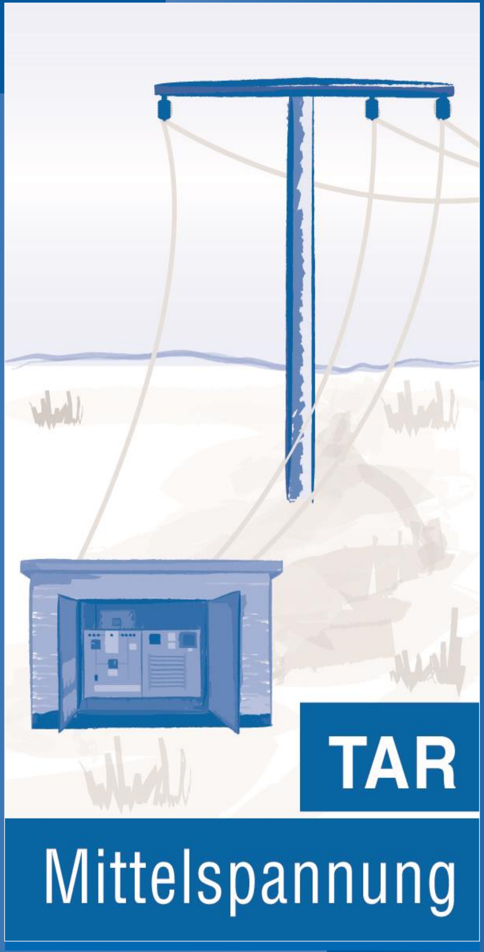
FNN

VDE

Summary of the draft VDE-AR-N 4110:2017-02



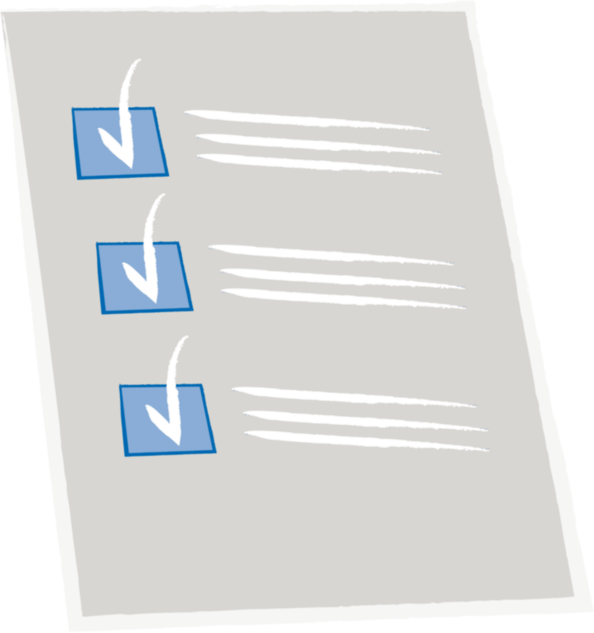
The following summary:

- does not cover all parts of the VDE-AR-N 4110 and is therefore not exhaustive;
- mainly covers the technical requirements for customer installations;
- and is purely informative.

February 2017

Overview

- Section 5 und 10.2.2 Static Voltage Stability
- Section 10.2.3 Dynamic Grid Support
- Section 10.2.4 Active Power Supply
- Section 10.3 Protection systems and protection settings



Section 5 and 10.2.2

Static Voltage Stability

10 power generating modules - Overview

Requirements for

- power generating modules and power generating units
- combined facilities of generation/demand/storage
- Storage

For combined facilities of generation/demand/storage it is important to note the

- Protection concept (10.3)
- Use of emergency generators (8.9)
- Frequency-dependent active power response (10.2.4.3)
- Dynamic grid support (10.2.3)
- Active power demand by the grid operator (reduction) (10.2.4.2)
- Static voltage stability (10.2.2)
- Evidence of electrical properties (11)

10.2 Behavior of the power generating module connected to the grid during steady-state operation

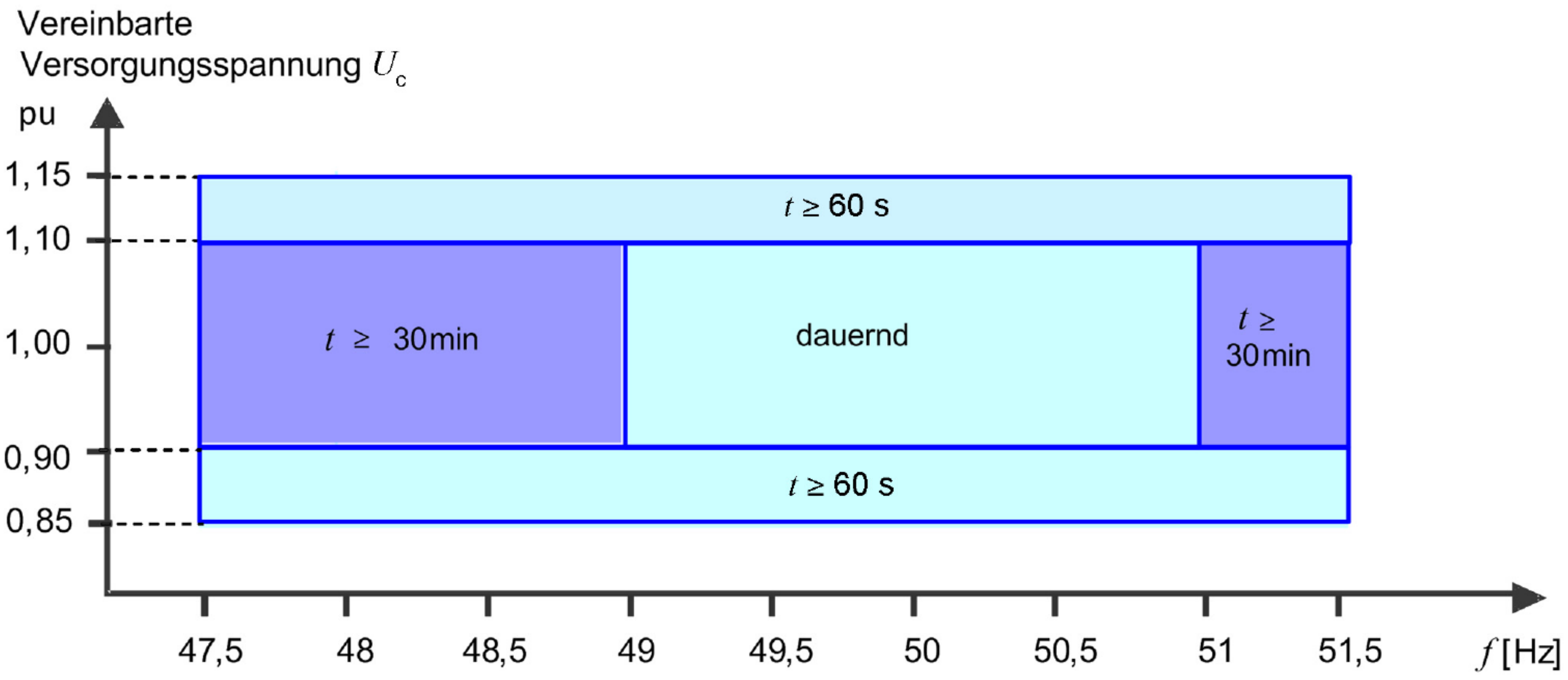


Bild 4 – Anforderungen an den quasistationären Betrieb von Erzeugungsanlagen

10.2 Behavior of the power generating module connected to the grid during steady-state operation

Definition of steady-state operation

- Voltage gradient < 5 % U_c min $^{-1}$
- Frequency gradient < 0.5 % f_n min $^{-1}$

power generating modules must remain on the grid in steady-state operation, as per Figure 4

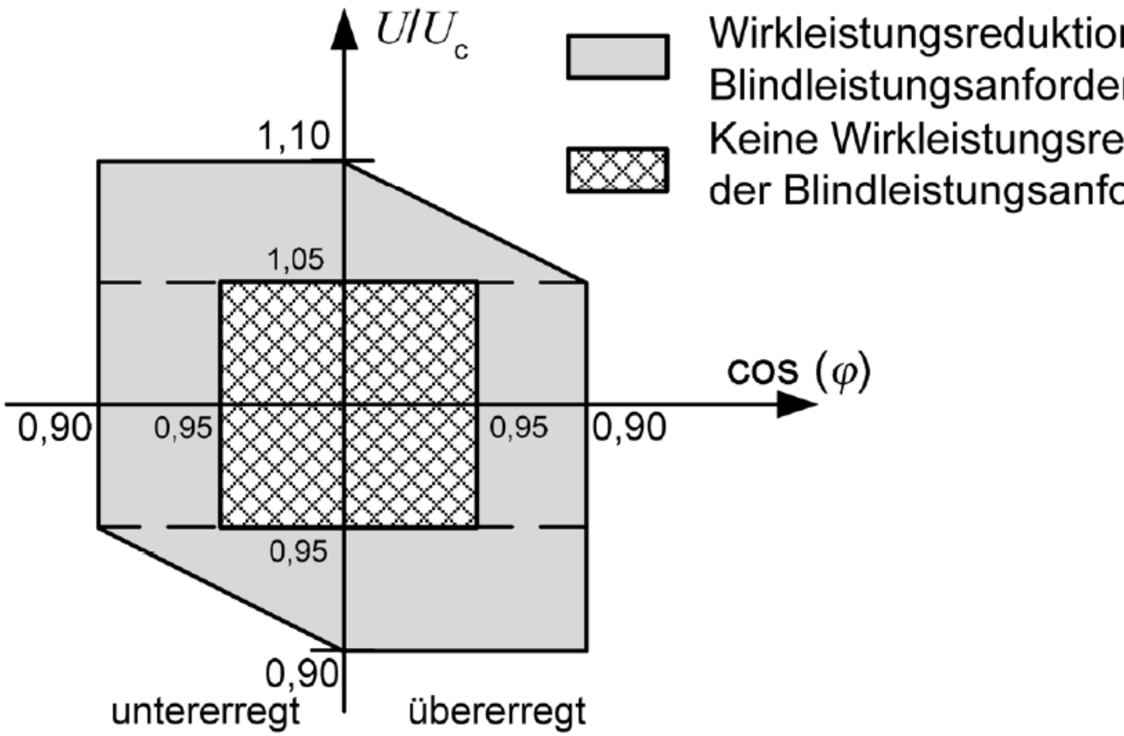
10.2 Behavior of the power generating module connected to the grid during steady-state operation

- In the voltage range from 90 % U_c to 110 % U_c voltage gradients of greater than 5% U_c min^{-1} can occur.
- For voltages outside the voltage range 90 % U_c to 110 % U_c the active power and the reactive power supply can be reduced to protect the power generating module.

10.2 Behavior of the power generating module connected to the grid: Rotating or grid oscillation, subnetwork operability and Black Start capability

- Oscillations in the continental European grid with frequencies of 0.15 – 1.5 Hz
  - With this, the voltage can lie outside Figure 4 for a few seconds
  - For this reason, do not isolate supply from power generating modules when there is a symmetrical voltage curve in operation at 0.8 U_c – 1.2 U_c for 5 sec.
  - During grid oscillation, the active power can be reduced to avoid overloading
- If a loss of stability occurs, the generation units must be isolated from the grid
- Subnetwork operability, Black Start capability, Isolated network and Black Start capability are not minimum requirements

10.2.2 Static voltage stability/ reactive power supply



MV – Directive 2008

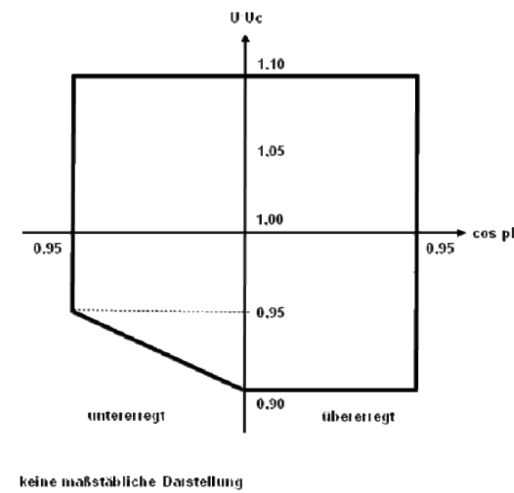


Bild 5 – Anforderungen an Erzeugungsanlagen an die Blindleistungsbereitstellung am Netzanschlusspunkt

10.2.2 Static voltage stability/ idle power supply

- Supply of reactive power in the power generating module to maintain voltage when slow (steady-state) voltage changes
- Requirements for the grid connection point
- Active power reduction of max. 10 % $P_{b\ inst}$ permitted outside the shaded area in Figure 5

Note: The reactive power area in the design is not yet fully complete in the project group (see introduction)

10.2.2 Static voltage stability/ reactive power capability below $P_{b\ inst}$

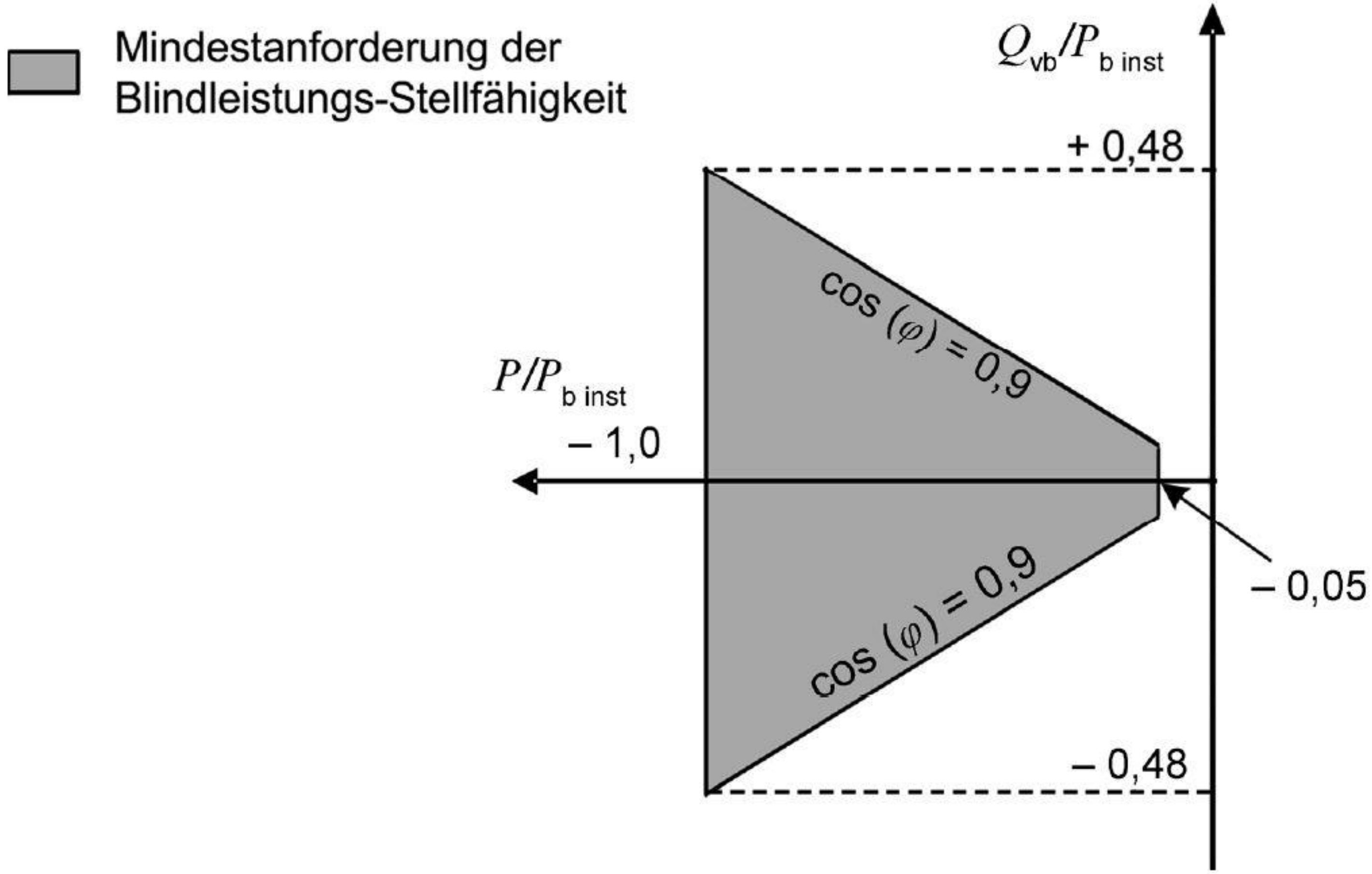


Bild 6 – *P*/*Q*-Diagramm der Erzeugungsanlage am Netzanschlusspunkt im Verbraucherzählpfeilsystem

10.2.2 Static voltage stability/ reactive power supply less than $P_{b\ inst}$

- Requirements for the reactive power capability at partial load P_{mom}
- $(0.05 < P_{mom} / P_{b\ inst} < 1)$ at grid connection point
- Maximum residual deviation ± 2.0 % with regard to P_{inst}, for power generating modules < 300 kVA maximum ± 4.0 % with regard to P_{inst}.
- Reactive power in range $0 \leq P_{mom} / P_{b\ inst} < 0.05$ no more than 5 % of sum of stipulated active power supply $P_{AV,\ E}$.

