Product Specification: Advantage 212 Variable Frequency Drive for Pump and Fan Applications

Section 15190—Variable Frequency Motor Controllers for Pump and Fan Applications

PART 1—General

1.01 Summary

- A. This section provides specification requirements for solid-state, pulse-width modulated (PWM) Adjustable
- B. Frequency Drive Controllers, herein referred to as AC Drives, for use with NEMA_® design inverter duty AC motors.
- C. The AC Drive supplier shall furnish, field test, and adjust all installed AC Drives for satisfactory operation.
- D. Any exceptions/deviations to this specification shall be indicated in writing and submitted no less than one week prior to the bid date.

1.02 References

- A. UL
- B. CSA,
- C. NOM117
- D. DNV
- E. CE
- F. C-Tick
- G. HPST
- H. UL 1995 Plenum Rated
- I. RoHS

1.03 Submittals

A. Standard catalog specification sheets showing voltage, horsepower, and maximum current ratings shall be furnished as part of the submittal package.

1.04 Warranty

A. An 18-month warranty, from date of shipment, shall be provided on materials and workmanship.

1.05 Quality Assurance

- A. The manufacturer of the AC Drive shall be a certified ISO 9001 facility.
- B. The AC Drive shall be UL Listed
- C. The AC Drive shall be designed, constructed, and tested in accordance with UL, cUL, IEC, RoHS and NEC standards.
- D. Every power converter shall be tested in the factory with an AC induction motor.

PART 2—Product

2.01 Manufacturers

A. The AC Drive shall be manufactured by Schneider Electric or previously approved equal. Substitutions must be submitted in writing three weeks prior to original bid date with supporting documentation demonstrating that the alternative manufacturer meets all aspects of the specifications herein. Supporting documentation should include a line by line review of this specification indicating whether the substitution meets or does not meet each item in this specification.

2.02 General Description

- A. The AC Drive shall convert the input AC mains power to an adjustable frequency and voltage.
- B. The input power section shall comply with the following requirements:
 - a. It shall utilize a full wave bridge design.
 - b. It shall convert AC line power of fixed voltage and frequency to fixed DC voltage.
 - c. It shall be insensitive to phase rotation of the AC line.
- C. The output power section shall change fixed DC voltage to adjustable frequency AC voltage.

2.03 Construction

A. Enclosure shall be rated for IP 20 and NEMA Type 1 with included conduit kit.

2.04 Application Data

- A. The AC Drive shall be sized to operate a variable torque load.
- B. The speed range shall be from a minimum speed of 1 Hz to a maximum speed of 200 Hz.

2.05 Environmental Ratings

- A. The AC Drive shall meet IEC / EN61800-3, UL 1995 type 1 plenum rated, and RoHS
- B. The AC Drive shall be designed to operate in an ambient temperature from -10 to 40 °C (+14 to 104 °F) without derating the drive, -10 to 50 °C (+14 to 122 °F) with derating the drive.
- C. The storage temperature range shall be -25 to 70 °C (-13 to 158 °F).
- D. The maximum relative humidity shall be 95%, non-condensing or dripping water. Compliant with IEC600068-2-3
- E. The AC Drive shall be rated to operate at altitudes less than or equal to 3300 ft (1000 m). For altitudes above 3300 ft (1000 m), the AC Drive current should be derated 1% for every 330 ft (100 m) up to 6,600 ft (2,000 m).
- F. IP54 environmental rating shall be available on certain models upon request. (See IP54 ratings)
- G. The top of the drive controller shall be IP21 and IP41.
- H. Pollution rating shall be 1 HP to 25 HP at 200/240 V, 1 HP to 5 HP at 380/480V: Pollution degree 2 per IEC / EN61800-5-1, 30 HP to 40 HP @ 200/240 V, 30HP to 100 HP @ 380/480 V: Pollution degree 3 per IEC / EN61800-5-1
- Vibration Resistance shall be 1.5mm to peak from 3 to 13 Hz, 1gn from 13 to 150 Hz, conforming to IEC/EN 60068-2-6.
- J. Shock resistance shall be 15 gn for 11 ms conforming to IEC/EN 60068-2-27

