Hybrid STATCOM / SVC
Workgroup 22nd October 2014

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National Grid – TNS Technical Policy

Agenda

- Summary from previous meeting
- Actions from previous meeting
- DAR Times & Clarification of the voltage fluctuation requirement
- Statistical Analysis of Scottish Storm Data
- Questionnaire
- Preliminary Feedback
- Alternative Interpretation of the RfG
- Summary
- Discussion

Summary from Previous Meeting

- NG Technical Specification – SVC's under fault conditions
  - Full capacitive capability available down to 0.95pu Volts
  - Full inductive capability available up to 1.3pu Volts for 1 sec
  - For voltages between min cont. and 0.8pu for ≤20s, reactive current proportional to volts
  - For voltage between 0.8 to 0.4pu for ≤1.5s, reactive current proportional to volts
  - For voltage below 0.4pu for ≤0.5s must immediately resume reactive output on ≥0.4pu

Notes:

1. **MSC and MSR must therefore remain switched in for 0.5 seconds if the voltage is less than 0.4pu**
2. **For operation between min cont. and 0.4 SVC's, MSR's and MSC's produce reactive current proportional to volts but Statcom's produce rated current.**

- Storm Data
  - Recent storms demonstrate 3 consecutive switched events in a 3 minute period

Note: Latest data show's 4 events in approximately 1 minute and 5 events in two minutes

- DAR Times
  - Typically >10sec
  - Reclaim time 3-20secs
- Questionnaire – Discussion
- Requirements for Generators (Further Observations)
  - With t1 set 5s & t2 at 60s can permit ~82% of capability for first minute
  - GB Grid Code and Generator Compliance currently requires t1 to be 5secs for full range and 1sec for 50%.
- Additional Study Work – Will produce further study case if required

