



	<b>DIN V VDE V 0126-1-1 (VDE V 0126-1-1)</b>	
	This is also a <b>VDE Pre-standard</b> ( <i>VDE-Vornorm</i> ) according to VDE 0022. It has been included in the VDE body of regulations under the VDE number indicated above and made public in "etz Elektrotechnik + Automation" magazine.	

**Any reproduction - including for in-house use - is prohibited.**

ICS 29.240.30

***Pre-standard***

## **Automatic disconnection device between a parallel-connected generator and the public low-voltage grid**

Selbsttätige Schaltstelle zwischen einer netzparallelen Eigenerzeugungsanlage und dem öffentlichen Niederspannungsnetz

Dispositif de déconnexion automatique entre un générateur et le réseau public à basse tension

Total number of pages: 15

DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE  
(DKE German Commission for Electrical, Electronic & Information Technologies of DIN and VDE)

# - Pre-standard -

**DIN V VDE V 0126-1-1 (VDE V 0126-1-1):2006-02**

## **Start of validity**

This pre-standard is valid as of 2006-02-01.

## **Foreword**

*Previous draft standard: E DIN VDE 0126-1-1 (VDE 0126-1-1):2005-05.*

A pre-standard is the result of standardization work, which has not been issued as a standard by DIN because of certain reservations as to the content or due to the standardization procedure diverging from that for standards. Experience made with this pre-standard is requested to be sent to DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE, Stresemannallee 15, 60596 Frankfurt am Main, Germany.

The working group responsible for this pre-standard is K 373 "Photovoltaic Solar Energy Systems", of the DKE German Commission for Electrical, Electronic & Information Technologies of DIN and VDE (DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE).

In the case of an undated reference in the normative text (reference to a standard without indication of the date of issue and without reference to a section number, table, figure etc.), the reference relates to the most recent valid edition of the referenced standard.

In the case of a dated reference in the normative text, the reference always relates to the referenced edition of the standard.

The connection between the quoted standards and the respective German standards - if such a connection exists - always results from the number of the respective IEC publication. For example: IEC 60068 has been adopted by CENELEC as the European standard EN 60068 and included in the German body of standards as DIN EN 60068.

## **Modifications**

Essentially, the following changes were made with respect to E DIN VDE 0126-1-1 (VDE 0126-1-1):2005-05:

- a) Complete revision of sections 4, 4.2, 4.5 and 6.6.2.2.1,
- b) Inclusion of supplementary explanations A2, A3 und A4.

## **Previous editions**

E DIN VDE 0126-1-1 (VDE 0126-1-1):2005-05

## Contents

	Page
Foreword.....	2
1 Scope .....	4
2 Normative references .....	4
3 Definitions.....	4
4 Requirements .....	5
4.1 Functional safety .....	6
4.2 Voltage monitoring .....	7
4.3 Frequency monitoring.....	7
4.4 Direct current monitoring .....	7
4.5. Detection of island operation.....	7
4.6 Marking.....	8
4.7 Special requirements.....	8
5 General requirements.....	8
6 Type test.....	8
6.1 Functional safety .....	8
6.2 Voltage monitoring .....	8
6.3 Frequency monitoring.....	9
6.4 Direct current monitoring .....	9
6.5 Detection of island operation.....	9
6.6 Residual current monitoring .....	11
7 Product conformity test.....	13
8 Installation specifications.....	13
Annex A (informative) Comments.....	14
A.1 Further methods of detecting islanding .....	14
A.2 Frequency limits .....	14
A.3 Operation of standby generating sets .....	14
A.4 Short-term disconnections.....	14
Bibliography .....	15
Figure 1 - Block circuit diagram of an automatic disconnection device (photovoltaic example).....	7
Figure 2 - Test circuit as per 6.5.1 - Example showing disconnection device integrated in inverter .....	9
Figure 3 - Test circuit as per 6.5.2 - Example showing disconnection device integrated in inverter .....	10
Figure 4 - Test circuit as per 6.6.2.1 - Set-up for single-phase feed inverter .....	12
Table 1 - Maximum break times .....	8

# - Pre-standard -

DIN V VDE V 0126-1-1 (VDE V 0126-1-1):2006-02

## 1 Scope

The automatic disconnection device is used as a safety interface between the generator and the low-voltage grid and serves as a substitute for a disconnecting switch accessible at all times by the distribution system operator (DSO). It prevents the unintentional feed of electrical energy from the generator into a subnetwork disconnected from the rest of the distribution grid (islanding), thereby offering protection (in addition to the measures specified in DIN VDE 0105-100 (VDE 0105-100), 6.2 to

- operating staff, against voltage in the disconnected subnetwork;
- materials, against inadmissible voltages and frequencies;
- consumers, against inadmissible voltages and frequencies; and
- materials, against the feed of faults by the generator.

