Minia

Application manual
Arc fault detection devices AFDD

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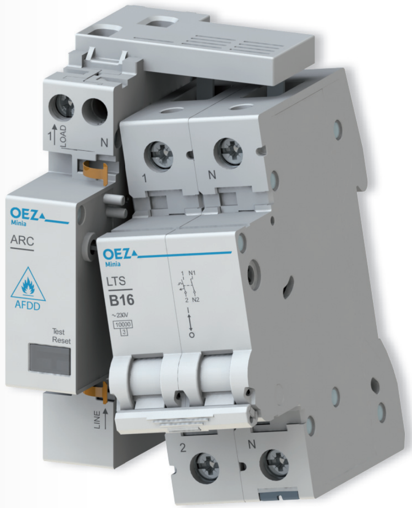
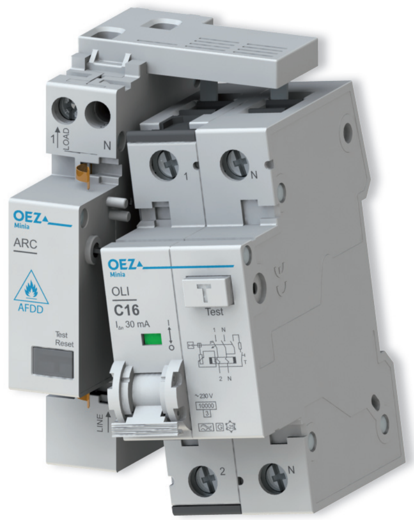
INTRODUCTION

STOP FIRE

AFDD

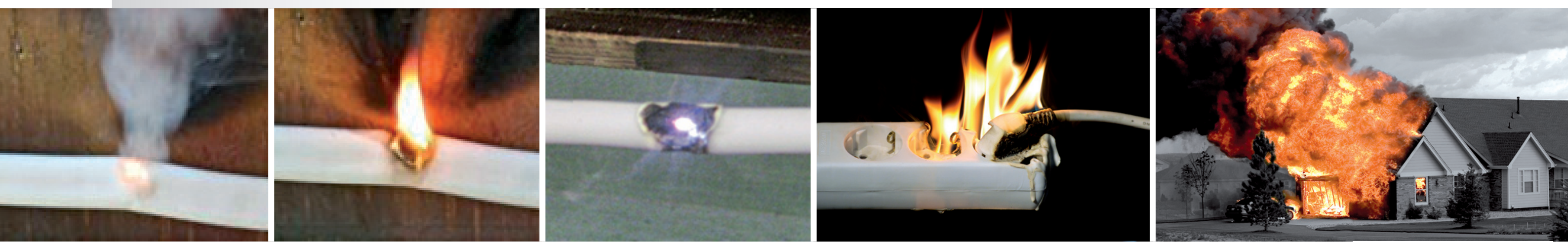


Set with a miniature circuit breaker LTS



Set with a residual current circuit breaker with overcurrent protection

Set with a miniature circuit breaker LTK



STOP FIRE

WHY USE ARC FAULT DETECTION DEVICES AFDD

Above commonly used smoke alarms the arc fault detection devices AFDD are another element in electrical installation, which can significantly reduce the number of deaths and damage caused by fire in electrical installation.

Arc fault detection devices AFDD reliably detect currents caused by arc fault (amperes) and quickly and safely disconnect the fault circuit to avoid fire. The AFDD switches off the arc fault current higher than 2.5 A, i.e. slightly smaller or same as the rated current of the circuit, i.e. currents, which miniature circuit breakers or residual current circuit breakers do not respond to. The AFDD are installed in the branch 1-phase circuits.

Arc fault detection devices AFDD are recommended by IEC 60 364-4-42 ed. 3.1:2014 (Low-voltage electrical installations - Part 4-42: Protection for safety - Protection against thermal effects / Combines IEC 60 364-4-42:2010 and AMD 1:2014).

The operator is responsible for consideration of solution risks resulting in use of arc fault detection devices AFDD.

Germany in the national standard VDE 0100-420:2016-02 has introduced mandatory use of AFDD beginning from 18. 12. 2017.

Fire statistics in European Union

25 thousand fire deaths
per year

approximately **0,5 million** fire injuries
per year

approximately **2 million** fires are reported

approximately **33 %** of the fires
are caused due to defects in the electrical installations

FIRES CAUSED BY ELECTRICAL INSTALLATIONS

Fire in electrical installation is usually caused by electric arc fault. Arc fault occurrence is caused by conductor damage or imperfect connection of conductors. This leads to the temperature increase of a conductor and insulation, carbonization of insulation, conductor disconnection, arcing and subsequently to the fire ignition.

Handling with socket outlet
- broken spring in a socket outlet
- cables damaged by mechanical strain, improper or excessive use (pulling the cable, frequent bending, cable winding on the appliance)

Permanently pressed conductors
- cables squashed by appliance
- cables pressed by furniture, doors, window, etc.
- too tight cable mounts

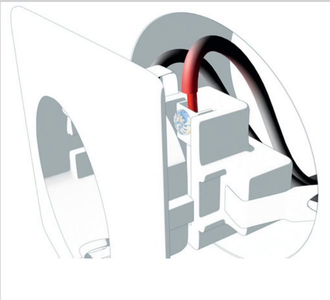
Cables with damaged insulation
- cables too tense and bent
- drilled cables, damaged by a wood screw or nail
- cables damaged by the environment: UV radiation, humidity, temperature, chemical
- cables destroyed by rodents

Recommended places for installation of arc fault detection devices AFDD

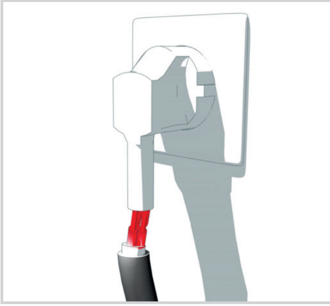
- Schools and nurseries
- Children's rooms and bedrooms
- Retirement houses
- Outlets with high load (washing machines, dryers, dish-washers)
- Barrier-free flats
- Wooden buildings
- Wood processing and paper industries, textile works
- Public buildings
- Stores with flammable materials
- Stations
- Museums
- Airports
- Buildings with older electrical installations (TN-S) – damaged insulation, poor quality connections, etc.
- Buildings with possible chimney effect, elevated buildings

STOP FIRE

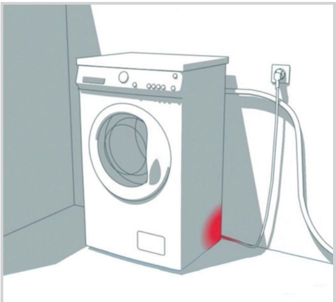
Causes of fire occurrence



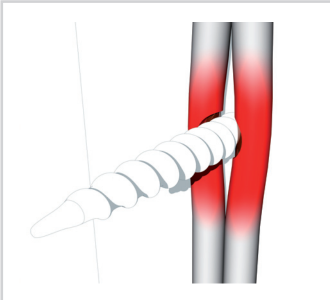
Loss of connection contact due to wrong tightening or similar.



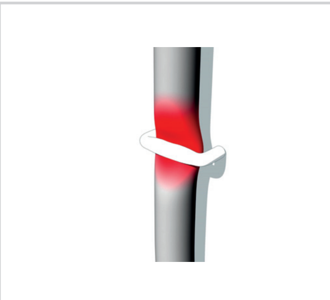
Cables damaged by improper or excessive use, e.g. by frequent bending, pulling the cable instead of the parts intended for it, cable winding on the appliance.



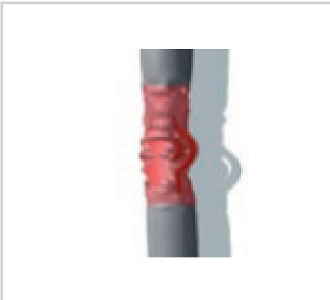
Cables leading to the appliances squashed by furniture, appliance, doors, windows, etc.



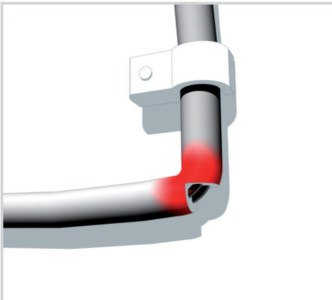
Conductor damaged by a nail or wood screws.



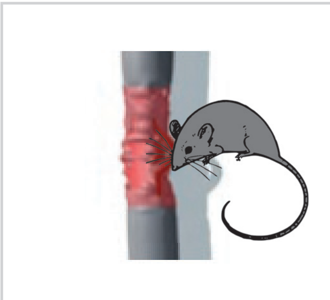
Too tight cable mounts.



Cables damaged by the environment: UV radiation, temperature, humidity, chemical.



Cables too tense and bent to the level of risk of damage.



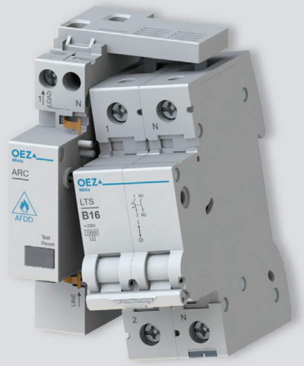
Cables destroyed by rodents.

STOP FIRE

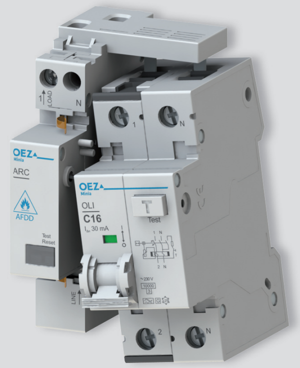
SULUTION USING OEZ DEVICES

Arc fault detection devices AFDD from OEZ is assembled from an arc fault detection unit ARC and a miniature circuit breaker LTS 1+N / / LTK 1+N or residual current circuit breaker with overcurrent protection OLI/OLE. Arc fault detection unit ARC is mounted from the left side.

Thanks to its kit construction it is possible to quickly assemble many designs from 1 A up to 40 A with all existing tripping characteristics of miniature circuit breakers, namely the design of AFDD with a miniature circuit breaker or the design of AFDD with a residual current circuit breaker with overcurrent protection.



ARC-16-1N-3M + LTS-16B-1N



ARC-16-1N-3M + OLI-16C-1N-030AC

Set of AFDD with a miniature circuit breaker

Breaking capacity I_{cu}	10 kA	6 kA
Rated current I_n	1, 2, 3, 4, 6, 10, 16 A for ARC-16-1N-3M and LTS 1+N	2, 4, 6, 8, 10,13,16 A for ARC-16-1N-2M and LTK 1+N
	20, 25, 32, 40 A for ARC-40-1N-3M and LTS 1+N	20, 25, 32, 40 A for ARC-40-1N-2M and LTK 1+N
Tripping characteristics of miniature circuit breaker part	B, C, D	B, C


ARC-16-1N-3M + LTS-16B-1N


ARC-16-1N-2M + LTK-16B-1N

Set of AFDD with a residual current circuit breaker with overcurrent protection

Breaking capacity I_{cu}	10 kA / 6 kA - according to the residual current circuit breaker with overcurrent protection (OLI/OLE)
Rated current I_n	6, 10, 16 A for ARC-16-1N-3M - according to the residual current circuit breaker with overcurrent protection (OLI/OLE)
	20, 25, 32, 40 A for ARC-40-1N-3M - according to the residual current circuit breaker with overcurrent protection (OLI/OLE)
Tripping characteristics of miniature circuit breaker part	B, C
Rated residual current I_{dn}	30, 300 mA


ARC-16-1N-3M + OLE-16C-1N-030AC

Arc fault detection unit ARC

Number of poles	1+N
Rated current I_n	1 ÷ 16 A for ARC-16-1N-3M and ARC-16-1N-2M
	1 ÷ 40 A for ARC-40-1N-3M and ARC-40-1N-2M
Rated operating voltage U_e	AC 230 V
Device width	ARC-...3M (3 modules)
	ARC-...2M (2 modules)


ARC-16-1N-2M


ARC-16-1N-3M

STOP FIRE

HOW ARC FAULT DETECTION DEVICES AFDD BREAK

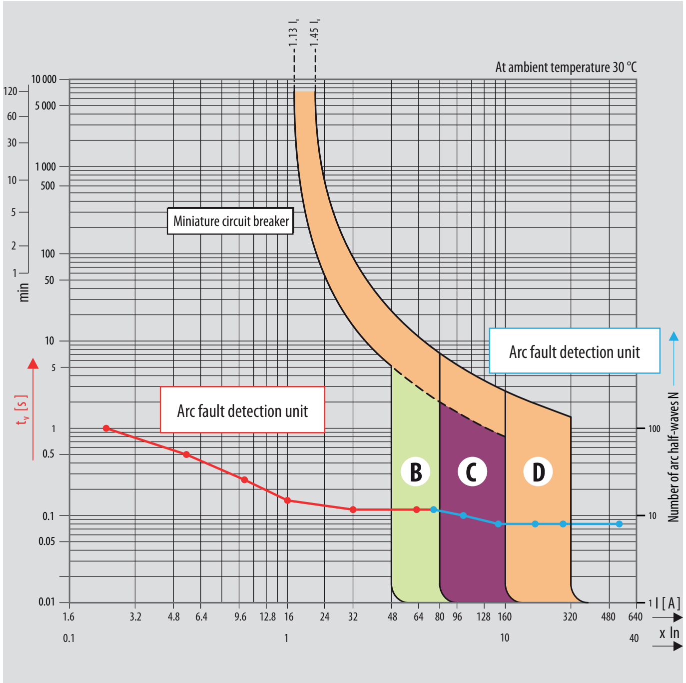
Arc fault detection devices AFDD, or arc fault detection units ARC, reliably detect the currents created by arc fault and promptly and safely disconnect the arc fault circuit.

Example of tripping characteristics – design with a miniature circuit breaker 16 A

Max. break times of fault current, which are broken by arc fault detection unit ARC:

2.5 A / 1 s	5 A / 0.5 s	10 A / 0.25 s	16 A / 0.15 s

ARC should break the fault current 100 A at the tenth half-wave at latest. Nevertheless the fault current should be indicating not only a certain value (min. 2.5 A), but also having a specific shape and a course, which is able to cause fire. For detailed information see the chapter STANDARDS.



