# WAVEGUIDE-STRIPLINES TURNSTILE

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**ABSTRACT:** This paper presents the solution of a problem of transition from the waveguide to the device that has four symmetrical striplines having been crossed with each other (WST). The segments are placed in an area of the crossing. They form a short section of the round waveguide with four side openings. The segments prevent “a leakage” of the power to an area between screens out the striplines. The general electromagnetic problem has been formulated for several regions coupled electromagnetically through opening apertures. The method of equivalent currents is used for the problem definition. Experimental parameters of the WST are presented.

## INTRODUCTION

It is necessary often to use the waveguide devices and stripline devices together. For example, there are planar stripline antennas with a power divider, which is done on symmetrical stripline [1]. But a converter has the waveguide input. At the same time the converter must be directly connected to the stripline antenna. A section of the waveguide $\lambda/4$ long ($\lambda$-wave-length) is in the antenna builded in order to try to get a matching for the waveguide with the antenna. A section of the waveguide $\lambda/4$ long complicates an antennas design. As a result, an antennas directivity is decreased. A problem is a transition from the waveguide to the stripline antenna in case that the antenna has a circular polarization of radiated field. It is necessary two or four devices to put into the waveguide. As a result, we have the device that is an analogue to the well-known turnstile. We`ll call the device that has four symmetrical striplines that joined in stripplane and round waveguide that arrangements at right angle to the plane of a cross as the waveguide-striplines turnstile (WST). This paper presents the solution of a problem of transition from the waveguide to the stripline antenna in case the antenna has a circular polarization of radiated field.

## GEOMETRY OF THE PROBLEM

Three-dimensional image of WST in a non-assembled state presents on fig.1. WST consist of round waveguide 1 and a flat laminated structure, that involves a first screen 2, a first dielectric plate 3, a central conductor 4, a second dielectric plate 5, a second screen 6. Besides, WST involves four segments 8-11 and matched metal plate 7. Central conductor 4 (fig.2) involves stripline resonator, four central conductors of stripline and matched transformers. Stripline resonator has a square form. Circular hole 12 cuts out at first screen. Axis Oz of round waveguides is perpendicular to the structure, passes through a structure centre. Axis Oz is axis of a fourth order symmetry of WST. Segments are placed between screens so that form a waveguide section with four openings. This short section of the waveguide is a continuation of round waveguide 1 into an area between screens. Matched plate is placed into the hole 12. As a result, there is aperture $M_1$ that is ring slot-shaped.

## THEORY

The general electromagnetic problem has been formulated for several of regions coupled electromagnetically through opening apertures. The method of equivalent currents is used for the problem definition. The one supposes that all regions are closed and structural components and opening apertures are taken into account by the action of the corresponding equivalent currents. The equality to zero of tangential components of the electric field $\dot{\vec{E}}$ on the matched plate, strip surface and the continuity of tangential components of the magnetic field $\dot{\vec{H}}$ with transition from one region to another one are used.

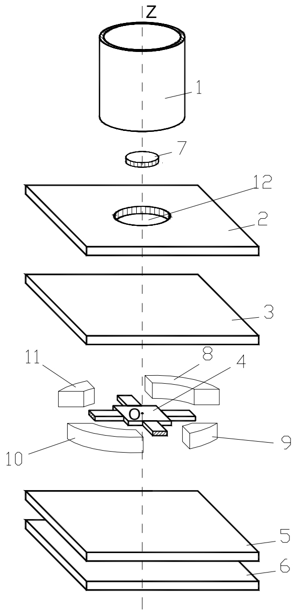


Fig. 1. Waveguide-striplines turnstile in a non-assembled state.

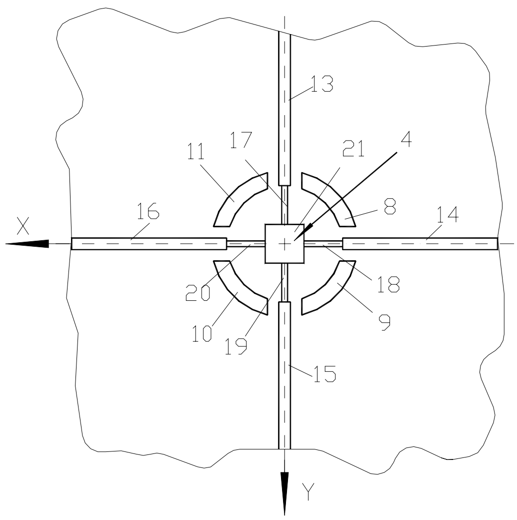


Fig. 2. Central conductor of the striplines and stripline resonator.

