Frequency Characteristics of LV Electric Apparatus From the Point of PLC

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Abstract — **Data transmittion via electric power network is a new trend at computer communication (PLC- Power Line Communication). Main advantage – very spread and realy existing potential transmitting network is rather complicated due to strong interferences and network highly variable impedance conditions. Therefore different low voltage nerwork configuratins and its frequenycy transmitting characterics are studied.**

Keywords — Low voltage electric network, frequency transmitting characteristics, power line communication.

I. INTRODUCTION

Electric power lines are used not only for electric energy transmission. For many years are also used for switching command signal transmission. Such applications are characterized by low transmission speed. Signal carrier frequency is several hundred hertz or 100 kHz approximately.

For high speed data transmission high frequency carrier signal must be used. Typical carrier frequency for high speed data transmission lies in the range 2 – 30 MHz. Power lines transmission conditions for such broad frequency range are very complicated and non stable. The problem is that transmitting frequency characteristics and impedance frequency characteristics are very variable and are non stable. Every network element like command and protecting electric apparatus, electric consumer and transmission line represents relatively strong attenuation element. In such case signal penetration range could be very limited and application of this technology is in low voltage networks only.

Transmitting properties of the basic low voltage network will be presented.

II. BASIC MODELS OF ELECTRIC ELEMENTS

Each electric apparatus, part of power line or electric consumer could be represented by specific single port or two port substitution diagram. Principal substitution diagram of the two-port element (TPE) is in Fig.1

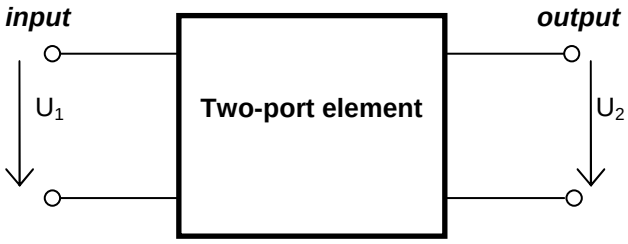


Fig.1 Basic diagram of a two port element

For TPE frequency transmitting characterization relation α_U between output and input voltage it is needed to know:

$$\alpha_U = \frac{U_2}{U_1}. \tag{2.1}$$

More frequently expression in dB is used

$$\alpha_U = 20 \cdot \log\left(\frac{U_2}{U_1}\right). \tag{2.2}$$

In case, when input and output TPE voltage is alternating then transmitting function is frequency dependent:

$$\alpha_U = \alpha_U(f). \tag{2.3}$$

Some protective apparatus and loads behave like single port elements. They are in circuit connected by two terminals and are characterized by impedance Z (see Fig. 2). Impedance Z could be relatively complicated in structure. Than its frequency characteristics can be complicated too.

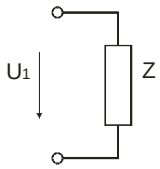
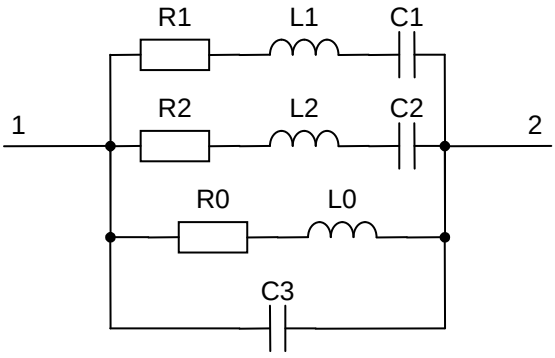


Fig. 2 Principal diagram of a single port element

Resulting structure of relatively simple part of power network principal diagram can be complicated and its frequency transmitting characteristics very broken.

III. EQUIVALENT CIRCUIT AND FREQUENCY CHARACTERISTICS OF SELECTED APPARATUS

For power network theoretical analysis equivalent circuit of the basic electric apparatus and its frequency impedance dependence was developed. Analyzed apparatus was circuit breaker, residual current circuit breaker, surge protector and digital time relay with an electronic power supply. Equivalent circuit of the presented apparatus together with the impedance frequency characteristics in the frequency range 100 kHz – 30 MHz are in Fig. 3 – 10.



R0 = 73,78 Ω

R1 = 7212,79 Ω

R2 = 36,25 Ω

L0 = $29{,}13 \cdot 10^{-6}$ H

L1 = $0{,}1 \cdot 10^{-12}$ H

L2 = $3{,}03 \cdot 10^{-6}$ H

C1 = $1{,}82 \cdot 10^{-3}$ F

C2 = $10{,}82 \cdot 10^{-12}$ F

C3 = $28{,}75. \ 10^{-6}$ F

Fig. 3 Equivalent circuit of Schrack BS017101 circuit breaker

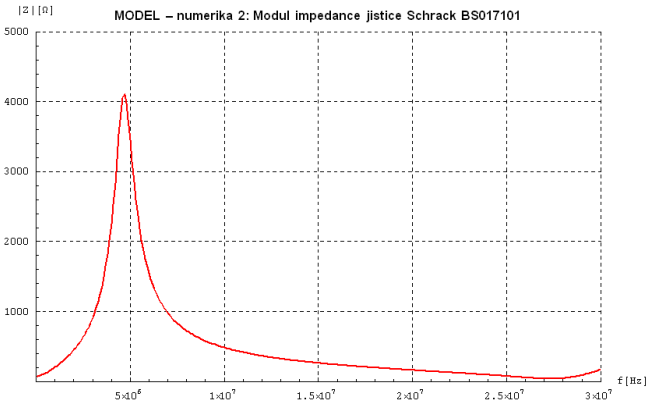
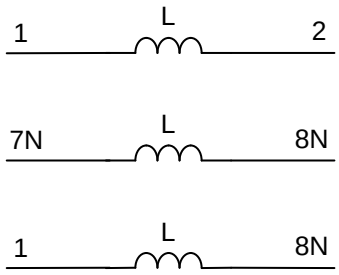