WHAT CURRENTS ARE NOT ALLOWED TO BREAK

Arc fault detection devices AFDD shall not break the operating arcs and courses of currents, which do not cause fires:

a) Arcing of brush motors
b) Arcing of light switches
c) Arcing on the contacts of socket outlets and older relays
d) Alternating current of fluorescent lights
e) Current course in use of light dimmer

RELIABILITY

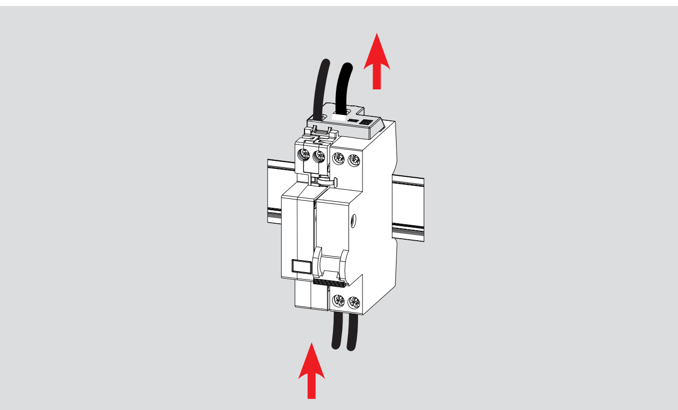
Arc fault detection unit ARC has an internal self-test function, which is automatically initiated every 15 hours in order to test the analogue electronics and the detection algorithms. ARC also includes the overvoltage protection, which will switch off AFDD at voltages above 275 V.

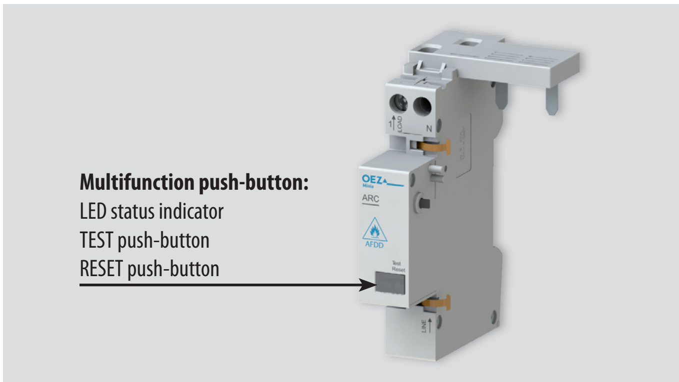
Multifunction push-button serves as a signalization, for manual testing and has the following functions:

a) LED status indicator – indicates the operating state of the unit (red light) or displays fault indications – see the table in the right down corner.
b) TEST push-button – manual test can be performed at any time, if the ARC unit is switched on and in normal operating state, i.e. the illuminated indicator should be lit red.
c) RESET push-button – for restoring of the operating state after AFDD switching off and switching on again.

Since AFDD is directionally sensitive it is necessary to observe the right direction of a connection to the load (LINE down and LOAD up). After the AFDD switches on, the illuminated multifunction push-button of ARC must be lit red.

More detailed information is described in the following chapters of the manual.





Status indicator – switched on
ARC switched on and in operation

Status indicator - fault indications after AFDD switching off and switching on again
ARC switched off: series or parallel arc fault
ARC switched off: overvoltage > 275 V
ARC not ready
ARC without power supply

NOTES

BASIC CHARACTERISTICS OF ARC FAULT DETECTION DEVICES

PROTECTION DEVICES

Arc faults and commonly established protection devices

Arc faults can take different forms. The various fault types will now be considered in relation to the modes of operation of the commonly established protective devices (residual circuit breakers and overcurrent protection devices).

a) Parallel arc faults
Parallel arc faults can be caused e.g. by aging of the insulation or by the presence of conductive soiling between the conductors.

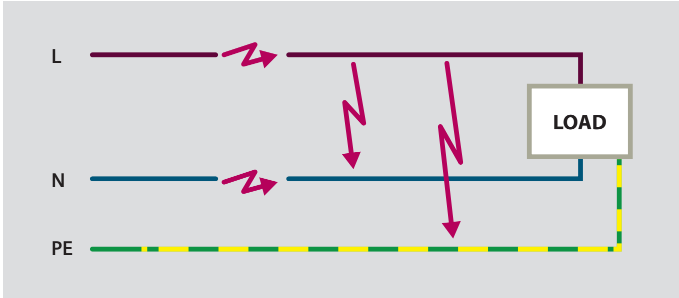
Parallel arc fault between two phase conductors (L-L) or between a phase conductor (L) and a neutral conductor (N)
Residual current circuit breakers are unsuitable for protection purposes in this case because no current flows through protective conductor PE or earth.

Parallel arcing fault between a phase conductor (L) and an protective conductor (PE)
Current flows through the arc from the phase conductor (L) to the protective conductor (PE). In this case an existing residual current circuit breaker with a maximum rated residual current of 300 mA can be used for fire protection purposes. This is expressly required for certain areas (e.g.„premises exposed to a fire hazard“ according to IEC 60364-4-42; HD 384.4.482 S1).
Overcurrent protection devices provide no protection in some cases because the impedances in the faulty circuit may be too high. It is then impossible to meet the switching off conditions with the short times needed to limit the energy at the fault location to values which would prevent an outbreak of fire.
Overload and short-circuit protection devices such as miniature circuit breakers can provide protection only under certain conditions. Success depends on the impedances in the faulty circuit, including the value of the arc voltage, and on whether the switching off conditions given by tripping characteristics for such current/time values are fulfilled, in order that limiting the energy at the fault location to values which would prevent an outbreak of fire. High impedance values limit the current level and can prevent timely switching off particularly at fault locations with high contact resistances or where extension cables are used downstream from the socket outlet (see the chapter Fault situation with parallel arc faults).

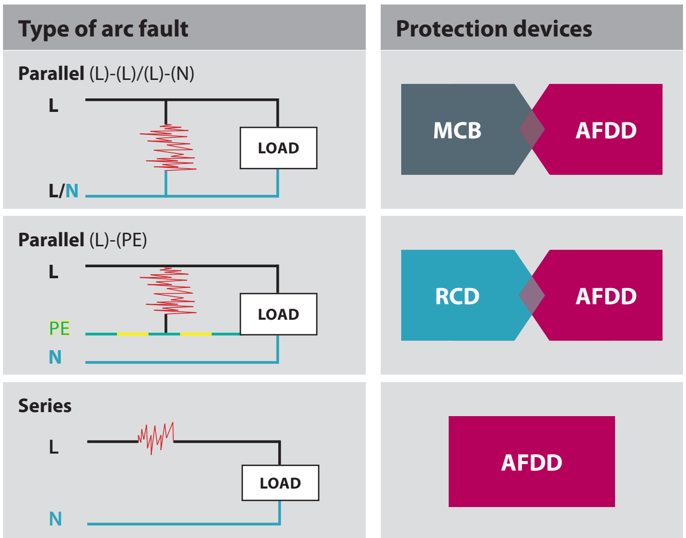
b) Series arc fault in an active conductor:
In this case no current flows to an protective conductor PE or earth, and the load current is even reduced on account of the arc voltage in series with the useful load. Residual current circuit breakers and overcurrent protection devices can provide no protection therefore in this case.
To sum up it can be said that no protection at all exists for the case of a series arc fault, and that the protection level needs to be improved for parallel arc faults between active conductors. To close these safety gaps, the OEZ company expanded the range of protection devices for low-voltage distribution systems of electrical energy about the arc fault detection devices AFDD.

The expanded protection concept for the prevention of fires

Arc fault detection device AFDD from OEZ expand the existing protection concept for the reduction of fires caused by electricity, which is based on residual current circuit breakers and overcurrent protection devices - closes the safety gap which has existed up to now. Figure Types of arc faults and protection devices shows the situation for individual fault types with regard to the protection devices.



Types of arc faults



Types of arc faults and protection devices suitable for fire protection: MCB – miniature circuit breaker, RCD – residual current circuit breaker, AFDD – arc fault detection device

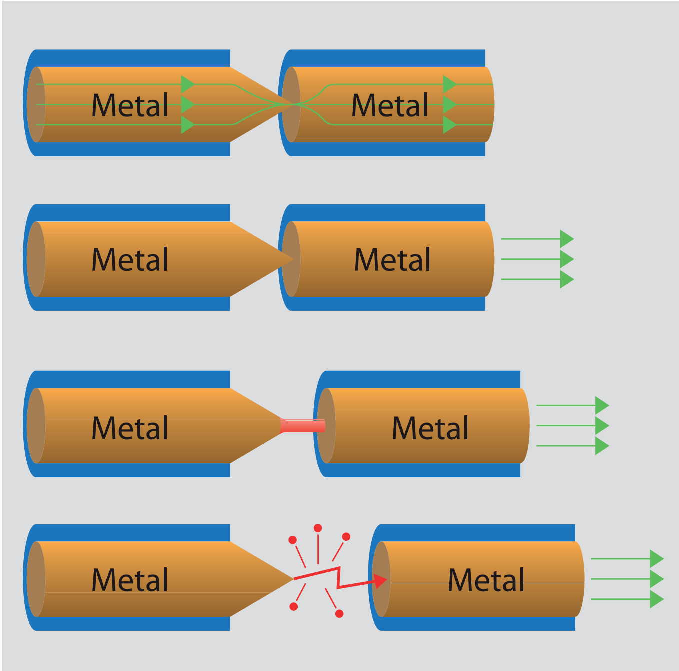
BASIC CHARACTERISTICS OF ARC FAULT DETECTION DEVICES

IGNITION AND BURNING CONDITIONS OF THE ARC

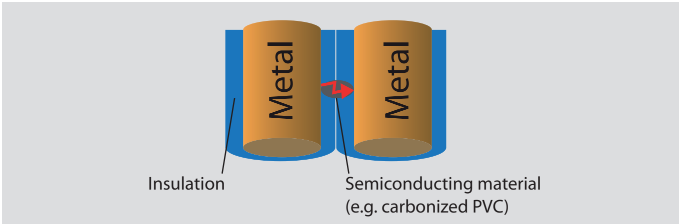
So-called "contact arcs" can result from direct or indirect contact between metal parts at fault locations which are in motion or have little conductivity. Movement (vibration, thermal expansion) of the metal parts, which were originally in direct contact with each other, results in arc occurrence, heating and ultimately melting of connection. Through further heating and repeat melting of connection, unstable arcs are formed briefly. The results are high temperatures on the metal parts (electrodes). The air is ionized, and after the arc is extinguished in the current zero crossing it is ignited again. Combustible materials in the vicinity (e.g. conductor insulation) are carbonized.

If the insulation between two conductors is damaged, parallel arc faults can form over a conductive insulating clearance even without direct metal contact. If there is insulation between the conductors, the insulation properties can be impaired due to aging and chemical, thermal or mechanical loading. Leakage currents can form on surfaces which are contaminated by dirt or condensation. These leakage currents and short discharges can heat up and carbonize the plastics. High temperatures at the fault location can cause a part of the carbonized material to vaporize, greatly heating up the surroundings and igniting a stable arc. The carbonized path between the electric conductors enables the arc to be re-ignited after the current zero crossing, with further heating up to the outbreak of a fire.

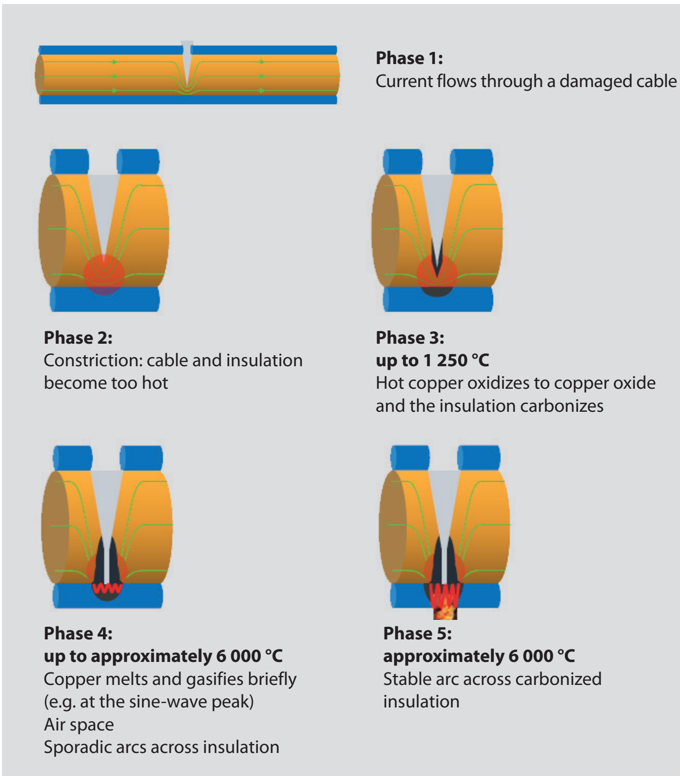
The outbreak of a fire as the result of a series arc fault will be describes using the example of a constriction in a cable. The current flow results in higher temperatures at the constriction. This increase in temperature causes hot copper to oxidize, leading in turn to an increase in resistance and even higher temperatures, and in some cases to melting of the copper. Gas is formed, particularly at the peak current point. This results at least briefly in an air gap with arc. The insulation at the fault location is carbonized. Over this clearance it is possible for a stable arc to burn and for the resulting flames to cause a fire.



Contact arc



Arc over a conductive path trough insulation



Outbreak of a fire due to series arcs

BASIC CHARACTERISTICS OF ARC FAULT DETECTION DEVICES

CONCRETE EXAMPLES OF FAULT SITUATIONS WITH SERIES ARCS

Series arcs were tested under laboratory conditions with various loads at phase voltage 230 V and widely used cable type such as CYKY/CYKYLo.

Definitions of terms used in the analysis and presentation of the conditions:

a) Arc: luminous discharge of electricity across an insulating medium, usually accompanied by the partial volatilization of the electrodes. The electric arc subsequently creates a broad-band high-frequency noise.

b) Arc stability: the ratio of arc duration to observation time over 100 ms. Arc stability is always less than 100 % because of the zero crossings of the AC voltage.

c) Incandescence (incandescent contact): a connection, which due to poor contact in the current flow heats up the contact material and causes it to glow. No high-frequency noise is created, and the incandescent contact can be regarded as series impedance.

