

Grid Interference on Plant Operation – Mitigating Actions

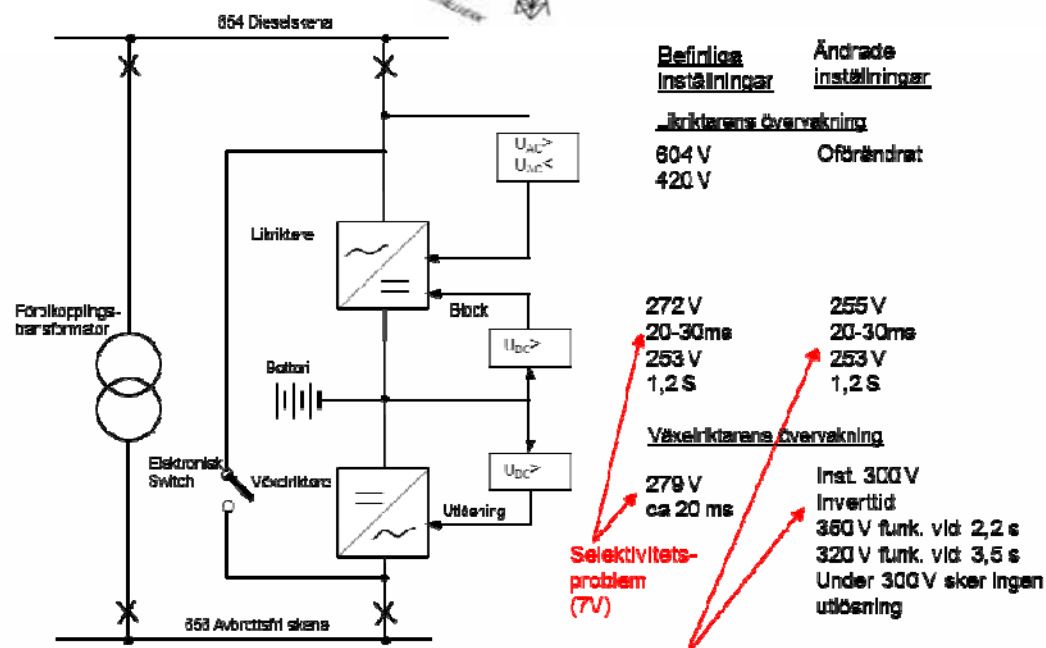
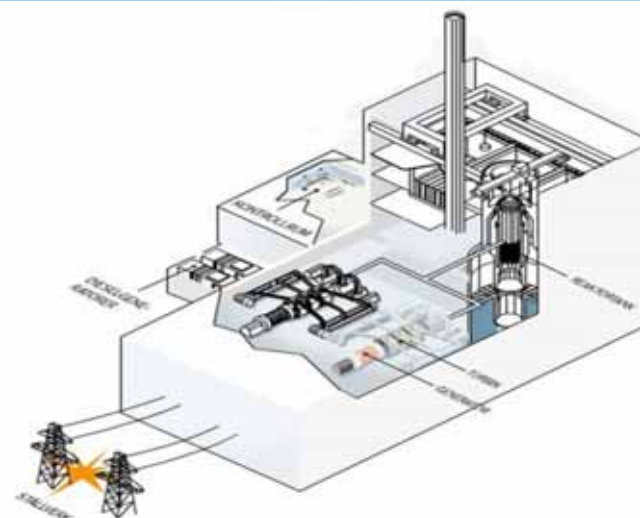
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GINO Seminar, Stockholm, June 14, 2016

Security: Open

Disturbances - F1 July 25, 2006

- F1 in operation, F2 in outage.
- Maintenance work in the 400 kV bus bar lead to a two-phase short circuit.
- Station breaker tripped - Overvoltage
- System 656 sub A och B lost power, sub C and D were still intact.
- After 22 minuter voltage to 654 och 656 in sub A och B was restored.



