I. INTRODUCTION

1.1 Background

The development of mobile internet to meet the needs of future data growth is the reason for increasing network capacity, transmission rate, and efficiency compared to 4G cellular communication technology [1]. The use of wireless communications bands is increasingly congested as a result of data growth so we need a technology to increase data throughput. This poses a new challenge to research the solution technology to be developed. The Federal Communications Commission (FCC) has announced the frequency spectrum for 5G communication technology which explains that mobile internet-based electronic devices can not only take advantage of faster throughput speeds than 4G technology, but also have low latency that can be utilized in various cellular communication applications [2]. In this case, technology is used with the Multiple Input Multiple Output (MIMO) system on Massive MIMO Antennas (Massive MIMO) which is one of the core technologies in the 5G communication system used as multi-antenna transmission which can provide increased channel capacity and increase signal strength by reduce the multipath effect. Massive MIMO with a very large number of antennas is known to produce a significant increase in efficiency [3], [4].

The use of MIMO technology in antennas (MIMO antennas) causes mutual coupling to occur between single antenna elements, as well as multipath components that can affect wave propagation. This can be overcome by providing a high isolation value between single antenna elements [5]–[8]. The MIMO antenna configuration scheme needs to be considered in antenna design. Based on [9], it is explained that simple MIMO antenna configuration schemes (such as 4 elements, 16 elements) are still not suitable for 5G communication needs because of their predicted speed of 1,000 times faster than 4G and better reliability. As a result of the need for 5G communication, the antenna configuration scheme that is carried out is the design for the Massive MIMO Antenna model. Interest in [10]–[12] explains that Massive MIMO Antenna can increase channel capacity and wider coverage of electromagnetic wave radiation emission. However, the design of Massive MIMO Antennas results in a larger size that hinders the antenna design process.

The following is a picture of a massive MIMO antenna system that acts as a massive multi-transmission [8].

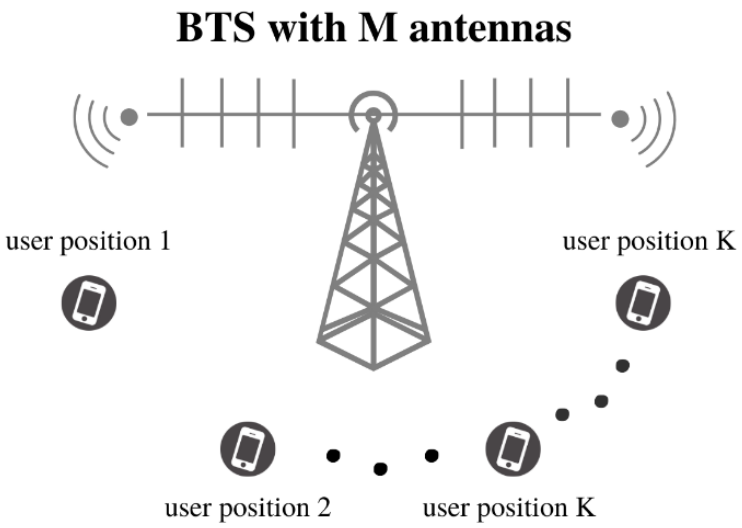


Figure 1. 1 Massive MIMO system.

Designing a large-scale antenna with a massive MIMO scheme is certainly a new challenge in the antenna simulation process. The antenna simulation process is limited because the capabilities of the simulation software are taken into consideration in the design process. However, the need for massive MIMO technology that continues to increase has forced the design of Massive MIMO Antennas to be carried out. Based on this, the authors propose the use of Scalable Techniques to predict the specification performance of Massive MIMO Antennas based on simple MIMO antennas using Array Factor (AF) Theory.

AF theory is used to calculate the overall antenna pattern by considering the element distance and element type for scalability purposes [13]. In [14] the impact of several elements on the AF for a uniform antenna arrangement is described. Another study proposed by [15] investigated the radiation parameters of large antenna arrays by combining the AF and active element patterns. The results also show that the AF pattern increases linearly with the number of antenna elements.

