Model research on the operation of Residual Current Devices in electrical networks low voltage

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Abstract – **The paper offers a simulation model and studying of the operation of Residual Current Devices in low voltage networks. The model is based on Matlab Simulink.**

Keywords – **Residual current devices, Low voltage systems, Simulation modelling.**

I. Introduction

Protective disconnection is a precaution applied commonly with protective earthing or automatic disconnection in systems: IT, TT and TN-S. It is generally the best and the most reliable protection measure developed to provide a protection against direct and indirect contact in the low voltage system.

Protective disconnection (using a special protective apparatus) is an automatic disconnection of the power supply of all live conductors in case of a danger for people as a result of an insulation fault. It switches off for fixed value of the casing voltage, the basic insulation or the leakage current [3].

The widespread protective apparatus is a device which activates itself from the residual current (the current with zero sequence) flowing after its point of mounting – residual current device (RCD). Residual current devices must meet the requirements of EN 61008-1/61008-2-1 and IEC 61008: Automatic residual current circuit-breakers for domestic and similar purposes. Bulgarian Ordinance [3] requires that in the TN-S system socket circuit protection must be realized with RCDs with nominal operating threshold $I_{\Delta n} \leq 30$ mA.

For electrical grid TN the use of RCDs is possible only when there is a separated protective conductor PE, which does not pass via protective apparatus (TN-S or TN-C-S system).

This paper offers a simulation model and studying of the operation of Residual Current Devices in low voltage networks.

II. Simulation model of RCD

The simulation models in Matlab Simulink for electrical grids low voltage are used [1,2]. The block modeled RCD is added (Fig.1).

The block consists of:

- Summing Block, monitoring the Rms value of the vector sum of the currents flowing through the phase and the neutral conductors at a point of the electrical installation- ST;
- Block Logic LB - after SB the signal is given to this block and time- current characteristic curve Type G is realized for RCD Type AC (Fig.2);
- Block „Switching" – interrupts the supply after the time delay. It is in LB.

III. Versions studies

For a research of the authenticity of the simulation model of RCD the following cases are considered:

1. The casing of the appliance is attached to a protective PE wire in TN-C-S system and its working insulation is gradually worsened. The phase and the neutral wire N go through RCD device. The results, in their graphic form, are shown in Fig. 2.
2. The casing of the appliance is attached to a protective PE wire and its working insulation R_{ins} is gradually worsened. Only the phase wire goes through RCD device (Fig. 3).
3. The connection between the casing of the appliance and the protective PE wire is severed and its working insulation is gradually worsened. The phase L and the neutral wire N go through RCD device (Fig. 3).
4. The casing of the appliance is attached to a protective PE wire and its working insulation is gradually worsened. The phase L, the neutral N and the protective wire PE go through RCD device (practically it is the case of TN-C network) (Fig. 3).
5. Realizing of different ratios between the nominal operating threshold $I_{\Delta n}$ (30 mA) and the operating residual current I_f. It is for checking up of the time- current characteristic curve (Table 1).

Figure 4 shows the alternation of the operating residual current I_f.. In the first part this current is almost equal to zero because the insulation is in very good state. After that the worsening of the insulation happens, leakage current appears and RCD trips with certain time delay.

Table I shows standardized tripping curve of RCDs and corresponding tripping time.

TABLE I
MAXIMUM OPERATING TIME

Tripping curve	I_n, A	$I_{\Delta n}$, A	Tripping time, s		
			$I_{\Delta n}$	$2.I_{\Delta n}$	$5.I_{\Delta n}$
G	All values	All values	0,3	0,15	0,04

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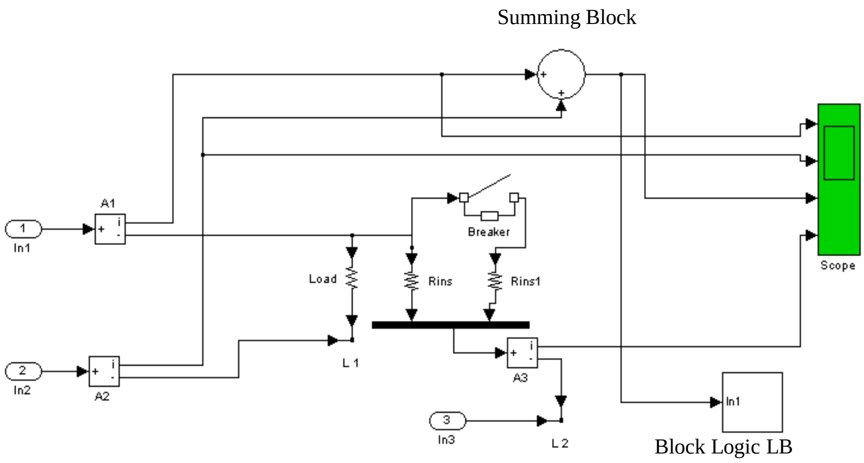

