Design and Configuration of 4G Repeater Booster Device at 1800MHZ

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ABSTRACT

The signal quality received by the mobile device may be poor due to impediments between the base station and the mobile station, such as building structures or vast distances. This poor quality will cause communication issues, therefore need a repeater at the receiver. The difference between active and passive repeaters is the power needs and the absence of active components (amplifiers). An active repeater requires an active power supply and components (amplifier), whereas a passive repeater does not (amplifier). When a 4G network signal is transmitted, it is likely to be attenuated by elements such as air, weather, or barriers. To address this, we need a repeater that can enhance the transmitted signal so that users can receive it correctly.

***Keywords**: Repeater, 4G Network, Omnidirectional, Antenna, Biquad Antenna, and VSWR*

1. INTRODUCTION

Mobile communication, signal booster works on the frequency of 900 MHz and 1800 MHz. Due to obstacles that occur between the base station and the mobile station, for example, due to building structures, other barrier materials, or long distances, the signal received by cellular devices may be of low quality. This low quality can cause communication to be disrupted, ranging from intermittent to drop calls. With the use of a repeater, this weak signal is taken and amplified with the help of an outdoor antenna and then forwarded via coaxial to the repeater unit. This repeater unit is filtered with a bandpass filter in the 800MHz or 1800MHz frequency[1]. Then channelled to the indoor antenna via coaxial to be retransmitted indoors. The main requirement for using this repeater must be that there is a minimum signal input[2].

The development of cellular communication technology is overgrowing starting from 2G, 3G, until now has reached the 4G network. The 4G network system is a development of the 2G network and 3G network that provides a network with large bandwidth and operates at a frequency of 1800 MHz[3]. When the network signal 4G is transmitted, the signal may experience attenuation caused by several factors such as air, weather, or obstacles that can block the signal transmission. To overcome this, we need a repeater that can amplify the user's signal to receive a signal in good condition[4].

The antenna is also an essential element in every wireless telecommunications system (wireless). Selection of the suitable antenna, proper design good and correct installation will guarantee the performance of the system the telecommunications. The antenna used to support the 4G network must be compatible, compact, and operate over a wide frequency band (broadband)[5].

The 4G network technology enables ultra-wideband connectivity for various electronic devices, including smartphones and laptops equipped with a USB modem. The 4G network system will provide a comprehensive IP solution that will enable users to access voice, data, and multimedia flows at higher data rates than prior generations. It runs at an 1800 MHz frequency[6][7]. When a 4G network signal is transmitted, it is likely to encounter attenuation, which various causes can cause, including air, weather, or obstructions that prevent the signal from being delivered. To address this, we require a repeater capable of amplifying the signal supplied by the user, ensuring that the user receives a signal in good form[8]. A network repeater is a device or media frequently used to extend a network from a single wired or wireless network region. Additionally, it supervises the entry and departure of transmissions for processing by receiving and transmitting information from the sending station. As a result, the repeater functions as a signal amplifier, extending the range of the previously confined signal to a specific distance[9].

2. LITERATURE REVIEW

2.1. Repeater As Signal Amplifier

Signal Amplifier Repeater is an electronic device that receives a signal and retransmits the signal with a higher power so that the signal can reach a wider area. The signal repeater amplifier is derived from the term telegraphy and refers to an electromechanical device used for the regeneration of telegraphic signals. The use of the term continues in telephone and data communications. In the wireless communication industry, it is a signal amplifier device that serves to increase the ability to capture mobile phone signals in an area. The signal amplifier consists of a receiving antenna, a signal amplifier, and a signal transmitting antenna[10].

The Repeater device must have 2 tools, namely to receive signals from the server (client) and to redistribute the Wifi signal (access point). As it is known that the use of wireless in this world is very common in our daily lives, with wireless we don't have to worry about messy cables, with this wireless at home, office, and campus. Wireless is called wireless, which is a technology that connects two devices to exchange data or voice without using cable media. Data is exchanged through the medium of certain light waves (such as infrared technology on TV remotes) or radio waves (such as Bluetooth on computers and cell phones) with a certain frequency[11]. The advantage of this technology is that it eliminates the use of cables, which can be quite aesthetically pleasing, as well as the complexity of the installation to connect more than 2 devices. The drawback of this technology is the possibility of interference with other wireless connections on other devices[12].

