The resonances overvoltages in power transformer

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The windings of power transformer with viewpoint electromagnetic interaction present itself the complex oscillatory system with theoretically unlimited number of the natural frequencies. In the case of the external source of the excitation will contain the frequency complying with natural frequency of the windings, the resonance overvoltages which values can vastly exceed excitation component one are possible. Depending on structures of the oscillatory system it is required different time for excitation of the resonance overvoltages.

The structure of the oscillatory system is in the first place defined by degree relationship between its separate components. The presence of weakly coupled circuit relieves the development of the resonance overvoltages. The typical example of such event is a winding with interleaving turns in coils. The transient process in such winding at applying of the rectangular impulse may be conditionally divided under two stages. At moment of applying of the impulse the distribution in winding corresponds to the distribution on capacity. In this case the equivalent longitudal capacity of interleaving coils below greatly, corresponding to uniform voltage distribution inside the coil. The voltage distribution on the turns is uniformly (fig. 1). Herewith noticeable difference between initial and final the voltage distribution between opposite turns of adjusting coils exists that is a reason of the transients between its (fig. 2). Practically the process occurring in winding as a whole does not affect on the transient process in interleaving coils.

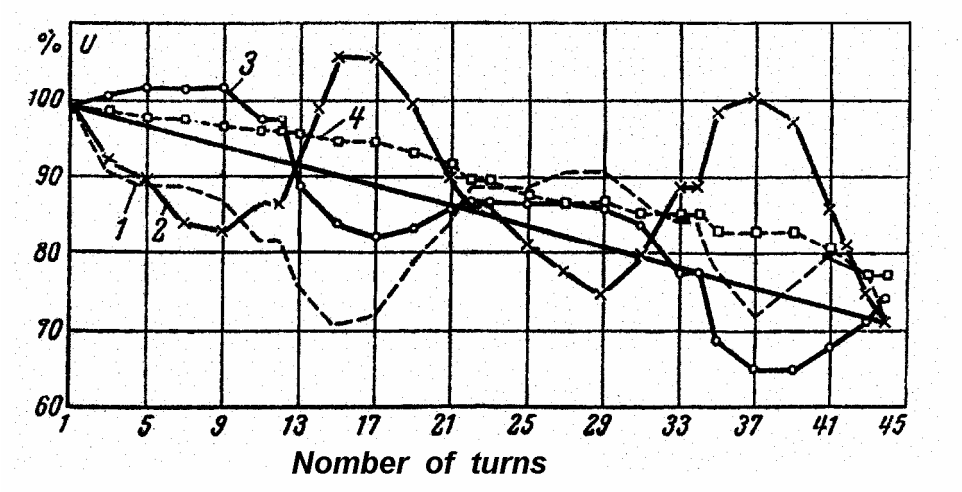

Fig. 1

The initial voltage distribution in interleaving coils (measuring):

1 – t = 0,09 μs; 2 – t = 0,15 μs; 3 – t = 0,5 μs; 4 – t = 0,4 μs

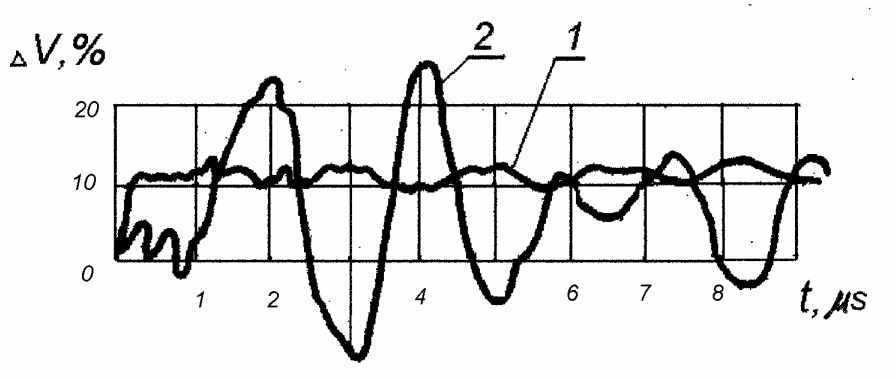

Fig. 1 The oscillogramm of voltage distribution in interleaving coils (English El.).

