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PROVINCIAL ELECTRICITY AUTHORITY

Provincial Electricity Authority's Regulation on the Power Network System Interconnection Code

B.E.2559 (2016)

Contents

Page

1. Terminology 1

2 .Objectives and Scope.. 3

3. Responsibilities of Connection Requester.. 3

4. Power Capacity Purchased from Power Producers.. 4

5. Technical Consideration Criteria... 4

6. Power Metering System and Component Equipment.. 5

7. Interconnection Patterns and Protection System.. 6

8. Power Quality Control Regulation...8

9. Supervisory Control..10

10. Communication System...10

11. Generation Capacity Increase or Power System Expansion...11

12. Additional Regulations for Power Generating System with Converter..11

Attachment 1: Specifications of Interconnection Patterns

Attachment 2: Equipment Specifications and Standards

Attachment 3: Voltage Fluctuation Regulation for Business and Industrial Use

Attachment 4: Harmonic Regulation for Business and Industrial Use

Attachment 5: Specifications and Regulations of Control Equipment to be Connected to the SCADA System of a Power Dispatch System Operator

Attachment 6: Converter Test Procedure and Methodology

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Provincial Electricity Authority's Regulation

On the Power Network System International Code

B.E.2559 (2016)

Whereas it has been stipulated under Section 81 of the Energy Industry Act, B.E. 2550 (2007), that a licensee who has an energy network system must allow other licensees or energy industry operators to utilize or connect to his energy network system in accordance with the codes stipulated and announced by the licensee operating the energy network system. In order to comply with the provision of the aforementioned law, Provincial Electricity Authority (PEA), by virtue of Section 31(2) of the Provincial Electricity Authority Act, B.E. 2503(1960), hereby issues the Provincial Electricity Authority's Regulation on the Power Network System Interconnection Code, B.E. 2559 (2016), which shall take immediate effect from now on. The Provincial Electricity Authority's Regulation on the Power Network System Interconnection Code, B.E. 2551 (2008), shall then be annulled and superseded by this regulation. Any other order and regulation in the part herein or which contravenes this regulation shall be superseded by this regulation.

1. Terminology

"Power Network System"	means	A power transmission system or a power distribution system of PEA
"Power Dispatch System"	means	An agency responsible for power system control in each of PEA's service areas
"Electricity Industry Operator"	means	A person granted a license for electricity industry operation, or a person exempted from the license requirement, undertaking the production, procurement, transmission or distribution of electricity, or the control of a power system, pursuant to the Energy Industry Act, B.E. 2550 (2007)
"Power Consumer"	means	A person executing an agreement to buy power from PEA
"Connection Requester"	means	An electricity industry operator requesting to connect his generator or power network system to PEA's power network system and/or a power consumer requesting to connect his generator to PEA's power network system
"Network User"	means	An electricity industry operator authorized by PEA to connect his generator or power network system and/or a power consumer authorized to connect his generator to PEA's power network system and successfully satisfied by PEA
"Very Small Power Producer (VSPP)"	means	An electricity industry operator selling electricity to PEA according to the Regulations for the Purchase of Power from Very Small Power Producer
"Small Power Producer (SPP)" means	means	An electricity industry operator selling electricity to Electricity Generating Authority of Thailand according to the Regulations for the Purchase of Power from Small Power Producers
"Power Producer"	means	A very small power producer (VSPP) or a Small Power Producer (SPP)
"Incident"	means	Any event that occurs and affects a power network system or its related operation, both with or without outage
"Point of Common Coupling (PCC)"	means	A location in PEA's power network system which is nearest to a network user and may be jointly connected by other network users or power consumers

"Interconnection Point"	means	The point at which a network user's equipment is connected to PEA's power network system
"Islanding"	means	Power dispatch to a certain power network system while there is no power dispatched by PEA to that network system
"Teleprotection System"	means	A protection system of a power network system controlled via a communication system
"Other Electricity Industry Operators"	means	Other electricity industry operators pursuant to the Energy Industry Act, B.E.2550 (2007)
"Remote Terminal Unit (RTU)"	means	A control device in the SCADA (supervisory control data acquisition) system, used for sending/receiving data for controlling or indicating the status of device/equipment pertaining to the power network system
"Supervisory Control Data Acquisition (SCADA)"	means	A remote supervisory control system related to the control and/or indication of the status of devices /equipment which are located far away in distance
"Converter"	means	A device that converts alternating current to directing current, or directing current to alternating current such as inverter

2. Objectives and Scope

2.1 Objectives

This Provincial Electricity Authority's Regulation on the Power Network System Interconnection Code, B.E. 2559 (2016), aims to provide minimum criteria of the designing technique, technical specifications of electrical equipment, and the installation standards that a connection requester wishing to connect to PEA's power network system must comply with, given the following objectives:

2.1.1 To establish appropriate methods to connect a system and equipment of a connection requester to a power network system, by stipulating fundamental requirements for interconnection of power systems to serve as implementing principles without any disparity;

2.1.2 To clarify and set up the fundamental regulations covering the minimum technical requirements for system designing for a connection requester to comply with, including technical specifications of electric equipment and installation standards at the interconnection point;

2.1.3 To ensure the efficiency and safety of synchronization of generators to PEA's power system and of the connection between power network systems; and,

2.1.4 To maintain the quality of power dispatch to power consumers in general at the standards of PEA after a network user has been connected to a power network system.

2.2 Scope

This Provincial Electricity Authority's Regulation on the Power Network System Interconnection Code, B.E. 2559 (2016), must be applied to the following connection requesters:

2.2.1 Small power producer (SPP);

2.2.2 Very small power producer (VSPP);

2.2.3 Power consumers possessing generators; and

2.2.4 Other electricity industries operators; except Electricity Generating Authority of Thailand (EGAT), and Metropolitan Electricity Authority (MEA)

3. Responsibilities of Connection Requester

A connection requester's design must have, at minimum, technical specifications of electrical equipment that are in line with the interconnection patterns stipulated in this Provincial Electricity Authority Regulation on the Power Network System Interconnection Code, B.E.2556 (2016).

PEA reserves the rights to approve or disapprove the interconnection to a power network system, by considering system safety and reliability, as well as benefits to the general public. A connection requester must accept and comply with PEA's decision and must not raise it as a case to make a claim for any compensation on PEA.

Last but not least, PEA reserves the right to revise, alter, or to prescribe other specifications for the sake of power system safety and security; thereby, a connection requester must accept and comply with the regular change.

4. Power Capacity Purchased from Power Producers

4.1 380/220-V distribution system:

4.1.1. A power producer is allowed to connect to a single-phase distribution system, only if the system can supply capacity not more than 5 kV. In case that the power producer wishes to connect several single-phase distributions to a power network system, capacity supplied to each phase must be stable; that is, the different between each phase must not exceed 5 kW.

4.1.2. The total power capacity from each connection requester's generator connected to the same transformer must not exceed 15% of distribution transformer load (kV- A).

4.2 22/33-kV distribution system:

4.2.1 For a 22-kV distribution system: not exceeding 8.0 MW/circuit;

4.2.2 For a 33-kV distribution system: not exceeding 10.0 MW/circuit;

The total purchased capacity for 22/33 kV of all circuits must not exceed 75% of each electrical system's distribution transformer load (kV- A).

4.3 115-kV distribution system

The total purchased capacity must not exceed 120 MW/circuit (single conductor), and 230 MW/circuit (double conductor).

5. Technical Consideration Criteria

In order to maintain the quality of power dispatched to meet PEA's standards after being connected by a network user, as well as ensure the safety and reliability of a power network system, the following technical consideration criteria are established.

5.1 PEA will assess the impact of the connection to the power network system from various aspects (as detailed below) before granting authorization for a connection requester to connect to a power network system. In this regard, work plans or projects of PEA must also be taken into consideration.

5.1.1 Electrical Current Dispatch

A connection requester possessing a generator must not cause electrical current overflowing in the distribution or transmission lines of the power network system in excess of the rated continuous current. The power dispatched to the transmission system must not negatively affect the overall stability of the power system.

5.1.2 Voltage Regulation

A connection requester possessing a generator must not cause any voltage failures in the power network system in accordance with PEA's standards. If the voltage level became out of standard, a connection requester must optimize his generator's performance to meet PEA's standard level.

5.1.3 Short Circuit

A connection requester possessing a generator must not allow the total short-circuit level of the power network system to exceed 85% of the short circuit interrupting capacity of the protective equipment, and must not interrupt the protection coordination of the protective equipment.

5.2 A connection requester failing to comply with the technical consideration criteria must conduct a study to rectify the impacts which may occur, with respect to the dispatch of electrical current, voltage regulation, short circuit, and the reliability of the power network system. Should it be necessary to improve the power network system, the connection requester must be responsible for the expense incurred. In this regard, PEA reserves the rights to consider and authorize the connection to a power network system on a case by case basis.

6. Power Metering System and Component Equipment

6.1 A connection requester is responsible for the installation of a power meter which could meter the capacity and/or energy sold to PEA, corresponding with his targeted power customers. As for the installation of a power meter and component equipment in order to sell power to EGAT, the connection requester must comply with EGAT's code.

6.2 The instrument transformer connected to the power meter must not be jointly connected to other meters or relays.

6.3 The power meter and component equipment must observe PEA's standards, which could be altered in accordance with technological improvement and which will be determined by PEA.

6.4 A network user must not undertake any act on his power meter and component equipment. If irregularity occurred, PEA must be notified accordingly.

6.5 For a small power producer (SPP) with direct connection to PEA's power station, if the power system phase located between PEA and SPP is not utilized by PEA, the power meter must be equipped to PEA's station, and the SPP must comply with the following conditions:

6.5.1 The SPP must be responsible for maintenance fees of the power system phase between PEA and the SPP. If a third party requests for joint interconnection to the system, PEA reserves the rights to approve or disapprove, considering system stability.

6.5.2 If the system phase located between PEA and the SPP is utilized by PEA, the power meter must be re-located to the SPP, and all the assets at the phase must be transferred to PEA.

7. Interconnection Patterns and Protection System

The interconnection patterns are categorized into two cases as follows.

7.1 Small Power Producers, Very Small Power Producers and Power Consumers possessing generators.

A connection requester must install basic equipment specified by PEA in order to be able to connect his power system to a power network system. The connection pattern is demonstrated in Attachment 1.

7.1.1 Disconnecting equipment must observe PEA’s requirements, as detailed in Attachment 2.

7.1.2 Protective equipment and component must meet the standards acceptable to PEA.

7.1.3 A connection requester’s transformer requires winding connection corresponding with the amount of capacity to be supplied to the system, and with the characteristics of the synchronization of generator to the system, pursuant to the Attachment 1. In case that it does not observe PEA’s requirements, prior consent from PEA must be obtained.

7.1.4 For a power network system with automatic reclosing scheme, a connection requester must ensure that his disconnecting equipment disconnects the power dispatch before the automatic reclosing of PEA functions; otherwise, PEA will not be liable for any equipment damage.

7.1.5 If PEA considers that it is appropriate to improve the reclosing method or necessary to install additional equipment such as synchronizing system, teleprotection system, or block reclosing system for both the part of the connection requester, and that of PEA, by charging the expense incurred to the requester’s account, the connection requester must abide by the consideration and PEA will not be liable for requester’s equipment damage resulting from the reclosing.

7.1.6 PEA does not allow a connection requester to use an automatic reclosing scheme for the power system connected to a network system.

7.1.7 Synchronization must be conducted at the generator circuit breaker or at the interconnection circuit breaker, as deemed appropriate.

7.1.8 A connection requester’s protection system must be designed to have anti-islanding function in order to prevent the connection of his generator to a network system while there is no power supply at the interconnection point of the power network system. Accordingly, disconnection must function immediately if there is no power supply in the power network system.

7.1.9 PEA reserves the rights to authorize islanding dispatch for each connection requester, on a case by case basis as deemed proper.

7.1.10 A connection requester must install a certain equipment to prevent system damage in compliance with this regulation, or other additional preventive equipment as considered appropriate. Installation of protection relays must be ensured to be in harmony with the protection system of PEA. The network user must be liable for damage resulted from faulty equipment, or other causes that occurred after the connection to the power network system.

7.1.11 The protection system designed by PEA is a minimally-protective system. Hence, a connection requester has to consider the appropriateness to install additional prevention equipment for preventing system’s malfunction in the case where it is not prescribed in this regulation, i.e., high impedance fault (HIF), and inadvertent islanding. After the interconnection to the power network system has been made, should there be any damage to the power network system, and/or to a third party caused by the network user’s power dispatch, the network user must be liable.

7.1.12 A connection requester must design and install protection coordination equipment to prevent inconsistency between equipment in the power network system.

7.1.13 In case that there is no any appropriate interconnection pattern applicable to a connection requester, PEA reserves the rights to consider and determine an interconnection pattern that is considered suitable, on a case by case basis.

7.1.14 PEA reserves the rights to alter the interconnection patterns and prevention equipment, as appropriate, to enhance principally the safety and reliability of the power network system and the benefits of the general public.

7.1.15 A power consumer owning a generator must design a system that do not dispatch power current into the power network system, nor over-consume the power which may negatively affect PEA's power network system as well as other power consumers.

7.2 Other Electricity Industry Operators

For other electricity industry operators wishing to connect to a power network system, PEA reserves the rights to approve or disapprove, on a case by case basis, considering the principal emphasis on safety and reliability to power network system and the benefits of the general public.

8. Power Quality Control Regulation

A connection requester must design systems to regulate power dispatch after having synchronized his generator to a power network system at the interconnection point, as detailed below.

8.1 Voltage Regulator and Power Factor

8.1.1 A connection requester must design a voltage regulation system in line with PEA's standards of maximum and minimum voltage levels.

PEA's Standards of Maximum and Minimum Voltage Levels

Voltage Level	Normal State		Emergency State	
	Maximum	Minimum	Maximum	Minimum
115 kV	120.7	109.2	126.5	103.5
33 kV	34.7	31.3	36.3	29.7
22 kV	23.1	20.9	24.2	19.8
380 kV	418	342	418	342
220 kV	240	200	240	200

8.1.2 A connection requester must design a power factor regulation system in order to keep the voltage level within the specified standards. A system with synchronous generator requires the power factor whose range is between 0.85 leading – 0.85 lagging or better, and be controlled by 2 methods:

1) A fixed displacement factor cos θ
2) A variable reactive power depending on the voltage Q(U)
For a system with a converter, the power factor must be adjustable and controllable as demonstrated in the table below.

Power Factor Adjustment and Reactive Electrical Power Control in System with Converter

Voltage Level at the Interconnection Point	**Ability to adjust the Power Factor at rated power input**	Reactive Power Control Methods
1) Low Voltage 2) Medium or High Voltage (Generation Capacity ≥ 500 kW)	0.95 lagging - 0.95 leading or better	At least one method: A fixed displacement factor cos Θ
3) Medium to High Voltage (Generation Capacity >500 kW)	0.90 lagging to 0.90 leading or better	At least two methods: 1) A fixed displacement factor cos Θ 2) A variable reactive power depending on the voltage Q(U)

8.2 Frequency Regulation

The frequency of a power network system will be regulated by Electricity Generating Authority of Thailand (EGAT) to be within the standard of 50±0.5 Hz per second. A very Small Power Producer (VSPP) must ensure that his generator is synchronized to the power network system at all time. In case of an incident, if the system frequency is not within a range between 47.00-52.00 Hz per second for more than 0.1 second, the VSPP must have the system designed to immediately disconnect the interconnection circuit breaker using an automatic system that is connected to the power network system. For a Small Power Producer (SPP), the code of EGAT must be complied with.

