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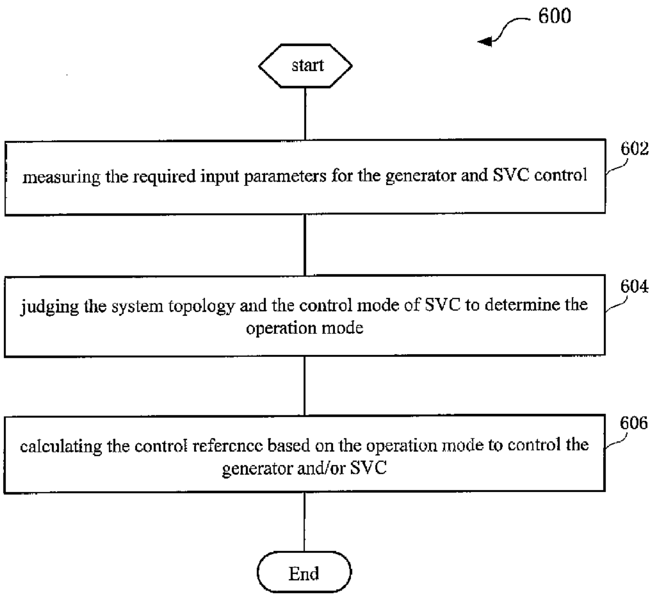

FIG. 6

(57) **Abstract**: The present invention provides coordinated control methods of generator and SVC for improving power plant active power throughput and controller thereof. The method comprises: measuring the required input parameters for the generator and SVC control Judging the system topology and the control mode of SVC to determine the operation mode; and calculating the control reference based on the operation mode to control the generator and/or SVC. The proposed methods and coordinated controllers enable the SVC to share the required reactive power output of the power plant, convert the generator into "unity-power-factor-generator", and therefore extend the active power output capability of the power plant.

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COORDINATED CONTROL METHOD OF GENERATOR AND SVC FOR IMPROVING POWER PLANT ACTIVE POWER THROUGHPUT AND CONTROLLER THEREOF

FIELDOF INVENTION

[0001] The invention relates to the technical field of door entry system, and more particularly to a coordinated control method of generator and SVC (static Var compensator) for improving power plant active power throughput and controller thereof.

BACKGROUND OF INVENTION

[0002] With the ever increasing electrical power load, power generation capacity needs to be scaled up accordingly to always achieve a balance between generation and consumption. No matter for existing or new power plants, it is always desirable to make fully utilization of the generation facilities.

[0003] Installing variable frequency drives for large-scale auxiliary motors of the power plant is the most commonly adopted way in industry to achieve this target which can help to reduce the in-house load considerably. Another solution is to reduce the reactive power consumption of the auxiliary system, which also allows the generator to produce more active power while still maintaining the same level of reactive power support to the grid. However, the auxiliary system only counts for a small part of the generation capacity, e.g. around 10% for coal-fired power plants, which limits the potential contribution from the above mentioned solutions in terms of power plant active power output capability improvement.

[0004] The present invention proposes a novel solution to achieve this target from generator point of view, i.e. to install SVC at the generation side to share the required reactive power output of the power plant. The main circuit topologies have been disclosed in prior art, such as a PCT application: PCT/US2011/181044, entitled "Method and Apparatus for Improving Power Generation in a Thermal Power Plant", which was filed on Jan. 21, 2011. Thereafter, the foregoing patent application is incorporated herein by reference.

[0005] By operating the generator and the SVC to control the power factor of the generator to improve the active power capability of the power plant, at least three problems need to be solved:

[0006] The control references obtained by the coordination controller depend on multiple factors, like the main circuit topologies, the primary controls adopted by the generator and the SVC, etc. While at present no prior art mentions how to ensure the generalization of the designed coordination controller by taking different possible factors into consideration.

[0007] The required reactive power output of the SVC varies along with the operation status of the generator and the power system whichare connected to the SVC. No prior mentions how to determine the operation point of the SVC to make the generator run at unity power factor in the full operation range.

[0008] The third problem to be solved is how to ensure the performance of the coordination controller, which mainly refers to the following two aspects: to guarantee the accuracy based on the accessible information, and to achieve fast response speed without affecting the stable operation of the generator.

[0009] Due to the above mentioned problems, a control method for coordinating generator and SVCand a controller thereofareproposed to improvepower plant active power throughputin the present invention.

SUMMARY OF INVENTION

[0010] To overcome the problems mentioned above, the present invention proposes a coordinated control method of generator and SVC for improving power plant active power throughput and controller thereof; which enable the SVC to share the required reactive power output of the power plant, convert the generator into "unity-power-factor-generator", and therefore extend the active power output capability of the power plant.

[0011] According to an aspect of the present invention, it provides acoordinated control method of generator and SVC for improving power plant active power throughput.The coordinated control method comprises:measuring the required input parameters for the generator and SVC control;judging the system topology and the control mode of SVC to determine the operation mode; and calculating the control reference based on the operation mode to control the generator and/or SVC.

[0012] According to a preferred embodiment of the present invention,the operation mode can be divided into 4 types; in whicha first type is that theSVC is connected to the low voltage side of a unit transformer and the SVC executes the reactive power control;a second type is that the SVC is connected to the high voltage side of the unit transformer and the SVC executes the reactive power control;a third type is that the SVC is connected to the high voltage side of the unit transformer and the SVC executes the voltage control; anda fourth type is that the SVC is connected to the low voltage side of the unit transformer and the SVC executes the voltage control.

[0013] According to a preferred embodiment of the present invention,in the first type of the operation mode, thecoordinated control method further comprises:calculating SVC reactive power reference Q_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, and unit transformer high side voltage reference V_H^*;calculating generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, and unit transformer high side voltage reference V_H^*; andsending the Q_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[0014] According to a preferred embodiment of the present invention,in the second type of the operation mode, thecoordinated control method further comprises:calculating generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, and unit transformer high side voltage reference V_H^*; calculating SVC reactive power output reference Q_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, unit transformer high side voltage reference V_H^*, and generator terminal voltage reference V_{Gen}^*, andsending the Q_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[0015] According to a preferred embodiment of the present invention,in the first type and/or second type of the operation mode, thecoordinated control method can also comprise:setting generator terminal voltage reference V_{Gen}^* according to unit transformer low side voltage reference V_L^*;calculating SVC reactive power reference Q_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*,and generator terminal voltage reference V_{Gen}^*, andsending the Q_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[0016] According to a preferred embodiment of the present invention,in the third type of the operation mode, thecoordinated control method further comprises:setting SVC voltage reference V_{SVC}^* according to unit transformer high side voltage reference V_H^*;calculating generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, and SVC voltage reference V_{SVC}^*, andsending the V_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[0017] According to a preferred embodiment of the present invention,in the third type of the operation mode, thecoordinated control method can also comprise:setting generator terminal voltage reference V_{Gen}^* according to unit transformer low side voltage reference V_L^*;calculating SVC voltage reference V_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*,and generator terminal voltage reference V_{Gen}^*, andsending the V_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[0018] According to a preferred embodiment of the present invention,in thefourth type of the operation mode, thecoordinated control method further comprises:calculating SVC voltage reference V_{SVC}^* according to generator active power reference P_{Gen}^* and unit transformer high side voltage reference V_H^*;calculating generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^* and unit transformer high side voltage reference V_H^*; andsending the V_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[0019] According to a preferred embodiment of the present invention,in thefourth type of the operation mode, thecoordinated control method can also comprise: setting SVC voltage reference V_{SVC}^* according to unit transformer low side voltage reference V_L^*; setting generator terminal voltage reference V_{Gen}^* according to unit transformer low side voltage reference V_L^*;andsending the V_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[0020] According to a preferred embodiment of the present invention,the generator terminal voltage reference V_{Gen}^* can also comprise a generator side feedback component calculated by generator reactive power closed-loop controller.

[0021] According to a preferred embodiment of the present invention,the SVC reactive power reference Q_{SVC}^* and/or SVC voltage reference V_{SVC}^* can also comprise a SVC side feedback component calculated by generator reactive power closed-loop controller.

[0022] According to a preferred embodiment of the present invention,the generator terminal voltage reference V_{Gen}^* can also comprise a generator side droop component calculated by generator reactive power droop controller for the fourth type of operation mode.

[0023] According to a preferred embodiment of the present invention,the SVC voltage reference V_{SVC}^* can also comprise a SVC side droop component calculated by SVC reactive power droop controller for the fourth type of the operation mode.

[0024] According to the other aspect of the present invention, it provides acoordinated controller for controlling generator and SVC. The coordinated controller comprises: a measuring module, configured to measure the required input parameters for the generator and SVC control; a judging module, configured to judge the system topology and the control mode of SVC to determine the operation mode; and a calculating module, configured to calculate the control reference based on the chosen operation mode to control the generator and/or SVC.

[0025] According to a preferred embodiment of the present invention,the operation mode can be divided into 4 types; in whicha first type is that theSVC is connected to the low voltage side of a unit transformer and the SVC executes the reactive power control; a second type is that the SVC is connected to the high voltage side of the unit transformer and the SVC executes the reactive power control; a third type is that the SVC is connected to the high voltage side of the unit transformer and the SVC executes the voltage control; and a fourth type is that the SVC is connected to the low voltage side of the unit transformer and the SVC executes the voltage control.

