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India Smart Grid Forum

Roadmap and Recommendations for Rollout of Grid Integrated Smart Inverters for Distributed Energy Resources

Joint Technical Report by ISGF and NISE

www.indiasmartgrid.org

India Smart Grid Forum

MARCH 2026

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ABSTRACT

In January 2025, the Bureau of Indian Standards (BIS) published IS 18968:2025, India's first comprehensive national standard governing the interconnection and interoperability of Distributed Energy Resources (DERs). As a modified adoption of Institute of Electrical and Electronics Engineers Standard IEEE 1547-2018, IS 18968 incorporates India specific grid requirements through the normative National Annex J, including 50 Hz system frequency, revised voltage thresholds, reactive power capabilities, and abnormal voltage and frequency ride-through settings. The standard establishes performance categories for normal and abnormal operating conditions, mandates voltage regulation functions such as Volt-Var and Volt-Watt, defines frequency droop response, and specifies communication and interoperability requirements for grid integrated smart inverters.

This Technical Report presents a structured roadmap for nationwide implementation of IS 18968 across regulatory, technical, and institutional domains. It outlines recommended DER performance category assignments, India specific voltage and frequency trip settings, and guidance for enabling advanced inverter functions to support grid stability under increasing renewable energy penetration. The roadmap highlights critical regulatory gaps particularly in frequency droop specifications and voltage trip clarifications and proposes coordinated actions by CEA, CERC, SERCs, DISCOMs, and BIS.

The roadmap also documents India's first IS 18968 compliance testing study conducted by the India Smart Grid Forum (ISGF) and National Institute of Solar Energy (NISE), demonstrating technical feasibility while identifying configuration gaps in OEM default inverter settings. A phased implementation roadmap (2025–2032) is proposed to transition IS 18968 from a published standard into an operational foundation for secure, interoperable, and grid-supportive DER integration in India.

EXECUTIVE SUMMARY

India now possesses its own national standard for the interconnection and interoperability of distributed energy resources (DERs) IS 18968: 2025, published by the Bureau of Indian Standards (BIS) in January 2025. This standard is a modified adoption of IEEE Standard 1547™-2018, adapted for Indian grid conditions through the normative National Annex J, which makes binding changes to frequency references (50Hz replacing 60 Hz), voltage tables, service criteria, reactive power settings, and abnormal operating performance trip thresholds.

IS 18968: 2025 establishes, for a comprehensive Indian standard governing how DERs including rooftop solar, battery energy storage systems (BESS), wind generators, combined heat and power, and electric vehicle chargers, must interconnect with and behave on India's distribution grid. It defines performance categories, voltage and frequency ride-through requirements, reactive power and voltage regulation capabilities, communication and interoperability mandates, and test and verification frameworks. Today's DERs with multiple roles are hybrid in nature so that devices can be added on the DC side (PV, different battery types) or AC side (Standby backup generator).

The Core Policy Imperative

IS 18968: 2025 exists on paper. The urgency now is implementation. The standard's requirements only deliver grid stability benefits once they are embedded in Central Electricity Authority (CEA) regulations, State Electricity Regulatory Commission (SERC) interconnection procedures, BIS product certification schemes, Distribution Company (DISCOM) interconnection agreements, and commissioning verification protocols. This roadmap provides a structured, phased pathway to achieve that embedding with technical recommendations grounded directly in the clauses of IS 18968: 2025.

This roadmap is organized into five implementation phases spanning 2025–2030. Each phase builds on the previous, ensuring regulatory groundwork precedes technical deployment, and that evidence from pilots informs national rollout. The roadmap covers: the critical India specific modifications in National Annex J; performance category assignment; voltage regulation function deployment; communications and DER integration; testing and certification ecosystem development; consumer protection provisions; and state level leadership priorities.

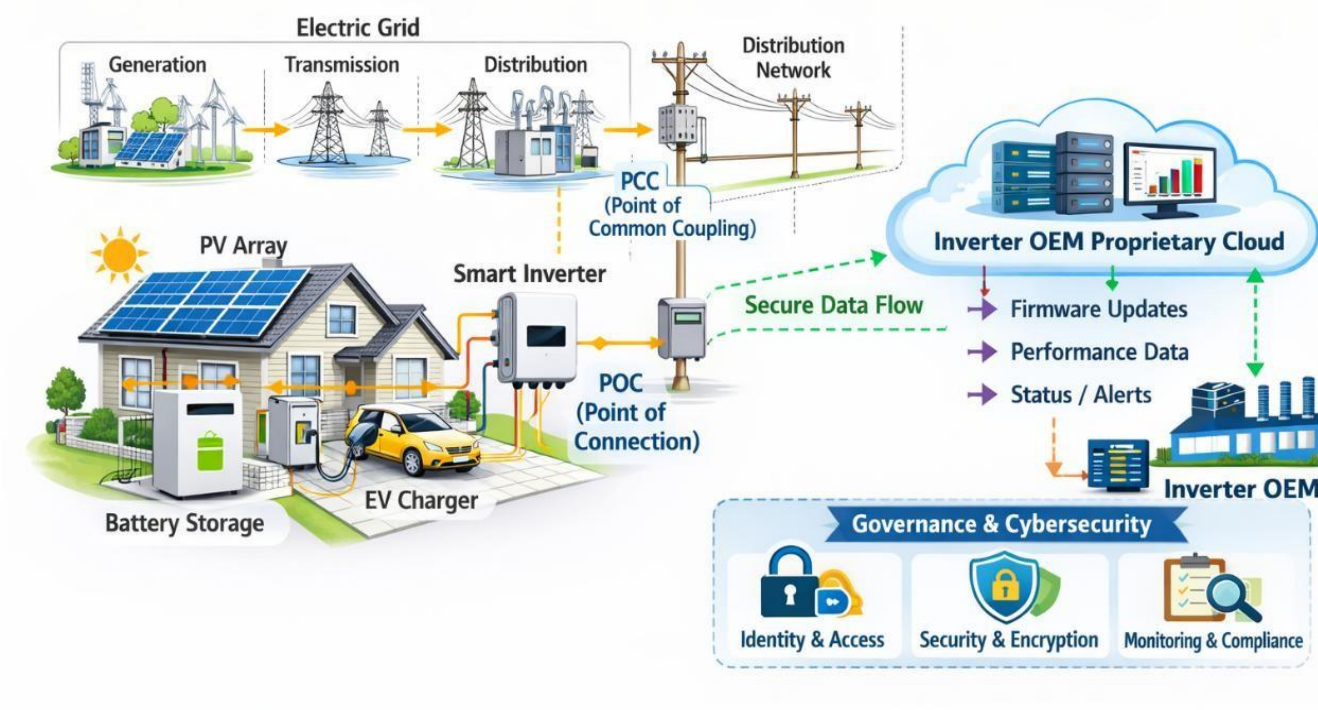

Figure 1: Architecture of a Smart Grid-Integrated Residential Solar System with Cloud Governance

1 UNDERSTANDING IS: 18968 – 2025: INDIA'S DER INTERCONNECTION STANDARD

1.1 Status and Structure

IS 18968: 2025 was adopted by BIS on the recommendation of India Smart Grid Forum (ISGF) establishing the Grid Integration of Renewables Sectional Committee (ETD 46) and published in January 2025. It is a modified adoption of IEEE Standard 1547™-2018, meaning the full text of the IEEE standard is adopted as the body of the Indian standard, with country specific modifications set out in the normative National Annex J. Key structural features:

- The standard is applicable to all DER technologies interconnected to Indian electric power systems (EPS) at primary or secondary distribution voltage levels
- It covers reference points of applicability (RPA), measurement accuracy, cease-to-energize requirements, control capabilities, reactive power and voltage regulation, response to abnormal grid conditions (Voltage and frequency ride-through), power quality, islanding, secondary networks, interoperability and communications, and test and verification
- It introduces the concept of the Authority Governing Interconnection Requirements (AGIR) in India, this would be CERC, SERCs, or CEA depending on the DER type and voltage level
- Emergency and standby DERs (As defined by the authority having jurisdiction) are exempt from ride-through, interoperability, and intentional islanding requirements

1.2 National Annex J — India-Specific Modifications (Normative)

National Annex J is normative (not merely informative), meaning its provisions are mandatory for Indian implementations. It makes the following specific changes to the IEEE base text.

Table 1: National Annex J — India-Specific Modifications

Annex J Clause	IS 18968 Clause Modified	What Changes	Indian Specific Requirements
J-1	Throughout	System frequency	50Hz replaces 60Hz as the nominal frequency for all testing and operational conditions.
J-2	4.3, Table 2	Applicable voltages at low-voltage PCC	Adds: Single phase line-to-neutral for 230V DER units; Three phase line-to-line for 400V DER units, reflecting Indian LT voltage standards.
J-3	4.4, Table 3	Measurement accuracy	Frequency measurement range changed to 40–55 Hz (From 50–66Hz); measurement window for frequency accuracy adjusted to 50 cycles under steady-state.
J-4	4.10.2, Table 4	Enter service criteria	Voltage: min ≥ 0.9 p.u., max ≤ 1.1 p.u. (tighter than IEEE default). Frequency: min ≥ 49.5Hz, max ≤ 50.1Hz.

J-5	4.10.3(b)	Enter service delay default	Default minimum delay changed to 60s (from 30s in IEEE base text).
J-6	4.10.4	Synchronisation voltage step limit	5% of nominal for both MV and LV PCC (IEEE base: 3% for MV, 5% for LV).
J-7	5.2, Table 7	Reactive power capability	60% injection and 60% absorption capability as % of nameplate kVA (Vs. varying IEEE defaults).
J-8	5.3.3, Table 8	Volt-VAR settings: Category A and B	$V_{Ref\ range}$: 0.9–1.1 V_N (wider than IEEE's 0.95–1.05 V_N). Q1 & Q4 for Category B set at 60% (Vs. 44% in IEEE base).
J-9	5.3.3, Table 9	Watt-VAR settings: Category A and B	Q3 for Category B set at 60% of nameplate apparent power rating for absorption and injection.
J-10	6.4.1, Tables 11–13	Abnormal voltage trip thresholds	Simplified: Overvoltage trip at V > 1.1 p.u. with 2s clearing time; Undervoltage trip at V < 0.8 p.u. with 2s clearing time (Applies to all categories).
J-11	6.5.1, Table 18	Abnormal frequency trip thresholds	OF: 52Hz default, 0.2s (range 50.05–52.0Hz). UF: 47.5Hz default, 0.2s (range 47.5–48.8Hz).
J-12	6.5.2	Frequency continuous operation range	47.5Hz to 52Hz. For OF events 50.05–52.0Hz: DER shall continue operating and adjust power per CEA requirements; in absence of CEA requirements, per area EPS/distribution license requirements.

Critical Implementation Note on National Annex J

The simplified voltage trip table in J-10 (overvoltage > 1.1 p.u. at 2s; undervoltage < 0.8 p.u. at 2s, replaces the three-tier Category I/II/III trip structure from the IEEE base text. This has significant implications for how DISCOMs and SLDCs specify trip settings for DERs. CEA and CERC must clarify whether J-10 applies to all three abnormal operating performance categories or only sets a minimum floor. The J-12 provision deferring frequency-droop active power adjustment to CEA requirements means CEA must urgently issue those requirements, as the standard currently leaves a normative gap.

2 IS 18968 PERFORMANCE CATEGORIES — ASSIGNING THE RIGHT CATEGORY TO INDIAN DERS

2.1 The Two-Dimensional Category Framework

IS 18968: 2025 organises DER performance requirements into two independent category dimensions. Every DER connected to an Indian grid must be assigned a category in each dimension by the AGIR (in India: CERC, the relevant SERC, or CEA).

Table 2: Two-Dimensional Category Framework

Normal Operating Performance: Category A or B (Reactive Power and Voltage Regulation)	Abnormal Operating Performance: Category I, II, or III (Ride-Through)
Category A: Minimum reactive power performance. Suitable for lower penetration areas and DER types with limited reactive power capability.	**Category I:** Essential ride-through meets basic bulk power system stability needs. Optional frequency droop for low frequency conditions. ROCOF ride-through 0.5 Hz/s.
Category B: Enhanced reactive power performance, all Category A capabilities PLUS watt-var (Active power, reactive power) mode and volt-watt (Voltage active power) mode. Mandatory for high penetration areas or areas with frequent large DER output variations.	**Category II:** Enhanced ride-through full BPS stability and coordination with existing reliability standards. Mandatory frequency droop for both low and high frequency. ROCOF: 2.0 Hz/s. **Category III:** Highest ride-through for very high DER penetration; addresses both BPS and distribution reliability. ROCOF: 3.0 Hz/s.

2.2 Recommended Category Assignment for India

IS 18968: 2025 places responsibility for category assignment on the AGIR. For India, the following assignment framework is recommended, to be formalised through CERC guidelines and state SERC orders.

Table 3: Recommended Category Assignment for India

DER Type/Context	Normal Category	Abnormal Category	Rationale
Residential rooftop solar ≤ 10 kW (PM Surya Ghar)	Category A	Category I (Transitional) Category II (From 2027)	Low individual impact: phased upgrade as DISCOM DER capacity grows.
Commercial/Industrial rooftop 10 kW – 500 kW	Category B	Category II	Significant grid impact; must support volt-var and volt-watt functions.
Ground Mounted solar/wind > 500 kW at distribution level	Category B	Category II or III (per SLDC)	High penetration impact; SLDC coordination required per J-12.

Battery Energy Storage Systems (All sizes)	Category B	Category III	Full ride-through and dynamic voltage support capability; bidirectional operation.
EV charging infrastructure (Grid-interactive)	Category B	Category II or III	Bidirectional capability; growing role in frequency response.
Combined Heat and Power (CHP)/gas Gensets	Category A	Category I	Limited grid support capability: societal benefits justify lower category.
DER in high-penetration circuits (>15% solar peak penetration)	Category B (mandatory)	Category III (recommended)	Grid stability requires maximum reactive support and ride-through.

Per IS 18968 Clause 1.4 and Annexure B, the AGIR is responsible for providing guidance on category assignment to Area EPS operators (DISCOMs/SLDCs). CERC should issue a national category assignment guideline within 12 months of the roadmap's adoption. SERCs may specify more stringent categories within their jurisdiction.

3 VOLTAGE REGULATION FUNCTIONS UNDER IS 18968: 2025

3.1 Requirements of IS 18968: 2025

IS 18968 Clause 5 mandates specific voltage and reactive power control capabilities for DERs, differentiated by Normal Operating Performance Category. The standard requires DERs to be capable of the following modes — with Area EPS operator (DISCOM/SLDC) approval required before any voltage regulation function may be actively deployed.

