Electromagnetic Compatibility Analysis of the Infocommunication Systems Components on the Flexible Structures Basis

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***Abstract*—The design requirements analysis for the infocommunication systems components on the basis of flexible printed circuit boards taking into account their electromagnetic compatibility is performed in the article. The basic parasite parameters of multi-layered printed circuit boards are considered and the recommendations on their diminishing are formulated. Also the information of mechanical actions influence on the electromagnetic compatibility of electronic modules is presented.**

Keywords—electromagnetic compatibility; flexible PCB; infocommunication systems components; parasitic parameters

I. INTRODUCTION

The reliability of the telecommunication equipment is greatly depended on constructive and technological solutions. Increasing of the connections elements density per unit of printed circuit boards (PCB) area and their quantity, electronic components (EC) size reduction complicate the task of reliability ensuring.

An actual scientific and practical direction is the development of infocommunication systems modules based on the flexible commutative boards that are widely used by providing opportunities to reduce dimensions and weight characteristics, bring down the cost and improve the reliability of devices containing such structures [1]. Especially this approach suitable for to use these flexible structures to portable telecommunication devices, systems for terrestrial and satellite communications [2].

Electromagnetic compatibility (EMC) requirements analysis for electronic modules components design is required. The task of EMC analysis of PCB based on flexible connection structures is quite time-consuming, since its decision become increasingly complex due to increasing of the EC packaging density and the upper frequency of useful and disturbance signals range, as well as the useful signals levels reducing and interference levels growth [3].

II. ANALYSIS OF INFOCOMMUNICATION SYSTEMS COMPONENTS EMC

EMC analysis of components as part of the infocommunication systems is assigned for comprehensive assessment of the engineering development quality, confirming the constructive and technological solutions correctness and ensuring the EC functioning under specified conditions, and with the required quality. The electronic modules reliability depends largely on effectiveness of such analysis.

EMC analysis is performed considering the parasitic parameters of electronic components. In computer simulation of signal integrity the frequency dependence of the PCB materials (gaskets, prepreg, solder mask, conformal coating) is taken into account. It is possible to reduce electronic modules production costs by eliminating PCB re-design for identifying pathways of high electromagnetic interferences during the tests due to a more accurate simulation of the real impact of the PCB components and materials [4].

Analysis of electronic components EMC consists of:

- signal integrity analysis, in particular the wave resistance of transmission lines analysis, power bus noises and crosstalk analysis, analysis of the transmission line load influence, as well as rational structure of multilayer PCB delimitation;
- time characteristics analysis, namely the researching of propagation delay in the transmission lines, and signals misphasing and their fronts jitter;
- PCB components EMC analysis, in particular the considering of the PCB interference emission level, conductive interferences on the power buses and the susceptibility to radiated interferences from external sources.

III. SELECTION OF PCB DESIGN ACCORDING TO EMC REQUIREMENTS

PCB construction choice is an important factor determining the mechanical and electrical characteristics during usage the complete device.

Basic requirements for the electronic modules construction for different purposes expressed in their ability to withstand the climatic conditions and mechanical effects during operation.

When equipment is exposed to vibrations and linear accelerations the recoverable and unrecoverable malfunctions can occur in it.

The electromagnetic noises and the parallel modulation are typical of recoverable malfunctions, and the examples of unrecoverable changes are breakages and damages. The acoustic distortion and the large signal noise appearance in the resulting signal, and also spurious modulation of a positive signal, which is caused by the piezoelectric and strain effects are recoverable failures [5].

In addition to the mechanical branch of electronic modules reaction there is also an electric one. It is caused by the deformation and mechanical stress. There is the notion of stability of the module, which is characterized by the normal functioning of the equipment under mechanical influences. Causes of stability loss may be:

- changing the transient resistance value in the connectors contact groups;
- variation the parameters of passive elements;
- active elements parameters variation;
- the appearance of noise voltages in conductors, oscillating into magnetic fields;
- occurrence of noise voltage in fluctuations due to an electric charge appearance under mechanical effects in high-quality dielectrics.

These constructive and technological trends in the development of the multilayer PCB wiring techniques impose a number of specific requirements for flexible bases materials quality and for technological operations in the circuit boards and cables manufacturing and assembly.

These parameters may affect on output parameters of electronic modules on a flexible substrate base:

- mechanical: the rigidity of the board, the natural-vibration frequency, dynamic flexibility, wear;
- electrical: the parasitic parameters of the conductors, electromagnetic compatibility and so on;
- technological: the number of layers, the dielectric base and conductive layers material, the interlayer connection type, conductors width and the gap between them [6].

For responsible circuit development the multilayer printed circuit boards (MCB) are used. Their implementation on the flexible material basis allows a significant reduction in dimensions and weight characteristics, as well as an increase in the printed wiring density.

The salient features of the MCB application are the following:

- PCB signal layers are exempted from the power buses, that facilitates signal conductors wiring;
- between the ground and power circuits polygons appears distributed capacitance, which reduce high-frequency noise;
- better suppression of electromagnetic and radio frequency interference is provided due to the reflection effect;
- reduction in the total cost of small-scale production. Despite the fact that the manufacture of multilayer printed circuit boards is more expensive, their probable emission can be less than from single- and double-layer boards. Consequently, in some cases, the use of a multilayer board only will allow to meet the requirements of electromagnetic radiation designed in construction, without carrying out additional tests and testing. MCB application can reduce the emitted interferences by 20 dB in comparison with the double-layer boards.

