Annexure-V_18th NPC

भारत सरकार
Government of India
केन्द्रीय विद्युत प्राधिकरण
Central Electricity Authority
पश्चिम क्षेत्रीय विद्युत समिति
Western Regional Power Committee
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No. WRPC/Prot.-AIP /NPC/2026/ 2262 – 2277 Date: 30.04.2026

To,
The Member Secretary, NPC
Central Electricity Authority
New Delhi – 110066

विषय: संबद्ध नवीकरणीय ऊर्जा संयंत्रों के लिए एकसमान द्वीप-विरोधी संरक्षण दर्शन तैयार करने हेतु गठित समिति की रिपोर्ट के संबंध में|

Subject: – Report of Committee constituted for the Preparation of the Uniform Anti-Islanding Protection Philosophy of the Connected RE plants: reg

Ref: NPC Division letter no. CEA-GO-15-14/3/2025-NPC Division dated 24.10.25

Please find enclosed herewith Report of Committee for the Preparation of the Uniform Anti-Islanding Protection Philosophy of the Connected RE plants constituted by NPC vide letter under reference.

Submitted for needful please.

भवदीय /Yours faithfully

Enclosed: As above.

(Deepak Sharma)
(सदस्य संयोजक/Member convener)

Copy to: All members as per list.

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REPORT OF THE COMMITTEE CONSTITUTED FOR PREPARATION OF THE UNIFORM ANTI-ISLANDING PROTECTION PHILOSOPHY FOR THE CONNECTED RE PLANTS

APRIL 2026



Western Regional Power Committee
Mumbai

Acknowledgement

The Committee acknowledges the cooperation extended by IIT-Bombay, IISc-Bangalore, AEGL, TBEA Inverter, Greenko, POWERGRID & Grid-India for giving their valuable inputs to finalize the report on Uniform Anti-Islanding Protection Philosophy.

The Committee also acknowledges and extends gratitude to the sincere efforts of Shri Himanshu Pandey AD-I, WRPC, for putting all the inputs in proper perspective and giving shape and helping in drafting the report.

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I. Abbreviations and Symbols

Abbreviations	Descriptions
AC	Alternating Current
AFD	Active Frequency Drift
AFDPF	Active Frequency Drift with Positive Feedback
AGEL	Adani Green Energy Limited
AI	Anti-Islanding
AIDT	Anti-Islanding Detection Technique
AIP	Anti-Islanding Protection
ALGBS	Automatic Load-Generation Balancing Scheme
ALPS	Active Islanding Protection Scheme
APTRANSCO	Andhra Pradesh Transmission Corporation
BCU	Bay Control Unit
CBRs	Converter Based Resources
CEA	Central Electricity Authority
CT	Current Transformer
DC	Direct Current
DEF	Directional Earth Fault
DER	Distributed Energy Resource
DG	Distributed Generation
DISCOM	Distribution Company
DSC	Decoupled Sequence Control
DTT	Direct Transfer Trip

E/F	Earth Fault
EPS	Electric Power System
EU	European Union
FRT	Fault Ride Through
GFL	Grid Following
GFM	Grid Forming
GIPCL	Gujarat Industries Power Company Limited
GRID-India	Grid Controller of India Limited
GSC	Grid Side Converter
HV	High Voltage
HVRT	High Voltage Ride Through
IBR	Inverter-Based Resource
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IEGC	Indian Electricity Grid Code
IISc	Indian Institute of Science
IIT	Indian Institute of Technology
ISTS	Inter-State Transmission System
LGB	Load-Generation Balance
LVRT	Low Voltage Ride Through
MW	Megawatt
NDZ	Non-Detection Zone
NERC	North American Electric Reliability Corporation
NPC	National Power Committee

NPSC	National Protection Standing Committee
O/C	Overcurrent
OEM	Original Equipment Manufacturer
OF/UF	Over Frequency / Under Frequency
OPGW	Optical Ground Wire
OV	Over Voltage
OV/UV	Over Voltage / Under Voltage
PCC	Point of Common Coupling
PLC	Power Line Communication
PLCC	Power Line Carrier Communication
PLL	Phase Locked Loop
PMU	Phasor Measurement Unit
PoI	Point of Interconnection
POWERGRID	Power Grid Corporation of India Limited
PPC	Power Plant Controller
PV	Photovoltaic
RCA	Relay Characteristic Angle
RE	Renewable Energy
RES	Renewable Energy Source
RIDS	Remote Islanding Detection Scheme
RLDC	Regional Load Despatch Centre
ROC	Residual Overcurrent
RoCoF	Rate of Change of Frequency
RPC	Regional Power Committee

SCADA	Supervisory Control and Data Acquisition
SEF	Sensitive Earth Fault
SG	Synchronous Generator
SLDC	State Load Despatch Centre
SMS	Slip Mode Frequency Shift
SRPC	Southern Regional Power Committee
STD	Standard
TANTRANSCO	Tamil Nadu Transmission Corporation
TOR	Terms of Reference
TRANSCO	Transmission Company
TS	Transmission System
UFR	Under Frequency Relay
UL	Underwriters Laboratories
UOV/UOF	Under/Over Voltage and Under/Over Frequency
UV	Under Voltage
VDE-AR-N	German Technical Connection Rule for High Voltage Networks
Vn	Nominal Voltage
VT	Voltage Transformer
WP	Watt Power
WRLDC	Western Regional Load Despatch Centre
WRPC	Western Regional Power Committee
WTG	Wind Turbine Generator
X/R	Reactance-to-Resistance Ratio

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IV. Executive Summary

- Section 1 of the report presents the background and necessity for development of a uniform Anti-Islanding Protection (AIP) philosophy for transmission-connected Renewable Energy (RE) plants in view of the rapid increase in penetration of converter-based generation such as solar and wind plants in the Indian power system. The section describes the constitution of the expert committee under the guidance of the National Power Committee (NPC) comprising representatives from GRID-INDIA, RPCs, POWERGRID, IIT Bombay, IISc Bangalore, OEMs, and RE developers for reviewing existing practices and recommending a standardized national protection philosophy. The Committee, across four meetings between December 2025 and April 2026 discussed the issues and based on these discussions the report has been framed.

- Section 2 of the report covers review of regulatory provisions and international standards relevant to anti-islanding protection applicable to converter-based resources. The section examines provisions of CEA Connectivity Regulations (2019 and amendments), Indian Electricity Grid Code (IEGC), IEEE 1547, IEEE 2800, IEC 62116, European Commission Regulation (EU) 2016/631, and international utility practices adopted in systems with high RE penetration. Based on the review, the section highlights that converter-level active anti-islanding protection techniques developed primarily for distribution-level DER applications are not suitable for transmission-connected RE plants and may conflict with grid support requirements such as LVRT and HVRT compliance.

- Section 3 of the report examines various islanding detection techniques presently adopted in RE plants including passive methods, active methods, hybrid methods, and communication-assisted islanding detection schemes. Passive techniques based on voltage and frequency variations are simple but suffer from large non-detection zones. Active techniques improve detection capability but may affect power quality and create coordination challenges among multiple inverters. Hybrid techniques provide improved reliability but still have operational limitations. Communication-assisted islanding detection scheme Direct Transfer Trip (DTT) is generally found to be a reliable approach for transmission-connected RE plants due to their high dependability and negligible non-detection zone.

- Section 4 of the report presents the recommended uniform anti-islanding protection philosophy for existing transmission-connected RE plants and RE Plants that are will be commissioned by April 2027. The section emphasizes separation of inverter-level protection functions from plant-level anti-islanding protection logic and highlights the

requirement for coordination of anti-islanding protection with LVRT and HVRT envelopes specified under grid regulations. The section recommends that RE plants should remain connected during permissible voltage disturbances and should disconnect only under confirmed islanding conditions persisting beyond specified limits. Implementation of communication-assisted islanding detection schemes such as RIDS, particularly DTT, is recommended as the preferred approach. For existing RE plants where communication-assisted schemes are not immediately feasible, suitably coordinated passive or hybrid protection schemes with standardized frequency limits are recommended as interim measures, while communication-assisted schemes are recommended for new RE plants.

- Section 5 of the report examines the feasibility of the inclusion of RE plants in islanding schemes. The section recommends that participation of RE plants in intentional islanding schemes should be undertaken only with the approval of RPCs/RLDCs. after a detailed technical assessment. It further highlights that the stable operation of islanded systems requires adequate contribution from grid-forming converter-based generation or conventional synchronous generation sources. Implementation of Automatic Load-Generation Balancing Schemes (ALGBS)/local frequency control is a perquisite for maintaining frequency stability within islanded systems during islanding operation. ALGBS/local frequency control should be disabled during normal grid operation.

- Section 6 of the report discusses the impact of increasing penetration of converter-based generation on conventional transmission protection systems due to limited fault current contribution from RE plants. Reduced sensitivity of distance protection, overcurrent protection, and earth-fault protection schemes has been observed in RE-dominated transmission corridors. To address these challenges, this report recommends the provision of controlled negative sequence current injection capability in inverter controls to support reliable fault detection and protection operation.

- Section 7 of the report presents recommendations on improving the protection system for RE systems using presently available protection relay functionalities such as directional earth fault protection, distance protection, and line differential protection to mitigate the challenges imposed by low fault current contribution from converter-based resources. The section recommends adoption of adaptive protection settings including multiple setting groups based on RE generation availability, use of voltage memory polarization and dual polarization methods for improving directional earth fault protection performance, and utilization of directional negative-sequence protection logic where coordinated converter contribution is available. The section further recommends implementation of duplicated line differential protection schemes on transmission lines connected to RE generators

considering availability of Optical Ground Wire communication infrastructure. In addition, implementation of weak-end infeed logic and permissive overreach schemes is recommended for improving distance protection performance under low fault current contribution conditions from inverter-based resources. These measures collectively provide a practical framework for strengthening protection reliability in RE-dominant transmission corridors.

Part -A- Uniform Philosophy for Anti-islanding Protection

Section-1:
Background and Introduction

1.1 In the 1st meeting of the National Protection Standing Committee (NPSC) held on 26.03.2025, it was observed that the mal-operation of Anti-Islanding features may be attributed to low set values of sensing parameters or voltage distortion during disturbances. However, it was emphasized that false detection of an unintended island cannot be considered a valid justification for non-compliance with grid support requirements. The NPSC suggested that the matter warrants detailed deliberation for the appropriate way forward and a separate expert group, including industry specialists, may be constituted to support the analysis. Accordingly, it was recommended that a committee may be constituted comprising representatives from WRPC, SRPC, Grid-India, experts from IITs, IISc- Bangalore, OEMs, POWERGRID, major Renewable Energy (RE) developers, and the NPC Secretariat, for examining the issue of mal-operation of Anti-Islanding features, and also assess the impact of renewable energy integration on earth fault protection.

1.2 The issue was further discussed in the 16th meeting of the National Power Committee (NPC) held on 04.07.2025. It was decided to constitute a Committee under SE (Protection), WRPC, with representation from WRPC, SRPC, GRID-India, experts from IITS, IISc-Bangalore, OEMS, POWERGRID, major Renewable Energy Developer, and NPC, for the preparation of a Uniform Anti-Islanding Protection Philosophy for grid-connected Renewable Energy (RE) plants.

1.3 As per the decision taken in the 16th National Power Committee (NPC) meeting held on 04.07.2025, the NPC Secretariat constituted a Committee on Anti-Islanding Protection of grid-connected Renewable Energy (RE) plants and other protection-related issues associated with grid-connected RE plants. The members of the Committee so constituted was notified vide NPC letter dated 24.10.2025.

S. No.	Name	Designation	Organization	
1	Shri P. D. Lone	Superintending Engineer	WRPC	Chairman
2	Shri Satyendra Kumar Dotan	Director (NPC)	CEA	Member
3	Shri Moka Venkata Subba Reddy	Executive Engineer	SRPC	Member
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7	Prof. Zakir H. Rather	Professor	IIT Bombay	Member
8	Shri Sanjay Bhatt	Assistant Vice President	AGEL	Member
9	Shri H. L. Parekh	Additional General Manager	GIPCL	Member
10	Shri Naveen Kumar	Chief Technology Officer (CTO)	TBEA Inverter	Member
11	Shri Ankit Vaish	Deputy General Manager	POWERGRID	Member
12	Shri Madhukar Goodelli	Deputy General Manager	WRLDC / GRID-India	Member
13	Shri Deepak Sharma	Deputy Director	WRPC	Member Convener

Table 1:Details of Committee Members

1.4 Terms of Reference (TOR)

The term of reference of Committee are as follows;

a) To review the existing anti-islanding protection practices and identify gaps.
b) To study the causes of mal-operations and suggest corrective measures.
c) To recommend uniform national settings for frequency, rate of change of frequency (df/dt), and voltage thresholds.
d) To ensure compatibility of the proposed philosophy with LVRT/HVRT and Grid Code requirements.
e) To examine the impact of renewable energy integration on earth fault protection and other critical protection aspects.
f) To prepare a comprehensive report with recommendations covering points (a) to (e)
g) To provide any other suggestions or recommendations on related matters.
h) The Committee shall submit its report within six months. The copy of the letter is enclosed as **Annexure -1.4**

In the 16th NPC meeting, it was decided that the matter regarding inclusion of Renewable Energy in islanding schemes may be referred to the existing Committee for Uniform Anti-Islanding Protection Philosophy of connected RE plants for detailed examination. The Committee may study the feasibility of incorporating Renewable Energy sources in islanding schemes and suggest suitable approaches.

