GUIDE SPECIFICATION

# Active Voltage Conditioner

## 1 General

### 1.1 Summary

A. This specification describes the Active Voltage Conditioner (AVC) for critical power applications. It is a power protection system designed for use by large industrial and commercial operations in environments where voltage fluctuations in the utility affects productivity. The system ensures a continual, regulated supply of utility voltage where electric infrastructure is stressed, unstable and unreliable.

B. Specification defines the electrical and mechanical characteristics and requirements for a solid-state, Active Voltage conditioner. The Active Voltage conditioner system shall provide high-quality AC power. The manufacturer shall design and furnish all materials and equipment to be fully compatible with electrical, environmental and space conditions at the site.

### 1.2 Standards

The AVC shall be listed to the following standards. Where a conflict arises between these documents and statements made herein, the statements in this specification shall govern.

| **Subject** | **Standard Reference** | | |
|---|---|---|---|
| Quality | ISO 9001 | | |
| Environmental | ISO 14001 | | |
| Regional Standards (markings) | USA | UL | c UL us |
| Standards Safety | IEC 62477-1, UL 508 | | |
| Electromagnetic Compatibility (EMC) | Emissions: CISPR 11 Class A Group 1<br>Immunity: IEC 61000-6-2 | | |

## 1.3 System description

A. General characteristics

1. The AVC shall be a three-phase low voltage product which provides continuous voltage correction.
2. The AVC shall provide line-to-line voltage correction, correcting phase angle and voltage magnitude.
3. The AVC shall require no energy storage. Power required to make up the correction voltage must be sourced from the utility/mains supply.
4. The AVC shall detect the voltage variation in less than 250µs and correct the voltage in less than 10 ms, regardless of the voltage disturbance depth, within the specification of the product.
5. he AVC shall have stepless output voltage correction with no energy storage. The efficiency of the AVC shall typically be greater than 98%.
6. The AVC will consist of voltage source converter(s), bypass circuit(s) and a series connected injection transformer. There shall be no power electronics in the load current path. The AVC shall have commonality of parts for ease of maintenance.
7. The AVC must incorporate a triple redundant internal bypass. and shall have high fault current capacity.

   The AVC connects between the power system supply and the load.
   An upstream circuit breaker is required to protect the AVC against short circuit faults.
   The AVC is rated to be connected to power systems having fault capacity of the values shown in the following table. To provide discrimination time for downstream protection, the AVC can withstand rated fault capacity for 200 ms.
   For 480 V model, current limiting molded case circuit breakers (MCCB) or fuses are required to provide very fast clearing of short circuit currents.

| **Short current withstand rating for 300kVA systems** without additional upstream protection* | | |
|---|---|---|
| **208 V models** | kA | 31.5 |
| **480 V models** | kA | 20* |

**Table 1-1: AVC short circuit withstand ratings**

Where the power system supply fault capacity exceeds the short circuit withstand rating of the AVC, additional current limitation is required - e.g., a current limiting circuit breaker or current limiting fuses in addition to the circuit breaker.

The AVC can sustain the fault currents listed above without damage and can be returned immediately to service following such a fault. Where higher fault currents occur, the system should be inspected for damage - service may be required.

* Short curciot withstand ratings can be increased by using additional circuit breaker. For motor load additioning downstream breakers might be required to avoid backfeed during fault scenarios.
Note: Breakers listed are 100% rated. Equivalent models of breakers rated at 80% are also acceptable, provided they are sized accordingly. i.e: 100% rated breaker for 400 A = 80% rated breaker for 500 A.

| I(peak) Let Through [kA] | $I^2t$ Let Through x 1,000,000 | Total Clearing time [ms] | Available Source Fault Current @ 480 VAC [kA] |
|---|---|---|---|
| 37 | 1.4 | 2.05 | 65 |
| 40.5 | 1.6 | 1.95 | 100 |

## 1.4 Modes of operation

The AVC shall have a power quality event monitor to monitor the incoming supply voltage and when it deviates from the nominal voltage level. The two converters that are not on the current path between the load and the utility add or subtract voltage via the injection transformer as required to provide continuous voltage correction.

Energy is to be sourced from the supply during the correction action. The AVC corrects the load voltage to its nominal value, thus eliminating voltage disturbances from the mains supply affecting the load. The AVC shall provide quadrant control for overvoltage and undervoltage with regenerative loads.

The AVC must incorporate a triple redundant fail-safe bypass that, in the event of an external overload or internal fault condition, will ensure the load is continually supplied from the utility.

The AVC shall allow remote access for diagnostics and monitoring purpose. The AVC shall use Modbus TCP for monitoring purpose. More information on Remote Monitoring is available in section 2.9

### 1.4.1 Utility Voltage Within Continuous Regulation Region

When the utility voltage is within continous regulation range (±10%) the AVC is active and waiting for a power quality event.

