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AN ADPTIVE TECHNIQUE TO IMPROVE LVRT IN MICROGRID SYSTEMS USING SFCL

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ABSTRACT

The challenge for networked microgrids (MGs) is to prevent rising system failure currents during low-voltage ride-through as the number of MGs on the local utility grid (UG) continues to grow. (LVRT). A super conducting active fault current restriction (SFCL) technique with three components is suggested as a solution to this problem. In order to reduce the effect of the MGs output fault current on the system fault current, 1) a novel phase angle adjustment (PAA) strategy is implemented; 2) the current injection (CI) strategy for LVRT is developed to fit the function of PAA; and 3) a novel converter current generation (CCG) strategy is developed to improve voltage support ability by taking network impedance characteristics into account. The back-to-back converter is used with the suggested SFCL technique as the communication interface between MGs and UG. The suggested SFCL technique has improved with superior LVRT performance, according to extensive tests and relevant findings, while the output fault current from the networked MGs has not increased the amplitude of the system fault current.

INTRODUCTION

Microgrids (MGs) are frequently recognized as an effective platform for combining a group of distributed generators (DGs) and loads that are located close to one another. In order to refine energy and provide ancillary services in the local distribution networks, MGs are coupled as a networked MGs system with an increasing level of integration of dispersed energy resources. Since the number and capacity of MGs have been steadily rising, the LVRT of networked MGs, which requires MGs to maintain connection with UG during voltage sags, is now more important than ever. The majority of LVRT procedures now in use are used for DGs (e.g., wind farms and photovoltaic arrays).

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Studying the LVRT of networked MGs is important since its unforeseen islanding mode will result in significant issues: 1) If networked MGs are abruptly disconnected, there will be an unnoticed reduction in UG capacity, which could render the original dispatch plan invalid; 2)

There will be significant degradation in UG voltage amplitude and frequency variations; and (3)

3) If MGs' power generation is insufficient, the essential load's power supply cannot be guaranteed; 4) When power cannot be transmitted to UG, the extra power generated by MGs will be wasted; in addition, the energy storage system may already be fully charged; 5) Reconnecting the MGs after the problem has been fixed would result in a significant inrush current and synchronization.The LVRT of MGs is essentially necessary. Yet, because MGs will also contribute fault current to the fault branch along with the UG, this LVRT auxiliary service will provide a significant difficulty of monotonically growing system fault current. Because that MGs fault current is an additional and harmful current, it is essential to lessen its effects in order to maintain the system fault current level. Otherwise, when system fault current surpasses the maximum endurance of electric equipment, the increased portion of fault current will have detrimental effects. Secondly, the injection of MGs fault current will necessitate the expensive replacement of grid components such fuses, circuit breakers, transformers, and transmission lines. Second, the increased MGs fault current will make relay protection more challenging and may potentially result in protection failure and catastrophic damage, which would threaten grid security andstability.

Finally, the high-level fault current will negatively impact equipment and person safety by increasing electromagnetic interference in the vicinity of the fault. To reduce the influence of DGs and MGs on system fault current during its LVRT, numerous research have been developed. Passive approaches are one. The more sophisticated protection tools, like inverse time admittance relays, are outfitted and improved to handle the rise in fault current. The phasor measurement unit (PMU) strategy and agent-based protection strategy are also suggested in with regard to the problem of protection communications.Fault current limiters are used to lessen the impact of DGs fault currents in order to prevent extensive modifications to protective devices and communication equipment. The other kind are active techniques. Initially, the DGs and MGs are disconnected after a UG failure occurs in accordance with IEEE Std 1547 2003 and IEEE Std 929 2000. The capacity threshold technique is then investigated to reduce the DGs output fault current while taking the size and position of the DGs into

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account.

FAULT-CURRENT LIMITERS (FCL)

Fault-current limiters using high temperature superconductors offer a solution to controlling fault-current levels on utility distribution and transmission networks. These fault- current

limiters, unlike reactors or high-impedance transformers, will limit fault currents without adding impedance to the circuit during normal operation. Development of superconducting fault- current limiters is being pursued by several utilities and electrical manufacturers around the world, and commercial equipment is expected to be available by the turn of the century.

Electric power system designers often face fault-current problems when expanding existing buses. Larger transformers result in higher fault-duty levels, forcing the replacement of existing bus work and switchgear not rated for the new fault duty. Alternatively, the existing bus can be broken and served by two or more smaller transformers. Another alternative is use of a single, large, high-impedance transformer, resulting in degraded voltage regulation for all the customers on the bus. The classic tradeoff between fault control, bus capacity, and system stiffness has persisted for decades.

Other common system changes can result in a fault control problem:

- In some areas, such as the United States, additional generation from cogenerators and independent power producers (IPPs) raises the fault duty throughout a system.
- Older but still operational equipment gradually becomes underrated through system growth; some equipment, such as transformers in underground vaults or cables, can be very expensive to replace.
- Customers request parallel services that enhance the reliability of their supply but raisethe fault duty.