Reviderade inställningar Ändrade inställningar

Linjekärlens övervakning
 604 V Oförändrat
 420 V

272 V 255 V
 20-30ms 20-30ms
 253 V 253 V
 1,2 S 1,2 S

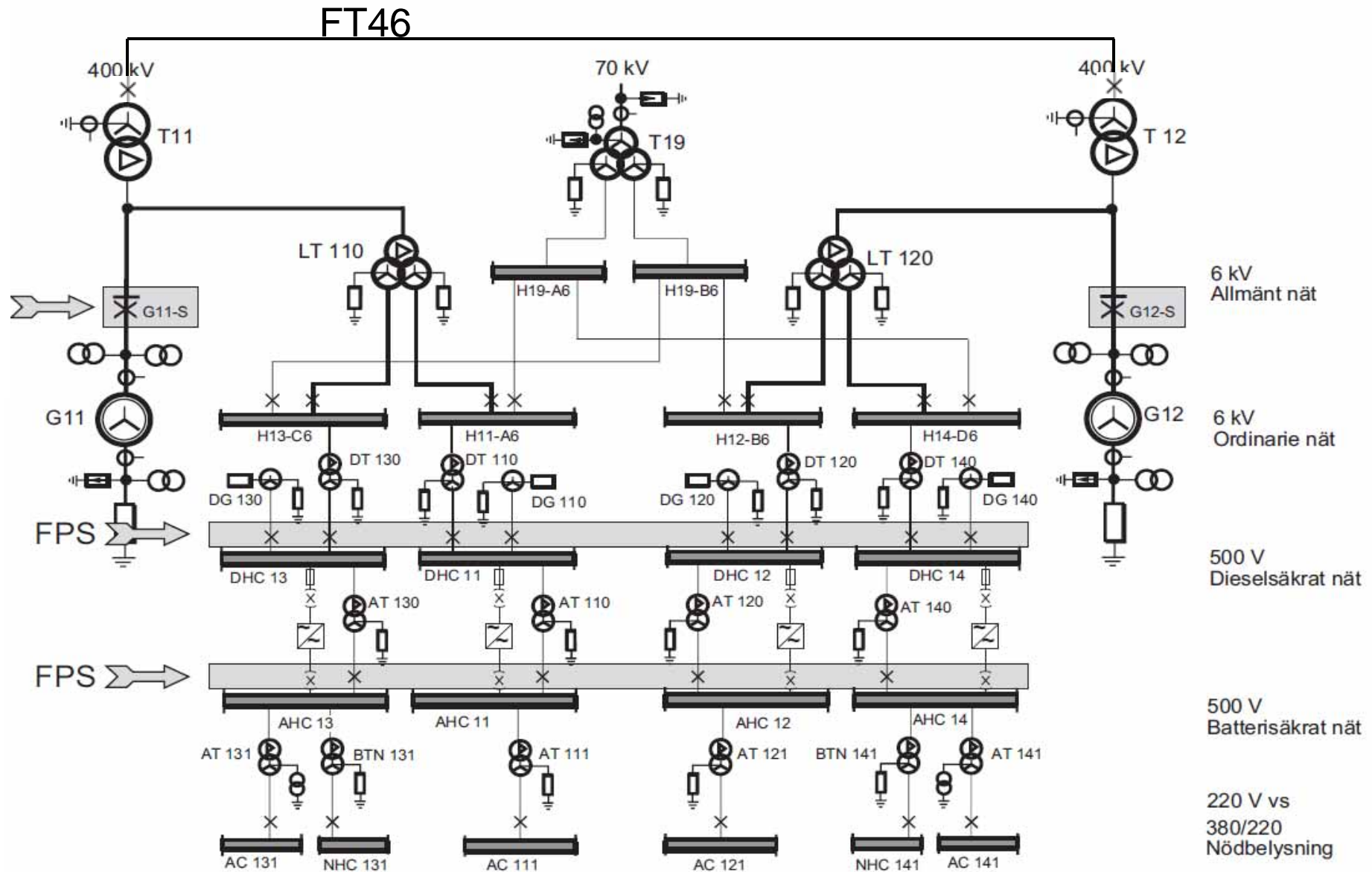
Växelriktarens övervakning

279 V Inst. 300 V
 ca 20 ms Invertid
