

### Introduction

When installing frequency converters and other electrical equipment the use of fuses does not provide sufficient protection.

To increase protection Residual Current Devices (RCDs) also known as Earth Leakage Circuit Breakers (ELCBs) are often applied. In some countries the use of RCDs is required by law. Generally it is required in laboratories, bathrooms and construction sites and almost always where electrical equipment is connected to a plug. This is mainly required to protect people against hazardous electric shocks. On farms and in similar buildings, RCDs are often required as fire guards.

The RCD embraces all live conductors (L1, L2, L3, N) except for the protective conductors PE and PEN (see figure 1).

This application note will help you select the right RCD. It does not specify where to apply them as that varies from country to country. You will have to observe local legislation.

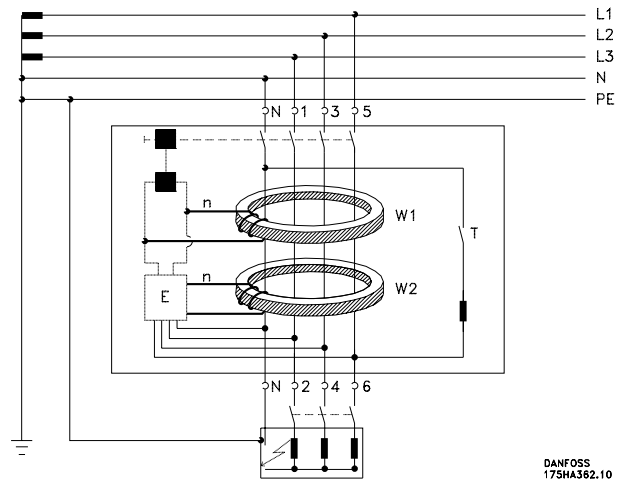


Fig. 1: Diagram of a RCD type B in a TN-S network

- E Electronics for tripping in the event of smooth DC fault current.
- T Test device.
- n Secondary winding
- W1 Core balance transformer to detect sinusoidal currents.
- W2 Core balance transformer to detect smooth DC fault currents.

DANFOSS  
175HA382.10

### RCD types

Figure 2 shows the fault currents which can be detected by the different RCD types.

	Form of residual current	Correct functioning of RCD-type		
		AC	A	B
Sinusoidal A.C.	Suddenly applied	+	+	+
	Slowly rising			
Pulsating D.C.	Suddenly applied		+	+
	With or without 0,06A			
	Slowly rising			
Smooth D.C.	Smooth D.C.			+

Fig. 2

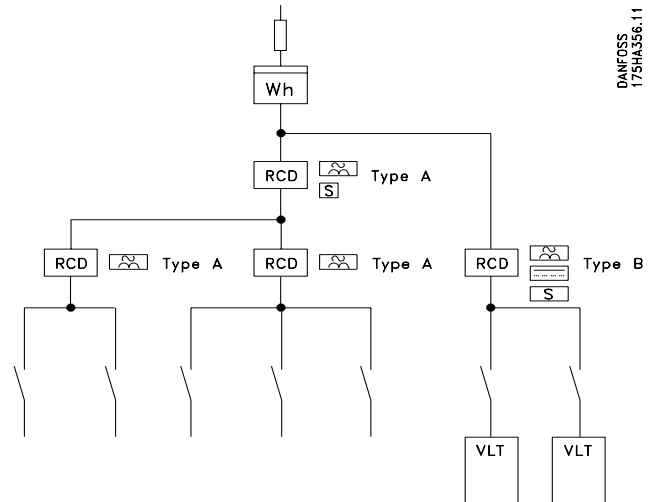
- RCD type AC is the oldest type and it can only detect AC fault currents.
- RCD type A is the most commonly used RCD type today. It can detect AC and pulsating DC fault currents, provided the DC fault currents cross or touch zero at least once in every full cycle.
- RCD type B is a new type. It can detect AC, pulsating DC and smooth DC fault currents. There are three vendors today: Siemens, ABB, Merlin Gerin and Bender.

Local authorities should be consulted for information on where the use of Bender RCMA type B is allowed to substitute RCD's.

Fig. 1 shows the diagram of an RCD type B. Type A or AC only has one coil (W1), in other respects it is similar to type B.

Monitoring devices (RCM) for example from Bender are also available in the market. Some of these RCM's can be installed for use as a protective measure. It is however only designed for monitoring and indication.

RCDs of type B are rather expensive compared to type A. Compared to isolation transformers however, the RCD type B has essential advantages, such as price, dimension, weight and energy cost. They do however have to be installed separately from any RCD type AC and type A. Planning example from EN 50178 is shown in figure 3.



DANFOSS  
175HA356.11

Fig. 3

### ■ Fault currents

For common line-side circuit configurations of frequency converters, figure 4, a DC content can occur in the fault current in the event of wrong connection to earth.