[0026] According to a preferred embodiment of the present invention,in the first type of the operation mode, the calculating module is further configured to: calculate SVC reactive power reference Q_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, and unit transformer high side voltage reference

V_H^*;calculate generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, and unit transformer high side voltage reference V_H^*; anda sending module is configured to send the Q_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[0027] According to a preferred embodiment of the present invention,in the second type of the operation mode, the calculating module is further configured to:calculate generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, and unit transformer high side voltage reference V_H^*; calculate SVC reactive power output reference Q_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, unit transformer high side voltage reference V_H^*, and generator terminal voltage reference V_{Gen}^*, anda sending module is configured to send the Q_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[0028] According to a preferred embodiment of the present invention,in the first type and/or second type of the operation mode, a setting module is configured to set generator terminal voltage reference V_{Gen}^* according to unit transformer low side voltage reference V_L^*; the calculating module is further configured to calculate SVC reactive power reference Q_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*,and generator terminal voltage reference V_{Gen}^*, anda sending module is configured to send the Q_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[0029] According to a preferred embodiment of the present invention,in the third type of the operation mode, a setting module is configured to set SVC voltage reference V_{SVC}^* according to unit transformer high side voltage reference V_H^*; the calculating module is further configured to calculate generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, and SVC voltage reference V_{SVC}^*, anda sending module is configured to send the V_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[0030] According to a preferred embodiment of the present invention,in the third type of the operation mode, a setting module is configured to set generator terminal voltage reference V_{Gen}^* according to unit transformer low side voltage reference V_L^*;a calculating module is further configured to calculate SVC voltage reference V_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*,and generator terminal voltage reference V_{Gen}^*, anda sending module is configured to send the V_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[0031] According to a preferred embodiment of the present invention,in thefourth type of the operation mode, acalculating module is further configured to:calculate SVC voltage reference V_{SVC}^* according to generator active power reference P_{Gen}^* and unit transformer high side voltage reference V_H^*;calculate generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^* and unit transformer high side voltage reference V_H^*; anda sending module is configured to send the V_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[0032] According to a preferred embodiment of the present invention,in thefourth type of the operation mode, asetting module is further configured to set SVC voltage reference V_{SVC}^* according to unit transformer low side voltage reference V_L^*; set generator terminal voltage reference V_{Gen}^* according to unit transformer low side voltage reference V_L^*;anda sending module is configured to send the V_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[0033] According to a preferred embodiment of the present invention,the generator terminal voltage reference V_{Gen}^* can also comprise a generator side feedback component calculated by generator reactive power closed-loop controller.

[0034] According to a preferred embodiment of the present invention,the SVC reactive power reference Q_{SVC}^* and/or SVC voltage reference V_{SVC}^* can also comprise a SVC side feedback component calculated by generator reactive power closed-loop controller.

[0035] According to a preferred embodiment of the present invention,the generator terminal voltage reference V_{Gen}^* can also comprise a generator side droop component calculated by generator reactive power droop controller for the fourth type of the operation mode.

[0036] According to a preferred embodiment of the present invention,the SVC voltage reference V_{SVC}^* can also comprise a SVC side droop component calculated by SVC reactive power droop controller for the fourth type of the operation mode.

[0037] According to another aspect of the present invention, it provides a power plant with SVC. The power plant comprises: at least one generator unit and corresponding unit transformer, which are connected to the large electrical power system at the high voltage side of the unit transformer; in which the generator is connected to the low voltage side of the unit transform;at least one SVC which can be connected to either low voltage side or high voltage side of the unit transformer; and a coordinated controller which controls the voltage and/or reactive power of the SVC, and the voltage and/or reactive power of the generator unit, according to any one of previous embodiments.

[0038] According to a preferred embodiment of the present invention,the SVC further comprises a thyristor-based static Var compensator or voltage source converter based static Var compensator.

[0039] According to a preferred embodiment of the present invention,the generator unit further comprises at least two local controllers for generator excitation voltage control and active power control; and the SVC further comprises local controller for voltage and/or reactive power control.

[0040] According to a preferred embodiment of the present invention,the coordinated controller is interfaced with the local controllers of the generator unit and the SVC.

[0041] Embodiments of the present invention provide methods for coordinating generator and SVC to improve power plant active power throughput and coordinated controller thereof, whichinstall the SVC at the generation side so as to take full utilization of the generation facility,and therefore improve the active power throughput capability of the power plant.

BRIEF DESCRIPTION OF THE DRAWINGS

[0042] The subject matter of the invention will be explained in more details in the following description with reference to preferred exemplary embodiments which are illustrated in the drawings, in which:

[0043] Fig.1A illustrates a type of main circuit topologies when installing SVC on the LV side of an unit transformer with SVC transformer;

[0044] Fig.1B illustrates a type of main circuit topologies when installing SVC on the

LV side of unit transformer without SVC transformer;

[0045] Fig.1C illustrates a type of main circuit topologies when installing SVC on the HV side of unit transformer with SVC transformer;

[0046] Fig.1D illustrates a type of main circuit topologies when installing SVC on the HV side of unit transformer without SVC transformer;

[0047] Fig.2 illustrates an equivalent circuit when SVC is installed on the LV side;

[0048] Fig.3 illustrates an equivalent circuit when SVC is connected to the HV side of the unit transformer;

[0049] Fig.4 illustrates a diagram of coordinated generator and SVC control system according to a preferred embodiment of the present invention;

[0050] Fig.5 illustrates a diagram of coordinated generator and SVC control system according to another preferred embodiment of the present invention;

[0051] Fig.6 illustrates a coordinated control method of generator and SVC for improving power plant active power throughput according to an embodiment of the present invention;

[0052] Fig.7 illustrates a coordinated control method of generator and SVC for improving power plant active power throughput according to another preferred embodiment of the present invention;

[0053] Fig.8 illustrates a coordinated control method of generator and SVC for improving power plant active power throughput according to another preferred embodiment of the present invention;

[0054] Fig.9 illustrates a coordinated control method of generator and SVC for improving power plant active power throughput according to another preferred embodiment of the present invention; and

[0055] Fig.10 illustrates a coordinated control method of generator and SVC for improving power plant active power throughput according to another preferred embodiment of the present invention.

DETAILED DESCRIPTIONOF EMBODIMENTS

[0056] Exemplary embodiments of the present invention are described in conjunction with the accompanying drawings hereinafter. For the sake of clarity and conciseness, not all the features of actual implementations are described in the specification.

[0057] Before describing the proposed method of the present invention, prior methods for operating two devices are briefly described for better understanding the innovation.

[0058] Fig.1 illustrates 4 types of main circuit topologies when installing SVC at the generator side of a power plant, in which SVC on the LV side of an unit transformer with SVC transformer in Fig.1A, SVC on the LV side of unit transformer without SVC transformer in Fig.1B, SVC on the HV side of unit transformer with SVC transformer in Fig.1C and SVC on the HV side of unit transformer without SVC transformer in Fig.1D.

[0059] As shown in Fig.1, SVC can be connected either to the low voltage side of the unit transformer (i.e. Figs.1A and 1B) or the high voltage side of the unit transformer (i.e. Figs.1C and 1D).

[0060] For the SVC on the LV side of unit transformer topologies, it is possible to save the SVC transformer because the terminal voltage of the generator is usually in the range of 10~20kV. But the unit transformer may require special design in order to block the harmonics from the SVC. For the SVC on the HV side of unit transformer topologies, SVC transformer is usually necessary in order to match the high side voltage of the unit transformer, which is usually 220~500kV for large-scale coal-fired power plant. But withthe development of SVC, the topology shown in Fig. 1D is also a practical way.

[0061] As illustrated in Fig.1, by installing SVC, the generator is able to operate at unity power factor so as to increase the active power capability of the power plant. However, it should be noted that the required reactive power outputs from the SVC to achieve the same target are different under these four topologies. Details to determine the operation point of the SVC to achieve unity (or any desired) power factor operation of the generator will be introduced below:

[0062] Fig.2 illustrates an equivalent circuit when SVC is installed on the LV side.

[0063] When SVC is connected to the LV side of the unit transformer, the equivalent circuit of the system is shown in Fig.2, where P_{Gen} and Q_{Gen} are the active and reactive power output from the generator; Q_{SVC} is the reactive power output from the SVC; Q_G is the total reactive power flow through the unit transformer, $Q_G = Q_{Gen} + Q_{SVC}$; X_T and X_S represent the reactance of unit transformer and equivalent reactance of the transmission system; V_{Gen} and V_L represent the generator terminal voltage and the unit transformer low side voltage, $V_{Gen} = V_L$; and V_S represents the Thevenin voltage of the bulk power system respectively.

[0064] Given the equivalent circuit, the active and the reactive power at the low voltage side of the unit transformer can be expressed as (1), where δ represents the phase angle of the unit transformer LV bus voltage with respective to the voltage of the bulk power system.

$$\begin{cases} P_{Gen} = \dfrac{V_L V_S}{X_T + X_S} \sin\delta \\ Q_G = \dfrac{V_L^2}{X_T + X_S} - \dfrac{V_L V_S}{X_T + X_S} \cos\delta \end{cases} \quad (1)$$

[0065] Since $\cos\delta = \sqrt{1 - \sin^2\delta}$, the expression of reactive power Q_G can be obtained as follows:

$$Q_G = \frac{V_L^2 - \sqrt{V_L^2 V_S^2 - P_{Gen}^2 (X_T + X_S)^2}}{X_T + X_S} \quad (2)$$

[0066] Considering $Q_G = Q_{Gen} + Q_{SVC}$, in order to fully compensate the reactive power output from the generator, we have

$$Q_{SVC} = Q_G = \frac{V_L^2 - \sqrt{V_L^2 V_S^2 - P_{Gen}^2 (X_T + X_S)^2}}{X_T + X_S} \quad (3)$$

[0067] Fig.3 illustrates an equivalent circuit when SVC is connected to the HV side of the unit transformer. As shown in Fig.3, the reactive power output from SVC can be divided into two parts, $Q_{SVC} = Q_{HG} + Q_{HS}$, other parameter definitions are the same as that of Fig.2.

