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Title: CONTROL AND PROTECTION SYSTEM FOR DIRECT SERIES
COMPENSATOR

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What is claimed is:

1. A control and protection system for a direct series compensator, the direct series compensator comprising a plurality of compensation modules connected in series, and the control and protection system comprising:

a plurality of control and protection units configured to generate voltage instructions for the plurality of compensation modules connected in series according to a power instruction sent from a scheduler;

a plurality of valve module interface units configured to forward the voltage instructions; and

a plurality of module control units configured to receive the voltage instructions and generate on and off commands for electronic components in the plurality of compensation modules connected in series according to the voltage instructions;

wherein the plurality of control and protection units, the plurality of valve module interface units and the plurality of module control units are arranged independently from each other,

each control and protection unit corresponds to a plurality of valve module interface units,

each valve module interface unit corresponds to a plurality of module control units, and

each module control unit corresponds to one compensation module.

2. The control and protection system according to claim 1, further comprising a valve module interface, wherein

the plurality of valve module interface units are further configured to share the valve module interface and forward the voltage instructions to the plurality of module control units through the valve module interface.

3. The control and protection system according to claim 1, wherein each

control and protection unit comprises a centralized control module, and the centralized control module is configured to generate the voltage instructions for the plurality of compensation modules connected in series according to the power instruction sent from the scheduler.

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4. The control and protection system according to claim 1, wherein each control and protection unit comprises:

a centralized control module configured to generate first injection voltage instructions for the plurality of compensation modules connected in series according to the power instruction sent from the scheduler, and perform coordinated control and centralized protection on the plurality of compensation modules connected in series; and

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a valve control module configured to generate the voltage instructions for the plurality of compensation modules connected in series according to the first injection voltage instructions or preset second injection voltage instructions.

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5. The control and protection system according to claim 4, wherein the centralized control module comprises a voltage balance control submodule, a protection submodule and/or a line overload control submodule for the plurality of compensation modules connected in series, and wherein

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the voltage balance control submodule is configured to balance a three-phase voltage of a line;

the protection submodule is configured to protect the compensation modules and/or work in conjunction with a protection function of an AC system in case that the AC system faults; and

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the line overload control submodule is configured to adjust the injection voltage instructions for the compensation modules when a current of a line connected to the direct series compensator or an adjacent line exceeds a set range, in order to keep the current within the set range.

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6. The control and protection system according to claim 4, wherein the valve control module comprises a coordinated control submodule for the plurality of compensation modules connected in series, and wherein

the coordinated control submodule is configured to control insertion and uninsertion of the compensation modules connected in series, and/or allocate the injection voltage instructions.

7. The control and protection system according to claim 4, wherein the module control unit comprises:

a DC voltage control module configured to stabilize a capacitor voltage of a corresponding compensation module;

a line overload control module configured to control a current of a line connected to the corresponding compensation module within a set range;

an overcurrent protection module configured to avoid the corresponding compensation module from overcurrent shock so as to protect the corresponding compensation module; and/or

a voltage instruction limiting module configured to limit the voltage instruction for the corresponding compensation module within a set range.

8. The control and protection system according to claim 7, wherein the DC voltage control module, the line overload control module, the voltage instruction limiting module and/or the overcurrent protection module are integrated on a same control board.

9. The control and protection system according to claim 5, wherein the control and protection system is applied to a multi-circuit line direct series compensator, and the centralized control module further comprises:

a multi-circuit line coordinated control submodule configured to allocate power instructions for a multi-circuit line.

10. The control and protection system according to claim 1, wherein the plurality of control and protection units comprise a main control and protection unit and a backup control and protection unit, and a priority of instructions generated by the main control and protection unit is higher than that of instructions generated by the backup control and protection unit.

11. The control and protection system according to claim 4, wherein the centralized control module and the valve control module communicate wirelessly or through optical fibers.

12. The control and protection system according to claim 1, wherein the plurality of compensation modules connected in series comprise a first compensation module and a second compensation module, and wherein:

the first compensation module is configured to receive the voltage instructions and send the voltage instructions to the second compensation module.

13. The control and protection system according to claim 1, wherein the plurality of compensation modules connected in series are arranged in a substation, a switching station room or a container, and the compensation modules adopt a cooling manner that combines internal liquid cooling and external air cooling.

CONTROL AND PROTECTION SYSTEM FOR DIRECT SERIES COMPENSATOR

Technical Field

5 **[0001]** This application relates to the field of flexible power transmission, in particular to a control and protection system for a direct series compensator.

Background

10 **[0002]** As large-scale power systems become more interconnected and various new devices are employed, the size and complexity of the power system have increased while simultaneously achieving more cost-effective and efficient power generation and transmission. In addition, as a large number of distributed generation systems are integrated into the grid, the current flow of power is from the distribution network to the transmission network, which is inverse of the traditional way from the transmission network to the distribution network . The constant growth in user load necessitates the implementation of flow control mechanisms to enhance the existing power transmission capacity. The evolving smart grid and complex power exchange in the power markets require frequent flow optimization control.

20 **[0003]** Direct series compensators offer a more flexible and advanced control method for smart grids, effectively enhancing the supply capacity and safety stability of the power system. A large number of compensation modules ensure equipment redundancy, thereby enhancing device reliability. Additionally, the direct series compensators can be deployed on transmission lines or substations, requiring
25 minimal space.

30 **[0004]** Currently, the control and protection system for the direct series compensators is quite simple, employing an on-site module control pattern that lacks flexibility and exhibits poor flow adjustment performance. Some universities and research institutes in China have conducted research on various series compensators

(such as series electric reactors, static synchronous series compensators, and power flow controllers), primarily focusing on topology structures, simulation modeling, and control strategies. However, reports on the structure and functional configuration of the control and protection system for series compensators are yet to be available.

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Summary

[0005] This application aims to provide a control and protection system for a direct series compensator to address the issues of inflexible control and poor flow adjustment performance.