Table 4: Voltage Regulation Mode (IS 18968 Clause 5)

Voltage Regulation Mode (IS 18968 Clause 5)	Category A	Category B	Default State
Constant Power Factor Mode (Clause 5.3.2)	Mandatory	Mandatory	Enabled (unity PF = 1.0 — no reactive power)
Voltage-Reactive Power (Volt-Var) Mode (Clause 5.3.3)	Mandatory	Mandatory	Disabled — must be enabled by Area EPS operator
Active Power-Reactive Power (Watt-Var) Mode (Clause 5.3.4)	Not required	Mandatory	Disabled — must be enabled by Area EPS operator
Constant Reactive Power Mode (Clause 5.3.5)	Mandatory	Mandatory	Disabled — must be enabled by Area EPS operator
Voltage-Active Power (Volt-Watt) Mode (Clause 5.4.2)	Not required	Mandatory	Disabled — must be enabled by Area EPS operator

3.2 India Specific Volt-Var Settings (National Annex J-8)

National Annex J-8 modifies the Volt-Var curve parameters from the IEEE base text. The most significant changes are:

- **V_{Ref} range:** Extended to 0.9–1.1 V_N (wider than IEEE's 0.95–1.05 V_N), better accommodating India's wider distribution voltage variations.
- **Q1/Q4 (Reactive Power at Voltage Extremes) for Category B:** Set at 60% of nameplate apparent power rating for injection/absorption (Vs. 44% in IEEE base text), providing stronger voltage support capacity.
- **Open Loop Response Time:** 10s default for Category A, 5s for Category B (Same as IEEE base text).
- **Autonomous V_{Ref} Adjustment:** IS 18968 Clause 5.3.3 permits DERs to autonomously calculate V_{Ref} based on locally measured voltage with a time constant adjustable from 300–5000s to accommodate feeder-to-feeder voltage offsets, stable voltage support also requires an explicit **reactive power response rate**

limit (dQ/dt, e.g., VAR/s or %kVARs/s) and a **deadband/droop** design. Without a ramp-rate limit and hysteresis/deadband near nominal voltage, fast local Volt–VAR action across many DERs can produce “bang-bang” behaviour (reactive power hunting) and adverse interactions with OLTC and switched capacitor banks. The solution is to pair autonomous VRef with: (i) a defined low-Q deadband around nominal voltage, (ii) bounded droop slope, (iii) dQ/dt limiting, and (iv) DISCOM-configurable/override settings (including freeze-VRef during switching events). This preserves DER voltage-support benefits while maintaining distribution-system stability and clear DISCOM responsibility for coordinated voltage regulation.

3.3 Implementation Recommendations for DISCOMs and SERCs

- DISCOMs must not leave all inverters on the default unity power factor setting indefinitely. The default is a starting point — IS 18968's value is only realised when voltage regulation functions are enabled by the area EPS operator (DISCOM) after network analysis
- For circuits with peak solar penetration above 10%, DISCOMs should conduct power flow studies to determine optimal Volt-Var settings, and issue DISCOM specific utility required profiles to inverter installers during the interconnection process
- The Volt-Watt function (Category B only) should be deployed with caution and only after consumer protection provisions are in place, as activation will reduce active power output for DER customers on high voltage circuits. IS 18968 Clause 5.4.2 confirming this function is disabled by default and requires area EPS operator approval to enable
- SERCs should issue state-level guidelines specifying: (a) The conditions under which DISCOMs must enable voltage regulation functions; (b) Reporting requirements for Volt-Watt activation; and (c) Consumer compensation mechanisms where Volt-Watt causes excessive generation curtailment.
- India's voltage standards (230V single-phase, 400V three-phase LT; 11/33kV MV) must be reflected in the volt-var V_{Ref} settings. J-8's wider V_{Ref} range (0.9–1.1 V_N) accommodates the reality that many Indian LT networks operate with voltages significantly above or below nominal

Reactive Power Priority (IS 18968 Clause 5 — Unchanged from IEEE Base)

IS 18968 prescribes reactive power priority over active power priority for voltage regulation, consistent with IEEE 1547-2018. This means when an inverter is current limited at maximum active power output, and is called on to provide reactive power for voltage regulation, it must reduce active power. This is particularly relevant for residential inverters in India, which are typically connected to the customer's load centre via a circuit breaker whose current rating limits the inverter's total output. DER system designers and DISCOM interconnection staff must account for this when sizing systems and explaining performance to customers.

Note: Most inverters if required under a FIT mode or a Net metering mode will need to compensate the customer for the loss of the KW in order to provide KVAR.

4 RESPONSE TO ABNORMAL GRID CONDITIONS — VOLTAGE AND FREQUENCY

4.1 India Specific Voltage Trip Settings (National Annex J-10)

National Annex J-10 replaces the three category voltage trip tables (Tables 11–13 of the IEEE base text) with a single simplified Indian table.

Table 5: India Specific Voltage Trip Settings

Trip Function	Voltage Threshold (p.u. of nominal)	Default Clearing Time (s)
Over Voltage Trip	V > 1.1 p.u.	2.0s
Under Voltage Trip	V < 0.8 p.u.	2.0s

This simplified table is a significant change from the IEEE base text, which has OV1, OV2, UV1, UV2 trip functions with different thresholds and clearing times for each of the three abnormal categories. The Indian J-10 table appears to set a baseline CEA and CERC must clarify through subsidiary regulation whether J-10 supersedes all category specific trip tables or merely sets the outer limits. Until this is clarified, it creates a normative gap that could lead to inconsistent DISCOM implementation.

4.2 Voltage Ride Through Requirements (IS 18968 Clause 6.4.2)

The voltage ride through tables (Tables 14–16) are unchanged from the IEEE base text and apply based on the assigned abnormal operating performance category. The continuous operation region for all categories is 0.88 p.u. to 1.10 p.u. Key ride-through requirements.

Table 6: Voltage Ride Through Requirements

Category	Low Voltage Ride Through	High Voltage Ride Through	ROCOF Ride Through
Cat I	Mandatory operation 0.70–0.88 p.u. (4s formula); Permissive 0.50–0.70 p.u. (0.16s)	Permissive operation 1.10–1.20 p.u. up to 1s; Cease to energize >1.20 p.u.	0.5 Hz/s
Cat II	Mandatory operation 0.65–0.88 p.u. (8.7 s formula); Permissive 0.30–0.65 p.u.	Same as Category I for high voltage	2.0 Hz/s
Cat III	Mandatory operation 0.50–0.88 p.u. (20 s); Momentary cessation 0.50 p.u. (1s)	Momentary cessation 1.10–1.20 p.u. (12 s); Cease to energize >1.20 p.u.	3.0 Hz/s

For Indian DISCOMs, the mandatory operation region is the most operationally critical: during low voltage events (Such as faults on adjacent feeders), Category II and III DERs must not reduce total apparent current below 80% of the pre-disturbance value. This is a significant improvement over current Indian inverter practice, where inverters typically trip immediately during voltage sags.

4.3 India Specific Frequency Trip Settings (National Annex J-11 and J-12)

J-11 replaces the frequency trip thresholds with Indian 50 Hz equivalents.

Table 7: India Specific Frequency Trip Settings

Function	Default Frequency (Hz)	Default Clearing Time (s)	Allowable Range
Over Frequency (OF)	52.0 Hz	0.2s	50.05–52.0 Hz, 0.16–1000s
Under Frequency (UF)	47.5 Hz	0.2s	47.5–48.8 Hz, 0.16–1000s

J-12 sets the continuous operation frequency range as 47.5 Hz to 52.0 Hz. For over Frequency events between 50.05 Hz and 52 Hz, DERs shall continue operating and adjust active power output per CEA requirements. In the absence of CEA requirements, the DER operator shall follow the requirements of the connected Area EPS/distribution licence.

Critical Regulatory Action Required: CEA Frequency Droop Specifications

J-12 delegates frequency droop active power adjustment requirements to CEA. However, CEA has not yet issued these specifications under IS 18968. Until CEA does so, there is a normative gap: DERs operating in the 50.05–52.0 Hz range will follow Area EPS operator instructions, which may be inconsistent across DISCOMs. CEA should also consider frequency-droop specifications as a notification under the Electricity Act, to close this gap, allow power sharing capabilities and prevent a fragmented implementation.

4.4 Frequency Ride Through and Frequency Droop (IS 18968 Clause 6.5.2 and 6.5.2.7)

The frequency continuous operation region is 58.8–61.2 Hz in the IEEE base text, adjusted to 47.5–52.0 Hz under J-12 for India. Key frequency-droop (Frequency-Power) requirements under IS 18968 Clause 6.5.2.7:

- All DERs of all three categories must provide frequency droop for high frequency (Over frequency) conditions as a mandatory default
- For low frequency (under frequency) Conditions: Category I DERs may (Optional) provide frequency-droop; Category II and III DERs SHALL (mandatory) provide it.
- Default droop parameters (Table 24): dbOF = dbUF = 0.036 Hz; kOF = kUF = 0.05; Tresponse = 5s. These apply to all three categories.
- The frequency droop settings must be approved by the regional reliability coordinator (NLDC/SLDC) if changed from defaults. Distribution utilities (DISCOMs) are discouraged from widening the frequency dead band beyond 0.036 Hz.

5 COMMUNICATIONS, INTEROPERABILITY, AND DER INTEGRATION

5.1 IS 18968 Clause 10 — Interoperability Requirements

IS 18968 Clause 10 is unchanged from the IEEE base text and mandates that all DERs have a local DER communication interface supporting at least one of three protocols.

Table 8: IS 18968 Clause 10 — Interoperability Requirements

Protocol	Transport / Physical Layer	India Readiness Assessment
IEEE Std 2030.5™ (SEP2 — Smart Energy Profile 2.0)	TCP/IP over Ethernet	NOT adopted in India. No BIS Indian Standard equivalent. No DISCOM or SLDC has deployed SEP2 infrastructure. Carries significant adoption risk.
IEEE Std 1815™ (DNP3 — Distributed Network Protocol 3)	TCP/IP over Ethernet	Adopted in India. DNP3 is the primary SCADA communication protocol deployed by SLDCs, NLDC, and DISCOMs. Operational experience exists in India.
SunSpec Modbus	TCP/IP over Ethernet OR RS-485	NOT Adopted in India. Used by some inverter OEMs as a proprietary interface in the US, but no Indian utility has operationalised a SunSpec. No BIS standard equivalent.

ι **Two Gaps in IS 18968 Clause 10.7 for India: Protocol Choice and Physical Transport Layer**
Of the three application-layer protocols IS 18968 Clause 10.7 designates as eligible, India has practical operational experience with only ONE — IEEE Std 1815 (DNP3), which is already deployed in DISCOM SCADA and SLDC systems. IEEE Std 2030.5 (SEP2) and SunSpec Modbus are North American-centric protocols with no Indian standard equivalents, no deployed Indian utility infrastructure, and no established Indian supplier ecosystem. Mandating these protocols without qualification would create unnecessary cost, fragmentation, and implementation barriers — and would miss an opportunity to leverage India's existing IEC-based infrastructure. The second gap is equally important: IS 18968 Clause 10.7 addresses only application-layer protocol selection — it is entirely silent on the physical wireless transport layer over which these protocols must run. This omission is significant in the Indian context. Wi-Fi (IEEE 802.11) and GPRS/SIM-based cellular (2G/3G/4G) are already the dominant physical communication channels used by residential and small commercial smart inverters across India today — built into virtually every commercially available inverter, including the SolarEdge SE 8K tested in the ISGF/NISE study. Ignoring these widely-deployed physical layers in IS 18968 implementation guidance would be impractical and would leave the majority of India's installed DER base — tens of millions of rooftop solar systems — without a recognised communication pathway. IS 18968 Clause 10.8 further requires that the local DER communication interface be active and responsive whenever the DER is operating in the continuous or mandatory operation region, with a maximum read response time of 30 seconds. This is a baseline floor — POSOCO/NLDC and DISCOMs deploying DERMS will require more

stringent performance for critical DERs. However, for non-critical residential DERs (Category A / Category I, ≤ 10 kW), Wi-Fi and GPRS/4G cellular comfortably meet the 30-second read response requirement under normal operating conditions and should be explicitly recognised as permissible physical transport layers in India's IS 18968 national implementation guidance. Wired Ethernet or dedicated SLA-backed cellular should be reserved as requirements for larger and more critical DERs (Category II/III, ≥ 100 kW, BESS).

The following table sets out India-specific guidance on physical transport layer selection by DER category, recognizing that IS 18968 Clause 10.7 is silent on this dimension and that India's implementation guidance must fill this gap explicitly:

Table 9: Physical and Transport Layer Protocol Landscape

Physical Transport Layer	Typical DER Size / Type	IS 18968 Clause 10.8 Suitability	India Recommendation
Wired Ethernet (TCP/IP)	Commercial / industrial ≥ 10 kW; ground-mounted ≥ 100 kW; BESS	High — deterministic latency; supports full DNP3/IEC 61850 stack; reliable for mandatory operation regions	MANDATORY for DERs ≥ 100 kW. Recommended for DERs ≥ 10 kW where site infrastructure permits. Required for Category II and III DER DERMS integration.
RS-485 (SunSpec Modbus)	Residential ≤ 10 kW; multi-inverter string systems	Adequate — meets 30 s read response; limited to 32 devices per RS-485 segment	PERMIT for residential DERs ≤ 10 kW as device-level interface. Requires DISCOM edge gateway to translate to DNP3/IEC 61850 for DERMS. Not suitable for fleet-scale DERMS direct connection.
Wi-Fi (IEEE 802.11 b/g/n/ac)	Residential rooftop ≤ 10 kW (PM Surya Ghar); small commercial ≤ 50 kW	Adequate for non-critical DERs — meets 30 s read response under normal conditions; subject to interference, range limits, router dependency	RECOGNISE as a permissible physical layer for non-critical residential DERs in IS 18968 implementation guidance. Suitable for Volt-VAR/Volt-Watt parameter updates and monitoring data retrieval. NOT suitable for real-time trip command or permit-service disable (Clause 4.6.1) due to latency and reliability constraints. DISCOM should specify minimum Wi-Fi performance criteria in interconnection agreements for Wi-Fi-connected DERs.

GPRS / SIM Cellular (2G/3G/4G/5G)	Residential and rural rooftop; DERs in areas without fixed broadband; EV charging stations	Good — 4G LTE meets 30 s read response comfortably; widely available across India including rural areas; SMNP smart meters use same cellular backbone	STRONGLY RECOMMENDED for rural and semi-urban residential DERs where Wi-Fi or wired Ethernet is impractical. India's 4G coverage (Jio, Airtel, Vi) reaches over 97% of inhabited areas — cellular SIM is the most universally available physical communication layer for DERs in India. Aligns with SMNP smart meter communication infrastructure. CEA/BIS should formally recognise GPRS/4G/5G as IS 18968-compatible physical transport layers in the national implementation guidance. SIM-based connectivity is already standard in many commercial inverter models sold in India.
RF Mesh (e.g., Wi-SUN, Zigbee, LoRaWAN)	Residential clusters; feeder-level DER aggregation; remote / rural DERs	Variable — Wi-SUN and LoRaWAN meet 30 s read response for monitoring; latency may be unsuitable for real-time control commands	ASSESS under SMNP Smart Meter National Programme RF mesh infrastructure for DER co-location. Wi-SUN (IEEE 802.15.4g) is used in SMNP smart meters — a DER communication layer sharing this infrastructure could dramatically reduce rollout cost. LoRaWAN suitable for monitoring-only DERs. Not recommended for control-critical DER communication due to bandwidth and latency limitations.

India-Specific Guidance: Wi-Fi and GPRS/SIM for Non-Critical DER Communication

IS 18968 Clause 10.7 does not specify a physical transport layer — it only mandates application-layer protocol support (SEP2, DNP3, SunSpec Modbus). In India's residential DER context, this flexibility must be explicitly acknowledged in national implementation guidance. The following principle is recommended: For non-critical DERs (residential rooftop ≤ 10 kW, Category A / Category I), Wi-Fi or GPRS/4G/SIM cellular are acceptable physical transport layers for IS 18968 Clause 10 communication, subject to minimum performance requirements (maximum read response ≤ 30 s per Clause 10.8; uptime ≥ 95% monthly average). For critical DERs (BESS, Category II/III, DERs ≥ 100 kW), wired

Ethernet or dedicated cellular with SLA-backed connectivity is required. CEA and BIS should codify this tier in the IS 18968 national implementation circular.

