

UST



Energy Efficiency & Power Quality Series

Comparison of Automatic Voltage Regulators
for
Industrial Power Quality Applications

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Utility Systems Technologies, Inc.

Phone: 888 403-9084
Fax: 518 377-2207

Email: sales@ustpower.com
Website: www.ustpower.com

P.O. Box 110
Latham, NY 12110

Comparison of Automatic Voltage Regulators for Industrial Power Quality Applications

Numerous voltage regulator technologies have the capability to correct voltage problems. However, most voltage regulators are designed for use in data centers or light commercial application where the load and environmental conditions are fairly benign. When computer-grade voltage regulators are used in industrial situations, there are often a number of operational limitations and other considerations that have to be addressed. Industrial-grade voltage regulators, on the other hand, are specifically designed for the special challenges and requirements found in manufacturing applications or where the loads demands are severe.

What is an industrial power quality application?

While there is no single definition for an industrial electrical application, it is safe to say that there can be significant differences in the electrical “environment” found in office or data center and a factory. The electrical characteristics found in industrial applications like a machine shop, plastic manufacturer, food processor, commercial printer, etc. can include high load inrush currents, low power factor, significant load swings, high harmonics, etc.

Here are some typical industrial characteristics as they apply to automatic voltage regulators:

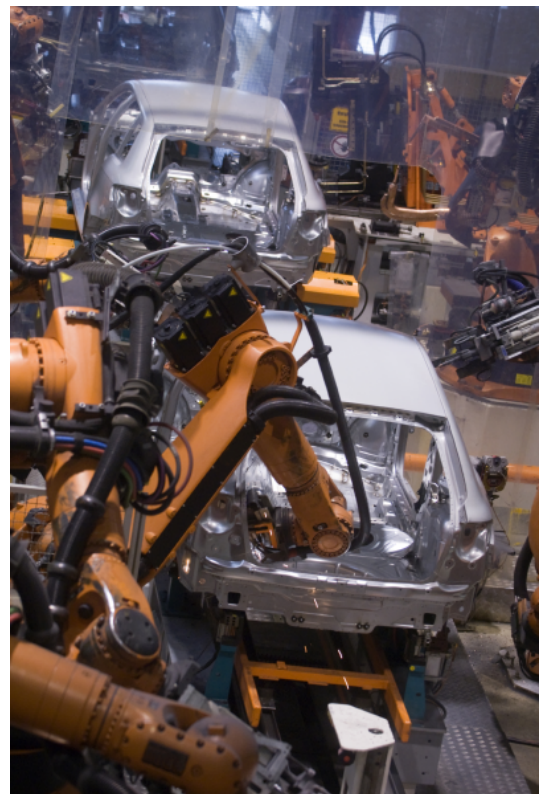
Large loads & load swings – In industrial applications, the load could be a single large device such as motor or transformer. It could also be a machining center requiring large currents while operating but only enough power for the controls at idle. The automatic voltage regulator (AVR) should not have any restrictions on minimum load or load type.

High load inrush current – High inrush current is the trademark of motor and transformer loads. The overload capacity of many automatic voltage regulators is so low as to be incompatible with high or frequent inrush. Subjecting an AVR to currents substantially above its overload capacity on a regular basis often results in premature failure of the device – sometimes within days or weeks.

Fault clearing requirements – Safety devices such as circuit breakers require a minimum amount of current to operate properly in the event of a fault. For example, limiting the current to a circuit breaker during a short circuit can prevent the breaker from opening which may create a very dangerous situation. The AVR must be able to pass enough current during fault conditions (without damaging itself) in order to avoid potentially dangerous situations.

High load harmonics – Some loads – power supplies, for instance - can produce significant harmonics. An AVR should be capable of reliably operating under high harmonic conditions and should do so without de-rating performance or reducing component life.

Low load power factor – Low power factor is common in many industrial applications often as the result of substantial motor loads. The automatic voltage regulator should operate reliably without restrictions on power factor and without de-rating its capabilities or the need to correct power factor for satisfactory operation.



Comparison of Automatic Voltage Regulator (AVR) Technologies for Industrial Applications

The table below shows the most common automatic voltage regulator technologies for power quality applications and their compatibility with the industrial characteristics described above:

Comparison of Automatic Voltage Regulators for Industrial Applications						
Technology \ Application	Ferroresonant Transformer	Double Conversion (UPS)	Servo-Induction	Electro-Mechanical	Electronic (Computer-Grade)	Electronic (Industrial-Grade)
Large Loads & Load Swings	●●●	●●●	●●●●	●●●●	●●●	●●●●
High Inrush Current	●	●	●●●	●●●	●	●●●●
Fault Clearing	●	●●●	●●●	●●●	●	●●●●
High Load Harmonics	●●	●●	●●●●	●●●●	●●●	●●●●
Low Load Power Factor	●●	●●●	●●●●	●●●●	●●	●●●●
Application Considerations	●●	●●	●●	●●	●●	●●●●