1. voltage across between ends of coils;
2. voltage between middle ports of coils

The end of transient process in the interleaving brings about the second stage of process, when the oscillation in winding is defined by equivalent longitudal capacity corresponding to uniform the voltage distribution in the interleaving coils (the large longitudal capacity of the coil). However, at presence in applying voltage the component with frequency corresponding to frequency of the nature frequency of interleaving coils the significant resonance overvoltages are developed in it. In practice this was observered under the impact of chop impulse with oscillation after chopping and provocate damage of the insulation in the middle part between interleaving coils. It also may by happen under operation of switch disconnector in GIS, directly connect with power transformer.

Change of disposition of turns reduces the value of the overvoltages due to of the reduction between its the difference between «initial» and «final» the voltage distribution.

Under application of the chop impulse with oscillations after choping the resonance overvoltages are observed in the low voltage winding also when the significant difference between initial and final voltage distribution is existed in it (for example when the low voltage windings are located between the common and the series windings in the autotransformer). Electrostatic screening of this windings practical is excluded this kind of the overvoltages.

At the last years the vacuum breakers are used widely. Their particularity is a possibility to cut off the current with high rate of change before its natural transition through zero that causes reignition process (fig.3, 4). At coincidence of the frequency of the repeated ignition with the natural frequency of the transformer windings the resonance overvoltages are appeared.