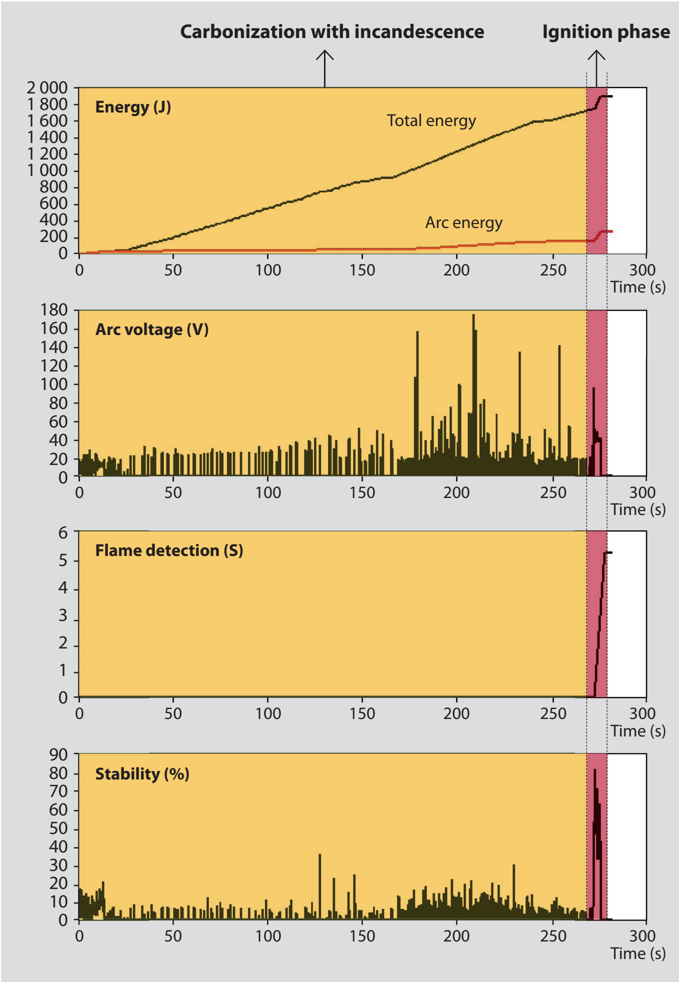
d) First flame: a flame, which burns continuously for 5 ms.

e) Significant flame: a flame, which burns continuously for 50 ms.

f) Stable flame: a flame, which burns continuously for 500 ms.

Fault status at arc current ≤ 3 A

The first graph (energy) illustrates the energy development over the observation time. Two energy values are presented. The black curve represents the total energy (total electric energy) which is released at the fault location mainly in the form of heat and radiation. The red curve represents the arc energy. The difference between total energy and arc energy is owed mainly to the incandescence. The development of the energy increase can be divided into two phases. In the first phase, the "carbonization phase" (yellow section), it is impossible to create a stable arc if the fault location is not yet carbonized. Short arcs form only when the distance between the conductor ends at the fault location is small enough, i.e. at the moment of contact or interruption. As a result of the low arc stability (bottom graph), the mean value of the power is low and the total energy increases only slowly. During the carbonization phase, the cable sample cannot be ignited but the PVC insulation suffers continuous carbonization.
In the second phase, the "ignition phase" (red section), the fault location is carbonized enough and the arc stability increases rapidly to 80 %. The arc becomes very stable, the energy increases rapidly, and flame formation begins (penultimate graph).



Development of the arc using the example 2 A / 230 V

BASIC CHARACTERISTICS OF ARC FAULT DETECTION DEVICES

Fault status at arc current range from 3 A to 10 A

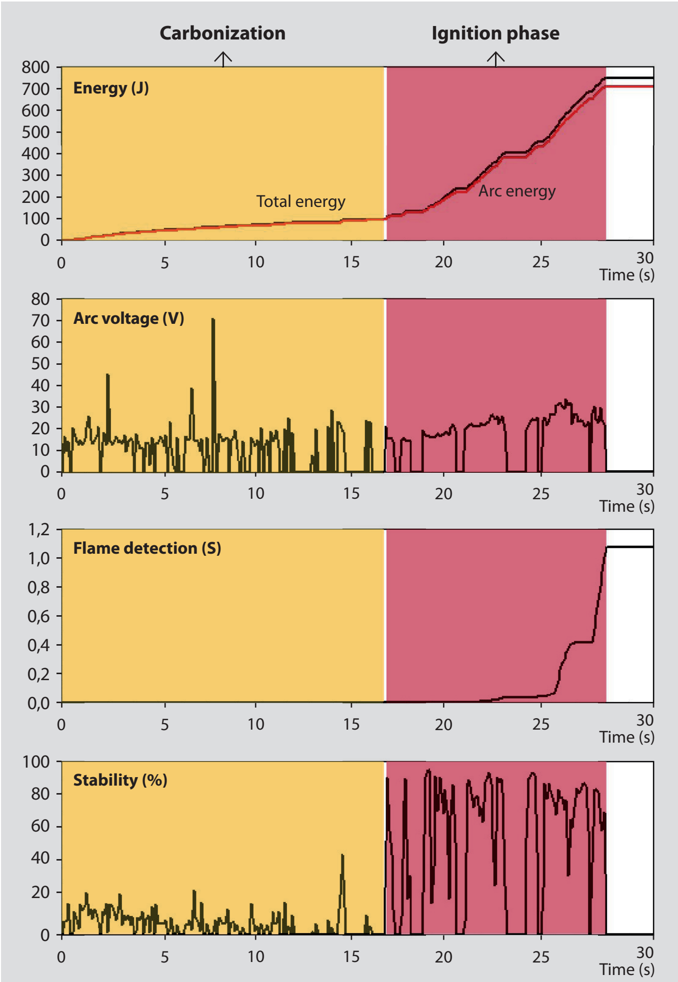
The graphs can also be divided into a carbonization phase and an ignition phase for higher arc currents. Once again the stability of the arc is initially very low because the fault location is still not carbonized. As a result of the low arc stability, the mean value of the power is low and the total energy increases only slowly so that the cable sample cannot be ignited. After a far shorter time than with lower currents, the fault location is carbonized enough and the arc stability increases rapidly to over 90 %.
The arc becomes very stable, the energy increases rapidly. After a few seconds the insulation is no longer able to withstand the heat and a flame is formed. During the test the arc voltage is very low at around 15 V to 30 V. This is typical for an arc at low voltage because a series arc can form only when the gap between the two conductors or electrodes is very small.

Fault status at arc current > 10 A

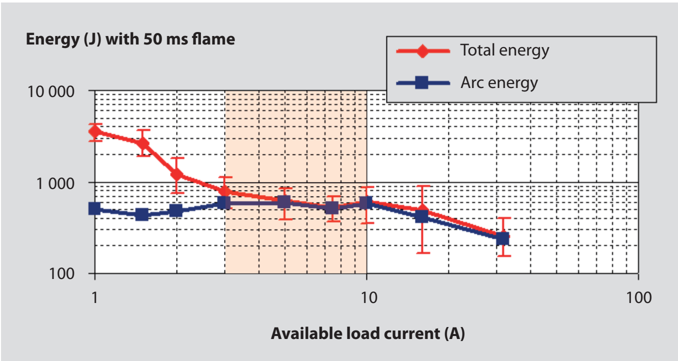
In this range, the power of the arc is so high that flames occur very quickly and without carbonization. Evidently, arcs with high power are unsuitable for effective carbonization of the fault location. The reason lies with the vaporization of the already formed carbonized material – absence of the carbonized material prevents from the formation of a useful carbon path. Furthermore, series arcs with high power are able to weld the two copper conductors together again.

Impact of load current on the outbreak of fire

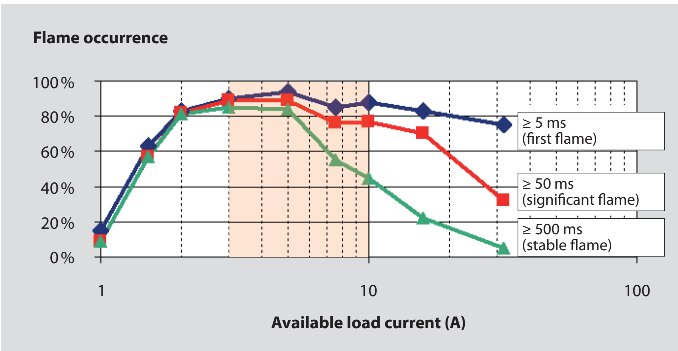
Fire outbreak tests were conducted with load currents in the range from 1 A to 32 A. The following graphs show average values from 100 measurements.
In the low range (below 3 A), the total electric energy, which is expended at the fault location mainly in the form of heat and radiation and is necessary for the formation of the significant flame is two to three times higher than the energy released by the arc. This energy difference is caused by incandescence. Below 2 A, even a stable arc hardly has enough power to ignite the cable, so the probability of an ignition is greatly reduced.
The probability of arc faults occurring is greatest in the medium range (3 A to 10 A), which is the category into which most common domestic electrical appliances belong. Here the arc energy is nearly as high as the total electric energy. This is underlined by the dominance of the arc over glowing in this range. In this medium current range, the amount of energy needed to ignite a PVC cable is evidently not dependent on the load current and lies relatively constant at approximately 450 Joule. Here the occurrence of first and significant flames lies at around 80 %.
In the upper range (above 10 A), the power of the arc is so high that flames occur very quickly and without carbonization. Therefore, significant and stable flames occur more and more rarely. One reason for this is the vaporization of the carbonized material, which prevents the formation of a carbon path. The probability of stable flames drops below 5 %. Similarly, arc stability also decreases notably with high load currents. The lower arc stability reduces the power, hardly allowing reliable ignitions to occur. Moreover, high-power series arcs can sometimes melt the two copper parts back together and "weld" the fault location. Even if stable arcs are rare above 10 A, the short and powerful flames which can occur in this range represent a serious danger.



Development of the arc using the example 5 A / 230 V



Energy of the significant flame as a function of load current



Probability of flames outbreak as a function of load current

BASIC CHARACTERISTICS OF ARC FAULT DETECTION DEVICES

FAULT SITUATION WITH PARALLEL ARC FAULTS

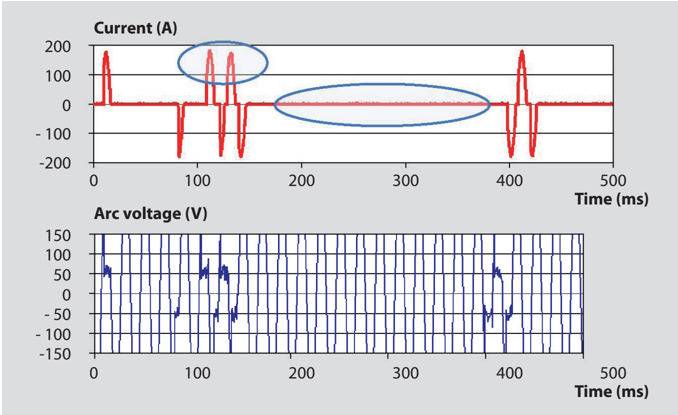
Basic considerations

Unlike series arc faults, for which no protection devices have been available up to now, parallel arc faults are detected under certain conditions by other protection devices such as residual current circuit breakers and overcurrent protection devices. For switching off of parallel arc faults by overcurrent protection devices it is necessary to consider the system conditions and their impedance values. In the following, the switching off conditions for the overcurrent protection devices (miniature circuit breakers and fuses) are examined to see whether they are sufficient in all cases for providing reliable fire protection. Graph shows the typical current and voltage curve of a parallel arc fault. In addition to a stable arc, the current curve can also include rather long gaps without any current flow because the arc is not always reignited after the current zero crossing. There is no assurance that the overcurrent protection device will be activated via the thermal release.

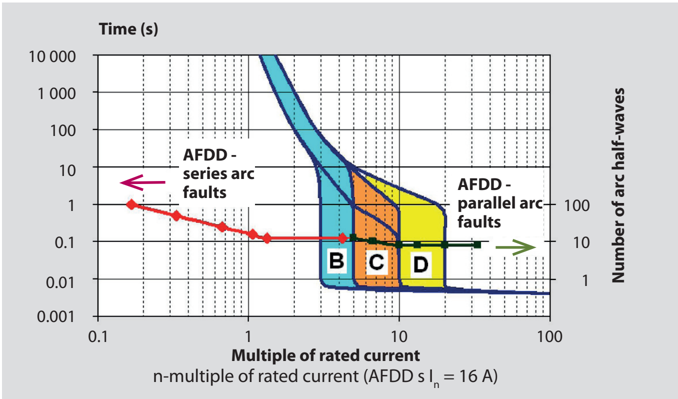
Given a high arc voltage in conjunction with high system impedance, it is well possible for the current peak value to lie below break current value of the short-circuit release. The high arc currents in these cases, which can also exceed 100 A, and the arc voltages in the range of 60 V produce an arc power of several kW (e.g. with 100 A and 60 V the arc power would be 6 kW). This results in high power densities at the fault location, which can lead to rapid ignition of the insulation material and therefore to the outbreak of a fire if it does not switch off within fractions of a second.

Switching off behaviour of overcurrent protection devices

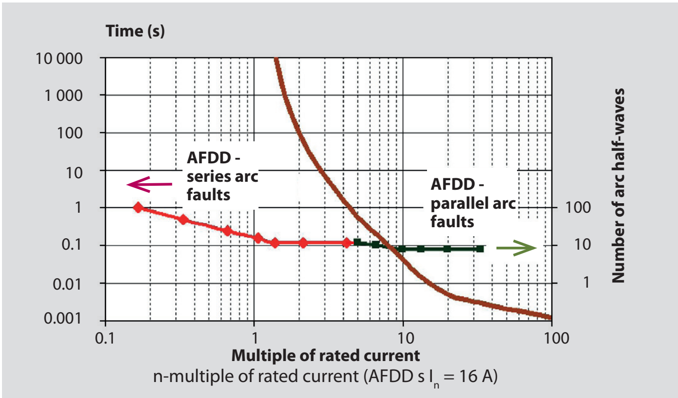
From measurements of prospective short-circuit currents at socket outlets in office buildings and apartments it is known that the majority of current values lie between 150 A and 500 A. Switching off of the miniature circuit breaker 16 A with characteristic (within 100 ms) is assured therefore in most cases by short-circuit release. If the fault does not occur at the socket outlet but on the supply line to the socket outlet, the situation will improve thanks to the then lower impedance and the resulting higher short-circuit current. With faults in an extension cable, on the other hand, the impedance will increase and therefore the short-circuit current will be notably reduced. The miniature circuit breaker is then no longer able to provide the desired protection. In all cases, a high arc voltage can also lead to the reduction of the short-circuit current and prevent switching off by short-circuit release. Similarly, the break times of the fuses can also be too long for fire protection purposes in critical conditions. Overcurrent protection devices can work only when the conduction interval for a certain current level lies above the tripping curve of the respective overcurrent protection device. Graph „Protection by miniature circuit breaker“ shows the tripping characteristics B, C an D for miniature circuit breakers as well as the tripping characteristics of AFDD. The break times of arc fault detection unit offer both supplementary and improved protection against parallel arc faults in some cross-over areas. As already explained, protection against series arc faults is provided only by ARC units. Miniature circuit breakers are unsuitable in these cases.
The last graph shows the tripping characteristics of a gL fuse and the tripping characteristics of AFDD. It is again evident that the break times of arc fault detection unit offer both supplementary and improved protection against parallel arc faults in the crossover area. For this reason, only the AFDD provides comprehensive protection against series arc faults.