 360 V funk. vid 2,2 s
 320 V funk. vid 3,5 s
 Under 300 V sker ingen utlösning

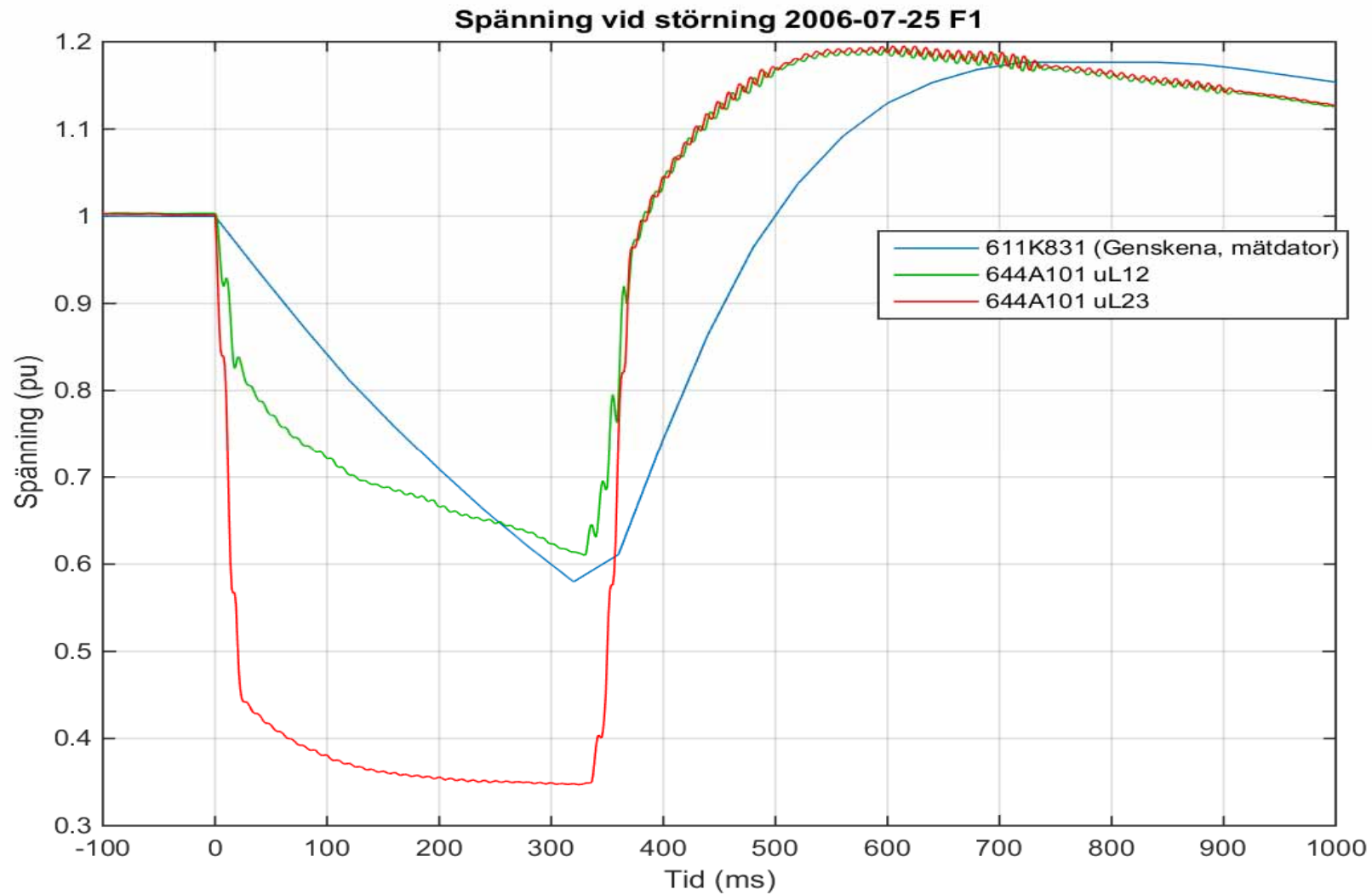
Selektivitetsproblem (7V)

Stora marginaler i n vä och tid gör att linjekärlaren hinna blockera vid överspänning. Minst 45V.

