Cabo Verde's new Renewable-Energy-Friendly Grid Code

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Organisational Aspects & Timeline of Grid Code Development

Organisational Aspects

- Project for grid code development initiated in 2015
  by DGE / MTIDE (Cabo Verde) and GIZ (Germany)
  within the “Renewable Energies on Islands” project
- DIgSILENT subcontracted for advisory consultancy services
- Project carried out by DIgSILENT
  in close cooperation with DGE/MTIDE and GIZ

Timeline

- Project started in 4th quarter of 2015
- First field trip in January 2016
- First draft of the grid code in February 2016
- Second field trip in March 2016
- Final grid code version handed over beginning of April 2016 (EN & PT)

DGE = Direção Geral de Energia / Directorate-General Energy

MTIDE = Ministério do Turismo, Investimento e Desenvolvimento Empresarial / Ministry of Tourism, Investment and Business Development

GIZ = Deutsche Gesellschaft für Internationale Zusammenarbeit

Organisational Aspects & Timeline of Grid Code Development

First field trip

- January 2016
- Individual meetings with key stakeholders (companies and institutions):
  - organised and supported by DGE
  - in total 8 meetings
  - on 4 islands (Santiago, São Vicente, Sal, Boa Vista)

Second field trip

- March 2016
- Presentation and discussion of draft version of grid code
- Two 1-day sessions on two islands (Santiago and São Vicente)
- Large number of participants
- Positive, constructive and cooperative discussions

The Power Systems of Cabo Verde

- **Several electric island systems with different sizes**
  - 9 inhabited islands, each has its own islanded electric power system
  - Sizes vary from approx. 500 kW to 35 MW (peak load of the systems)
- **Voltage levels**
  - High voltage (HV): 60 kV, only on Santiago
  - Medium voltage (MV): mainly 20 kV
    (on some islands also 6.3 kV, 10 kV, 15 kV)
  - Low voltage (LV): 230/400 V
- **Power generation**
  - Gen-sets with combustion engines using fuel oil or gasoline
  - Wind power parks
  - Solar photovoltaic (PV) parks and smaller PV installations

The Power Systems of Cabo Verde

- **Goals for future development**
  - Increase of renewable energies to 100%
    - Independence from fuel imports
    - Environmental aspects (decrease of pollution and CO_2 emission)
    - Green image important for tourist sector
  - Distributed generation (net metering)
  - Storage systems (to equalise the fluctuating power injection from renewables)

Understanding of a Grid Code

Network codes can have different tasks:

- Requirements for power generating installations
- Network operating guidelines (handbook)
- Requirements for demand side

The grid code developed for Cabo Verde defines requirements for future power generating installations and energy storage systems to ensure a stable, reliable and safe electric power supply with increasing renewable energies.

- It does not privilege any specific technology, but differentiates
  - synchronous generators (Type 1) and
  - other kinds of generators (Type 2).
- It is not a network operating handbook.
- It is an exclusively technical document.
- It does not describe a tender process or any framework for procurement.

Challenges for Development of Cabo Verde's Grid Code

- Requirements shall ensure operation with 100% renewable energies (RE)
  ⇒ More power electronic converters
  ⇒ Less conventional generators
  ⇒ Lower short-circuit power
  ⇒ Lower inertia (less rotating masses connected)
- Requirements shall apply to RE and conventional power generation
  ⇒ Grid code applicable to different technologies
- As an increasing number of small distributed generation units may be connected to the low voltage network in the future, the grid code shall address these as well
  ⇒ Grid code applicable to all voltage levels
- Grid code shall apply to power generation and storage systems
- Grid code shall apply for all islands
  ⇒ Suitable for different sizes of electrical systems

Technical Aspects

The main philosophy of the grid code:

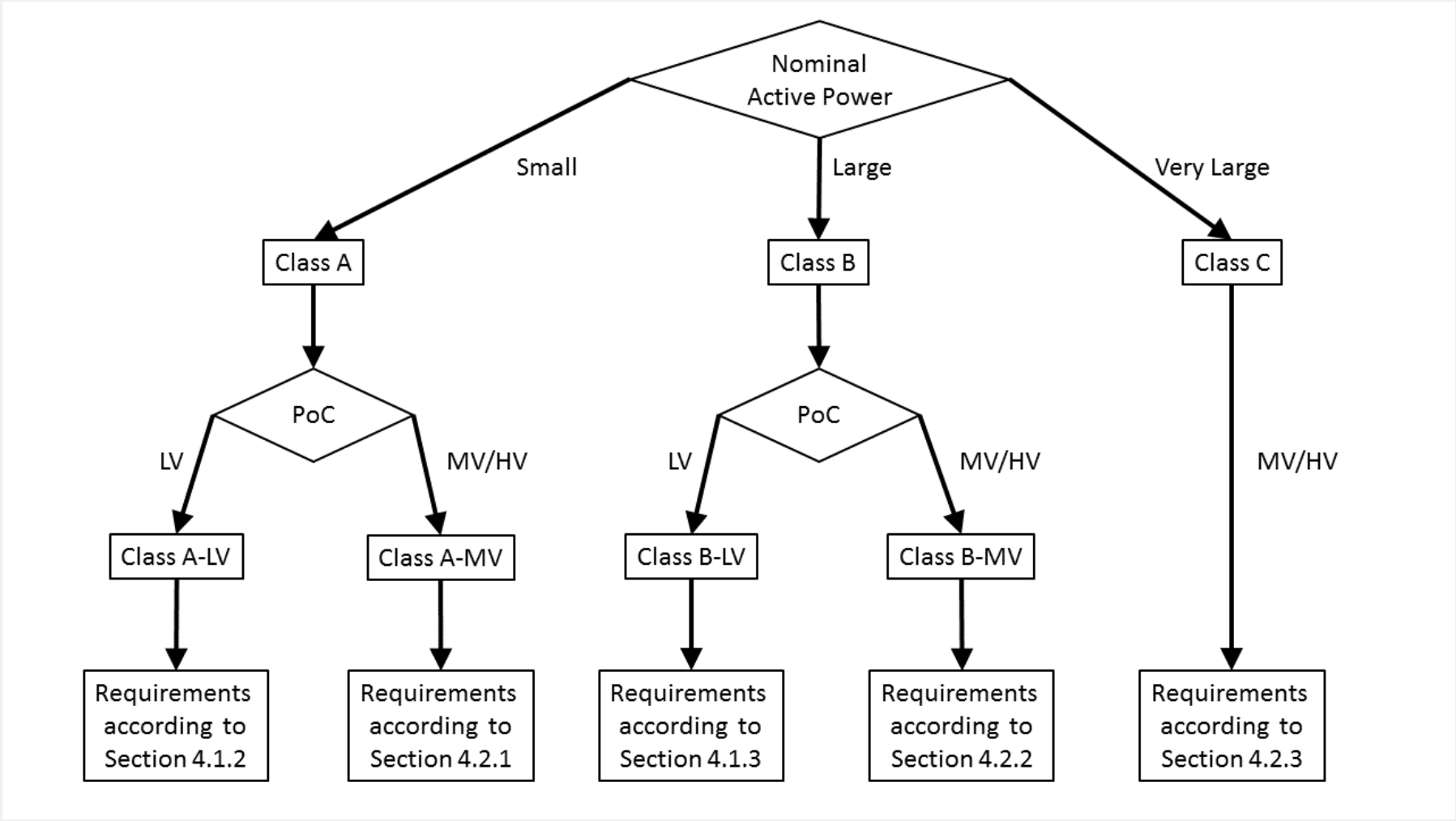
- Large power generating installations are considered to be system-critical
  - Behaviour of the system is dominated by these installations
  - Risk of system collapse in case of sudden loss of such an installation
  - “Large” in terms of nominal active power of the installation
  - “Large” is considered as 5% or more of peak load demand of the island
- Small power generating installations
  - A particular small installation itself can hardly impact the power system
  - A larger number of small installations can have a significant influence

