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Features

- Sensitive protection for bearings of large rotating machines
- Operates for shaft currents larger than 0.4 - 1.0 A AC, depending on the diameter of the shaft
- Fundamental or third harmonic operating principle
- AC or DC powered, galvanically isolated
- Shaft current transformer with test winding
- Can be applied to shafts with diameters up to 2960 mm
- Settable time delay
- Trip relay with heavy duty contacts and indicating flag
- Test switch

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1 APPLICATION

An emf is induced in the shaft of the generators due to the magnetic dissimilarities in the armature field. The emf normally contains a large amount of harmonics. Both the wave-shape and the magnitude of the induced voltage depend on the type and size of the machine and they also vary with the loading.

Normally, the induced voltage will be in the range 0.5 to 2 volts for turbo-generators and 10 to 30 volts for hydro-generators.

To prevent the rotor from being electrically charged, the shaft of the turbo-generators is usually grounded via a slip-ring on the prime mover side. For hydro-generators, the water in the turbine provides a connection to ground. If the bearing pedestal at the other side of the rotor is grounded, the induced voltage will be impressed across the thin oil-film of the bearing. Due to the low impedance of the loop formed by the shaft, the bearing and the ground structure, a breakdown of the oil-film insulation may give rise to a heavy current which leads to destruction of the bearing.

Consequently, the bearing pedestal furthest from the prime mover is usually insulated from ground and the insulation should be supervised by a suitable protection. Severe damage on the bearings is not expected to occur if the shaft current is less than one ampere.

Shaft current protection RARIC with a special current transformer ILDD is used to detect currents that can damage the bearings of a generator. The relay can be used for generators with shaft diameter up to 2960 mm. Min operate current is 0.4 to 1.0 ampere, depending on the diameter of the shaft.

The RARIC protection is available in two versions:

Version 1 has a linear frequency characteristic and operates on the fundamental and harmonic components in the shaft current.

Version 2 has a damping filter for the fundamental frequency and operates on the harmonics in the shaft current. This version is used when the shaft current transformer is exposed to a large fundamental frequency leakage flux.

2 DESIGN

2.1 The RARIC protection

The RARIC protection is built up of a test switch, terminal bases, plug-in modules and connection parts of type COMBIFLEX. The test switch and the terminal bases are screwed to two apparatus bars. The plug-in modules are inserted and screwed to the terminal bases. All internal connections are made on the rear of the terminal bases with COMBIFLEX socket leads. Leads with a 10 A COMBIFLEX socket at one end are used for external connections to the relay bases and leads with 20 A socket are used for connections to the test switch.

Fig. 1 shows the components of the RARIC protection and the connections to the measuring and test windings of the ILDD shaft-current transformer. The numbers below refer to the numbering of the components in Fig. 1.

1. Test switch RTXP 18
When a test handle RTXH 18 is inserted into the test switch, the trip and alarm circuits are opened. A relay test apparatus can be connected to terminals 3B and 4B on the test handle to inject current into the test winding A - B.
2. Damping filter RXTFB 4 (only for RARIC, Version 2)
contains capacitors, reactors and resistors. One parallel resonance and one series resonance circuit in the filter gives the frequency characteristic shown in Fig. 4.
3. Overcurrent relay RXIK1
is the measuring unit of RARIC. The operating value of RXIK 1 is steplessly settable 0.5 - 2 mA. The current input circuit has an resistance of 82 ohms and contains an RC circuit to suppress high frequency disturbance signals. The output circuit contains an impulse holding function which ensures operation also when intermittent input current signals are received.
4. Time relay RXKL 1
is a static relay with scale 30 ms to 99 h. The setting determines the delay of the trip signal.
5. Auxiliary relay RXME 18
has heavy-duty contacts which can be used in signal and tripping circuits. The relay is fitted with a red flag to indicate operation. The flag is manually reset by means of a resetting knob in the cover.
6. Power supply unit RXTUB 2
is an AC/DC converter which contains a transformer, full-wave rectifier and smoothing capacitors. The unit supplies auxiliary voltage to the relays in RARIC.
The output DC voltage is 24 volts (± 12 V).

RARIC is also available with a DC/DC converter RXTUG 22H for DC auxiliary voltage supply.

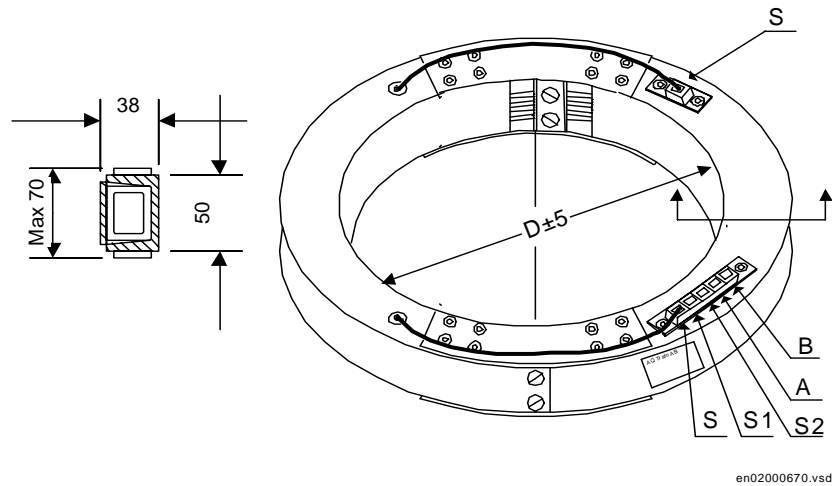


Fig. 2 Shaft current transformer ILDD with diameter D up to 2000 mm.

