Chapter 5

HIGH GAIN DIVERSITY ANTENNA WITH DUAL NOTCH CHARACTERISTICS

5.1 Introduction

MIMO antenna must possess wider bandwidth,higher channel capacity and high gain for wireless communication systems. For wide band applications interference from a strong narrow-band overload the receiver. Use of filter elements can acquire rejection characteristics. Additional filter device increases size, weight and complexity of the system. Hence antenna can be designed in such a way so that it can possess band reject characteristics for particular frequency band. This chapter discusses the design of MIMO antenna with dual notched characteristics.

5.1.1 Geometry and configuration of antenna

A simple square patch antenna with partial ground plane with simple line feed is used as basic structure. Both horizontal and vertical current elements i.e. dual polarization characteristics can be achieved by truncating all corners of radiating patch with $2mm$ï"$\frac{1}{2}$$2mm$ dimension. Distance between two radiating elements is kept as $\lambda/8$. For distance of $\lambda/8$ better isolation is achieved and it is shown in Figure 5.1. Table 5.1 shows dimensions of MIMO antenna. To reduce interference of signals in wide-band characteristics with other narrow-band systems, filtering technique is required. To

Parameter	W_g	L_g	W_f	S	L_p	Wp
Dimensions(mm)	9.79	47	2.8	0.7	13.2	11.6

Table 5.1: Dimensions of 2-element band notched MIMO antenna

create notch characteristics different slots have been etched (Figure 5.2.(a, b, c)). Radiating patch has slot etched on it, generates first notch (4.59 GHz to 6 GHz). To get second notch i.e. to reject signals at 8.92 GHz to 9.9 GHz another slot is etched on feed line.

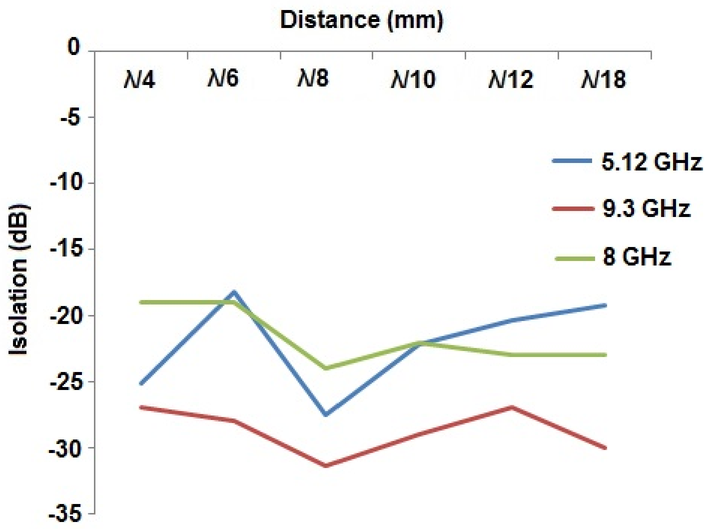

Figure 5.1: Isolation characteristics w.r.t. spatial distance between elements

Figure 5.3 represents the comparison of VSWR characteristics of various structures when different shapes of slot etched on radiating structure.Slot with smooth U shape gives band notched characteristics for 5.3 GHz (4.59 GHz to 6 GHz) required for WLAN rejection.

Figure 5.4 shows that the second notch is created by inserting one more U shape slot on microstrip feeding line. Parametric study has been done on length and width of U slots on feeding line. Though change in length of U shape slot does not affect notch characteristics but as width changes from 3 mm to 7 mm, the location of notch band changes(Figure 5.5).

The dimensions of optimized parameters for U shape slot on feeding line for rejecting 8.92 GHz to 9.9 GHz frequencies are $L_U = 4.605mm$, $W_U = 5mm$. Structure shown in Figure 5.5(d) shows optimized results which is chosen for fabrication.