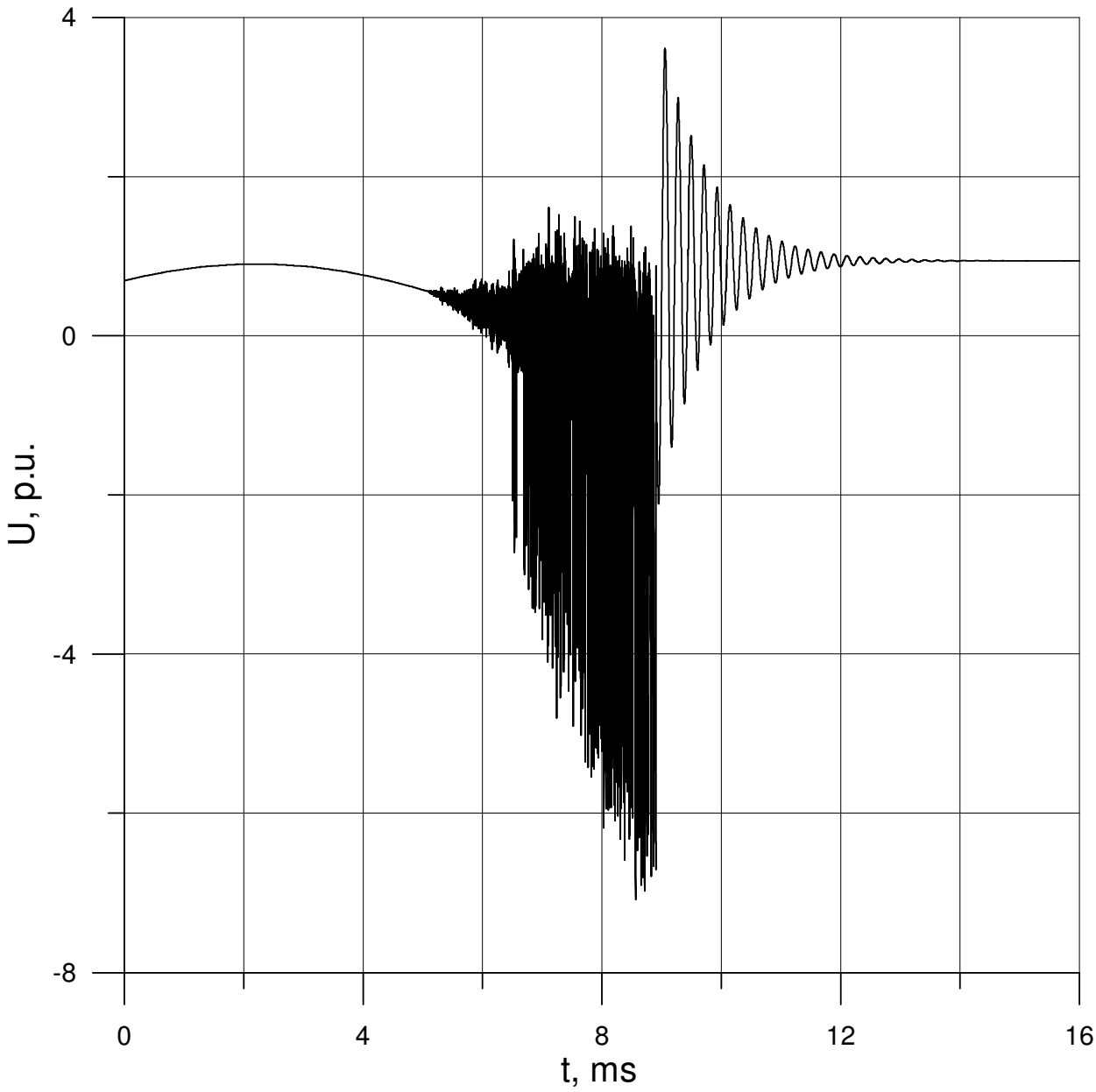

Fig. 3 Computed overvoltages at the furnace transformer (Um=40.5 kV) during by vacuum circuit breaker switching off

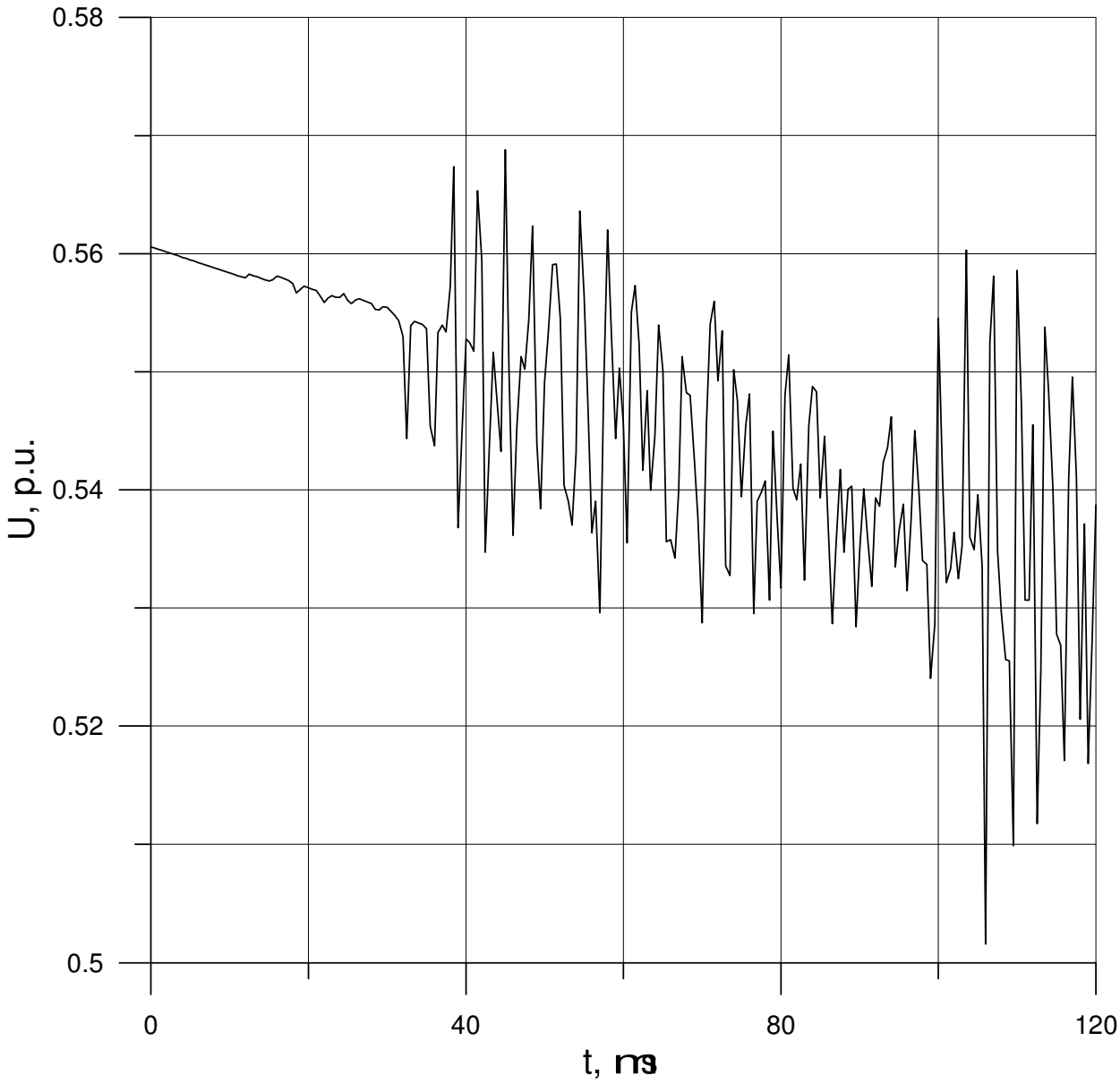

Fig. 4 Computed overvoltages at the furnace transformer (Um=40.5 kV) during by vacuum circuit breaker switching off (zoomed)