3 MODE OF OPERATION

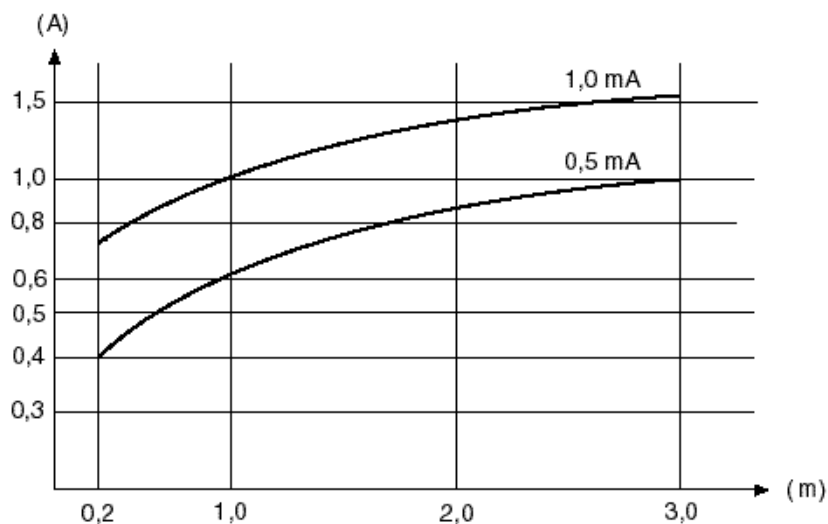
The ILDD shaft current transformer encompasses the rotor shaft and functions in principle like a cable current transformer. The measuring winding, which is connected to the RARIC protection, contains from 400 up to 800 turns, depending on the diameter of the transformer. When the current in the measuring winding exceeds the operate value of the overcurrent relay RXIK 1, it operates and tripping is given after the delay set on time relay RXXL 1.

If the shaft current is intermittent, for example due to intermittent breakdown of the insulation of the oil film in the bearing, pulses are fed to RXIK 1. If these pulses exceed the operating value of the relay, and the intervals between the pulses are shorter than 0.9 s, the contacts of the output relay will be continuously closed.

The impedance of the current measuring circuit in RXIK 1 is about 80 ohms. Hence, for Version 1, the operate voltage is about 40 mV at the lowest setting 0.5 mA of RXIK 1.

Fig. 3 shows the maximum primary operate current at 50 - 60 Hz for RARIC, Version 1, at relay settings 0.5 and 1 mA as function of the inner diameter of the ILDD transformer.

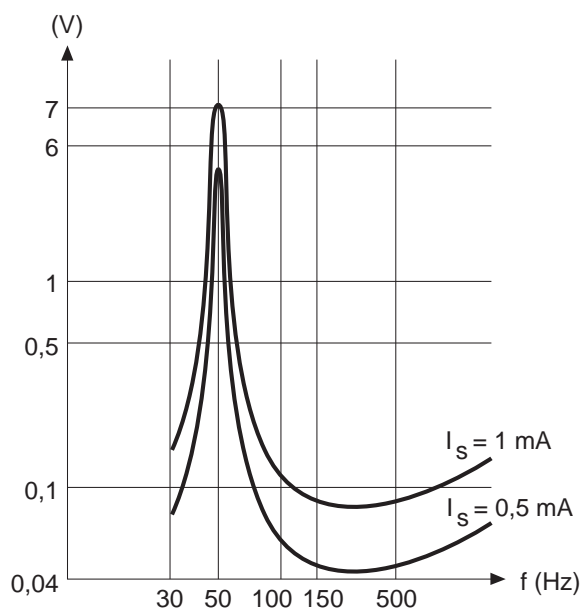
Fig. 4 shows the operate voltage for RARIC, Version 2, as function of the frequency. The curves in both figures are valid for sinusoidal currents and max. 5 ohms pilot-wire resistance between the transformer and the protection.



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Fig. 3 Primary operate current at relay setting 0.5 resp. 1 mA as function of the inner diameter of ILDD.

The filter in Version 2 rejects the fundamental voltage by more than 70:1.



502001-2

Fig. 4 Operate voltage of RARIC, Version 2 as function of frequency. Rated frequency = 50 Hz.

4 RECEIVING, STORAGE AND INSTALLATION

4.1 Receiving

Remove the protection from the transport case and make a visual inspection for transport damages. Check that all screws are firmly tightened and all relay elements are securely fastened.

Check on the rating plate of the relay units that the delivered relay has correct data as regards auxiliary voltage, frequency etc. Check against the list of apparatus that all units are included.

4.2 Storage

If the relay is to be stored before installation this must be done in a dry and dust-free place, preferably in the original transport case.

4.3 Installation

The RARIC protection can be placed in a 19" equipment frame for mounting in a 19" rack in a cubicle. The relay can also be placed in a relay case type RHGX.

On delivery, all internal connections in the protection are ready made. External connections (dotted lines on the circuit diagrams) are made with leads with 20 A COMBIFLEX sockets to the RTXP 18 test switch and with 10 A sockets to the relay terminal bases.