The driving factors for current limiters in Japan are somewhat different from those in theUnited States, given that IPPs and cogenerators are not as prevalent in Japan. Rather, the demandfor power in Japanese metropolitan areas continues to grow because of economic growth andincreased consumer use of electricity. In addition, industrial use of computers and otherpower-quality-sensitive equipment has forced the utilities to provide higher quality and more reliablepower. The quite successful approach to improved power quality in Japan has been to increaseconnections between various power systems and to concentrate generation capacity in larger,more efficient units. Increasinginterconnectiondoes, however, increase the maximumfaultcurrent available at any point in the system, and this is rapidly leading to the need for breakerupgrades and system reconfigurations. Adding to the complexity of the situation in Japan is

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DISTRIBUTED GENERATION

Distributed generation, also called on-site generation, dispersed generation, embedded generation, decentralized generation, decentralized energy or distributed energy generates electricity from many small energy sources. Currently, industrial countries generate most of their electricity in large centralized facilities, such as fossil fuel (coal, gas powered) nuclear or hydropower plants. These plants have excellent economies of scale, but usually transmit electricity long distances and negatively affect the environment.

Most plants are built this way due to a number of economic, health & safety, logistical, environmental, geographical and geological factors. For example, coal power plants are built away from cities to prevent their heavy air pollution from affecting the populace. In addition, such plants are often built near collieries to minimize the cost of transporting coal. Hydroelectric plants are by their nature limited to operating at sites with sufficient water flow. Most power plants are often considered to be too far away for their waste heat to be used for heating buildings.

Low pollution is a crucial advantage of combined cycle plants that burn natural gas. The low pollution permits the plants to be near enough to a city to be used for district heating and cooling. Distributed generation is another approach. It reduces the amount of energy lost in transmitting electricity because the electricity is generated very near where it is used, perhaps even in thesame building. This also reduces the size and number of power lines that must be constructed. Typical distributed power sources in a Feed-in Tariff (FIT) scheme have low maintenance, low pollution and high efficiencies. In the past, these traits required dedicated operating engineersand large complex plants to reduce pollution. However, modern embedded systems can provide these traits with automated operation and renewables, such as sunlight, wind and geothermal. This reduces the size of power plant that can show a profit.

DES technologies have very different issues compared with traditional centralized power sources. For example, they are applied to the mains or the loads with voltage of 480 volts or less; and require power converters and different strategies of control and dispatch. All of these energy technologies provide a DC output which requires power electronic interfaces with the distribution power networks and its loads. In most cases the conversion is performed by using a voltage source inverter (VSI) with a possibility of pulse width modulation (PWM) that provides

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fast regulation for voltage magnitude. Power electronic interfaces introduce new control issues, but at the same time, new possibilities. For example, a system which consists of micro- generators and storage devices could be designed to operate in both an autonomous mode and connected to the power grid. One large class of problems is related to the fact that the power sources such as microturbines and fuel cell have slow response and their inertia is much less. It must be remembered that the current power systems have storage in generators' inertia, and this may result in a slight reduction in system frequency.

ACTIVE FAULT CURRENT LIMITATION METHOD FOR LVRT OF NETWORKED MGS

There are two scenarios in the case of PAA. The Fig. represents scenario 1: the voltage's phase angle difference from UG to fault branch (δUG) is larger than that from MG to fault branch (δPCC). The Fig. represents scenario 2: the δUG is smaller than δPCC. Since the principle of PAA in positive/ negative sequence is the same, the vectors and variables are not distinguished in sequences in Fig. The VUG, VF, and VPCC are the normal voltage, fault voltage at fault branch, PCC voltage during LVRT of mth MG. The phase angle of MG fault current (Im) lags the phase angle of voltage formed on network impedance (Vline) due to its inductance features. However, similar characteristics exist in both scenarios. In the case without or with PAA, the phase angle of Im is different, thus the phase angle of VPCC is different. In the case without or with PAA, the amplitude of VPCC should be equal to VUG, and the system fault current (IF) is to the same as vector summation of UG fault current (IUG) and mth MG fault current (Im). However, in case without PAA, the IF is much larger than IUG; while, in the case with PAA, the IF is equal to IUG. Thus, the contribution of MG's fault current on system fault current is relieved by the PAA strategy no matter what kind of scenarios. Based on the analyses of Fig, the key of PAA is to calculate and determine the feasible phase angle of mth MG fault current (Im). During voltage and current sampling, the phase angle of Im and IUG is referenced to the phase angle of VPCC and VUG. Considering the long line distances from MGs to UG, there is a non- negligible angle between VPCC and VUG. However, the phase angles of VPCC and VUG are simply assumed to be the same in the existing method. To improve the mitigation ability of MG fault current, we propose a novel PAA strategy by considering voltage's phase angle differences from UG to fault branch (δUG) and from MGs to fault branch (δPCC).