10.2.2 Static voltage stability: Procedure for reactive power supply at the grid connection point

a) Q (U)
b) Q (P)
c) Reactive power kvar
d) displacement factor cos φ

MV – Directive 2008
a) fixed displacement factor cos φ
b) cos φ (P)
c) fixed reactive power MVar
d) Q (U)

- Control behavior of reactive power qualitatively according to PT1 – behavior for procedure a), b) and c)
- Specification of fixed setpoint or variable setpoint via remote control system (or other control technology)
- Reactive power adjustment of power generating module in range 6 s – 60 s (for 95 % of set point jumps)

Note: Testing of adjustment times by the working group pending

10.2.2 Static voltage stability
set point jump overall

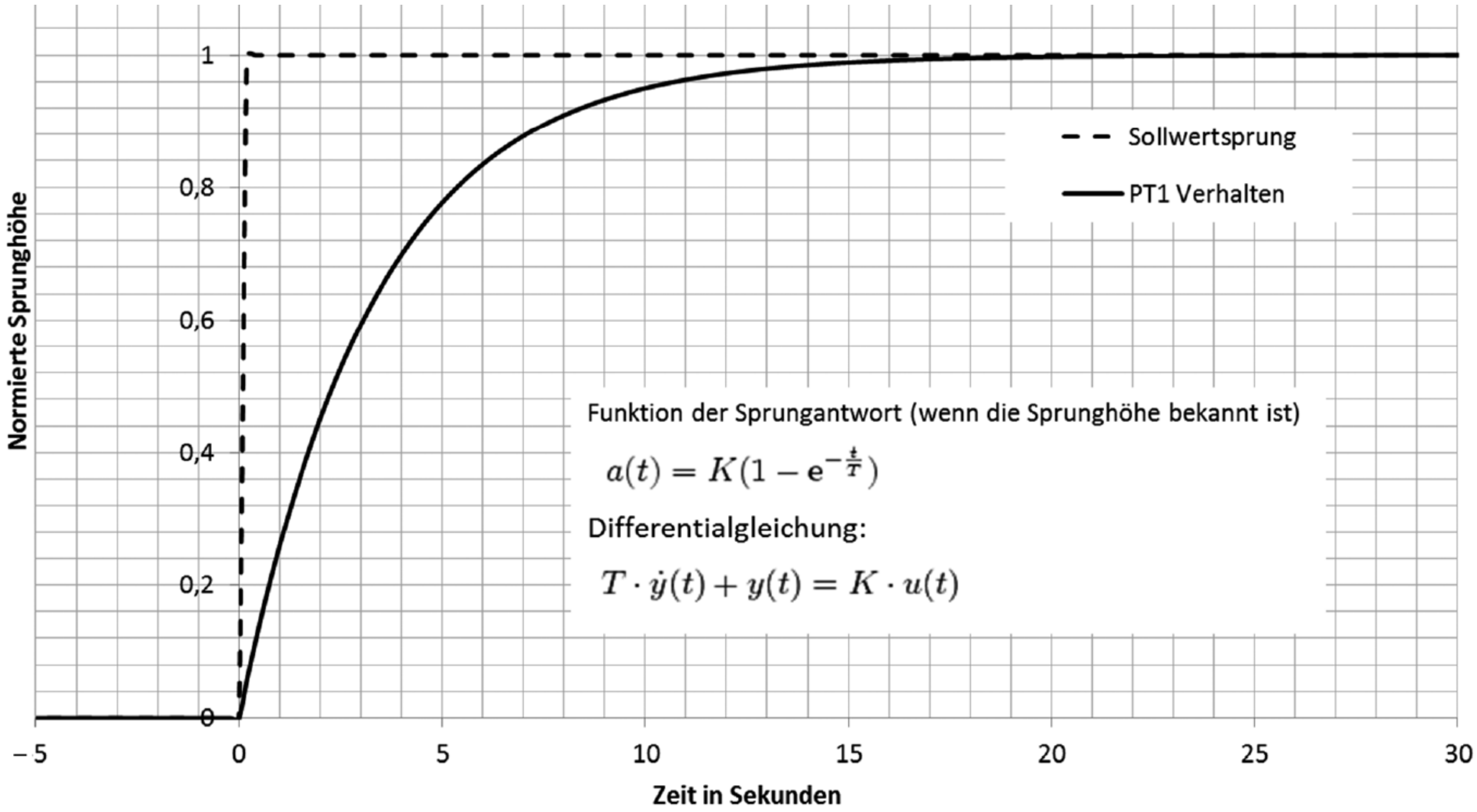


Bild 7 – Beispiel des Regelverhaltens bei einem Sollwertsprung mit der Höhe 1 (normiert) und einer Zeitvorgabe (3 Tau) von 10 s

10.2.2 Static voltage stability
set point jump with tolerances relevant to analysis

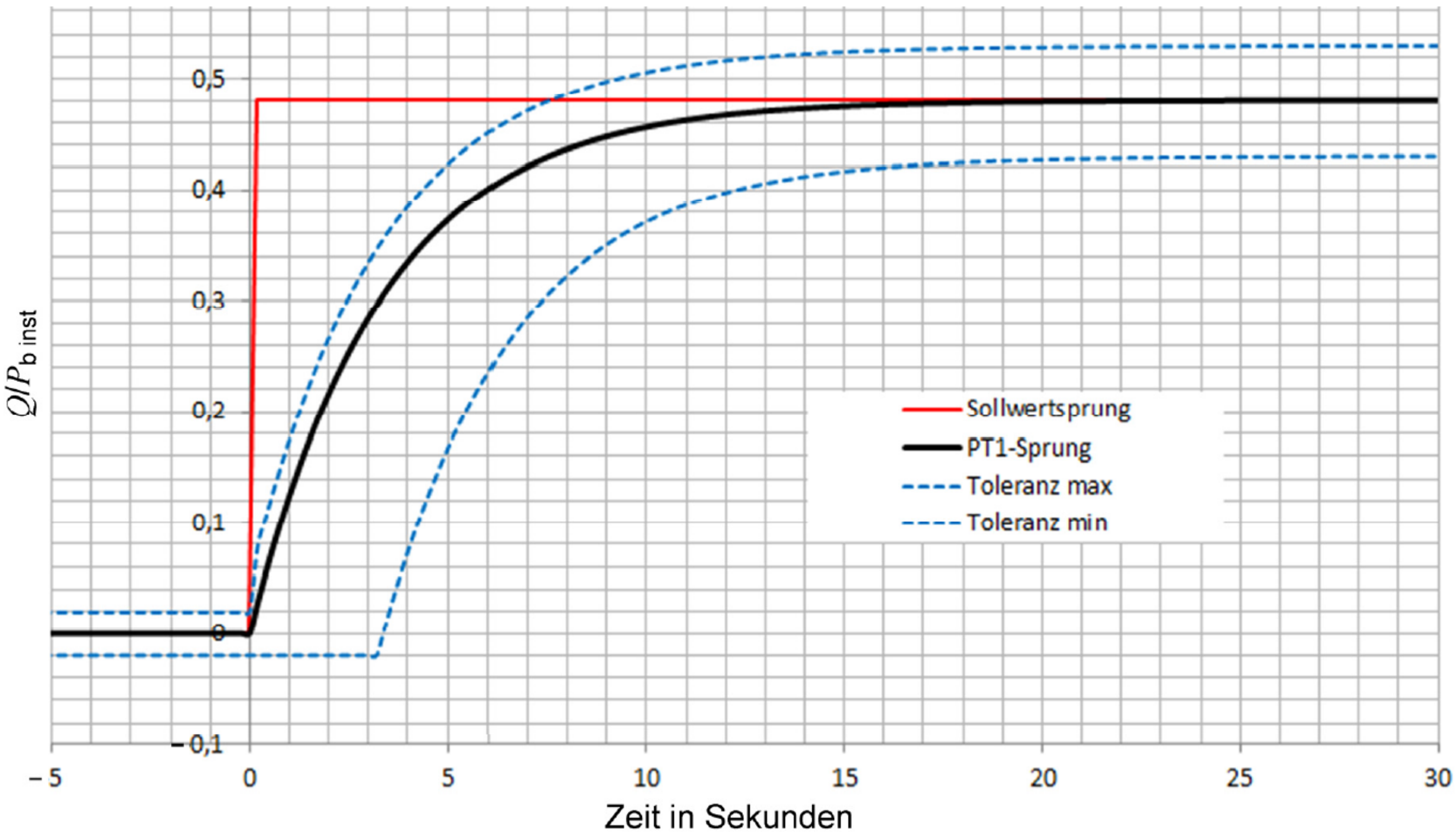


Bild C.3 – Veranschaulichung bei 3 Tau = 10 s

a) Reactive power – voltage curve Q (U)

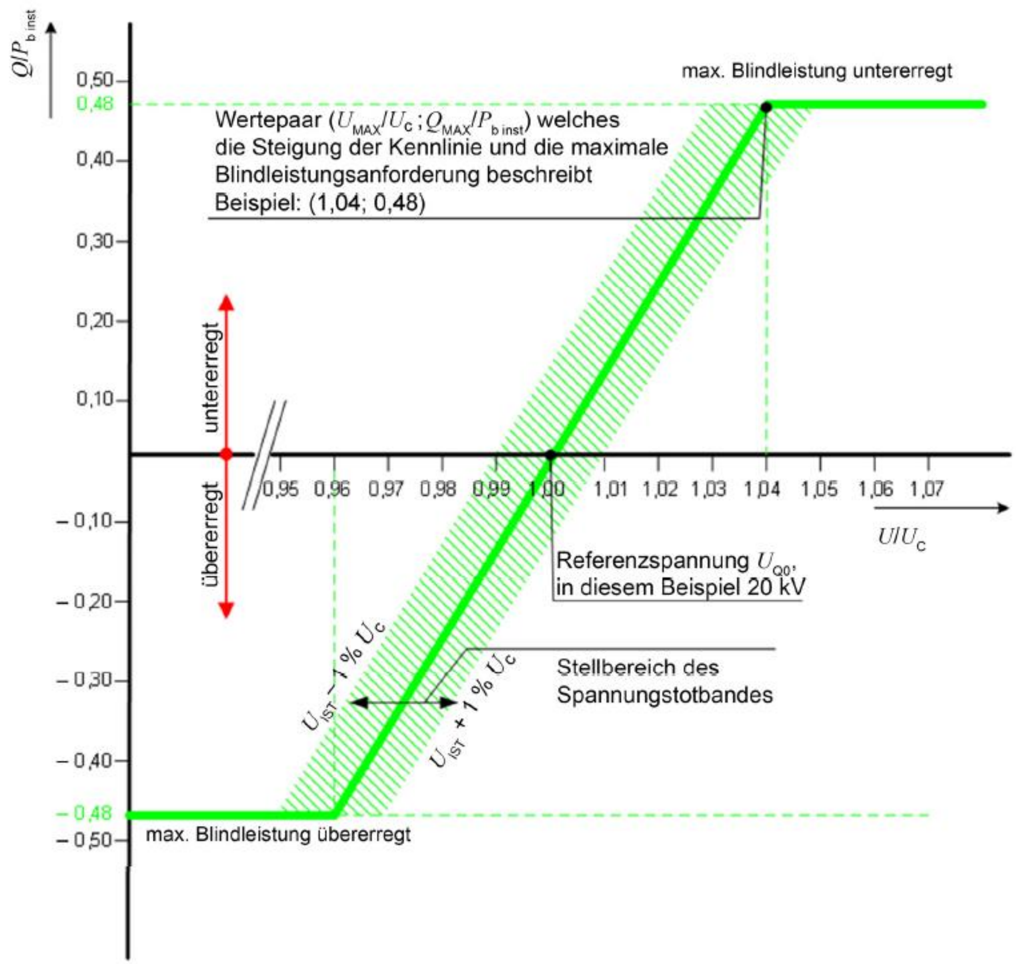


Bild 8 – Beispiel für die Standard-Q (U)-Kennlinie

a) Reactive power - voltage curve Q (U)

- The curve values are preset (in the course of planning)
- Curve adjustment by grid operator only within reference voltage U_{Q0} / U_C by remote control technology. I.e. horizontal parallel shift of the curve in 0.5 % U_C increments.
- Enabling/disabling of Q (U) – curves – control via remote control technology or manually.

b) Reactive power curve as function of performance Q (P)

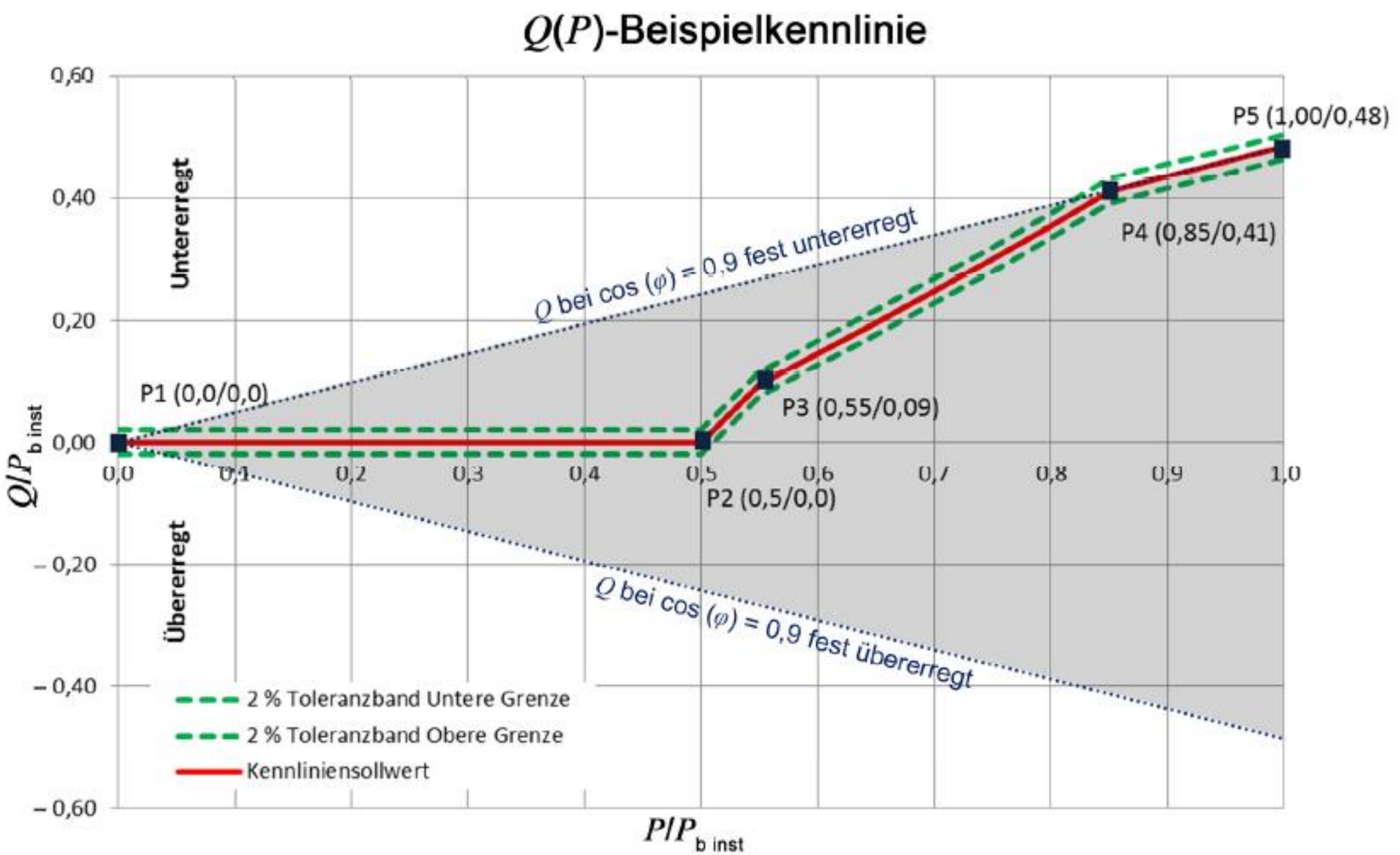


Bild 9 – Beispiel für eine *Q (P)*-Kennlinie

b) Idle power curve as function of performance Q (P)

- Supply of reactive power depending on the current active power supply $Q = f(P_{mom})$
- Curve adjustment via remote control is not foreseen. It will be defined over max. 10 grid points that can be set manually.
- Enabling and disabling of Q (P) – curve by remote control technology (disabled cos φ ~ 1)

c) Reactive power

- Supply of reactive power independent of active power supply
- Setpoint in relation to agreed active connection power ($Q_{EA, soll}$ / $P_{b\ inst}$ [%]) termination max. 1% $P_{b\ inst}$.
- Setpoints are in range shown by P/Q – diagram (Figure 6)
- Should remote control technology fail (> 1 min), the default – setpoint of 0 % should be applied, if no value is given by the grid operator.

d) Displacement factor cos φ

- Supply of reactive power to the grid with a constant ratio of active and apparent power.
- Specification of setpoint with minimum steps of Δ cos φ = 0.005.
- Maximum fault tolerance of reactive current supply calculated from the fault tolerance of ± 2 % or ± 4 % in regard to $P_{b\ inst}$.
- Grid operator provides setpoint (not provided cos φ = 1)
- Specification of setpoint possible via remote control technology.
- Reaction time max. 1 min for changes to setpoint.