Fig. 4 Impedance frequency characteristics of Schrack BS017101 circuit breaker in the frequency range 100 kHz – 30 MHz



$L = 384{,}75 \cdot 10^{-9}$ H

$L = 441{,}02 \cdot 10^{-9}$ H

$L = 503{,}91 \cdot 10^{-9}$ H

Fig. 5 Equivalent circuit of Schrack BD094110 residual current circuit breaker

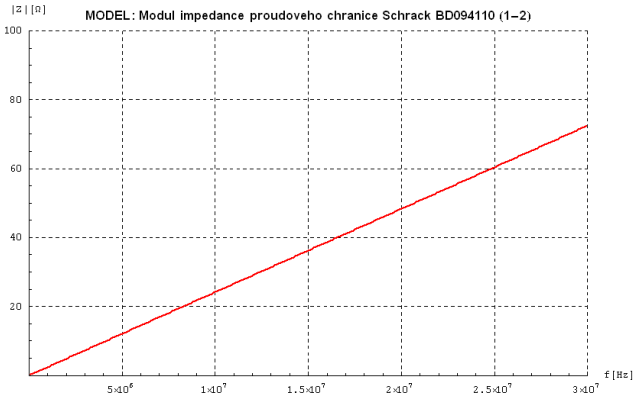
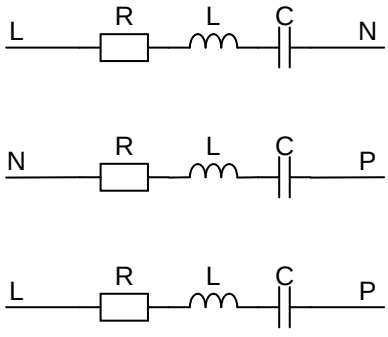


Fig. 6 Impedance frequency characteristics of Schrack BD094110 residual current circuit breaker in the frequency range 100 kHz – 30 MHz



R = 0 Ω
$L = 248{,}32 \cdot 10^{-9}$ H
C = $2{,}95 \cdot 10^{-9}$ F

R = 0 Ω
$L = 244{,}99 \cdot 10^{-9}$ H
C = $2{,}78 \cdot 10^{-9}$ F

R = 0 Ω
$L = 253{,}60 \cdot 10^{-9}$ H
C = $1{,}43 \cdot 10^{-9}$ F

Fig. 7 Equivalent circuit of Schrack AD2 surge arrester

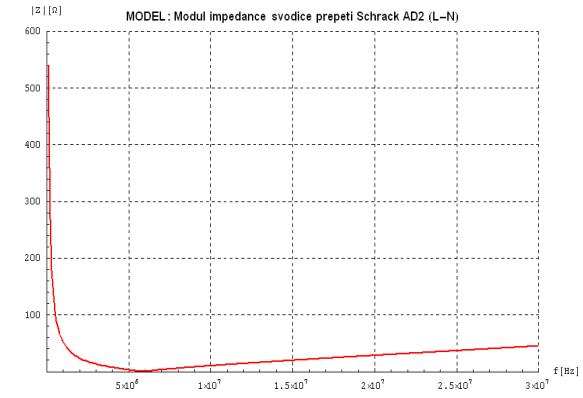
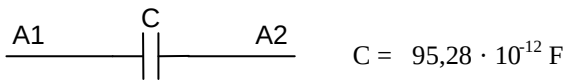


Fig. 8 Impedance frequency characteristics of the Schrack AD2 surge arrester in the frequency range 100 kHz – 30 MHz



$C = 95{,}28 \cdot 10^{-12}$ F

Fig. 9 Equivalent circuit of Schrack ZR368000 digital time relay (measured on the input terminals A1-A2)

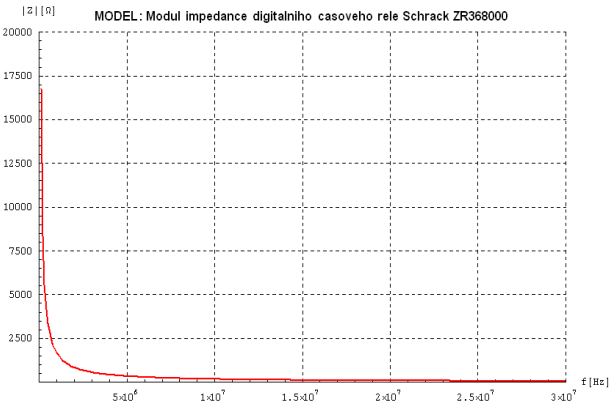


Fig. 10 Impedance frequency characteristics of Schrack ZR368000 digital time relay in the frequency range 100 kHz – 30 MHz

IV. Conclusion

Presented impedance characteristics in the range 100kHz and 30 MHz are one another different. With the exception of the circuit breaker having the resonant peak at the frequency near 5 MHz all apparatus have monotonous impedance characteristics. But looking on the equivalent circuit of the circuit breaker, in combination with other apparatus its cascade transmitting characteristics could have more resonant peaks and therefore for high frequency data transmitting could be usable in only limited narrow bands.

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