### 1.4.2 Utility Disturbance Occurs

When the utility voltage deviates from nominal or set point, due to voltage sags, surges, undervoltage, overvoltage or unbalance, the inverter will inject a correcting voltage via the Injection Transformer. The correcting voltage level is based on the disturbance level and the energy needed for correction is derived from the utility via the AVC rectifier.

### 1.4.3 Internal Bypass Operation

In the case of a AVC fault condition, e.g., an overload or internal fault, the bypass circuit will shunt the inverter side of the Injection Transformer, bypassing the inverter and effectively providing a direct connection from the utility supply to the output, without interruption to the load.

## 1.5 Performance requirements

A. General

1. The AVC shall be designed for indoor installation with ambient temperatures from 32°F - 104°F (0 - 40°C) and enclosure rating shall be NEMA1 (NEMA2 with optional Roof Kit).
2. The AVC shall be designed for operation at an altitude of up to 3280 ft (1000 m) without derating. Please check section 1.6 for more information on this.

### 1.5.1 Input characteristics

| | |
|---|---|
| Nominal power rating: | [ 225 kVA, 300 kVA- *specify!*] |
| Application voltage & frequency: | [208, 480 V, 60 Hz – *specify!*] |
| Maximum continuous supply voltage: | 110% |
| Frequency tolerance: | ± 5 Hz |
| Power system: | 3-wire plus ground input (grounded wye source)<br>4-wire system possible |
| Outage – control ride through: | 600 ms |

### 1.5.2 Output characteristics

| | |
|---|---|
| Voltage: | To match nominal input voltage (208, 480 V) |
| Equivalent series impedance: | < 4% (model specific) |
| Displacement power factor: | 0 lagging to 0.9 leading |
| Crest factor: | 3.0 |
| Overload capability from 100% supply voltage: | 150% for 30 seconds, once every 500 s |

### 1.5.3 Performance

| | |
|---|---|
| Efficiency: | > 98% (Under Nominal Conditions) |
| Sag correction response | Initial < 250 µs<br>Complete < ½ cycle |
| Voltage regulation accuracy: | ±1% typical, ±2% max |
| Sag correction accuracy | ±4% |
| Continuous regulation range | ±10% |
| Sag correction performance<br>Three phase sags<br>Single phase sags | 60% to 100% for 30 s, 50% to 90% for 10 s<br>40% to 100% for 30 s. |

### 1.5.4 Internal bypass characteristics

| | |
|---|---|
| Capacity: | 100% of model rating (kVA) |
| Maximum Overload Capacity (in bypass): | 125% for 10 minutes<br>150% for 1 minute<br>500% for 1 s<br>2000% for 200 ms |
| Transfer Time: | To Bypass < 0.5 ms<br>To Inverter < 250 ms |
| Equivalent Series Impedance: | Bypass < 2.5% typical |

## 1.6 Environmental conditions

The AVC must meet the following environmental conditions including cooling methods.

A. The AVC system shall be designed to operate continuously at full load without degradation of its reliability, operating characteristics, or service life in the following environmental conditions:

| | |
|---|---|
| Operating Temperature Range: | 0°C to 40°C (32°F to 104°F) |
| Operating Altitude: | < 3280 ft (1000 m) without derating |
| Capacity Derating with Altitude: | 1% every 328 ft (100 m) above 3280 ft (1000 m)<br>6560 ft (2000 m) maximum |
| Inverter Cooling | Forced ventilation |
| Transformer Cooling | Natural convection |
| Humidity | < 95%, non-condensing |
| Pollution Degree Rating | 2 |
| Noise | < 75dBA @6.56 ft (2 m) |

The AVC shall be designed for operation in altitudes up 3280 ft (1000 m), without the need for de-rating or reduction of the above environmental operating temperatures.

The AVC cabinet shall comprise of a floor standing steel enclosure to house the power system, control systems, and all associated necessary connections for the correct operation of the AVC in accordance with the requirement of the specifications. All switchgear and interconnections must be adequately protected to enable an isolated section to be safely maintained or repaired whilst the remaining system supports the load. AVC cabinet shall design for bottom cable entry and in case of customer need/want top entry through a cable duct, AVC manufacturer shall provide a side cable pulling enclosure.

## 1.7 Submittals

A. With proposals, brochures, one-line diagram, termination drawings, outline drawings and/or data sheets describing the proposed equipment shall be submitted with the proposal. All deviations to this specification shall be listed and included with the proposal.

After Construction of Equipment – one copy of drawings shall be furnished for each of the following:

1. Equipment installation outline including external cabling termination locations.
2. Equipment internal wiring diagram.

