GALVANIC COUPLING - EMC OF ELECTRICAL SYSTEMS (PART III.)

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Abstract *This papers deals with the analysis of the electromagnetic compatibility (EMC) – galvanic coupling problems focused to the area of power electrical systems. The description of galvanic coupling problem is divided into few separate parts according to the length of common conductors or the working frequency. The third one (PART III.) analyzes problem for circuits with distributed parameters and one long common conductor or processed signals with high working frequency. For detailed problem investigation a mathematical analysis, computer simulation method and verification measuring are used, too.*

Key words: *electromagnetic compatibility, galvanic coupling, common conductors, long lines.*

1. Introduction

The problem of galvanic coupling deals with individual electric equipments or their parts, which are interconnected in such a way, that minimum one common conductor connects these equipments and so mutual influence is generated.

2. Solution for the Higher Frequencies and Distributed Parameters

The working frequencies and the length of common conductor must be taken always into account. In all cases of the galvanic coupling, the fact that electrical components are not ideal and so they are containing certain parasitic capacitances, inductances and real resistances is valid. Due to higher working frequency of currents flowed by the common conductors, they must be taken as circuits with distributed parameters, during the process of predictive result galvanic coupling investigation. If the working frequencies will be lower, then the interconnecting circuits can be taken as circuits with concentrated parameters.

2.1. One common conductor - Theoretical analysis

The electric circuits interconnection realized by one common conductor with the distributed parameters, is a special case, where more electric circuits are utilizing one common conductor, which is either long or serves for high frequency signal conduction, as it is pictured in figure Fig. 1.

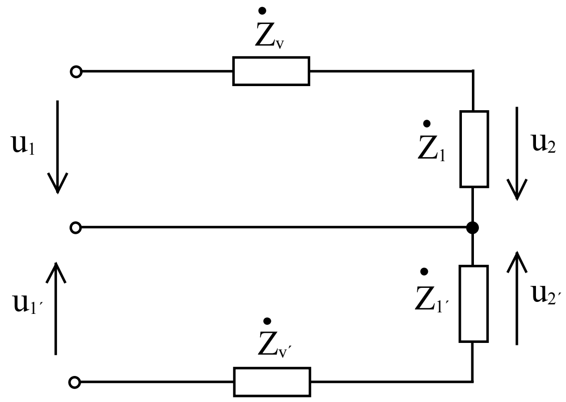

Fig. 1. The circuit interconnection by one common conductor - higher frequencies

The problem analysis will be done for the case of two electric circuits interconnection, the scheme of which is shown in figure Fig. 2. Let the upper circuit be supplied by a DC voltage source with the value U_1 = 5 V. As interface conductor the same cable as in the previous case was used, it means CYSY 4x1,5 mm^2 with the length 15m and with parameters R_0 = 0,047 Ω/m, L_0 = 343 nH/m, G_0 = 33,3 μS/m, C_0 = 118 pF/m.

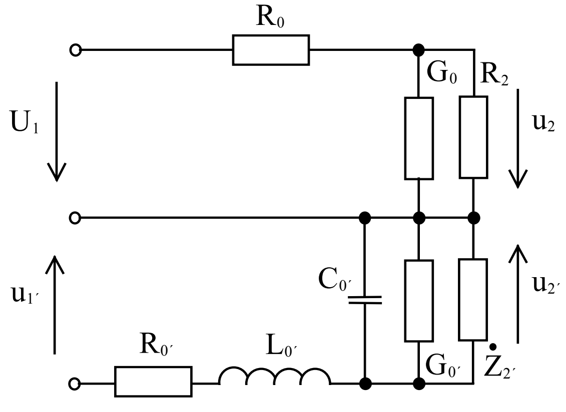

Fig. 2. The scheme of investigated circuit connection

The upper circuit has no signal change. The output voltage u_2 should be reflecting only voltage drops caused by long line longitudinal resistance and a vertical drop-in. Let the lower circuit be supplied by the same periodical impulse signal $u_{1'}$ as in the case of previous analysis. It is possible to state the mutual circuit galvanic coupling influence by finding the upper circuit real voltage u_2 course. According to 2nd Kirchoff's law, we can write equation for the investigated circuit:

$$u_2 = U_1 - u_{1'} + u_{2'} - R_0.I_1 = U_1 - u_{1'} + u_{2'} - R_0.\frac{U_1}{\frac{R_2.G_0}{R_2 + G_0} + R_0} \quad (1)$$

The analytical form for voltages $u_{1'}$ and $u_{2'}$ the description can be obtained from previous analysis, as equations for input and output voltages of long transmission line. By the substituting of these voltages, the searched relation for time dependence of voltage u_2 is possible to receive. Any accessible Excel program will do graphical interpretation of the resulting solution again, figures Fig. 3 up to Fig. 6.

