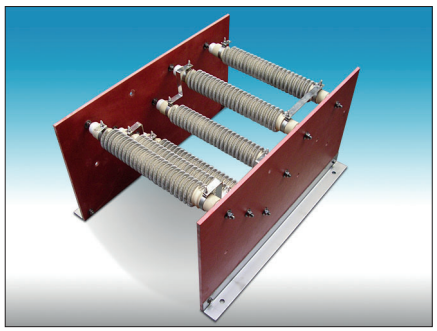
Cressall

Neutral earthing resistors



CHS controls

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Cressall neutral earthing resistors

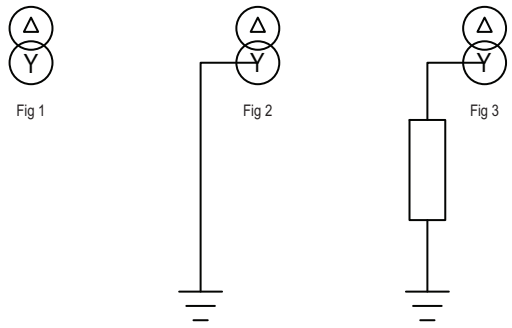
Cost-effective in design - reliable in operation!

Cressall neutral earthing resistors are installed all over the world. They can be found indoors and outdoors. The climate can vary from arctic cold to the heat and humidity of the Middle East. The neutral earthing resistors are built around a standard design with a high level of flexibility for each installation. The design meets all major standards like IEC, ANSI and IEEE. Long life with a minimum of maintenance is expected from an neutral earthing resistor and is an important part of the design.

Earthing System

The main purpose of earthing is to protect life and property in the event of an earth fault. There are basically three ways of neutral earthing in a star connected three phase system

- Un-earthed neutral, fig 1
- Direct earthed neutral, fig 2
- Impedance earthed neutral, resistive or inductive, fig 3



Earthing systems – un-earthed, direct earthed and impedance earthed neutral.

In case of an earth fault, systems with unearthed neutral exhibit a low fault current, but high over-voltages will arise on the other two phases and the fault may remain undetected. By comparison, direct earthed neutral will exhibit lower over-voltages on the other two phases, but the earth fault current will be very high. Neither of these characteristics is desirable. Therefore, depending on local regulations and practice, system voltage and the overall design of the system, the compromise solution of impedance earthed neutral, either by inductance or by resistance is usually selected.

Furthermore, a resistive earthing impedance – neutral earthing resistor - is in many cases the most economical solution. It is also worth noting that the presence of an neutral earthing resistor tends to reduce the magnitude of switching surges on the system by damping the oscillations resulting from cabling capacitance and transformer reactance.

The choice of earthing method is depending on local regulations and practice, voltage level and finally the size and design of the distribution network.

Impedance earthing by resistance, in form of an neutral earthing resistor with suitable accessories, is in many cases the most common and economical solution.

Air cooled neutral earthing resistors, neutral grounding resistors

Neutral earthing resistors, also called neutral grounding resistors are used for protecting transformers, generators and distribution networks.

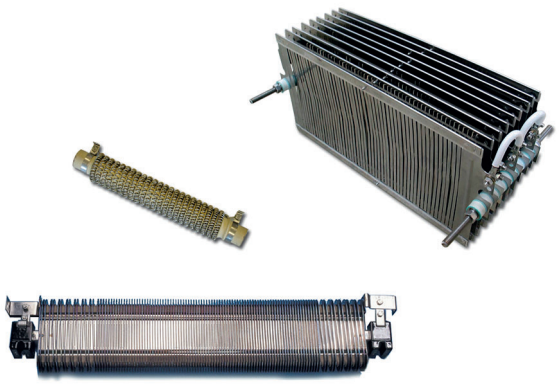
Standards

There are two Industrial standards specifically covering Neutral Earthing Resistors. The European standard is IEC60076-25:2023 “Power Transformers, Neutral Grounding Resistors” and the more established American standard IEEE-C57-32a (2020) “Standard for Requirements, Terminology, and Test Procedures for Neutral Grounding Devices”. The standards differ slightly, we can supply earthing resistors according to both.

Other applicable standards are IEC 60071/IEC 60664 for insulation coordination and IEC 60529 for ingress protection.

Rated current

The neutral earthing resistor will limit the fault current to a predetermined value, the resistor rated current. Choice of current depends on the characteristics of the system, protection relay system and if the resistor is connected to a transformer or a generator. Relatively low rated currents, 10-30 A, are normally used in Sweden. Internationally, higher rated currents are common, 200-600 A. For some application, like ocean-based wind parks, is a rated current in exceed of 1000 A not uncommon.



Resistor elements, RP Coil edge-wound, HP1500 Coil wire-wound and HPR Grid punched steel grids.

Connection time
The most common connection time is 10 s. It provides a good safety margin as most earth faults are disconnected after less than 1 s. The rated connection time is chosen to allow for the occurrence of multiple events. In the past, longer connection times were common, often based on oil-cooled resistors. The shorter the connection time, the more compact the design.