[0068] If only considering the power flow between the LV bus and the HV bus of the unit transformer, we can obtain the expression of reactive power Q_{Gen} as follows:

$$Q_{Gen} = \frac{V_L^2 - \sqrt{V_L^2 V_H^2 - P_{Gen}^2 X_T^2}}{X_T} \qquad (4)$$

[0069] In order to fully compensate the reactive power output from the generator, Q_{Gen} should be equal to zero, i.e. there will be no reactive power exchange between the generator and the unit transformer, which means the reactive power demand of the unit transformer should be balanced by Q_{HG}. Thus we have:

$$Q_{HG} = \frac{P_{Gen}^2 X_T}{V_L^2} \qquad (5)$$

[0070] Furthermore, by setting the Q_{Gen} in equation (4) to zero, we can derive the closed form expression for the value of V_H to which the SVC must regulate in order to make the generator operate at unity power factor. This expression is:

$$V_H = \sqrt{V_L^2 + \left(\frac{P_{Gen} X_T}{V_L}\right)^2} \qquad (6)$$

[0071] With the expression of V_H, we can calculate the power flow between the HV bus of the unit transformer and the power source, and thus obtain the expression of reactive power Q_{HS}:

$$Q_{HS} = \frac{V_H^2 - \sqrt{V_H^2 V_S^2 - P_{Gen}^2 X_S^2}}{X_S} \qquad (7)$$

[0072] Substituting the result of (6) into (7), we have:

$$Q_{HS} = \frac{\left(V_L^2 + \frac{P_{Gen}^2 X_T^2}{V_L^2}\right) - \sqrt{V_S^2 \left(V_L^2 + \frac{P_{Gen}^2 X_T^2}{V_L^2}\right) - P_{Gen}^2 X_S^2}}{X_S} \qquad (8)$$

[0073] Since $Q_{SVC} = Q_{HG} + Q_{HS}$, the total reactive power that the SVC delivers under this topology is:

$$Q_{SVC} = \frac{P_{Gen}^2 X_T}{V_L^2} + \frac{\left(V_L^2 + \frac{P_{Gen}^2 X_T^2}{V_L^2}\right) - \sqrt{V_S^2 \left(V_L^2 + \frac{P_{Gen}^2 X_T^2}{V_L^2}\right) - P_{Gen}^2 X_S^2}}{X_S} \qquad (9)$$

[0074] Based on the analysis above, there are mainly two types of control methods considering the different control targets of SVC.

SVC Var control:

[0075] Fig.4 illustrates a diagram of coordinated generator and SVC control system according to a preferred embodiment of the present invention.

[0076] As shown in Fig.4, the SVC is under Q control mode. The governor regulates the mechanical power output from the turbine according to the active power reference P_{Gen}^* or the generator speed reference ω_{Gen}^*; the excitation & PSS regulate the excitation voltage according to the voltage reference V_{Gen}^*; and the SVC regulates its terminal reactive power output depending on the main circuit topology and its controlmode according to the references and measurements defined in Table 1.

[0077] It shall be appreciated that the generator voltage reference can be given by a high level controller or manual controller according to the power plant operation scheme. And the skilled person in art can use a control method which combinesa feed forward control and feedback control to generates the Q_{SVC}^*.

SVC V control:

[0078] Fig.5 illustrates a diagram of coordinated generator and SVC control system according to another preferred embodiment of the present invention.

[0079] As shown in Fig.5, the SVC is under V control mode. The governor regulates the mechanical power output from the turbine according to the active power reference P_{Gen}^* or the generator speed reference ω_{Gen}^*; the excitation & PSS regulate the excitation voltage according to the voltage reference V_{Gen}^*; and the SVC regulates its terminal voltage depending on the main circuit topology and its controlmode according to the references and measurements defined in Table 1.

[0080] The skilled person in art knows that the generator voltage reference can be given by a high level controller or manual controller according to the power plant operation scheme. It shall be noted that a control method which combines a feed forward control and feedback control can be used to generate the V_{SVC}^*.

Table 1 Definition for the coordinated Gen+SVC controller

	Variable	Description
Inputs	P_{Gen}^*	Generator active power output reference
	Q_{Gen}^*	Generator reactive power output reference
	V_H^*	Unit transformer high side voltage reference (when unit transformer high side voltage reference is available)
	V_L^*	Unit transformer low side voltage reference (when unit transformer low side voltage reference is available)
	Q_{Gen}	Measured generator reactive power output
	Q_{SVC}	Measured SVC reactive power output
	Topo_SVC	Main circuit topology indicator of generator and SVC system (SVC is on the LV side or the HV side)
	Ctrl_mode	Control mode indicator of SVC (under Var control mode or V control mode)
Outputs	V_{SVC}^*	Voltage reference for SVC when SVC is under V control mode
	Q_{SVC}^*	Reactive power reference for SVC when SVC is under Var control mode
	V_{Gen}^*	Voltage reference for generator excitation system

[0081] Fig.6 illustrates a coordinated control method of generator and SVC for improving power plant active power throughput according to an embodiment of the present invention.

[0082] As shown in Fig.6, thecoordinated control method comprises:

[0083] Step 602, measuring the required input parameters for the generator and SVC control.

[0084] Step 604, judging the system topology and the control mode of SVC to determine the operation mode. The mentioned operation mode can be divided into 4 types; in which the first type is that theSVC is connected to the low voltage side of a unit transformer and the SVC executes the reactive power control; the second type is that the SVC is connected to the high voltage side of the unit transformer and the SVC executes the reactive power control; the third type is that the SVC is connected to the high voltage side of the unit transformer and the SVC executes the voltage control; and the fourth type is that the SVC is connected to the low voltage side of the unit transformer and the SVC executes the voltage control.

[0085] Step 606, calculating the control reference based on the operation mode to control the generator and/or SVC.

[0086] Fig.7 illustrates a coordinated control method of generator and SVC for improving power plant active power throughput according to another preferred embodiment of the present invention.

[0087] As shown in Fig.7, the coordinated control method comprises steps 702-710, in which step 702 is same to step 602.

[0088] Step 704, judging the system topology and the control mode of SVC and determining that the operation mode is the first type:theSVC is connected to the low voltage side of a unit transformer and the SVC executes the reactive power control.

[0089] Step 706, calculating SVC reactive power reference Q_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^* and unit transformer high side voltage reference V_H^*.

[0090] Step 708, calculating generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, and unit transformer high side voltage reference V_H^*.

[0091] Step 710, sending the Q_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[0092] Fig.8 illustrates a coordinated control method of generator and SVC for improving power plant active power throughput according to another preferred embodiment of the present invention.

[0093] As shown in Fig.8, the coordinated control method comprises steps 802-810, in which step 802 is same to step 702.

[0094] Step 804, judging the system topology and the control mode of SVC and determining that the operation mode is thesecond type:the SVC is connected to the high voltage side of the unit transformer and the SVC executes the reactive power control.

[0095] Step 806, calculating generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, and unit transformer high side voltage reference V_H^*.

[0096] Step 808, calculating SVC reactive power output reference Q_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, unit transformer high side voltage reference V_H^* and generator terminal voltage reference V_{Gen}^*.

[0097] Step 810, sending the Q_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[0098] In the alternative embodiments illustrated in Figs. 7 and 8, i.e. in the first type and/or second type of the operation mode, thecoordinated control method can also comprise:step 707 or step 807, setting generator terminal voltage reference V_{Gen}^* according to unit transformer low side voltage reference V_L^*;step 709 or step 809, calculating SVC reactive power reference Q_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*,and generator terminal voltage reference V_{Gen}^*; andthen sending the Q_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[0099] Fig.9 illustrates a coordinated control method of generator and SVC for improving power plant active power throughput according to another preferred embodiment of the present invention.

[00100] As shown in Fig.9, the coordinated control method comprises steps 902-910, in which step 902 is same to step 702.

[00101] Step 904, judging the system topology and the control mode of SVC and determining that the operation mode is thethird type:the SVC is connected to the high voltage side of the unit transformer and the SVC executes the voltage control.And then the method will be executed alternatively through steps 906 and 908, or steps 907 and 909 in sequence.

[00102] Step 906, setting SVC voltage reference V_{SVC}^* according to unit transformer high side voltage reference V_H^*.

[00103] Step 908, calculating generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^* and SVC voltage reference V_{SVC}^*.

[00104] Step 907, setting generator terminal voltage reference V_{Gen}^* according to unit transformer low side voltage reference V_L^*.

[00105] Step 909, calculating SVC voltage reference V_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*,and generator terminal voltage reference V_{Gen}^*.

[00106] Step 910, sending the V_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[00107] Fig.10 illustrates a coordinated control method of generator and SVC for improving power plant active power throughput according to another preferred embodiment of the present invention.

[00108] As shown in Fig.10, the coordinated control method comprises steps 902-910, in which step 1002 is same to step 702.

[00109] Step 1004, judging the system topology and the control mode of SVC and determining that the operation mode is thefourth type:the SVC is connected to the low voltage side of the unit transformer and the SVC executes the voltage control.And then the method will be executed alternatively through steps 1006 and 1008, or steps 1007 and 1009 in sequence.

