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(72) Inventeur/Inventor:
HUNT, MATTHEW, GB

(73) Propriétaire/Owner:
GREENTEC INTERNATIONAL LIMITED, GB

(74) Agent: HICKS INTELLECTUAL PROPERTY LAW

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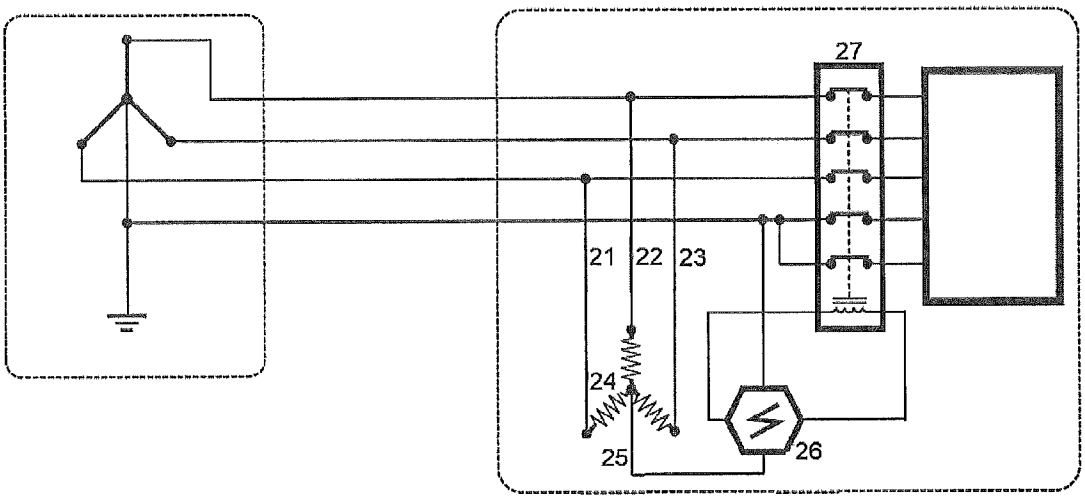

(57) Abrégé/Abstract:
This invention is a unique way of electronically measuring an open PEN situation in a multi-phase system without reference to mother earth. If the floating voltage becomes dangerous, the device disconnects the circuit, avoiding a potentially dangerous situation to develop.

ABSTRACT

This invention is a unique way of electronically measuring an open PEN situation in a multi-phase system without reference to mother earth. If the floating voltage becomes dangerous, the device disconnects the circuit, avoiding a potentially dangerous situation to develop.

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OPEN PEN DETECTION AND SHUT DOWN SYSTEM

TECHNICAL FIELD

This application relates to an open pen detection an shut down system.

BACKGROUND

Electrical safety is of paramount importance, and there are various components that are used to ensure electrical safety in any electrical installation. Examples of safety components that are used to ensure safety are circuit breakers, fuses and residual current devices.

Circuit Breakers (MCBs) and fuses react to overload currents and are designed to protect the wiring from faults caused by overloading a circuit. This could occur through a short-circuit or simply by powering too many devices on the circuit.

Residual Current Devices (RCDs) are life-saving devices designed to shut off the supply if a live wire connects to earth, which can prevent a fatal electric shock if a live wire is touched, can provide some protection against electrical fires and will usually trigger if a cable is severed. In the United States and Canada, RCDs are referred to as Ground Fault Interrupters (GFIs). An RCD and a GFI is the same device.

Note: In the United States and Canada, 'earth' is referred to as 'ground'.

In the United Kingdom, like many other countries, the local grid has three alternating current (AC) phases plus a neutral connection, which is earthed at the local sub-station. This neutral connection is known as a Protective Earth and Neutral (PEN) conductor. At the customer site, the Protective Earth (PE) and Neutral (N) cables are split out from each other. This earthing system is referred to as TN-C-S system. It is also referred to as Protective Multiple Earthing (PME) in the United Kingdom.

