International Journal of Electrical and Electronics Engineers
Vol. No.8 Issue 01, January-June 2016
www.arresearchpublication.com
IJEEE
ISSN 2321 - 2055

CPW-FED SUSPENDED PATCH ANTENNA FOR APPLICATIONS OF AUTOMOTIVE RADAR

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ABSTRACT

*A new approach for the high performance of the patch antenna at millimeter wave, especially 77 Ghz frequency is introduced in this paper. It is basically used for the application of automotive application. The antenna introduced is basically composed of the coplanar waveguide feed line, a feeding post, supporting posts and a radiating patch. The performance of the antenna was improved by raising the radiating patch in the air while leaving the feed network on the high dielectric constant substrate. The 2*1 array antenna was designed with a simple feed network. The fabricated antenna indicated broadband characteristics and high radiation efficiency. Efficiency was about around 94% for the single patch antenna and 93% for the patch array antenna respectively.*

I. INTRODUCTION

Safe driving backing technology is a very significant field in the growth of intelligent transport systems. 77 Ghz automotive radar front-end is crucial component of adaptive cruise control systems. Antenna is a very vital factor in defining the performances of the radar system. The antenna with high gain and wide bandwidth can be used to increase detection range and resolution. Inorder to make the compact radar systems the antenna size should be considerably. For the automotive radar applications , horn antennas are used because of the high performance volume but it has got certain disadvantages also such as it is very bulky, heavy and very costly. For the transition of the waveguide to microstrip it is mandatory to connect with the monolithic microwave integrated circuits. Patch antenna are preferred for the integrated antennas because they are generally of low profile, simple and low cost.

Reduced size and high performance of the antenna can be attained by integrating the patch antenna on the low dielectric constant material with high thickness while remaining the circuitry on the high dielectric constant regions in the related substrate. Micromachining technology is used to improve the performance of the antenna. To reduce the effective dielectric constant of the substrate under the patch antenna, there are different methods such as the making of the cavity around and under the patch antenna using the bulk micromachining , stacking substrates and coupling through the aperture and hanging the patch antenna over an air cavity using the membrane. Process of etching the substrate and the fabrication of the membrane is very tough.

II. DESIGN OF CPW-FED SUSPENDED PATCH ANTENNA

The antenna is collection of CPW feed line, a feeding post, two additional supporting posts and a radiating patch. In this type of antenna two additional backings to support the radiating patch can be used. CPW line used as a signal feed line shows better performance such as lower radiation loss and lesser crosstalk effects. CPW line has a uniplanar construction which suggests that all of the signal lines and ground planes are on the identical surface of the substrate. The ground plane of the CPW line can be used as the ground plane of the radiating patch when the radiating patch is maintained with the feeding post like the coaxial probe feeding method. CPW can be placed on the substrate of the high dielectric constant but the radiating patch is formed in the air. The radiating patch is reinforced with the metal posts on the air, there are no dielectric losses and the performance of the antenna can be enhanced. Appropriate input impedance of patch can be selected by locating the feeding post. Two additional backings are placed at the virtual ground of the radiating patch and associated to the ground plane of the CPW, the additional supports do not affect the performance of the antenna.

III. FABRICATION OF THE ANTENNA

To make the highly suspended patch antenna two procedure are used. One is thick photoresist lithography process and the thick metal electroplating process. In the first step Ti (200 Angstrom) metal seed layer is deposited by the thermal evaporation. For the formation of the CPW feed line, conventional lithography with the thick positive photoresist followed by the Cu electroplating was done. In the photoresist lithography process AZ 9260 positive photoresist was used because it provides fine pattern about the several tens micron order of photoresist thickness. In the thick metal electroplating process, the main effort is to control the current density because the current density provides the growth rate of the electroplating and the uniformity of the electroplated Cu surface. After eliminating the photoresist of the AZ 9260, the posts to drift the signals and backing the radiating patch are designed by the negative photoresist. The radiating patch is formed by the positive photoresist. In this the AZ9260 was spotted and Cu electroplating of 10 micrometre thickness was completed. Cu electroplating is completed to prevent the winding of the radiating patch. The last two steps are the stripping and the etching of the sacrificial layers excluding the antenna construction. The positive photoresist is spotted to form the radiating patch and the top Cu feed was etched using the Cu seed element.

IV. CHARACTERISTICS OF MICROSTRIP PATCH ANTENNA

a) There are an infinite no of resonant modes. The resonant frequency of the antenna is controlled by the size and shape of the patch, relative permittivity of substrate $\sqrt{\epsilon_r}$ and to some extent thickness of substrate. If patch is rectangular in shape with dimensions a and b, the resonant frequency is given by:-

$$f_{mn} = \frac{K_{mn} C}{2\pi \sqrt{\epsilon_r}}$$

where $K_{mn} = \sqrt{\left[\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{a}\right)^2\right]}$

b) The patch behaves to have a slight large dimension because of the fringing fields at the edge of the patch.

c) Each resonant mode have their own characteristic radiation patterns. Normally modes which are used are(1,0) and (0,1) modes. Both radiate strongest in broadside direction. The patterns are usually broad, with half- power beamwidths of order of 100 degree. The gains are typically of order of 5db.

d) Input impedance is dependent on the feed position for the coaxial – fed antennas. The variation of input resistance at echo at level with the feed location essentially follows that of cavity field. For the lowest mode ,it is usually large when the feed is close to the brink of the patch and decreases as feed moves inside the patch.

e) For coaxial feed case , by selecting the feed place properly, the resounding resistance can be synchronized to feedline resistance , while the use of thin substrates will reduce feed inductance at resonance , resulting in a voltage standing wave ratio (S) very near to unity.

f) The loss in the cavity comprises radiation , copper, dielectric and surface wave damages. For thin substrates surface wave can be ignored.

V. CONCLUSION

CPW fed suspended patch have been designed and fabricated using the surface micromachining technology. The suspended gives the liberty to select the substrate under the CPW feedline. The fabricated feedline have always shown very good performances. The proposed antenna can be easily integrated with the MMICs therefore it can be applied to the radar on the chip at mm-wave frequency.

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