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"IMPROVEMENT OF DISTANCE PROTECTION IN TCSC COMPENSATED TRANSMISSION LINE CONNECTED WITH DFIG FARM"

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ABSTRACT

The basic operation principle of distance relay is based on the fact that the line impedance is fairly constant with respect to the line. The distance protection operated based on the measured impedance at the remain point. Their several factors affecting the majored impedance at the relaying point in the case of cause or other zones. This factors related to power system parameters prior to the fault instant. In first zone, the first group is the structural condition of the line represented at the transmission line end by the short circuit. The second group is the prefault operation condition by the line load angle and the voltage magnitude angle at line ends. In case of second zone to lines are present the measured impedance evaluation. TCSC (Thyristor Controlled Series Capacitor) has been applied increasingly to control power through a network, limit short circuit current, cancel sub synchronous resonance, damp out power oscillations and improve transient stability. Presence of TCSC problem arises because of variable reactance eject to network modulation in current. Function of MOV (Metal Oxide Varistors) is protecting device. The control action in TCSC leads to a symmetric structure which produce sequence number. TCSC (Thyristor Controlled Series Capacitor) produce complicated impedance which negatively affects distance protection relay. TCSC using for long transmission line for improving power transfer capability. Facts controller in power system in transmission line enhance the power system control ability and stability introduce power system issues in the field of power system protection. Rapid changes in line impedance and transient give's fault associate with control action of facts controller, facts devices in the faulted loop gives changes to the line parameter by distance relay. For unbalance fault in line the TCSC modulated fundamental components of voltage and current and directional relaying algorithm based on sequence components. Operation of TCSC in capacitive mode, voltage and current inversion problem arises leads to challenge. The wind energy generation system produces additional complexity the distance protection performance due to the variation of wind speed and fault current level. Starting from fault detection, until relay tripping decision producer including online estimation for preliminary fault location, impedance of TCSC and fault resistance. The achieve results ensured that the proposed scheme improves significantly Mho distance relay operation and avoids under-reaching and over-reaching problem. Large shunt capacitance along the transmission line, and also without identifying the parameters of TCSC such as the capacitance, the inductance or the firing angle.

Keyword: Double Fed Induction Generator (DFIG), MHO Relay, Thyristor Controlled Series Capacitor (TCSC), Transmission Lines.

1.1 INTRODUCTION

All global energy systems are being challenged by the rise in electrical power consumption, which calls for the development of additional generation facilities as well as improved transmission and distribution infrastructure. Because of the environment, wind energy is regarded as one of the best sources of energy. However, the performance of distance protection is negatively impacted by the level of wind energy systems penetration in gearbox systems.Voltage level variations at local buses are caused by changes in wind speed. The distance relay tripping boundaries will be considerably impacted by changes in impedance seen by the relay. Crowbar resistance creates variations in fault current for double fed induction generators (DFIG), which are frequently utilised for wind energy around the globe. These variations have an impact on reach problems in distance protection. With increasing transmitted electrical power, the combination of rotor winding resistance and crowbar resistance affect 3-phase faults in the high impedance faults, which are considered a real challenge for distance relay for sensing. Flexible Alternating Current Transmission Systems (FACTS) are used to improve control of network conditions quickly from series and shunt compensation.

The active power transmission capacity is increased and the line reactance is decreased by the series capacitor. TCSC is a popular type of FACTS device that is more affordable than other FACTS devices since it does not require a high voltage transformer, like interface equipment.

When it comes to resolving issues with power system operation, such as the suppression of active power oscillations, the elimination of sub-synchronous oscillations, and voltage support, TCSC must be reliable. As a result, it first selected the world using various FACTS procedures. Shunt compensation devices, such as static synchronous compensators and static var compensators, on the other hand, act as controllable current sources by injecting reactive current in the line to maintain constant voltage values, enhance system power factors, and increase stability.

