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A protection scheme for MMC-MVDC Grid based on the characteristics of voltage traveling waves

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I. INTRODUCTION

With the widespread penetration of distributed new energy such as wind power and photoelectric and various DC loads, traditional AC systems cannot meet the needs of future energy structure. Flexible DC system based on MMC has the advantages of flexible control, large power supply radius, high power quality, narrow line corridor, etc., which make it become the development trend of future power grid, and also one of the hot topics studied by scholars in recent years. However, when a fault occurs in DC system, the fault current rises rapidly, which poses a great threat to the power electronic devices. Therefore, DC fault detection and isolation is of great significance to ensure the reliability and stability of the whole system.

This paper analyzes the fault characteristics of MMC-MVDC system, and the waveform characteristics of forward and backward traveling waves under the situations of forward faults. The criterion based on the amplitude of the backward voltage traveling wave and change rate of the forward voltage traveling waves is proposed. The simulation results show that the protection scheme is feasible and has a good ability to withstand fault resistance.

II. THE DESIGNATIONCHARACTERISTICS OF FAULT TRAVELING WAVES

A four-terminal flexible DC system as shown in Fig.1 is selected as the research object. This paper takes line1 as an example. When the fault traveling wave arrives at the detection device, the fault backward traveling wave is a negative step signal, and the forward traveling wave rises immediately after the sudden drop as shown in Fig.2.

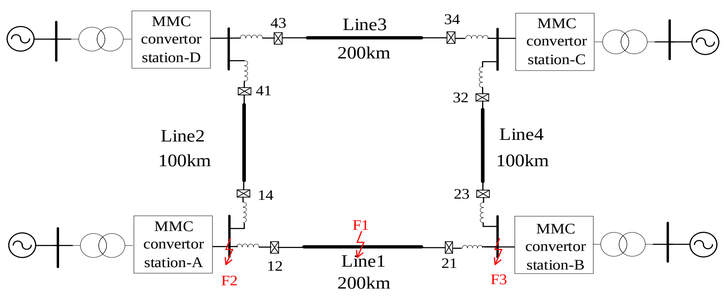
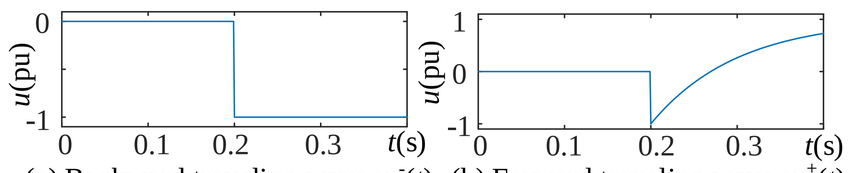


Fig.1. Topology of a four-terminal flexible DC system.



(a) Backward traveling wave $u_2^-(t)$ (b) Forward traveling wave $u_2^+(t)$

Fig.2. Schematic diagram of forward fault traveling wave.

III. PROTECTION SCHEME

a) *Signal acquisition and mode conversion*. The protective device monitors the voltage and current, and calculate the mode component. Then extract the fault component. The calculation method of fault component is

$$\begin{cases} \Delta u_1 = u_{1sample} - u_{1load} \\ \Delta i_1 = i_{1sample} - i_{1load} \end{cases}$$

b) *Pick up and timing.* Judge whether the voltage exceeds the starting threshold, if $\Delta u_1 < u_{1SET}$, the protection is picked up.

c) Internal-external Discrimination

Judge whether the local end meets the protection criterion within a specified time t_{SET}, and send the logical signal of the result to the contralateral protection, and receive the signal sent by the contralateral protective device. t_{SET} is a time setting value. First, calculate the forward and inverse traveling waves

$$\begin{cases} u_{1f} = \Delta u_1 + Z_{C1}\Delta i_1 \\ u_{1b} = \Delta u_1 - Z_{C1}\Delta i_1 \end{cases}$$

Then calculate the derivative of forward traveling wave du_{1f}, if d$u_{1f} > D_{SET}$ and $u_{1b} < u_{backSET}$ for three consecutive sampling times, it is judged as a forward fault, and sent the logical signal of RES_SEND=1 to the protective device on opposite side , otherwise the logical signal RES_SEND =0. Judge whether the protection actions or not. If the logical signal R satisfies $R = RES\_SEND \cap RES\_RECV$=1, the protection action.

The flowchart of the scheme is shown in Fig.3.