[00110] Step 1006, calculating SVC voltage reference V_{SVC}^* according to generator active power reference P_{Gen}^* and unit transformer high side voltage reference V_H^*.

[00111] Step 1008, calculating generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^* and unit transformer high side voltage reference V_H^*.

[00112] Step 1007, setting SVC voltage reference V_{SVC}^* according to unit transformer low side voltage reference V_L^*.

[00113] Step 1009, settinggenerator terminal voltage reference V_{Gen}^* according to unit transformer low side voltage reference V_L^*.

[00114] Step 1010, sending the V_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[00115] In above mentioned embodiments, the generator terminal voltage reference V_{Gen}^* can also comprise a generator side feedback component calculated by generator reactive power closed-loop controller; the SVC reactive power reference Q_{SVC}^* and/or the SVC voltage reference V_{SVC}^* can also comprise a SVC side feedback component calculated by generator reactive power closed-loop controller. For the fourth type of operation mode,the generator terminal voltage reference V_{Gen}^* can also comprise a generator side droop component calculated by generator reactive power droop controller;the SVC voltage reference V_{SVC}^* can also comprise a SVC side droop component calculated by SVC reactive power droop controller.

[00116] Correspondingly, the present invention also provides acoordinated controller for controlling generator and SVC, which comprises at leasta measuring module, a judging moduleand a calculating module. The measuring module is configured to measure the required input parameters for the generator and SVC control; the judging module isconfigured to judge the system topology and the control mode of SVC to determine the operation mode which can be divided into 4 types; and the calculating module isconfigured to calculate the control reference based on the chosen operation mode to control the generator and/or SVC.

[00117] In the first type of the operation mode, the calculating module further calculates SVC reactive power reference Q_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, and unit transformer high side voltage reference V_H^*;calculates generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, and unit transformer high side voltage reference V_H^*.Andthe coordinated controller further comprises a sending module, which sendsthe Q_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[00118] In the second type of the operation mode, the calculating module further calculates generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, and unit transformer high side voltage reference V_H^*; calculates SVC reactive power output reference Q_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, unit transformer high side voltage reference V_H^*, and generator terminal voltage reference V_{Gen}^*.And the coordinated controller further comprises a sending module,which sendsthe Q_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[00119] In a preferred embodiment of the present invention, in the first type and/or second type of the operation mode, the coordinated controller further comprises a setting module and a sending module, in which the setting module setsthe generator terminal voltage reference V_{Gen}^* according to unit transformer low side voltage reference V_L^*; the calculating module calculates the SVC reactive power reference Q_{SVC}^* according to generator .active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*,and generator terminal voltage reference V_{Gen}^*, andthe sending module sendsthe Q_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[00120] In the third type of the operation mode, the coordinated controller further comprises a setting module and a sending module, In which the setting module sets the SVC voltage reference V_{SVC}^* according to unit transformer high side voltage reference V_H^*; the calculating module is further configured to calculate generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, and SVC voltage reference V_{SVC}^*, andthe sending module sendsthe V_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.In an alternative embodiment of the present invention, the setting module is to set generator terminal voltage reference V_{Gen}^* according to unit transformer low side voltage reference V_L^*;a calculating module is further configured to calculate SVC voltage reference V_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*,and generator terminal voltage reference V_{Gen}^*, andthe sending module sendsthe V_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.

[00121] In thefourth type of the operation mode, the calculating module further calculates SVC voltage reference V_{SVC}^* according to generator active power reference P_{Gen}^* and unit transformer high side voltage reference V_H^*;calculates generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^* and unit transformer high side voltage reference V_H^*; andthe coordinated controller further comprises a sending module, which sendsthe V_{SVC}^* to a local controller of SVC and the V_{Gen}^* to an excitation voltage controller of generator.In an alternative embodiment of the present invention, the setting module is to set both of the generator terminal voltage reference $V_{Gen}^*$and SVC voltage reference V_{SVC}^*according to unit transformer low side voltage reference V_L^*;and the sending module sendsthe V_{SVC}^* to a local controller of SVC

and the V_{Gen}^* to an excitation voltage controller of generator.

[00122] The present invention also provides a power plant with SVC, which comprises at least one generator unit and corresponding unit transformer, and at least one SVC;moreover the generator unit and unit transformer are connected to the large electrical power system at the high voltage side of the unit transformer; in which the generator is connected to the low voltage side of the unit transform;the SVC which can be connected to either low voltage side or high voltage side of the unit transformer; and a coordinated controller which controls the voltage and/or reactive power of the SVC, and the voltage and/or reactive power of the generator unit, according to any one of previous embodiments.Generally, the coordinated controller is interfaced with the local controllers of the generator unit and the SVC.

[00123] In a preferred embodiment of the present invention,the SVC further comprises a thyristor-based static Var compensator or voltage source converter based static Var compensator.The generator unit further comprises at least two local controllers for generator excitation voltage control and active power control; and the SVC further comprises local controller for voltage and/or reactive power control.

[00124] Compared with the existing prior arts, the proposed solution of the present invention installs the SVC at the generation side and can take full utilization of the generation facility; therefore the active power throughput capability of the power plant can be greatly improved. Referring to the description of the exemplary embodiments, those skilled in the art appreciate the advantages of the present invention:the generator and the SVC can be controlled in a coordinated way under different system topologies or with different operation modes of SVC. Moreover, the generator can also be converted into a "unity power factor generator" in the full operation range without affecting the stable operation.

[00125] Though the present invention has been described on the basis of some preferred embodiments, those skilled in the art should appreciate that those embodiments should by no means limit the scope of the present invention. Without departing from the spirit and concept of the present invention, any variations and modifications to the embodiments should be within the apprehension of those with ordinary knowledge and skills in the art, and therefore fall in the scope of the present invention which is defined by the accompaniedclaims.

CLAIMS

1. A coordinated control method of generator and Static Var Compensator (SVC) for improving power plant active power throughput, wherein said coordinated control method comprises:

measuring the required input parameters for said generator and SVC control;

judging the system topology and the control mode of SVC to determine the operation mode; and

calculating the control reference based on said operation mode to control said generator and/or SVC.

2. The coordinated control method according to Claim 1, wherein said operation mode can be divided into 4 types; in which

a first type is that said SVC is connected to the low voltage side of a unit transformer and said SVC executes the reactive power control;

a second type is that said SVC is connected to the high voltage side of said unit transformer and said SVC executes the reactive power control;

a third type is that said SVC is connected to the high voltage side of said unit transformer and said SVC executes the voltage control; and

a fourth type is that said SVC is connected to the low voltage side of said unit transformer and said SVC executes the voltage control.

3. The coordinated control method according to Claim 2, wherein in said first type of the operation mode, said coordinated control method further comprises:

calculating SVC reactive power reference Q_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, and unit transformer high side voltage reference V_H^*;

calculating generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, and unit transformer high side voltage reference V_H^*; and sending said Q_{SVC}^* to a local controller of SVC and said V_{Gen}^* to an excitation voltage controller of generator.

4. The coordinated control method according to Claim 2, wherein in said second type of the operation mode, said coordinated control method further comprises:

calculating generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, and unit transformer high side voltage reference V_H^*;

calculating SVC reactive power output reference Q_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, unit transformer high side voltage reference V_H^*, and generator terminal voltage reference V_{Gen}^*, and

sending said Q_{SVC}^* to a local controller of SVC and said V_{Gen}^* to an excitation voltage controller of generator.

5. The coordinated control method according to Claim 2, wherein in said first type and/or second type of the operation mode, saidcoordinated control method can also comprise:

setting generator terminal voltage reference V_{Gen}^* according to unit transformer low side voltage reference V_L^*;

calculating SVC reactive power reference Q_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*,and generator terminal voltage reference V_{Gen}^*, and

sending said Q_{SVC}^* to a local controller of SVC and said V_{Gen}^* to an excitation voltage controller of generator.

6. The coordinated control method according to Claim 2, wherein in said third type of the operation mode, said coordinated control method further comprises:

setting SVC voltage reference V_{SVC}^* according to unit transformer high side voltage reference V_H^*;

calculating generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, and SVC voltage reference V_{SVC}^*, and

sending said V_{SVC}^* to a local controller of SVC and said V_{Gen}^* to an excitation voltage controller of generator.

7. The coordinated control method according to Claim 2, wherein in said third type of the operation mode, said coordinated control method can also comprise:

setting generator terminal voltage reference V_{Gen}^* according to unit transformer low side voltage reference V_L^*;

calculating SVC voltage reference V_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*,and generator terminal voltage reference V_{Gen}^*, and

sending said V_{SVC}^* to a local controller of SVC and said V_{Gen}^* to an excitation voltage controller of generator.

8. The coordinated control method according to Claim 2, wherein in said fourth type of the operation mode, said coordinated control method further comprises:

calculating SVC voltage reference V_{SVC}^* according to generator active power reference P_{Gen}^* and unit transformer high side voltage reference V_H^*;

calculating generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^* and unit transformer high side voltage reference V_H^*; and

sending said V_{SVC}^* to a local controller of SVC and said V_{Gen}^* to an excitation voltage controller of generator.

9. The coordinated control method according to Claim 2, wherein in said fourth type of the operation mode, said coordinated control method can also comprise:

setting SVC voltage reference V_{SVC}^* according to unit transformer low side voltage reference V_L^*;

setting generator terminal voltage reference V_{Gen}^* according to unit transformer low side voltage reference V_L^*; and

sending said V_{SVC}^* to a local controller of SVC and said V_{Gen}^* to an excitation voltage controller of generator.