IV. PARASITIC PARAMETERS OF PCB

Wires circuit on the can be both a source and a noise receiver. Correct conductors tracing reduces the sensitivity of analog circuitry to radiation sources [7].

PCB is sensitive to radiation because the conductors and leads of electronic components constitute the peculiar antenna. Capacitive coupling appear between flexible PCB conductors, located one above the other on adjacent layers. The examples of conductors located on different layers that form parasitic connection at intersection point and also the relationship between parallel signal tracks, are presented in fig. 1.

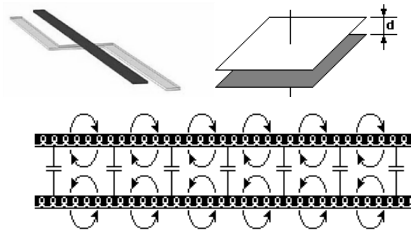

Fig. 1. Parasitic connections between flexible PCB conductors.

The magnitude of the parasitic capacitance is calculated by formula

$$C = \frac{\varepsilon \cdot \varepsilon_0 \cdot S}{d},$$

where ε is relative dielectric capacitivity, ε_0 is electric constant, equal $8.854187817 \times 10^{-12}$ F / m, S is conductors overlay square, d is insulation thickness.

On the basis of this function, one of the solutions for parasitic capacitances problem is conductor length or width reducing. In this way it is possible to reduce the capacitance value tenfold.

But conductor width is depended on technological process of PCB on a flexible basis manufacturing, and also foil thick (when foil-clad dielectric, for example, polyimide is using). Also the width of the conductor may be limited to the requirements specification for high-frequency circuits. As alternative solutions for this problems can be offer to increase PCB layers quantity (up to the maximum allowed) and reduce conductors overlay area at different layers. But it is important to remember

that the increase of layers number of flexible PCB can reduce its dynamic flexibility during electronic module usage.

The inductive coupling can occur between conductors that are close to each other, as well as by creating an interlayer connection as vias (fig. 2).

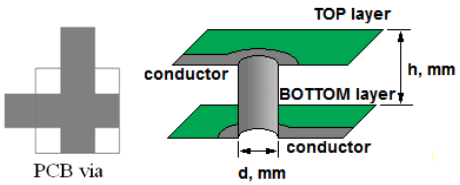

Fig. 2. The inductance of vias

It should be remembered that vias inductance with a capacity form a resonant circuit that may affect to electronic module functioning at high frequencies. Although the self-inductance of the vias is sufficiently small, and resonant frequency is approximately in the gigahertz range, but if the signal during its path has to pass through several vias, their inductance will be added (series connection), and the resonance frequency decreases. Therefore, it is important to avoid a large number of vias in flexible PCB at layout process for critical high frequencies wires of analog circuits.

As the test sample the self-oscillating circuit on the basis of inductance coil fabricated directly on the surface of the flexible PCB is selected. For the experiment the sample is fixed on a work area with two sides. The research of mechanical deformation takes place by the action of mechanical vibrations of different frequencies in the PCB.

The result of the experiment is the dependence of the inductance on the displacement of PCB central part, its left and right edges (fig. 3a), as well as the dependence of the output parameters of the inductor on the frequency of external mechanical vibrations (fig. 3b).

Abnormalities in the direction of increasing the inductance and its decrease were observed. The maximum deviation reached ± 0,10 uH.

The quality factor reducing can be the cause of the self-oscillations shape distortion and the appearance of the additional frequency instability. For inductance of 7.99 uH quality factor of the circuit will be 142.33, and for 8.10 uH it will equal to 143.31. The difference between these values is 0.98 or about 0.7%.

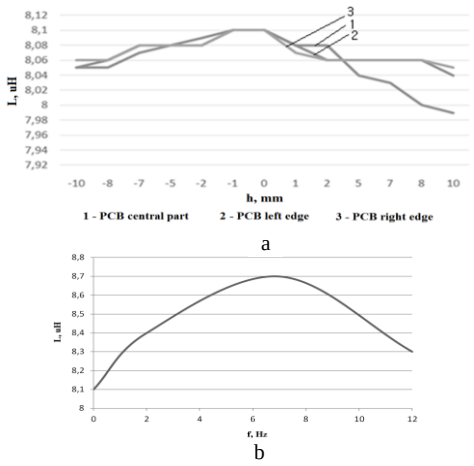

Fig. 3. PCB output parameters changing in dependence on its displacement and vibrations frequency

V. CONCLUSIONS

At the stage of designing the electronic module the required electrical characteristics of topology should be provided, as well as parasitic parameters of the circuit should be minimized. To reduce the parasitic parameters separation of data wires and supply conductors is recommended. It is also should be remembered that the lower the conductors bends number on the circuit board, the better the frequency characteristics of the circuit.

In the task of electronic modules EMC there are several sub-tasks such as the external electromagnetic fields impact on flexible connection structure, the signals delay and distortion in the interconnections wiring, and others. Among these problems in the first place now there is the problem of forecasting the electromagnetic radiation from the circuit boards wiring. Application of simplified models for such prediction at the modules development stage is difficult because of the complex object geometry.

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