White Paper

Neutral Grounding Resistors for Limiting Fault Current

ASCO Power Technologies®

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A Neutral Grounding Resistor (NGR) is an effective means for limiting fault current in industrial power distribution systems. This paper describes NGR design, its function in grounding systems, and its proper application for limiting faults.

An NGR can be applied only after a complete evaluation of a systems design, capabilities and fault current coordination scheme. Specifying engineers are responsible for evaluating system parameters and determining the correct NGR rating for the application.

SYSTEM GROUNDING

Providing sufficient grounding is essential when designing an industrial power system. It is important to understand that "System Grounding" refers to the grounding arrangement of the current carrying conductors in a power distribution system. It does not refer to "equipment grounding", which is provided for equipment operation and personnel safety. Industrial power systems can be either "Ungrounded", "Effectively (Solidly) Grounded" or "Resistance Grounded".

UNGROUNDED SYSTEMS

Ungrounded systems do not have a direct electrical connection between the generator (or the transformer secondary) and a ground point on the power distribution system. However, these systems have sufficient capacitance to safely manage potential faults. In ungrounded systems, the reference voltage of the neutral conductor will approach ground potential when ground faults are absent from all phases of the system. Ungrounded systems can continue to operate with a single ground fault on any phase, which allows for repair of the fault without interrupting power to the load. A single ground fault will raise the ground potential between the remaining two ungrounded phases to their full line-to-line value. The shift of phase-to-ground potential will place additional stresses on equipment connected to the system.

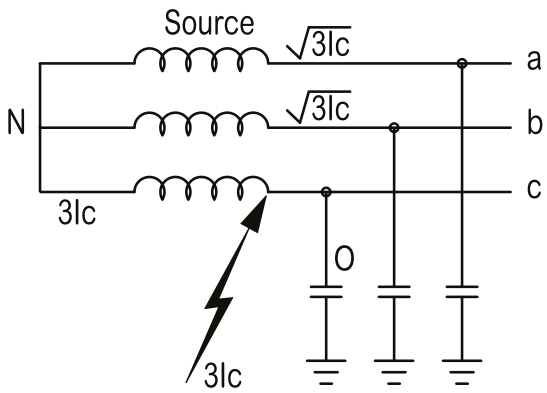

Figure 1: Ungrounded System

The ability of an ungrounded system to operate with a single ground fault may be an advantage for certain facilities where an unplanned shutdown could create an unsafe condition. While operation may continue, any ground fault condition should be investigated and repaired as soon as possible.

EFFECTIVELY GROUNDED SYSTEMS

Effectively Grounded systems feature a solid connection between the power system and a ground point. The grounding connection may be made without installing an impedance device or it may use a device to impart resistance or reactance to limit ground fault currents and mitigate their potentially damaging effects. An effectively grounded system will clear a ground fault by opening a circuit breaker or fuse.

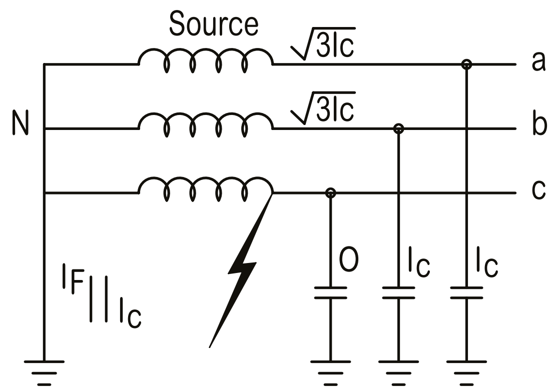

Figure 2: Solidly Grounded System

Arcing ground faults can produce significant damage by the energy they dissipate. Arcing ground faults may burn insulation and vaporize conductors. At levels below the fusing current, sustained faults can continue without tripping overcurrent protection devices, a scenario that is more likely in an ungrounded system. In a grounded system, a phase-to-ground fault would trip an over-current protection device to clear the fault. Proper application of a neutral grounding resistor can limit the ground fault current and resultant damage.

The occurrence of resonant conditions can create serious over-voltages when ground faults occur. The capacitance of the power distribution system and the inductance of the source (transformer or generator) windings can, under certain conditions, allow voltages in excess of the nominal system voltage and cause additional damage. A similar condition can occur during a re-striking ground fault, which can raise voltage to six times the nominal system voltage. A grounded neutral system prevents this voltage build-up by controlling the system phase-to-ground voltages to their nominal phase-to-neutral values.

RESISTANCE GROUNDING

Resistance Grounded systems use a resistive device that is installed between the neutral and ground conductors. This method offers the advantages of both ungrounded and effectively grounded systems and avoids most of their disadvantages. For example, potentially dangerous system over-voltages caused by arcing ground faults are suppressed by dissipating the energy at the resistor. Personnel safety and system stability are also significantly improved.