1.5 Proceedings of Committee:

1.5.1. The first meeting of the Committee constituted for a Uniform Anti-Islanding Protection Philosophy was held on 11.12.2025. The Committee discussed the complete outage incidents at 400 kV/110 kV Thappagundu Substation (TANTRANSCO) on 03.12.2024 and multiple substations of APTRANSCO on 24.11.2024, wherein RE generators continued generation

despite tripping of evacuation lines due to non-operation of Anti-Islanding protection. However, detailed information such as fault details, PMU data, and Anti-Islanding protection settings was not available; therefore, the events could not be analyzed further. SRPC was requested to furnish detailed information on the above events, including fault details of evacuation lines, PMU data (if available), Anti-Islanding protection settings at connected stations, and any similar incidents reported in the Southern Region.
After deliberations, the Committee decided the following:

- To undertake a survey of international practices adopted for Anti-Islanding detection methodologies.
- To review available technical literature on anti-islanding protection schemes.
- To propose reliable and practical detection methodologies considering LVRT/HVRT and frequency ride-through requirements as specified in CEA Standards and IEGC, with minimal financial and logistical implications for RE generators.
- To identify suitable Anti-Islanding protection approaches based on RE connectivity, including:
  o RE plants connected through pooling stations,
  o RE plants having grid-forming capability,
- To suggest suitable implementation approaches for both existing and upcoming RE plants, including simulation studies wherever required.
- To review the challenges with Distance protection, over-current (O/C) & earth-fault (E/F) protection and prepare guidelines on relay settings to improve protection sensitivity without compromising selectivity and reliability, and to review available literature for proposing suitable protection systems for networks in and around RE plants.

1.5.2. The second meeting of the Committee was held on 13.02.2026. The Committee deliberated on the protection requirements of renewable energy (RE) plants with particular reference to Anti-Islanding detection philosophy and its coordination with existing grid protection schemes. It was observed that implementation of Anti-Islanding protection at the individual inverter level often leads to nuisance tripping during grid disturbances and may adversely affect system stability. In view of this, it was agreed that Anti-Islanding protection should preferably be implemented at the plant level through coordinated detection and tripping logic. It was also felt that there is a need for standardization of converter protection settings, particularly under/over-voltage and frequency protection limits, to ensure uniform response of RE plants during grid disturbances. With the impact of increasing penetration of RE generation on conventional protection schemes, especially distance protection performance in RE-connected transmission corridors it was noted that there is a need for detailed analysis of

reported protection mal-operations and recommended exploring the adoption of line differential protection schemes for new RE-connected transmission lines to enhance reliability. The draft report on Anti-Islanding protection circulated would be revised, incorporating updated technical perspectives, field experiences, and inputs from system operators, utilities, OEMs, and RE generators. Members also emphasized the need to collect and analyze event data related to Anti-Islanding protection mal-operations from different regions for inclusion in the report.
Subsequent to the meeting, preliminary draft report of the Committee constituted for the Uniform Anti-Islanding Protection Philosophy was prepared and circulated among members vide email dated 18.03.2026, seeking their comments on the same.

1.5.3. The third meeting was held on 23.03.2026, wherein the Committee reviewed Section-4 of the draft report relating to equipment protection settings, particularly LVRT/HVRT requirements, and emphasized the need to incorporate OEM inputs to ensure protection settings without adversely affecting inverters.

The Anti-Islanding detection methodologies were reviewed and it was noted that DTT is preferable. Active Anti-Islanding methods were generally discouraged due to the risk of nuisance tripping, issues of harmonics and interactions of converters.
The importance of controlled negative-sequence current injection from inverters during faults for improving directional protection performance, fault classification, and auto-reclosure coordination was also discussed. It was agreed that suitable recommendations may be included for future inverter specifications.

1.5.4. The fourth meeting was held on 02.04.2026 OEMs and AGEL, wherein the applicability of a wider range of Anti-Islanding protection settings beyond the LVRT and HVRT envelope and their impact on inverter health was discussed

Section-2
Anti-Islanding Requirements and Practices for Large-Scale Renewable Energy Power Plants
(Literature Survey and International Practices)

2.1 Inverter Types:

The inverters deployed in the RE plants are of two types, the most predominant being the Grid Following inverters, which rely on Phase Locked Loop (PLL) to track the grid, while the other type is Grid Forming inverters, which act as voltage sources and are being increasingly preferred for the stability of a weak grid.

- **Grid-Forming (GFM) Control based sources**: Converter Interfaced sources that can create and maintain voltage and frequency at its terminals, effectively acting as an independent voltage source is known as GFM source. Besides various other grid support services, GFM converter-based sources can also provide black start service.
- **Grid-Following (GFL) Control based sources:** Converter interfaced sources that inject active and reactive power into the grid, while requiring PLL for continuous synchronization with the grid, and effectively acting as dependent current sources are known as GFL sources. GFL technology must have an active external grid for its operation.

The Grid Following (GFL) CBRs technology act as a current source that injects power into an existing grid and requires appropriate control techniques in order to remain interconnected and contribute in a proper way to the overall grid stability, whenever disturbances occur. The control of RES mainly depends on the synchronization algorithm, which should be fast and accurately detect the grid voltage status (e.g., phase, amplitude, and frequency). Typically, phase-locked loop (PLL) synchronization techniques are used for grid voltage monitoring. The design and performance of the PLL directly affect the dynamics of the RES grid side converter (GSC). Essentially, when there is no connection from the grid side, it cannot function in isolation and ceases to operate.

A Grid Forming (GFM) CBRs act as a voltage source and establishes its own voltage and frequency reference and regulates power output by adjusting the phase and magnitude of its internal voltage. If a disturbance occurs, the GFM inverter reacts instantly to counteract it, providing "virtual inertia" to slow down frequency changes similar to how a heavy rotating mass of a traditional power plant generator helps keep the grid stable. Essentially, when there is no connection from the grid side, it can also operate in isolation.

In the meetings, the requirement of Anti-Islanding Protection for GFL CBR-based plants was extensively discussed, wherein it was inferred that the GFL CBRs will cease to operate when there is no energization from the grid side and therefore, the AIP may not be required. However, conditions such as auxiliary power availed from the State Distribution Company may be available, also in some cases, the DG standby supply may also be available at the CBR-connected buses during the failure of supply from the grid side, or the Plant may have hybrid (GFM & GFL) CBRs. Under such scenarios, the AIP may be required as a safety measure to avoid accidents. The GFM CBR plants would certainly require the implementation of AIP, since they would remain connected with the grid irrespective of the supply availability from the grid side. However, the AIP of GFM CBRs will have to be bypassed during extending black start from the GFM-based battery storage system.

2.2 Unintentional Islanding.

Since the early integration of distributed energy resources (DERs), initially consisting of low-capacity generators connected to distribution systems, utilities and regulators have expressed concerns regarding safety, protection, and grid security due to the risk of unintentional islanding. To address these concerns, anti-islanding schemes and islanding detection methods became mandatory in DERs to ensure the protection of system components and personnel. These requirements are explicitly defined in standards such as IEEE 1547, IEC 62116, IEEE STD 929-2000, and UL 1741–2000, along with corresponding testing procedures. Consequently, inverters used in DER applications and RE plants are being typically equipped with unintentional islanding detection schemes.

The requirement of anti-islanding protection at distribution level primarily originated from distribution voltage level connected conventional distributed generators, and is actively being practiced in grid-tie inverter technologies used in rooftop and ground mounted distribution connected in renewable energy systems. Initially, inverter sizes were small and under low penetration of renewables, requirements for grid support functionalities were rather limited. Original Equipment Manufacturers (OEMs) concentrated mainly on steady-state operation, and during any disturbance or fault, the inverters were designed to disconnect from the grid as quickly as possible. As inverter technology was still in its nascent stage, OEMs introduced anti-islanding protection primarily to safeguard grid-tie inverters when a portion of the distribution system containing the inverters disconnects from the main grid and forms an island. Due to the absence of advanced protection logic and concerns about inverter safety, anti-islanding protection design was also applied to detect various known and unknown transient disturbances.

As inverter capacities increased and their penetration extended into transmission systems, OEMs retained the control programs and firmware originally developed for small-scale inverters and layered advanced control and protection logics on top of them. Consequently, anti-islanding protection became embedded in large-scale grid-tie inverters connected at transmission levels. Simultaneously, to comply with grid code requirements, OEMs introduced advanced protection algorithms such as Low Voltage Ride Through (LVRT), High Voltage Ride Through (HVRT), under-voltage, over-voltage, under-frequency, RoCoF and over-frequency protections. As a result, anti-islanding protection schemes began to coexist with these advanced protection algorithms without significant scrutiny, and this coexistence continues in many countries worldwide.

With the large-scale integration of renewable energy (RE), multiple inverter units were interconnected to form renewable energy power plants connected to transmission networks. Such utility-scale RE plants are expected to remain connected to the transmission network and support the grid during grid disturbances. Therefore, inverter-level islanding detection is generally discouraged in such large-scale applications. Instead, plant-level islanding detection schemes are required to ensure overall system protection and proper coordination with grid operations. The discussion focuses on anti-islanding and islanding detection for large-scale RE power plants, particularly examining their requirements and recommendations in grid codes and regulations across different regions.

Furthermore, the use of anti-islanding protection has also changed as inverters moved into transmission systems. In distribution networks, anti-islanding protection was primarily used to disconnect inverters when a section of the distribution system became isolated from the main grid. However, at the transmission level, it is predominantly viewed as a mechanism to disconnect large-scale inverters when the evacuating transmission lines are disconnected. **In case the Battery Storage system based on GFM inverter technology is identified for extending Black start facility, the AIPs of such a system is required to be bypassed during such operation. Such a provision should be brought out clearly by Grid-India in their black start procedures**.

2.3 Issues with Unintentional Islanding:

2.3.1 Personnel Safety – Unintentional islands can cause hazards for utility maintenance and operational personnel if they assume downstream lines are not energized during restoration.

2.3.2 Overvoltage – Transient overvoltages due to rapid loss of load are possible. If an adequate ground source is not present in the island, a ground fault can result in voltages that exceed 173% on the unfaulted phases.

2.3.3 Reconnection out of phase - This can result in large transient torques applied to motors connected to the islanded area EPS and their mechanical systems (e.g., shafts, blowers, and pumps), which could result in damage or failure.

2.3.4 Power Quality – Unplanned Island area EPS may not have suitable power quality for loads.

2.3.5 Protection – Unintentional islands may not provide sufficient fault current to operate fuses or overcurrent relay protection devices inside island.

2.4 Standards and Grid-Code Requirements on Anti-Islanding

2.4.1 IEEE 1547:

These standards have been widely adopted in USA, Canada, Philippines, and adapted in many South American nations. The scope of the Standard is for Interconnection and Interoperability of Distributed Energy Resources.
Regarding anti-islanding, the standard provides that the RE plant must detect the island and cease to energize the area EPS (Electric Power System) within 2.0 seconds of the formation of an island. (IEEE 1547-2003)[1].
In IEEE 1547-2018 update mandates "Ride-Through" for transient faults to prevent cascading blackouts, but strict isolation for true islands[2].

2.4.2 IEC 62116: Test procedure of islanding prevention measures for utility-interconnected photovoltaic Inverters

IEC 62116 standard is a testing standard, which defines a test bench to rigorously verify if an inverter's active AI method works even when generation perfectly matches load (the worst-case NDZ scenario). This also defines the disconnection of the island within 2 seconds, similar to the IEEE standard[3]

2.4.3 IEEE 2800-2022

Converter-based resource (CBR) plants are required to remain connected to the grid during disturbances and comply with ride-through requirements. However,

unintentional islanding protection schemes embedded within individual CBR units may interfere with ride-through performance and may lead to the tripping of multiple CBR units within a plant[4] ,Therefore, IEEE 28002022 recommends disabling active unintentional islanding protection schemes embedded within individual CBR units (Converters). If islanding protection is required for equipment protection purposes, active unintentional islanding detection may be permitted subject to agreement with the transmission system owner, and communication-based schemes may be utilized as the primary means for implementing this functionality. External methods such as Direct Transfer Trip (DTT) may be employed by monitoring breaker status and relay operations within the power system to detect islanding. Protection systems associated with interconnected networks may initiate trip signals that result in tripping of the breaker at the high-voltage side of the CBR transformer or the individual CBR unit breaker.

2.4.4 Indian grid standards

In accordance with the Central Electricity Authority (Technical Standards for Connectivity to the Grid) (Amendment) Regulations, 2019 [5]and the Indian Electricity Grid Code (IEGC)[6] the Low Voltage Ride Through (LVRT) and High Voltage Ride Through (HVRT) requirements are applicable to grid-connected Renewable Energy (RE) plants.

- **Low Voltage Ride Through (LVRT) Requirement**

As per the CEA regulations, "*The converter based generating station connected to the grid, shall remain connected to the grid when voltage at the interconnection point on any or all phases dips up to the level depicted by the lines in the following curve*

(V_T: Actual Voltage; V_n: Nominal Voltage).

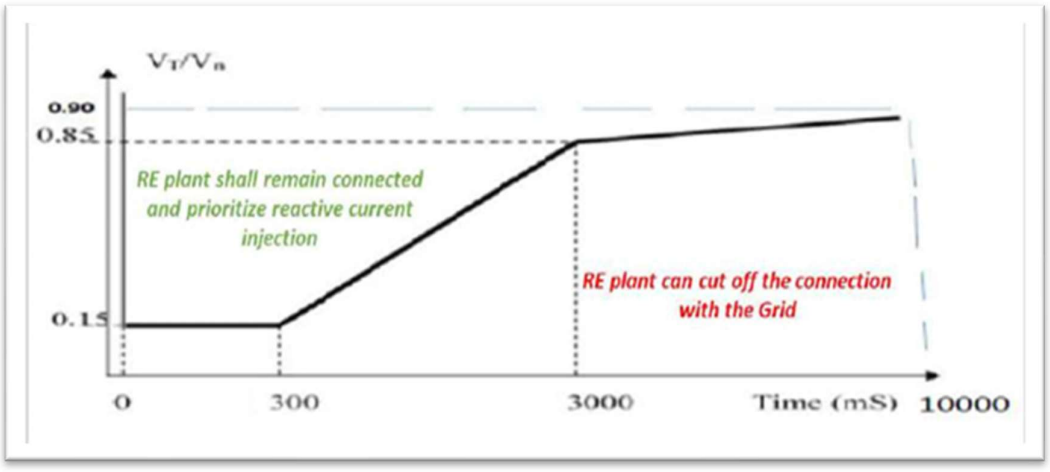


Figure 1: LVRT Requirement Specified in CEA connectivity standard

Provided that during the voltage dip, the supply of reactive power has first priority, while the supply of active power has second priority and the active power preferably be maintained during voltage drops, provided, a reduction in active power within the plant's design specifications is acceptable and active power be restored to at least 90% of the pre-fault level within 1 sec of restoration of voltage."

