

Voltage and Reactive Power Control

Introduction

Voltage changes continuously according to the varying electrical demand, transmission lines utilization, system control by the control centers, and emergency situations occurred in the system. Since customers require voltage quality, at delivery points, to meet the agreed criteria, it is the control centers' responsibility to control the voltage so that it can satisfy the agreement.

Controlling the voltage is regional problems. In other words, the voltage controlling problems are needed to be solved separately by each control area. This can be achieved by providing sufficient reactive power sources for controlling voltage level as specified by the agreement. The voltage controlling problems can be divided into two situations, which are normal situation, and emergency situation. The reactive power sources are classified into two types, static and dynamic. The static type consists of shunt capacitor, and shunt reactor. The dynamic type is the source of reactive power produced by generators, SVC, and OLTC that operates automatically. The control centers need to organize and compile the constantly updated information concerning the availability of relevant equipment. Also the control centers have to provide procedures, in writing, required for properly controlling of the equipment in order to support normal situation, and emergency situation that may lead to voltage collapse and cascade tripping both of which can cause a blackout.

Definition

AVR : Automatic voltage regulator

PSS : Power System Stabilizer

Purpose

- To control the voltage at delivery points according to the agreement without damaging customers' equipment.

- To control the power flow in the system to an optimal level in order to reduce losses.
- To control the reserve reactive power in order to ensure its sufficiency during normal and emergency conditions to prevent voltage collapse.
- To monitor the reactive power and to resolve problems in order to maintain EGAT's system security so that the international electricity purchasing can be completed according to agreements.

Requirement

R1. The control center of each country shall operate cooperatively to ensure that the policies and procedures are developed, maintained, and executed in order to monitor whether the control of real and reactive power in Thailand and in the neighbor countries are in accordance with the specification and having sufficient stability.

R2. The control center of each country shall provide, follow up, and examine reactive power absorption and injection sources to ensure the sufficiency of reactive power absorption and injection sources in their areas in order to maintain voltage levels, for all points, as specified in the standard during normal and emergency conditions.

R3. The control centers shall specify voltage levels or reactive power at interconnection points between the power system and the transmission system. The control centers shall notify the specification to generator operators. Normally, generators are operated in AVR mode.

R4. The control centers must know the conditions of all reactive power sources, both absorption and infection, in the system including the condition of AVR and PSS (if available) of all generators.

- 4.1 When the control centers are notified that AVR cannot be operated in automatic mode, the control centers shall give orders to the generator operators in order to vary or maintain voltage or reactive power.
- 4.2 In case where sources of reactive power supply are not available, the control centers shall have plans to remedy such the case.

R5. Generators must follow requirements 3 and 4.1. However, if there are exceptions to be made for any generators, the control centers shall specify the conditions for the exceptions.

5.1 The control centers shall have the list of generators, which are exempt from the reactive power or voltage requirement, within the specified responsible area.

5.2 The generators, which are exempt from such requirements, are required to supply reactive power according to the following requirements:

- The generators shall maintain voltages within 0.97-1.03 per unit at the delivery points.
- The generators shall maintain power factor within ± 0.85 per unit during maintaining voltage levels as specified above.

R6. The control centers shall maintain and spread out reactive power sources in order to support N-1 promptly and efficiently.

In case where the voltages and reactive power cannot be maintained to support the N-1 condition, the control centers shall implement operation procedures and follow the implemented operation procedures which may include load shedding and disabling automatic load tap changer transformers, if necessary, in order to avoid voltage collapse. The control centers shall notify control centers of neighbor countries if such event can affect power systems of the neighbor countries.

R7. The control centers shall examine if generator transformers' tap positions are appropriate, and shall reconsider the settings three times a year (according to seasons) or change the tap positions that seem appropriate. The control centers can ask generators to change the tap positions, however the generators have the right to object such proposal, and have to right to ask for explanation of such action, provided that both parties are reasoning based on technical basis.

R8. Voltage levels and amount of reactive power at international connection points shall be in accordance with mutual agreements that shall benefit the system stability for both parties and shall comply with N-1 criterion.

R9. The control centers shall have database containing information on reactive power sources in the responsible control area. The information consists of:

- Reactive capability curves of generators;
- Synchronous condensers;
- Static VAR compensators;
- Shunt reactor and shunt capacitors;
- On load tap change transformers and their settings; and
- Other reactive power sources such as transmission lines.

The control centers shall know current MVAR values, maximum and minimum MVAR absorption/injection capabilities, and operating restriction (if applicable) of each equipment so that the levels of reserve reactive power are accurate for all time.

Information concerning equipment, which can significantly affect neighbor power systems, shall be available online for each other, which depends on an agreement.

Standard

S1. Reactive power sources, both injecting and absorbing, shall be capable of supplying and consuming reactive power so that voltages at connection points can be controlled to be within defined levels, and shall be able to maintain the voltage at high for obtaining more reactive power from the increased voltage levels in order to support emergency situations especially when electricity demand is increasing.

S2. The lost of one controlling equipment shall not affect the stability of the interconnection system.