Technical Aspects

The main philosophy of the grid code:

- Power generating installations connected to the MV or HV network "build" the grid:
  - Voltage control
  - Reactive power capability
  - Frequency control
  - Dynamic voltage support during network faults (keep the system "alive")
  - etc.
- Power generating installations connected to the LV network
  - Shall give limited support (e.g. limited frequency sensitive mode)
  - Should not get lost during network faults (as far as possible), but…
  - Safety first
  - Avoid unintended islanded operation of network feeders

Classes of Power Generating Installations and Energy Storage Systems



Technical Aspects

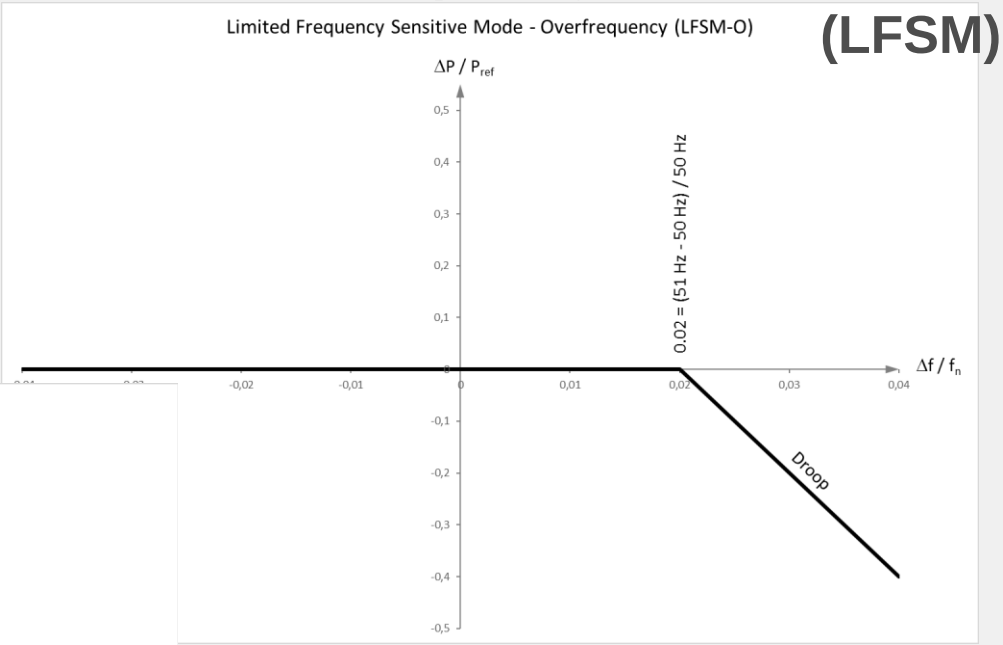
Technical Requirement	Class A-LV	Class B-LV	Class A-MV	Class B-MV	Class C
Neutral point connection	X	X	X	X	X
Voltage operating range	X	X	X	X	X
Frequency operating range	X	X	X	X	X
Limited Frequency Sensitive Mode – Overfrequency (LFSM-O)	X	X	X	(X)	(X)
Limited Frequency Sensitive Mode – Underfrequency (LFSM-U)	Storage	Storage	Storage	(X)	(X)
Frequency sensitive mode (FSM)				X	X
Synthetic inertia					X
Reactive power	X	X	X	X	X
Reactive power capability			X	X	X
Voltage control, reactive power control			X	X	X

