Measurements show that transmission through the periodically corrugated waveguide varies from zero to a maximum value upon a shift of one periodic plate with respect to another on the half period of corrugation. The experiments demonstrate that the waveguide can be used to control transmission of microwave radiation.

Keywords - periodic waveguide; stop band; tunability.

I. INTRODUCTION

The main physical phenomenon caused by periodicity is Bragg reflection. It results in the opening of the forbidden gap in the spectrum of the periodic structure. The Bragg reflection occurs both in the case of unbounded periodic medium as well as in a case of a bounded periodic structure like a periodic waveguide. However, in the waveguide geometry dispersions become more complex due to their folding and crossing. As a result, besides Bragg reflections there arise non-Bragg reflections in the periodic waveguide. The spectrum of a planar waveguide acquires qualitatively new, and very promising from practical point of view, features if the periodicity is introduced into the waveguide by the lateral modulation. In the latter case the transmission properties become controllable due to opportunity to change the lateral modulation profile. For example, gaps can be tuned by means of shifting of periodic boundaries [1, 2].

In [2], it was shown that the relative shift of two periodic plates in the waveguide causes transformation of the band-structure spectrum to the gapless one. In the last case a wave propagates in the periodic waveguide without the Bragg reflection. Here we are reporting on the experimental observation of this phenomenon at a microwave range of wavelengths.

II. EXPERIMENTAL RESULTS

We measured the transmission properties of a planar waveguide, made of two metal plates having the identical sinusoidal profile \( y(x) = \xi \cos(qx) \). Where \( q = 2\pi / a \); \( \xi \) and \( a \) are the amplitude and the period of the corrugations, equal correspondingly to 0.415 cm and 3.15 cm in our experiment. The preliminary calibration measurement showed that the number of periods for optimal observation of the Bragg reflection ranges between 18 and 25. The upper plate could slide with respect to the lower forming the phase shift \( \theta \) between the plates.

A standard microwave setup with three horn antennas was used for measuring of transmission characteristics of the periodic waveguide at a frequency range 8-12 GHz. We investigated propagation of the TE wave, having the polarization vector \( \mathbf{E} \) parallel to the grooves of the corrugation.

Location of a gap, \( f_g \), in the waveguide frequency spectrum and its width, \( \delta f_g \), could be tuned by changing a waveguide thickness \( d \) and phase shift between plates in accordance with formulas given in [1,2]. At some of waveguide thickness, \( f_g \) can coincide with one of the cutoff frequencies \( f_{0p} = (c / 2d) p \), \( c \) is speed of light, \( p \) is the mode index \( (p = 1, 2, 3...) \). In this geometric resonance case the cutoff frequency splits into two values, separated by the forbidden gap \( \delta f_g \). We investigated the propagation of the third mode of the waveguide. Corresponding to this mode resonant thickness can be found from the formula [3]

\[
d_r = \frac{a_r}{2} \sqrt{b^2 - m^2} \tag{1}
\]

For \( p = 3 \), the geometric resonance occurs at \( d_r = 4.49 \) cm and \( m = 1 \). The cutoff frequency splits into two values

\[
f_{31}^{\pm} = \left[ 1 \pm \frac{\sqrt{2} \xi}{3 \ d_r} \ (1 - \cos \theta)^{1/2} \right] f_{03} \tag{2}
\]

where \( f_{03} \) is the cutoff frequency of the third mode for the smooth waveguide; for the thickness given in Eq. (2), \( f_{03} = 10.02 \) GHz. A value of the gap, \( \delta f_g = f_{31}^+ - f_{31}^- \),
depends on the phase shift $\theta$ between the plates. In a case of the symmetrical waveguide, $\theta = \pi$, Eq. (2) gives $f_{31}^+ = 10.63\ \text{GHz}$ and $f_{31}^- = 9.40\ \text{GHz}$, with a gap $\delta f_{31} = 1.23\ \text{GHz}$. If $\theta = 0$ (asymmetric waveguide), the gap vanishes. Fig. 1 shows the measured transmission properties of the waveguide for these two cases.

The symmetric waveguide, $\theta = \pi$, yielded the band gap 1.24 GHz (curve2), close to the theoretical value 1.23 GHz. This band gap vanished upon a shift of the upper plate by $\pi$ (curve1); a wave propagates without reflections. The dependence of the transmission on the phase shift is plotted in Fig.2 for the selected from the band gap frequency of 10.42 GHz.

Fig.1. Measured transmission characteristics for the periodically corrugated waveguide in two cases: the thick solid line (curve 1) for the asymmetric waveguide, $\theta = 0$; and thin solid line (curve 2) for the symmetric waveguide, $\theta = \pi$.

These results are in a good agreement with Eq. (2) describing the controllable stop band in the spectrum for the periodically corrugated waveguide.

**III. CONCLUSION**

The wave transmission through a planar periodically corrugated waveguide was investigated theoretically and experimentally. The 1.24 GHz stop band was observed at the X-band of frequency. The width of the stop band could be controlled by changing the on the relative position of two corrugated plates. The transmission varies from zero to a maximum value upon shifting of one periodic plate with respect to another on the half period of the corrugation.

**REFERENCES**