S3. Protection system such as U/V load shedding shall be installed to prevent voltage collapse.

S4. Working in cooperation among control centers is necessary because it gives the best result for controlling voltages. Each control center shall control reactive power, in the

interconnection system, to be within the agreed levels during both normal and emergency situations.

S5. In case where demand or voltage reduction procedure, which may affect other control centers, is applied in order to maintain optimal voltage level, the others control centers shall be notified of such procedure.

Guideline

G1. Reactive Power Capability of Generators

G3.1 Generators shall be able to supply or absorb reactive power according to the reactive power capability curve that is defined in PPA, and shall perform yearly inspection to ensure that generators can perform according to the reactive power capability curve.

G3.2 The generators which are exempt from the Requirement 5.1, nevertheless, have the responsibilities to supply reactive power according to the following requirements.

- The generators shall maintain voltage level at delivery points to be within 0.97 – 1.03 per unit, or as requested by the control centers.
- While maintaining the voltage level as specify above, the generators shall keep power factor to be within ± 0.85 per unit.

G2. Procedures for Controlling Voltage and Reactive Power

G2.1 Voltage Control Priority

- Primary Voltage Control: The control centers shall control primary voltage by providing specific voltage levels to generators according to the Requirement 4. The generators shall adjust the AVR which will vary the excitation of generating units in order to achieve the specified voltage levels. For other voltage control equipment such as SVCs or automatic tap changing transformers, they are considered to be a part of primary voltage control. All equipment

that is used for the primary voltage control is considered to be dynamic.

- Secondary Voltage Control: The control centers shall employ voltage control mechanism by managing static reactive power sources, both absorption and injection, for examples, shunt reactors, capacitor bank, etc, all of which are within the considered zones in cooperate with the first step for voltage control in order to maintain specified voltage levels at essential delivery points that represent the zones.

G2.2 The control centers shall apply the following mechanism for voltage control.

- Disconnecting transmission lines. This procedure shall be mainly used during light load period, and it shall not reduce system security below N -1 criteria. For other periods, this procedure shall not be used.
- Adjusting synchronous condensers.
- Opening or closing shunt reactors and capacitor banks.
- Adjusting reactive power from power plants with AVR in automatic or manual mode depending on the control centers.
- Adjusting transformer taps.

G3. The Definition of Normal and Emergency Situation and Voltage Standard in each Situation

G3.1 Normal situation is when:

- All customers can receive electricity;
- All operation are within specified limit (equipment's limit, stability limit); and
- N – 1 criteria are applicable for all delivery points.

G3.2 Emergency situation is any situations that are deviated from the normal situation. The control centers shall have authority and shall perform their duties

according to procedures in order to immediately bring back the system to the normal situation efficiently.

G3.3 Voltage Levels

- During normal situation: 0.95 – 1.05 per unit
- During emergency situation: 0.90 – 1.10 per unit in order to prevent damages for equipment in the system

G4. N – 1 Criteria: In a circumstance where a component in the system is inoperative, such circumstance shall not endanger system stability in the following ways:

- System frequency falls under the specified range;
- System voltage drop enough to possibly cause voltage instability;
- System islanding; and
- Cascade trip beyond stability limit.

The rest of the system that is functioning shall be able to withstand the changes of demand and generation, the voltage deviation, and the stability problems in the system. However, in some circumstances, the control centers may allow load shedding in order to keep the main system in operating condition.

Measure

M1. The control centers shall retain the evidences of voltage/reactive power requirements for generators notifications for the Requirement 3.

M2. The control centers shall retain the evidences of generators that are exempt from voltage/reactive power Requirements 5.2 within their responsible areas.

M3. The control centers shall retain the evidences of ordering in accordance with the Requirement 4.1 after receiving notification from generators that AVRs are not controllable.

M4. The control center shall retain the evidences of changing taps positions of transformers notification for the Requirement 7 to generators.

Compliance

1. Procedures for monitoring the compliance of relevant parties
 - 1.1 Responsibility and cooperation during the inspection of compliance
In the power system of each country, the control center and the generators have to cooperate with the inspectors for examining the capability of absorbing or supplying reactive power of equipment.
 - 1.2 Inspection, cooperation, and time limit
Inspection, cooperation, and time limit are to be specified by inspectors.
 - 1.3 Evidence Keeping
The relevant parties shall keep information concerning voltage or reactive power for inspection by inspectors.

2. Degrees of non-compliance
 - 2.1 1st Degree: No evidences indicated that exempted generator operators had received notification of exemption in accordance with R5.2
 - 2.2 2nd Degree: As it falls into one of the following categories:
 - 2.2.1. No evidence indicated that orders in accordance with R4.1 had been given; or
 - 2.2.2.No evidences indicated generator operators had received notification concerning transformer tap changing in accordance with R7.
 - 2.3 3rd Degree: The specific voltage levels or reactive power had been prepared for some generating units but had not been prepared for other generating units in accordance with R3.
 - 2.4 4th Degree: No evidences indicated that specific voltage levels or reactive power had been sent to generator operators in accordance with R3.