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[0006] In one aspect of this application, a control and protection system for a direct series compensator is provided. The direct series compensator comprises a plurality of compensation modules connected in series. The control and protection system comprises a plurality of control and protection units configured to generate voltage instructions for the plurality of compensation modules connected in series according to a power instruction sent from a scheduler; a plurality of valve module interface units configured to forward the voltage instructions; and a plurality of module control units configured to receive the voltage instructions and generate on and off commands for electronic components in the plurality of compensation modules connected in series according to the voltage instructions; wherein the plurality of control and protection units, the plurality of valve module interface units and the plurality of module control units are arranged independently from each other, each control and protection unit corresponds to a plurality of valve module interface units, each valve module interface unit corresponds to a plurality of module control units, and each module control unit corresponds to one compensation module.

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[0007] According to some embodiments, the control and protection system further comprises a valve module interface, and the plurality of valve module interface units are further configured to share the valve module interface and forward the voltage instructions to the plurality of module control units through the valve

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module interface.

[0008] According to some embodiments, each control and protection unit comprises a centralized control module, and the centralized control module is configured to generate the voltage instructions for the plurality of compensation modules connected in series according to the power instruction sent from the scheduler.

[0009] According to some embodiments, each control and protection unit comprises: a centralized control module configured to generate first injection voltage instructions for the plurality of compensation modules connected in series according to the power instruction sent from the scheduler, and perform coordinated control and centralized protection on the plurality of compensation modules connected in series; and a valve control module configured to generate the voltage instructions for the plurality of compensation modules connected in series according to the first injection voltage instructions or preset second injection voltage instructions.

[0010] According to some embodiments, the centralized control module comprises a voltage balance control submodule, a protection submodule and/or a line overload control submodule for the plurality of compensation modules connected in series; the voltage balance control submodule is configured to balance a three-phase voltage of a line; the protection submodule is configured to protect the compensation modules and/or work in conjunction with a protection function of an AC system in case that the AC system faults; and the line overload control submodule is configured to adjust the injection voltage instructions for the compensation modules when a current of a line connected to the direct series compensator or an adjacent line exceeds a set range, in order to keep the current within the set range.

[0011] According to some embodiments, the valve control module comprises a coordinated control submodule for the plurality of compensation modules

connected in series, and the coordinated control submodule is configured to control insertion and uninsertion of the compensation modules connected in series, and/or allocate the injection voltage instructions.

5 **[0012]** According to some embodiments, the module control unit comprises:
a DC voltage control module configured to stabilize a capacitor voltage of a
corresponding compensation module; a line overload control module configured to
control a current of a line connected to the corresponding compensation module
within a set range; an overcurrent protection module configured to avoid the
10 corresponding compensation module from overcurrent shock so as to protect the
corresponding compensation module; and/or a voltage instruction limiting module
configured to limit the voltage instruction for the corresponding compensation module
within a set range.

15 **[0013]** According to some embodiments, the DC voltage control module,
the line overload control module, the voltage instruction limiting module and/or the
overcurrent protection module are integrated on the same control board.

20 **[0014]** According to some embodiments, the control and protection system
is applied to a multi-circuit line direct series compensator, and the centralized control
module further comprises a multi-circuit line coordinated control submodule
configured to allocate power instructions for a multi-circuit line.

25 **[0015]** According to some embodiments, the plurality of control and
protection units comprise a main control and protection unit and a backup control and
protection unit, and the priority of instructions generated by the main control and
protection unit is higher than that of instructions generated by the backup control and
protection unit.

30 **[0016]** According to some embodiments, the centralized control module and

the valve control module communicate wirelessly or through optical fibers.

[0017] According to some embodiments, the plurality of compensation modules connected in series comprise a first compensation module and a second compensation module, and the first compensation module is configured to receive the voltage instructions and send the voltage instructions to the second compensation module.

[0018] According to some embodiments, the plurality of compensation modules connected in series are arranged in a substation, a switching station room or a container, and the compensation modules adopt a cooling manner that combines internal liquid cooling and external air cooling.

[0019] According to the embodiments of this application, the control and protection system for a direct series compensator comprises the plurality of control and protection units and the plurality of valve module interface units, respectively responsible for the computation and communication of the plurality of compensation modules connected in series. Additionally, the structure of the control and protection system is clearer. With abundant software and hardware resources, the control and protection system of this application demonstrates superior performance and comprehensive functionality, making it suitable for engineering applications of large-capacity and multi-module direct series compensators.

[0020] It should be understood that the above general description and the following detailed description are only exemplary, and do not limit the application.

Brief Description of the Drawings

[0021] In order to more clearly explain the technical schemes of the embodiments of the application, the drawings needed in the description of the embodiments are briefly set forth below. The above and other objects, features and

advantages of the application will become more apparent by describing in detail exemplary embodiments with reference to the accompanying drawings.

[0022] Fig. 1 is a structural diagram of a control and protection system for a distributed series compensator in the prior art.

5 **[0023]** Fig. 2 is a structural block diagram of a control and protection system for a direct series compensator according to an exemplary embodiment of the application.

[0024] Fig. 3 is a structural diagram of a control and protection system for a direct series compensator according to an embodiment of the application.

10 **[0025]** Fig. 4 is a structural diagram of a direct series compensator system according to an embodiment of the application.

[0026] Fig. 5 is a structural diagram of a control and protection system for a direct series compensator in a double-circuit line application scenario according to an embodiment of the application.

15 **[0027]** Fig. 6 is a structural diagram of another control and protection system for a direct series compensator according to the application.

[0028] Fig. 7 is a structural diagram of another control and protection system for a direct series compensator according to an exemplary embodiment of the application.

Detailed Description of Embodiments

20 **[0029]** Exemplary embodiments will be described more fully below with reference to the accompanying drawings. However, the exemplary embodiments can be implemented in various forms and should not be construed as limited to the
25 embodiments set forth herein. These embodiments are provided to make this application more thorough and complete, and to fully convey the concept of the exemplary embodiments to those skilled in the art. In the drawings, the same reference numerals refer to the same or similar parts, so repeated descriptions will be
30 omitted.

