THE RING-LOADED CORRUGATED WAVEGUIDE

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Summary

The ring-loaded corrugated waveguide is shown to be very effective to the frequency broadbanding of the corrugated waveguide and the improvement of the transformer between the corrugated and uncorrugated waveguides.

The ring-loaded corrugated waveguide is the waveguide devised for the improvement of characteristics of the conventional corrugated one. The corrugated waveguide is applied to the primary horn of the reflector antenna for satellite-communication earth stations to achieve the higher efficiency and lower noise temperature[1,2], but the useful frequency bandwidth of the conventional waveguide, in which it is effective for the improvement of antenna property, is restricted to about one octave, besides this useful frequency bandwidth becomes narrower if the good matching is required between the corrugated and uncorrugated waveguides.
In the ring-loaded corrugated waveguide, the useful frequency bandwidth is about 1.8 times broader than that in the conventional corrugated waveguide. Moreover the very broad band transformer is obtained by applying the ring-loaded corrugated waveguide to the matching section.

The structure of the ring-loaded corrugated waveguide is shown in Fig. 1. Rings are added to the fins of the corrugated waveguide.
For EH_{11} wave propagating in the corrugated waveguide, which is useful for the improvement of antenna property, the useful frequency bandwidth is restricted to the frequency range in which the slot admittance Yc at r=a is capacitive susceptance. Therefore the frequency broadbanding of the corrugated waveguide is achieved by expanding the frequency range in which Yc is capacitive susceptance.
In the conventional corrugated waveguide, the lower edge frequency and the upper edge frequency of the useful frequency bandwidth are designated as f_L and f_H, respectively. Then the slot admittance Yc at f_L and f_H is located at the point B at f_L and point A at f_H on the admittance chart shown in Fig. 2, and Yc at frequency $f_1(f_L<f_1<f_H)$ is located at a point on the arc $\widehat{ADB}$.
In the ring-loaded corrugated waveguide, let Y_{10} and Y_{20} be the characteristic admittances of the ring-unloaded region and the ring-loaded region of a slot, then $Y_{10}<Y_{20}$. $(b-b_1)$ is chosen so that the slot admittance seen at $r=b_1+0$ towards the bottom of the slot is inductive susceptance at frequency f_L and capacitive susceptance at frequency f_H, respectively, and it is located at the point C at f_L and D at f_H in Fig. 2.
Then according to the relation $Y_{10}<Y_{20}$, the slot admittance seen at $r=b_1-0$ towards the bottom of the slot rotates clockwise at frequency f_L and anticlockwise at frequency f_H on the admittance chart and is located at the point C' at f_L and point D' at f_H. Therefore the slot admittance Yc at r=a is located at the point C" at f_L and point D" at f_H.
By loading the corrugated waveguide with rings to satisfy the above condition, the frequency range in which the slot admittance Yc is capacitive susceptance becomes broader than that in the conventional corrugated waveguide.
To make the above results more clear, the field analysis was performed with Maxwell equations. One of the numerical results is shown in Fig. 3. In the figure the variation of the useful frequency bandwidth is shown for the variation of (b_1-a) and the solid curves and dashed curves show the variations of the useful frequency bandwidths in the ring-loaded corrugated waveguide and the conventional corrugated waveguide, respectively.

In order to obtain the good property in the matching section between the corrugated and uncorrugated waveguides, it is necessary that the slot admittance Yc of the corrugated waveguide is near to the wall admittance of the uncorrugated waveguide.
Therefore the good matching is obtained by making the slot width of the corrugated waveguide narrow, but in this case frequency f_L at which Yc=0 remains constant, so the matching is difficult at and near the frequency f_L.
In the ring-loaded corrugated waveguide, frequency f_L' at which Yc=0 is lower than f_L, as shown in Fig. 3, and the slot admittance Yc at f_L is larger than that in the conventional corrugated waveguide. Thus the good matching is obtained even at the frequency f_L.
In Fig. 4 the two types of transformers between the corrugated and uncorrugated waveguides are shown. The transformer in Fig. 4 (a) contains the ring-loaded corrugated waveguide and the transformer in Fig. 4 (b) contains the conventional corrugated waveguide with the narrow slot-width. In Fig. 5 the experimental results are shown for these transformers.

In conclusion, the ring-loaded corrugated waveguide is very effective to the frequency broadbanding of the corrugated waveguide and the improvement of the transformer between the corrugated and uncorrugated waveguides.