2.06 Ratings

- A. The AC Drive shall be designed to operate at 208 Vac ± 10% or 230 Vac ± 10% or 460 Vac ± 10%.
- B. The AC Drive shall operate from an input frequency range of 50 to 60 Hz \pm 5%.
- C. The displacement power factor shall not be less than 0.96 lagging under any speed or load condition.
- D. The efficiency of the AC Drive at 100% speed and load shall typically be 95% or greater.
- E. The variable-torque rated AC Drive nominal full load current limit shall be not less than 110% for 60 seconds.

2.07 Protection

- Upon power-up, the AC Drive power converter shall automatically test for valid operation of memory, valid
- B. operation of precharge circuit, loss of communication, DC-to-DC power supply, and control
- The AC Drive power converter shall be protected against short circuits between output phases and also
- D. phase-to-ground.
- E. Upon loss of the analog process follower reference signal, the AC Drive power converter shall be programmable to display a detected fault condition signal.
- F. The output frequency shall be software enabled to fold back when the motor is in an overcurrent condition.
- G. The output switching frequency of the AC Drive power converter shall be selectable from 6 to 16 kHz. Derating of the AC Drive power converter may be required if the factory setting is modified.
- H. The AC Drive power converter shall provide an auto reset feature which can provide up to 10 programmable reset attempts after a detected fault has occurred.
- I Lead Length to be 50 meters max out to the motor without a choke.

2.08 Adjustments and Configurations

- A. The AC Drive power converter will be factory programmed to operate all specified optional devices.
- B. The acceleration and deceleration ramp times shall be adjustable from 0.1 to 3200 seconds.
- C. The AC Drive power converter configuration shall have provisions for an Energy Savings motor type.
- D. The AC Drive power converter shall have memory capability to retain and record drive operation and detected fault type for the past four faults.

2.09 Keypad Display Interface

- A. An operator interface shall offer the modification of AC Drive power converter adjustments through a keypad. All electrical values, configuration parameters, I/O assignments, application and activity function access, detected fault condition signals, local control, adjustment storage, and diagnostics shall be accessible.
- B. The AC Drive power converter software revision, output current, motor frequency, and motor voltage shall be readable through the drive display.

2.10 Operator Controls

- A. The control power for the digital inputs and outputs shall be 24 Vdc.
- B. The terminal block shall be used for all logic and analog signal connections to the power converter.

2.11 Serial Communication

- A. The AC Drive shall have serial communications capability for the following protocols:
 - A. Modbus™ (Standard)
 - B. LonWorks® (Optional)
 - C. BACnet® (Optional)
 - D. Metasys™N2 (Optional)
 - E. Apogee™ P1 (Optional)

2.12 Harmonic Mitigation

- A. Each drive shall include reduced harmonics technology to reduce power system harmonics.
- B. See Addendum A

PART 3—Installation

3.01 Inspection

A. Verify that the location is ready to receive work.

3.02 Protection

 Before and during the installation, the AC Drive equipment shall be protected from water and site contaminants.

3.03 Installation

- A. Installation shall be in compliance with the manufacturer's instructions, drawings, and recommendations.
- B. The AC Drive supplier shall provide a trained representative to inspect the contractor's installation, and to test and start up the AC Drive(s) furnished under this specification.
- C. See Schneider install document number 30072-451-90

3.04 Training

A. AC Drive training shall be provided by the AC Drive manufacturer.

3.05 Documentation

A. The AC Drive supplier shall supply a comprehensive 8-1/2 x 11-inch bound instruction and installation manual that includes wiring diagrams, layout diagrams, and outline dimensions.