[0030] The described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In the following description, numerous specific details are provided to give a thorough understanding of the embodiments of the disclosure. However, those skilled in the art may realize that the technical solution of the disclosure can be practiced without one or more of these specific details, or other ways, components, materials, devices or operations can be adopted. In these cases, well-known structures, methods, devices, implementations, materials or operations will not be shown or described in detail.

[0031] The flowchart shown in the drawings is only an exemplary illustration, and does not necessarily include all contents and operations/steps, nor does it have to be executed in the described order. For example, some operations/steps can be decomposed, while others can be merged or partially merged, so the actual execution order may change according to the actual situation.

[0032] Terms such as “first” and “second” in the specification and Claims of this application and the drawings are used to distinguish different objects, but not to describe a specific order. Further, the terms "comprise" and "have" and any variations thereof are intended to cover non-exclusive inclusion. For example, a process, method, system, product or device comprising a series of steps or units is not limited to the listed steps or units, but optionally comprises steps or units not listed, or optionally comprises other steps or units inherent to the process, method, product or device.

[0033] Fig. 1 is a structural diagram of a control and protection system for a distributed series compensator in the prior art. The control and protection system shown in Fig. 1 adopts a hierarchical arrangement featuring layered control, comprising a remote scheduling control layer, an instation centralized control and protection layer, and an on-site module control layer. The instation centralized control and protection layer faces significant hardware and software resource pressure as it is

required to receive power instructions from the upper level, perform injection voltage computation for the compensator, allocate injection voltage instructions, and communicate with compensation modules, making it impractical to apply to multi-module and large-capacity direct series compensators.

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[0034] To fully leverage the advantages of distributed series compensators in power flow optimization, ensure the safety of equipment and power systems, as well as promote the swift development of distributed power flow controllers, the inventors of this application have discovered the need for a control and protection system for a direct series compensator that offers a clearer structure, improved performance, comprehensive functionality, and is more suitable for engineering applications.

[0035] According to the embodiments of this application, the control and protection system for a direct series compensator comprises a plurality of control and protection units and a plurality of valve module interface units, respectively responsible for the computation and communication of a plurality of compensation modules connected in series. Additionally, the structure of the control and protection system is clearer. With abundant software and hardware resources, the control and protection system of this application demonstrates superior performance and comprehensive functionality, making it suitable for engineering applications of large-capacity and multi-module direct series compensators.

[0036] Specific embodiments of the application will be described in detail below with reference to the accompanying drawings.

[0037] Fig. 2 is a structural block diagram of a control and protection system for a direct series compensator according to an exemplary embodiment of the application. The control and protection system shown in Fig. 2 comprises a plurality of control and protection units 201, a plurality of valve module interface units 203 and

a plurality of module control units 205. The plurality of control and protection units 201 are configured to generate voltage instructions for the plurality of compensation modules connected in series according to a power instruction sent from a scheduler; the plurality of valve module interface units 203 are configured to forward the voltage instructions; and the plurality of module control units 205 are configured to receive the voltage instructions and generate on and off commands for electronic components in the plurality of compensation modules connected in series according to the voltage instructions.

[0038] According to an embodiment of the application, the plurality of control and protection units 201, the plurality of valve module interface units 203 and the plurality of module control units 205 are arranged independently from each other, each control and protection unit corresponds to a plurality of valve module interface units, each valve module interface unit corresponds to a plurality of module control units, and each module control unit corresponds to one compensation module. In this embodiment, a higher number of communication interfaces can be supported by independently configuring the valve module interface units, thereby facilitating communication with a large number of compensation modules. By integrating the plurality of module control units with the plurality of valve module interface units, the embodiment of the application exhibits enhanced computing and communication capabilities. Therefore, the embodiment of the application is suitable for engineering applications of multi-module and large-capacity direct series compensators.

[0039] According to an embodiment of the application, the control and protection system further comprises a valve module interface, and the plurality of valve module interface units 203 are further configured to share the valve module interface and forward the voltage instructions to the plurality of module control units through the valve module interface. In this embodiment, the cost can be reduced by sharing the valve module interface.

[0040] In some embodiments, each control and protection unit comprises a centralized control module, and the centralized control module is configured to generate the voltage instructions for the plurality of compensation modules connected in series according to the power instruction sent from the scheduler.

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[0041] In some other embodiments, each control and protection unit comprises a centralized control module and a valve control module. The centralized control module and the valve control module communicate wirelessly or through optical fibers. The centralized control module is configured to generate first injection voltage instructions for the plurality of compensation modules connected in series according to the power instruction sent from the scheduler, and perform coordinated control and centralized protection on the plurality of compensation modules connected in series. The valve control module is configured to generate the voltage instructions for the plurality of compensation modules connected in series according to the first injection voltage instructions or preset second injection voltage instructions.

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[0042] According to an embodiment of the application, the centralized control module comprises a voltage balance control submodule, a protection submodule and/or a line overload control submodule for the plurality of compensation modules connected in series.

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[0043] In some embodiments, the voltage balance control submodule is configured to balance a three-phase voltage of a line; the protection submodule is configured to protect the compensation modules and/or work in conjunction with a protection function of an AC system in case that the AC system faults; and the line overload control submodule is configured to adjust the injection voltage instructions for the compensation modules when a current of a line connected to the direct series compensator or an adjacent line exceeds a set range, in order to keep the current within the set range.

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[0044] In some other embodiments, the valve control module comprises a coordinated control submodule for the plurality of compensation modules connected in series. Here, the coordinated control submodule is configured to control insertion and uninsertion of the compensation modules connected in series, and/or allocate the injection voltage instructions.

[0045] According to an embodiment of the application, the module control unit comprises a DC voltage control module, a line overload control module, a voltage instruction limiting module and/or an overcurrent protection module. In some embodiments, the DC voltage control module is configured to stabilize a capacitor voltage of a corresponding compensation module; the line overload control module is configured to control a current of a line connected to the corresponding compensation module within a set range; the overcurrent protection module is configured to protect the corresponding compensation module from overcurrent shock so as to protect the corresponding compensation module; and the voltage instruction limiting module is configured to limit the voltage instruction for the corresponding compensation module within a set range.

