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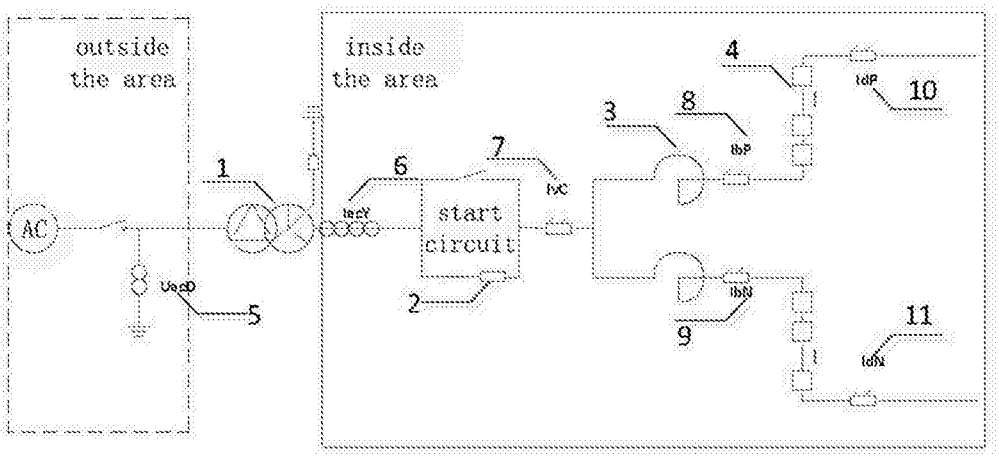
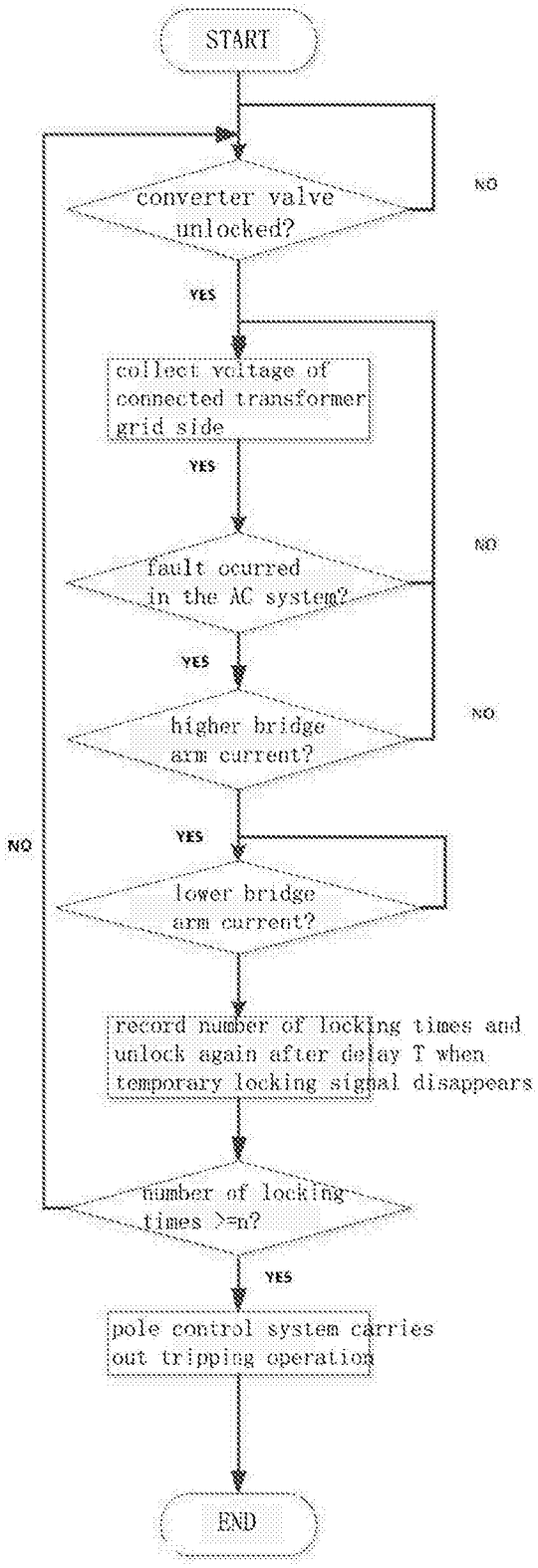