The MIMO system with the beamforming approach has dedicated communication capabilities between BTS and users. This happens because the MIMO Antenna work system has multipath propagation. Multipath propagation on

MIMO antennas makes it difficult to know the extent of the antenna's overall coverage when it transmits electromagnetic waves, in a MIMO system it is difficult to see how far BTS can reach users. An array antenna is used which has one propagation path and it can be seen how far the antenna can radiate. Thus, the predicted performance that can be achieved on the Massive MIMO Antenna is calculated based on its modular Array Antenna with the Array Antenna simulation scheme based on the MIMO configuration.

MIMO antenna with high isolation requires modification in its design. Modification of the MIMO antenna design is carried out by placing the port position on the antenna which will produce the polarization in opposite directions between antennas that are close to each other, including the Right Hand Circular Polarization (RHCP) and the Left Hand Circular Polarization (LHCP) [16]–[18]. Antenna design with RHCP and LHCP radiation patterns was carried out in 2 types of patch antennas that is rectangular antennas with truncated corners [19]–[21] and circular antennas with slot x [22].

1.2 Problem Identification

This research will focus on the design of Massive MIMO Antennas to predict the performance parameters generated by scalability techniques. However, the arrangement of MIMO antennas that make the antennas close each other can affect the performance between single antennas with the resulting mutual coupling effect. In addition, the scalability technique that is carried out needs to be reviewed further to predict the achievable specifications value.

The performance between adjacent MIMO antennas will not affect each other if adjacent antennas have high isolation value [16]–[18]. To produce high isolation value between adjacent antennas, a port placement modification technique is used to produce RHCP-LHCP polarizations between adjacent antennas. Modifications to produce RHCP-LHCP were carried out in the design of rectangular truncated corner antenna [19]–[21] and circular slotted x antennas [22].

The design that will be carried out on rectangular truncated corner antenna and circular slotted x antenna is each carried out by modifying the port position to produce RHCP-LHCP and simulating uniform antenna for each type of patch. Thus,

the effect and performance resulting from each type of patch will be compared and analysed to prove the scalability technique studied.

1.3 Objectives

The research will result in scaling the Massive MIMO Antenna design using scalability techniques. Antenna scalability is carried out on MIMO antennas by calculating predictions of the specifications that will be obtained by a Massive MIMO antenna based on a simpler MIMO antenna by simulating a simple modular array to scale it up into a Massive MIMO Antenna.

MIMO antenna can make the performance of adjacent antennas influence each other, so a solution is needed to make the antenna have a high isolation value. High antenna isolation values can be achieved by using an antenna type that produces RHCP-LHCP polarization. In this case, a rectangular patch antenna with a truncated corner and a circular patch antenna with x slot are used.

The simulation results of MIMO antenna configurations on rectangular patch antennas with truncated corners and circular patch antennas with x slots will be compared to ensure the scalability technique used to further calculate the Array factor to find out the pattern of increasing the performance of the antenna.

1.4 Scope of Research

Scope of research in this study are as follows.

