Circular Polarized Antenna for Video Surveillance Appliances

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Abstract
Video surveillance during natural calamities is crucial to rescue the survivors but the weather conditions make it hard to achieve effective communications between surveillance equipment and the controller. This research work addresses this problem by designing an antenna with high frequency(7.1-7.23) and circularly polarized antenna(LCHP) using FR4 epoxy substrate. The antenna has sufficient gain for effective communication 7.4dB. The antenna is easy to install and it has a low manufacturing cost.

Keywords: Metasurface, Video Broadcasting, antenna array, FR4 Epoxy, Circular polarization.
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Introduction
Video surveillance is one of the prime fields in this modern time. The main application of video surveillance is security monitoring, flood-survey during natural calamities[1-2]. In the old day, only static CCTV or any static devices are used for these kinds of applications. Wireless communication has enabled advanced technology such as UAV's with cameras, in the modern-day these kinds of devices are used widely for this kind of application[3]. The drawback of this wireless video surveillance technology is its limited quality of the video footage because to stream the high-quality video footage requires large bandwidth refer to table 1 and higher frequency[4]. To resolve this problem many companies started to use the frequencies without any established regulations, but this lead to a different kind of problem.

Table 1: Bandwidth required

Resolutions	Bandwidth [Mbps]
1280x720(HD)	3
1920x1080(FHD)	6
3840x2160(UH D)	25
4096x2160(4K)	32

Wireless communication has revolutionized other technological fields. As time evolve the requirement for various wireless services grown rapidly. Different industries started to use their standards sometimes this would cause ambiguity and poor communication between the devices. To prevent these problems the ITU has suggested some standards to use for various industrial applications. One of them is ITU-R BT.2069-7(10/2017) it specifies the frequencies that can be used for video broadcasting[5]. This research work concentrates on the 7.1-7.3 GHz band for the surveillance application. High-frequency communications are affected by the weather conditions such as fog and heavy rain[6]. This problem can be overcome by using the circular polarization concept[7-8]. A metasurface is used to achieve the required polarization[9-10].

Methodology

The antenna was designed and simulated using the HFSS software tools. A 1x2 antenna was designed for the frequency 7.15GHz having wide bandwidth. To achieve the wide bandwidth the split ring resonators (SRR) are used as resonating elements. These structures are etched on an FR4 substrate. After achieving the desired operating frequency and gain a metasurface is designed to achieve the polarization. The metasurface is consists of a double split-ring structure on an FR4 epoxy substrate layer of thickness 1.6mm. The dimensions of a single antenna are shown in fig 1 and table 2. A 1x2 array antenna is designed as shown in fig 2. The dimension and placement of the metasurface are as shown in fig 3. a gap with an optimized value is maintained in between the array and metasurface. This optimized value is obtained by tail and error procedure.

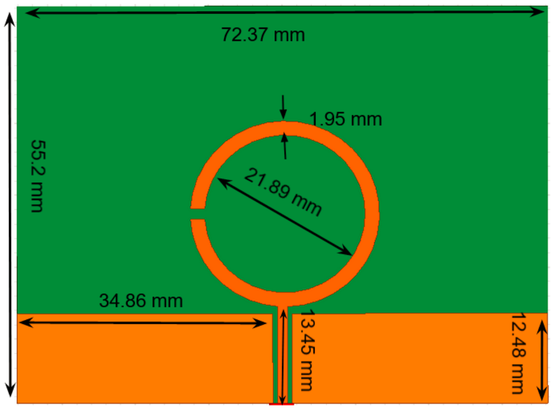
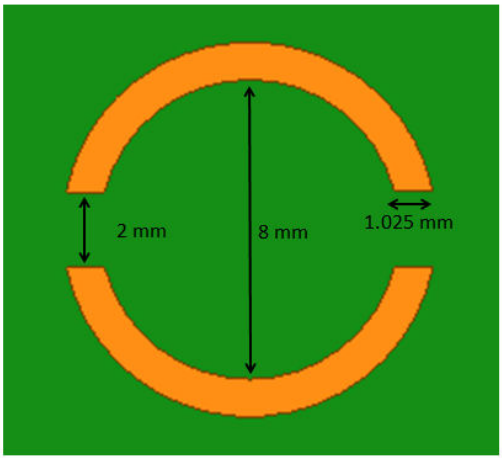


Fig 1: Antenna measurements

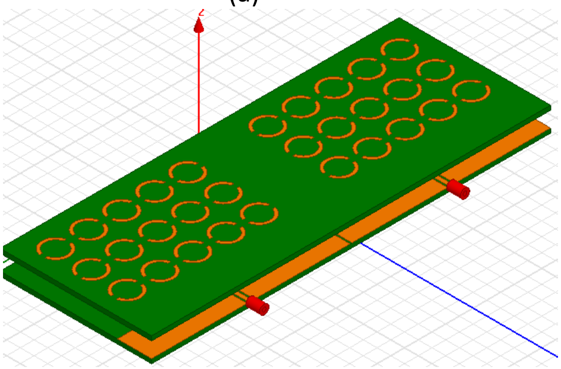
Table 2: Antenna measurements

Parameters	**Values [mm]**
Substrate length	72.37
Substrate width	52.2
Substrate Height	1.6
SRR Inner radius	21.89
SRR Width	1.95
Ground Length	34.86
Ground Width	12.48
Feed Length	13.45