Disturbances – F1 July 25, 2006



Interpretation of measurements

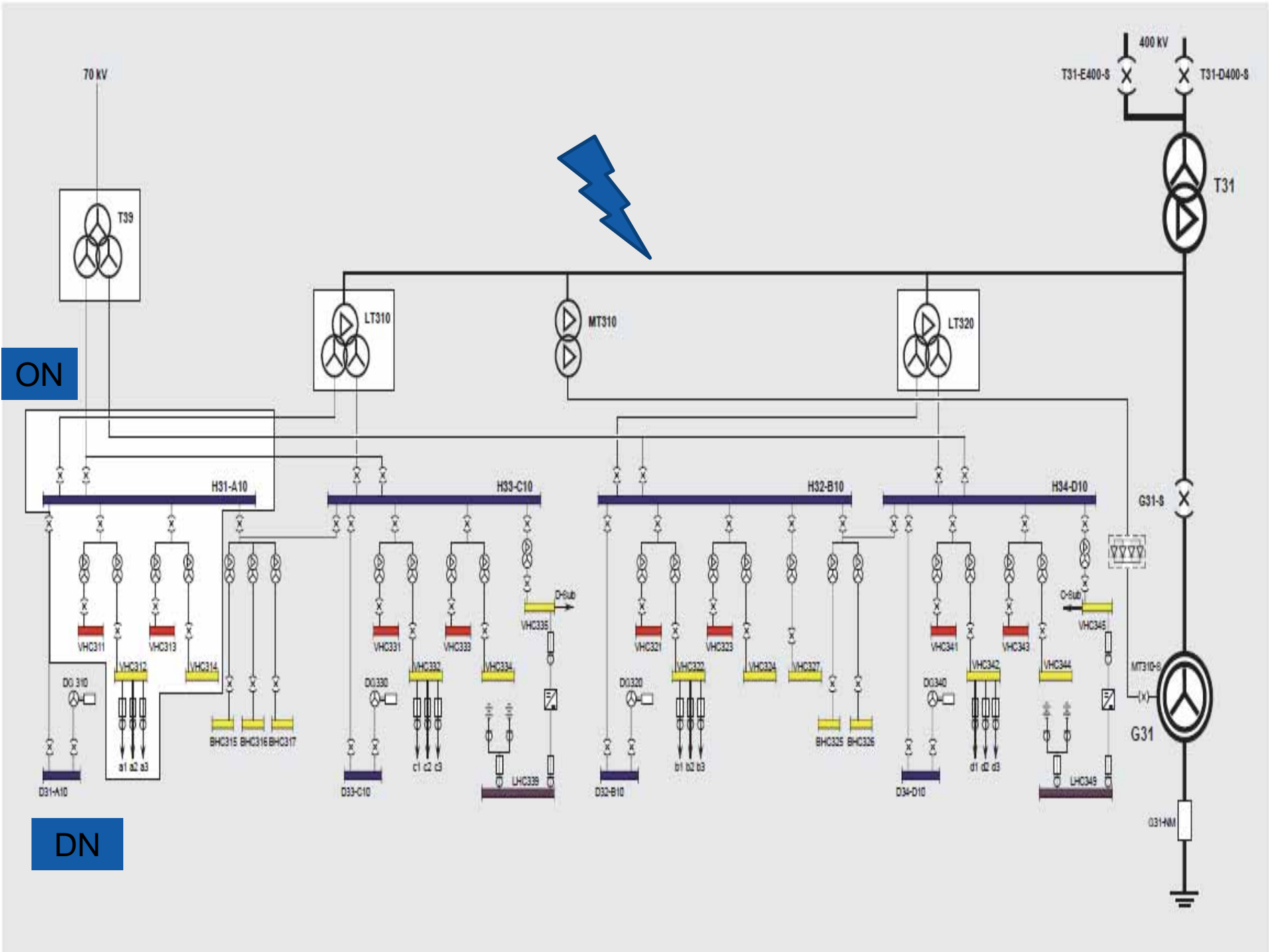


More disturbances

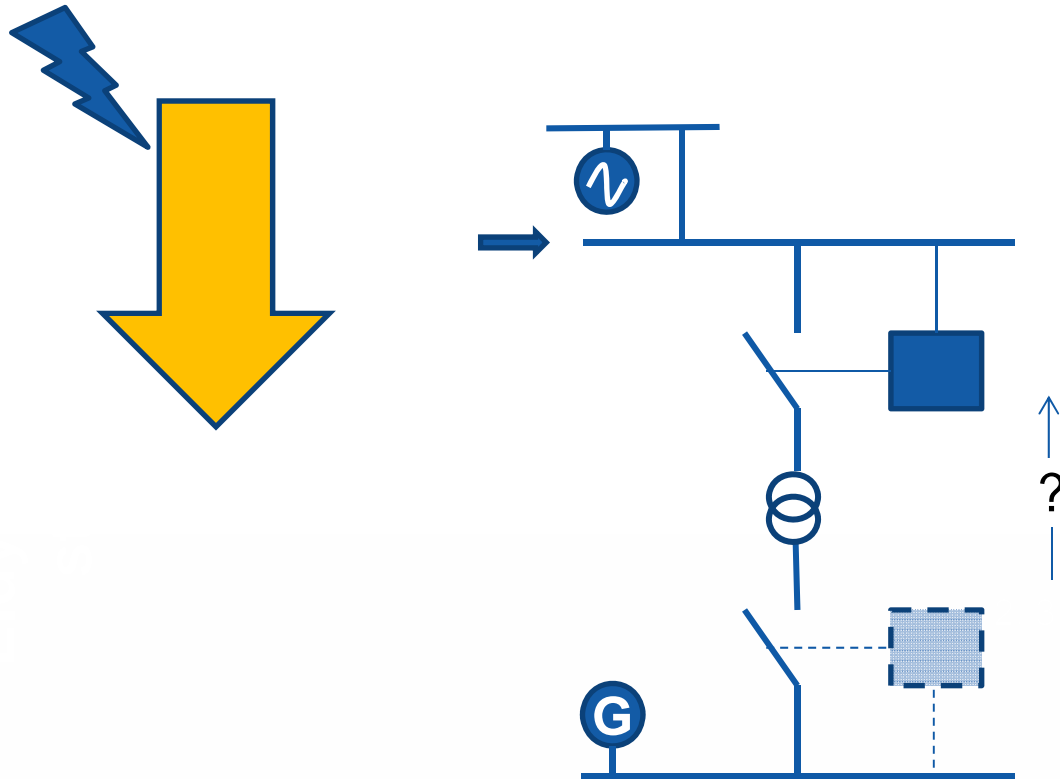
- Disturbances with international attention
 - Olkiluoto 1, 2008 – Plant Mod New Generator
 - Byron 2 January 30 – Open phase
 - Byron 1 February 28 – Open phase
 - Forsmark 3, May 30, 2013 – Open phase
 - Dungeness 2014, Open phase
- Other disturbances
 - TVO 1991 – Fire in transformer
 - Ringhals – Calibration of digital protection
 - Ringhals 3, Nov 14, 2006 – Transformer failure
 - Forsmark 1, November 27, 2007 – Blade fuse, defect batch
