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Fault Current Reduction and Control in Transmission and Distribution Lines Using Transformer Type SFCL

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Abstract: - Distributed generations are the renewable energy sources used to increase power generation when increasing in power consumption. These are located close to consumer in a micro grid. Interconnection of distributed generation to the grid make problems like excessive increase in fault current due to the abnormal operation, circuit breaker cannot work properly. This leads to situations where the circuit breaker needs to be modified according to each grid developments. Superconducting fault current limiters are the most suitable methods used to eliminate grid fault current and abnormal operation. It eliminates the fault current at the beginning and improves power quality. There are different types of SFCLs. We can change the fault current to the desired level using transformer type SFCL with two non-isolated secondary windings. This paper describes reduction in the fault current by placing the ideal position for SFCL in the micro grid. This model is simulated on MATLAB. In this model, the fault current created by artificial fault blocks in distribution and consumer grid and a wind farm used as distribution generation

Key Words— Distributed generation, Superconducting fault current limiters (SFCL), micro grid, transformer type SFCL, wind farm.

I. INTRODUCTION

The power generation needs to be increased as the power consumption increases. In The micro grid distributed generation used for extra power generation. There are some problems created in grid when using the distributed generation. it includes Excessive increase in fault current, Increases voltage sag, Power quality problems and Reduces transient stability. There are conventional methods for fault current limitation. It includes 1 upgrade substation: which will correct immediate problems. But this is the most expensive from all the conventional solutions, 2 bus splitting: this effectively reduces the number of sources that can feed a fault. But it also reduces the number of sources that supply load current during normal or contingency operating conditions, 3multiple circuit breaker upgrade: it is expensive, 4 current limiting reactors and high impedance transformers: it have a voltage drop under normal loading conditions and present a constant source of losses and 5 sequential breaker tripping: it has a disadvantage of the sequential tripping scheme is that it adds a delay of one breaker operation before final fault clearing.[3] The SFCL stands apart from the traditional methods mentioned above. Normally SFCL is in zero electric resistance. Therefore, it does not cause any loss in voltage and it maintains power quality and power stability. As the fault current rises SFCL quickly changes its high resistive state and eliminates the fault current quickly. Resistive type SFCL is the simplest form. It works with a single critical current level [1]. In the case of transformer type SFCL, it can change the current limiting value by tap change in secondary side. Therefore, the fault Current limiting value can be changed according to the variations in current caused by the position using the transformer type SFCL [2]. However, the best place to use SFCL can be determined by a transient test. Transformer type SFCL in its optimum position gives good efficiency

II. SIMULATION SET UP

The simpowersystems toolbox in MATLAB/simulation software is used for simulation works. This paper needs model of power system with an integrated wind farm and SFCLs. graphics tools, versatile analysis and open architecture are available in MATLAB. Here we can use model of resistive type SFCL as a super conducting material model for transformer type SFCL.

A. SFCL models:

Here the transformer SFCL with two non-isolated secondary windings is used as fault current limiter. It is capable to control fault current level. It includes two superconducting elements so it has two quench events. The secondary side of the transformer winding is two non-isolated windings with superconducting element. We can change the ratio between two non-isolated windings by changing the tap here. The ratio between two non-isolated secondary windings can controls the fault current limiting value. A small Transformer with 60 primary turns in winding and 45 + 15 turns in secondary side is used here. The Fig.1 is the MATLAB model of transformer SFCL with two non-isolated secondary windings [2].

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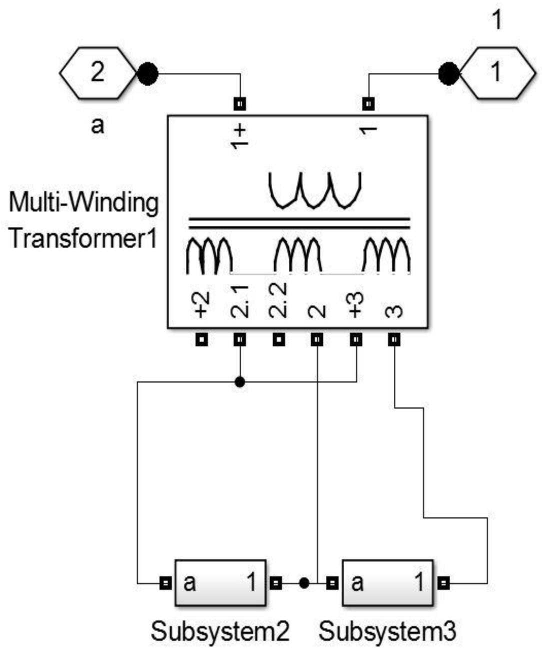