5.2 Communication Protocol Landscape in Indian Power System

India's power sector communication ecosystem has been built predominantly on IEC standards, not IEEE application-layer protocols. Understanding this reality is essential to designing an implementation path for IS 18968 Clause 10 that is practical, cost-effective, and consistent with existing investments:

Table 10: India's Actual Communication Protocol Landscape

Protocol / Standard	Adopted By	Indian Deployment Status	Relevance to IS 18968 DER Communication	Key Disadvantages Added
IEC 61850 (Communication networks and systems for power utility automation)	CEA, POSOCO, major DISCOMs (urban), PGCIL	Mandated by CEA for new substations. Widely deployed in 220 kV and above substations. Growing deployment at 33/11 kV. BIS IS/IEC 61850 series available. DER manufacturers (including SolarEdge, referenced in the ISGF/NISE testing study) already list IEC 61850 compatibility.	Good candidate for DER communication. IEC 61850-7-420 specifically addresses DER logical nodes. Seamless integration with existing substation automation systems.	High engineering complexity (SCL/CID expertise), 11/33 kV deployment still immature, Ethernet cost at residential sites, inter-vendor conformance testing burden
IEEE Std 1815 / DNP3 (Distributed Network Protocol 3)	NLDC, all SLDCs, most DISCOMs	Core SCADA protocol for DISCOM feeder automation and SLDC energy management systems. The most operationally mature protocol in Indian power sector. IS 3716 and	Already eligible under IS 18968 Clause 10.7. Should be designated as the PRIMARY IS 18968 protocols for India, given existing infrastructure.	Point-to-point polling model poorly suited for large DER fleets, no semantic data model, vendor-specific object mapping creates interoperability gaps, SAv5 security not universally deployed

		CERC regulations reference DNP3-compatible communication.		
IEC 60870-5-104 (Telecontrol protocol over TCP/IP)	DISCOMs, SLDCs (legacy systems)	Widely used in older SCADA systems and some DER pilot deployments. Referenced in the ISGF smart inverter testing study as a required protocol for smart inverters in India.	Not listed in IS 18968 Clause 10.7, but operationally familiar to Indian DISCOMs. Gateway mapping to DNP3 or IEC 61850 is well understood.	No DER-specific data model, legacy protocol being superseded, not suitable for new DERMS deployments
OpenADR 2.0 (Open Automated Demand Response)	Pilot stage — EU deployments mature; India emerging	Formally adopted in India. However, OpenADR 2.0b is an OASIS open standard now widely used in EU demand response and DER management programs. CERC/BEE have explored demand response frameworks.	Relevant for India's future DER aggregation and demand response programs. Used in EU for exactly the DER management use cases envisaged in IS 18968 Clause 10 management information (mode changes, power limits, schedules).	Operates only at the event signalling layer (not device layer), VEN client cost for small DERs, EU model focussed on commercial/industrial, not residential rooftop
IEEE Std 2030.5 / SEP2 (Smart Energy Profile 2.0)	USA only — Hawaii, California utility deployments	Not adopted in India. No BIS equivalent. No DISCOM or SLDC infrastructure in India. North American residential utility metering focus.	Listed in IS 18968 Clause 10.7 as eligible. However, deploying SEP2 in India without existing infrastructure would require a parallel investment with no synergy with current systems. NOT recommended as primary protocol for India.	Zero Indian infrastructure, need to check compatible with India's SMNP/DLMS smart meter architecture, requires IPv6 which Indian AMI doesn't support, fully parallel investment with no synergy to any existing Indian system

SunSpec Modbus (Solar and storage device communication)	USA — used by some North American utilities and aggregators	Not adopted by any Indian utility as a DER platform protocol. Used by some inverter manufacturers as a device-level register interface, but no utility-side SunSpec deployment in India.	Listed in IS 18968 Clause 10.7 as eligible. RS-485 physical layer has value for small residential inverters. However, SunSpec alone lacks the security and scalability needed for utility-grade. NOT recommended as primary platform protocol for India.	Register map only — no security, no session management, no event-driven messaging; RS-485 limited to 32 devices per segment; no semantic model; no cybersecurity features for CERT-In compliance

5.3 Recommendations: Adopt IEC 61850 and OpenADR 2.0 as India's Primary DER Communication Standards

Based on India's existing infrastructure investments, the global trajectory of DER communication standards, and the specific protocol landscape surveyed above, this roadmap recommends that India explicitly designate two standards as one of the primary communication protocols for IS 18968 implementations, supplementing (not replacing) DNP3 for legacy SCADA integration.

Primary Recommendation 1: IEC 61850 (with IEC 61850-7-420 for DER)

IEC 61850 should be India's primary DER communication standard.

1. **Already Adopted:** CEA mandates IEC 61850 for all new substations. BIS has adopted the IEC 61850 series as Indian Standards. PGCIL, state transmission utilities, and leading DISCOMs deploy IEC 61850 at HV/EHV level, with 33/11 kV deployment accelerating.
2. **DER Extension Exists**: IEC 61850-7-420 defines DER logical nodes active power, reactive power, voltage setpoints, mode controls, alarms, mapping directly to IS 18968 Clause 10 management information requirements (Clauses 10.3-10.6).
3. **Manufacturers Already Support It:** The ISGF/NISE testing study (November 2025) confirms smart inverters in India must support IEC 61850, IEC 60870-5-104, or Modbus. SolarEdge SE 8K (study DUT) supports Ethernet compatible with IEC 61850 mapping.
4. **Seamless Substation Integration:** DERs at 11/33 kV can connect to IEC 61850-equipped protection systems, using IEC 61850 end-to-end eliminates gateway translation costs. However, it can be high engineering complexity (SCL/CID expertise), 11/33 kV deployment still immature, ethernet cost at residential sites, inter-vendor conformance testing burden

5. **EU parallel:** The EU mandates IEC 61850-7-420 compatibility for DERs above defined size thresholds. India can adopt EU implementation experience directly.

Primary Recommendation 2: OpenADR 2.0 (IEC 62746-10-1:2018) for DER Demand Response and Aggregation

OpenADR 2.0b (Open Automated Demand Response) should be India's standard for DER management and aggregation.

1. **Purpose Built for IS 18968 Clause 10 Use Cases:** OpenADR defines utility-to-DER messaging for mode changes, power setpoints, schedules, and event notifications, precisely the management information IS 18968 Clause 10.6 requires.
2. **EU Model:** Germany, France, and the UK use OpenADR 2.0b for distribution-level demand response and DER aggregation. With India pursuing a similar DER aggregation market under CERC, OpenADR provides a proven, open international model.
3. **OASIS Open Standard:** OpenADR 2.0b is an OASIS open standard (not proprietary) with freely available specifications. BIS could adopt it as an Indian Standard at minimal cost.
4. **Aggregator Interface:** CERC's planned DER aggregation framework (Phase 5) needs a standardized aggregator-to-DER interface. OpenADR 2.0b is the most widely used open standard for this purpose globally.
5. **BEE Synergy:** BEE has explored Automated Demand Response for commercial/industrial consumers. OpenADR adoption for DER management would create a unified standard for both demand response and DER grid services.
6. **Challenge:** Operates only at the event signalling layer (not device layer), VEN client cost for small DERs can be too high, EU model focusses on commercial/industrial, not residential rooftop

5.4 Recommended IS 18968: 2025 Communication Protocol Hierarchy for India

The following protocol hierarchy is recommended for India's IS 18968 Clause 10 implementation. This hierarchy acknowledges IS 18968's existing protocol list while providing clear guidance on which protocols India should prioritise, build infrastructure for, and ultimately standardise through a BIS/CERC notification.

Table 11: Recommended IS 18968 Communication Protocol Hierarchy for India

Tier	Protocol	IS 18968 Clause 10.7 Status	India Recommendation
Tier 1 (Primary)	IEC 61850 / IEC 61850-7-420	Not listed in IS 18968 Clause 10.7 — but IS 18968 Clause 10.7	DESIGNATE as India's primary DER communication standard through CEA/BIS notification. Mandate for all

		explicitly permits additional protocols under mutual agreement. IEC 61850 profiles can be mapped to DNP3 (IS 18968-eligible) per IEC 61850-8-1 mapping.	DERs above 500 kVA from 2027. Align with CEA's existing IEC 61850 substation mandate.
Tier 1 (Primary)	IEEE Std 1815 (DNP3)	ELIGIBLE — listed in IS 18968 Clause 10.7	RETAIN as primary IS 18968-compliant protocol for legacy DISCOM/SLDC SCADA integration. Mandatory support for all DERs ≥ 10 kW by Phase 4. Designate as the transition protocol while IEC 61850 infrastructure scales.
Tier 2 (Application layer)	OpenADR 2.0b	Not listed in IS 18968 Clause 10.7 — functions at utility-to-aggregator/DER layer above device protocol	ADOPTED as an India standard for DER demand response dispatch and aggregation signalling. Commission BIS adoption of OpenADR 2.0b as an Indian Standard by 2026.
Tier 3	SunSpec Modbus (RS-485)	ELIGIBLE — listed in IS 18968 Clause 10.7	PERMIT for small residential DERs (< 10 kW) as a device-level register interface only. Not recommended as the primary utility DER protocol. RS-485 provides a low-cost communication port for residential inverters where Ethernet is impractical.
Tier 3 (Maybe not recommended)	IEEE Std 2030.5 (SEP2)	ELIGIBLE — listed in IS 18968 Clause 10.7	Maybe NOT recommended for India. No existing infrastructure. No BIS equivalent. Significant parallel investment required with no synergy to current DISCOM/SLDC systems. India should formally communicate to BIS ETD 46 that SEP2 should not be mandated as a primary protocol in the IS 18968: 2030 revision.

5.5 Information Requirements for DERS under IS 18968: 2025

Regardless of the protocol used, IS 18968 Clauses 10.3–10.6 define the minimum information elements that must be readable and/or writable through the local DER communication interface. These fall into four categories and both IEC 61850-7-420 and DNP3 can carry all of them:

- Nameplate Information (read-only): Active power rating, apparent power rating, reactive power injection/absorption ratings, normal and abnormal operating performance categories, AC voltage ratings, supported control mode functions, manufacturer, model, serial number, version.
- Configuration Information (read/write): The as-configured values of all nameplate parameters — including any configuration settings that reduce the nameplate capacity ('configured nameplate rating', per Clause 10.4).
- Monitoring Information (read-only): Real-time active power, reactive power, voltage, frequency, operational state, connection status, alarm status, and state of charge (for storage DERs).
- Management Information (read/write): All functional mode settings — constant power factor, volt-var curve points, watt-var curve points, volt-watt curve points, constant reactive power, voltage trip settings, frequency trip settings, frequency droop parameters, enter-service settings, active power limit, permit service (on/off).

5.6 Futurist DERMS Architecture Recommendations for India

IS 18968 Clause 10 mandates the DER-side interface. Building the utility-side integrated DER infrastructure is the responsibility of Area EPS operators (DISCOMs) and is not specified by IS 18968. The following architecture is recommended:

- DISCOMs should develop DERMS platforms capable of communicating with DERs via all three IS 18968-eligible protocols, to avoid vendor lock-in and accommodate the heterogeneous inverter market in India.
- POSOCO/NLDC should develop a national DERMS interoperability framework specifying: (a) Minimum DERMS capabilities for DISCOMs; (b) Data exchange formats for aggregated DER reporting to SLDCs and NLDC; (c) Cyber security baseline requirements aligned with CERT-In guidelines (noting that IS 18968 Clause 10.9 explicitly leaves cyber security out of scope of the standard itself).
- India's Smart Meter National Programme (SMNP) communication backbone deploying RF mesh or cellular GPRS/4G networks should be assessed for suitability as the physical communication layer for DER management, reducing the incremental cost of DERMS rollout for DISCOMs, particularly in RDSS-funded areas.
- For DERs below 10 kW (primarily residential), the Area EPS operator's decision to use the communication interface (per IS 18968 Clause 10.1) should be deferred until DISCOM DERMS capacity is established acknowledging the cost implications for small systems. This decision should be made by SERCs through their interconnection procedures, with a clear timeline for phased activation.
- The communication port type (Ethernet/RS-485) and protocol selected for a given region or DISCOM should be specified in state interconnection procedures, to prevent the confusion and cost that arises when different DISCOMs within a state mandate different protocol.

6 TESTING, CERTIFICATION, AND COMMISSIONING UNDER IS 18968: 2025

6.1 IS 18968 Clause 11 — Test and Verification Framework

IS 18968 Clause 11 specifying a comprehensive test and verification framework. All requirements in Clauses 4–10 must be verified through some combination of the following methods:

- Type Tests (Clause 11.2.2): Performed on one device or a system of devices in a factory, testing laboratory, or in the field. Results apply to the same product family (50%–200% power rating range of the tested unit). Type test results must be conducted against IS 18968 requirements — including J-11 frequency thresholds (52.0/47.5 Hz) and J-8 volt-var settings.
- Production Tests (Clause 11.2.3): Performed on every unit before customer delivery to verify operability. Must include a summary of normal and abnormal performance category capability, final function settings, and final operating mode settings.
- DER Evaluation (Clause 11.2.4): A desk study (design evaluation) and/or on-site as-built evaluation — used for DER systems that use supplemental devices or where the reference point of applicability is the PCC. Comprises basic (visual/connections check) or detailed (engineering verification with modelling and simulation) levels.
- Commissioning Tests (Clause 11.2.5): Tests on the as-installed system before energisation — visual inspection, isolation device operability, and functional performance tests. Must be based on written test procedures approved by the equipment owner and Area EPS operator.
- Periodic Tests (Clause 11.2.6): Scheduled reverification frequency determined by AGIR/DISCOM policies or manufacturer requirements. Required when software/firmware is updated, hardware is replaced, protection settings are changed, or protection functions are adjusted after commissioning.

6.2 Reference Point of Applicability and Testing Implications

IS 18968 Clause 4.2 (unchanged from IEEE base) defines when the RPA is the PCC vs. the PoC. This has major implications for testing burden:

- PoC (Inverter terminals) as RPA: Applies when aggregate DER nameplate ≤ 500 kVA, or when annual average load > 10% of aggregate DER nameplate and the system is not capable of exporting more than 500 kVA for longer than 30 s. In this case, BIS product certification (type testing of the inverter model) is the primary compliance verification method — streamlining interconnection for residential and small commercial DERs.
- PCC as RPA: Required for DERs regularly exporting more than 500 kVA. More extensive DER evaluation (including desk study and as-built evaluation) and potentially detailed commissioning tests are required in addition to type testing.
- For composite systems (DER units + supplemental devices such as STATCOM or capacitor banks): detailed DER evaluation and commissioning testing is required, as type testing alone is insufficient to verify compliance at the PCC.

6.3 India's First IS 18968 Compliance Test

6.3.1 The ISGF/UL/NISE SolarEdge Study (2025)

India has already taken a pioneering first step in building its IS 18968 testing ecosystems. India Smart Grid Forum (ISGF), in partnership with the National Institute of Solar Energy (NISE), and Underwriters Laboratories (UL) conducted the first known IS 18968: 2025 compliance test of a commercially available smart inverter in India in 2025 — providing critical early evidence on the gap between IS 18968 requirements and current OEM default settings in the market .It was done in two phases: a) Phase I: Initial test on the Smart Inverter and b) Phase II: 18968 compliance tests under normal and abnormal operation of the grid.

