# Documentation Update LVRT

**NOTICE** **Please Note that the content of this chapter, highlighted in red, has changed compared to the provided manual.**

## LVRT – Low Voltage Ride Through

Available Elements:

LVRT

*Why LVRT? - Motivation for LVRT*

The rapid development of distributed resources (DR) based on the renewable energy such as wind, solar and others has been changing the electric power system and concepts for its control, protection, metering and communication rapidly, too.

One of the important challenges for the interconnection between the DR and local electric power system (EPS) is the behaviour of the DR during disturbances within the electrical power system. Most of the disturbances within the EPS are characterized mainly by non-permanent system voltage collapses (voltage dip/sag) with different time durations.

According to traditional protection concepts a distributed energy resource should be tripped as fast as possible from the grid in case of a significant low voltage condition. This is no longer acceptable because of the continuous rising share of distributed energy resources within the energy market. Uncontrolled disconnecting significant parts of the power generation during disturbances within the grid endangers the system stability of the electrical power system.

It was reported[3] that during system fault with low voltage drops, a complete 5000 MW wind park (without LVRT capability) was decoupled from the electrical power system. The consequence was a dangerous system voltage and frequency instability.

Based on experiences like that, lots of electric utilities and state public utilities have issued interconnection standards which require Low-Voltage-Ride-Through (LVRT) capability during EPS disturbances.

*What does LVRT mean in detail?*

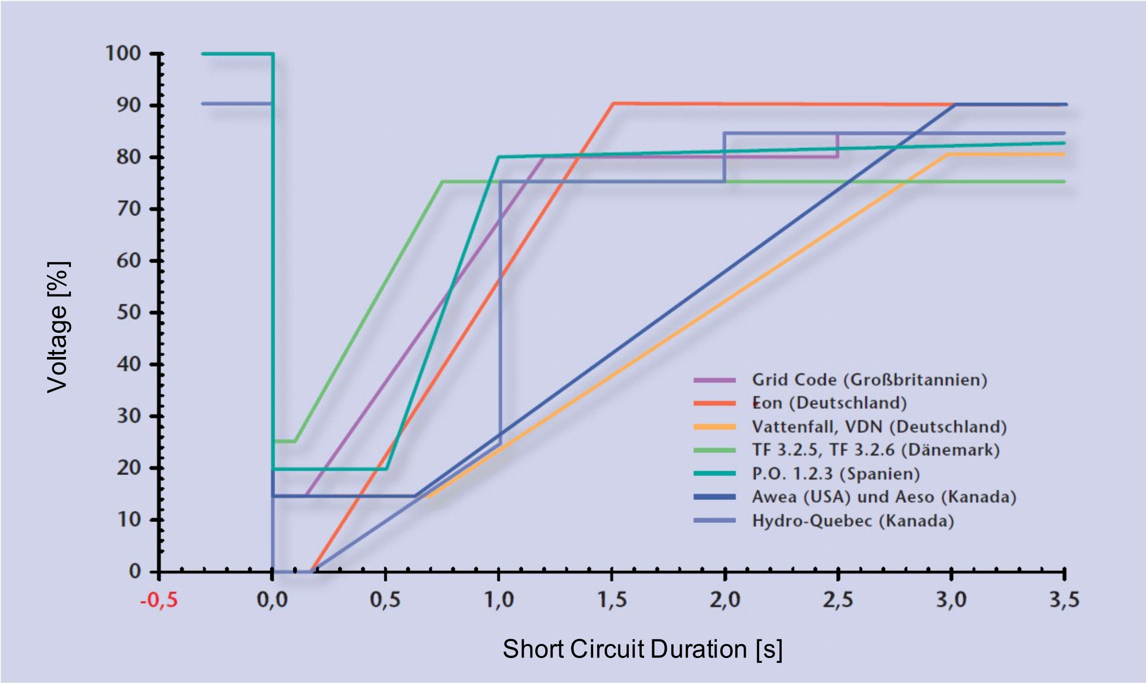
It is no longer allowed to decouple/disconnect a DR from the grid just because of a non-permanent voltage dip. Protective relays and control units have to take this into account.

Instead of that, the distributed resource has to be able to ride through such disturbances according to a *LVRT* profile. The shape of this *LVRT* profile is very similar according to the different guidelines within different countries or local utilities. But they could differ in details.