As a result, a system of integral equations is received relatively to the unknown distributions of electric currents on the matched plate $\dot{\vec{J}}^{E_1}$ , on the strip surface $\dot{\vec{J}}^{E_2}$ and magnetic currents on the apertures of the coupling opening $\dot{\vec{J}}^{M_q}$ , $q$ – number of the apertures. In particular:

on the matched plate:

$$\dot{\vec{E}}^1\left\{\dot{\vec{J}}^{E_1}\right\}+\dot{\vec{E}}^1\left\{\dot{\vec{J}}^{M_1}\right\}=-\dot{\vec{E}}^S, \tag{1}$$

on the $M_1$:

$$\dot{\vec{H}}^1\left\{\dot{\vec{J}}^{E_1}\right\}+\dot{\vec{H}}^1\left\{\dot{\vec{J}}^{M_1}\right\}+\dot{\vec{H}}^S=\dot{\vec{H}}^2\left\{-\dot{\vec{J}}^{M_1}\right\}+\sum_{q=2}^{5}\dot{\vec{H}}\left\{\dot{\vec{J}}^{M_q}\right\}+\dot{\vec{H}}\left\{\dot{\vec{J}}^{E_2}\right\}, \tag{2}$$

$\dot{\vec{E}}^s$ ( $\dot{\vec{H}}^S$ ) – electric (magnetic) field intensity of outer source; the upper index of electric and magnetic field vectors indicating a region for which the corresponding characteristic is written. Half-infinite round waveguide marked as a region 1, the continuation of round waveguide into an area between screens marked as a region 2.

Electric and magnetic fields are solved with Green tensor function usage. Galerkin method is used for the integral equation system solution. Electric and magnetic fields are solved with Green tensor function usage.

## RESULTS

It is made a prototype of the WST for an examination in frequency band 12 GHz. The sizes of screens are 100*100 $mm^2$. Diameter of the round waveguide is 19 mm. Segments was made out of a ring with inner diameter 19 mm and external diameter 23 mm. It was cut in the ring four slots 8 mm's wide. Segments height is 3 mm. The matching of WST has been investigated using stripline resonator, matched devices and a matching plate. Matched devices are made in form $\lambda/4$ – double-step transformers. Strip line resonator represents a square 10.4 centimeters on side. Relative dielectric constant of the first and second dielectric plates is 1,13. Matched plate has the diameter 9.2 mm and a thickness 100 micron. The wave $H_{11}$ is excited in the round waveguide. It was measured WST characteristics for two cases: segments was absent in first case, segments was placed in the prototype in the latter case.

A measuring of the voltage standing wave ratio was realized from the outside of the round waveguide. Graphs of dependences VSWR are presented on fig. 3. Dependences of power level in the arms are presented on fig. 4-5. Outputs I and II agrees with a situation a vector $\vec{E}$ is parallel relative to striplines arms WST. Outputs III and IV agrees with a situation a vector $\vec{E}$ is perpendicular relative to arms WST. Evidently, a level of the power in I – II arms is about equal. A level of the power in III – IV arms is essentially less then a level of the power in I – II arms. Fig.6 presented the dependence a total power in five arms: the power on an exits four striplines and the power of a reflected wave in the round waveguide. Evidently, a level of the total power is differs from the power of an incident wave on 5% in case the segments are placed in the prototype. However, in case the segments is absent then the total power is differs from the power of the incident wave on 50%. This fact indicates that a part of the power transmissions outside striplines and round waveguide. The segments prevent “a leakage” of the power in an area between screens out of the striplines.