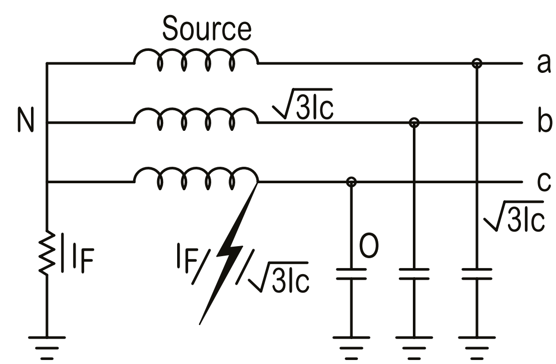

Figure 3: Resistance Grounded System

Resistance grounding systems can be classified as low or high resistance systems. Low Resistance systems use a neutral ground resistor to absorb 200 to 1200 amps of ground fault current. Low resistance grounding is typically used in systems with voltages exceeding 1000 volts line-to-line. High Resistance Grounding is typically limited to fault currents of 10 amps or less, and is used in systems operating below 1000 volts line-to-line due to the lower ground fault currents and associated higher resistance.

NEUTRAL GROUNDING RESISTORS

Neutral Grounding Resistors are installed in series with a power system's neutral grounding connection. By providing impedance, these devices can limit the ground fault current and mitigate damage that might otherwise result from a phase-to-phase grounding fault. The neutral grounding resistor provides a terminal for connecting the power system neutral conductor to the NGR. The opposite side of the NGR is connected directly to a suitable ground. In some cases, the resistor may actually be wired to the secondary of a single-phase transformer, which has its primary wired in series with the power system's neutral-to-ground connection.

The NGR also provides a convenient point for monitoring the ground fault current. A current transformer is often placed at the neutral connection to operate protective relay systems. In most cases, the current transformer ratio of the primary will be the same rating as the resistor. For example, a 400 amp resistor will have a 400:5 amp current transformer.

The neutral ground resistor will be rated for both current (in amps) and time (in seconds). IEEE Standard 32-1972 specifies the proper design criteria for 10 second, extended time, and continuous rated neutral grounding resistors.

Neutral Grounding Resistors, 15kV enclosure above left and 5kV enclosure above right.

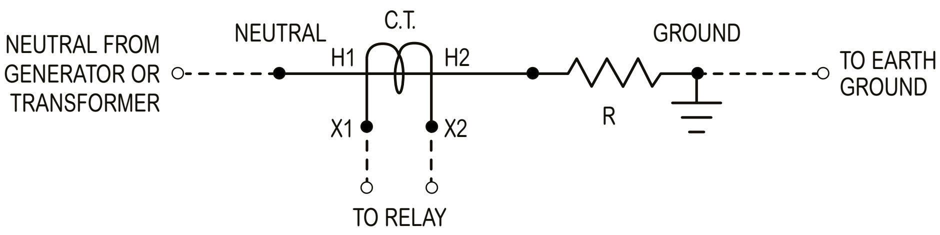

Figure 4: Typical Neutral Grounding Resistor Schematic with Current Transformer

INSTALLATION

Neutral grounding resistors are typically installed outdoors, on a suitable concrete pad as a part of the transformer/switchgear structure. For these applications, their enclosures must be rated for outdoor use, and may use internal neutral and ground connections.

RATINGS

It is beyond the scope of this paper to specify ratings for the neutral grounding resistor. The specifying engineer must coordinate the neutral grounding resistor with the overall design on the electrical distribution system and its specific characteristics. The selection of the ampere rating of the neutral grounding resistor current and time parameters must be selected to operate safely with the available fault current and overcurrent protective system.

System Voltage	Line to Neutral Voltage	Initial Current Amps	Ohms +/- 10%
2400	1390	100	13.9
2400	1390	200	6.9
2400	1390	400	3.4
2400	1390	600	2.3
2400	1390	800	1.7
2400	1390	1000	1.4
4160	2400	100	24.0
4160	2400	200	12.0
4160	2400	400	6.0
4160	2400	600	4.0
4160	2400	800	3.0
4160	2400	1000	2.4
7200	4160	100	41.6
7200	4160	200	20.8
7200	4160	400	10.4
7200	4160	600	6.9
7200	4160	800	5.2
7200	4160	1000	4.2
13800	8000	100	80
13800	8000	200	40
13800	8000	400	20
13800	8000	600	13.3
13800	8000	800	10
13800	8000	1000	8

Table 1: Common Neutral Grounding Resistor Ratings

SUMMARY

There is an increasing demand for service continuity of power distribution systems. Proper grounding of electrical power systems can significantly improve both reliability and safety. To achieve maximum system availability and obtain the benefits of grounding, resistive grounding is often the method of choice.

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