Application Note

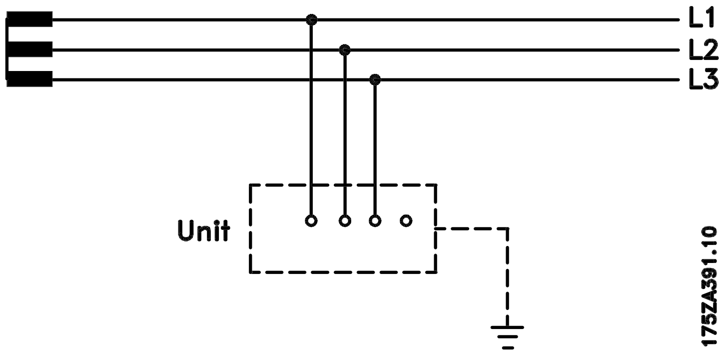
VLT® on IT Mains

VLT® 5000
VLT® 6000 HVAC

VLT on IT mains

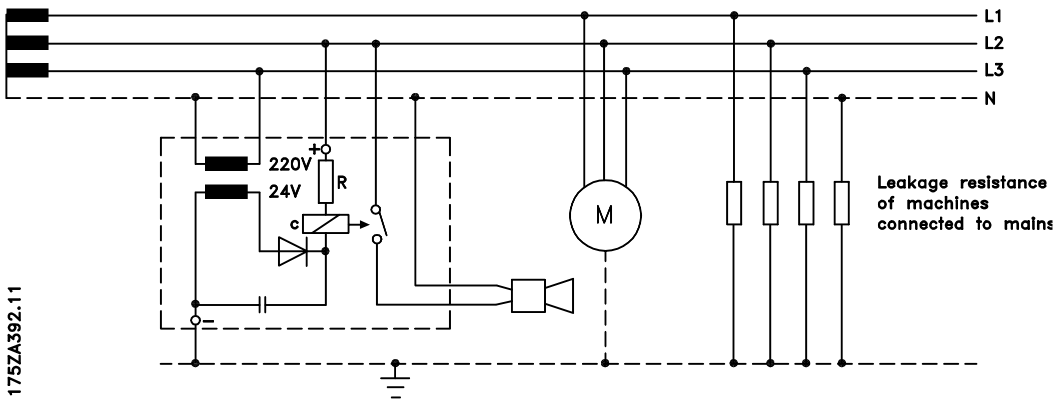
When using VLT on IT mains (Insulation Terre) special care has to be taken.
IT mains is a supply mains, where the star point in the supply transformer is floating to ground.
As opposed to TN mains, a ground fault will not cause a fuse to blow.
Units connected to such an IT mains must not trip when a ground fault occurs on the supply. The plant should be able to operate with one ground fault.

Fig. 1: IT-system



An "Insulation Monitoring Device" can be installed to monitor the system and to ensure that a ground fault is found and mended before a second ground fault occurs. An "Insulation Monitoring Device" will signal that a ground fault has been found in the system.

Fig. 2: IT-system with "Insulation Monitoring Device"



In IEC 1800-3 (1996) (Adjustable Speed Electrical Power Drive Systems) several warnings are mentioned, which must be noticed (see copy page 2 and 3).

