Electric protections: residual current circuit breakers
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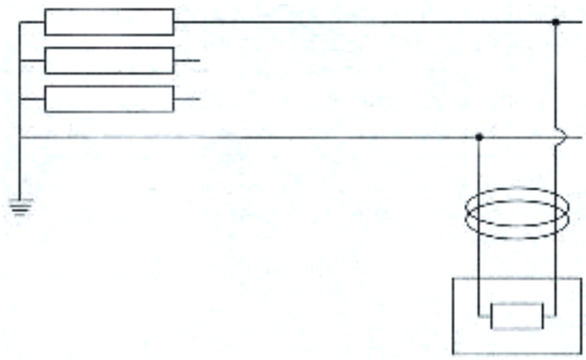
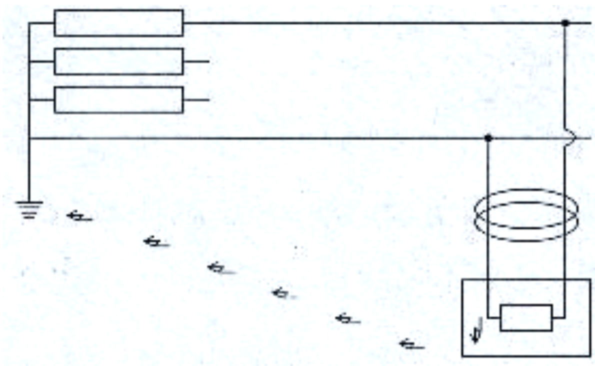
As it always happens, the massive use of a device stimulates the industry to research increasingly sophisticated and specific functioning techniques; observably, this was also the case for residual current circuit-breakers. Residual current devices, also called circuit breakers, are, together with thermo-magnetic switches, practically the only available solution to protect normal low voltage electrical systems (380-220V). In fact, different and very complex protections exist for specific systems or in MT-AT but we are not going to deal with them here. As the name suggests, they are sensible to the imbalance of the currents that go through it.

Fig.1-Let's use as an example a single-phase differential switch connected to a single-phase load.



In the figure, the differential is represented only by the toroid enclosing the conductors that supply the load. I have represented them in this way because this is the real essence of the device, i.e. a magnetic nucleus crossed by the active conductors of the circuit, which create in the same nucleus a magnetic field that mirrors the currents that cross it. We can easily understand that in the case of fig.1, and in general of any load functioning appropriately, the current travelling on a wire will be, in any instant, identical to that that travels on the other one. We all know that a current to circulate needs at least two wires, in an incorrect but clear way we could say: and outgoing one and an ingoing one. If the currents that travel on the two conductors enclosed by the toroid are identical and circulate in opposite directions, the magnetic fields that generate in the toroid have the same values but an opposite direction. What will the effect be? Nothing happens: the resulting magnetic field, the sum of the contributions of the two wires, will be nought. It is the same principle of the amperometric pliers, if to measure the current we embrace the whole cable instead of the single conductors we will still read zero. The same identical thing happens in residual current circuit-breakers. The difference between the circuit breaker and the amperometric pliers is that the former is equipped with a switch, called release device, which opens the circuit at the beginning when the reading differs from the zero of a specific value of Ind, while the amperometric pliers simply visualize the value of the margin from zero. The currents that travel on the conductors in the toroid will have a sum different from zero, only in the load an escape route for the current is present. In other words, if, after a failure in the utilizer, the "outgoing" current towards the load exceeds the "ingoing" one from the load, the difference will have gone somewhere else in an undesired way. Escape routes are usually the persons who touch an out of order device or the earthing conductor, when this is present. It is understandable why the earthing of machinery and stages is so important for the safety of people. It is better that the fault current travels through some cables than people with all the well known consequences. Naturally, the practical making of a circuit breaker is conceived so that the device can evaluate whether the fault current exceeds the calibration value or not and if this justifies the release of the protection. In the case of the triphase the reasoning is identical but with three or four wires that go through the toroid instead of two.



Now that the principle of the functioning of differential protections has been clarified, I would like to suggest a few considerations on their use. Electrical systems that employ circuit breakers function with alternating current, but will the earth fault current be alternating too? In other words, will a computer with an earth fault, supplied with alternating current, leak alternating current? Where does the leakage current end up once discharged in the ground by the earthing system? And, according to what has been written so far, wouldn't an equipment that sends signals to another one and which thus "leaks" current in the form of signals, cause the release of the differentials on its power supply? Why when we inadvertently short-circuit the exit of a final with an earthed chassis is the circuit breaker not released?
Let's proceed with order; where does the earth fault current end up? It is clear that the leaked current is enclosed in the delta star of the booth transformer through the ground; that's why with the neutral conductors disconnected from the ground the circuit breakers do not work. The same thing happens with insulation transformers and generator sets with a non-earthed delta star, in this way we take away the reclosing way of the earth fault current preventing the protections from working properly. Therefore it is important that the earthing system has the lowest possible resistance. If, on the contrary, the out of order device (generally because of a failure of the insulation) is earthed through a person who touches it, this person gets an electric shock. For the same reason it is said that by wearing shoes with a rubber sole the current is not dangerous. In reality things are more complicated; never be too trusting, even if you are wearing rubber shoes or you are on a wood ladder, electricity is dangerous anyway and to look for danger is stupid. What waveform will the fault current have? In the case of an earth phase it will be sinusoidal (or at least similar to it), but if the fault takes place inside an electronic appliance, for instance after the entry rectifier, the fault current can be direct, pulsating and unidirectional, or with many other forms. Until the current is sinusoidal the circuit breaker will work perfectly well, but it won't be reliable any longer if the current has a different waveform. In fact, a direct current is not able to excite the release device of the circuit breaker, for reasons linked to magnetic induction. However, a person can be electrocuted by a direct current, this is reason why A-type circuit breakers came out on the market, that is devices sensible to pulsating and direct unidirectional currents, in order to be added to the AC-type sensible only to alternating currents and used so far. Services are advised to use the A-type in consideration of the great quantity of electronic appliances currently used. The only negative side is that A-type circuit breakers

cost twice as much as the AC-type. Appliances with switching power supply, increasingly more diffused now, are particularly appropriate to create fault currents of a non-sinusoidal form because of their particular internal circuits.

Torna all'inizio

The elements so far collected allow us to understand why a machine with a signal output does not release the circuit breakers. Signal power supplies are usually taken below the device power supplier, that is after that the power supply transformer has broken the metal continuity of the lines making the earth reclosing of the leaked current impossible, similarly to what we have seen in the case of the transformer with the neutral disconnected from the earth. In conclusion, there are many circuit breakers with a fixed and adjustable calibration on the market. The choice of the trip values of such calibration must be made with great care, too often circuit breakers with calibrations that differ by many amperes or that are delayed by tens of seconds are used: the trip time must never exceed one second. The time delay has the only objective of permitting, in case of the failure of a secondary line, the release of the circuit breaker of the same line without releasing the general residual current device. A normal circuit breaker intervenes within milliseconds, thus there is no need to greatly delay the general device. Moreover, a calibration that exceeds one ampere becomes excessive even for a big general residual current device. People's safety must always be effected through circuit breakers with an Idn that does not exceed 0.03 Ampere, in practice this value must be used for all the lines that serve the final users.