US Pilot Installation of MCR-based SVC

Perfectly reliable SVCs are finally available

PermEnergo dramatically improved their system stability and gained from power savings when it installed this 3-phase, 25 Mvar, 110 kV, magnetically controlled shunt reactor at its Kudymkar Substation in NE European Russia in addition to an existing 3-phase, 32 Mvar, 110 kV shunt capacitor bank.

Converting existing shunt capacitor banks into SVCs by equipping them with MCRs in systems where dynamic reactive load and voltage control are required, would efficiently introduce MCRs into the US market.

PROJECT SUMMARY Magnetically controlled electric shunt reactors (MCRs) are a new type of saturable-core reactor, or transductor, which has a core magnetic field averaging ~10 times the strength of that used in earlier systems. This greater core saturation makes possible a corresponding decrease in reactor core mass and in the reactive power control system power rating.

These achievements result in substantial decreases in production cost and overall price, smaller installation space, simple maintenance, and above all, *perfect, transformer-like reliability.* Thus, they are superior to thyristor controlled reactors (TCRs)—their closest functional analogs—in reliability, efficiency, and cost.

SVCs, which are common FACTS controllers, use controllable shunt reactors as their major component. Usually these reactors are TCRs. In Russia, however, MCRs have been implemented in SVCs in place of TCRs, with superior results. TCRs are not as stable as desired, and require additional filters, as well as additional step-down transformers in electric power transmission applications of more than 35 kV. This results in further inefficiency and power loss.

IMMEDIATE RESULTS As an example, this was done three years ago at PermEnergo's substation in Kudymkar to improve the functioning of Russia's Northern Perm power system.

When this was done, the regional power system—which had previously suffered from wild instabilities—immediately stabilized and manual switching events dropped from 800 to only 12 per year, and on-load transformer tap changer use decreased as well. The system saved 7.3 GW-hours over the first year, and construction of a new power line became completely unnecessary for at least 10 more years—saving the utility well in excess of $25 million. In two short years, the utility all but recovered the cost of installing the MCR.

BENEFITS OF CONTROLLABLE REACTORS Generally, both MCRs and TCRs achieve similar benefits:

- Transmission of higher power through existing power lines, which is possible through increased steady-state power stability limits.
- Power savings of approximately 1 to 2% of transmitted power, which is achieved due to a decrease in grid reactive current and in associated ohm loss by compensation of excessive capacitance with reactor inductance.
- Currently installed capacitor banks control grid reactive load and voltage step-wise by on-off switching. Stepwise control is never ideally adequate to the actual state of the system. Controllable reactors facilitate smooth and automatic power regulation, minimize power loss, and dramatically decrease switching

operations. This allows for less wear on switching equipment and on transformer on-load tap changers.

MCR ADVANTAGES The strongest advantages of the MCR are economy, energy efficiency, and rock-like reliability.

- The latest models of TCRs, and newer STATCOMs, both use a special type of thyristors called gate turn-off thyristors (GTOs). Both TCR and STATCOM have an initial six-month "sudden death failure period" (SDFP), during which it is much more likely to fail due to the burn out of GTOs than afterwards. In systems containing hundreds of GTOs—one GTO failure of the control system per year for every 100 Mvar of reactive power is considered the best achievable mean time between failures after this initial SDFP—but during the SDFP, the control system is likely to fail a couple of times each month.
- Unlike TCRs (and STATCOMs), MCRs do not have an SDFP. As repeatedly emphasized, they have transformer-like reliability and so far have a decades-long time between failures. Since they use low-rated, small, and relatively inexpensive thyristor control systems, they can be somewhat overbuilt and hot-tested at the factory to higher specifications than necessary, ensuring proper function before installation.
- Also, because of the small size and low rated power and voltage of the MCR control system, spare control systems may be installed, if needed, as hot reserves.
- MCRs last far longer than TCRs (no MCR has been replaced in more than 20 years).
- MCRs have a transformer-like "plug-and-play" installation and they are as reliable and simple to operate and maintain as ordinary transformers.
- Without filters, the current-distortion coefficient of MCRs is about 3%, as against 5.8% for TCRs. Thus, fewer filters are required.
- MCR overvoltage limitation is 2.3 times the rated voltage, versus 1.8 times for TCRs.
- MCRs require about 10 sq. ft / Mvar installation space, versus 100 sq. ft / Mvar for TCRs.
- MCRs have a decided internal energy-savings advantage: at rated reactive power consumption, internal power losses in reactors of greater than 35kV rated voltage are only 0.4% in 180 Mvar MCRs and 0.7% in 32 Mvar MCRs. However, internal power losses are about 1.1% in TCRs of the same rated voltage, because TCRs of more than 35kV rated voltage require step-down transformers, which waste additional energy. MCR standby-mode losses are also lower.

SUMMARY MCRs appear to be the most reliable and economically advantageous way of gaining the power quality and reactive power compensation benefits of controllable reactors and SVCs for US electric power systems. Therefore, in March 2002, during the Power Delivery and Markets Council Meetings, EPRI members awarded Tailored Collaboration Status to MCR pilot installation in the US.

BENEFITS OF PARTICIPATION Cofunding can be used, or via EPRI's Tailored Collaboration funding process, the amount that money members need to contribute to the first demonstrations of this technology is about 50% for the overall cost of the project. EPRI will provide its own expertise for supervision of the project for members. Please call for a specific price quote.

WHO SHOULD JOIN EPRI invites every member of an EPRI Program to carefully consider the importance and advantages of this project and to contact us.

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