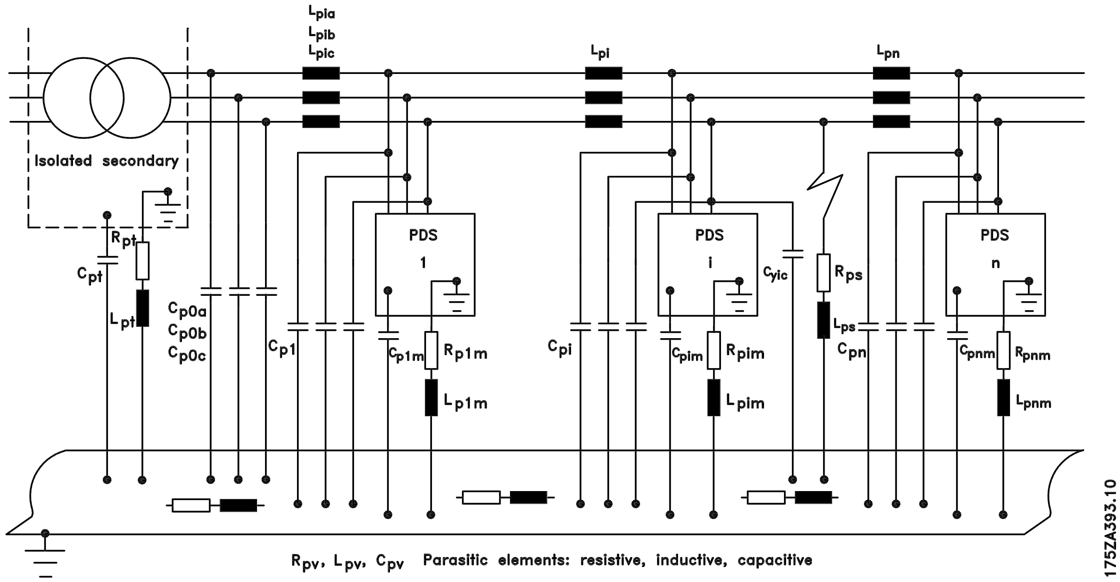
Citation from IEC 1800-3 appendix D, (1996) Adjustable Speed Electrical Drive Systems

D.2. Safety of filtering and leakage currents

D.2.1. Safety and RFI filtering in power supply systems isolated from earth

In complex processes like rolling mills, bar mills or paper mills, as well as centrifugals and auxiliary equipments in the sugar industry, crane equipment and chemical industry, it is useful and it is the state of the art to have a distributed isolated power supply system. Even if for example, the motors are installed outside the building and are exposed to high humidity, it must be possible to continue the process in spite of one short-circuit to earth. This short circuit is detected via an "earth fault monitoring system" and allows the whole process to be safely run until the next service interval.

Main transformer



Several PDS are working together in a complex process with distributed isolated power supply.*
Fig. D.3 - Safety and filtering

This "process safety philosophy" in industrial installations could be disturbed by a lot of parasitic elements as shown in the figure D.3; for example by capacitances C_{pv} between supply network and earth. The resulting capacitance is the sum of all Y-type capacitances and parasitic capacitances. The sum of all C_{pv} can reach values of several microfarads. Any RFI filtering system would increase this capacitance-to-earth to an extremely high value because of the large number of Y-type capacitances used (for example n-times the capacitors Cy). With increasing capacitance it would become more and more difficult and finally impossible to detect an earth fault correctly.

With "RFI filtering devices" (Cy), any short circuit to earth will cause very high current values to flow through the semiconductor switches within the power drive system. This is equivalent to short-circuit conditions in the earthing network on any output failure. This would lead to a tripping of function and releasing of electronic emergency protective devices, and finally to an undesired process shut-down with unforeseeable economic consequences.

With this shut-down, a safety problem for the operating or service personnel would occur because, in spite of switching off the main transformer, the capacitances Cy would remain loaded at dangerous voltages with dangerous energy contents.

**) PDS means "Power Drives Systems" which includes a VLT.*

These are the reasons why RFI filtering is not compatible with isolated networks of distributed processes, and therefore is not discussed in the above-mentioned examples. On the other hand, it can be expected that RFI filtering would not be very effective in these networks. This is because the return path of disturbance current flow to the disturbing source in systems isolated from earth is only capacitive. It will be hard to define or calculate because of resonances with the parasitic line inductances L_{pv}. Finally an increase of the disturbance currents flowing through some Cys through this less defined path could lead to interference problems with other equipment working on the same supply system.

**)PDS means "Power Drives Systems" which includes a VLT.*

Comments to D.2.1 section 2

Use "Isolation Monitoring Devices" on IT mains

If a VLT is connected to an existing IT mains, unexplainable ground faults may be reported.
IT mains is often supplied with an "Isolation Monitoring Device" (IMD) which is connected to monitor the system and detect, if an isolation fault occurs on the mains. When a fault occurs in the isolation, the monitor raises an alarm, so that the operator can start a fault location. See figure 2.
Some "Isolation Monitoring Device" uses DC as test voltage.
If the VLT is supplied with a RFI filter with high capacity (micro Farad) to ground, the "Isolation Monitoring Device" "may think" that there is an error in the system, because the test DC voltage generates a charging leakage current in the RFI filter in the VLT and signals "ground fault".
It may therefore be necessary to adjust the "Isolation Monitoring Device" or to replace it.
The "Isolation Monitoring Device" can also be jammed by the variable output frequency of the frequency converter. The "Isolation Monitoring Device" is normally not able to monitor ground faults in the DC bus.
With connected and switched-on consumers the insulation of the IT system must at least be 50 Ohm/V nominal voltage. For well maintained installations the indicated value is 300 Ohm/V nominal voltage.
To get a safe protection the IMD has to be designed according to:

- IEC 61557-8
- AST F1669M-96 ore
- DIN 57413 T8

The company Bender has a type IRDH265-4 and IRDH365-4 which can work together with the VLT. It can monitor ground faults on the motor side and compensate for a capacity up to 500 μF (see data sheet on page 6 and 7).

Comments to D.2.1 section 3

When a ground fault occurs in the mains supply, the potential energy in the capacitors of the motor cable between the VLT and the motor is discharged through the drive. The current measurement in VLT 2000, VLT 2800, VLT 3000/3500 and VLT 5000/6000 will protect the VLTs against these current shocks and thereby avoid trips. However, EMC filter components in the DC-bus for the VLT can cause a trip of the VLT frequency converters:

If the frequency converter has EMC filter in the DC-bus (see figure 5 on page 5, C_{E1} and C_{E4}), over-voltage in the DC-bus voltage can occur. At normal operation conditions, there will be approx. ½ DC-bus voltage over C_{EI} and C_{E4}, because the DC-bus voltage is floating relative to the ground potential.

If a ground fault should occur in one of the phases in the power line, +DC bus or -DC will alternately be in galvanic connection with ground, depending on whether the ground fault occurs in the plus- or minus diode in the phase. This means that C_{E1} and C_{E4} respectively will be charged to full DC bus voltage. The energy from C_{E1} and C_{E4} will charge the intermediate circuit electrolytes C1 and C2 up to twice the normal DC bus voltage. (C_{E1} and C_{E4} = 0,05 micro Farad).
If the frequency converter is on “stand-by”, the voltage can be doubled compared to normal operation which can result in a “trip” or destruction. The same problem can occur on TT mains.
The capacitors from the DC bus to ground are used to reduce the radio noise, especially when long motor cables are used. If the VLT is equipped with a switch, the capacitors can be disconnected from ground.

NB! Please note:
The switch must be kept closed whenever possible, otherwise high voltage ripple can be generated on the DC bus in the VLT.

However, in order to avoid over-voltage in the DC bus on IT mains with closed RFI switch, one of the following solutions are recommended:

- Open RFI switch (see fig. D.3 on page 2). Please note that PELV might not be observed when S1 is opened (please cf. the relevant Design Guide).
- If the unit is supplied with a brake module, it will protect the unit. Connect 22 k Ohm (Max.) as brake resistor. If braking is not required the brake resistor only needs to have a power rating of 15 W $\left(R = \frac{UxUx\ 2}{P} \right)$
- Connect a load resistance of 15 W over the ±DC bus terminals
- Use DC holding current (Parameter 124 in the VLT 5000).
- Keep the VLT in "RUN" mode.

Comments to D.2.1. section 4

The problem with long discharge time is also serious when using a VLT. Always use a measuring instrument to check that all the capacitors are discharged.

Comments to D.2.1. section 5

The standardized method for measuring EMC does not take into account that the mains supply can be IT mains. Therefore no statements about EMC compatibility for IT mains can be made. However, our experience in practice shows that our filters generally work as on TN mains.

NB! Please note:

- **The EMC filter module for VLT 2000 cannot be used on IT mains.**
- **The RFI filters for VLT 2800 400 V cannot be used on IT mains.**
- **EMC filter class B in VLT 3516-3562 cannot be used on IT mains.**
- **VLT 5060-5500 and VLT 6075-6550 have a low leakage resistance to ground. The resistance would be as low as 550 k Ohm. The reason is that protection against direct contact has been used by means of protective impedance. If EMC filters are used the "RFI switch 1" has to be opened.**
  As per week 19, 2002, the VLT 5075-5500 have been modified. After this modification the leakage resistance to ground increase is set to 3.5 M Ohm. RFI switch 1 and 2 have to be opened. This drive will have serial number (xxxxxx H192) or higher.