By means of *LVRT* the system stability is improved in situations, when the contribution of DRs is needed mostly. The importance of *LVRT* will rise with the growing share of DRs within the electrical power system.

Based on the technical requirements mentioned above, a *LVRT* protection function was developed for the *HighPROTEC* product line which covers the *LVRT* profiles (capabilities) defined by all relevant national and local grid interconnection standards.

The following drawing shows details on the different *LVRT* standards in different countries. Please note, that the standards and hence the grid codes are in some countries still under development.




Source: eBWK Bd. 60 (2008) Nr. 4

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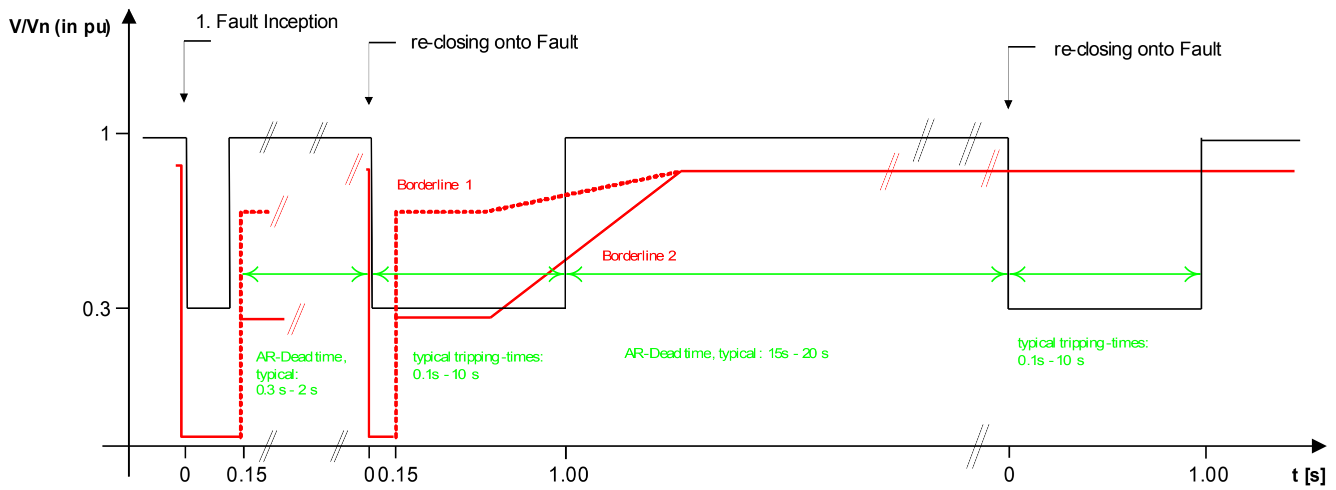
## Functional Principle of the LVRT

From the grid operators point of view, a *LVRT* profile defines a voltage profile which a distributed energy resource, that is connected to the grid, should be able to ride through in case of a low voltage event (voltage dip). The distributed energy resource is only allowed to disconnect from the grid if the voltage at the point of common coupling drops below the *LVRT* borderline. In other words, a LVRT protection function is a time-dependent voltage supervision according to a predefined voltage profile. The time-dependent voltage supervision will be started, as soon as the voltage at the point of common coupling falls below the start voltage level. The *LVRT* will be stopped, as soon as the voltage rises above the recover voltage level.

## Auto Reclosure controlled LVRT

As already mentioned, the purpose of LVRT is to keep the DR connected to the grid in case of a non-permanent voltage dip/sag. For faults within the electrical power system by which auto-reclosing function is used to coordinate with the short circuit protections like overcurrent or distance protections, it is to expect that more than one voltage dips are coming one after another in a time period which is determined by the preset auto-reclosing dead times and protection relay operating times. Voltage dips/sags caused by the dead times of auto reclosings are non-permanent. Hence the protective device has to be able to detect voltage sags/dips in accordance with an auto reclosure and issues a trip command in that case that the voltage drops below the profile or that all parameterized auto reclosure shots were unsuccessful.

The following figure[1] depicts the voltage excursion by an unsuccessful two-shot Auto-Reclosing. According to some grid codes[1] it is obligated for a distributed generation to ride through a series of temporary voltage dips, but can be disconnected from the electrical power system immediately for a permanent fault. This kind of applications can be realized easily using the feature of »*AR-controlled LVRT*« in *LVRT* protection function.