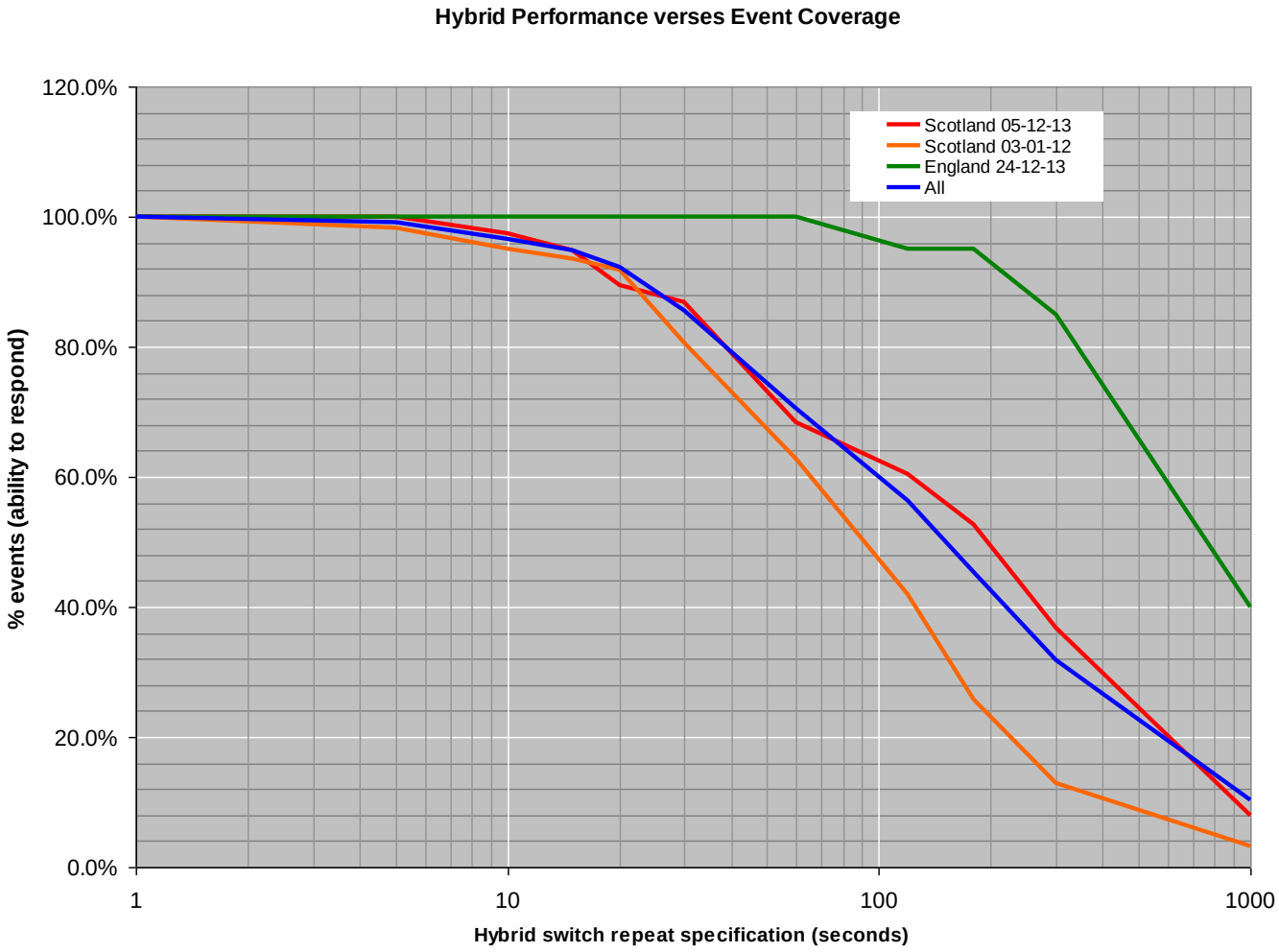
Actions from Previous Meeting

- ACTION 43: AJ and RI to clarify voltage fluctuation requirements
- ACTION 47: AJ and RI to further consider National Grid's interpretation of RfG and report back to workgroup
- ACTION 49: AJ and RI to use data to determine the number of repeated events occurring in a given area over a specific time period. This data could then be used to clarify the design requirements for hybrid STATCOM's.
- ACTION 79: RSP to provide information on tripping events and any data available on magnitude of voltage depression.
- ACTION 80: PT and CC to provide data from wind turbines that correlates with the fault events.
- ACTION 82: RI to correlate information from RSP presentation on fault incidents with control room logs.
- ACTION 85: RI to update questionnaire subject to working group comments and recirculate before the next meeting
- ACTION 87: RI to consider number of events occurring in a time period to understand repeatability time frame and frequency.
- ACTION 89: RI to circulate spreadsheet which was used to interpret hybrid statcom requirements.

DAR / Reclaim Times & Voltage Fluctuation Requirements

- National Grid
  - DAR Time – Typically ≥15 10s (Trip Reset Times) + 5s (deadline charge)
  - Reclaim 4 – 20 Seconds (Typically 4secs)
  - Clarification of Voltage Fluctuation Requirements
    - Fault events fall outside the voltage fluctuation and step requirements specified in the Grid Code
- Scottish Power
  - Dead Time – >15 seconds
  - Reclaim Time – 4 seconds
- SHE Transmission (SSE)
  - Dead Time – 10 seconds
  - Reclaim Time – 2 to 5 seconds

Analysis of Fault Data



Notes:

- Graphs which show the % readiness for the events which occurred verses repeat response ability of the device.

- The time on x axis, is the elapsed time in seconds before the STATCOM is ready to respond i.e. the time we are trying to determine. The % on y axis is the proportion switching events the STATCOM would have been ready to respond to for the examples.

- The above assumes that events less than 1 second apart are part of the same event and require a single response.

