EU Connection Code
HVDC Implementation *Update*

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Summary

- Current Progress to date
- RfG Progress
- Comparison between RfG Type D Power Park Modules & HVDC Converter requirements
- Next Steps

Current Progress to Date

- RfG needs to be implemented into the GB Codes by 17 May 2018 at the latest
- DCC needs to be implemented into the GB Codes by 15 September 2018
- HVDC needs to be implemented into the GB Codes by 29 September 2018
- In view of these timelines, the primary focus has been on RfG implementation.
- There are many similarities between the requirements for RfG Type D Power Park Modules and the HVDC Code
- It is therefore proposed to adopt the same technical requirements for HVDC as per Type D Power Park Modules unless there is good reason no to do so

RfG Progress

- RfG Has been split into 6 workstreams
  - Banding – (included as part of Banding / Fast Fault Current Injection)
  - Voltage/ Reactive – Consultation Completed – rolled into GC100
  - Frequency – Consultation Completed – rolled into GC101
  - Fault Ride Through / Fast Fault Current Injection – Study work completed – Workgroup report in preparation
  - Compliance – Workshop planned for 24 July 2017
  - System Management – Discussions ongoing
- In general it is recognised that there are some differences in the technical requirements between Type D Power Park Modules, HVDC DC Connections (Title II), DC Connected Power Park Modules and Remote End HVDC Converter Stations (Title III)

Summary - Comparison - RfG Type D Power Park Modules & HVDC Converter requirements (1)

Technical Requirement	RfG Type D PPM	HVDC Connection (Title II)	DC Connected PPM (Title III)	Remote End HVDC Connection (Title III)
Frequency Range	47 – 52Hz	47 – 52Hz with longer operating times	As per RfG – 48.5 – 49Hz set at 90 minutes	As per HVDC Connections (Title II)
Rate of Change of Frequency	1Hz/s measured over a 500ms timeframe	±2.5Hz/s measured as an average of the rate of change of frequency for the previous 1s	±2Hz/s measured as an average of the rate of change of frequency for the previous 1s	As per Article 11 HVDC Connection (Title II)
Active Power Controllability, Control range and ramping rate	Not specified	TBD	N/A	N/A?
Synthetic Inertia	Not mandatory – Not required as part of GB drafting	Not mandatory – Not required as part of GB drafting	Not mandatory – Not required as part of GB drafting	Not mandatory – Not required as part of GB drafting

Summary - Comparison - RfG Type D Power Park Modules & HVDC Converter requirements (2)

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Technical Requirement	RfG Type D PPM	HVDC Connection (Title II)	DC Connected PPM (Title III)	Remote End HVDC Connection (Title III)
FSM, LFSM_O, LFSM-U & Frequency Control	As defined in GC0087 Consultation	Broadly similar to RfG, there are however some differences eg delay times, droop, sustained operating times and control modules which require further consideration – stating point would be RfG	As per RfG	Required to meet Art HVDC Title II requirements but this is not entirely clear as the remote end HVDC Converter is required to work with DC Connected Power Park Modules to facilitate frequency response provision under Art 47(2)
Max loss of Active Power	Not specified but would be in accordance with the SQSS	To be determined but would be expected to be a consistent with the SQSS of 1800MW. The issue of two control areas requires further thought	Not specified	As per HVDC Connections (Title II)

Summary - Comparison - RfG Type D Power Park Modules & HVDC Converter requirements (3)

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Technical Requirement	RfG Type D PPM	HVDC Connection (Title II)	DC Connected PPM (Title III)	Remote End HVDC Connection (Title III)
Voltage Ranges	As per GC0048 Voltage / Reactive Consultation	Voltage ranges – proposed to be as per RfG	Voltage Ranges – wider than RfG (0.85 – 1.15 pu)	Voltage Ranges wider than RfG (0.85 – 1.15 pu)
Short Circuit Contribution during faults	As per GC0048 Fast fault current Injection proposals	Specified by RSO in co-ordination with TSO. Expectation would be to have the same performance requirement as proposed for RfG	As per RfG	As per HVDC Connections (Title II)
Reactive Capability	As per GC0048 Voltage / Reactive Consultation	Principles similar to RfG. HVDC Maximum range Q/Pmax set to 0.95 and V range 1.15 – 0.85pu . Proposal to set Q/Pmax to to 0.66 (0.95 PF lead to 0.95 lag in GB) to ensure consistency with RfG. Voltage range requires discussion	Broadly similar to RfG and HVDC Connection (Title II) but requires some amendments	Specified by RSO but would be broadly consistent with RfG and HVDC Title II.

Summary - Comparison - RfG Type D Power Park Modules & HVDC Converter requirements (4)

Technical Requirement	RfG Type D PPM	HVDC Connection (Title II)	DC Connected PPM (Title III)	Remote End HVDC Connection (Title III)
Reactive Power Exchanged with the Network	Not specified	Limits on reactive power exchanged with the network to be agreed with the TSO Limits required on voltage step change – proposal as per current Grid Code	Covered in Article 41 but shall be no greater than 5% of the pre-synchronisation voltage	As per HVDC Connections (Title II)
Reactive Power Control Mode	As per GC0048 Voltage / Reactive Consultation	Similar to RfG but requires further assessment. If anything, the time ranges are slightly reduced with more flexibility from the RSO	As per RfG	As per HVDC Connections (Title II)

Summary - Comparison - RfG Type D Power Park Modules & HVDC Converter requirements (5)

