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# Grooved Linear Microstrip Patch Antenna Array

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***Abstract*—**A simple impedance matching technique for inset feed grooved microstrip patch antenna based on the concept of coplanar waveguide feed line has been developed and investigated for a printed antenna at X-Band frequency of 10GHz. The proposed technique has been used in the design of Linear Grooved Microstrip patch antenna array. The characteristics of the antenna are determined in terms of Return loss, VSWR, gain, radiation pattern etc. The measured and simulated results presented are found to be in good agreement.

***Keywords*—**Gain, Microstrip patch, return loss, VSWR, Radiation pattern, CPW Feed, Inset feed.

## INTRODUCTION

MICROSTRIP antennas offer attractive features such as low profile, light weight, easy fabrication and so on. But also possess major shortcomings such as narrow impedance bandwidth, low efficiency and gain, which seriously limit the application of the microstrip patch antennas. These limitations are due to impedance mismatch of the feeding circuitry. In order to match the element to the feeding circuitry the simplest matching method involves choosing the feed location where the resonant resistance is equal to feed-line impedance. In most application, the microstrip patch antenna is fed using either coaxial probe feed or inset microstrip line as both are direct contact methods providing high efficiency [1]. The Coaxial feeding method is used mostly for application such as active antennas while microstrip line feeding is used for high gain microstrip arrays. In both cases the position or inset length determines the input impedance. The grooved antenna as shown in Fig.1 is similar to a cavity backed antenna as proposed by saloon [2] which is a form of suspended antenna designed to achieve high bandwidth and gain but the proposed design suffers from complex impedance matching network.

In this paper we propose a simple method for designing the inset feed section of grooved microstrip patch antenna array to reduce the mismatch between the patch and feed network using the concept of CPW feed .The design of linear grooved array using the same method has also been presented .

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Input impedance of the inset fed microstrip patch antenna mainly depends on the inset distance $Y_o$ and to some extent on the inset width [3]. In most cases inset gap is set at least the same width as the feed line itself [4]. This method does not ensure that the inset feed section has the same characteristic impedance as the feed line resulting in an impedance mismatch between the feed line and the point where the feed line connects to the microstrip patch antenna

In order to overcome the problem of impedance mismatch between the feed line and the inset feed section for grooved microstrip patch a new model has been proposed using the concept of CPW feed line. The model developed as shown in Fig. 1 involves treating the inset feed section of the microstrip patch antenna as CPW (Coplanar Waveguide) feed line choosing the feed location where the resonant resistance is equal to CPW feed-line characteristic impedance.

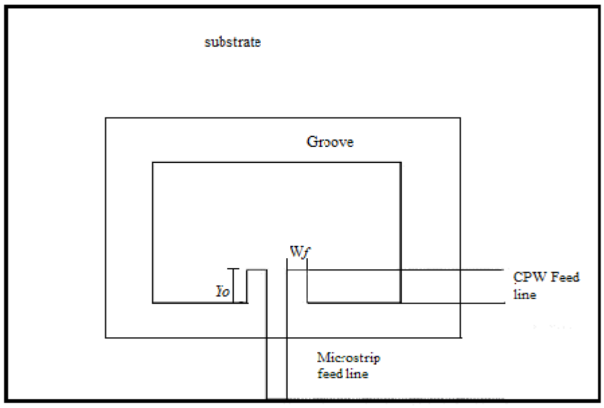


Fig. 1.Inset Feed Grooved Microstrip Patch designed model

The feed section is considered as a series combination of Microstrip line and the inset section as CPW feed line both of which are designed to have the same characteristic section the feed line width S is kept the same as the microstrip line width and the Slot width W which is also the inset width $W_f$ is changed to obtain the same characteristic impedance $Z_o$ as the Microstrip line as show in Fig.2.