The ILDD shaft current transformer should be mounted around the shaft at a place where any possible current through the bearing is flowing in the shaft. This means that it should be mounted at the rotor side of any bearing or slip-ring. To avoid disturbances the transformer shall be mounted on the turbine side of the machine which is free from field bars and at maximum distance from the end of the stator winding. See Fig. 12 and Fig. 13 for recommended mounting.

Screened cable, with twisted pairs and with the screen grounded only at the relay side is recommended for the connections between the protection and the shaft current transformer.

An inner diameter of the transformer 20 - 50 mm larger than the shaft diameter is suitably selected. Large diameter of the transformer has a negative influence on the sensitivity of the protection and it also increases the risk of stray fluxes entering the CT core.

The width of the transformer in axial direction is 38 mm for inner diameters up to 2 000 mm and 42 mm for inner diameters above 2 000 mm. An axial distance of at least 250 mm is required for assembling the transformer sections on the shaft.

Mounting details are not included in the delivery, since they must be designed to suit the specific machine. Examples on mounting supports, which can be used in most cases, are shown in Fig. 14.

5 SETTING, TESTING AND COMMISSIONING

5.1 Setting

The setting of the overcurrent relay RXIK 1 is suitably decided after checking the magnitude of the stray current to the relay when the generator is running at load. In case of induced stray currents, a setting 50% higher than the setting which gives unwanted operation is recommended.

The time delay set on time relay RXKL 1 should with margin override the time delay of the phase short-circuit back-up impedance or overcurrent protection. A normal setting is 3 s.

5.2 Testing and commissioning

5.2.1 Injection test

Set the overcurrent relay and the time relay according to the above. Insert the RTXH 18 test handle into the RTXP 18 test switch. The primary operating current of the protection is tested by injecting current of rated frequency into test winding A - B of the shaft current transformer from test terminals 3B - 4B on the handle. The test winding has four turns, hence the primary operate shaft current is four times the injected operate current. Observe that for RARIC Version 2, rated frequency is 150 or 180 Hz. For this version, the relay shall not operate at lowest setting when 3 V rated frequency voltage is applied to relay terminals 107:231 - 241, (see Fig. 4).

Without altering the settings, interchange the leads to the test terminals and check the operate value. It can be different from the earlier measured value. Both values should be recorded for comparison at future tests.

Set the injection current to 2 times the operate value and check the time delay.

5.2.2 Primary test

Connect a brush via a test lead to an ammeter and then further to ground via a series connected adjustable resistor, 0 - 30 ohms. When the machine is running, press the brush against the shaft near the insulated bearing and reduce the resistance until the relay operates. Record the operate current.

Check the external connections for the trip and alarm signals.

6 MAINTENANCE

Under normal conditions RARIC requires no special maintenance. The covers should be installed in place and the hole for the current setting knob should be blanked off with a plastic plug.

Maintenance testing at regular intervals, say every second years, should be made. The testing is suitably made by injection of current to the test winding, since this also checks the ILDD transformer and the wiring up to the protection.

7 TECHNICAL DATA

Table 1: Basic data

Current setting range (RXIK)	0.5-2 mA, 50-60 Hz
Operate shaft current at setting 0.5 mA and transformer diameters 160-3000 mm	Version 1: 0.4-1.0 A, 50-60 Hz Version 2: 0.4-1.0 A, 150 Hz
Reset ratio	> 99%
Filter characteristic, version 2	The filter rejects the fundamental by 70:1
Input impedance	80 ohm resistive
Overload capacity shaft diameter < 700 mm shaft diameter 700-1600 mm shaft diameter 1610-2500 mm shaft diameter > 2500 mm	50 A shaft current continuously and 200 A in 1 s 65 A shaft current continuously and 250 A in 1 s 75 A shaft current continuously and 300 A in 1 s 100 A shaft current continuously and 400 A in 1 s
Auxiliary rated voltage	100, 110 and 220 V, 50-60 Hz or 24-250 V DC
Power consumption from aux.voltage AC supply DC supply	Approx. 2 VA before and 8 VA after operation Approx. 3 W before and 7 W after operation
Time setting range (RXKL)	30 ms-99 h
Permissible ambient temperature	-5 to +55 °C
Permissible range auxiliary voltage supply	80-110 % of rated voltage

Table 2: Electromagnetic compatibility tests

Power frequency test (SS 436 15 03)	0,5 kV, class PL4
Fast transient test (SS 436 15 03)	4-8 kV, class PL4
1 MHz burst test (IEC 60255-22-1)	2.5 kV, class III

Table 3: Insulating tests (IEC 60255-5)

Dielectric test	2 kV, 50 Hz, 1 min
Impulse voltage test	5.0 kV, 1.2/50 µs, 0.5 J

Table 4: Contact data

Trip circuits (RXME 18)	
Max system voltage within a contact set	450 V dc, 400 V ac
Current-carrying capacity for already closed contact	55 A for 200 ms 30 A for 1 s 6 A continuously
Making and conducting capacity, L/R < 10 ms	30 A for 200 ms 20 A for 1 s
Breaking capacity, max. 250 Vac, PF > 0.1	20 A
Breaking capacity, dc, L/R < 40 ms	20 A at 24 V 18 A at 48 V 3 A at 110 V 1 A at 220 V