Current and voltage curve for a parallel arc fault



Protection by miniature circuit breaker



Protection by fuse

Assessment

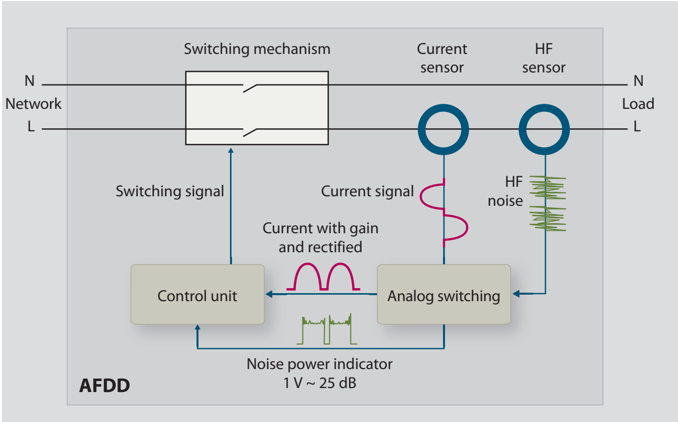
Graphs show that overcurrent protection devices provide sufficient protection against parallel arc faults in most cases. Nevertheless, the AFDD can ensure the protection in cross-over areas where there are special fault constellations.
The primary benefit of the AFDD is its protection against series arc faults. Here the response times of miniature circuit breakers and fuses, i.e. devices designed mainly for conductor protection purposes, are so long that they are unable to provide protection against fires.

BASIC CHARACTERISTICS OF ARC FAULT DETECTION DEVICES

DETECTION OF ARC FAULTS

Basic design of AFDD

Figure shows the basic design of AFDD. For detection, all active conductors –in this case the phase conductor and the neutral conductor - are passed through the unit and switched. The phase conductor is passed through two separate sensors: a current sensor for detecting the low-frequency (line frequency) signals and an HF sensor for detecting the high-frequency signals. Analogue electronics prepares the signals for processing in the control unit.
The HF power of the current is scanned in the range from 22 to 24 MHz. In the following the control unit is referred to as the RSSI (Received Signal Strength Indication – the unit measuring the power contained in the received signal) and represents the power of the arc at a defined frequency and bandwidth. When the control unit sees the criteria for an arc fault as fulfilled, the tripping signal will be created and directed via a shunt trip to the switching mechanism.



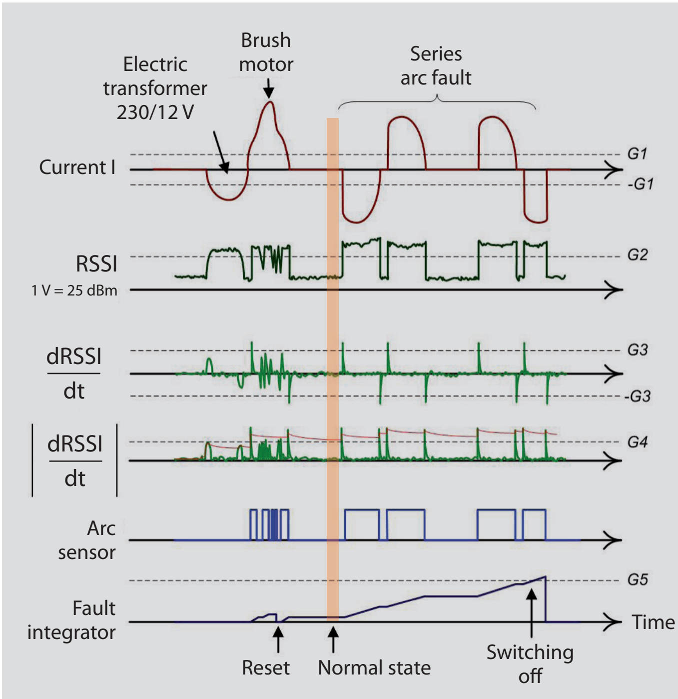
Basic design of AFDD

Detection of series arc faults

The detection of series arc faults accounts for approximately 80 % of the overall calculation work performed by the control unit. The remaining 20 % are taken up by the detection of parallel arcs.
The detection of series arc faults is based on examining the RSSI on steep edges. The derivative dRSSI/dt is used to calculate a reference signal which is "uploaded" from |dRSSI/dt| when the edge lies in the zero crossing area of the current I. Two conditions should be fulfilled for the system to interpret a signal as an arc and consequently for the fault integrator to rise:

- ► reference signal > limit value G4 and
- ► RSSI reaches at least the threshold G2.

As soon as the fault integrator rises above the limit value G5, the control unit will send the switching off command to the switching device. To prevent undesirable switching off, a distinction must be drawn between arc faults on the one hand and signals from loads such as brush motors and electronic transformers on the other, which in normal operation produce a high level of HF noise. This is achieved by the fault integrator being reset immediately to zero when certain "arc-untypical" events occur. A characteristic of such an event is for example that the RSSI shows interruptions in the signal curve.



Signal processing for assessing series arc faults

BASIC CHARACTERISTICS OF ARC FAULT DETECTION DEVICES

Detection of parallel arc faults

Series and parallel arc faults have different characteristics and are therefore analyzed in different ways. Figure presents an overview of the signal processing.

The calculation work required of the control unit to detect parallel arc faults is relatively small compared to the overall algorithm, but this is not because less effort is needed to detect parallel arc faults than series arc faults. The reason is rather that some of the signal variables which are calculated for the detection of series arcs can also be used for parallel arc faults.

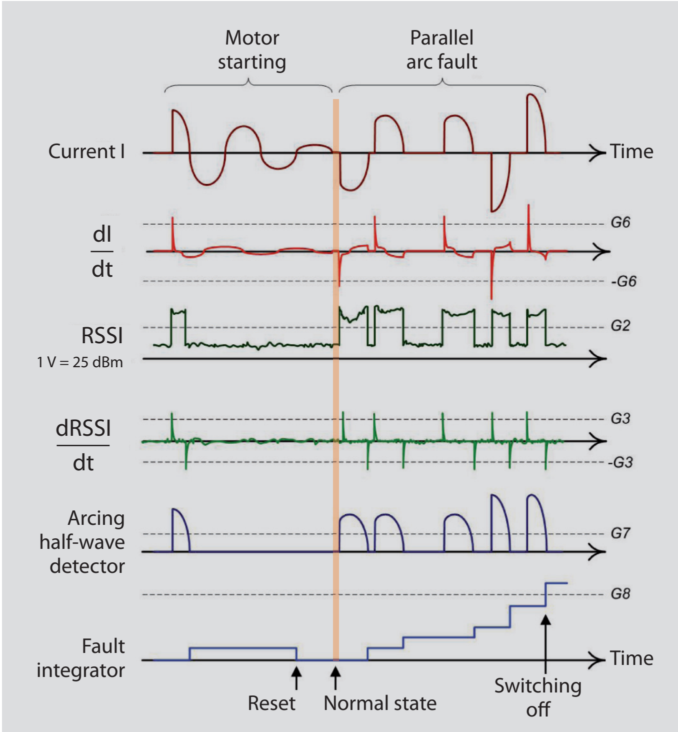
The algorithm for parallel arcing faults calculates not only the derivative dRSSI/dt but also the current derivative dI/dt. The function for detecting parallel arcs does not become active until the value for dI/dt exceeds the threshold value G6. If RSSI > limit G2 is also true, the current half-wave will also be interpreted as an arc current and the fault integrator will be raised by a value proportional to the arc current. If some time passes without another arc half-wave occurring, the fault integrator will be decreased again.

If a sufficient number of arc half-waves follow within a certain time window, the fault integrator will reach the threshold G8 and the control unit will send the switch off command.

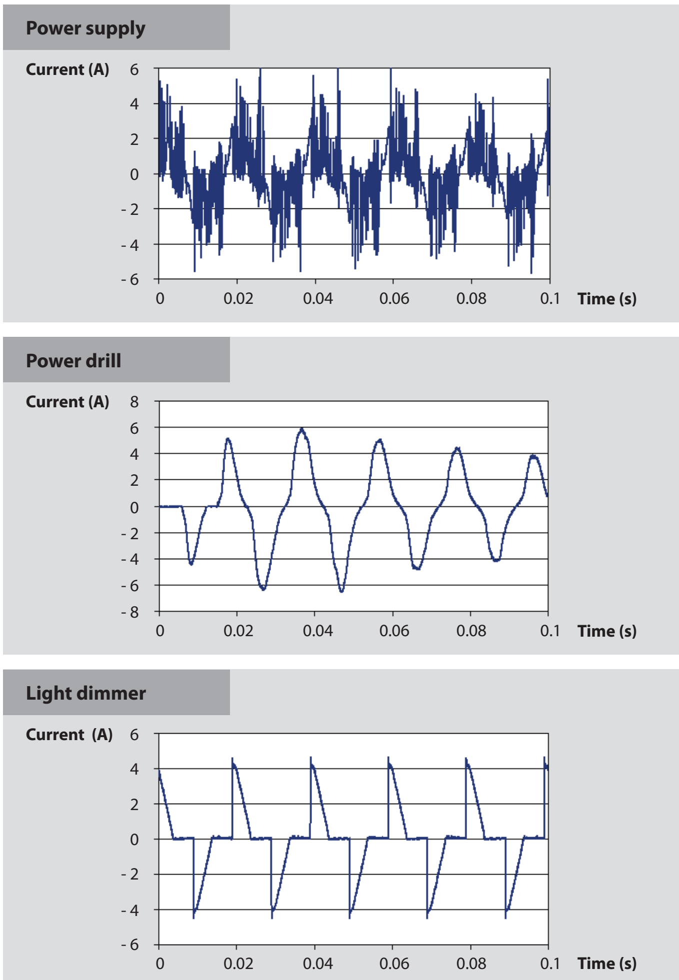
Prevention of undesirable switching off

For a protection device to be fully accepted, it must not only provide reliable protection against fires caused by electricity but also respond only when there are real faults. For the arc fault detection units this mean that it must distinguish reliably between arc faults, for which switching off is required within defined limits, and the operational arcs of electric loads, for which no switching off should occur.

The examples in graphs show a number of electric loads with high frequency components in the current, which – particularly in the case of brush sparking on a power drill – lie very close to the signals of an arc fault.



Signal processing for assessing parallel arc faults



Examples of electric loads with high-frequency signals

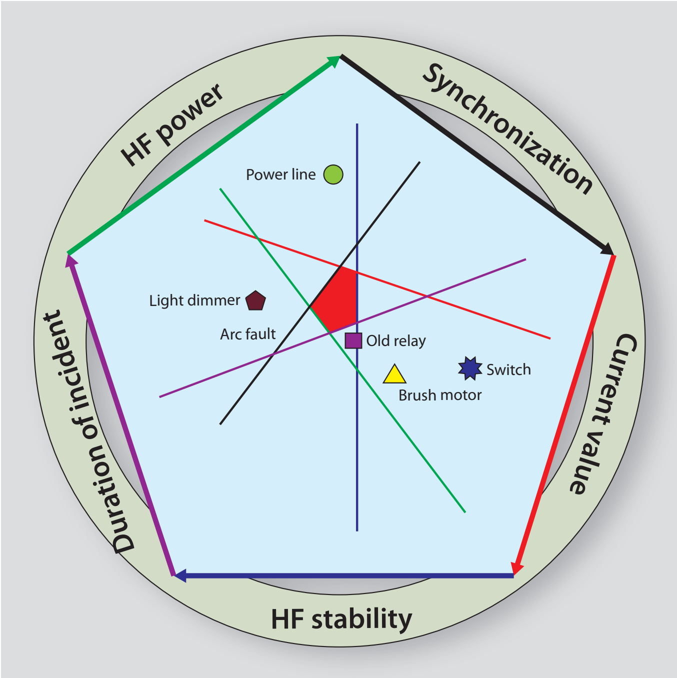
BASIC CHARACTERISTICS OF ARC FAULT DETECTION DEVICES AFDD

Examples of other operational faults

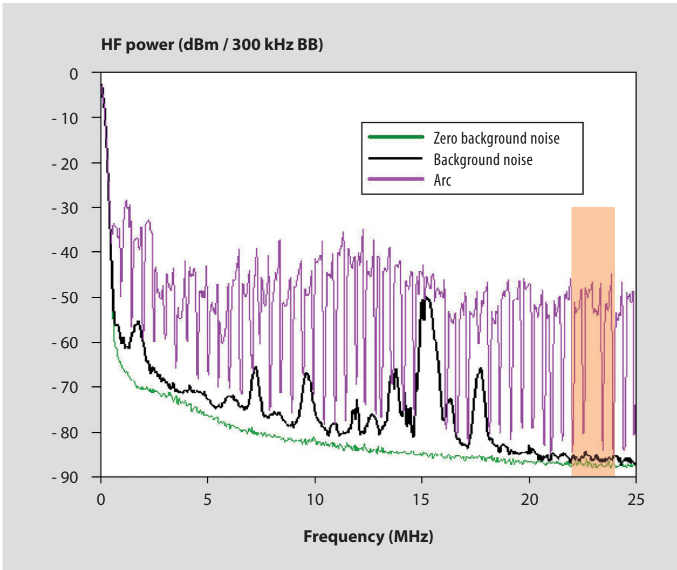
- inrush currents of fluorescent lamps
- arcs through thermostat contacts, light switches, plug connectors etc.

There should be no switching off for any of these operationally created signals, nor for arc faults in an adjacent circuit.
To reliably decide whether switching off is necessary for an arc fault; a number of factors are considered and compared with known fault signals.

These are high-frequency stability and arc power, current value, duration of arcing and its synchronization with the network. If all these parameters reach the values lying in the area highlighted red in the picture, the device will evaluate this situation to be caused by arc fault and switches off. For greater reliability against undesirable switching offs, the high-frequency background noise existing in installation systems was also taken into account. In the next picture it is obvious that this noise is highest between frequencies from about 14 ÷ 18 MHz. On the contrary, at higher frequencies above 20 MHz, the background noise is diminished and the difference between the levels of noise and arc is more noticeable. Therefore AFDD evaluate frequencies in the range between 22 and 24 MHz.
The described analysis parameters and criteria are based on experience with AFCI in the U.S. and on comprehensive laboratory investigations and simulations. The applicability of the findings in practical conditions was confirmed in comprehensive field tests.



