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Electrical Safety in mines

Ground Fault Protection Equipment
for the mining industry



Future needs origin

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The 40s – how everything started

The roots of the BENDER Company date back to the year 1936. Walther Bender, the founder of the company, began his work as an inspector for electrical power systems in open pit and underground coal mines in Germany.

Electrical installations used to be disconnected for high pot testing purposes which inevitably led to production outages. This inspired him to develop an „Insulation Monitoring Device and ground fault indicator for three-phase systems“, the so called „IMD“. In 1939 this work originated in the first patent. Since then it was possible to check the electrical installation during online operation and shut downs became obsolete.

It is important to note that the German underground mining society employed a majority of ungrounded or floating power systems. The nature of these systems forbid conventional current transformer based ground fault monitoring solutions.

The IMD was the first device to close this gap successfully. Weather BENDER finally opened an office in 1946. It was the foundation of the entire BENDER Group.



The 50s – the beginning of a successful cooperation

The IMD was offered as a compact single device to several large mining and industrial companies.

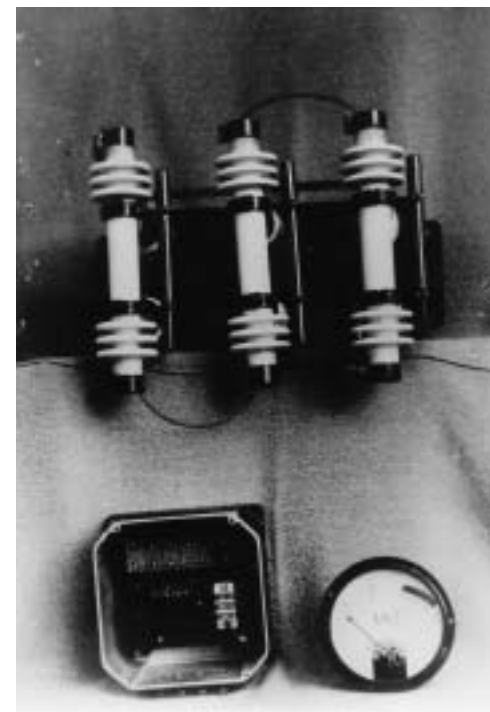
CALOR EMAG, a company specialized in switchgear and control equipment

for coal mining, became an important business partner. The IMD ideally extended the company's product range and added the additional layer of safety requested by their customers.

In addition to their normal switchgear, CALOR EMAG also manufactures flame and explosion-proof enclosures for the mining and petrochemical industry.

The IMDs were mounted in conjunction with their special electrical power distribution and control panels into those enclosures for underground coal mining.

This was the beginning of a successful cooperation between the two companies for decades of years to come.





The 60s – an idea gains acceptance

It was only a matter of time that other industries, such as steel mills, chemical plants as well as utilities and many others were showing interest in the electrical safety capabilities offered by the IMDs. Ungrounded systems could be found in limited numbers in these industries – everywhere, where increased electrical safety was paramount – BENDER Ground Fault Monitors were successfully used.

Thanks to future-oriented ideas and ongoing advancement in research and development of new products, the customer base was extended to other markets.

BENDER added ground fault protection devices for grounded and resistance grounded power systems as well.

This included a protection device for



underground lighting circuits. It enabled the user to automatically monitor ground faults and overload on the lighting circuits. This was very important as the miners also used the lighting circuits for signal commands as a communication tool.

On the suggestion of the mining industry, the ground fault lockout device

series 906, a miniaturized, epoxy resin block design, Ground Fault Relay, was developed. Its intent was to disconnect branches or feeders in case of a ground fault.

Off-line monitoring was an additional feature to prevent a restart of faulty equipment. The 906 series has been used since then by a number of national and international manufacturers of flame and explosion-proofed switchgear enclosures.

For heavy mining machines with flexible trailing cables, e.g. in potash mining, the SKS100 series trailing cable protection device was developed. In addition to the insulation monitoring function, these units provided a ground integrity monitoring function as well as off-line monitoring to prevent a restart of faulty equipment.



The 70s – marked by a new generation of protection devices for grounded power systems

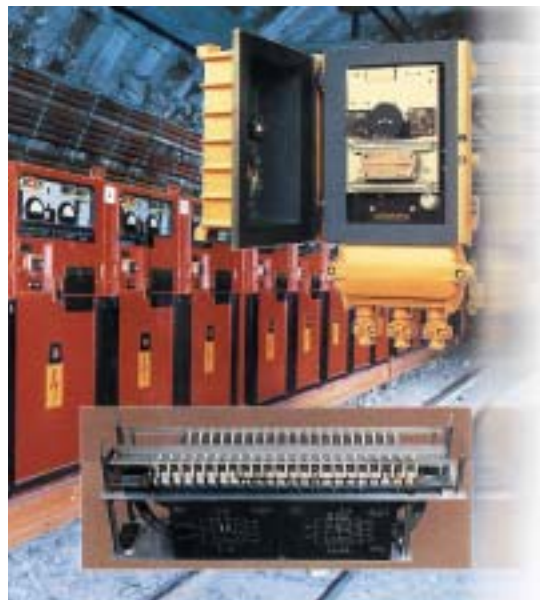
In 1972, Walther Bender handed-over the leadership of the company to his son and successor Christian D. Bender, who initialized a globally oriented business plan. New factories were built in Germany and BENDER started the mass production of electrical safety devices and in particular a new generation of IMDs, covered under the trade mark „A-ISOMETER“.

