REFLECTOR ARRAY ANTENNA DESIGN AT MILLIMETRIC (MM) BAND FOR ON THE MOVE APPLICATIONS

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ABSTRACT
This paper presents a reflector array which is designed at mm band (79GHz) for the applications like, it is easy to achieve gigabit rates with the help of mill metric wave technologies and it includes video transmission from set-top-box (STB) to an HDTV. Here the reflector array is considered as receiving antenna and the transmitting antenna is taken as microstrip patch antenna and patch antenna with a coaxial feed. The simulations were done by using An-soft HFSSv13. The simulated array antenna is designed by using Rogers ultralam 1300 with dielectric constant 3mm.

Keywords: reflector array, mm-band, beam steering, HFSSv13.

INTRODUCTION
The antenna is characterized as a metallic device for emanating (or) accepting radio waves [1]. The array is nothing but the systematic arrangement of comparable objects, often in lines and segments. The antenna array is an arrangement of at least two (or) more antennas. Numerous applications require radiation characteristics that may not be accomplished by a solitary component along these lines, so array antennas are utilized [1]. A reflector is a specific intelligent surface used to divert light towards a given object (or) scene. Reflector antennas give correspondence over substantial measurements [1]. A reflector array antenna is a kind of directive antenna in which different driven components mounted on a level surface used to mirror the radio waves in the desired direction. Reflectarrays have gotten substantially more interest since they joined the advantages of reflector antennas and phased arrays [2] [7]. The advantage of using reflectarray rather than that of a reflector is, it is easy to fabricate, less weight and the scanning ability is high [8] [9] [10]. Antenna reflectors can exist as an independent gadget for diverting radio frequency energy. The scope of mm band is from 30GHz to 300GHz. Because of the high frequency of millimeter waves and their spread qualities make them helpful for applications including a huge measure of PC information, cellular communications, and radar. The explanations behind utilizing mm band are since there are a few restrictions in the lower frequency bands. The confinements are, the data transmission will be less on account of s-band, needs a bigger satellite dish on account of c-band, just a little portion (1.3GHz-1.7GHz) of L-band is designated to satellite communications and for the most part utilize very little business offerings in x-band. The applications for mm band are scientific research, broadcast communications, weapon framework, security screening, thickness gauging and drug.

Nowadays the parabolic reflector antennas are utilized because of high gain and its directivity. However, a portion of the power that gets reflected from the parabolic reflector is obstructed, because of the little measurement of the paraboloid. To overcome the above inconvenience, we are utilizing the square reflector and circular reflector.

DESIGN TOPOLOGY
This paper consists of a reflectarray antenna which is taken as a receiving antenna and the source antenna may be taken as microstrip patch antenna, the circular patch antenna, patch antenna and patch antenna with a coaxial feed. A reflector is designed by utilizing Ansoft HFSSv13. A reflectarray consists of six columns and each column consists of five patches and the feeding may be taken in a series manner. For reflectarray, the substrate is designed by using Rogers ultralam1300(tm) material with thickness 100µm and \( \varepsilon_r=3\text{mm} \) [3].

The length and width of the patch for the transmitting antenna are calculated by using the formulae shown below [4].

\[
W = \frac{V_o}{2F_r} \sqrt{\frac{2}{\varepsilon_r + 1}}
\]

Where \( v_o \) = velocity of light in free space.

\[
L = \frac{C}{2F_r \sqrt{\varepsilon_{\text{reff}}}} - 2\Delta l
\]

\[
\Delta l = 0.412h \left( \frac{\varepsilon_{\text{reff}} + 0.03(w + 0.26h)}{\varepsilon_{\text{reff}} - 0.258(w + 0.8h)} \right)
\]

Where \( \Delta l \) = Extension in length due to fringing effects
The effective dielectric constant is given by

\[
\varepsilon_{\text{reff}} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \left[ 1 + \left( \frac{12h}{w} \right)^{1/2} \right]^{-1/2}
\]
Figure-1. Layout of the square reflector array. Dimensions are $L=13.78\text{mm}$, $W=18.56\text{mm}$, $L_a=1.12\text{mm}$, $W_a=1.56\text{mm}$, $D_p=1.12\text{mm}$, $D_{a1}=2.12\text{mm}$, $D_{a2}=5\text{mm}$, $W_{ms}=244\mu\text{m}$, $L_1=1.7\text{mm}$, $L_2=2\text{mm}$, $L_3=0.7\text{mm}$, $L_4=2.85\text{mm}$, $L_5=7.15\text{mm}$, and $L_6=1.35\text{mm}$.

