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Operation Method of Protection Devices in 5kV MVDC Microgrid System Interconnected with Distributed Generators

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1. Introduction

- MVDC(Medium Voltage DC) distribution system has been actively introduced as one of countermeasure for large transmission capacity with low energy loss.
- However, Protective relay scheme(OCR, OCGR, UVR, OVR) in MVDC distribution system is still applied by adopting the AC method. Moreover, experts have difficulties to find the rated range of commercialized circuit breakers(CB).
- Proposal for operation method of protection devices in MVDC Interconnected with distributed generators In order to implement the 5kV MVDC in Naju Korea

2. Design of protection devices in 5kV MVDC microgrid system

- Configuration: radial distribution system type, 0.75/5kV scaled unidirectional DC/DC converter for PV including in the parking lot, bidirectional DC/DC converter for ESS and loads and DC/AC inverters for EV charger and the factories.

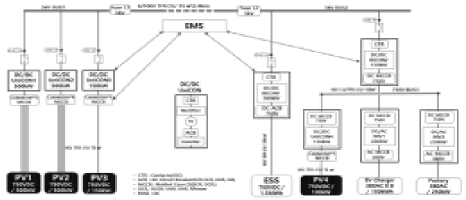

Fig. 1. Concept of MVDC microgrid system with DG

- Operational modes: day/night mode and emergency mode

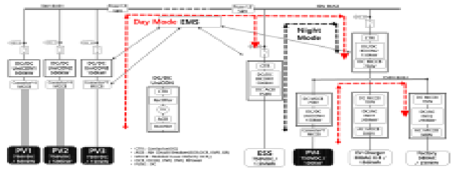

Fig. 2. Day and night operation modes

- TCC curves are not used for DC protection schemes like AC grid, it is very important to check the TCC curve of each protective relay by its manufacturer shown in Fig. 3.

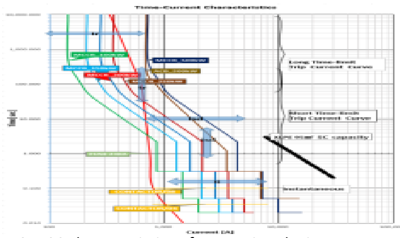

Fig. 3. TCC characteristics of protection devices

- protective apparatuses are considered for the grid, such as DC VCB, DC ACB, solid state DC breaker, hybrid DC breaker, DC MCCB, DC fuse and DC CTR[7-10].

3. Operation method of protection devices in 5kV MVDC microgrid system

- Components level: the IGBTs are blocked down by current and time variation(di/dt).
<converter blocking by AC-side ACB and DC-side CTR>
- Grid level: DC fuses are adapted for overcurrent fault in the 5kV underground cables and the connected bus bars

Fig. 4. Actual layout of 5kV MVDC grid in Naju Korea

4. Case study

- Fault currents in fault points are made known for the electromagnetic transient in the grid and the protection strategies on the fault condition. Fig. 5 shows the fault location when maximum current are occurred by PV.

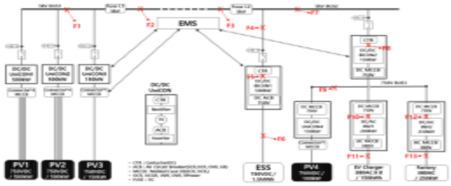

Fig. 5. Fault locations on the day mode

- According to the fault locations, operation characteristic of protectors(CB, CTR) and fault current are shown in Table 1.

Table 1. Fault current values by simulation

5kV Fault Point	Fault Current	Working Protectors	Fault Peak[kA]	Fault Peak of ACB-CTR Open[kA]
F1	I1+I2+I3	UniCon 1, 2, 3 CTR	7.03	6.91
F2, F3	I1+I2+I3	Fuse L1	7.03 / 4.23	6.91 / 4.16
F4, F7	I1+I2+I3	Fuse L2	4.23	4.16
F5	Ibicon1	Fuse L2 or BiCON1 CTR	4.23	4.16
F8	Ibicon2	Fuse L2 or BiCON2 CTR	4.23	4.16
750V Fault Point	**Fault Current**	**Working Protectors**	**Fault Peak[kA]**	**Over Current during Stop [kA]**
F6	Iess	DC ACB	15	1.33
F9	Iunicon4 + Ibicon2	All DC MCCB	4.3	3.9
F10	Iev	Inv1 DC MCCB	4.3	3.9
F12	Iinv2	Inv2 DC MCCB	4.3	3.9
F11	Iinv2	Inv1 AC MCCB	2.3	0.46
F13	Ifa	Inv2 AC MCCB	3.8	0.76

5. Conclusions

- This paper focuses on the protection design and its application in 5kV MVDC microgrid as the first initiation in Naju Korea.