Since then, the development of the company has been progressing at quite a rapid pace. International agreements and collaborations were established. Sales and support offices were founded in more than 100 countries. The idea to improve the safety of grounded or resistance grounded systems by monitoring ground fault current between the system and ground resulted in the development of

new products. In 1974, the new HW and HWS series protective devices were applied in 6 and 10 kV switchgear and distribution panels.

In addition to the detection of ground fault current, the ground integrity of the ground conductor in high voltage cables could also be monitored and detected.

The HW103 and HWS103 high-voltage ground fault monitor series provided completely new application fields and opened new markets. For the first time, CALOR EMAG supplied this kind of Ground Fault Monitors to Venezuela. The successful selling of the devices to mining companies in Belgium, France, Spain, Yugoslavia and Columbia led to an increase in the export business.





The 80s – the final step into the US

With the foundation of the subsidiary BENDER Inc. in Philadelphia, BENDER took up the challenge to establish the ground fault protection business for the global market and in particular in the North America. American and Canadian companies had been customers of BENDER products already, but the high technical nature of electrical safety devices and the evermore growing demand for application support required him to take a serious look at a permanent representation in the US and Canada. Both countries with its unlimited variety of industrial application had an insatiable need for electrical safety devices and solidly engineered ground fault solutions. Main power systems were either floating, solidly grounded or resistance grounded. The

variety of Bender products to accommodate for all these applications went quick into the hundreds.

BENDER became well known for being the second-to-none expert for electrical safety and a reliable source for Electrical Safety Products.

The reliability of the HW and HWS series of high voltage ground fault monitor inspired wellknown mining switchgear suppliers, such as SIEMENS, ABB, AEG, SAIT, to use this protective device too. That way, the HWV monitor series came to Poland, Russia and the Ukraine.

Next to ground fault current protection devices for the mining industry there

was also a demand for a high-class electronic over current, and short-circuit protection and control devices for flame and explosion-proof medium-voltage switchgear.

BENDER's answer was the development of the R1G electronic protection relay.



The 90s – state-of-art power conversion for drives become established on the market

Due to the increasing power requirements in underground coal mines, a number of electric cables for 6/10 kV connected in parallel had to be led through the shafts to the working sites underground. On the occurrence of a

ground fault, all the cables used to be disconnected. In order to avoid a hundred percent shut down, BENDER had to develop a method to identify the faulty cable only. A practical and economical solution was developed. Through zero sequence current transformers located at the cable ends and resistive artificial star points, ground fault currents could be detected and located with the Ground Fault Monitor HEP348 for parallel cable monitoring. .

Since the beginning of the nineties, variable speed drives became common for high-powered converter drives in big excavators.

BENDER in turn developed a revolutionary new measuring principle safter comprehensive research and development. The IRDH series Insulation Monitoring Devices inaugurated a new

era of Ground Fault Monitors by using a patented AMP (adaptive measuring pulse) measuring principle which particularly suited the reliable operation of excavators and other heavy equipment. It quickly became the favourite among the mining industry and was successfully applied worldwide.



The new millenium – new ideas based on 60 years of experience

BENDER recently upgraded its existing line of monitoring and protection devices for grounded and resistive grounded systems to fulfill the request for the mining industry in the United States of America and Canada.

The devices of the RC48N series measure the ground fault current and monitor the integrity of the neutral grounding resistor between the neutral point (starpoint) of a supply transformer and ground.

The RC48C series measures the ground fault current and in addition to that the integrity of the grounding conductor.

In continuous dialogue with the customers, the BENDER product range has been steadily increasing. Practice-oriented solutions are offered for all application fields where electrical safety is paramount.



The main emphasis of BENDER is placed on:

- ▶ Ground Fault Current Monitors
 - ▶ Ground Fault Relays
 - ▶ Insulation Monitoring Devices
 - ▶ fixed and portable Ground Fault
- Location systems
 - ▶ fixed and portable GFCIs
 - ▶ system monitoring devices
 - ▶ monitoring, test engineering, alarm, control and operator panels
 - ▶ various power supply units.

BENDER –known for its innovative management strategy



Originated from a small engineering office founded in 1936 and its roots in the mining industry where ELECTRICAL SAFETY has always been considered a high priority issue, BENDER has advanced to a world leader in Electrical Safety Products.

Today the BENDER Group with its affiliated companies is structured and staffed with talented personnel comprising a work force in excess of 400 employees motivated to reduce cycle time from product inception to commissioning while still surpassing the quality control requirements of ISO 9001.

A considerable percentage of earnings is invested in R & D.














BENDER key personnel actively participates on National and International Standard committees and organizations interested in ELECTRICAL SAFETY issues throughout the Industrial, Mining and Healthcare market. A close network of agencies and distributors has been established on all continents.







