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Design of Array of Slots to Generate Desired Radiation Patterns

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Abstract: *It is well known that the slots in the broad wall of rectangular waveguide along the axis do not radiate. However, the slots are displaced from the either side of the axis in array design. It is possible to produce required polarized fields by making slots suitably inclined. The work on such arrays for the generation of prefixed pattern is not available in the literature. With effect such a work is important in radar applications. In view of these facts, intensive studies are made to design array of displaced slots to produce narrow beams with a specified side lobe levels in the present work. Designed conductances are computed for array pattern and slots are designed to match their conductances with those of desired.*

Keywords: *Broadwall slot, Conductance,Offset slot parameter, Dissipation power.*

I. Introduction

The directional characteristics like high antenna gain, low side lobes and steerable beams are produced by the arrays of radiating elements. For point to point communication, low side lobes with narrow beamwidth are to be obtained. Without any aerodynamic drag, array antennas scans the beam electronically, thus the array antennas are preferred over horn and reflector antennas. For essential applications, design of waveguide slotted arrays is done to generate far field pattern with low side lobes. Sampling determines the element weights at the junction.

Development of theoretical analysis and design tools is used by the broad-wall slot arrays and is available in open literature. A design procedure is developed in 1978 by Elliot and Kurtz [1] that permits length and slot offset parameter to be determined with the specification of desired pattern and input admittance. Representation of the active admittance in terms of voltage, self and mutual admittance of the slot is presented. A similar design approach is developed for series slot array that are waveguide-fed [2] and broad wall slots that are spaced non-resonantly [3] . An improved version is presented by Robert S. Elliot [4].

Approximation of TE_{20}, internal mutual coupling and its folding into design formulas is indicated by Elliot et al. [5]. Characterization data of isolated slot procedure is used by Elliot, with an assumption that sinusoid represents electric field and shunt element represents the discontinuity in slot of an equivalent transmission line. Effect of finite waveguide wall thickness is neglected in the design of slotted array, though it is incorporated in analysis of isolated slot.

Based on method of least squares (MLS), a new method of optimization and design of standing wave fed and traveling wave fed centered inclined slot arrays of rectangular waveguide with cut in the broad wall is presented by Oraizi et al. [6]. Design of planar slot arrays that are waveguide fed, its analysis and development is presented by Rengarajan et al. [7]. This method achieves specifications of low average side lobe that is used in radiometer applications.

The array antennas are widely used in radar and wireless communications because of their low losses and high power handling capacity with low side lobe levels. M.Mondal and A. Chakrabarty [8] proposed that adjusting the slot offset parameter from the waveguide centre line and by controlling the slot excitation, the desired array pattern will be obtained. Determination of the resonant slot length and the circuit parameter variations with the change in the slot offset parameter is very much important in the array design.

To treat the slots in the broad wall of the rectangular waveguide, the theory enlarges on Stevenson method and based on the babinet's principle, a modified form of Booker's relation is used by Elliot and Kurtz [9]. The module with the slot cut in the broad wall of the rectangular waveguide is a two port device and the origin is taken at the cross section of the waveguide that bisects the slot. Propagation of the waveguide is done only by the dominant TE_{01} mode.

G.S.N.Raju et al[10] explained that arrays with the slots in the broad wall of the rectangular waveguide generate a beam with strong cross polarization which is a great limitation. This limitation is avoided by using cascading sections at the junctions. Resonance frequency can be reduced to about 9.4 GHz by increasing the slot length.

The initial length and the offset for each slot is selected based on the radiation pattern and input match requirements proposed by J.J. Gulick, R.S. Elliott [11]. After the initial set selection, array analysis is to be performed to determine input match requirements and the actual pattern. To obtain the desired pattern, the assumption to be considered is that, aperture field magnitude does not alter shape but scales by some constant and its phase will have constant shift but retains the shape.

In the present work, the element conductance is designed by normalizing it with respect to TE_{01} mode admittance. Formulation developed by R.E. Collin [12] is used to obtain resonant array conductance in the longitudinal slot of the broad wall for the triangular on different pedestal amplitude distribution. The slot offset parameter controls the excitation level of the slot and this characteristic is used to design the slot array.

