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# MEMS Keys as a Way to Delay the Phase of the Microwave Range

**[1] Anton ANTONENKO, [1] Michael GERAIMCHUK, [2] Orest IVAKHIV**

[1] Faculty of Instrument Design and Engineering, National Technical University of Ukraine "KPI", 37 Peremohy ave., 03056, Kyiv, Ukraine

[2] Precision Mechanics Department, L'viv Polytechnic National University, 12 Bandery Str., 79013 L'viv, Ukraine

[1] Tel.: +38 044 4549483, fax: +38 044 4068019

[1] E-mail: ehnaton1990@gmail.com

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**Abstract:** The paper deals with a new type of phase shifter antennas scanned beam shows the principle of constructing controlled microwave phase shifters that have a low cost. Also, given the results of a theoretical study of the main characteristics of dependency - controlled phase shift and frequency band working on the design parameters and then refined by calculating finite element program CST Microwave Studio. These inexpensive scanned antenna can be used in radar centimeter and millimeter wavelengths in the frequency range 2 ÷ 30 GHz. The results of calculation of capacitive and inductive coupling during switching detector elements and the simulation results of the phase shift in passing through the phase shifter television signal containing includes microelectromechanical systems - manageable sections that have to change the direction of polarization of the signal. Thus for supplying voltage-controlled permanent magnet field is used. According to the simulation results, which are presented in the conclusions can be drawn about the development of the design of optimal geometric parameters, the values obtained for the results of the optimization modeling. However revealed a high quality factor switching phase. *Copyright © 2015 IFSA Publishing, S. L.*

**Keywords:** MEMS keys, Phase shift, Vertical polarization, Horizontal polarization.

## 1. Introduction

Shifter is an integral part of many electronic systems. The development of these elements becomes especially important due to the structure of modern trends transmitter-receiver channels of communication systems for multi-channel schemes. Management phase and amplitude in each channel can implement advanced signal processing techniques and, by doing so, significantly improve receiver sensitivity and lower power requirements for transmitters.

In modern electronics have gained rapid consumption of encoding digital systems, which are characterized by high reliability, and their ability to grow thanks to the relentless increase in clock frequencies. In this regard, the urgent task is the creation of fast, efficient and small components for phase shifters.

Microwave phase shifter - the range is an important component of an important component of radio-technical systems. They are used in radar equipment, ligament and measurement technology, the phase modulation signal. Also, and this is extremely important, they are part of monopulse systems and phased antenna arrays (PAA), which control the phase of the radiating elements, providing spatial scanning beam antenna.

Depending on the nature of the management of differentiated smooth phase (analog) and discrete (stepped) phase shifter (PS). Analog phase shifters provide smooth and discrete - speed phase change (usually in increments 3600/2n, n – number of digits phase shifters). In the PAA commonly used electromechanical or semiconductor phase shifters, although manifested considerable interest and a new type of PI implemented based on MEMS.

In recent years, the field in the field of microwave phase shifters made significant progress. Firstly, this is due to the use of monolithic circuits that can not only dramatically minimize the size, but also to create a fundamentally new schemes (e.g., vector) and PS design with precision parameters in ultra-wide band of operating frequencies.

Second, researchers proposed new circuit and design of phase shifters that have the characteristics that are inaccessible using circuitry previous years. Thirdly, there proprietorship based on MEMS. In fact, the parameters of phase shifters that are reported in the current prospectus and on the web, so high that professionals unfamiliar with the current state of affairs in this area can cause some distrust.

The main parameters of phase shifters (except phase characteristics) are: the level of losses being made, bandwidth, dependent damping, introduced from the phase state (parasitic amplitude modulation), the maximum transmitted power, weight, size, switching time.

## 2. Polarization of an Electromagnetic Wave

Radio or television program is the distribution of electromagnetic waves having two transverse (perpendicular) components: the electric field E and the magnetic field H. These fields form a plane situated at right angles to the direction of wave propagation (Fig. 1). E-field orientation in relation to the earth's surface is called polarized electromagnetic wave [1].