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This system works well so long as the PEN conductor is working. If the PEN conductor is broken on the supply side, there is no longer a reference voltage for the three phases. If the load between phases is unbalanced (which it invariably is because there will be different loads on each phase), the voltage difference between phases can become substantial, with potentially fatal consequences. This scenario is called an 'Open PEN'.

The most common symptoms of an open PEN would be undervoltage, causing 'brown outs' on a circuit with equipment unable to cope with the low voltage; or overvoltage, which can damage electrical and electronic equipment, risks causing fires and electrocution.

MCBs and RCDs cannot identify an open PEN scenario and so a different form of protection is required. This is usually provided by additional electrical earthing when power if brought into a building.

The recently released 18th Edition of the IET Electrical Regulations (BS7671) has put measures in place to try and deal with this situation. The measures available are to measure the voltage level on the neutral in the premises to earth (mother earth) via an electrical electrode as a reference point, converting the electrical installation to a TT Network by disconnecting the existing PEN and creating a separate PEN conductor, or fitting an isolation transformer.

Depending on the application, these options are not always possible. A good example of this would be installing electric vehicle charging points on an upper level of a multi-storey car park. Reliably earthing the supply before it is fed into the charging points may not be possible, whilst isolating transformers are big, bulky and expensive and there may not be a suitable space to install them.

SUMMARY

The invention is a unique way of electronically measuring an open PEN situation in a multi-phase system without reference to mother earth. If the floating voltage becomes dangerous, the device disconnects the circuit, avoiding a potentially fatal situation to

develop. This system has been implemented electronically without the need for transformers.

This invention is different to the system devised by Gabrielsson, Flat and Berman (patent number US2018224488 (A1) – 2018-08-09) that uses transformers to measure RCD and ground connections.

Kawamura (patent US2019086464 (A1) – 2019-03-21) has devised a system to detect ground faults for DC applications. This is typically used for battery systems and is not suitable for AC grid connections.

This invention shall enable a three-phase power supply to be protected from an open PEN fault without the need for additional earth electrodes or isolation transformers.

This invention shall protect every circuit from any upstream open PEN faults.

This invention is as defined in the independent claims.

The invention is more compact, lighter and significantly cheaper than isolation transformers.

The invention is easier to install than either isolation transformers or earth electrodes.

The invention may also allow remote monitoring and reporting of open PEN faults.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described by the way of example and reference to the accompanying drawings, in which:

Figure 1 shows an example of a typical TN-C-S earthing system layout with a conventional earth electrode;
Figure 2 shows an example of a TN-C-S earthing system using the Open PEN device.

DETAILED DESCRIPTION

Figure 1 does not describe the invention itself but explains how a conventional electrical system may be configured in countries like the United Kingdom that implement TN-C-S power distribution. It is used to illustrate the difference between a conventional system and the Open Pen device.

In Figure 1, the dotted box on the left-hand side of the drawing (point 1) shows the output components of a distribution sub-station. The three phase power lines (3, 4 and 5) are tied together in a star, or Wye configuration (point 6). The centre point of the star is the neutral conductor (point 7). This is tied to mother earth using an electrical electrode (point 8). Because this neutral cable has been tied to earth, it is referred to as the Protective Earth/Neutral (PEN) conductor (9).

The dotted box on the right-hand side of the drawing (point 2) shows the power cables as they enter a customer site. The PEN conductor is split at this point (10) and is tied to earth using one or more electrical electrodes (11). A separate earth conductor is created at this point (12).

The entire power cable, incorporating the three live conductors (3, 4 and 5), the neutral (9) and the newly created earth conductor (12) are then fed into a distribution panel (13) for distributing through the customer site.

Figure 2 shows the same system using the Open PEN device at the customer site. Here, a connection is made into each of the three live conductors (21, 22 and 23) and tied together in a star (Wye) configuration (24) creating a virtual neutral (25). The voltage difference between the virtual neutral and the PEN connector is measured using a conventional voltage sensing relay (26). If the voltage difference is greater than a predetermined safety limit, the voltage sensing relay closes it contacts. This energises a three phase five pole shunt trip (27), opening the contacts and thereby disconnecting the power conductors from the customer site.

