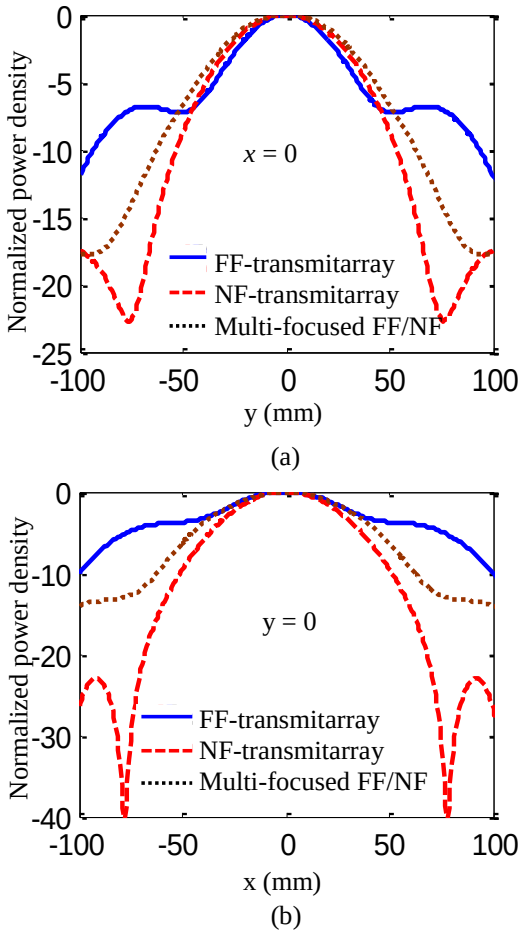

Figure 12: Simulated normalized power density along the transverse direction at R_o = 310 mm for the FF-focused transmitarray, NF-focused transmitarray, and dual-focused transmitarray from the antenna aperture (a) $x = 0$. (b) $y = 0$.

4. Design of NF/ NF and FF/FF dual- focused transmitarray

The previous concept is applied to obtain dual-focused in the near field region or dual-direction beams in the far field region. The design depends on the chess-board unit-cell element arrangement. The arrangement of the cells depends on the arrangement of the cells at different two distances in the Fresnel zone at R_o = 310 mm and R_o = 347 mm from the antenna aperture. Table 3 shows the phase distributions and corresponding hole radii for first quadrant of the NF/NF-Dual-focused transmitarray. The contour plot of the normalized power density in the x-y plane for the NF/NF-dual-focused transmitarray is shown in Fig.13. The contours of the power density for R_{o1} = 310 mm with -10 dB spot area of 48 mm × 45 mm are shown in Fig.13a. The contours of the power density for R_{o2} = 347 mm with -10 dB spot area of 57 mm × 50 mm are shown in Fig.13b. Design for FF/FF dual-focused transmitarray depends on rearranged for the cells in the array to get two beams at different angles ($\theta = 20^o$ and $\theta = -20^o$) using single structure. The chess-board design for FF/FF dual-focused transmitarray is the same as previous one except takes cell at $\theta = 20^o$ and the follow cell at $\theta = -20^o$ and then interchange the sequence to start with $\theta = -20^o$. Table 4 shows the phase distributions and corresponding hole radii for first half of the dual-direction beams transmitarray. The gain for $\theta = 20^o$ is 15 dB and for $\theta = -20^o$ is 17 dB. The 3D power pattern of dual beam transmitarray in the same structure is shown in Fig. 14. The HPBW is 8.6° and 8.5 ° for $\theta = 20^o$ and $\theta = -20^o$, respectively.

