4x4 Microstrip Antenna Array using Coplanar Feed Network

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Abstract— An Array of 4 x 4 Microstrip antenna is designed and excited by coplanar waveguide (CPW) feed network. To increase the impedance bandwidth of the array, each element of micrstrip antenna array is fed by a modified L-type probe. The CPW feed network provides simple structure by abandoning the traditional air bridges. The design and simulation of the antenna array is done using HFSS (High Frequency Structural Simulator) software. The linearly polarized array exhibits an impedance bandwidth (SWR) of 30% and a gain of around 10 dB.

Key words: CPW; L-type Probe; Antenna Array; Sheldahl ComClad HF(tm) substrate

I. INTRODUCTION

Recently, there exists a growing interest in the wireless short-range communications with high data rates at the wide unlicensed frequency band around 60 GHz since it enables a number of applications such as uncompressed high definition video streaming, mobile distributed computing, fast bulky file transfer and so on[1]. At 60 GHz there is much more free space loss than at 2 or 5 GHz since free space loss increases quadratically with frequency. In principle this higher free space loss can be compensated for by the use of antennas with more pattern directivity while maintaining small antenna dimensions.

For dense local communications, the 60 GHz band is of special interest because of the specific attenuation characteristic due to atmospheric oxygen of 10–15 dB/km. The 10–15 dB/km regime makes the 60 GHz band unsuitable for long-range (> 2 km) communications, so it can be dedicated entirely too short range (< 1 km) communications. The Microstrip antenna is fancied because of its numerous advantages such as low cost, ease of construction, light weight and so on. These advantages of Microstrip Antennas make them popular on many Wireless communication applications. The disadvantage of this antenna is its narrow bandwidth which can restrict its use in high frequency applications. This problem is overcome by the use of modified L-probe Feed. Each radiating antenna element of the array is fed by L-probe. An L-probe patch antenna array, fabricated on multilayer LTCC substrate was reported in [2]. Besides the microstrip patch antenna, the cavity array, the grid array and the slot array on LTCC substrate were also demonstrated to have acceptable performances [4]. The antenna array for 60 GHz applications is designed and fabricated using PCB technique is low in cost and ease of fabrication is there as given in [3].

In this paper, we present a 60GHz wideband Linear Microstrip Antenna Array. The wide bandwidth of the array is due to the modified L-Probe. A new coplanar waveguide (CPW) feed network is developed to excite the antenna array. Unlike the conventional CPW feed network, the fabrication process of the proposed network is simplified as no air bridge is required, while it maintains the advantages of the CPW line, including coplanar structure and less radiation loss.

The linearly polarized array exhibits wide band characteristics and also relative gain characteristics. Substrate used here is Sheldahl ComClad HF(tm). It has excellent electrical properties. It is especially attractive because of the combination of a dielectric constant of 2.6, a dissipation factor of 0.0025 and very low prices. It uses a common plastic as the base dielectric so designers can form, mould, bend & even insert-mould it in a plastic-injection process.

II. SINGLE ELEMENT AND FEED NETWORK

A. *Microstrip Antenna Element:*

Fig. 1 shows the L-Probe proximity-fed Microstrip Antenna

Element, which is composed of a radiating patch and an L- Shaped probe. Unlike the conventional L-Probe, which is placed beneath the radiating patch, the probe of this antenna has the vertical portion realized by a plated via hole (diameter D=0.3 mm) and the horizontal portion in the same layer of the radiating patch. The horizontal portion together with the radiating patch works as a CPW open-circuited stub, which introduces capacitance to cancel out the inductance caused by the vertical via hole. This method maintains the wideband characteristic of the patch antenna element. The antenna is fed

By a CPW line in the ground plane of the antenna. The Sheldahl Com Clad HF(tm) substrate with a thickness T=0.381 mm (0.0762 λ_o , λ_o is the free space wavelength at 60 GHz), metal thickness t=1/2 oz, dielectric permittivity ε_r =2.6 and loss tangent $\tan\delta$ =0.0028 at 60 GHz was chosen. Detailed dimensions of the antenna element are shown in Table 1. As shown in Fig. 2(a), this element exhibits a wide impedance bandwidth of over 31%. Fig. 2(b) depicts the return loss at 60 GHz.