Fig.1. MATLAB model of transformer type SFCL with two non-isolated secondary windings

Here 2, 2.1 & 2.2 are indicating taps in the secondary side of the transformer. The secondary send windings maybe in additive polarity or subtractive polarity. The quench events depend on the direction and ratio between the two secondary winding. The subtractive polarity winding gives quick response when fault occurs.

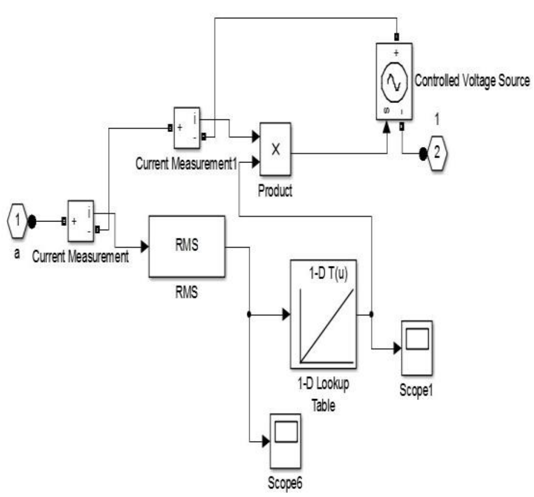

Fig.2. MATLAB model of resistive type SFCL

Fig.2. shows the MATLAB model of single phase resistive type SFCL. This model act as a super conducting materiel for transformer type SFCL shown in Fig.1.

A comparison of fault current limiting levels of a transformer type SFCL is given in the Fig.3. The limiting level of resistive type SFCL is also included in it.

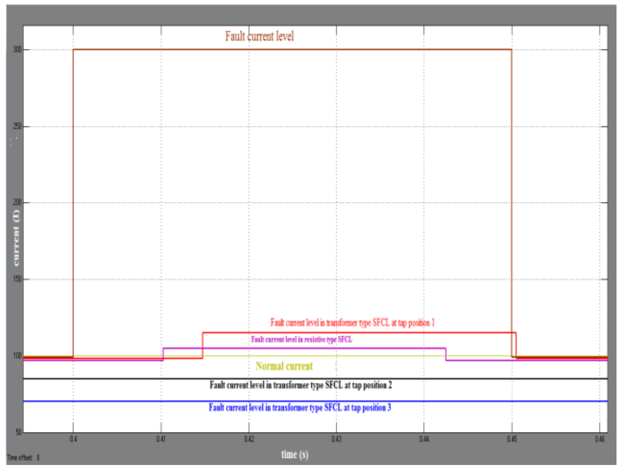

Fig.3. fault current limiting levels

From this Fig.3, it is clear that the transformer type SFCL capable for change in the fault current limiting value. The current levels indicated by black and blue lines are below the normal current level because of the fault current limiting value limited to less than normal current by tap changing.

