I GARD

The Power to Protect

Grounding of standby and emergency power systems

Power continuity is essential in many industrial and commercial installations where a trip out due to ground fault can have serious economic or operational consequences. An arcing phase to ground fault can pose a flash hazard to the maintenance worker close to the fault and can totally destroy the equipment. Consequential down time adds to the economic loss. Four typical grounding methods for stand by generators and emergency power systems are examined for these factors and the paper concludes that high resistance grounding provides the best power continuity, the best protection against arcing ground fault damage in low voltage distribution systems (up to 1000 V) and improves reliability and availability of stand by and emergency power systems

Standby and Emergency systems are often configured to provide 600 V or 480 V, 3-phase 4-wire service and are thus solidly grounded. In Solidly grounded systems the ground fault currents are very high and damaging and circuit protective devices have to operate to isolate the faulty circuit and interrupt the supply. This even applies to the emergency or standby system such as a fire pump where the faulted circuit is tripped and the system de-energized with potentially disastrous consequences if there were no power during an emergency.

Benefits of proper system grounding

System grounding -- the intentional connection of the neutral points of transformers, generators and rotating machinery to the earth ground network -- provides a reference point of zero volts, which offers many advantages over an ungrounded system, including:

- Reduced magnitude of transient over-voltages
- Simplified ground fault location
- Improved system and equipment fault protection
- Reduced maintenance time and expense
- Greater safety for personnel
- Improved lightning protection
- Reduction in frequency of faults.

Solidly neutral grounded systems offer partial protection

In a solidly grounded system, the neutral points have been intentionally connected to ground with a conductor having no intentional impedance. This reduces the problem of transient over-voltages found on the ungrounded system and speeds the location of faults.
However, solidly grounded systems lack the current-limiting ability of resistance grounding and the extra protection this provides against equipment damage and arcing ground faults.

The well-documented destructive nature of arcing ground faults in solidly grounded systems is caused by the energy dissipated in the fault. The faulted circuits need to be tripped and with conventional time-current coordination often it is difficult to selectively trip the circuit with minimum time delay resulting in extensive equipment damage.

Advantages of resistance grounded neutral systems

Resistance grounding is by far the most effective and preferred method. It solves the problem of transient over-voltages and reduces equipment damage. It accomplishes this by allowing the magnitude of the fault current to be predetermined and limited by a simple ohms law calculation:

$$I = E \div R$$

Where: I = Limit of Fault Current.
E = Line-to-neutral Voltage of System
R = Ohmic value of neutral grounding resistor

In addition, limiting fault currents to predetermined maximum values permits the designer to selectively co-ordinate the operation of protective devices that minimizes system disruption and allows quick location of the fault.

High Resistance grounding can be applied on distribution systems up to 5KV with low resistance grounding recommended at voltages between 15 and 36KV. Utility systems are usually solidly grounded, but on the secondary side of the supply transformer on the customer premises the grounding system is independent and full advantage can be taken of the benefits provided by High Resistance grounding.

High-resistance grounding of the neutral limits the ground fault current to a very low level (typically under 25 amps). It is used on low-voltage systems of 600 volts or less, under 3000 amps. By limiting the ground fault current, the fault can be tolerated on the system until it can be located, and then isolated or removed at a convenient time. This permits continued production, provided a second ground fault does not occur.
High-resistance neutral grounding can be added to existing ungrounded systems without the expense of adding fault clearing relays and breakers. This provides an economical method of upgrading older, ungrounded systems.
The resistor must be sized to ensure that the ground fault current is greater than the system's total capacitance-to-ground charging current. If not, then transient over-voltages can occur.
By strategic use and location of ground fault sensing relays, troubleshooting can be greatly simplified.
High-resistance neutral grounding combined with sensitive ground fault relays and isolating devices, can quickly detect and shut down the faulted circuit. This provides operating personnel with the added safety that's essential in today's operating environments. Another major advantage is the elimination of dangerous and destructive flashovers to ground, which can occur on solidly grounded systems.

Grounding of standby generators in 3-phase 4-wire systems.

In most large commercial buildings and industrial installations, generators are used for standby power or for emergency. So when the distribution includes a distributed neutral then by the electrical code it must be solidly grounded. There are three ways in which this can be integrated

1) Each generator neutral is independently grounded and the neutrals are connected together with the normal source neutral that is also grounded and then distributed.
2) Generator neutrals are connected and grounded at one location. Normal supply neutral is also grounded and the common neutral is distributed
3) The generator common neutral is connected to the normal supply neutral and is grounded only at one location.

