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Faraday shield for electronic components of a multilayer microwave board

***Abstract**. In this work the shielding method based on Faraday cage was proposed for multilayered microwave board designs. It was shown that with such an approach the compact multifrequency microwave designs can be built. Proposed shielding method reduces signal losses and signal interference between adjacent microwave paths and nodes.*

Streszczenie.** W pracy zaproponowano metodę ekranowania opartą na klatce Faradaya dla konstrukcji wielowarstwowych płytek mikrofalowych. Wykazano, że przy takim podejściu można zbudować kompaktowe konstrukcje mikrofalowe. Proponowana metoda ekranowania zmniejsza straty sygnału i interferencje sygnału między sąsiednimi ścieżkami mikrofalowymi i węzłami.* (Ekran Faradaya dla elementów elektronicznych wielowarstwowej płytki mikrofalowe**j)*

Keywords: Faraday cage, electromagnetic shielding, electromagnetic compatibility, multilayered boards.
Słowa kluczowe: ekran Faradaya, elementy mikrofalowe.

Introduction

Modern trends in the development of electronics are moving towards reducing the size and increasing the functionality of the electronic devices. Because of that the monolithic microwave integrated circuit (MMIC) technology and system on a chip (SoC) approach were rapidly developed recently [1-3]. The main drawback of using such methods is the output power restriction as proper heat transfer materials are not used in the fabrication of MMIC. To some extent it can be overcome by the concept of modular assemblies where MMICs are nodes that perform certain functions.

The most applicable assembly technologies today are LTCC and HTCC technologies, as well as various 3D microwave assemblies using multilayer organic-inorganic technologies [4, 5]. These technologies offer a cost-effective way to produce 3D integrated microwave and millimeter-wave components and system-on package assemblies with high performance. Moreover such technologies provide convenient interconnection between MMICs and passive components in buried layers.

Feasibility of Antenna-on-Chip and Antenna-in-Package integration using LTCC technology [6,7] and availability of planar transmission lines such as grounded coplanar waveguide, a microstrip, and a stripline that are easy to implement in the frame of multilayerd technology make multilayered packaging applications even more attractive.

Because of each node high functionality, their interaction requires a careful study of electromagnetic compatibility (EMC) issues. In connection with the general issues of miniaturization, the desirable options for creating multilayer modules are either the most miniature unified unit or a small-size module containing paths of different frequencies. These trends are especially pronounced in the space industry, where the microwave transceiver modules, must receive and transmit signals at physically separated frequencies, which again leads to EMC issues.

There are different ways to improve electromagnetic compatibility. For example densely populated via fences and multiple ground/power planes can be used to provide improved RF performance in terms of reduced electromagnetic coupling and radiation loss. Or some kind of PBG structure can be designed inside the cavity, to form a kind of bandstop filter at the desired frequency.

In this paper we propose the shielding method based on a Faraday cage [8] that is built inside the board with the help of multilayer assembly technologies. We believe that this method is the most prominent for electromagnetic coupling reduction and for shielding against electromagnetic radiation (EMR). This shielding technique is designed to protect microwave modules from external and internal parasitic EMR and can be used to shield the microwave module nodes from any EMR.

Shielding design

The shielding device for electronic components (see Fig. 1) is a multilayer board with active (crystals) and passive (capacitors, inductors, resistors) elements installed.

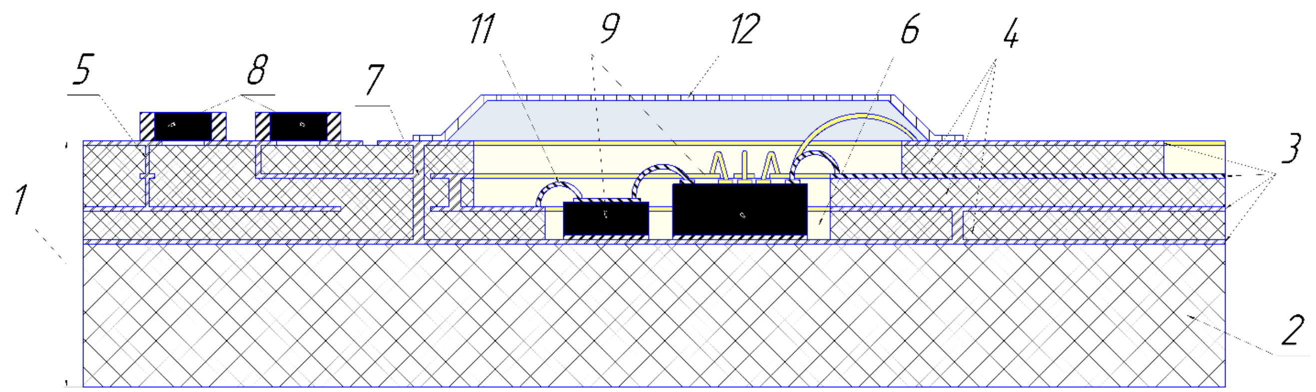

Fig. 1. General view of a multilayer microwave board.

