharan, S. K. (2020). High gain dual-band zeroth order omnidirectional circularly polarized antenna. *AEU-International Journal of Electronics and Communications*, vol. 121, no. 153228, pp. 1-11.

[12] Song, G., Zhang, B., Lyu, Y., Wang, X., Wu, B., He, C., & Lee, Y. C. (2020). Strain omnidirectional detection based on circular patch antenna. *Sensors and Actuators A: Physical*, vol. 315, no. 112275, pp. 1-8.

[13] Setiawan, M. I., Endri, J., & Sarjana, S. (2019). Rancang bangun antena mikrostrip path rectangular pada frekuensi 900 MHz untuk aplikasi GSM. *Respati*, vol. 14, no. 2, pp. 53-60.

[14] Dai, J., Chen, Z., Wang, X., Ye, L., Zhang, T., & Xu, K. (2019). Accurate optical vector network analyzer based on optical double-sideband suppressed carrier modulation. *Optics Communications*, vol. 447, pp. 61-66.

[15] KANG, H. B., & HU, C. F. (2013). A method for polarization scattering parameter measurement and calibration based on vector network analyzer. *The Journal of China Universities of Posts and Telecommunications*, vol. 20, pp. 117-120.

[16] Su, T., Wen, J., Shi, Z., Li, M., Chen, W., Zhu, N., & Li, W. (2019). Wideband optical vector network analyzer based on polarization modulation. *Optics Communications*, vol. 437, pp. 67-70.

[17] Lin, Y. C., & Shih, Z. S. (2018). Design and simulation of a radio spectrum monitoring system with a software-defined network. *Computers & Electrical Engineering*, vol. 68, pp. 271-285.

[18] Yudha, D. M. M., Sudiarta, P. K., & Indra, E. N. (2016). analisis parameter jaringan hsdpa kondisi indoor dengan tems investigation dan G-Nettrack Pro. *E-Journal Spektrum*, vol. 3, no. 1, pp. 40-46.