2.2. How Repeaters Work

The way this repeater works is by spreading data throughout the network, even though the data is not needed, it will still be spread throughout the network, the performance of the data will decrease or the access will be slower if there are more signal stops (Station) and data traffic increases. Repeaters are also usually installed at certain points to update the incoming signal transmission so that the signal conditions are like when it was first emitted from the transmitter[13].

Repeaters are classified into two types: active repeaters and passive repeaters. The two types of repeaters are distinguished by their supply requirements and the presence or absence of an active component (amplifier). An active repeater requires both a supply and an active element (amplifier), whereas a passive repeater does not. A supply and a functional component are required (amplifier). An active repeater's block diagram comprises four elements: an external antenna, an indoor antenna, an amplifier, and a transmission line. Simultaneously, a passive repeater's block diagram consists of three parts: an outdoor antenna, an indoor antenna, and a transmission line[14].

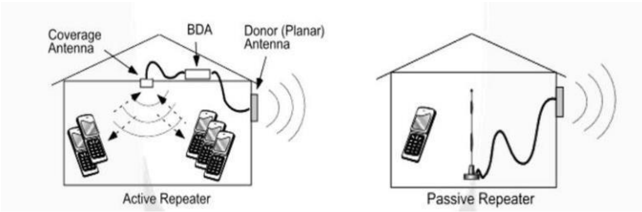

Figure 1 The Difference Between An Active Repeater And a Passive Repeater

2.3. Network Repeater Functions

2.3.1. Expanding Signal Coverage Area

Expanding the coverage area of the signal is the main function of the repeater, many people buy repeaters for this due to the limited distance from the wireless transmitter or what we call wi-fi. Repeaters are rarely used by restaurants, cafes, or mini restaurants because the use of wi-fi in restaurants is on a small scale and is not very important if there is none. However, it is different with large buildings, offices, companies, and so on.

2.3.2. Save Cost

Repeaters will be very helpful among entrepreneurs who have large buildings in the financial sector. The repeater can connect 2 adjacent buildings, with its ability to expand the coverage area of the signal. If there is a signal, it can communicate indirectly and there is no need to go down through the elevator and then walk to the next building. Imagine if 2 company buildings only use 1 transmitter, of course, the company's expenses will be smaller with the help of repeaters. Moreover, the cost of signal transmitters for offices is now quite expensive, of course, it will greatly save the company's expenses.

2.3.3. Saving Time

If the signal transmitter is on the ground floor so that the signal on the upper floor does not get, then install the repeater in the middle of the floor between the basement floor and the upper floor, but it is better to position the repeater closer to the signal transmitter. The distance of the repeater signal is as far as our eyes can see (Line Of Sight) which means the repeater can also penetrate between floors, in other words, it will save a lot of time. So there is no need to take data downstairs if the user is downstairs while other users are working upstairs, making it easier to communicate and practice with the boss and his employees. With this repeater function, employees can save time so that employees can increase their productivity and can save more time to rest.

2.3.4. Telephone Repeater

A telephone repeater is a type of repeater used on telephone lines. On telephone cable lines, the signal will usually be degraded due to long distances. Therefore a repeater must be used so that the signal received by the telephone user is clear. On the telephone, the signal is sent in both directions. This causes the repeater working system on this telephone repeater to be more complex. In this system, there should be no interference between one signal wave and another to avoid any feedback that might interfere with the communication flow. In addition to land, telephone repeaters are also used as a means of communication under the sea, or better known as submarine cable repeaters.