●●●● No limitation	●●● Minor limitation	●● Substantial limitation	● Critical limitation
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AVR Compatibility with Industrial Applications

Following is a brief discussion of each common automatic voltage regulator and its compatibility with industrial applications:

Ferroresonant Transformers

Ferros are only single phase units generally limited in size up to 15 kVA. An inrush above ~ 150% of rated current will cause the output voltage of the ferro to collapse: which can result in loads failing to start or operate properly. This problem requires over-sizing the unit by 2-300% of rated load current. This current limitation also substantially impacts fault clearing capability. The ferro may be tolerant of some harmonics but it can also significantly add to system harmonics. Power factor correction may be required for proper operation. The high heat rejection of the ferro can limit enclosure options and may not permit application in certain locations. Application requires an evaluation of load inrush currents, power factor and fault clearing requirements.

Double Conversion Type Voltage Regulators (UPS)

The double conversion or online UPS is good at protecting against power interruptions and provides some voltage regulation capability before resorting to battery operation. In industrial applications, the UPS usually needs to be sized close to the peak current to ensure the inverters are sufficiently large enough to support the load. The double conversion UPS is subject to de-rating for harmonics, power factor and environmental factors like temperature. Temperature control can be especially important for proper battery life. Inrush and overload currents may be shunted through the unit bypass via a transfer switch to protect the inverter. Application requires an evaluation of load inrush currents, power factor, source compatibility (such as generators) and load compatibility as well as any temperature constraints.

Servo-Induction & Electro-Mechanical Tap-Switching Voltage Regulators

The servo-induction and electro-mechanical tap-switching voltage regulators are essentially transformers capable of adjusting voltage by altering the turns ratio or flux orientation. Like a transformer, they are well suited for conditions found in industrial environments such as large loads & load swings, inrush and fault clearing currents, harmonics and poor power factor. These characteristics make such AVRs robust, easy to apply and very efficiency across the load range. Since these devices operate by physically moving components to achieve voltage regulation, application requires evaluation of some of their characteristics: 1) mechanical regulation is very slow (in electrical terms) and long correction times may not support or adequately protect sensitive loads from rapid voltage swings, 2) the time required for voltage correct increases as kVA size (and mass of components) increases, and 3) the maintenance interval for servo-motors, drives, brushes, contactors and other mechanical components is directly related to the number of voltage correction operations.

Computer-Grade Electronic Tap-Switching Voltage Regulators

Computer-grade electronic tap-switching voltage regulators eliminate the mechanical limitations of the servo-induction and electro-mechanical tap-switching voltage regulators but introduce some different issues. The power semiconductors in an electronic voltage regulator that permit rapid voltage correction and replace mechanical components are themselves very susceptible to damage from current overloads. Like the double conversion UPS, it is common to over-size the computer-grade electronic AVR to prevent overheating and premature failure the semiconductors from large and/or frequent inrush currents. Application of these units requires a good understanding of the load characteristics (load current and power factor) to ensure the switching semiconductors are properly sized for the application. Although the mechanical drive components may be eliminated, computer-grade electronic tap-switching voltage regulators typically utilize fans for cooling the semiconductor heat sinks.

Industrial-Grade Electronic Tap-Switching Voltage Regulators

Industrial-grade electronic tap-switching voltage regulators combine the very fast correction and solid-state design of electronic regulators with the reliability and ease of application of mechanical regulators - without the inherent weaknesses of either. The industrial-grade electronic AVR can be sized, applied and installed like a dry-type transformer. The design of the industrial-grade electronic tap-switching voltage regulator eliminates problems associated with high inrush currents, power factor limitations and high harmonics and ensures ample fault clearing current for the proper operation of safety devices.

For more information on the design and operation of these voltage regulator technologies go to:

http://ustpower.com/Support/Voltage_Regulator_Comparison.aspx

Summary

Voltage regulation in industrial applications can be critical to ensure the protection and proper operation of equipment and processes. The careful selection of voltage regulator technology can significantly increase the likelihood of meeting such objectives. Because of the dynamic nature of industrial operations, it is important that a voltage regulator be compatible with all load types and effectively operate without damage to itself while protecting load equipment. Only industrial-grade electronic tap-switching voltage regulators are designed by these criteria for the challenging and often harsh conditions found in many industrial applications.

Utility Systems Technologies, Inc. manufactures a broad variety of industrial-grade power conditioning products to support the financial, operational, energy saving and environmental goals of its customers. As a leader in the field of “green” power quality, all UST products have the highest performance and efficiencies available.