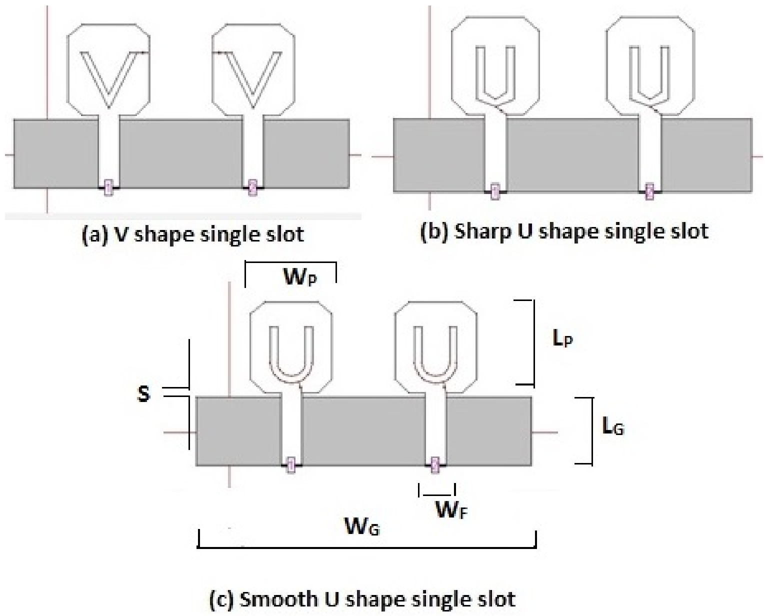

Figure 5.2: Basic structure of single notch antenna

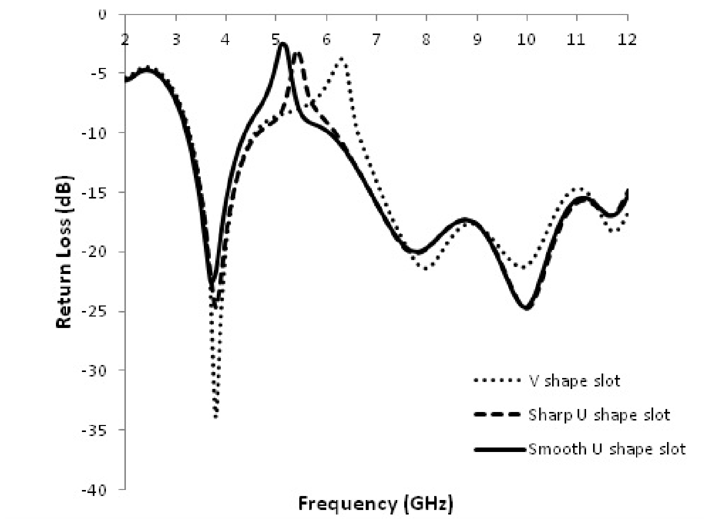

Figure 5.3: Comparative study of VSWR for various slot structures

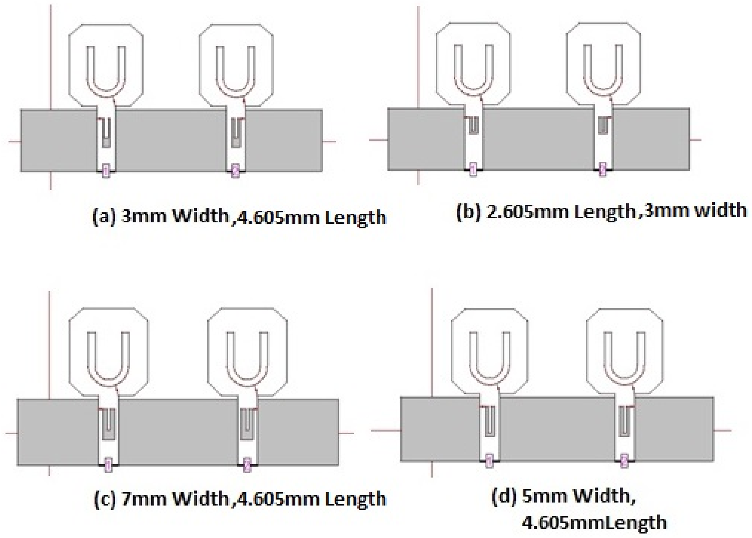

Figure 5.4: Different antenna configurations for creation of dual notch characteristics

