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Synthesis of Array of H-plane Tee Junctions of S-band wave guides for the generation of Sum patterns

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Abstract:

In microwave and radar applications shaped or narrow beam patterns are useful. Such radiation patterns can be designed by an array of slot coupled waveguide junctions by using the concept of Taylor distribution method. No literature is available on array of slot coupled H-plane Tee junctions of S band wave guide and no data on such array radiation patterns as reported.

In the present work,an array of H plane Tee junctions of S band wave guide with inclined slots in the narrow wall of primary wave guide are considered and excited with a suitable amplitude distribution. Using recursive formulation of transmission matrix and normalized power balance relation the resonant conductance for a given amplitude distribution are evaluated.The synthesis is carried outby considering a primary guide with matched termination and the amount of incident power absorbed in the terminating load. The results are presented in tabular form.

Introduction:

In guided missiles, supersonic aircrafts and atmospheric entry space vehicles the array of wave guide junctions are very useful, as they desire low profile or flush mounted antennas.In the array design the primary guide feeds cascaded H plane junctions. The radiation pattern obtained from an array of wave guide junctions depends on various parameters like inter element spacing between the elements, number of elements present in the array, the excitation given to elements and slot parameters (position andinclination of each element, offset displacement from the axis), which provide additional parameters for the array designer.

In the present work,an array ofcascaded plane Tee junctionsshown fig1. are considered andare excited with a suitable amplitude distribution.whenthe primary guide is matched terminated, the resulting resonant conductance is evaluated for different amounts of incident power delivered to the terminating load,for the number of array elements. An inclined slot in the wave guide radiate cross polarized component, which can be suppressed by slot coupled junctions [1].

Raju et al [1] reported that inestimating the performance of cascaded section of identical junctions, the side lobe levels are found to be high and the radiation pattern cannot be controlled in accordance with the given specification.The realization of desired radiation pattern is possible with junctions which are not identical. The primary guide will be loaded with impedance by each junction in the cascade/ array. The incident and reflected wave at input and output at nth load section are related by transmission matrix [2]. Cascaded section of Junctions can be represented by load line shown in fig 1.The impedance due to successive junctions appear in the planes of symmetry of individual sections shown in fig 2. At a particular frequency, the sections of lines between the consecutive planes are equal to their electrical lines and given by θ_d. The amplitude distribution is obtained by Taylor's method [3].Das [4]presents an analysis of the cascaded sections of a number of slot-coupled T junctions between rectangular and circular waveguides taking into account the mutual interactions of all possible modes generated by the discontinuities, as well as the effect of wallthickness. The formulation is based on solving a set of coupled integral equations resulting from the boundary conditions at the two interfaces of the waveguide sections representing the coupling slots.Elliot et al [5]derived A general relation between slot voltage and mode voltage **is** developed, and then formulas are derived for the active, self-reaction and mutual admittances among slots**,** by considering the mutualcoupling for a central slot and a peripheral slotin smallarrays if good patterns and impedance are to be obtained.The theory of Stevenson's method, andusesa modified form of Booker's relation basedonBabinet's principleto treat nonresonant longitudinal shunt slotsin the broad wall of a rectangularwaveguide.John [6] analyzed a one-dimensional array comprisingtilted edge slots cut in the narrow wall of a rectangularwaveguide is presented. The fields in the slots are calculatedfrom a hybrid finite element-boundary integral (FE-BI) equationmethod.Elliot et al [7] design procedure for arrays of longitudinal slots inone broad wall of each rectangular waveguide is extended to the case that the waveguides have ridges in the opposite broad walls. External mutualcoupling has been taken into account.

Formulation:

AMPLITUDE DISTRIBUTIONS:

Different amplitude distributions are used for the reduction of side lobe levels. The common amplitude distributions are uniform, circular, triangular, cosine and raised cosine on pedestal etcwith an objective to reduce the side lobe levels further, another standard distribution represented by raised cosine on pedestal is considered in the present chapter.