- **High Voltage Ride Through (HVRT) requirement**

As per the existing CEA regulations, "*The generating station connected to the grid, shall remain connected to the grid when the voltage at the interconnection point, on any or all phases (symmetrical or asymmetrical overvoltage conditions) rises above the specified values given below for specified time."*

S. No.	Voltage Level (p.u.)	Minimum Time to Remain Connected (seconds)
1	V > 1.30	0 (Instantaneous trip)
2	1.20 < V ≤ 1.30	0.2 s
3	1.10 < V ≤ 1.20	2 s
4	V ≤ 1.10	Continuous

Table 2:HVRT Requirement Specified in CEA connectivity standard

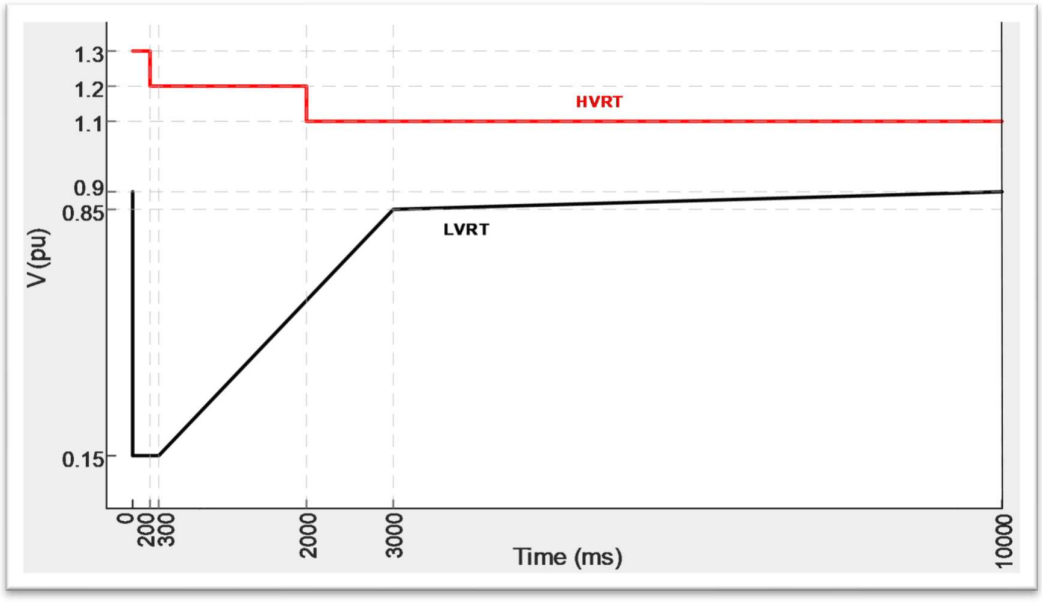


Figure 2 :LVRT/HVRT operating range

2.4.5 North America (NERC)

The NERC reliability guidelines explicitly state that anti-islanding requirements defined in IEEE 1547-2003, which are applicable to distribution systems, should not be applied to renewable energy resources connected to bulk power systems[7]. For individual inverters within an CBR plant, unintentional islanding protection, including passive and active anti-islanding functions, should be disabled as such functions may conflict with transmission system security requirements.

2.4.6 Australia

The Australian National Electricity Rules state that unintentional islanding protection may be applied depending on the requirements specified by the Australian Energy Market Operator (AEMO) or the Network Service Provider[8]. Generating plants with capacities greater than 5 MW may be required to automatically disconnect from the main grid whenever the connected portion of the network is separated from the national grid and forms an island supplying load.

2.4.7 Europe

The European Commission Regulation 2016/631 on requirements for grid connection of generators specifies that the detection method for identifying the transition from grid-connected operation to islanded operation shall be agreed upon between the generating facility owner and the system operator in coordination with the relevant transmission system operator[9]. Similar approaches are adopted by several European Union member states.

2.4.8 Finland

The Finnish grid code follows the European Commission Regulation with respect to black-start and islanding operation capability. Therefore, the requirements mentioned in **Section 2.4.7 are** applicable[10]. In addition, the use of protection devices based on the detection of rate of change of frequency (RoCoF) is prohibited, which makes this method unsuitable for islanding detection. Fingrid generally discourages the use of RoCoF or vector shift (phase jump) based protection methods due to the high risk of malfunction.

2.4.9 Denmark

In Denmark, Energinet.dk closely follows European Commission Regulation 2016/631 as mentioned in Section 2.4.7. Additionally, Energinet's Control Centre Electricity may change the operational status to an "alert state," where islanding detection is supported using PMU data along with island operation detection modules[11].

2.4.10 Great Britain

The Grid Code issued by the National Energy System Operator broadly follows the European Commission Regulation described in Section 2.4.7 Additionally, it specifies that detection of transition from grid-connected to islanded operation should not rely solely on network operator switchgear position signals[12]. For Scottish networks, non-synchronous generating units and power park modules are required to trip if voltage and frequency exceed specified operating ranges for defined durations.

2.4.11 Greater Mekong System (Cambodia, Myanmar, Thailand, etc.)

The requirements for islanding detection or transition from interconnected operation to islanded operation in the Greater Mekong System, which includes countries such as Cambodia, Myanmar, and Thailand, closely follow the European Commission Regulation described in Section 2.4.7[13]

2.5 Conclusion

Large-scale renewable energy power plants consist of multiple interconnected inverters operating collectively to supply significant power to transmission networks. These plants are expected to remain connected during major disturbances and comply with ride-through requirements. As a result, unit inverter-level islanding detection schemes are generally required to be disabled, and coordinated plant-level islanding detection schemes should be implemented instead. Across different grid codes, the common principle is that islanding detection for large-scale RE power plants should be coordinated with transmission system operators. Such schemes should not rely solely on breaker status signals but should employ advanced techniques, often supported by communication-assisted protection schemes. Detection techniques are emphasized in coordination between generating entities and network operators to develop reliable and secure islanding protection schemes.

Section-3
Anti-Islanding Detection methods

Islanding detection in general are associated with inverter-level systems designed to detect the unintended Island formation and disconnection the inverters from the main grid. This condition is also referred to as loss-of-mains for distributed energy sources. Several islanding detection methods are described in the literature and are generally classified as follows[14]-[15].

3.1 Passive Methods:

Passive methods are generally implemented using Local measurements such as over-voltage/under-voltage, ROCOF (rate of change of frequency, df/dt), vector shift or phase displacement protection, and over-frequency/under-frequency criteria are monitored to detect loss of grid connection.

The generalized workflow of passive islanding detection schemes (IDSs) depicted in the figures 3. below involves measuring these parameters and comparing them with predefined threshold values. If any parameter exceeds the specified threshold, the condition is identified as islanding and the relay initiates tripping.

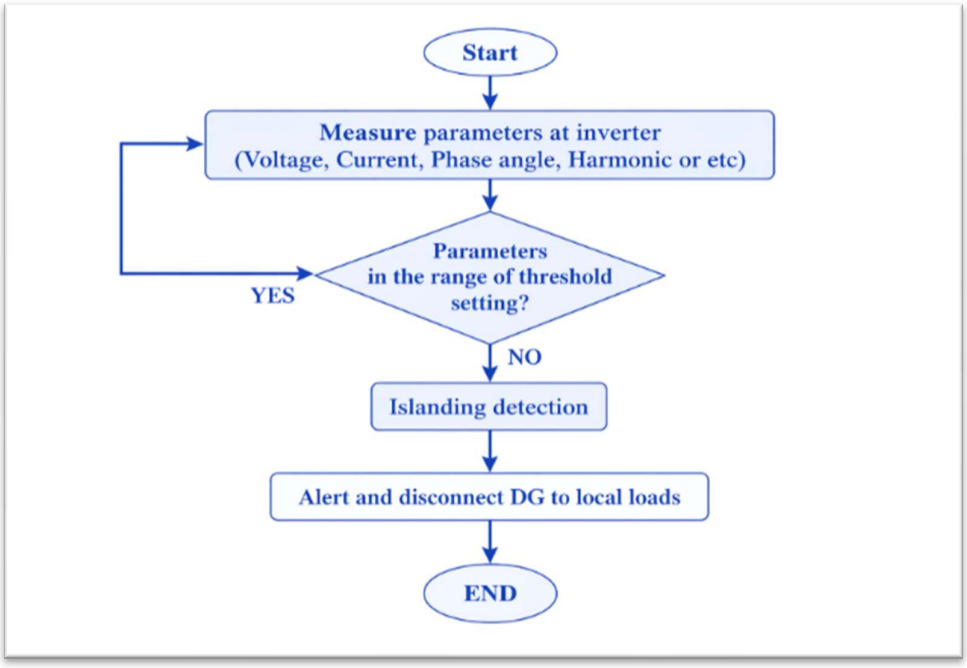


Figure 3:The generalized workflow of passive islanding detection schemes (IDSs)

Most common passive anti-islanding detection techniques are as follows;

3.1.1 **Under/Over Voltage and Under/Over Frequency (UOV/UOF)** protection is the most basic passive islanding detection technique. This method relies on the mismatch between renewable energy generation and local load within the islanded system. If the generated power approximately matches the local load (Pgen ≈ Pload), the resulting voltage and frequency deviations are minimal and insufficient to trigger protection, thereby creating a Non-Detection Zone.

3.1.2 **Rate of Change of Frequency (RoCoF / df/dt)** protection measures the rate at which system frequency changes. This method is effective when there is a significant active power imbalance between generation and load within the island.

3.1.3 **Vector Shift protection** detects sudden changes in the phase angle of the voltage vector, which may occur during islanding events. However, this method is prone to mal-operation during transmission system faults and switching events, even when islanding has not actually occurred.

These methods are simple and easy to implement and do not interfere with normal system operation; however, they suffer from a large Non-detection zone[1] (NDZ) and may malfunction when the local load closely matches the power supplied by the inverter.

3.2 Active Methods:

Active islanding detection schemes are developed to address the Non-Detection Zone (NDZ)[1] inherent in passive islanding detection methods. These schemes intentionally inject a small, controlled disturbance into the power system and analyze the system response to detect grid disconnection.

When the grid is strong and the RE generation remains connected with the grid, the injected disturbance is absorbed by the network without causing significant deviation in system parameters. However, under islanded conditions, where the system becomes electrically weak, the disturbance is amplified, leading to voltage or frequency deviations that exceed predefined thresholds.

As a result, islanding can be detected even when the generation and load are closely matched, a condition under which passive methods typically fail. In some active approaches, harmonic

[1] NDZ (Non-Detection Zone): The operating region in which an anti-islanding protection scheme fails to detect islanding due to minimal mismatch between generation and load. A smaller or zero NDZ indicates higher reliability and improved safety.

current injection is used to estimate grid impedance, which changes significantly during islanding, thereby resulting in a near-zero NDZ.

The generalized workflow of Active IDSs is depicted in Figure 4 below.

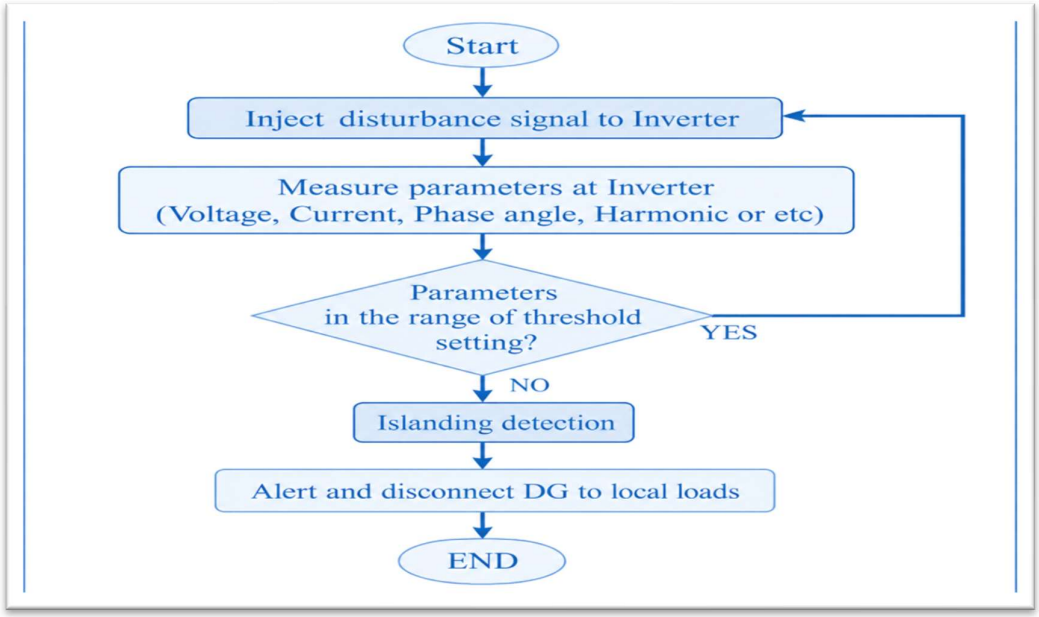


Figure 4:The generalized workflow of Active IDSs

Most common passive anti-islanding detection techniques are as follows;

3.2.1 Power Perturbation Method

This method introduces small, controlled variations in real or reactive power and monitors voltage and frequency response. It provides strong detection under balanced loads with a small NDZ. Low, randomized perturbations minimize power quality impact, and it works well in multi-DER systems. It can comply with IEEE 1547-2018 by disabling perturbations during ride-through events.

3.2.2 Active Frequency Drift

The inverter skews zero-crossing timing or phase angle to gradually change frequency. It offers moderate to strong detection and reduces NDZ compared to passive methods. Effectiveness depends on load characteristics. It may cause waveform distortion and harmonics, so careful tuning is needed in multi-inverter systems.

3.2.3 Sandia Frequency Shift

This method uses positive feedback between inverter phase and frequency. Small injected disturbances are amplified under islanding, triggering over/under-frequency protection. It has strong detection with small NDZ but may moderately affect power quality. Coordination is needed in high DER systems.

3.2.4 Reactive Power Variation Method

Controlled reactive power perturbations are injected, and voltage changes are monitored. It is effective in weak systems but NDZ increases in strong networks. Power quality impact is low, but coordination is needed in multi-DER setups to avoid masking and interference with voltage regulation.

Overall, the effectiveness of active islanding detection schemes lies in the fact that a small disturbance produces minimal impact when the RE generator is grid-connected but causes substantial variation in system characteristics when islanded.