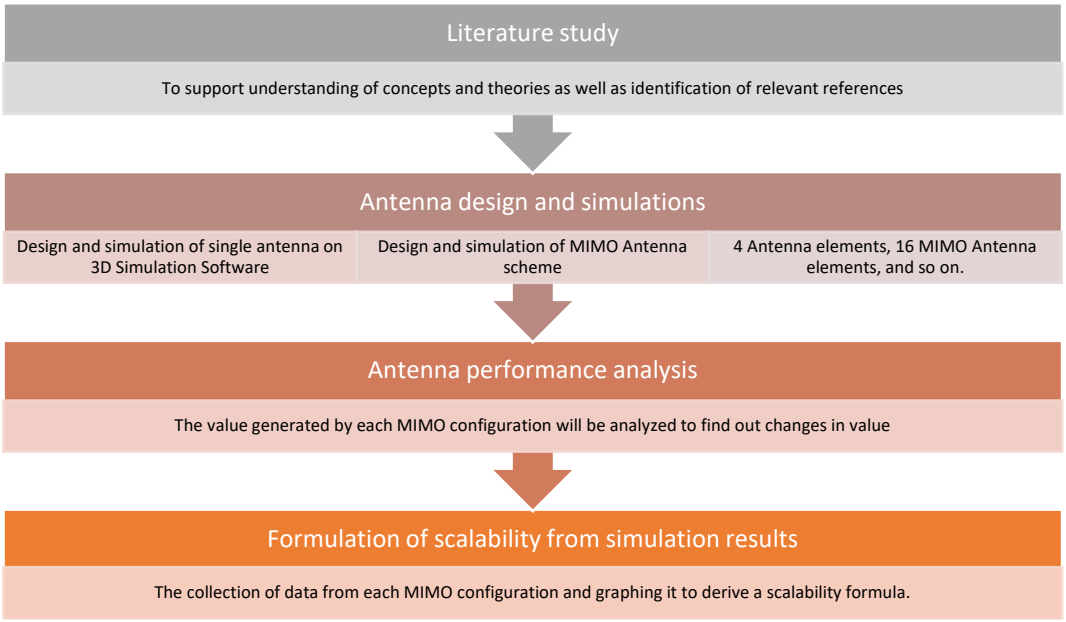
1. This study focuses on discussing the simulation process of 5G MIMO antenna design and scalability.
2. The design method used for the single element antenna is a rectangular truncated corner patch antenna and a circular patch antenna with x slots for RHCP-LHCP circular polarization.
3. This study focuses on the calculation and scalability of a massive MIMO antenna for 5G Antenna based on a simple modular array antenna configuration.

1.5 Hypothesis

Massive MIMO antenna design was carried out to meet the needs of 5G technology with a large channel capacity and a predicted speed of 1000 times greater than 4G technology [9]–[11]. Massive MIMO antennas are known to

increase channel capacity and wider coverage of electromagnetic wave radiation [10]–[12]. However, Massive MIMO antennas with very large configuration schemes are a challenge due to the limited capability of the simulation software in the design process. Thus, a scalability technique is carried out to predict the parameter performance that will be produced by a Massive MIMO Antenna based on a simpler MIMO antenna arrangement by simulating on modular array antenna [23].

1.6 Research Methodology



The research process begins with a literature study to support understanding of concepts and theories as well as identification of relevant references related to the development of 5G technology and Massive MIMO Antennas. Next, antenna design and simulation are carried out using a simple MIMO Antenna scheme in CST simulation software. The first stage of design and simulation is the design, simulation, and optimization of single patch rectangular antenna elements with truncated corners for RHCP-LHCP until the resulting parameters are in accordance with specifications. Next, the 4 MIMO Antenna configuration is performed as a single element. After that, bigger and more complex configurations (16 elements, 64 elements, etc.) configurations are carried out in exponential increments. As a comparison and to ensure the scalability technique being carried out, a circular patch antenna with an x slot with RHCP-LHCP polarization was also designed. The

purpose of this study is to perform further calculations, aiming to predict the specifications that can be generated from a larger MIMO configuration based on the formula derived from simulation results.

1.7 Thesis Organization

In general, this thesis is divide into five chapter's discussion. The explanation as follows:

1. CHAPTER 2 BASIC THEORY

   This chapter contains the basic concept and theories related to this study.

2. CHAPTER 3 EXPERIMENTAL DESIGN

   This chapter is consist of antenna design for RHCP-LHCP polarization MIMO configuration with a rectangular patch antenna with a truncated corner and a circular patch antenna with an x slot.

3. CHAPTER 4 ANALYSIS

   This chapter consist of analysis for scalability techniques that measure the antenna design of rectangular patch antenna with truncated corner and circular patch antenna with x slot.

4. CHAPTER 5 CONCLUSION AND SUGGESTION

   This chapter consist of conclusion of this research and the suggestion to develop it.