ISSN 0735-2727, Radioelectronics and Communications Systems, 2014, Vol. 57, No. 10, pp. 451–456. © Allerton Press, Inc., 2014.
Original Russian Text © A.E. Kogut, S.O. Nosatyuk, V.A. Solodovnik, R.S. Dolia, 2014, published in Izv. Vyssh. Uchebn. Zaved., Radioelektron., 2014, Vol. 57, No. 10, pp. 25–33.

Implementation of Higher Order Forced Oscillations Mode in Shielded Dielectric Resonators by Using Slotline

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Received in final form August 13, 2014

Abstract—The electromagnetic characteristics of the shielded hemisphere dielectric resonator in 8-mm waveband were investigated experimentally. The utilization of a slotline for the excitation of whispering gallery modes in such resonator was suggested. It has been defined that the suggested excitation technique is efficient. It provides an opportunity to excite the high Q-factor higher order modes in shielded dielectric resonator without additional energy losses. It has been proved experimentally that the unloaded Q factor achieved in the resonator under investigation may exceed the threshold values, which are limited by the dissipative losses in the dielectric resonator material, due to the shift of the resonance field in the air gap between the metal and the dielectric resonator elements. It was demonstrated that the symmetry breakdown of the investigated resonator leads to a significant deterioration of its electromagnetic characteristics.

DOI: 10.3103/S0735272714100033

INTRODUCTION

Creation of novel and efficient excitation techniques for high-Q resonance systems of millimeter wave band is a challenge not only from the perspective of the microwave electromagnetics as the fundamental direction of radiophysics science, but it also has a direct applied purpose. Experimental investigations of resonance systems in forced oscillations mode allow us to estimate the prospects for their application in specific microwave devices [1].

A wide class of such problems includes the excitation of high-Q dielectric resonators (DR) with the higher order modes of whispering gallery (WG) type. At the present time, these resonators are applied in a number of active and passive devices of millimeter wave band [2]. Highly stable generators, efficient power combiners and sensitive primary structural elements of dielectrometers have been designed on their basis.

However, along with the established advantages DR with WG modes have the following disadvantages caused by quite a number of unsolved problem tasks:

1. Conditions of the excitation are of first importance in forming of electromagnetic characteristics of these resonators in the forced WG oscillations mode. Excitation techniques by using a distributed coupling of DR with dielectric waveguides, as well as the coupling with the external energy transmission line at local areas are well-known. The latter ones include an excitation via probe or coupling slot in DR, which are placed in the flat metal mirror [3].

The excitation techniques presented have a number of significant disadvantages. Distributed coupling does not allow to obtain high values of the coupling parameter because a dielectric waveguide is located outside the DR in the areas of WG modes fields with low intensity. The use of local coupling leads to disruption of the DR integrity, thereby bringing additional energy losses, which in turn have a negative impact on the quality factor.

2. Despite small radiation energy loss, open DR possess limitations on the quality factor. The threshold value of the quality factor for them is mainly caused by losses in the dielectric material of the resonator.

Transition to a triple-layered DRs, that are shielded DRs of spherical shape with an air gap between metal and dielectric, allows to overcome this threshold. It has been demonstrated in [4, 5] that “ultrahigh quality factor” WG modes can be excited in such a resonant system at a specific ratio of the radii of spherical DR and