The raised cosine on pedestal aperture distribution is represented by

$$A(x) = (1 + 0.48 \cos\pi x) \text{ , } -L \le x \le L \text{ --- (1)}$$

The second derivative of this equation (1) indicates that the raised cosine on pedestal type of distribution does not contain impulses until the third derivative. It is a gently terminated aperture distribution and it does not exhibit a jump in amplitude at the edges.

The far-field complex radiation pattern due to line source is given by the equation

$$E(u) = \int_{-L}^{+L} A(x) e^{\frac{j2\pi L}{\lambda} xu} dx \text{-- (2)}$$

The raised cosine on pedestal aperture is presented in fig.(3). It is then applied to discrete arrays containing the number of elements equal to N= 20 and 50. This is done by considering individual weights of each radiating element. Fig.3. Amplitude distribution of raised cosine on pedestal distribution The continuous distribution, A(x) is discretized and the resultant excitation levels are shown in figs. (4 & 5) for N = 10 and 50. The ordinate indicates the element locations.

These locations are found out using Ishimaru spacing [8] . Radiation patterns are numerically computed for raised cosine on pedestal distribution for discrete arrays containing the number of elements equal to 10 and 50. The realized patterns in u - domain are presented in figs. (6 &7).

The incident and reflected waves at the input and outputof the nth loaded sectionarerelated by the following transmission matrix

$$\begin{bmatrix} I_{n-1} \\ R_{n-1} \end{bmatrix} = \begin{bmatrix} A_{11}^{n} & A_{12}^{n} \\ A_{21}^{n} & A_{22}^{n} \end{bmatrix} \begin{bmatrix} I_{n} \\ R_{n} \end{bmatrix} \text{-------} (3)$$

where$\theta_d = (2\pi/\lambda)\ d+\pi$, d being the inter element spacing. If P_x is the normalized power delivered to the xth junction and **Δ**is the fraction of power deliveredto the load, it is found

$$\sum_{n=1}^{N} P_x .+ \Delta = 1 \qquad \text{------(4)}$$

For inter element spacing equal to $\lambda_g / 2$,the voltage, V appearing across all the elements of Fig. 3is identical and hence it can be shownthat the conductance of xth element is obtained fromthe formula

$$g_x = \frac{P_x}{\Delta} \text{ -------------- } (5)$$

If a_x is the sampled values of the square ofthe amplitude distribution curve which is represented as curve of Fig.3 in the locations

$$p_x = \frac{1-\Delta}{\sum_{n=2}^{N} a_x} \text{----------- } (6)$$

The normalized powers ~~P~~$_x$is appearing in equation (4)are obtained asof the radiating elements,

For matched termination of the array,

$$R_x = 0 \text{ and } I_N^2 .1 = \Delta$$

where N is the total number of junctions, The conductance of the last coupling slot is, hence given by

$$g_N = P_N / I_N^2 \text{ ------------- } (7)$$

Substituting the values of$I_N$and g_N in equation(1) and solving the set of simultaneous equations

f or P=N,I_{x-1} and R $_{x-1}$ are found. Conductance of(N-1)th junction is given by

$$g_{N-1} = \frac{P_{N-1}}{|I_{N-1}+R_{N-1}|^2} \text{ --------- } (8)$$

Generating a recursive function in this way. the remaining slot conductance satisfyingthe amplitude distribution of curveof Fig.1 areevaluated for d = 0.5λ.,N=10,50 and Δ=0.05,0.1, Slot parameter resonant length are determined from thedata and presented in tabular form.

The method of synthesis described above is quitegeneral and can be applied for therealization of any ,desired radiation pattern using either an array ofwaveguide radiators excited through slot coupled junction or an array of slots radiating into free space.

