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New Approach for Precisely Measuring the Zero Sequence Parameters of EHV/UHV Transmission Lines

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Abstract--- A new method of measuring the zero sequence parameters of double-circuit EHV/UHV transmission lines with mutual inductance based on distribution parameter Model transmission line equations and distributed parameter model, a new approach is proposed to accurately measure the zero sequence parameters of long-distance double-circuit transmission lines using voltages and currents measured at the ends of lines. The mathematical model of the proposed method is explained in detail, the differential equations of two coupled lines with different self-parameters were solved for the first time with Laplace transform to get all the zero sequence parameters. And this approach is easy to implement since the measurement process is simple.

I. INTRODUCTION

The Ultra-high-voltage AC power transmission has outstanding advantages of high transmission capacity, long distance of power transmission, low line loss, small coverage, etc., which is an energy-saving and eco-friendly advanced power transmission technology. At present, China has three 1000 kV AC UHV projects completed in operation in total. As construction of UHV lines is underway, it is inevitable that power transmission lines in other voltage classes may parallel or cross with UHV lines in construction due to space limitation of power transmission corridor. While high-voltage lines are running, electromagnetic fields may arise in space surrounding the lines. As a result, induced voltage and current may arise in nearby low-voltage lines, triggering potential safety threats in low-voltage line shutdown overhaul. As UHV lines have high running voltage and transmission power, it is more necessary to focus on their induced power on low-voltage lines. Domestic and foreign studies on UHV AC power transmission line induction are more concerned with parallel construction. In Literature, computation and field measurement are made on induced voltage and current in 500kV one-tower two-circuit parallel line; in Literature, simulated computation and analysis are made on induced voltage and current in two-circuit UHV line with one line in power and one line in shutdown and 1000kV UHV and 500 kV/220 kV lines parallel with each other on the same tower respectively; in Literature, computation is made on induction of UHV AC power transmission lines on low-voltage power distribution lines below. Concerning line crossing, in Literature, methods of computation of power-frequency electromagnetic fields in crossing areas of AC power transmission lines are introduced; in Literature, theoretical computation is made on electrostatic induction of crossing and elongating conductors below 500 kV power transmission line.

Few systematic domestic and foreign studies are concerning power transmission line crossing induction. The field measurement is made of induced voltage and current of 110 kV crossing lines below UHV line simulated model is set up by CDEGS software to compute and analyze fluctuations in induced voltage and current of 110 kV lines under different transmission currents of UHV line, different crossing distances and crossing angles between UHV and

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110 kV lines, precautions in shutdown overhaul of low-voltage lines under UHV line are presented, and reference basis is offered for layout design of crossing lines.

II. LITERATURE SURVEY

Zhijian Hu et al (2015) presented the traditional measurement methods of capacitance parameters of coupled transmission lines bring large measurement errors under strong electromagnetic and the interference environment. To solve this problem, new anti-interference measurement methods based on the harmonic components are proposed. First, the voltages and currents at both the head end and the tail end of the transmission line are sampled synchronously based on global positioning system technology, then acquire the third harmonic components from the measured data with an interpolation algorithm, and substitute them to the calculation formulae, so the power frequency interference signals are filtered as noise and the capacitance parameters can be accurately measured. The wiring diagram of line parameter measurement and the hardware structure of the measuring system based on are given. The simulation results with and an example of measuring two coupled transmission lines are given. The comparison of measurement results between the proposed methods and the traditional methods is also shown. The parameters of the transmission lines are fundamental data for power flow calculation, power loss calculation, short circuit calculation, failure analysis and setting calculation of protective relays in power systems. Without accurate parameters, the accuracy of these calculation results cannot be guaranteed and may cause operation of the protective relays and other automation devices. Therefore, the accuracy of the transmission line parameters is very important for power systems. With the rapid development of power systems in recent years, the number of coupled transmission lines is increasing because of the crowded line corridors and high construction costs of the line towers, making the electromagnetic interference between the lines getting serious. It brings large negative influence on the measurement accuracy of the transmission line parameters. Up to the present, researchers have done a lot of work on the calculation and measurement of transmission line parameters. The main methods of obtaining the transmission line parameters include theoretical calculation and field measurement. The theoretical calculation methods are not accurate enough because the earth resistivity changes with the geographical conditions under the transmission lines, and they ignore the influence of climate and electromagnetic environment on the parameters, especially on the zero sequence parameters.

