SINGLE WIRE AND RESPECTIVE DOUBLE WIRE SCHEME EQUIVALENCE PRINCIPLE

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Abstract. This research paper gives results of investigations on an electrical single wire line, that connects a signal generator to alone conducting body. The single wire electrical circuit is described with differential equations considering the electric potential of the conducting body against vacuum potential. The analysis shows, that the obtained equations are equivalent to the concurrent two wire electric scheme and obey the Kirchhoff laws and current continuity.

Key words: single wire line, electric energy transmission, full current low.

Introduction

Electric power transmission systems have great importance in a state economy. Without them we can not imagine industry and everyday life. It is important that electricity transmission lines execute their task with the maximum efficiency in order to reduce expenses for the transmitted electric power as much as possible and to make the transmission line as cheap as possible.

Foundations of single wire electric circuits had been made by N, Tesla [1] and developed by Russian scientists S. Avramenko, D. Strebkov [2]. Investigations of the electric single wire systems are continued in works [3, 4, 5, 6].

Only one wire is necessary for creating such energy transmission lines, at the same time a wire may be thin and not made from copper.

System for measuring self capacity of the conducting bodies [7] was created in the result of the investigations, which allows experimentally determine the parameter that until now was not possible. If necessary the self capacity of a conducting body was calculated theoretically, but for bodies of an arbitrary form it resulted in a large deviation from real value.

Research object and methods

The single wire system operation depends on application described by self capacity of electric conducting bodies. This feature originates from effect of conducting body, namely, to accumulate a positive or negative electric charge $\pm q$ in itself, resulting in body's positive or a negative electric potential $\pm\varphi$ to space, which can be detected, for example, with an electroscope. The charged body has accumulated energy $E = \frac{C\varphi^2}{2}$, where C is body's self capacity. If body with one wire joins to the source of a negative electric potential $e = -\varphi$, then this is charged with a negative potential $-\varphi$. The conducting body respectively has obtained its own energy $E = \frac{C(-\varphi)^2}{2}$. We can deliver energy to conducting body with positive or negative current. During the charging process a current in a single wire can be described by equation $i_C(t) = C\frac{d\varphi(t)}{dt}$. If variable electric potential e is used, for example $e = U\sin(\omega t)$, then a stable alternating current flow in a single wire can be measured by AC ampere meter.

The use of a second wire to sustain a flow of current is not necessary. Current is dependent only from power source working frequency and output voltage and self capacity of conducting bodies. Power source one output is connected to ground.

Relation between electrical current of single wire and working frequency of generator were experimentally obtained and compared to theoretically calculated values. Schematic of such experimental measurement system is given in Fig. 1.

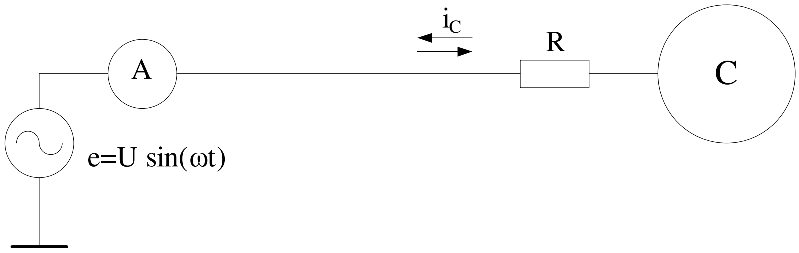
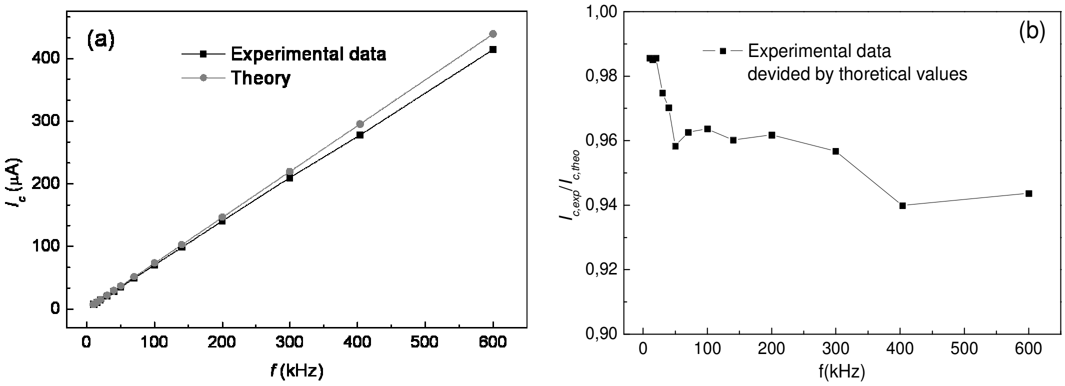


Fig. 1. **Single wire line current measuring scheme**

Theoretically current in a single wire is calculated using equation $I_C = \dfrac{U\omega C}{\sqrt{1+C^2R^2\omega^2}}$.