 - Forsmark 2, June 13, 2008, Thunder
 - Forsmark 3, July 13, 2012 - Thunder

Immediate Mitigating Actions as a Response to the Disturbances

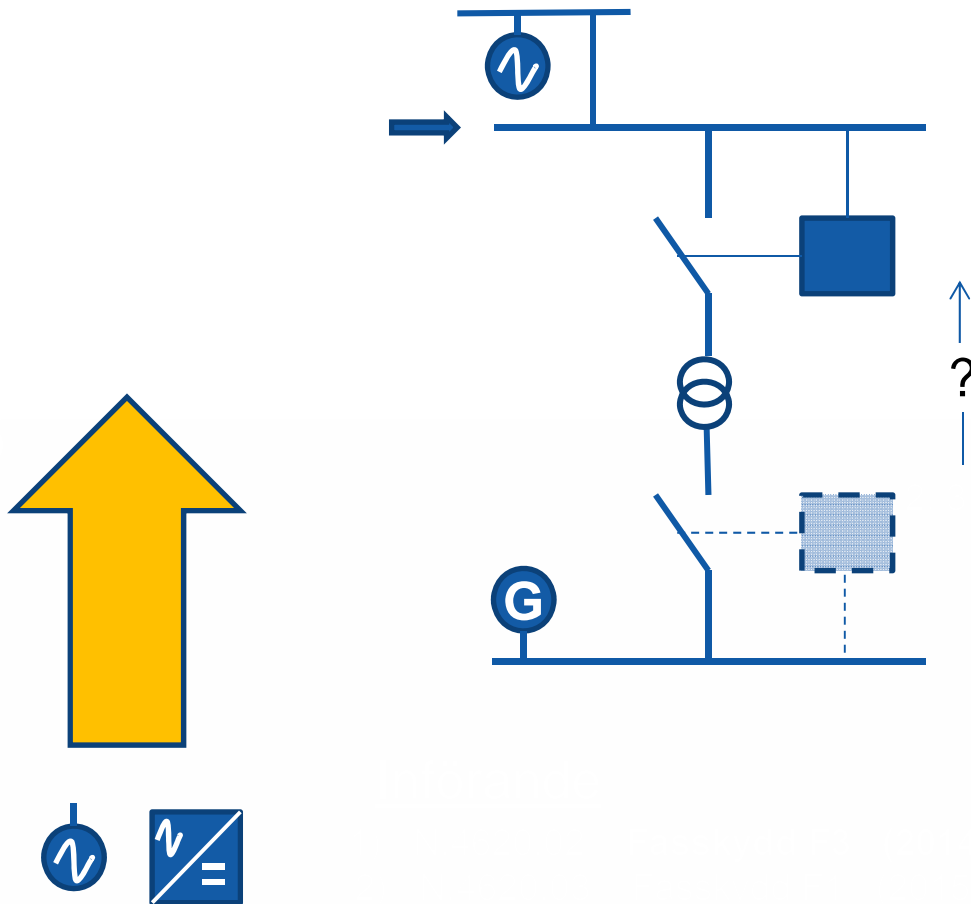
- DIDEISYS
- Phase order restored in under frequency protection
- Selectivity in UPS
- Power supply to Tachometer is DC
- Improve power supply for supervision
- Adjustment of over and under voltage protection
- Control of power electronics for supply to main recirculation flow modified
- Protection against unbalanced voltage installed (in progress)
- Supervision of unbalanced voltage
- Obvious faults have been corrected, but the generic problem remains