10. The coordinated control method according to any one of Claims 3-9, wherein said generator terminal voltage reference V_{Gen}^* can also comprise a generator side feedback component calculated by generator reactive power closed-loop controller.

11. The coordinated control method according to any one of Claims 3-9, wherein said SVC reactive power reference Q_{SVC}^* and/or SVC voltage reference V_{SVC}^* can also comprise a SVC side feedback component calculated by generator reactive power closed-loop controller.

12. The coordinated control method according to Claim8 or 9, wherein said generator terminal voltage reference V_{Gen}^* can also comprise a generator side droop component calculated by generator reactive power droop controller for the fourth type of said operation mode.

13. The coordinated control method according to Claim8 or 9, wherein said SVC voltage reference V_{SVC}^* can also comprise a SVC side droop component calculated by SVC reactive power droop controller for the fourth type of said operation mode.

14. A coordinated controller for controlling generator and Static Var Compensator (SVC), wherein said coordinated controller comprises:

a measuring module, configured to measure the required input parameters for said generator and SVC control;

a judging module, configured to judge the system topology and the control mode of SVC to determine the operation mode; and

a calculating module, configured to calculate the control reference based on said chosen operation mode to control said generator and/or SVC.

15. The coordinated controller according to Claim 14, wherein said operation mode can be divided into 4 types; in which

a first type is that said SVC is connected to the low voltage side of a unit transformer and said SVC executes the reactive power control;

a second type is that said SVC is connected to the high voltage side of said unit transformer and said SVC executes the reactive power control;

a third type is that said SVC is connected to the high voltage side of said unit transformer and said SVC executes the voltage control; and

a fourth type is that said SVC is connected to the low voltage side of said unit transformer and said SVC executes the voltage control.

16. The coordinated controller according to Claim 15, wherein in said first type of the operation mode,

said calculating module is further configured to: calculate SVC reactive power reference Q_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, and unit transformer high side voltage reference V_H^*;calculate generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, and unit transformer high side voltage reference V_H^*; and

a sending module is configured to send said Q_{SVC}^* to a local controller of SVC and said V_{Gen}^* to an excitation voltage controller of generator.

17. The coordinated controller according to Claim 15, wherein in said second type of

the operation mode,

said calculating module is further configured to:calculate generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, and unit transformer high side voltage reference V_H^*; calculate SVC reactive power output reference Q_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, unit transformer high side voltage reference V_H^*, and generator terminal voltage reference V_{Gen}^*, and

a sending module is configured to send said Q_{SVC}^* to a local controller of SVC and said V_{Gen}^* to an excitation voltage controller of generator.

18. The coordinated controller according to Claim 15, wherein in said first type and/or second type of the operation mode,

a setting module is configured to set generator terminal voltage reference V_{Gen}^* according to unit transformer low side voltage reference V_L^*;

said calculating module is further configured to calculate SVC reactive power reference Q_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*,and generator terminal voltage reference V_{Gen}^*, and

a sending module is configured to send said Q_{SVC}^* to a local controller of SVC and said V_{Gen}^* to an excitation voltage controller of generator.

19. The coordinated controller according to Claim 15, wherein in said third type of the operation mode,

a setting module is configured to set SVC voltage reference V_{SVC}^* according to unit transformer high side voltage reference V_H^*;

said calculating module is further configured to calculate generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*, and SVC voltage reference V_{SVC}^*, and

a sending module is configured to send said V_{SVC}^* to a local controller of SVC and said V_{Gen}^* to an excitation voltage controller of generator.

20. The coordinated controller according to Claim 15, wherein in said third type of the operation mode,

a setting module is configured to set generator terminal voltage reference V_{Gen}^* according to unit transformer low side voltage reference V_L^*;

a calculating module is further configured to calculate SVC voltage reference V_{SVC}^* according to generator active power reference P_{Gen}^*, generator reactive power reference Q_{Gen}^*,and generator terminal voltage reference V_{Gen}^*, and

a sending module is configured to send said V_{SVC}^* to a local controller of SVC and said V_{Gen}^* to an excitation voltage controller of generator.

21. The coordinated controller according to Claim 15, wherein in said fourth type of the operation mode,

said calculating module is further configured to:calculate SVC voltage reference V_{SVC}^* according to generator active power reference P_{Gen}^* and unit transformer high side voltage reference V_H^*;calculate generator terminal voltage reference V_{Gen}^* according to generator active power reference P_{Gen}^* and unit transformer high side voltage reference V_H^*; and

a sending module is configured to send said V_{SVC}^* to a local controller of SVC and said V_{Gen}^* to an excitation voltage controller of generator.

22. The coordinated controller according to Claim 15, wherein in said fourth type of the operation mode,

said setting module is further configured toset SVC voltage reference V_{SVC}^* according to unit transformer low side voltage reference V_L^*;set generator terminal voltage reference V_{Gen}^* according to unit transformer low side voltage reference V_L^*; and

a sending module is configured to send said V_{SVC}^* to a local controller of SVC and said V_{Gen}^* to an excitation voltage controller of generator.

23. The coordinated controller according to any one of Claims 16-22, wherein said generator terminal voltage reference V_{Gen}^* can also comprise a generator side feedback component calculated by generator reactive power closed-loop controller.

24. The coordinated controller according to any one of Claims 16-22, wherein said SVC reactive power reference Q_{SVC}^* and/or SVC voltage reference V_{SVC}^* can also comprise a SVC side feedback component calculated by generator reactive power closed-loop controller.

25. The coordinated controller according to Claim21 or 22, wherein said generator terminal voltage reference V_{Gen}^* can also comprise a generator side droop component calculated by generator reactive power droop controllerfor the fourth type of said operation mode.

26. The coordinated controller according to Claim21 or 22, wherein said SVC voltage reference V_{SVC}^* can also comprise a SVC side droop component calculated by SVC reactive power droop controllerfor the fourth type of said operation mode.

27. A power plant with Static Var Compensator (SVC), wherein said power plant comprises:

at least one generator unit and corresponding unit transformer, which are connected to the large electrical power system at the high voltage side of said unit transformer; in which said generator is connected to the low voltage side of said unit transform;

at least one SVC which can be connected to either low voltage side or high voltage side of said unit transformer; and

a coordinated controller which controls the voltage and/or reactive power of said

SVC, and the voltage and/or reactive power of said generator unit, according to any one of Claims 14-26.

28. The power plant according to Claim 27, wherein said SVC further comprises a thyristor-based static Var compensator or voltage source converter based static Var compensator.

29. The power plant according to Claim 27, wherein

said generator unit further comprises at least two local controllers for generator excitation voltage control and active power control; and

said SVC further comprises local controller for voltage and/or reactive power control.

30. The power plant according to Claim 29, wherein said coordinated controller is interfaced with said local controllers of said generator unit and said SVC.