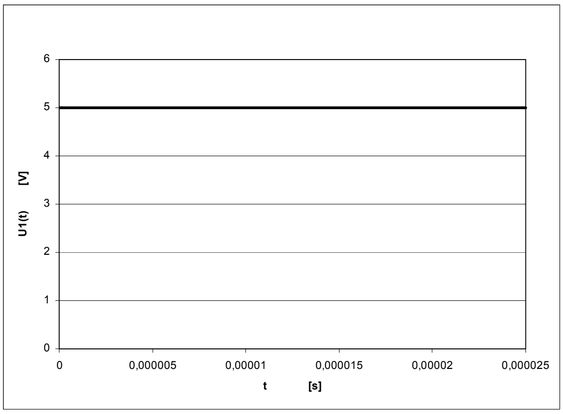

Fig. 3. The input voltage U_1

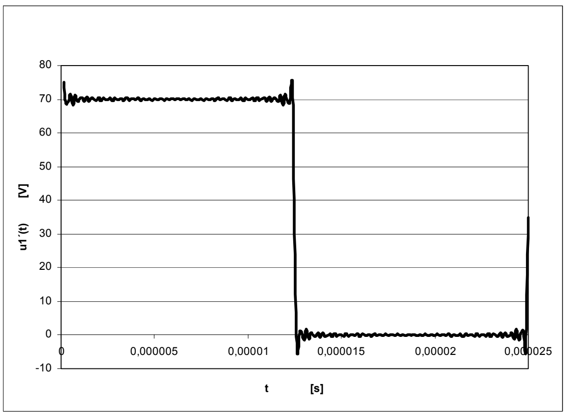

Fig. 4. The input voltage $u_{1'}$

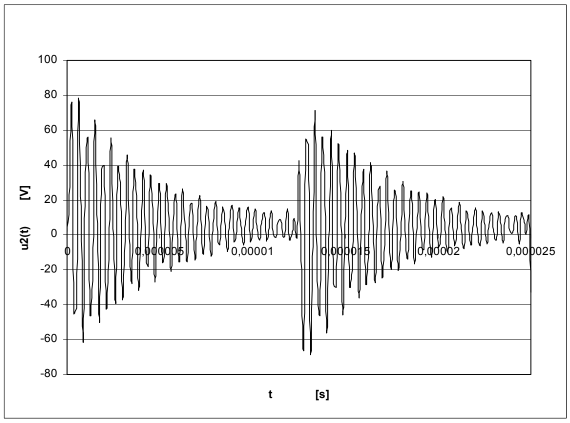

Fig. 5. The output voltage u_2

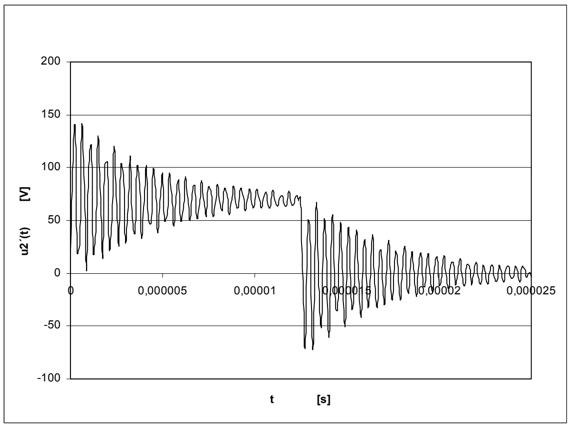

Fig. 6. The output voltage $u_{2'}$

2.2. One common conductor – Simulation and Measuring

Equally, as in the previous case multiple verification of correctness can be done by the PSPICE program simulation and by practical measurement. The results are presented in figures Fig. 7. and Fig. 8.

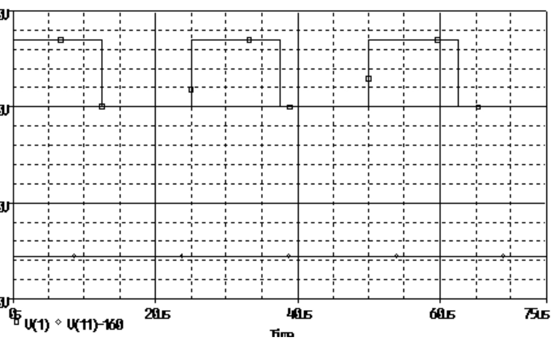

Fig. 7. The input voltage $u_{1'}$ and U_1 obtained by simulation in the PSPICE program