In the case of faults in the low-voltage grid, the automatic disconnection device protects the generator from

- inadmissible voltages; and
- inadmissible frequencies.

The automatic disconnection device does not protect the generator from overload and short circuiting. Such protection should be ensured otherwise in accordance with DIN VDE 0100-712 (VDE 0100-712), DIN VDE 0100-430 (VDE 0100-430) and DIN VDE 0100-530 (VDE 0100-530).

## 2 Normative references

The referenced documents below are required for the application of this document. For dated references, only the referenced edition applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

DIN EN 50160:2000-03, *Voltage characteristics of electricity supplied by public distribution systems.*

DIN EN 50178 (VDE 0160), *Electronic equipment for use in power installations.*

DIN EN 60664-1 (VDE 0110-1), *Isolation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests.*

E DIN VDE 0664-100 (VDE 0664-100):2002-05, *Residual current operated circuit-breakers type B to operate at residual alternating and residual direct currents - Part 100: RCCBs Type B.*

DIN EN 61000-6-2 (VDE 0839-6-2), *Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments.*

DIN EN 61000-6-3 (VDE 0839-6-3), *Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for residential, commercial and light-industrial environments.*

DIN EN 61008-1 (VDE 0664-10), *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCB's).*

DIN VDE 0100-430 (VDE 0100-430), *Erection of low-voltage installations - Part 4-43: Protection for safety.*

DIN VDE 0100-530 (VDE 0100-530), *Erection of low voltage installations - Part 530: Selection and erection of electrical equipment - Switchgear and controlgear.*

DIN VDE 0100-712 (VDE 0100-712), *Low-voltage installations - Part 7-712: Requirements for special installations or locations - Solar photovoltaic (PV) power supply systems.*

DIN VDE 0105-100 (VDE 0105-100), *Operation of electrical installations - Part 100: General requirements.*

## 3 Definitions

The following definitions apply to the application of this document:

### 3.1

#### **Disconnection device**

A device for ending the feed of electrical power from a parallel-connected generator into the grid by disconnecting it from the grid.

NOTE: The automatic disconnection device, which may be integrated in the generator, can obtain its supply voltage from the grid. Connection to the grid is also necessary for voltage and frequency measurement. In addition, passive elements (e.g. EMC filters) can be incorporated unswitched on the grid side.

### 3.1.1

#### **Separate disconnection device**

A disconnection device that works independently in terms of its safety function.

### 3.1.2

#### **Integrated disconnection device**

A disconnection device that forms a functional unit with the generator.

### 3.2

#### **Unintended islanding**

Island network operation ("islanding") exists when a subnetwork, in which decentralized generators cover the consumption of the connected loads, is disconnected from the larger rest of the grid. Possible causes for the disconnection include switching actions of the network operator, the triggering of protection devices or a shortage of materials. In the case of unintended islanding, this process is outside the network operator's control. The network operator has no influence over the voltage and frequency of the disconnected subnetwork.

### 3.3

#### **Earth leakage current**

Current which flows to earth from the live parts of the installation without there being an insulation fault.

NOTE: This current may have a capacitive component, caused especially by the use of capacitors.

### 3.4

#### **Earth fault current**

Current which flows to earth as the result of an insulation fault.

### 3.5

#### **Fault (or residual) current**

The vector sum of instantaneous values of the currents flowing in the primary circuit of the residual (fault) current device (expressed as root mean square, r. m. s.)

### 3.6

#### **Rated residual current ( $I_{\Delta n}$ )**

The value of the residual operating current set for the RCMU by the manufacturer at which the RCMU should switch off under specified conditions.

### 3.7

#### **Simple separation**

The isolation of circuits or between a circuit and earth through basic insulation.

### 3.8

#### **Residual current monitoring unit (RCMU)**

A residual current monitoring unit (RCMU) is a device which detects and switches off direct, pulse and alternating residual currents arising in the event of a fault in inverters with no simple isolation between the network and the photovoltaic generator.

## 4 Requirements

The following requirements apply to both integrated and separate safety disconnection devices, unless otherwise specified.

The disconnection device must disconnect the generator from the grid on the AC side due to

- voltage and/or frequency fluctuations in the low-voltage grid;
- d. c. feed into the low-voltage grid;
- unintended islanding; and
- intended islanding with standby generating units,

by means of two switches arranged in series.

# - Pre-standard -

## DIN V VDE V 0126-1-1 (VDE V 0126-1-1):2006-02

Before the grid is accessed, a 30 sec measurement should be taken to determine whether the voltage and frequency of the grid remain within the tolerance band as defined in 4.2.1, 4.2.2 and 4.3. If this is the case, the supply can be switched and fed into the grid, although 4.2 to 4.5 and 4.7 must be fulfilled from the start of the feed. Following a break triggered by one of the safety functions of the disconnection device, the switch back on is carried out in the same manner. Following a disconnection arising because of a short interruption, the feed may be switched back on once the voltage and frequency of the grid are within the tolerance band specified in 4.2 and 4.3 for a period of 5 sec. A short interruption is characterized by the upper and lower limits of the grid frequency and/or voltage being exceeded for a maximum period of 3 sec. Unintended islanding must also be detected when generation and consumption match each other in the separate network subsection.

