

D2. Static regulators - single-phase / three-phase

Standard Approach

Static regulators should not be evaluated under a single narrowly scoped IEC product standard; instead, the following standard matrix is more appropriate according to the product structure:

Power electronics safety: IEC/EN 62477-1. IEC 62477-1 defines safety requirements for power electronic converter systems and equipment.

Panel/enclosure structure: IEC/EN 61439-1 and IEC/EN 61439-2 according to the suitable panel type. IEC 61439-1 covers general definitions, service conditions, constructional requirements, technical characteristics and verification rules for low-voltage switchgear and controlgear assemblies.

Sudden input voltage variations / sag-swell simulation: IEC 61000-4-11 can be used as a supporting reference; this standard defines immunity test methods for voltage dips, short interruptions and voltage variations in equipment connected to low-voltage supply networks.

EMC: IEC 61000-6-2 can be used as the immunity standard and IEC 61000-6-4 as the emission standard for industrial environments.

Routine tests

1. Routine Tests

1 Visual and mechanical inspection

Main standard	IEC/EN 61439-1; IEC/EN 62477-1
Construction / method standard	Visual inspection, assembly, wiring, component, torque and label check
Static regulator notes	The panel, power semiconductor modules, heatsinks, fans, control board, display, contactor/switch, fuses, busbars and terminals are checked.

2 Panel/enclosure PE continuity

Main standard	IEC/EN 61439-1; IEC 60204-1 supporting
Construction / method standard	Low-resistance PE continuity measurement
Static regulator notes	Continuity is checked between the body, door, mounting plate, PE bar, fan body, heatsink block and door grounding braid.

3 Power semiconductor module connection check

Main standard	IEC/EN 62477-1; IEC/EN 61439-1
Construction / method standard	Visual inspection, torque check, driver/control cable and heatsink mounting check
Static regulator notes	Thyristor/IGBT/SSR module, heatsink, insulation pad, gate/driver connections, power busbars and tightening torques are checked.

4 Control board supply test

Main standard	IEC/EN 62477-1
Construction / method standard	Auxiliary AC/DC supply, SMPS outputs, board voltages and fuse check
Static regulator notes	The microprocessor board, measurement board, relay outputs, sensor inputs and fan supply are verified.

5	Fan / cooling test	
	Main standard	IEC/EN 62477-1; IEC/EN 61439-1
	Construction / method standard	Fan direction, airflow, fan alarm, thermostat/PWM control
	Static regulator notes	In a static regulator, semiconductor reliability depends on cooling. Fan direction, air duct, filter clogging, temperature sensor and fan fault alarm should be checked.
6	Display / HMI test	
	Main standard	IEC/EN 62477-1
	Construction / method standard	Menu, measurement screen, alarm history, parameter input-output check
	Static regulator notes	Input/output voltages, current, load ratio, frequency, alarm, temperature, bypass and operating mode screens are checked.
7	Input voltage range test	
	Main standard	IEC/EN 62477-1; IEC/EN 61439-1; IEC 61000-4-11 supporting
	Construction / method standard	Minimum/nominal/maximum input test with adjustable AC source or grid simulator
	Static regulator notes	It is verified that the regulator keeps the output within tolerance throughout the catalog input range or switches to protection outside the limits.
8	Output regulation test - single-phase	
	Main standard	IEC/EN 62477-1; IEC/EN 61439-1
	Construction / method standard	Output voltage measurement at minimum/nominal/maximum input
	Static regulator notes	For a single-phase product, the 220/230 V target voltage and the tolerance in the product documentation are verified.
9	Output regulation test - three-phase	
	Main standard	IEC/EN 62477-1; IEC/EN 61439-1
	Construction / method standard	Measurement of L-L and, if available, L-N output voltages
	Static regulator notes	For a three-phase product, the 380/400 V target output is checked. Phase-phase and phase-neutral measurements should be given separately in the report.
10	Correction speed function test	
	Main standard	IEC/EN 62477-1; IEC 61000-4-11 supporting
	Construction / method standard	The speed at which the output approaches the target is measured by applying an input voltage step
	Static regulator notes	If a correction speed claim such as 500 V/s is stated on the site, the input step, output deviation and recovery time should be included in the test report.
11	Dynamic regulation test - sudden input change	
	Main standard	IEC/EN 62477-1; IEC 61000-4-11
	Construction / method standard	A sudden drop/rise is applied to the input voltage; output deviation and recovery time are measured
	Static regulator notes	This is the most important verification that a static regulator is faster than a servo type. It is best performed with an oscilloscope or a fast-recording power analyzer.