One instruction manual shall be furnished and shall include as a minimum the following:

1. Safety instructions
2. System description, specifications, and control
3. Installation and start-up
4. Operator's guide
5. Warranty and service information

A copy of the final test report shall be furnished with the equipment certified copy of the final test is an available added option.

Factory witness test available as an added option. After installation of equipment, a signed field service report describing start-up and on-site testing shall be furnished.

## 1.8 User documentation

A. The specified AVC system shall be supplied
   a) "As built" drawings (these drawings may also be furnished in electronic format)
   b) Spare part lists
   c) User manuals including storage, installation, operation, and maintenance instructions for the equipment specified.

B. The manual shall include installation instructions, a functional description of the equipment with block diagrams, safety precautions, illustrations and step by step operating procedures.

## 1.9 Warranty (TBD by local sales and service organization)

All equipment in scope of supply shall be warranted for a minimum period of 24 months after comissioning or is 36 months after delivery from the factory or within 36 months after the purchaser was notified that the goods are ready for delivery whichever expires first.

## 1.10 Quality assurance

A. Manufacturer Qualifications
   i. The AVC manufacturer shall have ISO 9001 & 14001 certifications. The AVC manufacturer shall have a minimum of 15 years of experience in the production of static converters or variable speed drives. The AVC manufacturer shall be able to offer a remote diagnostic service, if required.

## 1.11 Factory testing

The AVC equipment shall undergo standard routine checks and testing such as.

- Visual checks
- Firmware upload
- Power/measurement connections and checks
- Firmware/system configuration
- Power Tests

The routine test shall also include a rated current and voltage test. If requested in Buyer's Datasheet, a factory acceptance test or factory inspection visit for Buyer's representative shall be scheduled upon award of contract.

## 1.12 Factory acceptance testing - optional

A. AVC manufacture shall offer factory testing capability in the presence of the Owner providing the manufacturer at additional cost with adequate prior notice. The manufacturer shall provide a copy of the test report upon completion of the acceptance testing.

# 2 Product

## 2.1 Fabrication

A. All materials and components making up the AVC shall be new, of current manufacture, and shall not have been in prior service except as required during factory testing.

## 2.2 Wiring

A. Wiring practices, materials, and coding shall be in accordance with the requirements of the NFPA 70 or local wiring rules and other applicable codes and standards.

## 2.3 AVC Cabinet

The AVC system shall consist of the following main components: low voltage converter(s), injection transformer and autotransformer, if required. These components are housed in enclosures and meets NEMA1 (NEMA2 with optional Roof Kit) requirements. The front of the AVC enclosure shall be painted in RAL7035. Interior surfaces may be bright (unpainted) Zinc galvanized steel.

## 2.4 Cooling

The AVC System shall be forced air cooled.

## 2.5 Components

The AVC shall be comprised of the following components. No failure in any of the electronic components shall disconnect the load from the supply.

### 2.5.1 Rack mounted rectifier module(s)

The rectifier module consists of the following: low harmonic bi-directional IGBT bridge rectifier, integrated sinusoidal filter and line reactor, radio interference filter, high speed input fuses, two phase input contactor isolation and pre-charge circuit.

### 2.5.2 Rack mounted inverter module(s)

The inverter module consists of the following: low harmonic bi-directional IGBT bridge rectifier, integrated sinusoidal filter, radio interference filter, high speed input fuses and output fuses, integrated SCR, and failsafe contactor bypass circuit.

### 2.5.3 Injection transformer

The AVC injection transformer shall be of dry type and comprised of a delta connected primary and 3 series connected windings between the supply and the load.

### 2.5.4 Internal AVC power electronics supply

The internal AVC power electronics supply shall consist of a circuit breaker protecting and allowing isolation of the power electronics.

### 2.5.5 User interface

The touch screen Graphic Display Module shall provide a pictorial representation of the status of the AVC, and display of system voltages and currents. It shall also display the

system event log and permits local control of the product. The availability of the Graphic Display Module shall not hinder the operation of the AVC.

The Graphic Display shall have the following characteristics:

a) USB PC access for commissioning and service purposes
b) Local stop, start and reset control
c) Power Quality Event log
d) System Event log
e) E-mail connectivity
f) Display in different languages for localization

The Graphical Display Module must contain a set of product web pages that can be accessed via the Ethernet port of the graphic display module and viewed on a remote PC using any standard browser.

The following pages must be supported:

a) Status Page
b) Event Log
c) Product information
d) Summary

## 2.6 Internal bypass

In the case of an external overload or internal fault condition the internal bypass circuit shall shunt the inverter side of the injection transformer, bypassing the inverter and effectively providing a direct connection from the utility supply to the output, without interruption to the load.

## 2.7 Injection transformer

The injection transformer shall be used by the inverter to inject a correcting voltage. The correcting voltage level shall be based on the disturbance level.