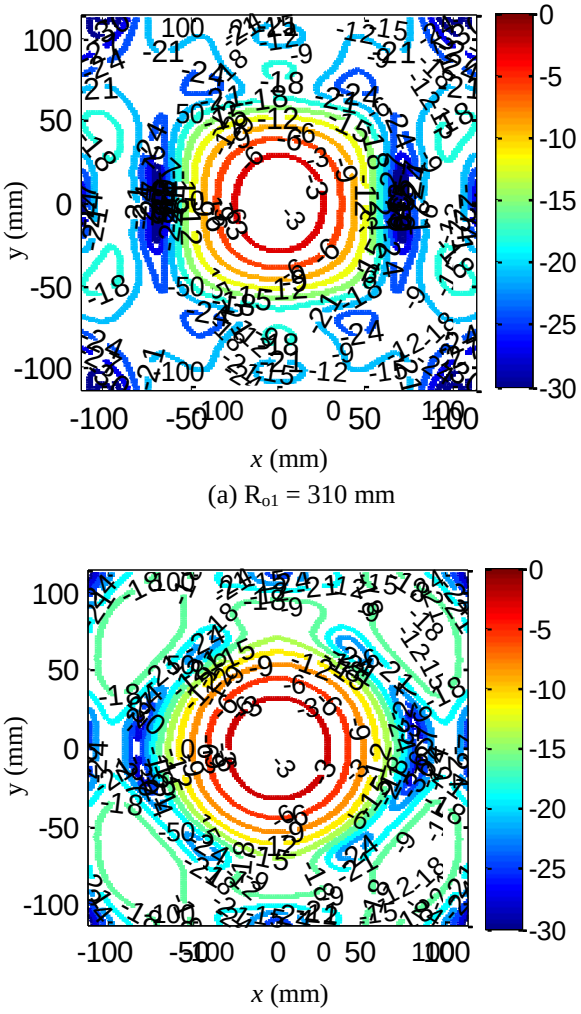

Figure 13: A contour plot of the simulated normalized power density of for the dual-focused transmitarray in a plane at (a) R_{o1} = 310 mm and (b) R_{o2} = 347 mm.

Table 2: The phase shift and the corresponding hole radius for FF/NF transmitarray (first quadrant).

306.00º 3.64 mm	313.67º 3.66 mm	353.92º 3.74 mm	14.12º 1.17 mm	134.71º 2.62 mm	130.24º 2.58 mm	360.38º 0.26 mm
313.67º 3.66 mm	330.02º 3.72 mm	344.11º 3.74 mm	64.86º 2.05 mm	72.94º 2.12 mm	248.86º 3.43 mm	213.61º 3.29 mm
353.92º 3.74 mm	344.11º 3.74 mm	41.34º 1.79 mm	43.73º 1.82 mm	180.70º 3.06 mm	158.36º 2.85 mm	404.29º 1.83 mm
14.12º 1.17 mm	64.86º 2.05 mm	43.73º 1.82 mm	157.76º 2.84 mm	130.24º 2.58 mm	338.27º 3.74 mm	267.59º 3.50 mm
134.71º 2.62 mm	72.94º 2.12 mm	180.70º 3.06 mm	130.24º 2.58 mm	316.07º 3.67 mm	240.75º 3.40 mm	533.81º 3.00 mm
130.24º 2.58 mm	248.86º 3.43 mm	158.36º 2.85 mm	338.27º 3.74 mm	240.75º 3.40 mm	512.45º 2.79 mm	12.12º 1.10 mm
360.38º 0.26 mm	213.61º 3.29 mm	404.29º 1.83 mm	267.59º 3.50 mm	533.81º 3.00 mm	12.12º 1.10 mm	382.88º 1.42 m

Table 3: The phase shift and the corresponding hole radius for NF/NF transmitarray (first quadrant).

306º 3.64 mm	317.56º 3 mm	353.92º 3.74 mm	48.99º 1.94 mm	134.71º 2.62 mm	226.4º 3.39 mm	360.38º 0.26 mm
317.56º 3.68 mm	330.02º 3.72 mm	363.52º 0.69 mm	64.86º 2.05 mm	138.56º 2.73 mm	248.86º 3.43 mm	355.15º 1.06 mm
353.92º 3.74 mm	363.52º 0.69 mm	41.34º 1.79 mm	94º 2.34 mm	180.7º 3.06 mm	269.7º 3.56 mm	404.29º 1.83 mm
48.99º 1.94 mm	64.86º 2.05 mm	94º 2.34 mm	157.76º 2.84 mm	226.4º 3.39 mm	338.27º 3.74 mm	439.13º 2.33 mm
134.71º 2.62 mm	138.56º 2.73 mm	180.7º 3.06 mm	226.4º 3.39 mm	316.07º 3.67 mm	397.32º 1.96 mm	533.81º 3.00 mm
226.4º 3.39 mm	248.86º 3.43 mm	269.7º 3.56 mm	338.27º 3.74 mm	397.32º 1.96 mm	512.45º 2.79 mm	243.03º 3.51 mm
360.38º 0.26 mm	355.15º 1.06 mm	404.29º 1.83 mm	439.13º 2.33 mm	533.81º 3 mm	243.03º 3.51 mm	382.88º 1.42 mm

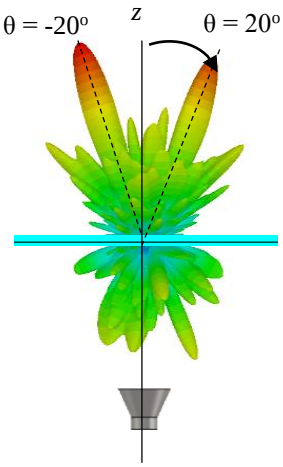

Figure 14: The 3D power pattern of dual beam transmitarray in the same structure.