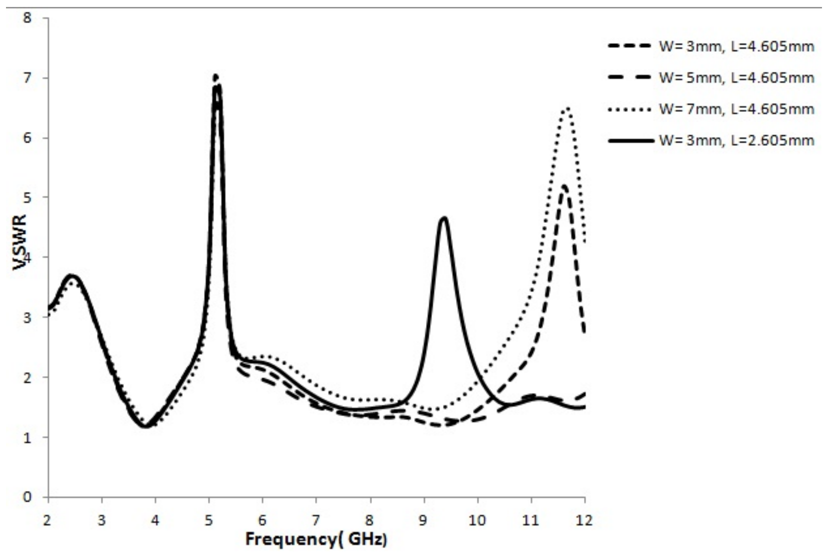

Figure 5.5: Comparative study of VSWR by changing lengths and width of slot on feed line

5.1.2 Results

FR4 substrate with h = 1.59 mm, ϵ_r = 4.4, $tan\delta$ = 0.002 is chosen for fabrication.The overall dimension of substrate is $47mm \times 25.7mm$. Figure 5.6 shows the fabricated notched MIMO antenna (top view and bottom view).

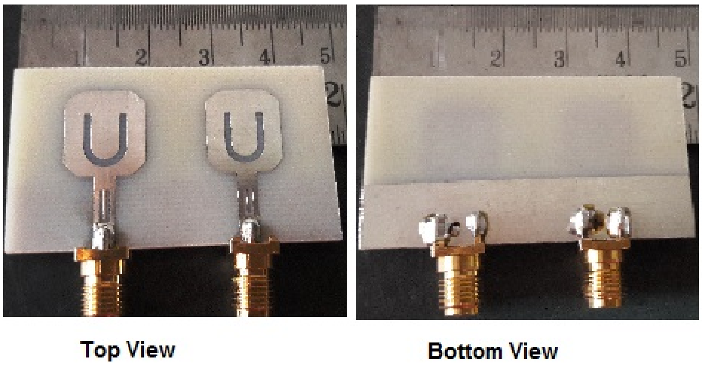

Figure 5.6: Fabricated MIMO antenna with dual notched characteristics

A. VSWR and isolation characteristics

Agilent N9925A (9 GHz) microwave vector network analyzer is used for measurement of notched and isolation characteristics for prototype. The VSWR characteristics (simulated and measured), impedance variation plot and insertion loss (isolation characteristics) for dual notch characteristics are shown in Figure 5.7 and Figure 5.8 respectively. Figure 5.9 describes impedance variation (real and imaginary) for proposed antenna which shows very high impedance for notched frequencies.

VSWR having value smaller than 2 is observed for entire operating frequency band except at notched locations. The notch is located at 4.59 GHz to 6 GHz (WLAN band) and 8.92 GHz to 9.9 GHz (Short range RADAR band) respectively. In MIMO antenna separation between two radiating elements is one of the important parameter for achieving good isolation. Hence two radiating elements are separated by $\lambda/8$ in proposed design. Simulated and measured results shows insertion loss is below -12 dB. The measured results are in good agreement with simulated results. Small variation in simulated and measured results may be due to losses in connector and variation in dielectric properties of the substrate.

