Design of Single Element Microstrip Patch Antenna of Key Shape Resonating at 3.5GHz for 5G Application

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DESIGN OF SINGLE ELEMENT MICROSTRIP PATCH ANTENNA OF KEY SHAPE RESONATING AT 3.5GHz FOR 5G APPLICATION

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ABSTRACT

This paper presents the design and simulation of dual band key shaped microstrip patch antenna exhibiting wide band operating frequencies for x band application. The proposed antenna is designed using CST Studio Suite. The proposed antenna is designed using FR4 (flame retardant-4) substrate. The impedance bandwidth of lower band is 2.0GHZ and at upper band is 4.0GHZ. The Computer Simulation Technology (CST) is used in this design .The performance of proposed antenna is analyzed in terms of bandwidth, gain, directivity, radiation pattern and radiation frequency. The simulation has been performed by using CST simulation technology.

KEYWORDS- Key-shaped patch antenna; S-band, microstrip feed line FR4 epoxy substrate microstrip feed line.

1. INTRODUCTION

Nowadays microstrip patch antenna have been widely used in high performance satellite and wireless communication application. Because this is very low-profile antenna and have attractive features, light weight, easy and inexpensive manufacturability, conformal structure and compatibility with integrated circuit technology.

A microstrip patch antenna feed line is easy to fabricate, simple to match controlling the insect position and rather simple to model. The basic properties of analytical models and design techniques for microstrip patch antenna can be found in reference.

2. ANTENNA DESIGN AND CONFIGURATION

The performance (operating frequency, radiation z efficiency, return loss, gain and other related parameters) of microstrip patch antenna 's mainly depends on their geometry, dimensions and the dielectric substrate characteristics. The geometrical configuration of the proposed Key- shaped patch antenna (front view and side view) fabricated on an FR4 epoxy substrate having permittivity of 4.4 and loss tangent of 0.02 and total volume of 30×20×1.7 mm^3 is shown in Fig. 1(a) and 1(b). Area of ground plane of the proposed patch antenna which located at the opposite side of the patch is 30×20 mm^2.

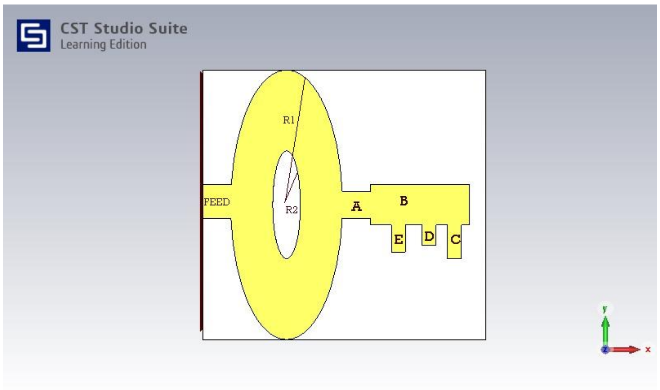

Fig.1 (a) Front view of proposed antenna

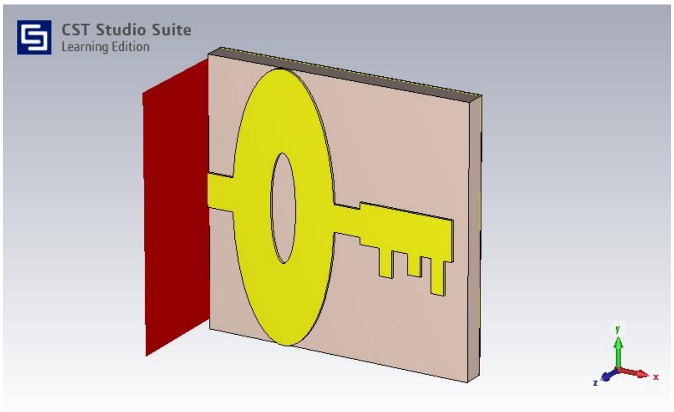

Fig.1 (b) side view of proposed antenna

The dimensions of components of Key-shaped patch Antenna are written in Table 1.