Table 4: The phase shift and the corresponding hole radius for dual beam transmitarray (first half).

216.16º 3.3 mm	204.23º 3.24 mm	243.38º 3.41 mm	258.22º 3.47 mm	323.25º 3.7 mm	2.74º 0.44 mm	90.92º 2.27 mm
182.43º 3.08 mm	85.13º 2.23 mm	210.55º 3.28 mm	140.87º 2.67 mm	292.94º 3.59 mm	248.56º 3.43 mm	64.3º 2.05 mm
311.93º 3.66 mm	186.69º 3.12 mm	340.86º 3.74 mm	243.99º 3.41 mm	65.49º 2.06 mm	354.5º 3.74 mm	200.13º 3.22 mm
189.44º 3.15 mm	206.26º 3.2 mm	219.04º 3.32 mm	264.88º 3.49 mm	305.56º 3.64 mm	17.74º 1.27 mm	82.91º 2.21 mm
99.67º 2.34 mm	220.99º 3.32 mm	129.79º 2.58 mm	280.61º 3.55 mm	217.73º 3.31 mm	35.24º 1.7 mm	357.13º 3.74 mm
252.11º 3.45 mm	22.89º 1.42 mm	282.55º 3.56 mm	83.13º 2.22 mm	11.38º 1.06 mm	198.87º 3.21 mm	152.05º 2.79 mm
306º 3.64 mm	313.68º 3.66 mm	336.55º 3.74 mm	14.13º 1.17 mm	65.68º 2.06 mm	130.25º 2.58 mm	206.78º 3.26 mm
15.24º 1.21 mm	259.77º 3.47 mm	45.68º 1.85 mm	320º 3.69 mm	134.51º 2.62 mm	75.75º 2.15 mm	275.18º 3.53 mm
213.42º 3.29 mm	107.24º 2.4 mm	243.54º 3.41 mm	166.86º 2.39 mm	331.48º 3.72 mm	281.49º 3.55 mm	110.87º 2.42 mm
198.82º 3.21 mm	196.88º 3.2 mm	228.42º 3.36 mm	255.49º 3.46 mm	314.94º 3.67 mm	8.36º 0.89 mm	92.29º 2.29 mm
179.42º 3.06 mm	219.19º 3.68 mm	208.35º 3.27 mm	16.5º 1.24 mm	292.98º 3.59 mm	127º 2.56 mm	67.62º 2.08 mm
78.07º 2.18 mm	189.49º 3.15 mm	106.19º 2.39 mm	245.23º 3.42 mm	188.58º 3.14 mm	352.92º 3.74 mm	319.94º 3.68 mm
179.39º 3.2 mm	222.99º 3.33 mm	224.62º 3.34 mm	276.98º 3.54 mm	304.49º 3.63 mm	21.5º 1.39 mm	72.16º 2.12 mm

5. Conclusion

The paper introduces a single transmitarray antenna structure with dual-focus using the chess-board arrangement. The dual-focus of the transmitarray in near-field and a dual-beam directions in the far-field are designed. The transmitarray consists of 13×13 unit-cell elements made of a perforated dielectric sheet. Different transmitarrays with dual-focus in the NF/NF, FF/FF, NF/FF and FF/NF regions are designed using the chess-board arrangement. The FF/NF-focused transmitarray introduces a maximum gains of 23.45 dB/17.26 dB with a side lobe level of -15.7 dB/-8 dB in the E-/H-plane. In the same structure the array produced power density closer to each other with -10 dB spot area of 63×60 mm^2 at a distance R_o = 310 mm. The NF/NF transmitarray with power focused in two near field distances at R_{o1} =310 mm and R_{o2} =347 mm is designed. Finally, dual-beam transmitarray is proposed to obtain two beams in different directions with angles 20º and -20º in the same structure using the chess-board arrangement. The maximum gains for beam at θ = 20º is 15 dB and for the beam at θ = -20º is 17 dB.

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