Factors for the detection of an arc fault



High-frequency noise (Background noise and arcs)

LEGISLATION AND ARC FAULT DETECTION DEVICES AFDD

STANDARDS

Protection and safety

Standardization bodies certainly paid attention to the undoubted advantages of AFDD and begin to implement the use of AFDD in the international or national standards. Some countries as a recommendation and other as an obligation. The right column summarizes the situation in the important standards in the Czech Republic and the world. For example in Germany the mandatory use of AFDD slowly becomes a reality.

With regard to positive benefits, the installation of AFDD will become mandatory in a rising number of countries and in a rising number of standards where this protection will be mentioned.

► Standards in the world*

IEC 60364-1/ EN 60364-1 - *Low-voltage electrical installations*
- Part 1: Fundamental principles, assessment of general characteristics, definitions
This standard defines the area of use, purpose and principles that apply to the configuration of low-voltage devices. *Part 131.3 „Protection against thermal effects"* requires the electrical system to be arranged in the way that it does not represent any risk of ignition of inflammable material as a result of high temperature or an arc fault. This can only mean that the protection against dangers resulting from arc faults must be granted. In the past there was no convenient protection device available for this purpose for circuits in the low-voltage installation. Even though nothing is written about the arc fault detection device AFDD in the mentioned part of the standard, it is clear that the arc fault detection device AFDD with its characteristics can fill this safety gap.

IEC 60 364-4-42 ed. 3.1, **EN 60364-4-42:2011+A1:2015** - *Low-voltage electrical installations.*
- Part 4-42: Protection for safety – Protection against thermal effects
Use of arc fault detection devices AFDD is especially recommended in this standard, it is referred to as the most advanced devices in this field and the places of use are recommended – quoted from the standard of the article ...:
„It is recommended that special measures be taken to protect against the effects of arc faults in final circuits:
- In premises with sleeping accommodation
- In locations with risks of fire due to the nature of processed or stored materials, i.e. BE2 locations, (e.g. barns, wood-working shops, stores of combustible materials)
-In locations with combustible constructional materials, i.e. CA2 locations (e.g. wooden buildings)
- In fire propagating structures, i.e. CB2 locations
- In locations with endangering of irreplaceable goods
In a.c. circuits, the use of arc fault detection devices (AFDD) in compliance with IEC 62606 will satisfy the above-mentioned recommendation.
If used, an AFDD shall be placed at the origin of the circuit to be protected. The use of AFDDs does not obviate the need to apply one or more measures provided in other clauses in this standard."

IEC 60364-5-53 - *Electrical installation of buildings*
- Part 5: Selection and erection of electrical equipment; Isolation, switching and control
In chapter 532 Devices for protection against thermal effects, of an article 532.6 Arc fault detection devices (AFDD) the optional use in the following way is stated – quoted from the standard:
„Where intended, AFDD should be installed:
- at the origin of the end circuit to be protected and
- in the alternating one-phase or two-phase circuits, which do not exceed 240 V. AFDD should be in compliance with EN 62606.
If necessary AFDD should be coordinated with the overcurrent protection devices according to the instructions of the manufacturer."

► Standards in Germany

DIN VDE 0100-420:2016-02+Amendment A1
Germany in the national standard DIN has introduced **mandatory use of AFDD beginning from 18. 12. 2017.**

LEGISLATION AND ARC FAULT DETECTION DEVICES AFDD

Product standard

IEC 62606 General requirement for arc fault detection devices, is the standard, which defines the scope of validity, construction requirements, operation, testing, labelling etc. The standard applies to, quoted from the standard:
„Arc fault detection devices (AFDDs) for household and similar uses devices are intended to mitigate the risk of fire in final circuits of a fixed installation due to the effect of arc fault currents that pose a risk of fire ignition under certain conditions if the arcing persists.“

Special test of devices are described for testing the switch off in connection with series and parallel arc faults. The required break times are then also tested under the defined conditions. The break times for small arc currents (typical for series arcs) are defined as a function of the arc fault current level - see table.

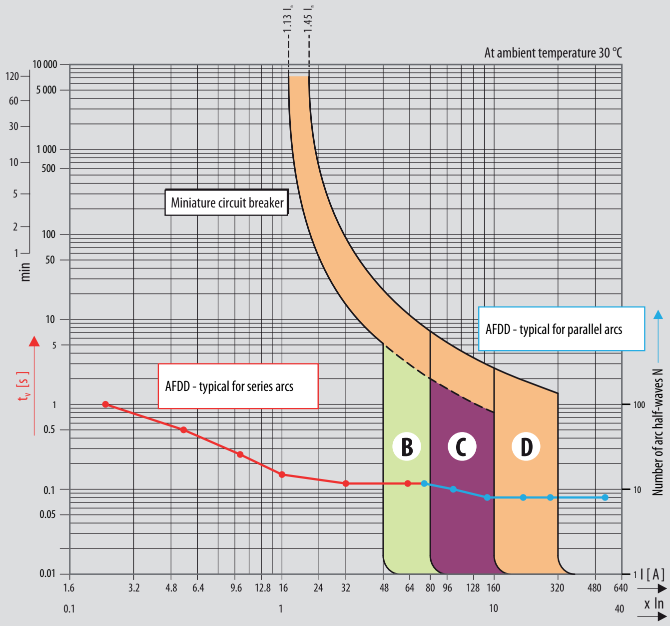
With the values from 2.5 A to 32 A the tripping curve of the arc fault detection unit ARC for series arc faults lies far below the thermal tripping curves for miniature circuit breakers and fuses. Fire protection is implemented using these low response values and short break times. The tripping curves for parallel and series arc faults are identical in this current range.

The switch off condition defined for high arc currents (see table) is not a fixed break time but a number of arc half-waves which are allowed to occur within 0.5 s. This is because of the often sporadic occurrence and unstable behaviour of the parallel arc fault with high currents. As explained on the page 11, fuses and miniature circuit breakers can also provide protection against parallel arc faults at and above certain current levels, as long as their switch off conditions are fulfilled.

Additional necessary tests are the ones, which shall ensure that the arc fault detection device not only provides sufficient protection against fires caused by electricity, but also reacts only if the real fault occurs.

Switching off conditions of AFDD

Arc fault current value	Switching off conditions of AFDD according to EN 62 606, IEC 62 606						
	Limit values of break time						
up to 63 A	Arc fault current [A]	2.5	5	10	16	32	63
	Maximal break time t_v [s]	1	0.5	0.25	0.15	0.12	0.12
	Maximal number of half-waves within 0.5 s						
over 63 A	Arc fault current [A]	75	100	150	200	300	500
	N – number of half-waves with rated frequency within 0.5 s	12	10	8	8	8	8



Terms definition according to the standard IEC 62606

Term	Explanation
Arc	A luminous discharge of electricity across an insulating medium, usually accompanied by the partial volatilization of the electrodes.
Arc fault	Dangerous unintentional parallel or series arc between conductors.
Arc Fault Detection Device (AFDD)	AFDD is a device intended to mitigate the effects of arc faults by disconnecting the circuit when an arc fault is detected.
Arc Fault Detection unit (AFD)	Part of the AFDD ensuring the function of detection and discrimination of dangerous earth, parallel and series arc faults and initiating the operation of the device to cause interruption of the current. In case of OEZ, Arc Fault Detection Unit ARC is connected with a miniature circuit breaker or residual current circuit breaker with overcurrent protection, which ensures circuit disconnection.
Parallel arc fault	Arc fault, where the arc current is flowing between active conductors in parallel with the load of the circuit.
Series arc fault	Arc fault, where the current is flowing through the load(s) of the final circuit protected by an AFDD.

NOTES


OEZ
ARC
AFDD
Test
Reset
B16
ARC-16-1N-3M

SUMMARY OF MODELS AND DESCRIPTION OF ARC FAULT DETECTION DEVICE AFDD

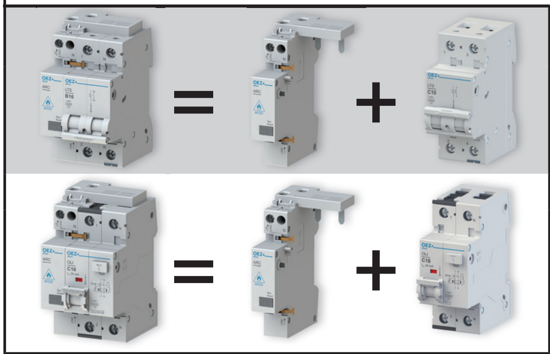
AFDD OEZ is assembled:

- from arc fault detection unit ARC and miniature circuit breaker LTS/LTK or
- from arc fault detection unit ARC and residual current circuit breaker with overcurrent protection OLI/OLE.

Arc fault detection unit ARC is offered in two designs:

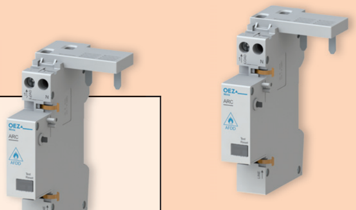
- 3-module design
  - with current range **1 ÷ 16 A**: ARC-16-1N-3M
  - with current range **1 ÷ 40 A**: ARC-40-1N-3M.
- 2-module design
  - with current range **1 ÷ 16 A**: ARC-16-1N-2M
  - with current range **1 ÷ 40 A**: ARC-40-1N-2M.

Summary of models AFDD

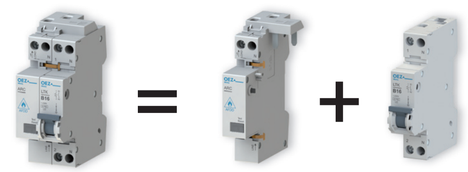


Arc fault detection unit ARC...3M **(3 modules)**

Type: **ARC-40-1N-3M** (1 ÷ 40 A); **ARC-16-1N-3M** (1 ÷ 16 A)

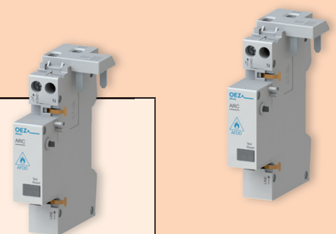


I_n (A)				1	1.6	2	4	6	8	10	13	16	20	25	32	40
Miniature circuit breakers LTS	LTS (10 kA)	1+N-pole	B			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
			C			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
			D			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		2-pole	B	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
			C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
			D	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Residual current circuit breakers with overcurrent protection OLI/OLE ($I_{\Delta n}$ = 30 mA)	OLI (10 kA)	Type AC **	B					✓		✓		✓	✓	✓	✓	✓
			C					✓		✓		✓	✓	✓	✓	✓
		Type A **	B					✓		✓		✓	✓	✓	✓	✓
			C					✓		✓		✓	✓	✓	✓	✓
		Type A-G	B							✓		✓	✓	✓		
			C							✓		✓	✓	✓		
	OLE (6 kA)	Type AC	B					✓		✓		✓	✓	✓	✓	✓
			C					✓		✓		✓	✓	✓	✓	✓



Arc fault detection unit ARC-…2M **(2 modules)**

Type: **ARC-40-1N-2M** (1 ÷ 40 A); **ARC-16-1N-2M** (1 ÷ 16 A)



I_n (A)				1	1.6	2	4	6	8	10	13	16	20	25	32	40
Miniature circuit breaker LTK	LTK (6 kA)	1+N-pole	B					✓		✓	✓	✓	✓	✓	✓	✓
			C			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

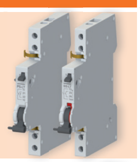
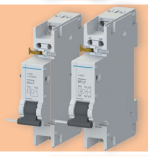
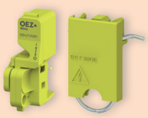
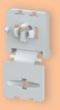
** Characteristic C also with $I_{\Delta n}$ = 300 mA.

✓ - possible combination

SUMMARY OF MODELS AND DESCRIPTION OF ARC FAULT DETECTION DEVICES AFDD

Summary of models of arc fault detection units ARC

Design	ARC			
				
Type	**ARC-16-1N-3M**	**ARC-40-1N-3M**	**ARC-16-1N-2M**	**ARC-40-1N-2M**
Rated current I_n	1 ÷ 16 A	1 ÷ 40 A	1 ÷ 16 A	1 ÷ 40 A
Width	3 modules		2 modules	
Standards	EN 62606			
Rated voltage U_n	AC 230 V			
Number of poles	1+N			
Power losses	0.6 W / pole			
Mounting	with miniature circuit breaker (MCB): *LTS (10 kA)* with residual current circuit breaker with overcurrent protection (RCBO): *OLI (10 kA) and OLE (6 kA)*		with miniature circuit breaker (MCB): *LTK (6 kA)*	

Accessories of MCB and RCBO	
Auxiliary and signal switches 	PS-LT-. . .; SS-LT-. . . * (for LTS, LTK, OLI/OLE)
Shunt trips and under-voltage releases 	SV-LT-. . .; SP-LT-. . . * (for LTS, OLI/OLE)
Locking insert 	OD-LT-VU01 (for LTK, OLI/OLE) OD-LT-VU02 (for LTS)
Sealing insert 	OD-LT-VP01 (for LTS, OLI/OLE)

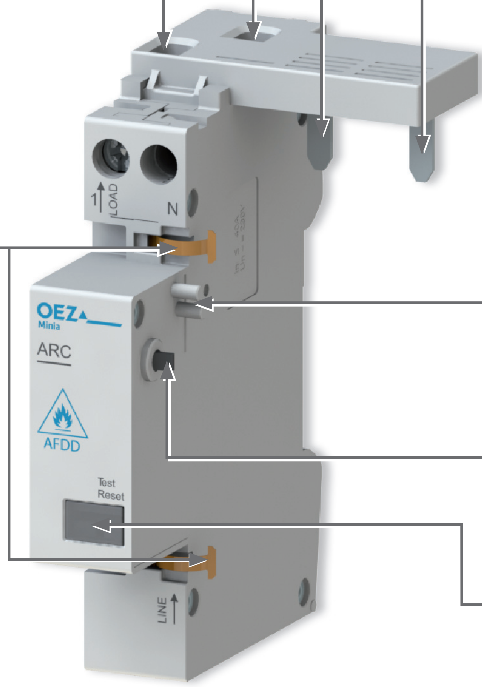
* Installation of accessories on OLI/OLE requires handle adapter OD-OL-NR01 (OEZ:38270).