Several such events were registered in furnace transformers (in their regulating winding) which have as a rule, the large range of the regulation events particularly, when one of its ends was insulated. The overvoltage ratio in this case is reached to 8 – 9-times to voltage at the input transformer. In this case the installation of arrester on the input of transformer becomes inefficient (fig.5). The installation R-C devices chosen depending on parameter furnace installation, excluding or reducing probability of the repeated ignition reduces the probability of arising of resonance overvoltages (fig. 6).

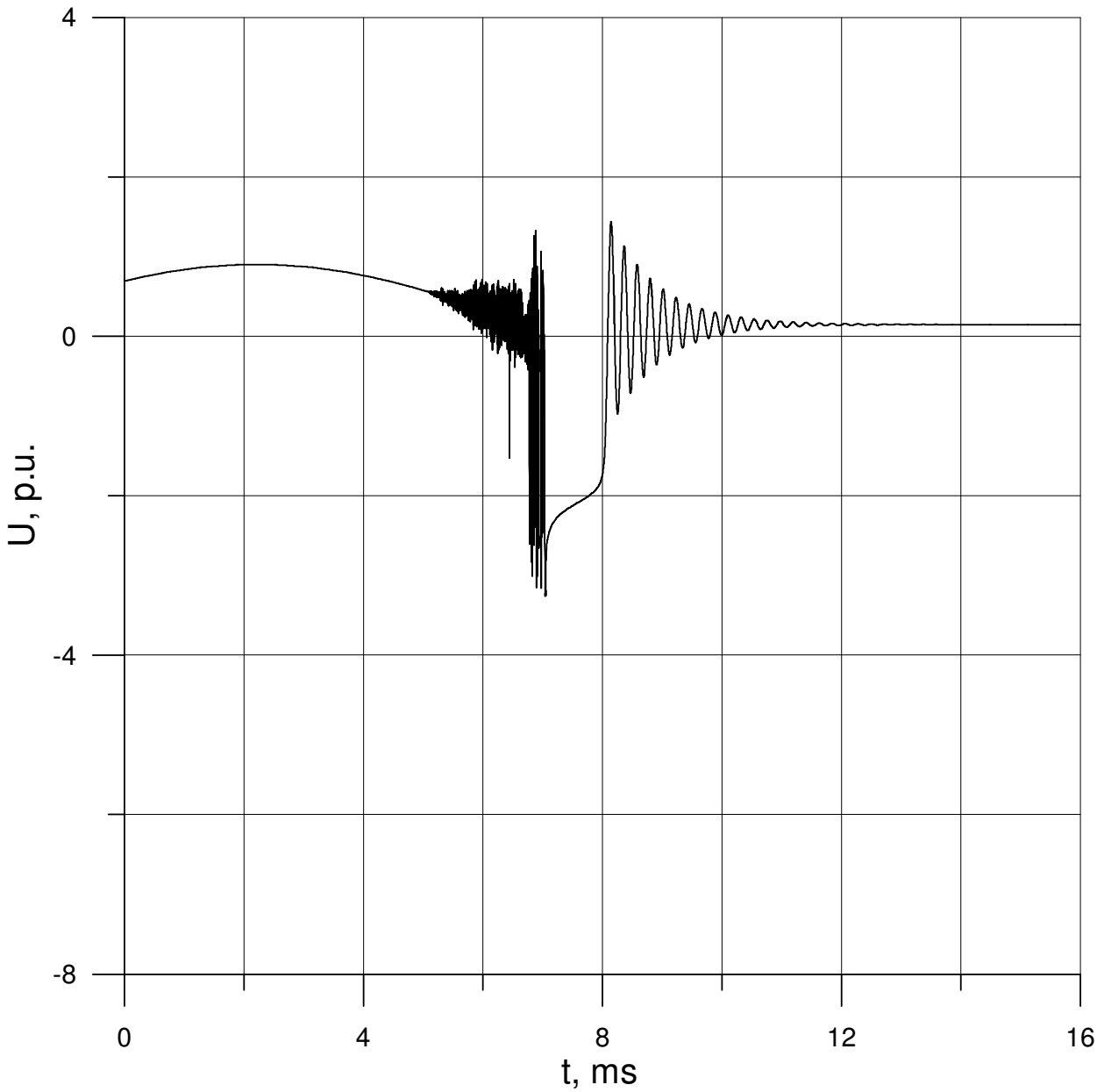

Fig. 5 The same of fig. 3, but with gapless arresters installed between phases and phases-to-earth

