Why the IT system is often the best choice for power supply systems of all types

Let us start initially with a clear commitment:

the IT system ("unearthed system") is a type of system infrequently used compared to the TN or TT system ("earthed system") – but it would often be the better alternative.

So why is the worse alternative accepted in practice? The answer is probably: habit, convenience, ignorance. Many electrical planners are unfamiliar with the IT system. It is barely touched upon in universities and training centres. The earthed system has therefore become increasingly widespread. The IT system is used infrequently and then above all only where its advantages are essential, e.g. in operating theatres and intensive care stations, or in railway signalling systems. Why? Because the issue here is human lives. But isn't it always about human lives when it comes to power supply systems?

Let us take a look at the advantages and disadvantages of the IT system:

FIRST ADVANTAGE: inherently safe – small difference, big impact

The IT system primarily differs from the TN or TT system in the electrical connection between earth and the star point on the transformer that supplies the system. This connection is present in earthed systems, in unearthed systems it is left out. As an alternative to the supply transformer, an IT system can also comprise another source of power, for

instance, a battery. In the unearthed system all-pole protection of all active conductors is necessary. The same applies to the N conductor, if distributed. Since in a single-phase system none of the two conductors are earthed, there will be two live conductors instead of a classical “Phase and neutral”.

What is then the big difference in the impact if there is only such a small difference in the implementation? If an uninsulated live conductor or an exposed-conductive-part is touched on a live load, NOTHING happens **with an intact unearthed system.** Why? Because a current can only flow in a circuit and the circuit has not been closed as the star point of the transformer has not been earthed. It is like a bird on a high voltage overhead power line, you are safe. What is the situation on the earthed system? In this case a closed circuit is set-up in advance and, to a certain degree, is just waiting for the fault. If in this case a person touches a live conductor or an exposed-conductive-part, a fault current immediately flows through the person due to the low impedance connection to the supply transformer. This situation would be dangerous without functional fast switch-off protection equipment. This circuit is protected via fuses and residual current devices (also called RCDs) such that, in the event of a fault, shutdown occurs quickly enough so the person is not seriously harmed. To make sure that this protection also functions, the protection equipment must be regularly checked. For instance, the functionality of RCDs in electrical installations must be tested every six months – also in domestic households. But how often is this check actually made?

The IT system offers inherent protection against touch voltages. The only exception here are AC systems with very high system leakage capacitances and asymmetric loads. Possible measures in these cases are, firstly, division into smaller subsystems and, secondly, the measurement of the capacitance and the calculation of the maximum current through the body in the event of a fault, which is possible using the new insulation monitoring device ISOMETER® iso685. It goes without saying that insulation faults must be rectified promptly to keep the system safe, even in the IT system.

SECOND ADVANTAGE:
fault localisation

It is possible to locate insulation faults during operation or in de-energised condition using so-called insulation fault location systems (IFLS). Permanently installed devices and mobile devices are available for this purpose. Fault location is in principle also possible in earthed systems using residual current monitoring (RCM) technology. However, with the restriction that this technology only works in energised systems and, unlike in the IT system, remains restricted to asymmetric insulation faults.

THIRD ADVANTAGE:
no undesirable service interruptions

As stated above, the IT system is inherently safe. This situation means, almost as a side effect, that in the event of an insulation fault – even if there is a dead earth fault – shutdown is not necessary. This is also the reason why IT systems are stipulated, e.g., in intensive care units. In the event of an insulation fault, the supply to life-supporting equipment is maintained. The IT system is in general, excellently suited to all applications in which shutdowns are undesirable, would have serious consequences or would cause high costs – in the process industry, in computer centres, in automation and, in principle, everywhere. Control circuits of all types are particularly important. Control errors and failures in control circuits – for example in a substation or in a nuclear power station – can have serious consequences. Based on the information provided by the insulation monitoring device it is possible to plan long-term servicing and maintenance work in the IT system and avoid unplanned service calls to rectify malfunctions.