SUMMARY OF MODELS AND DESCRIPTION OF ARC FAULT DETECTION DEVICES AFDD

Arc fault detection unit ARC

Terminals marked „LOAD"
are terminals for connection of load conductors. Since AFDD is directionally sensitive, It is necessary to observe the right direction of connection.

Conductors for electrical connection with a miniature circuit breaker (LTS/LTK) or residual current circuit breaker with overcurrent protection (OLI/OLE).



Metal lamellas
for mechanical connection with a miniature circuit breaker (LTS/LTK) or residual current circuit breaker with overcurrent protection (OLI/OLE).

Plastic coding pins to disable mounting of a miniature circuit breaker (LTS/LTK) or residual current circuit breaker with overcurrent protection (OLI/OLE) with inappropriate rated current I_n on ARC.

Release mechanism pin of ARC that ensures release of a miniature circuit breaker (LTS/LTK) or with a residual current circuit breaker with overcurrent protection (OLI/OLE).

Multifunction push-button, working as:

- LED status indicator
- RESET push-button
- TEST push-button

Status indicator of ARC

ARC switched on and in operation	**Operating state**
ARC switched off: series or parallel arc fault	**Fault indication**
ARC switched off: overvoltage > 275 V	
ARC not ready	
ARC without power supply	

- **LED status indicator**
  The LED of the Test/Reset push-button at the front indicates the operating state of the unit. This provides the user with simple and clear information about the reason for tripping (see table). In all cases in which the display of ARC shows no standby signal, it is recommendable to notify an electrician who can investigate more closely the reason for the particular message.

- **Reset push-button**
  After ARC switches off and switches on again, the LED indicator of the Test/Reset push-button will indicate the reason for the switching off. This display can be reset by pressing the Test/Reset push-button. Note! A failed regular functional self-test (the LED display will blink yellow – red) cannot be reset. In such case it is recommendable to notify an electrician who can test ARC again, investigate the reason of tripping and possibly replace ARC.

- **Test push-button**
  A function test can be performed on the device at any time by actuating the Test/Reset push-button of ARC in the normal operating state (illuminated indicator "red"). Arc fault detection unit ARC with the mounted miniature circuit breaker LTS/LTK or residual current circuit breaker with overcurrent protection OLI/OLE must switch to OFF. After the unit switches on, the illuminated indicator must be lit "red" again continuously.

Self-test
ARC has an internal self-test function. This self-test is automatically initiated every 15 hours in order to test the analog electronics and the detection algorithms (for more detailed information see the next pages).

Overvoltage protection
If the voltage increases between the phase conductor and the neutral conductor due to system faults such as neutral conductor interruptions, ARC will switch off at voltages above 275 V. The connected loads are thus protected against possible damage from overvoltage.

Overvoltage (V)	255	275	300	350	400
Max. break time (s)	no tripping	15	5	0.75	0.20
Min. break time (s)	no tripping	3	1	0.25	0.07

ARC FAULT DETECTION UNITS ARC

ARC-16-1N-3M

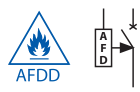
ARC-16-1N-2M

Description

- Protection against fire, which fills in the safety gap existing in the wiring until now – miniature circuit breakers, residual current circuit breakers and fuses – and which promotes installation safety to a higher level.
- Arc fault detection unit ARC (AFD unit) detects series and parallel arc faults and in case of a fault disconnects the circuit and prevents from fire. Circuit disconnection is ensured by a miniature circuit breaker LTS/LTK or residual current circuit breaker with overcurrent protection OLI/OLE, which is mechanically and electrically connected with its own arc fault detection unit. By connection of the arc fault detection unit with the miniature circuit breaker or residual current circuit breaker with overcurrent protection, you will create a functional unit – AFDD.
- We recommend to install AFDD especially for the socket and lighting branch circuits from 230 V up to 40 A. For more examples of recommended places for installation see page D3.
- AFDD must be installed at the beginning of the circuit to be protected. If it is possible, we should use one AFDD on one outlet, so that the user can use the benefits resulting thereof:
  – the number of unwillingly disconnected loads and conductors is minimized
  – it is easier to locate the fault
  –unwanted switching off is reduced due to smaller interference overlap.

  Since AFDD is directionally sensitive it is necessary to observe the right direction of connection to a load (see diagram).
- High resistance to unintentional switching off, i.e. switching off, which come from the arcs, which are not dangerous and normally occur in the line during operating state – e.g. arc on the switch contacts etc.
- Overvoltage protection of loads - ARC is equipped with the overvoltage unit which disconnects the circuit in case of a longer overvoltage.
- Test for reliable operation – ARC is equipped with a test push-button and self-test to test the circuit and the detection algorithms.
- Clear information about the reason of tripping - LED status indicator at the front of device.
- Reduction of inventory stock and variability of designs - thanks to kit construction ARC unit is assembled directly at the customer. It makes it possible to create hundreds of various designs of AFDD with minimum inventory stocks.
- Design ARC-...2M with width of 2 modules only for mounting into the switchboards with requirements of space saving and where the expected short-circuit currents do not exceed 6 kA.
- Easy maintenance - the arc fault detection devices AFDD meet EN 62606. So AFDD can be controlled by laymen and does not require maintenance.
- Accessories
  – auxiliary and signal switches PS-LT/SS-LT
  – shunt trips and undervoltage releases SV-LT/SS-LT
  – locking inserts OD-LT.

The accessories are mounted on the miniature circuit breakers LTS/LTK and residual current circuit breakers with overcurrent protection OLI/OLE.



3 modules

Rated current I_n	Type	Order code	Number of modules	Weight [kg]	Package [pcs]
1 ÷ 16 A	**ARC-16-1N-3M**	OEZ:45532	3	0.105	1
1 ÷ 40 A	**ARC-40-1N-3M**	OEZ:45534	3	0.105	1

2 modules

Rated current I_n	Type	Order code	Number of modules	Weight [kg]	Package [pcs]
1 ÷ 16 A	**ARC-16-1N-2M**	OEZ:45533	2	0.101	1
1 ÷ 40 A	**ARC-40-1N-2M**	OEZ:45535	2	0.101	1

ARC FAULT DETECTION UNITS ARC

Specifications

Type		ARC
Standards		IEC 62606
Approval marks		CE
Number of poles		1N
Rated current [1]	ARC-16-1N-..	1 ÷ 16 A
	ARC-40-1N-..	1 ÷ 40 A
Rated voltage		AC 230 V
Rated frequency		50 Hz
Switching off in case of overvoltage		> AC 275 V
Degree of protection		IP20 with connected conductors
Mechanical endurance		10 000 cycles
Tripping characteristic		according to IEC 62606
Power losses		0.6 W/pole
Connection		
Conductor Cu - rigid (solid)		0.75 ÷ 16 mm²
Conductor Cu - flexible with end sleeve		0.75 ÷ 10 mm²
Torque		2 ÷ 2.5 Nm
Working conditions		
Ambient temperature		-25 ÷ +45 °C
Working position		arbitrary
Climatic resistance (IEC 60068-2-30)		28 cycles (55 °C, 95 % relative humidity)
Requirements on other devices in the installation on EMC (electromagnetic compatibility)		must comply with CISPR 14-1 and IEC 61000-6-3 (values of limit class B) [2]

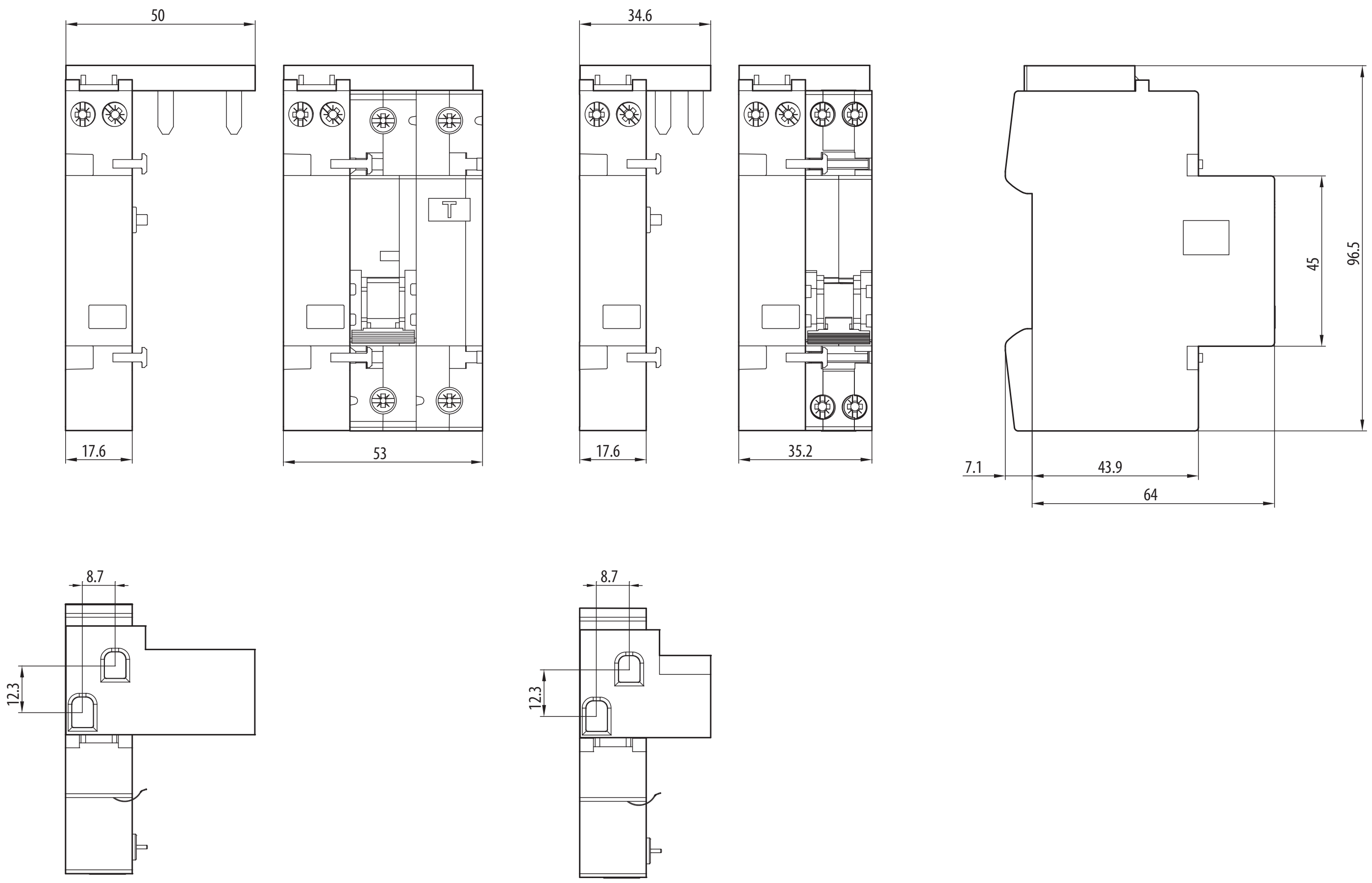
[1] Rated current is the current value, which arc fault detection unit ARC can conduct continuously. ARC is able to continuously conduct currents up to 16 A or up to 40 A. After the connection of ARC with a specific protective element, the rated current of the arc fault detection device AFDD is determined by the rated current of a protective element.

[2] The interference transmission requirements as defined in the standards CISPR 14-1 and IEC 61000-6-3 must be observed for the devices operated in the electrical installation. Non-compliant or defective devices may cause interference, which can influence the response sensitivity of the arc fault detection device (EN 61000-6-3: Electromagnetic compatibility (EMC) – Part 6-3: Basic standards – Emission – Residential, commercial and light industry environment. CISPR 14-1: Electromagnetic compatibility – Requirements for household devices, electric tools and simile devices – Part 1: Emission).

Dimensions

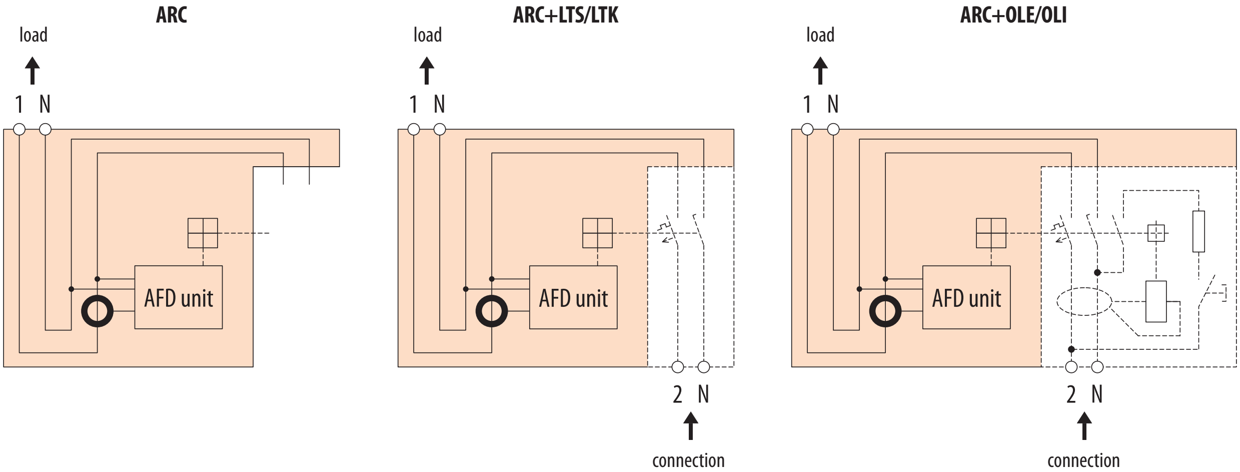
ARC-...3M + OLI/OLE

ARC-...2M + LTK



ARC FAULT DETECTION UNITS ARC

Diagram

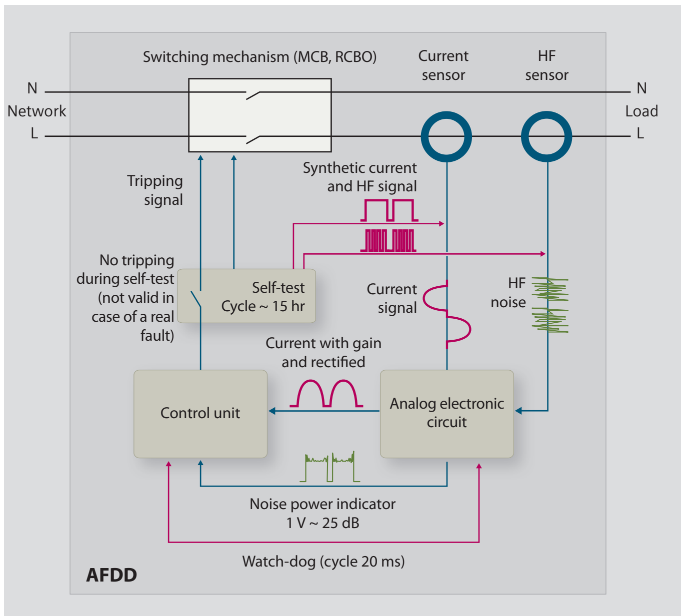


In use of 2-pole miniature circuit breakers LTS a pair of terminals marked „2 and 4“ will serve as the connection terminals of the arc fault detection device AFDD. „N“ conductor will be connected to the terminal marked „4“.