The multilayer board (1) consists of a ceramic substrate 0.5 mm thick (2), which serves as a heat sink, and several, consecutively deposited conductive metallic (3) and dielectric (4) layers. Conductive metallic layers were deposited on the substrate and on each dielectric layer. An electrical circuit topology and the grounded polygons are formed on conductive layers. The grounded polygons fill almost all the remaining space on the surface of the dielectric layer (Fig. 2).

Interlayer electrical connections are made using vias (5) and can connect not only adjacent but any layers inside the board. At the same time, there are wells (6) in the board, where active and passive elements (9) that require shielding are installed. As solid cages generally attenuate electromagnetic field better than mesh cages, the hollow closed region along the perimeter of the well is filled with metal, forming a solid metal shield (7) for elements installed in the well. The shield walls are grounded because of their electrical connections with conductive layers grounded polygons. The metal shield protects electronic components from any EMR outside of the well. Also it protects the outside components (8) from parasitic electromagnetic emission generated by the powerful elements that were installed inside the shielded well.

There are nonmetallic areas, which are called windows, (14) in the metal shield. These windows serve to supply power and control signals to the crystal and used to drive out the processed data from the crystal to the outer modules. The windows are used to drive all low-frequency signals through the shield barrier and should be as small as possible for the design used.

For high-frequency signals, there are shielded transitions (13) in the metallic barrier (7) (see Fig. 3 for details). These shielded transitions are composed of conductive layers grounded polygons and vertical metallic walls in the dielectric layers. The high-frequency conductive track inside the shielded transition and the grounded wall form the coplanar waveguide. The distance (10) in such a waveguide should correspond to the carrier microwave frequency. The shielded transition (13) and the barrier wall (7) are made of the same material to ensure the best microwave characteristics of the high-frequency track inside the shielded transition.

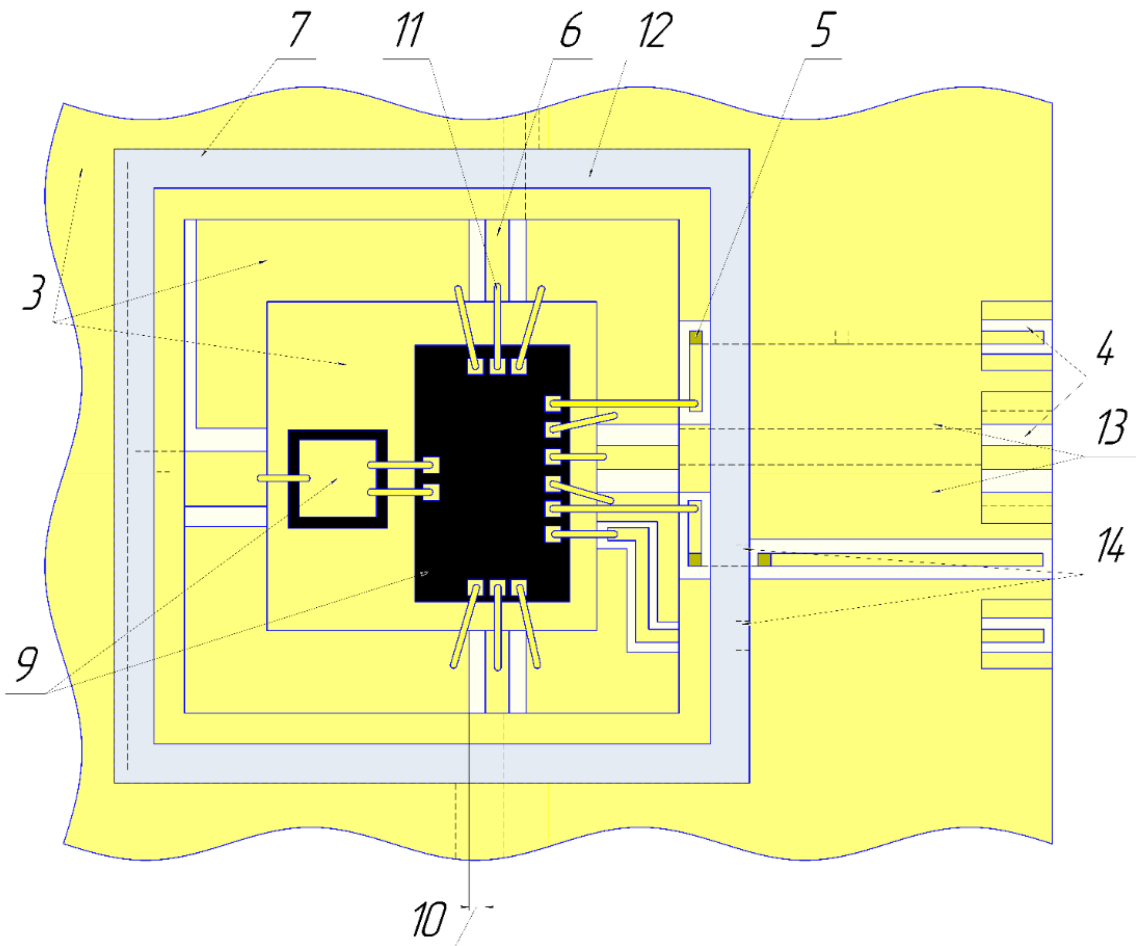

Fig. 2. General view of the well (6) with components (9) installed (14 – nonmetallic windows, 13 – shielded transition).