Similarly, the circular reflector has designed by using Ansoft HFSS and is as shown below.

Figure-2. Layout of the circular reflector array. Dimensions are $L=13.78\text{mm}$, $W=18.56\text{mm}$, $L_a=1.12\text{mm}$, $R_p=1.12\text{mm}$, $D_p=2.12\text{mm}$, $D_{a1}=3\text{mm}$, $D_{a2}=5\text{mm}$, $W_{ms}=244\mu\text{m}$, $L_1=1.7\text{mm}$, $L_2=2\text{mm}$, $L_3=0.7\text{mm}$, $L_4=2.85\text{mm}$, $L_5=7.15\text{mm}$, and $L_6=1.35\text{mm}$.

Now the microstrip patch antenna, patch antenna, circular patch antenna and patch antenna with a coaxial feed which is used as a transmitting antenna are shown below.

Microstrip patch antenna
Microstrip patch antenna is a printed kind of an antenna comprising a dielectric substrate sandwiched in the middle of a ground plane and a patch. Microstrip patch antenna is chosen because of the small gain and lower bandwidth. Microstrip patch antennas have many advantages when compared with other heavier type of antennas and they are light weight, low manufacture cost, low profile setup [4] [6].

Figure-3. Microstrip patch antenna. Dimensions are $L=6\text{mm}$, $W=7\text{mm}$, $L_1=1.081\text{mm}$, $W_1=1.377\text{mm}$, $L_2=1.2532\text{mm}$, and $W_2=0.2513\text{mm}$.

Circular patch antenna
Microstrip patch antennas are convenient to fabricate on a curved surface. Thus, the circular patch antenna is a kind of microstrip patch antenna. The advantages of using microstrip patch antenna are less cost, low size, and less weight. The disadvantages are low gain and lesser efficiency.

Figure-4. Circular patch antenna. Dimensions are $L=6\text{mm}$, $W=7\text{mm}$, $L_1=1.2532\text{mm}$, and $R=2\text{mm}$.

Patch antenna with a co-axial feed
The patch antenna is provided with a co-axial feeding because the impedance matching is easily obtained by altering the feed position. Impedance matching is the
most important factor to obtain the required bandwidth, otherwise, the efficiency will be lower [5].

A slot of width $x=0.1$ and $y=0.1$ has been kept on the radiating patch for better performance of the return loss and gain. Similarly, a slot has been kept on the patch for above antennas.

**RESULTS AND DISCUSSIONS**

Antenna performance is shown in terms of gain, directivity and radiation pattern and those parameters are shown for two reflectors which are considered as a receiving antenna and four antennas which are taken as a transmitting antenna.

**Measured return loss**

The return loss for the square reflector, circular reflector without slot and with slot by using microstrip patch antenna, a circular patch antenna, patch antenna and patch antenna with a coaxial feed is as shown below.

The above figure represents the return loss comparison of microstrip patch antenna, a circular patch
antenna, a patch antenna and patch antenna with a coaxial feed by using a square reflector without a slot. The return loss for patch antenna with coaxial feed is -10.3dB at 77GHz, for microstrip patch antenna is -11.75dB at 78.6GHz, for circular patch antenna, is -12.6dB at 69.5GHz and for patch antenna is -18.7dB at 74.9GHz.

Figure-9. Return loss for square reflector with a slot.

The above figure represents the return loss comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a square reflector with a slot. The return loss for patch antenna with coaxial feed is -10.53dB at 76GHz, for microstrip patch antenna, is -23.4324dB at 79.2GHz, for circular patch antenna is about -16.2592dB at 71.8GHz and for patch antenna is -20.25dB at 74.9GHz.

Figure-10. Return loss for circular reflector without a slot.