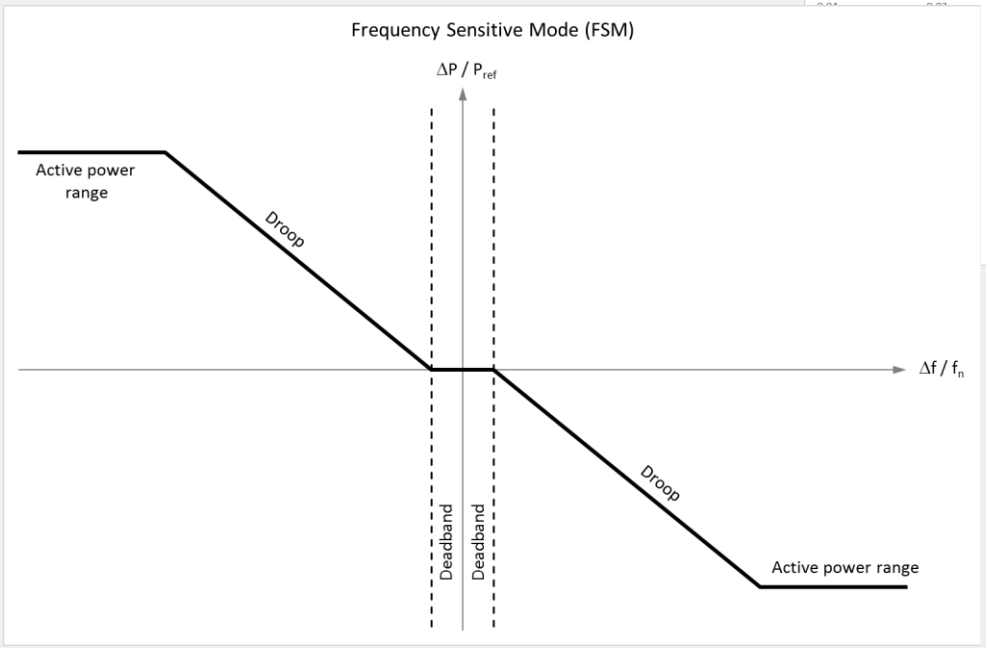
Technical Aspects

Technical Requirement	Class A-LV	Class B-LV	Class A-MV	Class B-MV	Class C
Power quality	X	X	X	X	X
Undervoltage-Ride-Through (UVRT)	Type 2	Type 2	X	X	X
Overvoltage-Ride-Through (OVRT)	X	X	X	X	X
Dynamic Voltage Support during UVRT or OVRT			X	X	X
Protective disconnection devices	X	X	X	X	X
Overcurrent protection	X	X	X	X	X
Connection and reconnection conditions	X	X	X	X	X
Synchronisation		X	X	X	X
Disconnection / Soft-Shutdown		X		X	X
Remote Control Access	Limited	X	X	X	X
Fault recoding and PQ monitoring		X	X	X	X