In case that the frequency at the interconnection point is not between 47.00 Hz – 52.00 Hz, the converter system must disconnect from the power system within 100 ms.

8.3 Voltage Fluctuation Regulation

A connection requester must design, install, and regulate his equipment in the manner that will not cause voltage fluctuation at the point of common coupling (PCC) that is excess of the levels acceptable to PEA, as specified in the Voltage Fluctuation Regulation for Business and Industrial Customers shown in Attachment 3. The Voltage Fluctuation Regulation could be reviewed and re-considered from time to time.

8.4 Harmonic Regulation

A connection requester must design, install, and control his equipment in the manner that will not cause frequency and current distortion at the point of common coupling (PCC) that is excess of the levels acceptable to PEA, as specified in the Harmonic Regulation for business and Industrial Customers shown in Attachment 4. The Harmonic Regulation may be reviewed from time to time.

8.5 Direct Current Dispatch to the Power Network System

A connection requester possessing a converter system must design a protection system so that the direct current dispatched to the power network system at the interconnection point will not exceed 0.5% of the rated current of the converter.

8.6 Installation of Power Quality Meter

For efficient inspection and regulation of power quality, connection requesters of the following categories must procure and install, at the interconnection point, a power quality meter with qualifications specified by PEA as follows.

8.6.1 A requester owning a generator /generators, with an aggregated generation capacity of more than 1 MW

8.6.2 A requester owning a converter-type generator /generators, with an aggregated generation capacity of more than 250 kW

A connection requester must procure, design and install monitoring systems in order to record information concerning power quality including voltage, frequency, electrical power, power factor, THDv, THDi, Pst, Plt, etc. In case of photovoltaic and wind power generating system, information such as light intensity, temperature, or wind speed must be recorded as detailed in Attachment 2. PEA must be able to observe and inspect the real-time power quality data via communication systems. All costs including monthly communication service fees must be the requester's responsibility, if there is.

9. Remote Terminal Unit (RTU)

Connection requesters applying schema No. 7,9,10 and 11 interconnection patterns must procure, design, and install Remote Terminal Unit (RTU) or Remote Control Switch (RCS), depending on circumstances. The requester must also install communication system linking to Supervisory Control and Data Acquisition (SCADA) system which is distributed by PEA's Power Dispatch System Operator, as detailed in Attachment 5. In addition, the requester must conduct a performance test on RTU and RCS interconnection, and must be responsible for the expense including monthly communication service fees.

10. Communication System

A connection requester must install, as specified by PEA, at least two direct communication channels in order to be contacted by PEA. An exception is for a connection requester owning a generation whose power purchase agreement involving a capacity of no more than 1 MW who requires only one communication channel: for example, telephone or low-frequency radio specified by PEA, etc., as deemed appropriate.

11. Generation Capacity Increase or Power System Expansion

A network user planning to increase the generation capacity or expand his power system from the part already authorized to connect to a power network system must obtain prior consent from PEA. Details of the plan must be submitted to PEA for consideration three months before commencement of the plan implementation.

12. Additional Regulations for Power Generating System with Converter

12.1 Active Power Control System

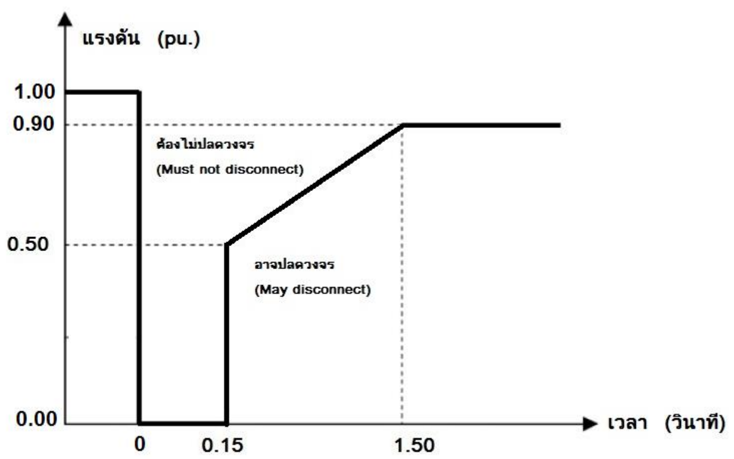
A connect requestor must design an Active Power Control System to help maintaining a specified voltage level. The system must be able to decrease the electric power from 100% to 0% on a 10% per minute manner.

12.2 Low voltage Fault Ride Through

When encountering low voltage fault, a connection requester's generator must not immediately disconnect itself from its power network system and stay connected for a certain period of time. The voltage level at the interconnection point must be maintained as follows:

The Period at which a Generator Must Stay Connected to Its Power Network System during a Temporary Low Voltage Fault

Voltage Level at the Connecting Point	**Time Duration** (Second**)**
1) Low-voltage 2) Medium or High Voltage (Generation Capacity ≥ 500 kW)	Not Required
3) Medium to High Voltage (Generation Capacity >500 kW)	Required (see below graph)



Low Voltage Fault Ride Through Capability

12.3 Under and Over Voltage Protection

A connection requester's power generating system must be able to disconnect from its power network system if the level on Line to Neutral voltage is out of the specified level as detailed in the following table:

Voltage Level at the Connecting Point	Disconnecting Period (Second)
V < 50%	0.3
50% ≤ V< 90%	2.0
90% ≤ V ≤ 110%	Stay connected
110% < V < 120%	1.0
V ≥ 120%	0.16

The disconnecting period when encountering over or under voltage

12.4 Anti-Islanding

To prevent islanding while there is no power supply at the power network system, a connection requester's generator must be capable to disconnect from the power network system within one second.

12.5 Response to Utility Recovery

After the disconnection, if the power network system resumes to its normal state, the connection requester's generator must be able to wait about 20 seconds to 5 minutes before re-connecting to the power network system.

12.6 Earthing/Short circuit protection/Isolation and Switching

The operation must observe the IEC 60364-7-712 standards.

12.7 Converter Test

A connection requester must conduct a converter test by following the procedure and methodology demonstrated in Attachment 6.

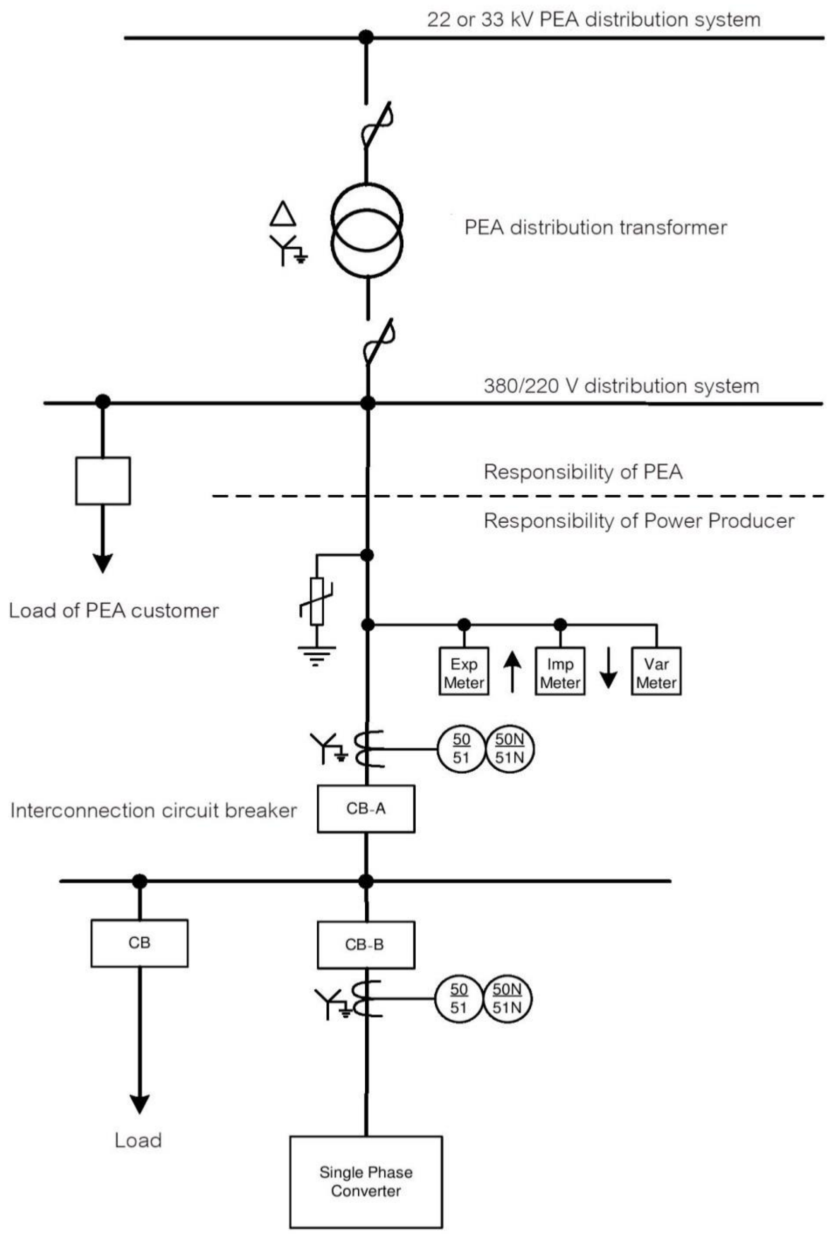
Effective Date: September 2016

(Sermsakul Klaikaew)
PEA Governor

Attachment 1

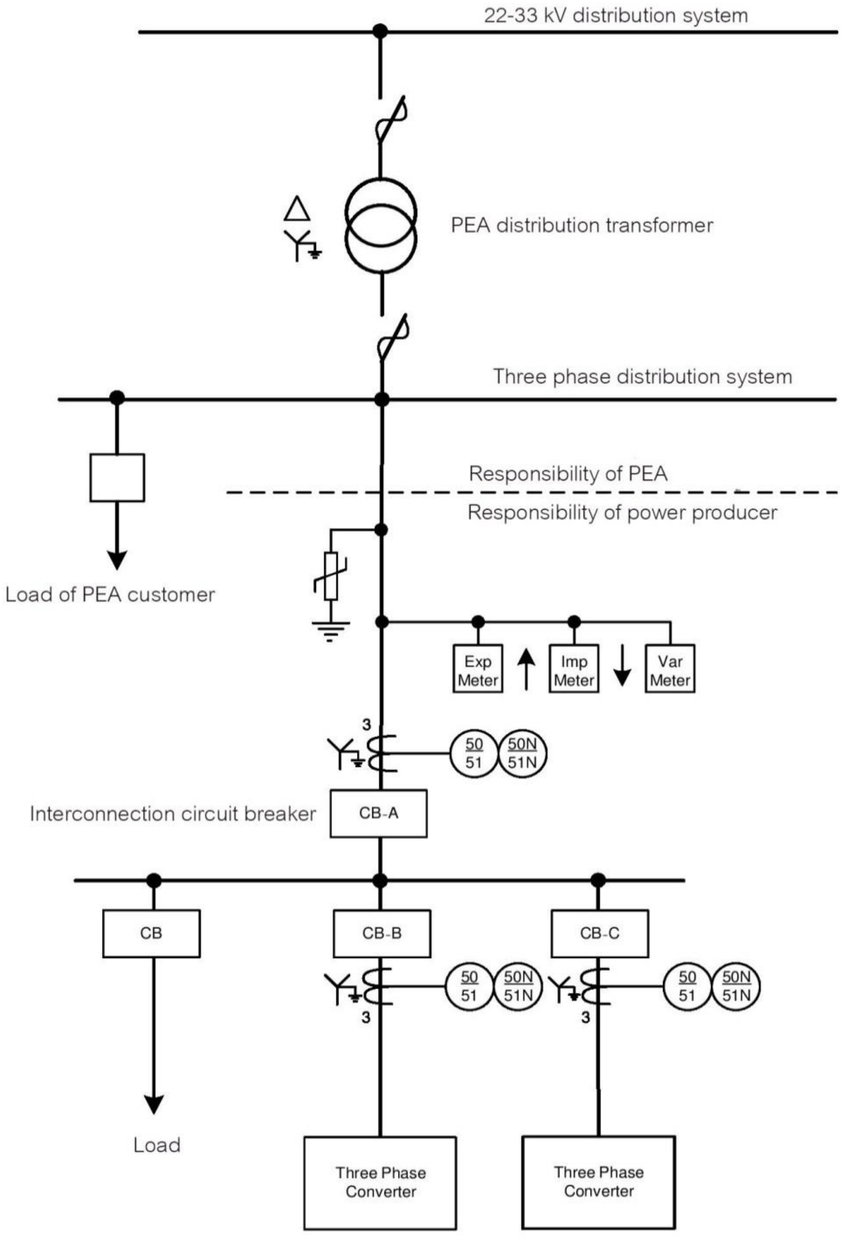
Specifications of Interconnection Patterns

Scheme No.1 : Interconnection Scheme for Power Producer or Power Consumer with Single Phase Coverter Connected to 220-V System of PEA