There are active and passive elements on the board. The elements which require shielding are installed in the protected wells (6), while the elements that do not require shielding are installed on the upper conductive layer of the board. Next, the crystal wires are bonded onto a conductive pattern, and a cover (12), made of a conductive material, is installed above the well for shielding and sealing the crystal.

Thus, shielding is formed along the entire length of the signal path, which makes it possible to create frequency independent channels within one module without greatly increasing its dimensions and weight.

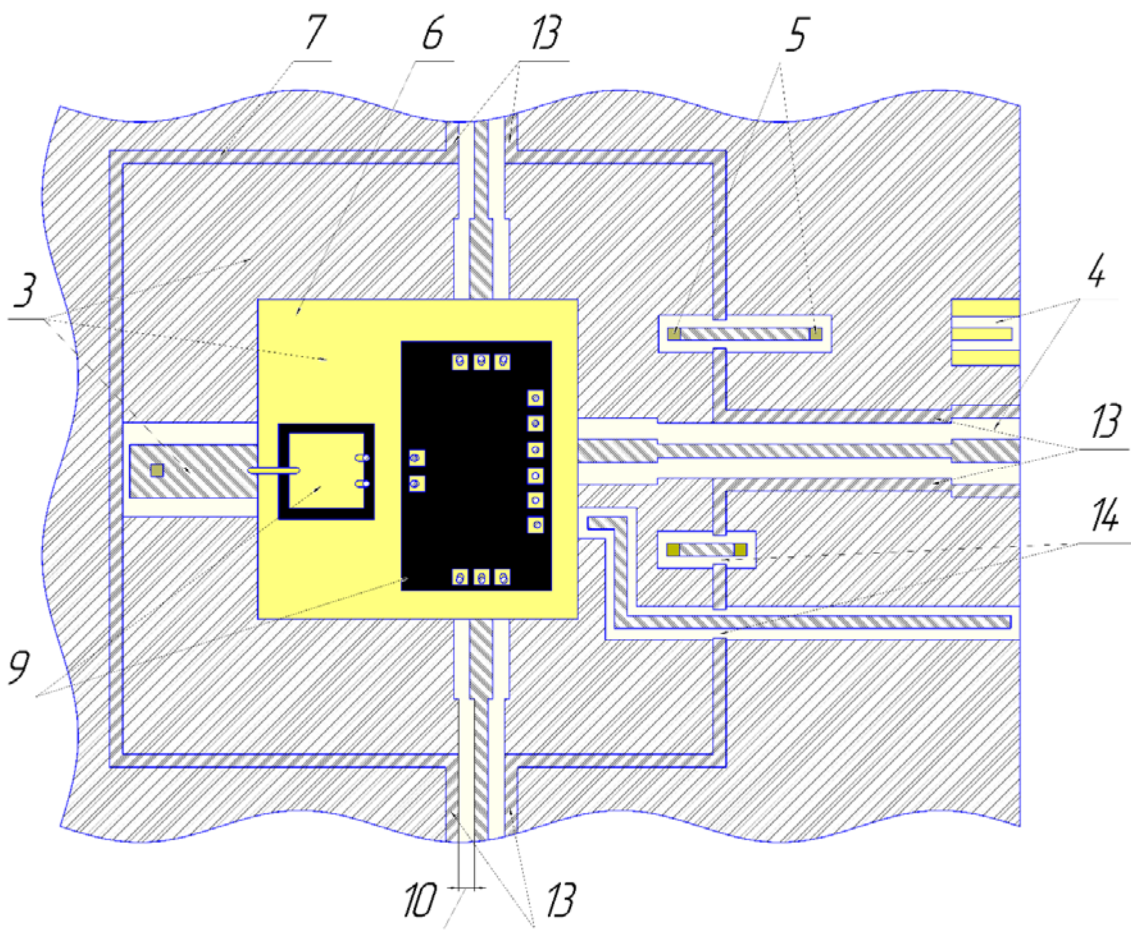

Fig. 3. Board *i*-th conductive layer cross section.

Conclusions

Based on the above, we can conclude that using the described method of electromagnetic shielding along with multilayer board technologies, it is possible to create electronic microwave modules with the minimum size and the maximum possible functionality. Also, for modules which contain channels of different frequencies this shielding method will greatly reduce signal losses and signal interference between adjacent signal paths or different nodes.

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