Selection Guide

Ground Fault Monitors, Insulation Monitoring Devices, Ground Fault Protection Systems and Ground Fault Location Systems

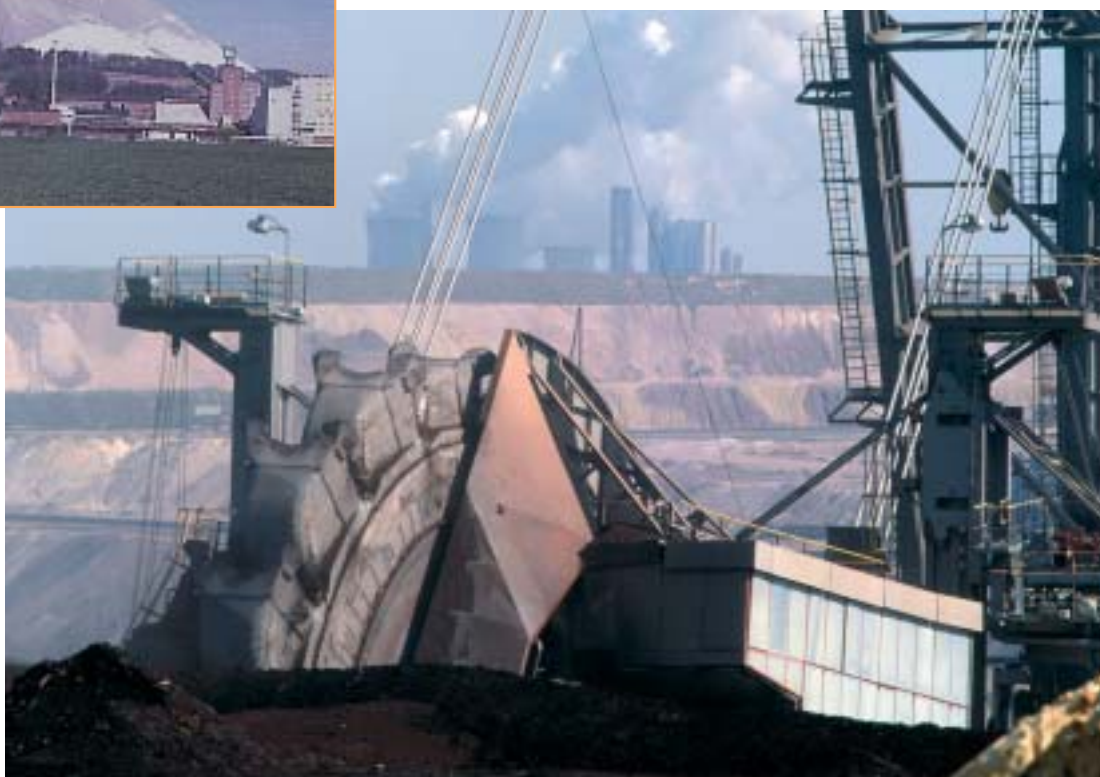
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Measuring, monitoring & protection device ▶	A Insulation Monitor		B Ground fault relay	
Power System ▶	ungrounded		solidly grounded	
Voltage ▶	AC	AC/DC & DC	AC	AC/DC & DC
Page ▶	8	9-10	11	
Application ▶	Mining Processing, Power generation Power distribution		Mining Processing, Power generation Mobile Gensets	
images ▶				
Type ▶	IR 470 LY	IR 475 LY	RCM 460 Y	RCMA 470 LY
Response value ▶	1...200 kOhm	2...500 kOhm	30...300 mA	30 mA...3 A
Notes ▶	1 Alarm LED-Bargraph	2 Alarms LED-Bargraph	external CT	external CT
images ▶				
Type ▶		IRDH 275	RCM 465 Y	RCMA 475 LY
Response value ▶		1 k...10 MOhm	30...300 mA	30...500 mA
Notes ▶		2 Alarms LC-Display	internal CT 18mm	internal CT
images ▶				
Type ▶		IRDH 375	RCM 470 LY	
Response value ▶		1 k...10 MOhm	10 mA...10 A	
Notes ▶		2 Alarms LC-Display	external CT	
images ▶				
Type ▶		IRDH 575	RCM 475 LY	
Response value ▶		1 k...10 MOhm for ground fault location	10 mA...10 A	
Notes ▶			internal CT	
images ▶				
Type ▶			W-, WR-, WS- series	W...A series
Response value ▶				
Notes ▶			standard, split-core, rectangular	

C		D	E	F
Ground fault relay & Ground continuity monitor CSA M421-00		Ground fault relay & Ground continuity monitor	Ground continuity monitor	Off-line insulation monitor
solidly grounded and resistance grounded		solidly grounded and resistance grounded	Ungrounded or grounded	Ungrounded or grounded
AC		AC (erase up to 10KV here)	AC & DC	AC & DC
12	13	14	15	15
Trailing cables up to 5kV		Power distribution, Shaft power supply up to 10 KV	Trailing	Mining processing
				
RC 48 C (Leave IΔ off) 0,1...10 A		HW 135 IΔ 0,1...10 A	RM 475 50...1000 Ohm	IREH 470 Y 0,1...2 M / 0,5...10 M
Ground continuity and shorted ground monitoring via ground check wire		Grounding conductor for low and high resistance and shorted	Ground Continuity and shorted ground monitoring via ground check wire	2 Alarms