Fig. 1. Simulation Model of RCD. A1, A2, A3 – Ampermeters; In1- Line, In2- Neutral, In3- PE; Rins- electrical resistance of the load's insulation; Rins1- for worsening of the insulation; Scope- for visualization of results

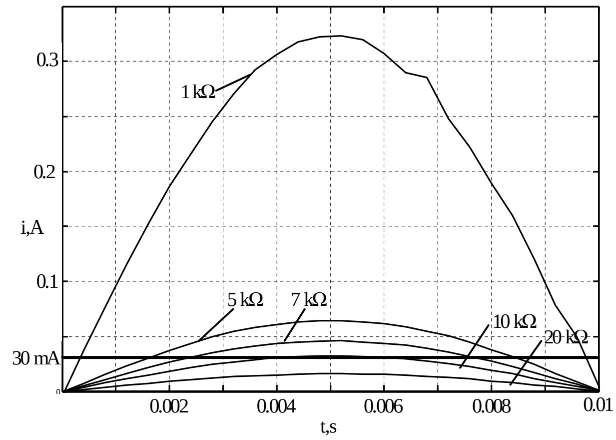

Fig.2. Dependence of operating residual current I_f via RCD device on working insulation R_{ins}

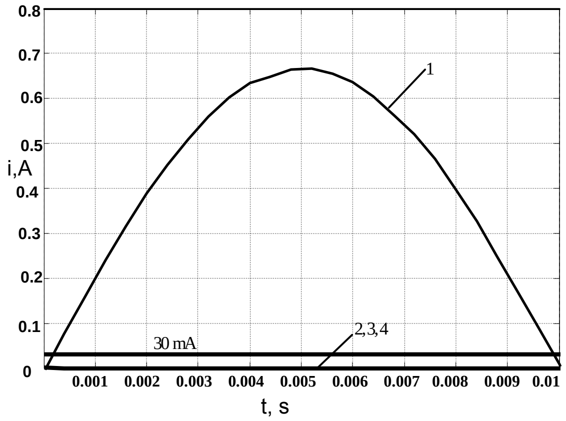

Fig. 3. Operating residual current I_f via RCD: 1 – the neutral wire N does not go through RCD; 2 – the connection between the casing of the appliance and the protective PE wire is broken; 3 – R_{ins}=400 Ω; 4 – The phase, the neutral and the protective wire go through RCD.

IV. CONCLUSION

The analytical experiments thus conducted lead to the following essential conclusion that the simulation model of RCD is authoritative and can be used for further investigations of the operation of RCDs. It was proved by:

1. RCD trips at a value of the appliance insulation resistance below 10 kΩ (it corresponds to the given nominal operating threshold).
2. When wire N does not go through RCD, the protection always trips, which corresponds to the real situation.
3. When the PE wire is: a) broken, b) the repeated earthing device has high resistance and c) L, N and PE wires going through RCD, the protection does not trip, which corresponds to the real situation.
4. Very good precision was achieved at the modeling of the time- current characteristic curve.

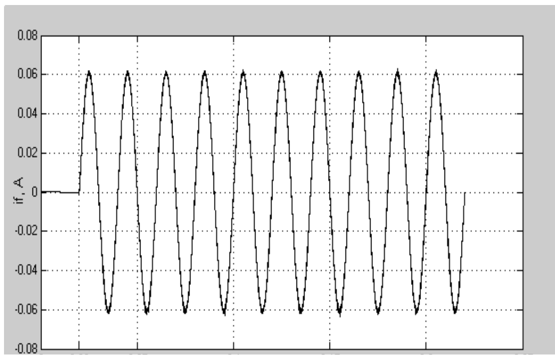

Fig. 4. Operating residual current I_f

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