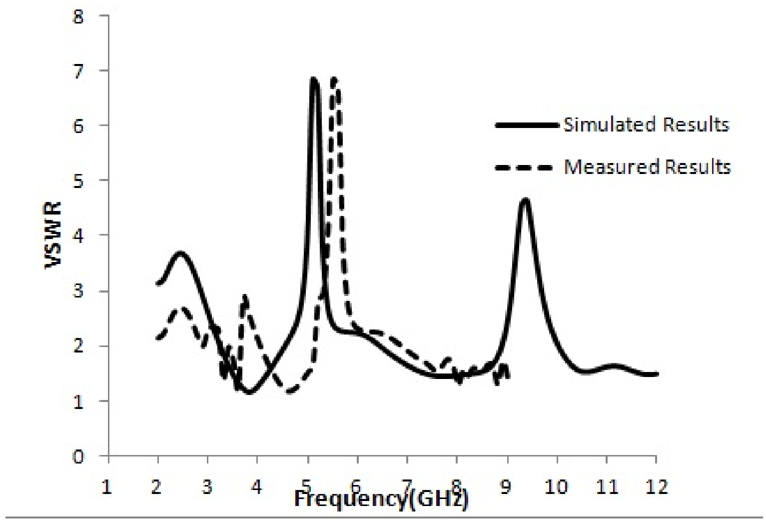

Figure 5.7: Comparative study of simulated and measured VSWR for dual notched MIMO antenna

