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„PRZEWODY" PROGRAM FOR CAPACITANCE AND INDUCTANCE DETERMINATION OF CAN-BUS TRANSMISSION LINES

The describing of the computer program which allows to determine residual parameters of the cable system with cylindrical section has been included in the paper. The wire capacitance and inductance, which are used in data transmission systems (i.e. CAN-bus), have a big influence on parameters of the transmission line. The knowing of these parameters allows to select the optimal conditions of the such systems from the point of view of transmission quality and electromagnetic compatibility.

1. Introduction

In the data transmission using CAN-bus (based on wires the most often made in spiral form) the typical phenomena occurs for signal line transmission. Their properties - connected with wire section, isolation type, geometrical configuration – have a big influence on parameters of the designed circuit. The reason is in fact that the spatial conductive structures have accumulation ability of the electric and magnetic field energy what means the parasitic capacitances and inductances, respectively. Ignorance of such line parameters creates impossibility of accurate determination of the signal time propagation in CAN-bus, analysis of disturbance propagation and determination of voltage drop between particular nodes. Because those factors have principled influence on correct bus operation (especially by determination bite time parameters and maximal bus load that is maximal number of net nodes), the possibility of their calculation plays a very important role. Currently applied, the simplified calculation method based on some assumptions and their recurrent modification (when the proper results are impossible to obtain) is not formal and requires – in designers opinion – big experience [1].

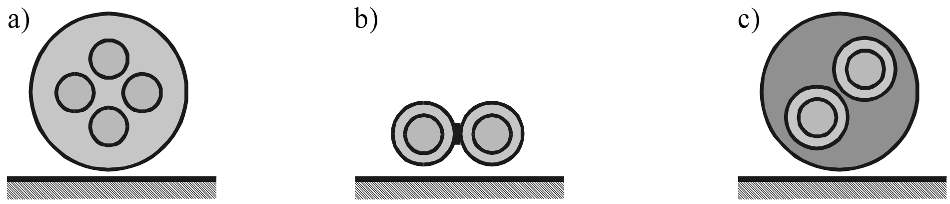


Fig. 1. Example configurations of CAN-bus wires: a) star quad signal cable; b) flat ribbon not twisted; c) twisted wire near ground.

The computer program elaborated on the basis of moment method has been described in the paper [2,3,4]. It makes possible calculations of the capacitance ad inductance of the transmission line from measurements of its geometrical parameters. It allows to beginning of the work on the controllers' configuration of CAN-bus in the best way for used transmission line (Fig.1). The applied method as well as elaborated computer program can be used in any other case when the knowledge about residual parameters is required.

2. Program user manual

The current program version was created in Delphi packet, so its using is analogue to the other Windows programs. Program start window (Fig.2) allows to introduce of analysed wire configuration in graphic form on the largest working area of this window.

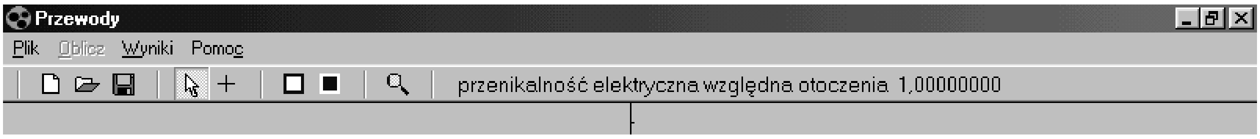


Fig. 2. Part of the main window of "PRZEWODY" program

After preliminary graphic wires' placement the accurate position corrections are made in adequate program window (Fig.3). This method allows to simplification of the data input because the data transposition from real-world measurements to specific co-ordinate system is not necessary.

The general parameters for whole wire system (number of Fourier coefficients, permittivities of environment, etc.) are established in calculation window (Fig.4). The number of Fourier coefficients is the parameter results from assumed calculation algorithm and has decisive influence on computation accuracy. After finishing of elementary parameters' calculations the results are presented in selected window (Fig.5).