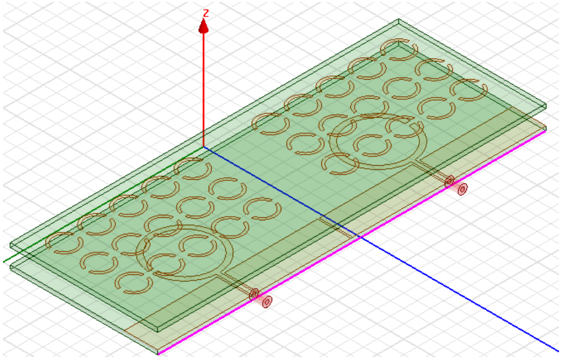
Fig 2: 1x2 antenna array



(a)



(b)



(c)

Fig 3: (a)Metasurface element,
(b)Metasurface on the array,
(c) arrangement of metasurface with the array.

The antenna and the metasurface will have a gap in-between this gap is optimized to obtain the maximum circular polarization.

Results

The 1x2 array antenna gives a bandwidth of 1.2GHz between 6.6GHz to 7.8GHz the centre frequency would be 7.2GHz with a 17.7dB return loss refer to fig 4, the gain of the array is 6.38dB refer to fig 5 and has radiation pattern as shown in fig 6. 1031

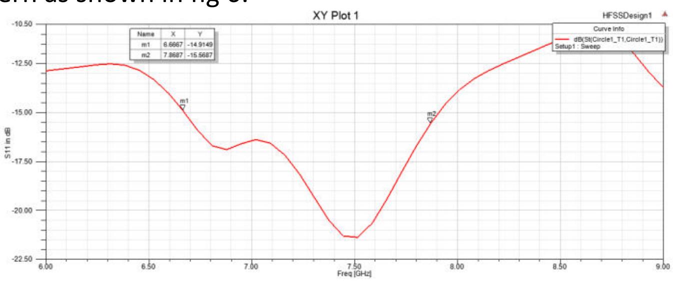


Fig 4: Return loss without metasurface

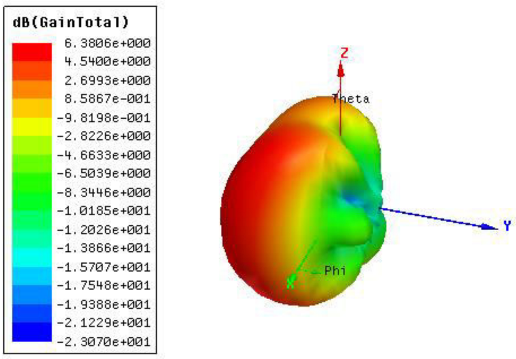


Fig 5: Gain without metasurface

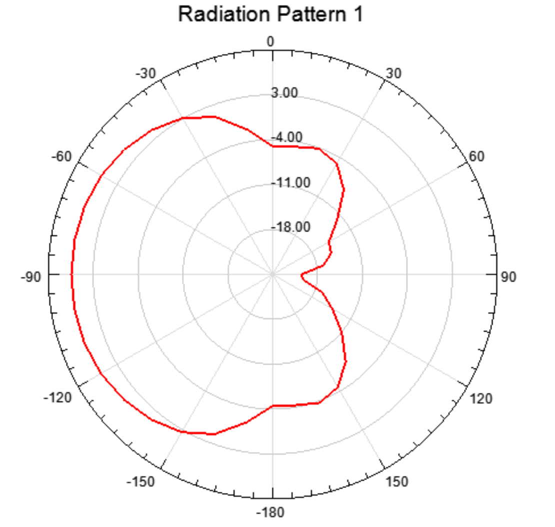


Fig 6: Radiation pattern without metasurface

The antenna has an axial ratio of about 18.53dB, it indicates there is no circular polarization at the required frequency band refer to fig 7.

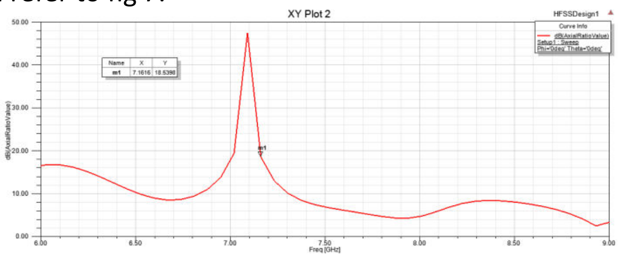


Fig 7: Axial ratio without metasurface

The metasurface is placed over the antenna with a pre-decided gap. At first glance, there is no change in the operating frequency or bandwidth refer to fig 8. But there is an increase in the gain of the antenna by 1.1dB with the same radiating pattern refer to fig 9.