### 4.1 Functional safety

The safety of the functions defined in 4.2 to 4.5 and 4.7 of the automatic disconnection device (see Figure 1) must be ensured in all operating conditions of the network. It may be a stand-alone unit or an integral part of the generator, and it must switch off in the event of a failure and show the fault status.

#### 4.1.1 One-fault safety

Observing basic safety principles, the disconnection device must be designed, built, selected, assembled and combined in such a way that it can withstand the expected operating loads (e.g. reliability in terms of its switching performance and switching frequency) and external influences (e.g. mechanical vibration, external fields, interruptions or failures in the energy supply).

An individual fault in the disconnection device should not result in loss of safety functions. Faults triggered by the same cause must be considered if the probability of the occurrence of such a fault is significant. If reasonably possible, the individual fault must be displayed and should trigger a shut-down of the generator.

NOTE 1: This requirement for registering individual faults does not mean that all faults must register. A large number of undetected faults can therefore lead to an unintended output signal and to a dangerous state.

NOTE 2: This system response means that

- the safety function remains operational when an individual fault occurs;
- some, but not all, faults are detected;
- an accumulation of undetected faults can lead to loss of the safety function.

#### 4.1.2 Switch-off device

The switches arranged in series must, independently of each other, have a breaking capacity which matches the rated current of the generator. At least one switch must be designed as a relay or contactor and be suitable for overvoltage category 2. In the case of single-phase feed units, the switch must have a contact of this overvoltage category both for the neutral line and for the phase line. In the case of multiphase feed units, one contact of this overvoltage category is required for all active lines. The second switch may consist of the electronic switching elements of the inverter bridge circuit or another circuit if the electronic switching elements can be switched off by control signals and it is ensured that a failure is detected and will stop operation when the feed is switched back on at the latest.

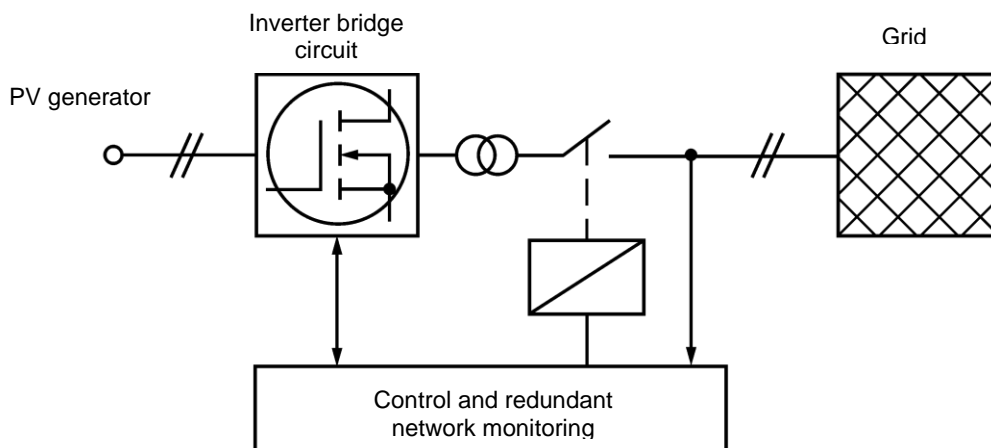


Figure 1 - Block circuit diagram of an automatic disconnection device (photovoltaic example)

## 4.2. Voltage monitoring

### 4.2.1 Voltage reduction (protection function)

Voltages of  $\leq 80\% V_N$  in the phase lines which are being supplied to must trigger a break within 0.2 sec. It should not be possible to change this limit in the device.

### 4.2.2 Voltage increase (protection function)

Voltages of  $\geq 115\% V_N$  in the phase lines which are being supplied to must trigger a break within 0.2 sec. It should not be possible to change this limit in the device.

### 4.2.3 Voltage increase (monitoring of voltage quality)

The goal is to stay within the voltage limits at the point of common coupling. A floating average should be measured over a 10-minute interval for each phase line being fed into. The trigger threshold can be set between  $110\% V_N$  and  $115\% V_N$  to take into account the drop in voltage between the installation location and the point of common coupling. The factory setting is a trigger threshold of  $110\% V_N$ . Exceeding this set value must trigger a break. The setting of this limit should only be made in consultation with the network operator.

## 4.3 Frequency monitoring

Network frequencies below 47.5 Hz and above 50.2 Hz must trigger a break within 0.2 sec.