Figure 2 Telephone Repeater

2.3.5. Optical Communications Repeater

This repeater serves to strengthen the signal range in the fiber optic cable. In fiber optic cables, digital information physically exists as light pulses. Light pulses (In Indonesian called light pulses) are formed from photons. The photons can be scattered randomly in the fiber optic cable. To amplify the signal, usually, in the fiber optic cable there is a phototransistor that functions to convert the light pulses into an electrical signal, which will then be amplified by an amplifier. After that, the electrical signal will be converted back into a pulse of light with the help of a laser beam. But now most fiber optic cables have been able to perform signal amplification without the need for pulse and signal transformation.

Figure 3 Optical Communications Repeater

2.3.6. Radio Repeater

This type of repeater, as the name suggests, serves to amplify radio signals. In general, this type of repeater has one antenna that functions as a receiver and transmitter. This type of repeater will change the frequency of the signal it receives before it is retransmitted. The signal emitted by this repeater signal will be able to penetrate the object barrier. Radio repeaters have many types. Some of them are broadcast relay stations, microwave relays, passive repeaters, cellular repeaters, and digipeaters. The repeater work system that is often used to strengthen the wifi signal on a computer network generally uses this type of repeater.

Figure 4 Radio Repeater

2.3.7. Repeater 4G

This type of repeater functions as a 4G signal amplifier which consists of several parts, namely reception antennas, signal amplifiers, and rebroadcast antennas. In this study, the system uses an external omnidirectional antenna to collect the best cellular signal, which is then forwarded to an amplifier unit that amplifies the signal, and retransmits it locally and significantly increases signal strength. For more sophisticated repeater models this can be used to amplify the signals from another GSM so this has an impact on the signal from all cellular operators can all be increased by using a repeater. This type of more modern model also allows some phones to use the same repeater at the same time, making it suitable for commercial as well as home use.

Figure 5 Repeater 4G

2.3.8. 4G LTE Network

Mobile broadband services continue to grow in line with the increasing mobility of people in their activities and the need for internet services. Various cellular technologies continue to be developed starting from GSM/GPRS/EDGE (2G), UMTS/HSPA (3G), and LTE technology. LTE is the latest standard in cellular network technology compared to GSM/EDGE and UMTS/HSPA. LTE is a new name for high-capacity services in mobile communication systems which is a step towards the 4th generation (4G) of radio technology designed to increase the capacity and speed of mobile telephony networks. LTE is a project in the third generation partnership project (3GPP). The evolution of cellular networks to LTE technology is shown in Figure 6.

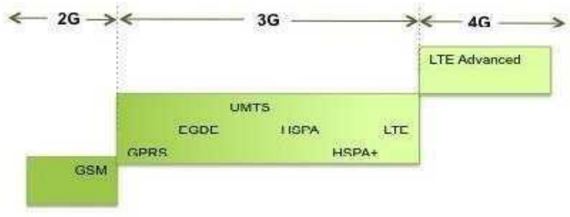

Figure 6 Mobile Network Evolution

3. RESEARCH METHODOLOGY

The design and manufacture of this tool will take several initial steps. The most important initial step in design is making block diagrams, making circuit schematics, and making prototypes. Then the next step is to select the appropriate components and characteristics for the final stage, namely the manufacture of mechanics.

Broadly speaking, the design steps consist of two parts, namely electronic design, and mechanical design. Electronic design, which is about all stages related to the tool circuit, such as circuit schematics, layout, and installation of components. While the mechanical design is the process of completing a tool which includes the manufacture of mechanical tools to optimize the appearance of the tool being made.

Electronic design is about all stages related to all tool circuits, for example, circuit layout schemes and component installation. In electronic design will also be discussed the tools that will be used for measurements that produce a wave. The tools used are nano Visual Network Analyzer and nanoVNA saver on a PC.

The tool block diagram is the initial stage in the design process for making tools, whereby making a block diagram it can be seen how the whole circuit works. So that the entire block diagram of the circuit will produce a system that can be enabled or can work according to the design. Here's a block diagram of the whole system. In Figure 7, there is a block diagram that describes the system in a series of programs that will be run.