[0046] In some specific embodiments, the DC voltage control module, the line overload control module, the voltage instruction limiting module and/or the overcurrent protection module can be integrated on the same control board, resulting in hardware configuration savings.

[0047] According to some embodiments, the control and protection system configures the centralized control module for the compensation module of each three-phase line, and the centralized control module further comprises a multi-circuit line coordinated control module, so that multi-circuit lines can cooperate with each other to regulate power flow. Here, the multi-circuit line coordinated control submodule is configured to allocate power instructions for a multi-circuit line.

[0048] According to some embodiments, the plurality of control and protection units comprise a main control and protection unit and a backup control and protection unit, and the priority of instructions generated by the main control and protection unit is higher than that of instructions generated by the backup control and protection unit.

[0049] According to the embodiment shown in Fig. 2, the control and protection system for a direct series compensator comprises a plurality of control and protection units and a plurality of valve module interface units, respectively responsible for the computation and communication of a plurality of compensation modules connected in series. Additionally, the structure of the control and protection system is clearer. With abundant software and hardware resources, the control and protection system of this application demonstrates superior performance and comprehensive functionality, making it suitable for engineering applications of large-capacity and multi-module direct series compensators.

[0050] Fig. 3 is a structural diagram of a control and protection system for a direct series compensator according to an embodiment of the application. Fig. 4 is a structural diagram of a direct series compensator system according to an embodiment of the application.

[0051] According to an embodiment of the application, N compensation modules of the direct series compensator can be connected in series in a substation or along a line in a centralized manner, or connected in series along a line in a distributed manner. Here, N is a natural number and N is greater than 1. As shown in Fig. 4, each compensation module comprises a full-bridge submodule and a bypass device.

[0052] As shown in Fig. 3, the control and protection system comprises control and protection units A and B, valve module interface units A and B, and

module control units.

[0053] Each control and protection unit comprises a centralized control module and a valve control module. As shown in Fig. 3, the centralized control module A and the valve control module A constitute the control and protection unit A, and the centralized control module B and the valve control module B constitute the control and protection unit B.

[0054] The functions of the control and protection unit A and the control and protection unit B are the same. In a specific embodiment, the control and protection unit A and the control and protection unit B are used as a main system device and a backup system device respectively, both the control and protection unit A and the control and protection unit B comprise control modules for realizing the selection of a main system and a backup system for the two devices, and instructions transmitted by the main device to the valve module interface unit A or the valve module interface unit B are executed preferentially.

[0055] In some embodiments, the valve module interface unit A and the valve module interface unit B have the same functions, and communicate with each compensation module control unit wirelessly or through optical fibers.

[0056] As shown in Fig. 3, the centralized control module converts the power instruction into the first injection voltage instructions for each compensation module, and performs coordinated control and centralized protection on each compensation module. The power instruction is sent through a receiving scheduler or set/pre-set by operators based on the real-time operating status of the power grid and load forecasting results.

[0057] In a specific embodiment, for example, the scheduler obtains an optimal line power instruction of the direct series compensator for optimization of the

power flow in the power grid according to the real-time operating status of the AC power grid, or obtains a power control instruction curve according to the real-time operating status of the power grid and the load forecasting results.

5 **[0058]** The valve control module receives the first injection voltage instructions sent from the centralized control module or the second injection voltage instructions preset, and the first injection voltage instructions and the second injection voltage instructions are processed by the valve control module to generate the voltage instructions for the compensation modules. The valve module interface unit receives
10 the voltage instructions for each compensation module and sends the same to each module control unit. The module control unit receives the voltage instructions for each compensation module and converts the same into the on and off commands for the electronic components in the corresponding compensation modules.

15 **[0059]** According to some embodiments, each centralized control module comprises, but is not limited to, a voltage balance control submodule, a protection submodule and/or a line overload control submodule for the plurality of compensation modules connected in series. The voltage balance control submodule is configured to balance a three-phase voltage of a line; the protection submodule for each
20 compensation module is configured to protect the corresponding compensation module and/or work in conjunction with a protection function of an AC system in case that the AC system faults; and the line overload control submodule is configured to adjust the injection voltage instructions for the compensation modules when a current of a line connected to the direct series compensator or an adjacent line exceeds
25 a set range, in order to keep the current within the set range.

[0060] According to some embodiments, the valve control unit comprises, but is not limited to, a coordinated control submodule for the plurality of compensation modules connected in series, and the coordinated control submodule is
30 configured to control insertion and uninsertion of the compensation modules

connected in series, and/or allocate the injection voltage instructions.

[0061] For example, the valve control unit receives an injection voltage instruction and voltages of corresponding compensation modules, selects
5 corresponding compensation modules to be inserted while maintaining the balance of the capacitor voltage of the module, and ensures that the sum of voltages of these inserted compensation modules is equal to the injection voltage instruction.

[0062] According to some embodiments, the control and protection module
10 of the module control unit comprises, but is not limited to, a DC voltage control module, a line overload control module, a voltage instruction limiting module and an overcurrent protection module. The DC voltage control module is configured to stabilize a capacitor voltage of a corresponding compensation module; the line
15 overload control module is configured to control a current of a line connected to the direct series compensator within a set range; the overcurrent protection module is configured to protect the corresponding compensation module from overcurrent shock so as to protect the corresponding compensation module; and the voltage instruction
limiting module is configured to limit the voltage instruction for the corresponding compensation module within a set range.

[0063] According to some embodiments, the DC voltage control module,
20 the line overload control module, the voltage instruction limiting module and/or the overcurrent protection module can be integrated on the same control board.

[0064] Fig. 3 shows an application scenario involving a single-circuit line.
25 When multiple single-circuit lines are connected in parallel, a multi-circuit line is formed. Fig. 5 is a structural diagram of a control and protection system for a direct series compensator in a double-circuit line application scenario according to an embodiment of the application. As shown in Fig. 5, for the multi-circuit line
30 application scenario, the compensation module of each circuit is equipped with a set

of instation centralized control units, that is, a control and protection unit as the main system device and a control and protection unit as the backup system device.