II. Amplitude Distributions

To reduce the side lobe level, different amplitude distributions are used like uniform, circular, triangle, raised cosine on pedestal, triangle on pedestal. The simplest is uniform amplitude distribution, as all elements are excited equally.

Two element uniform array radiation pattern is,

$$E(u) = \cos(kLu) \tag{1}$$

Here, $u = \sin\theta$

$k = 2\pi/\lambda$

$2L$ = array length

λ = operating wavelength

$E(u)$ = radiation field

The total filed intensity of the radiating isotropic sources $a(y_1), a(y_2), a(y_3) ----a(y_N)$etc… that has different amplitudes and same phase is,

$$E(u) = 2[a(y_1)\cos u + a(y_2)\cos 2u + a(y_3)\cos 3u + ---- + a(y_N)\cos Nu] \tag{2}$$

III. Radiation Pattern of Tapered Amplitude Distribution

In this paper, triangular on pedestal distribution is considered to reduce the side lobe levels further. The representation of triangular on pedestal distribution is,

$$A(x_n) = (1 - h|x_n|), \quad -1 \le x_n \le 1 \tag{3}$$

Where,

h is the pedestal height of 0.5,0.9

The radiation pattern due to line source is,

$$E(u) = \int_{-L}^{L} A(x)\ e^{j\frac{2\pi L}{\lambda}ux}\,dx \tag{4}$$

Where, $A(x)$ is the aperture distribution

The expression for radiation pattern of discrete array is,

$$E(u) = \sum_{n=1}^{N} A(x_n) e^{j\left[\frac{2\pi L}{\lambda}ux_n + \phi(x_n)\right]} \tag{5}$$

Here, $u = \sin\theta$

θ = angle of observer and broadside

N = Total number of elements

x_n = Spacing function = $\frac{2n-N-1}{N}$

$\phi(x_n)$ = Excitation phase 'n^{th}' element

$A(x_n)$ = Amplitude distribution of the n^{th} element

$2\pi/\lambda$ = Normalized array length.

The spacing function used in the above expression is suggested by Ishimaru [13].

The triangular on pedestal amplitude distribution and radiation pattern are as shown in the Fig. 1, 2 and 3.