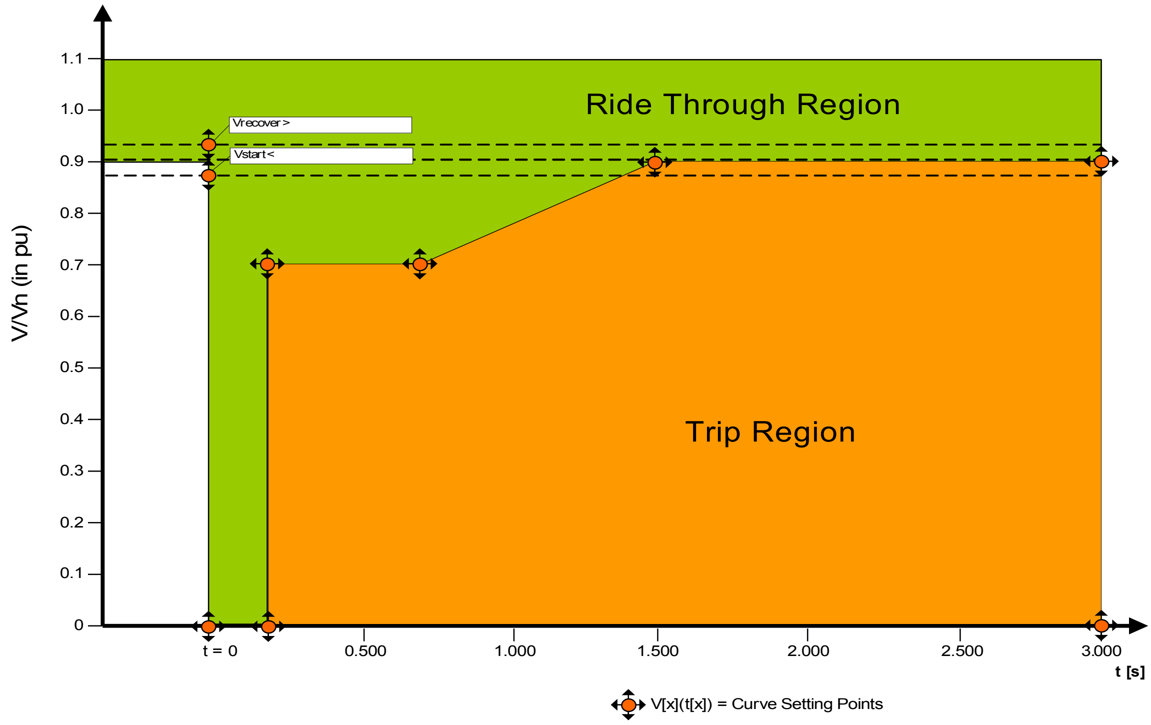

Source: Technische Richtlinie, Erzeugungsanlagen am Mittelspannungsnetz, Ausgabe Juni 2008, BDEW Bundesverband der Energie- und Wasserwirtschaft e.V. (Page 89).

*Figure: Run of voltage curve during an unsuccessful two-shot auto reclosure*

*Functional Description of the LVRT*

The *LVRT* element is designed for distributed generation resources that operate in parallel with the grid. It supervises system voltage disturbances by comparing them with a configurable voltage profile that is triggered once the system voltage falls below a configurable start value »*Vstart<*«.

Once triggered, the *LVRT* element supervises the system voltage consecutively and determines if the voltage excursion is above or below of the preset voltage profile. A trip signal is only issued if the voltage excursion exits the "Ride-Through" region and goes into the "Tripping" region.