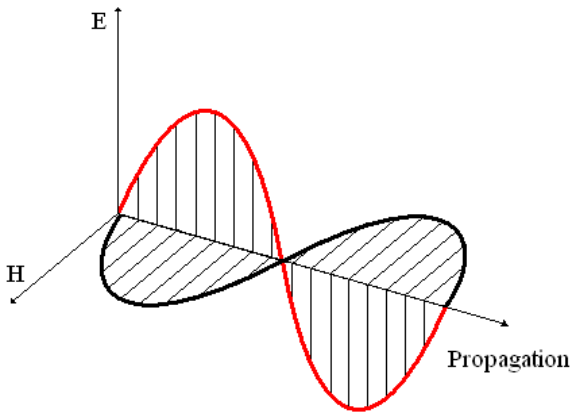


**Fig. 1.** Scheme of electromagnetic wave propagation.

Since the wave propagation vector H and E is always perpendicular to each other, they vary in space in the same way, describing the same shape curves, but in mutually perpendicular planes. Therefore, it suffices to know how changes in the space of one of these vectors, and the behavior of the other will be the same.

If the E-field vertical, the transmitted signal is called vertically polarized, if the E-field is horizontal, then the transmitted signal called horizontally polarized. If the E-field vector rotates a transmitted signal has a circular polarization. With satellite television broadcasting using only using only vertical and horizontal polarization.

This method allows the use of dual polarization radiation of one frequency in two different channels: one vertical polarization, the other horizontal polarization. However, the frequency of overlap can cause crosstalk, and therefore the transfer is usually not used. In practice the use frequency distribution without overlapping and adjacent channels to minimize intermodulation between the transmitted signals with opposite polarization.

Speed of propagation may depend on its polarization. Two wave linearly polarized at right angles to each other do not interfere.

Often this phenomenon is used to create different optical effects, where polarization is used to separate the images you right and left eye.

Circular polarization is applied to the antenna space lines, because reception is not important provision of the plane of polarization of the transmitting and receiving antennas. That is, the rotation of the spacecraft will not affect the possibility of communication with him. In a land line using linear polarization antenna - you can always choose in advance - horizontally or vertically placed plane of polarization antennas. Circumferential polarization antenna to perform more complex than linear polarization antenna.

Generally, circular polarization - something theoretical. In practice talking about elliptical polarization antenna - with the left or right direction of rotation [2].

## 3. Principle of Polarization Converter Construction

Currents in metallic waveguides occur in different parts in different ways. For vertical walls are perpendicular to flow up and down the walls. In the horizontal walls of the flow pattern is more complex. Currents of vertical sections of direction to the middle to the middle horizontal wall in the longitudinal direction of the currents continue to move in currents that flow in the capacitors. There's a current flows from one wall to the other horizontal. Just in these areas should be managed to locate items that affect the flow of current conditions, and consequently the conditions of wave propagation

along the waveguide [3]. Detailed disseminating currents shown in Fig. 2.

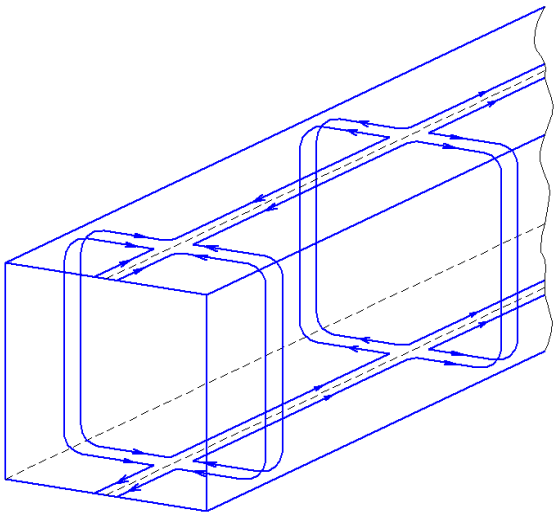

**Fig. 2.** Distribution of currents on the walls of the polarizer.

Managed type of polarization converter comprises two orthogonal symmetric periodic structures that incorporate isolated from the main part of the elements. Electrical connection elements isolated from the walls of the waveguide by using microelectromechanical structures (MEMS), which is implemented in the form of electromagnetic controlled capacitor having a disc-shaped electrode coated with an insulator with a high dielectric constant, and the second - a moving flat spring with magnetically material.