The above figure represents the return loss comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a circular reflector without a slot. The return loss for patch antenna with coaxial feed is -10.7dB at 69GHz, for microstrip patch antenna is -24.2dB at 73GHz, for circular patch antenna is about -18.35dB at 69GHz and for patch antenna is -11.1dB at 68GHz.

Figure-11. Return loss for circular reflector with a slot.

The above figure represents the return loss comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a circular reflector with a slot. The return loss for patch antenna with coaxial feed is -10.7358dB at 68GHz.

Total gain

The total gain for a square reflector, circular reflector without slot and with slot by using microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed is as shown below.

Figure-12. Gain plot for square reflector without a slot.

The above figure represents the gain comparison of microstrip patch antenna, a circular patch antenna, a
patch antenna and patch antenna with a coaxial feed by using a square reflector without a slot. The gain for patch antenna with coaxial feed is 8.9dB at 77GHz, for microstrip patch antenna is 7.6dB at 78.6GHz, for circular patch antenna is 7.9dB at 69.5GHz and for patch antenna is 7.6dB at 74.9GHz.

The above figure represents the gain comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a square reflector with a slot. The gain for patch antenna with coaxial feed is 9.1dB at 77GHz, for microstrip patch antenna is 9dB at 78.6GHz, for circular patch antenna is 6.36dB at 69.5GHz and for patch antenna is 9dB at 74.9GHz.

The radiation pattern for a square reflector, circular reflector without slot and with slot by using microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed is as shown below.

The above figure represents the gain comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a circular reflector with a slot. The gain for patch antenna with coaxial feed is 8dB at 77GHz, for microstrip patch antenna is 6.8dB at 78.6GHz, for circular patch antenna is 9.7dB at 69.5GHz and for patch antenna is 9.9dB at 74.9GHz.

The above figure represents the gain comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a circular reflector without a slot. The gain for patch antenna with coaxial feed is 9.95dB at 77GHz, for microstrip patch antenna is 5.8dB at 78.6GHz, for circular patch antenna is 9.6dB at 69.5GHz and for patch antenna is 9.9dB at 74.9GHz.

**Radiation pattern**

The radiation pattern for a square reflector, circular reflector without slot and with slot by using microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed is as shown below.
antenna, a patch antenna and patch antenna with a coaxial feed by using a square reflector without a slot. From the figure, it represents that it is having the omnidirectional radiation pattern which is suitable for RADAR applications.

Figure-17. Radiation pattern for square reflector with a slot.

The above figure represents the radiation pattern comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a square reflector with a slot. From the figure, it represents that it is having the omnidirectional radiation pattern which is suitable for RADAR applications.

Figure-18. Radiation pattern for circular reflector without a slot.

The above figure represents the radiation pattern comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a circular reflector with a slot. From the figure, it represents that it is having the omnidirectional radiation pattern which is suitable for RADAR applications.

E-Field

The E-field for a square reflector, circular reflector without slot and with slot by using circular patch antenna is as shown below.

Figure-19. Radiation pattern for circular reflector without a slot.

The above figure represents the radiation pattern comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a circular reflector with a slot. From the figure, it represents that it is having the omnidirectional radiation pattern which is suitable for RADAR applications.

Figure-20. E-field of circular patch antenna using square reflector without a slot.

The above figure represents the E-field of circular patch antenna by using a square reflector without a slot.
The above figure represents the E-field of circular patch antenna by using a square reflector with a slot.

**H-Field**

The H-field for the square reflector, circular reflector without slot and with slot by using circular patch antenna is as shown below.

The above figure represents the E-field of circular patch antenna by using a square reflector without a slot.

**CONCLUSIONS**

The reflector array antenna which is considered as a receiving antenna and the transmitting antenna is taken as a microstrip patch antenna, circular patch antenna, patch antenna and patch antenna with a coaxial feed is designed, simulated and compared. After comparison of all these antennas, microstrip patch antenna shows the better performance in terms of return loss, gain and radiation pattern at a frequency of 79GHz.

**FUTURE SCOPE**

The elements in the square and circular reflector has been designed with equal sizes and in future, the sizes and shapes of those elements may be varied which can be used for different applications.

**REFERENCES**


