HACETTEPE UNIVERSITY
ELECTRICAL-ELECTRONICS ENGINEERING

REFLECTARRAY ANTENNA DESIGN FOR X-BAND APPLICATIONS USING 3D PRINTER

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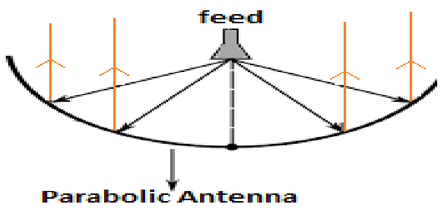
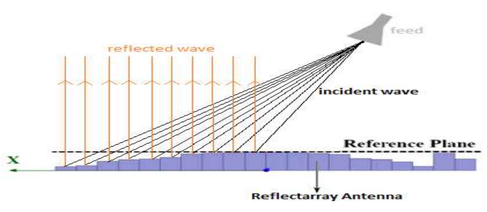
What Is the Reflectarray Antenna?

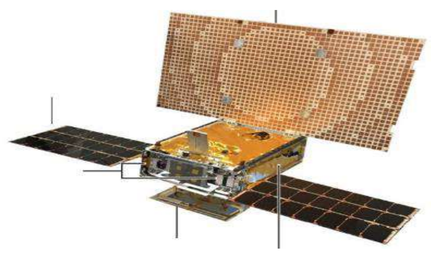
- The reflectarray is an antenna with a reflecting surface consisting of hundreds of elements on its aperture where the elements are designed to incident field with certain phase shift in order to collimate the beam in the desired direction.Reflectarray acts as a parabolic antenna.

Reflectarray Antenna vs. Parabolic Antenna

❖ Parabolic antennas are too large and heavy due to their curved reflecting surfaces but reflectarrays are light weight,simple manufacturing,low profile and low cost.Besides,reflectarray antennas have lower gain according to parabolic antennas.



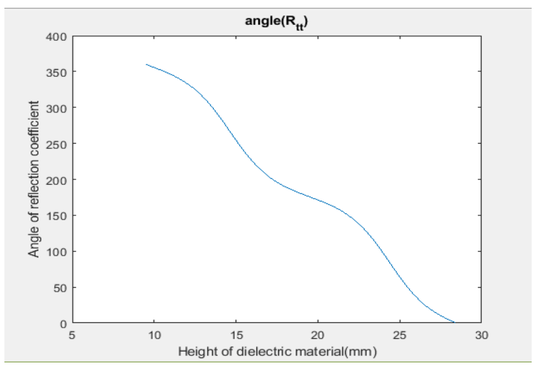


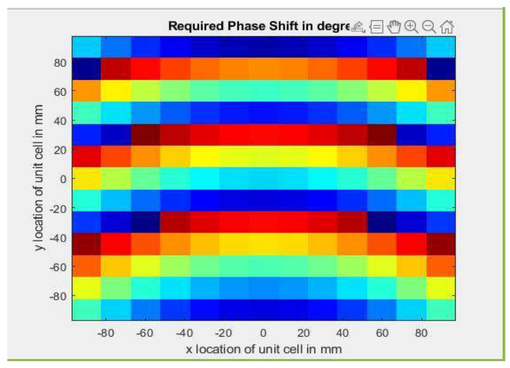


Theorethical Calculations and Design of Reflectarray

❖ Variable height dielectric elements are used in the reflectarray designs to beam steering.The height of each element is determined according to required phase shift and the reflection phase curve.

❖ The dielectric reflectarray has a square aperture with a side length of 19.5 cm and 13x13 = 169 variable height dielectric elements.





