ENERCON wind energy converters facing Fault Ride Through requirements

Eckard Quitmann
International Sales - Grid Integration / T&D Systems

Energy For The World
ENERCON Technology
WEC - Concept

- Stator
- Generator
- Rotor
- Rectifier
- Yaw Motor
- Excitation
- Control
- Generation
ENERCON Technology
WEC – Concept / Grid Management System

Chopper
UPS
Inverters
Control Cabinet
Transformer
Low Voltage Switch Gear

Level 0
Level 1
Level 2
Conversion
ENERCON WEC
Under-Voltage Ride Through (UVRT)

Voltage at 400V terminals of converter

Current at 400V terminals of converter

 Generator
 Rectifier
 DC Intermediate Link
 Converter
 Filter
 to unit transformer and grid

Voltage at 400V terminals of converter

Current at 400V terminals of converter
ENERCON participates worldwide in the development of grid codes, especially regarding Fault Ride Through

ENERCON has installed more than 1000 units worldwide with Undervoltage Ride Through (UVRT) capability
FRT requirements part I
Comparison: voltage dip curve

EON grid code defines only requirements for symmetrical 3 phase faults

ENERCON technology fulfills REE and e-on requirements
Reactive current requirements during symmetrical faults are very similar

ENERCON technology fulfils REE and e-on requirements
FRT requirements part III
Comparison: asymmetrical faults

- No infeed required
- Reactive power $Q$ consumption is limited
- Active power $P$ consumption is limited

no requirements for unsymmetrical faults
FRT requirements part IV
Faults in practice

1. Network faults are in general inductive, voltage phase angle shift depends on type of fault

2. System fault looks different to the WEC, due to vector group of unit transformer

3. Reactive- and active power infeed depend on
   i) type of fault and associated phase angle shift
   ii) network impedance after the fault is cleared
   iii) agreed method to calculate asymmetrical power
      (in Spain currently under discussion with AEE)

ENERCON technology fulfils REE and e-on requirements
ENERCON UVRT
Immediate active power recovery

3-phase fault, 25% $U_{\text{rated}}$, 0.5 sec, $P=2000$ kW

ENERCON WEC Transmission Configuration
- The WEC stays connected at faults
- It “rides through” voltage dips up to 4s!
- Active power recovers immediately after the fault
ENERCON UVRT
Mechanical torques during ride through

- No important transient torque shocks occur
- The generator is mechanically decoupled from the grid
- The dynamic stability of the transmission system is not endangered

$M_{\text{max}} < 115\%$
ENERCON UVRT
Testing in the field

E-66 Transmission

ENERCON UVRT Testing in the field

110kV Substation

different faults applied

Measurement

20kV
Model for the simulation of 3-phase faults available for
- E-70 / E4 (2 MW)
- E-48 (800kW)

Available as PSS/E model
Version 29 or 30

Example: Active Power E-66 / Voltage Drop to 70%
ENERCON UVRT
3 Phase Faults - Validated modelling

E-66 and E-70  2 MW Transmission Configuration

Measurement

\[ U_{\text{res}} \approx 45\% \]

3 sec

Simulation

\[ U_{\text{res}} \approx 45\% \]

3 sec

Voltage
ENERCON UVRT
3 Phase Faults - Validated modelling

E-66 and E-70  2 MW Transmission Configuration

Measurement

\[ U_{res} \approx 45 \% \]
3 sec

Simulation

\[ U_{res} \approx 45 \% \]
3 sec

Current

\begin{align*}
\text{Measurement} & : U_{res} \approx 45 \% \\
\text{Simulation} & : U_{res} \approx 45 \% \\
\end{align*}
ENERCON UVRT
3 Phase Faults - Validated modelling

E-66 and E-70 2 MW Transmission Configuration

Measurement

\[ U_{\text{res}} \approx 25\% \]
3 sec

Simulation

\[ U_{\text{res}} \approx 45\% \]
3 sec

Power (Active, Reactive)
Thank you for your attention!