## 2.8 Control connections

The following integrated I/O must be available. Dry as well as wet contacts are used for the control connection in the AVC.

a) relay outputs for AVC system status, these shall be run, warning and fault
b) Remote start stop and reset control terminals

| Control Connection | Description |
|---|---|
| **Relay Outputs** | AVC status information<br>250 VAC/30 VDC, 1 A |
| **Isolated Thermal Switch** | Transformer over temperature information<br>24 VDC/24 VAC, 1 A<br>Normally closed (NC) contact |
| **Digital Inputs** | AVC Remote control<br>Start/Stop/Inhibit<br>Dry contacts |

## 2.9 Remote Monitoring

The AVC provides remote access for monitoring purposes. Following monitoring connections are available:

- Integrated Web server. Using the integrated web server, the same information as displayed on the GDM is available on any networked PC connected to the AVC. In addition, downloading event and service information is possible from the integrated web server.
- Modbus TCP. For connection to plant wide SCADA or monitoring systems the AVC has a list of registers that can be accessed.
- Email Connectivity. An email notification service can be set up to send notifications of power quality and system events.

| Communication Type | Description | Connection |
|---|---|---|
| **Remote Web Pages** | Webserver via HTTP, Ethernet | Standard RJ45 |
| | SW upgrade via SSH | Standard RJ45 |
| **Monitoring system** | Modbus TCP | Standard RJ45 |
| **Remote notifications** | E-mail | Standard RJ45 |

## 2.10 Options

### 2.10.1 Roof kit

Root kits shall be available where small amounts of liquid may fall onto the top of the enclosures. The root kit option shall increase the units' protection degree to IP21. These shall only be for indoor use. There shall be a 7.84" clearance from the enclosure top to the root kit to allow for ventilation of the transformer enclosure. The root kit shall cover both the transformer and controller enclosures.

### 2.10.2 Side Cable Pulling Enclosure

A side cable pullingt enclosure of 85.3" x 32.7" x 33.2" (2167 x 830 x 844 mm) option allows easier power connections for top cable entry.

### 2.10.3 Power cable connection landing bars

Standard termination on the AVC shall have horizontal bars. Power cable connection landing bars shall provide copper coated vertical bars with dimensions and hole positions according to IEC or NEMA standard for all the termination positions. Both mechanical and compression connectors are able to connect to these power cable connection landing bars.

# 3 Field Services

## 3.1 Field quality control

A. The following inspections and test procedures shall be performed by factory trained field service personnel during the AVC start-up.

## 3.2 Visual and mechanical inspection

A. Verify that AVC modules are ready to install

B. Verify that required utilities are available, in proper location and ready for use

C. Inspect equipment for signs of shipping or installation damage.

D. Verify installation per drawings and installation manuals.

E. Inspect cabinets for foreign objects.

F. Check all control wiring connections.

G. Check all terminal screws, nuts, and/or spade lugs for tightness.

H. Clean interiors to remove construction debris, dirt, and shipping materials.

I. Ensure adequate clearances around and above the enclosure for air-flow/cooling requirements.

## 3.3 Electrical inspection

A. Confirm input voltage and phase rotation is correct.

B. Verify that required utilities are available, in proper location and ready for use

C. Check fans spin freely (by hand).

D. Check power terminals L1, L2 L3, L1', L2', L3' have been fully insulated.

## 3.4 Unit start-up and site testing

A. The manufacturer's field service personnel shall provide site testing if requested. Site testing shall consist of a complete test of the AVC system, and the associated accessories supplied by the manufacturer. The test results shall be documented, signed, and dated for future reference.

## 3.5 Manufacturer's field service

A. Service Personnel

1. The AVC manufacturer shall directly employ a nationwide service organization, consisting of trained Customer Engineers dedicated to the start-up, maintenance, and repair of AVC and power equipment.

2. The manufacturer shall provide a fully automated national dispatch center to coordinate field service personnel schedules. One toll-free number shall reach a qualified support person 24 hours/day, 7 days/week, and 365 days/year.

## 3.6 Maintenance & service contracts – optional

A. A complete offering of preventive and full-service maintenance contracts for both the AVC system and battery system shall be available. An extended warranty and preventive maintenance package shall be available. Warranty and preventive maintenance service shall be performed by factory trained Customer Engineers.

## 3.7 Maintenance training – optional

A. The manufacturer shall make available to the customer various levels of training ranging from basic AVC operation to AVC maintenance

## 3.8 Spare parts kits – optional

A. Customer and Field Engineers must have immediate access to recommended spare parts with additional parts storage located in regional depots. Additional spare parts shall be accessible on a 7 x 24 basis from the national depot and must be expedited on a next available flight basis or via direct courier.

**END OF SECTION**


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