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State of the Art of M-SSSC Technology

The Modular Static Synchronous Series Compensator (M-SSSC) represents a new product concept for controlling and managing power networks.

The typically understood limits imposed by the fixed characteristics of traditional technologies, power electronics or otherwise, do not always directly apply to modular technologies. Most characteristics are open for change dependent on how the modules are configured or used.

Each module has an MVAr power rating (generally in 1 or 10 Mvar module), and through the combination of these devices, the combined power rating is in principle limitless. The size of the network need sets the power size of the devices deployed. This is possible because unlike many other power electronic devices a transformer is not required, nor do the devices need to be located at a single point on a circuit.

This same flexibility extends to voltage level to which the solution is applied. As the M-SSSC module is connected directly at line potential the design of the M-SSSC module does not change at all. The selection of insulators used in the platform and corona shielding system allows the same devices to be used at 33 kV as at 400 kV. The current rating of the devices is dependent on the power electronic components used in the design but again the parallel use of converters allows for the in the increase in rating of such installations.

The limitations of the technology are system dependent and can be often mitigated with a modular design approach to the overall solution rather than bulk installations. As with all large installations challenges with substation space, planning permission and resources occur. Using a modular approach of implementing smaller installations throughout the power system instead of large bulk installations reduces the burden of a fitting such an installation in one location. As the core application of the technology, power flow control (PFC), is independent of the position in a circuit, having two installations at either end of a circuit with 50% of the devices required is just as effective from a PFC perspective as one large installation with 100% of the solution. Installations can therefore be planned around other constraints such as substation space with optimum utilization of the space on a circuit rather than on a single substation. This approach can also be used in extending existing applications, as needs change the amount of M-SSSC modules in one location can be increased incrementally, decreased or transferred to a new location.

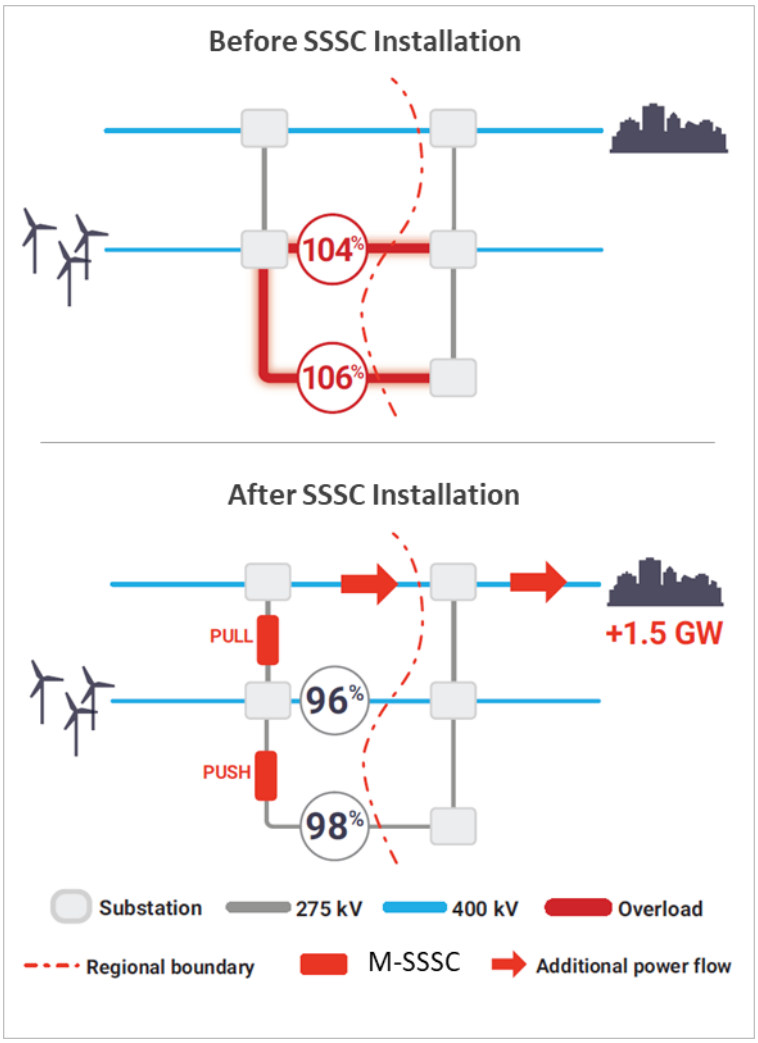

Figure 1: M-SSSC Distributed Installations

As with all inverter-based technology harmonics are a factor in selecting the size, location and function of the M-SSSC solution. There are two main approaches of managing the harmonics of this type of solution: firstly reducing harmonic impact on a device and installation level and secondly reducing harmonic impact on a system level while solving the PFC need. On a device and installation level, the M-SSSC PWM is tuned to factor the line current, operating point and existing harmonics at the point of Common Coupling (PCC). Changing the PWM scheme can change the Norton equivalent impedance of the system to change the reflection of certain harmonic orders, both to increase or decrease amplification. On a wider system approach the existing harmonics at the PCC differ site to site, selecting the optimal M-SSSC solution will depend on the local requirements. The modularity of the M-SSSC allows the impact to be reduced by distributing the installations over a system to avoid harmonic limit breaches in one location. Combining the two approaches to minimize the harmonic impact is likely to result in the best performance s rather than focusing on one method alone.

The Technology Readiness Level (TRL) of the M-SSSC technology is at TRL 9 with actual systems proven in operational environments. Areas where this technology is likely to develop are additional control modes for existing installations and incremental changes to the design to meet a broader set of requirements. As system operators become familiar with this type of active controller potential needs and improvements are identified through use of the M-SSSC technology, this can lead to new control modes and control strategies being developed for existing installations. The incremental developments for broader set of requirements include low temperature operation, higher seismic requirements and transient stability applications. The core of the technology will remain the same, a Modular Static Synchronous Series Compensator based on VSC technology capable of “pushing” and “pulling” power on circuits with a fast acting bypass for protection.

As discussed above the core technology has become a platform to build the additional control strategies upon for digitizing the gird and enabling a more active network. A wide range of EMT simulation, HIL and RTS tools are readily available for study of these devices. An area of development that is needed is a standard or specification for an M-SSSC. For other FACTs devices or series compensation devices standards exist against which to design

and test. For SSSC and M-SSSC technology there is no standard readily available. This makes the technical assure process and the testing process a high bar to clear. Type testing of equipment must be carried out to ensure it is fit for purpose and meets the requirements of the standard, without a standard available OEMs and system operators must negotiate a set of tests to carry out for each device and installation. This can lead to requirements for exotic tests as no standard directly applies in this case.

In addition to PFC other applications that the M-SSSC is used in are like that of other series compensation and FACTS solutions; transient stability, voltage stability of long lines and power oscillation damping. These applications are being studied and have already been used as part of justification for M-SSSC installations in the UK, Australia, Latin America and the USA. A final application of the technology as a mobile installation is also possible to help resolve short-term overloads during emergency scenarios or outages. This mobile application has been demonstrated in Austria already as part of technology trial.