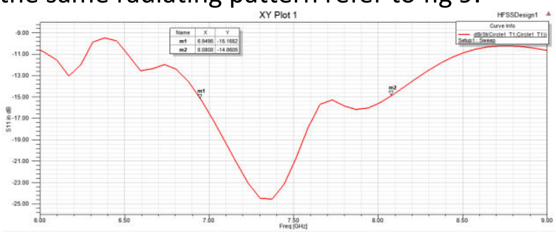
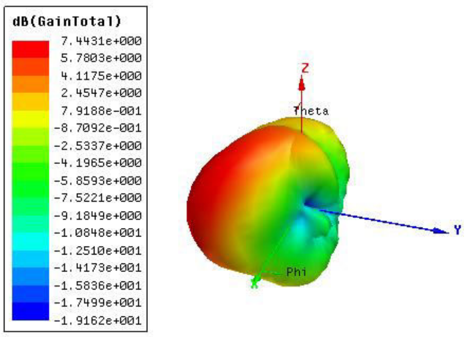
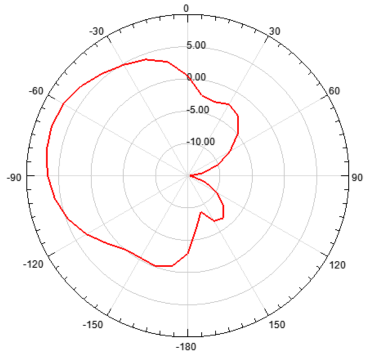


Fig 8: Return loss with metasurface



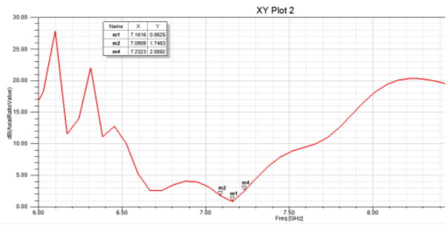
(a)



(b)

Fig 9: (a) Gain with metasurface, (b) Radiation pattern with metasurface

After the deployment of the metasurface, the radiation of the array becomes circularly polarized from 7.09GHz to 7.23GHz and it is evident by the axial ratio shown in fig 10(a). When the magnitude of left-hand circular polarized(LCHP) and right-hand circular polarization(RCHP) are measured the results shows that the most of radiation is LCHP (20.15) and there is only a tiny amount of radiation in RCHP (0.04) refer to fig 10(b).



(a)

Fig 10: (a) Axial ratio with metasurfaceThe gap between the antenna and metasurface is optimized using the trial and error method. The variations in the axial ratio were noted down at 7.16GHz for every 0.2mm step during the experiment refer to table 3. The observations were plotted for analysis refer to fig 11.

Table 3: Variation of axial ratio observations

Distance [mm]	Axial ratio [dB]
3.4	7.518
3.6	4.192
3.8	8.723
4	9.603
4.2	9.306
4.4	41.55
4.6	31.22
4.8	19.81
5	3.681
5.2	12.463
5.4	11.712
5.6	0.8625
5.8	11.221
6	18.736
6.2	11.745

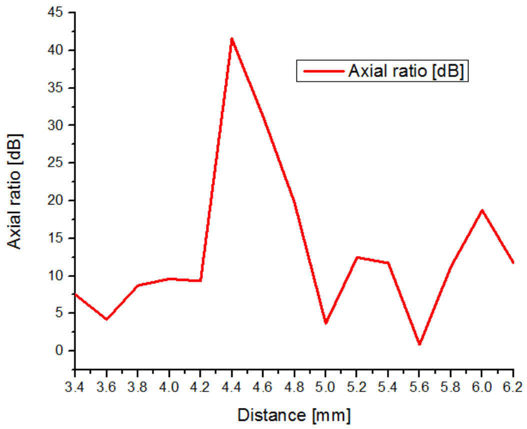


Fig 11: Variation of axial ratio

The optimum gap between the array and the metasurface is observed to be 5.6mm. Any other values will not produce circular polarization with the respective setup.
The antenna performance has been increased notably with the addition of metasurface refer to table 4. There is a change in overall bandwidth by 0.1GHz, but the gain has been increased by 1.06dB. In original the 1x2 array doesn't have circular polarization, after the addition of metasurface it gained the circular polarization property at frequency range 7.09GHz to 7.23GHz.

Table 4: Comparative analysis

Parameters	**Without metasurface**	**With metasurface**
Operating range	6.67GHz to7.86GHz	6.9GHz to 8GHz
Gain	6.38dB	7.44dB
Polarization	Linear polarization	Circular polarization (7.09GHz to 7.23GHz)

Conclusion
The proposed metasurface can produce circularly polarized radiation at frequency band 7.9GHz-7.23GHz. The circularly polarized antenna is immune to noise caused by extreme weather conditions and able to stream high-quality video. The antenna has sufficient gain for effective communication and compliance with the ITU suggested technical specifications. Hence the antenna can be used with any kind of UAV's which involve in video surveillance during natural calamities.

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