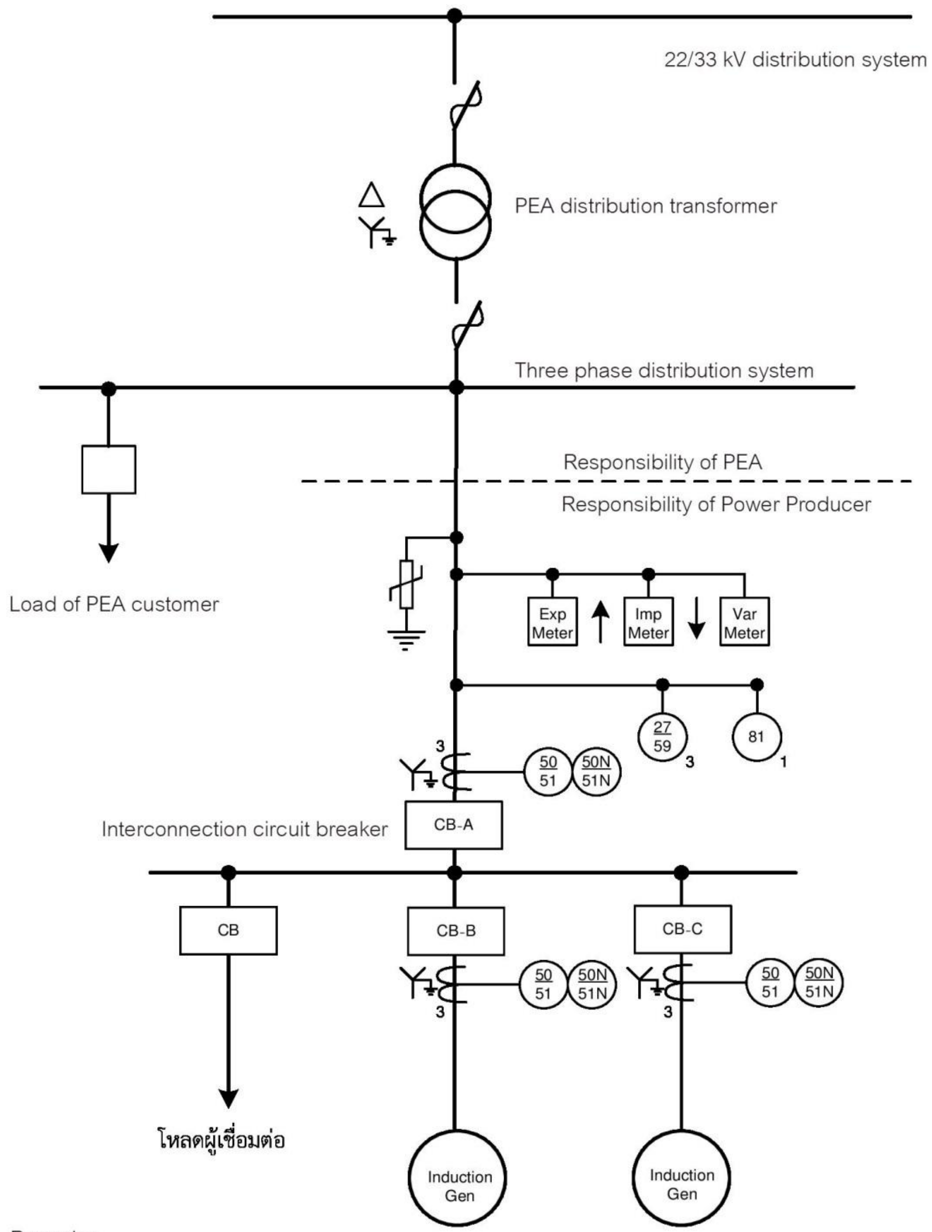
1. The converter must have minimum functions as follows:
    1.1. Under- and over- voltage relay (27/59)
    1.2. Under- and over- frequency relay (81)
    1.3. Synchronizing check relay (25)
    1.4. Anti-islanding protection
2. The converter must be tested as regulated by PEA
3. Export Meter is not required for power consumers with generation system

Scheme No.2 : Interconnection Scheme for Power Producer or Power Consumer with Three Phase Converter Connected to Three Phase Low-voltage Distribution System



1. The converter must have minimum functions as follows:
   1.1. Under- and over- voltage relay (27/59)
   1.2. Under- and over- frequency relay (81)
   1.3. Synchronizing check relay (25)
   1.4. Anti-islanding protection
2. The converter must be tested as regulated by PEA
3. Export Meter is not required for power consumers with generation system

Scheme No.3 : Interconnection Scheme for Power Producer or Power Consumer with Induction Generator Connected to Three Phase Distribution System

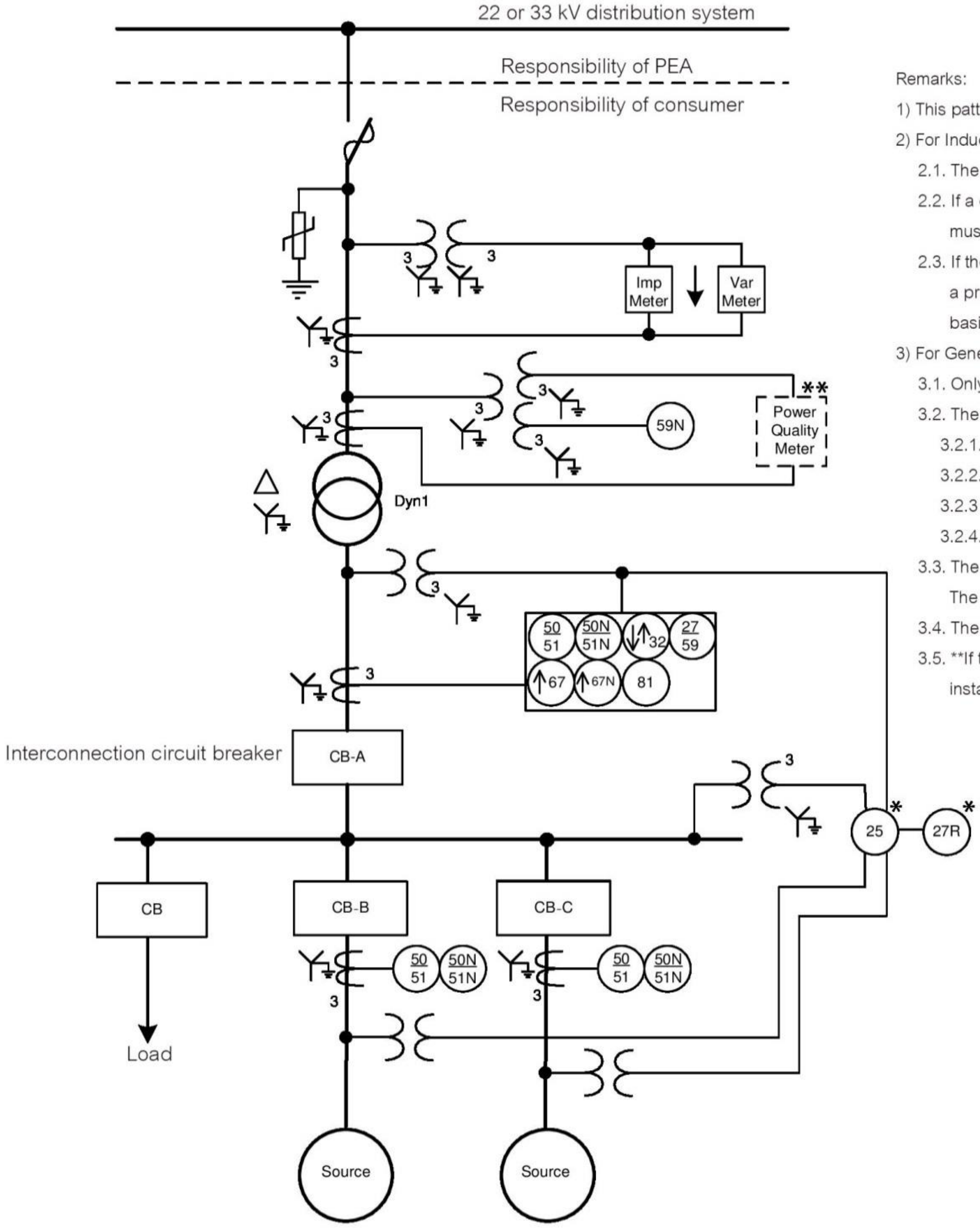


Remarks:

1. Only "three phase" induction generator interconnection is allowed.
2. If a capacitor is installed, its capacity and installation location must be illustrated in the pattern.
3. If the installed capacitor can be self-excited, a protection system will be considered on a case by case basis.
4. Export Meter is not required for power consumers with generation system

Relay No.	Description	Command
27/59	Under- and over- voltage relay	Trip CB-A
81	Under- and over- frequency relay	Trip CB-A

Scheme No.4 : Interconnection Scheme for Power Consumer Possessing Generators or Converters (≤1 MW totally) Connected to 22 or 33 kV System



Remarks:

1) This pattern is applicable for all types of generators.

2) For Induction Generator:

2.1. The marked (*) relay no. may not be neccessary.

2.2. If a capacitor is installed, its capacity and location must be detailed in the pattern.

2.3. If the installed capacitor can be self-excited, a protection system is considered on a case by case basis.

3) For Generator with Converter:

3.1. Only "three phase" converter is allowed.

3.2. The converter must have minimum functions as follows:

3.2.1.Under- and over- voltage relay (27/59)

3.2.2.Under- and over- frequency relay (81)

3.2.3 Synchronizing check relay (25)

3.2.4. Anti-islanding protection

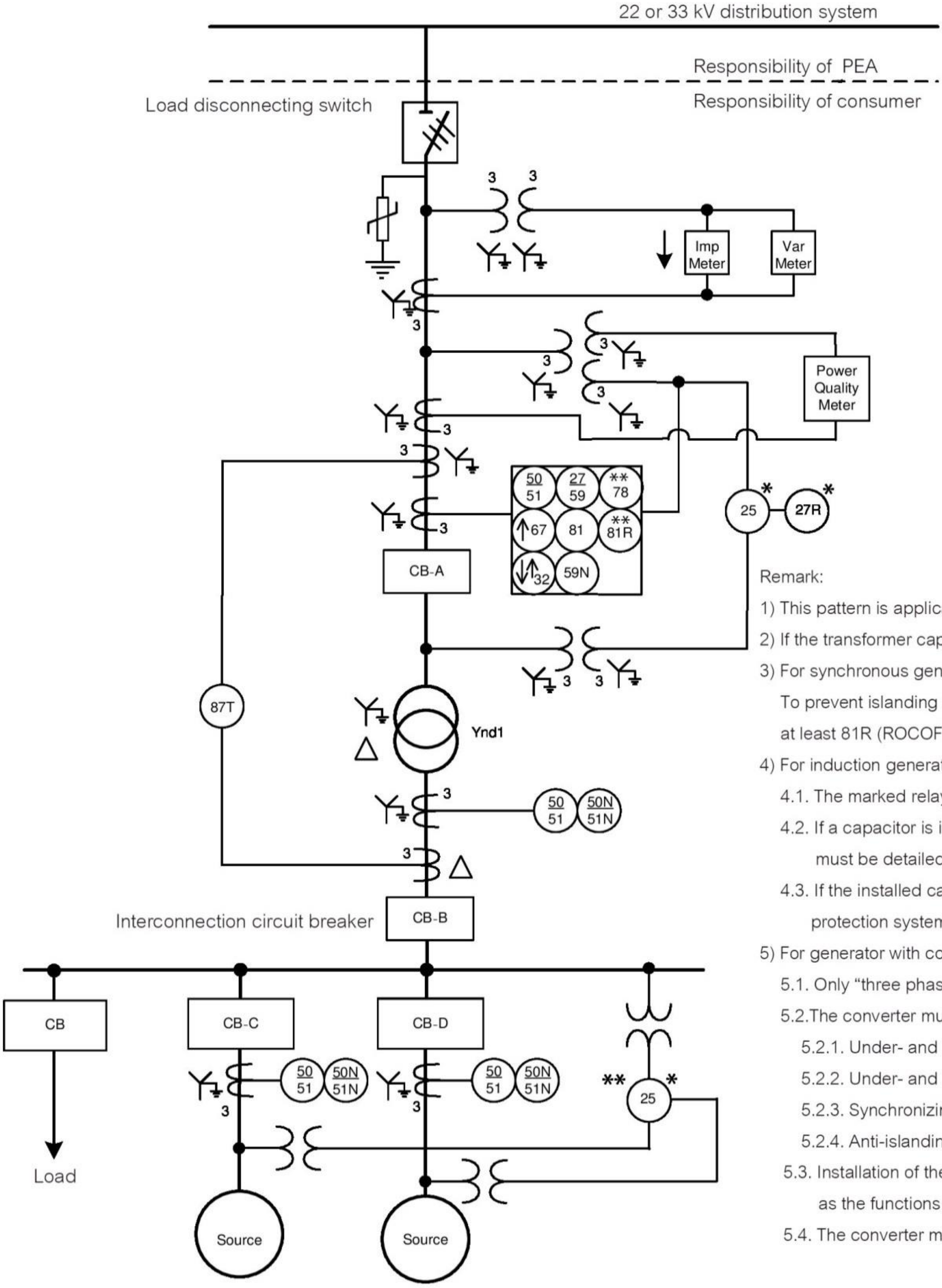
3.3. The marked (*) relay no. may not neccessaray. The functions can be applied in the coverter.

3.4. The converter must be tested as regulated by PEA.

3.5. **If the total converter capacity is over 250 kW, installation of a power quality analyzer is required.

Relay No.	Description	Command
25	Synchronizing check relay	To allow closing of CB-A , CB-B , CB-C
27/59	Under- and over- voltage relay	Trip CB-A
50/51 50N/51N	Phase and ground overcurrent relay	Trip CB-A, CB-B and CB-C
59N	Zero sequence overvoltage relay	Trip CB-A
67/67N	Directional phase and ground overcurrent relay	Trip CB-A
81	Under- and over- frequency relay	Trip CB-A
27R	Instantaneous undervoltage relay	To block closing of CB-A
32	Directional electricity power relay	Trip CB-A

Scheme No.5 : Interconnection Scheme for Power Consumer Possessing Generators or Converters (totally over 1 MW) Connected to 22 or 33 kV System

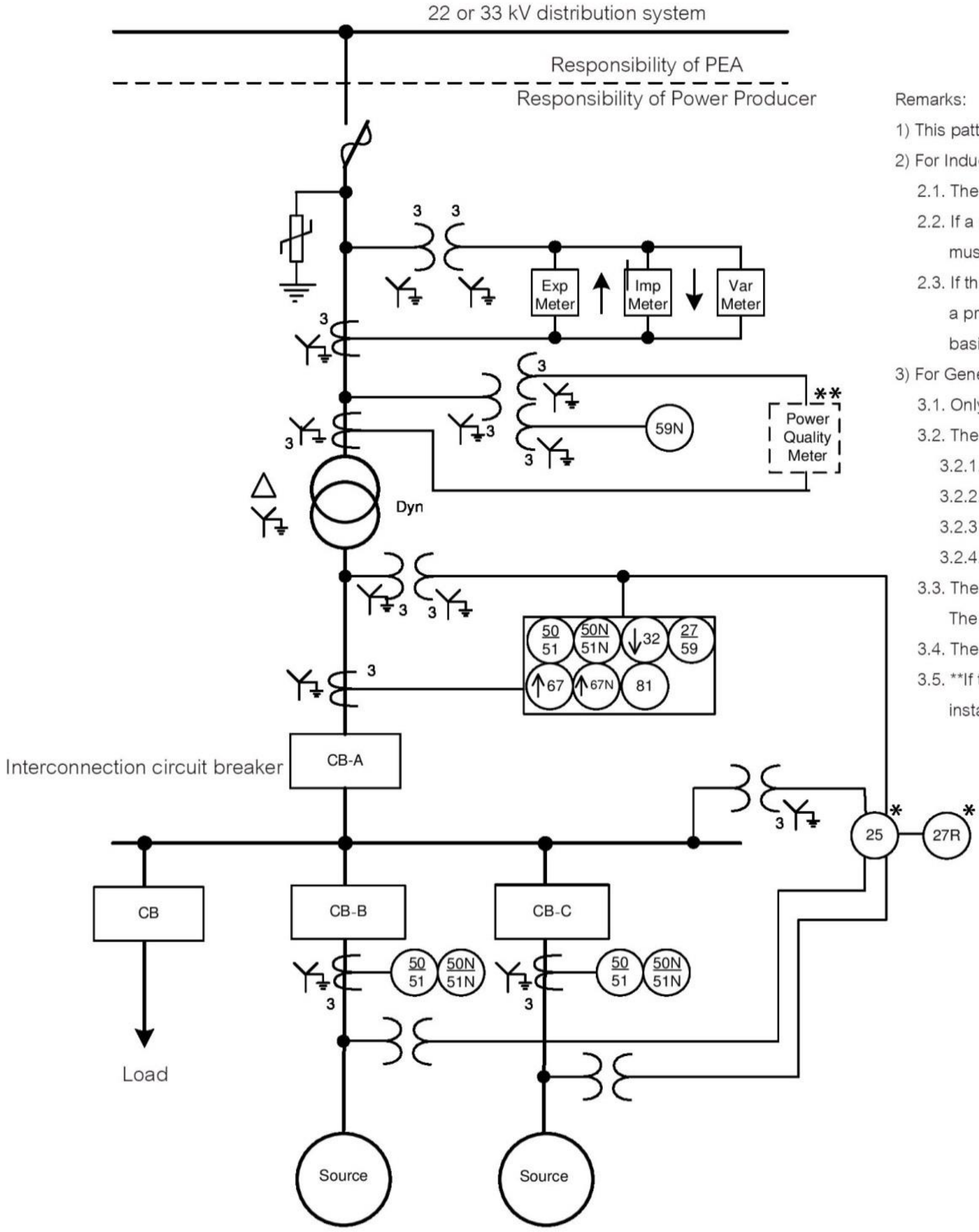


Remark:

1) This pattern is applicable for all types of generators.
2) If the transformer capacity is over 5 MVA, 87T must be applied.
3) For synchronous generator:
   To prevent islanding in PEA's power network system, at least 81R (ROCOF) and 78 (Vector Shift) must be installed.
4) For induction generator:
   4.1. The marked relays (*,**) may not be necessary.
   4.2. If a capacitor is installed, its capacity and location must be detailed in the pattern.
   4.3. If the installed capacitor can be self-excited, a protection system is considered on a case by case basis.
5) For generator with converter:
   5.1. Only "three phase" converter is allowed.
   5.2. The converter must have minimum functions as follows:
      5.2.1. Under- and over- voltage relay (27/59)
      5.2.2. Under- and over- frequency relay (81)
      5.2.3. Synchronizing check relay (25)
      5.2.4. Anti-islanding protection
   5.3. Installation of the marked relay (**) may not be necessary as the functions can be applied in the converter.
   5.4. The converter must be tested as regulated by PEA.