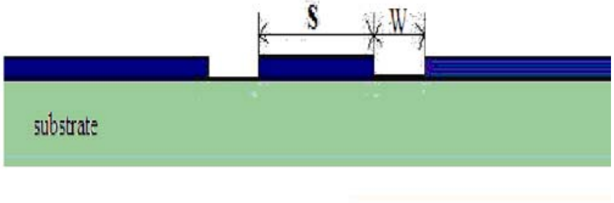


Fig.2 (a) Schematic of CPW feed

## II. GROOVED PATCH ANTENNA DESIGN

As stated earlier the grooved patch is similar to cavity backed antenna as shown in Fig.3(a) . In our simple design the inset section is considered as the series combination of Microstrip line and CPW feed line both of which are designed to have the same characteristic impedance $Z_o$ . For the design of CPW inset section the feed line width S is kept the same as the Microstrip line width and the Slot width W is changed to obtain the same characteristic impedance $Z_o$ as the Microstrip line.

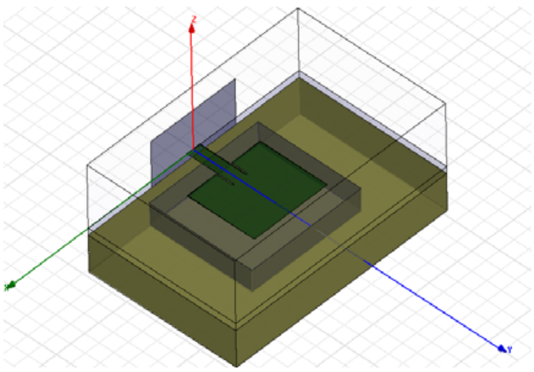

Fig. 3(a) Grooved Microstrip patch antenna with CPW inset feed

The transmission line model has been used for the design of rectangular patch antenna, as shown in Fig. 1 The substrate employed for grooved rectangular patch antenna is again the same Taconic TLC with $\varepsilon_r$=3.2, of thickness 0.79 mm. The grooved cavity has been created in copper metal that with length of 15mm, width of 17mm and height of 1.5mm.The inset distance is calculated again by means of a curve fit formula for 50 ohm input impedance [3].

The inset width $W_f$ which is also Slot width W was calculated using the design formula for CPW feed line [5]. For the inset section the feed line width S was kept the same as the Microstrip line width and the Slot width W was changed to obtain the same characteristic impedance of 50ohm. Fig. 3(b) shows the variation in characteristic impedance $Z_o$ with changes in inset width $W_f$ .

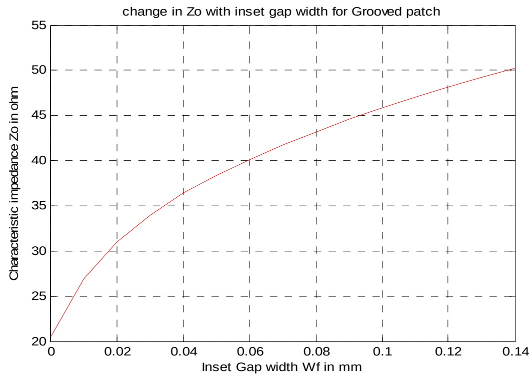


Fig. 3 (b) Characteristic impedance variation with Inset gap $W_f$ for GCPW feed line

## III. GROOVED PATCH ANTENNA DESIGN ARRAY

The same impedance matching technique was used in the design of 1×2 and 1×4 linear Grooved array as shown in Fig.4 (a-b) where centre to centre spacing between the elements was 0.67λ. The simulated results are summarized in Table II.