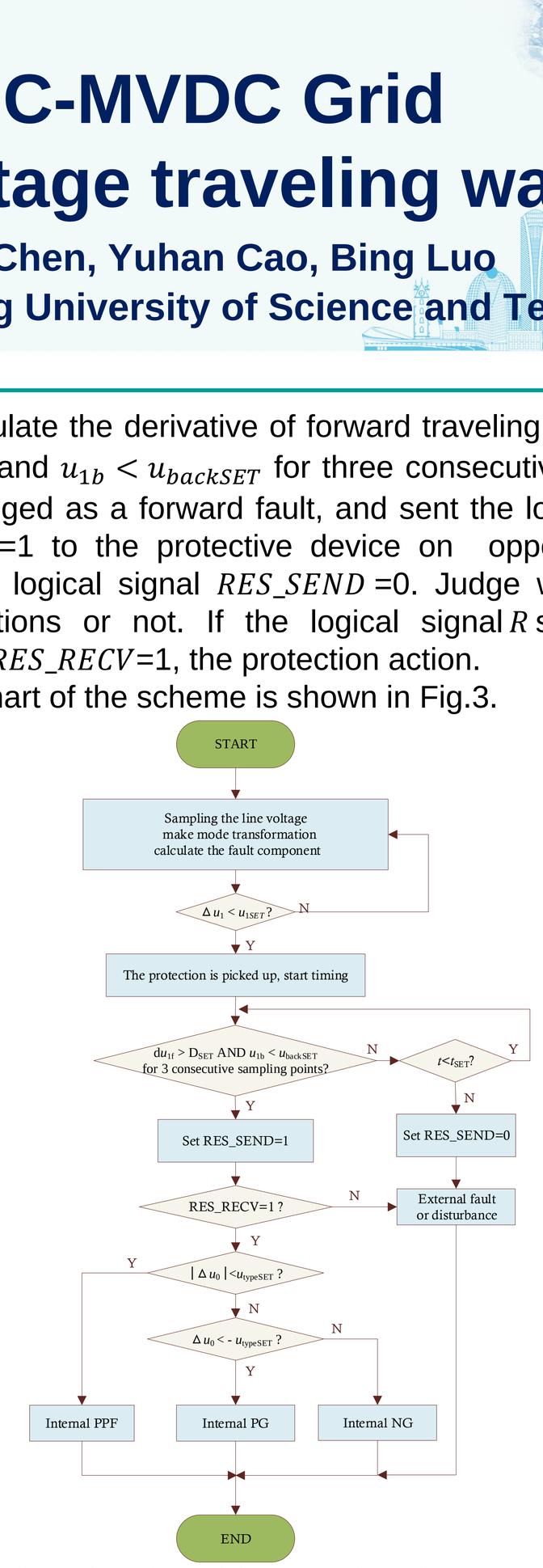


Fig.3. Flow chart of the protection scheme

IV. CASE STUDY

F1, F2 and F3 are simulated and verified as shown in Fig. 4 and Fig. 5. Among them, F1 selects three fault cases: 0km and 30km from the converter station A. The faults occur at 0.6s, and the data of 1 ms after the fault is selected for analysis, which contains a lot of transient information.

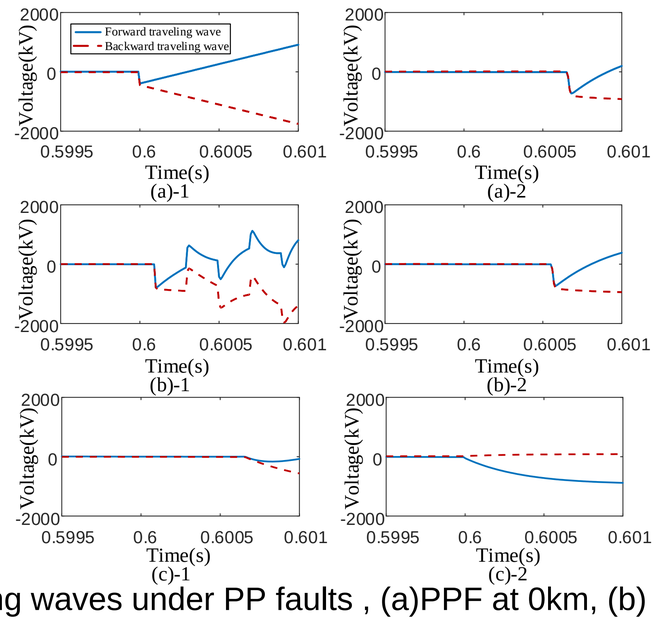


Fig.4. traveling waves under PP faults , (a)PPF at 0km, (b) PPF at 30km, (c) PPF at F3, “-1” represent the relay12 while “-2” represent the relay21

V. CONCLUSION

This paper presents a backup protection method based on the characteristics of line-mode fault traveling wave.A large number of simulation tests have proved the feasibility of the protection scheme. The proposed protection scheme has the advantages of simple, good sensitivity and selectivity, low sampling frequency, and little reliance on communication.

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