Fig. 3. Window of the wire context menu

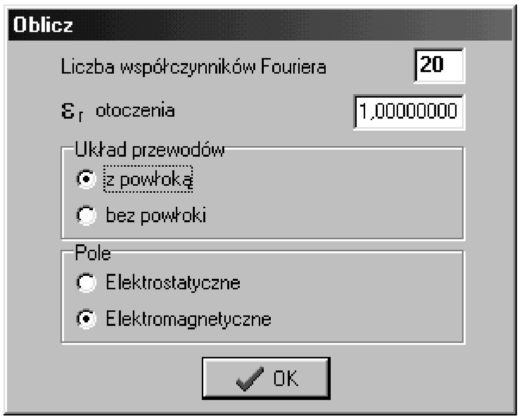
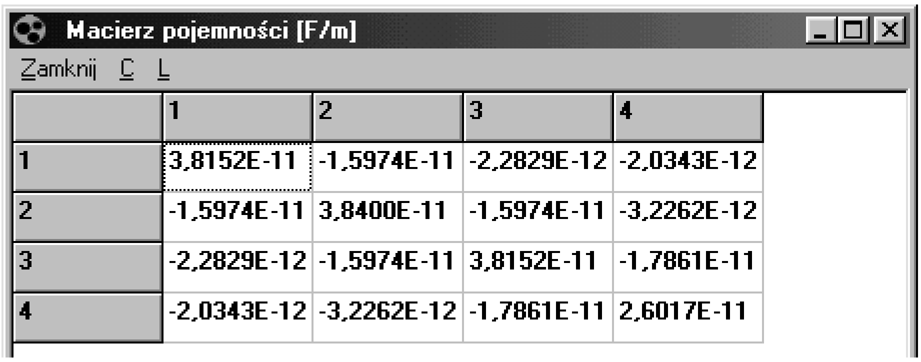


Fig. 4. Window of program configuration


Macierz pojemności [F/m]

Zamknij C L

	1	2	3	4
1	3,8152E-11	-1,5974E-11	-2,2829E-12	-2,0343E-12
2	-1,5974E-11	3,8400E-11	-1,5974E-11	-3,2262E-12
3	-2,2829E-12	-1,5974E-11	3,8152E-11	-1,7861E-11
4	-2,0343E-12	-3,2262E-12	-1,7861E-11	2,6017E-11

Fig. 5. Results window of elementary capacitance calculation.

3. Simulations and experimental investigations

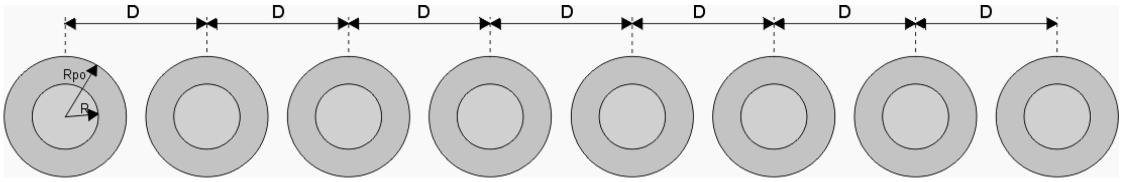
For verification of the calculations correctness in "PRZEWODY" program the simulations for typical cylindrical cable systems have been made. They were carried out for two types of eight-wires tape cables, ten-wires tape cable and flat phone cable (four wires) (Fig.6,7,8). Verification was only made for the samples' capacitances. The inductance is determined on the basis of capacitance matrix, so the correctness of its calculation guaranties the proper results for inductance.

The capacitances of the selected wire configurations (Table 1) were calculated with the following assumptions:

- number of Fourier coefficients: NF=6;
- relative permittivity coefficient of wire isoaltion: ε_r=3,5 (for PCW);
- relative permittivity coefficient of environment: ε_r=1;

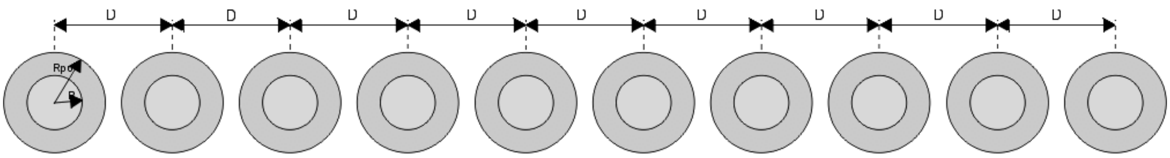
• radiuses and distances between cable were determined from measurements of cable wires and coats using micrometer;

• selected calculation option for cable systems with coat.