Resistor element
Cressall uses different resistor elements depending on rated current and the resistance value.
- HP1500, wire-wound resistor is normally used for a rated current up to 50 A
- HPR Grid, punched steel grid resistor is normally used for a rated current between 100-200 A
- RP Coil, oval edge-wound resistor is mainly used for higher rated currents

The resistor elements will be made from high temperature stainless steel or nickel-chrome alloy capable of withstanding temperature excursions to 1000°C whilst retaining their strength. It guarantees long and reliable life even if the temperatures exceed 760°C, specified by ANSI IEEE C57.32a and IEC 60076-25. Higher working temperature resulting in a more compact and economical design.

Temperature coefficient of resistance
The resistors have a positive temperature coefficient of resistance, resulting in increased resistance value when the temperature rise.

Cressall can offer a range of resistor alloys with coefficients ranging from 0,001 to 0,148% per °C. The alloy used is chosen to provide a cost-effective solution when considering the total fault energy into the resistor. A lower temperature coefficient of resistance allows more current to flow increasing the energy into the resistor resulting in a resistor design that is potentially larger and more expensive compared to one using an alternative material.

ANSI IEEE C57.32a states that the resistance change of a neutral earthing resistor should not change by more than 67% from cold value over the temperature range. This is to ensure that the final fault current is sufficiently high to allow protective circuitry to operate as intended. IEC 60076-25 does not specify any resistance change with temperature, however there is an advisory comment in the standard that maximum resistance change should be selected based on the network and protection system.

Insulation level
Insulation level is based on IEC 60071 for voltages above 1000 VAC and IEC 60664 for voltages up to 1000 VAC. The insulation level is normally graded from the HV terminal to the earth. Neutral earthing resistors never experience voltages in excess of the line voltage, insulation level should therefore be specified based on the line voltage. Despite this, it is not uncommon that the insulation level is specified based on the system voltage. This has a minor impact on size, weight and price for earthing resistors designed for lower voltages, but the impact is significant for higher voltages.

Enclosure
The majority of the neutral earthing resistors are enclosed for outdoor installation, ingress protection is normally IP 23 or IP 54, up to IP 56 on request. The enclosure is manufactured of either pre-galvanised or hot dipped galvanised steel, alternatively of stainless steel grade AISI R304/R316L. Some resistors are supplied open for installation in a switchgear or similar.

Enclosed neutral earthing resistor with current transformer on the low voltage side of the resistor.

Enclosures up to 54 kV insulation voltage are normally earthed, earthing resistors for higher voltages normally use a live frame design with the mid-point of the resistor path electrically connected to the enclosure.

Connections
The neutral earthing resistor is designed for ease neutral termination via
- External air insulated HV cable box with a bushing or copper terminal on support insulator, normally bottom cable entry via undrilled gland plate
- Internal connection to copper terminal on support insulator, normally bottom cable entry via undrilled gland plate
- External bushing, side or roof mounted
- Direct on resistor element, IP 00 versions

LV system earth is normally a 1 kV external bushing or internal copper terminal on a support insulator. Both are separated from the enclosure/framework earth. Auxiliary circuit terminals are normally located in an external terminal box.

Accessories
Neutral earthing resistors are frequently used together with devices like
- Manually operated off-load isolators
- Vacuum contactors
- Current and voltage transformers
- Anti-condensation heater
- Lightning arresters

Traditionally, such auxiliary devices have been considered to be part of the switchgear, but considerable space and cost advantages can be achieved by combining them with the neutral earthing resistor. The neutral earthing resistor and its associated devices then arrive on Site as one integrated unit, with considerable savings in cabling requirements and installation times. We can also offer standard solution for multi generator earthing with up to 9 vacuum contactors connected to one neutral earthing resistor.

Neutral earthing resistors for installation in hazardous location
Cressall can also supply earthing resistors for Ex classified environments, ATEX or IECEx certified for Zone 2 Exn installation.

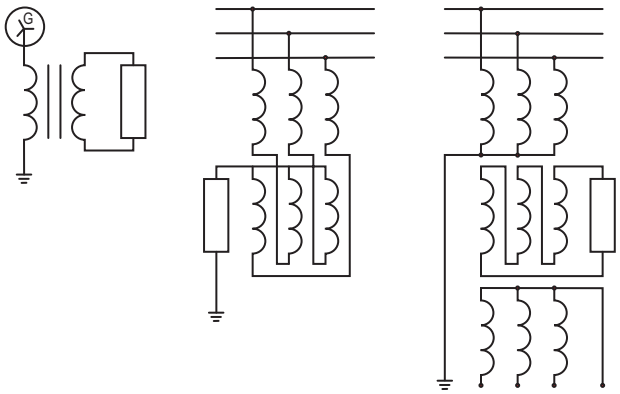
Transformer earthing systems

Cressall does also supply complete earthing systems consisting of a dry type earthing transformer in combination with an earthing resistor, all in one enclosure. Common types are

- Single phase transformer with secondary resistor, commonly used for generator earthing
- Earthing transformer, Zn with an earthing resistor
- Open-delta transformer with secondary resistor

For single phase transformer and open delta transformers is the resistance value coordinated with the transformer impedance.

Transformer earthing systems can also be supplied with accessories like current transformers and switching devices.



Principle diagram for generator earthing by a single phase transformer and secondary resistor, Zn transformer with neutral earthing resistor and open-delta transformer with secondary resistor.

Single phase transformer with secondary resistor.

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