Paris Session 2022

Losses of Isolated DC-DC

SC B4, PS1/2-11 DC/DC converters, Question 1.17 How do DC-DC converters compare with other types of AC-DC converters in terms of power losses?

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Isolated DC-DC converter at different operating frequencies

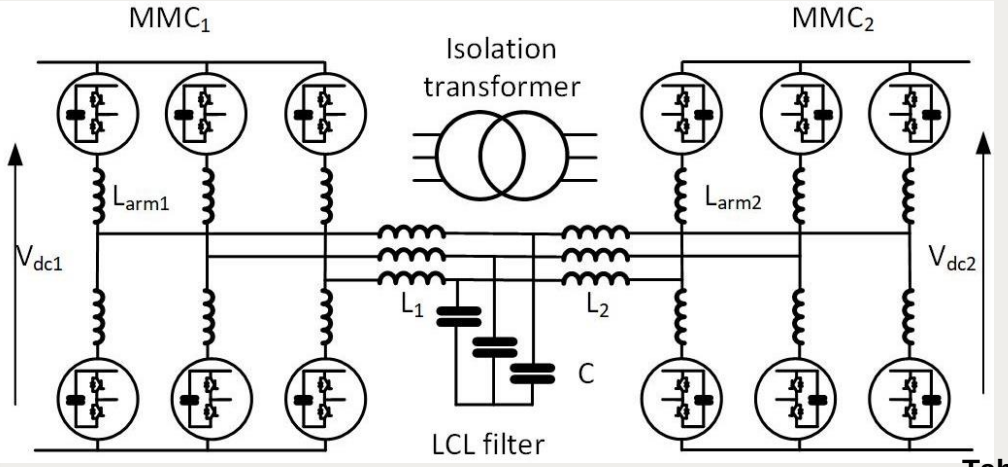

Figure 1 Isolated DC-DC converter

Isolated DC-DC converter:
- 2 MMC, 3-phase bridges,
- Either transformer or LCL filter in the inner AC circuit,
- Wide range of stepping ratios,
- Regulates power flow,
- Isolates DC faults,

MMC inside a DC-DC:
- Some performance requirements are different, compared with HVDC MMC.
- Can be optimized for efficiency and size.

MMC converter operating at frequencies higher than 50Hz:
- Switching losses increase,
- Conduction losses remain the same,
- Size of all passive components reduces (proportionally),
- Size of transformer (LCL filter) reduces,
- Weight reduces,

Table 1 Power losses, weight and volume of 1GW MMC converter (320kV) at different operating frequencies [1]

Freq. (Hz)	C_{cell} (µF)	L_{arm} (mH)	Total weight[1] (Ton)	Total volume[1] (m^3)	L_{arm} power losses (MW)	ΔV_{cell} (%)	SMs Switching Losses (MW)	SMs Conduction Losses (MW)	Total Power Losses (MW)	Total Power Losses (%)
50	1500	50	1791	1613	0.15	6.5	1.07	2.84	4.06	0.41
100	750	30	903	810	0.12	6.4	1.83	2.84	4.79	0.48
200	375	25	458	407	0.1	6.8	2.99	2.84	5.93	0.59
300	250	20	305	270	0.09	6.9	4.47	2.83	7.39	0.74
400	190	15	235	208	0.07	7.0	5.97	2.83	8.87	0.89
500	150	15	188	165	0.07	7.0	7.44	2.83	10.34	1.03
600	120	15	153	134	0.07	7.3	8.84	2.82	11.73	1.17
700	107	10	135	118	0.06	7.2	10.47	2.82	13.35	1.34
800	94	10	120	104	0.06	7.3	11.86	2.83	14.75	1.48
1000	75	5	94	82	0.04	7.5	15.11	2.84	17.99	1.8

[1] A. Jamshidifar, M. Hajian, D.Jovcic and Y Audachya, “High power MMC VSC Optimal Design for DC/DC converter applications” IET Power Electronics Vol. 9, issue 2, February 2016, pp 247-255

Isolated DC-DC converter at different operating frequencies

Onshore applications:
- Frequencies 100-300Hz,
- Total losses 1-1.5%
- Size/weight up to 5 times lower than when operating at 50Hz.

Offshore applications:
- Frequencies 300-600Hz,
- Total losses 1.5-2.5%
- Size/weight up to 10 times lower than when operating at 50Hz.

Table 2 Power losses, weight and volume of 1GW DC-DC converter (320kV/250kV) at different operating frequencies [1]

Freq. (Hz)	LCL weight (Ton)	LCL volume (m^3)	LCL inductors losses (MW)	Total Weight (Ton)	Total volume (m^3)	Total power losses (MW)	Total power losses (%)
50	458	379	1.16	4040	3605	9.32	0.93
100	256	196	0.77	2062	1816	10.35	1.04
200	145	99	0.5	1061	913	12.36	1.24
300	105	69	0.39	721	619	15.17	1.52
400	91	54	0.34	561	470	18.08	1.81
500	71	43	0.29	447	373	20.97	2.1
600	62	37	0.26	368	350	23.72	2.37
700	55	32	0.24	325	268	26.94	2.69
800	49	28	0.22	289	236	29.72	2.97
1000	42	23	0.19	230	187	36.17	3.62

Onshore applications

Offshore applications

[1] A. Jamshidifar, M. Hajian, D.Jovcic and Y Audachya, “High power MMC VSC Optimal Design for DC/DC converter applications” IET Power Electronics Vol. 9, issue 2, February 2016, pp 247-255