Relay No.	Description	Command
25	Synchronizing check relay	To allow closing of CB-A , CB-C, CB-D
27/59	Under- and over- voltage relay	Trip CB-A
50/51	Phase overcurrent relay	Trip CB-A
59N	Zero sequence overvoltage relay	Trip CB-A
67	Directional phase overcurrent relay	Trip CB-A
81	Under- and over- frequency relay	Trip CB-A
27R	Instantaneous undervoltage relay	To block closing of CB-A
87T	Transformer differential relay	Trip CB-A and CB-B
78 & 81R	Anti-islanding relay	Trip CB-A
32	Directional electricity power relay	Trip CB-A

Scheme No.6 : Interconnection Scheme for Power Producer Possessing Generators or Converters (≤1 MW totally) Connected to 22 or 33 kV System

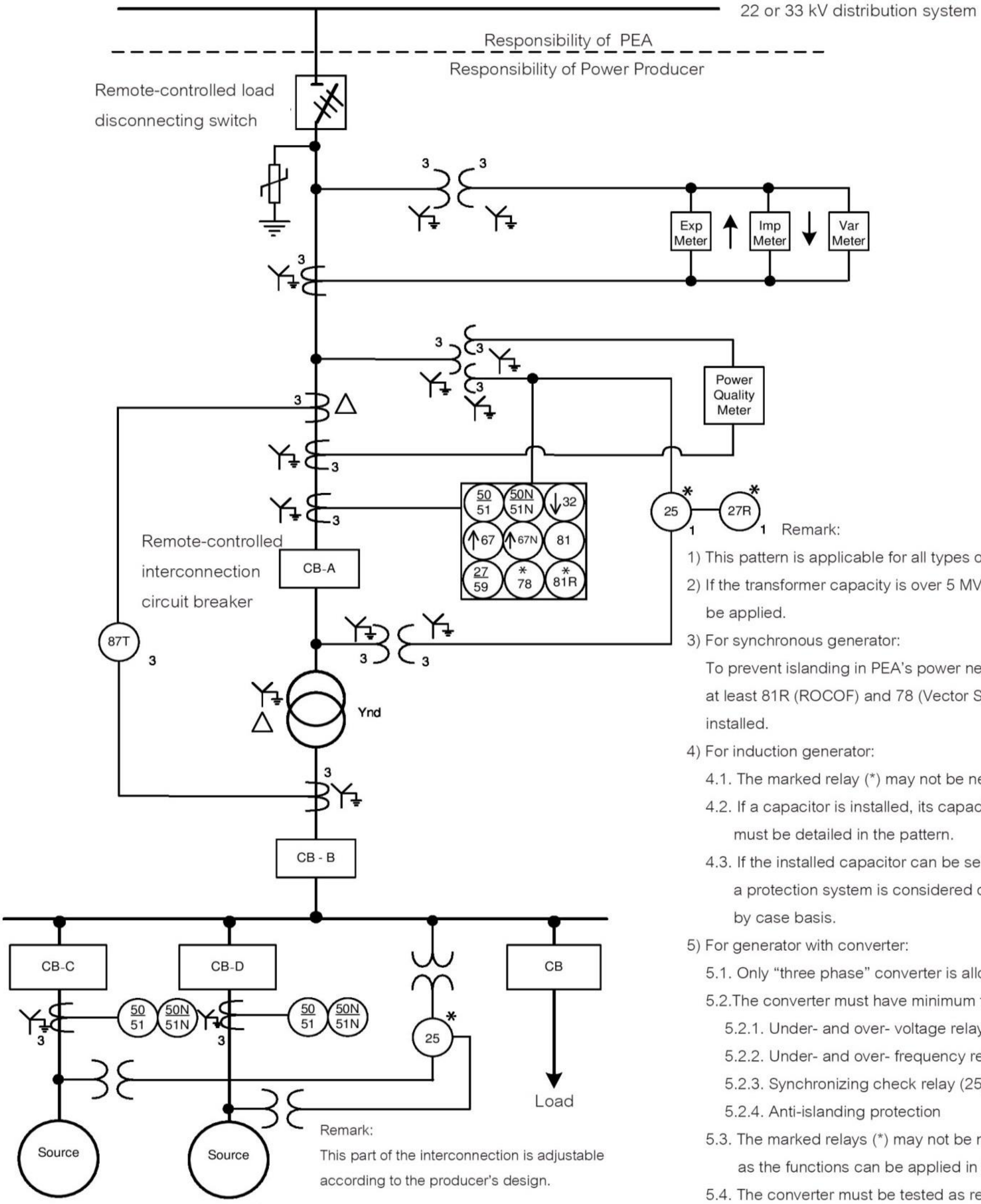


Remarks:

1) This pattern is applicable for all types of generators.
2) For Induction Generator:
   2.1. The marked (*) relay no. may not be neccessary.
   2.2. If a capacitor is installed, its capacity and location must be detailed in the pattern.
   2.3. If the installed capacitor can be self-excited, a protection system is considered on a case by case basis.
3) For Generator with Converter:
   3.1. Only "three phase" converter is allowed.
   3.2. The converter must have minimum functions as follows:
      3.2.1.Under- and over- voltage relay (27/59)
      3.2.2.Under- and over- frequency relay (81)
      3.2.3 Synchronizing check relay (25)
      3.2.4. Anti-islanding protection
   3.3. The marked (*) relay no. may not neccessaray. The functions can be applied in the coverter.
   3.4. The converter must be tested as regulated by PEA.
   3.5. **If the total converter capacity is over 250 kW, installation of a power quality analyzer is required.

Relay No.	Description	Command
25	Synchronizing check relay	To allow closing of CB-A , CB-B , CB-C
27/59	Under- and over- voltage relay	Trip CB-A
50/51 50N/51N	Phase and ground overcurrent relay	Trip CB-A, CB-B and CB-C
59N	Zero sequence overvoltage relay	Trip CB-A
67/67N	Directional phase and ground overcurrent relay	Trip CB-A
81	Under- and over- frequency relay	Trip CB-A
27R	Instantaneous undervoltage relay	To block closing of CB-A
32	Directional electricity power relay	Trip CB-A

Scheme No. 7 : Interconnection Scheme for Power Producer Possessing Generators or Converters (totally over 1 MW) Connected to 22 or 33 kV System

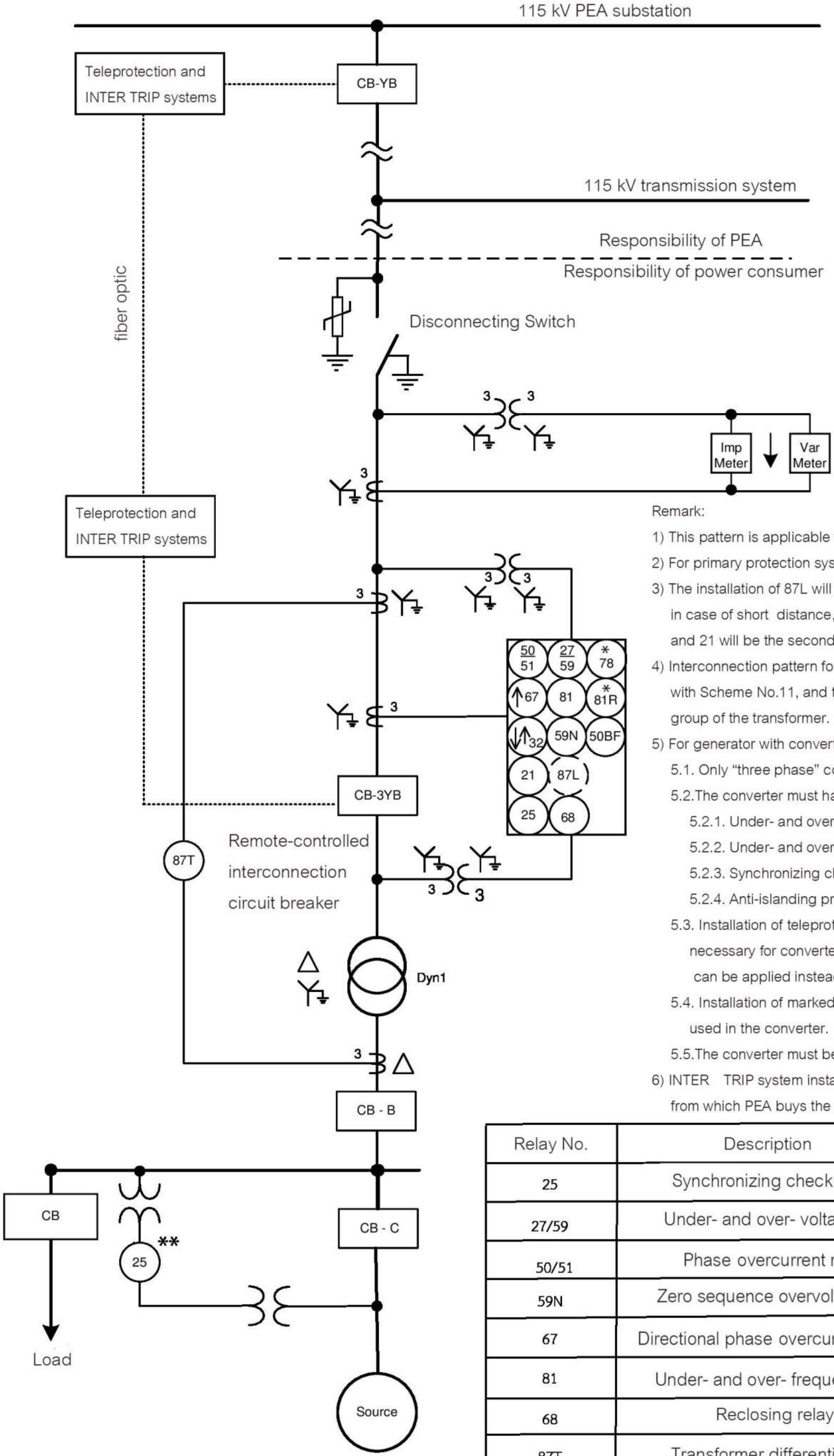


Remark:

1) This pattern is applicable for all types of generators.
2) If the transformer capacity is over 5 MVA, 87T must be applied.
3) For synchronous generator:
   To prevent islanding in PEA's power network system, at least 81R (ROCOF) and 78 (Vector Shift) must be installed.
4) For induction generator:
   4.1. The marked relay (*) may not be necessary.
   4.2. If a capacitor is installed, its capacity and location must be detailed in the pattern.
   4.3. If the installed capacitor can be self-excited, a protection system is considered on a case by case basis.
5) For generator with converter:
   5.1. Only "three phase" converter is allowed.
   5.2. The converter must have minimum functions as follows:
      5.2.1. Under- and over- voltage relay (27/59)
      5.2.2. Under- and over- frequency relay (81)
      5.2.3. Synchronizing check relay (25)
      5.2.4. Anti-islanding protection
   5.3. The marked relays (*) may not be necessary as the functions can be applied in the converter.
   5.4. The converter must be tested as regulated by PEA.