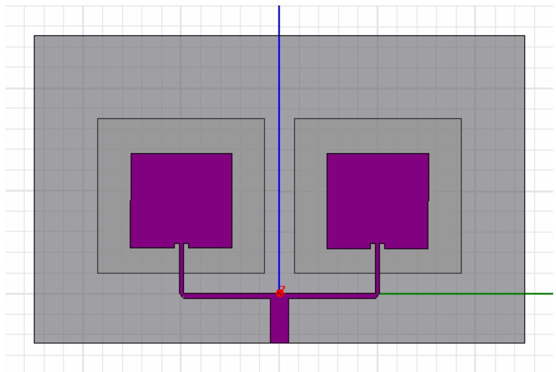

Fig. 4 (a) Grooved 1×2 linear Microstrip Patch Array with CPW inset feed

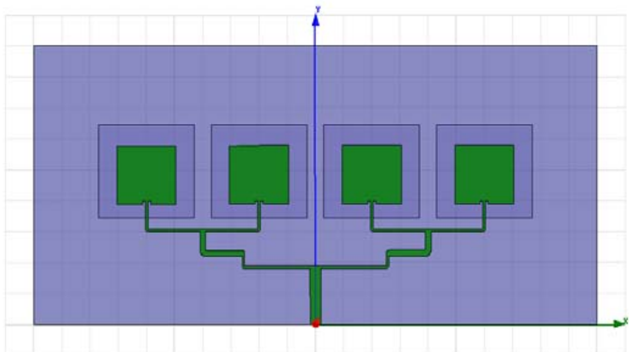

Fig. 4 (b) Grooved 1×4 linear Microstrip Patch Array with CPW inset feed

TABLE II
GROOVED MICROSTRIP PATCH ARRAY USING CPW CONCEPT

| Parameter | 1×1 | 1×2 | 1×4 |
|---|---|---|---|
| **Return loss (db)** | -28.79 | -15.83 | -28.51 |
| **VSWR** | 1.07 | 1.38 | 1.07 |
| **Gain (db)** | 8.45 | 10.77 | 13.09 |
| **Impedance bandwidth** | 12% | 12% | 12% |

## IV. RESULTS AND DISCUSSION

The characteristics of grooved patch antenna and array's are determined in terms of Return loss, and Gain using HFSS. Fig 5(a)-(d) shows the Return loss, VSWR, Radiation patterns Gain vs. Theta for the grooved patch respectively. The gain comes out to be 8.43dB which is comparable to suspended Microstrip patch antenna. The return loss is well below -20dB over the entire bandwidth. . The measured results as shown in Fig.8 (a-c) are found to be in good agreement with simulated results.