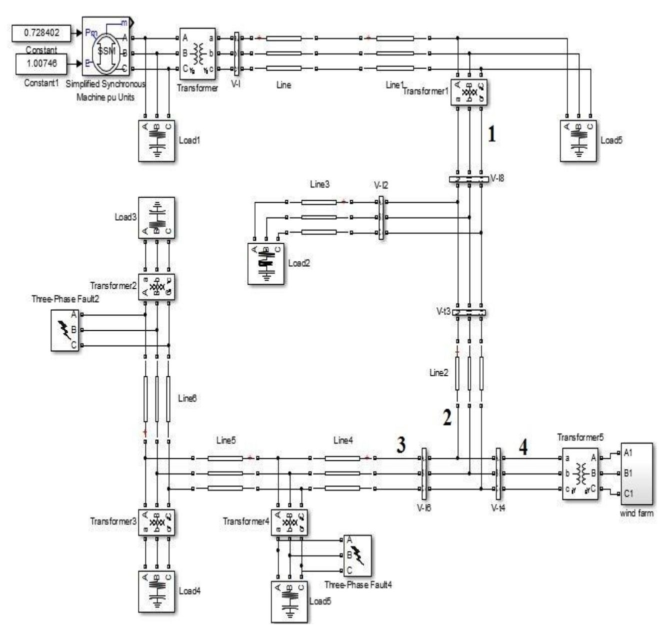

Fig.4. Power system model

In this Fig.4. shows a power system model for the test. It includes a synchronous generator as a generating station with a step-up transformer and a wind farm as distributed generation. To generate fault current, two artificial fault current blocks are placed. It includes a step-down transformer with an output of 22 kV as a substation. The wind farm is connected via a transformer that provides 22-volt output. The fault blocks are connected in the distribution grid and consumer grid. This power system includes industrial load of 6 MW and a domestic load of 3 MW. It also has transformers that supply 400V per domestic load [3]. In some places in the power grid SFCL do not work properly so we need to find the most suitable place and connect them there. By integrating in the right places has many advantages and we need to remove them from the wrong place because it became expensive. The exact location of these connections can be determined by a transient analysis with and without SFCL. This test is performed on a power grid model as shown in the Fig.4.

There are four selected locations for placing SFCL in the grid to perform the transient analysis. The selected positions are Location 1 in Substation, Location 2 in Branch Network, Location 3 in Wind farm integration point with the grid and combined Location 1& 4 (in Wind Farm) represented as 1,2,3and 4 in the figure xxx. First, perform a transient analysis in each of these locations with or without SFCL. From its result we can find a suitable place for placing SFCL. The percentage reduction of fault current in distribution and consumer grids using resistive type SFCL during this test is shown in the table 1.

Table 1. Percentage reduction of fault current

SFCL Position	% Change in wind farm fault current (fault at customer grid)
At location 1	59% Increased
At location 2	31% Increased
At location 3	30% Decreased
At location 1 & 4	7% Decreased

From this table we can understand that SFCLs in location 1and 2 are increase the fault current. Location 3 and 4 reduce the fault current but percentage limiting value of the fault current in location 4 is less than location 3. Therefore, location 3 can be selected as the optimal location. The graphical representation of percentage of fault current reduction is shown in Fig.5.

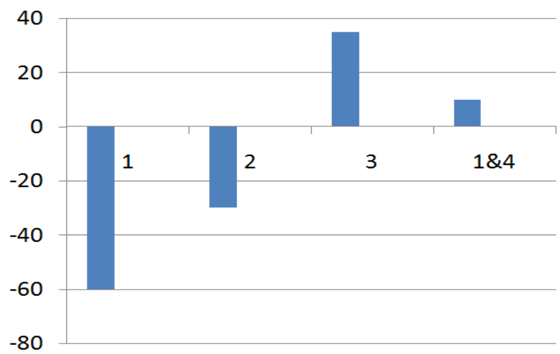

Fig.5. comparison of fault current reduction with position

Feasible location for this Power Grid is the integrating point of two generating stations. It is Mark as location 3 in Fig.4. After that install Transformer type SFCL in location 3 and check it's working. By installing this SFCL we can improve percentage reduction in fault current using its tap position.

III. RESULTS AND DISCUSSION

To get the reduction in fault current with control, we need to install the Transformer type SFCL in location 3 and check results by changing its tap positions in secondary. For this the current wave forms in distribution and consumer gird without SFCL is shown in Fig.6. and Fig.7. respectively.