## 4.4 Direct current monitoring

A direct current feed to the low-voltage grid due to defective generator operation must trigger a break within 0.2 sec. For this, either the malfunction itself or a measured d. c. component of the current of more than 1 A can serve as a trigger criterion.

## 4.5 Detection of island operation

### 4.5.1 Single unit operation

Island network operation must trigger a break under the test conditions of the type test specified in 6.5.

### 4.5.2 Multiple unit operation

Island operation can be detected independently for each individual unit so that the requirements set out in 4.5.1 are fulfilled for each individual unit. Alternatively, the automatic disconnection device can receive break commands via an interface from another protection device with equivalent island network detection. A break command must trigger a break within 0.2 sec. The protection device issuing the break signal and the interface must also fulfil the functional safety requirements defined in 4.1.1.

# - Pre-standard -

DIN V VDE V 0126-1-1 (VDE V 0126-1-1):2006-02

## 4.6 Marking

A generator with an automatic disconnection device must indicate "VDE 0126-1-1" on the name plate that can be seen on the outside. Further marking as defined in DIN EN 50178 (VDE 0160) should be attached or included in the accompanying documentation as required.

## 4.7 Special requirements

### 4.7.1 Photovoltaics

A residual current monitoring unit (RCMU) is required for inverters without simple separation between the grid and the photovoltaic generator. In the event of a failure, the d. c. and a. c. components of the residual current depend on the type of inverter and on the d. c. voltage of the PV generator.

An external residual current device is required in a disconnection device without an integrated RCMU. In this case, the tests defined in 6.6 do not apply. The residual current device required should be specified by the manufacturer in the operating instructions.

The generator-side insulation resistance before the switch to the grid must be  $\geq 1 \text{ k}\Omega/\text{V}$  relative to the maximum inverter input voltage, but at least 500 k $\Omega$ . Leakage currents greater than 300 mA must trigger a break within 0.3 sec. Irrespective of the rated power of the inverter, any sudden residual currents should trigger a break in accordance with Table 1.

**Table 1 - Maximum break times**

r. m. s. value of residual current/(mA)	Break time/(sec)
30	0.3
60	0.15
150	0.04

The break times apply to the entire temperature range stated by the manufacturer.

In the case of inverters without simple separation between the grid and the PV generator, both switches mentioned in 4.1.2 must be designed as a relay or contactor with the requirements stipulated there.

NOTE: A design featuring an interrupting device between the inverter and the PV generator and an interrupting device between the inverter and the grid is possible.

## 5 General requirements

The limits set out in DIN EN 61000-6-3 (VDE 0839-6-3) concerning radio interference should be observed. The test interference quantities stipulated in DIN EN 61000-6-2 (VDE 0839-6-2) should be used as the basis for interference immunity.

## 6 Type test

Unless otherwise specified, the following tests apply to integrated and separate disconnection devices. A separate disconnecting device should be tested together with a suitable feeder. In this context, it should be ensured that the break signal is generated by the disconnection device and not by the feeder.

### 6.1 Functional safety

One-fault safety and fault recognition with subsequent break as defined in 4.1 should be tested by means of a fault simulation.

### 6.2 Voltage monitoring

In order to test the voltage monitoring, the automatic disconnection device should be run via an a. c. voltage source with variable amplitude at nominal a. c. voltage and any power level. The trigger time specified in 4.2 must be observed in the case of voltage jumps in which the lower and upper limits (according to 4.2) are not exceeded by more than 3% of the nominal voltage. The test should be carried out for each phase line which is fed into.

### 6.3 Frequency monitoring

In order to test the frequency monitoring, the automatic disconnection device should be run via an a. c. voltage source with variable amplitudes and frequencies at any power level. The trigger time of the frequency monitoring specified in 4.3 must be observed during a gradual change in frequency from the nominal value up to the relevant limit with a change rate of 1 Hz/sec. Functioning of the frequency monitoring should be checked within the voltage range specified in 4.2 at the lower limit for nominal voltage and at the upper limit.

### 6.4 Direct current monitoring

Testing of the break following direct current feed is conducted using optionally a) or b):

- a) A direct current of 1 A is applied to the measurement meter of the disconnection device (e.g. current transformer, resistance). The break should happen within 0.2 sec.
- b) By simulating a fault, a measurement should be taken to determine whether defective operation with a d. c. component of the input current of over 1 A triggers a break within 0.2 sec.

### 6.5 Detection of island operation

Testing the break following unintended island operation is carried out using one of the methods described in 6.5.1 to 6.5.3. The method used must fulfil the functional safety requirements set out in 4.1.

