

POSSIBILITIES FOR THE EXTENSION OF USE OF ELECTRICAL FUSE IN FAULT CURRENT LIMITER DEVICES

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1 Introduction

The use of fault current limiter devices is usually accepted in MV and HV network. This paper deals with the fuses and fault current limiter devices as whole working together.

The result are both the reduction of current values and the increase of the reability of the components of the electric circuit.

2 Current limiter devices with L-C parallel circuits

The principled schema regarding the work of a current limiter device using a L-C parallel circuit (in fact L_0-C_0) is shown in Fig.1.

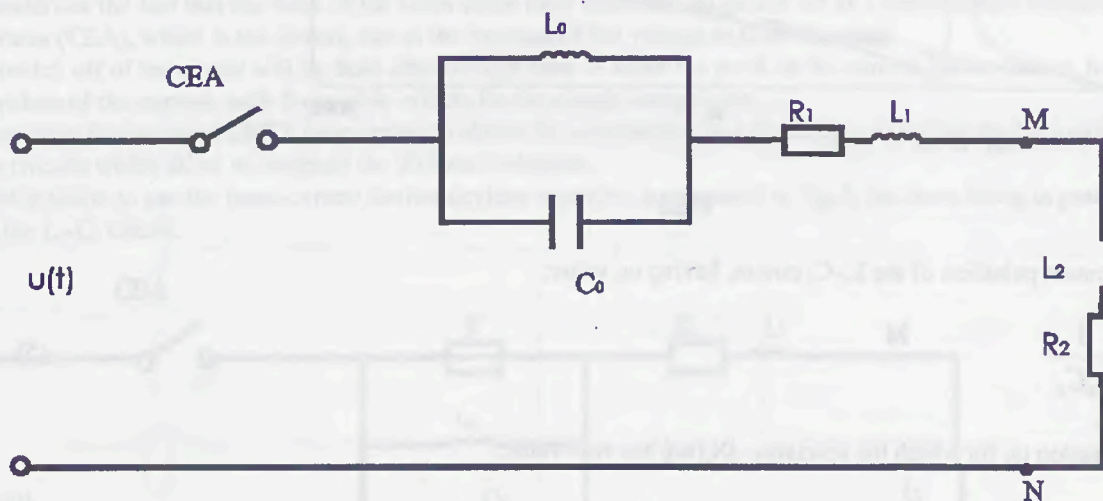


Fig.1

According to the normal state of the circuit supplied by an alternative voltage with U -amplitude, ω -pulsation, and θ - initial phase:

$$u(t) = U \sin(\omega t + \theta) \quad (1)$$

the impedance Z_s :

$$\underline{Z}_s = R + j\omega L, L = L_1 + L_2, R = R_1 + R_2 \quad (2)$$

will be completed by the contribution of the L_0-C_0 parallel circuit.

We can notice that usually they prefer the capacity behaviour of the L_0-C_0 circuit, [4], which works as a series compensator of reactive energy in normal state and as current limiter device in fault state respectively.

The total impedance of the circuit is:

$$\underline{Z}_s^* = R + jX_e, \quad (3)$$

where:

$$X_e = \omega L - \frac{\omega L_0}{\omega^2 L_0 C_0 - 1} \quad (4)$$

The graphical representation of the $|X_e(\omega)|$ function shown in Fig.2 shows the following values of the pulsation:

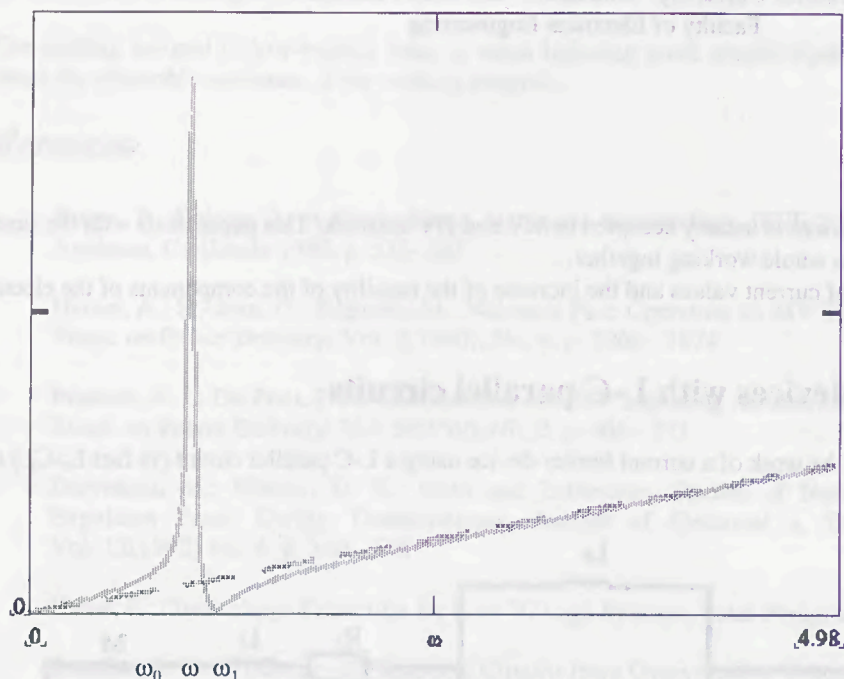


Fig.2

- the resonant pulsation of the L_0 - C_0 circuit, having ω_0 value:

$$\omega_0^2 = \frac{1}{L_0 C_0} \quad (5)$$

- the pulsation ω_1 for which the reactance $|X_e(\omega)|$ has zero value:

$$\omega_1^2 = \omega_0^2 \left(1 + \frac{L_0}{L}\right) > \omega_0^2 \quad (6)$$

When the L_0 - C_0 circuit works as a series compensator of reactive energy, it is desired that the ω pulsation of the supply should be between ω_0 and ω_1 , e.g.:

$$\omega^2 = \omega_0^2 \left(1 + \frac{L_0}{2L}\right) \quad (7)$$

which makes real the following relation:

$$X_e = -\omega L \quad (8)$$

For the fault situation, e.g. short circuit, as a result of an accidental electric connection between the M and N points of the schema shown in Fig.1, the effect of the limitation of the current is obtained by the change of the L_0 or C_0 values which will be L_0' or C_0' respectively, so that the new resonant pulsation to get the value given by the (7) relation:

$$\frac{1}{L_0' C_0} = \omega_0^2 \left(1 + \frac{L_0}{2L}\right) \quad \text{or} \quad \frac{1}{L_0' C_0} = \omega_0^2 \left(1 + \frac{L_0}{2L}\right) \quad (9)$$

Taking into account the (5), (7) and (9) relations, results:

$$L_0' = \frac{L_0}{1 + \frac{L_0}{2L}} < L_0 \quad \text{or} \quad C_0' = \frac{C_0}{1 + \frac{L_0}{2L}} < C_0 \quad (10)$$

which in case of a fault situation indicates the necessity of the diminution of L_0 or C_0 values to the L_0' or C_0' values.

It is obviously possible to obtain a double work of this L_0 - C_0 circuit, as a series compensator of reactive energy in normal state and as a current limiter device in fault state respectively, e.g. short circuit. This is possible by modifying the L_0 or C_0 values to their limits L_0' or C_0' respectively.

3 The usage of the fuses in current limiters schemes

This work intends to show the usage of the ensembles which consist of fuses and current limiter devices for the protection of the circuits when a fault situation appears, e.g. short circuit; it is the break of the fuses which makes the opportune and efficient work of the current limiter device. Having as a resonant pulsation the supply pulsation itself, see relations (5, ... , 9) and Fig. 2.

We underline the fact that the work of the fuses when fault states can do switch off of a commutation effective apparatus (CEA), which is the circuit, due to the increase of the voltage at their terminals.

The switch off of the circuit will be done after enough time to allow the work of the current limiter device, for the low values of the current, with favourable effects for the circuit components.

We mention that we used EMTP programme to obtain the information by calculations regarding the behaviour of these circuits which allow to compare the different solutions.

A first solution to use the fuses-current limiter devices ensemble is presented in Fig.3, the fuses being in parallel with the L_0 - C_0 circuit.

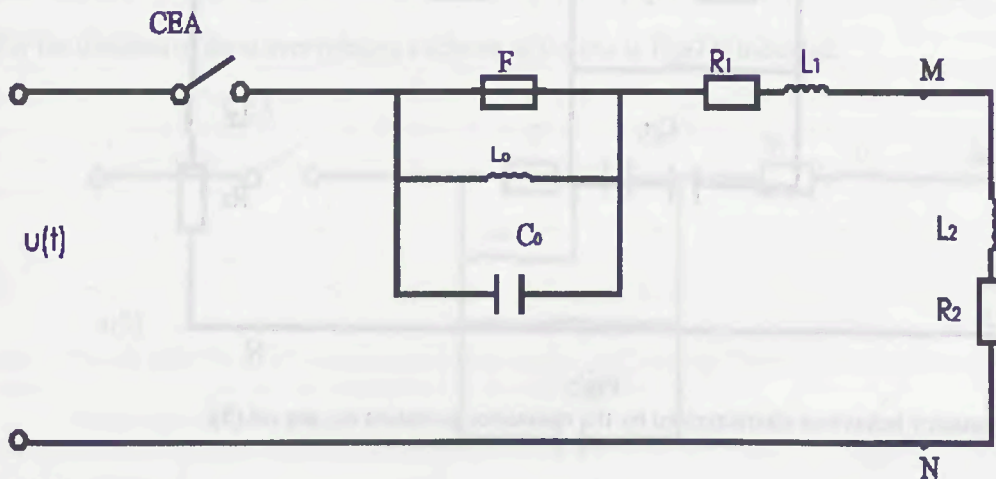


Fig.3

Fig.4 shows the evolution of the current of the circuit which permits the identification of the successive work stages.