[0065] According to an embodiment of the application, on the basis of that shown in Fig. 3, each centralized control module of the control and protection system in Fig. 5 further comprises a multi-circuit line coordinated control submodule for allocating power instructions for multi-circuit lines.

[0066] Fig. 6 is a structural diagram of another control and protection system for a direct series compensator according to the application, which is suitable for direct series compensators with smaller capacity and fewer compensation modules.

[0067] As shown in Fig. 6, the control and protection system for the direct series compensator comprises control and protection units, valve module interface units and module control units, and the control and protection unit comprises a centralized control module.

[0068] According to some embodiments, the centralized control module A and the centralized control module B have the same functions, and serve as a main device and a backup device respectively. Both the centralized control module A and the centralized control module B comprise control modules for realizing the selection of a main system and a backup system for the two devices, and instructions transmitted by the main device to the valve module interface unit A or the valve module interface unit B are executed preferentially. The valve module interface unit A and the valve module interface unit B have the same functions, and communicate with each compensation module control unit wirelessly or through optical fibers.

[0069] According to some embodiments, the centralized control module receives the power instruction from the scheduler and outputs the voltage instructions

for each compensation module. The valve module interface unit receives the voltage instructions for each compensation module and sends the same to each module control unit. The module control unit receives the voltage instructions for each compensation module and converts the same into the on and off commands for the electronic components in the corresponding compensation modules.

[0070] Fig. 7 is a structural diagram of another control and protection system for a direct series compensator according to an exemplary embodiment of the application. As shown in Fig. 7, the control and protection system comprises control and protection units, valve module interface units, a valve module interface and module control units. The centralized control module A and the valve control module A constitute the control and protection unit A, and the centralized control module B and the valve control module B constitute the control and protection unit B. The control and protection unit A and the control and protection unit B have the same functions, and both comprise control modules for realizing the selection of a main system and a backup system for two devices, and instructions transmitted by the main system to the valve module interface unit A or the valve module interface unit B are executed preferentially.

[0071] As shown in Fig. 7, the valve module interface unit A and the valve module interface unit B have the same functions and share the valve module interface, and the valve module interface communicates with each compensation module control unit wirelessly or through optical fibers.

[0072] According to some embodiments, the centralized control module receives the power instruction from the scheduler and converts the same into an injection voltage instruction for the compensator; the valve control module receives the injection voltage instruction for the compensator and outputs the voltage instructions for each compensation module; the valve module interface unit receives the voltage instructions for each compensation module and sends the same to each

module control unit; and the module control unit receives the voltage instructions for each compensation module and converts the same into the on and off commands for the electronic components in the corresponding compensation modules.

5 **[0073]** As shown in Fig. 7, the compensation module 1 and the compensation module 2 communicate wirelessly or through optical fibers. For example, the compensation module 1 receives an output voltage instruction for the compensation module 2 sent from the valve module interface and sends the same to the compensation module 2, and the compensation module 2 receives an output
10 voltage instruction for the compensation module 1 sent from the valve module interface and sends the same to the compensation module 1.

[0074] According to some embodiments, the compensation modules of the direct series compensator can be installed at a place optimal for controlling the power
15 flow, for example, they are connected in series in a substation or switching station room in a centralized manner. The compensation modules adopt a cooling manner that combines internal liquid cooling and external air cooling.

[0075] The portable nature of a container allows flexible connection to
20 different lines, so in some specific embodiments, the compensation modules of the direct series compensator are connected in series in a container in a centralized manner. The direct series compensator can be flexibly connected to power lines based on grid regulation requirements, and the compensation modules adopt a cooling manner that combines internal liquid cooling and external air cooling.

25 **[0076]** The embodiments of the application have been introduced in detail above. Specific examples are applied herein to illustrate the principle and implementation of the application. The above embodiments are only used to help understand the method of the application and its core ideas. The changes or
30 deformations made by those skilled in the art based on the ideas of the application and

the specific implementation and application scope of the application are within the scope of protection of the application. To sum up, the content of this specification should not be construed as a limitation of the application.