#### 6.5.1 Impedance measurement

##### 6.5.1.1 Test circuit

The test circuit (see Figure 2) simulates a balanced parallel feed/load status and voltage and frequency stability conditions of a network zone which can form a network island through interruption. Even under these conditions the automatic disconnection device must reliably detect the interruption to the network and switch off the generator within 5 sec.

The test circuit has the following properties:

The direct voltage side of the inverter is supplied by a variable energy source. In the case of generators without inverter, the power supply is provided by a suitable drive. On the alternating voltage side of the feeder, resistors ( $R_1$ ), reactors ( $L_1$ ) and capacitors ( $C_1$ ) are arranged in parallel to the output so that the level of the apparent power (taken or given) across the enclosed break device (S) for increasing the impedance of the grid connection is less than 5% of the rated power of the unit on the grid side (test alignment).

The break device is arranged in parallel to a testing resistor of  $1 \Omega$  ( $R_3$ ). Based on an impedance of  $Z_N \leq 0.5 \Omega$  in the network, in which the tests are carried out, the impedance ( $R_2, L_2$ ) is increased in selectable stages with permitted deviations (including the operational network impedance fluctuations) of  $\pm 0.25 \Omega$  to values of up to  $1 \Omega$  ohmic resistance and up to  $0.8 \Omega$  ohmic resistance combined with  $0.5 \Omega$  reactance, thereby testing whether a break occurs within 5 sec following a jump in impedance of  $1 \Omega$ .

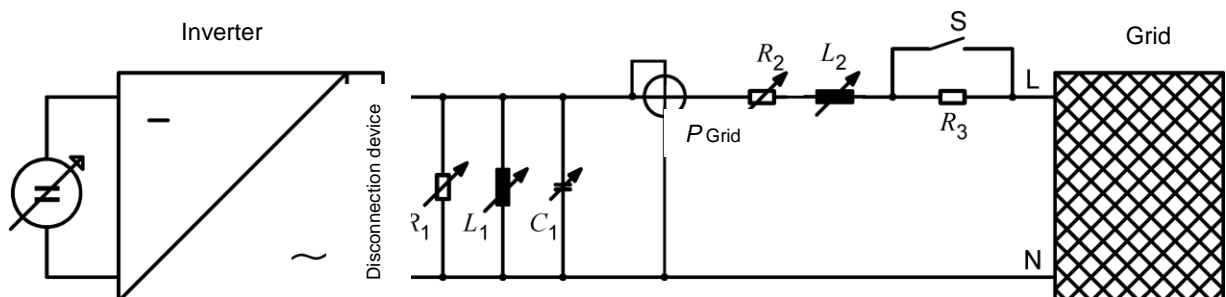


Figure 2 - Test circuit as per 6.5.1 - Example showing disconnection device integrated in inverter

# - Pre-standard -

DIN V VDE V 0126-1-1 (VDE V 0126-1-1):2006-02

## 6.5.1.2 Test procedure

Using the variable power source, 100% of the inverter's rated power is fed into its input. The rated power should also be set for generators without inverter. Resistors, reactors and capacitors should be set to test alignment on the a. c. voltage side. Break device S is then opened in this state. A break should be triggered within 5 sec of the break device opening.

If voltage and frequency are within the tolerance band, the disconnection device should not reconnect until at least 30 sec after the break.

Between 20 sec and 60 sec after the disconnection device has reconnected, break device S is closed, and then reopened after at least 30 sec have passed. A break should be triggered within 5 sec of the break device opening.

This test should be repeated at the different network impedances.

To test a 3-phase disconnection device, a test circuit according to Figure 2 should be connected consecutively to each of the phases. The other two phases are then connected directly to the grid. The breaks should each be triggered within 5 sec of the break device S opening.

## 6.5.2 Oscillating circuit test

### 6.5.2.1 Test circuit

The d. c. voltage side of the inverter is supplied by a suitable direct voltage source. In the case of generators without inverter, the power supply is provided by a suitable drive. Resistors, reactors and capacitors are arranged in parallel to the output on the a. c. voltage side of the generator; these form an RLC oscillating circuit and can be finely adjusted to the active and reactive power generated (Figure 3). Both the RLC oscillating circuit and the generator should be connected via separate switches to the grid or a suitable grid simulator.

This oscillating circuit should have a Q factor of at least 2. The active power taken by the oscillating circuit must match that emitted by the generator or the inverter to at least  $\pm 3\%$ . At nominal voltage, the harmonic distortion of the reactor current should be below 3%. The following relationships apply for the inductance and capacity settings:

$$L = \frac{V^2}{2\pi \cdot f \cdot P \cdot Q} \quad C = \frac{P \cdot Q}{2\pi \cdot f \cdot V^2}$$

where  $U$  is the grid voltage,  $f$  the grid frequency and  $P$  the active power fed from the generator.