While these methods significantly reduce or eliminate the NDZ associated with passive techniques, their primary limitations include potential power quality degradation and interaction among multiple inverters employing different active schemes. Therefore, careful design, coordination, and compliance with applicable standards such as IEEE 1547-2018 are essential for their successful implementation

3.3 Hybrid Methods:

Hybrid islanding detection schemes combine both passive and active islanding detection techniques in a coordinated manner to enhance detection reliability and overcome the limitations of individual approaches. In these schemes, the passive islanding detection method serves as the primary line of defense and continuously monitors system parameters without disturbing normal grid operation. When the passive method detects conditions indicative of possible islanding, an active detection technique is selectively activated to confirm the islanding condition.

By employing a two-stage detection process, hybrid islanding detection schemes effectively mitigate the large Non-Detection Zone (NDZ) associated with passive methods while limiting the continuous system perturbations introduced by active methods. During normal grid-connected operation, the passive stage ensures minimal impact on power quality, whereas the active stage provides decisive and reliable islanding detection only when required. This

coordinated approach results in higher overall detection effectiveness and improved system security. The generalized workflow of hybrid islanding detection strategies is depicted in the figure below.

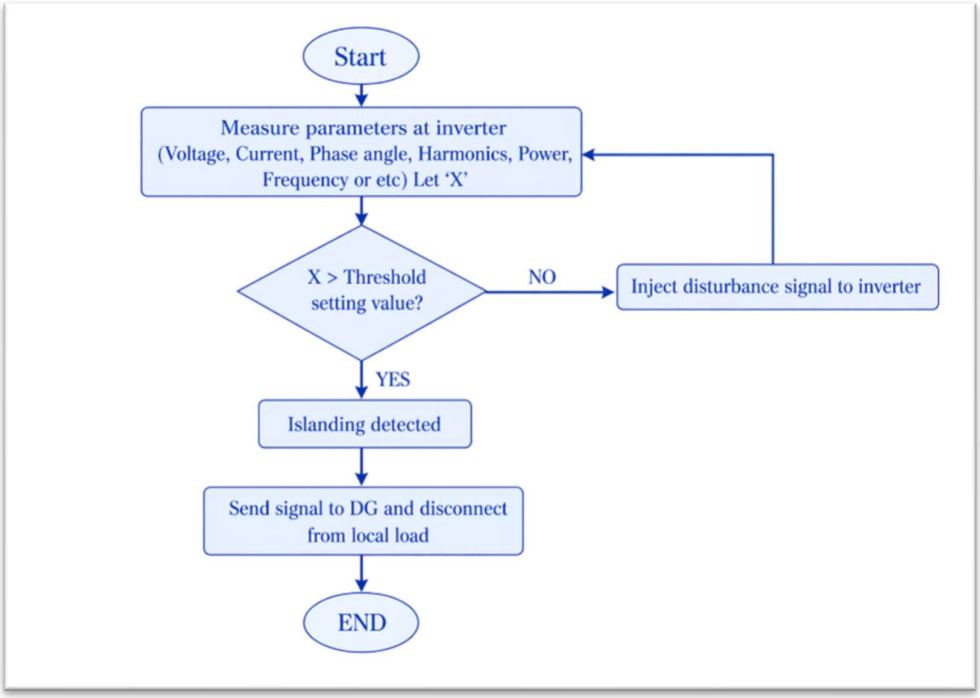


Figure 5:The generalized workflow of hybrid islanding detection strategies

3.4 Communication-Based Methods:

The Remote Islanding Detection Scheme (RIDS) or Direct Transfer Trip (DTT) detects islanding from the utility side rather than at the RE Generator end, using signals from phasor measurement units (PMUs), supervisory control systems, or breaker status information. These schemes are applicable to both inverter-based and synchronous-based RE Generation and rely on grid and network connectivity for operation.

The detection strategy is based on communication between the utility system and the RE Plant. Remote schemes depend on dedicated communication links to exchange information between the grid and the renewable energy (RE) plant. Measurements are typically performed at the grid side, often at the Point of Interconnection.

These schemes are generally of two types in RID, a PLC transmitter from the utility end system generates a continuous low frequency carrier signal of 200-400Hz. Each of the distributed generator connected at this interconnection with the utility has its own receiver, all listening

the transmitted signal. Whenever there is isolation from the utility side the signal gets lost and the distributed generation does not receive the signal which enables the permissive trip signal of the distributed generators and trips it. This method of Islanding detection is suitable for distributed generation where the length of feeders connecting the distributed generation is small. However, in case of RE plants the feeder lengths may be large and the carrier signal strength may attenuate while reaching the RE plants. Also, there are issues of cyber security since a deliberate attack may cause nuisance tripping of the plant. This method is at experimental stage for distributed generation connected

In DTT method, the utility substation communicates directly with the RE plant through SCADA or fiber-optic communication. When the substation breaker opens, a trip signal is immediately transmitted to the RE plant via links such as PLCC or OPGW, resulting in fast disconnection of the generation. The communication link plays a critical role in ensuring the reliable operation of the protection system.

DTT islanding detection schemes based on communication link are considered the most reliable anti-islanding protection methods, offering zero Non-Detection Zone (NDZ) and independence from the type of RE generation. However, this high reliability comes with increased system complexity, advanced signal processing requirements, and dependence on a robust communication infrastructure. Due to their high cost and need for reliable communication, these schemes are generally unsuitable for small-scale systems and are typically implemented in large utility-scale RE projects, usually above 5–10 MW, where communication infrastructure is already available or economically justified.

3.5 Computational intelligence-based Method:

Under this method, intelligent techniques that use advanced signal processing methods for effective and efficient islanding detection. This technique is generally highly accurate and can be employed where conventional islanding detection techniques fail, particularly in the cases of multi objective threshold selection-based criteria.
In practical implementations, inverter OEMs typically employ combinations of passive, active, and communication-based islanding detection schemes.

3.6 Comparison of Anti-Islanding Detection Techniques (AIDTs)

Before comparing islanding detection approaches, it is important to recognize that each technique operates within specific technical boundaries and application constraints. Common challenges applicable to most islanding detection schemes include the presence of a Non-Detection Zone (NDZ), the possibility of false or ineffective operation, potential system

instability or power quality degradation due to positive feedback, and relatively high implementation costs in certain cases.

Feature / Parameter	Remote IDSs/Communication methods	Passive AIDTs	Active AIDTs	Hybrid AIDTs
Basic principle	Detect islanding using communication or utility-side signalling from grid control center	Detects islanding by monitoring local electrical parameters only without injecting any signal	Detects islanding by injecting controlled disturbances into inverter output	Combines passive monitoring with selective activation of active disturbance
Detection location	Utility side / grid control centre	Local (at inverter or PCC)	Local (at inverter or PCC)	Local (at inverter or PCC)
Typical measured / influencing signals	Breaker status, communication signals, transfer-trip, PLC signals	Voltage magnitude, frequency, ROCOF, phase angle, harmonics	Same as passive methods plus injected ΔP, ΔQ, frequency or phase shift	Passive parameters continuously; active perturbation only when islanding is suspected
Detection mechanism	Direct confirmation of grid disconnection via communication	Relies on natural deviations in voltage or frequency caused by load–generation mismatch after islanding	Relies on artificially inducing deviations to accelerate detection of islanding	Two-stage detection: passive suspicion followed by active confirmation
Non-detection zone (NDZ)	Zero	High	Very small	Very low
Speed of detection	Very fast; instantaneous upon signal	Slower; depends on natural voltage/frequency drift	Faster due to forced perturbation	Moderate
Impact on power quality	None	None	Slight disturbance due to perturbation	Minimal
Reliability	Very high	Limited for balanced load conditions	High	Very high
Implementation complexity	Very high	Low	Moderate	High
Cost of implementation	High (especially for small systems)	Low	Moderate	Moderate to high
Typical examples	Transfer trip, PLC signalling	OV/UV, OF/UF, ROCOF, phase angle	Frequency shift, power disturbance,	Voltage–Q shift, positive feedback

Feature / Parameter	Remote IDSs/Communication methods	Passive AIDTs	Active AIDTs	Hybrid AIDTs
		jump, passive harmonic detection	impedance measurement, SMS, AFD, AFDPF, ALPS	with voltage imbalance
Suitability for high DER penetration	Limited	Poor	Good	Excellent
Compliance with IEEE 1547-2018	Fully compliant	Limited due to NDZ	Compliant with proper tuning	Highly compatible

Table 3:Comparison of Anti-Islanding Detection Techniques (AIDTs)

3.7 Anti-islanding philosophy adopted by DER inverter OEM in India.

3.7.1 Watt Power String inverter:

The Watt Power (WP) string inverter uses both passive and active anti-islanding control through reactive power and frequency positive feedback. The relationship is defined as:

$$\mathbf{\Delta I_q = k \cdot (f_r - f_{avg}) \cdot I_d}$$

Where:

- $\mathbf{f_{avg}}$= average grid frequency
- $\mathbf{f_r}$= instantaneous grid frequency
- $\mathbf{I_d}$= present active current

When the inverter is properly connected to the grid, the PCC clamps the voltage and frequency, making $\mathbf{f_r - f_{avg} \approx 0}$and $\mathbf{\Delta I_q \approx 0}$.

During islanding, when the grid is disconnected:

- If $\mathbf{f_r - f_{avg} > 0}$Hz, the inverter supplies inductive reactive power. The positive feedback between reactive power and frequency causes the system frequency to rise continuously until over-frequency protection activates.
- If $\mathbf{f_r - f_{avg} < 0}$Hz, the inverter supplies capacitive reactive power. The positive feedback causes the frequency to drop continuously until under-frequency protection activates.

- During islanding, the grid is disconnected, causing grid frequency deviation wherein inverters and nearby load form a self-powered islanded system. In this scenario, inverter will supply reactive power, which will intensify the frequency deviation until the active anti-islanding protection is triggered.

3.7.2 TEMIC central inverter:

- Passive Method: Voltage phase jump (range: +/- 1deg to +/- 35 deg)
- Active Method: Slip Mode Frequency shift (setting: +/- 15Hz)

3.7.3 TBEA central inverter:

TBEA inverters uses both passive and active anti-islanding control through reactive power and frequency positive feedback.

3.7.4 Fimer central inverter:

As per user manual data they employed Passive Method with configurable settings listed below

- Under frequency limit: -5Hz, Range (-30 Hz to 0 Hz)
- Over frequency limit: 5Hz, Range (0 Hz to 30 Hz)
- Under voltage limit: 7%, Range (0% to 100%)
- Over voltage limit: 130%, Range (100% to 200%)

3.8 Evaluating Islanding Detection Methods: Challenges and Optimal Selection of Island Detection method for RE Plants.

Remote, passive, active, and hybrid islanding detection schemes exhibit distinct operational characteristics and suitability depending on network scale and DER penetration.

Passive islanding detection methods are simple, low-cost, and non-intrusive, but their large non-detection zones significantly reduce reliability under balanced load–generation conditions. **A more critical operational flaw is their poor selectivity during transient faults. Because they lack an active verification mechanism, passive sensors often struggle to distinguish between a localized islanding event and a temporary system-wide fault. This signal deterioration frequently causes mal-operation, where renewable plants trip offline unnecessarily due to external disturbances, undermining the overall stability and reliability of the power system.**

Active islanding detection methods substantially reduce the non-detection zone and improve detection reliability by injecting controlled perturbations, though they introduce power quality disturbances and involve moderate implementation complexity and cost. **The primary risk occurs in high-density renewable clusters, where many CBRs operate in close proximity. In these environments, the small perturbations from individual plants can constructively interfere, magnifying power quality distortion to unacceptable levels. This collective injection often leads to unstable inter-inverter oscillations, where the detection logic of one plant interferes with another, potentially destabilizing the very local grid it is trying to monitor.**

Hybrid islanding detection methods combine passive monitoring with selective active confirmation, achieving very low non-detection zones, high reliability, minimal impact on power quality, and a balanced trade-off between complexity and cost, making them the most suitable approach for power systems with high penetration of converter-based renewable energy resources. **However, a critical vulnerability exists during system-wide transients or nearby faults. In large-scale renewable hubs, a single fault can cause passive sensors at multiple plants to simultaneously misinterpret the disturbance as an islanding event. This triggers a controlled "perturbation storm" where every plant injects a confirmation signal at once.**

In case of a RE plant connected to the grid, the most favorable choice is DTT islanding detection schemes based on communication, which offer zero non-detection zone and have the highest reliability, with no impact on power quality; however, their reliance on communication infrastructure results in implementation complexity and cost. **While the implementation involves higher upfront costs and infrastructure complexity, these factors are increasingly justified by the operational risks of local methods. When compared to the mal-operation of passive sensors, the cumulative distortion of active injection, and the synchronized "perturbation storms" of hybrid triggers in complex RE hubs, the stability offered by remote communication becomes essential. For high-penetration power systems, the investment in communication-based detection is a necessary trade-off to ensure grid resilience and prevent the widespread nuisance tripping of renewable assets.**

Section-4

Recommendations for the Adoption of a Uniform Anti-Islanding Protection Philosophy for Renewable Energy (RE) Plants.

During the discussions, it transpired that there are two distinct protections whose boundaries have not been demarcated and their settings have often resulted in mal operations. Further during the discussions, it was also noted that in case of DGs, AIPs have been serving both the purposes of protecting the inverters from damage due to adverse grid parameters and disconnecting the CBRs from the grid when the grid is not energized, due to economic reasons and simplicity. This was more predominant in the case of DGs and also RE plants that were introduced in the initial phases and therefore, recommendations for settings need careful examination of the detection methods employed in AIP. However, when the CBR-based RE plants got matured, more sophisticated protections were employed to the inverters and along with these protections, the AIP also co-existed. Therefore, in the case of RE plants connected through pooling stations, the AIP should only perform its intended purpose of disconnection of the RE generation when the grid is not energized and dedicated protection of the inverters should only protect the inverters. The approach, therefore, is to clearly separate out other protections and settings of these protections in such a way that they do not interfere in each other's jurisdictions. The inverter protection has also been dealt with in this section to demarcate the boundaries of both these protections.

