Improvement of the Bandwidth and Scattering Parameter Performances of 5G Branch-Line Coupler Design for the Use in Intelligent Transportation System (ITS)

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***Abstract*—This paper presents a design of 5G branch-line coupler that operates at 10 GHz frequency range. The proposed coupler is implemented with four stubs and two slots to improve the performances including the scattering parameter and also the bandwidth. Advanced Design System (ADS) software is used to design and perform the simulation stage. The proposed 5G coupler with stub and slot technique has enhances the bandwidth up to 60% as compared to the one proposed earlier in the literature. Additionally, the simulation results show that the scattering parameter and phase differences have also improved. The proposed design is suitable to be used later in Butler Matrix for Intelligent Transportation System (ITS) application.**

***Index Terms*—5G Technology; Branch-Line Coupler; Stub Technique; Wideband**

I. INTRODUCTION

Intelligent Transport System (ITS) is a system that utilises communication technology to improve the efficiency and safety in the transportation system. The idea of having the ITS in today's world is to provide every car on the road with the ability to communicate with each other. The communication includes sending location, speed and also traffic and danger occurring on the roads. Thus, this help in improving the performance and reliability of current conventional transportation system. Also, this ITS enable the vehicles to operate safely and well coordinate according to the given information. As ITS plays with number of input and output signals that leads to crowded data transferred, therefore, the most suitable communication technology to be used for this system is a 5th Generation (5G) technology. This technology is expected to have hundred times faster data rates especially for high mobility, massive connectivity in crowded areas, thousand times higher system capacity/km2, less than 1ms reduced latency (virtually zero latency), energy saving and cheaper especially for terminals [1]. By the year of 2020, it is estimated that 50 billion devices are connected to the internet with the foundation of the Internet of Things (IoT) and 75% of it consist of traffic, where 90% of it is vehicle [1].

The drawback of 5G technologies is, it offers short coverage range due to its high frequency. Thus, multi-input-multi-output (MIMO) technology is introduced to extend the range of 5G technologies by concentrating the signal in ultimate/one direction. Since MIMO technology has multiple antenna, signal can be transmitted and received from multiple direction [2],[3].

Beam-forming network is the example of MIMO technology used to concentrating the receiving or transmitting directional signal instead of broadcasting the signal to wide area [4]. To date, numerous number of beam-forming system that have been introduced which includes Butler Matrix [5]-[7], Blass Matrix [8] and Rotman Lens [9],[10]. The simplest among all is Butler Matrix where only few number of couplers used in its topology compare to other type of beam-forming network [7]. Butler Matrix consists of 3 main components, which are; the 3-dB coupler, 450 phase shifter and crossover. As yet, various design of 3-dB coupler has been presented [11]-[15], however, only a few of them operate in 5G technologies as it is still a new technology.

In [12], the authors implement the multilayer technique to design the 5G coupler and also, as reported, the effect of the stub and slot in the used technique also studied. The result shows that the stub and slot give effect towards the performance of the 5G coupler. The bandwidth coverage of this design is 2 GHz which is considered as wideband. However, as known, multilayer has issues during fabrication and realization where, the alignment of the substrate, patch and slot must be 100% aligned. A small misalignment will degrade the whole results and performances [16].

Hence, to solve the issue raised by using multilayer technique, in [13], the authors implement the most basic 3-dB coupler design, the branch-line coupler. The design consists of one single layer with implementation of two stubs and two slots to maintain the performance of the coupler. The advantage of using branch line coupler includes; simplest type of coupler, cheap to fabricate and many development and research have been done from it. Even though it solves the alignment issue, however, as known, the branch-line coupler concerning issue is the narrow bandwidth coverage [17]. The bandwidth performance of the coupler reported in [13] is only operating in 900 MHz.

Therefore, the purposes of this paper is improved the