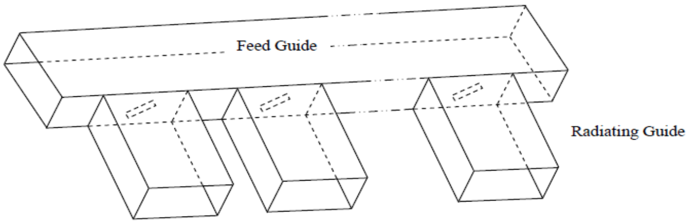

Fig.1 H plane Tee junction array

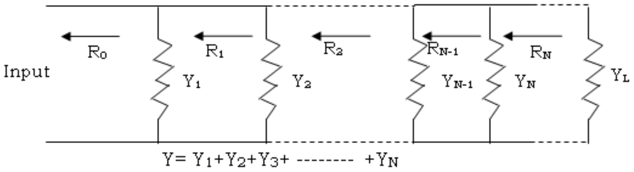

Fig.2.Equivalent circuit of array of slots with matched termination

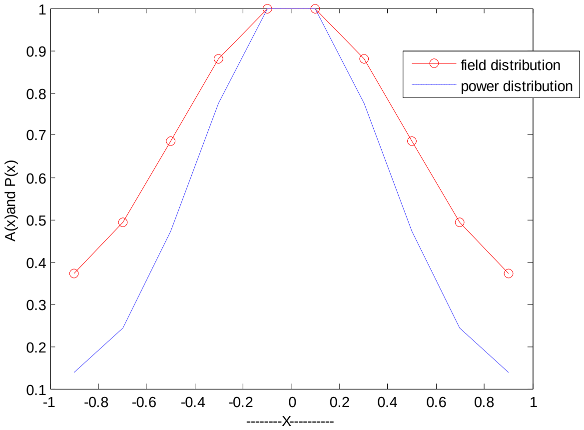

Fig.3.Amplitude and Power distribution for A(x)= 1+0.48 cosπx

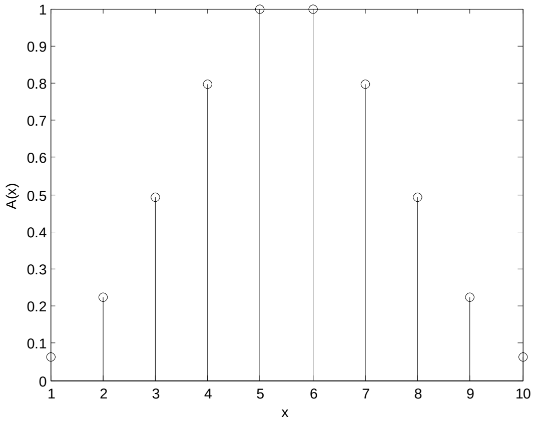

Fig 4 Excitation levels for number of elements = 10

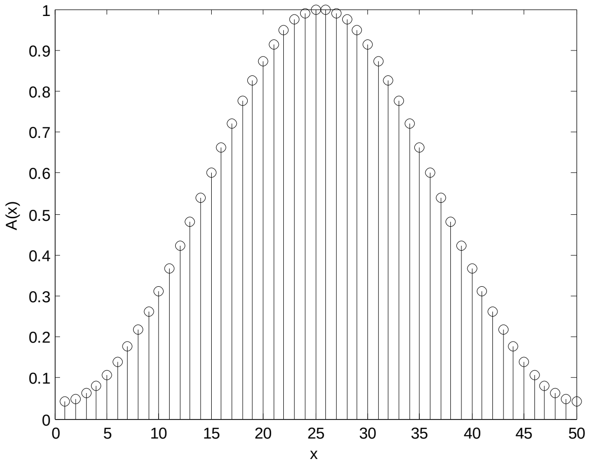

Fig.5 Excitation levels for number of elements = 50

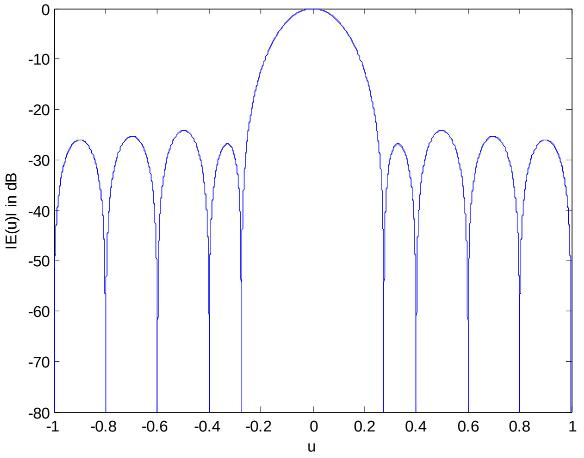

Fig. 6 Pattern for discrete array of 10 elements

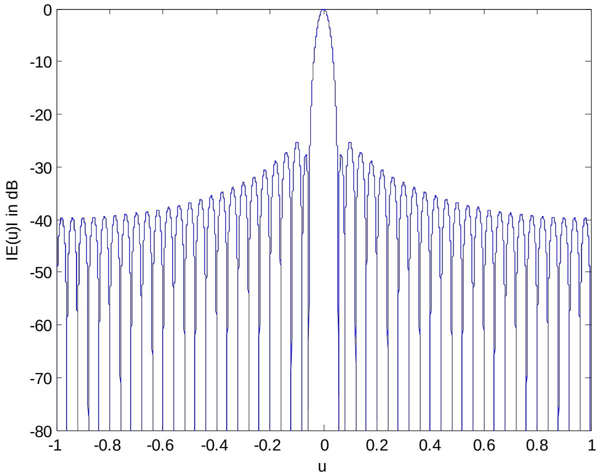

Fig.7.Pattern for discrete array of 50 elements

Results:

From the expressions of self-reaction and discontinuity inmodal current, the admittanceparametersare numericallycomputedfor S band H plane Tee junction array. The realized patterns in u-domain using raisedcosine on pedestal are presented in figs. (6-7) and theproposed element weights are presented in figs.(5-6). Therequired conductances of slots to produce the desiredradiation patterns are obtained from the expressions. Therealized conductances are obtained from the admittanceparameter.Therequired