DRAWING

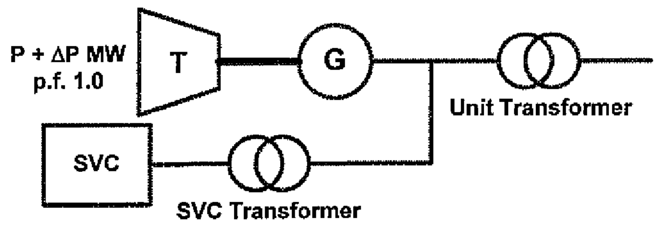

FIG.1A

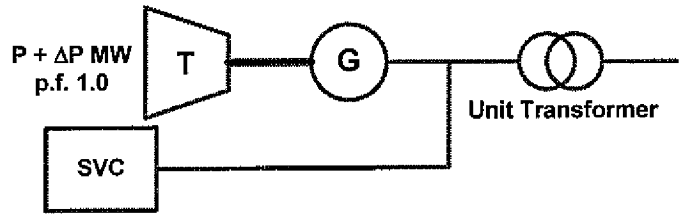

FIG.1B

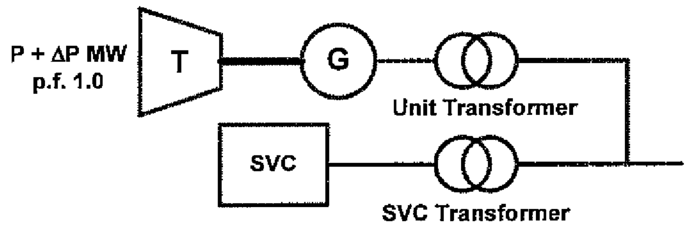

FIG.1C

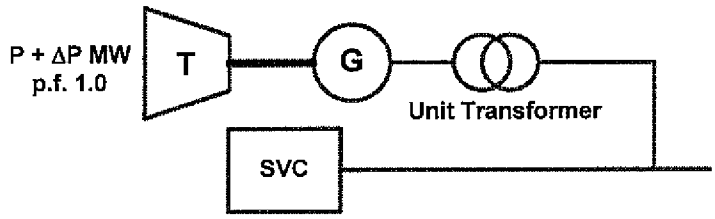

FIG.1D

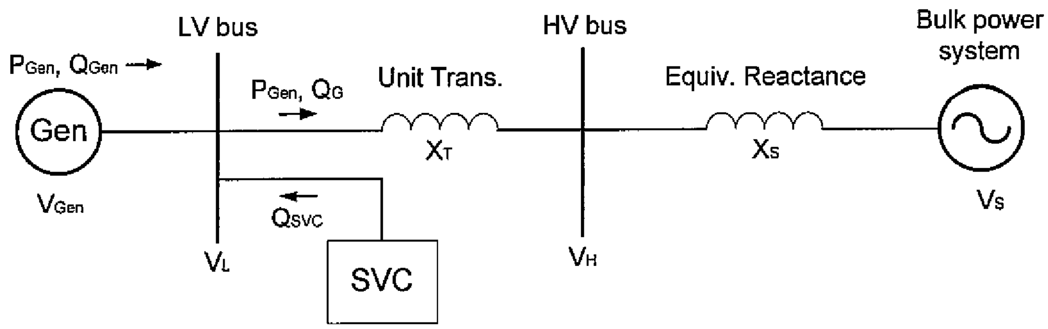

FIG. 2

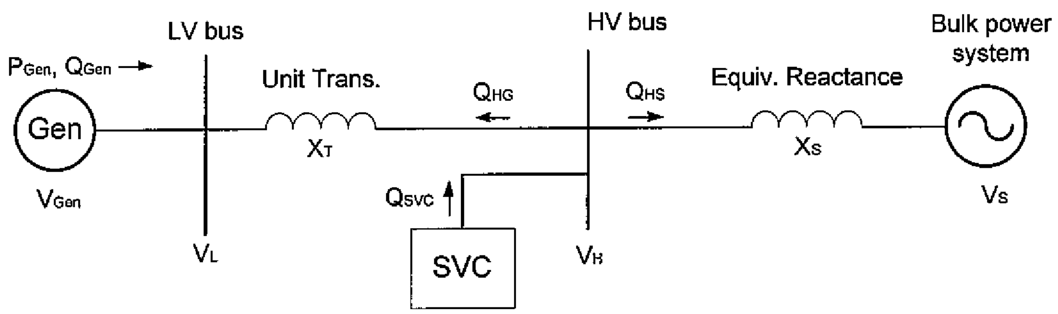

FIG.3

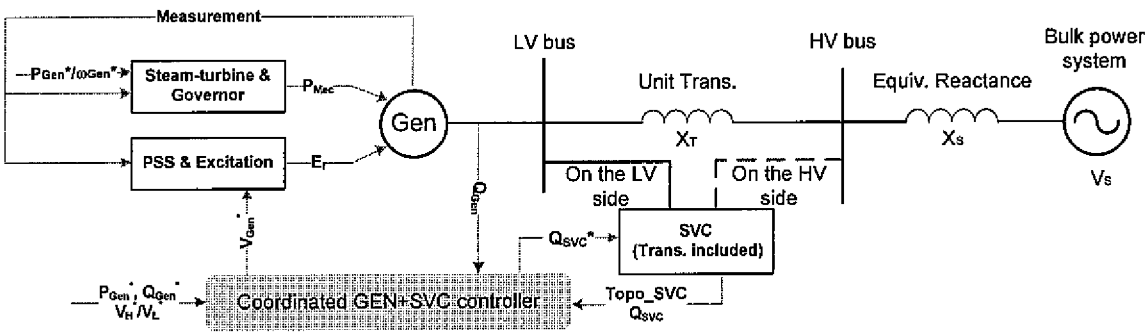

FIG. 4

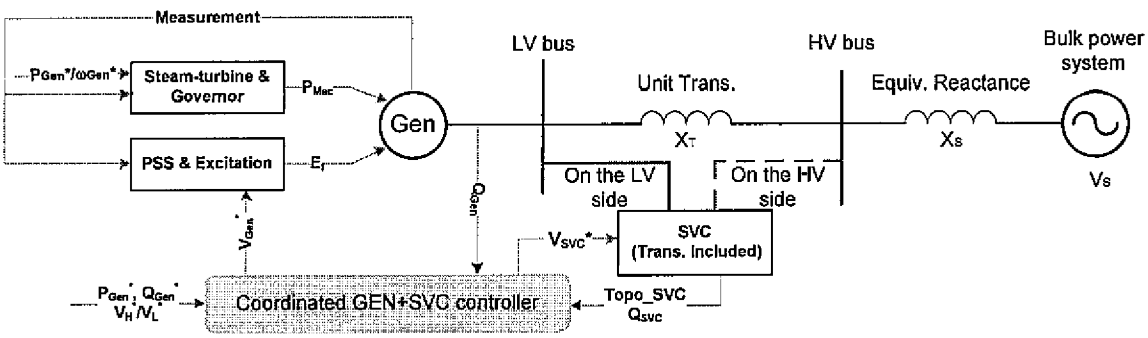
Measurement
PGen*/ωGen*
Steam-turbine & Governor
PMec
PSS & Excitation
Ef
Gen
VGen*
QGen
LV bus
Unit Trans.
XT
HV bus
Equiv. Reactance
Xs
Bulk power system
Vs
On the LV side
On the HV side
SVC (Trans. Included)
VSVC*
PGen*, QGen*
VH*/VL*
Coordinated GEN+SVC controller
Topo_SVC
QSVC

FIG. 5

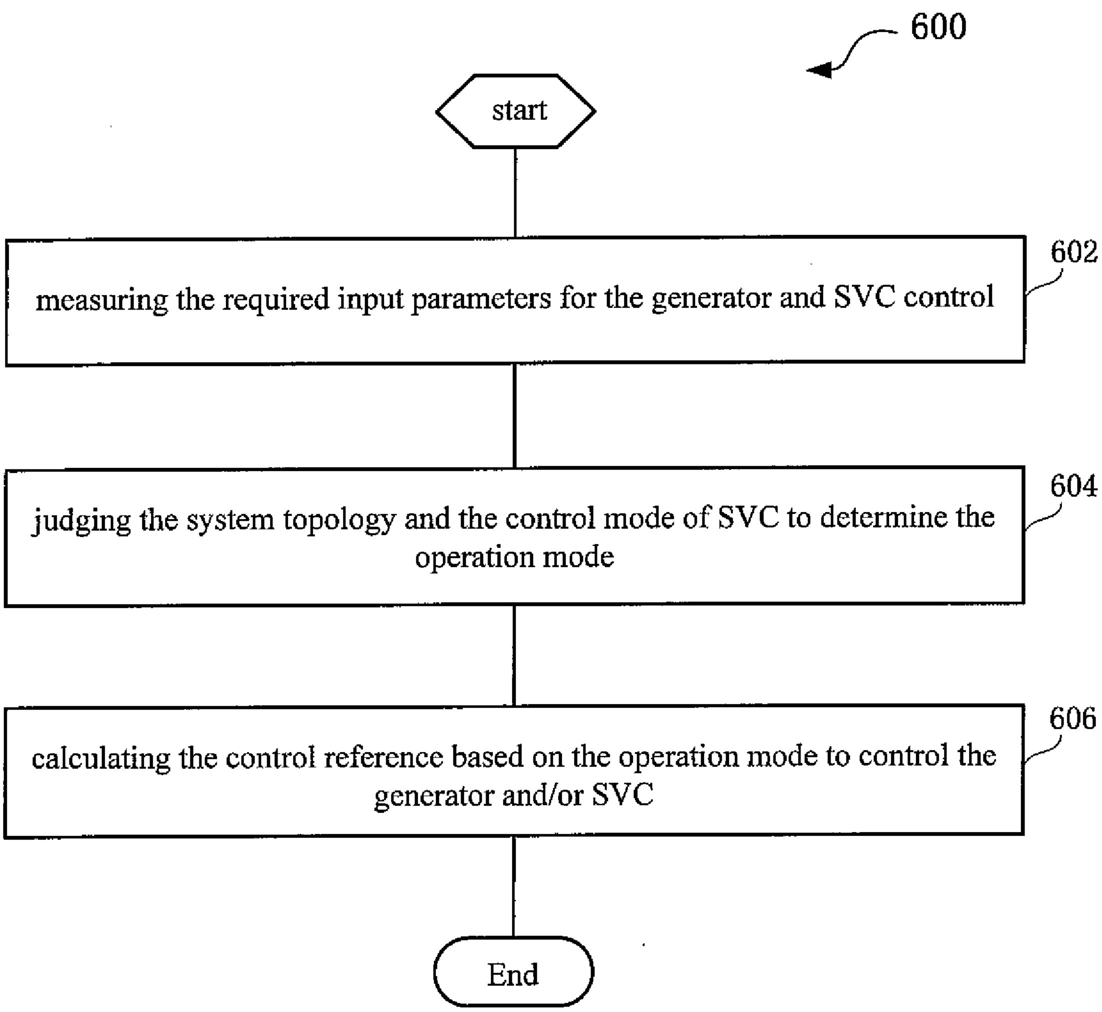
600
start
measuring the required input parameters for the generator and SVC control
602
judging the system topology and the control mode of SVC to determine the operation mode
604
calculating the control reference based on the operation mode to control the generator and/or SVC
606
End

