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# Criss-Cross Metamaterial-Substrate Microstrip Antenna with Enhanced Gain and Bandwidth[1]

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**Abstract**—Metamaterials have been an attractive topic for research in the field of electromagnetics in recent years. In this paper, a criss-cross structure has been suggested; this shape has been inspired from the famous Jerusalem Cross. The software analysis of the proposed unit cell structure has been validated experimentally thus giving negative response of ε and μ. Following this, a microstrip patch antenna based on suggested metamaterial has been designed. The theory and design formulas to calculate various parameters of the proposed antenna have been presented. The design of a metamaterial based microstrip patch antenna has been optimized for providing of an improved gain, bandwidth and multiple frequency operations. All the antenna performance parameters are compared and presented in table and response-graphs. Also it has been observed that the physical dimensions of the metamaterial based patch antenna are smaller compared to its conventional counterpart operating in the same frequency band. The response of the patch antenna has been verified experimentally either. The important part of the research was to develop metamaterial based on some signature structures and techniques that would offer advantage in terms of bandwidth and multiple frequency operation, that is demonstrated in the paper. The unique shape suggested in this paper provides an improvement in bandwidth without reducing the gain of the antenna.

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## 1. INTRODUCTION

Microstrip antennas are widely used by RF and microwave engineers and researchers. Due to many exclusive advantages provided by these devices, their popularity and usage has grown at an exponential rate over the years. On the other hand, there is always another side of the picture. Their disadvantages like low gain and narrow bandwidth have put limitations on their applications. The desire to obtain a compact antenna configuration further deteriorates these two parameters, because both gain and bandwidth are directly depend on the size of an antenna.

Therefore, the most recent design problem of microstrip antennas for most of the practical wireless communication applications is size reduction together with gain and bandwidth enhancement. In order to increase the gain, techniques like use of stacked configuration [1], inclusion of an amplifier type active circuitry [2] and loading of high permittivity dielectric substrate [3] are used.

Bandwidth expands if the substrate thickness is increased or the dielectric constant is reduced. The use of thick substrates containing air or foam along with impedance matching technique [4], suspended microstrip antenna with a dielectric resonator [5], truncating and slotting the patch in C shape, U shape, E shape [6] etc. have allowed one to expand the bandwidth up to 30%.

Use of metamaterials (MM) for further improvement of the performance of microstrip antennas (MSA) has been the recent trend in this field. Authors of [7] have proved that the gain and bandwidth of MSA can be increased by placing an array of left-handed metamaterials (LHM) in front of the patch. Papers [8, 9] show

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