III. PROPOSED APPROACH

The complexity of electromagnetic coupling of extra high voltage (EHV) triple-circuit transmission lines brings a great challenge to precisely measure their zero sequence parameters. This paper summarized the methods proposed in the published literature and pointed out their advantages and deficiencies. With respects of previous researchers, a new method for precisely measuring the zero sequence parameters of EHV triple-circuit transmission lines was put forward based on two-end synchronous measurement. The long-distance EHV triple-circuit transmission model was built based on distributed parameter model. The calculation formulae of zero sequence parameters were deduced using the two-end synchronous data. The connection modes were given as well as the measurement procedure. The proposed method was simulated by mat lab and the results show the traditional method is inaccurate and the improved traditional method can improve the measurement precision of short-distance line parameters, but it will lead to huge errors if applied to 200 km or above transmission lines. While the proposed method can greatly increase the measurement accuracy and efficiency which is capable of meeting the requirement of field measurement.

3.1. Proposed Block Diagram

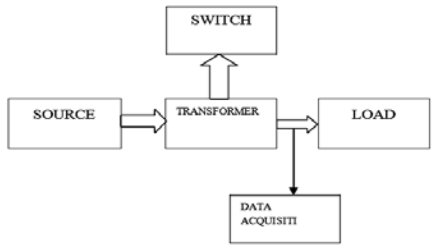

Fig. 3.1: Proposed Block Diagram

3.2. Transmission Line

For bulk power transmission over land, the most frequent transmission medium used is the overhead line. This overhead line is normally bipolar, i.e. two conductors with different polarity. HVDC cables are normally used for submarine transmission. The most common types of cables are the solid and the oil-filled ones. The solid type is in many cases the most economic one. Its insulation consists of paper tapes impregnated with high viscosity oil. No length limitation exists for this type and designs are today available for depths of about 1000 m. The self – contained oil-filled cable is completely filled with low viscosity oil and always works under pressure. The maximum length for this cable type seems to be around 60 km. The development of new power cable technologies has accelerated in recent years and today a new HVDC cable is available for HVDC underground or submarine power transmissions. This new HVDC cable is made of extruded polyethylene and is used in VSC based HVDC systems.

3.3. Classification of Transmission Line

3.3.1. Short Transmission Line

When the length of an overhead transmission line is up to about 50 Km and the line voltage is comparatively low it is usually considered as a short transmission line. Due to a smaller length and lower voltage, the capacitance effects are small and hence can be neglected. Therefore, while studying the performance of a short transmission line, only resistance and inductance of the line are taken into account.

3.3.2. Medium Transmission Line

When the length of an overhead transmission line is about 50-150 Km and the line voltage is moderately high it is considered as a medium transmission line. Due to sufficient length and voltage of the line, the capacitance effects are taken into account. For purpose of calculations, the distributed capacitance of the line is divided and lumped in the form of condensers shunted across the line at one or more points.

3.3.3. Long Transmission Line

When the length of an overhead transmission line is more than 150 Km and line voltage is very high (.100 KV), it is considered as a long transmission line. For the treatment of such a line, the line constants are considered uniformly distributed over the whole length of the line and rigorous methods are employed for a solution.

3.4. Ultra High Voltage Transmission

The global energy consumption steadily growing, but energy is increasingly being drawn from resources located far from the place of usage. The topic of transporting energy over long distances is growing in importance. Oil is often shipped in super-tankers and gas in pipelines. Coal for electricity production uses rail transportation, a solution that can require the costly reinforcement of tracks. It may be more economical to generate the electricity close to the source of the coal and transmit it to the consumers. As many renewable energy sources such as hydropower, wind, and sun, are location-dependent in their production, there is often no alternative to long-distance transmission. The transmission of electrical energy is thus set to play an important and growing role.

