CHAPTER I
INTRODUCTION

1.1. Background

Multiple Input Multiple Output (MIMO) transmission becomes an interesting thing to be researched and developed because antenna structure is accompanied by device complexity on terminal part and size limitations. Each antenna on MIMO system must be connected with current to multiplex signals simultaneously on digital signal processing. The processing is performed on spatial domain that connect transmitters and receivers. The current setting of the voltage source becomes the way the antenna works on the MIMO system. The complexity of the device affects size, cost constraints, and power dissipation. An electronically steerable parasitic array radiator (ESPAR) antenna can be designed on a Beamspace (BS)-MIMO system because of its beamforming capability by using parasitic elements to reduce the number of terminals, then device complexity can be reduced[1]. The concept is done by an ESPAR antenna in the beamspace domain. The independent channel concept in conventional MIMO systems is used on BS-MIMO systems which have an orthogonal basis pattern in beamspace domain, where the basis pattern is the result of decomposition of ESPAR antenna radiation pattern in orthonormal function. Therefore, the radiation pattern produced by ESPAR antenna in BS-MIMO system is linear combination of basis pattern, or it can be called pattern mapping or aerial modulation [2].

Physically, the shape and direction of the ESPAR antenna radiation pattern are obtained by assigning a reactance value to each parasitic element. However, the calculation of the combination of reactance in the ESPAR antenna becomes quite complex because the relation of the radiation pattern to the antenna geometry is non-linear. Thus, the combination of reactance in the parasitic element is sought using genetic algorithm (GA) in order to utilize beamforming ability of ESPAR antenna. The Genetic Algorithm has been widely used in the electromagnetic field as in the search for a combination of switch configurations [4] and on the search for a combination of reactance on a 5 elements ESPAR antenna [5]. In [5], the correlation of the radiation pattern between the desired patterns with the achieved pattern in the *channel-ignorant* condition has a median value of 99.6%, 99.6%, and 99.5% on QPSK, 8-PSK, and 16-QAM modulations. While correlation in the *channel-aware* conditions has a median value of 86.2% in BPSK modulation and 87.6% in QPSK modulation. Different geometry with more element can affect the correlation.

To improve the correlation, research needs to be done by analyzing the correlation of radiation pattern when the number of ESPAR antenna element increases to 7 elements on the different channel condition. Theoretically, the correlation of the radiation pattern can increase due to the influence of the ADoF dimension, where the number of ADoF is equal to the number of antenna elements in the ESPAR antenna. The dimension of ADoF in the BS-MIMO system shows the number of basis patterns that can be used to form the desired radiation pattern. Therefore, the desired radiation pattern becomes GA reference to search the reactance value on each parasitic element.

The Genetic Algorithm is an optimization algorithm technique for obtaining the best solution from a set of solutions that have a certain chance of using genetic operators to obtain the optimum solution of many possibilities [6]-[7]. The solution is represented by a fitness value that is a function that states the performance of a solution. In this case, the solution is the reactance value of the parasitic element of the ESPAR antenna.

1.2. Objective

The radiation pattern of ESPAR antennas in BS-MIMO is a representation of information symbols. The purpose of this research is to analyze the effect of the number of elements on the ESPAR antenna on the correlation of the radiation pattern in different channel conditions. A genetic algorithm is used to determine the value of reactance in each parasitic element of ESPAR antenna. Therefore, the ESPAR antenna can be used in BS-MIMO.

1.3. Problem

Issues that will be formulated in this thesis as follows :

