Power Factor Controllers

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History

The science of correcting power factor to lower kVA usage is not new – indeed, the concept has been around for over 75 years. The technology is well understood and knowledge is wide spread throughout the world. Early techniques to compensate for lagging power factor were dominated by rotary or synchronous 'condensers' (the word condenser is nothing more than an old fashioned word for capacitor). These worked well but were usually large and required maintenance as they are basically rotating machinery. Power factor correction could be achieved at low and medium voltages and control could be quite precise. Before the age of computers various analog devices and designs were employed to provide automatic adjustment of the excitation on these synchronous machines so as to correct power factors. It was well known that capacitors produced a leading power factor, and so it was natural to try and use them to correct lagging power factor. The problem was, these early capacitors were unreliable and usually low power. This meant that they had to be arranged in capacitor banks, and switched onto the supply in 'lumps' to try and approximate the requirements. This caused another issue – the devices that produced the lagging power factor could easily produce almost an infinitely variable lagging power factor whereas the compensating capacitors were only available in 'lumps'. Therefore. the whole science of using capacitors to correct power factor is based on approximations. Variable power factor capacitors did not exist.

Today

Today, capacitors are much more reliable and compact in design but still only available in these 'lumps'. Electronic and microprocessor based controllers have been developed to selectively switch various pre-configured banks of capacitors onto the supply in order to approximate the actual power factor correction requirements.

Controllers measure the power factor, measure the site load, calculate the amount of correction required and then assess what capacitors it has connected to it and switches them onto or off of the supply to optimize the power factor at close to unity (optimum), as it can. If the site load is steady, then this works well enough and the problem is mostly solved. This is indeed the normal scenario globally, for greater than 80% of the power factor market.

But what if the load changes? The controller then reassesses the new load and adjusts accordingly by switching more or less capacitance onto the supply. *But what if the load is very fast changing?* Sadly, capacitors cannot be switched on and off very quickly, with typically 20-30seconds between operations. The reason for this is that capacitors must be discharged before being re-energised and the time to discharge is typically 3 or 5 minutes (the major part of the discharge occurs in the first 30 seconds after disconnection and so it is widely considered safe and appropriate to switch capacitors at 20-30 second intervals. If capacitors are switched with significant charge still in them, their life is severely reduced and immediate failure can occur). If the load changes faster than 20 seconds, the standard power factor controller will not control the power factor perfectly at all. With averaging techniques and a wider control band of acceptable power factor limits, results are usually adequate, but it is far from ideal and most of the times results in periods of over and under correction. This is the norm, even in 2019, and even from the major Power Factor Controller suppliers such as Schneider, ABB, Frako, KBR, Janitza, Ducati, Nova, etc. The limiting factors are how small the smallest capacitor bank can be economically made, and how fast they can be switched. These are physical things and simple power factor controllers switching capacitors using contactors can not do any better.

Fast Changing Loads

In reality, most site loads are somewhat fast changing. A sawmill for example, can saw 5 metre logs from end to end in under 10 seconds, thus the saw might be idling for 5 minutes and then be called upon to operate at full load for 7 or 8 seconds, and then return to idling. The power factor controller will do nothing in the 7 or 8 seconds of huge load. Quarries and mining operations have the same issues. Conventional power factor systems survive with these conditions by virtue of the averaging effect across a whole site where dozens of loads are on and off all the time. However, clients are demanding greater control and power utility companies are trying to tighten the parameters that they use to calculate penalty tariffs (state dependent). It follows, that as Power Factor Controller system designers, we need to do better.

Active Systems

A number of companies started producing variable speed drives and other power electronic power supplies and invertors. Before long, Static VAr Compensators came onto the market. These devices changed the whole power factor game because not only can they correct power factor exactly, they are blindingly fast, can cope with the leading power factor that occasionally occurs, are able to correct all 3 phases separately or together, and are claimed to be physically smaller than the same size capacitor based system. It would seem that the long serving capacitor based system has been replaced. However – not all is as it seems and the new SVG systems have a number of drawbacks that include:

1) Active systems are sometimes twice the cost of a conventional system and this can make the whole project not feasible because the return on investment numbers cannot be tweaked to satisfy financial requirements
2) Contrary to claims, they produce twice the heat of capacitor based systems and to make it worse, the maximum temperature that they can operate in is lower than capacitor based systems
3) Reliability has been poor and the worst aspect of any failure is that quite specialist skills and people are required to repair the system. More often than not, it requires to be sent back to the vendor for repair/replacement – leaving the site completely unprotected

There is no doubt that SVG's can control power factor beautifully, and they certainly have their place. Most, if not all, of the approximations and compromises that conventional controllers exhibit are just not present in an SVG, leading to them being specified and recommended by consultants and vendors alike.

Alternative Solution

What if there was a new controller and a new way of switching capacitors, such that the benefits of an SVG were able to be provided at half the price of an SVG and further, this new technology was able to be easily and economically added to existing systems to effectively update them and thereby extend their service life for another 10-15 years? There is!

Introducing kVArCorrect's Rapid System. Features include sub-second and safe capacitor switching in 1.25kVAr increments. This provides power factor capacitor based correction from 1.25kVAr up to 1mVAr in 1.25kVAr steps at sub-second speed. Switching speeds down to 100 milliseconds have been tested but there is very little point and certainly no effective gains and so the systems are shipped with <1 second switching. At the heart of the system is the all new kVArCorrect SmartVAr Rapid Controller which dispenses with old fashioned techniques of selecting the best sized capacitor combination it can find, trying it on load to see if it is fine or not and then switching it back out or adding more to it with the execution cycle being 20-30 seconds. Instead of this time-consuming exercise, the controller measures the actual required kVAr requirement to attain a unity power factor and switches capacitors to the nearest 1.25kVAr onto the supply. It does this sub-second and will adjust the amount in the next processing cycle (once again, sub-second), and so on. This is exactly how an SVG works with the difference being that this system uses 1.25kVAr steps. The system uses capacitors rated at almost twice the operating voltage and careful cooling design ensures reliability. The efficiency of the system is almost twice that of an SVG system and the temperature specification is higher. Leading power factor can be handled with additional leading power factor modules and they too are controlled by the new controller. Installation is simpler than SVG installation with only 1 CT required as opposed to usually 3. Repairs can be performed by site electricians and remote diagnostics of the system is available with additional communication modules easily added.

To add this technology to an existing power factor control system only requires replacement of the existing controller, installation of the wall mount Rapid System and some simple wiring between the two. The new controller is the familiar and standard 144mm square physical format and so will fit into the same cutout that the old controller comes out of. Effectively, older systems are thus equipped with the latest functionality without the need to replace them. Life of the system is significantly extended and therefore the return on investment of the capital investment is significantly enhanced.

Ask your kVArCorrect representative about the kVArCorrect Rapid system!

About the Author

The opinions expressed here are the researched views of Allan Ramson, General Manager, kVArCorrect Ltd. All claims have been substantiated by testing and observations from the Australasian market between 2007 and 2018. Having been associated with the design, manufacture and supply of many thousands of power factor capacitors and over 500 power factor systems, kVArCorrect are confident that their solutions are leading the way.

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