PROPOSED SYSTEM

For a power delivery system with distributed generation (DG) units,

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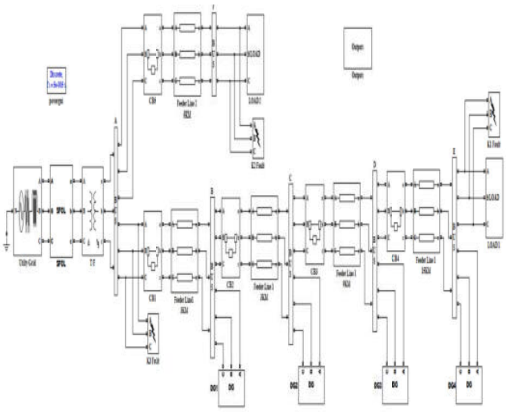
its failure current and

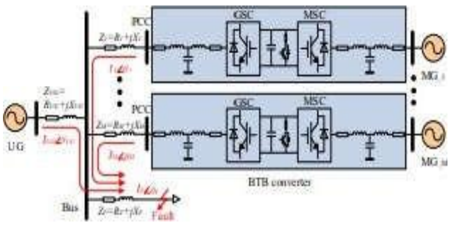
caused overvoltage under anomalous circumstances should be taken into account carefully.

Taking into account the use of a superconducting fault controller (SFCL) may be a viable

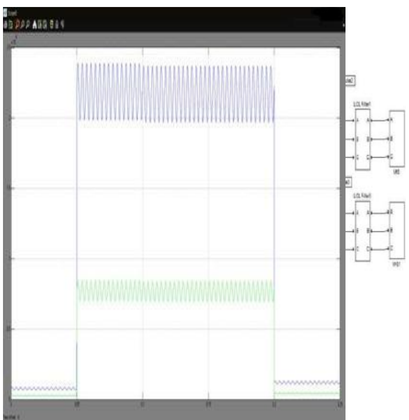
answer, in this article, the impacts of a voltage correction type active SFCL on them are studied



\sthrough theoretical reasoning and



modelling. An air-core superconducting inductor and a PWM converter make up the active SFCL. By changing the converter's output current, the magnetic field in the air-core can be controlled. Next, the corresponding resistance of the



active SFCL can be controlled for current restriction and potential overvoltage reduction.

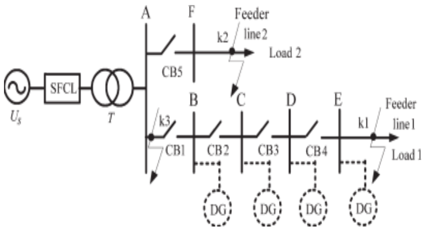


Fig.1.StructureofnetworkedMGs andthecorrespondingfaultcurrentflow,Application of theactive SFCL in a distribution system with DG units.

SIMULATION RESULTS

Fig 2Existing simulation circuit

Fig 3 proposed simulation circuit

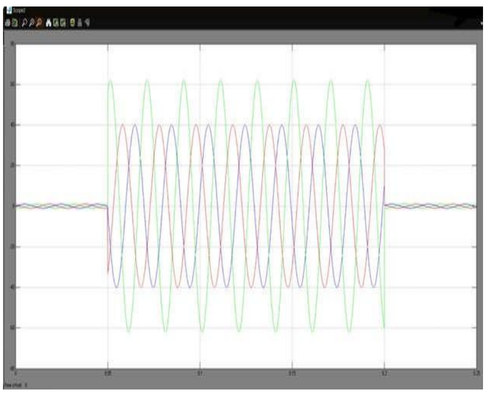


Fig 4. Fault currents in mg

Fig 5. Mg active and reactive powers

CONCLUSION

Under the UG fault condition, in view of the high-level system fault current during the LVRT of networked MGs, an SFCL method is proposed to avoid monotonically increasing system fault currents during the LVRT of networked MGs. In this method, in order to improve the voltage control ability of LVRT, the CCG strategy is proposed by embedding the network impedance characteristics. Then, in order to achieve a better fault current limitation by relieving the impact of MGs fault current, the PAA strategy is proposed with considering voltage's phase angle difference from UG and MGs to fault branch. Meanwhile, the CI strategy is conducted to fit the feature of PAA. Numerous simulation results have validated the improvements of the proposed SFCL method with a successful LVRT, meanwhile, the networked MGs fault current does not increase the system fault current amplitude. Considering the fields with a high proportion of sensitive load, the BTB converter is widely used for the PCC connection point of DGs and MGs

to provide high power quality. To reduce the fault current level, the SFCL method can be applied to the BTB converter, and can be also used to the other inverter products, such as wind and photovoltaic inverter, AC/DC microgrids, and HVDC transmission system.

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