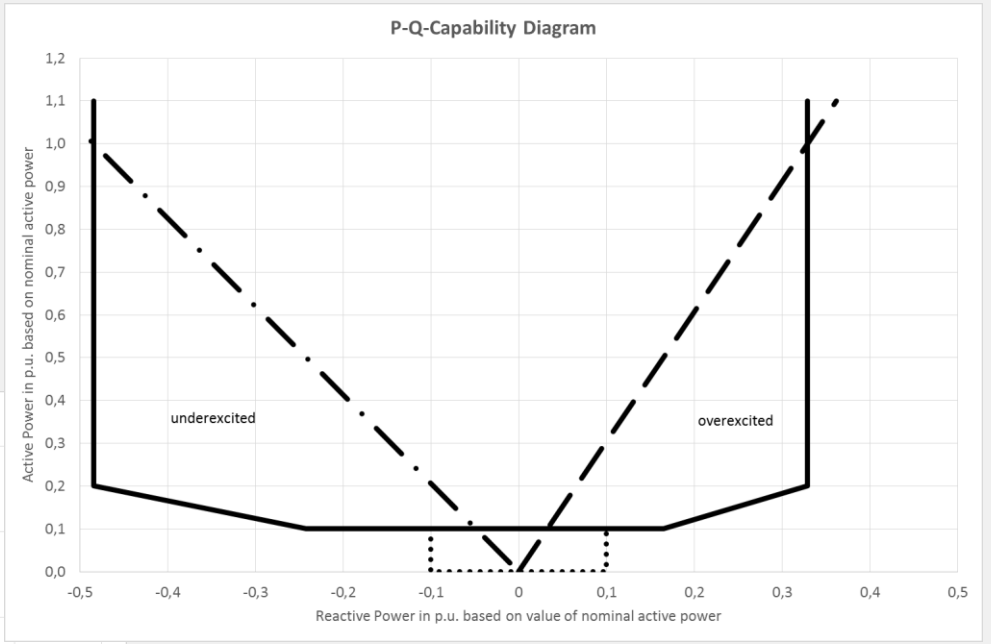
Technical Aspects

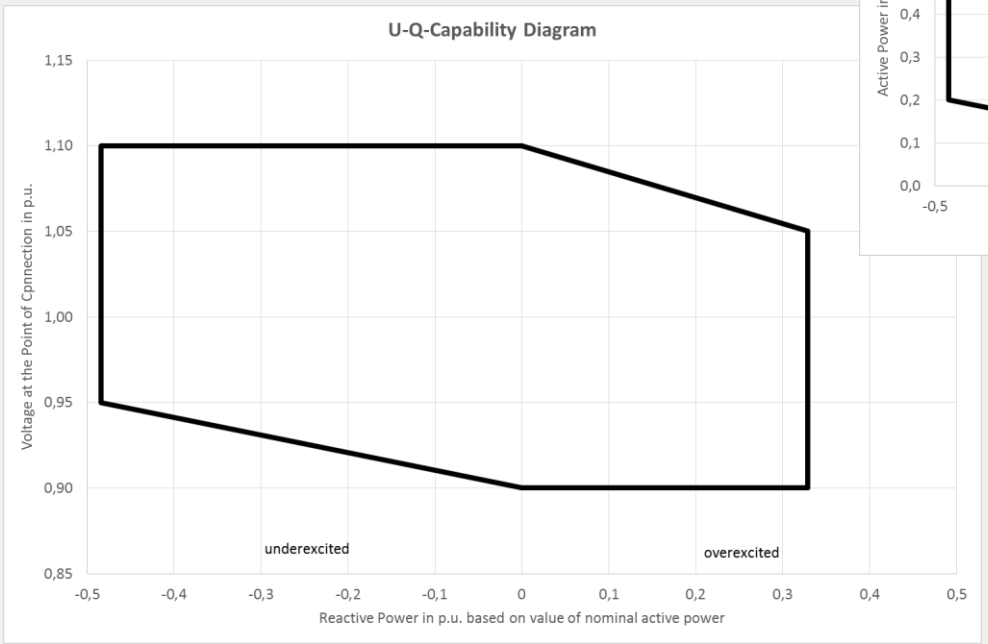
Frequency Sensitive Mode (FSM) and Limited Frequency Sensitive Mode (LFSM)