Addendum A

Data Bulletin 8800DB0702R06/11 07/2011

Replaces 8800DB0702 08/2007

Reduced Harmonics Technology in Altivar™ 212 Adjustable Speed Drives

Retain for future use.

Introduction

This data bulletin provides an introduction to power line harmonics and describes the reduced harmonics technology (RHT) used in Altivar™ 212 adjustable speed drives for mitigating power line harmonics.

Power line harmonics and harmonic distortion are words found in almost every specification for adjustable speed drives. While harmonics is a term referred to regularly, there are few industry guidelines on this subject. An increasing number of electronic devices that generate power line harmonics are being installed and retrofitted into buildings. This includes devices that convert AC power to DC power and draw power intermittently. Personal computers, electrical control equipment, lighting ballasts, and adjustable speed drives are examples of these types of devices. This intermittent current draw, caused by the capacitors charging in these devices, can have high peak current values. Managing these high peak current values and managing the input current waveform are the keys to mitigating power line harmonics.

What are Harmonics?

Intermittent current draw can cause the building's power grid to carry power flowing at frequency multiples of the 60 Hz base frequency, in addition to the 60 Hz power supplying the building's electrical needs. Power flowing at frequency multiples other than 60 Hz, consisting of voltage and current components, is often called harmonic distortion. In other words, power line harmonics exist in the form of current and voltage waveforms that are present at frequencies other than base frequencies. This can be thought of as non-productive power that is flowing through the conductors along with the productive power that is supplying the building's electrical needs. This harmonic distortion is measured as the sum of various frequency components which are integer multiples of the 60 Hz base power line frequency. This total sum of the harmonic current distortion is often referred to as THDI.

Another way to understand harmonics is to consider two of your favorite musical instruments. When a saxophonist and blues guitarist hit the C note on their respective instruments, you hear the common base frequency. However, you also hear the various distinctive tones each instrument makes. These various audible tones are generated from various frequency components which are integer multiples of the base frequency, just as currents flow at multiples of the base power line frequency.

Why the Concern About Power Harmonics?

While various harmonic tones give the various musical instruments their character, power line harmonics are less desirable. The impact of intermittent current draw in electronic control equipment and personal computers is often only a minor concern as the power draw is small. However, devices that draw a significant amount of power, such as adjustable speed drives and lighting loads, can have a pronounced negative impact on the building's power grid. These impacts include transformer and



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conductor overheating, circuit breaker tripping, fuse opening, and interference with communication networks. Lack of awareness of power harmonics can lead to improperly sized power conductors and disruption of the operation of sensitive equipment. Other variables of an installation can reduce or intensify the actual level of harmonics. These variables include system impedance, line voltage imbalance, transformer size and loading, percent of transformer load that exhibits intermittent current draw, and the available short circuit current. Sites or installations where the AC drive load is a significant portion of the transformer load require the most design

What Can Be Done About Power Line Harmonics?

Reducing the high peak current values and managing the input current waveform are the keys to harmonic mitigation. Various methods of harmonic mitigation are available today, such as adding AC line reactors or DC chokes, tuned harmonic trap filters, 12- and 18-pulse AC drive designs, and other active front-end devices that recreate an AC sine wave that virtually eliminates power harmonics. Each method offers cost—benefit trade-offs. A common mistake is to specify a solution that increases the installation and operating costs. The best solution is a trade-off between acceptable harmonic distortion and acceptable costs.

What Does the Altivar 212 Drive Offer?

The Altivar 212 adjustable speed drive, designed specifically for pump and fan applications, has a unique and effective approach to reducing harmonics called reduced harmonics technology (RHT). The Altivar 212 drive offers a unique, optimized power section and a powerful motor control method that significantly reduces harmonic currents. The Altivar 212 drive reduces harmonics by 60% or more without the use of additional harmonic reduction devices.