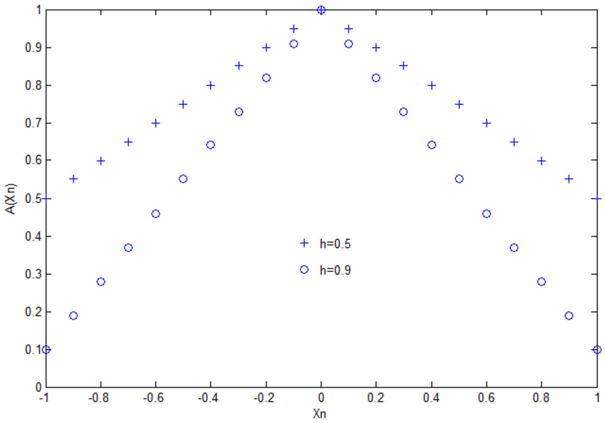

Fig.1: Amplitude distribution of triangular on pedestal height 0.5, 0.9

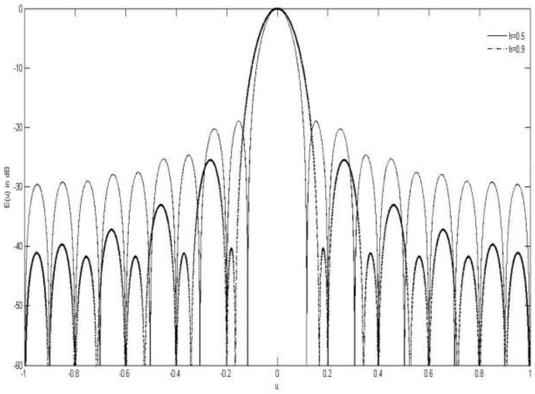

Fig.2: Radiation pattern of triangular on pedestal height 0.5,0.9 for N=20

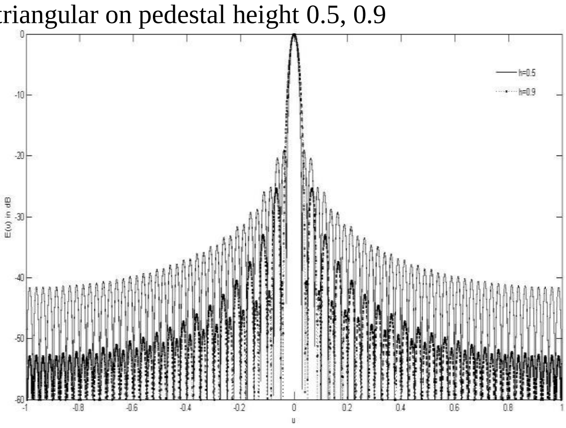

Fig.3: Radiation pattern of triangular on pedestal height 0.5,0.9 for N=40

IV. Formulation of Longitudinal Slot Resonant Array:

Resonant array is a broadside array with $\lambda_g/2$ spacing with slot offsets placed alternatively on the opposite sides of the centre line as shown in Fig. 4.

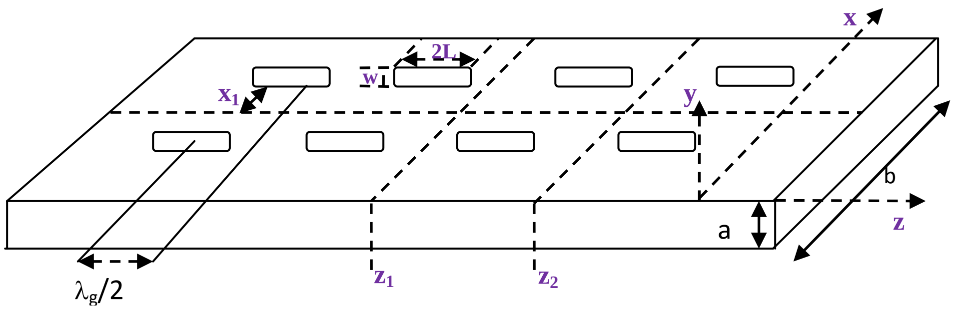

Fig. 4: Resonant array with longitudinal slots in the broad wall of rectangular waveguide

The assumptions made in the longitudinal slots in the broad wall of rectangular waveguide shown in Fig. 4 are waveguide is infinitely long, propagation of the TE_{10} mode is allowed by the waveguide in the positive z direction, walls of the waveguide are perfectly conducting, matched load terminates the slot so that no incident wave exists.

The additional scattered modes are present due to the presence of slot in discontinuity region. Magneto motive force equals the slot current and its expression is,

$$I = 2\int \mathbf{H}.\,ds \tag{6}$$

The voltage across slot is,

$$V_s = \int \mathbf{E}.\,ds \tag{7}$$

The slot admittance expression is,

$$Y_s = \frac{2\int \mathbf{H}.ds}{\int \mathbf{E}.ds} \tag{8}$$

Relation between slot admittance that radiates into half space and the impedance of the complimentary dipole (Z_D) is as follows [14]:

$$Y_s = \frac{2}{\eta^2} Z_D \tag{9}$$

The field equations for the regions $z \le z_1$ are:

$$\mathbf{E} = A_{10}\mathbf{E}_{10}^{e+} + \Gamma A_{10}\mathbf{E}_{10}^{e-} + \sum_p^1 C_p \mathbf{E}_p^-$$
$$\mathbf{H} = A_{10}\mathbf{H}_{10}^{e+} + \Gamma A_{10}\mathbf{H}_{10}^{e-} + \sum_p^1 C_p \mathbf{H}_p^- \tag{10}$$

Where, A_{10} is the incident mode amplitude
Γ is the reflection coefficient for TE_{10} mode
C_p is mode amplitude that is backward scattered