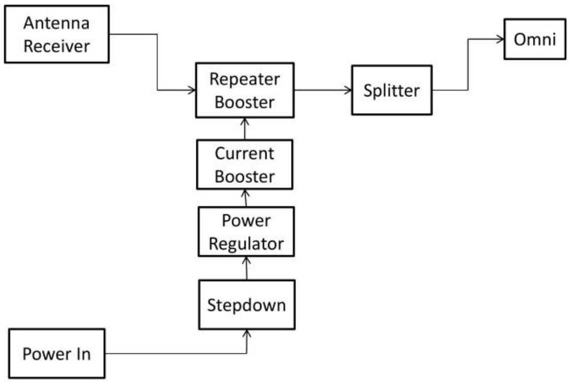

Figure 7 Hardware System Block Diagram

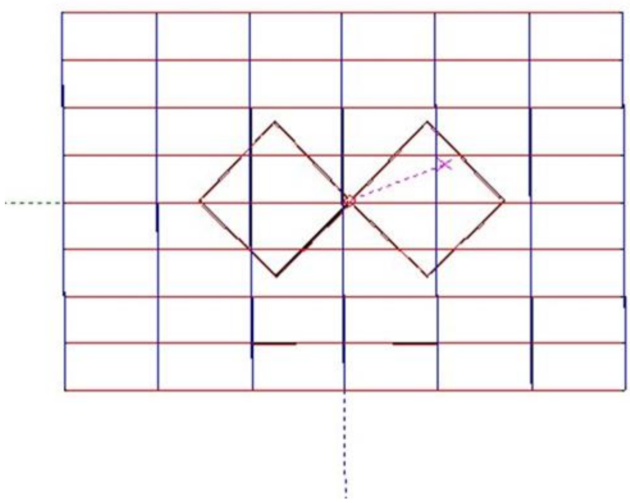

Figure 9 Biquad Antenna Physical Form

It can be seen in Figure 9 that the physical form of the front view biquad antenna consists of a main driven element that is mounted vertically, equipped with a reflector element that functions to increase the directivity of the antenna so that it has a more directional and distant transceiver (transmitter-receiver) capability.

4. RESULT AND DISCUSSION

Measurement data retrieval as test data is carried out in stages for each test parameter. The following are the results of the tests carried out.Before taking further test data, it is first necessary to do a simulation in the form of an initial antenna design to find out how big the antenna dimensions, construction, and components that support antenna functions such as reflector components, driven elements, and balun components are used. The following is an overview of the results of design testing on the antenna.

Figure 8 Tool Overall

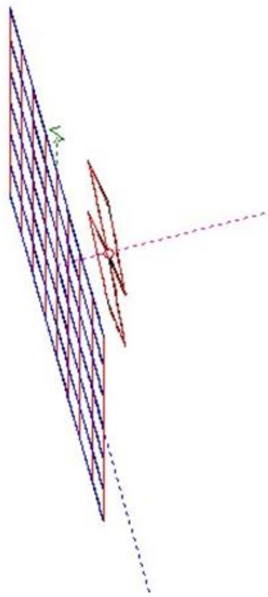

Figure 10 Biquad Antenna Shape And Reflector (Side View)

Figure 11 Biquad Antenna Circuit Results

4.1. SWR Value Testing

To ensure that the specifications of the antenna used are truly matching with the radiofrequency device used, it is very important to test the SWR value on the antenna. In this test, the antenna SWR parameter values are plotted using MMANA-GAL software, the test is carried out by setting the working frequency value, then plotting a graph based on the antenna design that has been made.

