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Energy Efficiency & Power Quality Series

Comparison of Automatic Voltage Regulators
for
Utility Versus 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 Utility versus Power Quality Applications

When it comes to voltage regulation for large industrial or commercial applications, confusion often surrounds two different types of automatic voltage regulators (AVR): the medium-voltage mechanical AVR and the low-voltage mechanical or electronic AVR. Spurring the befuddlement is the fact that both of these distinct technologies are called voltage regulators. Customers don't always understand the distinct purposes for the two technologies. The medium-voltage mechanical AVR is geared to compensate for voltage drops in the electric utility's distribution network. Low-voltage AVRs, however, are designed to protect an end user's equipment from power quality problems, particularly voltage levels that are too high or too low.

Medium-voltage mechanical automatic voltage regulators (AVR)

Electric utilities use medium-voltage mechanical automatic voltage regulators (shown right) to adjust voltage levels as loads increase or decrease on each branch line in a distribution network. To keep the networks stable, utilities will adjust the voltage in tiny increments - and only after an adequate amount of time has passed - to make sure that a voltage problem is not simply a momentary issue.



The medium-voltage AVR is a transformer with multiple taps which are used to change the turns ratio and thereby alters output voltage. This type of AVR includes electronic and/or mechanical controls that tell the unit when and how to change taps.

Most medium-voltage AVRs regulate voltage use thirty two 5/8% taps - permitting a maximum voltage-regulation range of ± 10 percent ($5/8\% \times 16 = 10\%$). The maximum and minimum percentages of voltage regulation can be set for each unit, within the $\pm 10\%$ regulation range.



Such units include an adjustable automatic-delay timer, which prevents the unit's operation the instant that a voltage deviation is detected. Typically, delay settings can be set to fall between a few seconds and several minutes. This delay allows a utility to coordinate the operation of multiple regulators on a distribution network, in order to maintain system stability and minimize the total number of operations by the regulators.

The "mechanical" part of these regulators consists of hundreds of components (see left) necessary to change taps. They include servomotors, gears, shafts, bearings, bushings, contactors, limit switches, nuts, bolts, springs, and a host of other parts. Because mechanical systems require regular maintenance - and because the time to maintenance is directly related to the number of operations performed - the utility tries to minimize the total number of operations to reduce its maintenance costs.

More, because a medium-voltage AVR uses time delays and mechanical drives to change taps, the speed of voltage adjustment is clearly not of prime concern to utilities. That it may take many seconds for this type of AVR to correct large voltage swings is less important to a utility than are AVR reliability and maintenance costs.

Low-voltage automatic voltage regulators (AVR).

The low-voltage automatic voltage regulator is designed to stabilize voltages within a prescribed range to protect and permit proper operation of the end user's equipment. Unlike the medium-voltage AVR, the low-voltage AVR is expected to correct voltage-level problems without delay, as quickly as possible, and as often as is necessary.

For the end user, time is of the essence when it comes to correcting voltage problems. Voltage that's too high can damage printed circuit boards, while voltage that's too low can cause equipment to malfunction or even shut down. Following the widespread introduction of sensitive electronics to virtually every facet of business and industry, the range and speed of voltage correction has become ever more important to commercial and public interests. A single problem caused by poor voltage levels can easily cost thousands to hundreds of thousands dollars in lost productivity, material and profit.

Low-voltage AVR's are available in both mechanical and solid-state electronic versions. The mechanical version differs from the medium-voltage AVR's used by utilities only in two ways: it's not oil-filled, and its smaller size usually permits slightly better voltage correction times. The electronic version (controls shown right) provides both ultra-fast voltage correction and eliminates the need for mechanical maintenance. Both of these low-voltage AVR's provide a much broader voltage-regulation range than their medium-voltage cousin: typically, one on the order of +10 to -25% of nominal voltage. Because most electrical equipment can be satisfied with voltages with the range of $\pm 5\%$ of nameplate, these low-voltage regulators usually stabilize voltage within a range of ± 1 to ± 3 percent.



Summary

The table below shows the key features of products referred to as "voltage regulators".

Comparison of Automatic Voltage Regulators for Utility and Power Quality Applications			
Technology \ Feature	Medium-Voltage Mechanical AVR - Utility Application -	Low-Voltage Mechanical AVR - Power Quality Application -	Low-Voltage Electronic AVR - Power Quality Application -
Transformer Type	Oil-filled	Dry type	Dry type
Voltage Level	7620 to 34.5K VAC	< 600 VAC	< 600 VAC
Input Voltage Range	$\pm 10\%$	± 15 to $\pm 20\%$	+10/-25%
Number of Taps	32	6 to 18	6 to 7
Output Voltage Regulation	5/8%	1 to 3%	3%
Full Range Correction Speed	9+ seconds	2.5 to 4+ seconds	0.02 to 0.04 seconds
Operation	Servo-motor drive with brushes	Servo-motor drive with brushes or contactors	Electronic switching with SCRs
Maintenance	Regular inspection of oil, mechanical components and brushes	Regular inspection of mechanical components and brushes	No scheduled maintenance
Maintenance Interval	Depends on number of operations	Depends on number of operations	No regular period

While these devices do regulate voltage, the differences in their design and operation clearly demonstrate that their purpose is not the same.

The medium-voltage mechanical AVR is designed to provide highly accurate control of distribution voltage levels for an electric utility. Fineness of regulation, reliability and integration of system operation: all are key to the bulk-voltage regulation provided by these units.

The low-voltage AVR is designed to protect sensitive end-user equipment from power quality problems whether they originate from the grid or elsewhere. Speed and range of correction are the most important characteristics of this type of power quality AVR.

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

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

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.