Study of Fault Response in AC/DC Converters with 12-Phase Transformers

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Introduction

In recent years, the introduction of renewable energy sources and the accompanying deployment of battery storage systems has been advancing. On the demand side, the number of DC-based devices is also increasing. From these perspectives, DC distribution networks, which can reduce power losses by decreasing the number of AC/DC conversion stages, have attracted significant attention. To interconnect DC distribution networks with AC power systems, AC/DC power conversion technologies are indispensable. In transformer-based AC/DC converters, increasing the number of secondary phases of the transformer enables suppression of current harmonics flowing into the primary side and reduction of ripple in the DC output voltage. This paper examines two configurations of AC/DC converters using a 12-phase transformer, in which faults are applied on the primary side and the resulting variations in the DC output voltage are analyzed.

Experimental Procedures

Figure 1 shows the system configuration. In the AC/DC converters considered in this study, two rectification configurations are examined: a series configuration and a parallel configuration. Here, rectifying 12-phase power yields DC power. In the series configuration, four such DC powers are connected in series, whereas in the parallel configuration, they are connected in parallel. The series configuration alleviates the voltage stress in high-voltage applications, while the parallel configuration alleviates the current stress in high-current applications. In both configurations, the DC output voltage was 380 V. Under these conditions, a single line-to-ground fault was applied on the primary side, and the influence of the rectification configuration on the variation of the DC output power was investigated.

Results and Discussion

Figure 2 shows the DC output voltage of the parallel configuration, while Figure 3 shows that of the series configuration. The horizontal axis represents time, covering 0.25 seconds. As observed in the figures, in both configurations the correct output cannot be sustained immediately after the fault occurs. Moreover, there is no substantial difference between the waveforms under fault and normal conditions. In this simulation, the responses of the series and parallel configurations under line-to-ground fault did not exhibit any notable distinction. Future work will involve conducting similar verifications on actual equipment.

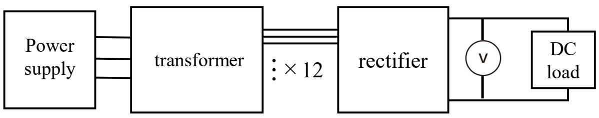

Figure 1 System Configuration

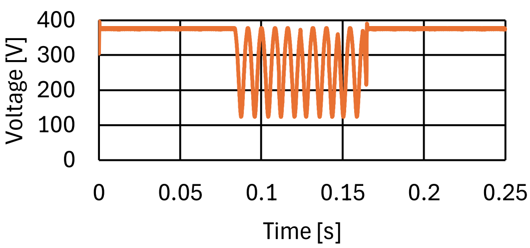

Figure 2 Output voltage (Parallel Configuration)

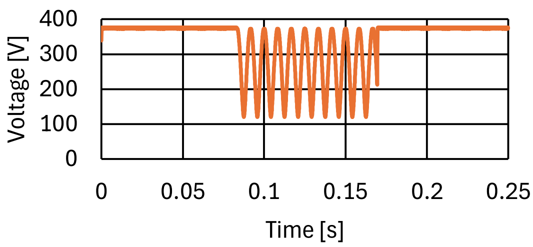

Figure 3 Output voltage (Series Configuration)

References

[1] METI, "Energy White Paper 2025" p.69(2025)