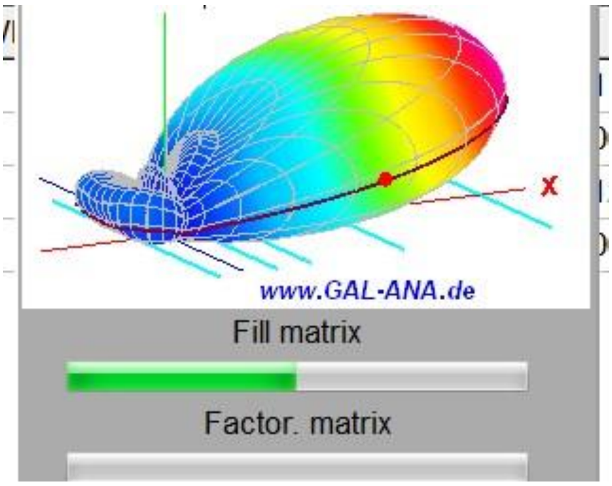

Figure 12 Initial View Of MMANA-GAL Software

The following are the results of the SWR value plot testing carried out.

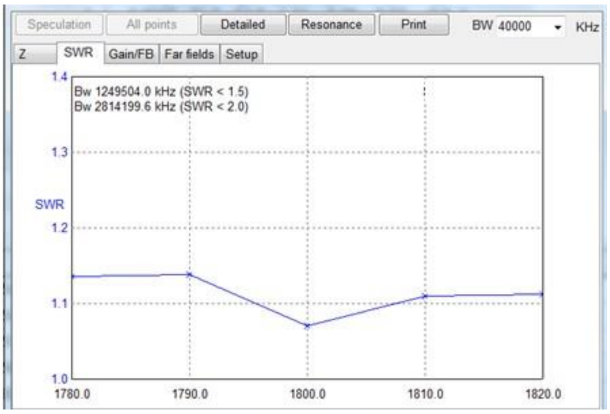

Figure 13 SWR Measurement Curve

From this test, the SWR value is <1.5 with a bandwidth range of 1249504 kHz, while for a wider bandwidth at the value of 2814199 kHz get the result <2. From this test value, it can be concluded that the antenna made is quite good to use because it is still at a value of <1.5, and with a 4000 kHz bandwidth plot range, it still stays at a figure below <1.1 almost flat.

4.2. Radiation Pattern Test

The radiation pattern formed from the installed biquad antenna can be observed by plotting the distribution and the resulting pattern. The appearance of this radiation pattern from a vertical or horizontal point of view, which forms a certain pattern according to the characteristics of the antenna distribution. The use of antennas that are directed at the blank spot area, in certain areas that are not evenly distributed, makes the selection of this type of antenna according to its designation. The following is the resulting radiation pattern.

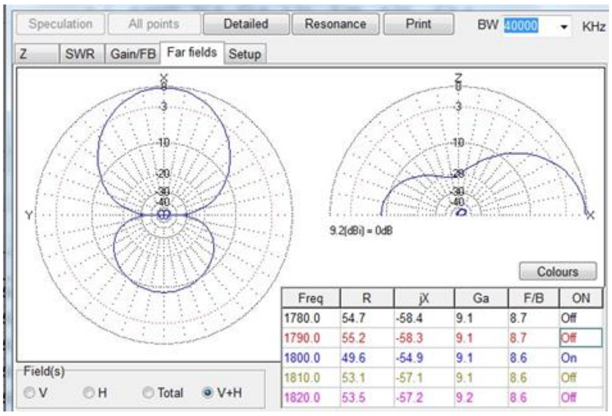

Figure 14 The Resulting Impedance

Table 1. Generated Radiation Pattern

Freq	R	jX	Ga	F/B	On
1780.0	54.7	-68.4	9.1	8.7	Off
1790	55.2	-58.3	9.1	8.7	Off
1800.0	49.6	-54.9	9.1	8.6	On
1820.0	53.1	-57.1	9.1	8.6	Off
1820.0	53.5	-57.2	9.2	8.6	Off

For a 3-dimensional view, the actual form of radiation can be seen in the image below