FIG. 6

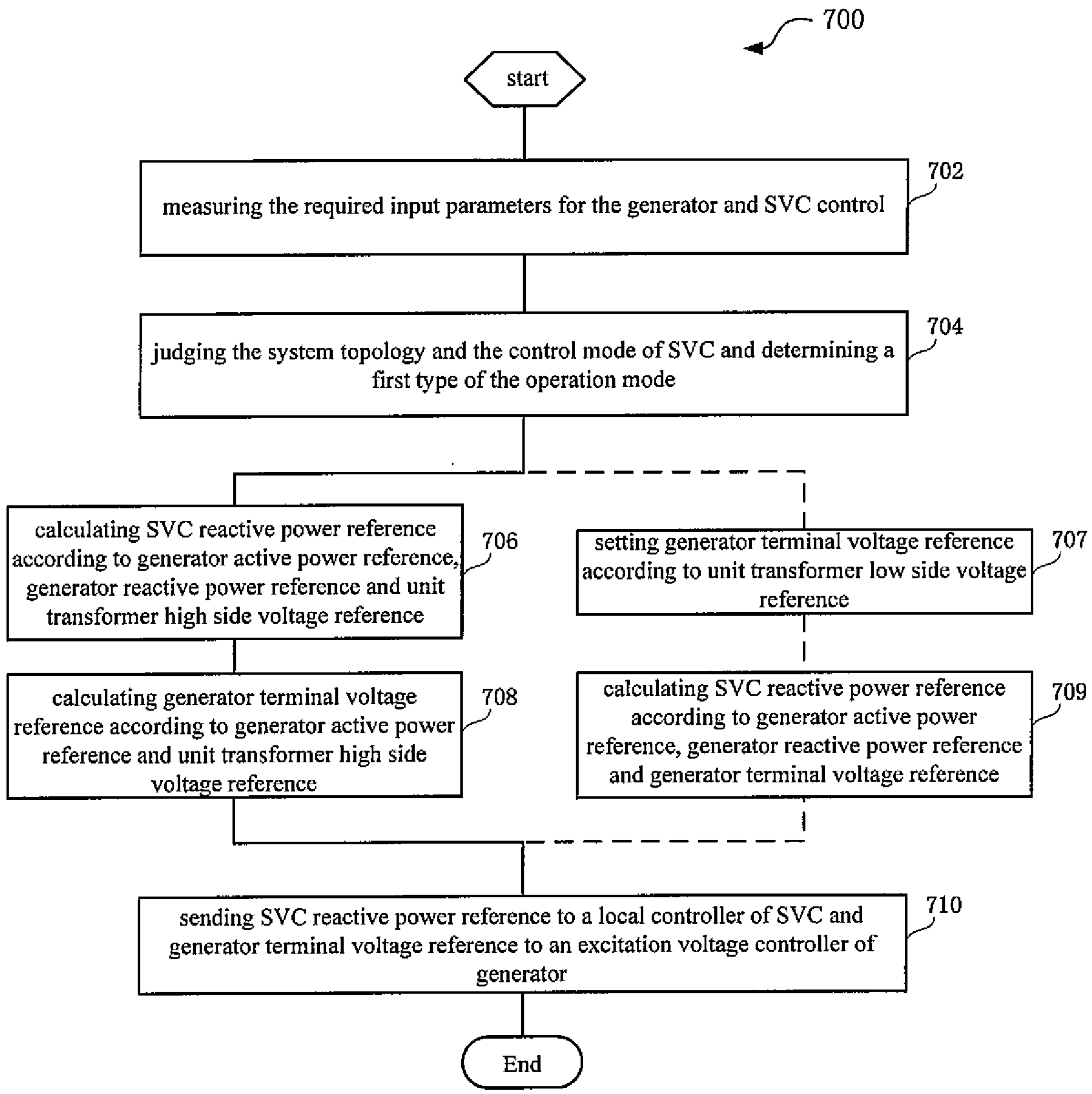
700
start
measuring the required input parameters for the generator and SVC control
702
judging the system topology and the control mode of SVC and determining a first type of the operation mode
704
calculating SVC reactive power reference according to generator active power reference, generator reactive power reference and unit transformer high side voltage reference
706
setting generator terminal voltage reference according to unit transformer low side voltage reference
707
calculating generator terminal voltage reference according to generator active power reference and unit transformer high side voltage reference
708
calculating SVC reactive power reference according to generator active power reference, generator reactive power reference and generator terminal voltage reference
709
sending SVC reactive power reference to a local controller of SVC and generator terminal voltage reference to an excitation voltage controller of generator
710
End

FIG. 7

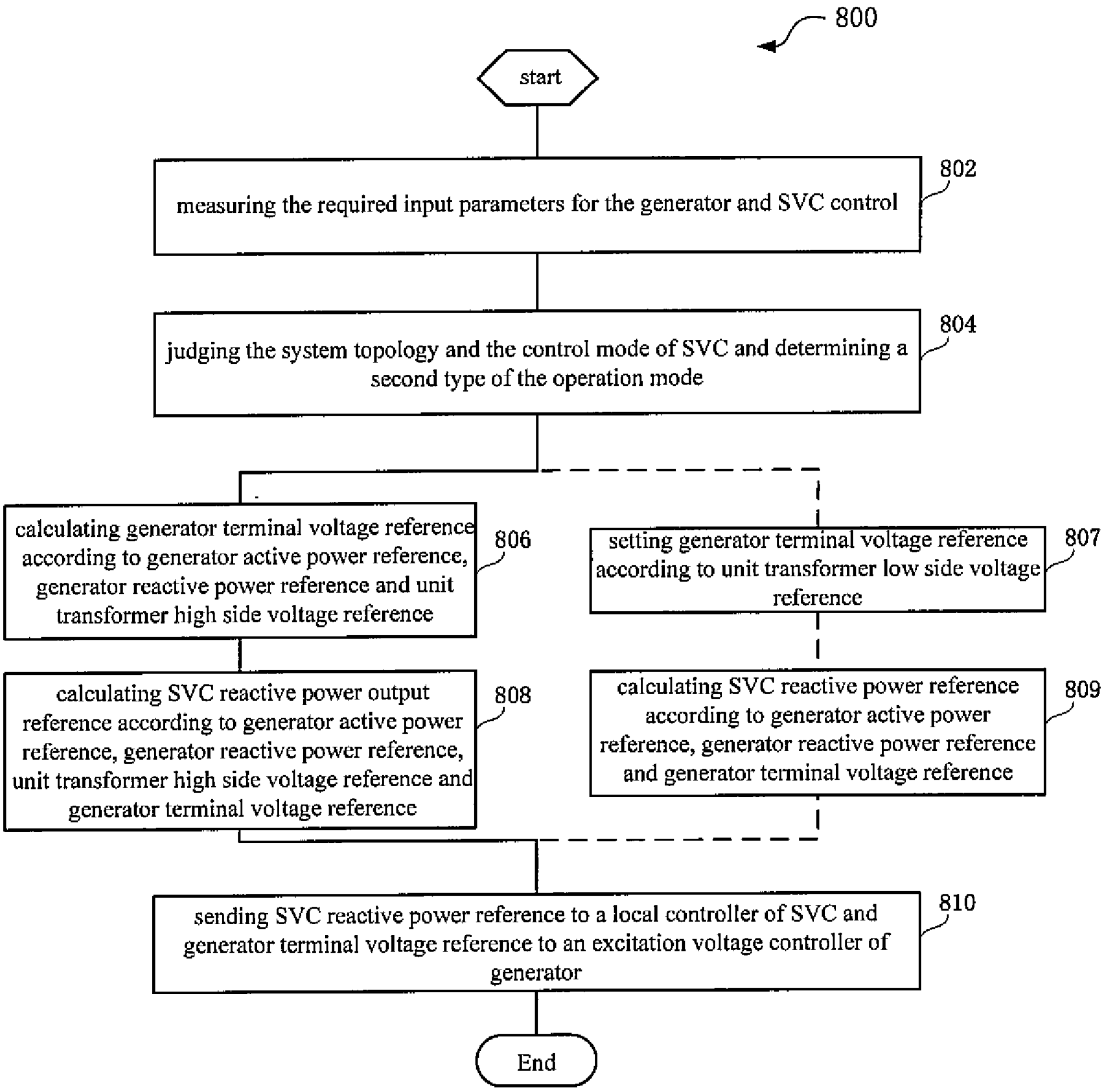
800
start
measuring the required input parameters for the generator and SVC control
802
judging the system topology and the control mode of SVC and determining a second type of the operation mode
804
calculating generator terminal voltage reference according to generator active power reference, generator reactive power reference and unit transformer high side voltage reference
806
setting generator terminal voltage reference according to unit transformer low side voltage reference
807
calculating SVC reactive power output reference according to generator active power reference, generator reactive power reference, unit transformer high side voltage reference and generator terminal voltage reference
808
calculating SVC reactive power reference according to generator active power reference, generator reactive power reference and generator terminal voltage reference
809
sending SVC reactive power reference to a local controller of SVC and generator terminal voltage reference to an excitation voltage controller of generator
810
End