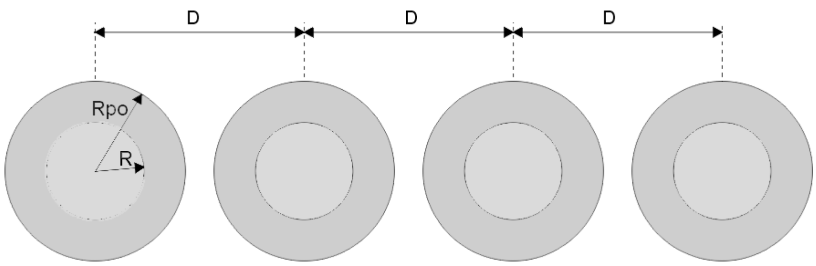
Sample 1: coat radius R_{po}=0,00047m, wire radius R=0,00027m, separation D=0.00094m
Sample 2: coat radius R_{po}=0,000655m, wire radius R=0,000295m, separation D=0.000131m

Fig. 6. Parameters of tested wires - samples 1 and 2



Sample 3: coat radius R_{po}=0,00075m, wire radius R=0,000385m, separation D=0.00015m
Sample 4: coat radius R_{po}=0,000705m, wire radius R=0,000305m, separation D=0.00018m

Fig. 7. Parameters of tested wires - samples 3 and 4



Sample 5: coat radius R_{po}=0,00048m, wire radius R=0,000125m, separation D=0.000131m

Fig. 8. Parameters of tested wires - sample 5

Table 1

Selected elements of capacitance matrix for the particular samples

Matrix items	CAPACITANCE computed per length unit, pF/m				
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
C_{11}	91,320	75,091	82,779	44,342	55,553
C_{12}	42,142	33,843	37,739	18,659	24,290
C_{13}	1,9831	2,192	2,035	1,982	4,4747
C_{14}	0,9039	0,933	0,870	0,877	-
C_{15}	0,5934	0,609	0,537	0,549	-
C_{16}	0,4963	0,513	0,395	0,409	-
C_{17}	0,9275	0,928	0,332	0,347	-
C_{18}	-	-	0,325	0,345	-
C_{19}	-	-	0,678	0,659	-

For the calculation verification the selected cylindrical wire configurations were laboratory measured using automatic General Rardio 1683 RLC bridge. The capacitance was measured for the cables with 1m length (it allows to treat of capacitance as capacitance per length unit). The all measurement results are made between one extreme wire (as reference wire) and others wires in the quad.

Table 2

Selected elements of the capacitance matrix measured for particular samples

Matrix items	**CAPACITANCE measured per length unit, pF/m**				
	Sample 1	**Sample 2**	**Sample 3**	**Sample 4**	**Sample 5**
C_{11}	97,012	77,334	83,195	39,987	55,832
C_{12}	44,813	35,013	38,890	18,752	22,958
C_{13}	1,798	1,972	2,117	1,796	3,6291
C_{14}	0,742	0,989	0,811	0,778	-
C_{15}	0,641	0,591	0,563	0,587	-
C_{16}	0,601	0,560	0,435	0,441	-
C_{17}	0,592	0,554	0,355	0,379	-
C_{18}	-	-	0,349	0,377	-
C_{19}	-	-	0,344	0,371	-

4. Conclusions

The presented computer application guarantees determination possibility of the element capacitance and inductance of wire system in CAN-bus. In relation to the other this type programs the elaborated tool has the following advantages:

- program can be modified by addition of the other options allowed to create integrated tool for CAN-bus configuration;
- visualization of the geometrical configuration of the modelled wires;
- bigger accessible RAM memory area (in relation to LEITUNG program, for example), which allows to fast calculation of the more complicated wire systems.

The results from experimental investigations have a good agreement with computer calculations. For the simulation of the cable system with wire number bigger than 6 (ribbon) the significant error for the farthest wire from reference was occurred. It is caused by program algorithm but for CAN-bus (4 wires) it is not significant constraint. Passing over this case the results from program calculations are nearly the same like laboratory tests; maximal error don't exceed 12,8%. The main errors which influence on the obtained results can be described as:

- errors caused by inaccuracy of wire measurements using micrometer, big coat plasticity deformed during measuring process; solution – microscope measurements and statistical data processing;
- errors caused by inaccuracy wire manufacturing, for example differences in isolation radius of the particular cables and non-repeatable distance between them;
- measuring errors from RLC bridge.

The more detailed description of the program algorithm as well as its new possibilities will be presented in another papers.

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