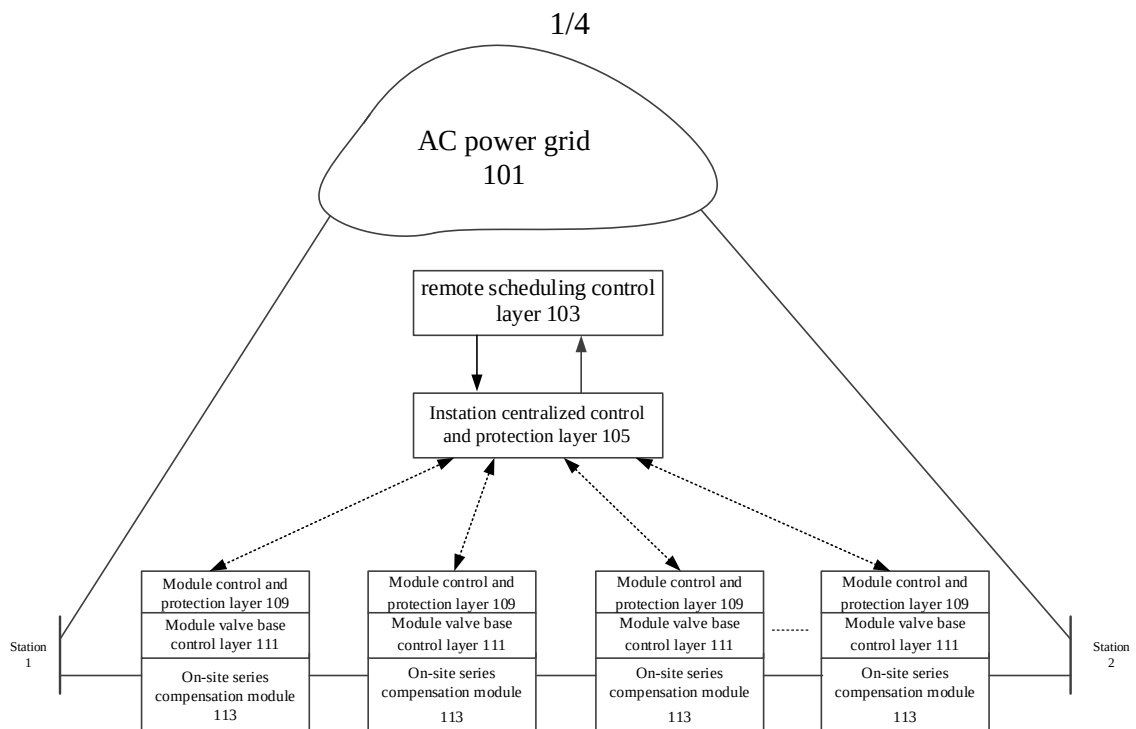


Fig. 1

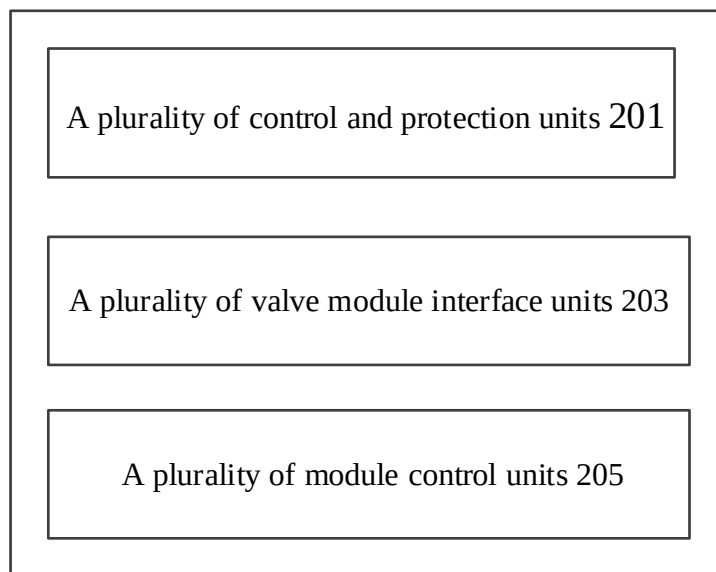


Fig. 2

