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Study Committe B4

DC System and power electronics

Paper ID_10795

±500 kV, 3000 MW Bipole LCC HVDC Transmission Bukdangjin – Godeok Project – Key Design Aspects

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Summary

This paper presents the key features and execution experience of the ±500 kV, 3000 MW Bipole LCC HVDC Transmission Bukdangjin – Godeok Project. The HVDC system is owned and operated by Korea Electric Power Corporation (KEPCO). GE along with JV partner KAPES was awarded first and second phase of the projects.

Key Features

- Both converter stations are connected to their respective AC networks through 345 kV AC feeders via double busbar
- Complete link is designed to transmit total 3000 MW power from Bukdangjin to Godeok station at ±500kV DC
- 12-pulse converter per pole with Dedicated Metallic Return (DMR)
- 2 HVDC Mass impregnated (MI) cables of length 35 km (5.6 km sea cable + 29.4 km ground cable) each are used in parallel for HVDC Lines
- 2 XLPE MV cables are used in parallel as DMR (Dedicated Metallic Return)
- Bukdangjin (Rectifier) is solidly grounded and transfer switches are at the inverter end
- Filters sub-banks are designed for higher MVAr than usual size due to deficit of space at rectifier
- Power Demand Override (PDO) function to carry out automatic rapid emergency changes in power flow

Scheme Overview

An overall single line diagram is shown in Figure 1 (next slide). This scheme is developed in two phases, the highlighted boxes in Figure 1 represent the scope of supply of the second phase.

DC Circuit Configuration

- Bipole with MV cable in service as return conductor
- Bipole with NBGS (Neutral Bus Ground Switch) closed at inverter with MV cable out of service
- Monopole with MV cable in service as return conductor
- Monopole with other HV cable as return conductor
- Monopole with MV cable and other pole HV cable both as return conductor

Scheme Parameters

The key main scheme parameters of this HVDC link are summarized in Table 1. The rated DC voltage and power in Table 1 is defined at the DC bus of the Godeok converter station.

The DC current rating of the HVDC cables is 3000 Adc, hence the scheme is designed to operate at a higher sending end voltage than ±500 kV to meet the active power requirement on the receiving end.

Main Scheme Parameter

Parameter Description	Bukdangjin	Godeok	Unit
Steady State AC Voltage range	345 ± 5%	345 ± 5%	kVrms
Steady State AC Frequency	60 ± 0.2	60 ± 0.2	Hz
Maximum Short Circuit Current for equipment rating	63	63	kArms
Minimum Short Circuit Level	12000	4500	MVA
Nominal DC Power per pole	1515		MW
Nominal DC Voltage per pole	±505		kV_{dc}
Nominal DC Current per pole	3000		A_{dc}
Minimum Steady State Rectifier Firing Angle	13	-	°
Minimum Steady State Inverter Extinction Angle	-	17	°
Converter Transformer Parameters			
Vector Group (Single Phase Two Winding)	YN/y0 and YN/d11		-
Rated Power	315/315		MVA
Rated Valve Winding Voltage	220		kV_{rms}
Base Impedance (@ Rated MVA and KV)	0.17		pu
Taps	-8% to +32		%
HVDC Smoothing Reactor per pole	40		mH
Number of thyristors per valve	72	72	
Installed Capacitive Reactive Power Phase 1	4 x 238	9 x 136	MVAr
Installed Inductive Reactive Power Phase 1	-	1 x 80	MVAr
Additional Installed Capacitive Reactive Power Phase 2	5 x 238	6 x 136	MVAr

Table 1 – Main Scheme Parameter

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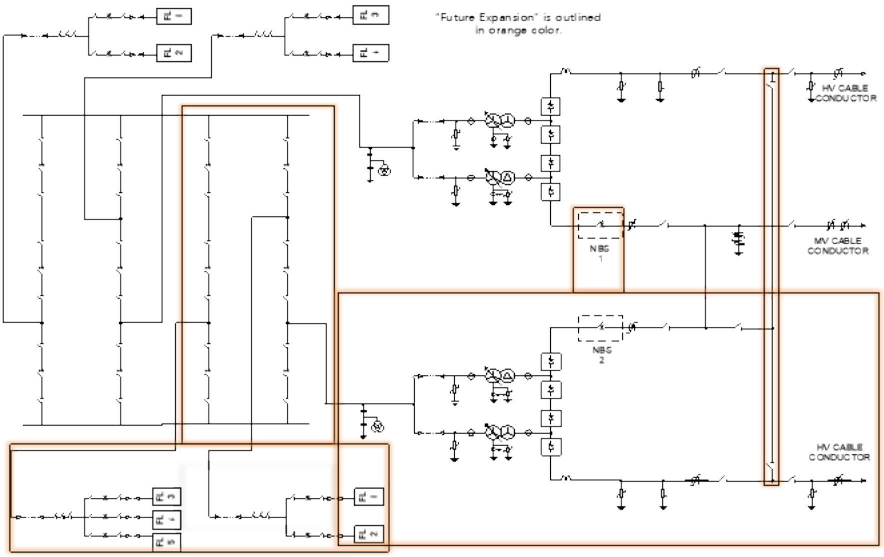