FOURTH ADVANTAGE:
early detection of deteriorations

A further key advantage is that deteriorations in the level of insulation can be detected immediately. In an earthed system fault currents can be

resolved in the single-digit milliamp range using sophisticated residual current monitoring (RCM) technology – but no further. This means that even if only the ohmic parts of the differential current could be selected, the deterioration of the insulation level would be detected below 40 kΩ with a mains voltage of 400 V and a resolution of 10 mA . This is a significant improvement over a grounded system that is not monitored and at some point simply switches off unexpectedly. In the IT system an insulation value of 40 kΩ corresponds to the recommended primary response value. It is possible to measure in the megaohm range and above in the IT system – which signifies a factor of at least 1,000 compared to the earthed system. Therefore, deteriorations in the insulation can be measured and rectified very early.

FIFTH ADVANTAGE:
detection of symmetrical faults

In an IT system it is possible to detect symmetrical faults using an actively measuring insulation monitoring device in accordance with IEC 61557-8. Symmetrical faults are deteriorations in the insulation of a similar order of magnitude on all phase conductors. Such faults are not unusual. For example, the insulation values in photovoltaic installations often deteriorate to a similar degree on the positive and negative side.

SIXTH ADVANTAGE:
measurements in DC systems

RCDs for pure DC systems such as battery systems are not currently available. Possible options are either devices for residual current monitoring (RCM) with a DC supply voltage or implementation as an IT system with insulation monitoring. In DC systems the ISOMETER® iso685 also offers the advantage that it indicates whether the fault is on the positive or negative side.

SEVENTH ADVANTAGE:
measurement in mixed AC systems with DC components

If there are battery systems, inverters, switch mode power supplies etc. in the AC system, DC fault currents are possible. The widespread use of Type A

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RCDs for pure AC systems are unsuitable here. In the earthed system it is only possible to use RCDs of type B or it must be ensured by other means that the system is shut down on the occurrence of DC currents above 6 mA. An appropriate alternative is to operate the installation as an unearthed system and to monitor it using an insulation monitoring device.

EIGHTH ADVANTAGE:
offline monitoring

As an insulation monitoring device in accordance with IEC 61557-8 actively measures the insulation in the IT system, it can also monitor completely de-energised IT or TN systems. This aspect is important, for example, for railway points heating, fire extinguishing pumps on ships, redundant cooling systems in nuclear power stations. In this way it is also possible to detect an insulation fault on a heater for railway points in summer so it can be repaired in good time. Otherwise, the fault would only be found on switching on in the winter – in the form of the immediate failure of the installation exactly when it is needed.

NINTH ADVANTAGE: closing the gap between the periodic tests

The insulation monitoring device stipulated for the IT system continuously monitors the insulation value. Conversely, during the periodic tests (keyword DGUV Vorschrift 3 test) only the instantaneous state of the insulation is measured. This state can deteriorate dramatically immediately after the test and remain unnoticed for a long time. Continuous monitoring by means of the additional usage of residual current monitoring systems (RCM technology) is also possible in the earthed system.

TENTH ADVANTAGE:
prevention of fire

Insulation faults in electrical installations are the most common cause of fire. The probability of fire in the IT system is much lower. Firstly, insulation faults can be detected and rectified at an early stage. Secondly, as there is no low impedance return path, a current large enough to cause a fire does not flow in the event of an insulation fault. The restriction applies to systems in which the system leakage capacitance is not too excessive.

ELEVENTH ADVANTAGE:
long-term view

The new ISOMETERs® iso685 and iso1685 are able to record a full set of system parameters with date and time information over many years. In conjunction with other recorded system information, this aspect permits event-based fault analysis and makes it easier to find and rectify faults that occur sporadically; it also improves the information available for making decisions on future investments. The evaluation can be undertaken in the device itself or via Ethernet.