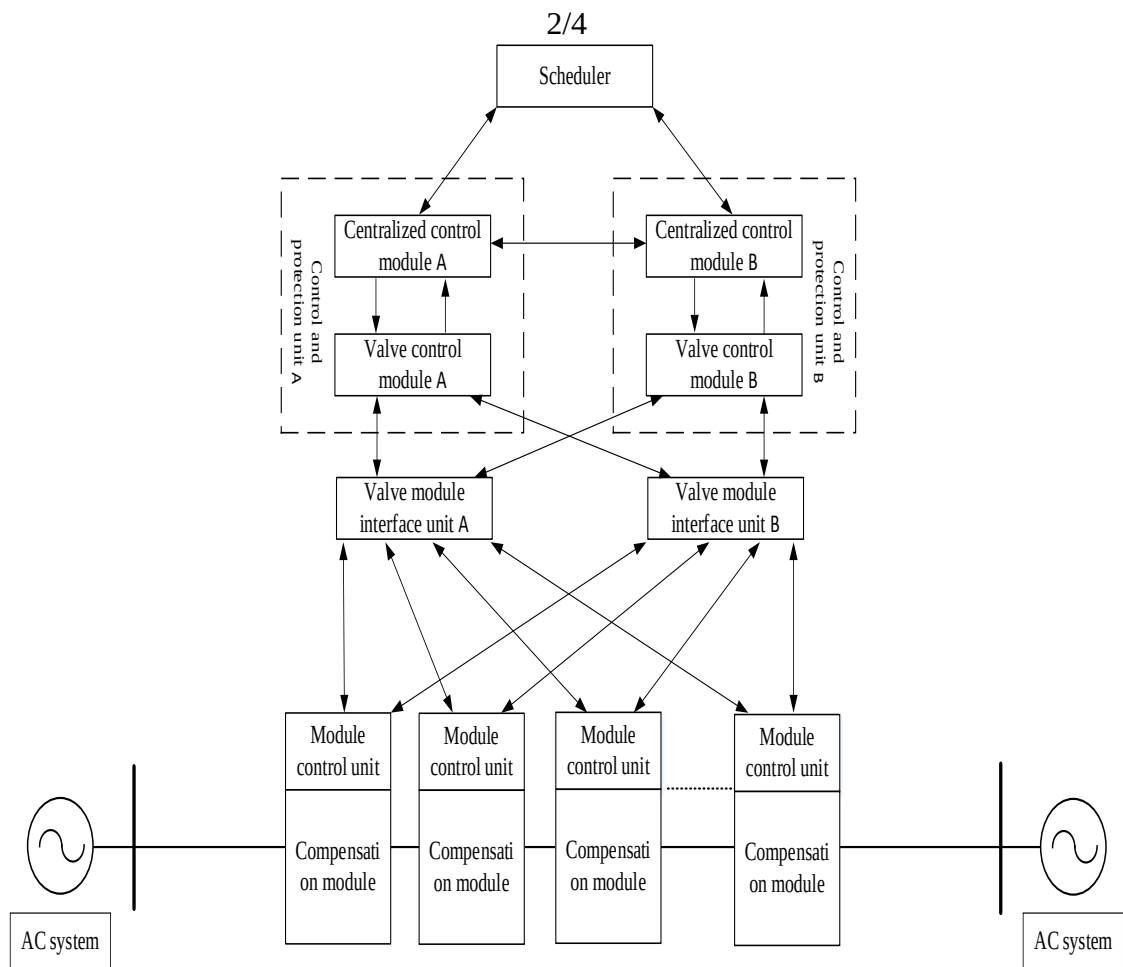


Fig. 3

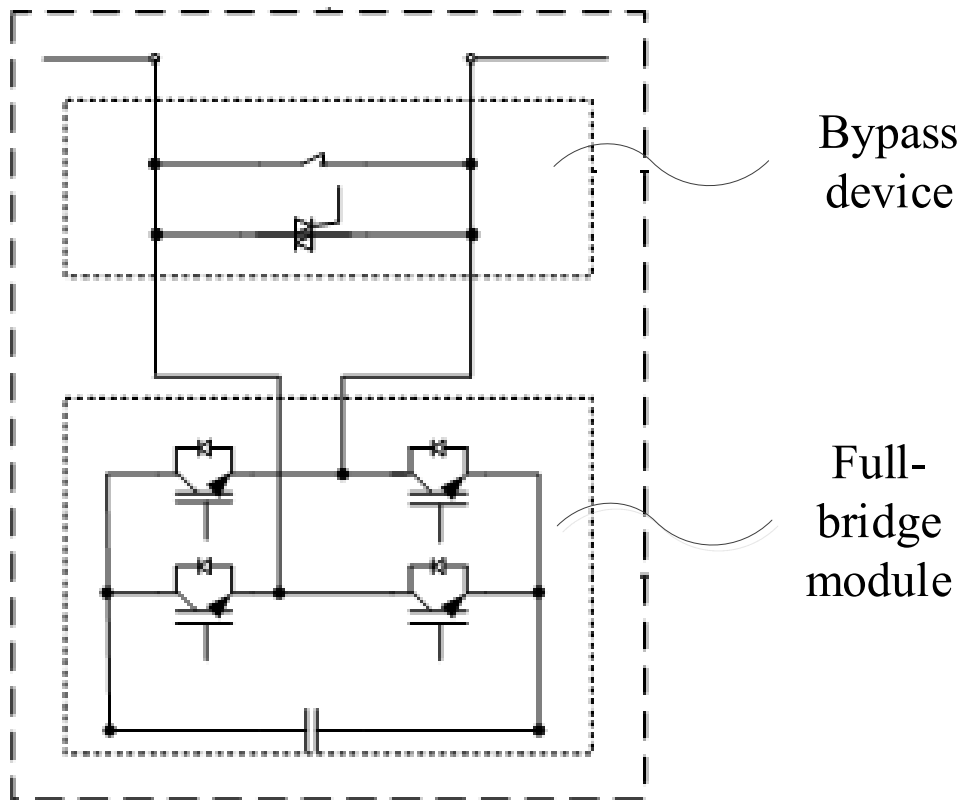


Fig. 4

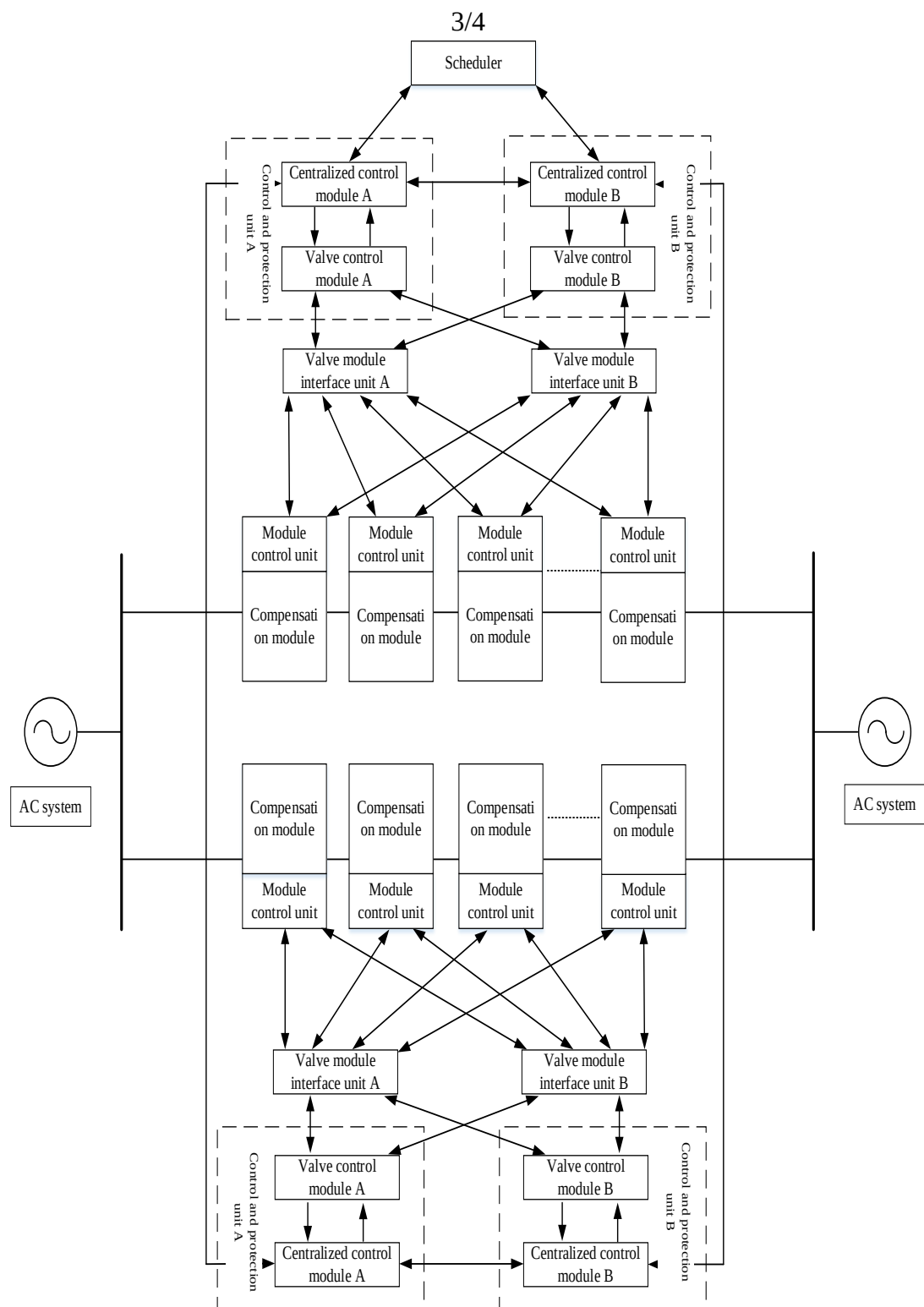