In all of the above the ground fault current has multiple paths through the ground and the neutral conductor to return to the source. Sensing ground fault current becomes very difficult and may cause nuisance tripping, or ground faults may not be sensed at all.

<u>Automatic Transfer switches</u>

Automatic Transfer Switches are used to supply the emergency load. Four wire system necessitates the use of four pole devices with or with out an overlapping neutral. The Ground Fault protection and coordination becomes difficult and complex. Changing the distribution to three wires overcomes this. Connecting Stand by or Emergency supply in a 3 phase 3-wire systems only requires 3 pole transfer switches. Where as four-wire distribution systems with the sources independently grounded require four pole transfer switches. In multiple source distribution schemes where single grounding location of the Neutral is used the application of ground fault protection becomes very complex and very expensive. False tripping can occur if circulating load neutral currents and the returning ground fault current are not properly sensed.

<u>Converting a Solidly grounded system to high resistance grounding</u>

In most large commercial and industrial distribution systems at 600 V the single-phase 347 V load is very limited (mostly the high voltage lighting). The load is essentially 3 phase motors and transformers and therefore conversion of 3 phase 4 wire to 3 phase 3 wire is entirely practical and feasible. If the neutral is not distributed it can be impedance grounded. Only 3 pole transfer switches are used. Small lighting transformers are used for the 347/600 V or 120/208 V distribution to service single phase loads. Fig –1 shows a typical arrangement. The generator bus is grounded through an artificial neutral and the normal supply transformer neutral is grounded through high resistance. A 3-pole Automatic transfer switch feeds the essential load. Only alarm and indication of ground fault is required and no tripping occurs in the main and standby switchboards.

Fire pumps are usually 3 wire loads and conversion to 3-wire distribution becomes an easy retrofit for existing installations. This concept is being retrofitted in a high-rise office tower in down town Toronto. The two 1750KVA generators will be converted to High Resistance Grounding. A Ground Alarm relay will alarm to the building management system on the occurrence of a ground fault The Maintenance Electrician will then be able

to find the faulty circuit by tracing a pulsing ground current using a hand held multi meter while the system remains energized and working. The rest of the supply distribution will remain unaffected and is 3-phase 4-wire solidly grounded.

Many other examples can be found where high resistance grounding has improved the reliability and availability of standby power for example in Hospitals, Data Centers, Server Farms, Air Traffic Control Centers,

Summary

Ungrounded delta systems have many operating disadvantages including high transient over-voltages and difficulty in locating faults.
Solidly grounded neutral systems provide greater safety for personnel, limit the system potential to ground, and speed the detection and location of the ground fault. However, the system must be shut down after the first ground fault. Applying coordinated ground fault protection is very difficult and almost impossible with multiple sources and standby generators.
Low-resistance grounded neutral Systems only limit the magnitude of the ground fault current so that serious damage does not occur. The system must still be shut down after the first ground fault. This level of resistance grounding is generally used on medium and high-voltage systems.
If the power system is changed to Resistance grounding then the ground fault current can be reduced to 10 A or less which has significant impact on reducing the fire risk and equipment damage. In addition it ensures that stand by power and emergency power systems continue to operate and do not suffer trip out of a faulted feeder.

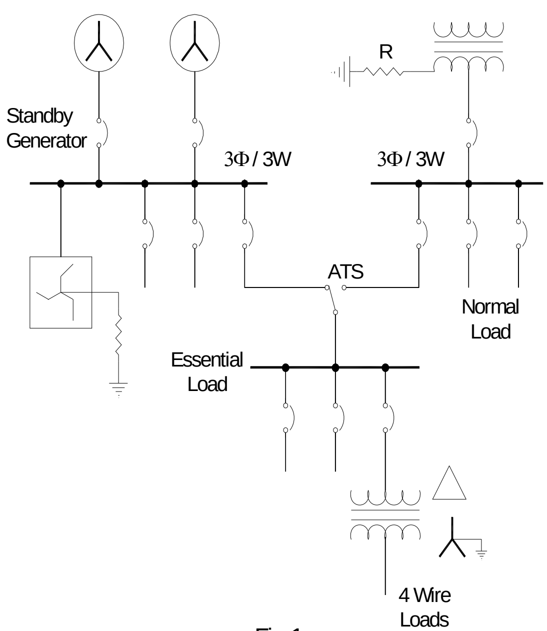

Fig-1

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