As an example in the graph Fig. 2.a measured and theoretical current of single wire is shown for a case when a capacity *C* is determined by electric conducting ball with diameter *D* = 20 mm. Deviation of measured and theoretical current is shown in Fig. 2.b.



a **b**

Fig. 2. **Measured and theoretical current as a dependence of frequency (2.a) and deviation of measured and theoretical current (2.b) in case of capacity of ball with diameter *D*=20mm**

Graphs Fig. 2.a and Fig. 2.b show a good relation between experimentally measured current to theoretically calculated values. Deviation from theoretical data within a range of 6 % is caused by numerous effects mainly due to the change of electrical field around conducting body caused by a presence of connection to it.

Using obtained experimental results, a mathematical model of a single wire line with the current measuring device is created. An equivalent scheme of experimental setup (Fig. 1) in a linear variant is shown in Fig. 3. As follows, to create mathematical model ammeter is replaced with the corresponding *r*, *L*, C_1 circuit.

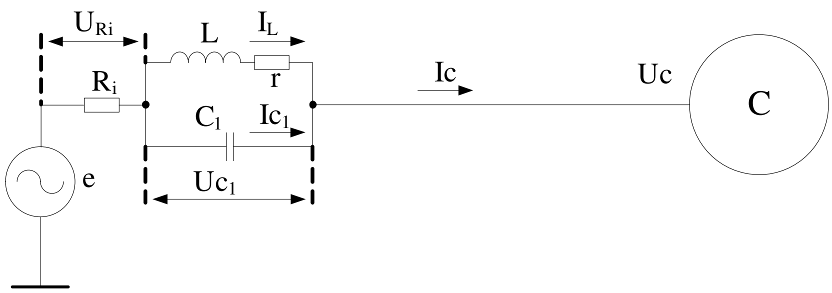


Fig. 3. **The equivalent linear scheme**

Using Kirchhoff's laws, linearized electrical circuit can be described by set of linear equations

$$\begin{cases} I_C = I_{C1} + I_L \\ e = U_{Ri} + U_{C1} + U_C \; . \\ U_{C1} = U_L + U_r \; . \end{cases} \tag{1}$$

Voltage U_C is considered as voltage of conducting body against vacuum zero electrical potential. From (1) we obtain differential equations of currents I_L, I_C, I_{C1} and voltages U_C and U_{C1}. As an example differential equation of current I_C is given in following equation:

$$R_i L C C_1 \frac{d^3 I_C}{dt^3} + (R_i r C C_1 + L(C + C_1)) \frac{d^2 I_C}{dt^2} + (R_i C + r(C + C_1)) \frac{dI_C}{dt} + I_C = \\ = CU\omega((1 - C_1 L\omega^2)\cos(\omega t) - C_1 r\omega \sin(\omega t)). \tag{2}$$

The differential equations of the other scheme signal functions are similar. Only indices and free members are changed.

Analysis of the obtained equations shows that they also, in the same way, describe the corresponding two wire scheme, shown in Fig. 4.

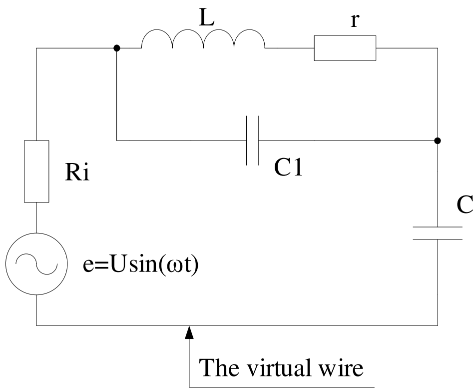


Fig. 4. **The correspondent double wire scheme**

As the conclusion of fact, that schemes in Fig. 3 and Fig. 4 have been described by the same differential equation, is that they are equivalent. It is also confirmed by executed experiments. It offers supposition, that the electric conducting body, which is electrically recharged from voltage source *e* (Fig. 3), is linked to a generator through a space with a second quasi wire. Meanwhile this connection shows no parasitic capacity's. And as this connection is equivalent to a conducting electric wire, we can name it as “the virtual wire”.