S.NO.	Basic	Dimension(mm)
1.	**Substrate**	30x20x1.7
2.	**Patch**	
	Radius of outer ellipse(R1)	(4,10)
	Radius of inner ellipse(R2)	(1,2)
	Rectangle A	3.5x2
	Rectangle B	7.1x3
	Rectangle C	1x4
	Rectangle D	1.5x3
	Rectangle E	1x3.5
3.	Feed line	3.6x2.5
4.	**Ground plane**	30x20

Table 1. Design specification of proposed Key-shaped patch antenna

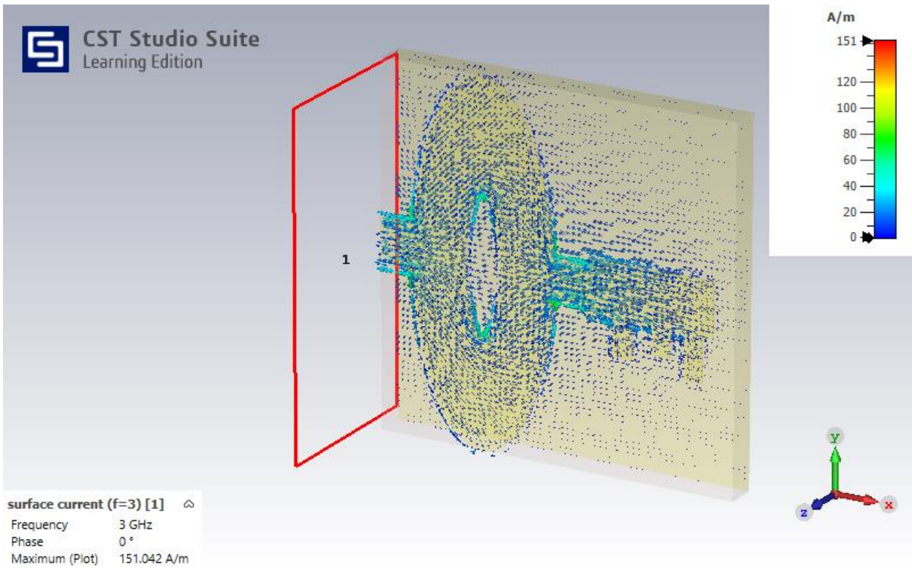

Fig. 1(c). Surface current distribution on proposed antenna

3. PARAMETRIC ANALYSIS

A parametric study is carried out to optimize the design and explain the effect of the design parameter on the return loss and gain performance.

S-parameters are a way of expressing things with general waves instead of voltages and currents. It describes how much the waves are reflected or transmitted from/through a device. With a device like an antenna, there's not only 1 but 4 S-parameters. The first one S_11 is also known as the reflection coefficient.

S-parameters describe the input-output relationship between ports (or terminals) in an electrical system. For instance, if we have 2 ports (intelligently called Port 1 and Port 2), then S12 represents the power transferred from Port 2 to Port 1. S21 represents the power transferred from Port 1 to Port 2. In general, SNM represents the power transferred from Port M to Port N in a multi-port network.

A port can be loosely defined as any place where we can deliver voltage and current. So, if we have a communication system with two radios (radio 1 and radio 2), then the radio terminals (which deliver power to the two antennas) would be the two ports. S11 then would be the reflected power radio 1 is trying to deliver to antenna 1. S22 would be the reflected power radio 2 is attempting to deliver to antenna 2. And S12 is the power from radio 2 that is delivered through antenna 1 to radio 1. Note that in general S-parameters are a function of frequency (i.e. vary with frequency).