10.2.2.6 Special requirements for combined facilities of generation/demand/storage with demand facilities

- Requirements for the static voltage stability/ reactive power supply for power generating modules and storage must be maintained at the grid connection point.
- Impact of loads is not taken into account
- For reactive power supply Q(U); Q(P); kvar; cos φ, a simplified solution can be implemented if
  - P_{inst}, installed active power of the power generating module ≤ 50 % of the agreed reference power $P_{AV, B}$ of the combined facility of generation/demand/storage
  - Agreement of the grid operator

10.2.2.6 Special requirements for combined facilities of generation/demand/storage with demand facilities

Simplified solution

- for Q(P); kvar; cos φ, the measurement of reactive and active power can be undertaken at the generation unit (with computed correction)
- For Q (U), the voltage measurement must be taken at the voltage level of the grid connection point. Shift of the measuring point within the voltage level is possible if $\Delta U \leq 0.2\ \%\ U_C$.
- Measurement of reactive power supply at the generation unit.

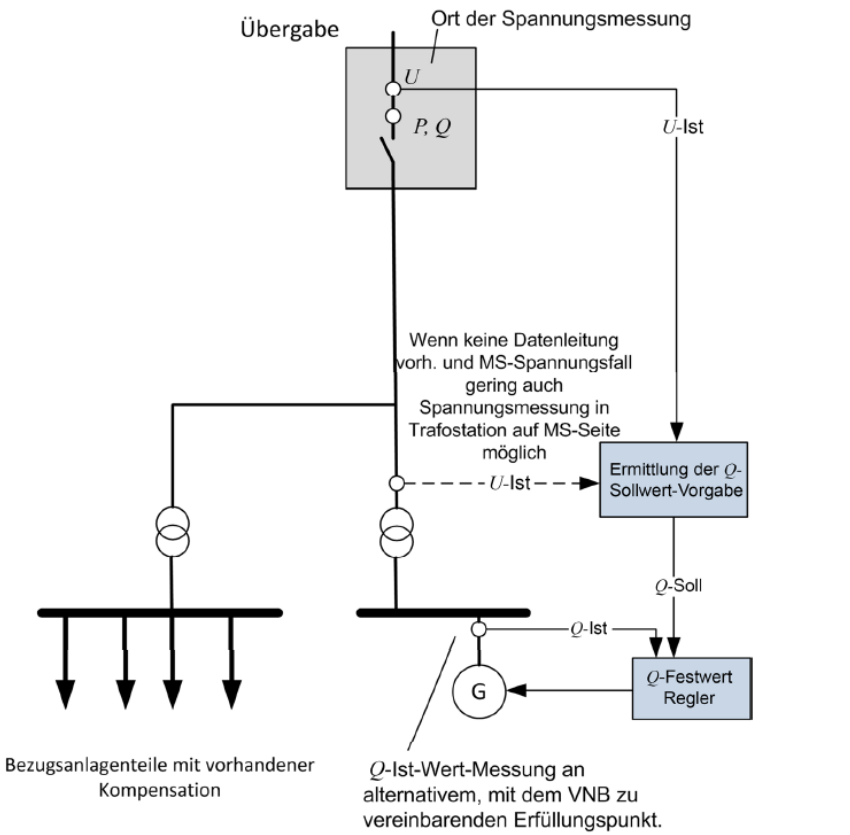


Bild 11 – Beispiel der Erfüllung der *Q*(*U*)-Kennlinien-Regelung an zu vereinbarendem Ort bei Mischanlagen

Section 10.2.3

Dynamic Grid Support

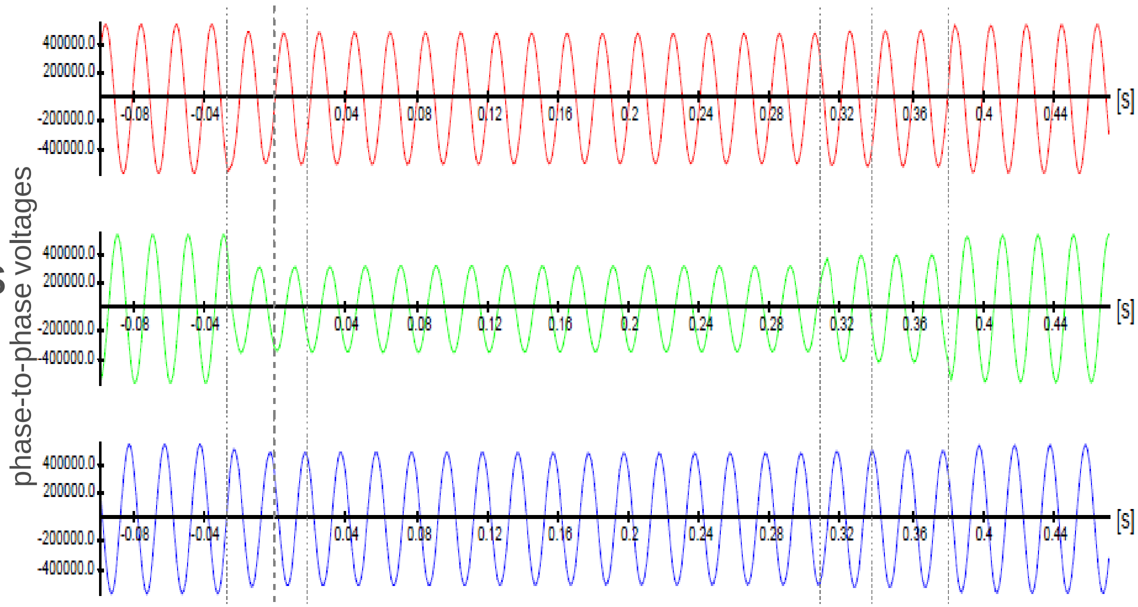
Outline

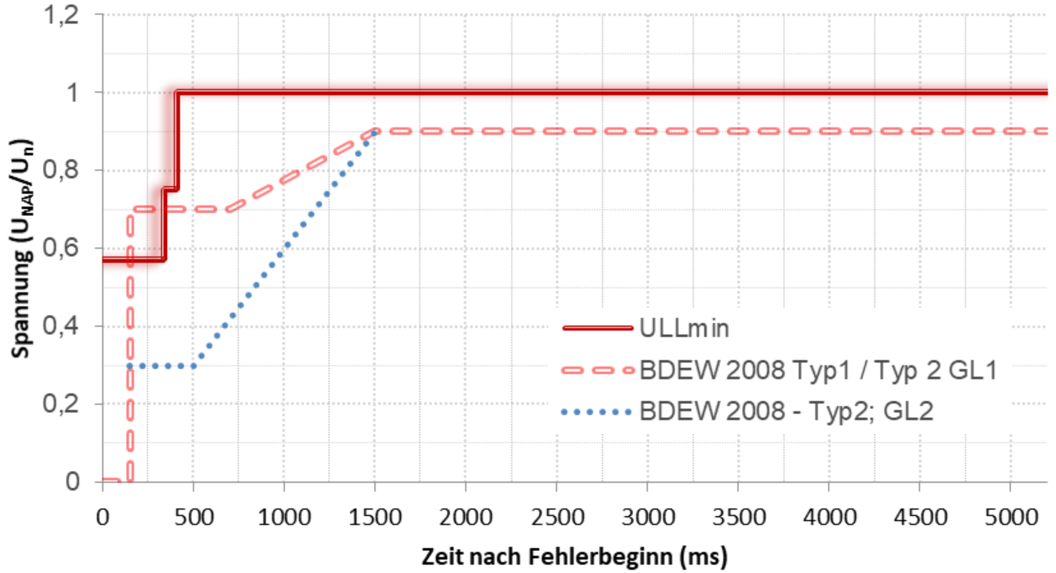
- Introduction and brief review of BDEW medium voltage directive
- Draft AR-N 4110 - overview
- Type 1-modules
  - Time constraints
  - Other requirements
  - Multiple faults
- Type 2-modules
  - Fault start / fault end
  - Time constraints
  - Comprehensive and Restricted Dynamic Grid Support
  - Multiple faults
- Behavior after fault end (Type1 and Type 2)

Introduction with review

Motivation

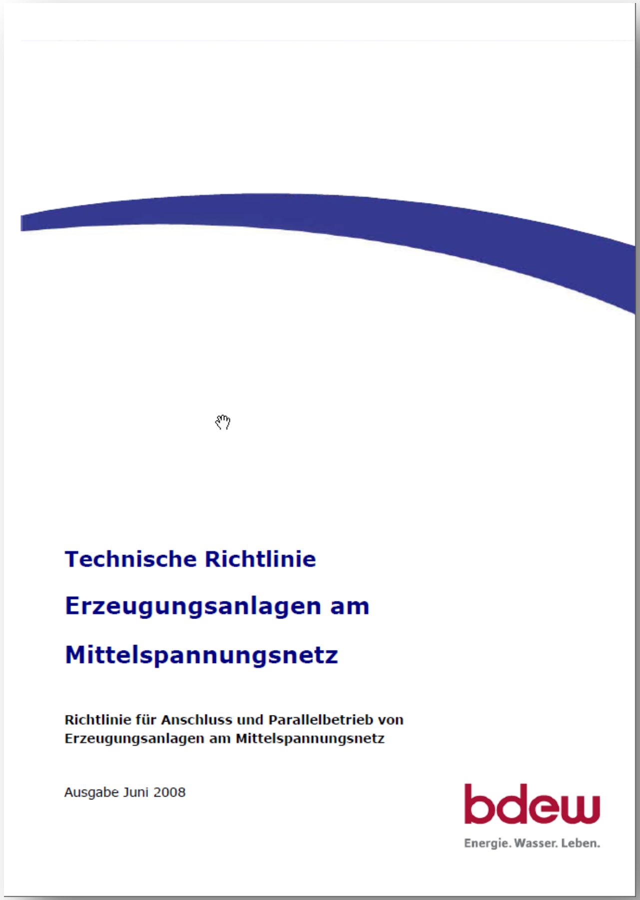
- Example: Two-phase faults in high voltage grid
- max. changes to voltage: Positive sequence: 20% negative sequence: 21%
- Unsymmetrical faults far more frequent than symmetrical
- Also incorporate fault-remote systems in the voltage support
- Support after the fault, to maintain reactive power allowance





Status Quo: dyn. grid support in the BDEW medium voltage directive

- Riding through grid faults with defined timed limits
- Supply of a short-circuit current with agreement of the grid operator, in accordance with TransmissionCode 2007 (TC2007)
- Increase in voltage should be limited in non-faulty phases
- Type-2 modules: Temporary disconnection allowed in principle if necessary upon agreement with the grid operator
- Grid support also in the case of repeated Automatic Restart (AR)
- Active power re-establishment min. 10% P_n/s

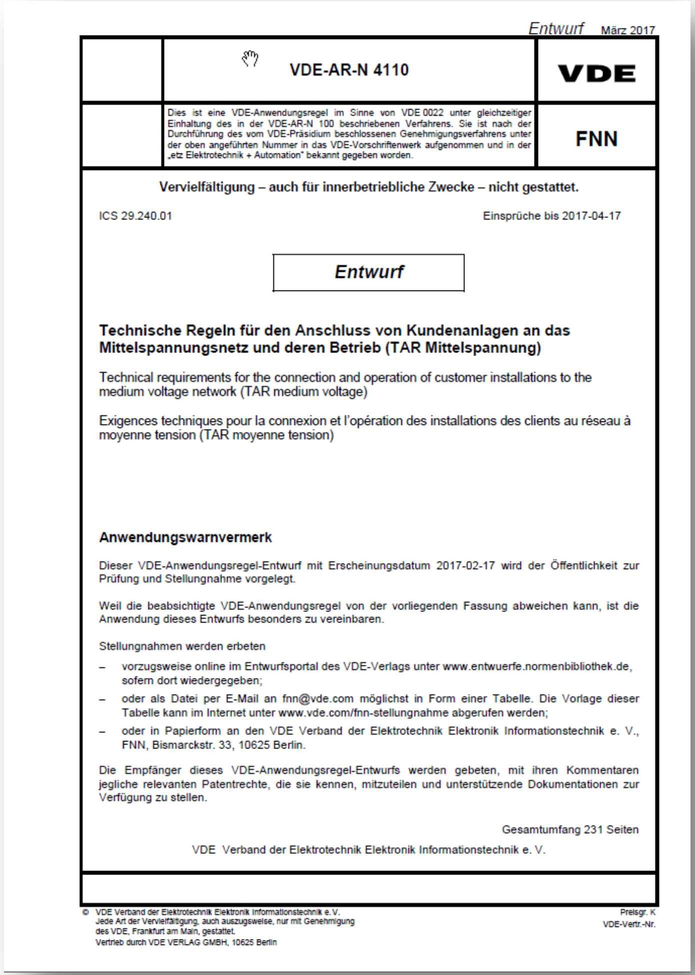

Technische Richtlinie
Erzeugungsanlagen am
Mittelspannungsnetz

Richtlinie für Anschluss und Parallelbetrieb von Erzeugungsanlagen am Mittelspannungsnetz

Ausgabe Juni 2008

bdew
Energie. Wasser. Leben.

Draft AR-N 4110



Entwurf März 2017

VDE-AR-N 4110

VDE

Dies ist eine VDE-Anwendungsregel im Sinne von VDE 0022 unter gleichzeitiger Einhaltung des in der VDE-AR-N 100 beschriebenen Verfahrens. Sie ist nach der Durchführung des vom VDE-Präsidium beschlossenen Genehmigungsverfahrens unter der oben angeführten Nummer in das VDE-Vorschriftenwerk aufgenommen und in der „etz Elektrotechnik + Automation" bekannt gegeben worden.

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Vervielfältigung – auch für innerbetriebliche Zwecke – nicht gestattet.

ICS 29.240.01 Einsprüche bis 2017-04-17

Entwurf

Technische Regeln für den Anschluss von Kundenanlagen an das Mittelspannungsnetz und deren Betrieb (TAR Mittelspannung)

Technical requirements for the connection and operation of customer installations to the medium voltage network (TAR medium voltage)

Exigences techniques pour la connexion et l'opération des installations des clients au réseau à moyenne tension (TAR moyenne tension)

Anwendungswarnvermerk

Dieser VDE-Anwendungsregel-Entwurf mit Erscheinungsdatum 2017-02-17 wird der Öffentlichkeit zur Prüfung und Stellungnahme vorgelegt.

Weil die beabsichtigte VDE-Anwendungsregel von der vorliegenden Fassung abweichen kann, ist die Anwendung dieses Entwurfs besonders zu vereinbaren.