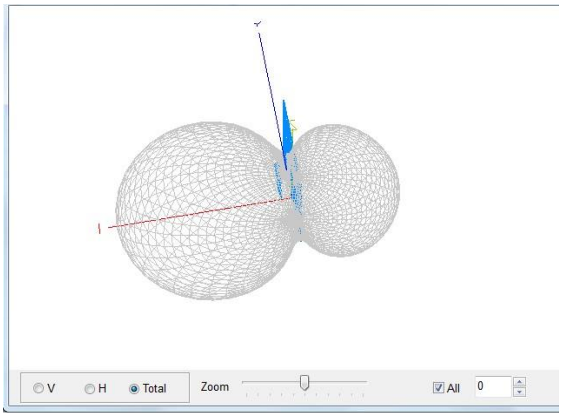

Figure 15 3D Radiation Pattern Display

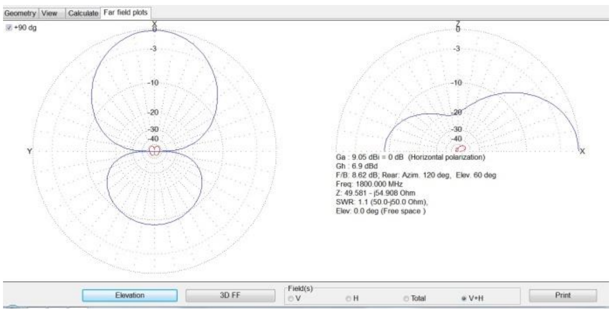

Figure 16 Radiation Pattern Measurement Results

Table 2. Radiation Pattern Measurement Results

Z	SWR	Elev
49.581	1.1	0.0deg

In Figure 14, it can be observed the radiation pattern produced by the biquad antenna. The figure describes the shape of the radiation a vertical point of view and from a vertical point of view. Based on the planning of the service area antenna which is designed as a sectoral antenna to be able to provide a solution for strengthening 4G signal reception in certain blank spot areas, then the sectoral antenna v with the maximum adjustable direction by iBI will provide maximum radiation at the targeted point.

4.3. Gain Value Test

Antenna gain value greatly determines the quality of gain that the antenna can produce from the 0db reference value of a standard antenna. To test this gain value, use the MMANA-GAL software with plotting mode Gain/FB. From the results of the tests carried out, it is known that the performance of the biquad antenna can produce a gain value of 9.06 from the 0 dB reference standard antenna.

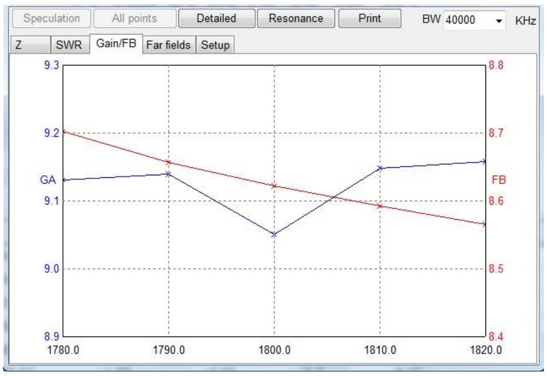

Figure 17 Gain Measurement Results Curve On Biquad Antenna

Table 3. Specification Of Measurement Results Using MMANA-GAL Software

Specification	Measurement Results
Frequency Antenna	1800 Mhz
Gain	Min 9.06 dB dan max 9.16 dB
SWR	< 1.1 - < 2
Bandwidth	40000 kHz (1780 Mhz – 1820 Mhz)
Dimension Antenna	16 x 8 cm

From Table 3, it can be explained that the measurement results using the mmana-gal software, with a center antenna frequency of 1800 MHz, a bandwidth of 40000 kHz, getting a Gain reading of the lowest value of 9.06 dB and the highest value of 9.16 dB for reading the SWR (Standing Wave Ratio) results. optimal reading of <=1.1 at center frequency value 1800 Mhz, with these results, the antenna designed has a good performance to be applied.

5. CONCLUSION

The test results with open signal repeater devices can support repair coverage areas in areas that previously had difficulty getting a 4G signal. When adding repeater devices, it tends to be easier to get a 4G signal. The readings of the spectrum analyser of the repeater device can work well with a high-frequency value of 1872 MHz. The repeater device is designed to use omnidirectional as a donor antenna, capturing all 4G signals from all directions originating from the BTS antenna and its surroundings.

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