The benefits of TCSC include boosting system stability, decreasing system loss, improving voltage profile of line, and changing impedance, which has a significant impact on impedance measured by distance relay and leads to improper operation of conventional distance protection. On the other hand, MOV is not active for high impedance faults, resulting in distance relay creating impedance values smaller than the real, giving results relay overreaching. For high fault currents, the metal-oxide varistor (MOV) acting then TCSC operates in bypass mode, the impedance create distance relay increases, causing relay under-reaching. There are several techniques for using adaptive distance protection settings to safeguard MOV series compensated transmission lines (TLs) mentioned in the literature. The methods rely on impedance calculations of the compensator during faults based on a set capacitance value and measure fault current flowing through the circuit, the compensator being positioned at one end or both ends. By calculating the voltage drop across the series compensator based on a set series capacitor, further research investigations improved distance protection when the compensator was placed in the middle of the line. Such approaches don't take that into account. impacts of wind farms as well as the automatic adjustments of compensation percentages for distance protection. In reality, a number of research studies have looked into how TCSC affects distance protection, albeit few of these studies have really offered improved distance protection for TCSC compensated lines. As an illustration, the suggested approach determines the TCSC's dynamic impedance during faults based on capacitance and inductance impedance, with the TCSC positioned at one end. A plan based on artificial intelligence is used to predict the voltage drop across the TCSC and subtract it from the voltage measured at distant relays in order to cancel out the influence of the TCSC. This technique is employed for transmission lines with a medium length. having a maximum fault resistance of 20. The method is tested for medium-length transmission lines with fault resistance no greater than 10 when taking into account factors. The penetration of wind energy systems for protected transmission lines was not taken into account by the previously mentioned methodologies. Combining differential and distance protection on a gearbox line connected to a wind energy system can improve distance protection performance. The fault resistance is calculated using a method that uses active power calculations for both ends of the line before estimating the fault site. With the exception of long transmission lines, it ignores the line resistance with respect to fault resistance, which reduces its fundamental drawback. Enhancing the coverage of zone 2 of the distance relay for transmission lines linking with the proposed and tested double fed induction generators (DFIG) It is wise to not research how these enhancements may affect compensated Transmission lines. Provide adjustable distance protection settings based on synchronised voltage and current measurements at the local and remote ends for series compensated transmission lines connecting with wind power. The key disadvantage is that, prior to that, the compensator's voltage across it and current through it are measured to continually estimate its impedance while a defect existAdditionally, there is no research on how ground fault resistance influences the performance of the proposed adaptive distance relay setting. Regarding another protection strategy for gearbox lines, differential protection. The performance of differential protection is negatively impacted by the bad source of the wind farm, which specifically occurs a few cycles after fault detection. Additionally, there is a constant requirement for long-distance sharing of real-time measured data between local and remote relays. Authors believe that there is still a lot of potential to build effective distance protection techniques for compensated Transmission lines with TCSC and connect to wind energy systems based on all of the aforementioned studies. This article provides a distance protection method appropriate for TLs linked to wind farms that have received TCSC compensation. the firing angle, capacitance, and inductance of the TCSC without identifying its impedance and fault resistance. Only the voltage measurement at the right side of the TCSC is necessary for the scheme distance protection. In addition to the distance relay's local current and voltage measurements at each end of the line. In contrast to the introduced system, the proposed method does not require current and voltage monitoring devices at the left side of the TCSC. improving wind farm, TCSC model, and long transmission line distance protection. Implementation involves communication.