VLT® on IT mains

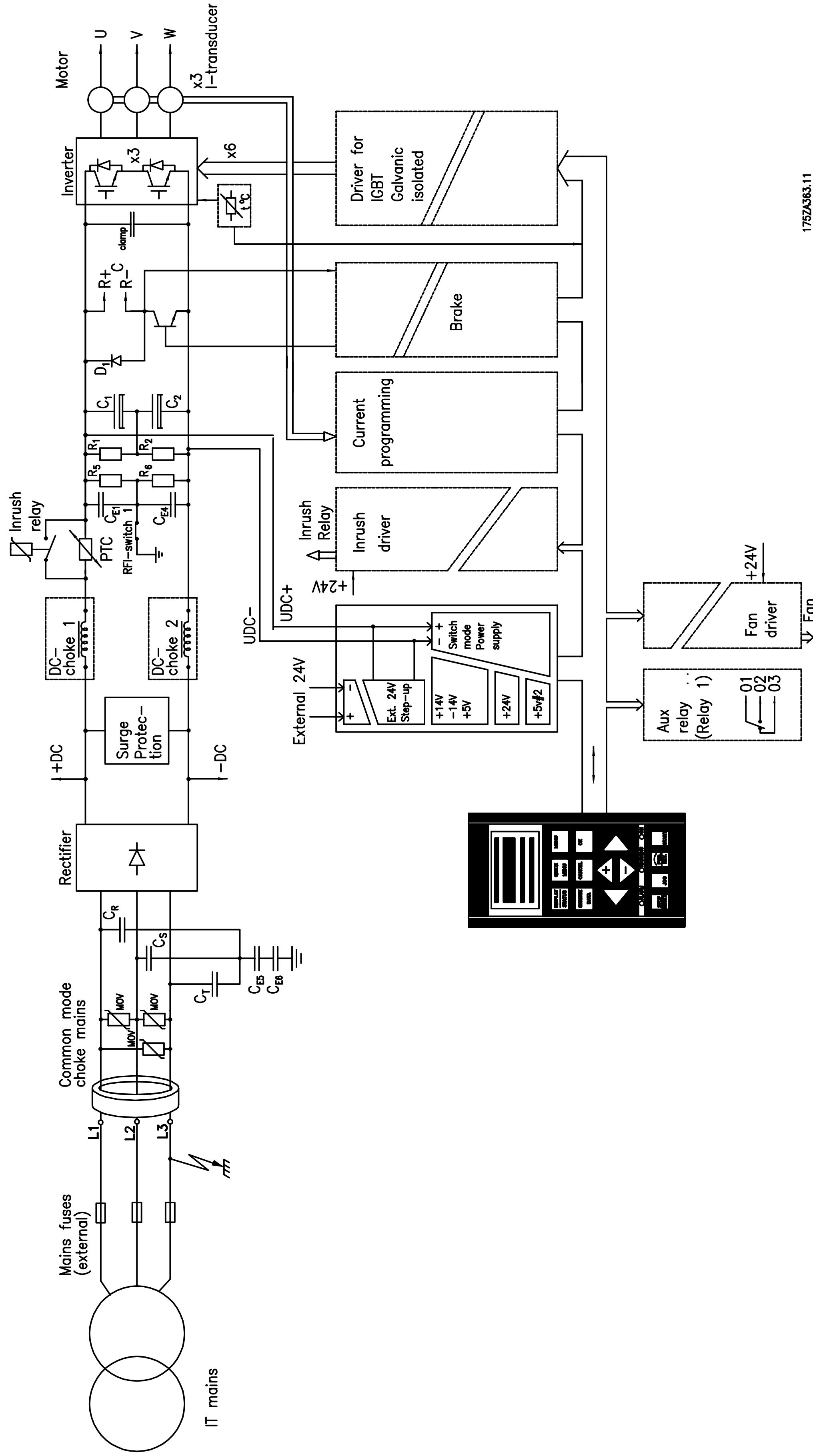
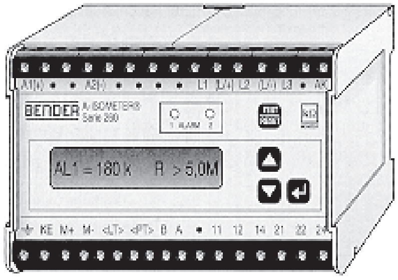


Fig. 3

BENDER

A-ISOMETER® IRDH265-4..