Relay No.	Description	Command
25	Synchronizing check relay	To allow closing of CB-A , CB-C, CB-D
27/59	Under- and over- voltage relay	Trip CB-A
50/51 50N/51N	Phase and ground overcurrent relay	Trip CB-A
67/67N	Directional phase and ground overcurrent relay	Trip CB-A
81	Under- and over- frequency relay	Trip CB-A
27R	Instantaneous undervoltage relay	To block closing of CB-A
87T	Transformer differential relay	Trip CB-A and CB-B
78 & 81R	Anti-islanding relay	Trip CB-A
32	Directional electricity power relay	Trip CB-A

Scheme No.8 : Interconnection Scheme for Power Consumer Possessing Generators Connected to 115 kV System

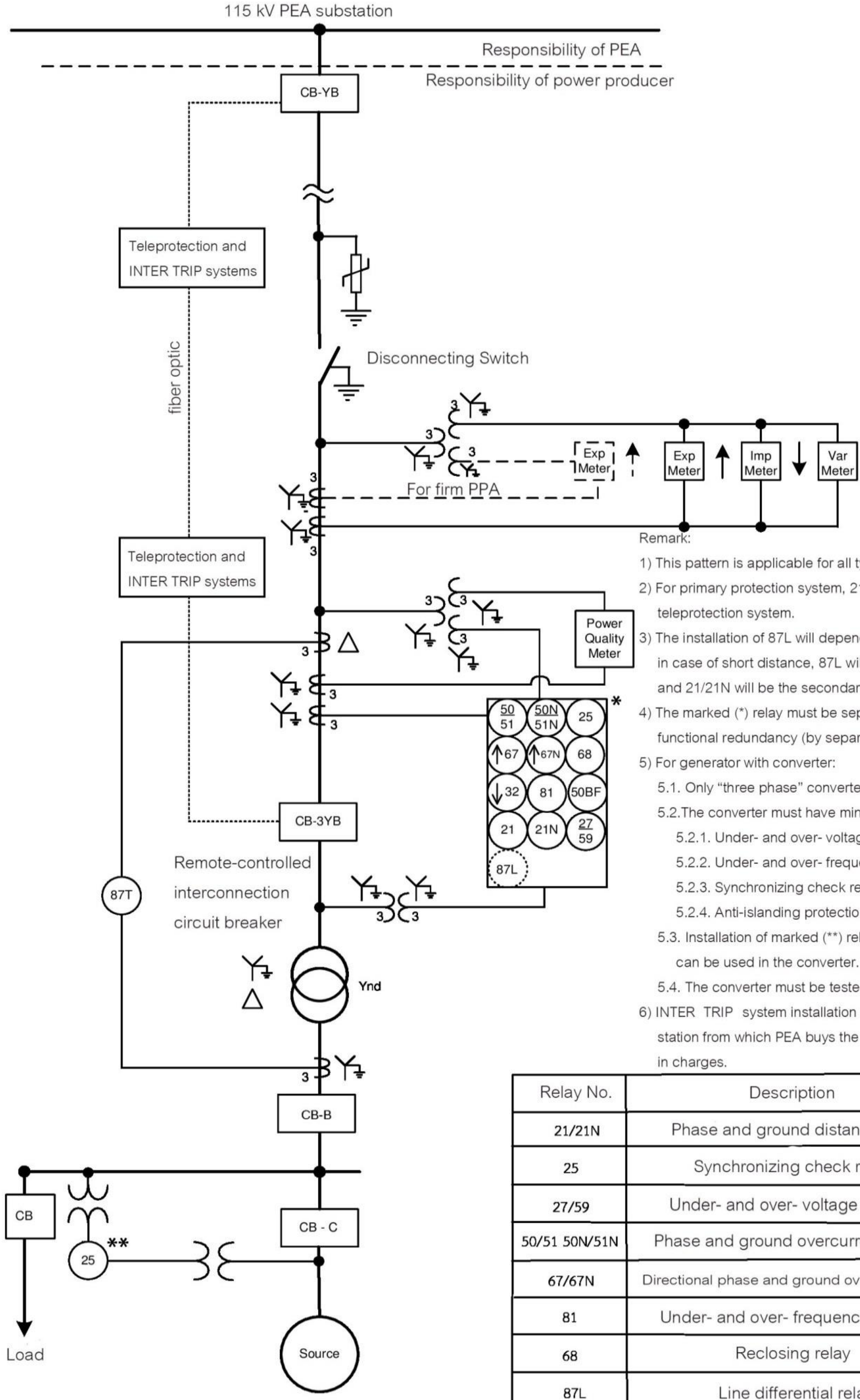


Remark:

1) This pattern is applicable for all types of generators.
2) For primary protection system, 21 will be used jointly with teleprotection system.
3) The installation of 87L will depend on the distance from the substation; in case of short distance, 87L will be the primary protection system, and 21 will be the secondary.
4) Interconnection pattern for power consumer's Terminal Station must comply with Scheme No.11, and the protection system must conform to the vector-group of the transformer.
5) For generator with converter:
   - 5.1. Only "three phase" converter is allowed.
   - 5.2.The converter must have minimum functions as follows:
     - 5.2.1. Under- and over- voltage relay (27/59)
     - 5.2.2. Under- and over- frequency relay (81)
     - 5.2.3. Synchronizing check relay (25)
     - 5.2.4. Anti-islanding protection
   - 5.3. Installation of teleprotection and INTERN TRIP systems may not be necessary for converters whose total rate is ≤ 5 MW; the marked (*) relay can be applied instead.
   - 5.4. Installation of marked (**) relay may not be necessary as the function can be used in the converter.
   - 5.5.The converter must be tested as regulated by PEA.
6) INTER TRIP system installation must start at the EGAT's high-voltage station from which PEA buys the power, as well as all PEA's substations in charges.

Relay No.	Description	Command
25	Synchronizing check relay	To allow closing of CB- 3YB and CB-C
27/59	Under- and over- voltage relay	Trip CB-3YB
50/51	Phase overcurrent relay	Trip CB-3YB
59N	Zero sequence overvoltage relay	Trip CB-3YB
67	Directional phase overcurrent relay	Trip CB-3YB
81	Under- and over- frequency relay	Trip CB-3YB
68	Reclosing relay	To block or allow reclosing of CB-3YB
87T	Transformer differential relay	Trip CB-3YB , CB-B
50BF	Circuit breaker fail relay	Alarm CB-3YB
78 & 81R	Anti-islanding relay	Trip CB-3YB
32	Directional electricity power relay	Trip CB-3YB

Scheme No.9: Interconnection Pattern for Power Producer Connected to 115 kV System of PEA and Supplying Power Directly to PEA Substation

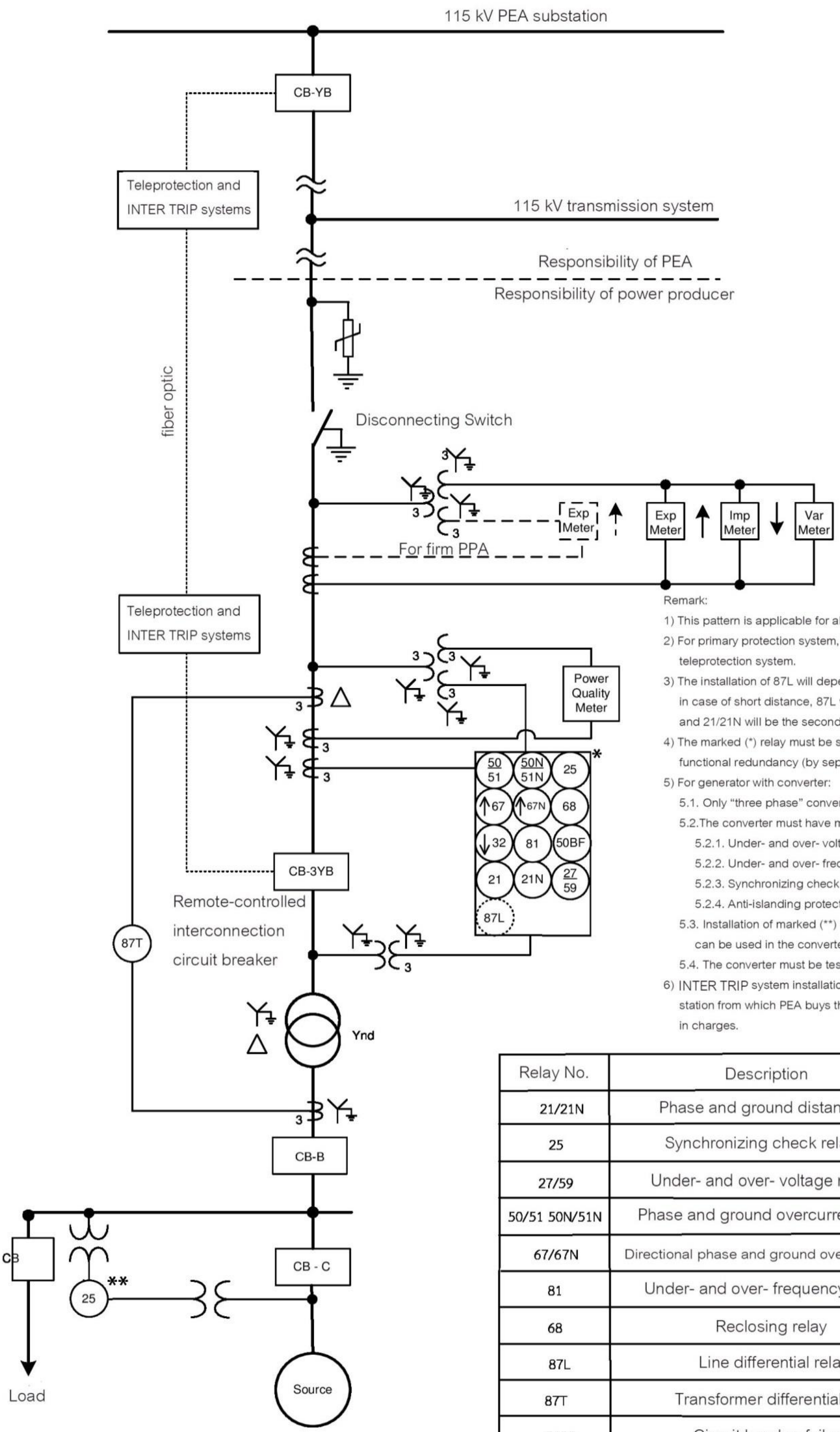


Remark:

1) This pattern is applicable for all types of generators.
2) For primary protection system, 21/21N will be used jointly with teleprotection system.
3) The installation of 87L will depend on the distance from the substation: in case of short distance, 87L will be the primary protection system, and 21/21N will be the secondary.
4) The marked (*) relay must be separated into two sets for the purpose of functional redundancy (by separating VT from CT).
5) For generator with converter:
   - 5.1. Only "three phase" converter is allowed.
   - 5.2.The converter must have minimum functions as follows:
     - 5.2.1. Under- and over- voltage relay (27/59)
     - 5.2.2. Under- and over- frequency relay (81)
     - 5.2.3. Synchronizing check relay (25)
     - 5.2.4. Anti-islanding protection
   - 5.3. Installation of marked (**) relay may not be necessary as the function can be used in the converter.
   - 5.4. The converter must be tested as regulated by PEA.
6) INTER TRIP system installation must start at the EGAT's high-voltage station from which PEA buys the power, as well as all PEA's substations in charges.

Relay No.	Description	Command
21/21N	Phase and ground distance relay	Trip CB-3YB
25	Synchronizing check relay	To allow closing of CB- 3YB and CB-C
27/59	Under- and over- voltage relay	Trip CB-3YB
50/51 50N/51N	Phase and ground overcurrent relay	Trip CB-3YB
67/67N	Directional phase and ground overcurrent relay	Trip CB-3YB
81	Under- and over- frequency relay	Trip CB-3YB
68	Reclosing relay	To block or allow reclosing of CB-3YB
87L	Line differential relay	Trip CB-3YB , CB-YB
87T	Transformer differential relay	Trip CB-3YB , CB-B
50BF	Circuit breaker fail relay	Alarm CB-3YB
32	Directional electricity power relay	Trip CB-3YB

Scheme No.10: Interconnection Pattern for Power Producer Selling ≤ 10 MW and Connected to 115 kV System

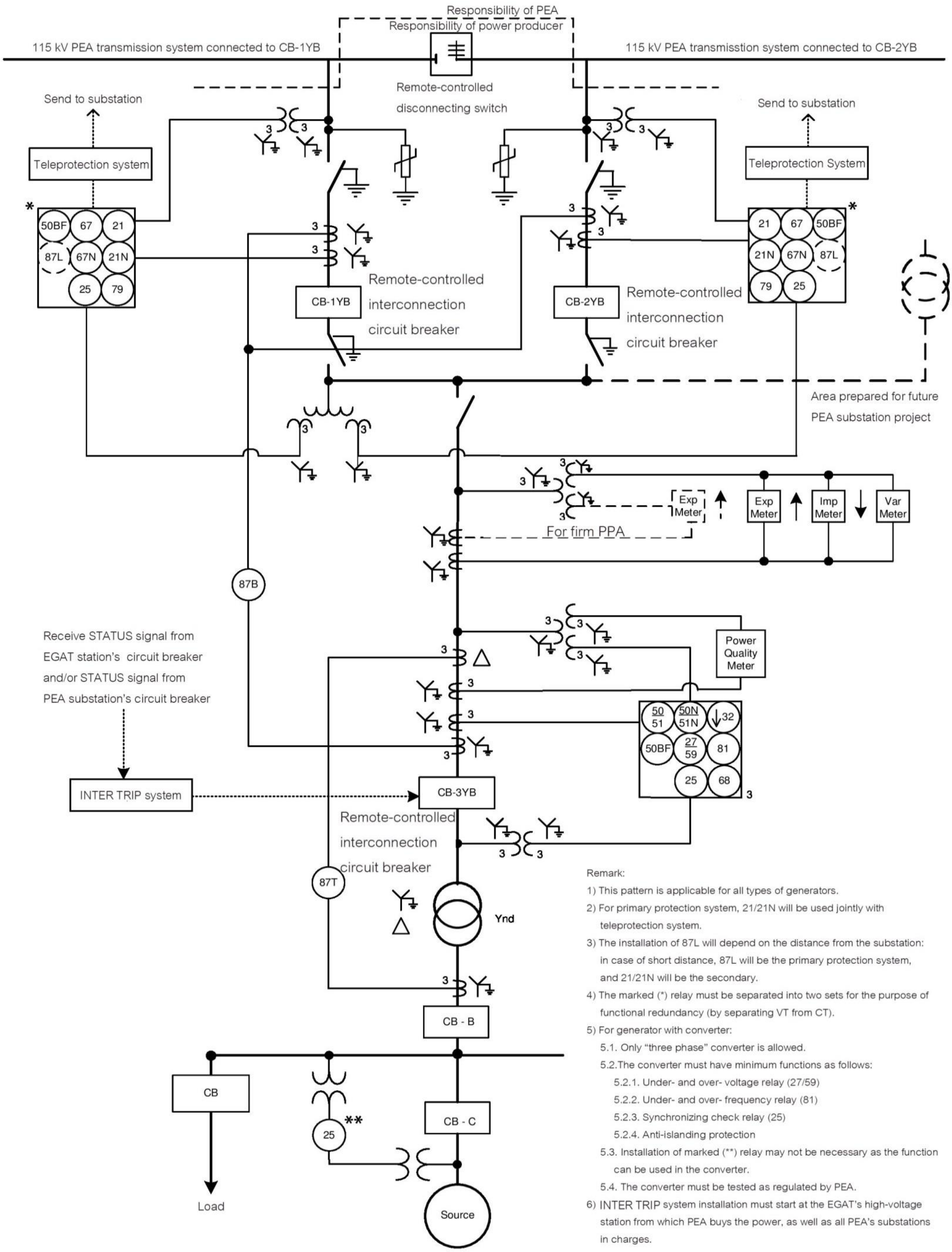


Remark:

1) This pattern is applicable for all types of generators.
2) For primary protection system, 21/21N will be used jointly with teleprotection system.
3) The installation of 87L will depend on the distance from the substation: in case of short distance, 87L will be the primary protection system, and 21/21N will be the secondary.
4) The marked (*) relay must be separated into two sets for the purpose of functional redundancy (by separating VT from CT).
5) For generator with converter:
   - 5.1. Only "three phase" converter is allowed.
   - 5.2.The converter must have minimum functions as follows:
     - 5.2.1. Under- and over- voltage relay (27/59)
     - 5.2.2. Under- and over- frequency relay (81)
     - 5.2.3. Synchronizing check relay (25)
     - 5.2.4. Anti-islanding protection
   - 5.3. Installation of marked (**) relay may not be necessary as the function can be used in the converter.
   - 5.4. The converter must be tested as regulated by PEA.
6) INTER TRIP system installation must start at the EGAT's high-voltage station from which PEA buys the power, as well as all PEA's substations in charges.