Scheme Fig. 3 must satisfy full current law, which follows from Maxwell equations, which requires equality of income and outcome currents for same district of space with surface *S*. In conventional case it can be seen in Fig. 5.

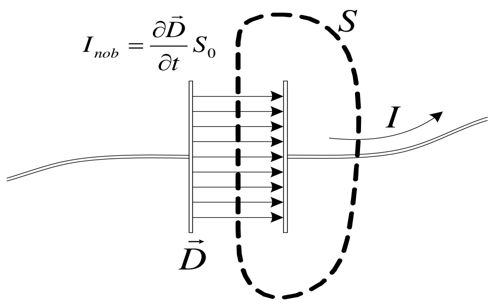


Fig. 5. **Full current low in circuit with ordinary capacitor**

Sum of displacement currents, incoming in space district S, must be equal out coming current *I*.

$$\oint_S (\vec{j} + \frac{\partial \vec{D}}{\partial t})\, dS = 0\,, \qquad (3)$$

where $\vec{j}$ - electric current density;

$\dfrac{\partial \vec{D}}{\partial t} = \vec{j}_{sh}$ - displacement current density;

$\vec{D}$ - electro inductance.

Analogically full current law applies in the model of single wire scheme (Fig. 6).

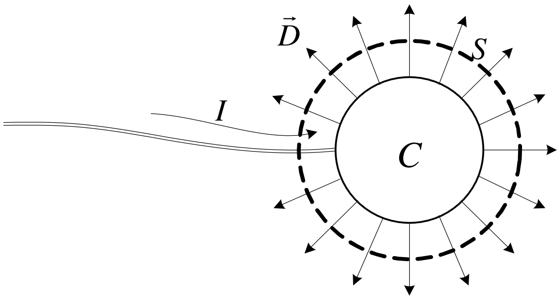


Fig. 6. **Full current law in single wire circuit**

Equation (3) can be equally used to calculate conducting and displacement currents for single wire case (Fig. 6) in respect to traditional model of capacitor (Fig. 5). In addition we can take in account also power supply ***e*** and support capacity C_{atb}, witch is shown in Fig. 7.

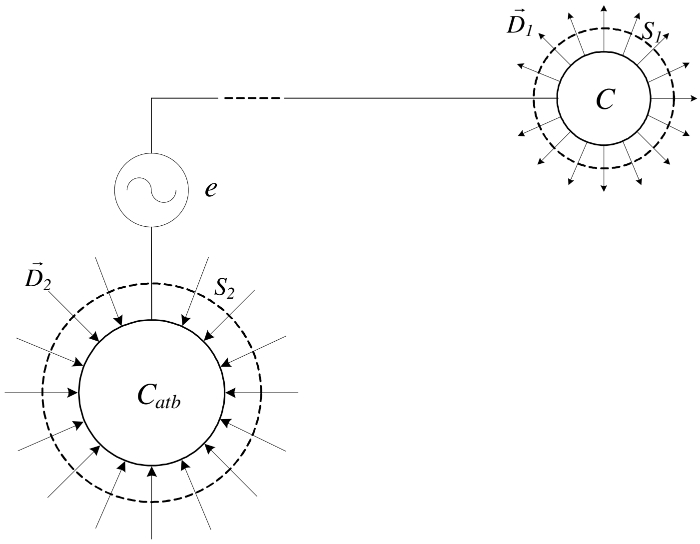


Fig. 7. **Single wire scheme with support capacity C_{atb}**

Radius of integration surfaces S_1 and S_2 of displacement currents (Fig. 7) can be expanded until as shift currents of bodies C and C_{atb} are connected with each other through free space. In experiments the grounding is used as support capacity C_{atb}.

This physical process fulfills requirement of full current low, and can be described and named as virtual wire.

Conclusions

1. Experimentally measured current of single wire shows good relation to theoretically calculated values of current (Fig. 2).

2. It can be supposed, that nature of the physical processes, that takes place in the space around a charged conducting bodies, can be described by formation of virtual electric connection (wire) between them.
3. The virtual wire operates independently on the conducting body's *C* distance to the voltage supply *e*.
4. The electric resistance of the virtual wire can be assumed identical to zero (R=0).
5. The appearance of virtual wire can not be explained with the operation of some parasitic capacities, because otherwise scheme and the their descriptive differential equations would be changed.
6. The appearance of virtual wire can be explained with operation of displacement currents.
7. Ohm's law, Kirchhoff's law and full current law applies in single wire scheme.

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