Table 12: IS 18968 Compliance Tests Under Normal and Abnormal Operation of the Grid

Test	IS 18968 Requirement	Inverter OEM Default	Compliance Gap
Volt-Watt	Category B: curtail active power from 100% at V1 = 1.06 VN to 0% at V2 = 1.10 VN (IS 18968 Table 10 default, disabled by default)	Curtailment begins at 246 V (1.07 p.u.); zero output at 260 V (1.13 p.u.)	OEM volt-watt curve active and partially aligned — but curtailment threshold (1.07 p.u.) slightly above IS 18968 Category B default (1.06 p.u.). Confirms the inverter HAS volt-watt capability; needs settings alignment with Area EPS operator.
Volt-VAR	Category A/B: reactive power injection at low voltage; absorption at high voltage per IS 18968 Table 8/J-8 settings	Injecting +2800 VAR at 0.80 p.u.; absorbing −2600 VAR at 1.17 p.u.; zero reactive power near nominal voltage	OEM volt-var characteristic broadly aligned with IS 18968 spirit but VRef and knee points differ from J-8 Category B defaults. Confirms the inverter HAS volt-var capability; needs DISCOM-specified settings activation per IS 18968 Clause 5.3.3.
Voltage Ride-Through (VRT)	Continuous operation 0.88–1.10 p.u.; mandatory operation 0.70–0.88 p.u.; cease to energize < 0.50 p.u. and > 1.20 p.u. (Category I, Table 14)	LV trip at 184 V (0.80 p.u.); HV trip at 271 V (1.18 p.u.)	OEM defaults trip at 0.80 p.u. — within J-10 India simplified threshold (0.80 p.u.) but above the IS 18968 base text 0.70 p.u. mandatory operation floor. Inverter does not ride through the 0.70–0.80 p.u. mandatory operation region by default.

Frequency Ride-Through (FRT)	Continuous operation 49.0–51.0 Hz (per ISGF 50 Hz scaled calculation); mandatory operation 47.5–49.0 Hz and 51.0–51.5 Hz for 299 s	LF trip at 48 Hz; HF trip at 51.5 Hz	OEM LF default (48 Hz) trips within the mandatory operation region (47.5–49.0 Hz) — non-compliant with IS 18968 FRT requirement for the 48.0–49.0 Hz band.

The ISGF/NISE study verified several conclusions critical for IS 18968 implementation policy: (1) commercially available smart inverters do possess the technical capability to support volt-var, volt-watt, VRT, and FRT — the standard is technically implementable with existing market products; (2) OEM default settings frequently diverge from IS 18968 requirements, confirming that BIS certification testing must verify actual IS 18968-compliant settings, not just hardware capability; (3) the HiL methodology at NISE is a sound and cost-effective test platform for IS 18968 compliance evaluation that CPRI and ERDA should replicate and scale. The study also recommended expanding testing to cover communication interface compliance (IS 18968 Clause 10), multi-vendor benchmarking, and field demonstration with DISCOM collaboration — all consistent with this roadmap's Phase 2 actions.

6.4 ISGF and NISE Pilot Study — IS 18968 Compliance Test Evidence

Before a formal national certification ecosystem can be established, India now has critical foundational evidence: the IS 18968 compliance testing study conducted by the India Smart Grid Forum (ISGF) in collaboration with the National Institute of Solar Energy (NISE). This is the first documented IS 18968: 2025 compliance test on a commercially available smart inverter in India — using a Hardware-in-the-Loop (HIL) methodology at NISE's accredited PV inverter testing facilities.

Table 13: ISGF and NISE Pilot Study — IS 18968 Compliance Test Evidence

Study Parameter	Detail
Study Title	Inverter Testing for the Compliance of IS 18968: 2025 (IEEE 1547-2018) — Testing of SolarEdge SE 8K Photovoltaic Inverter
Conducting Organisations	India Smart Grid Forum (ISGF) in collaboration with National Institute of Solar Energy (NISE), Haryana
Publication Date	24 November 2025
Device Under Test (DUT)	SolarEdge SE 8K — commercially available 8 kVA 3-phase grid-interactive PV inverter. Rated: 380/220 V (LL/LN), 50/60 Hz ±5 Hz, IP65. Supports Volt-VAR, Volt-Watt, fixed power factor, active/reactive power control. Communication: RS485 ×2, Ethernet, ZigBee, Wi-Fi, optional cellular.
Test Venues	Phase 1: UL Laboratory, Bengaluru (12–16 May 2025). Phase 2: NISE, Haryana — grid simulator with RT-LAB HIL real-time simulation platform, data acquisition at 6.25 kHz sampling rate (10–13 November 2025).
Tests Conducted	(1) Volt-Watt — active power curtailment vs. voltage; (2) Volt-VAR — reactive power injection/absorption vs. voltage in normal operating conditions. (3) Voltage

	Ride-Through (VRT) — LVRT and HVRT (4) Frequency Ride-Through (FRT) — as per IS 18968- 230 V 50 Hz Indian grid code in abnormal operating conditions
Key Result — Volt-Watt	Full function confirmed. Active power reduced smoothly from ~7.5 kW to 0 kW as voltage rose from nominal to 1.13 p.u. Consistent with IS 18968 Clause 5.4.2. No undesirable transients observed.
Key Result — Volt-VAR	Full function confirmed. Reactive power transitioned from +2,800 VAR injection (low voltage) to –2,600 VAR absorption (high voltage). Consistent with IS 18968 Clause 5.3.3 and National Annex J-8 settings.
Key Result — VRT	Partial compliance. OEM default HV trip at 271 V (1.18 p.u.) EXCEEDS National Annex J-10 limit (1.1 p.u.). OEM default LV trip at 184 V (0.8 p.u.) is consistent with J-10. Inverter demonstrated ride-through within its OEM-defined operating envelope.
Key Result — FRT	Partial compliance. OEM default LF trip at 48 Hz is within J-11 range (47.5–48.8 Hz) but not the J-11 default (47.5 Hz). OEM default HF trip at 51.5 Hz is consistent with J-11 range. FRT test adapted from IS 18968's 60 Hz base to 50 Hz by mathematical scaling.
Overall Assessment	Partial IS 18968: 2025 compliance. Ride-through, Volt-Watt, and Volt-VAR grid support functions demonstrated successfully. Primary gap: OEM default configurations do not match National Annex J thresholds for HV trip (1.18 p.u. vs. J-10's 1.1 p.u.) confirming that manufacturer firmware reconfiguration to J-compliant default settings is required before formal IS 18968 certification can be granted.
ISGF Recommended Next Steps	Multi-vendor testing across 5+ inverter models; DISCOM field demonstrations; IS 18968 deployment guidelines and best practices; data-driven policy frameworks for certification; research on cybersecurity and communication standards for DER inverters in India.

Policy Significance of the ISGF/NISE Study

This study matters for three specific reasons that should be cited in all CEA and SERC IS 18968 implementation proceedings: 1. TEST INFRASTRUCTURE IS READY: NISE's HiL grid simulator is operational and capable of IS 18968 compliance testing. No new laboratory investment is needed to begin a national type-testing programme — NISE, alongside CPRI and ERDA, can begin accepting IS 18968 type-test applications now. 2. OEM DEFAULT SETTINGS GAP IS CONFIRMED: The study provides the first empirical proof that commercially available inverters sold in India have OEM default settings that do not match National Annex J. The HV trip default (1.18 p.u.) is materially higher than J-10's requirement (1.1 p.u.). BIS must therefore require J-compliant DEFAULT settings — not merely capability — as a condition of IS 18968 certification. A product that is capable of meeting J-10 but ships with non-J-10 defaults is not IS18968-compliant. 3. VOLT-WATT AND VOLT-VAR EMPIRICAL EVIDENCE: The study provides India's first domestic empirical evidence that these functions work as designed in a real inverter under simulated Indian voltage conditions. This evidence base supports SERC decisions on enabling these functions on high-penetration feeders.

6.5 Building India's IS 18968 Certification Ecosystem

India currently lacks an IS 18968-specific certification scheme. Building this ecosystem is the highest-priority action for the 2025–2027 period:

- BIS should update IS 16221 and the ALMM (Approved List of Models and Manufacturers) scheme to mandate IS 18968 certifications for all new inverter models listed from 2027 onwards, with a 12/18-month transition window for existing listed models.
- Central Power Research Institute (CPRI), Electrical Research and Development Association (ERDA), and at least two NABL-accredited private laboratories should be equipped and accredited to conduct IS 18968 type testing — specifically the Indian-specific tests required by National Annex J (50 Hz frequency tests, 47.5/52 Hz trip threshold verification, 230/400 V voltage table compliance, extended enter-service delay verification).
- BIS should develop a certification mark for IS 18968: 2025 compliance, analogous to the BIS hallmark, to enable easy identification of compliant inverters by DISCOMs and consumers.
- MNRE should amend the PM Surya Ghar scheme guidelines to mandate IS 18968 certified inverters for all solar installations from the start of FY 2027.

7 PHASED IMPLEMENTATION ROADMAP (2025–2032)

IS 18968: 2025 provides India with a comprehensive technical framework for the interconnection and interoperability of distributed energy resources (DERs). However, the practical impact of a technical standard emerges only when it is systematically embedded into regulatory frameworks, certification schemes, interconnection procedures, and utility operational practices. The phased roadmap presented in this section outlines a structured pathway through which policymakers, regulators, utilities, testing institutions, and technology providers can collectively operationalise the provisions of IS 18968 over the period 2025–2032.

The sequencing of phases recognises the need to first establish regulatory clarity and certification infrastructure, followed by controlled deployment of grid-support functionalities, and ultimately integration of DERs into advanced grid management and energy market mechanisms.

7.1 Phase 1: Regulatory Foundation (2025 – 2026)

First phase is to establish regulatory clarity, and institutional alignment, and the foundational certification ecosystem required for the implementation of IS 18968: 2025 across India.

The initial phase focuses on establishing the regulatory and institutional groundwork necessary for the implementation of IS 18968. During this period, stakeholders across the regulatory, technical, and manufacturing ecosystem can work collaboratively to address normative gaps, align existing connectivity regulations with the new standard, and initiate the development of a national certification and testing ecosystem. The outcomes of this phase are intended to provide clarity to utilities and manufacturers while creating the institutional mechanisms needed to support large-scale deployment of IS 18968compliant smart inverters. The key goals and action plans for this phase is as follows:

- Clarify implementation aspects of National Annex J and related operational parameters
- Embed IS 18968 within existing CEA connectivity standards and regulatory frameworks
- Establish a national framework for DER performance category assignment
- Initiate development of IS 18968 testing and certification ecosystem
- Provide early market signals to manufacturers and developers regarding compliance requirements

Clarification of Technical Provisions in National Annex J: Certain provisions within National Annex J require supplementary regulatory interpretation to ensure consistent implementation across the country. In particular, parameters related to frequency-droop response under J-12 and the simplified voltage trip thresholds introduced in J-10 may benefit from additional clarification through regulatory notifications or technical guidelines. Such clarification would help ensure that utilities, manufacturers, and testing laboratories interpret these provisions in a uniform manner and reduce the risk of divergent implementation practices among DISCOMs.

Integration of IS 18968 into National Connectivity Standards: To support systematic adoption, IS 18968 may be integrated into the CEA Technical Standards for Connectivity of Distributed Generation Resources. Updating these regulations to reference the new standard would help align DER interconnection procedures across states and provide clear guidance to utilities and developers regarding technical expectations for new installations. A transition window could allow manufacturers and installers adequate time to adapt their equipment and procedures to the updated requirements.

Development of a National DER Performance Category Framework: The performance category framework defined in IS 18968 requires contextual interpretation for different DER types and deployment scales in India. A national guideline developed through collaboration between CERC, CEA, and state regulators could provide recommended category assignments for residential, commercial, and utility-scale DER systems. Such guidance would support DISCOMs in specifying performance categories within interconnection agreements while maintaining consistency across states.

Initiation of the Certification and Testing Ecosystem: A critical component of implementation is the development of a robust testing and certification ecosystem aligned with Clause 11 of IS 18968. BIS, in coordination with technical institutions such as CPRI, ERDA, and NISE, may develop detailed laboratory testing protocols reflecting the India-specific requirements defined in National Annex J. Establishing a recognised certification pathway would provide clarity to manufacturers and ensure that the inverter models entering the Indian market meet the operational characteristics required by the IS 18968 standard.

Leveraging Early Testing Initiatives: India has already taken a significant step toward building its testing ecosystem through the ISGF–NISE Hardware-in-the-Loop smart inverter testing study conducted in 2025. This study demonstrated the technical feasibility of implementing key grid-support functions such as Volt-VAR, Volt-Watt, and ride-through capabilities in commercially available inverters. It also highlighted the importance of aligning manufacturer default settings with the thresholds defined in National Annex J. The methodology and insights from this study can serve as a useful reference for scaling the national type-testing programme.

Providing Market Transition Signals: During this phase, policy advisories linking government programmes such as PM Surya Ghar to IS 18968-compliant inverter certification could help signal the future direction of the market. Early communication of such expectations allows manufacturers sufficient time to undertake firmware adjustments, type testing, and certification processes before compliance requirements become mandatory.

Institutional Support: The successful completion of this foundational phase depends on coordinated engagement across the regulatory, policy, and technical ecosystem. Institutions such as **CEA and CERC** can support the initiative by clarifying regulatory interpretations and aligning national connectivity standards with IS 18968. **BIS**, through the ETD-46 committee, can facilitate the development of testing procedures and certification pathways. **MNRE and the Ministry of Power** can help signal market transition through policy advisories and programme alignment. System operators such as **NLDC, RLDCs, and SLDCs**, along with research and implementation organisations including **ISGF and NISE,** can contribute technical expertise, testing methodologies, and early evidence to inform regulatory decision-making and guide the national implementation pathway.

7.2 Phase 2: Certification and Early Market Transition (2027– 2028)

During this phase it is expected to operationalise the certification ecosystem and initiate the transition of the inverter market toward IS 18968-compliant products and interconnection practices.

Following the establishment of the regulatory foundation, the second phase focuses on building the operational mechanisms required for market adoption of IS 18968-compliant smart inverters. This period is expected to see the gradual transition of the inverter market toward compliance through certification frameworks, testing protocols, and early utility-level implementation initiatives. The emphasis during this phase is on creating a reliable ecosystem in which manufacturers, testing laboratories, utilities, and regulators can collectively support the deployment of compliant DER technologies. The key goals and action plans for this phase is as follows:

- Establish a formal BIS certification pathway for IS 18968 compliant inverters
- Facilitate the transition of existing inverter models toward compliance
- Expand testing capacity across accredited laboratories in India
- Initiate early utility-level pilots demonstrating grid-support functionalities
- Provide market clarity for manufacturers and installers regarding compliance timelines

Operationalisation of the BIS Certification Framework: During this phase, BIS may finalise the testing protocols developed in Phase 1 and operationalise the certification scheme for IS 18968 compliant inverter models. This would involve aligning certification requirements with Clause 11 testing provisions and National Annex J parameters. A recognisable certification mark or designation may also be introduced to help utilities, installers, and consumers identify IS 18968 compliant products within the market.

Transition Pathway for Existing Inverter Models: The inverter market in India currently includes a large installed base of products that were designed prior to the publication of IS 18968. A structured transition pathway may therefore be beneficial, allowing manufacturers sufficient time to update firmware configurations, align default protection settings, and complete certification testing. A transition window of approximately 12–18 months could enable manufacturers to bring existing models into compliance without disrupting ongoing rooftop solar deployment programmes.

Expansion of Testing and Verification Capacity: To support certification at scale, multiple laboratories across India may be equipped and accredited to conduct IS 18968 type testing. Institutions such as CPRI, ERDA, NISE, and NABL-accredited private laboratories could collectively support the development of testing infrastructure capable of evaluating ride-through performance, voltage regulation functions, and communication interface requirements defined in the standard.