In addition to the voltage sensing relay disconnecting the shunt trip, the output from the relay can also be used to trigger an alarm signal. This signal could be used to activate a beacon or read by a Programmable Logic Controller (PLC) or computer system in order to provide remote monitoring of an Open PEN condition.

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CLAIMS

1. A customer site entry device for creating a Virtual Neutral from a three-phase power source and measuring a voltage difference between the Virtual Neutral and a Protective Earth and Neutral (PEN) conductor, wherein the PEN conductor is a customer site conductor based on a Protective Multiple Earthing system,

wherein an elevated voltage difference between the virtual neutral and the PEN conductor indicates that the PEN conductor is broken, and wherein the measured voltage difference is without reference to real ground.

2. The device of claim 1, further comprising a switching system to disconnect the three-phase power source, including the Protective Earth and Neutral conductor, in the event of the voltage difference exceeding a safe limit.

3. The device of claim 2, wherein the safe limit is a predetermined limit.

4. The device of claim 2 or 3, wherein disconnecting the Protective Earth and Neutral conductor is performed by disconnecting separate Neutral and Earth conductors split from the Protective Earth and Neutral conductor.

5. The device of any one of claims 2 to 4, wherein the switching system is a five-pole shunt trip, wherein three of the poles are for three respective phases of the three-phase power source, one of the poles is for disconnecting Neutral, and one of the poles is for disconnecting Earth.

6. The device of any one of claims 2 to 5, further comprising an output to trigger an alarm signal when the voltage difference exceeds the safe limit, to provide warning of an open-circuit Protective Earth and Neutral conductor, wherein the alarm signal activates a beacon or is read by a Programmable Logic Controller (PLC) or computer system.

7. The device of any one of claims 1 to 6, wherein the Virtual Neutral is created by the device connecting to each of three live conductors of the three-phase power source, and tying the live conductors but not the PEN conductor together in a star configuration.

8. The device of claim 7, wherein the Virtual Neutral is at a centre point of the star configuration.

9. The device of any one of claims 1 to 8, comprising a voltage sensing relay for measuring the voltage difference.

10. The device of any one of claims 1 to 9, wherein at the customer site the Protective Earth and Neutral conductor splits into separate earth and neutral conductors.

11. The device of any one of claims 1 to 10, wherein the measured voltage difference is dependent on the PEN conductor being broken on a supply side and on existence of a phase-to-phase voltage difference.

12. The device of any one of claims 1 to 11, wherein the device is an isolating transformer-free device.

13. The device of any one of claims 1 to 12, configured to isolate a customer site distribution panel from the three-phase power source when the PEN conductor is broken.