The field equations for the regions $z \ge z_2$ are:

$$\mathbf{E} = TA_{10}\mathbf{E}_{10}^{e+} + \sum_p^1 D_p \mathbf{E}_p^+$$

$$\mathbf{H} = TA_{10}\mathbf{H}_{10}^{e+} + \sum_p^1 D_p \mathbf{H}_p^+ \tag{11}$$

Where, T is the transmission coefficient for TE_{10} mode
D_p is the mode amplitude that is forward scattered

The considered regions $z \le z_1$ and $z \ge z_2$ are related by means of reciprocity theorem.

$$\oint\left[\mathbf{E} \times \mathbf{H}_p^+ . \hat{n}ds - \mathbf{E}_p^+ \times \mathbf{H}. \hat{n}ds\right] = 0 \tag{12}$$

Where, $\hat{n}$ is the unit outward normal vector.

Using normalization of modes and the power orthogonality, equation (12) yields,

$$C_p = \frac{1}{2}\oint_s (-a_x) E_s(z)\, \mathbf{H}_p^+ ds \tag{13}$$
$$D_p = \frac{1}{2}\oint_s (-a_x) E_s(z)\, \mathbf{H}_p^- ds \tag{14}$$

The modes that have tangential magnetic fields along the slot are excited. In the broad wall only TE modes are excited. If $C_p = D_p$, the longitudinal slot becomes a shunt element.

The normalized field component is [18],

$$h_z^e = \frac{j\pi}{\sqrt{k_0\beta_{10}\eta b^3 a/2}} \tag{15}$$

For a slot of length 2L and width w, using the equation (15) for dominant TE_{10} mode in equation (13) yields,

$$C_{10} = -\frac{j\pi}{\sqrt{2b^3 a k_0 \beta_{10}\eta}} \cos\left(\frac{\pi x_0}{b}\right) \int_{-L}^{L} wE_s(z) e^{-j\beta_{10}z} dz \tag{16}$$

Similarly,

$$D_{10} = -\frac{j\pi}{\sqrt{2b^3 a k_0 \beta_{10}\eta}} \cos\left(\frac{\pi x_0}{b}\right) \int_{-L}^{L} wE_s(z) e^{+j\beta_{10}z} dz \tag{17}$$

Where,
C_{10} is the dominant mode amplitude that is backward scattered
D_{10} is the dominant mode amplitude that is forward scattered

The voltage across the slot of half wavelength long due to incident TE_{10} mode is,

$$V(z) = V_m \sin[k(L - |z|)] \tag{18}$$

Thus, the equations (16) and (17) are simplified as:

$$C_{10} = D_{10} = \frac{-jV_m}{\pi}\sqrt{\frac{2bk_0}{a\eta\beta_{10}}} \cos\left(\frac{\pi x_0}{b}\right)\left(\cos\beta_{10}L - \cos k_0 L\right) \tag{19}$$

The reflection coefficient Γ is,

$$\Gamma = \frac{C_{10}}{A_{10}}$$
$$\Gamma = \frac{-jV_m}{A_{10}\pi} k \tag{20}$$

Where, $k = \sqrt{\frac{2bk_0}{a\eta\beta_{10}}} \cos\left(\frac{\pi x_0}{b}\right)\left(\cos\beta_{10}L - \cos k_0 L\right)$

The transmission coefficient is,

$$T = 1 + \frac{D_{10}}{A_{10}} = 1 + \frac{C_{10}}{A_{10}} = 1 + \Gamma \tag{21}$$

The energy balance equation is defined as,
Power radiated=Incident power-Reflected power-transmitted power

$$|V_m|^2 Y_s = |A_{10}^2|(1 - |\Gamma|^2 - |T|^2) \tag{22}$$

Thus, the normalized admittance of the shunt element is,

$$\frac{Y_{in}}{Y_{10}} = \frac{4k^2}{Y_s} \tag{23}$$

Substitute the value of k and Y_s in equation (23).

$$\frac{Y_{in}}{Y_{10}} = \frac{2\eta^2}{Z_D}\left(\sqrt{\frac{2bk_0}{a\eta\beta_{10}}}\cos\left(\frac{\pi x_0}{b}\right)\left(\cos\beta_{10}L - \cos k_0 L\right)\right)^2$$

$$\frac{Y_{in}}{Y_{10}} = \frac{4\eta b k_0}{Z_D a\beta_{10}}\cos^2\left(\frac{\pi x_0}{b}\right)\left(\cos\beta_{10}L - \cos k_0 L\right)^2 \tag{24}$$

For a half wave thin dipole, the value of Z_D is 73.13.