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Gesamtumfang 231 Seiten

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Preisgr. K
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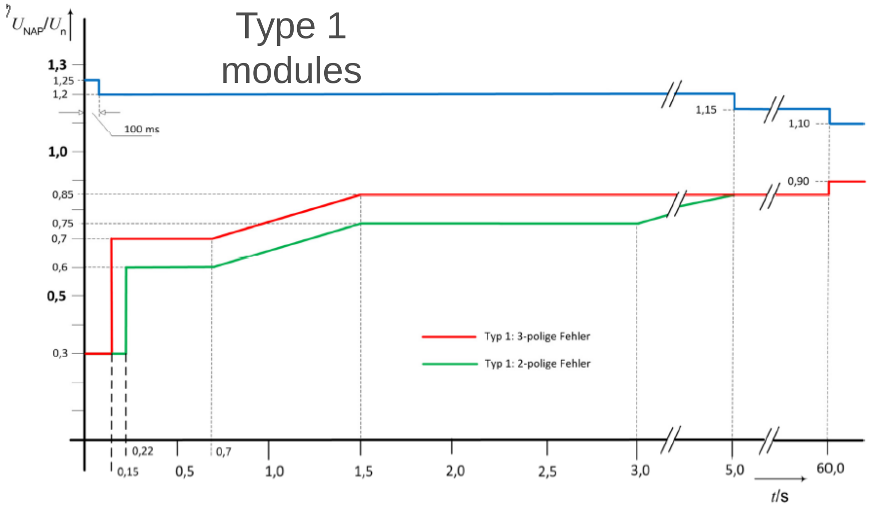
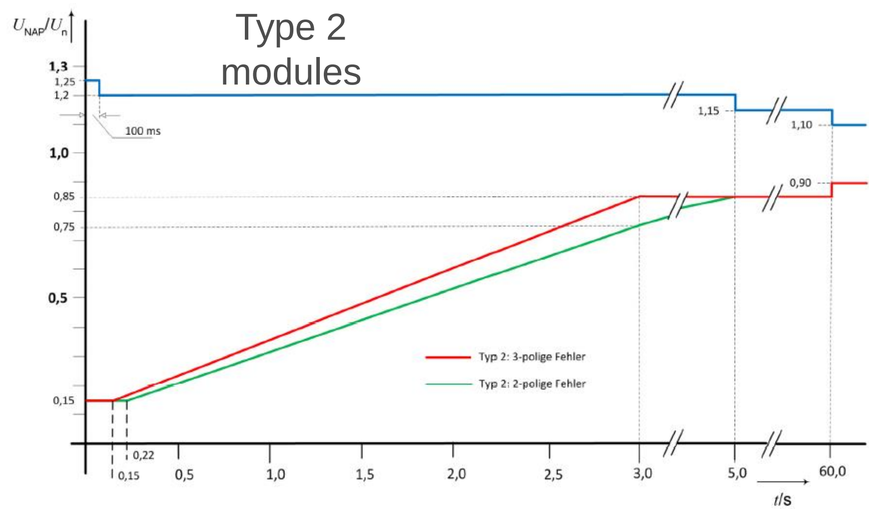
Dynamic Grid Support for AR-N-4110 - Fundamentals

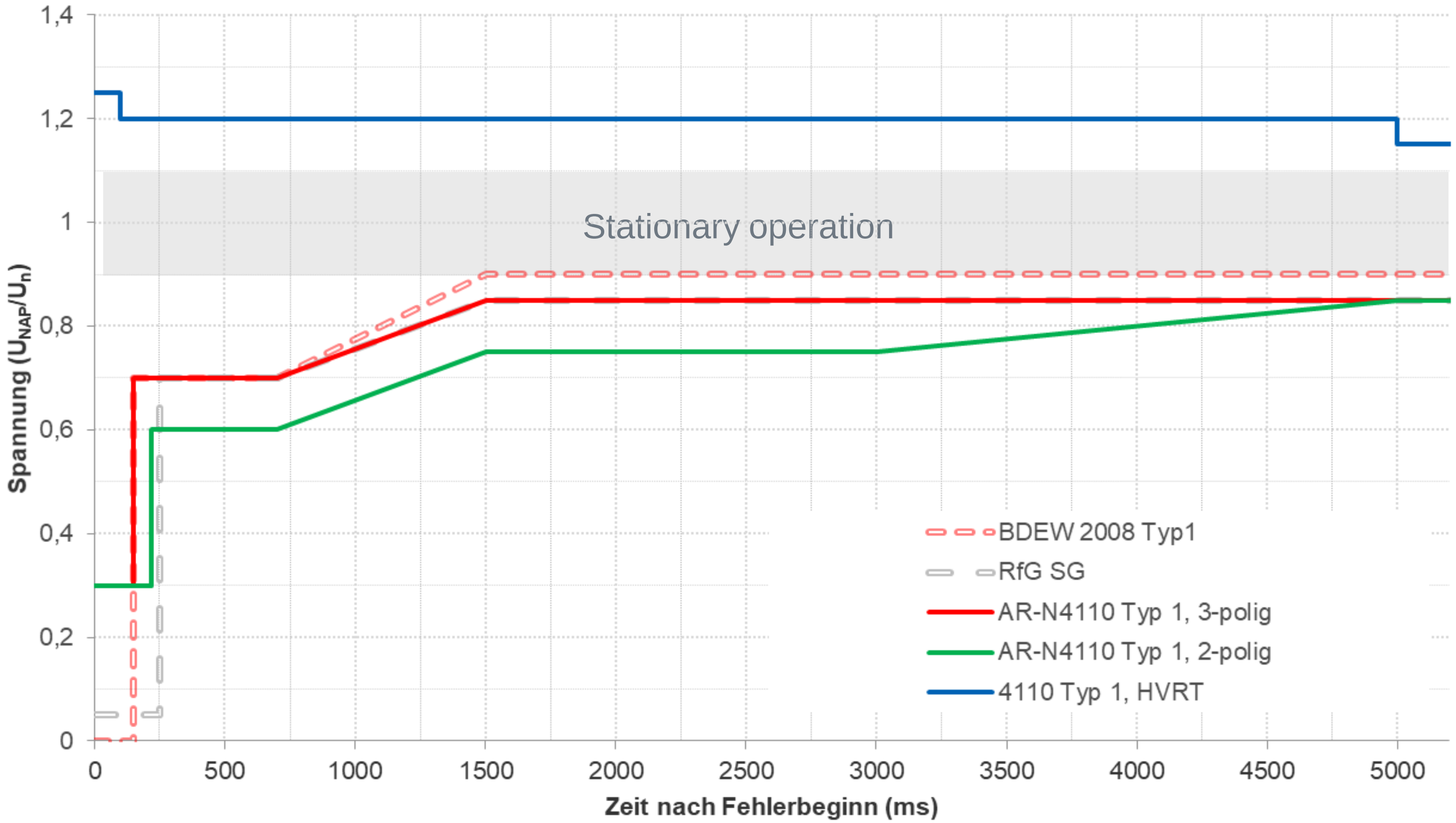
- power generating modules must ride through *symmetrical and unsymmetrical* grid faults
- to evaluate: smallest/largest of the three phase-to-phase voltages on the GCP (half-frequency oscillation RMS)
- Dynamic reactive current support in the positive and negative sequence
- Multiple faults must also be ridden through
- Voltage surges within the FRT curves must not lead to tipping





Type 1 modules
(directly linked synchronous generators)

Type 1 modules: Time constraints



- LVRT requirements were **slightly adjusted** (RfG curve for **symmetrical faults**)
- **Two-phase faults:** often more profound issue, usually non-critical for PGM (green curve)
- New: Requirements for riding through **surges** (HVRT)

Other / general requirements Type 1 modules

- Voltage drops within the a.m. limit curve should be ridden through if S_k“ is > 5 $S_{A,Ges}$ after end of fault in the relevant grid
- Voltage regulator settings and software status must be defined and traceable
- Maximum voltage increase in the functioning external conductors maximum 5% U_C compared to pre-fault voltages

- Behavior after fault end

  Increase in active current as quickly as possible, response time maximum 3 seconds

Multiple faults

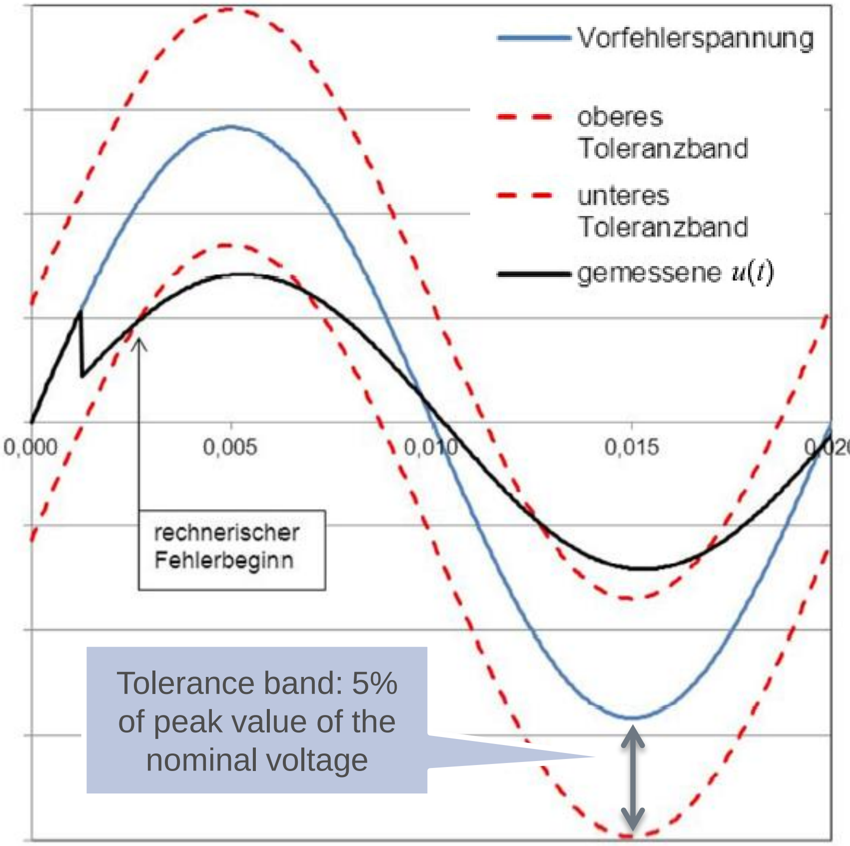
- It must be possible to ride through multiple consecutive faults
- Thermal design of the generator according to DIN EN 60034-1 must be guaranteed
- Tipping permitted, if these thermal limits are exceeded due to multiple faults

Type 2 modules
generators that do not comply with Type 1

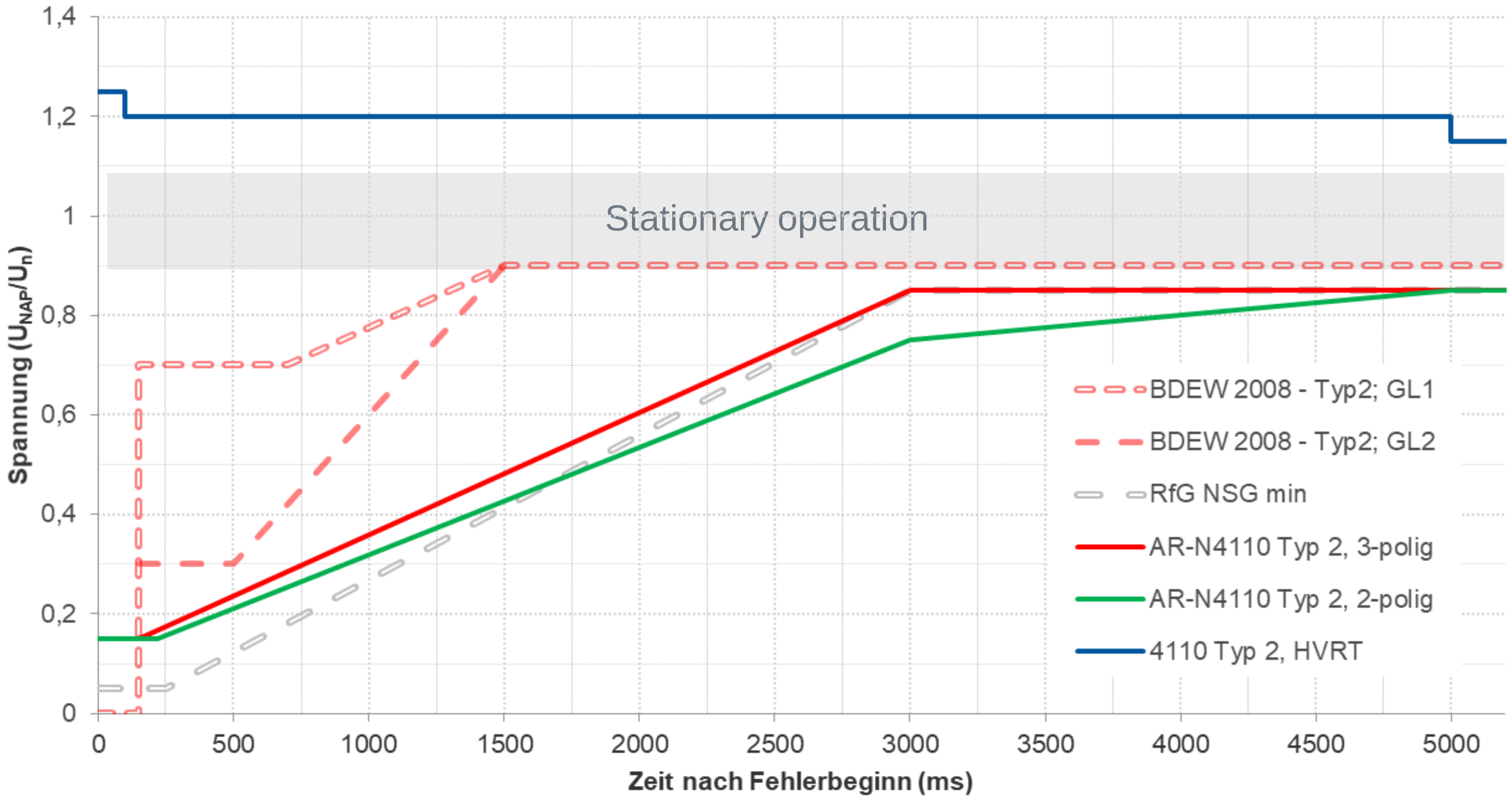
Type 2 modules: Fault start and end

- Criteria for fault start:
  - sudden voltage changes compared to 50 pre-fault voltage periods
  - Voltages > 1.1 U_C [max. 1.15 U_C] or < 0.9 U_C
    U_C: Agreed supply voltage, usually equals U_n
- Criteria for fault end:
  - 5s after fault start
  - Restoration of all L-voltages in the range of 0.9 U_C< U <1.1 U_C
- New faults, as soon as a criterion for fault end is completed

Example of a sudden voltage change



Type 2 modules: Time constraints



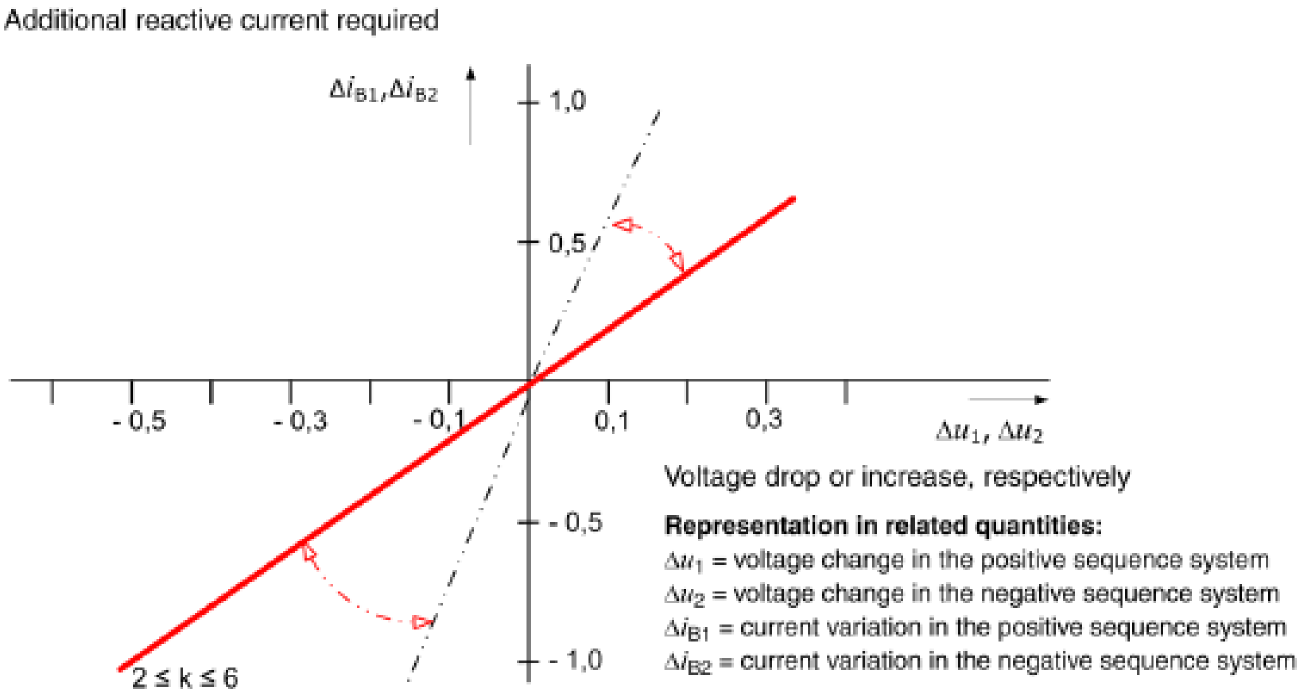
- Requirements of Type 2 modules **expanded**, to conform to RfG limit curve
- **Two-phase faults:** often more profound issue, usually non-critical for EZA (green curve)
- New: Requirements for riding through **surges** (HVRT)