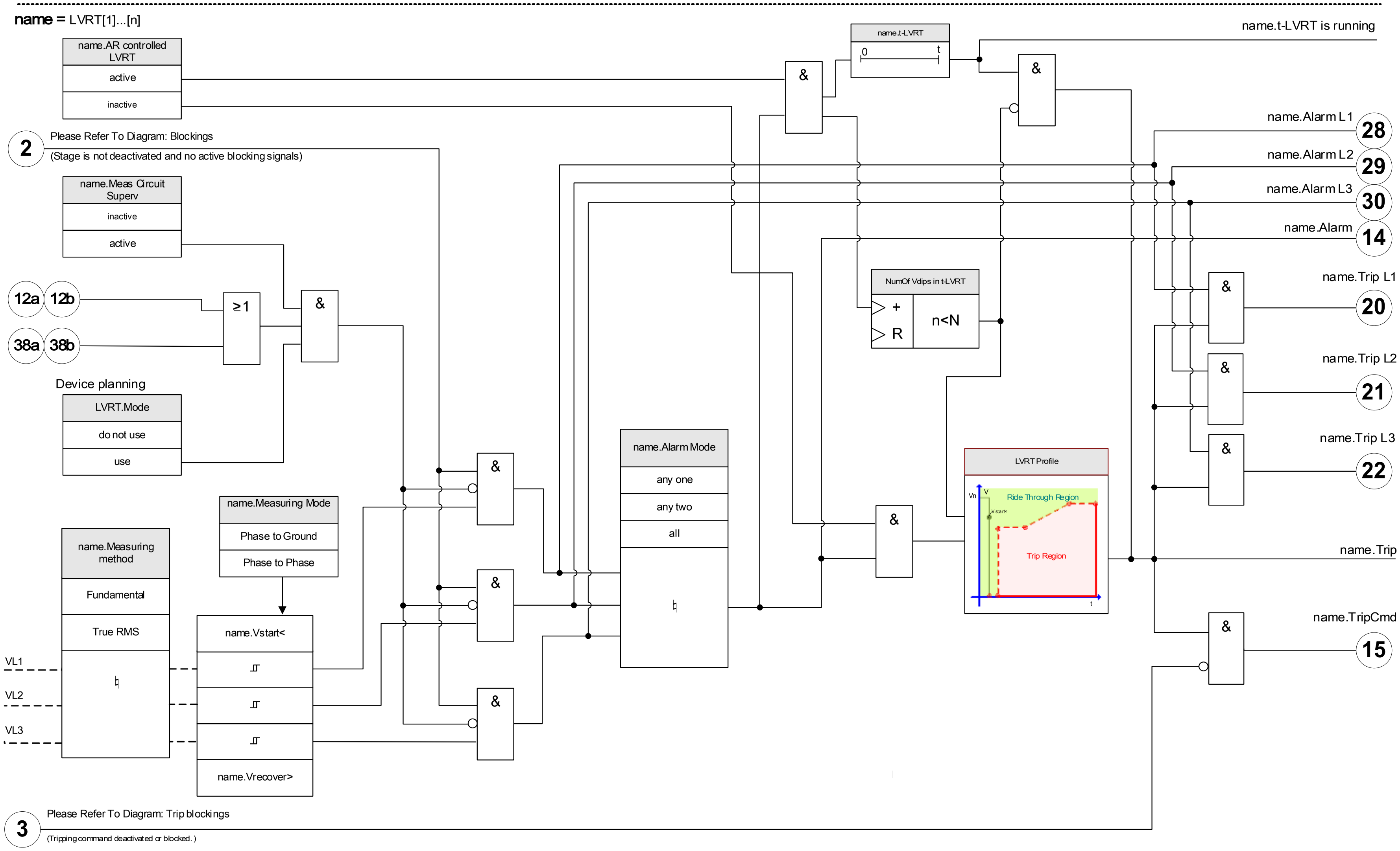

The *LVRT* element will change into standby again as soon as the system voltage recovers: That means, the voltage has risen above the preset recover voltage »*Vrecover*«.

*Auto Reclosure controlled LVRT*

In case that the *LVRT* should be able to ride through auto reclosures, the parameter »*ARControlledLVRT«* has to be set to »*active«*.

In order to supervise the Low Voltage Ride Through events during reclosure, the user has to set the supervision timer »tLVRT*« at least equal or greater than* the complete Multi-Shot AR-runtime. In addition to that the number of permitted *LVRTs* has to be set whichis usually the number of auto reclosure attempts. The actual *LVRT* supervision will be controlled to ride through the preset *LVRT* voltage pattern. By reaching the preset number of LVRT events »*NumberOfLVRT«*, the actual *LVRT* supervision assumes that the detected system fault is permanent, ignores the voltage profile and issues a tripping command instantaneously in order to disconnect the distributed resource from the electrical power system.