Substitute the value $Z_D, k = \lambda_0/2$ and shift the origin as $x_1 = x_0 - \frac{a}{2}$ in equation (23) and the equation gets modified as,

$$\frac{Y_{in}}{Y_0} = 2.09\frac{b}{a}\frac{k_0}{\beta_{10}}\cos^2\left(\frac{\pi\beta_{10}}{2k_0}\right)\sin^2\left(\frac{\pi x_1}{b}\right) \tag{25}$$

The normalized conductance of the resonant longitudinal slot with an offset parameter x_1 is,

$$g_i = 2.09\frac{b}{a}\frac{\lambda_g}{\lambda_0}\cos^2\left(\frac{\pi\lambda_0}{2\lambda_g}\right)\sin^2\left(\frac{\pi x_1}{b}\right) \tag{26}$$

Where,

a is the narrow wall dimension of rectangular waveguide
b is the broad wall dimension of rectangular waveguide
λ_g is the guided wavelength
λ_0 is the free space wavelength.

The equivalent circuit of the waveguide and slot is connected as a shunt element across a transmission line with unit characteristic impedance, conductance g_i and has a propagation phase constant β.

By offsetting every other slot on opposite sides from the centre line, an additional phase of π is introduced, due to $\lambda_g/2$ spacing all slots excited in phase. The equivalent circuit of array consists of I conductance's connected across a transmission line with $\lambda_g/2$ spacing is shown in Fig. 5.

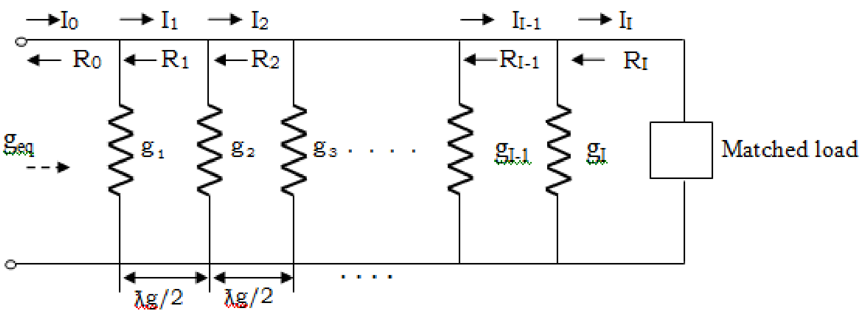

Fig. 5: Equivalent circuit of array of slots in broad wall

It is possible to evaluate the required conductance's of the slots in the array following the method proposed by G. A. Yevastropov and Tsarapkin [19]. This method takes care of internal reflections into account. For the sake of conductances the method is briefly given below. The power delivered to junctions is given by P_i and P_d represents power dissipated in the matched load.

According to the power balanced condition,

$$\sum_{i=1}^{I} P_i + P_d = 1 \tag{27}$$

When the feed guide is matched terminated R_I=0. In such cases the amplitude of incident wave into the matched load is used as a reference.

If I_I is incident voltage, we have,

$$P_d = I_I^2.1 \tag{28}$$

Hence, the normalized conductance presented by Ith junction is,

$$g_I = \frac{P_I}{I_I^2} = \frac{P_I}{P_d} \tag{29}$$

The conductance of I-1th junction is,

$$g_{I-1} = \frac{P_{I-1}}{|I_{I-1}+R_{I-1}|^2} \tag{30}$$

Using a recursive set of relations, the expression for the slot conductance is,

$$g_I = \frac{P_I}{\sum_{q=1}^{I} P_q} \frac{1-P_d}{P_d} \quad (31)$$

V. Results

Using equation (31) the required conductance of each slot in the array are evaluated for P_d=0.1, 0.15. Computations are made for small and large arrays. The results are presented in Tables 1 to 8.
In order to design the corresponding slots in the array, the realized conductances are computed by different slot displacements x_1= 3 mm, 4 mm. The realized conductances by using the equation (26) are also presented in the same tables. This method can be extended to any type of arrays.