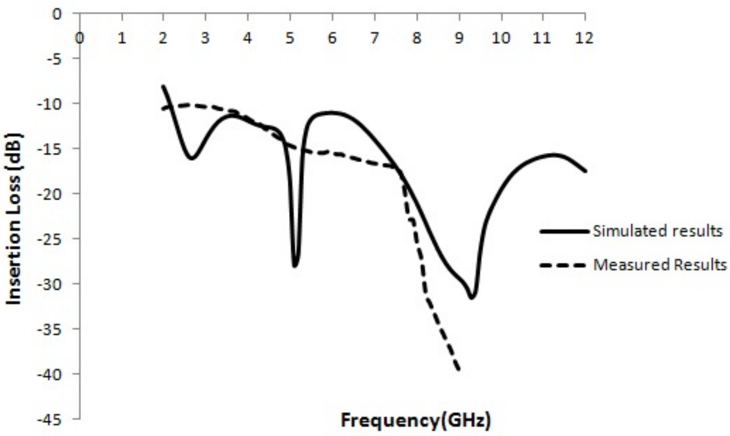

Figure 5.8: Isolation characteristics for dual notched MIMO antenna

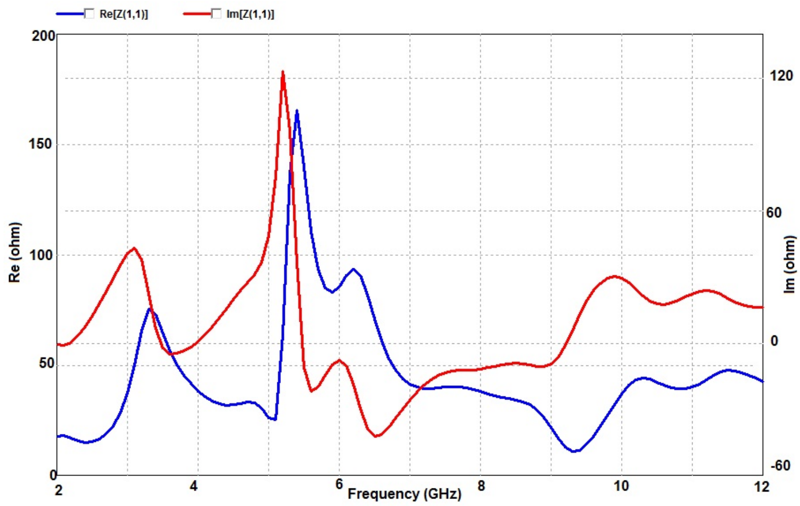

Figure 5.9: Impedance variation plots for dual notched MIMO antenna

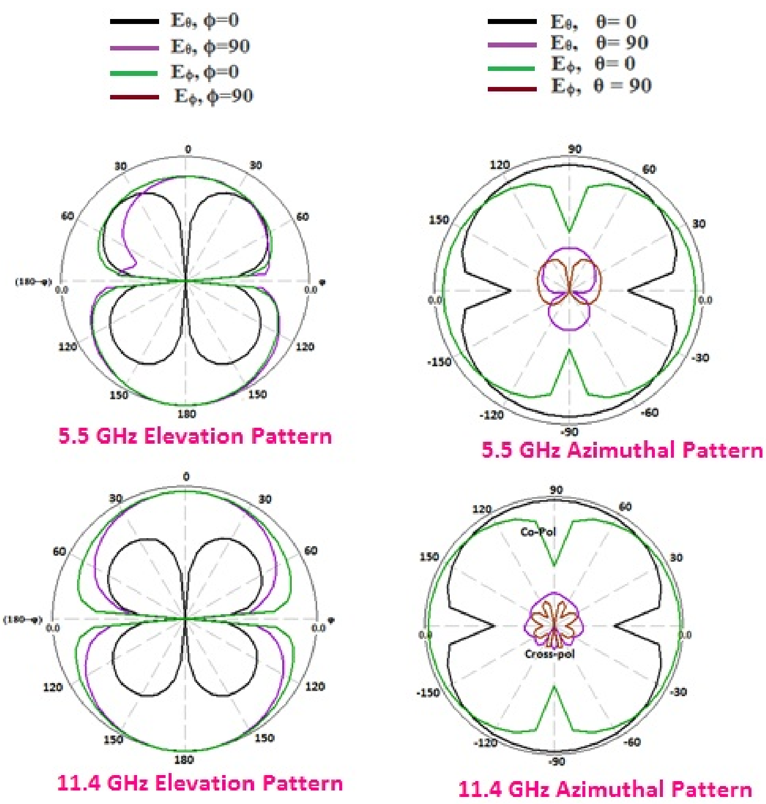

Figure 5.10: Radiation characteristics for dual notched MIMO antenna(E-plane and H-plane

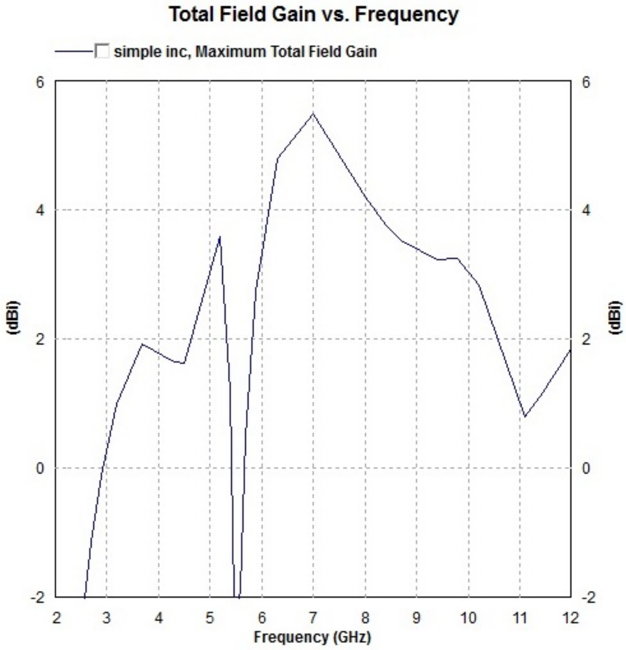

Figure 5.11: Gain variation of dual notched MIMO antenna

B. Radiation characteristics

Simulated gain characteristics as shown in Figure 5.10 shows gain varies from 2 dBi to 5.45 dBi across entire band with sudden drop at WLAN and short range RADAR band. Figure 5.11 shows sharp decrease in the radiation efficiency at both notched bands.In the operating band,the maximum radiation efficiency is 72%.

In Figure 5.12, radiation characteristics are shown for frequencies, 5.5 GHz and 11.4 GHz. H-plane pattern is omnidirectional in nature. In E-plane radiation pattern is shape of a figure of eight. Discrimination in Co-polarization and cross polarization is observed in E-plane as well as in H-plane characteristics.