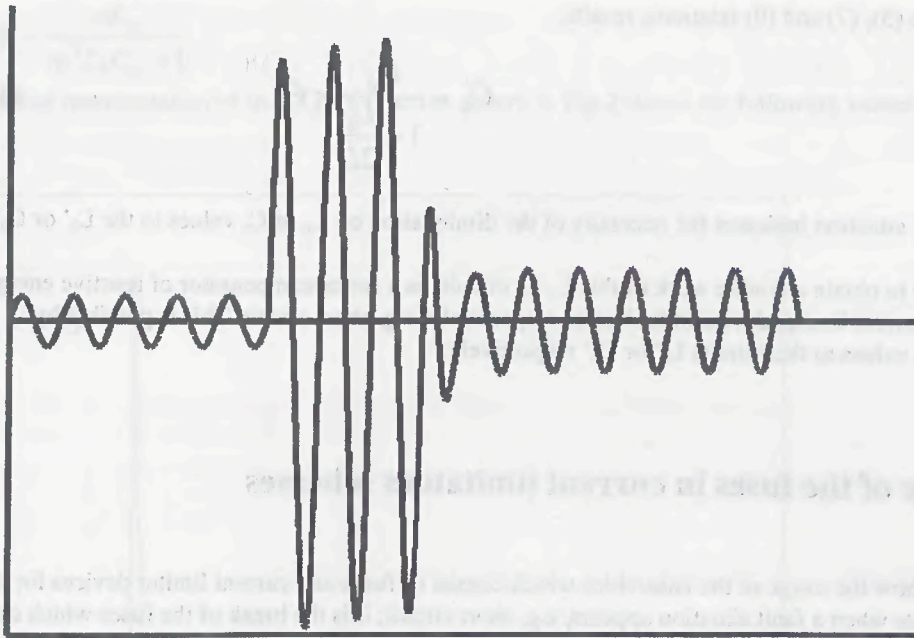


Fig.4

Fig.5 shows the solution to use the ensemble fuses-current limiter devices as a series compensator of reactive energy in normal stage and as a current limiter devices in fault stage. The fuses work makes possible the passing

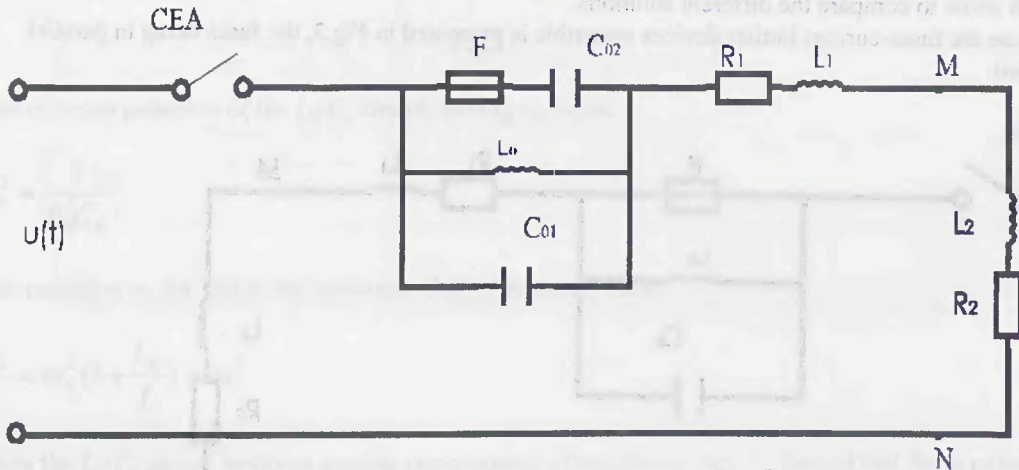


Fig.5

from the series compensator behaviour characterised by the resonance pulsation ω_0 , see rel.(5):

$$\omega_0^2 = \frac{1}{L_0(C_{01} + C_{02})} \tag{11}$$

to the current limiter behaviour characterised by the ω pulsation, see rel.(1)&(7):

$$\omega^2 = \frac{1}{L_0 C_{01}} \tag{12}$$



Fig.6

The evolution in time of the current for the circuit in Fig.5 is shown in Fig.6 and it confirms the efficient work of the current limiter device after the work of the fuses, which completes the series compensator of reactive energy in normal stage.