conductance and realized conductance are presented in the tables (1,2,3 and 4). Thetabulated results correspond to arrays of 10 and 50elements. All these results are presented for 0.05 and 0.1 offractional power dissipated in load.

Table.1. array with number of elements N=50, $\Delta=0.05$ and $A(x)= 1+0.48 \cos\pi x$

No. of elements	Amplitude level	Required Conductance	realized conductance	Resonant length of slot (cm)
1	0.3731	0.0252	0.0255	5.04
2	0.4929	0.0450	0.0451	5.28
3	0.6866	0.0915	0.0921	5.56
4	0.8803	0.1656	0.1645	5.78
5	1.0000	0.2561	0.2592	5.98
6	1.0000	0.3442	0.3451	6.18
7	0.8803	0.4067	0.4087	6.38
8	0.6866	0.4171	0.4176	6.44
9	0.4929	0.3687	0.3754	6.30
10	0.3731	0.3348	0.3387	6.16

Table.2 array with number of elements N=10, Δ=0.1 and A(x)= 1+0.48 cosπx

No. of elements	Amplitude level	Required Conductance	realized conductance	Resonant length of slot (cm
1	0.3731	0.0238	0.0243	5.02
2	0.4929	0.0426	0.0430	5.26
3	0.6866	0.0864	0.0873	5.54
4	0.8803	0.1554	0.1563	5.76
5	1.0000	0.2374	0.2391	5.94
6	1.0000	0.3113	0.3158	6.10
7	0.8803	0.3502	0.3509	6.20
8	0.6866	0.3279	0.3240	6.12
9	0.4929	0.2514	0.2491	5.96
10	0.3731	0.1925	0.1907	5.84