References

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(2) P. J. B. Clarricoats, "Theoretical analysis of cylindrical hybrid modes in a corrugated

horn", Electronics Letters 5, (9), P. 187, May, 1969

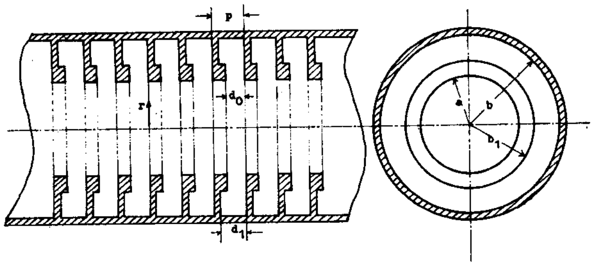

Figure 1. Ring-loaded corrugated waveguide.

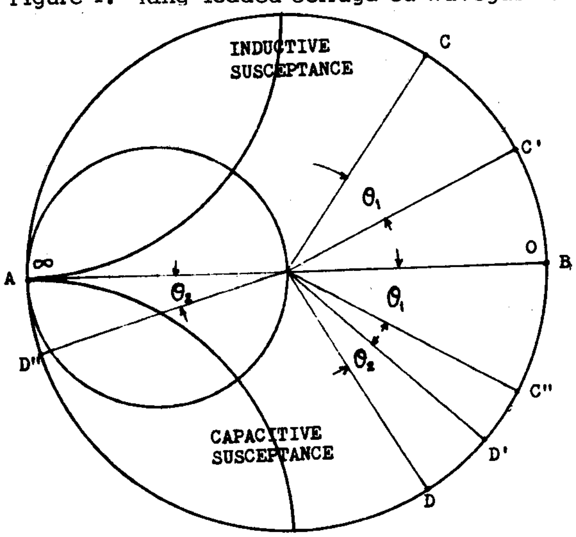

Figure 2. Admittance chart.

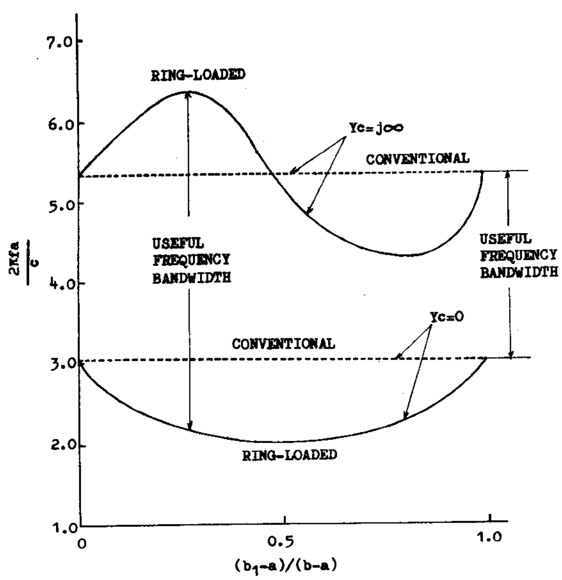

Figure 3. Useful frequency bandwidth for $(b_1-a)/(b-a)c$; light velocity, $b/a=1.583$, $p/a=0.36$ $d_0/a=0.0257$, $d_1/a=0.103$.

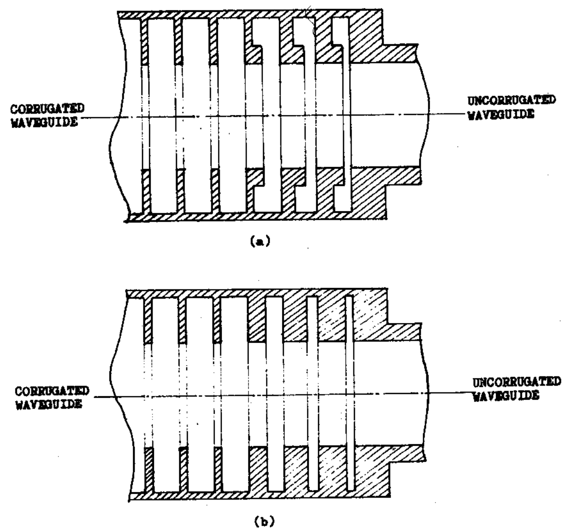

Figure 4. Transformers between the corrugated waveguide and uncorrugated waveguide.

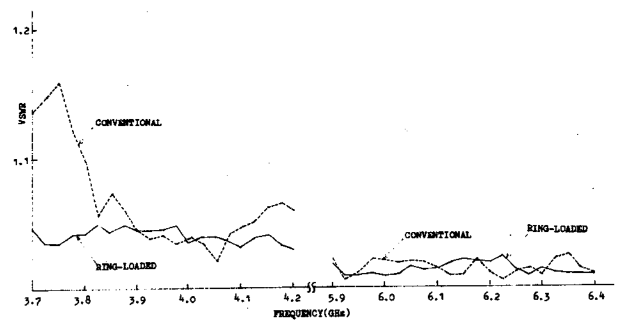

Figure 5. VSWR for the transformers shown in Figure 4 (a), (b).