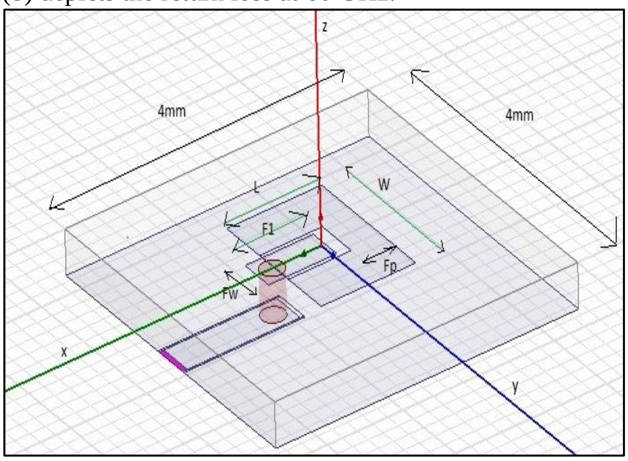


Fig. 1: Geomrtey of L-Probe Microstrip Antenna Element

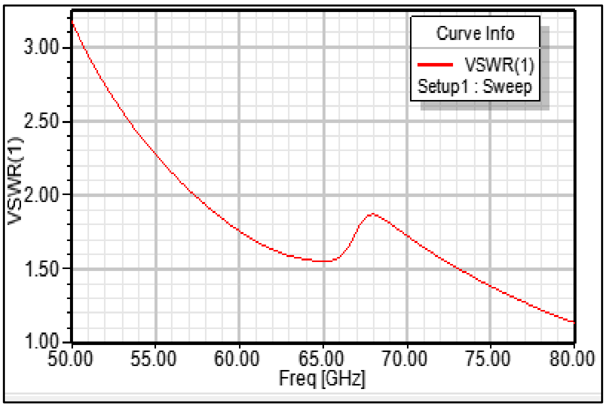


Fig. (a):

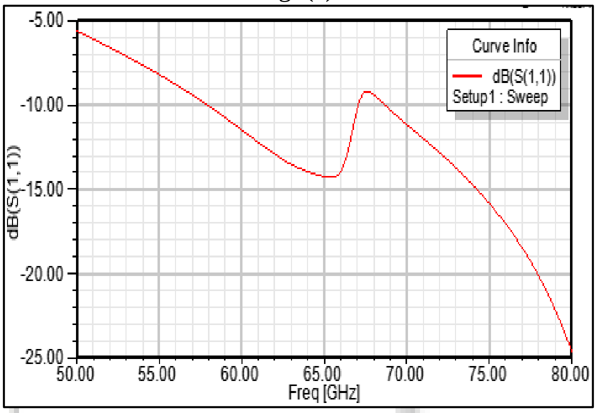


Fig. (b):

Fig. 2: Simulated results of L-Probe Micorstrip Antenna element (a)Impedance bandwith (b) Return loss

Parameters	**F_1**	**F_W**	**F_P**	**T**
Value in(mm)	O.9	0.45	O.425	0.381
in(λ)	0.27	0.13	0.13	0.11
Parameters	g_1	g_2	L	W
Value in(mm)	0.15	0.05	1.25	1.8
in (λ)	0.04	0.01	0.37	0.57

Table 1: Dimensions for Antenna Element

λ Is one electrical wavelength referring to 60 GHz

B. CPW Feed Network:

A coplanar waveguide (CPW) is a type of strip transmission line defined as a planar transmission structure for transmitting microwave signals. A CPW structure consists of a median metallic strip of deposited on the surface of dielectric substrate slab with two narrow slits ground electrodes running adjacent and parallel to the strip on the same surface. Beside the Microstrip line, the CPW is the most frequent use as planar transmission line in RF/microwave integrated circuits. CPW Feed line has many attractive features such as low loss, low dispersion, easy integration for monolithic microwave circuits (MMICs) and a simple configuration with single metallic layer.

The proposed coplanar waveguide feed network is a 4-way power divider. The CPW line is described as a center conductor strip separated by narrow gaps from two ground planes on both sides. Thus, a quasi-TEM wave can be guided in the gaps. The input CPW line is connected to the two coupled CPW lines through a transition that has two additional shorted-circuited slotline stubs. The transition transmits signal from the ground–signal–ground (GSG) input CPW line to two ground–signal–signal–ground (GSSG) coupled CPW lines. The other end of each coupled CPW line is connected to two output CPW lines (ports 2 and 4 or ports 3 and 5) by using a chamfered T-junction. The edge-coupled CPW comprises two parallel coupled strip conductors symmetrically located between two ground planes.

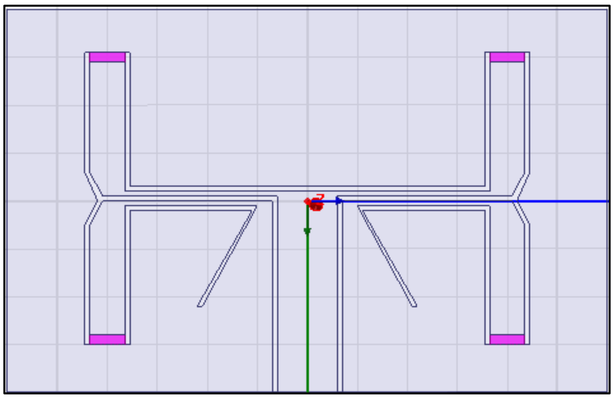


Fig. 3: Geometry of CPW Feed Network

Consequently, this network provides two pairs of differential outputs All gaps, are 0.05 mm. Fig. 4 shows the simulated -parameter results, including S11, S21, and S41. It is noted that S21 = S31 and S41 = S51 for this feed network. The insertion loss of the four output ports is about 7.58 dB from 50 to 70 GHz, which indicates that the designed 1:4 feed network can successfully divide an incoming signal into four outputs with generally equal amplitudes.