Table.3. array with number of elements N=50, Δ=0.05 and A(x)= 1+0.48 cosπx

No.of elements	Amplitude level	Required Conductance	realized conductance	Resonant slot length in cm
1	0.3522	0.0046	0.0046	4.32
2	0.3573	0.0048	0.0048	4.34
3	0.3675	0.0051	0.0051	4.36
4	0.3825	0.0055	0.0055	4.40
5	0.4021	0.0061	0.0063	4.46
6	0.4261	0.0069	0.0068	4.50
7	0.4540	0.0079	0.0078	4.56
8	0.4854	0.0091	0.0089	4.62
9	0.5198	0.0106	0.0107	4.70
10	0.5566	0.0123	0.0122	4.76
11	0.5954	0.0142	0.0146	4.84
12	0.6354	0.0164	0.0167	4.90
13	0.6761	0.0189	0.0191	4.96
14	0.7168	0.0217	0.0218	5.02
15	0.7568	0.0247	0.0250	5.08
16	0.7956	0.0280	0.0287	5.14
17	0.8325	0.0315	0.0314	5.18
18	0.8669	0.0353	0.0345	5.22
19	0.8983	0.0393	0.0396	5.38
20	0.9262	0.0434	0.0435	5.32
21	0.9501	0.0478	0.0477	5.36
22	0.9698	0.0523	0.0524	5.40
23	0.9848	0.0569	0.0575	5.44
24	0.9949	0.0616	0.0632	5.48
25	1.0000	0.0663	0.0663	5.50
26	1.0000	0.0710	0.0695	5.52
27	0.9949	0.0756	0.0764	5.56
28	0.9848	0.0802	0.0802	5.58
29	0.9698	0.0845	0.0841	5.60
30	0.9501	0.0886	0.0882	5.62
31	0.9262	0.0924	0.0925	5.64
32	0.8983	0.0958	0.0945	5.65
33	0.8669	0.0986	0.0970	5.66
34	0.8325	0.1009	0.1009	5.70
35	0.7956	0.1025	0.1018	5.68
36	0.7568	0.1034	0.1035	5.69
37	0.7168	0.1034	0.1034	5.69
38	0.6761	0.1026	0.1018	5.68
39	0.6354	0.1010	0.0100	5.70
40	0.5954	0.0986	0.0970	5.66
41	0.5566	0.0956	0.0945	5.65
42	0.5198	0.0922	0.0925	5.64
43	0.4854	0.0886	0.0882	5.62
44	0.4540	0.0850	0.0841	5.60
45	0.4261	0.0818	0.0802	5.58
46	0.4021	0.0794	0.0785	5.57
47	0.3825	0.0780	0.0764	5.56
48	0.3675	0.0781	0.0729	5.54
49	0.3573	0.0710	0.0695	5.52
50	0.3522	0.0663	0.0663	5.50

Table.4. junction array with number of elements N=50, Δ=0.1 and A(x)= 1+0.48 cosπx