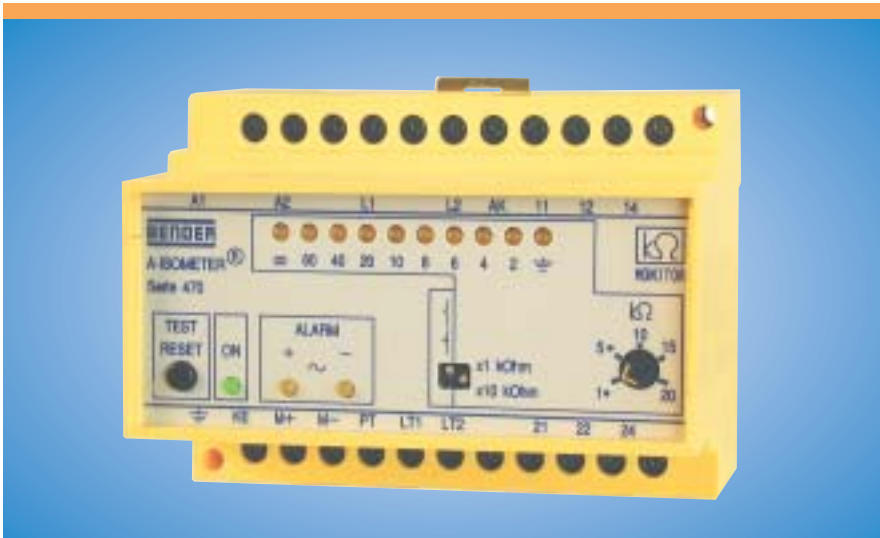
Ground Fault Protection for Surface and Underground Mining



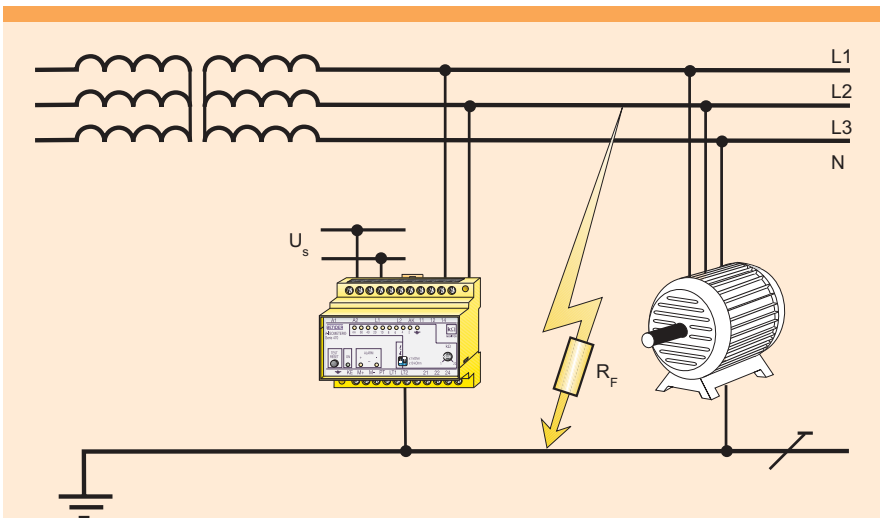


A-ISOMETER® IR470LY

Insulation Monitoring Device for ungrounded AC systems A-ISOMETER® IR470LY



A-ISOMETER® IR470LY



Blindtext

Application field:

The A-ISOMETER® of the IR470LY series monitor the insulation resistance of ungrounded single and threephase AC systems up to AC 50...400Hz ...793V.

In order to avoid unclear system conditions, DC components should be isolated from the system being monitored.

Features:

- ▶ LED bar graph to indicate the insulation resistance value
- ▶ Extended voltage range via coupling devices

Examples:

- ▶ Motors
- ▶ Lighting circuits
- ▶ Ventilation fans
- ▶ Generators

More examples could be (some typical words used in mining in the US):

- ▶ Longwall equipment,
- ▶ conveyors,
- ▶ cutting machines,
- ▶ power shovels,
- ▶ loaders,
- ▶ drag lines,
- ▶ pumps ,
- ▶ power tools.

A-ISOMETER® IRDH275 / IRDH375

PRODUCTS & TECHNICAL DETAILS

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Insulation Monitoring Device for ungrounded AC/DC systems and DC systems A-ISOMETER® IRDH275 / IRDH375



IRDH275



IRDH375

Application fields:

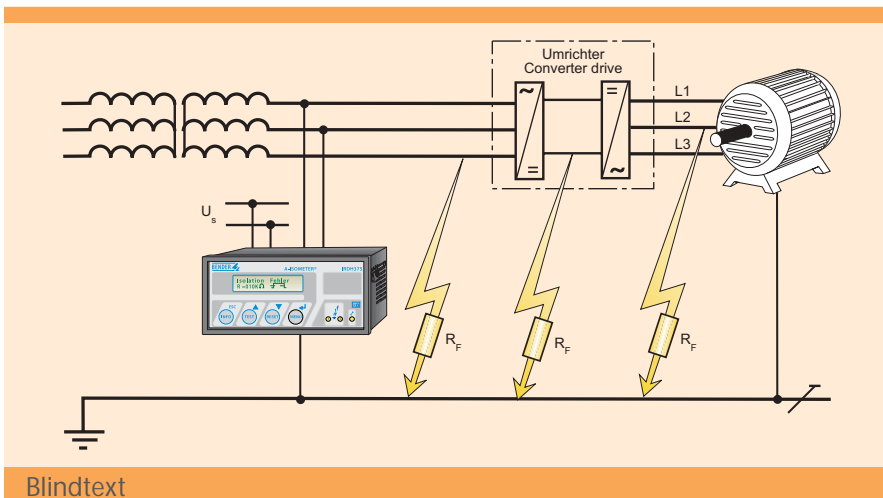
The A-ISOMETER® of the IRDH275/375 series monitor the insulation resistance of ungrounded power supply systems. The devices are suitable for universal use in 3(N)AC, AC/DC 0...793V and DC systems 0...650V. AC systems may include extensive DC supplied loads, such as converters or thyristor-controlled DC drives.

Features:

- ▶ Wide response range 1 kOhm... 10 MOhm
- ▶ Separately adjustable response values for prewarning/main alarm
- ▶ Comprehensive self-monitoring function
- ▶ Info key for the indication of the selected parameters and current system leakage capacitance.

Examples:

- ▶ Variable-speed drives
- ▶ Ungrounded systems with high leakage capacitances
- ▶ Battery systems





A-ISOMETER® IRDH575

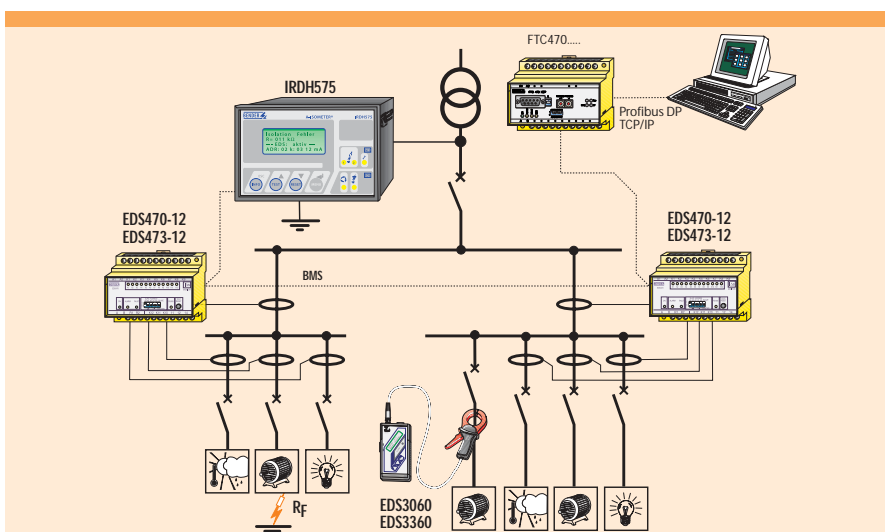
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PRODUCTS & TECHNICAL DETAILS

Insulation Monitoring and Insulation Fault Systems for ungrounded AC/DC and DC Systems A-ISOMETER® IRDH575



A-ISOMETER® IRDH575



Blindtext

Application field:

The A-ISOMETER® of the IRDH575 series monitor the insulation resistance of grounded power supply systems.

It is suitable for universal use in 3(N)AC, AC/DC 0...793V and DC systems 0...650V. AC systems may include extensive DC supplied loads, such as converters or thyristor-controlled DC drives. In combination with insulation fault evaluators of the EDS47... series and the respective measuring current transformers, the device can be extended to provide an insulation fault location system. For insulation fault location in sub circuits, the portable insulation fault location system EDS30... can be used.

Features:

- ▶ Separately adjustable response values for pre-warning/main alarm
- ▶ Comprehensive self-monitoring function
- ▶ Info key for the indication of the selected parameters and the current system leakage capacitance.
- ▶ Can be extended to provide an insulation fault location system

Examples:

- ▶ Substations
- ▶ Main circuits
- ▶ Control circuits

Portabel Ground Fault Location Equipment

EDS3060 series

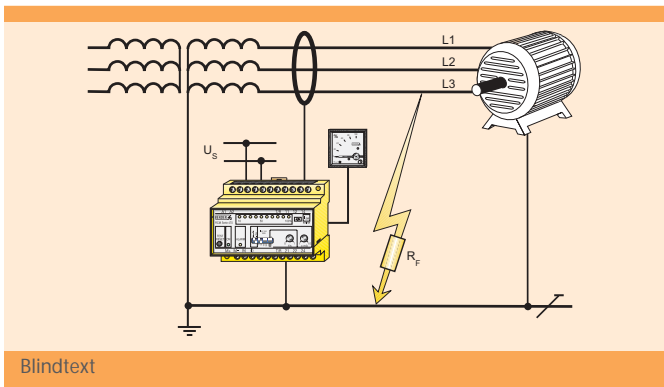
High sensitive Ground Fault Current Monitor for grounded and resistance grounded systems RCM460Y/465Y, RCM470LY/475LY



RCM475Y

Application fields:

The ground fault current monitors of the RCM... series monitor the leakage current (AC or pulsating current) of ungrounded power supply systems by means of an external zero sequence current transformer (RCM460Y/RCM470LY) or a zero sequence current transformer integrated in the device (RCM465Y/RCM475LY).