Type 2 modules: Comprehensive Dynamic Grid Support

- Supply of an additional reactive current from fault start (standard configuration, if not explicitly stated otherwise)
- Objective: Optimum grid support for symmetrical and unsymmetrical faults
- Minimization of surges in non-faulty phases → grid support in positive and negative sequence
- Voltage measurement and provision of additional reactive current at the PGU
- Reactive current is prioritized
- After fault end:
  Increase in active current to pre-fault value within maximum one second (response time)

Type 2 modules: Comprehensive Dynamic Grid Support

- Context: 1 min mean value for the grid voltage ($U_2 \rightarrow 0$)
  → unchanged reference for the whole duration of the fault
- $$\Delta u_1 = \frac{U_1 - U_{1min}}{U_C}$$
  $$\Delta u_2 = \frac{U_2}{U_C}$$
- zus. Blindstrom:
  $$\Delta i_{B1,2} = k \cdot \Delta u_{1,2}$$
- Dynamik:
  $$T_{an_{90\%}} \leq 30\text{ ms}$$
  $$T_{ein\_\Delta x} \leq 60\text{ ms}$$



Restricted Dynamic Grid Support

- Intermediate supply to the grid through comprehensive dynamic grid support can limit the effectiveness of an Automatic Restart (AR)
- Therefore: Grid operator can request that grid faults are ridden through without current supply
- Criterion for fault start: $U < 0.8\ U_C$
- For voltage surges above this limit: undertake comprehensive dynamic grid support

Multiple faults

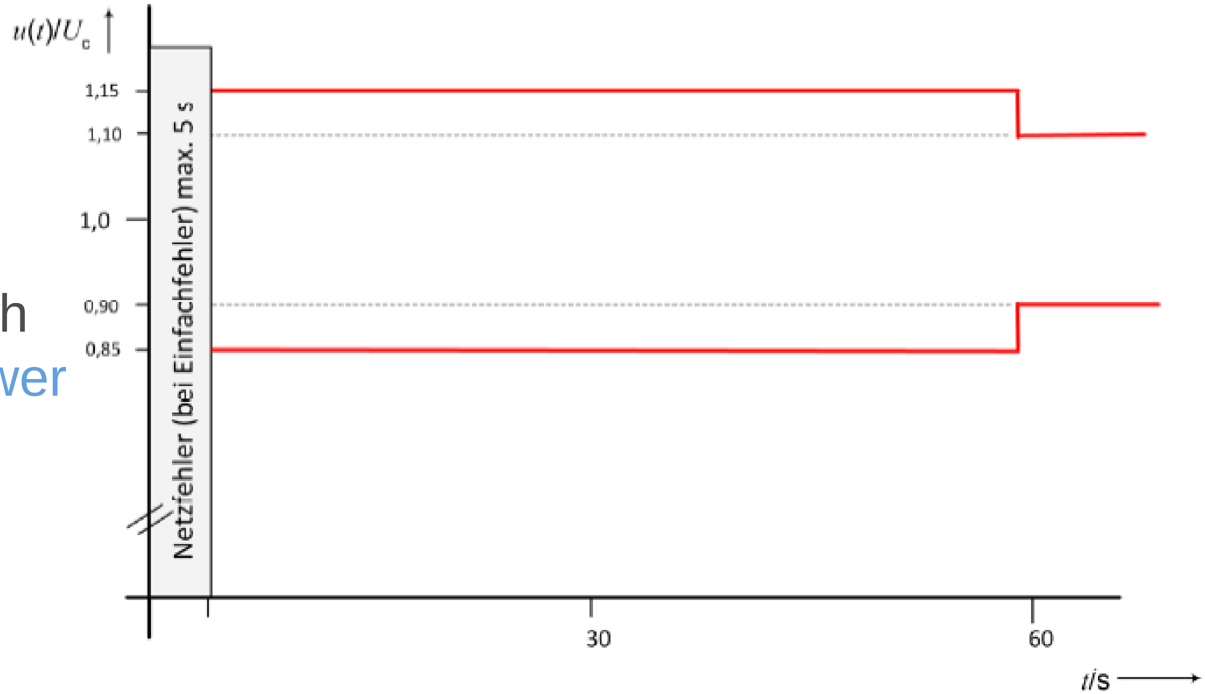
- It must be possible to ride through an arbitrary sequence of grid faults
- For some plant types, limitation is possible (e.g. thermal limits with the use of choppers)

  → Requirement is limited to the energy to be removed or not supplied to the grid of $P_{Emax} \cdot 2s$
- between multiple grid fault sequences, a time of 30min is estimated

Behavior after fault end (Type 1 and Type 2)

Conduct between fault endings and stage. Plant (Type 1 & 2)

- after fault end, the grid voltage is possibly still outside the range U_C ± 10% until the HV/MV transformers stepping switch re-adjusts
- modules may still have to supply a reactive current, to prevent a triggering of the protection mechanisms
- possible support through adaptation of active power



Summary

- Requirements of AR-N 4110 for dynamic grid support are more extensive than previously and were aligned with the RfG framework
- The required conduct was specifically defined regarding:
  - unsymmetrical faults
  - definition of fault start / end for Type 2 modules
  - conduct after the fault
  - dynamic
  - Multiple faults

Section 10.2.4

Active Power Supply

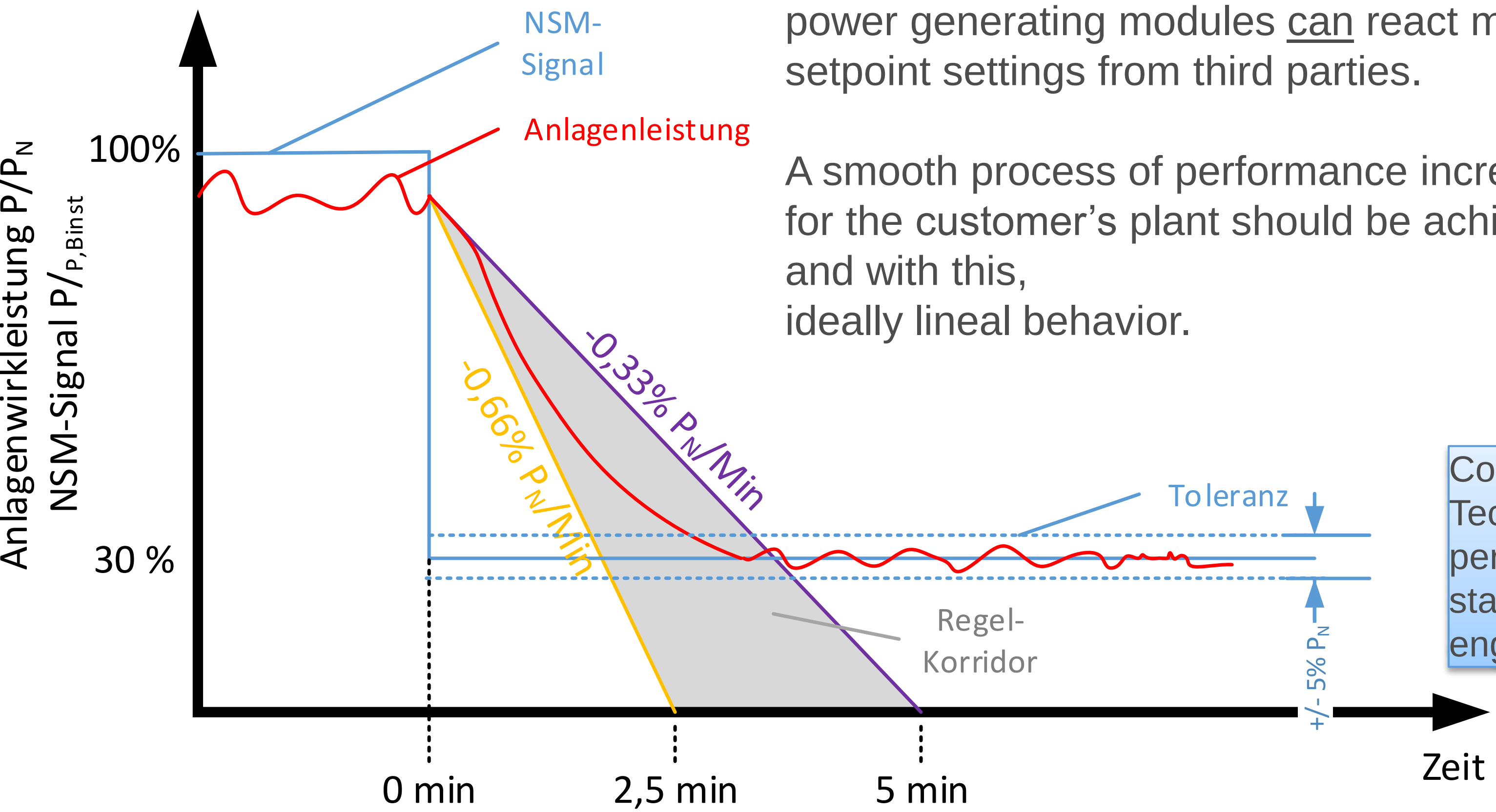
Requirements for power generating modules – active power supply

- 10.2.4.1 Overview
  - Speed restrictions
  - Prioritisation
- 10.2.4.2 Grid security management
  - DSO requirements
  - Implementation for combined facilities of generation/demand/storage
- 10.2.4.3 Active power supply for over or under frequency
  - Requirements of grid retention
  - P-f curve

PGM – active power supply / overview

- Challenges:
  - increasing number of plants participate in direct marketing
  - higher power gradients up to 15 min change as a result
  - sudden power changes are always dangerous
  - synchronized plant behavior potentially critical
  - with system performance, “many cooks” are increasingly involved.
  - also for surface circuits by DSO (cascade), a greater change to performance is required.
  - in future, controllable demand facilities are also likely

PGM – active power supply / limitation of gradients



Limitation of performance gradients are for increasing and reducing active power supply and active power usage

– no faster than in 2.5 min (0.66 % P_N per second);

– no slower than in 5 min (0.33 % P_N per second).

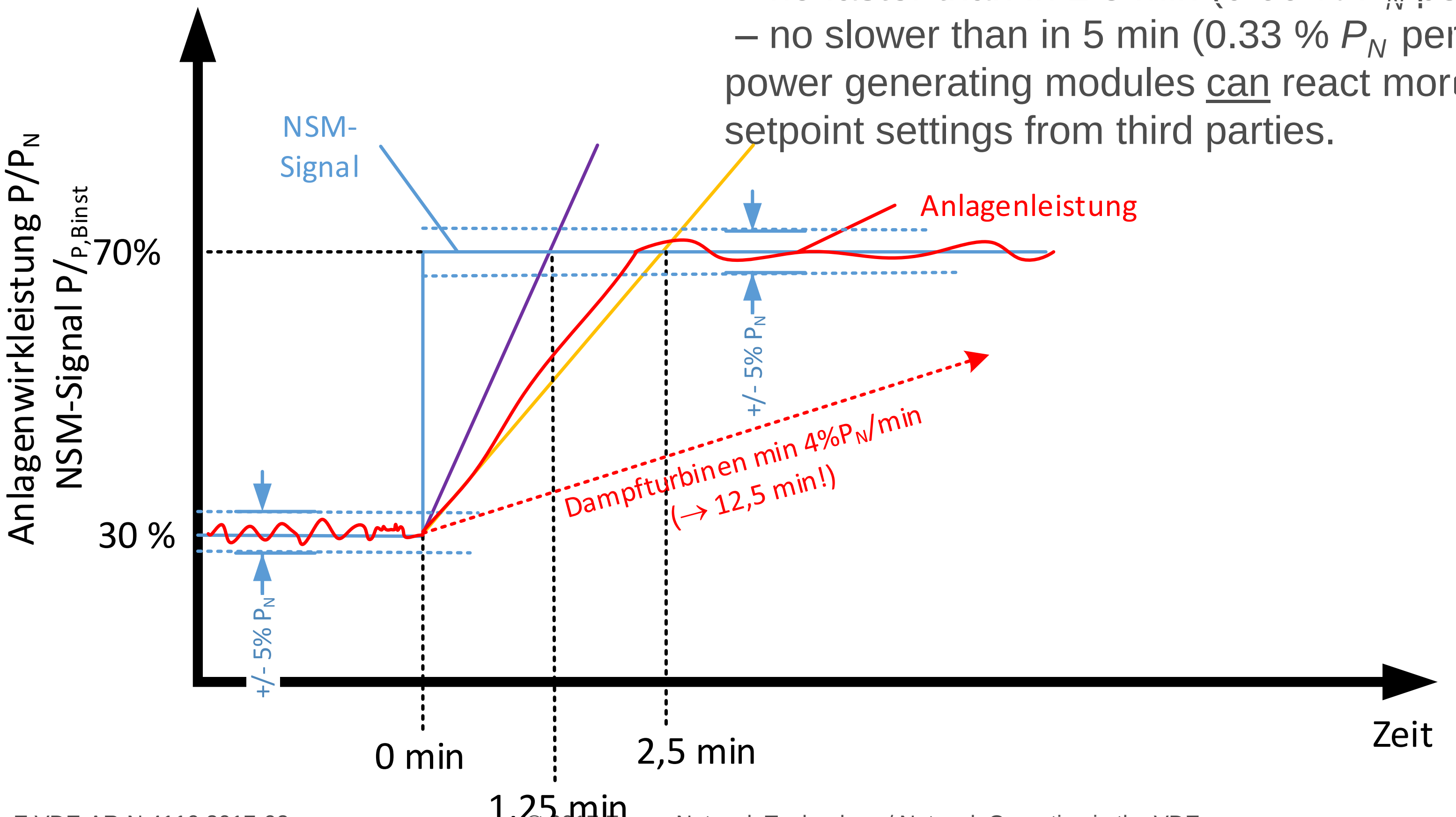
power generating modules can react more slowly to setpoint settings from third parties.

A smooth process of performance increase or reduction for the customer's plant should be achieved, and with this, ideally lineal behavior.

