E1. Solar PV / solar inverter transformers and reactors

Standard Approach
Transformer section: IEC/EN 60076-1; IEC/EN 60076-11 if the dry-type power transformer scope is suitable; IEC/EN 61558 family for LV isolation/safety-type products. IEC 60076-1 gives the general standard for single-phase and three-phase power transformers.
Reactor / choke / filter reactor section: IEC/EN 60076-6. This standard covers many reactor types including shunt, series, filter/tuning, motor starting and smoothing reactors.
Verification together with inverter/drive system: IEC 61800-3 EMC requirements and test methods; IEC 61800-5-1 is used as an auxiliary reference for power electronics safety. IEC 61800-3 covers EMC requirements for AC/DC motor drives and power drive systems containing electronic converters.
THD / harmonic / power quality measurement: IEC 61000-4-7 is used for harmonic and interharmonic measurements, and IEC 61000-4-30 for power quality measurement methods. IEC 61000-4-7 defines the measurement method and instrument requirements for spectral components superimposed on the fundamental frequency in 50/60 Hz systems.
Outdoor / environmental conditions: IEC/EN 60529 for IP, IEC 60068 series for humidity and temperature cycles, and IEC/EN 61439 family for panel/enclosure are used as auxiliary references.

1. Additional Routine / Special Test Recommendations

1

Frequency / harmonic check suitable for inverter output

Main standard	IEC/EN 60076-1 for transformer; IEC/EN 60076-6 for reactor; IEC 61000-4-7 / IEC 61000-4-30 for system measurement
Construction / method standard	Measurement of THDi, THDv, individual harmonics, RMS current, RMS voltage and frequency with a power analyzer
Description for solar PV / solar inverter application	Solar inverter output should not be considered like a conventional sinusoidal load. The OMSAN document mentions THDi of 30-60%, high dv/dt and high RMS current levels in PV/wind inverters. Therefore, not only the nominal 50 Hz test but also the harmonic spectrum should be evaluated.

2

Harmonic spectrum design verification

Main standard	IEC 61000-4-7; IEC/EN 60076-1 on the transformer calculation side; IEEE C57.110 may be used as an auxiliary reference for the K-factor approach
Construction / method standard	Calculation of additional loss, RMS current, eddy/stray loss and temperature effect based on the site/inverter harmonic report
Description for solar PV / solar inverter application	On the transformer side, not only the THDi percentage but also the harmonic distribution is important. The OMSAN document states that inverter harmonics create additional eddy current and stray loss in windings due to upper-frequency components, increasing temperature rise and insulation stress.

3

Temperature rise test - for enclosed panel / site condition

Main standard	IEC/EN 60076-11 or IEC/EN 61558-1 for transformer; IEC/EN 60076-6 for reactor; IEC/EN 61439-1 for panel
Construction / method standard	Steady-state temperature measurement at rated RMS current or under conditions close to the actual inverter/PWM/harmonic load profile
Description for solar PV / solar inverter application	High ambient temperature, enclosed inverter cabinet, low air circulation and harmonic currents must be evaluated together in a solar PV site. The OMSAN renewable energy document especially emphasizes thermal modeling, hot-spot analysis, cooling ducts and additional heating caused by harmonics.

4 dv/dt test - if inverter output / drive-type application exists

Main standard	IEC 61800-3 and IEC 61800-5-1 for system; IEC/EN 60076-6 for reactor/filter
Construction / method standard	Measurement of dv/dt and peak voltage at the inverter output, transformer input/output or after-filter point with an oscilloscope and suitable high-voltage differential probe
Description for solar PV / solar inverter application	If the solar inverter output has PWM characteristics, the insulation system and cables are affected by high-voltage edges. In the sine filter test plan, dv/dt measurement with an oscilloscope at points such as drive output and motor terminal is recommended; on the solar PV inverter side, the same logic should be adapted to the inverter-transformer-filter interface.

5 IP test - for outdoor enclosures

Main standard	IEC/EN 60529
Construction / method standard	Dust, water and access-to-hazardous-parts test according to IP code
Description for solar PV / solar inverter application	If an IP declaration such as IP23, IP44, IP54 or IP55 exists for outdoor enclosures, it must be applied. Dust, rain, sun, wind and maintenance access should be considered in a solar PV site.

6 Humidity and temperature cycle test

Main standard	IEC 60068-2-30 or IEC 60068-2-78; IEC 60068 series for outdoor storage/transport
Construction / method standard	Repetition of insulation resistance and dielectric withstand after humidity-temperature cycling or steady damp heat test
Description for solar PV / solar inverter application	Day/night temperature difference, condensation and humidity in solar PV sites may accelerate insulation ageing. After the test, winding-to-frame, phase-to-phase and screen-to-frame insulation resistance and hipot checks should especially be performed.

7 Grounding and screen continuity

Main standard	IEC/EN 60076-1, IEC/EN 60076-6; IEC/EN 61439-1 for panel/enclosure; IEC 60204-1 auxiliary for machine/panel application
Construction / method standard	Low-resistance continuity measurement, connection diagram and terminal verification
Description for solar PV / solar inverter application	PE and screen continuity are critical for common-mode noise, leakage current, EMC and personnel safety in solar inverter systems. Transformer screen, reactor screen, enclosure frame, cover, mounting plate and PE bar must be checked separately.

8 THD performance test - in filtered systems

Main standard	IEC 61000-4-7; IEC 61000-4-30; IEC 61800-3 auxiliary in sine/LCL filter systems
Construction / method standard	Comparison of THDi, THDv and individual harmonics with filter in service / out of service
Description for solar PV / solar inverter application	For sine filters, it is recommended to add performance lines such as THDv, dv/dt, motor terminal peak voltage and waveform to the report; in solar PV systems, this can be applied as THD measurement at the inverter output / transformer output / grid connection point.