1. Formation of an orthogonal basis pattern based on the number of elements on the ESPAR antenna using the Gram-Schmidt method. The process needs to involve geometric antenna parameters such as a number of elements (M_{esp}) and inter-element distance (d_{ij}). Where the number of elements used in this research is 5 and 7 elements, while the inter-element distance is $\lambda/16$.
2. The formation of the desired radiation pattern is obtained from the number of available basis patterns (N). The basis pattern is influenced by conditions when the channel is considered perfect (*channel-ignorant*) and the channel is considered to have a lot of scatterers (*channel-aware*). In addition, the formation of ESPAR antenna radiation pattern involves the order of modulation used *(M)*. Thus, through a combination of symbols, the number of radiation patterns that can be generated on the BS-MIMO system is as much as M^N.
3. Determination of reactance values on parasitic elements to produce radiation patterns that have a high correlation to the desired radiation pattern. The genetic algorithm is used to find the best reactance value represented by the fitness value as a result of the correlation function of the radiation pattern. Genetic algorithm processes require mutual impedance matrices ($\mathbf{Z}_{ij}$) and array manifold vectors ($\boldsymbol{a}_m(\varphi)$) obtained from antenna geometry parameters to form radiation patterns.

Therefore, it can be compared to the radiation patterns required by the BS-MIMO system.

The problem in this research is shown through diagram block and pseudocode as in Fig.1.1 and appendix 1, respectively.

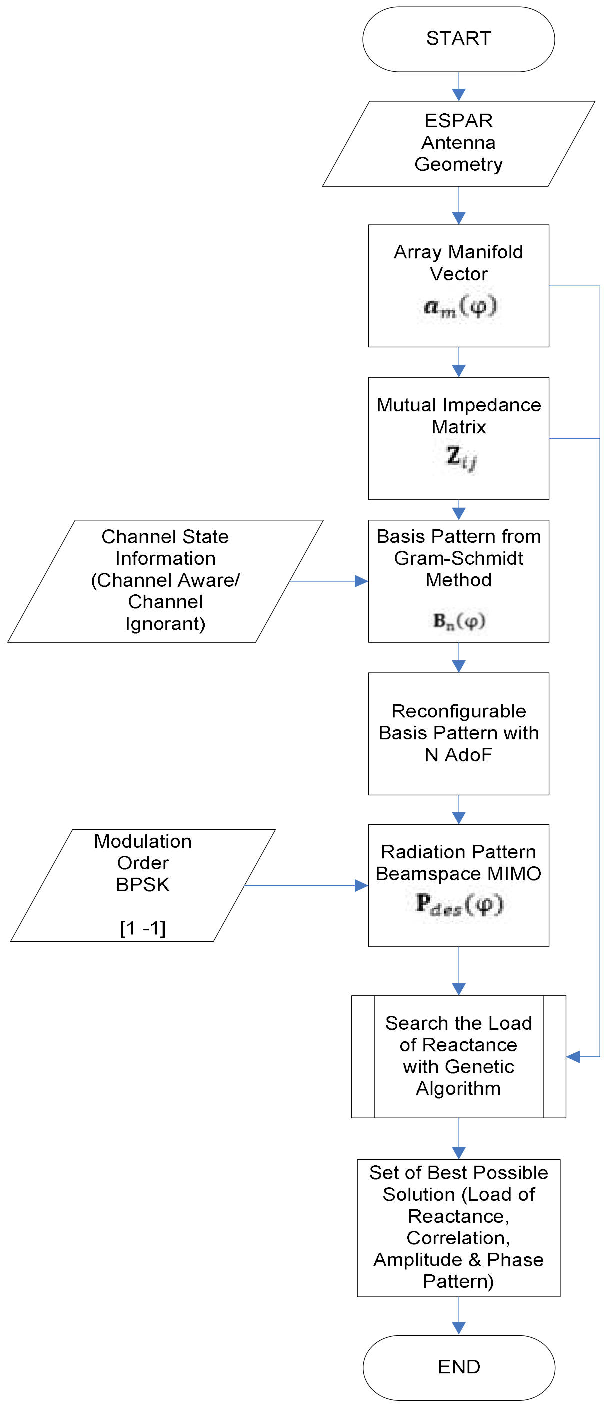

Figure 1.1: Diagram block of research system ESPAR antenna in BS-MIMO

1.4. Scope of Work

Scope of work of this thesis are:

1. In principle, structure of ESPAR antenna consist of one active elements and some parasitic elements. This research uses ESPAR antenna with 5 elements and 7 elements to analyze the correlation.
2. The reference radiation pattern is obtained from the *channel-ignorant* and *channel-aware* condition.
3. The radiation pattern is analyzed on the azimuth angle with resolution of 51 points in the form of amplitude and phase patterns.
4. The correlation analysis of radiation pattern is represented by cummulative distribution function (CDF) through median value with BPSK modulation scheme

1.5. Research Method

The method used in this research is shown in Fig.1.2. Parameters that affect the correlation of radiation pattern, i.e. ESPAR antenna geometry parameters, MIMO beamspace system, genetic algorithm parameters, and channel conditions. The ESPAR antenna radiation pattern in the BS-MIMO system is obtained by finding the value of reactance in the parasitic element using a genetic algorithm. Channel conditions affect the desired radiation patterns that GA will search. Therefore, the correlation is ratio of the radiation pattern of the genetic algorithm compare with the radiation pattern obtained through the BS-MIMO system under *channel-ignorant* and *channel-aware* conditions

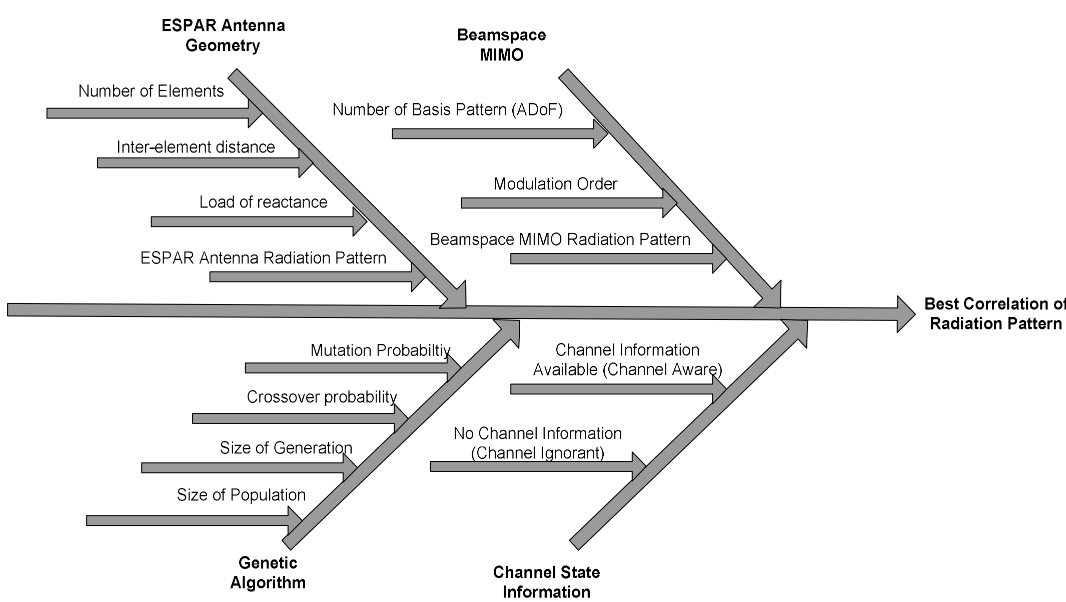

Figure 1.2: Fishbone diagram of ESPAR antenna research on BS-MIMO

1.6. Hypothesis

Correlation of ESPAR antenna radiation patterns can be increased by adding the number of antenna elements. This happens because the number of variables sought by the genetic algorithm equals the number of parasitic elements in the ESPAR antenna. Therefore, the more number of elements, the more probability the reactance value can used to produce radiation patterns that have a high correlation to the desired radiation pattern in the same generation (iteration) size.

The magnitude of the correlation in the genetic algorithm is shown in the fitness function as a result of the maximum value of the multiplication of the desired radiation pattern with the radiation pattern generated by GA, where $\text{Fitness} = \max(\mathbf{P}_{rad}\mathbf{P}_{des}^{*})$. The desired radiation pattern is obtained by involving the BS-MIMO system, while the radiation pattern generated by GA is obtained by involve the reactance value.