Comments:
Techn. minimum performance stated for combustion engines

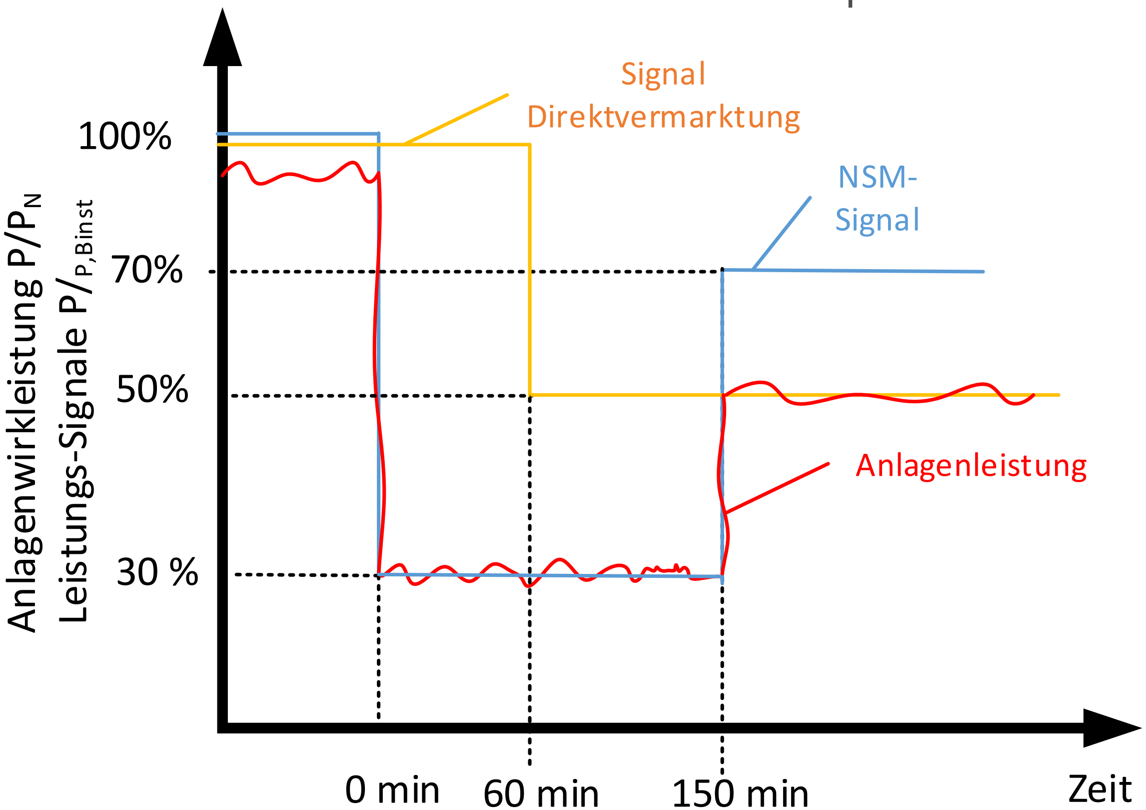
PGM – active power supply / performance increase

Limitation of performance gradients are for increasing and reducing active power supply and active power usage
– no faster than in 2.5 min (0.66 % P_N per second);
– no slower than in 5 min (0.33 % P_N per second).
power generating modules can react more slowly to setpoint settings from third parties.

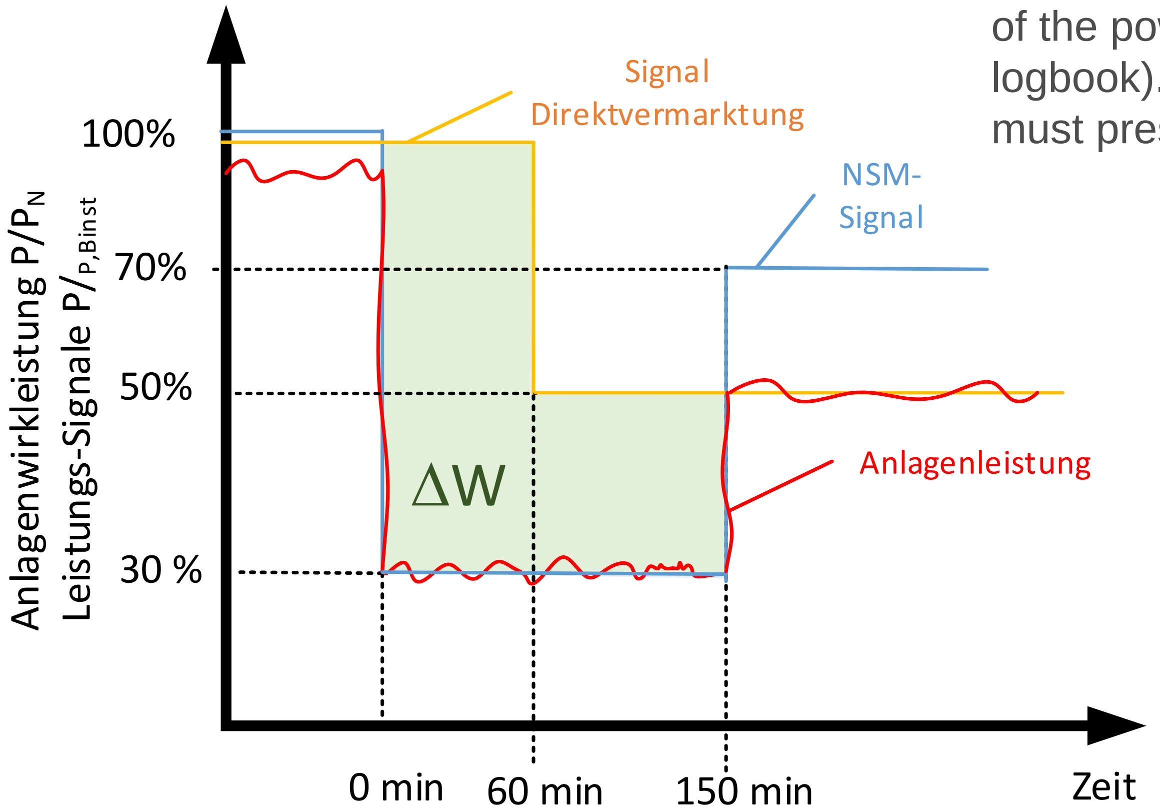


PGM – active power supply / priority regulations

With temporally overlapping active power specifications of grid operators (grid security management) and third parties (market specifications, personal requirement improvements etc.), smaller services always matter

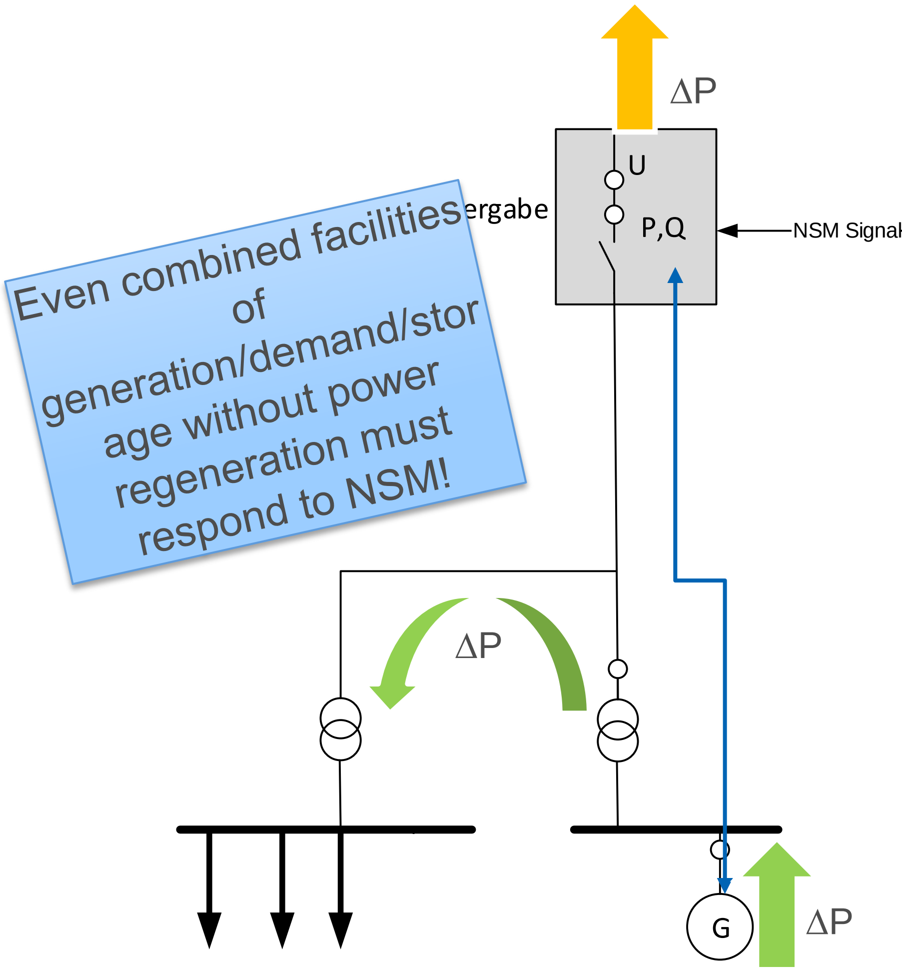


PGM – active power supply / logbook



The plant operator must always retain evidence for the prior 12 months of power regulation for grid security management and interference by third parties during operation of the power generating module (e.g. in a logbook). Upon demand, the grid operator must present this evidence.

PGM – active power supply / combined facilities of generation/demand/storage



Reference value NSM is P_{binst}
→Signal independent of instantaneous power
→Can be directly switched to PGU/PGM. (simple standard case)

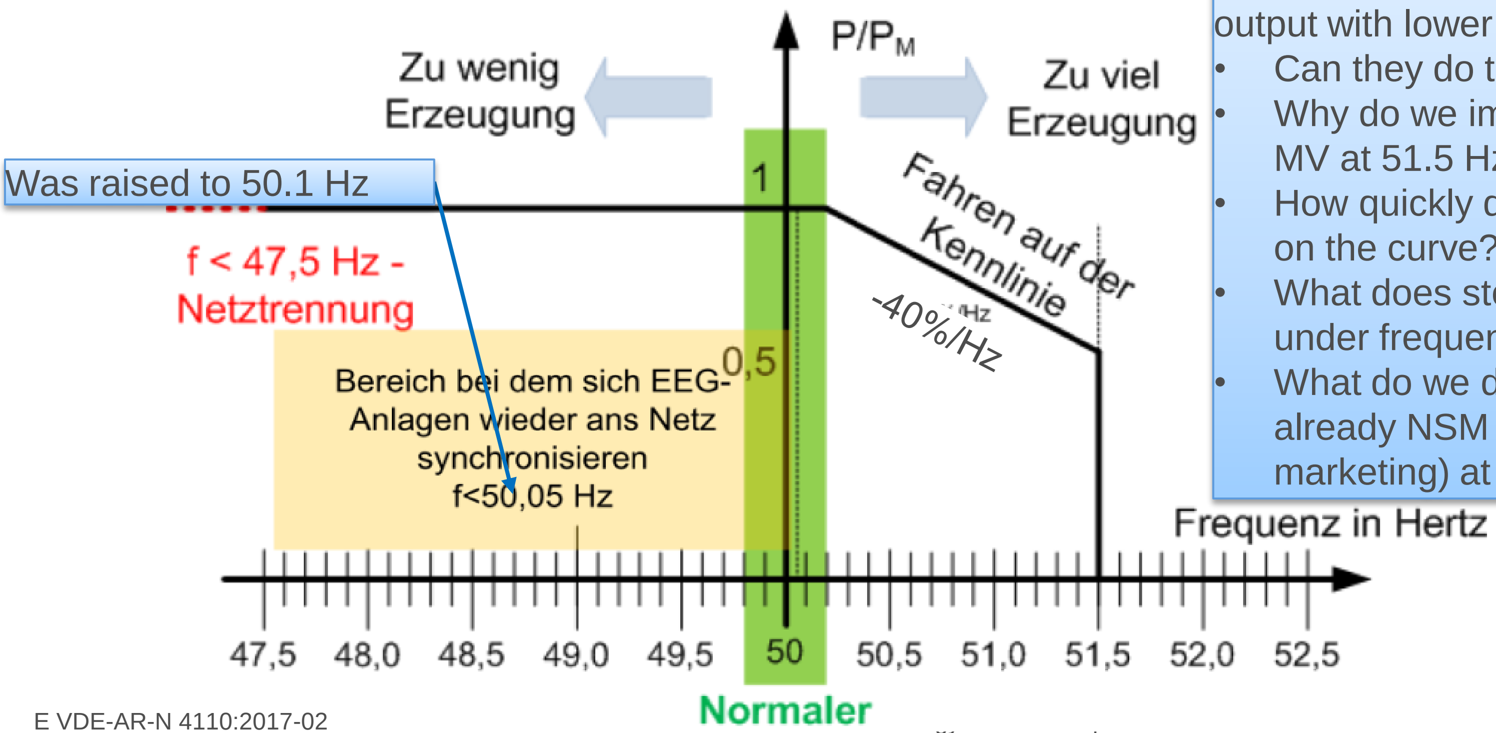
Could an (appropriate) load setting instead of a “reduction” also occur?

→Technically OK; providing “**grid power**” at GCP is **guaranteed**.

Problem: Evidence management
→ Requirement that ΔP must be metrologically traceable

PGM – Active power supply for over/under frequency

- Frequency: Primary value
  - (integrated grid / SYSTEM / Cross-Border Issue)
  - entso-e values must be observed
    (Rfg: generator > 0.8 kW = Significant Grid User)
  - 50.2 Hz problem & P-f curve known (Basis)



Questions:
Turbines & combustion engines reduce output with lower revolutions.
- Can they do that?
- Why do we immediately switch off in MV at 51.5 Hz?
- How quickly do the modules operate on the curve?
- What does storage actually do at under frequency?
- What do we do with market or already NSM limited modules (e.g. marketing) at f< 49.8 Hz?

Active power supply during frequency deviations
Fundamentals

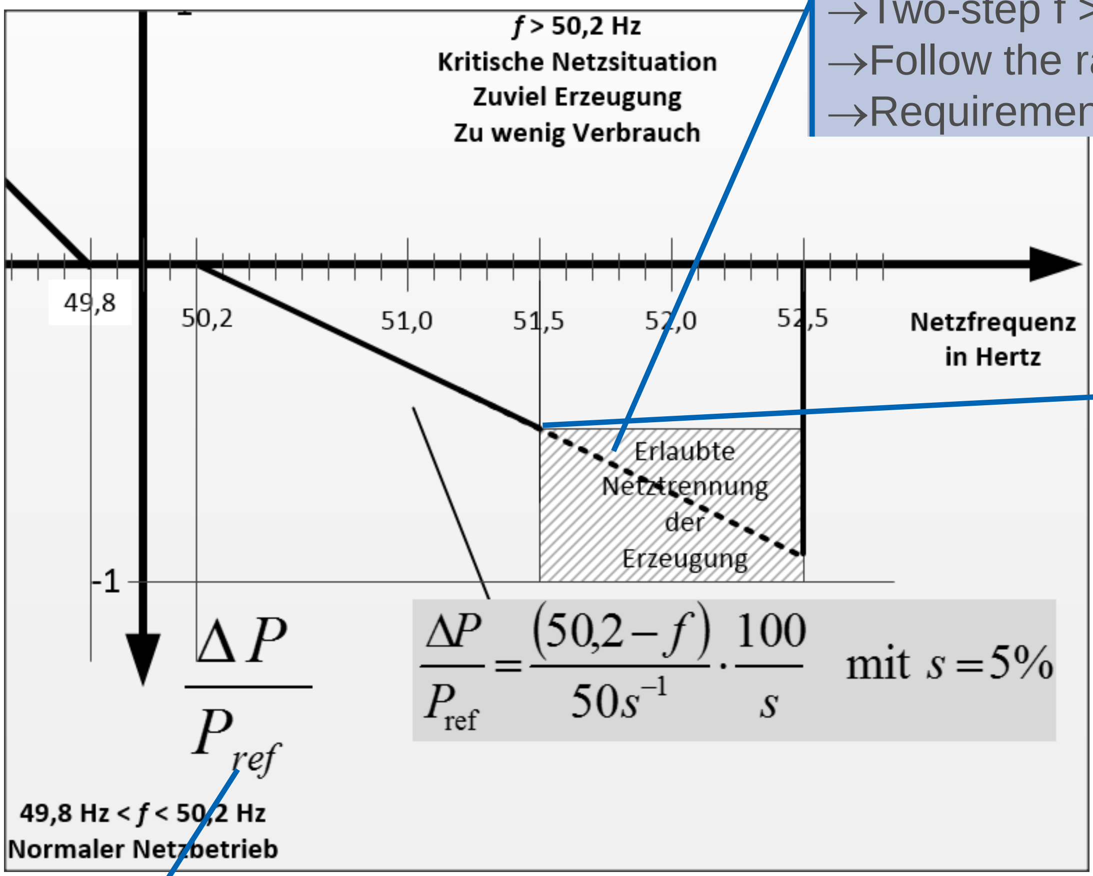
Most recently: 2006

- if f <49.8 Hz or f>50.2 Hz then: System is at risk
  - P-changes have priority over market (complies with EnWG Art.13)
  - P-changes do not have priority over NSM

  Reason: if NSM was used, the grid is close to 100% capacity at the MV level; additional capacity increase risks tripping protection and a loss of the entire production.