Table 4: Contact data

Alarm circuits (RXKL1, RXTUG22H/RXIK1)	
Max. system voltage within a contact set	250/250 V dc 250/250 V ac
Current-carrying capacity for already closed contact	30/- A for 200 ms 15/10 A for 1 s 5/4 A continuously
Making and conducting capacity, L/R < 10 ms	30/20 A for 200 ms 10/10 A for 1 s
Breaking capacity, dc, L/R < 40 ms	2/1,5 A at 24 V 1/0,5 A at 48 V 0,4/0,2 A at 110 V 0,2/0,1 A at 220 V

Table 5: Weights and dimensions

Weight	
RARIC , version 1	4 kg
RARIC , version 2	5 kg
ILDD	$10 + 80(D - 300) / 2300$ kg where D is the inner diameter in mm
Dimension	
RARIC , version 1	4U 24C
RARIC , version 2	4U 36C
ILDD	See Fig. 11

8 DIAGRAMS

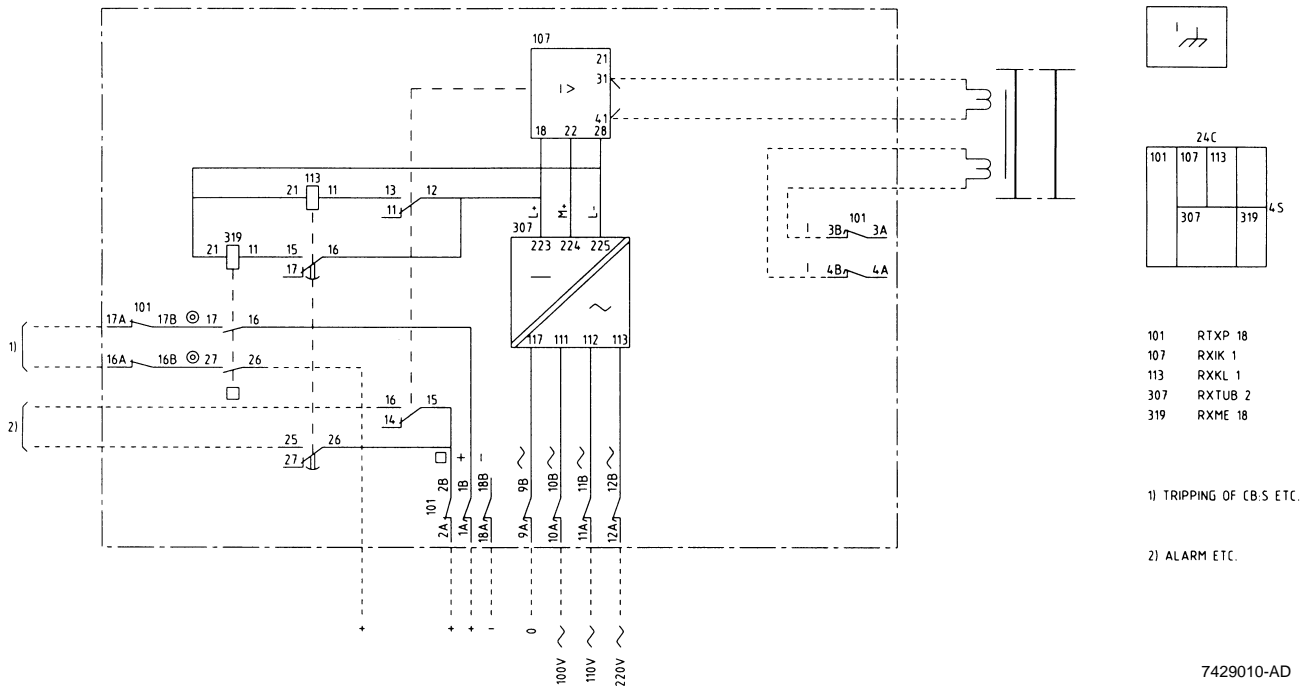


Fig. 5 Circuit diagram 7429 010-AD for RARIC, RK 649 101-AD, Version 1, with AC/DC-converter RXTUB 2