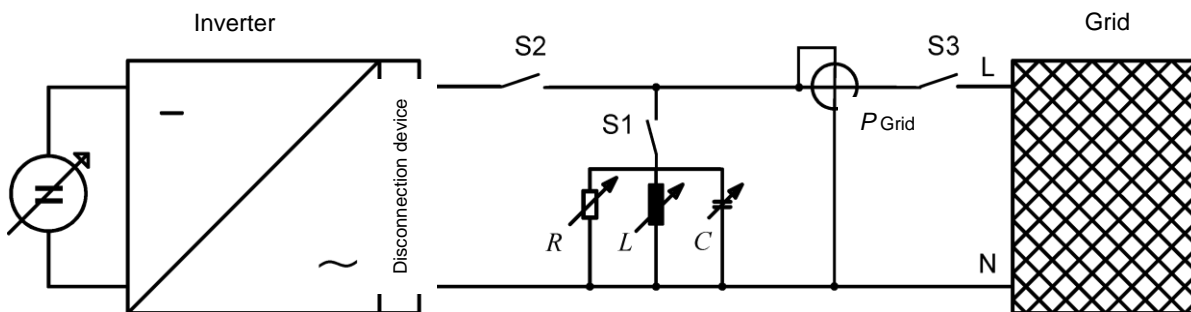


Figure 3 - Test circuit as per 6.5.2 - Example showing disconnection device integrated in inverter

### 6.5.2.2 Test procedure

The test should be conducted as follows:

1. The output of the generators is determined using the direct voltage source or a suitable drive for systems without inverter.

## - Pre-standard -

DIN V VDE V 0126-1-1 (VDE V 0126-1-1):2006-02

2. The system is connected to the grid or grid simulator by closing S3 and S2. Without any oscillation circuit connected (S1 opened), the active ( $P$ ) and reactive ( $P_{Q,WR}$ ) power flowing into the grid from the generator is now measured.
3. The generator is disconnected from the grid (S2 open).
4. The oscillating circuit is balanced as follows:
  - a) The inductance is set in such a way that  $Q > 2$ .
  - b) The capacity is set in such a way that  $P_{QC} + P_{QL} = -P_{Q,WR}$ .
  - c) The resistance is set in such a way that the active power taken from the entire oscillating circuit is equal to  $P_{WR}$ .
  - d) The oscillating circuit and the generator are connected to the grid (S1, S2 and S3 closed) and the generator is put into operation.

NOTE: The purpose of the balancing is to keep the fundamental component of the current as small as possible using S3. Fine tuning of the oscillating circuit (step 6) allows the worst possible conditions to be created in terms of possible islanding.

5. To start the test, open S3 and measure the time until the device switches off.
6. After each successful test, one parameter ( $L$  or  $C$ ) is altered by approx. 1% within the total range of approx.  $\pm 5\%$  and the test repeated.

The entire test procedure should be carried out at  $P = 25\%$ ,  $50\%$  and  $100\%$  of the rated output. The entire test is deemed successful if the break time for each individual test is less than 5 sec.

The test should be carried out at nominal frequency of  $\pm 0.1$  Hz and a nominal voltage of  $\pm 3\%$ .

To test a 3-phase disconnection device, a test circuit according to Figure 3 should be connected consecutively to each of the phases. The other two phase lines are then connected directly to the grid. The breaks should each be triggered within 5 sec of the break device S opening.

### 6.5.3 Three-phase voltage monitoring

Three-phase monitoring of the phase line voltages is permissible as a criterion for island network detection only with single-phase feeders. As soon as at least one phase line voltage exceeds the limits of  $80\% V_N$  or  $115\% V_N$  specified in 4.2, a break should take place within 0.2 sec. Here, too, the requirements regarding functional safety set out in 4.1 should be fulfilled.

NOTE: Three-phase voltage monitoring is also permissible where a number of single-phase feeders, which feed into different phase lines, are integrated in a single unit if the currents of these feeders are controlled independently of each other so that different phase relations can be set.

In order to test the voltage monitoring, the automatic disconnection device should be run via an alternating voltage source with variable amplitude at nominal alternating voltage and any output. The trigger time specified in 4.2 must be observed in the case of voltage jumps in which the lower and upper limits (according to 4.2) are not exceeded by more than 3% of the nominal voltage. The test should be repeated for all phase line combinations.

### 6.6 Residual current monitoring

All tests should be carried out at  $0.85 V_N$ ,  $V_N$  and  $1.10 V_N$ .

NOTE: These voltage limits ensure that the voltage monitoring does not trigger during the test.

#### 6.6.1 Separate disconnection device

The residual current monitoring of a disconnection device which is not integrated in the inverter is tested in accordance with E DIN VDE 0664-100 (VDE 0664-100):2002-05.

9.9.1 "Test circuit" to 9.9.3 "Testing of correct triggering under load at reference temperature" are applied here. In the test according to 9.9.2.2 "Test for correct triggering when switching on to a residual current", it should be noted that the disconnection device can trigger with a delay.