The diagrams below illustrate the distinct operating regions in which the inverter is required to ride through disturbances within the LVRT/HVRT voltage–time windows and the regions in which anti-islanding protection is permitted to operate.

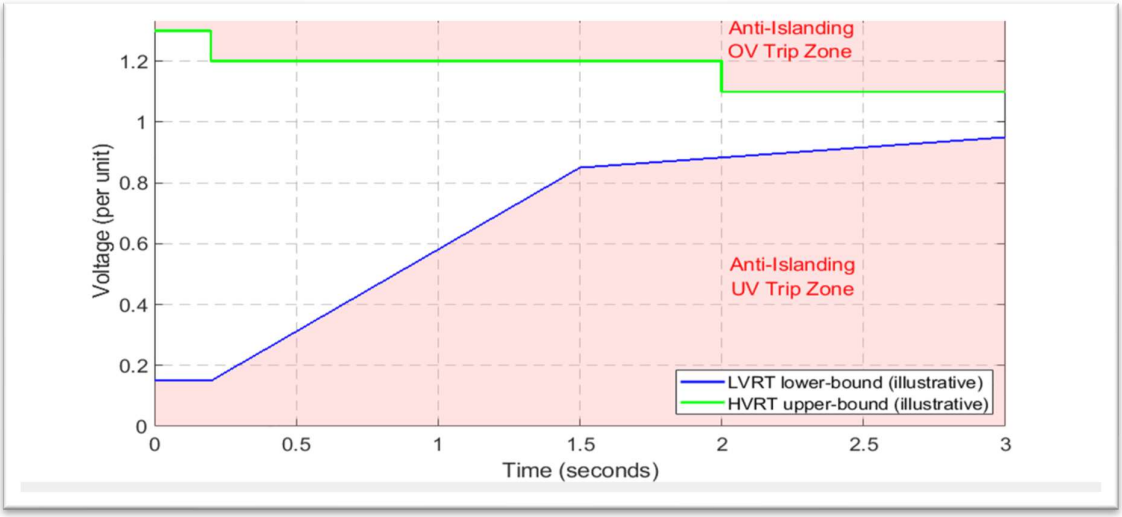


Figure 6 :Voltage Ride-Through with Anti-islanding Trip Zones (50 HZ)

As per CEA (Technical Standards for Connectivity to the Grid) Regulations, 2007 (and subsequent amendments), when the POI voltage remains within the LVRT or HVRT envelope, the RE generating station shall remain connected and support with reactive current injection as mandated in the grid code. Within the mandated ride-through window, anti-islanding tripping is intentionally suspended to prevent nuisance disconnections during grid disturbances and to ensure compliance with ride-through obligations.

Outside the permissible voltage and frequency envelopes, anti-islanding protection is permitted to operate, however not mandated unless there is a loss of mains/grid. In the event of confirmed islanding, the RE generation is required to cease energizing the system within two seconds. This approach ensures compliance with ride-through requirements while maintaining system safety. However, some RE generation facility may have a provision of islanded operation, local demand (for example, hybrid RE-BESS system) and adequate control mechanism in place for islanded operation. Such RE generation facility under a grid disturbance driven operating point outside VRT envelope, may be permitted to operate in islanding mode in due consultation and agreement with respective Transmission utility/SLDC/DISCOM/RLDC/RPC. The LVRT and HVRT values shown are representative of common practice in India.

Accordingly, CBR protections have been divided under Inverter protections and AIP as described in the following sections;

Recommendations on adoption of Anti Islanding methods and settings:

4.1 Inverter Protection:

The inverters of the grid-connected RE generators based on GFL, GFM and hybrid GFL & GFM CBRs shall have the following protections:

4.1.1 Activation of LVRT/HVRT protection should be kept outside VRT envelope as mandated in CEA (Technical Standards for Connectivity to the Grid) Regulations, 2007 (and amendments).

4.1.2 All LVRT/HVRT and frequency thresholds required in grid code regulations are to be complied at PoI, and in case of RE power plant, corresponding terminal voltages at WTG/inverter terminals shall be mapped accordingly based on the voltage drop/rise in the collector system of RE to avoid undesired undervoltage/overvoltage tripping of WTGs or PV inverters.

4.1.3 The other settings, such as Grid Short Circuit protection, AC over-current protection, DC over-voltage protection, overheat protection, DC overload protection, Earth fault protection, Lightning protection, Leakage current protection and Grid imbalance protection should be kept as recommended by the OEM.

4.2 AIP protection for RE plants connected to 66kV and above Voltage level:

4.2.1 Existing grid connected RE plants:

- **If the RE plant supports Hybrid, Active and Passive AIPs, Hybrid AIP must be chosen as first choice and all other AIPs should be disabled.**

- **If the RE plant supports Active and Passive AIPs, Active AIP must be chosen and all other AIPs should be disabled.**

- **If only Passive method is supported, then RoCoF method of Island detection should be disabled and Vector shift > 10 ^{o} with a time delay of 1.8 sec be adopted so that the generation is tripped within 2 seconds of Island detection through this method.**

- **Since Under-frequency/over-frequency is not an issue with CBR-based RE generators, the frequency for tripping the IBRs may be kept +/- 3Hz of the normative frequency with a time delay of 1.8 seconds so that it will avoid mal-operations. A necessary amendment is required in clause B2(2) of the Central Electricity Authority (Technical Standards for Connectivity to the Grid) (Amendment) Regulations, 2019.**

4.2.2 For all grid-connected RE Plants (to be commissioned after April 2027):

- **For all the transmissions emanating from the RE plants should be equipped with optical fiber/PLCC communication so that the AIP method can be implemented.**
- **The AIP should be based on the DTT Islanding Detection Scheme and all other Islanding Detection Schemes for grid-connected RE Plants shall be disabled. For ensuring correct detection, the DTT-based AIP should acquire the status signal of breakers of outgoing lines of Plant to**

pooling station (ISTS) and HV & LV breakers of IDT (Interconnecting Duty Transformer.

The schematic diagram of grid Connected RE plants is as given below;

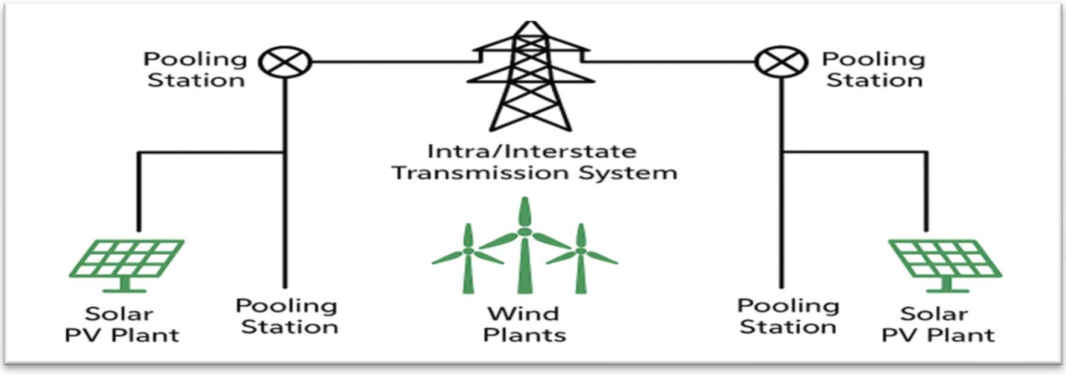


Figure 7:schematic diagram of grid Connected RE plants

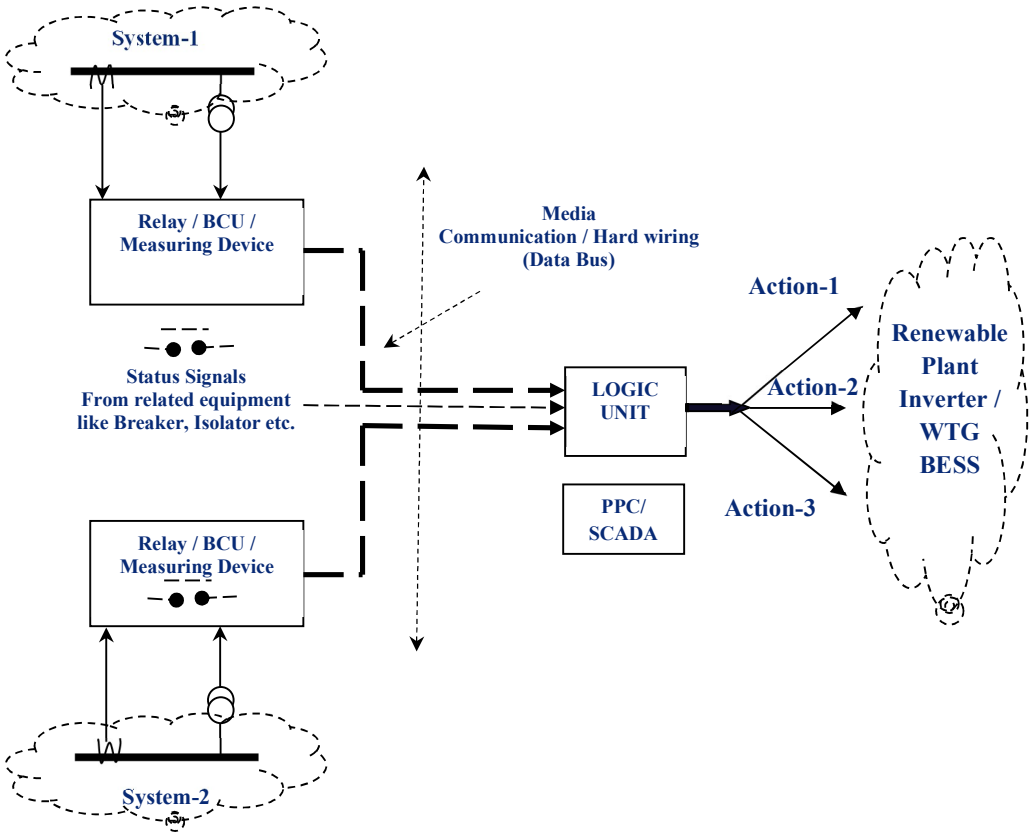


Figure 8:General Structure of DTT – Based on Analogue and Status

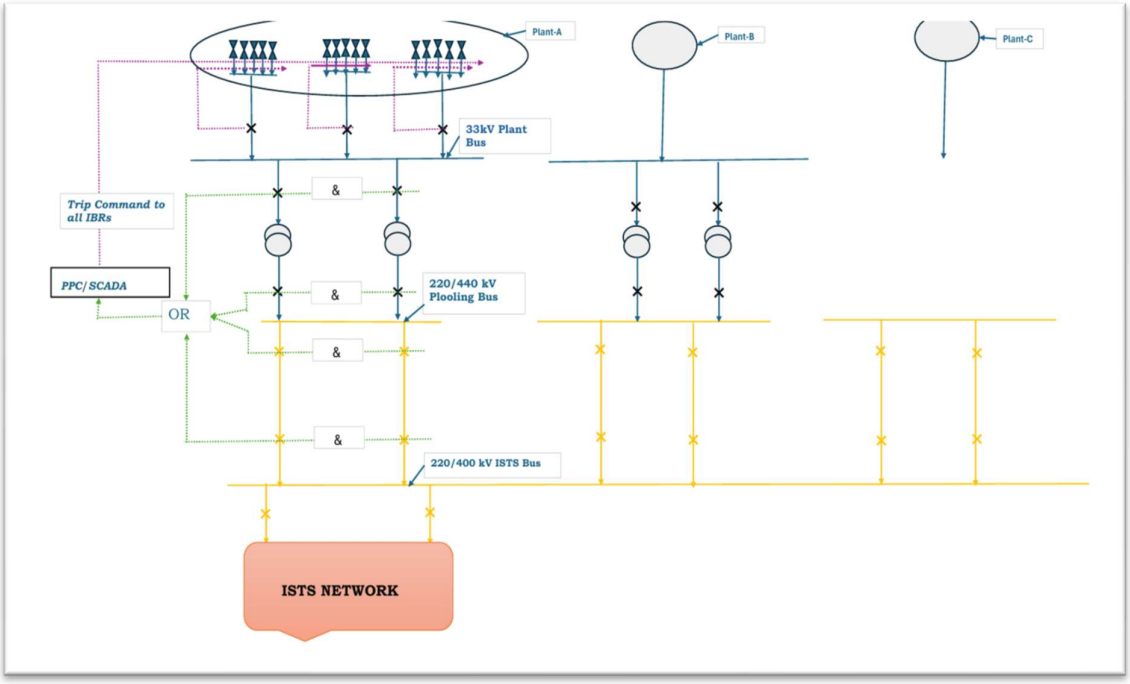


Figure 9:Diagram showing SLD and the RID scheme

- **The generic DTT (Direct Transfer Trip) logic diagram for anti-islanding protection tripping of RE generators, which is based entirely on breaker status, is depicted in the above diagram. The inclusion of voltage signal has been omitted in this logic. However, for redundancy the scheme may include under voltage signal and the scheme may be finalized in consultation with the respective system operator/RPCs.**

- **Remote-end Grid Breaker Status (Open/Close) to be received via PLCC / OPGW (DTPC Channel is preferable), providing the breaker status signal of evacuating lines terminating at ISTS pooling station to the PPC/SCADA of RE generators shall be the responsibility of the ISTS licensee. The status of other breakers under the control of RE generator/RE Developer shall be made available to the PPC/SCADA by the respective RE generator/RE Developer.**

- **The actual field implementation of the DTT logic shall be done in consultation and approval of the concerned system operator (RLDC/SLDC).**

4.3 AIP protection for RE plants connected to HV system (11kV up to 66kV):

4.3.1 Existing:

- **If the RE plant have a facility of Hybrid, Active and Passive AIPs, Hybrid AIP must be chosen as the first choice and all other AIPs should be disabled.**

- **If the RE plant has a facility of Active and Passive AIPs, Active AIP must be chosen and all other AIPs should be disabled.**

- **If only the Passive method is available, RoCoF method & all other methods of Island detection should be disabled and Vector shift > 10 ^{o} with a time delay of 1.8 sec shall be implemented.**

4.3.2 For all grid-connected RE Plants connected to HV system (11kV up to 66kV): (to be commissioned after April 2027):

- **Hybrid method of islanding detection should be used.**

4.4 General important considerations regarding AIP protection for RE plants included in Islanding schemes:

4.4.1 RE Plant having a storage system which are intending to run in an Islanded operation for charging of the storage system, shall automatically disable the AIP when an island is formed, subject to approval of the concerned system operator/RPC.