Fig. 5

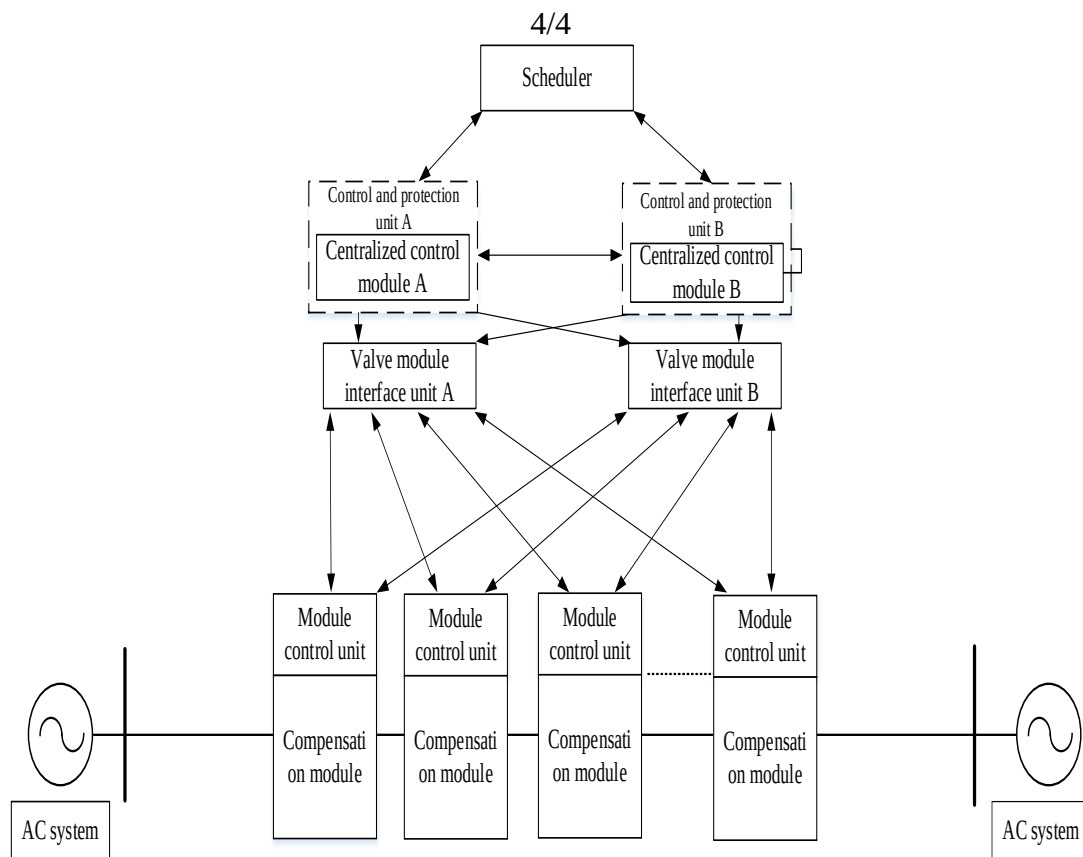


Fig. 6

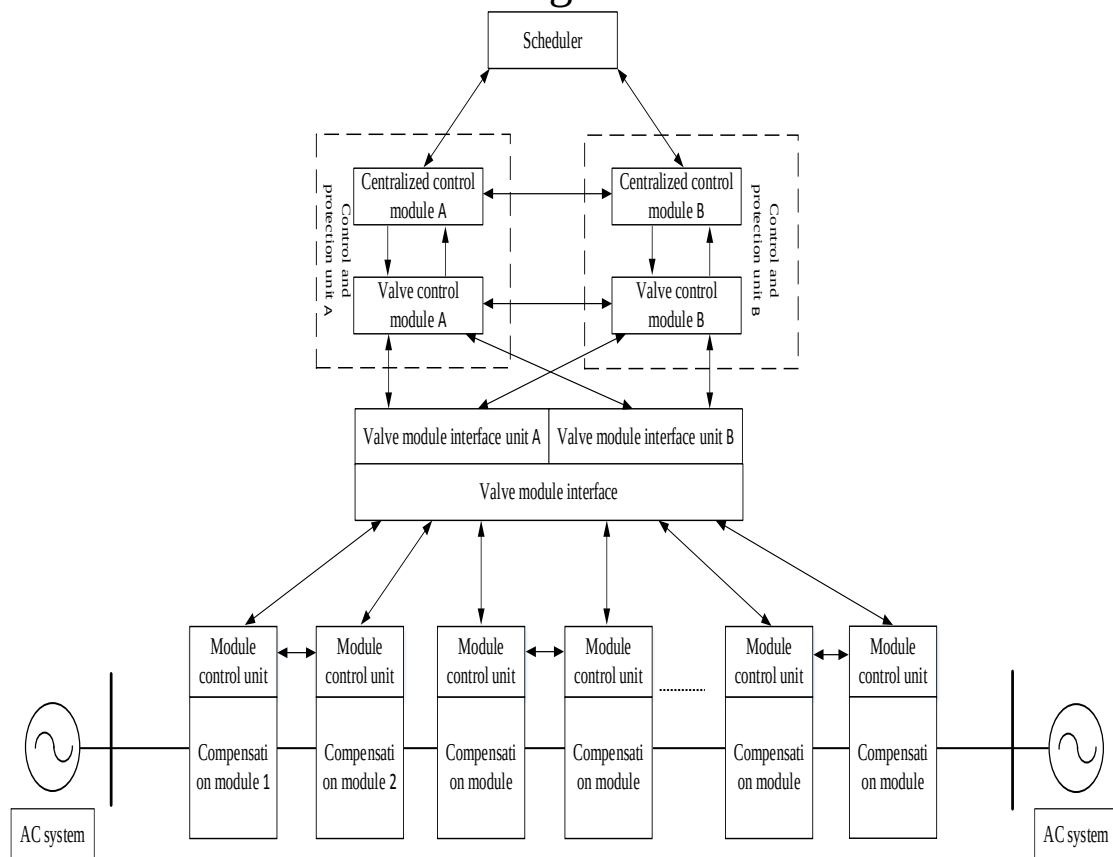


Fig. 7