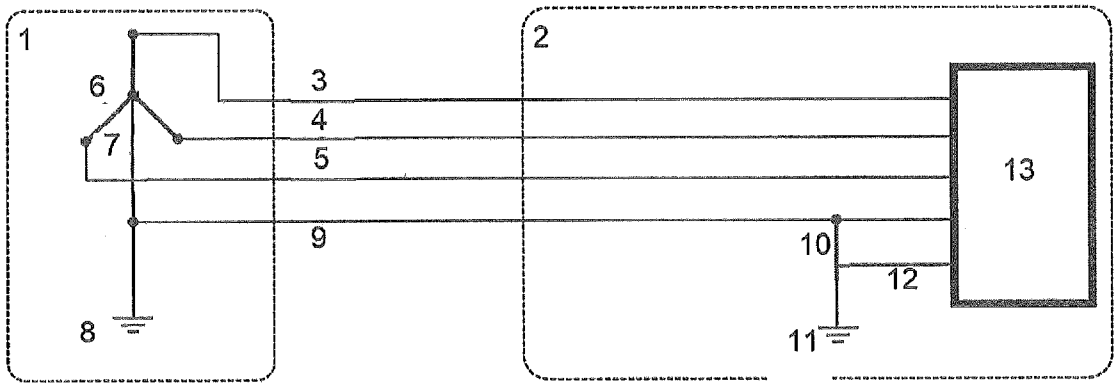


Figure 1

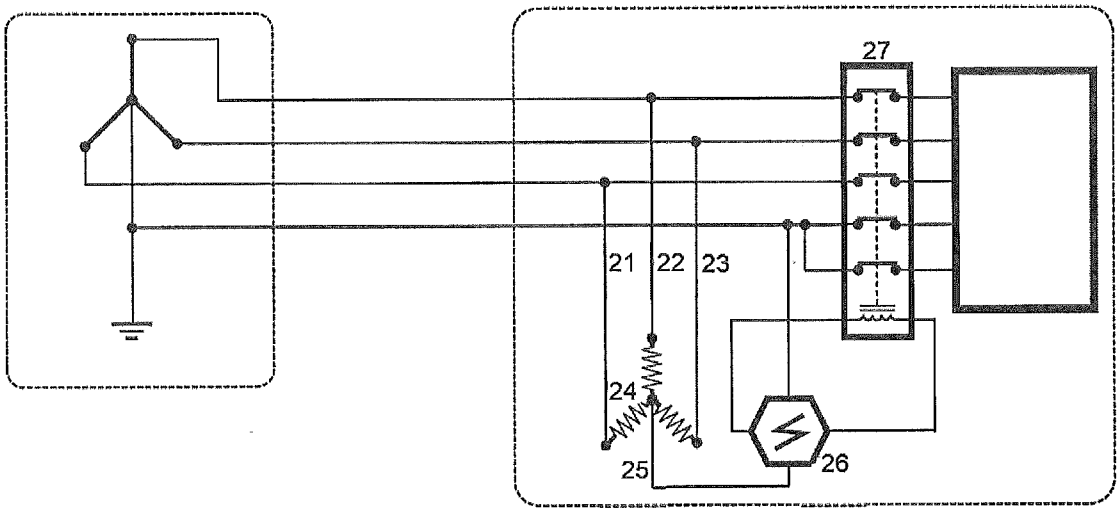
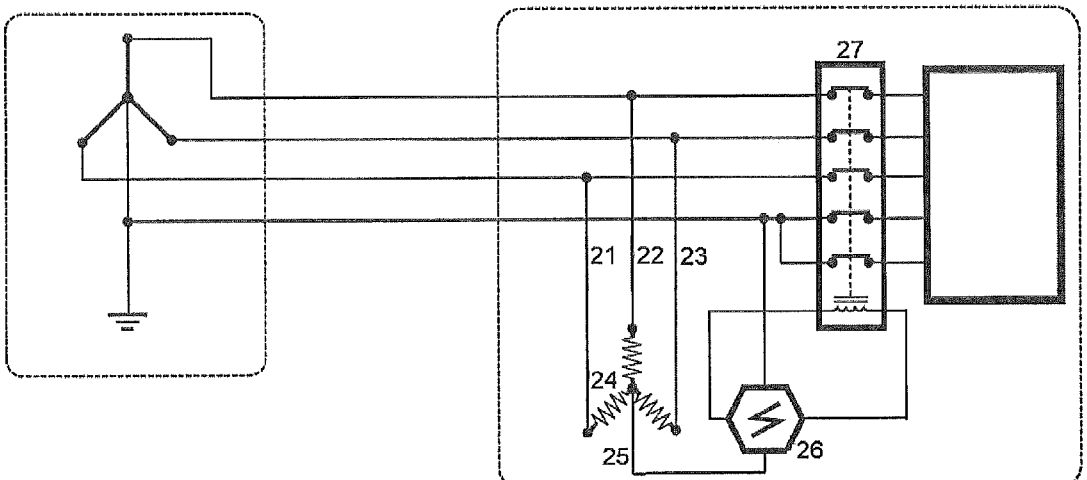


Figure 2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