9 Derating check according to high ambient temperature

Main standard	IEC/EN 60076-1 / 60076-11 for transformer; IEC/EN 60076-6 for reactor; IEC/EN 61439-1 for panel
Construction / method standard	Current/power derating calculation according to design temperature, ambient temperature, load profile and cooling condition
Description for solar PV / solar inverter application	Ambient temperatures above 40°C and internal enclosure temperature under sunlight are very important in solar PV sites. The OMSAN document lists thermal load and current density calculations for reactors, and hot-spot and cooling duct checks for transformers, as particular design inputs.

10 Reactor inductance / reactance verification

Main standard	IEC/EN 60076-6
Construction / method standard	Measurement of L for each phase with an LCR meter or AC test setup; calculation of %X or Z% under rated current/frequency conditions
Description for solar PV / solar inverter application	In solar inverter reactors, the required inductance must be determined by system analysis. The OMSAN document states that for LV reactors, optimum selection in the 3-5% reactance range, saturation check, loss according to harmonic frequencies and LCL resonance risk should be considered.

11 DC bias / DC link choke check - if a DC reactor exists

Main standard	IEC/EN 60076-6; IEC 61800-5-1 auxiliary for system
Construction / method standard	Inductance measurement under DC bias; L-I check at 0 A, rated DC current and, if necessary, 1.2-1.5 In points
Description for solar PV / solar inverter application	If a DC link reactor or DC choke is used, inductance at 0 A alone is not sufficient. The OMSAN renewable energy document states that the DC bias effect in DC reactors must be evaluated separately.

12 LCL / LC resonance check - in filtered inverter systems

Main standard	IEC/EN 60076-6; IEC 61800-3 auxiliary
Construction / method standard	Resonance/cut-off frequency calculation using measured L and C; frequency response or system test if necessary
Description for solar PV / solar inverter application	If an LCL filter is used in solar PV inverters, the resonance risk must be checked specifically. In the OMSAN document, resonance risk in LCL filters is listed as a design topic requiring attention.

13 Loss measurement and additional loss evaluation

Main standard	IEC/EN 60076-1 for transformer; IEC/EN 60076-6 for reactor; IEC 60076-19-1 auxiliary for measurement uncertainty
Construction / method standard	No-load/load loss, I^2R loss from DC resistance, additional loss calculation according to harmonic frequencies
Description for solar PV / solar inverter application	Inverter-sourced harmonics may increase eddy/stray losses in the transformer and copper, core and stray losses in the reactor. Therefore, the report should state not only the nominal 50 Hz loss, but also the harmonic load effect where possible.

14 Insulation system / partial discharge check - in special designs

Main standard	IEC/EN 60076-3, IEC/EN 60076-11; IEC 60270 for partial discharge
Construction / method standard	Insulation resistance, applied voltage, induced voltage and partial discharge measurement in special projects
Description for solar PV / solar inverter application	If insulation stress caused by dv/dt and harmonics is high in solar inverter transformers, a PD test may be requested especially in cast-resin or high-reliability products. The OMSAN document lists low partial discharge level and insulation design with high dv/dt withstand as production/design criteria.

15 Thermal camera test

Main standard	IEC/EN 60076-11 thermal approach for transformer; IEC/EN 60076-6 for reactor; IEC/EN 61439-1 for panel
Construction / method standard	IR thermography at rated load or after actual operation with inverter
Description for solar PV / solar inverter application	Terminals, busbars, winding exits, core clamping points, reactor air gap, fan area, screen/PE connections and internal enclosure hot spots must be checked.

16 Grid compatibility performance check

Main standard	IEC 61000-4-7 / IEC 61000-4-30 for measurement; IEC 61800-3 auxiliary for inverter system
Construction / method standard	Measurement of THD, voltage/frequency, power factor, harmonic spectrum, transients and load variation at the PCC point
Description for solar PV / solar inverter application	The OMSAN document emphasizes the functions of these products in reducing harmonic level, improving power quality, extending inverter/transformer life and ensuring grid compatibility. Therefore, PCC measurement becomes a very strong acceptance test in filtered solar PV systems.

2. Lines Recommended to Be Added to the Test Report

Report line	Recommended content
Application type	Solar PV / solar inverter transformer, inverter reactor, DC link choke, sine/LCL filter
Inverter information	Inverter power, output voltage, switching frequency, topology, expected harmonic spectrum
Standard approach	IEC/EN 60076-1, IEC/EN 60076-11, IEC/EN 60076-6, IEC/EN 61558, IEC 61800-3, IEC 61000-4-7 / 4-30
Harmonic measurement	THDi, THDv, individual harmonics, measurement point, measuring instrument standard
dv/dt / peak voltage	Measured value at inverter output, transformer input/output or after filter
Reactor value	Inductance, Z% / reactance, phase balance, saturation/linearity
Filter verification	L, C, cut-off frequency, resonance check, THD performance
Temperature / derating	Ambient temperature, internal enclosure temperature, load ratio, temperature rise, derating note
Insulation	Insulation resistance, hipot, induced voltage, partial discharge in special projects
Grounding / screen	PE continuity, screen continuity, frame-cover-mounting plate connection
Environmental tests	IP, humidity-temperature cycle, outdoor enclosure check
Thermal camera	Hot-spot screenshot and maximum temperature points
Site/grid performance	THD, power factor, voltage/frequency and grid compatibility note at PCC