Design Principle of the Altivar 212 Drive

The key design principles contributing to the Altivar 212 drive's reduced harmonic technology are as follows:

- 1. The optimized power section
- 2. A powerful motor control processor combined with the design of the motor control algorithm

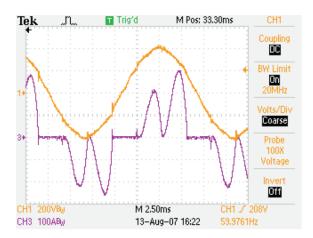
The power section is optimized by reducing the DC bus capacitance value to approximately 3%–5% of the capacitor value of an equivalent horsepower, standard AC drive. This modifies the input current waveform characteristics by significantly reducing current spikes typically observed during the capacitor charging cycle. Total current draw is reduced, lowering input current harmonics and input line current values. The second key design aspect of the Altivar 212 drive is the powerful motor control processor and the engineering of the motor control algorithm. As there is less DC bus capacitance, there is more DC ripple on the DC bus. The motor control processor and algorithm manage the ripple and produce a sinusoidal current waveform to the motor.

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Typical 6-Pulse AC Drive Input Waveforms

Figure 1 shows typical input voltage and current waveforms of a 100 hp 6-pulse AC drive. The double-humped waveform shows the peak current reaching 300 A as the capacitors charge. Total harmonic current distortion (THDI) = 80% in this example.

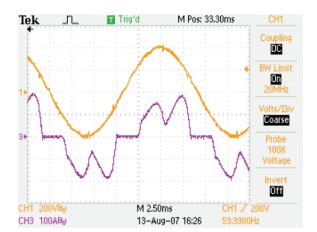
Figure 1: Typical 6-Pulse AC Drive Input Waveforms



Typical 6-Pulse AC Drive with Line Reactor Input Waveforms

Figure 2 shows typical input voltage and current waveforms of a 100 hp 6-pulse AC drive with a 3% input line reactor. The double-humped waveform shows the peak current reaching 190 A as the capacitors charge, but note that the peak currents are reduced in comparison to Figure 1. THDI = 38% in this example.

Figure 2: Typical 6-Pulse AC Drive with Line Reactor Input Waveforms



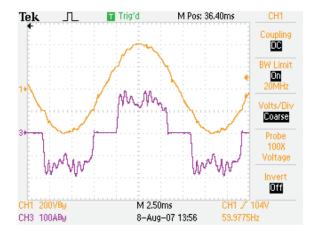
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Altivar 212 AC Drive Input Waveforms

Figure 3 shows typical input voltage and current waveforms of a 100 hp Altivar 212 AC drive. Note the dramatic change in the shape of the input current waveform. The current peaks reach up to 190 A, similar to results with a line reactor. However, because of the reduced capacitance, the input current is a square-shaped waveform, eliminating the large double-humped waveform which generates large harmonic currents. This square current waveform produces less harmonic currents. The THDI is reduced to 33% in this example.

Figure 3: Typical Altivar 212 AC Drive Input Waveforms



What About Standards Compliance?

Today, there are no clear product standards governing harmonics. IEEE 519-1992, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems, is often referenced when discussing harmonic mitigation. However, this standard was developed to cope with harmonic issues in electrical transmission lines and power grids. IEEE 519-1992 is a systems standard which cannot be effectively applied to individual products.

The international standard IEC 61000-3-12, "Electromagnetic Compatibility (EMC)—Part 3-12 Limits," is increasingly being referenced. IEC 61000-3-12 discusses harmonic current limits produced by equipment connected to public low voltage systems. This IEC standard provides criteria for evaluating individual products. For compliance to IEC 61000-3-12, Table 4, the THDI must be less than 48%. As previously noted the Altivar 212 drive's THDI is below 35% without AC line reactors or DC chokes.