Insulation monitoring device for IT AC systems with DC components and IT DC systems



Application in modern power supply systems

- Three-phase systems with converter drives
- DC systems with power converters or direct DC converters
- Mixed AC/DC supply systems
- UPS systems
- Heaters with phase control
- Systems with switched-mode power supply
- Systems with very high leakage capacitances

Product description

The A-ISOMETERS IRDH265-4 monitor modern power supply systems by micro-processor-controlled measuring voltage. These systems frequently contain converters, power converters, thyristor controls and directly connected DC components and due to interference suppression arrangements often high system leakage capacitances to earth exist. The integrated AMP measuring principle adapts itself automatically to the respective system conditions. The voltage range can be extended with coupling devices. Further details on this subject you will find in chapter 1.9 "Coupling devices".

Device characteristics:

- universal for 3(N)AC systems, AC/DC systems up to 690 V and DC systems up to 500 V
- the voltage range can be extended with coupling devices
- automatic adaptation to system leakage capacitances up to 500 µF
- safe measuring thanks to the AMP measuring principle and microcontrollers
- Two adjustable response values 10 ... 990 kΩ
- LC display
- RS485 interface
- Connection monitoring
- Automatic self test

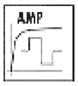
Ordering details

Type	Nominal system voltage	Supply voltage	Art. No.
IRDH265-4	AC 0-690/DC 0-500 V	AC 230 V	91068001
IRDH265-413	AC 0-690/DC 0-500 V	AC 90 ... 132 V*	91068004
IRDH265-415	AC 0-690/DC 0-500 V	AC 400 V	91068017
IRDH265-416	AC 0-690/DC 0-500 V	AC 500 V	91068009
IRDH265-422	AC 0-690/DC 0-500 V	DC 19.2 ... 84 V*	91068002
IRDH265-423	AC 0-690/DC 0-500 V	DC 77...286 V*	91068003

Other supply voltages on request.

* This information represents absolute values for the supply voltage, to which the working range is not applicable.

Measuring principle



IRDH265-4 series operates with the AMP measuring principle.

This ensures safe monitoring of modern control voltage systems. The chapter on "Measurement Technology" contains a detailed description of the measuring principle.

Standards

IRDH265-4 series complies with the standards DIN 57413 T8 / VDE 0413 T8, IEC 61557-8, EN 61557-8 and ASTM F1669M-96.

Further details on these standards and certifications you will find in chapter "Standards".

When installing the device, the safety instructions supplied with the equipment must be observed !

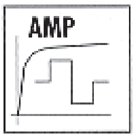
Certifications:

Summary of the measuring principles

The IT system, its structure and its components are directly interrelated with the measuring principle of the insulation monitoring system. For planning purposes, it is therefore important to know which insulation monitoring device operates with which measuring principle. The table opposite shows the selection of measuring principles, taking the system parameters into account.

System form	Generation	Remarks	ISOMETER
pure AC system	• Transformer • Generator • inverter	single or polyphase	DC
DC system	• Battery • Rectifier • Solar cell • Fuel cell	• without AC components • with AC components from rectifiers	AMP
AC system with DC components	• Transformer • Generator via galvanically connected rectifiers	single or polyphase	AMP, DC
ACsystem with electronic actuators	• Thyristors • Triac • GTOs as electric actuators	• high harmonic current • DC components	AMP
AC system with variable frequency	• Frequency converters	• wide range of frequencies	AMP

The AMP measuring principle



The AMP measuring principle (patent applied by BENDER) is based on a specially clocked measuring voltage which is controlled by a microcontroller and adapts itself automatically to the respective system conditions. Software-supported evaluation differentiate between system leakage current which occur as interference variables on the evaluation ciruit, and the measurement variable, which is proportional to the ohmic insulation resistance. Consequently broadband interference influences (such as those which are created when a frequency converter is in operation) do not have a negative influence on the exact determination of the insulation resistance.

The adjustment parameters (response values, special alarm and display functions) are programmable, and are stored in a non-volatile memory. Some devices are fitted with interfaces for connection to data aquisition systems.

Devices with this measuring principle can be used universally in AC, DC and AC/DC systems, with voltage or frequency variations, high system leakage capacitances and DC components. These divices are able to cope with today,s modern distribution systems, which usually contain influen-cing variables of this sort (the key words are frequency converters and EMC).

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