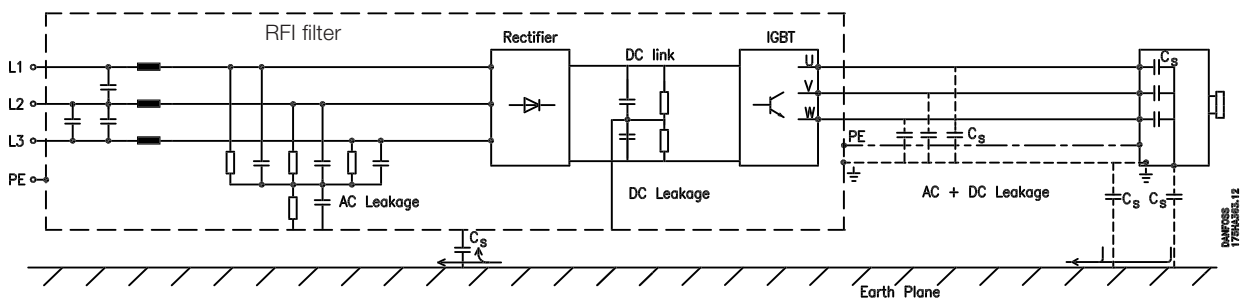


Fig. 4

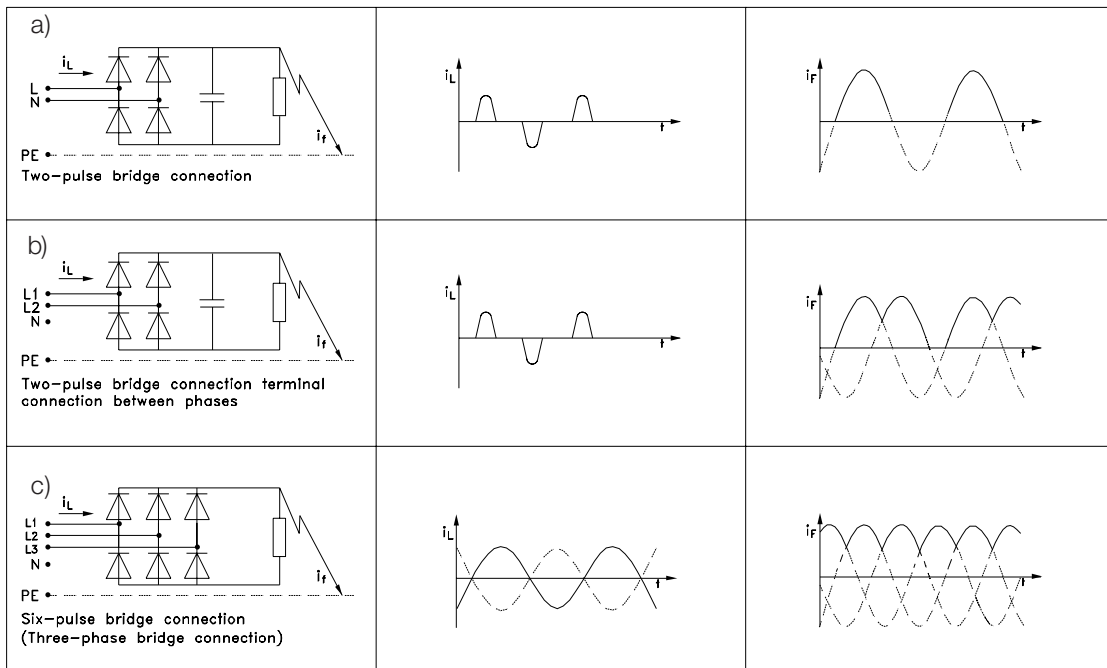
### ■ Choosing RCD type

The RCD type AC is never to be used with frequency converters as the fault current is a combination of AC and pulsating DC.

A single and a two phase frequency converter has a B4 rectifier as shown in figure 5a and 5b. The pulsating DC fault current always touches zero within two pulses.

Three phase frequency converters have a B6 rectifier. As shown in figure 5c, the fault current does not cross zero. This is because all the diodes are never off at the same time.

Therefore RCD type B must be applied. This RCD type has two monitoring circuits, one of which is designed for monitoring DC fault currents ( $W2 + E$  in figure 1).



DANFOSS  
175HA358.10

Fig. 5

■ **How to apply RCDs with VLT**

Three phase VLT frequency converters require a RCD type B.

If an RFI filter is mounted in the drive and either the switch of the RCD or a manually operated switch is used to connect the drive to the mains voltage a time delay of minimum 40 ms is required (RCD type B).

If no RFI filter is mounted or a CI contactor is used for mains connection, no time delay is required.

The reason why the RFI filter may cause problems at start is that simultaneous cut-in of the three phases will have the result that the earth leakage current from the capacitors will be close to zero. See figure 4 for the diagram of an RFI filter.

If the phase is cut in before the other two phases the resulting current will exceed the trip level of the RCD.

Single phase VLT frequency converters require a RCD type A. There is no particular need for a time delay whether RFI filters are mounted or not.

■ **The market situation**

Since the introduction of the RCD type B the authorities have become more stringent as regards the use of RCDs. The RCD type B is seen as *the* solution to all problems.

However, the above clearly shows that much precaution should be taken when applying RCDs in an installation with frequency converters.

The use of RCDs is required by the authorities all over the world. Local legislation should therefore be investigated before installing a frequency converter. Some installations do not require the use of RCDs.