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Comparison of Harmonic Mitigation Methods

Table 1 provides an overview of various harmonic mitigation solutions, summarizing the advantages, disadvantages, typical THDI, and typical cost ratio

Table 1: Comparison of Harmonic Mitigation Methods

Solution	Advantage	Disadvantage	Typical THDI (%)	Typical Cost Ratio
Typical 6-pulse—No harmonic mitigation	Widely used	No improvement of the current wave shape Difficult to comply with standards	> 80	1
RHT technology	Simple design Lowest cost	Limited hp range Difficult to comply with the most severe standards Poor voltage sag ride-through	< 35	0.90-0.95
AC line reactors or DC choke	Simple Medium cost	Difficult to comply with the most severe standards	< 40	1.05–1.15
Passive filter (broadband)	Significant improvement of the current wave shape Possible to install after commissioning (corrective action)	Separately mounted solution Potential for resonance issues	5–12	1.35–1.70
Multi-pulse (12- or 18-pulse configuration)	Significant improvement of the current wave shape Integrated solution	Large size, heavy Expensive for >100 hp Performance deteriorates in case of voltage unbalance	5–12	1.75–2.5
Active front end (IGBT¹ converter)	Sinusoidal current Optional regenerative control is possible	High cost for pump and fan market Engineered design	< 5	2.0-3.0

¹ IGBT = Insulated Gate Bipolar Transistor

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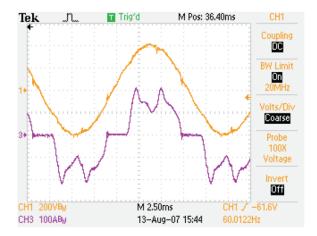
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More on RHT in Altivar 212 Drives

There are several other benefits from the reduced harmonics technology used in the Altivar 212 drive. Because the peak current drawn through the input diodes is significantly reduced, the diodes are stressed less, compared to a typical 6-pulse AC drive. The design of the filtering on the diode section and use of long life plastic film capacitors ensure a robust front-end power section on the Altivar 212 drive.

AC line reactors are often used when the incoming AC line power is above voltage specifications to reduce the effect of high line voltage. Adding a line reactor will not significantly reduce or add to the Altivar 212 drive's THDI. Figure 4 shows typical voltage and current waveforms of a 100 hp Altivar 212 drive with a line reactor. The THDI is reduced to 33% in this example.

Figure 4: Typical Altivar 212 AC Drive with Line Reactor Input Waveforms

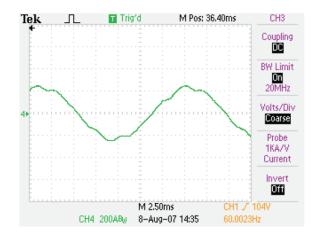


With lower DC bus capacitance, the Altivar 212 drive has a reduced capacity to ride through AC power line dips or sags. The Altivar 212 drive has an auto-restart feature and a robust catch-on-the-fly algorithm designed to minimize the effect of voltage dips and sags. The catch-on-the-fly algorithm has also proven to do an exceptional job of catching a reverse spinning load, bringing the load to a standstill and accelerating in the proper direction. This catch-on-the-fly algorithm is a useful feature for wind-milling fan loads. If voltage ride-through is a major concern in an installation, the Altivar 61, with its industry leading voltage sag ride-through capability, may be the preferred solution.

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Figure 5 shows a typical waveform of the Altivar 212 drive's output current. The motor control processor and the motor control algorithm are designed to produce a sinusoidal waveform with very little distortion to the motor.

Figure 5: Typical Altivar 212 AC Drive Output Current Waveform



Altivar 212 Drive Benefits

The Altivar 212 drive has many benefits for pump and fan installations.

- Reduces harmonic distortion
- Reduces enclosure size requirements
 - no line reactor or other external filtering
 - reduced capacitance
- Reduces heat dissipation
 - no line reactor or other external filtering
 - reduced capacitance
- Improves efficiency
 - no line reactor or other external filtering
- · Reduces cost of installation
 - saves installation time
 - minimizes wire size
 - reduces wiring between components