outside
the area
inside
the area
AC
1
2
3
4
5
6
7
8
9
10
11
start
circuit

FIG. 1


START
converter valve unlocked?
NO
YES
collect voltage of connected transformer grid side
YES
fault ocurred in the AC system?
NO
YES
higher bridge arm current?
NO
YES
lower bridge arm current?
NO
record number of locking times and unlock again after delay T when temporary locking signal disappears
number of locking times >=n?
YES
pole control system carries out tripping operation
END

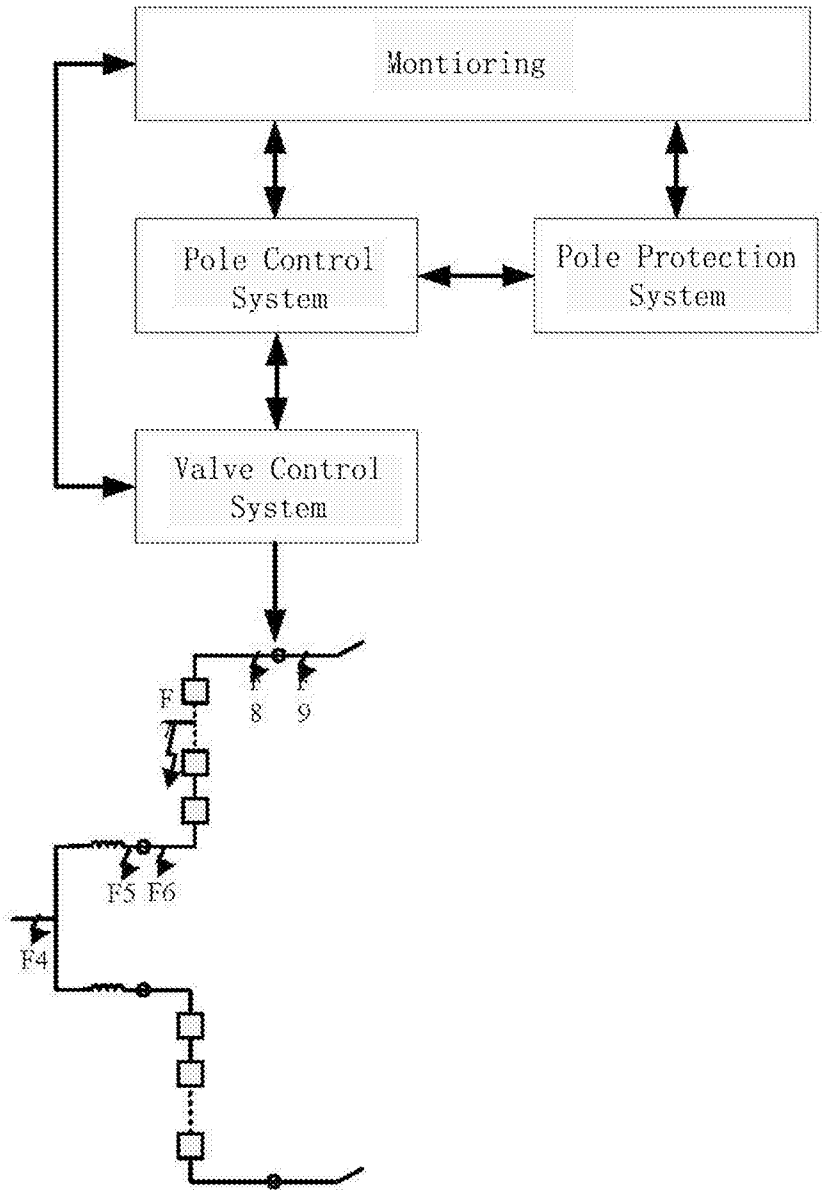

Montioring
Pole Control System
Pole Protection System
Valve Control System
F
F 8
F 9
F5 F6
F4