Y/X	1	2	3	4	5	6	7	8	9	10	11	12	13	Color Legand
1	155,86	118,87	88,59	64,55	47,45	37,16	33,72	37,16	47,45	64,55	88,59	118,87	155,86	360,00
2	214,69	178,15	148,04	124,49	107,60	97,44	94,05	97,44	107,60	124,49	148,04	178,15	214,69	330,00
3	279,35	243,29	213,58	190,36	173,70	163,67	160,33	163,67	173,70	190,36	213,58	243,29	279,35	300,00
4	349,63	314,07	284,79	261,90	245,48	235,60	232,31	235,60	245,48	261,90	284,79	314,07	349,63	270,00
5	65,29	30,26	1,43	338,88	322,72	312,99	309,75	312,99	322,72	338,88	1,43	30,26	65,29	240,00
6	146,09	111,62	83,24	61,05	45,15	35,58	32,39	35,58	45,15	61,05	83,24	111,62	146,09	210,00
7	231,81	197,90	169,99	148,17	132,54	123,14	120,00	123,14	132,54	148,17	169,99	197,90	231,81	180,00
8	322,20	288,86	261,43	240,00	224,64	215,39	212,31	215,39	224,64	240,00	261,43	288,86	322,20	150,00
9	57,05	24,27	357,33	336,28	321,19	312,12	309,09	312,12	321,19	336,28	357,33	24,27	57,05	120,00
10	156,07	123,91	97,45	76,78	61,97	53,07	50,10	53,07	61,97	76,78	97,45	123,91	156,07	90,00
11	259,11	227,54	201,57	181,29	166,76	158,02	155,10	158,02	166,76	181,29	201,57	227,54	259,11	60,00
12	5,93	334,95	309,46	289,57	275,31	266,74	263,88	266,74	275,31	289,57	309,46	334,95	5,93	30,00
13	116,32	85,92	60,92	41,41	27,43	19,03	16,22	19,03	27,43	41,41	60,92	85,92	116,32	0,00

Y/x	1	2	3	4	5	6	7	8	9	10	11	12	13
1	21,45	23,29	24,25	24,99	25,55	25,98	26,11	25,98	25,55	24,99	24,25	23,29	21,45
2	16,44	19,18	21,94	23,07	23,66	23,99	24,1	23,99	23,66	23,07	21,94	19,18	16,44
3	14,24	15,35	16,5	17,95	19,75	20,81	21,1	20,81	19,75	17,95	16,5	15,35	14,24
4	10,69	13,01	14,07	14,78	15,27	15,62	15,73	15,62	15,27	14,78	14,07	13,01	10,69
5	24,97	26,27	28,31	11,64	12,61	13,05	13,19	13,05	12,61	11,64	28,31	26,27	24,97
6	22,08	23,53	24,41	25,2	25,65	26,04	26,17	26,04	25,65	25,2	24,21	23,53	22,08
7	15,76	17,37	20,17	21,98	22,74	23,13	23,24	23,13	22,74	21,98	20,17	17,37	15,76
8	12,62	13,94	14,78	15,46	16,03	16,4	16,55	16,4	16,03	15,46	14,78	13,94	12,62
9	25,23	26,59	9,818	11,8	12,67	13,04	13,22	13,04	12,67	11,8	9,818	26,59	25,23
10	21,44	23,1	23,98	24,6	25,07	25,38	25,47	25,38	25,07	24,6	23,95	23,1	21,44
11	14,86	15,91	17,14	18,78	20,5	21,28	21,49	21,28	20,5	18,78	17,14	15,91	14,86
12	27,86	11,91	13,2	13,91	14,34	14,62	14,72	14,62	14,34	13,91	13,2	11,91	27,86
13	23,37	24,33	25,1	25,77	26,3	26,88	27,02	26,88	26,3	25,77	25,1	24,33	23,37

❖ You can see the values of phase shift angles(left bottom)and the heights of each dielectric cells(right bottom).

❖ Also,it is necessary to use the following equation to calculate the phase shift angles of each dielectric slab.

❖ k0=propagation constant in vacuum;

❖ r0=unit vector in the desired direction of the main beam

❖ ri=position vector from the center of the reflectarray plane to ith radiating element

❖ di=distance from the feed to ith element

$$\phi_i = k_0(d_i - \vec{r_i} \cdot \hat{r_0}) + 2\pi N; \quad N = 0, 1, 2, \ldots, \qquad (1)$$