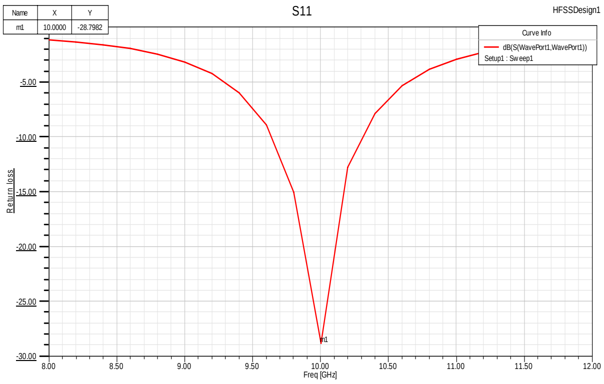


Fig. 5 (a) Return Loss of Grooved patch antenna

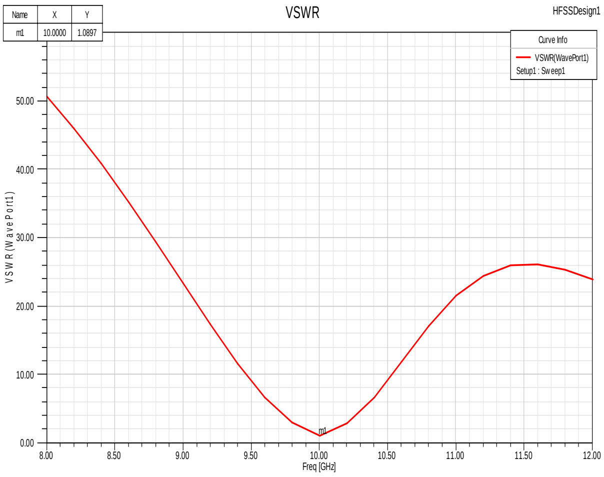


Fig. 5 (b) VSWR of Grooved patch antenna

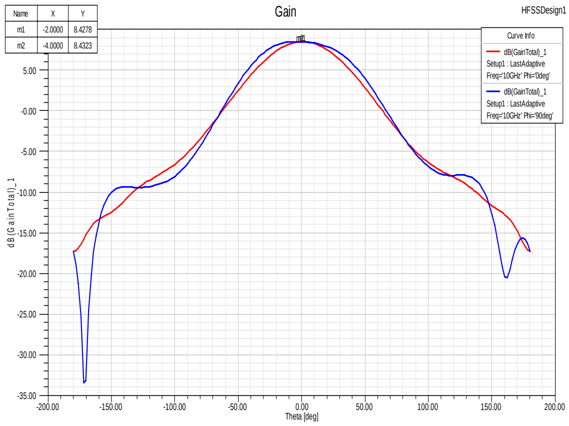


Fig. 5 (c) Gain of Grooved patch antenna

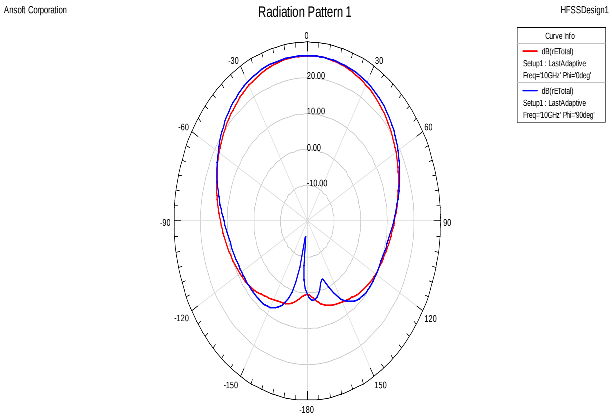


Fig. 5 (d) E & H- Plane Pattern of Grooved patch

Fig 6(a)-(d) shows the simulated results for 1×2 grooved array for which measured results as shown in Fig.9 (a-c) are found to be in good agreement with simulated results

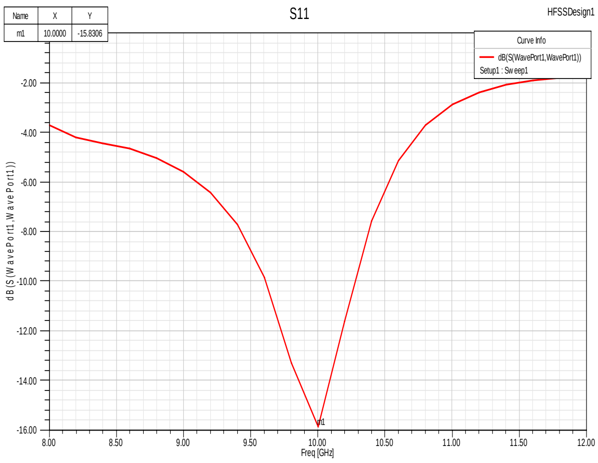


Fig 6 (a) Return Loss of 1×2 Grooved patch Array

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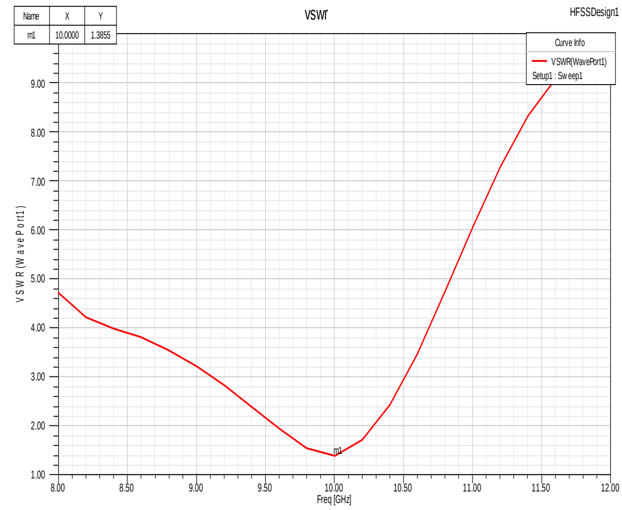