Early Utility Demonstration Programmes: Utilities may begin controlled demonstration projects on selected feeders with moderate DER penetration. These demonstrations could focus on validating the operational behaviour of smart inverter functions such as Volt-VAR and Volt-Watt under real distribution network conditions. The results from such pilots would provide valuable insights for utilities and regulators regarding feeder-level voltage management and DER integration strategies.

Strengthening Coordination Between Utilities and Regulators: As utilities begin to encounter operational scenarios involving high DER penetration, regulators and utilities may benefit from structured coordination mechanisms to review pilot results, share operational experiences, and refine interconnection procedures. These discussions could also inform the development of state-level guidelines on enabling grid-support functionalities.

Institutional Support: This phase benefits significantly from collaboration between utilities, regulators, and technical institutions to generate operational evidence under real grid conditions. **Pilot state SERCs and DISCOMs** can play a central role by hosting demonstration feeders and evaluating smart inverter behaviour in high-DER circuits. **SLDCs and NLDC/GRID-INDIA** can support monitoring and analysis of frequency response and system impacts during pilot deployments. Technical institutions such as **CPRI** and inverter **OEMs** can assist with device testing, configuration alignment, and performance validation, while **ISGF** can support knowledge dissemination and documentation of pilot learnings to inform future regulatory and operational frameworks.

7.3 Phase 3: Controlled Functional Activation (2028 – 2029)

This phase is intended to gradually enable grid-support functionalities of smart inverters while ensuring system reliability, consumer transparency, and operational learning for utilities.

Once a baseline market of certified smart inverters begins to emerge, the third phase focuses on the controlled activation of grid-support functionalities within distribution networks. The aim is to transition from purely hardware compliance toward active utilisation of DER capabilities for voltage management and grid stability. During this stage, utilities may begin deploying advanced inverter functions in a measured and data-driven manner based on feeder characteristics and DER penetration levels. The key goals and action plans for this phase is as follows:

- Enable voltage regulation functions on feeders with increasing DER penetration
- Develop utility procedures for activating Volt-VAR and Volt-Watt functions
- Establish monitoring and reporting mechanisms for DER operational performance
- Provide regulatory oversight to ensure consumer transparency in cases of generation curtailment
- Build operational experience for utilities in managing DER-enabled grid support.

Feeder Level Technical Studies: Utilities may undertake feeder-level hosting capacity and power flow studies to identify circuits where voltage regulation support from DERs would be beneficial. Such studies would help determine optimal settings for Volt-VAR and Volt-Watt curves and guide the selective activation of these functionalities on high-penetration feeders.

Controlled Activation of Voltage Regulation Functions: Where appropriate, utilities may enable Volt-VAR functionality to support voltage stabilisation in distribution networks experiencing fluctuations due to high solar generation. Activation of Volt-Watt functionality may also be considered under specific conditions, particularly in circuits where sustained overvoltage risks arise during periods of high DER output.

Operational Monitoring and Performance Reporting: During this stage, utilities may begin collecting operational data from DER systems to evaluate the performance of voltage regulation functions and ride-through capabilities under real network conditions. Such data can inform future policy decisions and support refinement of DER operational strategies.

Consumer Transparency and Regulatory Oversight: As grid-support functions may occasionally affect active power output, it may be useful for utilities and regulators to establish clear communication mechanisms to inform consumers about the operational behaviour of smart inverters. Transparency regarding the circumstances under which such functions may be activated can help maintain consumer confidence in distributed generation programmes.

Institutional Support: Advancing this phase requires coordinated efforts to scale technical capacity and certification infrastructure across the sector. **BIS** and national testing institutions such as **CPRI, ERDA, and NABL-accredited laboratories** can support the operationalisation of IS 18968 testing protocols and product certification processes. **CEA and MNRE** can help align certification requirements with national programmes and regulatory frameworks. **SERCs and DISCOMs** can simultaneously build technical capacity for implementing performance category assignments and commissioning procedures, while **GRID-INDIA and ISGF** can support training programmes and technical guidance for utilities undertaking DER integration activities.

7.4 Phase 4: DERMS Integration and Advanced Grid Operations (2029 – 2030)

This phase is expected to integrate DER capabilities into utility-level management platforms and enable coordinated operation of distributed resources across the distribution network.

With increasing numbers of certified DER installations and operational experience in grid-support functionalities, the fourth phase focuses on integrating distributed resources into advanced distribution management systems. This stage represents the transition from individual DER devices operating autonomously to coordinated management of distributed resources at the utility level. The key goals and action plans for this phase is as follows:

- Deploy DER Management Systems (DERMS) within utilities
- Integrate DER operational data into distribution system monitoring platforms
- Expand communication infrastructure supporting DER interoperability
- Enable coordinated voltage and power management using distributed resources
- Strengthen coordination between DISCOMs, SLDCs, and national grid operators

Development of DERMS Platforms: Utilities may progressively deploy DERMS platforms capable of monitoring and managing distributed energy resources across their networks. Such systems would allow utilities to visualise DER output, monitor voltage conditions, and coordinate distributed resources to support grid stability.

Integration with Existing Communication Infrastructure: The communication interfaces defined in IS 18968 may be integrated with existing SCADA and grid monitoring systems. Protocols already deployed in Indian utilities, such as DNP3 and IEC-based communication frameworks, may provide a foundation for this integration. The objective is to ensure seamless interoperability between DER devices and utility management platforms.

Coordination with System Operators: As DER penetration increases, coordination between DISCOMs and system operators such as SLDCs, RLDCs and NLDC may become increasingly important. Aggregated DER behaviour may influence frequency response, voltage stability, and overall grid reliability. Structured data exchange between distribution utilities and system operators can support improved situational awareness and system planning.

Integration with National Digital Infrastructure Initiatives: The communication backbone established through national programmes such as the Smart Metering under RDSS may provide an opportunity to leverage existing data communication networks for DER monitoring and management. This approach may help reduce infrastructure costs while supporting wider grid digitalisation efforts.

Institutional Support: The national rollout phase requires alignment across state regulatory frameworks and distribution system operations. **CEA and SERCs** can support this process by updating connectivity regulations, interconnection procedures, and consumer protection guidelines consistent with IS 18968 requirements. **DISCOMs** play a critical role in integrating performance categories and smart inverter functionality within interconnection agreements and operational practices. System operators including **SLDCs, RLDCs and NLDC/GRID-INDIA** can assist with monitoring aggregated DER impacts on system stability. **MNRE and BIS** can further reinforce adoption through alignment of certification schemes and national solar deployment programmes.

7.5 Phase 5: Market Integration and Grid Services Participation (2030 – 2032)

This phase is enable distributed energy resources to contribute actively to grid services, system reliability, and emerging energy market structures.

The final phase of the roadmap focuses on the long-term evolution of DER from passive generation assets into active participants in grid services and electricity markets. As utilities gain operational experience and DER communication infrastructure matures, distributed resources may begin to contribute to broader grid reliability services and emerging energy market mechanisms. The key goals and action plans for this phase is as follows:

- Enable DER aggregation frameworks for grid services participation
- Integrate distributed resources into ancillary services and demand response programmes
- Establish regulatory mechanisms for compensation of grid-support services
- Strengthen cybersecurity and data governance frameworks for DER integration
- Align DER integration with long-term grid modernisation strategies

Development of DER Aggregation Frameworks: As DER deployment expands, aggregation mechanisms may be developed to coordinate multiple distributed resources and enable their participation in grid service programmes. Aggregators could play a role in consolidating distributed capacity and interfacing with utility or market platforms.

Participation in Grid Services: Distributed resources equipped with advanced inverter capabilities may be able to contribute to services such as voltage support, frequency response, and demand response. Over time, regulatory frameworks may evolve to recognise and compensate such contributions to system reliability.

Cybersecurity and Data Governance: The increasing digitalisation of DER infrastructure highlights the importance of robust cybersecurity frameworks. Utilities, regulators, and technology providers may collaborate to establish guidelines that protect communication interfaces, data flows, and grid operations associated with DER integration.

Alignment with Long-Term Grid Modernisation: By the end of the roadmap period, IS 18968-compliant DER systems may become an integral component of India's evolving smart grid architecture. Their integration into advanced grid management platforms and energy market structures could support a more flexible, resilient, and distributed electricity system.

Institutional Support: The optimisation phase represents the transition toward advanced DER participation in grid services and future standard evolution. **CERC, RLDC, NLDC/GRID-INDIA** can support the development of DER aggregation frameworks and market participation mechanisms for grid services. **The Ministry of Power and BIS (ETD-46)** can coordinate the development of future revisions of IS 18968, reflecting lessons learned from large-scale deployment and emerging DER technologies. **Industry associations, inverter manufacturers, and national research laboratories** can contribute technical insights and international benchmarking, while **academic institutions and research organisations** can support innovation in advanced grid integration technologies and cybersecurity frameworks.

8 CONSUMER PROTECTION IN THE IS 18968 IMPLEMENTATION CONTEXT

The deployment of grid-interactive smart inverters conforming to IS 18968: 2025 represents an important step toward enabling higher penetration of distributed energy resources (DERs) within India's electricity distribution networks. Smart inverter technologies introduce capabilities such as voltage regulation, frequency response, and active power management, allowing DER systems to support grid stability during changing network conditions. While these capabilities enhance the reliability and operational flexibility of distribution systems, certain inverter functions may also influence the active power output of customer-owned DER installations when activated by the Area Electric Power System (Area EPS) operator, typically the distribution utility.

As India continues to expand rooftop solar installations under programmes such as PM Surya Ghar, maintaining consumer confidence in distributed energy initiatives becomes increasingly important. Transparent disclosure of inverter functionality, clear regulatory oversight, and appropriate monitoring mechanisms can help ensure that grid-support functions are deployed in a manner that balances system reliability with consumer interests. This section highlights the smart inverter functions that may affect consumer generation and outlines recommended consumer protection considerations that state regulators and utilities may incorporate during the rollout of smart meters.

8.1 IS 18968 Functions that Can Impact Consumer Generation

IS 18968 introduces several inverter functionalities that may, under certain operating conditions, reduce the active power output of a DER system. These functions are designed primarily to support grid stability and protect distribution infrastructure during abnormal or high-stress operating conditions. However, because many DER installations are consumer-owned, it is important that such operational capabilities are implemented with appropriate transparency and regulatory oversight. The principal functions that may influence consumer generation include the following:

Volt-Watt Function (IS 18968 Clause 5.4.2):

The Volt-Watt functionality allows a smart inverter to automatically reduce active power output when grid voltage exceeds a defined threshold. This function can be particularly useful on feeders experiencing sustained overvoltage conditions due to high solar penetration during midday generation peaks. While the Volt-Watt function is disabled by default and must be explicitly enabled by the distribution utility, its activation may result in temporary reduction of solar generation in affected circuits. This functionality applies to Category B DER systems and is typically activated only when required for network voltage management.

Frequency-Droop Response for Over-Frequency Conditions (IS 18968 Clause 6.5.2.7):

Smart inverters are also capable of responding to grid frequency deviations through a frequency-droop mechanism. When system frequency exceeds the defined dead band threshold (under National Annex J settings), inverters may gradually reduce active power output in order to assist in stabilising grid frequency. In the context of the Indian grid, which generally operates within a relatively stable frequency band, the impact of this function on consumer generation is expected to be minimal. Nevertheless, the presence of this functionality should be transparently communicated to DER owners.

Active Power Limiting Through Communication Interface (IS 18968 Clause 4.6.2):

IS 18968 also allows the Area EPS operator to limit the active power output of a DER system through the inverter communication interface. This capability may be utilised during specific operational conditions such as local network congestion or system security events. Although such interventions are expected to be infrequent, they represent an operational control mechanism that could affect DER output and therefore merit disclosure within interconnection agreements.

Configured Nameplate Rating (IS 18968 Clause 10.4):

The standard also includes a configurable parameter known as the configured nameplate rating, which allows the effective operational capacity of a DER system to be set below its physical nameplate rating. This configuration may be used in certain interconnection scenarios to maintain network stability or comply with system planning requirements. Because this setting can influence the maximum output available from a DER installation, its use should be clearly communicated to consumers during the interconnection process.

8.2 Recommended Consumer Protection Provisions (SERC-Level)

In order to ensure that smart inverter functionalities are implemented transparently and equitably, state regulators may consider incorporating consumer protection provisions within their DER interconnection frameworks. These provisions can help ensure that consumers remain informed about the operational characteristics of their systems while allowing utilities to deploy grid-support functions when necessary for system reliability.

Pre-Installation Disclosure Requirements:

Interconnection agreements and installation documentation may include clear disclosure statements indicating that the installed inverter complies with IS 18968: 2025 and that certain grid-support functions may affect system output under specific operating conditions. Such disclosures may explain, in clear and accessible language, that the distribution utility may enable Volt-Watt functionality or active power limiting under defined circumstances and that frequency-droop response is enabled by default in accordance with the standard.

Monitoring and Reporting of Generation Curtailment:

Distribution utilities may maintain operational records of events in which grid-support functions result in generation curtailment. Such records could include information on feeder location, duration of the event, and estimated impact on DER output where feasible. Aggregated reporting of these events to state regulators may help support transparency and enable periodic assessment of DER integration practices.

Periodic Regulatory Review and Corrective Measures:

State regulators may periodically review data on generation curtailment associated with grid-support functions. Where such events are found to have a material impact on DER generation within specific feeders or service areas, regulators and utilities may consider evaluating appropriate corrective measures. These could include network upgrades, adjustment of inverter control settings, or other technical solutions aimed at improving feeder hosting capacity.

Installer Yield Estimate Transparency:

Installers and system designers may incorporate the potential operational impacts of voltage regulation functions when preparing generation yield estimates for consumers. Where feeder voltage data is available through the interconnection review process, such information may assist installers in providing more accurate projections of expected system performance.

Disclosure of Permit-Service Disable Capability:

IS 18968 includes a provision allowing the Area EPS operator to disable the permit service function, which causes the DER to cease energising the grid within a defined timeframe. Although this capability is primarily intended for safety or system protection purposes, it may be beneficial for interconnection agreements to clarify the conditions under which such actions may be exercised.

8.3 Equity Considerations: PM Surya Ghar Beneficiaries

The PM Surya Ghar initiative aims to expand rooftop solar adoption across India while delivering tangible economic benefits to households through reduced electricity costs. Many programme beneficiaries may be first-time participants in distributed energy systems and may rely on projected solar generation savings when making investment decisions.

In areas where feeders experience chronic voltage congestion or network constraints, frequent activation of voltage management functions could potentially affect the generation output of rooftop solar systems. Ensuring that such impacts are transparently communicated and appropriately monitored can help maintain public confidence in distributed solar programmes. As India continues to expand consumer participation in the energy transition, aligning technical standards such as IS 18968 with supportive regulatory frameworks will remain important for balancing grid stability, consumer protection, and equitable access to distributed energy benefits.

8.4 Way Forward

Consumer protection within the IS 18968 implementation framework will benefit from coordinated engagement among regulatory authorities, utilities, technical institutions, and industry stakeholders. **State Electricity Regulatory Commissions (SERCs)** can support this process by incorporating disclosure requirements, reporting mechanisms, and oversight provisions within state interconnection regulations. **Distribution utilities (DISCOMs)** play a key role in communicating operational practices to consumers and maintaining transparency regarding the activation of grid-support functions.

National institutions such as **CEA, MNRE, and BIS** can further support consumer protection by aligning technical standards, certification processes, and rooftop solar deployment programmes with transparent operational guidelines. Industry stakeholders **including inverter manufacturers, system integrators, and installer networks** can contribute by ensuring that consumers receive clear information about smart inverter functionality during system installation and commissioning. Through coordinated institutional engagement, the implementation of IS 18968 can support both grid reliability and sustained consumer confidence in distributed energy systems.