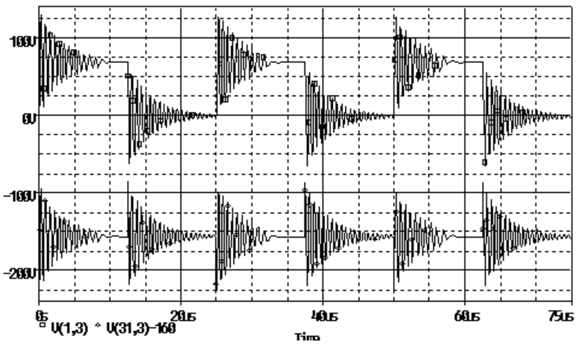

Fig. 8. The input voltages $u_{2'}$ and u_2 obtained by simulation in the PSPICE program

The coincidence of the obtained results is evident. Small differences concerning the input and output voltage oscillation damping are given by the fact, that for the input and output voltage the infinite Fourier's series were replaced by only the first 40 components in the Excel program. The measured courses voltages of the voltages are pictured in next figures Fig. 9. up to Fig. 12.

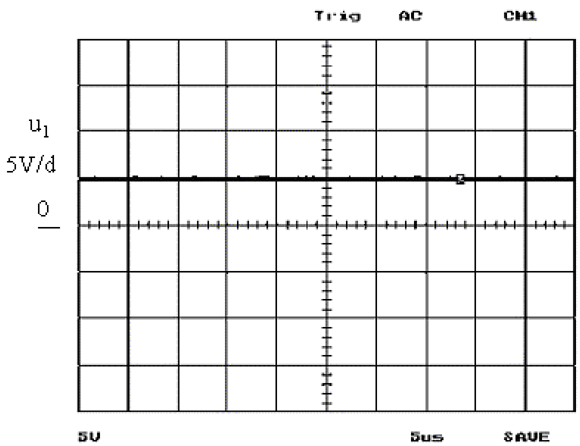

Fig. 9. The measured input voltage u_1

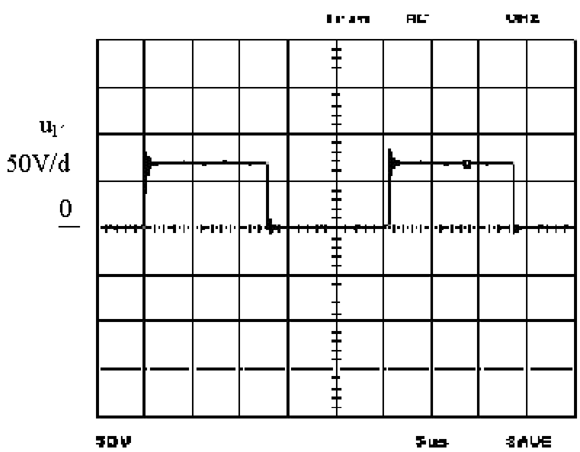

Fig. 10. The measured input voltage $u_{1'}$

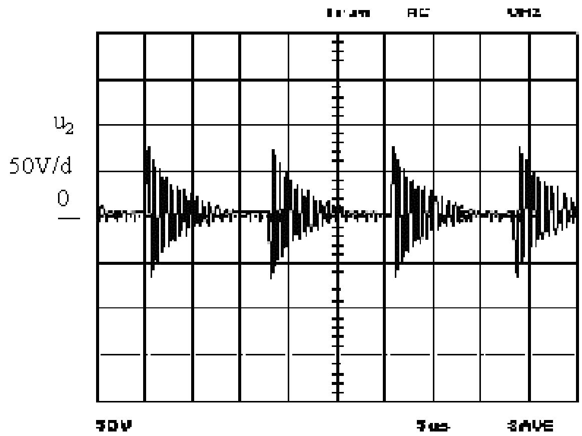

Fig. 11. The measured output voltage u_2

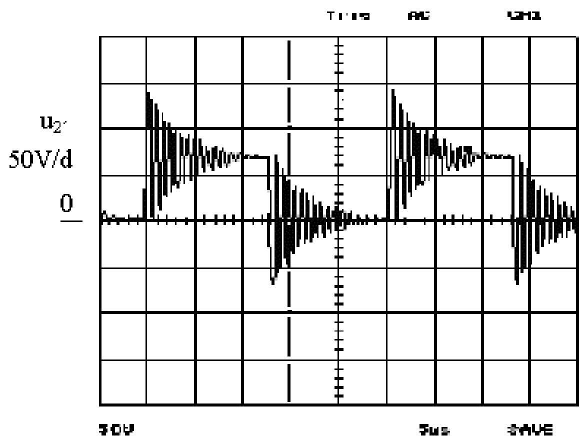

Fig. 12. The measured output voltage $u_{2'}$

3. Conclusion

All performed analyzes indicate, that the derived equations are correct and can be utilized for predictive stating of galvanic coupling influence. Based on above-mentioned, the fact, that derived equations are valid, results in the conclusion, that they can be utilized by electrical equipment constructers for the creation of construction vision, which concerns of galvanic coupling influence.

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