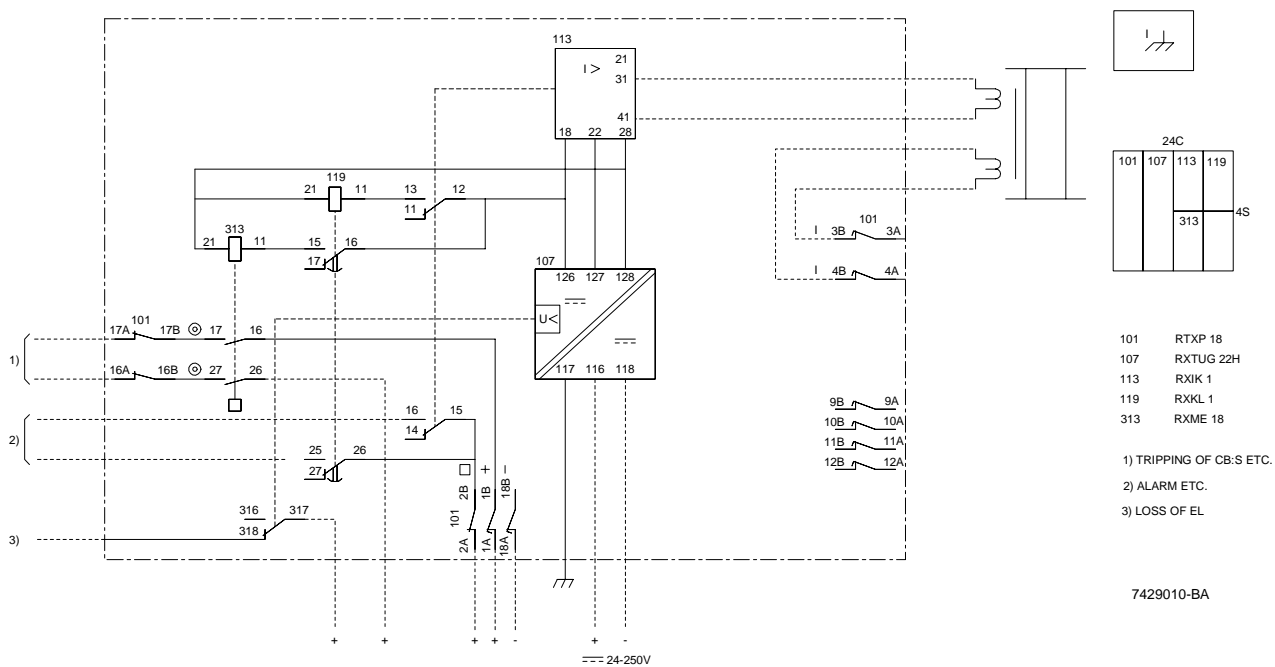


Fig. 6 Circuit diagram 7429 010-BA for RARIC, RK 649 101-BA, Version 1, with DC/DC-converter RXTUG 22H

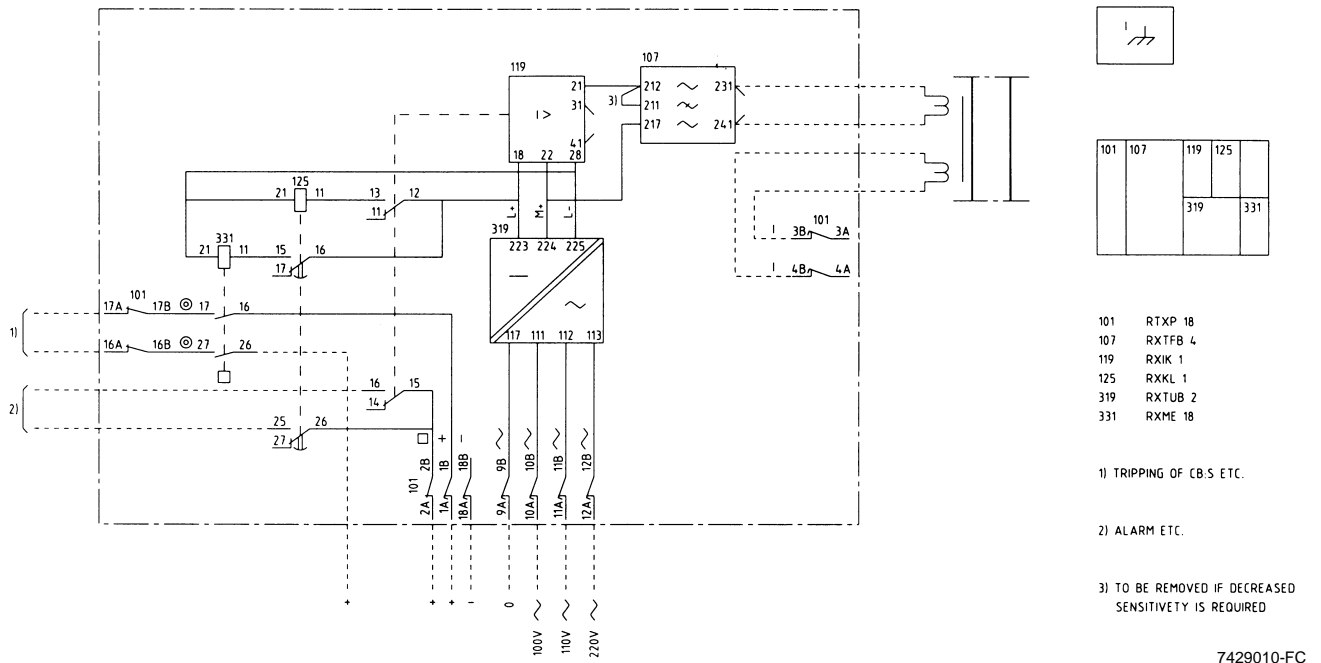


Fig. 7 Circuit diagram 7429 010-FC for RARIC, RK 649 101-FC, Version 2, with AC/DC-converter RXTUB 2.