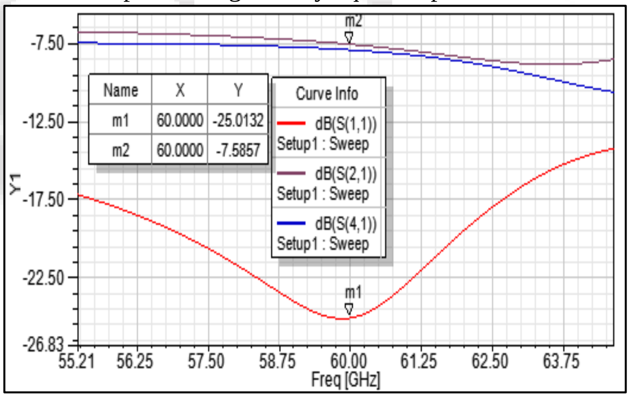
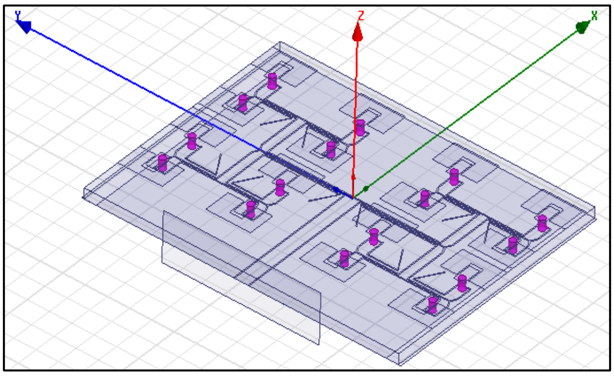


Fig. 4: Simulated Results of S-Parameters

III. LINEARILY POLARIZED ARRAY

A. Array Design:

An array with 2 x 2 L-shaped probe Microstrip Patch Antenna elements is designed as shown in Fig. 5. The 4-way power divider, as shown in Fig. 3, used to feed array of 4 x 4 elements, which are identical to the antenna shown in Fig. 1. Due to the differential outputs provided by the feed network, elements in pairs are placed opposite to each other and spaced with different distances. The reason is that enough space should be left for the CPW feed network. The inner conductor of the Input probe is connected to the input CPW line. This line, together with the feed network, is printed on the bottom side of the substrate. Thus, the antenna fixture is hollowed inside for ensuring the feed network be functioned properly.



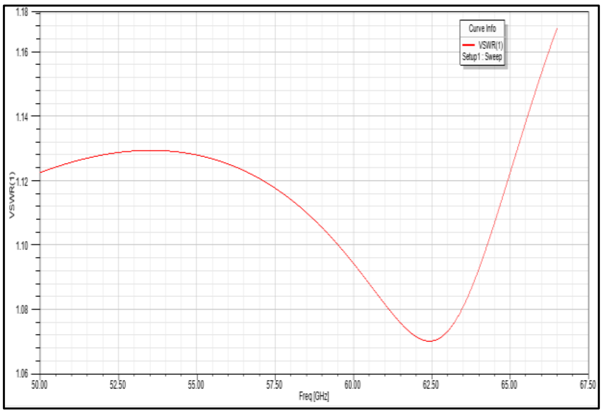


Fig. 6: VSWR Plot with the Frequency

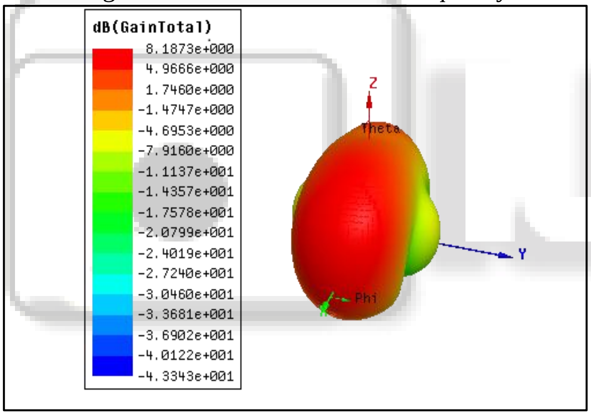


Fig. 7: 3-D Polar Plot of Array

B. *Array Performances:*

The simulation was worked out by the Ansoft HFSS Solution. The gain of the antenna is enhanced when arranged in an array, gain is increased 2-3 times when used in an array. Wide band with can be achieved by the use of CPW Feed network. Fig. 6 shows plot of VSWR with respect to frequency. Impedance bandwith of 30% is obtained. Fig.7 shows the polar plot having Gain of around 10 dB.

IV. Conclusion

A low-cost wideband L-Probe Microstrip Antenna Array at millimeter-wave band has been investigated. The single element was modified by placing the horizontal portion of the L-Probe at the same layer of the radiating patch. For exciting elements, a novel coplanar waveguide (CPW) feed network has been proposed. Compared with the conventional CPW feeding circuitry, this network has a simple structure and provides pairs of broadband differential outputs. Finally, 4 x 4 array with linear polarization was designed.

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