1.2 Transmission line parameters

Figure illustrates the two sources Transmission lines system, which consists of:

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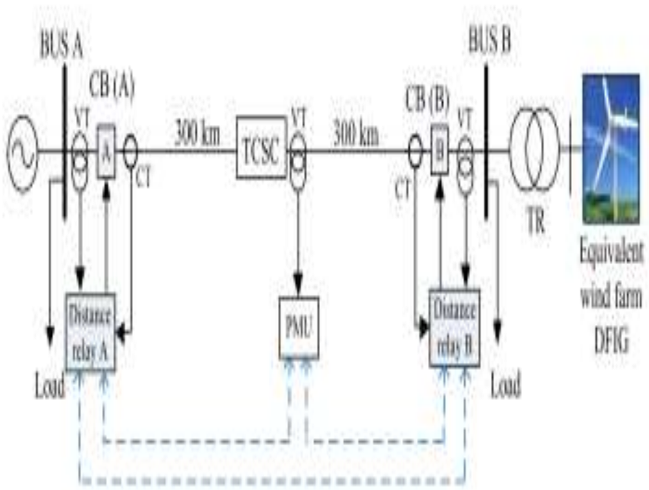
• 600 km long transmission lines with a 345 kV rated voltage and a 50 Hz frequency.

• At bus A, an infinite bus source is represented.

• At bus B, a source from a wind farm is present.

• Bus A and B are connected to electrical loads including transformers and double-fed induction motors with ratings of 390MW and 200Mvar.

• The protected Transmission line is connected to the TCSC in the middle.



A. TCSCs

Inductors and capacitors are examples of continuous elements, while power electronic switches are examples of discrete elements.

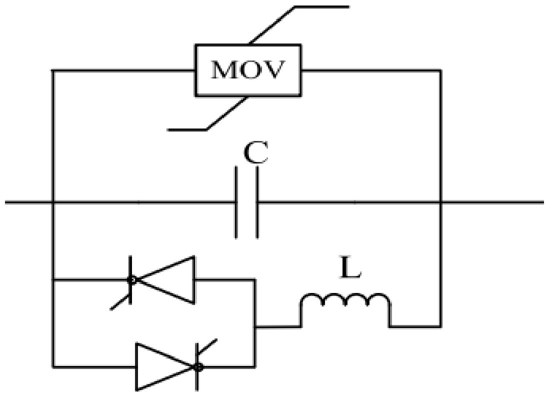


Fig. 1.2 A (b): TCSC Model

The quasi-static and phasor dynamic models are the two primary models used by TCSC. a quasi-static model used in transient and oscillatory stability research. This model's fundamental frequency reactance, whose value depends on the firing angle, makes it unsuitable for sub-synchronous resonances and inaccurate. The dynamics of higher order harmonics must be taken into account in order to increase the accuracy of the phasor dynamic model, which is thought of as being halfway between a time-domain circuit and a sinusoidal steady-state approximation representation of a quasi-static model. In MATLAB/Simulink, the TCSC time domain circuit model is used. The MATLAB TCSC model was enhanced in a straightforward manner and offers good accuracy under operational conditions. Transmission line TCSC is set to a 40% line compensation level.

B. Wind Farm

The wind farm, which is situated at bus B and has 150 1.5 MW DFIG turbines. The DFIG's parameters were established in accordance with the MATLAB/Simulink library.

Wind Farm	150 wind turbines ×1.5 MW,50 Hz
DFIG of each wind turbine	Rotor resistance = 0.016 p.u. Rotor inductance = 0.16 p.u. Stator resistance = 0.023 p.u. Stator inductance = 0.18 p.u. Magnetizing inductance = 2.9 p.u. Inertia constant = 0.685 s, Friction factor = 0.01 p.u. Pairs of poles = 3

Table 1.2 B: Parameters of Wind farm

To achieve good dynamic performance, the stator is connected to the grid directly, while the rotor is connected to the grid through a bi-directional voltage source converter (VSC). The intricate Matlab Specialised Power Systems model. To accurately simulate VSC-based energy conversion systems connected to power grids, use renewable energy systems. IGBT converters (insulated-gate bipolar transistors) are utilised to get a good accuracy with switching frequencies. The model is discretized at 5 microseconds, which is a small step time ideal for evaluating the dynamic behaviour of the control system across only brief time intervals. The model's dynamic and steady-state performance was utilised to validate its resilience when watching how the turbine responded to changes in wind speed and the effects of voltage sag brought on by remote faults.