Fig. 6 (b) VSWR of 1×2 Grooved patch Antenna

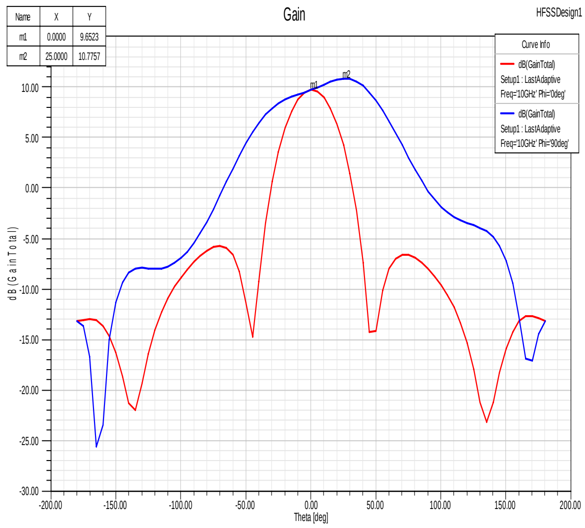


Fig. 6 (c) Gain of 1×2 Grooved patch Array

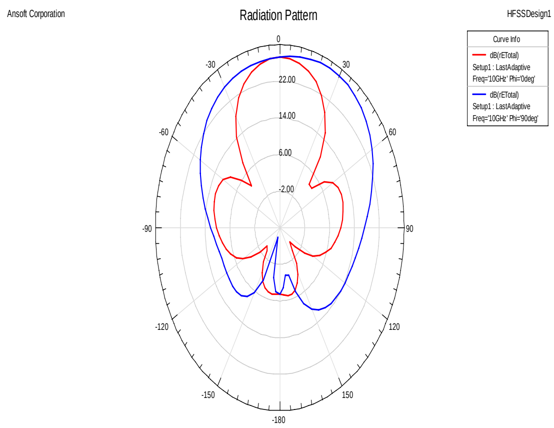


Fig. 6 (d) E & H- Plane Pattern of 1×2 Grooved patch Array

Fig 7(a)-(d) shows the simulated results for 1×4 grooved array for which measured results as shown in Fig.10 (a-c) are found to be in good agreement with simulated results