When snug fit electrode to dielectric cover a large capacitance. In the presence of the control magnetic field generated by an electromagnet, moving away from the electrode dielectric cover a considerable distance. The effective dielectric constant of the capacitor gap in this case is much smaller. The distance between the plates is much larger, which leads to low terminal capacitance.

Thus we have two values of capacitance between the isolated element and the housing waveguide, which leads to two values, velocity of wave propagation in the waveguide with the periodic structure.

If both pairs of periodic structures are in the same position, the orthogonal wave propagating in the waveguide with the same speed, i.e. in phase and does not affect the type of polarization of the wave coming.

## 4. Using the Template

Managed type of polarization converter (Fig. 3) consists of a square waveguide 1 and attached to its opposite sides of four internal periodic structures with 8 isolated using dielectric plugs informative 7 elements ( IE ) 3. In the structure of IE has a disk coated with a dielectric film 5 with a high dielectric constant. Outside the waveguide has four solenoids 2. When in off the electromagnet, isolated element attached to the body of the waveguide through a capacitor formed by an elastic plate 6, which is made of solf-magnetic material. In the on mode electromagnet elastic plate is deformed and pressed flat to the body of his part of the waveguide, which in place of pressing stuck dielectric disc 4 is designed to disambiguate electrical contact spring – waveguide.

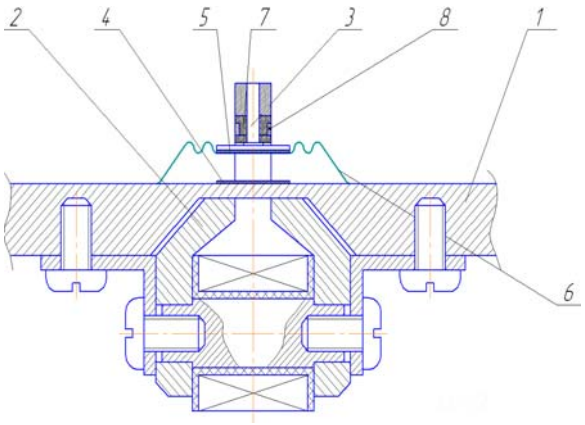


**Fig. 3.** The design of one of the four sections.

Speed of propagation, the plane of polarization coincides with the plane of pairs of periodic structures is dependent on the position of the elastic plate 6. In the absence of a magnetic field manager that creates an electromagnet 2, isolated elements connected to the body through the waveguide 1 large capacity, the value of which is determined by the area of the disk of the isolated element 3, the thickness and dielectric constant of the dielectric film. If the magnetic field is present - the capacity is much lower because the distance between the elements of the capacitor is much larger and filled with air. The difference between these vessels and the distinction propagation velocity along the periodic structure is shown at Fig. 4.

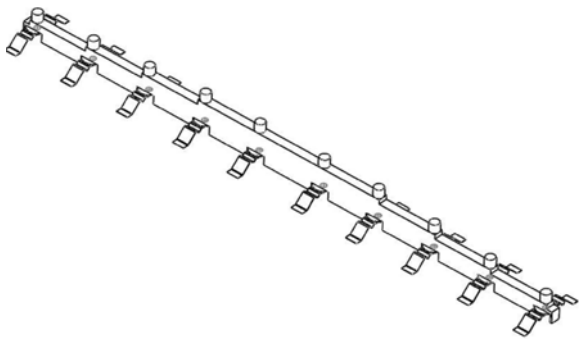

**Fig. 4.** Periodic structure.

## 5. Simulation Results of Polarization Converter

For simulation it was chosen only part of the polarization converter Fig. 5, since all device simulation is a very time consuming process, therefore, to obtain the necessary shift $90^0$ having the results of one section, it is possible to develop a device with the number of sections.