- The English data appears more favourable but this is simply due to the lack of time resolution as events are recorded to the nearest minute

Example of Events & Timings

Event	Time	Notes	Events <1 min	Time Diff.	Elapsed Seconds
Dounreay – Thurso – Mybster – Dunbeath – Brora – Shin (UTS) 132kV cct	05:14:00		1	00:00:00	0
Dounreay – Thurso – Mybster Shin (UTN)	05:14:00		2	00:00:00	0
Fort Augustus – Broadford 132 kV cct	05:58:00		1	00:44:00	0
Sloy – Inveraray (ISW)	06:06:34	Red	1	00:08:34	0
Peterhead – Blackhillock 275kV cct (VH)	06:14:00		1	00:07:26	0
Blackhillock – Keith 275kV cct (HK1)	06:14:00		2	00:00:00	0
Keith – Kintore 276kV cct (XK)	06:14:15	R-Y	3	00:00:15	15
Inverary – Ardkinglas – Sloy – Inverarnan 132kV cct (SN1/KS1/IK1)	06:14:32	Yellow	4	00:00:17	32
Inverary – Ardkinglas – Sloy – Inverarnan 132kV cct (SN1/KS1/IK1)	07:03:03	Blue	1	00:48:31	0
Inverary – Ardkinglas – Sloy – Inverarnan 132kV cct (SN1/KS1/IK1)	07:17:21	Yellow	1	00:14:18	0
Sloy – Windyhill – Dunoon – Whistlefield East 1 132kV cct (SWE1/GL1)	07:27:11	Red then R-Y	1	00:09:50	0
Hunterston – Kilmarnock South 400kV cct	07:28:42	Yellow	1	00:01:31	0
Kilwinning – Meadowhead 2 132kV	07:28:53	Red	2	00:00:11	11
Sloy – Windyhill – Dunoon – Whistlefield East 1 132kV cct (SWE1/GL1)	07:29:24	Yellow	3	00:00:31	42
Sloy – Windyhill – Dunoon – Whistlefield East 1 132kV cct (SWE1/GL1)	07:29:50	Yellow	4	00:00:26	68
Kilwinning – Meadowhead 2 132kV	07:33:30	Red	1	00:03:40	0
Inverkip - Strathaven 400kV cct	07:38:01	Blue	1	00:04:31	0
Coalburn Strarhaven 400kV cct	07:40:04	Red	1	00:02:03	0
Hunterston – Kilmarnock South 400kV cct	07:43:01	Yellow	1	00:02:57	0