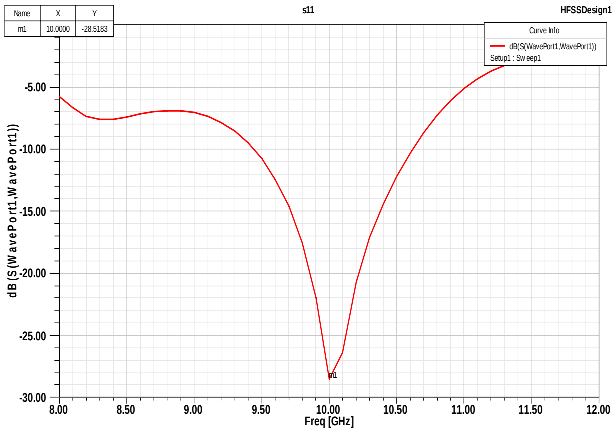


Fig 7 (a) Return Loss of 1×4 Grooved patch Array

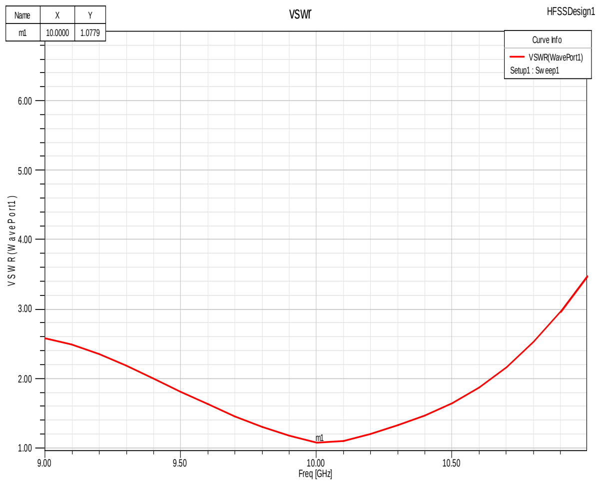


Fig. 7 (b) VSWR of 1×4 Grooved patch Antenna

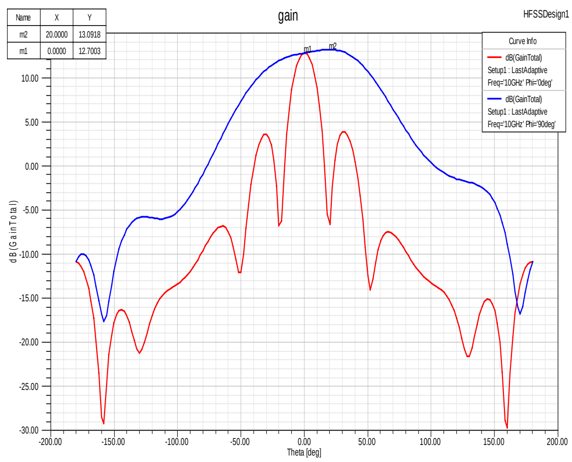


Fig. 7 (c) Gain of 1×4 Grooved patch Array

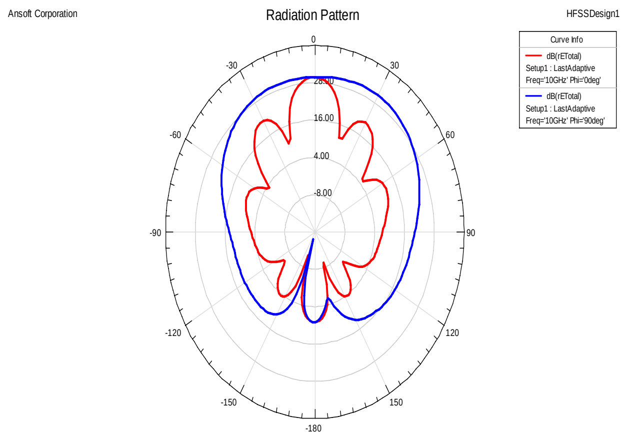


Fig. 7 (d) E & H- Plane Pattern of 1×4 Grooved patch Array

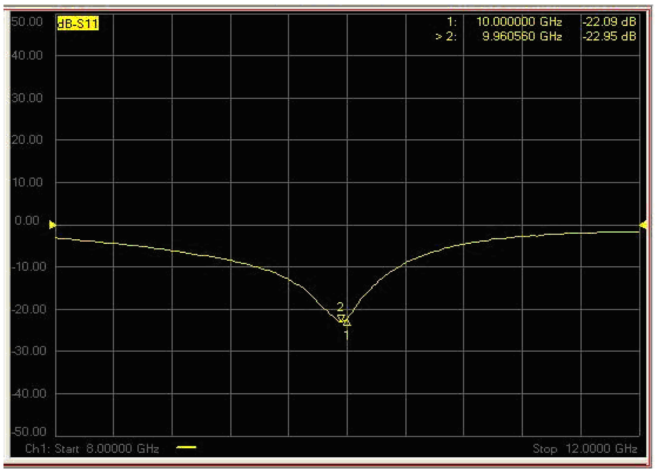


Fig. 8 (a) Measured Return Loss of Grooved patch

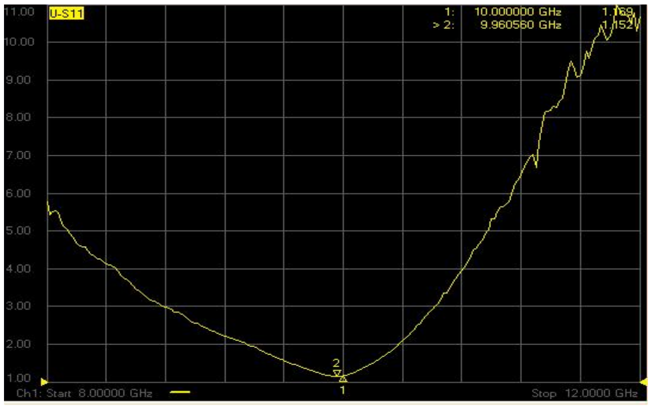


Fig. 8 (b) Measured VSWR of Grooved patch using CPW feed

As substrate height increases, the inset width $W_f$ required for achieving the desired characteristic impedance $Z_o$ also increases, however this doesn't create serious limitations for the design of grooved patch design using CPW feed line concept.