Classic approach – Analysis of disturbances

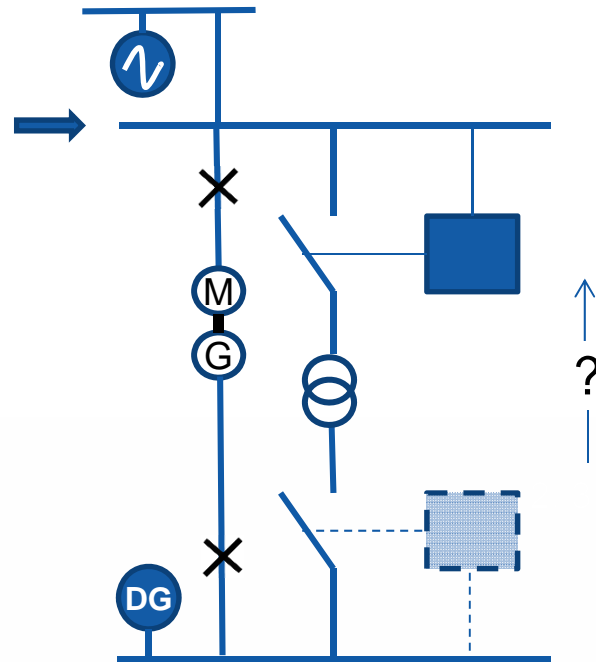


Reverse approach – What can we withstand?



Holistic approach – Passive protection

Electric separation

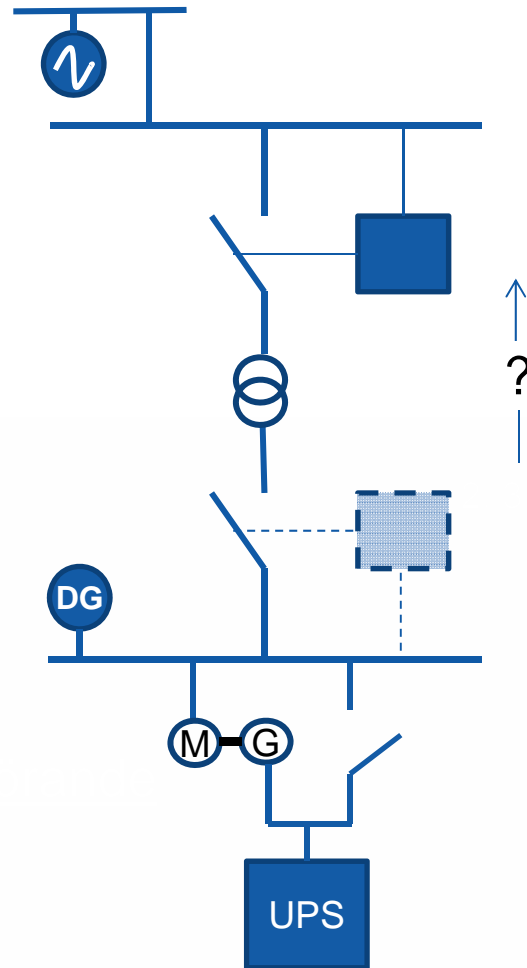


Combine active and passive separation with reverse approach

- Implementation of active protection against unbalanced voltage should provide an adequate protection for rotating machines
- Rectifiers remain – in particular UPS