9 STATE LEVEL LEADERSHIP — PRIORITY ACTIONS FOR SERCS AND DISCOMS

The implementation of IS 18968: 2025 will require coordinated action across multiple institutional levels within India's electricity governance framework. While national institutions such as the Central Electricity Authority (CEA), the Central Electricity Regulatory Commission (CERC), and the Bureau of Indian Standards (BIS) play an important role in defining technical standards and certification frameworks, the operational adoption of DER interconnection requirements occurs primarily at the state level. State Electricity Regulatory Commissions (SERCs) and distribution utilities (DISCOMs) are therefore key actors in translating the provisions of IS 18968 into practical interconnection procedures, commissioning requirements, and operational grid practices.

Given India's federal electricity governance structure, the success of IS 18968 implementation will depend significantly on how effectively state regulators and utilities incorporate the standard within their regulatory frameworks and operational processes. This section outlines recommended priority actions for SERCs and DISCOMs across the implementation phases described in Section 7, followed by a set of states that may be well positioned to serve as early implementation leaders based on their DER penetration levels, grid conditions, and institutional readiness.

9.1 SERC Priority Actions by Phase

The phased roadmap described earlier in this report provides a national implementation pathway for IS 18968. At the state level, regulators and utilities may consider adopting complementary actions that align regulatory processes with technical deployment activities. The following table summarises suggested priority actions for SERCs and DISCOMs across the implementation phases.

Table 14: SERC Priority Actions by Phase wise

Phase	SERC Actions	DISCOM Actions
Phase 1 (2025–2026)	Launch formal IS 18968 stakeholder proceedings inviting input from DISCOMs, DER developers, inverter manufacturers, and consumer groups. Issue an interim order requiring all new DER interconnection agreements to reference IS 18968 performance requirements pending full regulatory adoption.	Conduct an audit of existing interconnection agreements to assess compatibility with IS 18968 provisions. Initiate internal training programmes for utility engineers and technical staff on IS 18968 performance categories and communication interface requirements.
Phase 2 (2026–2027)	Adopt IS 18968 provisions within state DER interconnection procedures, specifying performance category assignments, commissioning requirements, and consumer disclosure provisions. Issue consumer protection guidelines addressing potential impacts of Volt-Watt functionality.	Develop IS 18968-compliant interconnection application forms and agreement templates. Initiate pilot projects on 3–5 high DER penetration feeders within each DISCOM service area to evaluate smart inverter functionality under real grid conditions.

Phase 3 (2027–2028)	Review pilot programme outcomes including Volt-Watt impacts, hosting capacity improvements, and potential contributions of frequency-droop response. Consider regulatory provisions for mandatory Category B assignment for commercial and industrial DER installations.	Enable Volt-VAR functionality on high DER penetration feeders in accordance with SERC guidelines. Begin systematic commissioning verification using the IS 18968 Clause 11 testing framework.
Phase 4 (2028–2030)	Issue final state-level IS 18968 implementation orders specifying performance category assignments, voltage regulation default settings, and consumer protection provisions including potential compensation mechanisms. Submit periodic implementation status reports to the Ministry of Power.	Integrate IS 18968 requirements into digital DER interconnection portals and establish monitoring systems for DER installations above defined capacity thresholds (e.g., >10 kW).

These actions are intended to support a coordinated approach in which regulatory frameworks evolve in parallel with technical deployment. Early stakeholder engagement, pilot deployments, and structured regulatory reviews can help ensure that DER integration practices remain aligned with local grid conditions while maintaining consistency with national standards.

9.2 Recommended Early Mover States

India's distribution networks exhibit significant variation in terms of DER penetration, grid topology, operational challenges, and institutional readiness. Some states may therefore be particularly well positioned to act as early implementation leaders for IS 18968 due to their existing DER deployment levels, availability of grid data, and technical capacity within utilities.

Early-mover states can play an important role in generating practical operational experience, validating smart inverter functionalities, and developing implementation models that may later be replicated in other jurisdictions. The following states illustrate potential early implementation opportunities based on current grid conditions and DER adoption patterns.

Table 15: Recommended Early Mover States

State	IS 18968 Priority Rationale	Key IS 18968 Focus
Gujarat	Highest rooftop solar penetration nationally, with frequent midday low-voltage network overvoltage conditions on rural feeders. RDSS-funded feeder monitoring provides useful data for DER integration analysis.	Volt-VAR and Volt-Watt activation (Clauses 5.3.3 and 5.4.2); Category B assignment for rooftop systems above 10 kW.

Rajasthan	Large rooftop solar, supported by advanced metering infrastructure in utilities.	DER communication protocol pilots (Clause 10.7); IS 18968 type testing collaboration with local testing labs.
Tamil Nadu	High penetration of wind and solar resources and frequent frequency excursions due to variable renewable generation. Extensive operational grid data available through TANGEDCO.	Category II/III ride-through performance (Clauses 6.4 and 6.5); frequency-droop functionality and coordination with NLDC under Clause 6.5.2.7.
Maharashtra	Dense urban DER installations in Mumbai secondary networks and significant industrial DER installations in cities such as Pune and Nagpur.	Secondary network DER provisions (Clause 9); anti-islanding clearing time considerations (Clause 8.1.2).
Karnataka	Rapid smart meter deployment and strong rooftop solar adoption in urban areas such as Bengaluru. Active participation of the technology sector in distributed energy initiatives.	Communication interface requirements (Clauses 10.7 and 10.8); commissioning test procedures under Clause 11.2.5.

Experience gained from these early deployments may provide valuable operational insights for utilities and regulators across the country. Lessons related to voltage regulation, communication interfaces, commissioning procedures, and DER monitoring can inform future regulatory guidance and help accelerate national adoption of IS 18968-compliant smart inverter technologies.

9.3 Way Forward

State-level implementation of IS 18968 will benefit from close coordination between national institutions, state regulators, utilities, and technical organisations. **CEA and CERC** can support this process by providing technical guidance and aligning national regulatory frameworks with evolving DER integration practices. **SERCs and DISCOMs** play a central role in operationalising the standard through state interconnection regulations, pilot deployments, and feeder-level implementation strategies.

Technical institutions such as **CPRI, NISE, and ERDA**, along with industry associations and inverter manufacturers, can contribute technical expertise, testing support, and knowledge-sharing platforms to assist utilities and regulators during implementation. Through collaborative engagement across these institutions, India can develop a structured and evidence-based pathway for state-level adoption of IS 18968.

10 CONCLUSION — FROM STANDARD TO IMPLEMENTATION

IS 18968: 2025 represents a significant milestone in the evolution of India's electricity distribution ecosystem. For the first time, India now has a comprehensive national standard governing the interconnection and interoperability of distributed energy resources (DERs). Built upon the globally recognised IEEE 1547-2018 framework and adapted to Indian grid realities through the binding provisions of National Annex J, the standard establishes clear technical expectations for how distributed resources should behave when connected to the electricity system.

The modifications introduced through National Annex J ensure that the standard reflects India's operational conditions. These include the adoption of a 50 Hz system frequency, alignment with Indian low-voltage distribution standards of 230/400 V, revised enter-service criteria suited to Indian grid conditions, expanded reactive power capability, and modified voltage and frequency protection thresholds. Together, these provisions create a technically robust framework capable of supporting the rapid expansion of distributed renewable energy resources across the country.

With the publication of IS 18968, the technical foundation is now firmly in place. The next phase of progress lies in translating this standard into operational practice across regulatory frameworks, certification systems, and utility procedures. The effectiveness of IS 18968 will ultimately depend on how systematically it is embedded within CEA regulations, SERC interconnection procedures, BIS certification schemes, and DISCOM operational practices. Until such institutional integration occurs, the grid support capabilities envisioned by the standard will remain largely unrealised.

10.1 The Immediate Implementation Priority

Among the various implementation actions identified in this report, one step stands out as particularly important in the near term. National Annex J-12 delegates the specification of frequency-droop active power response parameters to the Central Electricity Authority (CEA). These parameters are essential for enabling DER systems to contribute to system frequency stability during over-frequency and under-frequency events.

Issuing these specifications through an appropriate regulatory notification would provide clarity to manufacturers, testing laboratories, and utilities regarding the operational behaviour expected from smart inverters operating under IS 18968. Such guidance would also help ensure consistent implementation of frequency-droop functionality across different states and distribution networks. In parallel, incorporating IS 18968 within the CEA Technical Standards for Connectivity of Distributed Generation Resources would provide the regulatory anchor needed to align national interconnection practices with the new standard.

Together, these steps can help initiate the broader implementation chain enabling certification processes, regulatory adoption by SERCs, and operational deployment by utilities.

10.2 India's Structural Advantages for Implementation

India enters the implementation phase of IS 18968 with several important structural advantages. The country possesses a mature institutional framework for electricity regulation, including organisations such as the Central Electricity Authority, the Central Electricity Regulatory Commission, State Electricity Regulatory Commissions, and the Bureau of Indian Standards. These institutions collectively provide the governance architecture required to translate technical standards into operational practice.

India also benefits from an expanding ecosystem of technical institutions and testing laboratories, including organisations such as CPRI, ERDA, and NISE, which can support certification, testing, and performance validation of smart inverter technologies. In parallel, domestic manufacturing capabilities for solar and power electronics equipment are growing rapidly under national industrial initiatives, including production-linked incentive programmes.

Equally important is the scale and urgency of distributed renewable energy deployment. Rooftop solar installations are expanding rapidly under initiatives such as the PM Surya Ghar programme, and DER penetration is already approaching operational thresholds in several states. These developments create both the need and the opportunity for implementing advanced grid-interactive standards such as IS 18968.

10.3 From Technical Standard to Operational Practice

The successful implementation of IS 18968 will ultimately depend on coordinated action across the electricity sector. National regulatory institutions can provide the policy and technical framework; state regulators can translate these provisions into interconnection procedures; testing laboratories and certification bodies can ensure equipment compliance; and distribution utilities can operationalise the standard through transparent and consistent interconnection agreements.

Equally important is maintaining consumer confidence during this transition. Distributed energy resources represent a significant investment for households and businesses participating in India's clean energy transition. Ensuring transparency in smart inverter functionality, clear communication regarding grid-support mechanisms, and fair treatment of prosumers will be essential for sustaining public trust in distributed renewable energy programmes.

10.4 A Coordinated Path Forward

India now possesses all the essential components needed for successful DER integration: a technically sound standard, capable regulatory institutions, expanding testing infrastructure, a growing domestic manufacturing base, and a rapidly increasing distributed renewable energy sector. The challenge ahead lies not in developing new technology or standards, but in coordinating the institutional processes that translate these frameworks into everyday operational practice.

With sustained collaboration among policymakers, regulators, utilities, technical institutions, and industry stakeholders, IS 18968 can serve as the foundation for a more resilient and flexible electricity distribution system one capable of accommodating high levels of distributed renewable generation while maintaining grid stability and consumer confidence. The transition from standard to implementation will therefore mark an important step in India's broader journey toward a modern, digitally enabled, and distributed energy future.

ANNEXURE A: QUICK REFERENCE — NATIONAL ANNEX J MODIFICATIONS SUMMARY

The following table provides a concise reference for implementation teams on the key Indian-specific values from National Annex J that differ from the IEEE 1547-2018 base text.

Parameter	IEEE 1547-2018 Value	IS 18968: 2025 (National Annex J) Value
Nominal system frequency	60 Hz	50 Hz (J-1)
LV single-phase applicable voltage	120 V systems	230 V line-to-neutral (J-2)
LV three-phase applicable voltage	120/240 V systems	400 V line-to-line (J-2)
Frequency measurement range (steady state)	50–66 Hz	40–55 Hz (J-3)
Enter service voltage min (default)	≥ 0.917 p.u. (ANSI Range B)	≥ 0.9 p.u. (J-4)
Enter service voltage max (default)	≤ 1.05 p.u.	≤ 1.1 p.u. (J-4)
Enter service frequency min (default)	≥ 59.5 Hz	≥ 49.5 Hz (J-4)
Enter service frequency max (default)	≤ 60.1 Hz	≤ 50.1 Hz (J-4)
Enter service minimum intentional delay	30 s (default)	60 s (J-5)
Synchronisation step voltage limit at MV	3% of nominal	5% of nominal (J-6)
Reactive power capability (inj. and abs.)	44% of nameplate kVA (Cat B)	60% of nameplate kVA (J-7)
Volt-var V_{Ref} adjustable range	0.95–1.05 V_N	0.9–1.1 V_N (J-8)
Q1/Q4 for Category B volt-var	44% of nameplate apparent power	60% of nameplate apparent power (J-8)
Overvoltage trip threshold (default)	1.10 p.u. (OV1), 1.20 p.u. (OV2)	1.1 p.u., 2 s clearing (J-10)

Undervoltage trip threshold (default)	0.70 p.u. (UV1), 0.45 p.u. (UV2)	0.8 p.u., 2 s clearing (J-10)
Overfrequency trip (default)	62.0 Hz, 0.16 s (OF2); 61.2 Hz, 300 s (OF1)	52.0 Hz, 0.2 s (J-11)
Underfrequency trip (default)	56.5 Hz, 0.16 s (UF2); 58.5 Hz, 300 s (UF1)	47.5 Hz, 0.2 s (J-11)
Frequency continuous operation range	58.8–61.2 Hz	47.5–52.0 Hz (J-12)
Frequency-droop active power requirement	Per IEEE 1547-2018 Table 23 formula (60 Hz base)	Per CEA requirements; absent CEA requirements: per area EPS/distribution licence (J-12)

ANNEXURE B: COMPREHENSIVE GLOSSARY OF ACRONYMS AND TECHNICAL TERMS

This glossary covers all acronyms and key technical terms used in this roadmap document, organised into three sections: (A) Indian Regulatory and Institutional Acronyms; (B) Technical Acronyms and (C) Technical Terms and Concepts defined or used in IS 18968: 2025. All IS 18968 clause references are to IS 18968: 2025 (BIS, January 2025).

a. Indian Regulatory and Institutional Acronyms

Acronym	Full Form and Description
ALMM	Approved List of Models and Manufacturers — MNRE's list of approved solar modules and inverters eligible for use in government-supported DER projects.
BESCOM	Bangalore Electricity Supply Company — the DISCOM serving Bengaluru and surrounding areas in Karnataka.
BIS	Bureau of Indian Standards — India's national standards body established under the Bureau of Indian Standards Act, 2016. Website: www.bis.gov.in.
BPS	Bulk Power System — any electric generation resources, transmission lines, interconnections with neighbouring systems, and associated equipment. IS 18968 Category II and III requirements are specifically designed to protect BPS stability during high DER penetration.
CEA	Central Electricity Authority — the statutory technical authority under the Ministry of Power. Responsible for the Technical Standards for Connectivity of Distributed Generation Resources (2013 Regulations
CEA-TSCR	CEA Technical Standards for Connectivity Regulations (2013) — the current central regulatory instrument governing DER interconnection in India.
CERC	Central Electricity Regulatory Commission — the central regulatory authority for the Indian electricity sector. Acts as the Authority Governing Interconnection Requirements (AGIR) for central sector and wholesale market-connected DERs.
CERT-In	Indian Computer Emergency Response Team — responsible for cybersecurity guidelines for critical infrastructure.
CHP	Combined Heat and Power — a DER technology that simultaneously produces electrical power and useful heat from a single fuel source.
CPRI	Central Power Research Institute — India's primary electrical testing and research institution.
ERDA	Electrical Research and Development Association — an IS 18968 type-testing laboratory based in Vadodara, Gujarat.
ETD 46	Grid Integration of Renewables Sectional Committee of BIS — the technical committee responsible for IS 18968: 2025 development and future revisions.