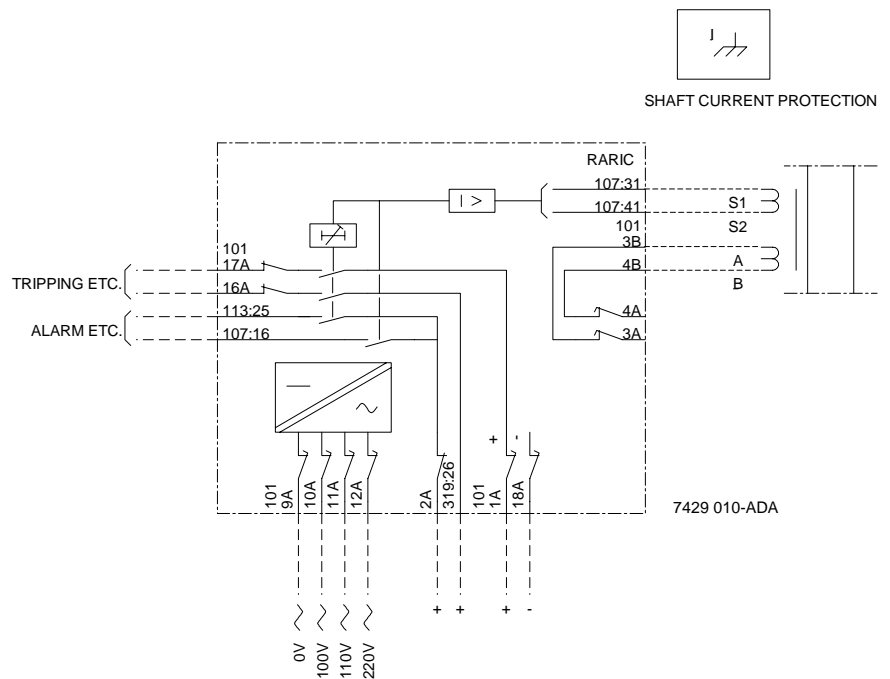


Fig. 8 Terminal diagram 7429 010-ADA for RARIC, RK 649 101-AD, Version 1.