Table 1: Number of elements =20,h=0.5,x_1=4 mm, Pd=0.l

N	Amplitude level	Required conductance	Realized conductance
1	0.5385	0.0213	0.0213
2	0.5897	0.0261	0.0261
3	0.6410	0.0317	0.0316
4	0.6923	0.0383	0.0381
5	0.7436	0.0458	0.0457
6	0.7949	0.0545	0.0547
7	0.8462	0.0657	0.0656
8	0.8974	0.0790	0.0789
9	0.9487	0.0960	0.0958
10	1.0000	0.1179	0.1177
11	1.0000	0.1337	0.1334
12	0.9487	0.1388	0.1385
13	0.8974	0.1436	0.1439
14	0.8462	0.1492	0.1494
15	0.7949	0.1552	0.1550
16	0.7436	0.1610	0.1605
17	0.6923	0.1654	0.1658
18	0.6410	0.1706	0.1704
19	0.5897	0.1736	0.1738
20	0.5385	0.1756	0.1754

Table 2: Number of elements =20,h=0.5, x_1=4 mm, Pd=0.15

N	Amplitude level	Required conductance	Realized conductance
1	0.5385	0.0201	0.0201
2	0.5897	0.0245	0.0246
3	0.6410	0.0297	0.0298
4	0.6923	0.0354	0.0358
5	0.7436	0.0427	0.0428
6	0.7949	0.0511	0.0511
7	0.8462	0.0610	0.0611
8	0.8974	0.0731	0.0732
9	0.9487	0.0884	0.0882
10	1.0000	0.1072	0.1075
11	1.0000	0.1208	0.1205
12	0.9487	0.1231	0.1233
13	0.8974	0.1256	0.1259
14	0.8462	0.1282	0.1280
15	0.7949	0.1294	0.1295
16	0.7436	0.1304	0.1302
17	0.6923	0.1298	0.1298
18	0.6410	0.1277	0.1279
19	0.5897	0.1243	0.1241
20	0.5385	0.1183	0.1181

Table 3: Number of elements =20,h=0.9, x_1=4 mm, Pd=0.1

N	Amplitude level	Required conductance	Realized conductance
1	0.1518	0.0026	0.0026
2	0.2461	0.0066	0.0067
3	0.3403	0.0131	0.0130
4	0.4346	0.0215	0.0215
5	0.5288	0.0325	0.0325
6	0.6230	0.0465	0.0466
7	0.7173	0.0645	0.0648
8	0.8115	0.0888	0.0887
9	0.9058	0.1211	0.1212
10	1.0000	0.1683	0.1681
11	1.0000	0.2022	0.2020
12	0.9058	0.2078	0.2077
13	0.8115	0.2107	0.2105
14	0.7173	0.2085	0.2083
15	0.623	0.1983	0.1985
16	0.5288	0.1787	0.1784
17	0.4346	0.1465	0.1466
18	0.3403	0.1052	0.1054
19	0.2461	0.0617	0.0616
20	0.1518	0.0251	0.0250

Table 4: Number of elements =20,h=0.9, x_1=4 Pd=0.15

N	Amplitude level	Required conductance	Realized conductance
1	0.1518	0.0024	0.0024
2	0.2461	0.0064	0.0064
3	0.3403	0.0123	0.0123
4	0.4346	0.0201	0.0202
5	0.5288	0.0305	0.0306
6	0.6230	0.0437	0.0438
7	0.7173	0.0606	0.0607
8	0.8115	0.0829	0.0828
9	0.9058	0.1126	0.1124
10	1.0000	0.1542	0.1544
11	1.0000	0.1827	0.1825
12	0.9058	0.1831	0.1832
13	0.8115	0.1799	0.1800
14	0.7173	0.1717	0.1715
15	0.6230	0.1560	0.1562
16	0.5288	0.1335	0.1333
17	0.4346	0.1040	0.1039
18	0.3403	0.0713	0.0711
19	0.2461	0.0402	0.0400
20	0.1518	0.0160	0.0159