	Membership includes CERC, MNRE, NLDC, leading DISCOMs, inverter manufacturers, and IITs.
IEEE	Institute of Electrical and Electronics Engineers — the international standards body that published IEEE Std 1547™-2018, which IS 18968: 2025 modifies and adopts as an Indian national standard.
IREDA	Indian Renewable Energy Development Agency.
IS	Indian Standard — the designation for standards published by the Bureau of Indian Standards (BIS).
MNRE	Ministry of New and Renewable Energy — responsible for PM Surya Ghar scheme, PLI scheme for solar manufacturing, and policy on rooftop and distributed solar.
MoP	Ministry of Power — the apex policy ministry for India's electricity sector.
NABL	National Accreditation Board for Testing and Calibration Laboratories — the body that accredits Indian laboratories for conformance testing.
NLDC	National Load Despatch Centre — the apex body for integrated operation of India's national grid, part of POSOCO.
NRTL	Nationally Recognised Testing Laboratory — IS 18968 Clause 11.2.3 references NRTLs for certified production facility approvals. In India, NABL-accredited laboratories serve this role.
PFC	Power Finance Corporation — may be involved in financing DER infrastructure deployment through RDSS or similar schemes.
PLI	Production Linked Incentive — MNRE's scheme to boost domestic solar module and inverter manufacturing.
PM Surya Ghar	PM Surya Ghar Muft Bijli Yojana — the Government of India's flagship rooftop solar scheme targeting 1 crore households. The primary driver of residential DER growth in India;
POSOCO	Power System Operation Corporation of India — operates NLDC and provides technical oversight to SLDCs.
PV	Photovoltaic — solar photovoltaic systems are the dominant DER technology in India and the primary target of IS 18968 implementation efforts. Inverter-based PV systems are capable of all IS 18968 performance categories.
RDSS	Revamped Distribution Sector Scheme — MoP's scheme for distribution infrastructure modernisation, including smart metering and feeder separation.
RLDC	Regional Load Despatch Centre — operates below NLDC and above SLDCs in India's load despatch hierarchy. Relevant to Category III DER coordination and frequency-droop setting approvals.

REC	Rural Electrification Corporation
SERC	State Electricity Regulatory Commission — the state-level regulatory authority. Acts as the AGIR for state-level DER interconnection under IS 18968. Responsible for specifying performance categories in state interconnection procedures, adopting consumer protection guidelines, and reviewing DISCOM generation loss reports.
SLDC	State Load Despatch Centre — the real-time grid operator for each state. Acts as the regional reliability coordinator under IS 18968 for Category II and III DER frequency-droop setting approvals and coordination with DISCOMs on high-penetration feeder management.
SMNP	Smart Meter National Programme — India's programme for mass deployment of smart prepaid electricity meters. The communication backbone (RF mesh or cellular GPRS/4G networks) being deployed under SMNP may be leveraged as the physical communication layer for DERMS under IS 18968 Clause 10.
STATCOM	Static Synchronous Compensator — a power electronics-based reactive power compensation device. May be used as a supplemental DER device under IS 18968 Clause 1.4 to help smaller or older DERs meet reactive power requirements at the PCC.
TANGEDCO	Tamil Nadu Generation and Distribution Corporation — the DISCOM for Tamil Nadu.
UGVCL / PGVCL	Uttar Gujarat Vij Company Ltd. / Paschim Gujarat Vij Company Ltd. — Gujarat DISCOMs with advanced metering infrastructure;
V2G	Vehicle-to-Grid — bidirectional EV charging technology where EV batteries can export power back to the grid.
DERMS	Distributed Energy Resource Management System — utility-side software platform for real-time monitoring, management, and control of DERs via IS 18968 Clause 10 communication protocols (SEP2, DNP3, SunSpec Modbus). Connects to each DER's local DER communication interface to read nameplate, monitoring, and configuration data, and to write management settings (mode changes, power limits, trip settings).
DISCOM	Distribution Company — the Area EPS operator in India's electricity supply chain. Under IS 18968, DISCOMs are the Area EPS operators responsible for specifying DER performance categories in interconnection agreements, enabling voltage regulation functions (volt-var, volt-watt), approving commissioning tests, and operating DERMS platforms.
GPRS	General Packet Radio Service — a mobile data protocol used in 2G/3G cellular networks. One of the communication network technologies available to carry IS 18968 Clause 10 protocol traffic (SEP2/DNP3/SunSpec Modbus) between DERs and DERMS platforms in Indian distribution networks, alongside RF mesh and 4G/LTE.
IIT	Indian Institute of Technology — India's premier technical universities.

ISGF	India Smart Grid Forum- India’s premier technical nonprofit organisation. Recommended as partners for IS 18968 pilot testing, technical training curriculum development and delivery (targeting 3,000+ DISCOM and SLDC engineers), as well as for research on Indian grid-specific implementation challenges.
MEA	Ministry of External Affairs — referenced in Phase 5 in the context of bilateral harmonisation of IS 18968 with international standards (IEEE 1547-2018, IEC 62116, EN 50549) for equipment trade facilitation and cross-border power system integration with South and Southeast Asian neighbours.
NIST	National Institute of Standards and Technology (USA) — cybersecurity framework standards (NIST SP 800 series) referenced as an international benchmark for developing India's DER communication network cybersecurity framework, alongside CERT-In guidelines and IEC 62351. IS 18968 Clause 10.9 explicitly leaves cybersecurity out of scope of the standard.

b. IS 18968: 2025 Technical Acronyms (from the Standard)

The following acronyms appear in the body of IS 18968: 2025 and its National Annex J. All definitions are drawn from IS 18968 Clause 3.2 and the standard body text.

Acronym	Full Form and IS 18968 Definition
AGC	Automatic Generation Control — a system that regulates the output of generators within a prescribed area in response to changes in system frequency and tie-line loading. Referenced in IS 18968 in the context of intentional island scheduled transitions (Clause 8.2.2).
AGIR	Authority Governing Interconnection Requirements — defined in IS 18968 Clause 3.1 as 'a cognizant and responsible entity that defines, codifies, communicates, administers, and enforces the policies and procedures for allowing electrical interconnection of DER to the Area EPS.' In India: CERC, SERCs, or CEA depending on context. May delegate authority to the Area EPS operator (DISCOM/SLDC).
AHJ	Authority Having Jurisdiction — the authority with rights of inspection and approval of Local EPS premise electrical systems. Determines emergency and standby DER designations (IS 18968 Clause 4.13). In India: electrical inspectorates, local authorities.
Area EPS	Area Electric Power System — defined in IS 18968 Clause 3.1 as 'an EPS that serves Local EPSs.' In India: the distribution network owned and operated by a DISCOM.
BESS	Battery Energy Storage System — an energy storage DER. BESS are recommended for Normal Category B and Abnormal Category III under IS 18968, as they have full ride-through capability and bidirectional operation.

BPS	Bulk Power System — defined in IS 18968 Clause 3.1 as 'any electric generation resources, transmission lines, interconnections with neighbouring systems, and associated equipment.' IS 18968 Category II and III requirements are specifically designed to protect BPS stability.
DER	Distributed Energy Resource — defined in IS 18968 Clause 3.1 as encompassing sources such as synchronous machines, induction machines, and static power inverters/converters connected to the electric power system at distribution voltage levels. Includes solar PV, BESS, wind generators, CHP, and EV chargers.
DTT	Direct Transfer Trip — a fast communications-based protection scheme that disconnects a DER when upstream breakers or reclosers open. IS 18968 Clause 8.1.2 (extended anti-islanding clearing time up to 5 s) can reduce costly DTT requirements by allowing time for islands to collapse naturally.
DNP3	Distributed Network Protocol 3 — one of three eligible communication protocols under IS 18968 Clause 10.7 (IEEE Std 1815™). Uses TCP/IP over Ethernet transport/physical layer.
EMI	Electromagnetic Interference — IS 18968 Clause 4.11.1 requires DERs to comply with IEEE Std C37.90.2, IEC 61000-4-3, or equivalent, with a minimum electric field strength of 30 V/m.
EMS	Energy Management System — referenced in IS 18968 Clause 3.2. May act as a DER managing entity alongside utilities and aggregators.
EPS	Electric Power System — defined in IS 18968 Clause 3.1 as 'facilities that deliver electric power to a load.' The term encompasses both Area EPS (utility grid) and Local EPS (customer-side system).
ESS	Energy Storage System — IS 18968 uses this term for DERs that can both inject and absorb active power (e.g., batteries). IS 18968 Clause 4.5 notes that ESS are allowed to continue charging but may cease active charging when maximum state of charge is reached.
EV	Electric Vehicle — grid-interactive EV charging infrastructure increasingly functions as a DER
FIDVR	Fault-Induced Delayed Voltage Recovery — a grid disturbance condition referenced in IS 18968 Annex B and implicit in Category II and III ride-through requirements. Occurs when motor loads stall after a fault and draw high reactive current, preventing rapid voltage recovery.
HV	High Voltage — in IS 18968 context, refers to overvoltage trip (OV) and high-voltage ride-through (HVRT) conditions. IS 18968 National Annex J-10 sets the India-specific OV trip at V > 1.1 p.u. with 2 s clearing time.

IEC	International Electrotechnical Commission — IS 18968 normative references include IEC 61000-4-3, IEC 61000-4-5, and IEC/TR 61000-3-7 for EMC and power quality. IEC 61000-4-5 is covered by IS 14700 (Part 4/Sec 5).
IEEE	Institute of Electrical and Electronics Engineers — the source of IEEE Std 1547™-2018 on which IS 18968 is based, and of several normative references including IEEE Std 519™, IEEE Std 1453™, IEEE Std 1815™, IEEE Std 2030.5™.
kVA	Kilovolt-Ampere — unit of apparent power. IS 18968 uses kVA extensively in the RPA determination rule (PCC applies for aggregate DER > 500 kVA; PoC for ≤ 500 kVA per Clause 4.2) and in reactive power capability specifications (Table 7, as modified by National Annex J-7).
kW	Kilowatt — unit of active (real) power. IS 18968 references kW in the context of active power ratings, volt-watt function active power setpoints, and frequency-droop active power adjustment formulas (Table 23).
kVAR	Kilovolt-Ampere Reactive — unit of reactive power. IS 18968 uses kVAR for nameplate reactive power ratings and reactive power injection/absorption specifications (Tables 7, 8, 9).
LV	Low Voltage — in IS 18968 context, the distribution voltage level below the medium-voltage system. In India: 230 V (single-phase) and 400 V (three-phase) LT networks as specified in National Annex J-2. IS 18968 Clause 4.3 defines low-voltage PCC applicable voltages with reference to the low-voltage winding configuration of the Area EPS transformer.
LV Ride-Through / LVRT	Low-Voltage Ride-Through — the ability of a DER to continue operating during temporary undervoltage conditions. IS 18968 Clauses 6.4.2.3.2 and 6.4.2.3.3 specify LVRT capability and performance requirements for Category I, II, and III DERs.
HV Ride-Through / HVRT	High-Voltage Ride-Through — the ability of a DER to continue operating during temporary overvoltage conditions. IS 18968 Clauses 6.4.2.4.2 and 6.4.2.4.3 specify HVRT requirements. Under J-10 (Indian values): OV trip at V > 1.1 p.u. with 2 s clearing; permissive operation in 1.10–1.20 p.u. range with Category I/II clearing times; momentary cessation for Category III in the 1.10–1.20 p.u. range.
EMC	Electromagnetic Compatibility — IS 18968 normative references include IEC 61000-4-3 (radiated immunity) and IEC 61000-4-5 (surge immunity) as mandatory EMC test standards. The Indian equivalents are IS 14700 (Part 4/Sec 3) : 2023 and IS 14700 (Part 4/Sec 5) : 2019, which are identical adoptions. EMC compliance is verified through type testing (IS 18968 Clause 11.2.2).
TDD	Total Demand Distortion — the conventional power systems measure of harmonic current distortion relative to load demand current, used in IEEE Std 519. IS 18968 Clause 7.3 deliberately replaces TDD with TRD (Total Rated-current Distortion) for

	DER, because DER harmonic distortion is more meaningfully expressed relative to the DER's rated current capacity (Irated) rather than the variable load demand current.
MV	Medium Voltage — defined in IS 18968 Clause 3.1 as 'a class of nominal system voltages equal to or greater than 1 kV and less than or equal to 35 kV.' In India: 11 kV and 33 kV are the primary MV distribution levels.
NP	Network Protector — an automatic switching device used in secondary grid and spot network distribution systems. IS 18968 Clause 9 specifies requirements for DERs interconnecting to systems with network protectors, including restrictions on causing NPs to open, preventing NP closure, or exceeding NP loading capability.
NRTL	Nationally Recognised Testing Laboratory — IS 18968 Clause 11.2.3 allows manufacturers with NRTL-certified production facilities to use approved practices for production test requirements. In India: NABL-accredited laboratories serve this function.
OF	Overfrequency — IS 18968 Clause 6.5.1 defines overfrequency trip functions OF1 and OF2. National Annex J-11 sets the India-specific OF default trip at 52.0 Hz with 0.2 s clearing time (range: 50.05–52.0 Hz).
OV	Overvoltage — IS 18968 Clause 6.4.1 defines overvoltage trip functions OV1 and OV2 in the IEEE base text. National Annex J-10 simplifies this to a single India-specific OV trip at V > 1.1 p.u. with 2 s clearing time.
p.u.	Per Unit — IS 18968 uses per-unit notation extensively for voltage and power quantities. Voltage is expressed as p.u. of nominal voltage (e.g., 0.9 p.u. = 90% of nominal). Active power is expressed as p.u. of DER nameplate active power rating.
PCC	Point of Common Coupling — defined in IS 18968 Clause 3.1 as 'the point of connection between the Area EPS and the Local EPS.' Equivalent in most cases to the utility revenue meter. The primary Reference Point of Applicability (RPA) for DERs with aggregate nameplate > 500 kVA (IS 18968 Clause 4.2).
PoC	Point of DER Connection — defined in IS 18968 Clause 3.1 as 'the point where a DER unit is electrically connected in a Local EPS and meets the requirements of this standard exclusive of any load present in the respective part of the Local EPS.' The RPA for DERs ≤ 500 kVA meeting the conditions of IS 18968 Clause 4.2 (typically the inverter terminals).
PQ	Power Quality — IS 18968 Clause 7 specifies power quality requirements including: DC injection limit (0.5% of rated current), rapid voltage changes (RVC), flicker (E_{Pst} ≤ 0.35, E_{Plt} ≤ 0.25), harmonic current distortion (TRD ≤ 5%), and overvoltage limitation.
ROCOF	Rate of Change of Frequency — IS 18968 Clause 6.5.2.5 specifies ROCOF ride-through requirements: Category I: 0.5 Hz/s; Category II: 2.0 Hz/s; Category III: 3.0 Hz/s. The ROCOF is averaged over a minimum 0.1 s window (IS 18968 Clause 4.3).