4.4.2 In case of RE Plant having sufficient storage to run continuously as a microgrid that operates independently or in conjunction with the main grid, the AIP may be decided in consultation with the respective system operator.

4.4.3 The AIP of GFM IBRs will have to be bypassed during extending black start from the GFM-based battery storage system or any such system capable of extending black start.

Section-5

Inclusion of RE generators in Islanding Schemes

The recommendations of AIP for different types of RE plants have been given in the preceding section. This section deals with the precautions and changes in settings required in case of inverters of RE generating plants for including them in the Islanding schemes.

5.1 Important points to be considered for inclusion of RE Plants in Islanding schemes:

5.1.1 RE plants capable of operating in islanded mode should be included in Islanding scheme strictly in consultation with the local TRANSCO & DISCOM and approval of RLDC/RPC.

5.1.2 It is preferable that the RE generators included in the Island are based on Grid Forming IBR or a mix of Grid Forming & Grid Following CBR-based RE Generators.

5.1.3 The ratio of conventional generation to CBRs-based RE generation should preferably be more than 70%.

5.1.4 Island formation only with Grid Following CBRs without GFM CBRs or conventional generators is not technically feasible since GFL requires an external reference supply at its terminal.

5.1.5 The RE weather station telemetry should be available at the Islanding Control Centre and should be monitored during Islanded operation.

5.1.6 The shift toward a converter-based resource (CBR) system reduces grid inertia, making the island susceptible to high Rates of Change of Frequency (RoCoF). To prevent nuisance tripping of renewable energy (RE) sources, RoCoF-based Anti-Islanding Protection (AIP) of RE plants should be disabled and replaced with a DTT Islanding Detection Scheme. If a remote scheme is not feasible, AIP should be based on Hybrid or Active Islanding Detection method**.**

5.1.7 Reliable islanding schemes require high certainty in both load and generation, as island formation is often triggered by unpredictable grid events. The intermittent nature of renewable energy (RE) makes maintaining a post-islanding balance difficult. Further, high solar and wind penetration reduces system inertia, leading to high RoCoF and deteriorated frequency nadir even during small load-generation imbalances. To mitigate these risks, an Automatic Load-Generation Balancing Scheme (ALGBS) or equivalent frequency control shall be deployed to ensure real-time generation-demand balance. Additionally, load-shedding blocks should be divided into smaller increments to enable finer control and minimize frequency excursions within the island. Any such load-generation control/ALGBS shall be disabled during grid connected operation.

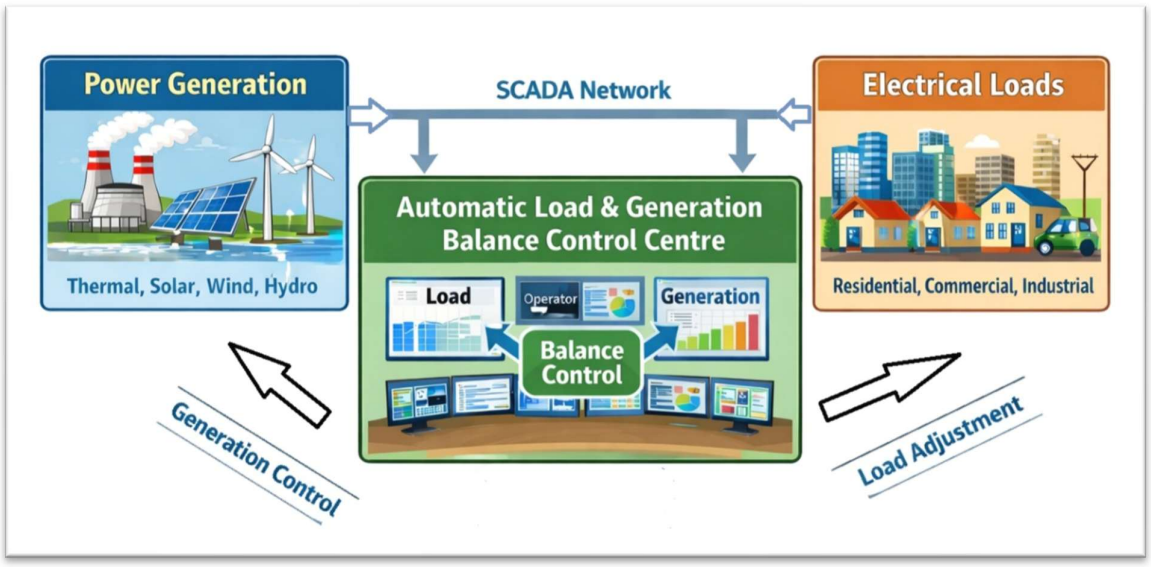


Figure 10:General structures ALGBS

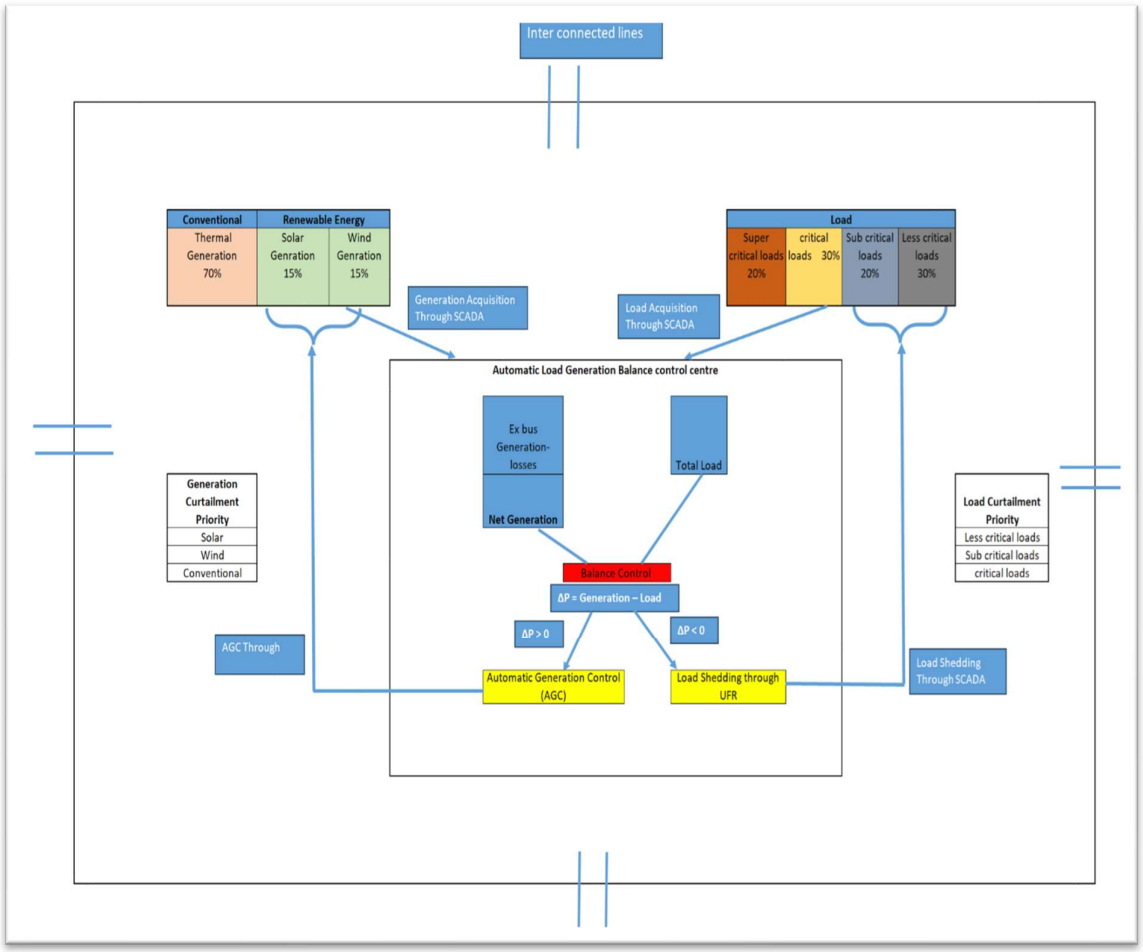


Figure 11:General Architecture of ALGBS

The ALGBS, hosted at the Island's Control Centre, utilizes SCADA to acquire real-time feeder data on local loads and generation within the Island. The ALGBS is activated when frequency reaches to 48.7Hz, so that under normal conditions, unintended tripping of loads is avoided. By continuously monitoring the Load-Generation Balance (LGB)—including system losses—the scheme identifies the necessary quantum of load shedding and transmits "Trip Enable" signals to the relevant feeders. These feeders are equipped with Under Frequency Relays (UFR); when the frequency threshold of the UFR is met and the ALGBS enable signal is present, the feeder trips to restore balance in the Island. Ultimately, the ALGBS ensures that demand dynamically tracks available generation to maintain island stability. The frequency settings for Pre-Island Preparatory Load Shedding, Islanding shall typically be kept as follows;

5.2 <u>Recommendations:</u>

5.2.1 The trigger frequency settings proposed are on the higher side than those of a traditional islanding scheme with conventional generators due to the uncertainty of available generation in the Island and the less time available for getting prepared for Island due to low Inertia of the System.

Pre-Island Preparatory Load Shedding: 48.5 Hz:

Major disturbance is sensed by frequency decay. At 48.5 Hz under frequency load shedding takes place by way of opening designated feeders, prior to islanding, to ensure generation rich island.

The load-shedding blocks should be of a smaller size than the traditional Islanding schemes, preferably 2% of the Island generation capacity, to have finer control over the frequency after Island formation. Otherwise, the logic of the ALGBS should be such that it automatically selects the feeders so that the generation in the Island is always greater than around 2%.

Islanding: 48.1 Hz:

- **The RE generators should be switched to frequency control mode and conventional generators should be switched over to speed control mode at 48.1 Hz.**
- **The ALGBS starts tracking the load generation in the island and if frequency is falling and load is more automatic trip enable signal is passed to the feeders. When frequency in the Island reaches 49Hz, the designated feeders are tripped.**

- **A logic needs to be built that will take care of RE generation variability or intermittency, particularly for the period of operation during Low to High (Ramp-up) and High to Low (Ramp-down) for establishing the Load-Generation Balance during the transitions.**

- **Auto restoration of loads in blocks of 2% should be possible if frequency rises to 50.5Hz**

Part-B- Protection Review of RE connected system

Section: 6

Assessment of the Impact of Renewable Energy (RE) Integration on Earth Fault Protection and Other Critical Protection Functions

In this section, the impact of the integration of Renewable Energy (RE), particularly converter-based resources such as solar PV and wind, on earth fault protection and other critical protection schemes in power systems is reviewed. The traditional protection schemes deployed in the power system have been designed primarily around the response of the synchronous generators (SGs) to different fault conditions and other contingency events. Several features of fault current from SGs, such as their high current amplitude and sequence components, are used to design several conventional protection schemes. However, current output from CBRs is limited by thermal capacity of converter switches and modulated by the control system, and therefore, the fault current characteristics are significantly different from those of SGs. Therefore, a protection system built on the fault characteristics of SGs is prone to maloperate when subjected to low magnitude and peculiar fault current characteristics from CBRs. It is imperative to formulate corrective measures, such as modification of traditional protection systems or using new protection schemes, to ensure adequate and accurate operation of system protection.

In RE-rich grids, the following issues are mainly observed:

1. Non-detection of faults by primary protection schemes such as distance protection and overcurrent protection & Directional Earth fault protection at the RE end.
2. Delayed fault clearance at the grid end for faults occurring in the Zone-2 portion of the line connected with RE generation.
3. Impact on distance protection
4. Impact on differential protection

Due to the above factors, several protection challenges arise, which are illustrated as follows.

6.1 Impact on Earth Fault Protection

6.1.1 Reduced Fault Current Contribution

Traditional synchronous Machine provide high short-circuit current (as high as 7-8 per unit) during faults, enabling overcurrent relays to operate quickly. In contrast, inverter-based RE sources are current-limited and typically contribute maximum of only about 1.1–1.4 per unit current for a few cycles during a fault. Moreover, the fault current from

IBR/CBRs is not always inductive/reactive as is the case in SGs, rather its power factor can be as high as close to unity depending on the fault level.

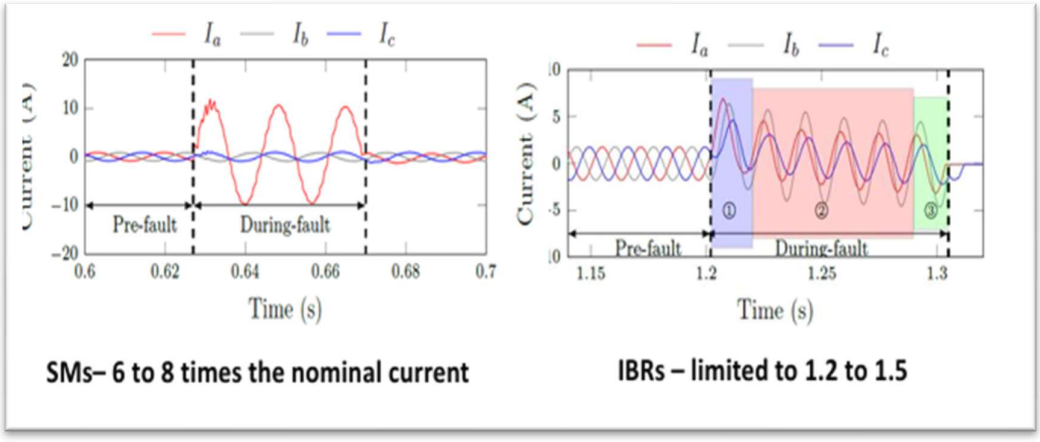


Figure 12:Indiaction of Fault current of SMs and IBR

As a consequence:

- Directional Earth Fault (DEF) and Residual Overcurrent (ROC) relays may fail to detect faults.
- Sensitive Earth Fault (SEF) settings require revision to enable detection of low-current earth faults.