No.of elements	Amplitude level	Required Conductance	realized conductance	Resonant slot length in cm
1	0.3522	0.0044	0.0043	4.30
2	0.3573	0.0045	0.0046	4.32
3	0.3675	0.0048	0.0049	4.34
4	0.3825	0.0052	0.0053	4.38
5	0.4021	0.0058	0.0057	4.42
6	0.4261	0.0066	0.0066	4.48
7	0.4540	0.0075	0.0074	4.54
8	0.4854	0.0086	0.0085	4.60
9	0.5198	0.0100	0.0102	4.68
10	0.5566	0.0116	0.0117	4.74
11	0.5954	0.0134	0.0133	4.81
12	0.6354	0.0155	0.0152	4.86
13	0.6761	0.0178	0.0174	4.92
14	0.7168	0.0204	0.0209	5-00
15	0.7568	0.0232	0.0239	5.06
16	0.7956	0.0262	0.0262	5.10
17	0.8325	0.0295	0.0287	5.14
18	0.8669	0.0330	0.0329	5.22
19	0.8983	0.0366	0.0361	5.24
20	0.9262	0.0404	0.0415	5.30
21	0.9501	0.0443	0.0435	5.32
22	0.9698	0.0483	0.0477	5.36
23	0.9848	0.0523	0.0524	5.40
24	0.9949	0.0563	0.0575	5.44
25	1.0000	0.0603	0.0603	5.46
26	1.0000	0.0642	0.0632	5.48
27	0.9949	0.0679	0.0663	5.50
28	0.9848	0.0714	0.0695	5.52
29	0.9698	0.0745	0.0729	5.54
30	0.9501	0.0773	0.0764	5.56
31	0.9262	0.0796	0.0802	5.58
32	0.8983	0.0814	0.0812	5.58
33	0.8669	0.0825	0.0834	5.61
34	0.8325	0.0829	0.0841	5.61
35	0.7956	0.0826	0.0834	5.61
36	0.7568	0.0815	0.0812	5.58
37	0.7168	0.0795	0.0802	5.58
38	0.6761	0.0769	0.0764	5.56
39	0.6354	0.0753	0.0729	5.54
40	0.5954	0.0697	0.0695	5.52
41	0.5566	0.0655	0.0663	5.50
42	0.5198	0.0611	0.0603	5.46
43	0.4854	0.0568	0.0575	5.44
44	0.4540	0.0526	0.0524	5.40
45	0.4261	0.0489	0.0477	5.36
46	0.4021	0.0458	0.0455	5.34
47	0.3825	0.0435	0.0435	5.32
48	0.3675	0.0419	0.0417	5.31
49	0.3573	0.0414	0.0415	5.30
50	0.3522	0.0410	0.0396	5.28

Conclusion:

It is evident from the literature thatarray of H plane junction formed by S band wave guides are considered for the first time. The arrays are designed with slot coupled junctions to produce narrow beam using tapered amplitude distribution. The proposed distribution is cosine on pedestal. This distribution is found to give a narrow beam ofabout -25dB. The design adopted in this paper uses recursive formulation, which takes care of internal reflections. A non-radiating port in the array is matched terminated.

Using the analysis presented in preceding chapters the desired conductance of each junction is realized. The resultant radiation patterns for proposed distribution are numerically evaluated and are presented in u-domain.

References:

1. B.N. Das, G.S.N. Raju and Ajoy Chakraborty. 'Design *of* waveguide array using cascaded sections of cdplanarE-H plane T-junctions presented in 1987,IEEEAP-SIn. Synpoeium,Virginia Tech.June 15-19, 1987, pp.31&313. SynposiumDigest. Vol. I.
2. G. A. Yevstropov and Tsarapkin, “Investigation of slotted waveguide antenna with identical resonant radiators”, Radio Engg. Elect. Phys. (U.S.A), Vol.10, No.9, p-1429, September 1965
3. T.T.Taylor,”Design of line source antennas for narrow beamwidth and low

side lobes”,IRETrans.A&P ,AP-7,pp-16-28,1955.
4. B. N. Das and P. V. D. SomasekharRao,Analysis of Cascaded Sections of T Junctions Between Rectangular and Circular Waveguides,lEEEtransactions on microwave theory and techniques, vol. 39. no. i. january i991.
5. ROBERT S. ELLIOTT, AND L. A. KURT2, The Design of Small Slot Arrays, IEEE transactions on antennas and propagation, vol. ap-26, no. 2, march 1978.
6. John C. Young,, Jiro Hirokawa, and Makoto Ando, , Analysis of a Rectangular Waveguide, Edge Slot Array With Finite Wall Thickness, IEEE transactions on antennas and propagation, vol. 55, no. 3, march 2007.
7. David. Y.kim and ROBERT S. ELLIOTT,A Design Procedure for Slot ArravsFedSingle-Ridge Waveguide, IEEE transactions on antennas and propagation, vol. 36, no. 11, november1988.
8. R.F. Harrington, “Matrix methods for field problems,” Proceedingsof the IEEE, Vol. 55, No. 2, pp. 136-149, February 1967.
9. R.F. Harrington, “Time Harmonic Electromagnetic Fields,” New York, McGraw Hill, 1961

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