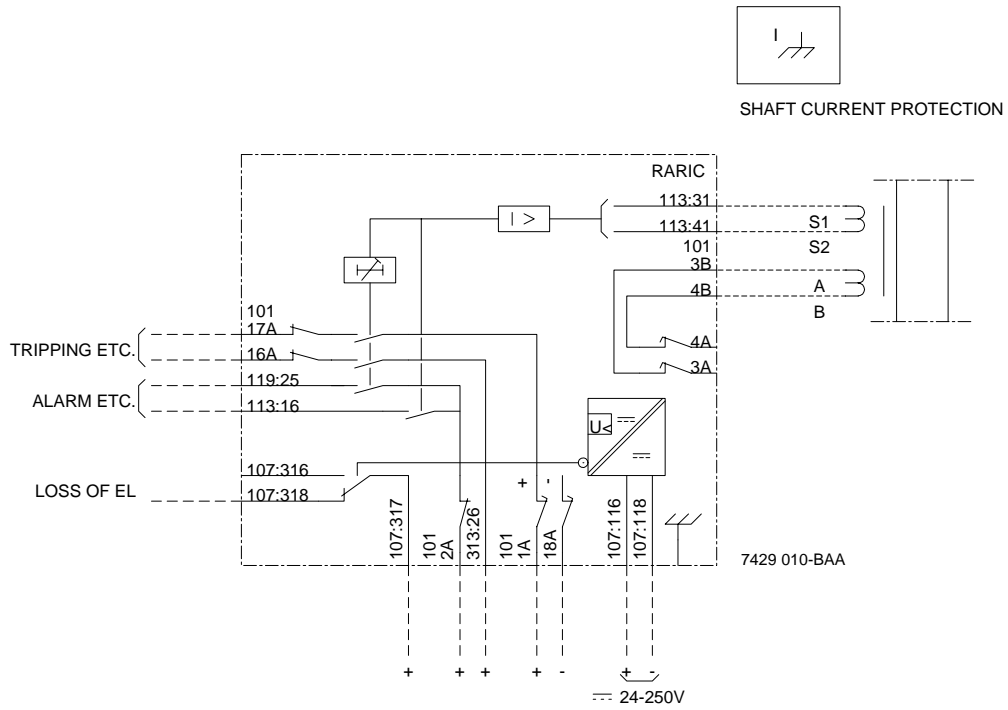


Fig. 9 Terminal diagram 7429 010-BAA for RARIC, RK 649 101-BA, Version 1

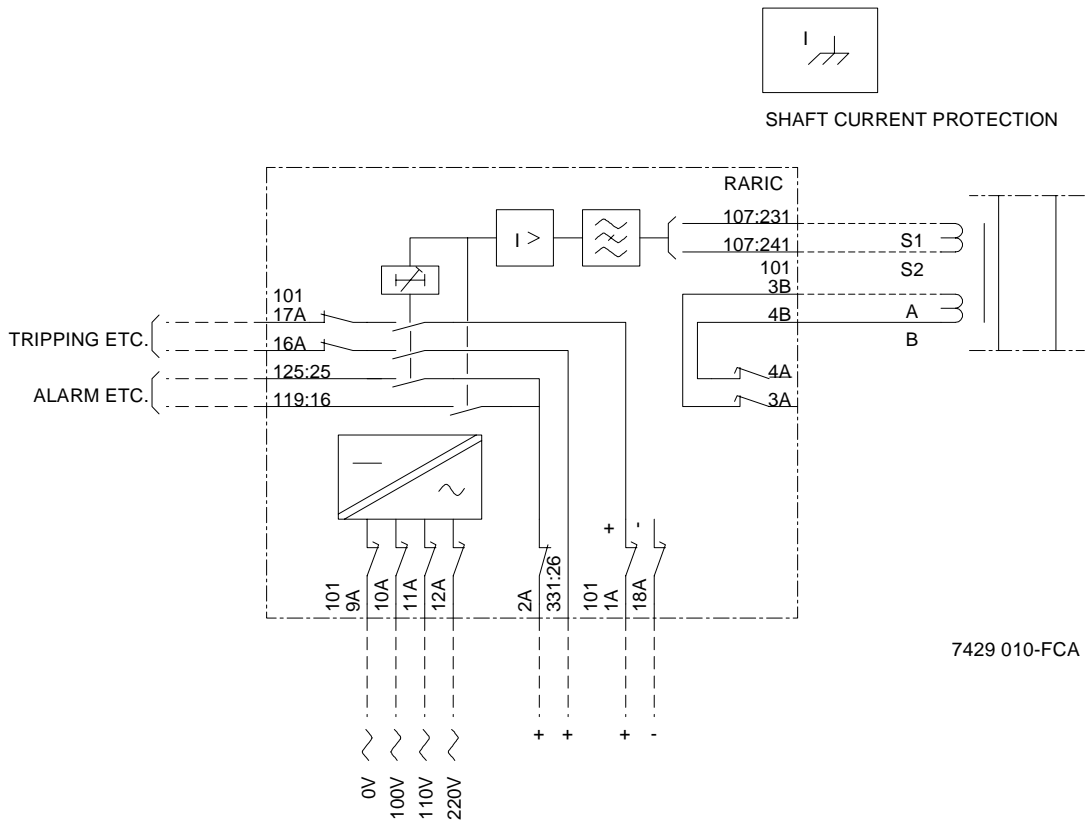
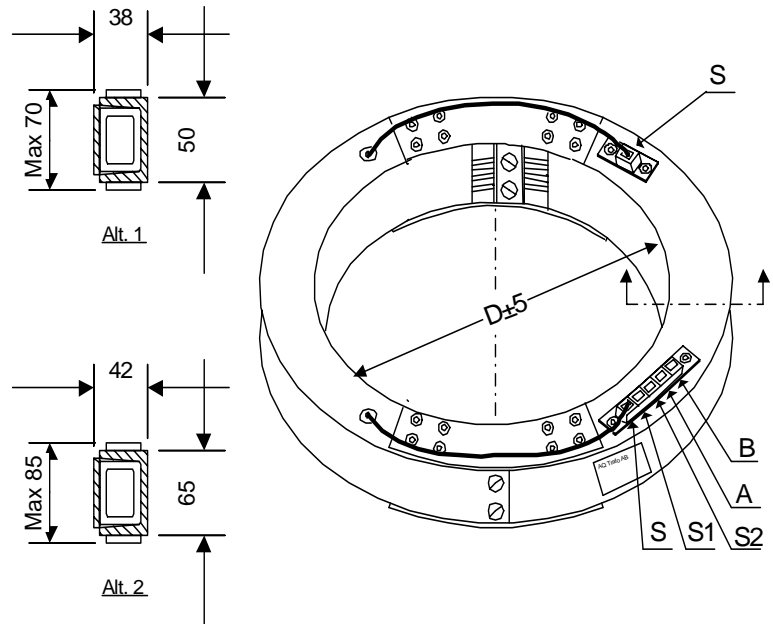


Fig. 10 Terminal diagram 7429 010-FCA for RARIC, RK 649 101-FC, Version 2

9 DIMENSION ILDD



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Fig. 11 Dimensions of the shaft current transformer ILDD. The measuring windings of the two halves are interconnected via the terminals S. All dimensions are in mm.

Transformer with $D \leq 2000$ mm has the cross-section dimensions according to Alt. 1.

Transformer with $D > 2000$ mm is split up in four parts and has the cross-section according to Alt. 2.

10 MOUNTING

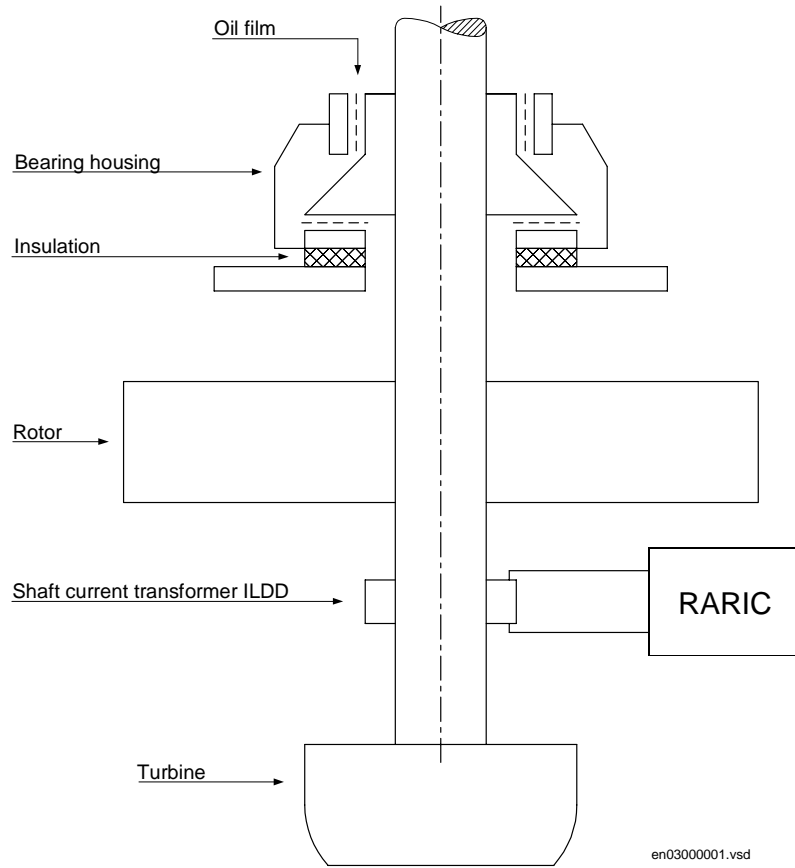


Fig. 12 Recommended mounting of the shaft current transformer ILDD on hydro generators