Blindtext

Features:

- ▶ For preventive maintenance of electrical installations and loads
- ▶ Alarm instead of power interruptions
- ▶ Independent of load current and nominal voltage of the installation
- ▶ Continuous indication of the ground fault current (RCM470/475)

Examples:

- ▶ Motors
- ▶ Lighting circuits
- ▶ Pumps
- ▶ Ventilation

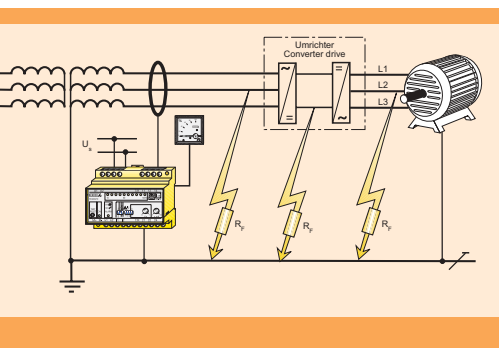
High sensitive Ground Fault Current Monitor for AC/DC and DC grounded systems and high resistance systems RCMA470/475LY

Application field:

The AC/DC sensitive residual current monitors of the RCMA470/475 series monitor fault and residual currents in earthed power supply systems utilizing external or internal measuring current transformers. The devices are particularly used in installations where smooth DC currents or residual cur-



RCMA470



rents occur the value of which is greater than zero. This is the case with loads having sixpulse bridge rectifiers or one-way rectifiers with smoothing function, such as charging devices, converters, machines with variable-speed electric motors etc.

Features:

- ▶ AC/DC sensitive residual current measurement
- ▶ Pre-warning/main alarm selectable
- ▶ Internal and external indication of the residual current

Examples:

- ▶ Grounded systems with variable-speed drives
- ▶ Battery systems
- ▶ Charging stations
- ▶ Excavator and conveyor systems
- ▶ Mills and vibrators
- ▶ Pumps, fans, compressors

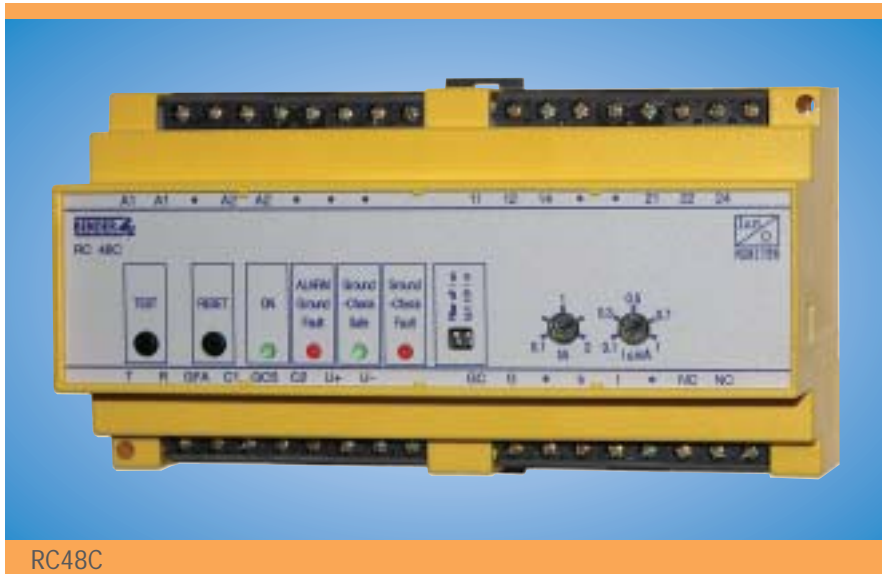


RC48C

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PRODUCTS & TECHNICAL DETAILS

Ground Fault Current and Ground Integrity Monitor for grounded and resistance grounded AC systems RC48C



RC48C

Application fields:

The RC48C monitors the residual current in resistance grounded installations and monitors the grounding conductor for low resistance.

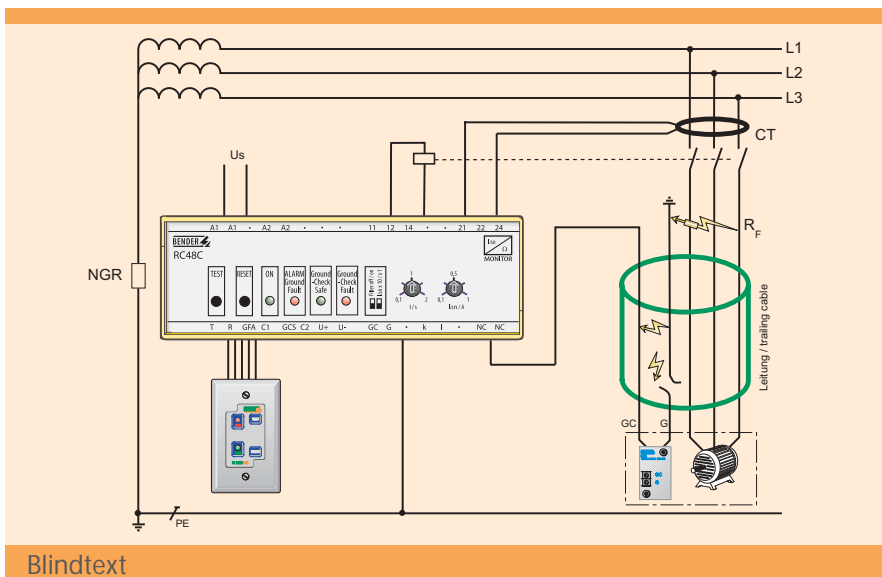
The grounding conductor is monitored for low resistance by means of the termination device E6... that is connected between the conductors G (ground) and GC (ground check) at the end of the cables being monitored. By evaluating the voltage drop at this termination device, the RC48C recognizes series resistance faults (cable high resistance or open) or cross resistance faults (short circuit) of the cable.