➢ Stages

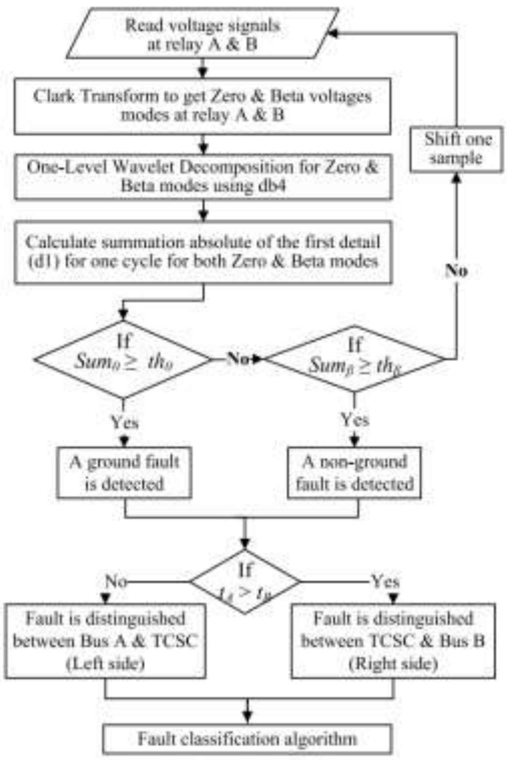
i. It will first identify the issue before differentiating between faults that occur in front of or behind the TCSC.
ii. Sort the defect categories.
iii. Computing all the parameters, including fault resistance, TCSC impedance, and online fault localization.
iv. The MHO distance relay's settings are now complete.

❖ Fault Detection Process:

We can also distribute and find faults by using a flow chart. Only a single level descript wavelet is used as the mother wavelet for fourth order Daubechies (db4). To gather enough fault transient data, the Clark converts voltage signals at relays A and B with a 200 kHz sample frequency. In order to extract the absolute sum for the zero (0) and beta () modes for the first (d1) cycle moving window, the transient travelling waves between 50 and 100 kHz are extracted (sample by sample). The number of sample cycle orders in a sliding window that covers a full power cycle (20 ms) is represented by the number n in the formula, which is used to calculate the absolute sum at k.

$$Sum0(k) = \sum_{n=k-N+1}^{k} \left| d1_{V0(n)} \right|$$

$$Sum\beta(k) = \sum_{n=k-N+1}^{k} \left| d1_{V\beta(n)} \right|$$



Flowchart 1.2 (c): Fault detection algorithm

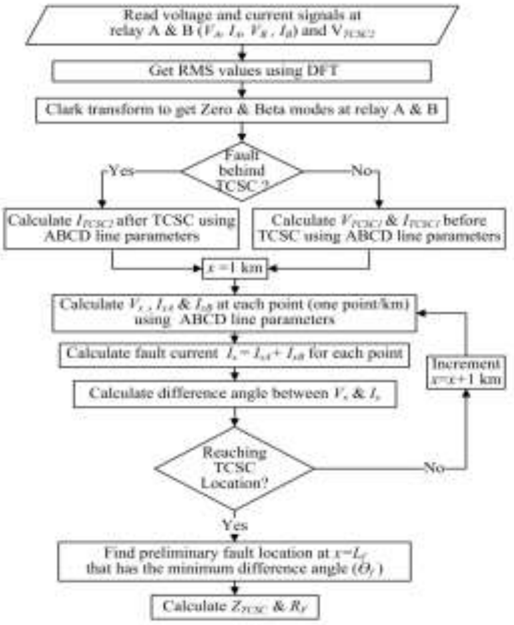
When a problem is detected, the threshold numbers th0 and th (which stand for zero and beta mode threshold, respectively), are exceeded by either Sum0, Sum, or both. Additionally, a fault is identified as a ground fault when Sum0 exceeds the threshold th0. By contrasting the fault detection times for both relays A and B (tA and tB, respectively), fault detection can be distinguished as occurring either in advance of or behind the TCSC. To give a reference time for comparing the two predicted times, time synchronisation is necessary. If tA is greater than tB, the fault is distinguished between the TCSC and bus B (in front of the TCSC), otherwise it is distinguished to be behind the TCSC (between bus A and the TCSC). The TCSC is placed in the middle of the protected Transmission line.