## V. CONCLUSION

The presented technique replaces the usual hit and trial method used in determining the inset gap with a method developed from concept of coplanar feed line. The newly developed method for designing the inset section of microstrip patch antenna using the concept of CPW has been successfully tested for single and linear grooved patch antenna array. The new technique is applicable to Grooved and Micromachined patch antennas

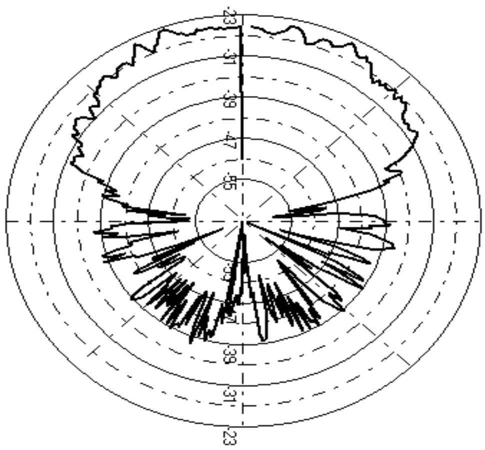


Fig. 8 (c) Measured H plane pattern of Grooved patch

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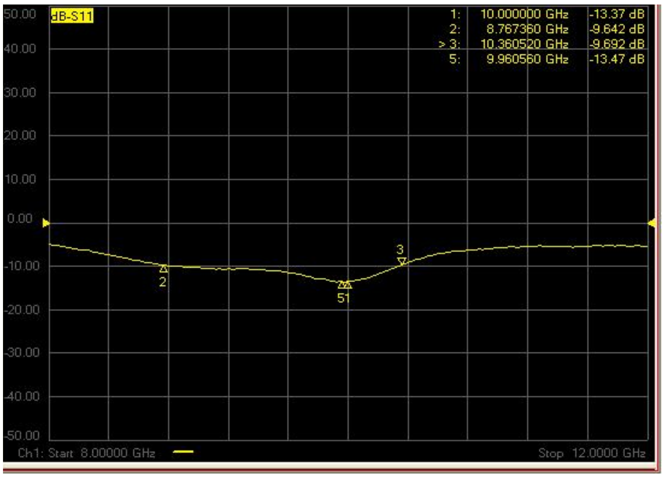