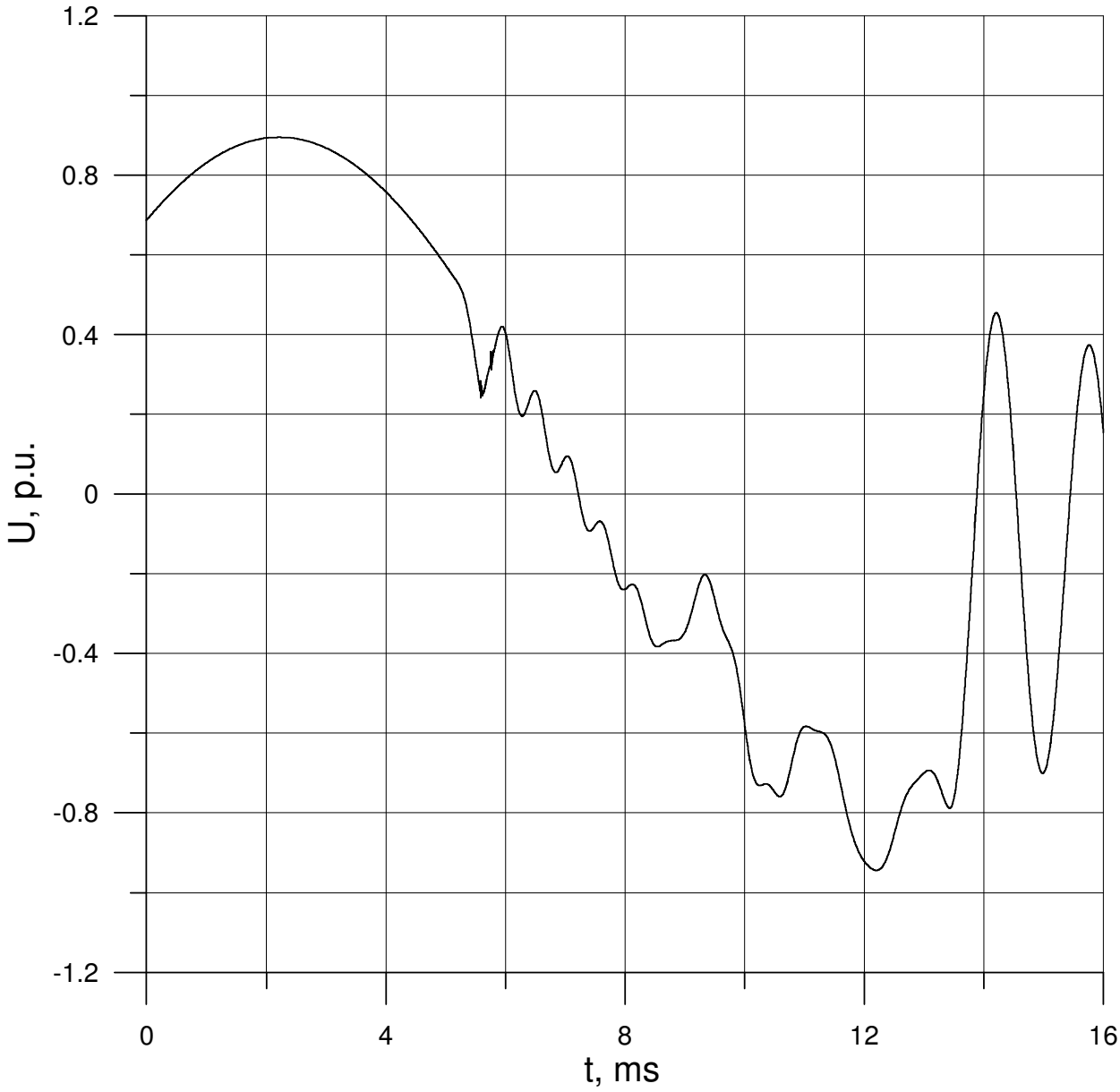

Fig. 6 The same of fig. 5, but with RC-circuits (R=25 Ohm, C=0.25 μF) installed at the both sides of circuit breaker