Features:

- ▶ External alarm indicator and test combination
- ▶ Fault memory
- ▶ Band pass filter

Application:

- ▶ Trailing cables in resistance grounded installations

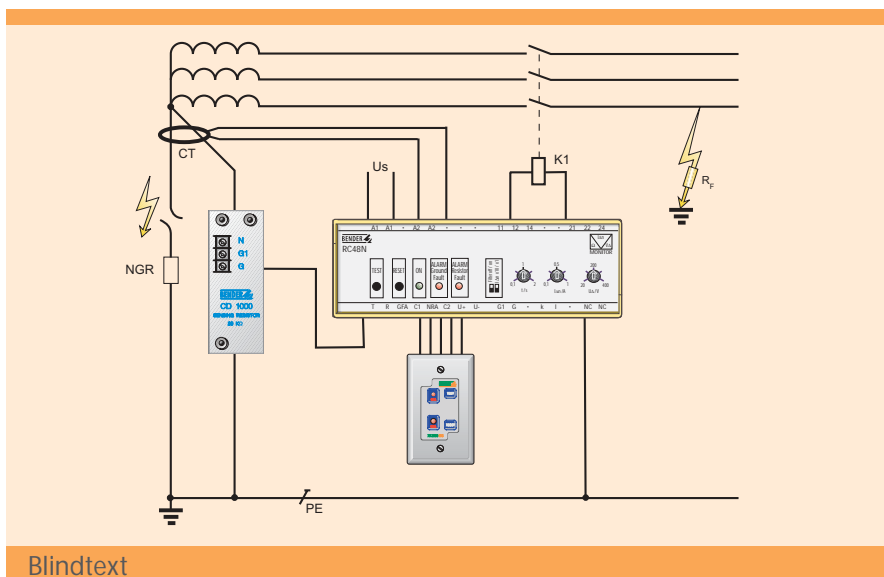


Blindtext

Ground Fault Current and Neutral Grounding Integrity Monitor for resistance grounded AC systems RC48N



RC48N



Blindtext

Application field:

The RC48N monitor is used to monitor the zero sequence current, the resistance value of the neutral grounding resistor and the voltage drop on the neutral grounding resistor. For residual current monitoring, the neutral grounding conductor and the connection of the coupling device to the neutral have to be passed through the zero sequence current transformer.

Alternatively, all active conductors (phases + N) can be passed through the transformer. When the band pass filter is switched on, only the narrow-band 60 Hz-components of the residual current are detected. In addition, the RC48N monitors the resistance value of the neutral grounding resistor (NGR) and the voltage drop on the neutral grounding resistor via the coupling devices CD1000 and CD5000.

Features:

- ▶ For systems up to 5 kV
- ▶ Data memory
- ▶ Test and reset button
- ▶ Adjustable response values
- ▶ External alarm indicator and test combination

Application:

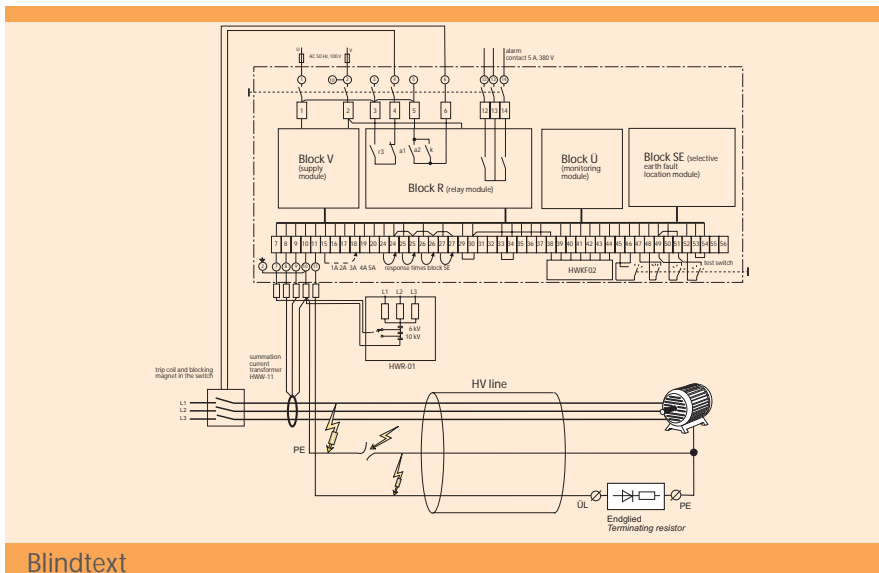
- ▶ Monitoring of trailing cables in resistance grounded installations



Ground Fault Current and Ground Integrity Monitor for grounded and resistance grounded high voltage AC systems HW103



HW103



Blindtext

Application fields:

The high voltage cable monitor monitors the cable in accordance with the German standard for mine safety DIN VDE 0118 in electrical installations for ground fault, open-circuit of the ground conductor, and for conducting objects penetrating the cable. Earth fault monitoring is based on the residual current monitoring principle. The evaluation of the ground fault current is indirectly carried out via the zero sequence current transformer HWW-11.