# LVRT



name = LVRT[1]...[n]
name.AR controlled LVRT
active
inactive
2
Please Refer To Diagram: Blockings
(Stage is not deactivated and no active blocking signals)
name.Meas Circuit Superv
inactive
active
12a
12b
38a
38b
≥1
Device planning
LVRT.Mode
do not use
use
name.Measuring Mode
Phase to Ground
Phase to Phase
name.Measuring method
Fundamental
True RMS
VL1
VL2
VL3
name.Vstart<
name.Vrecover>
3
Please Refer To Diagram: Trip blockings
(Tripping command deactivated or blocked.)
name.Alarm Mode
any one
any two
all
name.t-LVRT
0
t
NumOf Vdips in t-LVRT
+
R
n<N
LVRT Profile
Ride Through Region
Trip Region
name.t-LVRT is running
name.Alarm L1
28
name.Alarm L2
29
name.Alarm L3
30
name.Alarm
14
name.Trip L1
20
name.Trip L2
21
name.Trip L3
22
name.Trip
name.TripCmd
15

## Device Planning Parameters of the Low-Voltage-Ride-Through

| *Parameter* | *Description* | *Options* | *Default* | *Menu path* |
|---|---|---|---|---|
| Mode | Mode | do not use,<br>use | do not use | [Device planning] |

## Setting Group Parameters of the Low-Voltage-Ride-Through

| *Parameter* | *Description* | *Setting range* | *Default* | *Menu path* |
|---|---|---|---|---|
| Function | Permanent activation or deactivation of module/stage. | inactive,<br>active | inactive | [Protection Para<br>/<1..4><br>/Intercon-Prot<br>/LVRT<br>/General settings] |
| ExBlo Fc | Activate (allow) or inactivate (disallow) blocking of the module/stage. This parameter is only effective if a signal is assigned to the corresponding global protection parameter. If the signal becomes true, those modules/stages are blocked that are parameterized "ExBlo Fc=active". | inactive,<br>active | inactive | [Protection Para<br>/<1..4><br>/Intercon-Prot<br>/LVRT<br>/General settings] |
| Blo TripCmd | Permanent blocking of the Trip Command of the module/stage. | inactive,<br>active | inactive | [Protection Para<br>/<1..4><br>/Intercon-Prot<br>/LVRT<br>/General settings] |
| ExBlo TripCmd Fc | Activate (allow) or inactivate (disallow) blocking of the module/stage. This parameter is only effective if a signal is assigned to the corresponding global protection parameter. If the signal becomes true, those modules/stages are blocked that are parameterized "ExBlo TripCmd Fc=active". | inactive,<br>active | inactive | [Protection Para<br>/<1..4><br>/Intercon-Prot<br>/LVRT<br>/General settings] |
| Measuring Mode | Measuring/Supervision Mode: Determines if the phase-to-phase or phase-to-earth voltages are to be supervised | Phase to Ground,<br>Phase to Phase | Phase to Ground | [Protection Para<br>/<1..4><br>/Intercon-Prot<br>/LVRT<br>/General settings] |
| Measuring method | Measuring method: fundamental or rms | Fundamental,<br>True RMS | Fundamental | [Protection Para<br>/<1..4><br>/Intercon-Prot<br>/LVRT<br>/General settings] |

| *Parameter* | *Description* | *Setting range* | *Default* | *Menu path* |
|---|---|---|---|---|
| Alarm Mode | Alarm criterion for the voltage protection stage. | any one,<br>any two,<br>all | any one | [Protection Para<br>/<1..4><br>/Intercon-Prot<br>/LVRT<br>/General settings] |
| Meas Circuit Superv | Activates the use of the measuring circuit supervision. In this case the module will be blocked if a measuring circuit supervision module (e.g. LOP, VTS) signals a disturbed measuring circuit (e.g. caused by a fuse failure). | inactive,<br>active | inactive | [Protection Para<br>/<1..4><br>/Intercon-Prot<br>/LVRT<br>/General settings] |
| AR controlled LVRT | Activates the supervision of the number of voltage dips during a defined time (t-LVRT). | inactive,<br>active | inactive | [Protection Para<br>/<1..4><br>/Intercon-Prot<br>/LVRT<br>/General settings] |
| Number of V dips to trip | Number of voltage dips until the disconnection signal (trip) will be issued.<br><br>Only available if:AR controlled LVRT = active | 1 - 6 | 1 | [Protection Para<br>/<1..4><br>/Intercon-Prot<br>/LVRT<br>/General settings] |
| t-LVRT | This timer defines the supervision interval (window/period) for counting the number of voltage dips to trip ("No of V dips to trip"). The first voltage dip will start the timer. The counted number of voltage dips will be reset if the timer is expired. The timer will also be reset if the maximum "No of V dips to trip" is reached.<br><br>Only available if:AR controlled LVRT = active | 0.00 - 3000.00s | 30.00s | [Protection Para<br>/<1..4><br>/Intercon-Prot<br>/LVRT<br>/General settings] |
| Vstart< | A voltage dip is detected if the measured voltage falls below this threshold. | 0.00 - 1.50Vn | 0.90Vn | [Protection Para<br>/<1..4><br>/Intercon-Prot<br>/LVRT<br>/LVRT Profile] |
| Vrecover> | The voltage is recovered if the measured voltage raises above this threshold. | 0.10 - 1.50Vn | 0.93Vn | [Protection Para<br>/<1..4><br>/Intercon-Prot<br>/LVRT<br>/LVRT Profile] |
| V(t1) | Voltage value of a point V(t(n)). These points define the LVRT profile. | 0.00 - 1.50Vn | 0.00Vn | [Protection Para<br>/<1..4><br>/Intercon-Prot<br>/LVRT<br>/LVRT Profile] |