- When does that cease?
  - If 49.8 Hz < f <50.2 Hz → generally OK;
  - But please slowly return to “Normal status”!
  - If f is in “Range”: Active power changes of a maximum of 10 % P_N /min
  - if f over 10 min long within the tolerance range → normal grid operation

Active power supply at **over-**frequency



Expanded range for "overshots" by 5 sec.
→Two-step f > protection
→Follow the range curve where possible
→Requirements not (yet) compulsory

Control times according to Entso-e Rfg:
"As fast as technically feasible"

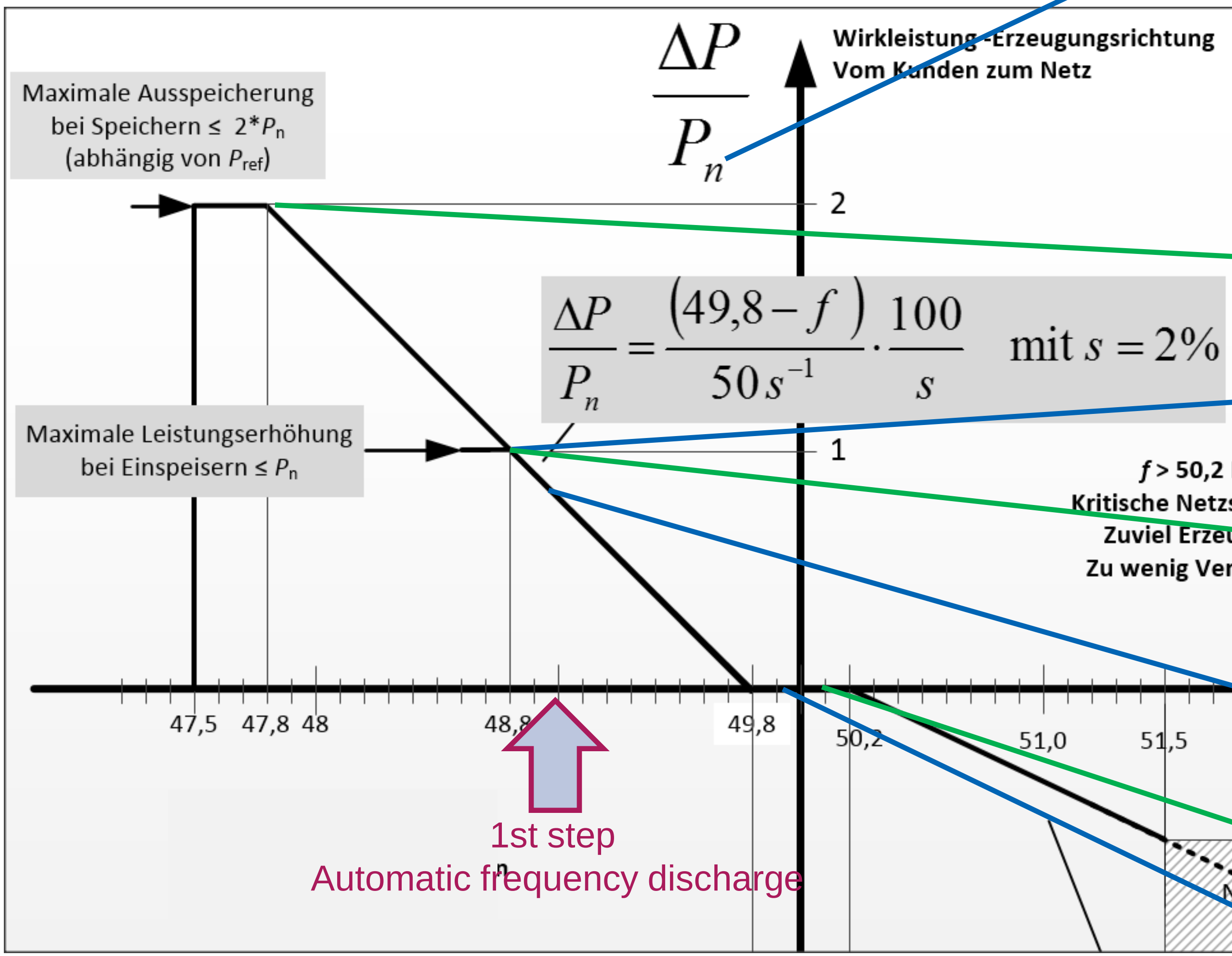
→ As fast as possible
→ Precision comes second

Response time: 2s
Settling time 20s
Measuring tolerance < 10 mHz
P deviation +/- 10%P_N

$P_{ref}=P_{MOM}$ for Type 2: → No change (remains locked at f=50.2 or f=49.8)
$P_{ref} = P_N$ for Type 1: → RfG (fixed curve slope)

Active power supply at **under**frequency

Caution!
Different axis scaling!
DP refers to the NOMINAL output



Example 1:

Example 2:

ΔP = -200%
Storage no longer discharges; P=-100%

ΔP = 100%
Storage charges; P=-20%

ΔP = 100%
Storage no longer discharges; P=-100%

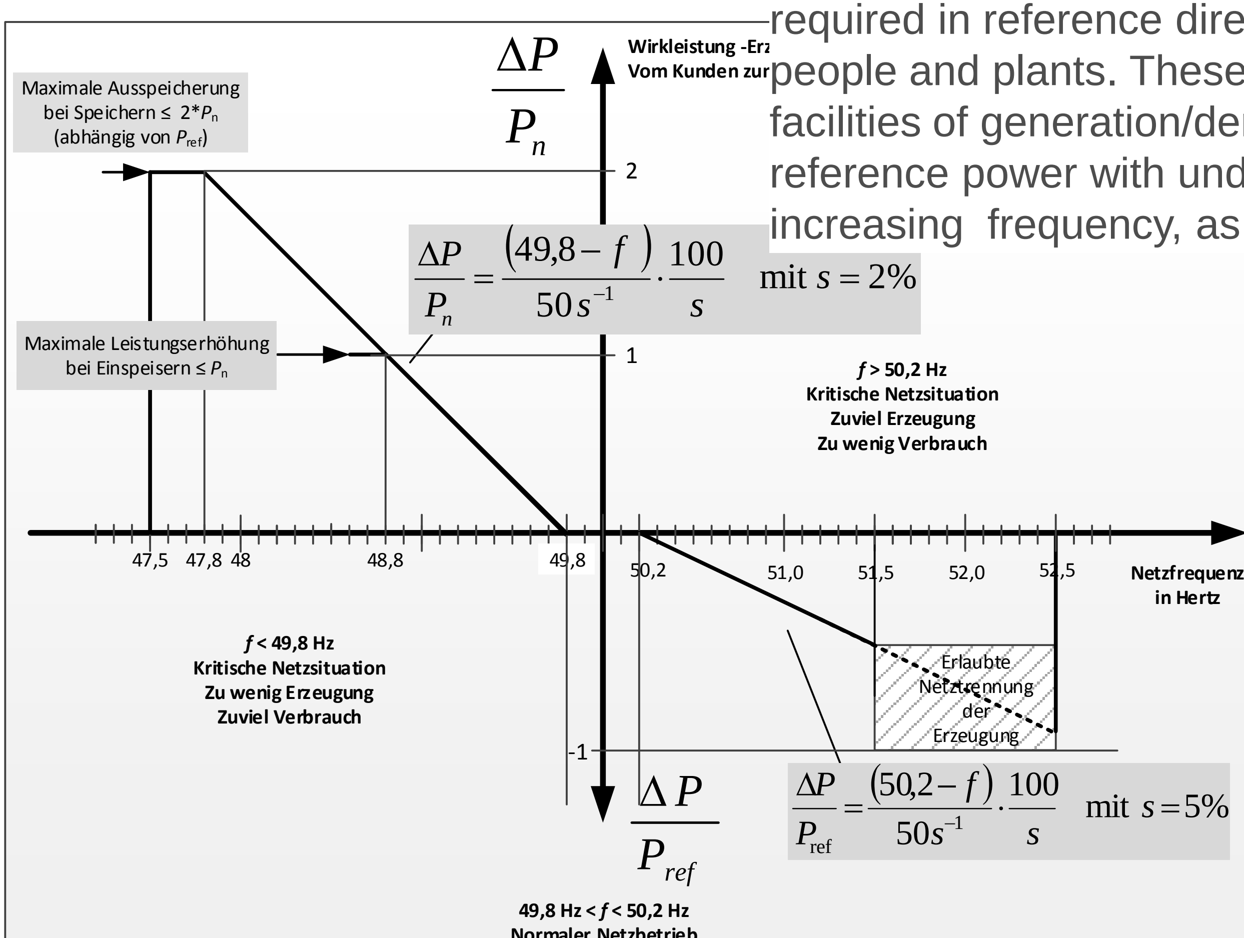
ΔP = 80%
Storage no longer discharges; P=0%

Storage is off 0 %

Storage charges at 80 %

P-f requirements

ΔP requirement! (Direction **change** is always correct)
Applies to generators (with storage capacity W > P_N*30s)
Applies to applications according to Art. 14 EnWG with electronic control (e.g. load applications for storage or electronically controlled electro-thermal applications) required in reference direction, providing there is no risk to people and plants. These demand facilities or combined facilities of generation/demand/storage should lower the reference power with under frequency or increase it with increasing frequency, as shown in Figure 17.



P-f requirements - control times

Limited requirements due to technical restrictio

- Wind: Increase only when wind > 50% P_N
- Combustion engines:
  - ≤ 2 MW minimum 66 % Pn per minute
  - > 2 MW minimum 20 % Pn per minute
- Increase through steam turbines; minimum 4 % P_n /min
- For hydroelectric power plants, a response time of 15 s and a settling time of 30 s is necessary.
- Evidence management in and response times relating to Δf = 500 mHz

Control times according to Entso-e Rfg:
“As fast as technically feasible”

-> as fast as possible
-> precision comes second
Storage:
Response time: 2s
Settling time 20s
Measuring tolerance < 10 mHz
P deviation +/- 10%P_N

(still) no firm requirements for the f< range with PGM:
The more who participate now, the sooner it will be possible to make exceptions later
-> The fewer who participate now, the stricter the subsequent directive will be

Ch. 6.3.3 Protection technology (general)

For purchasers and for power generating modules

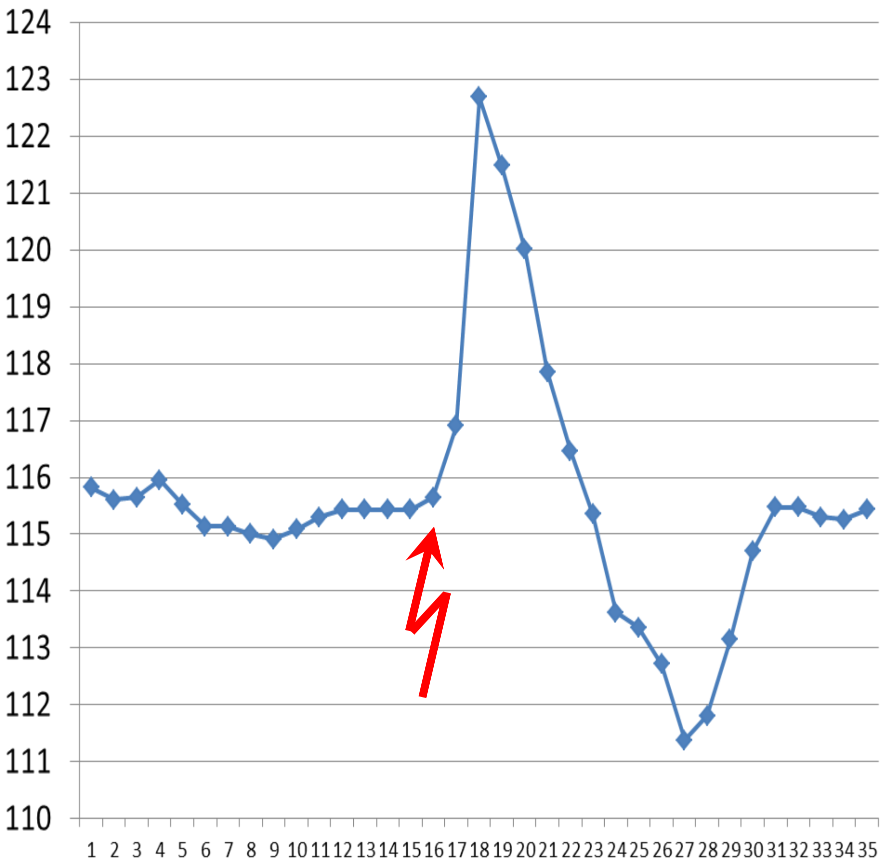
- Applies to demand facilities and to power generating modules, i.e. for
  - grid protection systems
  - the subscriber's short-circuit protection systems and
  - disconnection protection systems (for power generating modules)
- Responsibility lies with the respective owner
- The grid operator can request the installation of a frequency relay and provide the settings for this
- Regular protection inspections are mandatory
- For this, at least one testing terminal bar must be installed
- In justified cases, disturbance recorders must be installed at the grid connection point (e.g., if no metrological evidence of compliance with grid support is available)
- All information necessary for fault investigation must be exchanged between the grid operator and the subscriber.

Ch. 10.3 Protection systems and protection settings (for power generating modules)

Experience gained from grid faults with voltage protection systems

Case 1) short circuit in 110kV grid

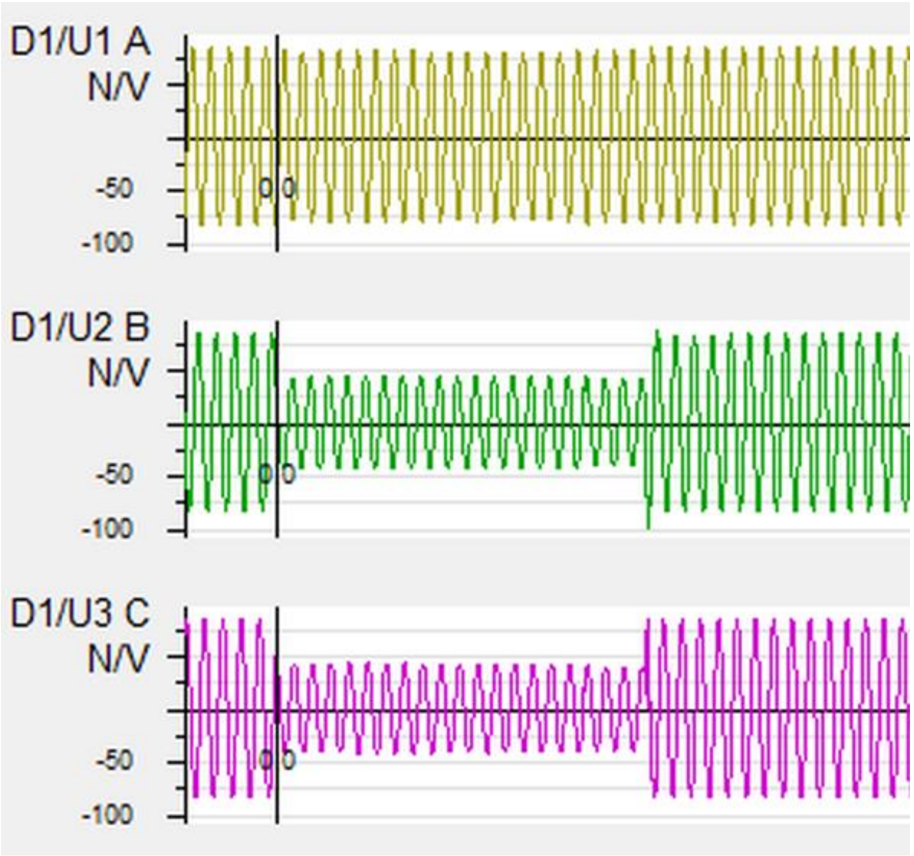
L-L voltage in kV (minute values)