FIG. 3

DESCRIPTION

Tripping method applicable to situation that number of unlocking times exceeds limit since flexible DC control system has been temporarily locked

TECHNICAL FIELD

The present invention belongs to the technical field of electric and electronic control, particularly relates to a tripping method applicable to the situation that the number of unlocking times exceeds a limit after a flexible DC control system is temporarily locked.

BACKGROUND

A flexible DC converter valve technology based on a modular multilevel converter (MMC, hereafter referred to MMC) is mainly applied to new energy power generation system networking, asynchronous power grid connection, and the like, with the advantages that it can be independently adjusted with active power and reactive power, with no need of large-capacity reactive compensation and filter, commutation failure will not occur, and a receiving end can be connected to a passive system, etc.

A flexible DC power transmission system generally adopts the modular multilevel converter as its primary device. The MMC consists of 6 arms (hereinafter referred to as converter valve arms in the present application), and each arm is formed by connecting one reactor L and N submodules (SM) in series. With high modularization, MMC circuits can meet different requirements for power and voltage levels by increasing and decreasing the number of submodules connected to the converter, which is beneficial to fulfilling the integrated design, shortening the project cycle and saving the cost.

When an AC fault occurs in the flexible DC power transmission system at a connected transformer grid side, because a control system is delayed in sampling and communication and an internal link of a control device has delay, under the rated power operation, the fault occurs at the connected transformer grid side, which is easy to cause the overcurrent of the converter valve arms. At present, the industry generally tends to make the converter valve locked and carry out a tripping operation directly after the overcurrent of arms, to isolate the converter valve from the

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AC system to protect converter valve equipment. By this method, the ride-through rate that the flexible DC transmission technology deals with the AC system fault is decreased, and the flexible DC transmission technology based on MMC cannot be fully brought into play.

SUMMARY

This invention aims to provide a tripping method applicable to the situation that the number of unlocking times exceeds a limit after a flexible DC control system is temporarily locked, which not only can improve the fault ride-through function of the flexible DC transmission technology based on MMC, but also can reliably protect converter valve equipment.

The present invention specifically adopts the following technical solution:

A tripping method applicable to the situation that the number of unlocking times exceeds a limit after a flexible DC control system is temporarily locked, a flexible DC power transmission system implementing the method based on a modular multilevel converter, wherein

after a pole control system determines that a short-time fault occurs in an AC system at a connected transformer grid side, a valve control system determines whether bridge arm current is greater than a set protection value of converter valve equipment or not; if the bridge arm current is greater than the set protection value, the valve control system is triggered to lock temporarily and the pole control system is notified to lock; after the valve control system and the pole control system are locked, the temporary locking state of the valve control system is removed when the bridge arm current gradually reduces to be lower than the set protection value of the converter valve equipment; after the valve control system is unlocked, the pole control system is allowed to unlock again after a set delay and provide reactive power for the AC system through a converter valve; and

when the valve control system and the pole control system repeat the process of temporary locking and unlocking and the number of unlocking and locking times exceeds the limit because a fault occurs in the AC system at the connected transformer grid side, the pole control system fulfills the locking and tripping function; wherein, the tripping method applicable to the situation that the number of unlocking times exceeds the limit after the flexible DC control system is temporarily locked comprises the following steps:

Step 1: determining whether the converter valve is in an unlocked state or not, if the

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converter valve is in the unlocked state, proceeding to Step 2, or otherwise repeating Step 1;

Step 2: collecting AC voltage at the connected transformer grid side;