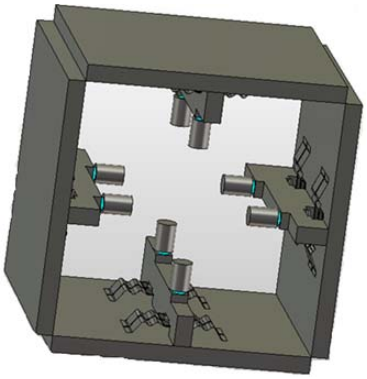

**Fig. 5.** A model of the study.

After transmission of television signals via a system of commuting polarizer C ranges, well, both with vertical and horizontal polarization was received significant change in the magnetic field switching and its absence (Fig. 6 and Fig. 7).

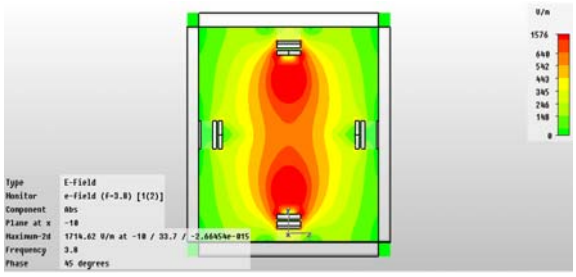

**Fig. 6.** Changing the pitch at vertical polarization.

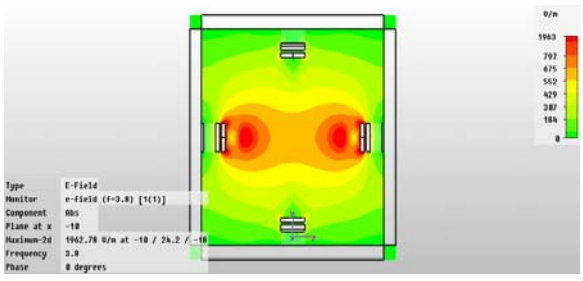

**Fig. 7.** Changing fields in horizontal polarization.

From these diagrams, which clearly shows that the resulting signal passing through such a MEMS structure, made significant changes in the phase shift when switching (change of position) N elastic membranes. When you squeeze the stress position change magnetic field is much larger than the switching position of the same membrane.

The change in phase shift can be seen in the chart gap passage of two signals (Fig. 8). From these results it can be argued that to achieve the desired effect to position 5 pair of MEMS structures. Also from this graph shows that the signal is constant over the entire frequency range, which is a measure of uniformity of structure and uniform influence on the signal passed through it.

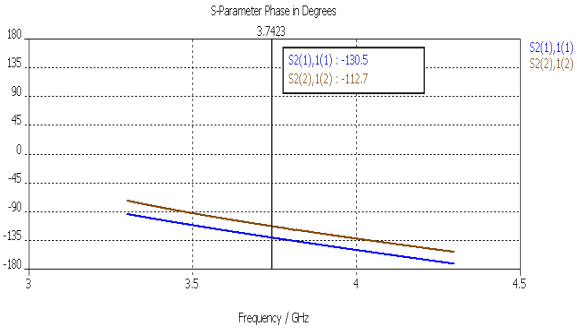


**Fig. 8.** The phase delay between vertically and horizontally polarized signal.

As a result of the optimization were yours-values for significant impact on the phase delay provides: height cylinders (pins), the comb structure. By increasing the height of pins is increased degrees Celsius phase shift. The results of this dependence are shown in Fig. 9.