❖ Fault Classification:

Local voltages and currents at relays A and B before and after the fault's onset are compared using the discrete Fourier transform (DFT) to classify the fault. It depends on whether the voltage drops off during defective phases and the current increases during certain phases. The implemented algorithm minimises computational load without depending on a threshold value.

❖ Online Fault Location:

A fault location algorithm based on the ABCD parameters and phase sequences of transmission lines. In this instance, the TCSC compensated TL connected to the wind farms is implemented using this manner. The applied methodology is explained by simulating a malfunction behind the TCSC as illustrated in Fig.



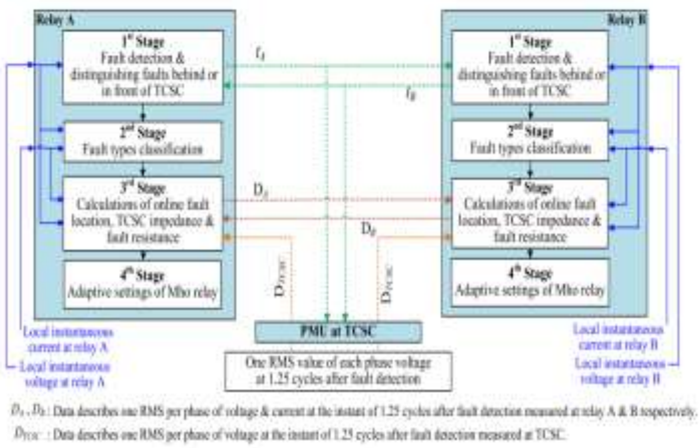
Flowchart 1.2 (d): Online fault location

❖ Setting of MHO Distance relay:

MHO relay is a widely used long-distance relay because it has a low cost and simple comparator implementation feature. For transmission line protection, the first zone setting is 80%, while the second zone setting is 120%. Due to the impact of TCSC, wind farms, and fault resistance, the traditional distance relay is unable to operate in the proper fault zone. To address this malfunction, an adaptive MHO distance relay configuration can be made. It bases its zone circle shifting on a calculation of fault and TCSC impedance.

❖ Implementation of the Proposed mho distance relay:

Each distance relay A and B uses its local voltage measurement to identify faults in the first stage. By comparing the fault detection times, each relay transmits its fault detection time to the other relay for fault detection that occurs behind or after the TCSC. Each relay then sends the detection time to the phase management unit (PMU), which is located at TCSC. Using its own local current and voltage measurements, each relay, A or B, will classify the fault type in the second stage without transmitting any data. The estimated RMS value for each phase of the observed voltage and current at the instant 1.25 cycles after fault detection is sent by each relay to the other relay in the third stage. Following TCSC, PMU will send one RMS value for each phase of the measured voltage.



Block 1.2 (e): Diagram implementation of purposed scheme relay A and B

➢ Conclusion

This paper has proposed a scheme for changing adaptively the settings of the Mho distance protection by shifting the relay characteristics. Distance relay operation includes fault detection, classification, and updating characteristics zones for relay tripping decision. As one time value is transferred in one stage, limited RMS values, rather than instantaneous values, are transferred in another stage, and the remaining stages are dependent on local measurements, the proposed relay only requires a minimal amount of communication. When a defect occurs close to the first zone's end and close to the buses, the accurate functioning of the scheme appears in distinct situations. It can be utilised to upgrade, enhance, or renew the current MHO distance relay.

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