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CLARIFYING RIPPLE SPECIFICATIONS

BACKGROUND

As of November 2022, the ripple voltage allowed on the dc output of stationary battery chargers is specified by IEEE standard **2405.2022**. Prior to this date, ripple was specified by legacy standard NEMA PE5. The dc output ripple measurement can be confusing, partly because the limits on ripple voltage have changed during the evolution of these standards.

This document is a summary of dc output ripple specifications from the manufacturer of ATevo, AT10.1, AT30 & SCR/SCRf Series industrial battery chargers. Also included is an FAQ section, to understand the sources of ripple and how to measure ripple voltage.

ATevo Series Battery Chargers (1PH & 3PH)

- ATevo meets the requirements of IEEE 2405.2022 for dc output ripple specifications.
- Prior to 11/2022, earlier ATevo models meet the requirements of NEMA PE5 (current to time of shipment).

Notes:

1. mVrms = millivolts root mean square

The term 'rms' is a measurement of the effective value of an ac voltage. Therefore, the ripple voltage is the value of the ac voltage that can be measured at the battery terminals or at the output terminals of the battery charger.

Where the ripple voltage is shown as a percentage in the table above, this is the percentage of the dc output voltage. For example: a filtered charger operating without a battery at 132.0 Vdc would have a maximum ripple value of 2.64 Vac.

The 1996 version of NEMA PE5 is ambiguous about the rating of the battery used to qualify a battery charger for this specification. We use the PE5-1983 requirement for a battery whose Ampere-hour (AH) rating is four (4) times the output current rating of the charger.

2. The ATevo Series battery charger was (and is) **not** offered in an un-filtered variant. Regarding other technology, one should **never** operate an **UN**-filtered charger, without a known (good) battery connected to the dc bus.

FREQUENTLY-ASKED QUESTIONS (FAQs)**What causes ripple?**

The input power for a battery charger is obtained from the ac power utility. Alternating current (ac) voltage, well...**alternates**. In the USA, it changes polarity sixty (60) times a second, a *frequency* of 60 Hertz (Hz). The battery charger changes the alternating voltage to dc (direct current) voltage with a *rectifier* circuit. The output of the rectifier circuit still has some of the alternating voltage left in it, so it's normally applied to a filter, which makes it look and act more like pure direct current (a "pure" dc voltage is like what you would get from a battery).

Of course, no filter is perfect, and there is always a little ac voltage left in the output of a battery charger. The better the filter is, the lower the ac ripple voltage is. If you need to disconnect your battery for maintenance, and want to be assured of a low ripple value, you should order a battery eliminator filtered charger.

All bets are off with an unfiltered battery charger (**not** available on ATevo). As the name implies, there is no filter, and the amount of ripple voltage in the output can be very large. This type of charger depends on the battery to do most of the filtering.

How do I measure ripple?

You measure the ripple voltage using an ac voltmeter connected to the battery terminals. If the battery is disconnected (of course, only if you have a filtered charger or eliminator), measure the ripple at the output terminals of the battery charger. An analog voltmeter, like the old Simpson 260, is best, because the reading on a digital voltmeter might be too jumpy to get a good measurement. If you do use a digital voltmeter, it should have a **'true rms'** measurement range.

Why is ripple a problem?

When you want to charge a battery, you need to deliver pure direct current to the battery terminals. Anything other than pure dc doesn't charge the battery. In fact, if the ripple is large enough, it can cause unnecessary heating in the battery, in some cases reducing the life expectancy.

High ripple voltages on the dc bus can also affect the operation of your dc loads. This is especially true in communications applications.

Finally, high ripple voltages translate to high ripple currents to the battery, possibly requiring larger wiring between the charger and the battery.

Why can't I run my unfiltered charger without a battery?

(aka I want to test my loads, but the battery isn't installed yet.)

The ripple voltage at the output of an unfiltered charger can be very high, with high peak voltages (up to 200V or more for a 130V charger). This is especially true for single phase chargers. Unfiltered chargers depend on the battery to provide the filtering, and limit the peak output voltages. Powering the dc loads without a battery connected can apply destructive peak voltages to sensitive equipment. We have received reports of dc relays being destroyed when the charger was turned on without the battery connected.

- *Lesson 1:* Never purchase an unfiltered battery charger.
- *Lesson 2:* If you do, never operate it without a battery.
- *Lesson 3:* Maintain that battery very diligently.

I have a filtered battery charger...**The ripple shouldn't be higher than 100 mV, but I measure a much higher voltage. What's wrong?**

Of course, there is always the possibility that one (1) of the filter components in the battery charger is defective (usually capacitor 'C1' or 'C2'). These may need replacing after about ten (10) years. Before replacing components, check the other equipment on the dc bus. Some equipment (especially inverters, or instruments with switching power supplies) can increase ripple on the dc bus, even when measured at the battery terminals.

AT10.1 and AT30 Series Battery Chargers

- AT10.1 & AT30 chargers meet the requirements of NEMA PE5-1996 for dc output ripple specifications.
- AT10.1 & AT30 chargers were **not** offered/manufactured in 260 Vdc variants.

Notes:

1. mVrms = millivolts root mean square

The term 'rms' is a measurement of the effective value of an ac voltage. Therefore, the ripple voltage is the value of the ac voltage that can be measured at the battery terminals or at the output terminals of the battery charger.

Where the ripple voltage is shown as a percentage in the table above, this is the percentage of the dc output voltage. For example: an unfiltered charger operating with a battery at 132 Vdc would have a maximum ripple value of 2.64 Vac.

The 1996 version of NEMA PE5 is ambiguous about the rating of the battery used to qualify a battery charger for this specification. We use the PE5-1983 requirement for a battery whose Ampere-hour (Ah) rating is four (4) times the output current rating of the charger.

2. Remember that one should **never** operate an **UN**-filtered charger, without a known (good) battery connected to the dc bus.

SCR/SCRF Series Battery Chargers

The SCR/SCRF Series was designed to meet the requirements of NEMA PE5-1985. However, the 1985 standard dropped any limits on dc output ripple voltage (probably an accident), although it does provide a discussion of test methods. We fall back to the 1983 version of the standard, which allowed two voltage limits: 'A' (30 mVrms) and 'B' (100 mVrms). The manufacturer could choose either limit, as long as it was stated in the specifications for the product. The SCR/SCRF series of battery chargers meets the requirements of Limit 'A' in NEMA PE5-1983 for output ripple requirements. Note that neither the 1983 or 1985 version addressed the ripple requirement for an unfiltered charger, or for a filtered charger without battery, or for eliminator filtering. Therefore, those figures in the table below are typical, not guaranteed maximums.

Notes:

1. mVrms = millivolts root mean square

The term 'rms' is a measurement of the effective value of an ac voltage. Therefore, the ripple voltage is the value of the ac voltage that can be measured at the battery terminals or at the output terminals of the battery charger.

NEMA PE5-1983 considers only the case of a filtered charger with battery. Ripple voltages shown as a percentage in the table above are for reference only, not limits set by the NEMA standard. Measurements for a filtered charger assume a battery Ampere-hour (Ah) capacity of four (4) times the output current rating of the charger.

2. Remember that you should ***never*** operate an **UN**-filtered charger without a known (good) battery connected to the dc bus.



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