RMS	Root Mean Square — IS 18968 uses RMS values for voltage and current measurements. The minimum steady-state voltage measurement accuracy is ±1% Vnom (10-cycle window) per National Annex J-3.
RPA	Reference Point of Applicability — defined in IS 18968 Clause 3.1 as 'the location where the interconnection and interoperability performance requirements specified in this standard apply.' Either the PCC or the PoC, determined by the rules in IS 18968 Clause 4.2.
RVC	Rapid Voltage Change — IS 18968 Clause 7.2.2 limits RVC caused by DERs: at MV PCC: ≤ 3% of nominal step/ramp change; at LV PCC: ≤ 5% of nominal. National Annex J-6 sets the synchronisation step limit at 5% of nominal for both MV and LV.
SCADA	Supervisory Control and Data Acquisition — utility-side system for real-time monitoring and control of grid equipment. IS 18968 Clause 10 communication interface requirements enable DER data to be integrated into SCADA/DERMS platforms.
SEP2	Smart Energy Profile 2.0 — one of three eligible communication protocols under IS 18968 Clause 10.7 (IEEE Std 2030.5™). Uses TCP/IP over Ethernet.
SunSpec Modbus	A standard defining common register values for DER devices including inverters and meters. One of three eligible communication protocols under IS 18968 Clause 10.7. Can use either TCP/IP over Ethernet or RS-485 physical layer — the only IS 18968 protocol supporting RS-485.
THD	Total Harmonic Distortion — IS 18968 references voltage THD in the context of measurement accuracy (J-3: measurement accuracy requirements apply when voltage THD < 2.5%). IS 18968 Clause 7.3 uses TRD (Total Rated-current Distortion) rather than THD for current distortion limits.
TRD	Total Rated-current Distortion — IS 18968 Clause 7.3 uses TRD (rather than conventional THD or TDD) as the measure of DER current distortion quality. Maximum TRD limit: 5% of rated current (Irated). Calculated as: $\%TRD = \sqrt{I_{rms}^2 - I_1^2} / I_{rated} \times 100\%$.
UF	Underfrequency — IS 18968 Clause 6.5.1 defines underfrequency trip functions UF1 and UF2. National Annex J-11 sets the India-specific UF default trip at 47.5 Hz with 0.2 s clearing time (range: 47.5–48.8 Hz).
UV	Undervoltage — IS 18968 Clause 6.4.1 defines undervoltage trip functions UV1 and UV2 in the IEEE base text. National Annex J-10 simplifies this to a single India-specific UV trip at V < 0.8 p.u. with 2 s clearing time.
VN	Nominal Voltage — IS 18968 uses VN as the reference voltage for volt-var and volt-watt settings. In India: 230 V (single-phase LV), 400 V (three-phase LV), 11 kV / 33 kV (MV) as per National Annex J-2.

V2G	Vehicle-to-Grid — bidirectional charging technology enabling EV batteries to supply power back to the grid. Future DER category for IS 18968 revision. Currently treated as a Category B DER under IS 18968.

c. Key Technical Terms and Concepts (IS 18968: 2025)

The following terms are defined in IS 18968: 2025 Clause 3.1 or used with specific technical meaning in the standard. Understanding these terms is essential for DISCOM engineers, SERC officers, and DER developers implementing IS 18968 in India.

Term	Definition and IS 18968 Context
Abnormal Operating Performance Category	The grouping (Category I, II, or III) specifying DER technical capabilities and settings under abnormal voltage or frequency conditions — i.e., outside the continuous operation region. Assigned by the AGIR (CERC/SERC/CEA in India). Category III provides the highest ride-through capability. Defined in IS 18968 Clause 3.1 and Clause 6.
Active Power	The real power consumed by electrical resistance; measured in watts (W) or kilowatts (kW). IS 18968 uses active power as the basis for: DER nameplate rating, RPA determination (500 kVA threshold), frequency-droop adjustment formulas, and volt-watt function setpoints. Generator sign convention applies throughout IS 18968 (positive = injection to grid).
Apparent Power	The combination of active power and reactive power; measured in volt-amperes (VA) or kilovolt-amperes (kVA). Calculated as the product of RMS voltage and RMS current without reference to phase angle. IS 18968 uses apparent power for: RPA threshold (500 kVA), nameplate kVA ratings, and reactive power capability specifications (Table 7 as modified by J-7).
Area EPS Operator	The entity responsible for designing, building, operating, and maintaining the Area EPS. In India: DISCOMs for distribution-level DER. IS 18968 gives the Area EPS operator the authority to: specify performance categories, enable voltage regulation functions, specify communication protocols, approve extended anti-islanding clearing times, and direct DERs to cease to energize (Clause 4.6.1).
Cease to Energize	Cessation of active power delivery under steady-state and transient conditions, with limitation of reactive power exchange. IS 18968 Clause 4.5 specifies: for DER < 500 kVA, reactive power exchange in cease-to-energize state shall be < 10% of nameplate rating from passive devices only; for DER ≥ 500 kVA: < 3%. Does not necessarily imply disconnection or trip.
Clearing Time	The time between the start of an abnormal condition and the DER ceasing to energize the Area EPS. Includes detection time, any adjustable delay, operating time of interposing and interrupting devices. IS 18968 Clause 3.1.

	National Annex J-10 specifies India-specific default clearing times (2 s for both overvoltage and undervoltage).
Configured Nameplate Rating	A configuration setting (IS 18968 Clause 10.4) that limits the effective capacity of the DER below its physical nameplate rating. This setting affects power output and must be disclosed to DER customers in Indian interconnection agreements, as it can reduce generation below expected levels.
Continuous Operation	Exchange of current between the DER and an EPS within prescribed normal operating conditions (voltage 0.88–1.10 p.u.; frequency 47.5–52.0 Hz under J-12). IS 18968 requires the DER to remain in operation indefinitely within this region. The communication interface must be active whenever the DER is in this region (Clause 10.8).
DER Managing Entity	An entity that monitors and manages the DER through the local DER communication interface. Defined in IS 18968 Clause 3.1 as potentially being a utility, aggregator, building energy management system, or other. Relevant to India's developing DER aggregation market.
DER System	Multiple DER units within a single Local EPS, assessed based on aggregate nameplate rating. IS 18968 Clause 4.1: 'Unless specified otherwise, the term DER means DER system.' The aggregate DER nameplate rating determines whether the RPA is the PCC or PoC.
DER Unit	An individual DER device within a group of DER that collectively form a system. IS 18968 Clause 3.1. A single residential rooftop solar inverter is a DER unit; a large commercial solar installation with multiple inverters is a DER system.
Dynamic Voltage Support	The ability of a DER to supply reactive current (and possibly active current) to the Area EPS during low-voltage or high-voltage ride-through, to support voltage recovery. IS 18968 Clause 6.4.2.6. Optional for all categories — activated by mutual agreement with the Area EPS operator. Particularly valuable for Category III DERs during distribution faults.
Enter Service	The process by which a DER begins operation with an energised Area EPS. IS 18968 Clause 4.10 specifies enter service criteria (voltage and frequency within range, permit service enabled), performance during entry (ramp rate limits), and synchronisation requirements. National Annex J-4 and J-5 modify the Indian voltage/frequency ranges and default delay (60 s).
Flicker	The subjective impression of fluctuating luminance caused by voltage fluctuations. IS 18968 Clause 7.2.3: DER contribution to flicker at the PCC shall not exceed Epst = 0.35 (short-term, 600 s) and Eplt = 0.25 (long-term, 2 h). Assessed per IEEE Std 1453 and IEC/TR 61000-3-7.

Frequency Droop (Frequency-Power)	A DER control function that adjusts active power output in proportion to frequency deviation from the deadband. IS 18968 Clause 6.5.2.7 (Table 22): mandatory for ALL categories in overfrequency conditions; mandatory for Category II and III in underfrequency conditions (optional for Category I). Default: db = 0.036 Hz deadband; k = 0.05 droop; Tresponse = 5 s. National Annex J-12 defers the active power adjustment formula to CEA requirements for Indian conditions.
Hosting Capacity	The amount of DERs that can be accommodated on the distribution system under existing conditions without adversely impacting operational criteria or requiring significant infrastructure upgrades. IS 18968 voltage regulation functions (volt-var, volt-watt) can increase hosting capacity by mitigating voltage impacts of DER injection — a key justification for early activation of these functions in India.
Inadvertent Export	The unscheduled, transient export of power onto the grid from non-exporting or limited-export DER systems, typically due to mismatch between system output and load consumption. IS 18968 Clause 4.2 references export limits in the context of RPA determination (500 kVA for 30 s threshold). Must be addressed in Indian interconnection rules for behind-the-meter DER.
Intentional Island	A planned electrical island capable of being energised by one or more Local EPSs — with DER and load, ability to disconnect from and parallel with the Area EPS, and intentional planning. IS 18968 Clause 8.2. Intentional Local EPS Islands (microgrids fully behind the PCC) and Intentional Area EPS Islands (utility microgrids including portions of the Area EPS) are both addressed.
Interconnection System	The collection of all interconnection and interoperability equipment and functions used to interconnect a DER to an Area EPS. IS 18968 Clause 3.1. Includes the inverter, isolation device, protection relays, communication interface, and any supplemental DER devices.
Interoperability	The capability of two or more different systems, networks or technologies to communicate and exchange information. IS 18968 Clause 10 mandates interoperability through standardised communication protocols (SEP2/DNP3/SunSpec Modbus) and information models (nameplate, configuration, monitoring, management data).
Island	A condition in which a portion of an Area EPS is energised solely by one or more Local EPSs through the associated PCCs while that portion is electrically separated from the rest of the Area EPS. IS 18968 Clause 8.1: DER must detect unintentional islands and trip within 2 s (extendable to 5 s by mutual agreement under Clause 8.1.2).

Local DER Communication Interface	A local interface capable of communicating to support the information exchange requirements of IS 18968 Clause 10. Must support at least one of: IEEE Std 2030.5 (SEP2), IEEE Std 1815 (DNP3), or SunSpec Modbus (Clause 10.7). Must be active whenever the DER is in continuous or mandatory operation (Clause 10.8). The DER-side interface that DERMS systems in India will connect to.
Local EPS	Local Electric Power System — an EPS contained entirely within a single premises or group of premises. IS 18968 Clause 3.1. The customer-side system including all DER units, supplemental DER devices, and loads, connected to the Area EPS at the PCC.
Mandatory Operation	Required continuance of active current and reactive current exchange of the DER with the Area EPS during abnormal voltage or frequency disturbances within defined limits. IS 18968 Clause 3.1. During mandatory operation, Category II and III DERs must not reduce apparent current below 80% of pre-disturbance value. The mandatory operation region defines the core ride-through requirement for Indian DERs.
Momentary Cessation	Temporarily ceasing to energise an EPS while remaining connected to the Area EPS, in response to a disturbance, with capability for immediate output restoration when conditions normalise. IS 18968 Clause 3.1. Used for Category III DERs during high-voltage ride-through (1.10–1.20 p.u.) and very deep low-voltage events (< 0.50 p.u.).
Normal Operating Performance Category	The grouping (Category A or B) specifying DER reactive power capability and voltage/power control capability during normal grid operations. Category A: minimum performance for lower-penetration areas. Category B: enhanced performance including watt-var and volt-watt modes; mandatory for high-penetration areas. IS 18968 Clause 3.1 and Clause 5.
Permit Service	A DER setting that indicates whether a DER is allowed to enter or remain in service (IS 18968 Clause 3.1). When the Area EPS operator disables permit service (Clause 4.6.1), the DER must cease to energise and trip within 2 s. All enter-service and management parameters include permit service as a key setting (Table 39).
Permissive Operation	An operating mode where the DER performs ride-through either in mandatory operation or momentary cessation, in response to abnormal voltage or frequency. IS 18968 Clause 3.1. DERs in permissive operation regions may trip or cease to energise but are not required to maintain current output.
Power Factor	Ratio of active power to apparent power (unitless, 0–1). IS 18968 Clause 5.3.2 specifies constant power factor mode as the default voltage regulation mode with unity (1.0) setting — providing no reactive power. The default is

	a starting point; DISCOMs must actively specify non-unity power factor settings or enable other modes to realise voltage regulation benefits.
Reactive Power	Power stored or returned to the circuit each half cycle, resulting from phase shift between voltage and current waveforms. Measured in vars (volt-amperes reactive) or KVARs. IS 18968 National Annex J-7 requires DERs to be capable of injecting and absorbing reactive power up to 60% of nameplate kVA rating — the key parameter for voltage regulation on Indian distribution networks.
Restore Output	Return of DER operation to the state prior to an abnormal voltage or frequency excursion after ride-through. IS 18968 Clause 6.4.2.7: the DER must restore active current to at least 80% of pre-disturbance level within 0.4 s of voltage returning to the continuous operation region.
Ride-Through	Ability to withstand voltage or frequency disturbances within defined limits while continuing to operate as specified. IS 18968 Clause 3.1. The ride-through requirements (Clauses 6.4.2 for voltage, 6.5.2 for frequency) are the most operationally significant change IS 18968 makes to current Indian DER interconnection practice, where inverters typically trip immediately during grid disturbances.
Supplemental DER Device	Equipment used to obtain compliance with IS 18968 requirements that is not part of the DER unit itself. IS 18968 Clause 1.4. Examples: capacitor banks, STATCOMs, harmonic filters, protection devices, plant controllers. Where supplemental devices are used, a detailed DER evaluation (desk study and as-built) is required rather than relying solely on type testing.
Trip	Inhibition of immediate return to service, which may involve disconnection. IS 18968 Clause 3.1. Distinguished from cease-to-energize: trip is a more severe response requiring a deliberate return-to-service sequence per Clause 4.10. Default voltage and frequency trip thresholds for India are specified in National Annex J-10 and J-11 respectively.
Type Test	A test of one or more devices manufactured to a certain design to demonstrate that the design meets IS 18968 requirements. IS 18968 Clause 11.2.2. Results apply to the same product family within 50%–200% of the tested unit's power rating. Type testing by NABL-accredited labs (CPRI, ERDA) is the primary compliance verification method for DERs at the PoC in India.
Unity Power Factor	A power factor setting of 1.0 — the DER draws or injects no reactive power. IS 18968 Clause 5.3.2: constant power factor mode with unity setting is the DEFAULT installed mode. This means a newly installed IS 18968-compliant inverter provides NO voltage regulation support until the DISCOM (Area EPS

	operator) specifies a non-unity setting or enables another voltage regulation mode.
Volt-Var Mode	Voltage-Reactive Power Mode — IS 18968 Clause 5.3.3. The DER modulates reactive power absorption/injection as a function of measured grid voltage, following a piecewise linear V-Q characteristic. National Annex J-8 specifies Indian-specific volt-var settings with VRef range 0.9–1.1 VN and Q1/Q4 at 60% of nameplate apparent power for Category B. Disabled by default; requires Area EPS operator approval.
Volt-Watt Mode	Voltage-Active Power Mode — IS 18968 Clause 5.4.2. The DER limits maximum active power output as a function of measured voltage, following a piecewise linear V-P characteristic. Category B DERs only. Disabled by default; requires Area EPS operator approval. Activation reduces DER customer generation and requires consumer protection disclosures and SERC reporting.
Watt-Var Mode	Active Power-Reactive Power Mode — IS 18968 Clause 5.3.4. The DER modulates reactive power as a function of active power output. Mandatory for Category B; not required for Category A. Disabled by default; requires Area EPS operator approval. Provides predictable voltage support correlated with DER generation level.
Zero-Sequence Continuity	Circuit topology providing continuity between two defined points in the zero-sequence network representation. IS 18968 Clause 3.1. Critical for RPA determination under Clause 4.2: if zero-sequence continuity is maintained between PCC and PoC, the PoC may be used as the RPA for DER ≤ 500 kVA. Transformers with delta or ungrounded-wye windings in the path produce discontinuity.

This roadmap is grounded in IS 18968: 2025 (BIS, January 2025) — Indian Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces (Modified Adoption of IEEE Std 1547™-2018). All clause and table references are to IS 18968 : 2025. National Annex J provisions are normative.

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Roadmap and Recommendations for
Rollout of Grid Integrated Smart Inverters for Distributed Energy Resources