# - Pre-standard -

## DIN V VDE V 0126-1-1 (VDE V 0126-1-1):2006-02

In this test, the break time is the time between automatic switching on and switching off due to the residual current.

Functioning with pulsating direct residual currents is tested under 9.21.1. Functioning with smooth direct residual currents is tested in accordance with 9.21.2.1 "Test of correct triggering with continuous rise of smooth direct residual current" to 9.21.2.7 "Test of correct triggering with pulsating direct residual current with superimposition of smooth direct residual current".

### 6.6.2 Integrated disconnection device

The residual current monitoring of a disconnection device integrated in the inverter is tested at rated output and maximum d. c. supply voltage in accordance with the following sections.

#### 6.6.2.1 Test circuit

A switchable, variable resistor is connected between a d. c. voltage line and the neutral line (N). In the case of an inverter with PV+ and PV- d. c. voltage connections, there are two configurations (see Figure 4): N with PV+ ( $R_1$  in Figure 4), and N with PV- ( $R_2$  in Figure 4). A variable capacitor is mounted in parallel to the switchable resistor in the test as per 6.6.2.2.3 ( $C_1$ ,  $C_2$  in Figure 4).

#### 6.6.2.2 Test procedure

The tests are carried out as described in 6.6.2.1 for each d. c. voltage connection and neutral line link.

##### 6.6.2.2.1 Test circuit

The disconnection device is set up as for its intended use. The test circuit must have negligible inductance and correspond to Figure 4. The instruments for measuring the residual current must be at least class 0.5 and must display the r. m. s. values up to a frequency of 2 kHz. The instruments for measuring the time should not have a relative error proportion greater than 10% of the measured value.

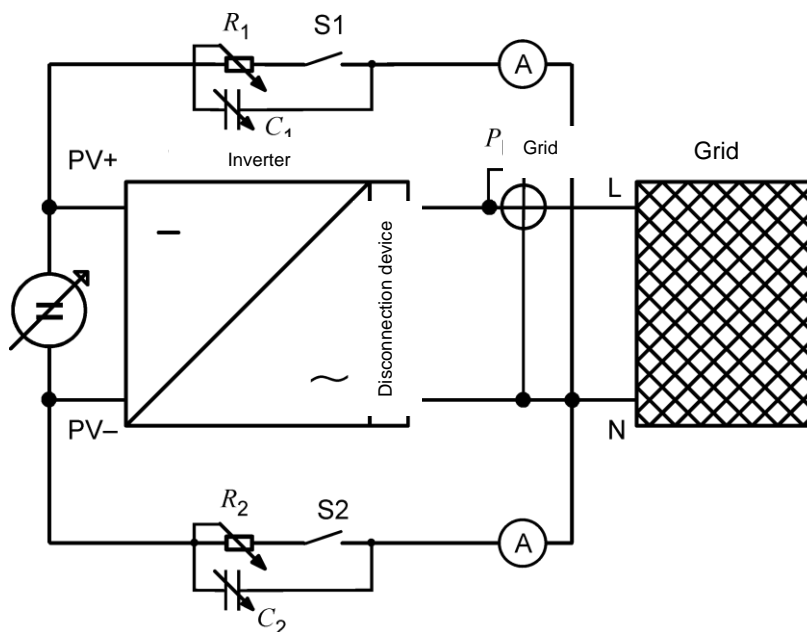


Figure 4 - Test circuit as per 6.6.2.1 - Set-up for single-phase feed inverter

##### 6.6.2.2.2 Test for correct triggering in the event of steadily rising residual current

The test switch S1 is closed. The residual current is gradually raised, with efforts to reach 300 mA within 30 sec. The trigger current is measured 5 times. All 5 measured values must be  $\leq 300$  mA. The test is repeated using the test switch S2. In systems with more than two generator connections, the test circuit should be extended correspondingly and the test repeated for all different switch positions.

#### **6.6.2.2.1 Test for correct triggering with sudden instance of residual current**

This test determines the functioning of the RCMU when capacitive leakage current arises during operation which is superimposed by a sudden instance of ohmic residual current. With switches S1 and S2 open, the capacitor  $C_1$  is increased until the disconnection device switches off, in order to determine the maximum capacitive residual current.  $C_2$  is not connected during this test. The capacitor  $C_1$  is then set so that the capacitive leakage current occurring during the test is lower by the figure indicated in Table 1 than the maximum determined capacitive leakage current.

The resistor  $R_1$  is set successively to each of the ohmic residual current values given in Table 1. The test switch S1 is switched on. The disconnection device should trigger. Five break time measurements are made for each residual current value. No value should exceed the limit specified in Table 1.