Step 3: determining whether the change of the AC voltage at the connected transformer grid side exceeds a set AC voltage threshold range or the change rate is higher than a set change rate threshold or not; if so, proceeding to Step 4, or otherwise returning to Step 2;

Step 4: collecting, by the valve control system, the bridge arm current of the converter valve in real time and determining whether the bridge arm current of the converter valve is greater than the set protection value of the converter valve equipment or not; if so, allowing the valve control system to lock and notifying the pole control system to lock, then proceeding to Step 5, or otherwise returning to Step 2;

Step 5: collecting, by the valve control system, the current bridge arm current of the converter valve in real time and determining whether the bridge arm current of the converter valve reduces to the set protection value of the converter valve equipment or not; if so, proceeding to Step 6, or otherwise repeating Step 5;

Step 6: if a temporary locking signal of the valve control system is removed, unlocking the valve control system and notifying the pole control system to unlock after a set delay T;

Step 7: counting up the number of times the flexible DC control system completes temporary locking and unlocking cycles during the fault occurring at the connected transformer grid side; if the number exceeds a set limit, proceeding to Step 8, or otherwise returning to step 1; and

Step 8: fulfilling the locking and tripping function by the pole control system, so as to open circuit breakers at both sides connected to the transformer.

The present invention further comprises the following preferred solutions:

in Step 3, the AC voltage threshold range is 0.8Upu-1.2Upu; and the AC voltage change threshold is 0.01Upu/5ms-0.05Upu/5ms, where 1Upu indicates a rated AC voltage.

in Step 4, the range of the set overcurrent protection value of the bridge arm current of converter valve equipment, i.e. an overcurrent threshold, is 1.15Ipu-1.5Ipu, where 1Ipu indicates IGBT rated operating current.

in Step 5, the range of a defined reset value of the bridge arm current of converter valve equipment, i.e. reset threshold, is 30A-60A.

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in Step 6, the set time T is 15ms.

In Step 7, the set limit of times the flexible DC control system completes temporary locking and unlocking cycles during the fault occurring at the connected transformer grid side is 2-5.

The present invention has the following beneficial effects:

The fault ride-through success rate of the converter valve based on MMC in the case that the AC system connected to the transformer malfunctions can be improved, and the availability of the converter valve can also be enhanced.

DESCRIPTION OF DRAWINGS

FIG. 1 is the structural schematic diagram of the flexible DC power transmission system apparatus according to the present invention;

FIG. 2 is the flow diagram of the tripping method applicable to the situation that the number of unlocking times exceeds a limit after a flexible DC control system is temporarily locked according to the present invention; and

FIG. 3 is the corresponding connection relationship diagram of a monitoring system, a pole control system, a protection system and a valve control system.

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DETAILED DESCRIPTION

The technical solution and the control advantages of the present invention will be more clear from the following detailed description of the present invention in combination with the drawings.

In order to facilitate readers to understand the technical solution of the present invention, the technical terms related to the solution of this application are explained as follows:

In the flexible DC transmission system, a DC control protection system and a converter valve are the core equipment for implementing AC/DC conversion. Similar to the traditional DC, the DC control protection system controls the converter valve through a valve control system.

The flexible DC power transmission system is a complex multiple-input and multiple-output system. In order to improve its operation reliability, the control protection system is divided into three layers according to the principle of hierarchical design, which are a monitoring layer, a pole control system and pole protection layer, and an I/O layer (including a

valve control system, see FIG.3). The pole control system and the protection system adopt the method of point-to-point connection via an optical fiber, the pole control system and the valve control system also adopt the method of point-to-point connection via an optical fiber, and the valve control system drives the SM of a converter valve to actuate. The tripping function in the situation that temporary locking exceeds the limit, described in this document, is mainly applicable to the pole control system and the valve control system.

Monitoring layer, fulfilling the functions of : starting and stopping control, sequence control for DC units within a station; and control, monitoring, measurement, alarm, recording, remote transmission, setting of parameters/fixed values for all the circuit breakers, isolation switches and other devices throughout the station; and connecting control and protection devices at different levels together via a redundant computer network.

