

Title: **Residual Current Devices** ✓

Description of Invention

This invention is concerned with residual current devices.

A typical electronic residual current device (RCD) operates by using Detector D to detect imbalance between live and neutral currents. If the difference between live and neutral currents exceeds a pre-determined threshold level a Thyristor (SRC1 in Figure 1) is triggered into conduction allowing a current to flow from the live line to neutral line through the coil of a solenoid S. Mechanical energy produced by the solenoid is used to trip a switching mechanism M which opens contacts disconnecting the faulty circuit. A test circuit is usually also provided to apply a simulated fault current when a button is pressed. This causes the device to trip in exactly the same way as for a real fault as described above.

If the neutral becomes disconnected there will be no path for current to flow through the solenoid in the device shown in Figure 1. This device will therefore no longer provide protection against a live to earth fault. To provide protection in the event of loss of neutral supply, the earth conductor can be used to provide a return path for the solenoid current. A typical device employing this technique is shown in Figure 2. The coil current can now flow either to neutral or to earth. The pair of diodes D1 and D2 are required to prevent currents flowing from neutral to earth.

A problem with the device shown in Figure 2 is that if the test button is pressed in a healthy circuit the coil current will split between the neutral and earth return paths. The coil current can be significant (typically 1A). If there is another RCD upstream of this device it will sense the imbalance caused by the current flowing to earth. The upstream device will therefore also trip. If the test button is used regularly as instructed then a significant nuisance could result.

A typical solution is to place a Zener diode in the earth path as shown in Figure 3. This will ensure that no current flows to earth as long as the neutral voltage is below the Zener voltage. The Zener voltage is selected so that this is true for most healthy circuits. A typical value might be 10V, and when the test button is pressed, no significant current flow into the earth line is produced. However, if the neutral becomes disconnected and a fault signal is produced, when the SCR is triggered into conduction the voltage across ZD1 will exceed the Zener voltage. The Zener diode will conduct and the current will flow to earth thus allowing the device to operate.

The circuit shown in Figure 3 will prevent nuisance tripping when the test button is pressed for single pole switching devices that disconnect only the live conductor. However, many devices use double pole switching that disconnects the neutral as well. When the contacts separate an arc is drawn between the contacts raising the voltage at the neutral connection point to typically 40-50V. As the contacts separate the voltage increases to typically 160V. These voltages are much higher than a Zener voltage of typically 10V and the current flows preferentially to earth. If a very high Zener voltage is used, say 200V, insufficient current will flow to operate the device on loss of neutral.

This problem is reduced or overcome in accordance with this invention by a residual current device comprising a circuit element to permit flow of current from the switching device to earth in the event of loss of neutral, the circuit element comprising a first circuit member which resists flow of current up to a first threshold value, and a second circuit member which permits flow of current at low impedance, the second circuit element being triggered by flow of current from the first circuit element when the voltage applied thereto exceeds said threshold voltage.

Thus the first threshold value may exceed the voltage developed as the contacts are separated during testing of a double pole device: e.g. for a circuit operating at 230V, the threshold value may be 200V. The second circuit member

may be triggered at a low current to permit flow of current from live to earth at low impedance.

The first circuit member may comprise one or more Zener diodes, and the second circuit element may comprise a thyristor.

Preferably in addition to the first and second circuit members, the circuit element comprises a resistor and a capacitor.

A circuit element which is a preferred embodiment of this invention will now be described with reference to Figures 4 to 7 of the accompanying drawings, in which :-

Figure 4 is a graph showing the circuit characteristics desired for the performance of the invention;

Figure 5 shows a circuit element used in the performance of the invention;

Figure 6 is a circuit diagram of the circuit breaker which is the preferred embodiment of the invention; and

Figure 7 is an alternative form of execution of the invention.

The circuit breaker which is the preferred embodiment of this invention is designed to withstand up to a given threshold V_T without conducting under normal operation but which will trigger into a low impedance state when the voltage across it rises above V_T as will happen in the event of loss of neutral. A suitable value of V_T may be 200V for a 230V supply. Such a device will withstand the voltages encountered in normal double pole operation but will automatically open a low impedance path to earth in the event of loss of neutral, (see Figure 4).

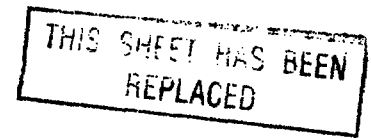
The circuit element of the preferred embodiment of the invention is shown in Figure 5 (the single Zener diode shown will probably need to be constructed from a number of lower voltage Zener diodes in series). If an increasing positive voltage is applied across the circuit element (TA to TB) no significant current will flow until the voltage rises above the Zener voltage ZD2 - typically 200V. When this voltage is exceeded a current limited by resistor R will flow into the gate of SCR2. When this current exceeds the gate current required

to trigger the SCR2 (typically $200\mu\text{A}$) SCR2 will become conductive with a volt drop of typically 1V. Conduction will persist until the current reaches zero. A capacitor C may be used to form a low pass filter with resistor R. This will remove noise from the gate current thus preventing spurious triggering.

The circuit element may be incorporated into the RCD circuit of Figure 2 in series or in parallel with SCR1. The series arrangement is shown in Figure 6. With no neutral the solenoid will only operate when SCR1 and SCR2 are conductive i.e. when a fault current flows. The device shown in Figure 6 will therefore continue to provide protection when neutral supply is lost. The parallel arrangement is shown in Figure 7. The solenoid will operate when SCR1 or SCR2 becomes conductive i.e. the device will trip on loss of supply neutral. The preferred arrangement will depend on the application.

With both of the above arrangements it may be necessary to place a diode D3 across the coil as shown to prevent an inductive voltage spike as the coil current approaches zero and SCR1 starts to turn off. Such a voltage spike can trigger SCR2 into conduction when not required.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately or in any combination of such features, be utilised for realising the invention in diverse forms thereof.



CLAIMS

1. A residual current device comprising a circuit element to permit flow of current from the switching device to earth in the event of loss of neutral, the circuit element comprising a first circuit member which resists flow of current up to a first threshold value, and a second circuit member which permits flow of current at low impedance, the second circuit element being triggered by a flow of current from the first circuit element when the voltage applied thereto exceeds said threshold voltage.
2. A residual current device according to Claim 1 wherein the first circuit member comprises a Zener diode.
3. A residual current device according to Claim 2 wherein the first circuit member comprises a plurality of Zener diodes in series.
4. A residual current device according to any one of the preceding claims wherein the second circuit element comprises a Thyristor.
5. A residual current device according to any one of the preceding claims wherein the circuit element comprises a resistor and a capacitor.
6. A circuit breaker according to any one of the preceding claims wherein the circuit element is in series with a Thyristor.
7. A residual current device according to any one of Claims 1-5 wherein the circuit element is in parallel with a Thyristor.
8. A residual current device constructed and arranged substantially as herein report described with reference to 4, 5, 6 and 7 of the accompanying drawings.

This Sheet Has Been Replaced