Fig.9 (a) Measured Return loss of 1×2 Grooved patch array using CPW Feed

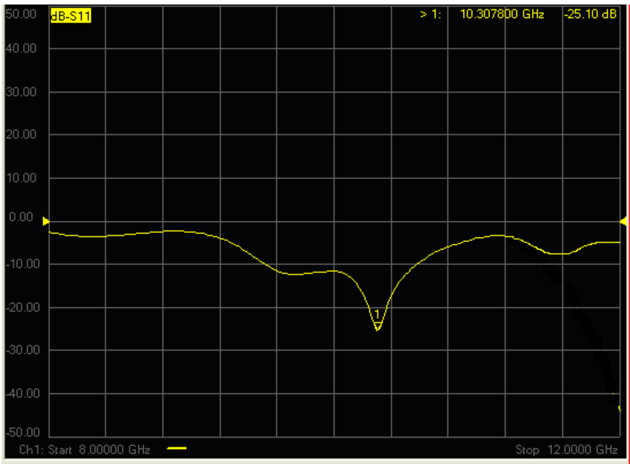


Fig. 10 (a) Measured Return loss of 1×4 Grooved patch array using CPW Feed

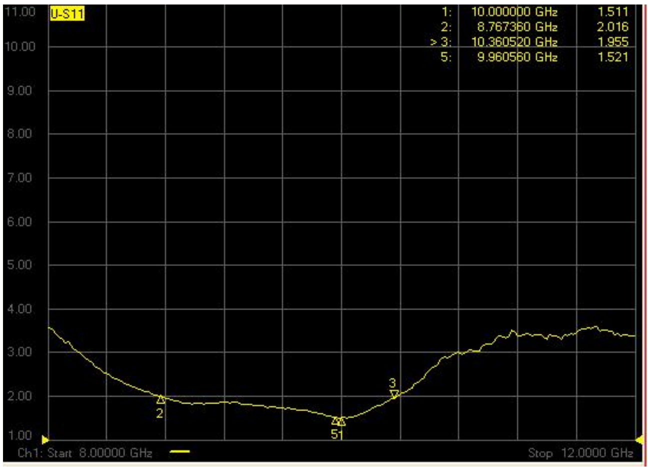


Fig. 9 (b) Measured VSWR of 1×2 Grooved patch array using CPW Feed

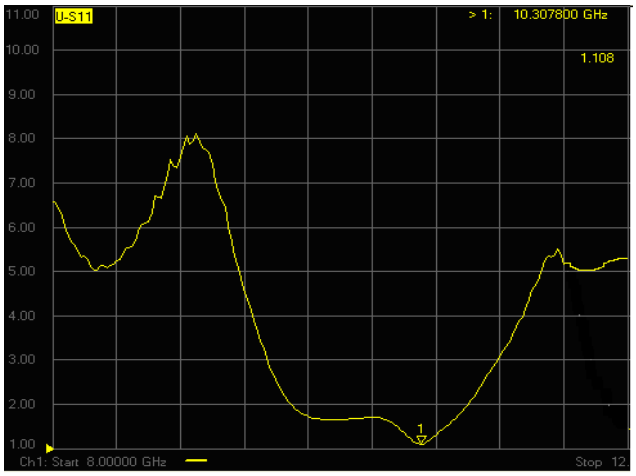


Fig. 10 (b) Measured VSWR of 1×2 Grooved patch array using CPW Feed

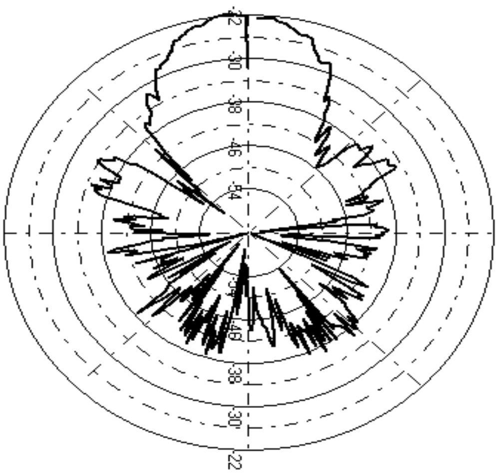

Fig. 9 (c) Measured H plane pattern of 1×2 Grooved patch array

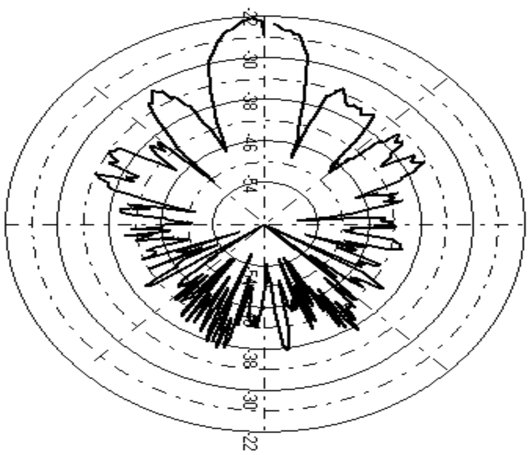

Fig. 10 (c) Measured H plane pattern of 1×4 Grooved patch array