TWELFTH ADVANTAGE:
safe handling of non-linear loads, in particular inverters

These days systems contain ever fewer linear (ohmic) loads. The incandescent lamp has been replaced with energy-saving lamps or LEDs, computers and television are connected to the system via switch mode power supplies, the washing machine contains an inverter and frequency converters are used in large numbers for motors in industry. A powerful insulation monitoring device in the IT system has no problem with these issues and correctly measures the insulation value for the entire system. The IT system is particularly suitable for usage with inverters, as in the event of a serious insulation fault in the link circuit on large inverter drives in an IT system, damage to the inductive elements or supplying generators and transformers due to DC currents and the related saturation effects in iron cores cannot occur. The ISOMETER® iso685 was developed for monitoring systems with frequency converters and makes it possible to logically link system parameters to shut down drives automatically in a critical system state. Differentiation between faults in the link circuit and on the motor side in inverter drives is possible in the iso685 without additional expense or other equipment.

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THIRTEENTH ADVANTAGE:
no stray currents

Stray currents often cause problems in earthed systems. These are currents that do not flow via the L, N and PE conductor, but find other paths. They cause pitting corrosion on pipes, lightning protection systems, ball bearings, foundation earth electrodes and other conductive components. They can also result in the destruction of Shielding on signal cables and even fire; as a consequence magnetic field interference can occur that causes problems in IT and communication systems. As the return path to the transformer's star point is not closed in the unearthed system, stray currents cannot propagate in unearthed systems.

FOURTEENTH ADVANTAGE:
more stable in the event of transients

In IEC 62109-1:2010 the possibility of reducing the overvoltage category from OVC IV to OVC III by means of isolation using isolating transformers, optocouplers or similar electrical isolation is

described because transients do not cause such high currents as in earthed systems. The practical consequence is that components in the electrical loads in the IT system are subjected less to voltage spikes and as result have a longer service life.

Now let us look at the disadvantages of the IT system:

FIRST DISADVANTAGE:
IT systems should not be too large

Very large IT systems can become complex and have an undesirably high system leakage capacitance. It is therefore recommended to divide very large IT systems into separate units using isolating transformers, which can cause additional costs and power losses that, however, overall are mostly negligible. The division into galvanically separated subsystems also has advantages, such as the filtering effect in comparison to interference or the possibility adapt the voltages to the loads supplied. What constitutes a large system must be evaluated in the specific case and depends on the system param-eters. For instance, the world's largest PV fields can be monitored entirely by individual type isoPV ISOMETERs®. Which means that a single ISOMETER® does not miss a faulty connector, a damaged cable or a damaged PV module, despite an installation the size of ten football pitches or more.

SECOND DISADVANTAGE:
voltage increase in the event of insulation faults

In an IT system with an insulation fault on one conductor, the line-to-line voltages on the other conductors increase in relation to the earth potential. In the event of a dead earth fault on a conductor in the 230 V system, the voltages on the other conductors increase in relation to the earth potential to approx. 400 V. System components on which the potential in relation to earth is an issue, in particular Y capacitors and overvoltage limiters, should therefore be suitable for the maximum rated voltage. Voltage increase can be avoided when the secondary side of the transformer is connected in Delta mode. ■

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Coupling device
AGH-PV-3

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CONCLUSION:

The IT system has many advantages over earthed systems and is suitable not only for the high requirements in operating theatres or in nuclear power stations, but practically everywhere. In many cases these days this system is not considered at all, even though it would be the better choice. The latest generation of insulation monitoring devices also offers many economical and technical advantages that benefit the operator. Sometimes the costs for an insulation monitoring device are cited as an argument against an IT system, but the opposite is the case: given the advantages listed above and and the economic impact they have, use in the commercial sector is always worthwhile!

NORMATIVE REFERENCES

IEC 61557-8:2014-08
Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures
Part 8: Insulation monitoring devices for IT systems

DIN EN 62109-1 (VDE 0126-14-1):2011-04
Sicherheit von Wechselrichtern zur Anwendung in photovoltaischen Energiesystemen
Teil 1: Allgemeine Anforderungen
(IEC 62109-1:2010) Deutsche Fassung EN 62109-1:2010

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