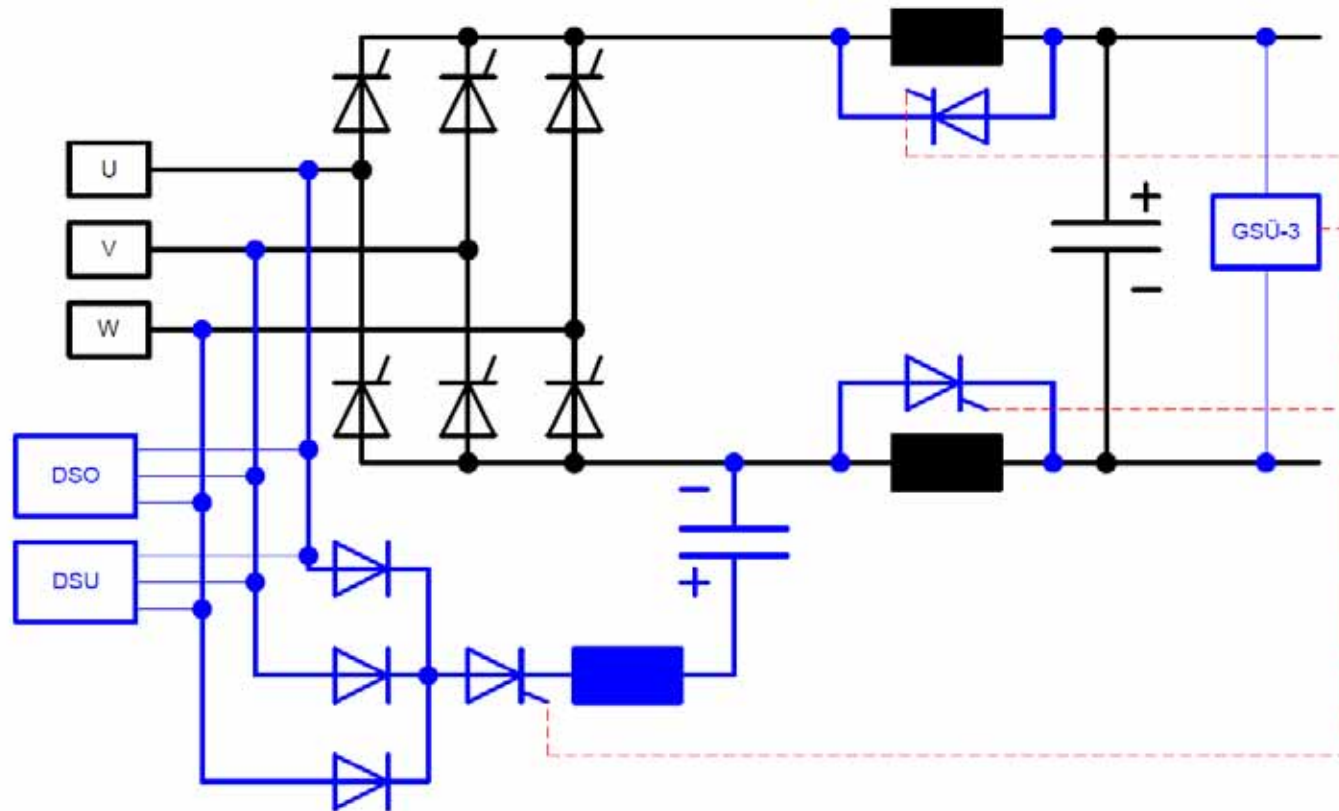
Passive separation - light

Electric separation –
Where it bites best
Much smaller MG-set



Over Voltage Protection in System 655 (UPS) – since 2010

Principle Diagram / 6 puls rectifier + analouge overvoltage limiter GSÜ3-B



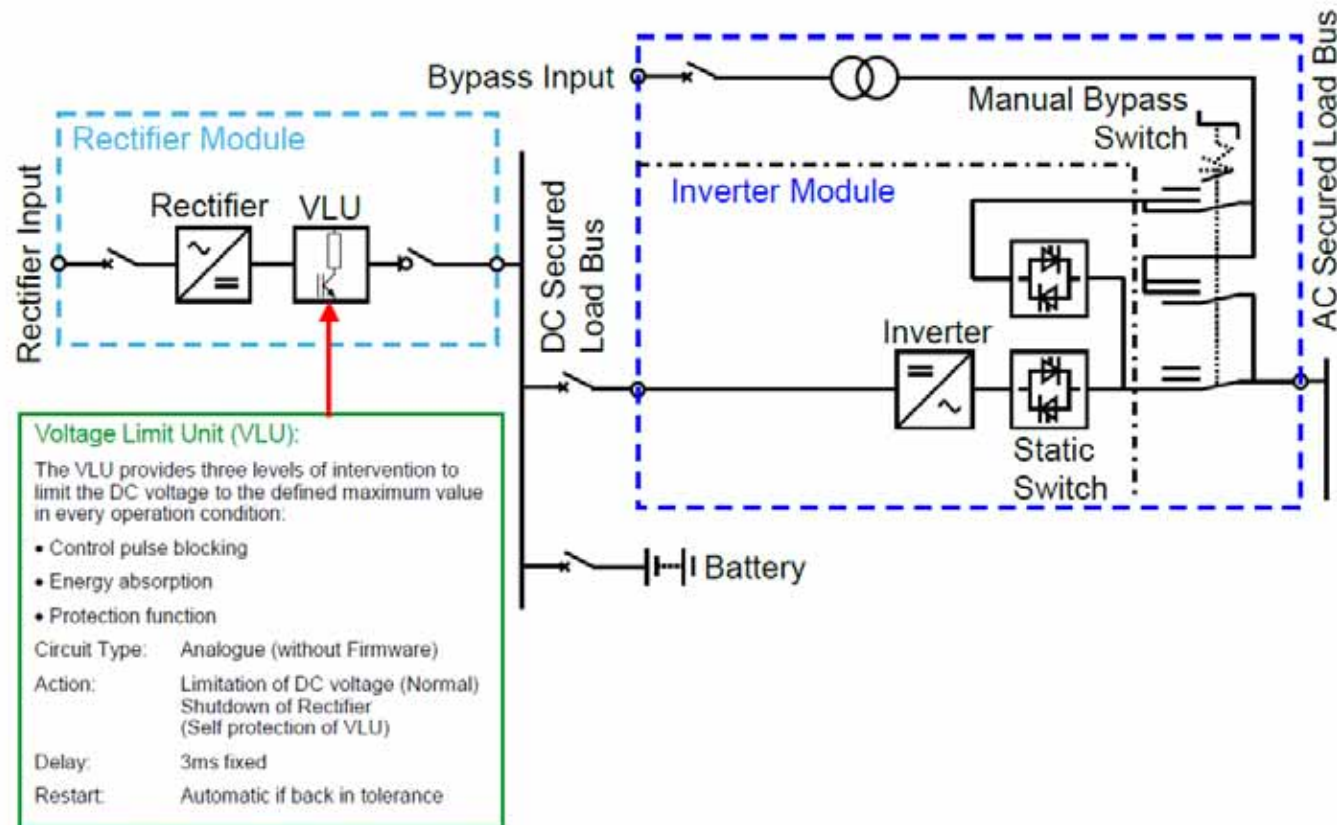
Black colour = Classical 6 puls Rectifier

Blue colour = GSÜ3-B (analouge overvoltage limiter)

Klaus Riekoetter

Over Voltage Protection – not implemented

Voltage Limitation Unit - VLU



Smorgardsbord of mitigating actions

- Design Process
- Integral testing
- **Electric separation**
- Unbalance protection
- Transient overvoltage protection (surge arresters)
- Analysis (simulation) of postulated disturbances
 - V&V
- Transient registration
- Supervision
- Compensatory measures during operation
 - Island operation of DG during thunder and electrical maintenance
 - No major electrical work until the lid is off (decay heat, availability of water)
 - Specific plan during challenging plant modifications

Electric separation - smorgasbord

- Feed of one or two trains from standby network
 - Both non-safety and safety busbar
 - Only safety busbar
- Active protection "trigger happy"
- Feed from different locations in the grid (only applicable in some plants)
- "Filter" MG-set (or static)
 - Separate between safety and non-safety
 - Separate sensitive equipment (UPS)
 - Electronic switch – to be or not to be?
- Rectifier as a barrier
 - Breaker before rectifier – w or w/o automatic restart
 - Cooperation with vendors
 - How to specify at procurement?

Idea of effort in Energiforsk

- Provide a selection ("smorgasbord") of available mitigating actions
- Application of mitigating actions dependent on other factors
 - Economy
 - Life cycle of plant as well as specific equipment