PLN-ABB Power Grids Workshop
ABB HVDC converter transformers
ABB HVDC converter transformers
Ludvika, Sweden - Factory history and facts

- Factory in operation since 1893
- Developed 400 kV AC which became a standard for all over the world
- Developed 500 kV, 600 kV, 800 kV and 1100 kV HVDC
- Technical Lead Center of the fundamental R&D
- Global center of excellence for niche products like HVDC Transformers and Shunt reactors

- Products
  - HVDC
  - Shunt reactors
  - AC-Transformers
  - Service
ABB HVDC converter transformers
Ludvika, Sweden - Key figures

- Employees: 800
- Workshop area: 50 000 m²
- MVA/year: 20 000-25 000
- Units/year: 60-80 depending on mix
- Power/voltage: up to 1 200 MVA and 1100 kV
ABB HVDC converter transformers
Ludvika, Sweden - Major developments

- 2015: Worlds first UHVDC transformer connected to UHVAC passed the test
- 2015: World’s largest HVDC transformer, Celilo
- 2014: UHVDCC/UHVAC prototype passed the test
- 2012: 1100 kV UHVDC prototype passed the test
- 2010: 800 kV UHVDC put into commercial operation in China
- 2008: 800 kV UHVDC unit passed the test
- 2007: HVDC unit short circuit tested
- 2005: 800 kV AC for PGCIL and NTPC in India
- 2004: World’s largest variable shunt reactor
- 2000: HVDC light transmission
- 1999: Dryformer, oil-free power transformer
- 1982: 600 kV HVDC for Itaipu, Brazil
- 1976: 1765 kV AC transformer for AEP, USA
- 1965: 800 kV AC for HQ in Canada
- 1954: HVDC line Gotland to mainland Sweden
- 1952: 400 kV line starting in Harsprånget
- 1948: World’s first variable shunt reactor
- 1920: 120 kV transmission line in Sweden
- 1893: 3-phase transmission at Hällsjön, Sweden
We have in June 2012 successfully developed and tested the world's first 1100 kV UHVDC transformer prototype with accompanying bushing:

- Enables higher power level ever
- Enables even greater energy efficient transmission
Purpose of converter transformer
An integral and key part of the HVDC-system

The role of the converter transformer
- To separate DC and AC network
- To adopt voltage to converter valve
- Tapping range for part of the DC voltage and reactive power control

Typical features of HVDC transformer
- Large transformer units
- Harmonics in current or voltage
- Reactive loading
- Close interaction with HVDC system
ABB has supplied to more than half of the 190 HVDC projects
The track record of a global leader

60 HVDC Classic Projects since 1954
25 HVDC Upgrades since 1990
26 HVDC Light Projects since 1997
ABB HVDC converter transformers
HVDC from ABB - Value of project experience

- Strongest in experience and installed base for HVDC transformers
  - Projects are won by proposing good solutions that suit our customers’ need
    - Experience from all technical solutions and a large range of technical challenges
    - Experience from a multitude of projects and different customers around the world
- Gain in new projects from experience
  - Designs well optimized projects
  - Understanding different customer needs
  - Able to execute efficient projects
HVDC from ABB – the advantages
System/transformer/components – close cooperation

- All-ABB solutions:
  - System + transformers + transformer components
  - HVDC technology synchronized as a team within ABB
    - For project deliveries
    - For R&D
- Gain in new projects from cooperation
  - Safe and reliable solutions – maximum flow of information
  - All key supply within ABB control
  - Existing and new efficient products
    - Example: 800 kVdc from R&D to commercial operation in record time
Power and voltage development over time HVDC
From Gotland to 1100 kVdc
ABB HVDC converter transformers
Three Gorges-Changzhou 500kV 3000MW

- Single phase two-winding
  - 297.5 MVA
  - 525/210.4 kV
- One spare of each type
  - (Y/Y and Y/D) per station
Before put into Valve Hall

After put into Valve Hall
ABB HVDC converter transformers

Summary

The single most important component in the power system should not be the weakest link.
Power and productivity for a better world™
Converter transformer

300 kV DC unit
Single phase 300 MVA
3 winding transformers YN / y0 / d
345/√3 / 122/√3 / 122 kV
Impedance 17.2 %
Cooling OFAF

Y winding on high DC level
D winding on low DC level
Y and D connections outside valve hall
In operation since 1984
Converter Transformers
Single phase 315 MVA
3 wdg transformers YN / y0 / d
400/$\sqrt{3}$ / 213/$\sqrt{3}$ / 213 kV
Impedance 18%
Cooling OFAF

Y  wdg on high DC level
D  wdg on low DC level
Y  bushings through valve hall wall
D  connection created outside valve hall
In operation since 1990
Converter transformer

Single phase 312 MVA
3 winding transformers YN/y0/d 60 Hz
345/√3 / 207/√3 / 207 kV
Impedance 13 %
Cooling OFAF

Y winding on high DC level
D winding on low DC level
Y and D connections outside valve hall
In operation since 1990
Sapei 500kV HVDC link

Design

Converter transformer

Single phase 194 MVA
3 winding transf. YN/y0/d
400/\sqrt{3} / 207,7/\sqrt{3} / 207,7 kV
Impedance 12,0 %
Cooling OFAF

Y winding on high DC level
D winding on low DC level
Y and D connections inside valve hall

*Transformer in SC-testing at KEMA Holland*

*The only large HVDC transformer ever S-C tested*

Transport weight 230 ton
Transport dim L x H x W 9,4 x 4,8 x 3,65
In operation since 2010
Technology working for existing projects
Songo – reconnectible replacement unit

- Non-ABB origin of other units
- Matching old unit data
- Reconnectable to secure for future upgrade from 533 kVdc to 600 kVdc
- Transformers to the receiving station Apollo also being supplied
Celilo Upgrade  560 kV HVDC link
Design

Converter transformer
Single phase 770 MVA
3 winding transformers YN/y0/d
540/√3 / 239,5/√3 / 239,5 kV  60 Hz
Impedance 19,0 %
Cooling OFAF

Y winding on high DC level
D winding on low DC level
Y and D connections outside valve hall
Transport weight  391 ton
Transport dim  L x H x W 13,3 x 4,85 x 4,05
In operation since