| Parameter | Description | Setting range | Default | Menu path |
|---|---|---|---|---|
| t1 | Point in time for the corresponding voltage value V(t(n)). These points define the LVRT profile. | 0.00 - 20.00s | 0.00s | [Protection Para /<1..4> /Intercon-Prot /LVRT /LVRT Profile] |
| V(t2) | Voltage value of a point V(t(n)). These points define the LVRT profile. | 0.00 - 1.50Vn | 0.00Vn | [Protection Para /<1..4> /Intercon-Prot /LVRT /LVRT Profile] |
| t2 | Point in time for the corresponding voltage value V(t(n)). These points define the LVRT profile. | 0.00 - 20.00s | 0.15s | [Protection Para /<1..4> /Intercon-Prot /LVRT /LVRT Profile] |
| V(t3) | Voltage value of a point V(t(n)). These points define the LVRT profile. | 0.00 - 1.50Vn | 0.70Vn | [Protection Para /<1..4> /Intercon-Prot /LVRT /LVRT Profile] |
| t3 | Point in time for the corresponding voltage value V(t(n)). These points define the LVRT profile. | 0.00 - 20.00s | 0.15s | [Protection Para /<1..4> /Intercon-Prot /LVRT /LVRT Profile] |
| V(t4) | Voltage value of a point V(t(n)). These points define the LVRT profile. | 0.00 - 1.50Vn | 0.70Vn | [Protection Para /<1..4> /Intercon-Prot /LVRT /LVRT Profile] |
| t4 | Point in time for the corresponding voltage value V(t(n)). These points define the LVRT profile. | 0.00 - 20.00s | 0.70s | [Protection Para /<1..4> /Intercon-Prot /LVRT /LVRT Profile] |
| V(t5) | Voltage value of a point V(t(n)). These points define the LVRT profile. | 0.00 - 1.50Vn | 0.90Vn | [Protection Para /<1..4> /Intercon-Prot /LVRT /LVRT Profile] |

| *Parameter* | *Description* | *Setting range* | *Default* | *Menu path* |
|---|---|---|---|---|
| t5 | Point in time for the corresponding voltage value V(t(n)). These points define the LVRT profile. | 0.00 - 20.00s | 1.50s | [Protection Para /<1..4> /Intercon-Prot /LVRT /LVRT Profile] |
| V(t6) | Voltage value of a point V(t(n)). These points define the LVRT profile. | 0.00 - 1.50Vn | 0.90Vn | [Protection Para /<1..4> /Intercon-Prot /LVRT /LVRT Profile] |
| t6 | Point in time for the corresponding voltage value V(t(n)). These points define the LVRT profile. | 0.00 - 20.00s | 3.00s | [Protection Para /<1..4> /Intercon-Prot /LVRT /LVRT Profile] |
| V(t7) | Voltage value of a point V(t(n)). These points define the LVRT profile. | 0.00 - 1.50Vn | 0.90Vn | [Protection Para /<1..4> /Intercon-Prot /LVRT /LVRT Profile] |
| t7 | Point in time for the corresponding voltage value V(t(n)). These points define the LVRT profile. | 0.00 - 20.00s | 3.00s | [Protection Para /<1..4> /Intercon-Prot /LVRT /LVRT Profile] |
| V(t8) | Voltage value of a point V(t(n)). These points define the LVRT profile. | 0.00 - 1.50Vn | 0.90Vn | [Protection Para /<1..4> /Intercon-Prot /LVRT /LVRT Profile] |
| t8 | Point in time for the corresponding voltage value V(t(n)). These points define the LVRT profile. | 0.00 - 20.00s | 3.00s | [Protection Para /<1..4> /Intercon-Prot /LVRT /LVRT Profile] |
| V(t9) | Voltage value of a point V(t(n)). These points define the LVRT profile. | 0.00 - 1.50Vn | 0.90Vn | [Protection Para /<1..4> /Intercon-Prot /LVRT /LVRT Profile] |

