The need for neutral earthing

Neutral earthing is employed in electrical systems to:

- Limit the potential of current-carrying conductors with respect to the general mass of earth
- Provide a current return path for earth faults in order to allow protective devices to operate

Neutral earthing is usually applied on the secondary winding of transformers and on the windings of generators within generation, distribution, transmission and industrial networks.

Types of neutral earthing

Electrical systems are usually earthed via their star point or neutral.
There are three choices:

- Neutral solidly earthed
- Neutral earthed via impedance, usually a resistor in the UK
- Isolated

On systems that have no neutral, special three phase transformers or reactors may be used to artificially derive a neutral.

Solidly earthed systems are characterised by high levels of fault current. High value earth faults can be cleared quickly. They can also lead to damage that is difficult to repair. Solidly earthed systems provide the best control of transient and temporary overvoltages that can arise between earth and the electrical system. Insulation that is applied between phase and earth can be rated based on the phase to earth voltage. Lower rated insulation can reduce the cost of electrical systems and equipment.

Isolated systems have one big advantage. They can continue operating in the presence of a single earth fault. This is because there is no return path available for the flow of earth fault current. Hence protective devices will not operate. Isolated systems also have big disadvantages. Transient, temporary and permanent overvoltages can easily occur on such systems, stressing insulation. Insulation that is applied between phase and earth must be rated based on the phase to phase voltage, and often for even higher voltages.

Despite the name, isolated systems are not really isolated from earth. Stray capacitance will exist between conductors and the general mass of earth. Conductors themselves exhibit inductance along their length. When earth faults occur, small currents will flow using stray capacitance as a return path. Arcing behaviour at the fault, combined with resonance interactions between the stray capacitance and inductance, can lead to the generation of high levels of transient overvoltages.

Such systems are not widely adopted due to their disadvantages.

High resistance earthed systems are becoming popular for critical applications where availability of supply is essential. They allow the system to continue operating in the presence of a single earth fault, but do not suffer from the insulation stresses associated with isolated systems

Neutral earthing via an impedance is employed when it is desirable to limit the magnitude of fault current to manageable levels. High levels of fault current are undesirable as they can lead to irreversible damage equipment and systems.

Types of earthing via an impedance

Earthing can be accomplished via:

- Resistors
- Inductors
- Resonant devices

The resultant fault current levels will be lower than for solidly earthed systems.

A solid earth fault does not cause much damage to a system. It simply involves the flow of high current. A fault involving an arc is a different prospect. An arc behaves exactly like a welding set’s electrode. High temperatures are generated and any metal in the vicinity melts. Inserting impedances into the neutral earth connection attempts to limit the destruction caused by arcing earth faults. As an example of damage, consider a large rotating machine. An arc can damage the windings. But the winding can be replaced. A higher current arc could damage the magnetic iron rendering the machine irreparable.

Limiting fault currents can also have the advantage of reducing earth potential rise on an earth electrode system and help meet the required limits for human safety and the operation of telecommunication systems.

The resultant fault current must be of such a magnitude that protective devices operate in a timely and co-coordinated manner.

Resistors are used in the UK and many other countries as means of applying impedance between neutral and earth. They can be used directly or via a single-phase transformer. Using a 'low' resistance value means that insulation that is applied between phase and earth can be rated based on the phase to earth voltage. Where a 'high' value of resistance is used, the insulation that is applied between phase and earth can be rated based on the phase to phase voltage.

Inductors are not wildly used, but have the advantage of presenting increased impedance to higher frequency harmonic currents.

Resonant devices that are also known as arc suppression coils and Petersen coils are used in parts of Northern and Eastern Europe. They use an inductor that is tuned to the stray capacitances of the system in such a way to nullify the flow of earth fault current. This has the advantage that protective devices can ignore temporary faults, such as 'follow current' after a lighting flashover. It had the disadvantage that overvoltages can be left on the system for a long time. This can stress insulation and convert common benign earth faults into damaging phase to phase faults. One innovative concept is to combine this type of neutral earthing with a resistor that bypasses the resonant device after a short time delay.

LV, MV and HV systems
LV systems are arranged in accordance with the wiring regulation of the country. In the UK solid earthing is used on the 400V (formally 415V) system. Arc damage from earth faults is not a big issue. The low voltage means the energy in the arc is limited.

In the UK, HV and MV systems can employ either solid earthing or resistance earthing.

Solid earthing is generally used for systems in excess of 110kV. Insulation costs make the general use of resistors at the level uneconomic

High resistance earthing
An exciting development in the field of neutral earthing is the use of high resistance earthing systems. These systems provide a means to minimise financial losses caused by loss of power in critical installation such as continuous process or petrochemical plant. Loss of power can result in the spoilage of a complete production batch.

These systems can be used where all loads are connected phase to phase. These systems allow continued operation in the presence of a single earth fault. This is without the disadvantages that an isolated system would have. It is essential to locate a first fault before a second fault occurs. A 'pulsing' neutral earthing resistor that switches its value allows the use of hand held sensors to easily locate faults.