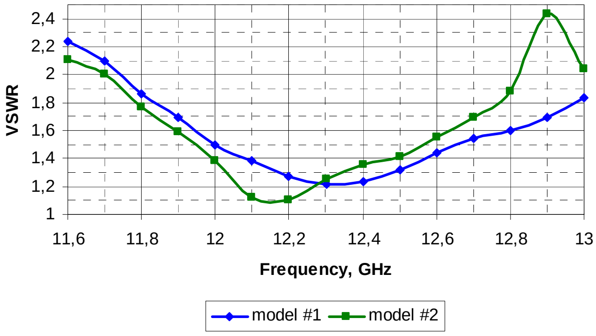


Fig. 3. The dependency of the VSWR from the frequency at input of the round waveguide.

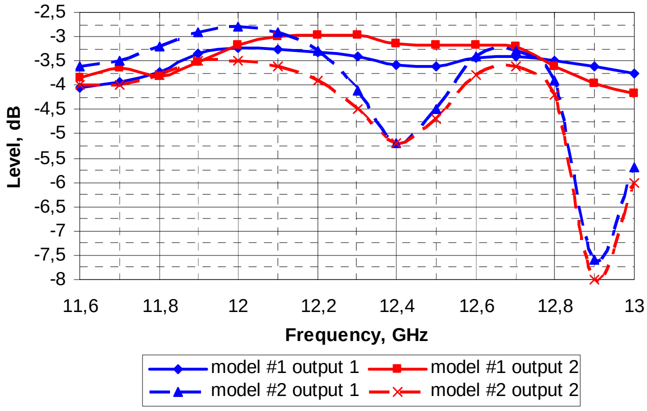


Fig. 4. The dependency of the power level from the frequency at the I and the II arms.

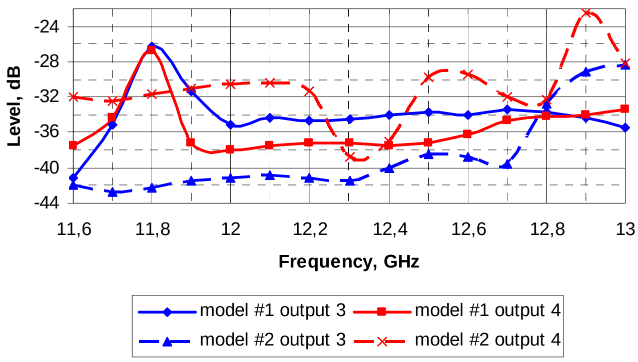


Fig. 5. The dependency of the power level from the frequency at the III and the IV arms.

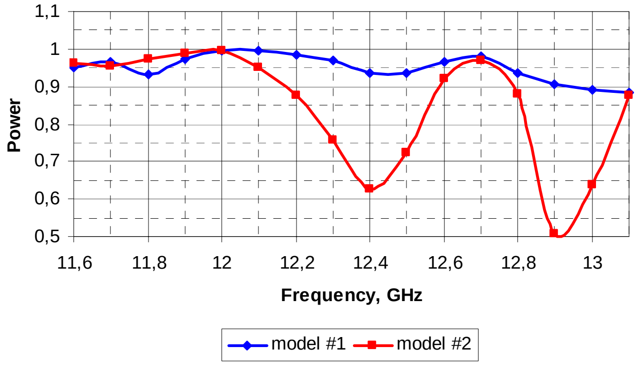


Fig. 6. The dependency of the total power level from the frequency at the I- IV arms.

## CONCLUSION

The matching of WST from the direction of round waveguide has been investigated using strip line resonator, matching section and a matching plate. Matching sections are included between the resonator and strip lines. Matching plate is included in the aperture of the round waveguide. The segments are placed on screens of strip line in such a way that they form a short section of a round waveguide with four side openings.

It is shown that the loss of the power for the device with the segments is less in comparison with the power loss for the device without the segments for one order. The segments prevent “a leakage” of the power in an area between screens out of the striplines.

## REFERENCES

[1]. Voytovich N.I., Panchenco B.A., Sokolov A.N. Planar antenna for satellite TV reception. 1998 International Symposium on electromagnetic Theory. Proceedings, 25-28 May 1998, Thessaloniki, Grecce, V.I, pp. 244-246.