| Parameter | Description | Setting range | Default | Menu path |
|---|---|---|---|---|
| t9 | Point in time for the corresponding voltage value V(t(n)). These points define the LVRT profile. | 0.00 - 20.00s | 3.00s | [Protection Para<br>/<1..4><br>/Intercon-Prot<br>/LVRT<br>/LVRT Profile] |
| V(t10) | Voltage value of a point V(t(n)). These points define the LVRT profile. | 0.00 - 1.50Vn | 0.90Vn | [Protection Para<br>/<1..4><br>/Intercon-Prot<br>/LVRT<br>/LVRT Profile] |
| t10 | Point in time for the corresponding voltage value V(t(n)). These points define the LVRT profile. | 0.00 - 20.00s | 3.00s | [Protection Para<br>/<1..4><br>/Intercon-Prot<br>/LVRT<br>/LVRT Profile] |

*General application notes on setting the LVRT*

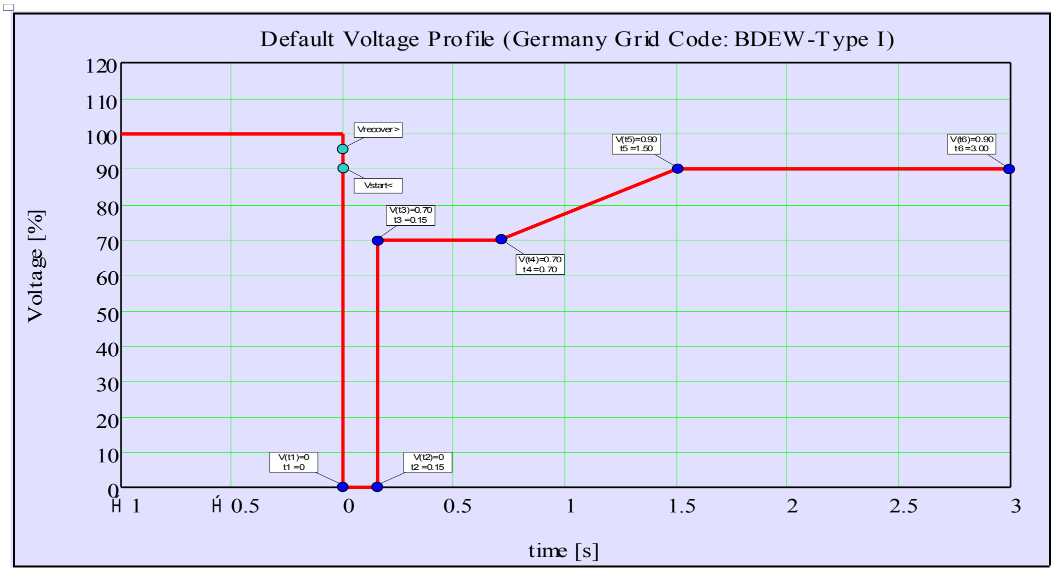
*The LVRT menu comprises among other things the following parameters:*

- By means of »*Vstart*«, the *LVRT* will be started (triggered).
- By menas of »*Vrecover*« the *LVRT* will detect the end of the disturbance.
- Please note, that the »*Vrecover*« should be greater than »*Vstart*«. If this is not the case, the internal plausibility supervision will set »*Vrecover*« to 103% of »*Vstart*«.
- »*Vk*«, »*tk*« are the set points for setting the *LVRT*-profile.

*Special application notes on setting the LVRT-profile*

- In many cases not all available setpoints are needed in order to build up the *LVRT*-profile.
- In case that not all available setpoints are used, the unused setpoints can be set to the same values as the last set point.
- Set points should be selected in a manner of left-to-right with time begin at t=0 (tk+1>tk).
- The voltage setpoints must be selected in a ascending manner (Vk+1>Vk).
- The voltage value for last used set point should be set greater than the starting voltage. If this is not the case, the starting voltage will be modified internally to the value of maximum voltage set value.