12	Dynamic regulation test - sudden load change	
	Main standard	IEC/EN 62477-1; IEC/EN 61439-1
	Construction / method standard	The load step is changed suddenly; output voltage, current and recovery time are monitored
	Static regulator notes	It is verified that the output returns to the target without excessive deviation during load changes. This is especially important for UPS, CNC and sensitive device loads.
13	Static regulation test - output accuracy under steady load	
	Main standard	IEC/EN 62477-1; IEC/EN 61439-1
	Construction / method standard	Output voltage is measured over time under constant load
	Static regulator notes	Output accuracy, regulation tolerance and measurement stability under steady load are reported.
14	Phase protection test - three-phase products	
	Main standard	IEC/EN 61439-1; IEC/EN 62477-1
	Construction / method standard	Simulation of phase loss, phase sequence and phase imbalance
	Static regulator notes	Alarm/output trip behavior is verified in case of phase loss, reverse phase sequence or excessive phase imbalance.
15	Overload protection	
	Main standard	IEC/EN 62477-1; IEC/EN 61439-1
	Construction / method standard	Current threshold check with adjustable load or electronic simulation
	Static regulator notes	Alarm, current limiting, bypass, output trip or protection behavior under overload is verified according to the product design.
16	Short-circuit / electronic protection function test	
	Main standard	IEC/EN 62477-1; IEC/EN 61439-1
	Construction / method standard	Protection simulation by safe test method; special setup if an actual short-circuit is required
	Static regulator notes	In routine testing, electronic protection, fuse/switch and alarm functions should be verified by a safe method instead of applying a direct high-energy short-circuit.
17	Lower-upper voltage limit test	
	Main standard	IEC/EN 62477-1; IEC 61000-4-11 supporting
	Construction / method standard	Input/output voltage is applied below and above the programmed lower/upper limits
	Static regulator notes	It is checked that programmable lower/upper limit protections generate alarm or trip the output at the correct threshold.
18	Bypass test - if available	
	Main standard	IEC/EN 61439-1; IEC/EN 62477-1
	Construction / method standard	Manual/automatic bypass transition test
	Static regulator notes	It is verified that the load is safely supplied through bypass when the regulator is disabled; interlock, phase sequence and alarm behavior are checked.

19	Alarm relay test	
	Main standard	IEC/EN 62477-1; IEC/EN 61439-1
	Construction / method standard	Fault scenario simulation and relay contact measurement
	Static regulator notes	General fault, low/high voltage, overload, fan fault, overtemperature, phase fault and bypass status contacts are tested.
20	Fault log test	
	Main standard	IEC/EN 62477-1
	Construction / method standard	Alarm generation, memory recording and record check after power interruption
	Static regulator notes	It is verified that fault history is correctly recorded in the HMI and retained after power interruption when required.
21	Insulation resistance	
	Main standard	IEC/EN 62477-1; IEC/EN 61439-1
	Construction / method standard	Insulation resistance measurement; manufacturer procedure for electronic boards
	Static regulator notes	Power circuit-body, input/output-body and control circuit-body are evaluated separately. High megger voltage should not be applied directly to sensitive electronic boards.
22	Dielectric withstand / hipot	
	Main standard	IEC/EN 62477-1; IEC/EN 61439-1
	Construction / method standard	AC/DC withstand test according to the electronic equipment procedure
	Static regulator notes	The test configuration must be defined so that semiconductor modules, measurement boards, SPDs and EMI filters are not damaged. If necessary, electronic boards are disconnected and the power circuit-body test is performed.
23	Input/output measurement accuracy test	
	Main standard	IEC/EN 62477-1; IEC 61000-4-30 supporting for measurement
	Construction / method standard	Comparison of display/HMI with reference multimeter/power analyzer
	Static regulator notes	Input/output voltage, current and frequency values displayed on the HMI are compared with a reference instrument.
24	Efficiency check - for high-power units	
	Main standard	IEC/EN 62477-1
	Construction / method standard	Input/output active power measurement; efficiency calculation at a specific load ratio
	Static regulator notes	This is valuable for high-power units in terms of sales and energy loss. Load ratio, input power, output power and efficiency percentage should appear in the report.
25	Final parameter check	
	Main standard	IEC/EN 62477-1; customer specification
	Construction / method standard	Parameter list, target voltage, tolerance, limits and protection threshold check
	Static regulator notes	Before shipment, target output, lower/upper limits, delays, bypass setting, alarm thresholds and communication parameters are verified.

26 Software / firmware version check

Main standard	IEC/EN 62477-1; manufacturer procedure
Construction / method standard	Version check via HMI/service software
Static regulator notes	Software version, product power, serial number and customer-specific parameters may be added to the test report.

27 Label and connection diagram check

Main standard	IEC/EN 61439-1; IEC/EN 62477-1
Construction / method standard	Label, terminal marking, warning and connection diagram check
Static regulator notes	Power/kVA, input range, output voltage, tolerance, correction speed, phase, frequency, IP, CE, bypass, PE and alarm connections are checked.

2. Optional / Special Tests

1 Full-load burn-in test

Main standard	IEC/EN 62477-1; IEC/EN 61439-1
Construction / method standard	Long-term operation at nominal or specified load
When recommended?	Recommended to observe the stability of the semiconductor module, cooling, control board and protection systems.