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Technical Requirement	RfG Type D PPM	HVDC Connection (Title II)	DC Connected PPM (Title III)	Remote End HVDC Connection (Title III)
Priority to Active or Reactive Power	As per RfG Fast Fault Current Injection / Fault Ride Through proposals	Defined by TSO – would be expected to be the same as RfG proposals	Art 40(3) defined by RSO in coordination with the TSO. Proposal would be expected to be the same as RfG	As per HVDC Connections (Title II)
Power Quality	Not specified in RfG current GB practice would be expected to apply	Specified by RSO in coordination with the TSO. The proposal would be to maintain current GB practice	As per Article 44 – Further consideration required but current GB practice would be assumed to be the starting point	As per Article 50 – Further consideration required but current GB practice would be assumed to be the starting point
Fault Ride Through Capability	As per RfG Fault Ride Through proposals	Broadly similar to RfG but needs to include Blocking Voltage. Proposal would be to adopt similar requirements as RfG Type D PPM but further assessment necessary	As per RfG – Note linkage between RfG and Art 42 of HVDC Code	As per HVDC Connections (Title II)

Summary - Comparison - RfG Type D Power Park Modules & HVDC Converter requirements (6)

Technical Requirement	RfG Type D PPM	HVDC Connection (Title II)	DC Connected PPM (Title III)	Remote End HVDC Connection (Title III)
Post fault Active Power Recovery	As per RfG Fault Ride Through proposals	The proposal would be to adopt the same approach as RfG	As per RfG	As per HVDC Connections (Title II)
Fast Recovery from DC Faults	Not specified	To be determined	Not specified	As per HVDC Connections (Title II)
Energisation and Synchronisation of HVDC Converter Stations	Synchronisation - As per RfG System Management group	Covered in Article 28 but shall be no greater than 5% of the pre-synchronisation voltage	Covered in Article 41 but shall be no greater than 5% of the pre-synchronisation voltage	As per HVDC Connections (Title II)
Interaction between HVDC Systems or other plants and equipment	Not specified	To be determined	Not specified	As per HVDC Connections (Title II)
Power Oscillation Damping	Only required if specified by the relevant TSO	To be determined	As per RfG	As per HVDC Connections (Title II)

Summary - Comparison - RfG Type D Power Park Modules & HVDC Converter requirements (7)

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Technical Requirement	RfG Type D PPM	HVDC Connection (Title II)	DC Connected PPM (Title III)	Remote End HVDC Connection (Title III)
Subsynchronous torsional interaction damping capability	Not specified	To be determined although the current GB requirements would be considered appropriate as a suitable starting point	Not specified	As per HVDC Connections (Title II)
Network Characteristics	Not specifically covered although loose reference is made in the fault ride through requirements	To be determined	As per HVDC Code (Art 42) but broadly the same as HVDC Connections (Title II)	As per Article 49 which links back to the requirements for DC Connected Power Park Modules
HVDC System Robustness	Not specified	To be determined but a suitable starting point would be the GB SQSS	Not specified	As per HVDC Connections (Title II)
Electrical Protection Schemes and Settings	As per RfG System Management	The philosophy is broadly similar to RfG but further assessment is required.	As per RfG but note additional requirements in Art 43 of HVDC Code	As per HVDC Connections (Title II)

Summary - Comparison - RfG Type D Power Park Modules & HVDC Converter requirements (8)

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Technical Requirement	RfG Type D PPM	HVDC Connection (Title II)	DC Connected PPM (Title III)	Remote End HVDC Connection (Title III)
Priority Ranking of Protection and Control	As per RfG System Management	The philosophy is broadly similar to RfG but further assessment is required.	As per RfG but note additional requirements in Art 43 of HVDC Code	As per HVDC Connections (Title II)
Changes to protection and control schemes and settings	As per RfG System Management	The philosophy is broadly similar to RfG but further assessment is required. Control Mode and associated setpoint changes by remote operation need further consideration	As per RfG	As per HVDC Connections (Title II)
Black Start	As defined in GC0087 Consultation	Not mandatory. Some additional requirements will need to be considered especially in respect of Art 37 (2).	As per RfG	As per HVDC Connections (Title II)

Summary - Comparison - RfG Type D Power Park Modules & HVDC Converter requirements (9)

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Technical Requirement	RfG Type D PPM	HVDC Connection (Title II)	DC Connected PPM (Title III)	Remote End HVDC Connection (Title III)
Operation of HVDC Systems	Not applicable	Ability to send and receive signals	Not applicable	As per HVDC Connections (Title IV)
Parameters and Settings	Not directly applicable but broadly linked to Art 15(5)(c).	To be determined but expected to require additional general text in the GB Grid Code	As per RfG	As per HVDC Connections (Title IV)
Fault Recording and Monitoring	RfG is different from HVDC but the general requirements and principles for fault recording and monitoring are broadly similar to RfG	To be covered in System Management group	As per RfG	As per HVDC Connections (Title IV)
Simulation Models	RfG is different from HVDC but the general requirements and principles for modelling are broadly similar to RfG	To be covered in System Management group	As per RfG	As per HVDC Connections (Title IV)

Discussion / Next Steps

- RfG and the current GB Grid Code will be used to as a starting point to determine any HVDC parameters / requirements.
- Some areas of further analysis / investigation are required as outlined in the attached table which are specific to HVDC Converters as some of the requirements are over and above RfG
- System Management issues workgroup applies to all three Connection Codes (RfG, DCC and HVDC) though it is recognised there are differences