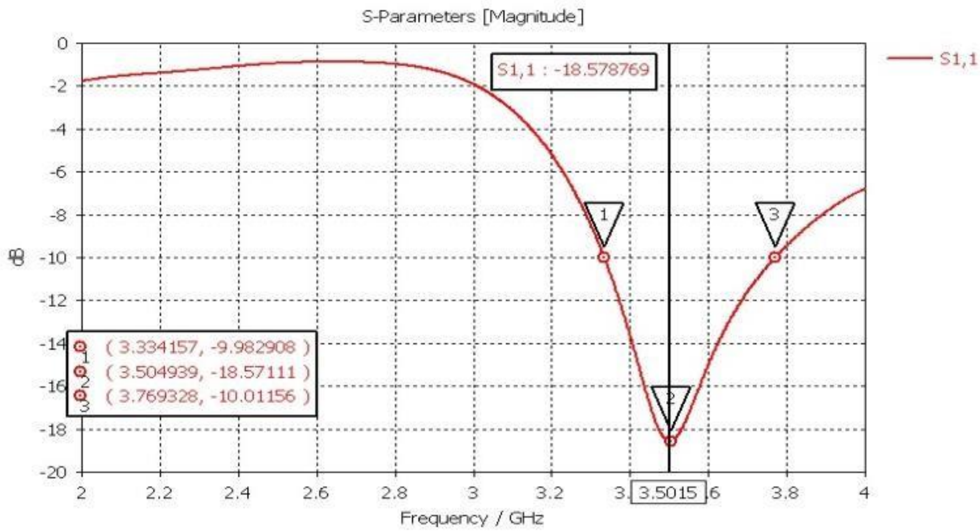

Fig. 2 (a) S-parameter as a function of frequency

Z parameter is used to determine the quality factor of an antenna which can give you an insight about the attainable bandwidth. Z(ant)=R+jX, where R=R(rad)+R(Loss), so you can predict somehow the losses and the efficiency. It could also be useful for determining an equivalent circuit model of the antenna.

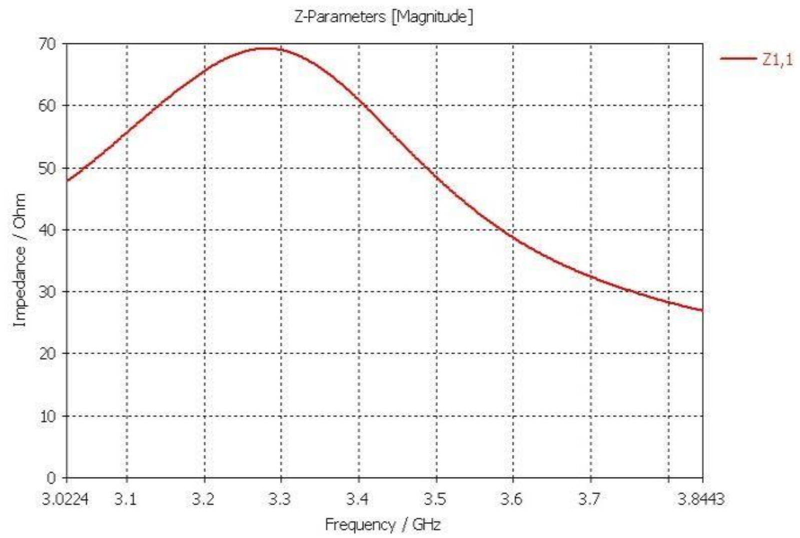

Fig.2(b) Z Parameters of proposed antenna

Y parameters typically refer to the admittance parameters or the impedance parameters, which describe the electrical behaviour of an antenna or a network of antennas when it is connected to a transmission line or other components. Y parameters are used in network analysis and characterize how an antenna or network responds to an electrical signal.