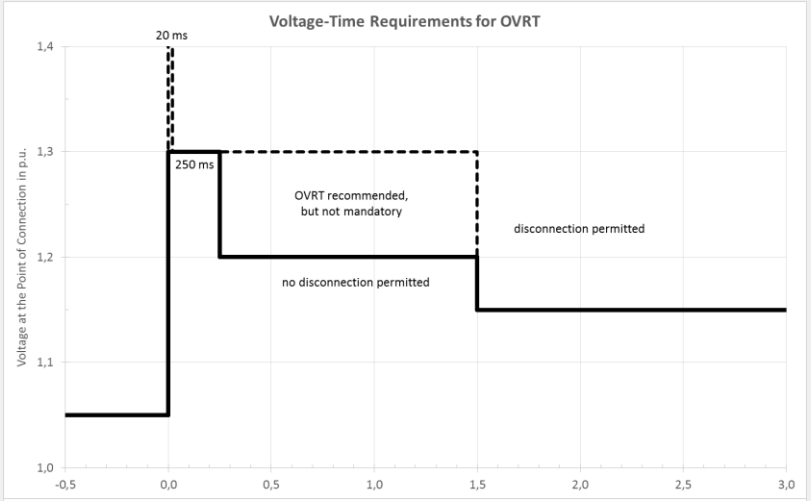
Reactive Power Capability

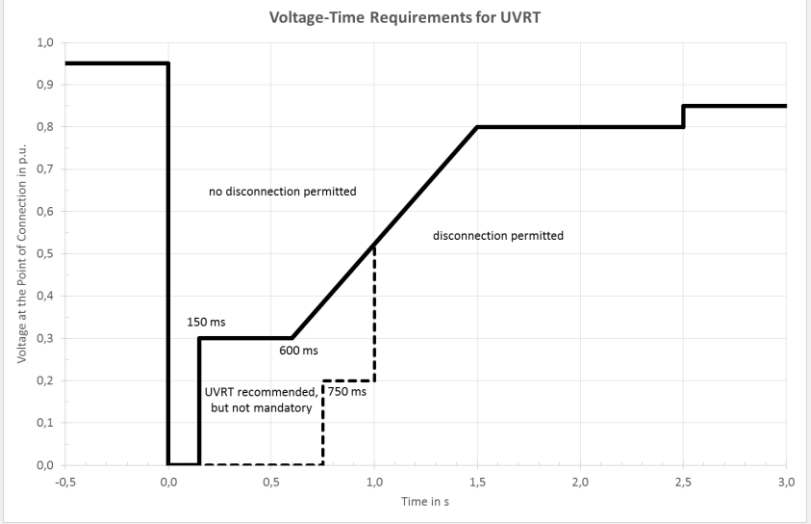


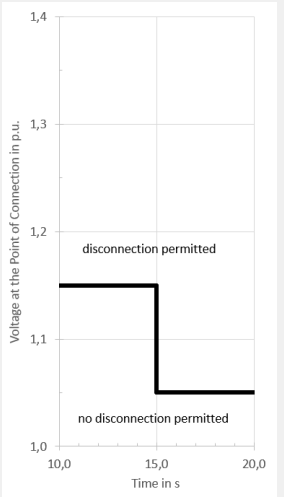


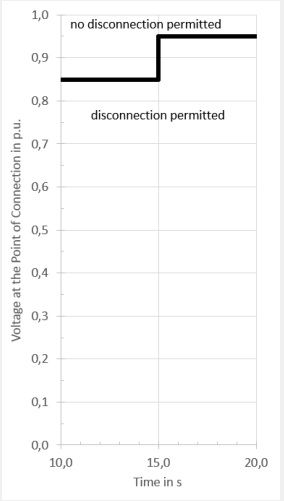
Figures for Type 2 installations

Overvoltage- and Undervoltage-Ride-Through









Figures for connections to MV or HV network

Dynamic Voltage Support during UVRT and OVRT

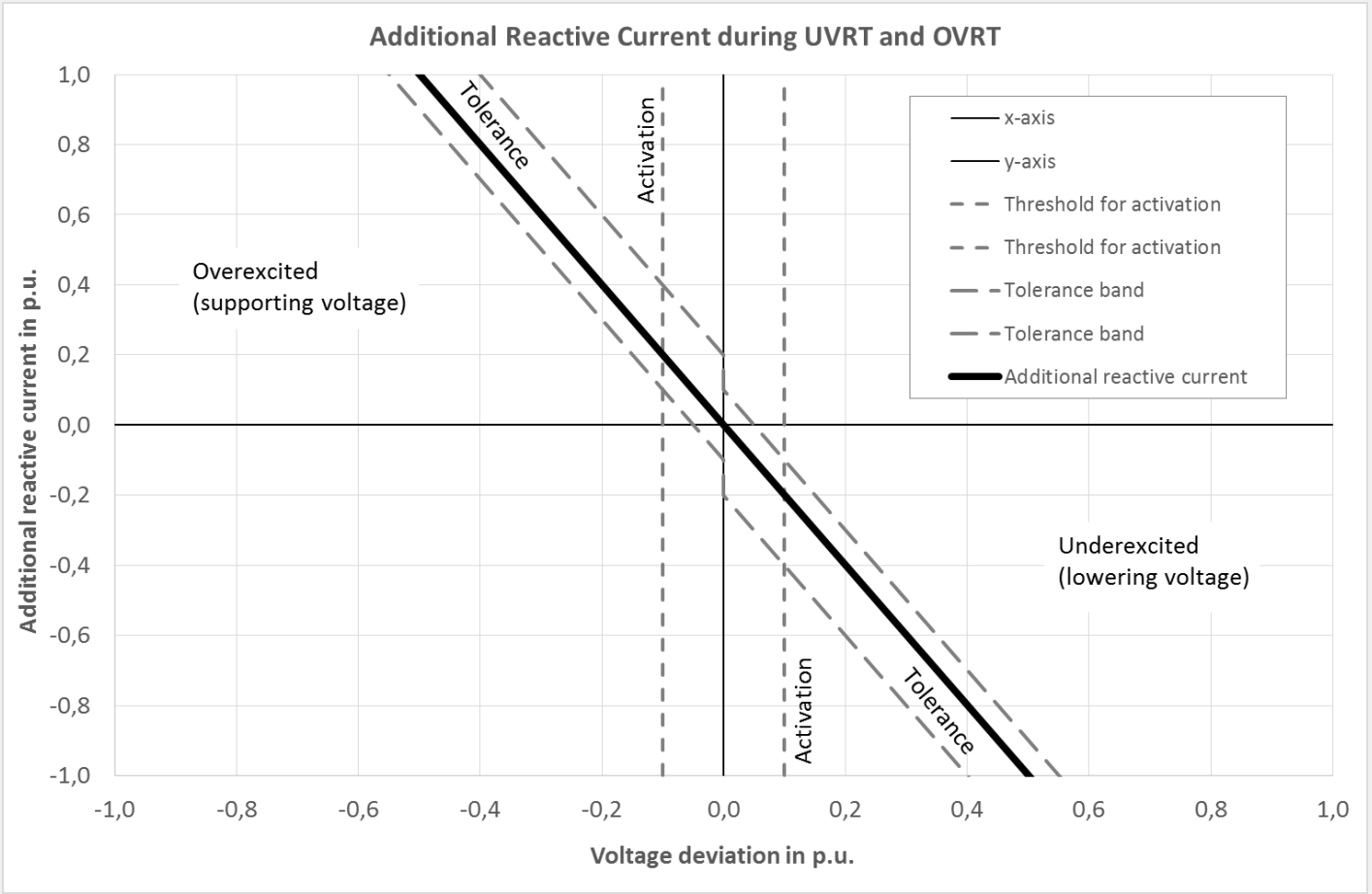


Figure drawn in generation-oriented way

Conclusions

- During the 1st quarter of 2016 a grid code has been developed for Cabo Verde
- Meetings and discussions with key stakeholders
- The grid code
  - Applies to
    - power generating installations and
    - energy storage systems
    - in all voltage levels (LV, MV, HV)
  - Does not privilege any specific technology
  - Defines technical requirements for power generating installations and energy storage systems to ensure a stable, reliable and safe electric power supply with increasing renewable energies
  - Comprises aligned technical requirements for different classes

Thank you very much!

Muito obrigado!

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