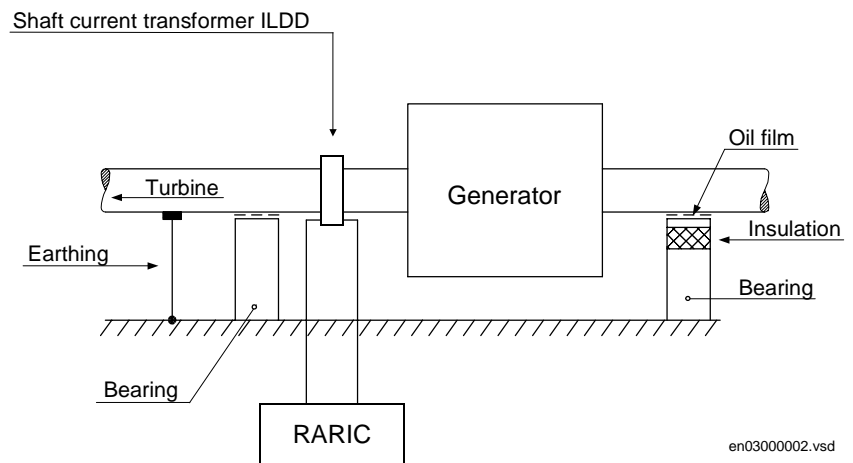
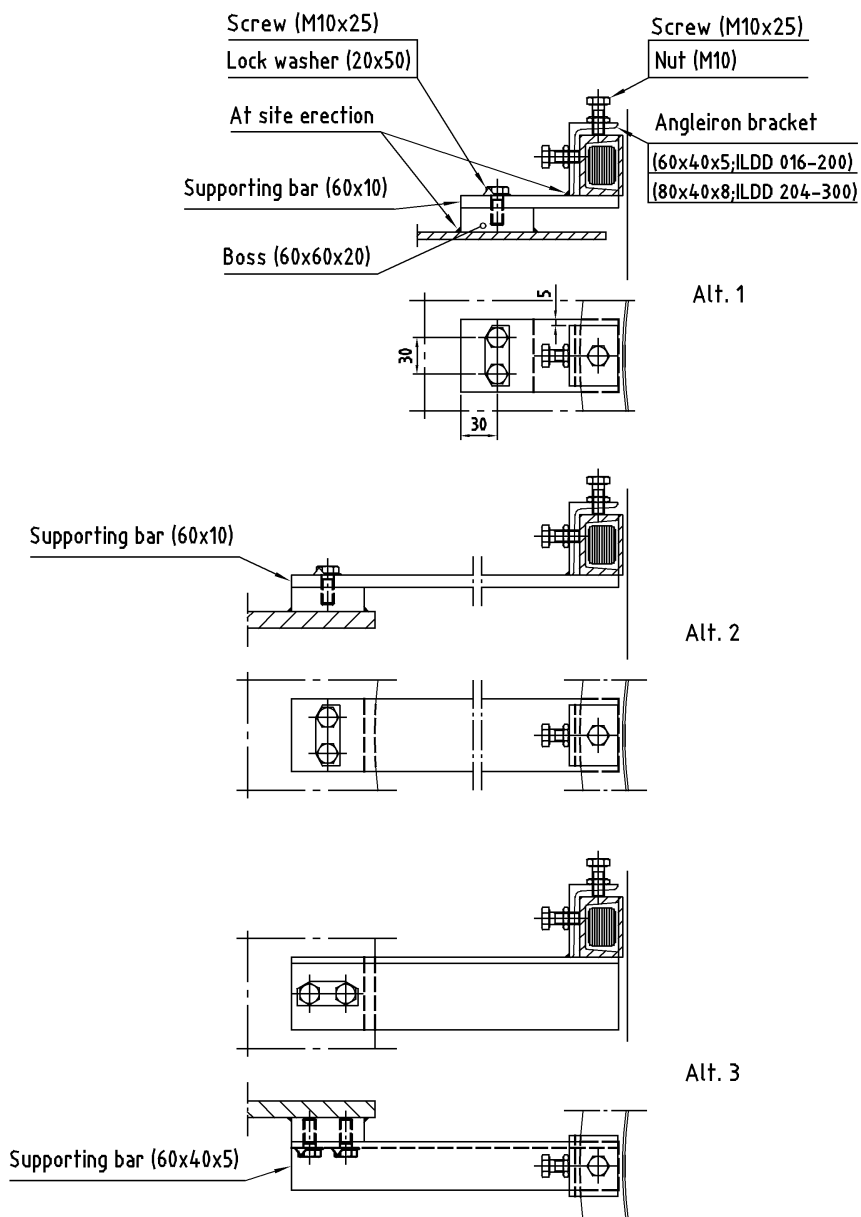


Fig. 13 Recommended mounting of the shaft current transformer ILDD on turbo generators

The transformer should be mounted with 4 supports. One of the alternatives 1, 2 or 3 can normally be used. Except the supporting bar all details are the same for all alternatives. Site weldings indicated for alternative 1 applies to all alternatives.



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Fig. 14 Examples of mounting supports.