Table 5: Number of elements =40,h=0.5, x_1=3 mm, Pd=0.1

N	Amplitude level	Required conductance	Realized conductance
1	0.5190	0.0101	0.0101
2	0.5443	0.0113	0.0113

Table 6: Number of elements =40,h=0.5, x_1=3mm,Pd=0.15

N	Amplitude level	Required conductance	Realized conductance
1	0.5190	0.0096	0.0096
2	0.5443	0.0106	0.0106

3	0.5696	0.0125	0.0125
4	0.5949	0.0138	0.0138
5	0.6203	0.0152	0.0152
6	0.6456	0.0167	0.0167
7	0.6709	0.0183	0.0183
8	0.6962	0.0201	0.0201
9	0.7215	0.0221	0.0221
10	0.7468	0.0241	0.0242
11	0.7722	0.0265	0.0265
12	0.7975	0.0290	0.0290
13	0.8228	0.0318	0.0318
14	0.8481	0.0350	0.0349
15	0.8734	0.0384	0.0383
16	0.8987	0.0423	0.0422
17	0.9241	0.0467	0.0466
18	0.9494	0.0517	0.0516
19	0.9747	0.0573	0.0573
20	1.0000	0.0641	0.0640
21	1.0000	0.0686	0.0684
22	0.9747	0.0696	0.0697
23	0.9494	0.0713	0.0711
24	0.9241	0.0726	0.0725
25	0.8987	0.0740	0.0740
26	0.8734	0.0753	0.0755
27	0.8481	0.0771	0.0770
28	0.8228	0.0784	0.0785
29	0.7975	0.0801	0.0800
30	0.7722	0.0817	0.0815
31	0.7468	0.0831	0.0830
32	0.7215	0.0844	0.0845
33	0.6962	0.0861	0.0860
34	0.6709	0.0874	0.0873
35	0.6456	0.0888	0.0886
36	0.6203	0.0898	0.0897
37	0.5949	0.0908	0.0907
38	0.5696	0.0915	0.0914
39	0.5443	0.0920	0.0919
40	0.5190	0.0922	0.0920

3	0.5696	0.0118	0.0118
4	0.5949	0.0130	0.0130
5	0.6203	0.0144	0.0143
6	0.6456	0.0157	0.0157
7	0.6709	0.0172	0.0172
8	0.6962	0.0189	0.0189
9	0.7215	0.0207	0.0207
10	0.7468	0.0225	0.0226
11	0.7722	0.0249	0.0248
12	0.7975	0.0271	0.0271
13	0.8228	0.0297	0.0296
14	0.8481	0.0323	0.0324
15	0.8734	0.0356	0.0355
16	0.8987	0.0391	0.0390
17	0.9241	0.0430	0.0429
18	0.9494	0.0474	0.0473
19	0.9747	0.0525	0.0524
20	1.0000	0.0582	0.0582
21	1.0000	0.0616	0.0618
22	0.9747	0.0625	0.0626
23	0.9494	0.0634	0.0633
24	0.9241	0.0641	0.0640
25	0.8987	0.0648	0.0647
26	0.8734	0.0654	0.0654
27	0.8481	0.0660	0.0659
28	0.8228	0.0662	0.0664
29	0.7975	0.0667	0.0669
30	0.7722	0.0673	0.0672
31	0.7468	0.0674	0.0674
32	0.7215	0.0674	0.0674
33	0.6962	0.0671	0.0673
34	0.6709	0.0670	0.0670
35	0.6456	0.0663	0.0665
36	0.6203	0.0659	0.0658
37	0.5949	0.0647	0.0648
38	0.5696	0.0636	0.0635
39	0.5443	0.0620	0.0619
40	0.5190	0.0601	0.0600