Figure 1 – a) Bukdangjin

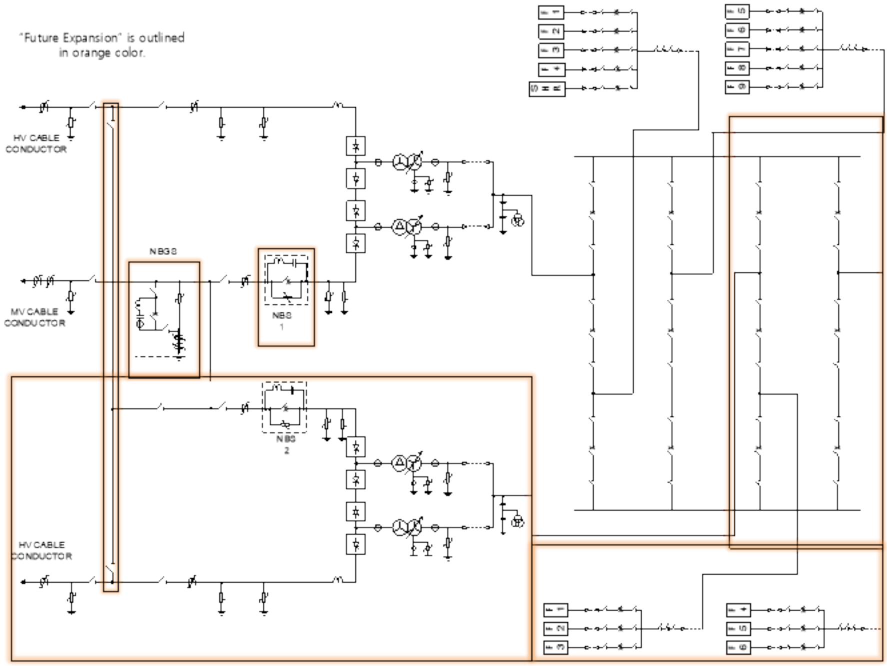

Figure 1 – b) Godeok

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AC Filter & Reactive Power

- Limited space available for filter resulted in higher MVAr ratings sub-banks than usual
- Scheme is operated as HVDC Back-to-Back due to a weak AC Network at Godeok site and short DC line
- DC voltage is varied within the defined range over the full active power range to maintain the AC system reactive exchange within limits
- Additional functions added in HVDC control to avoid excessive step-change in AC voltage, communication failure
- HVDC link is also designed to regulate the AC voltage as per the operator demand
- The filter switching-in points are summarized in the table below.

Bukdangjin			Godeok		
Reactive Power Element	Switching power level (Monopole)	Switching power level (Bipole)	Reactive Power Element	Switching power level (Monopole)	Switching power level (Bipole)
1	Deblock	Deblock	1&2	Deblock	Deblock
2	21%	Deblock	3	21%	Deblock
3	35%	21%	4	35%	21%
4	48%	26%	5	42%	26%
5	-	36%	6	48%	31%
6 to 9	-	Based on Reactive Power and AC voltage Control	7	Based on Reactive Power and AC voltage Control	36%
			8		42%
			9 to 15		Based on Reactive Power and AC voltage Control

Valve & Valve Cooling

- Liquid-cooled H400 series valves are installed
- Up to 6 thyristor with heat sink are clamped by glass-reinforced plastic (GRP) as shown in Figure 4-a
- Thyristor is 125mm, 8.5kV electrically triggered device
- The assembly of six-thyristor clamped with protective devices & gating electronics is called a valve section
- Two electrical valve sections are housed within a module, see Figure 4-b
- Direct liquid cooling is used which enables a single-circuit system with mixed de-ionized water and ethylene glycol is used to prevent freezing of coolant

Figure 4-a : Group of 6 thyristors with bands, heatsinks and power connections

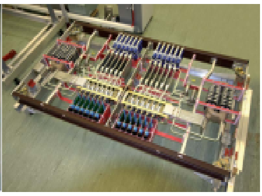

Figure 4-b : H400 valve module (VM)

Site Layout Arrangement

- Single phase, 2-winding transformers (6 units per pole) due to high power but transportation limitation
- As a result of which double valves (6 assemblies per pole) are housed in the valve hall as shown in Figure 5
- Overall site layout arrangement is shown in Figure 6

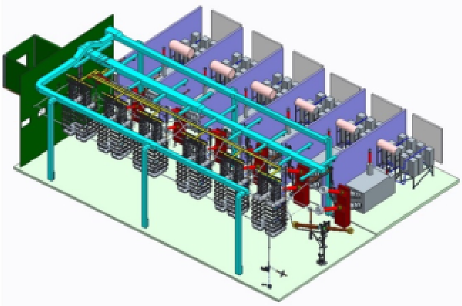

Figure 5 – 3D Model of Valve Hall and Converter Transformer Interface

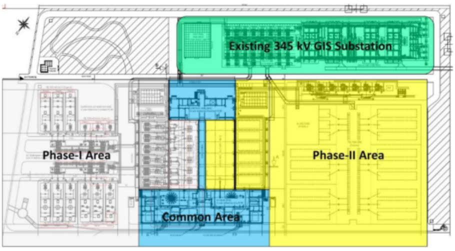

Figure 6 – Overall Site Layout Arrangement indicating Phase 1, 2 and common area

Project Progress

At the time of writing of this paper, phase 1 of this project has been commissioned and in operation. The design of phase 2 is approved and equipment has been either manufactured and is at site, or under erection. Commissioning is to take place during 2022.

Conclusion

This paper provides an overview of the converter station design aspects of the Bukdangjin-Godeok HVDC Transmission Project, a ±500 kV, 3000 MW bipole scheme which will transfer power from the Bukdangjin to the Godeok. This paper describes the key features of the bipole link with some technical parameters of major HVDC equipment and also special consideration, design practices and engineering challenges in the overall converter station design

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