Relay No.	Description	Command
21/21N	Phase and ground distance relay	Trip CB-3YB
25	Synchronizing check relay	To allow closing of CB- 3YB and CB-C
27/59	Under- and over- voltage relay	Trip CB-3YB
50/51 50N/51N	Phase and ground overcurrent relay	Trip CB-3YB
67/67N	Directional phase and ground overcurrent relay	Trip CB-3YB
81	Under- and over- frequency relay	Trip CB-3YB
68	Reclosing relay	ปิดกั้นหรืออนุญาตให้ปิดกลับวงจรของ CB-3YB
87L	Line differential relay	Trip CB-3YB , CB-YB
87T	Transformer differential relay	Trip CB-3YB , CB-B
50BF	Circuit breaker fail relay	Alarm CB-3YB
32	Directional electricity power relay	Trip CB-3YB

Scheme No.11: Interconnection Pattern for Power Producer Selling > 10 MW and Connected to 115 kV System



Remark:

1) This pattern is applicable for all types of generators.
2) For primary protection system, 21/21N will be used jointly with teleprotection system.
3) The installation of 87L will depend on the distance from the substation: in case of short distance, 87L will be the primary protection system, and 21/21N will be the secondary.
4) The marked (*) relay must be separated into two sets for the purpose of functional redundancy (by separating VT from CT).
5) For generator with converter:
   - 5.1. Only "three phase" converter is allowed.
   - 5.2. The converter must have minimum functions as follows:
     - 5.2.1. Under- and over- voltage relay (27/59)
     - 5.2.2. Under- and over- frequency relay (81)
     - 5.2.3. Synchronizing check relay (25)
     - 5.2.4. Anti-islanding protection
   - 5.3. Installation of marked (**) relay may not be necessary as the function can be used in the converter.
   - 5.4. The converter must be tested as regulated by PEA.
6) INTER TRIP system installation must start at the EGAT's high-voltage station from which PEA buys the power, as well as all PEA's substations in charges.

Scheme No.11: Interconnection Pattern for Power Producer Selling > 10 MW and Connected to 115 kV System (continue)

			Connected to **CB-1YB**			Connected to **CB-2YB**			Connected to **CB-3YB**				
		Bus differential relay	Phase and ground distance relay	Directional phase and ground overcurrent relay	Circuit breaker fail relay	Phase and ground distance relay	Phase and ground overcurrent relay	Circuit breaker fail relay	Under- and over-frequency relay	Under- and over-voltage relay	Phase and ground overcurrent relay	Transformer differential relay	Circuit breaker fail relay
Relay No.		**87B**	**21/ 21N**	**67/ 67N**	**50BF**	**21/ 21N**	**67/ 67N**	**50BF**	**81**	**27/59**	**50/51 50N/51N**	**87T**	**50BF**
Alarm		■	■	■	■	■	■	■	■	■	■	■	■
Function of Relay	**CB-1YB**	●	▲	●	○			○					○
	CB-2YB	●			○	▲	●	○					○
	CB-3YB	●			○			○	●	●	●	●	○
	CB-B											●	○

■ Alarm

● Trip and lockout

▲ The breaker trip and reclose/lockout subjected to the protection system pattern of PEA in each service area, which will be considered by PEA

○ Trip when the 50BF sends a warning signal

Table 1: Input/Output of FRTU-RCS Load Break Switch Connected to 22 or 33 kV System (Scheme No. 7)

1.1 Analog Input Points:

Item	Bay Name	Point Name	Descriptor		Point Type	DNP Mapping Points			Remark
			Unit	Scale		Object	Class	Addr#	
1	22 or 33 kV RCS	Current Phase A	A	0..600	AI	O:32 V:02	2		Depend on **“CT Ratio”**
2	22 or 33 kV RCS	Current Phase B	A	0..600	AI	O:32 V:02	2		Depend on **“CT Ratio”**
3	22 or 33 kV RCS	Current Phase C	A	0..600	AI	O:32 V:02	2		Depend on **“CT Ratio”**
4	22 or 33 kV RCS	Voltage A-B	kV	0..xx	AI	O:32 V:02	2		Depend on **“Rated of Voltage”**
5	22 or 33 kV RCS	Voltage B-C	kV	0..xx	AI	O:32 V:02	2		Depend on **“Rated of Voltage”**
6	22 or 33 kV RCS	Voltage C-A	kV	0..xx	AI	O:32 V:02	2		Depend on **“Rated of Voltage”**
7	22 or 33 kV RCS	Frequency	Hz	0..60	AI	O:32 V:02	2		
8	22 or 33 kV RCS	Active Power	MW	+/-	AI	O:32 V:02	2		Calculated point for direct ac inputs
9	22 or 33 kV RCS	Reactive Power	MVAR	+/-	AI	O:32 V:02	2		Calculated point for direct ac inputs
10	22 or 33 kV RCS	Power Factor	%	+/- 100	AI	O:32 V:02	2		Calculated point for direct ac inputs

1.2 Control Output:

Item	Bay Name	Point Name	Descriptor		Point Type	DNP Mapping Points			Remark
			Pulse On Close	Pulse On Trip		Object	Class	Addr#	
1	22 or 33 kV RCS	RCS Command	Close	Open	SBO	O:12 V:01	-		

1.3 Status Input Points:

Item	Bay Name	Point Name	Descriptor				Point	DNP Mapping Points			Remark
			0	1	2	3	Type	Object	Class	Addr#	
1	22 or 33 kV RCS	RCS Status	Undef.	Close	Open	Fault	SOE	O:02 V:02	1		
2	22 or 33 kV RCS	RCS Control Mode	Undef.	Local	Remote	Fault	DI	O:02 V:01	1		
3	22 or 33 kV RCS	Mechanical Device Status	Undef.	Lock	Free	Fault	DI	O:02 V:01	1		
4	22 or 33 kV RCS	Gas Low Pressure Alarm/Lockout	Normal	Alarm	-	-	DI	O:02 V:01	1		
5	22 or 33 kV RCS	Battery Common Alarm	Normal	Alarm	-	-	DI	O:02 V:01	3		
6	22 or 33 kV RCS	Enclosure Door Open	Normal	Alarm	-	-	DI	O:02 V:01	1		
7	22 or 33 kV RCS	Phase Fault Condition	Normal	Alarm	-	-	SOE	O:02 V:02	1		
8	22 or 33 kV RCS	Earth Fault Condition	Normal	Alarm	-	-	SOE	O:02 V:02	1		

Table 2: Input/Output of interconnection to PEA's 115 kV system (Scheme No. 9 and 10)

2.1 Analog Input Points:

Item	Bay Name	Point Name	Descriptor		Point Type	DNP Mapping Points			Remark
			Unit	Scale		Object	Class	Addr#	
1	115kV DG_ -Line_	Current Phase A	A	0..600	AI	O:32 V:02	2		Depend on **"CT Ratio"**
2	115kV DG_ -Line_	Current Phase B	A	0..600	AI	O:32 V:02	2		Depend on **"CT Ratio"**
3	115kV DG_ -Line_	Current Phase C	A	0..600	AI	O:32 V:02	2		Depend on **"CT Ratio"**
4	115kV DG_ -Line_	Voltage A-B	kV	0..150	AI	O:32 V:02	2		
5	115kV DG_ -Line_	Voltage B-C	kV	0..150	AI	O:32 V:02	2		
6	115kV DG_ -Line_	Voltage C-A	kV	0..150	AI	O:32 V:02	2		
7	115kV DG_ -Line_	Frequency	Hz	0..60	AI	O:32 V:02	2		
8	115kV DG_ -Line_	Active Power	MW	+/-.....	AI	O:32 V:02	2		Calculated point for direct ac inputs
9	115kV DG_ -Line_	Reactive Power	MVAR	+/-.....	AI	O:32 V:02	2		Calculated point for direct ac inputs
10	115kV DG_ -Line_	Power Factor	%	+/- 100	AI	O:32 V:02	2		Calculated point for direct ac inputs

2.2 Control Output:

Item	Bay Name	Point Name	Descriptor		Point Type	DNP Mapping Points			Remark
			Pulse On Close	Pulse On Trip		Object	Class	Addr#	
1	115kV DG_ -Line_	_YB-01 Command	Close	Open	SBO	O:12 V:01	-		
2	115kV DG_ -Line_	_YB-01 Close Bypass Sync. Command	Close	-	SBO	O:12 V:01	-		
3	115kV DG_ -Line_	_YS-01 Command	Close	Open	SBO	O:12 V:01	-		
4	115kV DG_ -Line_	_YS-02 Command	Close	Open	SBO	O:12 V:01	-		

2.3 Status Input Points:

Item	Bay Name	Point Name	Descriptor				Point Type	DNP Mapping Points			Remark
			0	1	2	3		Object	Class	Addr#	
1	115kV DG_ -Line_	_YB-01 Status	Undef.	Close	Open	Fault	SOE	O:02 V:02	1		
2	115kV DG_ -Line_	_YB-01 Control Set on	Undef.	Local	Remote	Fault	DI	O:02 V:01	1		
3	115kV DG_ -Line_	_YS-01 Status	Undef.	Close	Open	Fault	DI	O:02 V:01	1		
4	115kV DG_ -Line_	_YS-01 Control Set on	Undef.	Local	Remote	Fault	DI	O:02 V:01	1		
5	115kV DG_ -Line_	_YS-02 Status	Undef.	Close	Open	Fault	DI	O:02 V:01	1		
6	115kV DG_ -Line_	_YS-02 Control Set on	Undef.	Local	Remote	Fault	DI	O:02 V:01	1		
7	115kV DG_ -Line_	_YG-02 Status	Undef.	Close	Open	Fault	DI	O:02 V:01	1		
8	115kV DG_ -Line_	50BF Switch Status	Undef.	On	Off	Fault	DI	O:02 V:01	1		
9	115kV DG_ -Line_	Under/Over Frequency Relay Status	Undef.	On	Off	Fault	DI	O:02 V:01	1		
10	115kV DG_ -Line_	Sync. Switch Status	Normal	Auto	Manual	Fault	DI	O:02 V:01	1		
11	115kV DG_ -Line_	Inter-Trip Switch Status	Undef.	On	Off	Fault	DI	O:02 V:01	1		
12	115kV DG_ -Line_	Distance Relay Phase A	Normal	Trip	-	-	SOE	O:02 V:02	1		
13	115kV DG_ -Line_	Distance Relay Phase B	Normal	Trip	-	-	SOE	O:02 V:02	1		
14	115kV DG_ -Line_	Distance Relay Phase C	Normal	Trip	-	-	SOE	O:02 V:02	1		
15	115kV DG_ -Line_	Distance Relay Earth Fault	Normal	Trip	-	-	SOE	O:02 V:02	1		
16	115kV DG_ -Line_	Distance Relay Trip	Normal	Trip	-	-	SOE	O:02 V:02	1		
17	115kV DG_ -Line_	Distance Relay zone 1	Normal	Trip	-	-	SOE	O:02 V:02	1		
18	115kV DG_ -Line_	Distance Relay zone 2	Normal	Trip	-	-	SOE	O:02 V:02	1		
19	115kV DG_ -Line_	Distance Relay zone 3	Normal	Trip	-	-	SOE	O:02 V:02	1		
20	115kV DG_ -Line_	O/C Relay Phase A	Normal	Trip	-	-	SOE	O:02 V:02	1		
21	115kV DG_ -Line_	O/C Relay Phase B	Normal	Trip	-	-	SOE	O:02 V:02	1		
22	115kV DG_ -Line_	O/C Relay Phase C	Normal	Trip	-	-	SOE	O:02 V:02	1		
23	115kV DG_ -Line_	E/F Relay	Normal	Trip	-	-	SOE	O:02 V:02	1		

2.3 Status Input Points:(continue)

Item	Bay Name	Point Name	Descriptor				Point Type	DNP Mapping Points			Remark
			0	1	2	3		Object	Class	Addr#	
24	115kV DG_ -Line_	O/C or E/F Time Delay	Normal	Trip	-	-	SOE	O:02 V:02	1		
25	115kV DG_ -Line_	O/C or E/F Instantaneous	Normal	Trip	-	-	SOE	O:02 V:02	1		
26	115kV DG_ -Line_	Directional O/C Relay Phase A	Normal	Trip	-	-	SOE	O:02 V:02	1		
27	115kV DG_ -Line_	Directional O/C Relay Phase B	Normal	Trip	-	-	SOE	O:02 V:02	1		
28	115kV DG_ -Line_	Directional O/C Relay Phase C	Normal	Trip	-	-	SOE	O:02 V:02	1		
29	115kV DG_ -Line_	Directional E/F Relay	Normal	Trip	-	-	SOE	O:02 V:02	1		
30	115kV DG_ -Line_	Under/Over Frequency Step 1	Normal	Alarm	-	-	DI	O:02 V:01	1		
31	115kV DG_ -Line_	Under/Over Frequency Step 2	Normal	Trip	-	-	SOE	O:02 V:02	1		
32	115kV DG_ -Line_	Under/Over Voltage Step 1	Normal	Alarm	-	-	DI	O:02 V:01	1		
33	115kV DG_ -Line_	Under/Over Voltage Step 2	Normal	Trip	-	-	SOE	O:02 V:02	1		
34	115kV DG_ -Line_	Transformer Differential Relay	Normal	Trip	-	-	SOE	O:02 V:02	1		
35	115kV DG_ -Line_	Transformer Internal Protection	Normal	Trip	-	-	SOE	O:02 V:02	1		
36	115kV DG_ -Line_	Teleprotection	Normal	Trip	-	-	SOE	O:02 V:02	1		
37	115kV DG_ -Line_	Time Delayed (CB Fail)	Normal	Trip	-	-	SOE	O:02 V:02	1		
38	115kV DG_ -Line_	Synchronizing Check	Normal	Operated	-	-	SOE	O:02 V:02	1		
39	115kV DG_ -Line_	Sync. Relay MCB Trip	Normal	Alarm	-	-	DI	O:02 V:01	1		
40	115kV DG_ -Line_	Protection Relay DC Supply	Normal	Fail	-	-	DI	O:02 V:01	1		
41	115kV DG_ -Line_	DC Supply Control Circuit	Normal	Fail	-	-	DI	O:02 V:01	1		
42	115kV DG_ -Line_	AC Supply Control Circuit	Normal	Fail	-	-	DI	O:02 V:01	1		
43	115kV DG_ -Line_	Gas low press warning	Normal	Alarm	-	-	DI	O:02 V:01	1		
44	115kV DG_ -Line_	Gas low press lockout	Normal	Lockout	-	-	SOE	O:02 V:02	1		
45	115kV DG_ -Line_	Trip Cct. Supervision 1 (TC1)	Normal	Fail	-	-	DI	O:02 V:01	1		
46	115kV DG_ -Line_	Trip Cct. Supervision 2 (TC2)	Normal	Fail	-	-	DI	O:02 V:01	1		
47	115kV DG_ -Line_	Spring Charge	Normal	Fail	-	-	DI	O:02 V:01	1		

Table 3: Input/Output of Interconnection to PEA's 155 kV System (Scheme No.11)