The effectiveness of the ÜL/SL (ÜL = monitoring conductor; SL = Ground conductor) is monitored in combination with the termination device EV22S.

Features:

- ▶ For cable lengths up to 2 miles
- ▶ For use in premises demanding a high level of safety, e.g. explosion-proof high voltage switchboards

Examples:

- ▶ Monitoring of supply cables without mechanical protection in underground mines
- ▶ Ground fault clearing in underground mining
- ▶ Monitoring of excavators with trailing cables, e.g. tunnel driving machines



RM475



IREH470LY

Ground Integrity Monitor for AC systems RM475



RM475

Application field:

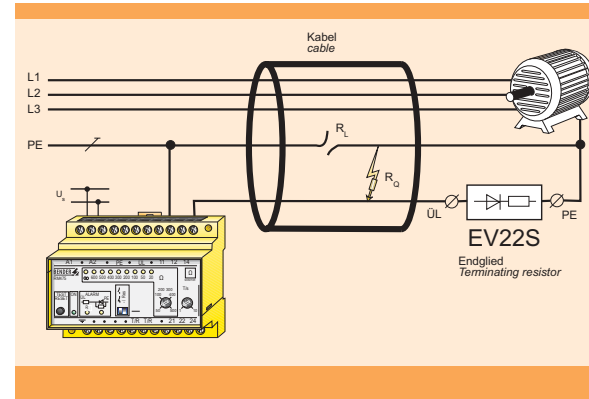
The ground loop monitor RM475LY, in combination with the cable end unit EV22S, monitors a closed and voltage-free loop for interruption (series resistance) and short circuit (cross resistance).

Features:

- ▶ LED bar graph indicator
- ▶ Suitable for installation into standard distribution panels
- ▶ Fault memory

Examples:

- ▶ Trailing cable with supplementary monitoring conductor
- ▶ Ground loops



Insulation Monitoring Device for off-line equipment A-ISOMETER® IREH470LY

Application field:

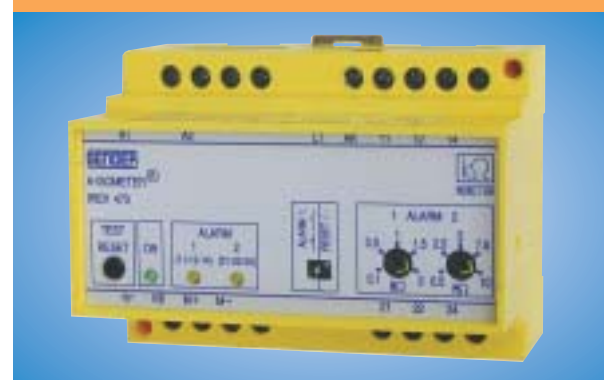
The IREH... series monitor the insulation resistance of disconnected loads in grounded and ungrounded power supply systems. The devices are used, for example, for motors, pumps for fire fighting purposes or dewatering, slide-valve drives.

Features:

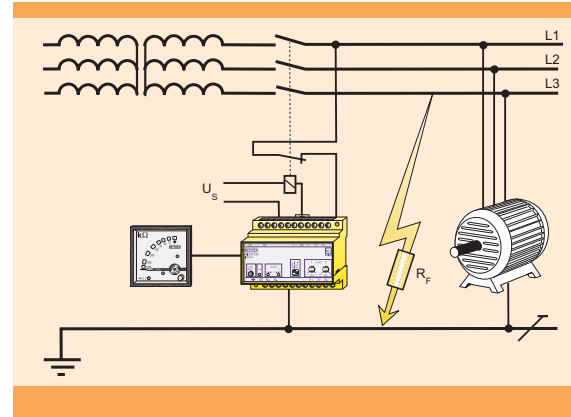
- ▶ External measured-value display
- ▶ Nominal range can be extended via coupling devices
- ▶ Pre-warning/main alarm

Examples:

- ▶ Fire extinguisher pumps
- ▶ Exhaust air extraction systems
- ▶ Motors
- ▶ Water pumps
- ▶ Slide-valve drives
- ▶ Elevators



A-ISOMETER® IREH470LY





Dipl.-Ing. Christian D. Bender



Walther Bender-House

▲ Today our vision has become reality. With full commitment and the ability to assert ourselves, we pursue the objective to be worldwide market leader in electrical safety products.

Grünberg

▲ Our know-how and the competency of our employees assure you that you have put your trust in the right partner.



Production facilities

Modern production facilities and thorough testing are the basics for quality products with a long mechanical life.



Seminar group

Together we develop innovative solutions which meet the demands of our customers.

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Power in electrical safety