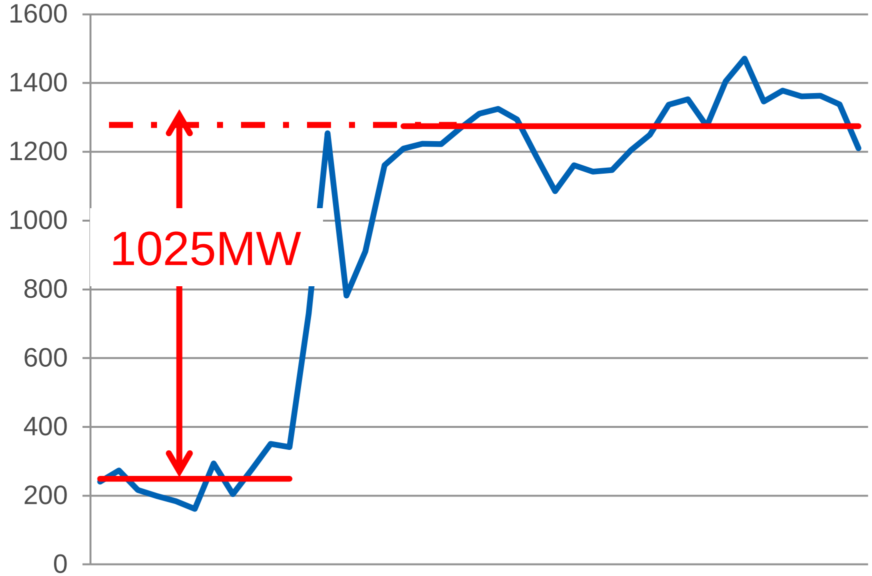


- Two-phase short circuit 110kV
- fault clearing time 90ms
- Loss of generation capacity >900MW
- Suspected cause: Response by surge protection systems

*) source: Effects of grid disruption on energy balance and voltage maintenance, T. Henning, U. Welz, H. Kühn SuL 2014

Case 2) Two-phase short circuit in 380kV grid

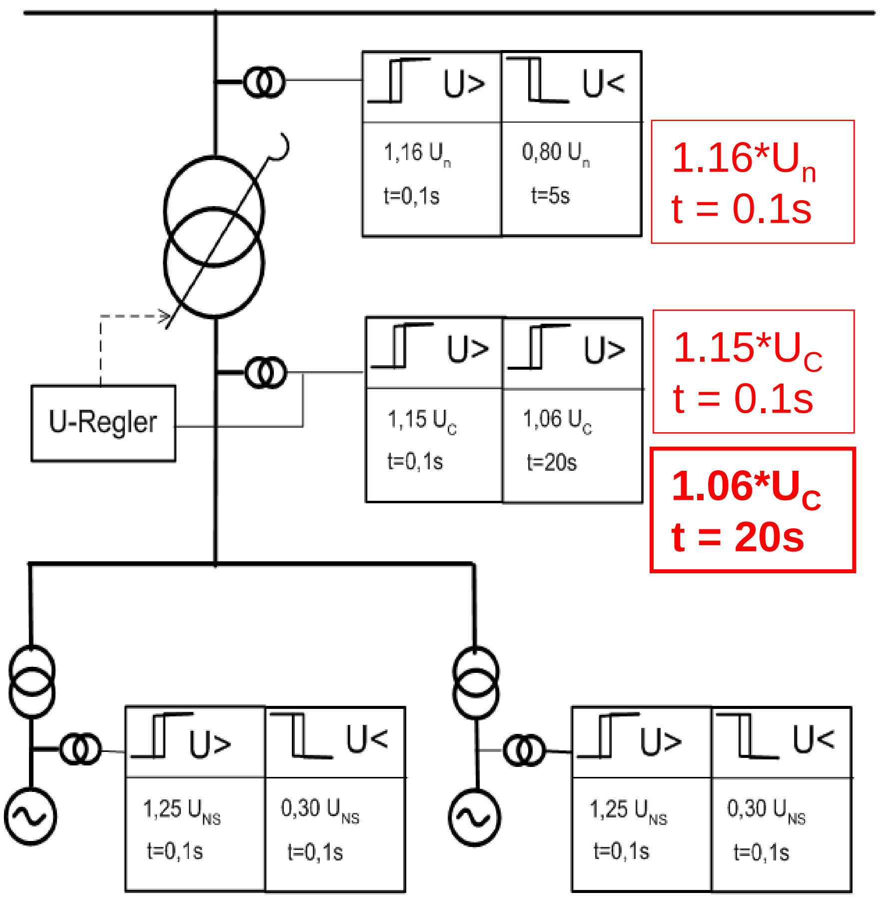




- Two-phase short circuit 380kV
- fault clearing time approx. 400ms
- Loss of over 1000 MW
- Suspected cause: Response by surge protection systems

*) source: Effects of grid disruption on energy balance and voltage maintenance, T. Henning, U. Welz, H. Kühn SuL 2014

Suspected cause for the loss of generation capacity



- Example formulation of voltage relay
  VDN guidelines from 2004

*) source: Effects of grid disruption on energy balance and voltage maintenance, T. Henning, U. Welz, H. Kühn SuL 2014

	BDEW 2008		VDE-AR-N 4110	
Function - GCP	Can be omitted by connection to MV grid, if no dynamic grid support is required		Always available	
Voltage increase U>>	1,15 U_C	0,1 s	1,20 U_{MS}	0,3 s
Voltage increase U>	1,08 U_C	60 s	1,10 U_{MS}	180 s
Voltage decrease U<	0,80 U_C	2,7 s	0,80 U_N	2,7 s
QU protection Q→&U<	0,85 U_C	0,5 s	0,85 U_N	0,5 s
Function – PGU	Connection to busbars		Connection to busbars	
Voltage increase U>>	1,20 U_C	0,1 s	1,25 U_{MS}	0,1 s
Voltage decrease U<	0,80 U_{NS}	1,5-2,4 s	0,80 U_{NS}	1,5-2,4s
Voltage increase U<<	0,45 U_C	0,3 s	0,3 U_{MS}	0,8 s
	Connection to MV grid		Connection to MV grid	
Voltage increase U>>	1,15 U_{NS}	0,1s	1,25 U_{NS}	0,1 s
Voltage decrease U<	0,80 U_{NS}	1,0s	0,80 U_{NS}	1,0 s
Voltage decrease U <<	0,45 U_{NS}	0,3 s	0,45 U_{NS}	0,3 s

Important – Important – Important – Important – Important – Important

Requirements for voltage relays (Ch. 10.3.1)

- Resetting ratio voltage increase ≤ 1.02
- Resetting ratio voltage drop ≥ 0.98
- Measurement error ≤ 1%
- Analysis of fundamental oscillation root mean square

Ch. 10.3 Protection systems and protection settings (for power generating modules)

Frequency Protection Systems

Frequency protection systems

BDEW 2008

≤ 47.5 Hz	isolation from grid
47.5–51.5 Hz	isolation not permitted
≥ 51.5 Hz	isolation from grid

VDE-AR-N 4110

≤ 47.5 Hz	isolation from grid
47.5–51.5 Hz	isolation not permitted
51.5-52.5 Hz	isolation permitted
52.5 Hz	isolation from grid

PGU frequency protection systems

Frequency decrease	f<	47.5 Hz	0.1 s *
Frequency increase	f>	51.5 Hz	≤ 5 s **
Frequency increase	f>>	52.5 Hz	0.1 s *

* better: 5 repeat measurements

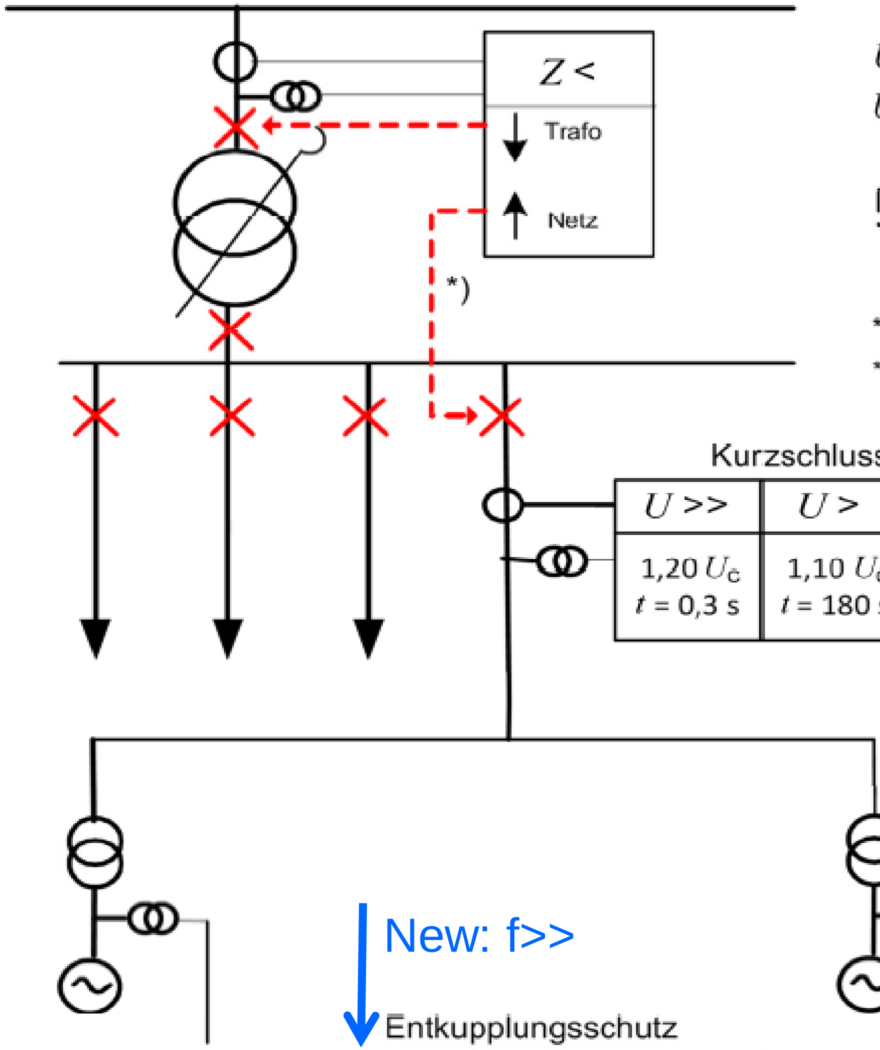
** according to PGU property

Ch. 10.3 Protection systems and protection settings (for power generating modules)

Protection overviews

Connection to the busbar of an UW

VDE



U_C - vereinbarte Versorgungsspannung

$U_{NS} = U_c / ü$ mit $ü$ = Übersetzungsverhältnis der Maschinentransformatoren

[dashed box] Schutzfunktion ist konzeptionell zu berücksichtigen und nach NB-Vorgabe zu realisieren

*) Mitnahmeschaltung nur bei im Stich angeschlossenen UW

**) Auslösung LS am Netzanschlusspunkt nach 0,5 s

Kurzschlussschutz und übergeordneter Entkupplungsschutz

$U >>$	$U >$	$U <$	$f >$	$f <$	$Z <$	$Q \rightarrow$ & $U <$**
1,20 U_c t = 0,3 s	1,10 U_c t = 180 s	0,8 U_c t = 2,7 s	51,5 Hz t = 5400ms	47,5 Hz t = 400ms	U_F = 0,8 U_c I_F = 0,2 I_N $I_E \geq$ 1,2 I_{CE}	0,85 U_c t = 0,5 s

f> and f< optional (according to grid operator)

New: Distance relay with U/I-stimulus required IOR not permitted

New: f>>

Entkupplungsschutz

$U >>$	$U <$	$U <<$	$f >>$	$f >$	$f <$
1,25 U_{NS} t = 0,1 s	0,8 U_{NS} t = 1,5 – 2,4 s	0,3 U_{NS} t = 0,8 s	52,5 Hz $t \leq$ 100ms	51,5 Hz t = 5 s	47,5 Hz $t \leq$ 100ms

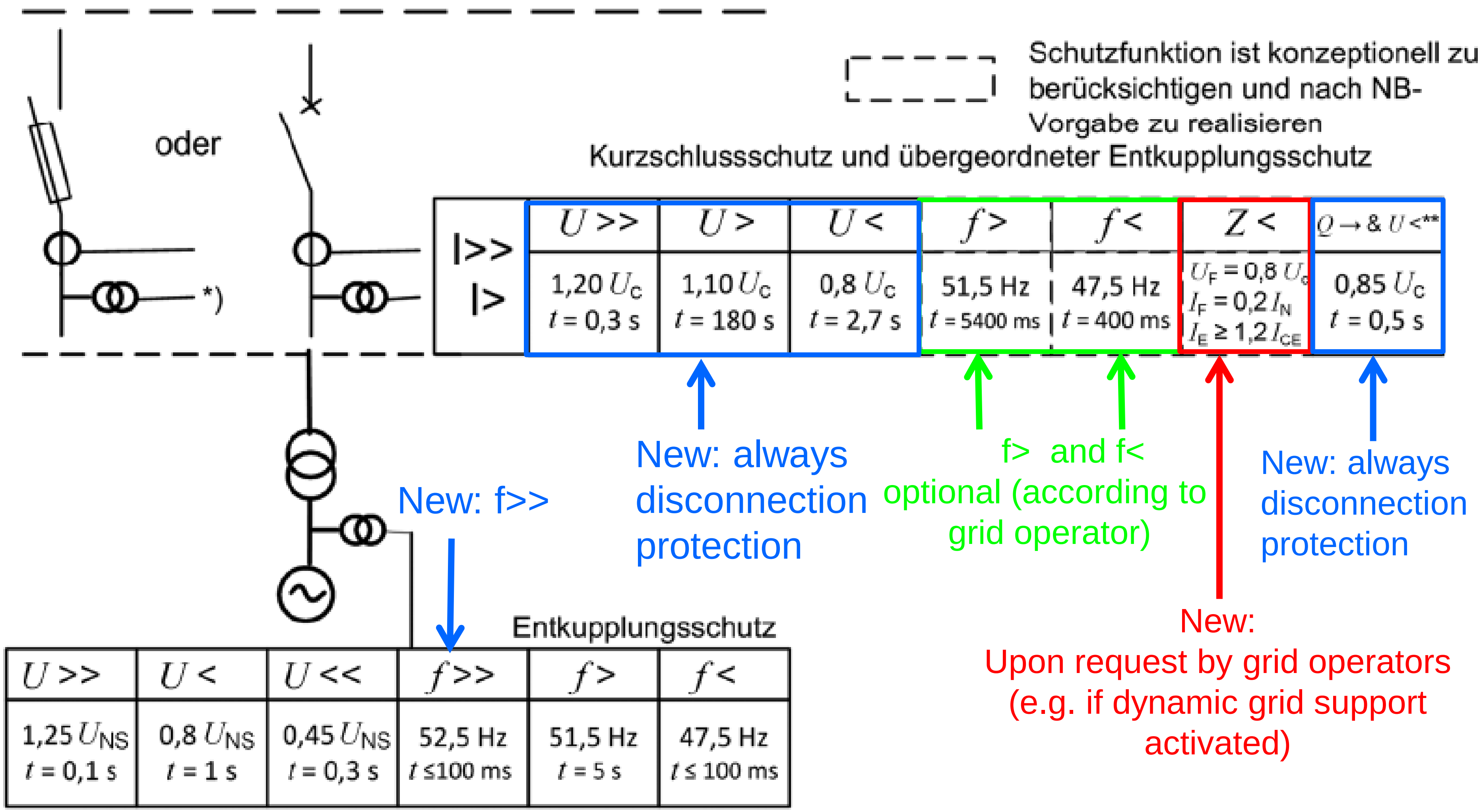
New: f>>

Entkupplungsschutz

$U >>$	$U <$	$U <<$	$f >>$	$f >$	$f <$
1,25 U_{NS} t = 0,1 s	0,8 U_{NS} t = 1,5 – 2,4 s	0,3 U_{NS} t = 0,8 s	52,5 Hz $t \leq$ 100ms	51,5 Hz t = 5 s	47,5 Hz $t \leq$ 100ms

Section 10.3

Protection systems and protection settings - Frequency protection systems and protection overviews


Schutzfunktion ist konzeptionell zu berücksichtigen und nach NB-Vorgabe zu realisieren
Kurzschlussschutz und übergeordneter Entkupplungsschutz
oder
*)
I>>
I>
U>> 1,20 Uc t = 0,3 s
U> 1,10 Uc t = 180 s
U< 0,8 Uc t = 2,7 s
f> 51,5 Hz t = 5400 ms
f< 47,5 Hz t = 400 ms
Z< UF = 0,8 Uc IF = 0,2 IN IE ≥ 1,2 ICE
Q→ & U<** 0,85 Uc t = 0,5 s
New: always disconnection protection
f> and f< optional (according to grid operator)
New: always disconnection protection
New: Upon request by grid operators (e.g. if dynamic grid support activated)
New: f>>
Entkupplungsschutz
U>> 1,25 UNS t = 0,1 s
U< 0,8 UNS t = 1 s
U<< 0,45 UNS t = 0,3 s
f>> 52,5 Hz t ≤100 ms
f> 51,5 Hz t = 5 s
f< 47,5 Hz t ≤ 100 ms