6.1.2 Change in Zero-Sequence Network

In traditional synchronous generator behaviour, the response during asymmetrical faults is well understood through sequence component analysis. However, in current inverter-based resources /CBRs, the negative sequence components depend on the control system design and implementation.

Furthermore, RE plants often use transformer connections such as Dy or Yg–D, and they may not have a solid earth reference.

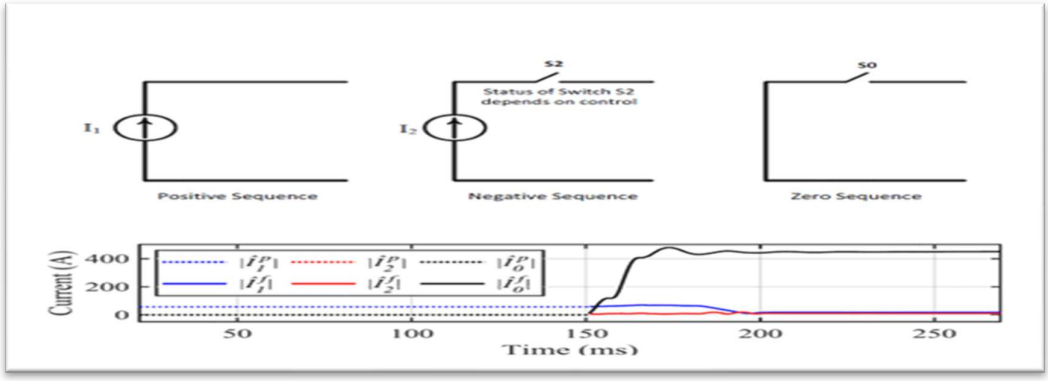


Figure 13:Zero sequence Network and Response of SMs and IBR/ CBR

Due to this following impact was observed:

- Changes in zero-sequence voltage and current paths, reducing the effectiveness of traditional neutral displacement relays.
- Isolated or high-impedance grounding practices in RE parks further complicate earth fault detection.

6.1.3 Inverter Control Behavior

During fault conditions, inverters may block current injection or switch to fault ride-through (FRT) mode in accordance with grid code requirements. Furthermore, the behaviour of the inverter during FRT determines the nature and magnitude of the fault current contribution.

Due to this control-dependent response, CBRs may or may not fully comply with grid code requirements under all fault conditions.

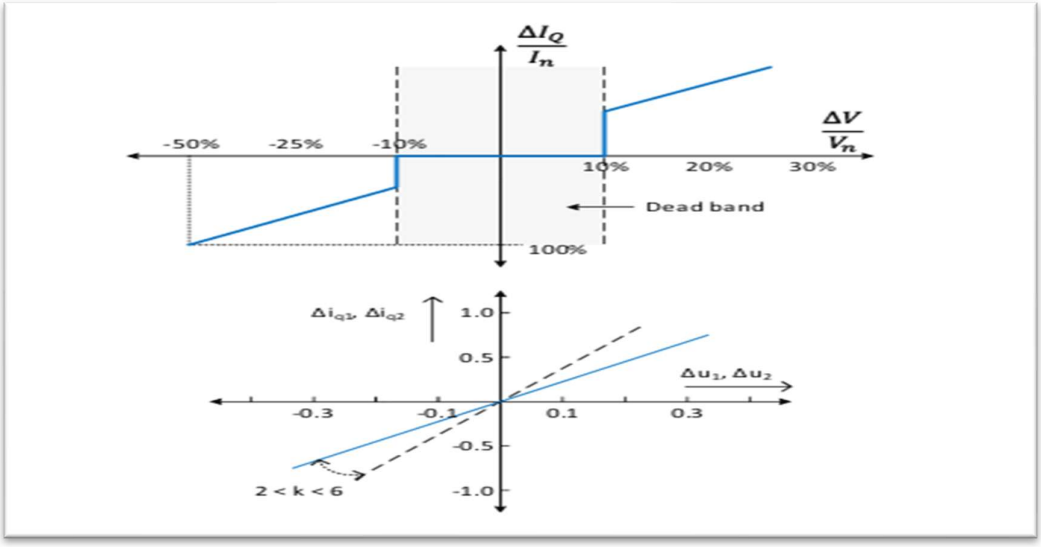


Figure 14:Inverter control Behavior during Fault

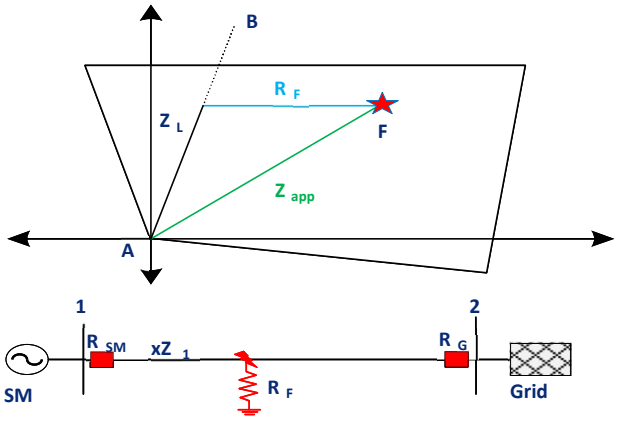
As a result:

- Earth fault current contribution may be delayed or absent.
- Protection elements may under-reach due to insufficient fault current levels.

6.2 Impact on Other Critical Protection Aspects

6.2.1 Distance Protection

The distance relaying principle is widely employed in transmission line protection.



(a)

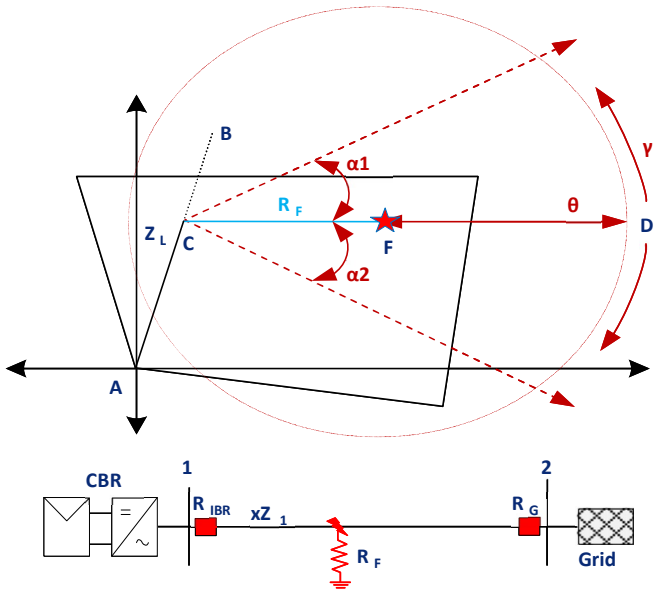


Figure 15: Apparent impedance calculated during a resistive fault by the relay (a) near a conventional generator and (b) an CBR.

The line AB in the relay characteristics in Figure 15 represents the transmission line, and for a bolted fault on the transmission line, the apparent impedance falls anywhere on this line, depending on the location of the fault. However, fault currents are not always resistance-free, especially when the fault current travels through the tower, ground or the fault current involves an arc. For such resistive faults in a transmission line, the apparent impedance is given by,

$$Z_{app} = xZ_{1L} + \left(\frac{I_F}{I_L}\right) R_F = xZ_{1L} + \Delta Z$$

Where, Zapp is the calculated apparent impedance, xZ1L is the positive sequence impedance of the transmission line till the fault point, IF and IL are the fault current and the relay local current respectively, and RF is the fault resistance which is a purely horizontal component. The CBR control system limits the fault current to 1.1 - 1.4 p.u. to protect the switches, whereas the fault contribution from the synchronous generator-dominated grid will be around 6 to 8 times the nominal value. The ratio will therefore take a high value, and the apparent impedance will tend to have a large horizontal shift (line CD in Figure) and may fall outside the relay characteristics. The apparent impedance calculation as shown in Figure will have multiple errors as listed below:

1. Limited fault current from CBRs resulting in further horizontal shift (FD)
2. Large phase angle difference between the fault currents injected by CBRs and the grid, causing an angular shift in either anti-clockwise (α1) or clockwise (α2) direction.
3. Frequency deviation of CBR fault currents from the system fault current results in apparent impedance rotation along a circle (center F and radius FD).

6.2.2 Differential Protection

Differential relaying makes quick decisions and offers high sensitivity and reliability. Unlike distance protection, differential protection of transmission lines is unaffected by power swing or load encroachment. Moreover, the operation of differential protection is not affected by the issues of zero sequence mutual coupling and uncertainty of line parameters. In RE dominated region, for a fault on the interconnecting transmission line, the fault current from CBR and from the grid may not have the same phase angle due to phase angle modulation by the converter control system. This discrepancy in the fault current angles at the ends of the transmission line may cause differential relay maloperation. A large difference in the fault current angles between CBRs and the grid can lead to low sensitivity for differential relays, and the effect is more prominent when the CBR is connected to a weak grid. For high-resistance faults in a line connecting IBR to a strong SG-based grid, the current through the faulted path is very low and even close to zero when it is assumed that the CBR control suppresses the zero-sequence current. Moreover, for a severe bolted fault, the differential relay was more prone to maloperate for longer lengths, higher CBR capacity and faults closer to RE plant.

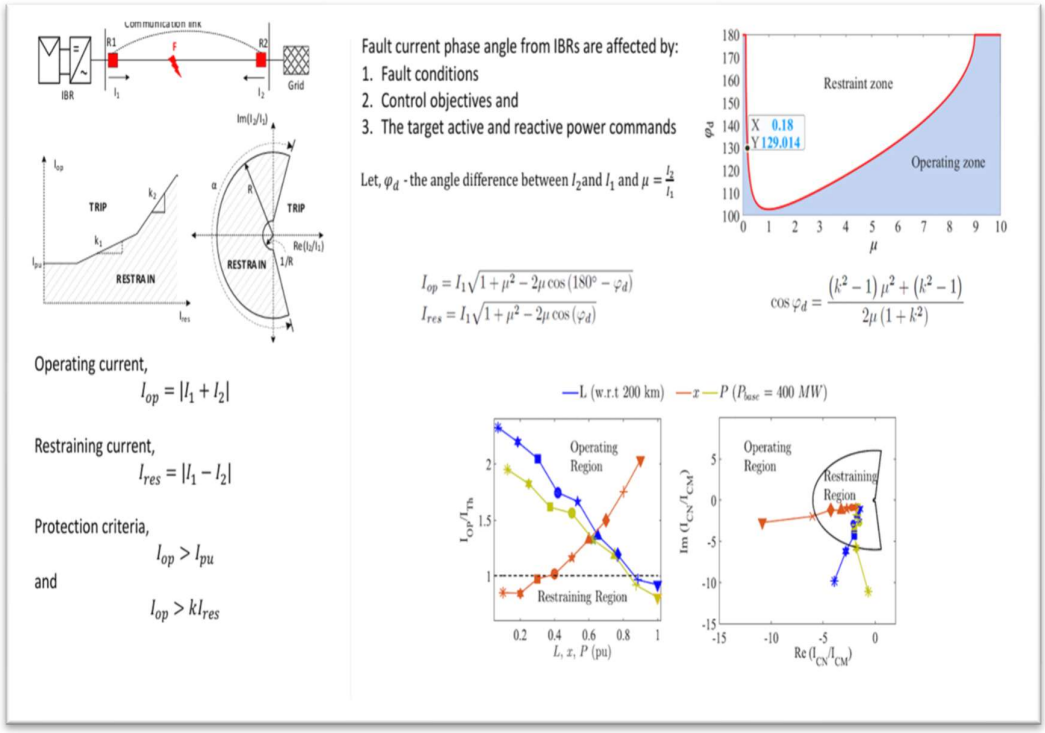


Figure 16: Response of Differential Protection during fault in case of IBR/CBR

6.2.3 Overvoltage Protection

In RE dominated regions, post fault clearance accompanied by delayed active power recovery and lack of adequate reactive power support may lead to sustained overvoltage in the transmission system and consequently at the RE plant side leading to overvoltage tripping of transmission lines and inverters/WTGs. Therefore, adequate overvoltage protection settings and coordinated protection schemes shall be worked out to address this specific protection challenge.

6.2.4 Frequency Protection

High RE penetration reduces overall system inertia, leading to higher rates of change of frequency (ROCOF) during system disturbances. Moreover, RE dominated systems are more prone to high frequency deviations compared to conventional system including power system oscillations that need to be factored in the protection system.

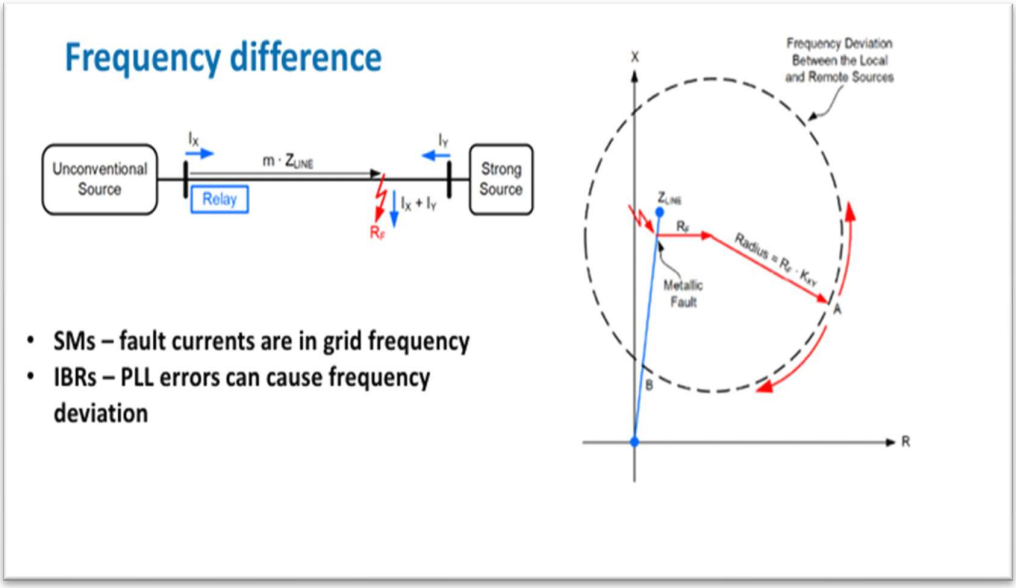


Figure 17: Response of Frequency Protection during fault in Case of SMs and IBR/CBR

6.3 Negative Sequence Current Injection Requirements from CBRs connected at Transmission Levels:

Negative sequence current injection is being made mandatory primarily because of the fundamental shift from Synchronous Generators (SGs) to Converter-Based Resources (CBRs) like wind and solar.