FIG. 8

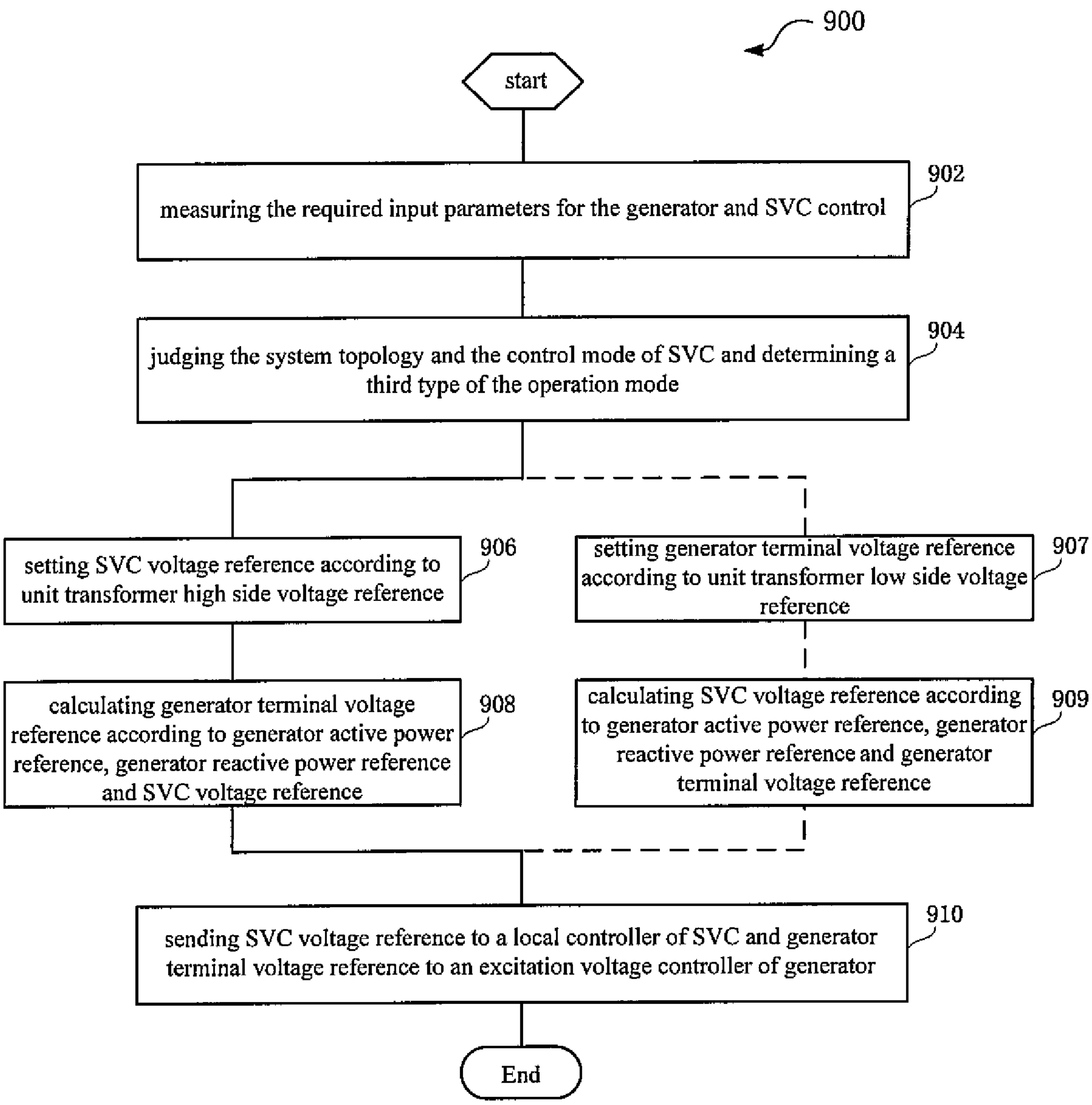
900
start
measuring the required input parameters for the generator and SVC control
902
judging the system topology and the control mode of SVC and determining a third type of the operation mode
904
setting SVC voltage reference according to unit transformer high side voltage reference
906
setting generator terminal voltage reference according to unit transformer low side voltage reference
907
calculating generator terminal voltage reference according to generator active power reference, generator reactive power reference and SVC voltage reference
908
calculating SVC voltage reference according to generator active power reference, generator reactive power reference and generator terminal voltage reference
909
sending SVC voltage reference to a local controller of SVC and generator terminal voltage reference to an excitation voltage controller of generator
910
End

FIG. 9

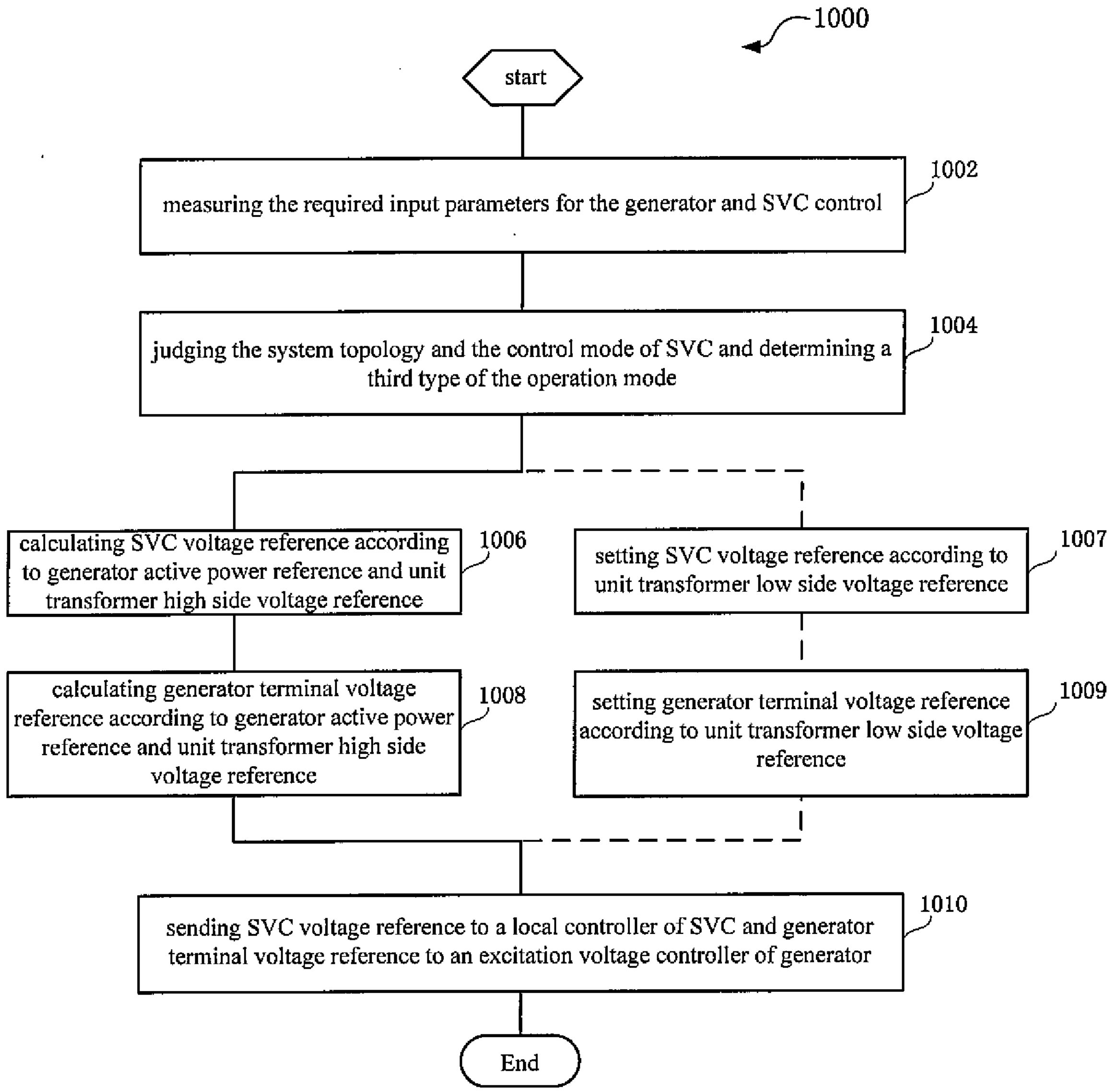
1000
start
measuring the required input parameters for the generator and SVC control
1002
judging the system topology and the control mode of SVC and determining a third type of the operation mode
1004
calculating SVC voltage reference according to generator active power reference and unit transformer high side voltage reference
1006
setting SVC voltage reference according to unit transformer low side voltage reference
1007
calculating generator terminal voltage reference according to generator active power reference and unit transformer high side voltage reference
1008
setting generator terminal voltage reference according to unit transformer low side voltage reference
1009
sending SVC voltage reference to a local controller of SVC and generator terminal voltage reference to an excitation voltage controller of generator
1010
End

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2012/087001

A. CLASSIFICATION OF SUBJECT MATTER

H02J 3/18 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H02J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT,WPI, EPODOC, google： SVC, power, plant, generator, reactive, active, control, operation, factor, mode

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2011/091267 A2 (ABB INC.) 28 July 2011 (28.07.2011) the whole document	1-30
A	CN 102480130 A (BYD CO. LTD.) 30 May 2012(30.05.2012) the whole document	1-30
A	US 2012/0139506 A1 (MITSUBISHI ELECTRIC CORPORATION) 07 June 2012 (07.06.2012) the whole document	1-30
A	CN 102668295 A (ABB RESEARCH LTD.) 12 September 2012 (12.09.2012) the whole document	1-30
A	CN 102723781 A (SHANGHAI MUNICIPAL ELECTRIC POWER CO.) 10 October 2012 (10.10.2012) the whole document	1-30

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 September 2013 (05.09.2013)	**26 Sep. 2013 (26.09.2013)**
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer WANG, Mingjia Telephone No. (86-10) 62413293

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2012/087001

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
WO 2011/091267 A2	28.07.2011	US2011181044A1	28.07.2011
		AU2011207343A1	30.08.2012
		EP2526605A2	28.11.2012
		CA2800783A1	28.07.2011
		CN102918734A	06.02.2013
CN 102480130 A	30.05.2012	None	
US 2012/0139506 A1	07.06.2012	JP2012123450A	28.06.2012
CN 102668295 A	12.09.2012	WO2011050303A1	28.04.2011
		AU2010310516A1	17.05.2012
		US2012248874A1	04.10.2012
		JP2013509157A	07.03.2013
CN 102723781 A	10.10.2012	None	