Questionnaire Slide 1

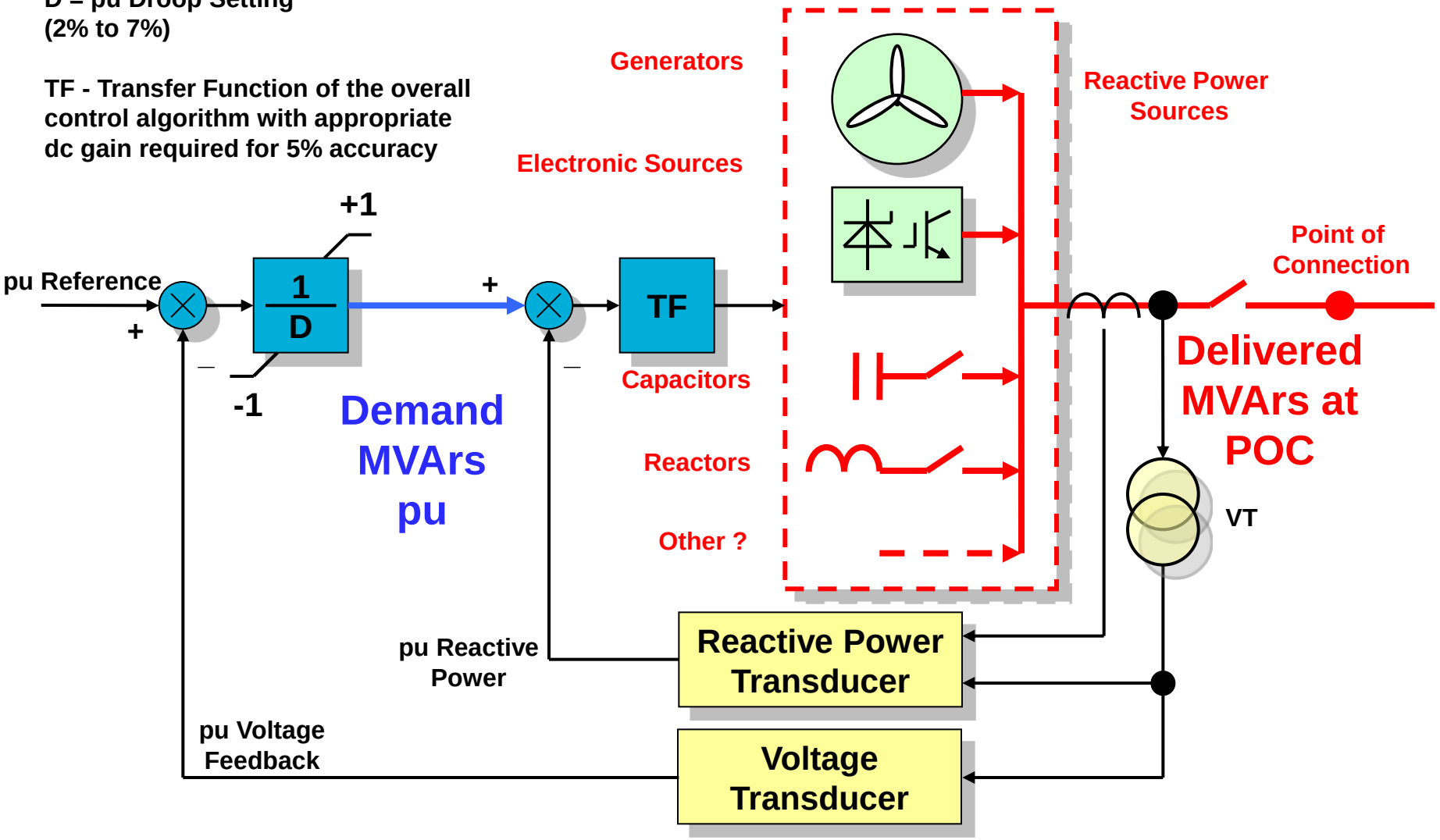
Hybrid STATCOM / SVC Questionnaire

1. Sent out questionnaire asking for comments 10-09-14.
2. Points raised by Mick (MB) 23-09-14.
3. New questionnaire sent 06-10-14.
4. Responses from working group.
5. NG Research.

Questionnaire Slide 2

D = pu Droop Setting
(2% to 7%)

TF - Transfer Function of the overall control algorithm with appropriate dc gain required for 5% accuracy



Preliminary Feedback

- European Hybrid SVC TSO Connected
- European Hybrid Manufacturer
- UK Switch Gear Manufacturer installing on UK Wind Farms

European TSO Connected Hybrid SVC – Example 1

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General Information

- 3 x Hybrid SVC's currently in service, consisting of a mechanically switched shunt capacitor & shunt reactor in combination with SVC
- The reactive component details are as follows:
- 1 * 150MVAr Caps (on 2 of the devices these are connected at a 25kV Bus Bar on the other at 225kV).
- 1 * 150MVAr Reactors 25kV Bus bar
- Electronic 100MVAr TCR

Timing Tolerance s on the Switching

- 100ms to close or open ±20ms
- Tolerance on opening and closing time is <1ms
- Controller learns and can adapt to aging, supply voltage and temperature variations.
- Circuit Breakers are spring SF6 types
- Spring Recharge Time 15 Seconds to reclose with no delay on reopen, therefore 3-4 operations per minutes are possible

Additional Benefits

- Equipment has a variety of additional benefits over and above increased reliability which is only limited by spring recharge time

Costing Information

- Estimated 20% saving on fully electronic SVC
- According to NG figures SVC's are approximately 12-50% cheaper than STATCOM's
- Likely to typically maintain cost saving identified by manufacturers