2 Oscilloscope recording of dynamic response time

Main standard	IEC/EN 62477-1; IEC 61000-4-11 supporting
Construction / method standard	Output voltage is monitored with an oscilloscope or fast recorder during sudden input/load changes
When recommended?	Recommended when a 500 V/s correction speed or fast regulation claim will be demonstrated during customer acceptance testing.

3 Harmonic distortion measurement

Main standard	IEC 61000-4-7; IEC 61000-4-30
Construction / method standard	Measurement of input/output THDv, THDi and individual harmonics
When recommended?	Recommended for sensitive loads or CE/EMC files because the static semiconductor structure may affect the grid waveform.

4 EMC immunity tests

Main standard	IEC 61000-6-2; IEC 61000-4-2, -4, -5, -6, -11 for specific tests
Construction / method standard	ESD, EFT/burst, surge, RF immunity and voltage dip tests
When recommended?	Applied for CE/EMC or customer specifications in industrial environments and products containing electronic control boards and displays.

5 EMC emission tests

Main standard	IEC 61000-6-4; CISPR 11 / CISPR 32 supporting if required
Construction / method standard	Conducted/radiated emission measurement
When recommended?	Conducted/radiated emission may need to be checked due to semiconductor switching and the control board.

6	Voltage sag/swell test with grid simulator	
	Main standard	IEC 61000-4-11; IEC/EN 62477-1
	Construction / method standard	Sag, swell, short interruption and voltage variation scenarios with programmable AC source
When recommended?	Recommended for weak grids, generator supply, facilities with frequent voltage fluctuations and critical loads.	
7	Thermal camera test	
	Main standard	IEC/EN 62477-1 thermal safety approach
	Construction / method standard	IR thermography under load
When recommended?	Hot spots are checked around semiconductor modules, heatsinks, fan area, contactors, fuses, busbars, terminals and control board.	
8	High ambient temperature test	
	Main standard	IEC/EN 62477-1; IEC 60068-2-2 supporting for environmental test
	Construction / method standard	Operation under load at a specified ambient temperature
When recommended?	Recommended in closed panel rooms, hot climates, generator cabins or high-IP enclosures.	
9	Parallel operation test - if available	
	Main standard	IEC/EN 62477-1; IEC/EN 61439-1
	Construction / method standard	Load sharing between modules, synchronized operation and fault behavior check
When recommended?	If there is a parallel module or parallel device structure, current sharing, communication, bypass and system behavior in case of a module fault should be tested.	
10	Generator compatibility test	
	Main standard	IEC/EN 62477-1; IEC 61000-4-30 supporting
	Construction / method standard	Operation under frequency/voltage fluctuation using a generator or generator simulator
When recommended?	Recommended to verify regulation behavior under frequency deviation and voltage instability in generator-fed facilities.	
11	Sensitive load simulation	
	Main standard	IEC/EN 62477-1; IEC 61000-4-30 supporting
	Construction / method standard	Operation with UPS, CNC, medical device or electronic load profile
When recommended?	Applied when output accuracy, transient deviation, harmonic effect and protection thresholds are critical for sensitive loads.	
12	IP test - enclosed products	
	Main standard	IEC/EN 60529
	Construction / method standard	Dust/water and access-to-hazardous-parts test according to IP code
When recommended?	Applied if an enclosure rating such as IP20, IP31, IP42 or IP54 is declared.	
13	Short-term overload test	
	Main standard	IEC/EN 62477-1; customer specification
	Construction / method standard	Loading with specified current and duration; protection and temperature monitoring
When recommended?	Recommended for motors, compressors, CNC or loads with high starting current.	

Sound level test

Main standard	IEC 60076-10 supporting reference; customer specification
Construction / method standard	Sound pressure or sound level measurement
When recommended?	Recommended for fan-cooled, high-power or indoor quiet areas.

3. Recommended Additional Lines for the Test Report

Report line	Recommended content
Product type	Single-phase / three-phase static regulator
Rated values	kVA, input voltage range, output voltage, frequency, current
Technology	Semiconductor structure, microprocessor control, variac-free structure
Regulation accuracy	Output voltage and tolerance at min/nominal/max input
Correction speed	Input step, output deviation, recovery time, V/s value
Dynamic regulation	Results of sudden input change and sudden load change
Static regulation	Output accuracy under steady load
Protection functions	Phase fault, lower/upper voltage, overload, short-circuit/electronic protection
Bypass	Manual/automatic bypass, interlock, alarm status
Display verification	Comparison of HMI measurements with reference instrument
Insulation / hipot	Power circuit-body; electronic circuit protection note
PE continuity	Body, door, mounting plate, heatsink block, PE bar
Fan / cooling	Fan direction, airflow, fan fault alarm, temperature sensors
Efficiency	For high-power units: load percentage, input/output power and efficiency
Parameter / software	Firmware version, target output, limits, alarm thresholds
Optional performance	Burn-in, harmonic, EMC, generator compatibility, thermal camera