New Technologies in Automatic Power Factor Control - Comprehensive Solution for Power Quality

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Automatic power factor controllers (APFC) are introduced to the market based on the growing requirements for the power quality and to improve life-time and reliability of the other components thus improving the return of investment. In the following article we discuss some key features of such an advanced power factor controller line – the NOVAR APFCs. This product line includes compact budgetary solution with only 96x96 cut-out footprint NOVAR 100x as well as fully featured 144x144mm NOVAR 11xx and 12xx and a fast power factor controller NOVAR 1312 with thyristor switching blocks KATKA. These controllers can be equipped with optional communication port and free configuration and visualization software. Following in this article we will present some of its more advanced functions and features.

Precision and sensitivity of measurement

The growing price of energy creates the necessity to compensate reactive power also in situations with low energy consumption (for example during state holidays, night). Also many installations are operated with overrated measuring current transformers where the real current signals can be relatively weak even under normal load conditions. In such situations it is better to use PFCs with better current sensitivity. Standard minimal measured current is typically around 50mA. The improved line of NOVAR 1xxx APFC is able to measure the minimum of 2 mA thus allowing much better operation in the mentioned scenario. These advanced controllers can be as well suitable for current transformers with rated secondary current of 1A which is another common case.

4-Quadrant compensation, Under/Over-compensation

Electromechanical electricity meters are being massively replaced by static (digital) solutions to evaluate energy consumption more precisely and separately for different loads. Distribution company usually offers different billing conditions for over- and under-compensation. Therefore NOVAR controllers can be set to use different strategies and target values in both cases. By default it is configured to fit requirements of most typical applications. But it also enables power factor control at applications where direction of energy flow can change. The NOVAR devices are able to perform complete 4-quadrant compensation allowing further optimizations of the total costs.

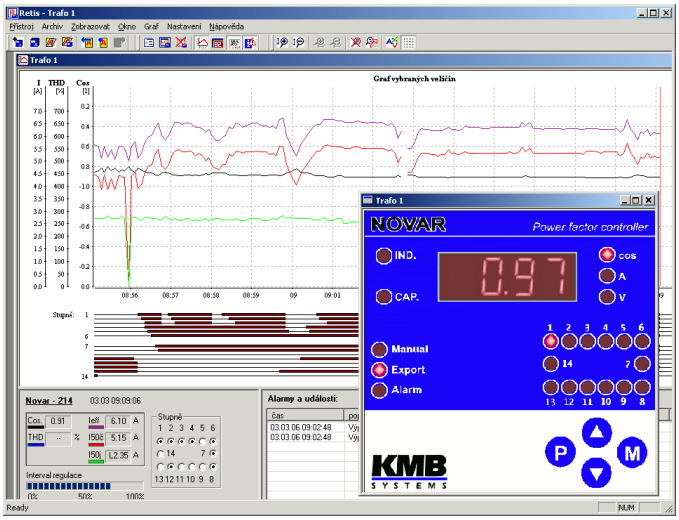

Fig. 1: RETIS on-line data acquisition, visualisation and device management over optional remote communication

Step selection strategies

Reliability of the whole system is mostly related to usage of each step's contactor and capacitor. The critical quantity in is the total number of connections/disconnections of each step. It is the responsibility of an APFC to choose optimal combination of steps which provides sufficient compensation while it is using the right steps improving its lifetime. The combination of steps in each control intervention should be targeted to the exact missing reactive power in the network. FIFO/LIFO strategies commonly used in many other APFCs utilizes steps equally. But this strategies can be used only if all the steps are of the same or predetermined capacity. But in many applications there are steps with different capacities or even reactors connected to the systems. So NOVAR PFC implements a usage counter and an active time register for each step. These two values are evaluated in the step selection logic to improve its decisions towards infrastructure lifetime as the quality of control stays uncompromised. Any combination of capacitors and reactors can be used for system control.

To maximize the effect of compensation it is important to quickly and correctly react to variations of the power factor. Every unnecessary reaction is limiting the lifetime of the installation. So the NOVAR APFC is dynamically changing the step blocking time in relation to the severity of the actual power factor lag. Also if the system compensates both high and low loads than the dynamics of the system can also become a problem. We have defined separate control areas with tuned bandwidth logic for different load levels to eliminate this unwanted behavior.

Free Step Configuration and Automatic Step Detection

Typically the power factor correction is applied for loads of inductive character such as engines, transformers etc. But in some applications it can also be required to actively de-compensate capacitive reactive power. It is often a case with long power lines under low load where the capacity can become significant. In such cases the compensating system uses special reactors instead of capacitors. Common are also mixed systems with booth chokes and capacitors in different steps. Such a system of course requires controller capable to control booth. Every NOVAR APFC is capable to automatically detect all connected steps and use them for most optimal compensation. Each value can be also manually set to a predefined value in certain applications.

Fast Compensation

Least but not last some systems require very fast response to changes in the load. This scenario includes for example often starting and stopping engines such as the one used in elevators or electric cranes. Similar situation is with welding machines, etc. For connection and disconnection of fast compensating steps it is necessary to use special solid state relays (thyristor switches) instead of contactors and a fast variant of a power factor controller. The reaction time of such system must be able to reach up to several interventions per second. A special fast controller NOVAR 1312 supports all the mentioned and can additionally also operate in mixed mode – having booth fast and slow steps connected to the different pre-configured steps. For switching it uses KATKA thyristor switches, which are provided in different configurations for most voltage systems and currents. This combination allows for compensation of even most complex scenarios.

Fig. 2: KATKA thyristor switches controlled by the NOVAR 1312 in fast PFC application

Built-in diagnostic capabilities and control system protection

Diagnostic features are very important to provide optimal and correct operation of the system. A failing contactor is very often broken in the contacted state which constantly adds a capacitive power and may even lead to unnecessary charges. Fuses of the step or other factors can also cause the fail of the step. The controller must be able to detect such situations as fast as possible and provide signal to operator to fix them. The NOVAR controllers are using alarms (visual or wired external) when step is detected to be malfunctioning in either way. It is also automatically displaced from control operation until fully repaired.

Fig. 3: Switchboard controlled by NOVAR APFC with 7 capacitors

Fig. 4: Front side of the APFC NOVAR 1114, up 14 steps, keyboard configurable parameters

A significant parameter for each capacitor is its maximal effective current. If it is exceeded the capacitor may be damaged. The most harmful for a capacitor is a fast change of voltage or the harmonic distortion. The best solution is to use specially tuned chokes for each step. But this solution rapidly increases price and dimensions of the overall solution. A protection of capacitors can be as well handled by the controller itself. The PFC must evaluate the current and harmonic distortion and correctly disconnect all the steps if the preset operation conditions are not met. If voltage event is detected it is important for the protection to immediately disconnect all the connected capacitors as soon as possible. Reaction time should be in this case below the time of one period (less than 20ms).

Conclusions

In the article we have presented solutions to improve power quality. An advanced line of automatic power factor controlers NOVAR has been introduced and its various key features were presented such as operation in fast compensation process using KATKA thyristor switches or power factor control in overcompensated environment. Also several software principles that are used for protection of the compensation system has been described. For additional information please go to our web pages at www.kmbsystems.eu or visit our booth at exhibition fair Hannover Messe, Germany in April 2009 where we will be gladly prepared to demonstrate all the mentioned devices.