Traditional grid protection relies on the "natural" behavior of SGs, but inverters do not naturally produce the same electrical signatures during faults. Mandatory injection is required for the following critical reasons:

6.3.1 Enabling Fault Detection (Relay Sensitivity):

Conventional protection relays, such as Instantaneous Negative Sequence Overcurrent (50Q), identify unbalanced faults (like a single-phase-to-ground fault) by looking for a high level of negative sequence current.

Inverters naturally suppress negative sequence current to protect their own power electronics. Without a mandatory requirement to inject it, an inverter might provide almost zero negative sequence current, leaving a fault "invisible" to existing relays.

Mandatory injection ensures there is enough current for relays to "see" and clear the fault before it damages equipment.

6.3.2 Maintaining Proper Directionality (67Q Elements):

Relays often use the phase angle between negative sequence voltage and current to determine if a fault is "Forward" (on the protected line) or "Reverse" (behind the relay). Because inverters are software-controlled, their current can be in any phase relationship. Without a standard, an inverter might inject current that makes a forward fault look like a reverse fault, causing the relay to fail to trip or trip the wrong line.
Standards and Grid codes (like IEEE 2800 and VDE-AR-N 4120) mandate an inductive phase relationship (leading voltage by 90° to 100°), essentially forcing the inverter to "act like a machine" so legacy relays can understand the signal.

6.3.3 Accurate Fault Identification (Phase Selection)

When a fault occurs, distance relays must decide which specific phase to trip. This logic often compares the angle of negative sequence current to zero sequence current.
In systems with high inverter penetration, the "unnatural" phase angles from uncontrolled inverters cause misidentification. For example, a Phase-A-to-ground fault might be incorrectly identified as Phase-C-to-ground.
Standards ensure a consistent angular relationship, allowing the relay to accurately identify and trip only the faulted phase.

6.3.4 Supporting "Weak" Grids

As the SGs are not coming up, the grid is becoming "weak" (low short-circuit ratio). In these areas, there is very little natural fault current. Mandatory injection ensures that even in a grid dominated by renewables, there is a predictable "synthetic" fault response to maintain system stability.

Summary of Mandatory Protection Requirements:

Problem without Injection	Consequence	Mandatory Solution
Low Amplitude of negative sequence currents	Relays don't "see" the fault.	Minimum k-factor (gain) for injection.
Random Phase Angle	Relays trip the wrong direction.	Forced Phase Angle (90° inductive).

Inverter Suppression	Phase selection fails.	Decoupled Sequence Control (DSC).

Table 4:Summary of Mandatory Protection Requirements

6.4 Recommendations:

6.4.1 **During LVRT:** For unbalanced faults, in addition to increased positive-sequence reactive current, the CBR unit shall inject negative sequence current which is dependent on CBR unit terminal (inverter terminal) negative sequence voltage. The minimum magnitude of the negative sequence current injection should be 1% of the negative sequence voltage at the CBR terminal. The negative sequence current injection should lead the CBR unit terminal negative sequence voltage by an allowable range as specified below: - 90 degrees to 100 degrees for full converter-based CBR units - 90 degrees to 150 degrees for type III WTG.

Assuming pre-fault negative sequence current output is zero or negligible, the negative sequence reactive current injection during a fault is an incremental negative sequence reactive current (ΔIR-2). If the CBR unit's total current limit is reached, either ΔIR-1, or ΔIR-2, or both may be reduced with a preference of equal reduction in both currents. Additionally, the incremental positive-sequence reactive current (ΔIR_1) injection shall not be reduced below incremental negative sequence reactive current (ΔIR_2). In case of type III WTGs, the ΔIR_1 and ΔIR_2 injection during a fault is driven by machine parameters and control dynamics and may not be controllable in a manner described above.

When operating in reactive current priority mode, a full converter-based CBR unit shall be capable of injecting negative-sequence reactive current of 50% of its maximum current rating when the CBR unit terminal negative-sequence voltage is greater than or equal to 25% of nominal voltage. Injecting higher negative-sequence reactive current for a lower negative-sequence voltage at CBR unit terminals is permitted. In case of type III WTGs, the negative-sequence current injection is due to machine parameters and control dynamics.

The above provisions may be appropriately considered in the future amendments of the Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations.

Section:7

Recommendations on improving the protection system for RE systems

In this section, measures to mitigate the challenges imposed by Renewable Energy plants in case of earth faults and other critical protection aspects using presently available protection relay functionalities, such as directional earth fault, distance protection and line differential protection, are reviewed. Certain measures that can be implemented without any additional capital expenditure are recommended. These measures are outlined below.

7.1 Directional Earth Fault (DEF) relays:

To improve the performance and reliability of DEF relays in systems with high Renewable Energy (RE) penetration, several technical measures can be implemented:

7.1.1 Modify Directional Polarizing Methods:

Traditional voltage or current polarization can be unreliable with inverters.

- **Memory Voltage: Use "Voltage Memory" features that store the pre-fault voltage phase angle for a few cycles. This prevents the relay from being confused by the rapid phase shifts inherent in inverter control loops.**

- **Dual Polarization: Use both Zero-Sequence Voltage (V_0) and Zero-Sequence Current (I_0) from a local transformer neutral simultaneously to increase the security of the directional decision.**

The above approaches of settings may be implemented if it is available in the existing relays. In case of upcoming projects, the project developers/ISTS licensees may incorporate these features in the relay's specifications.

7.1.2 Implement Negative Sequence Logic (with Caution):

If the inverters are programmed to provide a controlled amount of negative sequence current (I_2):

Directional Negative Sequence (67Q): This is often more sensitive than standard earth fault (67N) logic. However, this requires coordinating with the RE developer to ensure the inverters don't suppress I_2 entirely during faults.

The line owners may take care of this fact in the existing/upcoming system.

7.1.3 Compensate for Capacitive "Sympathetic" Tripping:

In systems with extensive cabling (like wind farms):

- **Sensitive Earth Fault (SEF) with Harmonic Filtering: Use relays that can filter out the high-frequency transients and charging currents common in cable networks.**

- **Phase Angle Shifting: Adjust the Relay Characteristic Angle (RCA) to ensure the relay ignores the purely capacitive (90-degree) current that flows during external faults.**

The line owners may take care of this fact in the existing/upcoming system.

7.1.4 Adopt Adaptive Protection Settings (Futuristic approach):

Since fault levels vary based on weather (wind/solar intensity), "fixed" settings are often inadequate.

- **Multiple Setting Groups: Program the relay with different setting groups that switch automatically based on the number of inverters online or the status of the RE plant.**

- **Dynamic Pickup Thresholds: Use relays that can communicate with the plant's SCADA system to lower pickup thresholds when the RE source is the primary infeed (weak infeed conditions).**

Since this approach requires proper study and coordination among the transmission utilities, these types of schemes are required to be implemented in consultation with RPCs/RLDCs.

7.2 Implementation of Line Differential Protection:

As mandated by the Central Electricity Authority (CEA), all transmission lines are being provided with Optical Ground Wire (OPGW). Accordingly, duplicated line differential protection may be considered for transmission lines connected to Renewable Energy (RE) generators. Present-day line differential relays support direct end-to-end communication for line lengths of up to approximately 100 km. Considering the advantages of unit protection, line differential schemes are effective in mitigating challenges arising due to low fault current contribution from the RE side.

This may be made applicable to all upcoming projects in the vicinity of RE Generation pocket by CTUIL.

7.3 Implementation of Weak-End Infeed Logic at RE Generation End

In general, the RE generation end contributes little or no-fault current to transmission line faults, making the operation of distance protection functions difficult. In cases where a fault occurs in the Zone-2 portion of the line from the grid end, fault clearance may be delayed due to non-receipt of carrier signals. To address this issue, weak-end infeed logic at the RE end enables echo-back of the carrier signal to the grid end when there is no reverse zone pickup at the RE end, thereby accelerating tripping. This logic is particularly useful when line differential protection is unavailable due to reasons such as communication failure.

The above approaches of settings may be implemented if it is available in the existing relays. In case of upcoming projects, the project developers/ISTS licensees may incorporate these features in the relay's specifications.

7.4 Permissive Overreach Scheme for Distance Protection

Considering the challenges associated with low fault current contribution from the RE end, it is prudent to mandatorily implement permissive overreach schemes for distance protection on transmission lines connected to RE generation.

The above approaches of settings may be implemented if it is available in the existing relays. In case of upcoming projects, the project developers/ISTS licensees may incorporate these features in the relay's specifications.

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केंद्रिय विद्युत प्राधिकरण/Central Electricity Authority

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To,

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विषय:- संबद्ध नवीकरणीय ऊर्जा संयंत्रों के लिए एकसमान द्वीप-विरोधी संरक्षण दर्शन तैयार करने हेतु समिति का गठन के संबंध में।

Subject: Constitution of Committee for the preparation of the Uniform Anti-islanding Protection Philosophy of the connected RE plants-reg.

Sir/Madam,

SRPC vide email dated 26.02.2025 informed that during the SR Protection Co-ordination Sub-Committee (PCSC) deliberations, instances were observed where renewable energy (RE) generation and downstream loads continued to operate during complete outages of certain substations, suggesting possible formation of electrical islands, though this couldn't be confirmed due to lack of PMU data. SRLDC inferred such islanding and sought details from TRANSCOs/STUs about connected generation, load, and anti-islanding protection schemes. In response, TRANSCOs/STUs requested guidance on appropriate voltage and frequency settings for RE stations. SRLDC recommended an under-frequency setting of 47.5 Hz and highlighted that various OEMs use differing protection mechanisms, including df/dt and phase displacement protections. To ensure consistency, PCSC advised SRLDC to consult NLDC and the National Protection Standing Committee (NPSC) for insights from other regions and to develop a uniform protection philosophy applicable across the Southern Region.

2. In this context, the above matter was subsequently deliberated in the 1st meeting of the National Protection Standing Committee (NPSC) held on 26.03.2025, wherein, the following were decided :

a) After detailed deliberations it emerged that the Anti Islanding protection depends on frequency, rate of change of frequency, Vector Shift Protection or angle detection and Voltages at the time of grid supply failure. It often mal-operates by falsely detecting islanding. This results in premature inverter disconnection (within 2 seconds), thereby disabling Low Voltage Ride through (LVRT) functionality.

b) The reasons for mal operation of the Anti-Islanding features may be due to the low set values of the sensing parameters or voltage distortion at the time of disturbances. However, it was felt that false detection of unintended island, which does not actually exist, is not justifiable for noncompliance with grid support requirements.

c) The matter needs detailed deliberations and may be referred to Protection subgroup of NPC for detailed deliberations and way forward. If required, a separate group including some expert from industry may be formed at subgroup level.

3. The issue was further discussed in the 16th meeting of the National Power Committee (NPC) held on 04.07.2025. It was decided to constitute a Committee under the Chairmanship of SE (Protection), WRPC, with representation from WRPC, SRPC, GRID-India, experts from IITs, OEMs, POWERGRID, a major Renewable Energy Developer, and NPC, for preparation of a Uniform Anti-Islanding Protection Philosophy for grid-connected Renewable Energy (RE) plants.

4. In this regard, NPC Secretariat vide email dated 16.09.2025 requested WRPC, SRPC, GRID-India and POWERGRID, to send nominations for the Constitution of the Committee for the preparation of the Uniform Anti-islanding Protection Philosophy of the connected RE plants. Further, WRPC and SRPC have also been requested to seek nominations from IITs (for academic expertise), OEMs, and a major Renewable Energy (RE) developer for the said Committee. Accordingly, based on the nomination received from WRPC, SRPC, GRID-India, POWERGRID and from IITs /IISc (for academic expertise), OEMs, and a major Renewable Energy (RE) developer, the Committee is constituted as follows:

S. No.	**Name**	**Designation**	**Organization**	
1.	Shri. P. D. Lone	Superintending Engineer	WRPC	**Chairman**
2.	Shri. Satyendra Kumar Dotan	Director (NPC)	CEA	Member
3.	Shri. Moka Venkata Subba Reddy	Executive Engineer	SRPC	Member
4.	Dr. Sarasij Das	Associate Professor	IISc Bangalore	Member
5.	Shri. Venkateswarlu Ande	Vice President	M/s Greenko	Member
6.	Shri. Thakur Prasad	Senior Vice President	M/s. Watt power	Member
7.	Prof. Zakir H. Rather	Professor	IIT Bombay	Member
8.	Shri Sanjay Bhatt	Assistant Vice President	AGEL	Member
9.	Shri. H. L. Parekh	Additional General Manager	GIPCL	Member
10.	Shri. Naveen Kumar	Chief Technology Officer (CTO)	TBEA Inverter	Member
11.	Shri. Ankit Vaish	Deputy General Manager	POWERGRID	Member
12.	Shri. Madhukar Goodelli	Deputy General Manager	WRLDC / GRID-India	Member
13.	Shri. Deepak Sharma	Deputy Director	WRPC	**Member Convener**

5. The **Terms of Reference** of the Committee are as follows: -

a) Review existing Anti-Islanding Protection practices and identify gaps.
b) Study causes of mal-operations and suggest corrective measures.
c) Recommend uniform national settings for frequency, df/dt, and voltage thresholds.
d) Ensure compatibility with LVRT/HVRT and grid code requirements.
e) Examination of the impact of RE on earth fault protection and other critical protection aspects shall also be examined by the Committee.
f) Prepare a comprehensive report with recommendations on above (a) to (e)
g) Any other suggestions/recommendations on related matters.

6. The Committee shall submit its report within six months.
7. The committee can co-opt for any member, as per the requirement.

This issues with the approval of the competent authority.

भवदीय,/Yours faithfully,

24/10/2025

(ऋषिका शरण/Rishika Sharan)

(सदस्य सचिव (एनपीसी) /Member Secretary(NPC))

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Copy for kind information to:

1. SA to Chairperson, CEA,
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