One of the shortcomings of the schema presented in Fig.5 refers to the overvoltage of the fuses terminals one it is switched off.

For the diminish of these overvoltages a schema as the one in Fig.7 is indicated:

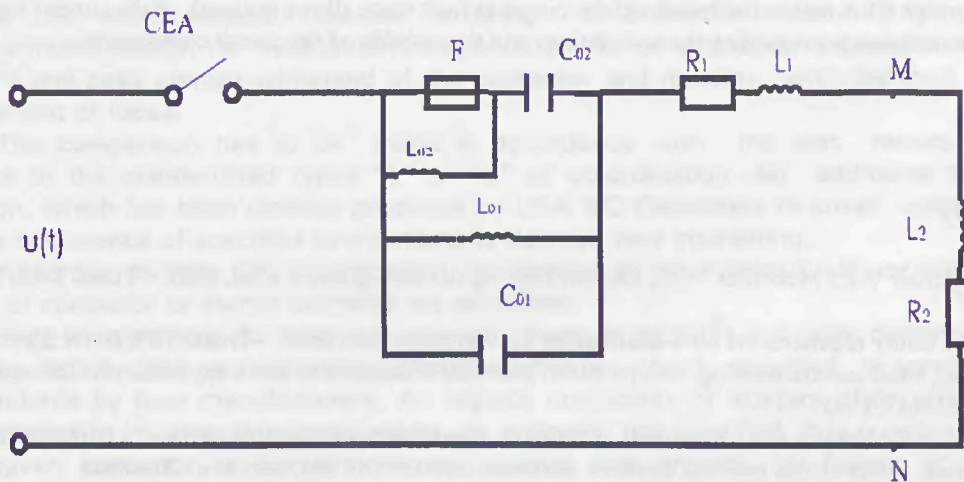


Fig.7

The current evolution in time regarding the circuit shown in Fig.7 which goes through the CEA, is shown in Fig.8 and it's similar to the one previously presented, but the overvoltages which appears at the fuse terminals are 5-6 times lower in the studied circumstances.

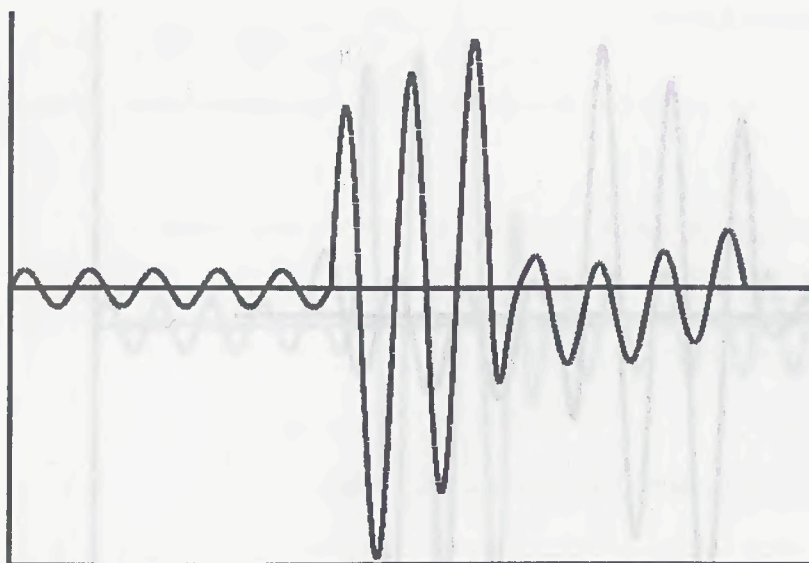


Fig.8

4 Conclusions

This study suggests the extension use of the fuses in the current limiter devices. For this, taking into account the possibilities of the L-C parallel circuit we propose different kinds of the fuses-current limiter devices ensembles. The behaviour of these ensembles can be appreciate by the help adequate soft (EMTP), which makes possible to compare them.

There is the possibility of a double functionality of these ensembles, as a series compensator of reactive energy in normal stage and as a current limiter device in fault stage, the passing from one to another is made by the switch of the fuse.

We propose a solution to diminish of the overvoltage which appears at the fuse terminals.

The period after which CEA makes the switch off the circuit at fault stage allows the work of the current limiter device with certain advantages regarding the solicitations and the reability of the circuit components.

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