Table 7: Number of elements =40,h=0.9, x_1=4 mm, Pd=0.1

N	Amplitude level	Required conductance	Realized conductance
1	0.1253	0.0009	0.0009
2	0.1714	0.0017	0.0017
3	0.2174	0.0028	0.0028
4	0.2634	0.0041	0.0041
5	0.3095	0.0056	0.0056
6	0.3555	0.0075	0.0075
7	0.4015	0.0096	0.0096
8	0.4476	0.0120	0.0120
9	0.4936	0.0148	0.0148
10	0.5396	0.0180	0.0180
11	0.5857	0.0215	0.0215
12	0.6317	0.0256	0.0256
13	0.6777	0.0302	0.0303
14	0.7238	0.0354	0.0356
15	0.7698	0.0413	0.0417
16	0.8159	0.0486	0.0489
17	0.8619	0.0575	0.0574
18	0.9079	0.0677	0.0676
19	0.9540	0.0803	0.0800
20	1.0000	0.0957	0.0956
21	1.0000	0.1058	0.1057
22	0.9540	0.1074	0.1076
23	0.9079	0.1094	0.1092
24	0.8619	0.1104	0.1104
25	0.8159	0.1115	0.1112
26	0.7698	0.1114	0.1114
27	0.7238	0.1111	0.1109

Table 8: Number of elements =40,h=0.9, x_1=3,pd=0.15

N	Amplitude level	Required conductance	Realized conductance
1	0.1253	0.0009	0.0009
2	0.1714	0.0016	0.0016
3	0.2174	0.0026	0.0026
4	0.2634	0.0038	0.0038
5	0.3095	0.0053	0.0053
6	0.3555	0.0070	0.0070
7	0.4015	0.0090	0.0090
8	0.4476	0.0113	0.0113
9	0.4936	0.0139	0.0139
10	0.5396	0.0169	0.0169
11	0.5857	0.0202	0.0203
12	0.6317	0.0241	0.0241
13	0.6777	0.0284	0.0284
14	0.7238	0.0334	0.0333
15	0.7698	0.0390	0.0390
16	0.8159	0.0455	0.0455
17	0.8619	0.0533	0.0532
18	0.9079	0.0624	0.0624
19	0.9540	0.0733	0.0735
20	1.0000	0.0875	0.0872
21	1.0000	0.0956	0.0955
22	0.9540	0.0963	0.0961
23	0.9079	0.0963	0.0963
24	0.8619	0.0960	0.0960
25	0.8159	0.0952	0.0951
26	0.7698	0.0938	0.0936
27	0.7238	0.0912	0.0913

28	0.6777	0.1092	0.1093
29	0.6317	0.1064	0.1066
30	0.5857	0.1028	0.1026
31	0.5396	0.0972	0.0971
32	0.4936	0.0897	0.0899
33	0.4476	0.0811	0.0812
34	0.4015	0.0714	0.0712
35	0.3555	0.0602	0.0601
36	0.3095	0.0482	0.0484
37	0.2634	0.0367	0.0369
38	0.2174	0.0261	0.0261
39	0.1714	0.0166	0.0166
40	0.1253	0.0091	0.0090

28	0.6777	0.0880	0.0881
29	0.6317	0.0838	0.0839
30	0.5857	0.0787	0.0788
31	0.5396	0.0725	0.0726
32	0.4936	0.0654	0.0655
33	0.4476	0.0578	0.0576
34	0.4015	0.0494	0.0492
35	0.3555	0.0405	0.0406
36	0.3095	0.0321	0.0320
37	0.2634	0.0243	0.0240
38	0.2174	0.0167	0.0167
39	0.1714	0.0106	0.0106
40	0.1253	0.0057	0.0057

VI. Conclusions

It is evident from the results that the slot array in the broad wall of a rectangular waveguide is successfully designed. It has been possible to bring out realized conductances closed to desired ones. The same used for small and large arrays. The desired radiation pattern is specified very clearly and it is generated using distribution represented by triangle on pedestals and the side lobe levels controlled by the inherent taper itself. The array design has become simple because the characteristics are controlled by x_1 by keeping other parameters constant.

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