3.1 Analog Input Points: (Bay No. 1, 2 and 3)

Item	Bay Name	Point Name	Descriptor		Point	DNP Mapping Points			Remark
			Unit	Scale	Type	Object	Class	Addr#	
1	115kV DG_ -Line_	Current Phase A	A	0..1200	AI	O:32 V:02	2		Depend on **"CT Ratio"**
2	115kV DG_ -Line_	Current Phase B	A	0..1200	AI	O:32 V:02	2		Depend on **"CT Ratio"**
3	115kV DG_ -Line_	Current Phase C	A	0..1200	AI	O:32 V:02	2		Depend on **"CT Ratio"**
4	115kV DG_ -Line_	Voltage A-B	kV	0..150	AI	O:32 V:02	2		
5	115kV DG_ -Line_	Voltage B-C	kV	0..150	AI	O:32 V:02	2		
6	115kV DG_ -Line_	Voltage C-A	kV	0..150	AI	O:32 V:02	2		
7	115kV DG_ -Line_	Frequency	Hz	0..60	AI	O:32 V:02	2		
8	115kV DG_ -Line_	Active Power	MW	+/-.....	AI	O:32 V:02	2		Calculated point for direct ac inputs
9	115kV DG_ -Line_	Reactive Power	MVAR	+/-.....	AI	O:32 V:02	2		Calculated point for direct ac inputs
10	115kV DG_ -Line_	Power Factor	%	+/- 100	AI	O:32 V:02	2		Calculated point for direct ac inputs

3.2 Control Output): (Bay No.1, 2 and 3)

Item	Bay Name	Point Name	Descriptor		Point Type	DNP Mapping Points			Remark
			Pulse On Close	Pulse On Trip		Object	Class	Addr#	
1	115kV DG_ -Line_	_YB-01 Command	Close	Open	SBO	O:12 V:01	-		
2	115kV DG_ -Line_	_YB-01 Close Bypass Sync.Command	Close	-	SBO	O:12 V:01	-		
3	115kV DG_ -Line_	_YS-01 Command	Close	Open	SBO	O:12 V:01	-		
4	115kV DG_ -Line_	_YS-02 Command	Close	Open	SBO	O:12 V:01	-		
5	115kV DG_ -Line_	Auto Reclose On/Off Command	On	Off	SBO	O:12 V:01	-		Only Bay No. 1 and 2

3.3 Status Input Points: (Bay No.1 and 2)

Item	Bay Name	Point Name	Descriptor				Point	DNP Mapping Points			Remark
			0	1	2	3	Type	Object	Class	Addr#	
1	115kV DG_ -Line_	_YB-01 Status	Undef.	Close	Open	Fault	SOE	O:02 V:02	1		
2	115kV DG_ -Line_	_YB-01 Control Set on	Undef.	Local	Remote	Fault	DI	O:02 V:01	1		
3	115kV DG_ -Line_	_YS-01 Status	Undef.	Close	Open	Fault	DI	O:02 V:01	1		
4	115kV DG_ -Line_	_YS-01 Control Set on	Undef.	Local	Remote	Fault	DI	O:02 V:01	1		
5	115kV DG_ -Line_	_YS-02 Status	Undef.	Close	Open	Fault	DI	O:02 V:01	1		
6	115kV DG_ -Line_	_YS-02 Control Set on	Undef.	Local	Remote	Fault	DI	O:02 V:01	1		
7	115kV DG_ -Line_	_YG-02 Status	Undef.	Close	Open	Fault	DI	O:02 V:01	1		
8	115kV DG_ -Line_	50BF Switch Status	Undef.	On	Off	Fault	DI	O:02 V:01	1		
9	115kV DG_ -Line_	Auto Reclose Relay Status	Undef.	On	Off	Fault	DI	O:02 V:01	1		
10	115kV DG_ -Line_	Under/Over Frequency Relay Status	Undef.	On	Off	Fault	DI	O:02 V:01	1		
11	115kV DG_ -Line_	Sync. Switch Status	Normal	Auto	Manual	Fault	DI	O:02 V:01	1		
12	115kV DG_ -Line_	Inter-Trip Switch Status	Undef.	On	Off	Fault	DI	O:02 V:01	1		
13	115kV DG_ -Line_	Distance Relay Phase A	Normal	Trip	-	-	SOE	O:02 V:02	1		
14	115kV DG_ -Line_	Distance Relay Phase B	Normal	Trip	-	-	SOE	O:02 V:02	1		
15	115kV DG_ -Line_	Distance Relay Phase C	Normal	Trip	-	-	SOE	O:02 V:02	1		
16	115kV DG_ -Line_	Distance Relay Earth Fault	Normal	Trip	-	-	SOE	O:02 V:02	1		
17	115kV DG_ -Line_	Distance Relay Trip	Normal	Trip	-	-	SOE	O:02 V:02	1		
18	115kV DG_ -Line_	Distance Relay zone 1	Normal	Trip	-	-	SOE	O:02 V:02	1		
19	115kV DG_ -Line_	Distance Relay zone 2	Normal	Trip	-	-	SOE	O:02 V:02	1		
20	115kV DG_ -Line_	Distance Relay zone 3	Normal	Trip	-	-	SOE	O:02 V:02	1		
21	115kV DG_ -Line_	Distance Switch on to Fault	Normal	Trip	-	-	SOE	O:02 V:02	1		
22	115kV DG_ -Line_	Distance Relay VT Failure	Normal	Alarm	-	-	SOE	O:02 V:02	1		
23	115kV DG_ -Line_	Directional O/C Relay Phase A	Normal	Trip	-	-	SOE	O:02 V:02	1		

3.3 Status Input Points: (Bay No. 1 and No. 2):(continue)

Item	Bay Name	Point Name	Descriptor				Point	DNP Mapping Points			Remark
			0	1	2	3	Type	Object	Class	Addr#	
24	115kV DG_ -Line_	Directional O/C Relay Phase B	Normal	Trip	-	-	SOE	O:02 V:02	1		
25	115kV DG_ -Line_	Directional O/C Relay Phase C	Normal	Trip	-	-	SOE	O:02 V:02	1		
26	115kV DG_ -Line_	Directional E/F Relay	Normal	Trip	-	-	SOE	O:02 V:02	1		
27	115kV DG_ -Line_	Line Differential Relay	Normal	Trip	-	-	SOE	O:02 V:02	1		
28	115kV DG_ -Line_	BUS Differential Relay	Normal	Trip	-	-	SOE	O:02 V:02	1		
29	115kV DG_ -Line_	Teleprotection	Normal	Trip	-	-	SOE	O:02 V:02	1		
30	115kV DG_ -Line_	Time Delayed (CB Fail)	Normal	Trip	-	-	SOE	O:02 V:02	1		
31	115kV DG_ -Line_	Synchronizing Check	Normal	Operated	-	-	SOE	O:02 V:02	1		
32	115kV DG_ -Line_	Sync. Relay MCB Trip	Normal	Alarm	-	-	DI	O:02 V:01	1		
33	115kV DG_ -Line_	Auto Reclose Relay	Normal	Trip	-	-	SOE	O:02 V:02	1		
34	115kV DG_ -Line_	Auto Reclose Lockout	Normal	Trip	-	-	SOE	O:02 V:02	1		
35	115kV DG_ -Line_	Protection Relay DC Supply	Normal	Fail	-	-	DI	O:02 V:01	1		
36	115kV DG_ -Line_	DC Supply Control Circuit	Normal	Fail	-	-	DI	O:02 V:01	1		
37	115kV DG_ -Line_	AC Supply Control Circuit	Normal	Fail	-	-	DI	O:02 V:01	1		
38	115kV DG_ -Line_	Gas low press warning	Normal	Alarm	-	-	DI	O:02 V:01	1		
39	115kV DG_ -Line_	Gas low press lockout	Normal	Lockout	-	-	SOE	O:02 V:02	1		
40	115kV DG_ -Line_	Trip Cct. Supervision 1 (TC1)	Normal	Fail	-	-	DI	O:02 V:01	1		
41	115kV DG_ -Line_	Trip Cct. Supervision 2 (TC2)	Normal	Fail	-	-	DI	O:02 V:01	1		
42	115kV DG_ -Line_	Spring Charge	Normal	Fail	-	-	DI	O:02 V:01	1		

3.4 Status Input Points: (Bay No.3)

Item	Bay Name	Point Name	Descriptor				Point Type	DNP Mapping Points			Remark
			0	1	2	3		Object	Class	Addr#	
1	115kV DG_ -Line_	_YB-01 Status	Undef.	Close	Open	Fault	SOE	O:02 V:02	1		
2	115kV DG_ -Line_	_YB-01 Control Set on	Undef.	Local	Remote	Fault	DI	O:02 V:01	1		
3	115kV DG_ -Line_	_YS-01 Status	Undef.	Close	Open	Fault	DI	O:02 V:01	1		
4	115kV DG_ -Line_	_YS-01 Control Set on	Undef.	Local	Remote	Fault	DI	O:02 V:01	1		
5	115kV DG_ -Line_	_YS-02 Status	Undef.	Close	Open	Fault	DI	O:02 V:01	1		
6	115kV DG_ -Line_	_YS-02 Control Set on	Undef.	Local	Remote	Fault	DI	O:02 V:01	1		
7	115kV DG_ -Line_	50BF Switch Status	Undef.	On	Off	Fault	DI	O:02 V:01	1		
8	115kV DG_ -Line_	Under/Over Frequency Relay Status	Undef.	On	Off	Fault	DI	O:02 V:01	1		
9	115kV DG_ -Line_	Sync. Switch Status	Normal	Auto	Manual	Fault	DI	O:02 V:01	1		
10	115kV DG_ -Line_	Inter-Trip Switch Status	Undef.	On	Off	Fault	DI	O:02 V:01	1		
11	115kV DG_ -Line_	O/C Relay Phase A	Normal	Trip	-	-	SOE	O:02 V:02	1		
12	115kV DG_ -Line_	O/C Relay Phase B	Normal	Trip	-	-	SOE	O:02 V:02	1		
13	115kV DG_ -Line_	O/C Relay Phase C	Normal	Trip	-	-	SOE	O:02 V:02	1		
14	115kV DG_ -Line_	E/F Relay	Normal	Trip	-	-	SOE	O:02 V:02	1		
15	115kV DG_ -Line_	O/C or E/F Time Delay	Normal	Trip	-	-	SOE	O:02 V:02	1		
16	115kV DG_ -Line_	O/C or E/F Instantaneous	Normal	Trip	-	-	SOE	O:02 V:02	1		
17	115kV DG_ -Line_	Under/Over Frequency Step 1	Normal	Alarm	-	-	DI	O:02 V:01	1		
18	115kV DG_ -Line_	Under/Over Frequency Step 2	Normal	Trip	-	-	SOE	O:02 V:02	1		
19	115kV DG_ -Line_	Under/Over Voltage Step 1	Normal	Alarm	-	-	DI	O:02 V:01	1		
20	115kV DG_ -Line_	Under/Over Voltage Step 2	Normal	Trip	-	-	SOE	O:02 V:02	1		
21	115kV DG_ -Line_	Transformer Differential Relay	Normal	Trip	-	-	SOE	O:02 V:02	1		
22	115kV DG_ -Line_	Transformer Internal Protection	Normal	Trip	-	-	SOE	O:02 V:02	1		
23	115kV DG_ -Line_	BUS Differential Relay	Normal	Trip	-	-	SOE	O:02 V:02	1		

3.4 Status Input Points: (Bay No.3):(continue)

Item	Bay Name	Point Name	Descriptor				Point Type	DNP Mapping Points			Remark
			0	1	2	3		Object	Class	Addr#	
24	115kV DG_ -Line_	Time Delayed (CB Fail)	Normal	Trip	-	-	SOE	O:02 V:02	1		
25	115kV DG_ -Line_	Synchronizing Check	Normal	Operated	-	-	SOE	O:02 V:02	1		
26	115kV DG_ -Line_	Sync. Relay MCB Trip	Normal	Alarm	-	-	DI	O:02 V:01	1		
27	115kV DG_ -Line_	Protection Relay DC Supply	Normal	Fail	-	-	DI	O:02 V:01	1		
28	115kV DG_ -Line_	DC Supply Control Circuit	Normal	Fail	-	-	DI	O:02 V:01	1		
29	115kV DG_ -Line_	AC Supply Control Circuit	Normal	Fail	-	-	DI	O:02 V:01	1		
30	115kV DG_ -Line_	Gas low press warning	Normal	Alarm	-	-	DI	O:02 V:01	1		
31	115kV DG_ -Line_	Gas low press lockout	Normal	Lockout	-	-	SOE	O:02 V:02	1		
32	115kV DG_ -Line_	Trip Cct. Supervision 1 (TC1)	Normal	Fail	-	-	DI	O:02 V:01	1		
33	115kV DG_ -Line_	Trip Cct. Supervision 2 (TC2)	Normal	Fail	-	-	DI	O:02 V:01	1		
34	115kV DG_ -Line_	Spring Charge	Normal	Fail	-	-	DI	O:02 V:01	1		

Remark: All inputs/outputs detailed in Table 3 are minimal rates, and PEA reserves the rights to increase inputs/outputs as deemed proper.

Table 4: Input/Output of FRTU-RCS Load Break Switch Connected 115 kV System (Scheme No. 11)

4.1 Control Output:

Item	Bay Name	Point Name	Descriptor		Point Type	DNP Mapping Points			Remark
			Pulse On Close	Pulse On Trip		Object	Class	Addr#	
1	115 kV LBS	LBS Command	Close	Open	SBO	O:12 V:01	-		

4.2 Status Input Points:

Item	Bay Name	Point Name	Descriptor				Point	DNP Mapping Points			Remark
			0	1	2	3	Type	Object	Class	Addr#	
1	115 kV LBS	LBS Status	Undef.	Close	Open	Fault	SOE	O:02 V:02	1		
2	115 kV LBS	LBS Control Mode	Undef.	Local	Remote	Fault	DI	O:02 V:01	1		
3	115 kV LBS	Gas Low Pressure Alarm/Lockout	Normal	Alarm	-	-	DI	O:02 V:01	1		
4	115 kV LBS	Battery Common Alarm	Normal	Alarm	-	-	DI	O:02 V:01	3		
5	115 kV LBS	Enclosure Door Open	Normal	Alarm	-	-	DI	O:02 V:01	1		

Table 5: Input/Output of 22-33 kV Synchrocheck Relay at PEA Substation (Primary)

5.1 Control Output:

Item	Bay Name	Point Name	Descriptor		Point Type	DNP Mapping Points			Remark
			Pulse On Close	Pulse On Trip		Object	Class	Addr#	
1	22 or 33 kV DG_	_VB-01 Close Bypass Sync.Command	Close	-	SBO	O:12 V:01	-		

5.2 Status Input Points:

Item	Bay Name	Point Name	Descriptor				Point Type	DNP Mapping Points			Remark
			0	1	2	3		Object	Class	Addr#	
1	22 or 33 kV DG_	Sync. Switch Status	Normal	Auto	Manual	Fault	DI	O:02 V:01	1		
2	22 or 33 kV DG_	Sync. Relay	Normal	Fail	-	-	DI	O:02 V:01	1		
3	22 or 33 kV DG_	Sync. Relay	Normal	Operated	-	-	SOE	O:02 V:02	1		
4	22 or 33 kV DG_	Sync. Relay MCB Trip	Normal	Alarm	-	-	DI	O:02 V:01	1		

Attachment 6

Converter Test Procedure and Methodology

Converter Efficiency Test Methodology

1. Requirement for Converter Testing Institute

1.1 The power generating system must be certified by PEA's laboratory test.

1.2 The laboratory must observe general requirements for the competence of testing and calibration laboratories, ISO/IEC17025:2005, or must be verified by an unbiased organization/institute approved by PEA.