In general the factory default *LVRT*-profile is preset based on the Type-I curve from Germany Grid Code[1] (BDEW 2008) as shown in the following drawing:




*LVRT-Default Profile (BDEW-TypI)*

## Global Protection Parameters of the Low-Voltage-Ride-Through

| *Parameter* | *Description* | *Setting range* | *Default* | *Menu path* |
|---|---|---|---|---|
| ExBlo1 | External blocking of the module, if blocking is activated (allowed) within a parameter set and if the state of the assigned signal is true. | 1..n, Assignment List | -.- | [Protection Para<br>/Global Prot Para<br>/Intercon-Prot<br>/LVRT] |
| ExBlo2 | External blocking of the module, if blocking is activated (allowed) within a parameter set and if the state of the assigned signal is true. | 1..n, Assignment List | -.- | [Protection Para<br>/Global Prot Para<br>/Intercon-Prot<br>/LVRT] |
| ExBlo TripCmd | External blocking of the Trip Command of the module/the stage, if blocking is activated (allowed) within a parameter set and if the state of the assigned signal is true. | 1..n, Assignment List | -.- | [Protection Para<br>/Global Prot Para<br>/Intercon-Prot<br>/LVRT] |

## Inputs of the Low-Voltage-Ride-Through

| *Name* | *Description* | *Assignment via* |
|---|---|---|
| ExBlo1-I | Module input state: External blocking1 | [Protection Para<br>/Global Prot Para<br>/Intercon-Prot<br>/LVRT] |
| ExBlo2-I | Module input state: External blocking2 | [Protection Para<br>/Global Prot Para<br>/Intercon-Prot<br>/LVRT] |
| ExBlo TripCmd-I | Module input state: External Blocking of the Trip Command | [Protection Para<br>/Global Prot Para<br>/Intercon-Prot<br>/LVRT] |

## Signals (Output States) of the Low-Voltage-Ride-Through

| *Signal* | *Description* |
|---|---|
| active | Signal: active |
| ExBlo | Signal: External Blocking |
| Blo TripCmd | Signal: Trip Command blocked |
| ExBlo TripCmd | Signal: External Blocking of the Trip Command |
| Alarm L1 | Signal: Alarm L1 |
| Alarm L2 | Signal: Alarm L2 |
| Alarm L3 | Signal: Alarm L3 |
| Alarm | Signal: Alarm voltage stage |

| *Signal* | *Description* |
|---|---|
| Trip L1 | Signal: General Trip Phase L1 |
| Trip L2 | Signal: General Trip Phase L2 |
| Trip L3 | Signal: General Trip Phase L3 |
| Trip | Signal: Trip |
| TripCmd | Signal: Trip Command |
| t-LVRT is running | Signal: t-LVRT is running |

## Counter Values of the Low-Voltage-Ride-Through

| *Value* | *Description* | *Menu path* |
|---|---|---|
| NumOf Vdips in t-LVRT | Number of Voltage dips during t-LVRT | [Operation<br>/Count and RevData<br>/LVRT] |
| Cr Tot Numb of Vdips | Counter Total number of voltage dips. | [Operation<br>/Count and RevData<br>/LVRT] |
| Cr Tot Numb of Vdips to Trip | Counter Total number of voltage dips that caused a Trip. | [Operation<br>/Count and RevData<br>/LVRT] |

## Direct Commands of the Low-Voltage-Ride-Through

| *Parameter* | *Description* | *Setting range* | *Default* | *Menu path* |
|---|---|---|---|---|
| Res LVRT Cr | Reset of the counter for the total number of voltage dips and reset of the counter of the total number of voltage dips that caused a trip. | inactive,<br>active | inactive | [Operation<br>/Reset] |


References:

[1] Technische Richtlinie „Erzeugungsanlagen am Mittelspannungsnetz – Richtlinie für Anschluss und Parallelbetrieb von Erzeugungsanlagen am Mittelspannungsnetz“, Juni 2008, BDEW, Berlin

[2]IEEE Std 1547™-2003, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems.

[3]Title: Can China Wind Power meet the challenge of “Low-Voltage-Ride-Through” Date: 18.05.2011 Author: Shi Feng-Lei. http://energy.people.com.cn/GB/14667118.html.