Fast Hybrids Available from European Manufacturer – Example 2

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General Information

- Hybrid currently being quoted, consisting of a mechanically switched shunt capacitor & shunt reactor in combination with a Statcom
- Typical examples discussed include 2x10MVAr MSC and 2x10MVAr MSR with ±10MVAr Statcom

Timing Tolerances on the Switching

- Grid code compliant in respect of meeting the initial 1 second response time
- Repeat capability depends on switch type fitted, typically determined by the spring recharge time
- Can offer switches with repeatable 1 second response but no experience to date
- Controller learns and can adapt to aging, supply voltage and temperature variations

Additional Benefits

- Equipment has a variety of additional benefits over and above increased reliability

Costing Information

- No response received

UK Installed High Speed Switches Example 3

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General Information

- Transformer switching application on UK Wind Farm
- Switch controller designed for transformers but a similar devices in the same range available for capacitor and reactor switching
- 36kV Vacuum Switch with 171kV BIL rating rated at 2000A
- Coil energise with spring return but coil energise and return are available (i.e. PoW make and break)

Timing Tolerances on the Switching

- Tolerance on opening and closing time is <300us (Coil energise and return)
- Controller learns and can adapt to aging, supply voltage and temperature variations
- Maximum limit on open and close time only determined by heating in coil driver
- Currently capable of ten consecutive switching operations 1 second apart

Additional Benefits

- Equipment has a variety of additional benefits over and above increased reliability

Alternative Interpretation of RfG

- Can be argued that the system is not in steady state until t2 has expired
- Repeat events could therefore be determined by t2

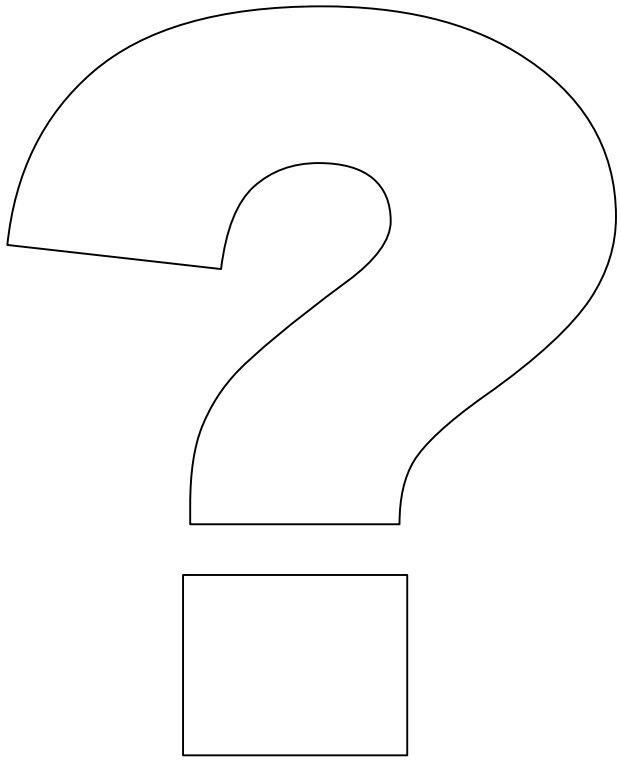
RfG States:

*Following a step change in Voltage, the Power Park Module shall be capable of achieving **90% of the change** in Reactive Power output within a time t1 to be specified by Relevant Network operator while respecting the provisions of Article 4(3) in the range of 1 - 5 seconds and settle at the value defined by the operating Slope within a time t2 to be specified by Relevant Network Operator while respecting the provisions of Article 4(3) in the range of 5 - 60 seconds, with a steady-state reactive tolerance no greater than 5% of the maximum Reactive Power.*

Next Steps

- Require responses to questionnaire
- Asses responses and fault statistics
- Agree consensus on the requirement for repeatable performance
- Agree consensus on performance during low voltage events
- Draft Working Group Report and Legal Text
- Present Report to GCRP
- Industry Consultation
- Report to the Authority

Questions



Discussion