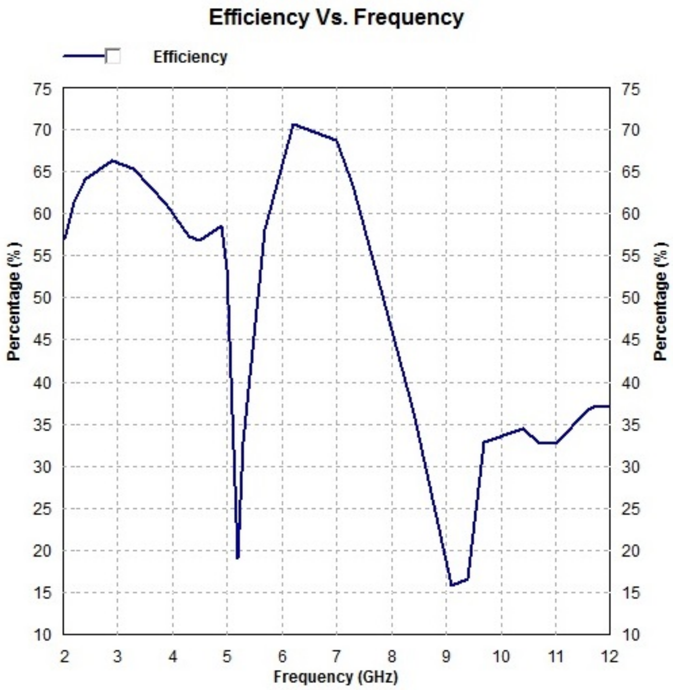

Figure 5.12: Radiation efficiency of dual notched MIMO antenna

C. Surface current distribution

The surface current distribution of dual notched MIMO antenna was studied by exciting port 1 while port 2 is terminated with 50Ω matched load. Figure 5.13 shows maximum amount of current is seen near the slots etched on radiating patch as well as on feed line. Some of the surface current flows from port 1 to port 2 through the ground reduces isolation between elements. Horizontal as well as vertical components of field are visible due to truncated corners of radiating patch.

Comparative study of proposed two element dual notched antenna with other structures

Proposed MIMO antenna gives two notches at frequency range for WLAN and short range RADAR application. At the same time it maintains less coupling between two radiating elements as well as possess high gain. This has been shown by comparing proposed structure with existing in literature and given in Table 5.2.

In this work, two frequency bands (WLAN and short range RADAR) are rejected at a time according to the required application. Proposed antenna shows better characteristics compare to existing ones [61 - 66] in terms of gain,isolation etc. In future work

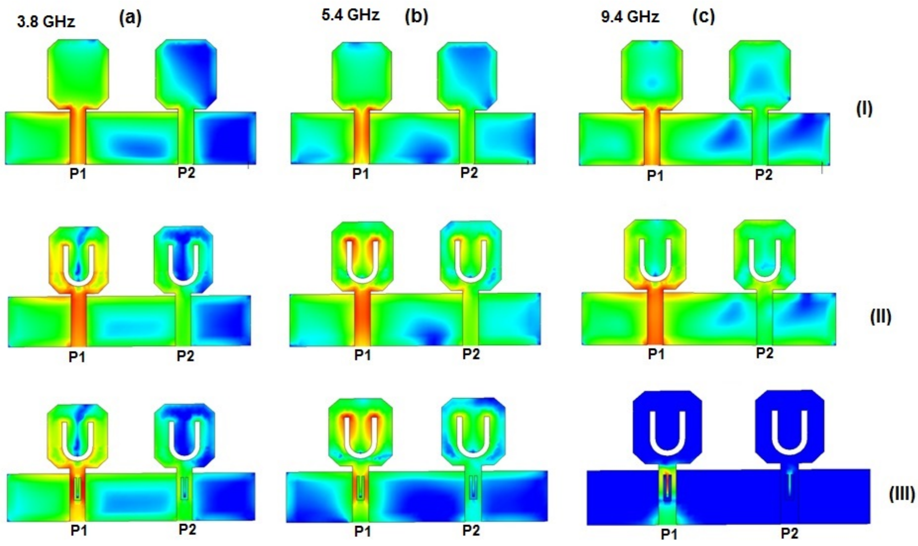

Figure 5.13: surface current distribution characteristics of dual notched MIMO antenna

References	Size (mm $\times mm$)	Rejected Band(GHz)	Isolation(dB)	Maximum Gain (dBi)	ECC
Ref.[61]	41×41	3.5/5.5	less than-15	3	-
Ref.[62]	Single element	3.375-3.945/5.425-6.150	-	4	-
Ref.[63]	30×30[$Single\ element$]	3.5/5.5/7.8	-	3.5	-
Ref.[64]	39×35	5-6/10-12	-	4	-
Ref.[65]	20×20[$Single\ element$]	3.3-3.6/5.15-5.85	-	4	-
Proposed	23×47	4.59-6/8.92-9.9	less than-10	5.45	0.00011

Table 5.2: Comparative study of proposed antenna with existing antenna from literature

re-configurable antenna for band notch application can be designed to extend range of applications. For higher frequency applications, bandwidth requirement is also higher. To extend range of applications beyond ISM band, WiFi, antenna structures can be designed for high frequency applications such as satellite communication with higher data rate. Next chapter proposes design of MIMO antenna for K/Ku band applications.