Self-test

ARC has an internal self-test function (see the next picture). This self-test is automatically initiated every 15 hours in order to test the analog electronics and the detection algorithms. The software in the control unit generates synthetic HF and current signals, which are similar to the signals of an arc fault. These signals are fed into the system's detection path behind the sensors and are assessed by the analog circuit and the control unit. It is now imperative therefore for the control unit to create the trip command.

During the self test the trip signal for the tripping relay is disabled for a short time (ms) to avoid a real tripping of the device. After a successful test the tripping path is enabled again. A negative test result will cause the device to be tripped immediately. The self-test will be postponed, however, if there are initial signs of a real arcing fault or if the current consumption in the respective branch circuit is higher than the average. The test concept is rounded off by an external watch-dog which checks the program flow and the firmware integrity every 20 ms.



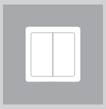
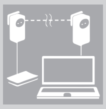
ARC FAULT DETECTION UNITS ARC

High resistance to unintentional switching off

AFDD must not only provide reliable protection against fire caused by electricity, but also react only in case of real fault. For OEZ AFDD it means that it must reliably select between arc faults, for which switching off is required within the stated limits, and operating arcs (or current behaviour) of electric loads, during which switching off should not occur.

See the next table for the examples of electric loads with a high-frequency component, which lies very close to the course of arc fault. AFDD should not switch off in case of any of these signals arising in service or in case of arc fault of the adjacent circuit.

Examples of loads generating electric arcs/current course when ARC does not switch off

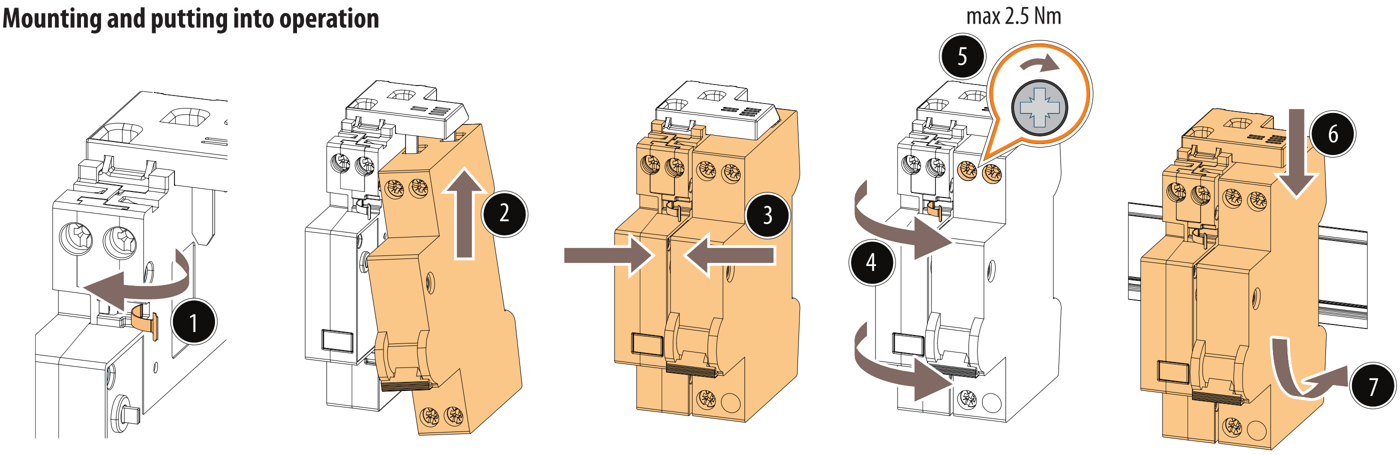
	Arcing of brush motors - power drills, blenders, vacuum cleaners
	Arcing of a light switch etc.
	Arcing on the contacts of socket outlets and older relays
	Surge current of fluorescent lights
	Data signal from the device for operation of computer network via power sockets (powerline)
	Current behaviour using light dimmer

Procedure after the arc fault detection unit ARC trippinig

Status indicator	Meaning of status indicator	Check/cause	Measure
(blinking yellow)	**Series or parallel arc**	Smell test: “smell of plastic?” Is discolored plastic visible (socket outlet, switch, cable, load)?	Replace or have repaired the fault part.
		Switch on the ARC unit again. If tripping is repeated within a short time.	Disconnect and switch off all the devices (lights) and switch on the ARC unit again ---> tripping occurs again: notify an electrician ---> no tripping: switch on and plug in the loads one after the other until tripping occurs ---> check whether the device is faulty (notify an electrician if necessary).
		Switch on the ARC unit again. No repeat tripping within a short time: Does a load have a faulty switch or a damaged cable, or is discoloration visible on /in the wall (maybe in the neighboring room)?	Actuate the suspicious switch and wait for the reaction of the ARC unit ---> have it repaired by an electrician if necessary. If the cable is faulty ---> have it repaired by an electrician. In case of discoloration: notify an electrician.
(blinking red)	**Overvoltage > 275 V**	Overvoltage between L and N	If the fault reoccurs even after switching on the ARC unit once again, you should ask the power supply company whether it knows of any faults in the supply. If no fault is known, arrange for an electrician to check the system.
(blinking yellow-red)	**ARC not ready**	ARC has an internal fault.	Call an electrician to test or replace the ARC unit.
(without signalling)	**No power supply**	Check whether the general voltage supply is active.	Wait until the general voltage supply is active again.
		Whether an backup protection device has interrupted the supply.	Check the cause of the switch off (notify an electrician if necessary) and switch on the protection device again after the cause is eliminated.

ARC FAULT DETECTION UNITS ARC

Mounting and putting into operation



1. Swing the metal lamellas of arc fault detection unit ARC.

2. Switch off the miniature circuit breaker LTK. Place the terminal rear parts of the miniature circuit breaker LTK on the conductors protruding out of the arc fault detection unit ARC.

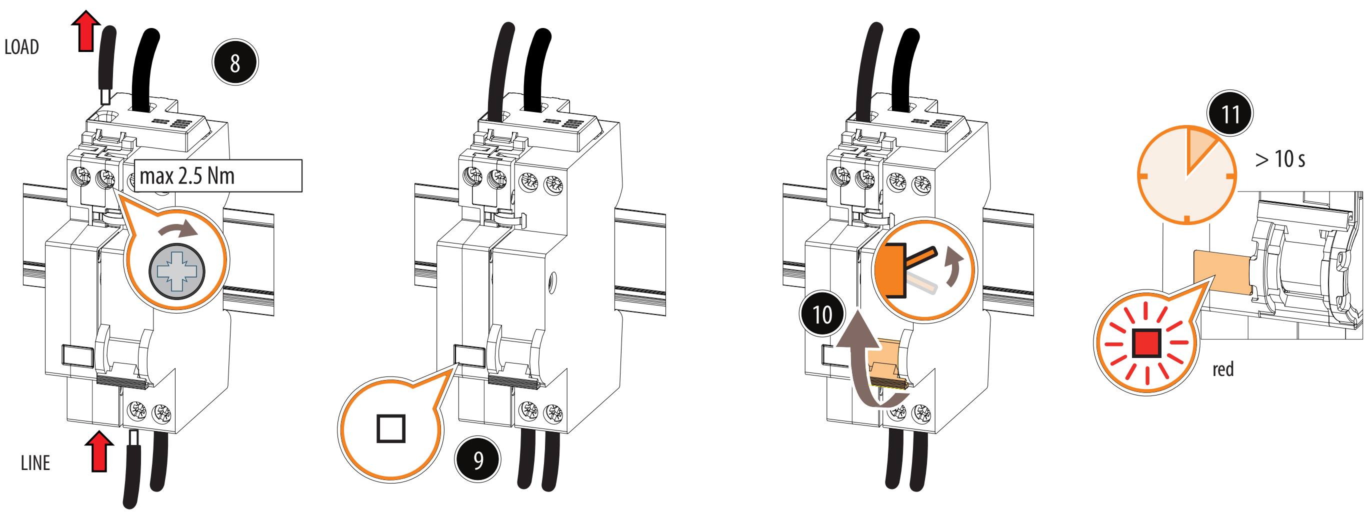
3. Put the devices together in the way that the side plastic coding pins and release mechanism pins of the arc fault detection unit ARC fit into the opposite holes in the miniature circuit breaker LTK. Metal lamellas cannot stay between the devices.

4. Attach the devices by the metal lamellas.

5. Tighten the terminal upper screws of the miniature circuit breakers LTK (max. 2.5 Nm).

6. Hang the device on a “U“ rail.

7. Push in.



8. Connect load conductors on the arc fault detection unit ARC terminals marked 1, N (LOAD). Connect supply conductors on the arc fault detection unit ARC terminals marked 2, N2. Tighten all terminal screws.

9. No light on LED status indicator. Arc fault detection device AFDD is not active, no voltage supply.

10. Switch on the miniature circuit breaker LTK. If the miniature circuit breaker cannot be activated, push the LED status indicator, which also serves as a push-button.

11. Once the miniature circuit breaker is switched on, LED status indicator lights red in time > 10 s. Time gap is caused by an internal test after activation.

Arc fault detection device AFDD is now mounted, connected and put into service correctly.

Mounting of a residual current circuit breaker with overcurrent protection OLI/OLE or miniature circuit breaker LTS is similar as mounting of a miniature circuit breaker LTK described above.

DEVICES INTENDED FOR MOUNTING WITH ARC FAULT DETECTION UNIT ARC

LTK-16B-1

Miniature circuit breaker LTK (6 kA)

1+N-pole

I_n	Characteristics B			Characteristics C			Number	Package
[A]	Type	Code	Weight [kg]	Type	Code	Weight [kg]	of modules	[pcs]
2	-	-	-	**LTK-2C-1N**	OEZ:43452	0.140	1	1
4	-	-	-	**LTK-4C-1N**	OEZ:43453	0.134	1	1
6	**LTK-6B-1N**	OEZ:43443	0.133	**LTK-6C-1N**	OEZ:43454	0.118	1	1
8	-	-	-	**LTK-8C-1N**	OEZ:43455	0.137	1	1
10	**LTK-10B-1N**	OEZ:43445	0.133	**LTK-10C-1N**	OEZ:43456	0.123	1	1
13	**LTK-13B-1N**	OEZ:43446	0.120	**LTK-13C-1N**	OEZ:43457	0.097	1	1
16	**LTK-16B-1N**	OEZ:43447	0.122	**LTK-16C-1N**	OEZ:43458	0.115	1	1
20	**LTK-20B-1N**	OEZ:43448	0.113	**LTK-20C-1N**	OEZ:43459	0.132	1	1
25	**LTK-25B-1N**	OEZ:43449	0.137	**LTK-25C-1N**	OEZ:43460	0.126	1	1
32	**LTK-32B-1N**	OEZ:43450	0.148	**LTK-32C-1N**	OEZ:43461	0.145	1	1
40	**LTK-40B-1N**	OEZ:43451	0.113	**LTK-40C-1N**	OEZ:43462	0.144	1	1

ARC-16-1N-2M + LTK-16B-1

For complete information on the above mentioned devices see the catalogue Modular devices Minia.

DEVICES INTENDED FOR MOUNTING WITH ARC FAULT DETECTION UNIT ARC

LTS-10C-1N

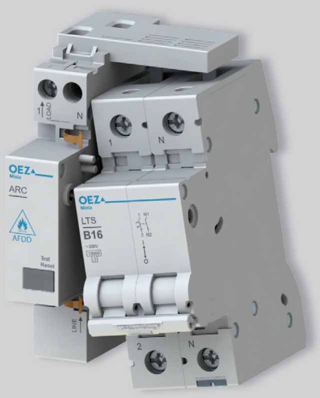
Miniature circuit breaker LTS (10 kA)

1+N-pole

I_n	Characteristics B		Characteristics C		Characteristics D		Number	Weight	Package
[A]	Type	Code	Type	Code	Type	Code	of modules	[kg]	[pcs]
2	**LTS-2B-1N**	OEZ:43292	**LTS-2C-1N**	OEZ:42011	**LTS-2D-1N**	OEZ:43294	2	0.347	6
4	**LTS-4B-1N**	OEZ:43293	**LTS-4C-1N**	OEZ:42012	**LTS-4D-1N**	OEZ:43295	2	0.347	6
6	**LTS-6B-1N**	OEZ:42000	**LTS-6C-1N**	OEZ:42013	**LTS-6D-1N**	OEZ:42024	2	0.347	6
8	**LTS-8B-1N**	OEZ:42001	**LTS-8C-1N**	OEZ:42014	**LTS-8D-1N**	OEZ:42025	2	0.347	6
10	**LTS-10B-1N**	OEZ:42002	**LTS-10C-1N**	OEZ:42015	**LTS-10D-1N**	OEZ:42026	2	0.347	6
13	**LTS-13B-1N**	OEZ:42003	**LTS-13C-1N**	OEZ:42016	**LTS-13D-1N**	OEZ:42027	2	0.347	6
16	**LTS-16B-1N**	OEZ:42004	**LTS-16C-1N**	OEZ:42017	**LTS-16D-1N**	OEZ:42028	2	0.347	6
20	**LTS-20B-1N**	OEZ:42005	**LTS-20C-1N**	OEZ:42018	**LTS-20D-1N**	OEZ:42029	2	0.347	6
25	**LTS-25B-1N**	OEZ:42006	**LTS-25C-1N**	OEZ:42019	**LTS-25D-1N**	OEZ:42030	2	0.347	6
32	**LTS-32B-1N**	OEZ:42007	**LTS-32C-1N**	OEZ:42020	**LTS-32D-1N**	OEZ:42031	2	0.347	6
40	**LTS-40B-1N**	OEZ:42008	**LTS-40C-1N**	OEZ:42021	**LTS-40D-1N**	OEZ:42032	2	0.347	6