Pole control system, i.e. converter control, which mainly fulfills such the functions as active power control, reactive power control, DC voltage control, inner current circuit control, modulation voltage production, etc.

Valve control system, which mainly fulfils the functions of bridge arm current circuit suppressing and control, MMC module triggering, lowest level approximation control, etc.

MMC: Modular Multilevel Converter

The introduction made in the embodiments of the present invention is based on the topological structure that the main circuit which adopts a connecting transformer and a modular multilevel converter (see FIG.1). The flexible DC transmission system includes a connected transformer 1, a charging resistance 2, a bridge arm reactor 3, and a cascaded MMC submodule 4, which are connected via an A/B/C three-phase cable to form an electrical connection system.

Operating parameters include voltage of connected transformer grid side 5, current of connected transformer valve side 6, current of start circuit 7, upper bridge arm current of converter valve 8, lower bridge arm current of converter valve 9, positive current 10, and negative current 11.

A tripping method applicable to the situation that the number of unlocking times exceeds a limit after a flexible DC control system is temporarily locked, as shown in FIG. 2, includes the following steps:

Step 1: determining whether a converter valve is in an unlocked state or not, if so,

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proceeding to Step 2, or otherwise repeating Step 1;

Step 2: collecting AC voltage at the connected transformer grid side;

Step 3: determining whether the change of the AC voltage at the connected transformer grid side exceeds the set AC voltage threshold range or the change rate is higher than the set change rate threshold or not; if so, proceeding to Step 4, or otherwise returning to Step 2, wherein

the AC voltage threshold range is 0.8Upu-1.2pUu; and the AC voltage change threshold is 0.01Upu/5ms-0.05Upu/5ms, where 1Upu indicates a rated AC voltage;

Step 4: collecting, by the valve control system, the bridge arm current of a converter valve in real time and determining whether the bridge arm current of the converter valve is greater than the set protection value of converter valve equipment or not; if so, allowing the valve control system to temporarily lock and notifying the pole control system to lock, then proceeding to Step 5, or otherwise returning to Step 2, wherein

the range of the set overcurrent protection value of the bridge arm current of converter valve equipment, i.e. an overcurrent threshold, is 1.15Ipu-1.5Ipu, where 1Ipu indicates IGBT rated operating current; if it is beyond the range, the valve control system will determine to start temporary locking;

Step 5: collecting, by the valve control system, the bridge arm current of the converter valve in real time and determining whether the bridge arm current of the converter valve weakens to a defined reset value of the converter valve equipment or not; if so, proceeding to Step 6, or otherwise returning to Step 5, wherein

the range of a defined reset value of the bridge arm current of converter valve equipment, i.e. reset threshold of current, is 30A-60A;

Step 6: recording, by the pole control system, the number of times of transmitting a temporary locking signal by the valve control system, and locking the converter valve; and moreover, transmitting an unlocking command again after a T delay and proceeding to Step 7, wherein

the set time T is 15ms;

Step 7: If the pole control system determines that the number of times of temporary locking triggered by the valve control system in a continuous AC system fault exceeds n, proceeding to Step 8, or otherwise returning to Step 1, wherein the set limit of temporary locking and

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unlocking circles the flexible DC control system completes during a fault occurring at the connected transformer grid side is 2-5; and

Step 8: allowing the pole control system to open circuit breakers to isolate the AC system from the MMC.

Although the embodiments of the present invention are illustrated and described in detail in combination with the drawings of description, those skilled in the art should understand that the above embodiments are only the preferred embodiments of the present invention. The detailed description is intended to help readers better understand the spirit of the present invention, rather than limiting the protection scope of the present invention. On the contrary, any improvement or modification made based on the inventive spirit of the present invention should fall within the protection scope of the present invention.