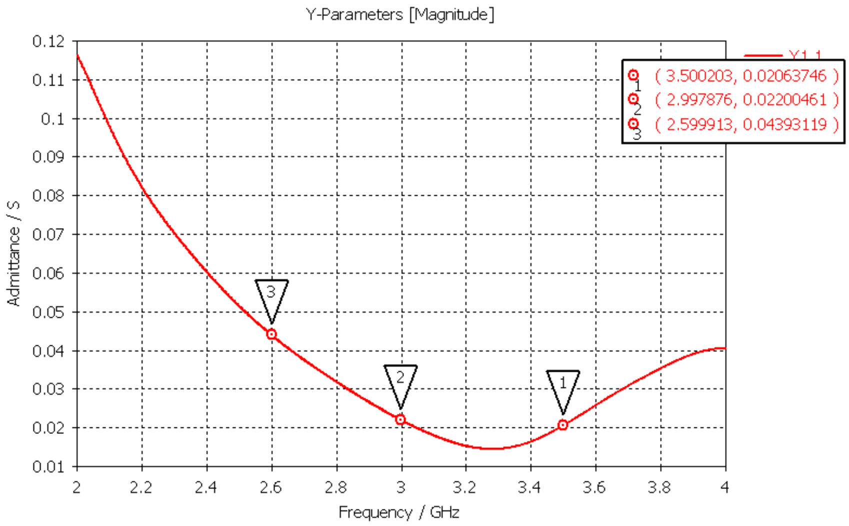

Fig. 2(c) Y Parameters of proposed antenna

VSWR In practice, the most commonly quoted parameter in regards to antennas is S11. S11 represents how much power is reflected from the antenna, and hence is known as the **reflection coefficient** (sometimes written as gamma: Γ or **return loss**. If S_{11}=0 dB, then all the power is reflected from the antenna and nothing is radiated. If S_{11}= -10 dB, this implies that if 3 dB of power is delivered to the antenna, -7 dB is the reflected power. The remainder of the power was "accepted by" or delivered to the antenna.

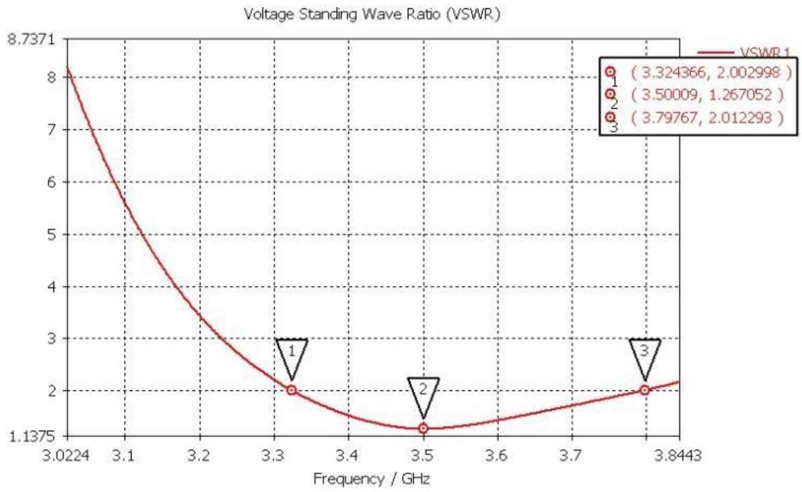

Fig. 2(d) VSWR of key shape antenna (<2)