1.3 Any power generating systems certified from foreign laboratory must be inspected and verified by an unbiased organization/institute in Thailand, or PEA.

2. Test Categories

2.1 Laboratory Test

The institute specified in 1) conducts the experiment in order to affirm that a converter in question is applicable for power quality control in real usage, and in compliance with PEA's regulations. Thus, only one converter of each model is examined in a test. The test topics can be categorized as follows.

Test Topics and Result Analysis Criteria

No	Test Topics	Evaluation Procedure
1.	Active Power Control	Topic No. 12.1
2.	Reactive Power Control and Methodology	Topic No. 8.1.2
3.	Under/Over Frequency Protection	Topic No. 8.2
4.	Voltage Fluctuation	Topic No. 8.3
5.	Harmonics	Topic No. 8.4
6.	DC Supply	Topic No. 8.5
7.	Low Voltage Fault Ride Through	Topic No. 12.2
8.	Under/Over Voltage Prevention	Topic No. 12.3
9.	Anti-Islanding	Topic No. 12.4
10.	Response to Utility Recovery)	Topic No. 12.5

2.2 Power Quality Measurement and Field Test

The power quality assessment and field test conducted by PEA are detailed as follows.

2.2.1 Field Test Topics

1) Anti-Islanding Protection

2) Response to Utility Recovery

3) Load Rejection

2.2.2 Power Quality Assessment Topics

1) Voltage Level

2) Frequency

3) Harmonics

4) Voltage Fluctuation

3. Laboratory Test Procedure and Methodology

3.1 Harmonics

Applying the standard methodology regulated by IEEE or IEC, as deemed appropriate.

3.2 Voltage Fluctuation

Applying the standard methodology regulated by IEEE or IEC, as deemed appropriate.

3.3 Direct Current (DC) Power Supply

Applying the standard methodology regulated by IEEE or IEC, as deemed appropriate.

3.4 Reactive Power Control

The testing on reactive power control efficiency aims to assure how much reactive power, in maximum, a power generating system is able to control its acquiring and supplying level. The test can be conducted as follows:

a) Equipment installation and connection must follow the manual or technical regulations stipulated by the product manufacturer.

b) Power supply parameters are inspected and controlled to maintain the functional stability of the power generating system equipment.

c) The testing starts with the generating system supplying 0% of its power rated, and then increasing the power supply to reach its maximum rate. The results including the amount of the reactive power, and the power factor are recorded.

d) The pattern for the next step is based on c); however, the reactive power supply is gradually increased to 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, and 100% of its power rated respectively.   The results including the amount of the reactive power, and the power factor are recorded.

e) The power generating system supplies 0% of its power rated, and then the acquisition of reactive power is increased to reach its maximum rate. The results including the amount of the reactive power and the power factor are recorded.

f) The next step is similar to e); however, the acquisition rate of reactive power is gradually increased to 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, and 100% of its power rated respectively.   The results including the amount of the reactive power and the power factor are recorded.

g) The results recorded from c) to f) can be concluded using table as illustrated below.

Record of Reactive Power Control Test Result (Example)

P (Generating System)	P(as measured)	±Q(maximum, as measured)	PF. (as measured)
0 %			
10 %			
20 %			
30 %			
40 %			
50 %			
60 %			
70 %			
80 %			
90 %			
100 %			

A testing institute may apply an additional test methodology standard to evaluate the maximal acquisition and supply of reactive power of a power generating system, as deemed appropriate by this regulation.

3.4.1) A Fixed Displacement Factor cosΘ

To affirm the ability of power generating system to control its supply level, in Static Power Factor Control mode, the following methods are applied:

a) Equipment installation and connection must follow the manual or technical regulations stipulated by the product manufacturer.

b) Power supply parameters are inspected and controlled to maintain the functional stability of the power generating system equipment.

c) The power generating system is customized to supply power when power set-point is 0.90 lagging (or 0.95 lagging);the power supply is gradually increased from 0% to 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%,and 100% of its power rated respectively.

d) The test is performed after the system preparation. The minimum result is recorded as illustrated in the table below.

e) The power generating system is customized to supply power when the Power Setpoint is 0.90 leading (or 0.95 leading); the power supply is gradually increased from 0% to 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%,and 100% of its power rated respectively.

f) The test is performed after the system preparation. The minimum result is recorded as illustrated in the table below.

g) The generating system is customized to supply power when the Power Setpoint is 1.0;the power supply is gradually increased to 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%,and 100% of its power rated respectively.

h) The test is performed after the system preparation. The minimum result is recorded as illustrated in the table below.

Test Result Record (Example)

P (Generating System)	PF. (setting value)	P(as measured)	Q (as measured)	PF. (as measured)
0 %	0.90 lagging			
10 %	0.90 lagging			
20 %	0.90 lagging			
30 %	0.90 lagging			
40 %	0.90 lagging			
50 %	0.90 lagging			
60 %	0.90 lagging			
70 %	0.90 lagging			
80 %	0.90 lagging			
90 %	0.90 lagging			
100 %	0.90 lagging			

Test Result Record (Example)

P (ระบบผลิตไฟฟ้า)	PF. (setting value)	P(as measured)	Q (as measured)	PF. (as measured)
0 %	0.90 leading			
10 %	0.90 leading			
20 %	0.90 leading			
30 %	0.90 leading			
40 %	0.90 leading			
50 %	0.90 leading			
60 %	0.90 leading			
70 %	0.90 leading			
80 %	0.90 leading			
90 %	0.90 leading			
100 %	0.90 leading			

A testing institute may apply an additional test methodology standard to assess a system's power supply control capability in Static Power Factor Control mode, as deemed appropriate by this regulation.

3.4.2) A Variable Reactive Power Depending on the Voltage Q (U)

To affirm the ability of power generating system to control its supply level, in Static Voltage Control mode, the following methods are applied:

a) Equipment installation and connection must follow the manual or technical regulations stipulated by the product manufacturer.

b) Power supply parameters are inspected and controlled to maintain the functional stability of the power generating system equipment.

c) The power generating system is regulated to supply power at a particular variable voltage set-point (as indicated in table below).

d) The test starts after the equipment preparation. The result is recorded as illustrated in the table below.

e) The generating system is regulated to supply power at a particular variable voltage set-point (as indicated in table below).

f) The test starts after the equipment preparation. The result is recorded as illustrated in the table below.

Test Result Record (Example)

P,setpoint (%)	V,setpoint (Vac)	P (as measurred)	V_{L1} (Vac)	V_{L2} (Vac)	V_{L3} (Vac))	Q (as meassured) (Var)	Expected Q (Var)	Shifting Q (dQ)
Lower Limits								
<20	0.93Vn							
<20	0.91Vn							
20-30	0.91Vn							
40	0.91Vn							
50	0.91Vn							
60	0.91Vn							
70	0.91Vn							
80	0.91Vn							
90	0.91Vn							
100	0.91Vn							
100	0.90Vn							
100-10	0.90Vn							
10-<5	0.90Vn							

Test Result Record (Example)

P,setpoint (%)	V,setpoint (Vac)	P (as measured)	V_{L1} (Vac)	V_{L2} (Vac)	V_{L3} (Vac))	Q (as measured) (Var)	Expected Q (Var)	Shifting Q (dQ)
Lower Limits								
<20	1.07Vn							
<20	1.09Vn							
20-30	1.09Vn							
40	1.09Vn							
50	1.09Vn							
60	1.09Vn							
70	1.09Vn							
80	1.09Vn							
90	1.09Vn							
100	1.09Vn							
100	1.10Vn							
100-10	1.10Vn							
10-<5	1.10Vn							

A testing institute may apply an additional test methodology standard to assess a system's power supply control capability in Static Voltage Control mode, as deemed appropriate by this regulation.

3.5 Active Power Control

The assessment of active power control efficiency aims to guarantee the power control ability of a particular power generating system. The test procedure is detailed as follows.

1. The tested power generating system must have adjustable power decease rate, minimally 10% per second.
2. Every 10% deceases from power rated must occur while the power generating system is connected to its power network system.
3. Test methods and procedure are detailed as follows.
   a) Equipment installation and connection must follow the manual or technical regulations stipulated by the product manufacturer.
   b) Power supply parameters are inspected and controlled to maintain the functional stability of the power generating system equipment.
   c) The power control setting must allow power supply to decrease from 100% to 0% of power rated, gradually 10% each time. Other functional features of the generating system must function properly and regularly during the experiment.
   d) The test begins with the power generating system supplying 100% of power rated; afterward, the power supply rate is deceased as mentioned in c). The result including power supply rate, and time duration required for a particular decrease of power supply are recorded as illustrated in the table below.

A testing institute may apply an additional test methodology standard to assess a system's power control ability, as deemed appropriate by this regulation.

3.6 Low Voltage Fault Ride Through

To ensure the system's Low Voltage Fault Ride Through ability, the following test methods should be applied:

a) Equipment installation and connection must follow the manual or technical regulations stipulated by the product manufacturer.

b) Power supply parameters are inspected and controlled to maintain the functional stability of the power generating system equipment.

c) Low Voltage Fault Ride Through function setting of the converter set must be in compliance with the regulations. Other functions of the converter set must be maintained to operate regularly.

d) The setting value mentioned in c) is recorded.

e) The test begins with the simulation of low voltage fault incident occurring in a power network system. As such, the voltage level is reduced to 70-80%, 30-50% and less than 5% of its normal level respectively.

f) The maximum time duration that the generating system is able to stay connected with its power network systen is recorded as illustrated in the table below.

g) The test can be sub-categorized as follows.

Test Result Record

Power Supply (Pn)	Fault Type	V (V/Vn)	Time Duration (sec)
>0.9Pn, 0.3Pn and 0.1Pn respectively	three-phase faults	0.7-0.8 Vn	
		0.3-0.5 Vn	
		0-0.049 Vn	
	Phase-phase faults	0.7-0.8 Vn	
		0.3-0.5 Vn	
		0-0.049 Vn	
	Single line to ground faults	0.7-0.8 Vn	
		0.3-0.5 Vn	
		0-0.049 Vn	

A testing institute may apply an additional test methodology standard to evaluate the Fault Voltage Ride Through capability, as deemed appropriate by this regulation.

3.7 Under- and Over-Voltage Protection

Over-voltage Test and Under-voltage Test require, at least, Trip Time Test which can be detailed in the table below.

Over-voltage Test Procedure

Topic	Number of Tests Conducted	Procedure
Trip Time Test	(m)	(1) Equipment installation and connection must follow the manual or technical regulations stipulated by the product manufacturer. (2) Power supply parameters are inspected and controlled to maintain the functional stability of the power generating system equipment. (3) Over-voltage Trip Setting is in compliance with the voltage test value (*m). Other functions must be controlled to operate regularly. (4) The setting value is recorded. (5) The AC power supply's voltage level (utility system simulation model) is increased to reach the similar level as the Over-voltage Trip Setting

Topic	Number of Tests Conducted	Procedure
		value: >90%-≤ 100% of the Over-voltage Trip Setting value; the voltage level must be maintained for more than two times of the Time Delay regulated. (6) The voltage level is then adjusted to >110% of the Overvoltage Trip Setting value, and must be maintained until the power generating device stops providing power supply to the system. (7) The time duration required for the power generating equipment to stop its power supply is recorded.
*m = The Over-voltage Level which must be tested 2 times		

Remark: The experimenter may consult the test standards stipulated by IEEE or IEC as deemed appropriate.

Under-voltage Test Procedure

Topic	Number of Tests Conducted	Procedure
Trip Time Test	(m)	(1) Equipment installation and connection must follow the manual or technical regulations stipulated by the product manufacturer. (2) Power supply parameters are inspected and controlled to maintain the functional stability of the power generating system equipment. (3) Under-voltage Trip Setting of the generating system equipment is in compliance with the voltage test value (*m). Other functions must be controlled to operate regularly. (4) The setting value is recorded. (5) The AC power supply's voltage level (utility system simulation model) is decreased to reach the similar level as the Under-voltage Trip Setting value: 110% to ≥100% of the Under-voltage Trip Setting value; the voltage level must be maintained for two times of the Time Delay regulated or longer. (6) The voltage level is then reduced to <90% of the Under-voltage Trip Setting value, and must be maintained until the power generating equipment stops providing power supply to the system. (7) The time duration required for the power generating equipment to stop its power supply is recorded.
*m = The Overvoltage Level which must be tested 2 times		

Remark: A test conductor may consult the test standards stipulated by IEEE or IEC as deemed appropriate.

3.8 Under- and Over- Frequency Protection

Over-frequency Test and Under-frequency Test require, at least, Trip Time Test which can be concluded in the table below.

Over-frequency Response Test Procedure

Topic	Number of Tests Conducted	Procedure
Trip Time Test	1	(1) Equipment installation and connection must follow the manual or technical regulations stipulated by the product manufacturer. (2) Power supply parameters are inspected and controlled to maintain the functional stability of the power generating system equipment. (3) The power generating system's over-frequency Trip Setting value is 52.1 Hz. Other functions must be controlled to operate regularly. (4) The setting value is recorded. (5) The AC power supply's frequency level (utility system simulation model) is increased to reach the similar level as the Over-frequency Trip Setting value: ≥90% to ≤ 100% of the Over-frequency Trip Setting value; the frequency level must be maintained for two times of the Time Delay or longer. (6) The frequency level is then adjusted to at least >101% of the Over-frequency Trip Setting value, and must be maintained until the power generating equipment stops providing power supply to the system. (7) The time duration required for the converter to stop its power supply is recorded.

Remark: A test conductor may consult the test standards stipulated by IEEE or IEC as deemed appropriate.

Under-frequency Response Test Procedure

Topic	Number of Tests Conducted	Procedure
Trip Time Test	1	(1) The Equipment installation and connection must follow the manual or technical regulations stipulated by the product manufacturer. (2) Power supply parameters are inspected and controlled to maintain the functional stability of the power generating system equipment. (3) Under-frequency Trip Setting value of the generator is 46.9 Hz. Other functions must be controlled to operate regularly. (4) The setting value is recorded. (5) The AC power supply's frequency level (utility system simulation model) is reduced to reach the similar level as the Under-frequency Trip Setting value: ≥100% to ≤ 110% of the Under-frequency Trip Setting value; the frequency level must be maintained for more than two times of the Time Delay regulated. (6) The frequency level is then reduced to at least <99% of the Under-frequency Trip Setting value, and must be maintained until the power generating device stops providing power supply to the system. (7) The time duration required for the power generating device to stop its power supply is recorded.

Remark: A test conductor may consult the test standards stipulated by IEEE or IEC as deemed appropriate.

3.9 Anti -Islanding Protection

A test conductor follows the test standards stipulated by IEEE or IEC as deemed appropriate.

3.10 Response to Utility Recovery

A test conductor follows the test standards stipulated by IEEE or IEC as deemed appropriate.