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CLAIMS

1. A tripping method applicable to a situation that the number of unlocking times exceeds a limit since a flexible DC control system has been temporarily locked, a flexible DC power transmission system implementing the method based on a modular multilevel converter, wherein

after a pole control system determines that a short-time fault occurs in an AC system at a connected transformer grid side, a valve control system determines whether bridge arm current is greater than a set protection value of converter valve equipment or not; if the bridge arm current is greater than the set protection value, the valve control system is triggered to lock temporarily and the pole control system is notified to lock; after the valve control system and the pole control system are locked, the temporary locking state of the valve control system is removed when the bridge arm current gradually reduces to be lower than the set protection value of the converter valve equipment; after the valve control system is unlocked, the pole control system is allowed to unlock again after a set delay and provide reactive power for the AC system through a converter valve; and

when the valve control system and the pole control system repeat the process of temporary locking and unlocking due to a fault occurring in the AC system at the connected transformer grid side and the number of unlocking and locking times exceeds the limit, the pole control system fulfills locking and tripping function, wherein, the tripping method comprises the following steps:

step 1: determining whether the converter valve is in an unlocked state or not, if the converter valve is in the unlocked state, proceeding to step 2, or otherwise repeating step 1;

step 2: collecting AC voltage at the connected transformer grid side;

step 3: determining whether the change of the AC voltage exceeds a set AC voltage threshold range or the change rate is higher than a set change rate threshold or not; if so, proceeding to step 4, or otherwise returning to step 2;

step 4: collecting, by the valve control system, the bridge arm current of the converter valve in real time and determining whether the bridge arm current of the converter valve is greater than the set protection value of the converter valve equipment or not; if so, making the valve control system locked temporarily and notifying the pole control system to lock, then proceeding to step

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5, or otherwise returning to step 2;

step 5: collecting, by the valve control system, the current bridge arm current of the converter valve in real time and determining whether the bridge arm current of the converter valve reduces to the set protection value of the converter valve equipment or not; if so, proceeding to step 6, or otherwise repeating step 5;

step 6: if a temporary locking signal of the valve control system is removed, unlocking the valve control system and notifying the pole control system to unlock after a set delay T;

step 7: counting up the number of times the flexible DC control system completes temporary locking and unlocking cycles during the fault occurring at the connected transformer grid side; if the number exceeds a set limit, proceeding to step 8, or otherwise returning to step 1; and

step 8: fulfilling the locking and tripping function by the pole control system, so as to open circuit breakers at both sides of the connected transformer.

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2. The tripping method applicable to a situation that the number of unlocking times exceeds the limit since the flexible DC control system has been temporarily locked according to claim 1, wherein

in step 3, the AC voltage threshold range is 0.8Upu-1.2Upu; and the AC voltage change threshold is 0.01Upu/5ms-0.05Upu/5ms, where 1Upu represents a rated AC voltage.

3. The tripping method applicable to a situation that the number of unlocking times exceeds the limit since the flexible DC control system has been temporarily locked according to claim 1, wherein

in step 4, the range of the set overcurrent protection value of the bridge arm current of converter valve equipment, i.e. an overcurrent threshold, is 1.15Ipu-1.5Ipu, where 1Ipu represents IGBT rated operating current.

4. The tripping method applicable to a situation that the number of unlocking times exceeds the limit since the flexible DC control system has been temporarily locked according to claim 1, wherein

in step 5, the range of a defined reset value of the bridge arm current of converter valve equipment, i.e. reset threshold, is 30A-60A.

5. The tripping method applicable to a situation that the number of unlocking times exceeds

the limit since the flexible DC control system has been temporarily locked according to claim 1, wherein

in step 6, the set time T is 15ms.

6. The tripping method applicable to a situation that the number of unlocking times exceeds the limit since the flexible DC control system has been temporarily locked according to claim 1, wherein

in step 7, the set limit of times the flexible DC control system completes temporary locking and unlocking cycles during the fault occurring at the connected transformer grid side is 2-5.

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