2pole

I_n	Characteristics B		Characteristics C		Characteristics D		Number	Weight	Package
[A]	Type	Code	Type	Code	Type	Code	of modules	[kg]	[pcs]
1	**LTS-1B-2**	OEZ:42035	**LTS-1C-2**	OEZ:42051	**LTS-1D-2**	OEZ:42068	2	0.347	6
1.6	-	-	**LTS-1,6C-2**	OEZ:42052	**LTS-1,6D-2**	OEZ:42069	2	0.347	6
2	**LTS-2B-2**	OEZ:42036	**LTS-2C-2**	OEZ:42053	**LTS-2D-2**	OEZ:42070	2	0.347	6
4	**LTS-4B-2**	OEZ:42037	**LTS-4C-2**	OEZ:42054	**LTS-4D-2**	OEZ:42071	2	0.347	6
6	**LTS-6B-2**	OEZ:42038	**LTS-6C-2**	OEZ:42055	**LTS-6D-2**	OEZ:42072	2	0.347	6
8	**LTS-8B-2**	OEZ:42039	**LTS-8C-2**	OEZ:42056	**LTS-8D-2**	OEZ:42073	2	0.347	6
10	**LTS-10B-2**	OEZ:42040	**LTS-10C-2**	OEZ:42057	**LTS-10D-2**	OEZ:42074	2	0.347	6
13	**LTS-13B-2**	OEZ:42041	**LTS-13C-2**	OEZ:42058	**LTS-13D-2**	OEZ:42075	2	0.347	6
16	**LTS-16B-2**	OEZ:42042	**LTS-16C-2**	OEZ:42059	**LTS-16D-2**	OEZ:42076	2	0.347	6
20	**LTS-20B-2**	OEZ:42043	**LTS-20C-2**	OEZ:42060	**LTS-20D-2**	OEZ:42077	2	0.347	6
25	**LTS-25B-2**	OEZ:42044	**LTS-25C-2**	OEZ:42061	**LTS-25D-2**	OEZ:42078	2	0.347	6
32	**LTS-32B-2**	OEZ:42045	**LTS-32C-2**	OEZ:42062	**LTS-32D-2**	OEZ:42079	2	0.347	6
40	**LTS-40B-2**	OEZ:42046	**LTS-40C-2**	OEZ:42063	**LTS-40D-2**	OEZ:42080	2	0.347	6



ARC-16-1N-3M + LTS-16B-1N

For complete information on the above mentioned devices see the catalogue Modular devices Minia.

DEVICES INTENDED FOR MOUNTING WITH ARC FAULT DETECTION UNIT ARC

OLE-10B-1N-030AC

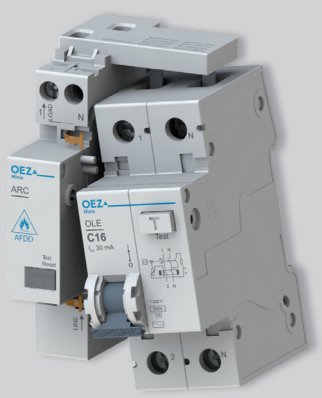
Residual current circuit breaker with overcurrent protection OLE (6 kA)

Residual current circuit breaker with overcurrent protection, type AC

6 000
3

- They react to sine-wave alternating residual current (type AC).

$I_{\Delta n}$ [mA]	I_n [A]	Characteristics B Type	Code	Characteristics C Type	Code	Number of modules	Weight [kg]	Package [pcs]
30	6	**OLE-6B-1N-030AC**	OEZ:38313	**OLE-6C-1N-030AC**	OEZ:38320	2	0.25	1
	10	**OLE-10B-1N-030AC**	OEZ:38314	**OLE-10C-1N-030AC**	OEZ:38321	2	0.25	1
	16	**OLE-16B-1N-030AC**	OEZ:38315	**OLE-16C-1N-030AC**	OEZ:38322	2	0.25	1
	20	**OLE-20B-1N-030AC**	OEZ:38316	**OLE-20C-1N-030AC**	OEZ:38323	2	0.25	1
	25	**OLE-25B-1N-030AC**	OEZ:38317	**OLE-25C-1N-030AC**	OEZ:38324	2	0.25	1
	32	**OLE-32B-1N-030AC**	OEZ:38318	**OLE-32C-1N-030AC**	OEZ:38325	2	0.25	1
	40	**OLE-40B-1N-030AC**	OEZ:38319	**OLE-40C-1N-030AC**	OEZ:38326	2	0.25	1



ARC-16-1N-3M + OLE-16C-1N-030AC

For complete information on the above mentioned devices see the catalogue Modular devices Minia.

DEVICES INTENDED FOR MOUNTING WITH ARC FAULT DETECTION UNIT ARC

OLI-16C-1N-030AC

Residual current circuit breaker with overcurrent protection OLI (10 kA)

Residual current circuit breaker with overcurrent protection, type AC

10 000 3

- They react to sine-wave alternating residual current (type AC).

$I_{\Delta n}$ [mA]	I_n [A]	Characteristics B Type	Code	Characteristics C Type	Code	Number of modules	Weight [kg]	Package [pcs]
	6	**OLI-6B-1N-030AC**	OEZ:38271	**OLI-6C-1N-030AC**	OEZ:38278	2	0.25	1
	10	**OLI-10B-1N-030AC**	OEZ:38272	**OLI-10C-1N-030AC**	OEZ:38279	2	0.25	1
	16	**OLI-16B-1N-030AC**	OEZ:38273	**OLI-16C-1N-030AC**	OEZ:38280	2	0.25	1
30	20	**OLI-20B-1N-030AC**	OEZ:38274	**OLI-20C-1N-030AC**	OEZ:38281	2	0.25	1
	25	**OLI-25B-1N-030AC**	OEZ:38275	**OLI-25C-1N-030AC**	OEZ:38282	2	0.25	1
	32	**OLI-32B-1N-030AC**	OEZ:38276	**OLI-32C-1N-030AC**	OEZ:38283	2	0.25	1
	40	**OLI-40B-1N-030AC**	OEZ:38277	**OLI-40C-1N-030AC**	OEZ:38284	2	0.25	1
	6	-	-	**OLI-6C-1N-300AC**	OEZ:38285	2	0.25	1
	10	-	-	**OLI-10C-1N-300AC**	OEZ:38286	2	0.25	1
	16	-	-	**OLI-16C-1N-300AC**	OEZ:38287	2	0.25	1
300	20	-	-	**OLI-20C-1N-300AC**	OEZ:38288	2	0.25	1
	25	-	-	**OLI-25C-1N-300AC**	OEZ:38289	2	0.25	1
	32	-	-	**OLI-32C-1N-300AC**	OEZ:38290	2	0.25	1
	40	-	-	**OLI-40C-1N-300AC**	OEZ:38291	2	0.25	1

Residual current circuit breaker with overcurrent protection, type A

10 000 3 -25

- They react to both sine-wave residual current and pulsating direct residual current (type A).

$I_{\Delta n}$ [mA]	I_n [A]	Characteristics B Type	Code	Characteristics C Type	Code	Number of modules	Weight [kg]	Package [pcs]
	6	**OLI-6B-1N-030A**	OEZ:38292	**OLI-6C-1N-030A**	OEZ:38299	2	0.26	1
	10	**OLI-10B-1N-030A**	OEZ:38293	**OLI-10C-1N-030A**	OEZ:38300	2	0.26	1
	16	**OLI-16B-1N-030A**	OEZ:38294	**OLI-16C-1N-030A**	OEZ:38301	2	0.26	1
30	20	**OLI-20B-1N-030A**	OEZ:38295	**OLI-20C-1N-030A**	OEZ:38302	2	0.26	1
	25	**OLI-25B-1N-030A**	OEZ:38296	**OLI-25C-1N-030A**	OEZ:38303	2	0.26	1
	32	**OLI-32B-1N-030A**	OEZ:38297	**OLI-32C-1N-030A**	OEZ:38304	2	0.26	1
	40	**OLI-40B-1N-030A**	OEZ:38298	**OLI-40C-1N-030A**	OEZ:38305	2	0.26	1
	6	-	-	**OLI-6C-1N-300A**	OEZ:38306	2	0.26	1
	10	-	-	**OLI-10C-1N-300A**	OEZ:38307	2	0.26	1
	16	-	-	**OLI-16C-1N-300A**	OEZ:38308	2	0.26	1
300	20	-	-	**OLI-20C-1N-300A**	OEZ:38309	2	0.26	1
	25	-	-	**OLI-25C-1N-300A**	OEZ:38310	2	0.26	1
	32	-	-	**OLI-32C-1N-300A**	OEZ:38311	2	0.26	1
	40	-	-	**OLI-40C-1N-300A**	OEZ:38312	2	0.26	1

Residual current circuit breaker with overcurrent protection, type AC-G

-25 10 000 3 G

- They react to sine-wave alternating residual current (type AC).
- Special residual current circuit breakers which reduce the number of undesirable releases.

$I_{\Delta n}$ [mA]	I_n [A]	Characteristics B Type	Code	Characteristics C Typ	Code	Number of modules	Weight [kg]	Package [pcs]
	10	**OLI-10B-1N-030AC-G**	OEZ:38328	**OLI-10C-1N-030AC-G**	OEZ:38333	2	0.25	1
30	16	**OLI-16B-1N-030AC-G**	OEZ:38329	**OLI-16C-1N-030AC-G**	OEZ:38334	2	0.25	1
	20	**OLI-20B-1N-030AC-G**	OEZ:38330	**OLI-20C-1N-030AC-G**	OEZ:38335	2	0.25	1
	25	**OLI-25B-1N-030AC-G**	OEZ:38331	**OLI-25C-1N-030AC-G**	OEZ:38336	2	0.25	1

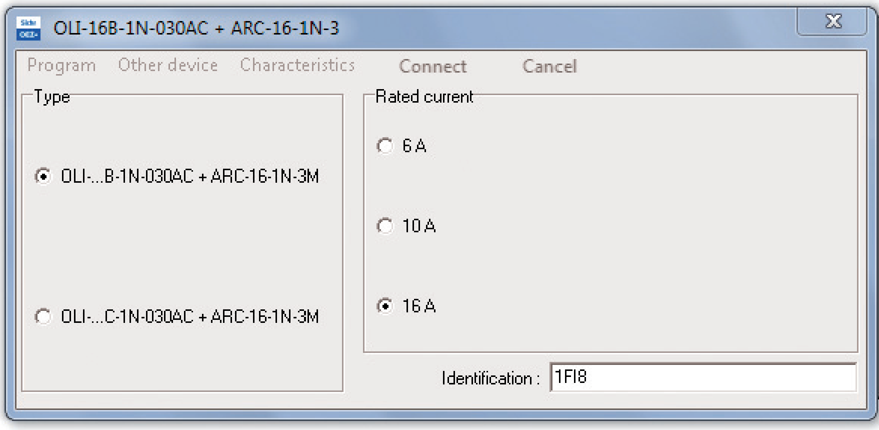
ARC-16-1N-3M + OLI-16C-1N-030AC

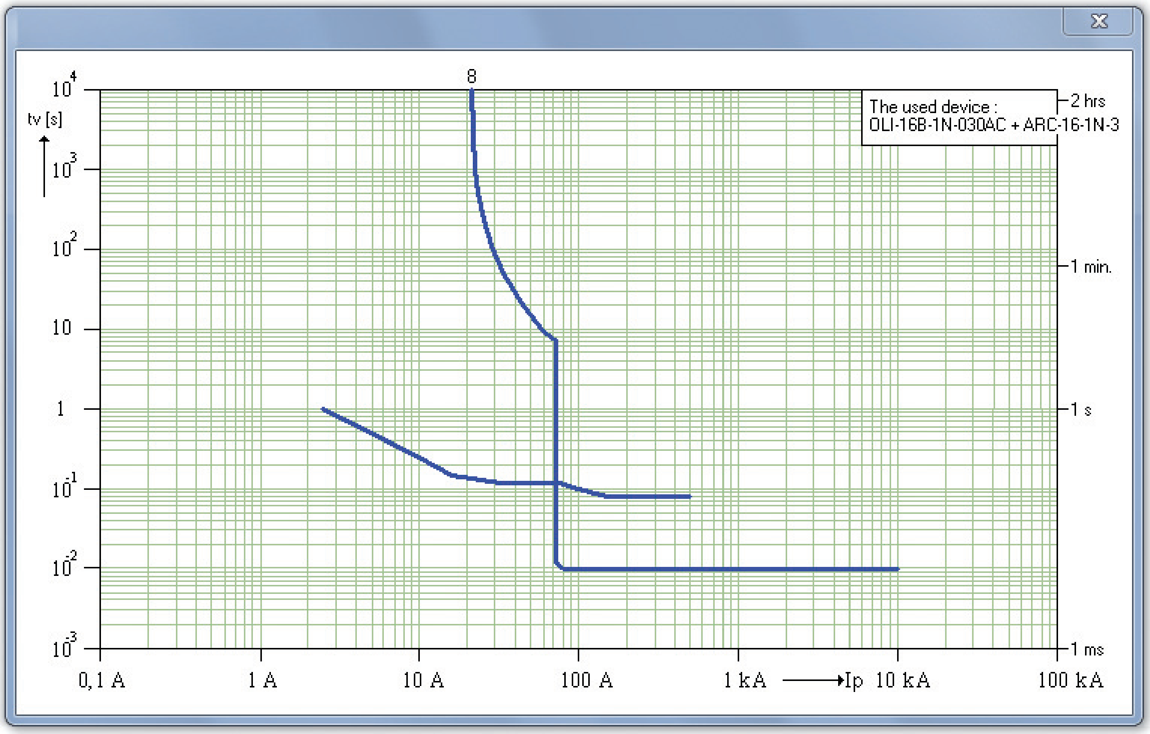
For complete information on the above mentioned devices see the catalogue Modular devices Minia.

ARC FAULT DETECTION UNITS ARC

Design of a circuit with the AFDD in Sichr software

Arc fault detection devices AFDD OEZ are newly also in the Sichr software that is used to design and control the low-voltage line networks. First it is necessary to make a transition from a three-phase network TN-C to a single-phase network TN-S and then it is possible to choose a specific version of an arc fault detection unit ARC combined either with a miniature circuit breaker LTS/LTK or a residual current circuit breaker with overcurrent protection OLI/OLE.
An excellent tool is a projection of the AFDD characteristics directly with the characteristics of other devices for a visual control of the circuit protection settings. You must keep in mind that arc fault detection device AFDD has also other decision criteria for switch off, not only the current value of an arc fault (see page 14 and figure Factors for the detection of an arc fault). Accessories to arc fault detection devices AFDD such as auxiliary releases and switches can be selected via OEZ Configurator.





NOTES

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