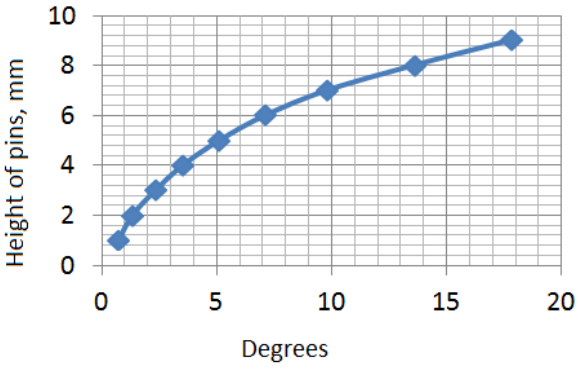


**Fig. 9.** Dependence of the phase shift by increasing the height of pins.

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When a signal of circular polarization of the input polarization converter, the output of which is

connected orthomode converter (OC) 2 outputs OC incoming signals depending on the position of switching elements (Fig. 10 and Fig. 11).

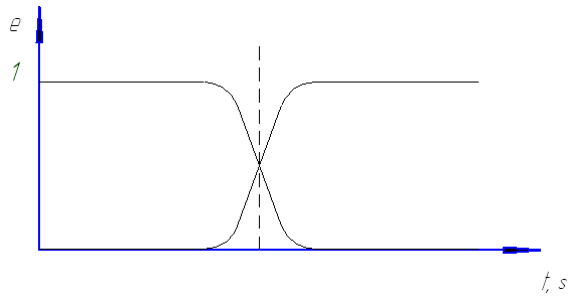


**Fig. 10.** Changing the signal in the time of its type polarization.

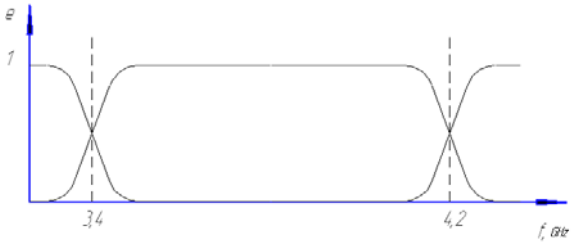


**Fig. 11.** Changing the signal in the frequency range of its type polarization.

## 6. Consistency of System

Another important parameter in the converted transformer polarization is consistent throughout the range of frequencies. In result of the optimization of geometrical parameters appliance do, it was found that the coherence of the whole system is affected by distance between the switching elements. This dependence is shown in Fig. 12.

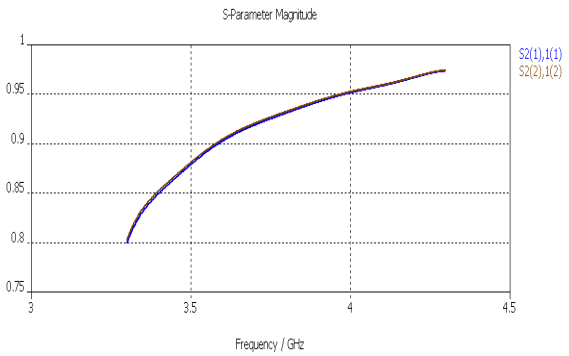


**Fig. 12.** Adequate coordination of the two polarized signals.

At a distance of 20 mm between sections MEMS consistency is quite adequate, it can be seen in Fig. 13.

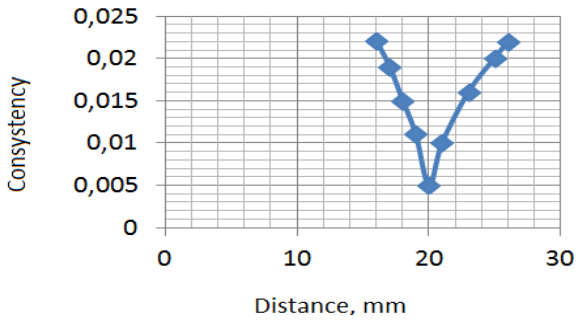


**Fig. 13.** Consistency structure with two sections.

## 7. Conclusions

The character of the dependence of the phase shift of the resonance managed shifters on their basic design parameters which allows to evaluate the maximum achievable performance of such devices, as well as to calculate the design parameters required to achieve the desired phase shift and the bandwidth of the device.

On the basis of experimental studies revealed the advantages and disadvantages of phase shifters designed structures, suggest ways to improve their performance, as well as the perspectives of their application.

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