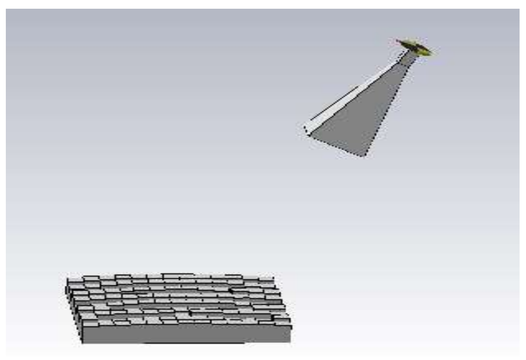
Application Areas

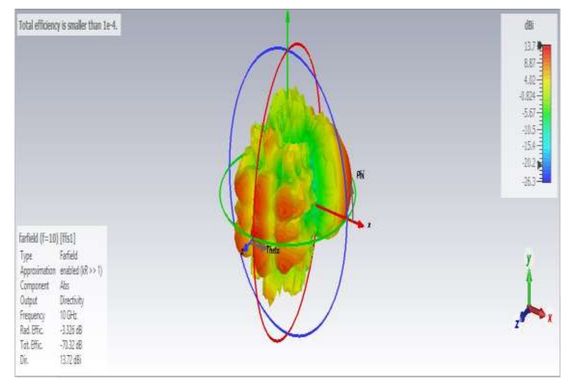
❖ Reflectarray antennas are used for point-to-point communications, wireless WAN/LAN links for data communications,satellite communications and spacecraft communication antennas.

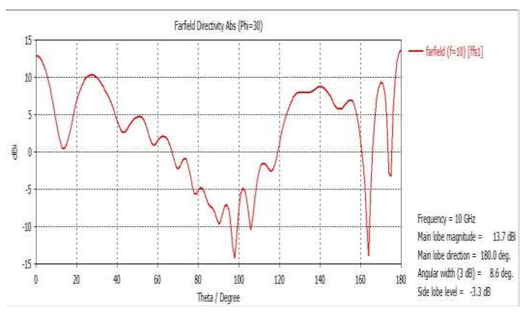
Simulations of Final Design

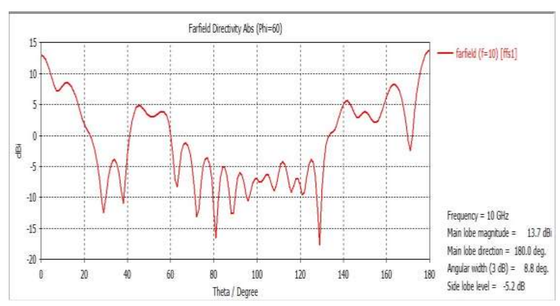
The radiation performance of the dielectric array is obtained using the full-wave simulation software CST Microwave Studio.

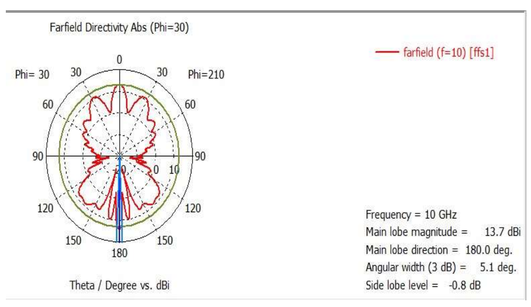
Polar plots,cartesian plots and 3D plot of directivity 10 GHz are shown in figures below.

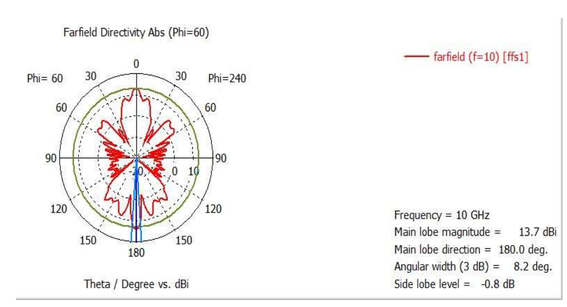






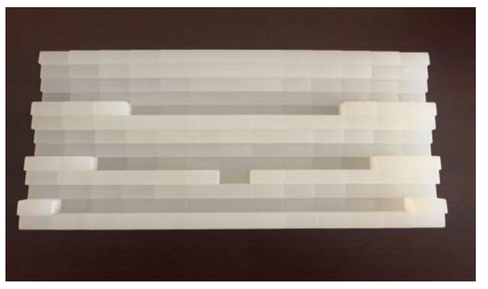






Hardware Prototype

The antenna was produced by Ak-Sil H10 Shore Silicone.To make this producing,a mold was printed using 3D printer at Prof. Dr. Attila Yılmaz's laboratuary.Later,it was filled by silicone and after freezing,antenna was produced.



Acknowledgements

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❖ I thank Prof. Dr. Birsen SAKA TANATAR and Dr. Noaman NASEER for their supports and helping.