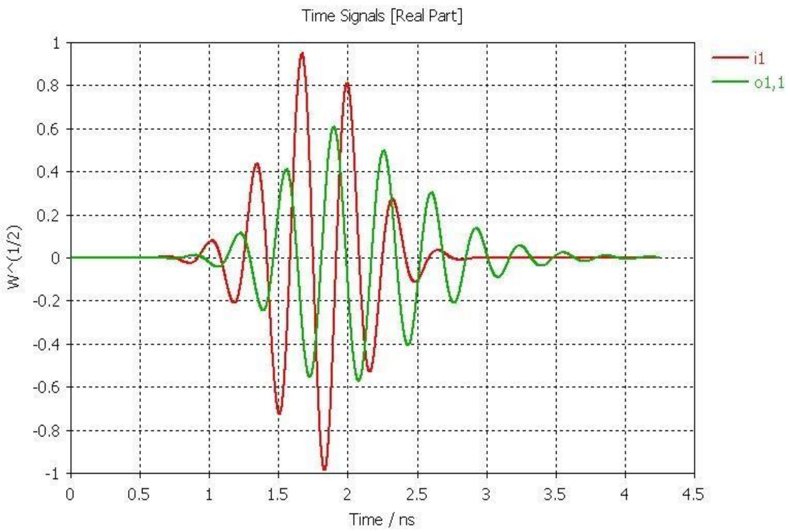

Fig. 3 Time signals of Key-shaped antenna

The directivity analysis group is a natural extension of the Projections from a monitor from a box analysis is group in which surface equivalence is once again invoked to determine the farfields radiated outside of a closed box from the radiating sources (Es, Hs) located inside the box, as depicted in the above figure. These farfields (Er, Eθ, Eϕ) are projected onto a sphere of a sufficiently large radius (in this case, 100meters) using the farfield exact script command and related to the angular distribution of radiation intensity (U) - the power radiated from an antenna per unit solid angle. This allows us to determine the directivity (D) which in mathematical terms is written as $D=4\pi U/Prad$ in which Prad is the power radiated out of the monitor box. Often the maximum directivity is reported for an antenna, which is defined as maximum (D_{max}) over all angles.

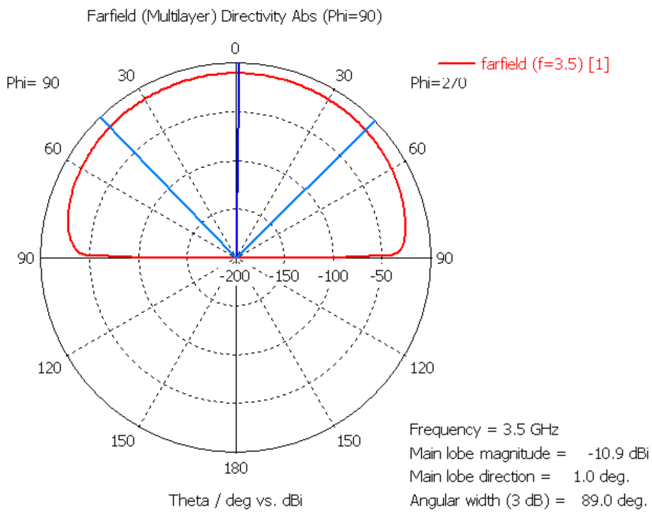

Fig.4(a) Radiation Pattern for Key-shaped antenna

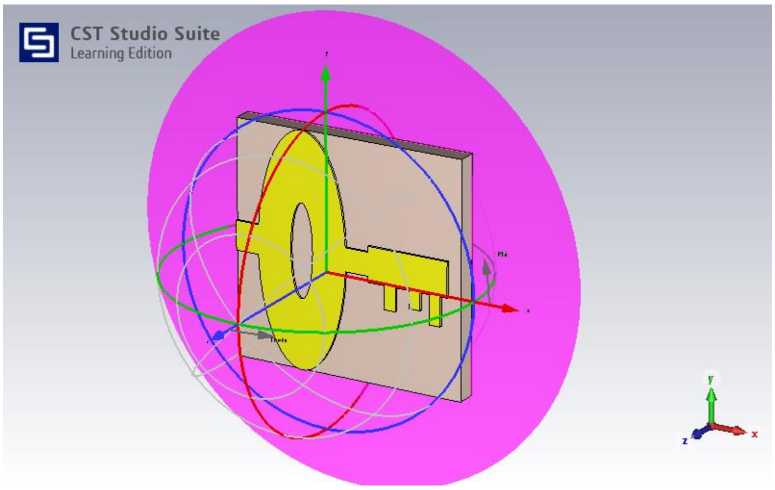

Fig. 4(b) Far Field Zone for Key-shaped antenna

4. CONCLUSION

A microstrip line feed Key-shaped patch antenna has been designed by using FR4 epoxy substrate and simulated using CST Studio Suite antenna simulation software. This antenna gives good response with low frequency. The optimized antenna design not only meets the stringent requirements of 5G application but also offers several advantages, including a compact form factor, ease of integration and cost-effectiveness. The unique geometry and promising performance characteristics make it compelling option for various practical applications.

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