Fig.6. Fault current in distribution line without SFCL

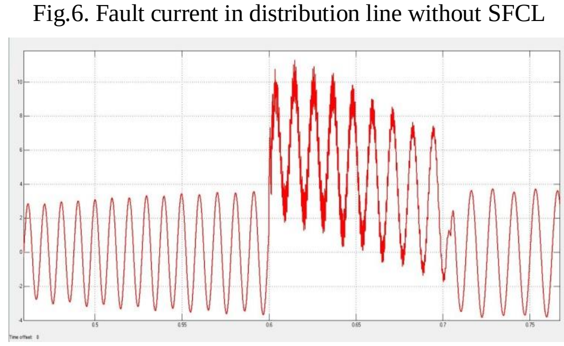

Fig.7. Fault current in consumer grid without SFCL

Fig.6. and Fig.7. gives fault current levels without SFCL. It shows the maximum fault current level is up to 30 A in distribution lines. The fault current reduction after placing Transformer type SFCL in position 3 is shown below. The blue and red colored wave forms shown in this output indicates currents through consumer and distribution lines respectively.

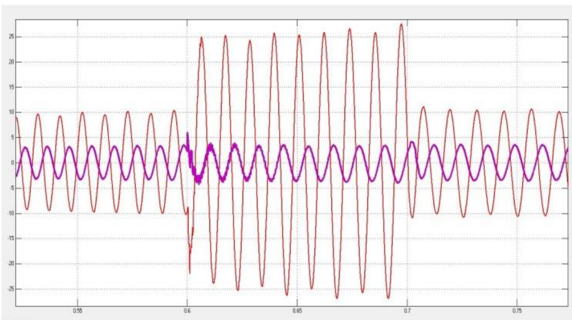

Fig.8.Fault currents with transformer type SFCL in first tap position

Fig.8. gives reduced fault current level by Transformer type SFCL with its first tap position in the secondary. It is clear from this fig 8 that the fault current reduced to 25 A from 30A

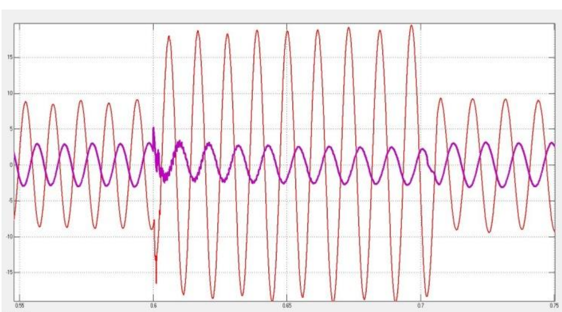

Fig.9. Fault currents with transformer type SFCL in second tap position

The fig.9. shows fault current reduction when Tap connected to second position of the transformer type SFCL. Then the fault current reduced to 15A from 25A.

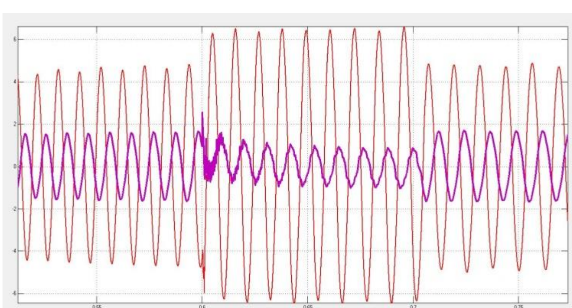

Fig.10. Fault currents with transformer type SFCL in third tap position

The fig.10. shows fault current reduction when Tap connected to third position of the transformer type SFCL. Then the fault current reduced to 6A from 15A. From these we can see that we can easily change the fault current to the desired level using transformer type SFCL.

IV. CONCLUSION

Superconducting fault current limiter is the device use to limit fault current in the best way on a smart grid. Integrating point of two generating stations (location 3) has been found to be the optimum location for integrating SFCL to reduce the fault current in the consumer grid and distribution line. Using the tap changes in the transformer type SFCL with two non-isolated windings, it is possible to reduce the fault current level as we want. It can be used as a solution to problems caused by fault current changes due to smart grid development. There is no need to replace circuit breakers during increase in grid current. Transformer type SFCLs in optimum location will give control with protection from fault current.

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