The test is repeated using the test switch S2 and capacitor  $C_2$ .  $C_1$  is not connected in this case. In systems with more than two generator connections, the test circuit should be extended correspondingly and the test carried out for all different switch positions.

#### **6.6.2.2.2 Test for identification of an insulation fault before the feed**

At least one PV phase connection of the inverter is connected to a voltage source with the maximum permitted generator voltage. The inverter is connected to the grid. Then, each PV generator connection of the inverter with earth potential is linked successively via a resistor, which is below the value defined in 4.7.1. In each case, the inverter must identify the fault and should not begin the feed.

### **7 Product conformity test**

Before any automatic disconnection device is released, the manufacturer should subject it to a product conformity test with regard to the safety parameters.

### **8 Installation specifications**

There is no need for initial and repeat tests of the automatic disconnection device over and above the product conformity test. If the automatic disconnection device is designed as a separate device, it may not be used within a TN-C system. In this case, a TN-C-S system should be set up.

# - Pre-standard -

DIN V VDE V 0126-1-1 (VDE V 0126-1-1):2006-02

## Annex A (informative)

### Comments

#### A.1 Further methods of detecting islanding

European harmonization means that other methods which provide equal protection may also be permitted.

#### A.2 Frequency limits

In conformity with the requirements for network power plants, the lower trigger limit is set at 47.5 Hz. This is to prevent further generators being switched off in the event of power deficiencies in the grid which cause a reduction in the frequency. With regard to the upper frequency limit, there may be deviations to these specifications for various reasons:

An increase of the frequency in the grid system is an indication of excess power. The disconnection of generators in this case can therefore help adapt generation to the demand, thereby helping stabilize the grid. The trigger threshold of larger power plants is nevertheless set relatively high (51.5 Hz), as switching off these plants and the required "reduction to auxiliary power" and subsequent restart can be problematic. If these power plants are required to satisfy short-term demand, this could result in critical grid conditions. For small-scale generators, this type of operation is neither required nor useful; the upper frequency limit for these has therefore been set at 50.2 Hz.

#### A.3 Operation of standby generating units

When carrying out certain work on the grid, it is necessary for the distribution system operators to disconnect subnetworks from the rest of the network (e.g. replacement of distribution transformers). In order to maintain supplies to customers during this time, the network operator uses emergency generating units (usually diesel units). In most cases, interruption-free supply is also possible.

The emergency generating units are controlled so that the power generated is adapted to the current load in the network. However, a large number of uncontrolled generator units in this subnetwork could lead to excess load, leading in turn to the emergency generating units being switched off for protection. Stable operation of these emergency generation units would then no longer be possible. To avoid this, care should be taken to ensure that the generating units are disconnected in such cases. After disconnecting the subnetwork from the rest of the grid with the emergency generator unit, the network operators should set a frequency of 50.3 Hz as a frequency criterion for switching off the generators. This value should be strictly observed, as any customers' interruption-free power supplies are generally disconnected from the grid at 50.4 Hz.

To ensure the desired selectivity between the individual operating statuses, it is therefore necessary to set the upper trigger threshold of the generator units as precisely as possible to 50.2 Hz.

In order to facilitate interruption-free resynchronization of the subnetwork with the rest of the grid, the frequency of the subnetwork is once again synchronized to the present network frequency after conclusion of standby generator operation. To ensure that the generators do not switch back on again immediately after the frequency has returned to the tolerance band, thereby threatening the stability of network operation in this phase, a waiting period of 30 sec should be observed after the generators have been switched off for a longer period.

#### A.4 Short-term disconnections

In cases where the generator is disconnected briefly for protection (usually due to a network failure resulting from the voltage going below the specified band range for a period of up to 3 sec), a waiting period of 5 sec is permitted before resynchronization in contrast to the value of 30 sec given above, measured from the time at which the voltage and frequency return to the tolerance band. Here, however, the specific features of the generators themselves need to be considered, e. g. complete standstill for rotating units.

## - Pre-standard -

DIN V VDE V 0126-1-1 (VDE V 0126-1-1):2006-02

### Bibliography

Standards series DIN EN 60146, *Semiconductor convertors*.

Date: May 21, 2020

To whom it may concern:

This is to certify that I possess advanced knowledge of the German and English languages and that the attached translation from German into English was translated by me and is an accurate translation of the document received by this office.

The document is designated as:

**Ex. A. DIN VDE Standard**

Eva Harrison, Translator, of Morningside Translations, attests to the following:

“All statements made in this declaration of my own knowledge are true, and all statements made on information and belief are believed to be true. I make these statements under the understanding that willful false statements and the like are punishable by fine or imprisonment, or both (18 U.S.C. 1001).”

“To the best of my knowledge, the aforementioned documents are a true, full, and accurate translation into English of the specified document.”

*Eva Harrison*

---

Signature of Eva Harrison