3.5. Alternative Scenarios for Long Distance Bulk Power Transmission – 800 KV HVDC

- 500 kV conventional as also series compensated
- 750 kV conventional as also series compensated
- 1200 kV conventional as also series compensated

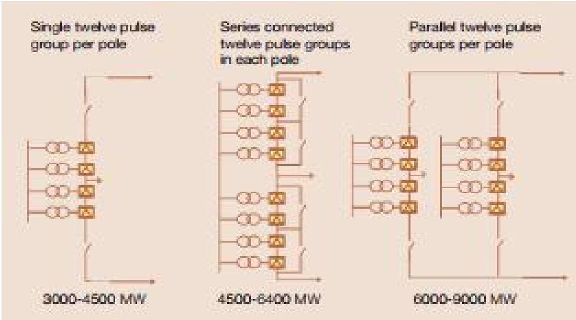

Fig. 3.5.1: Alternative Converter Configurations for 800 kV HVDC Line

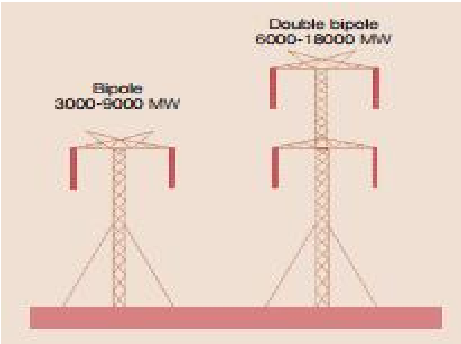

Fig. 3.5.2: Using 800 kV HVDC, Power Transfer of up to 18000 MW is Possible in a Single Right of Way

3.6. Development of EHV Transmission Systems EHVAC

The first 735 kV systems were commissioned in Canada in 1965. Since then, voltage levels up to 765 kV have been introduced in Russia with neighboring countries, U.S.A, South Africa, Brazil, Venezuela and South Korea. The general trend of 800 kV investments is indicated in the diagram, which shows the total capacity of power transformers and generator step-up transformers for 800 kV delivered by ABB.

3.6.1. Merits of HVDC

- Undersea cables, where high capacitance causes additional AC losses. (e.g., 250 km Baltic Cable between Sweden and Germany).
- Endpoint-to-endpoint long-haul bulk power transmission without intermediate.
- Increasing the capacity of an existing power grid in situations where additional wires are difficult or expensive to install
- Power transmission and stabilization between unsynchronized AC distribution systems.
- Connecting a remote generating plant to the distribution grid, for example Nelson River Bipolar.

3.7. Design Aspects for Transmission Lines

The general design criteria for AC and DC transmission lines can be divided into electrical and mechanical aspects, both having considerable effects on the investment and operation costs. The power transmission capacity determines the voltage level and the number of parallel circuits, which has a great influence on the investment costs. Other aspects are emergency loading capability and reactive power compensation of AC lines. The power losses affect mainly the operating costs and should, therefore, be optimized with regard to investment cost of the line conductors at the given voltage level.

3.8. Power Transmission Capacity

The power transmission capacity of long EHVAC lines is limited by the reactive power consumption of the line inductance, which exceeds the reactive power generation of the line capacitance at load levels above surge impedance loading (which is solely determined by the geometrical configuration of the line). Extensive use of series capacitors may, however, increase the transmission capacity of a line to about 150-200% of surge impedance loading. The thermal loading capability is usually not decisive for long AC transmission lines due to limitations in the reactive power consumption. The emergency loading capability is dependent on maximum allowable conductor temperature and reactive power constraints. The requirements on emergency loading are determined by the number of redundant lines. The power transmission capacity of HVDC lines is mainly limited by the maximum allowable conductor temperature in normal operation. The requirements on emergency loading of HVDC lines depend on the number of redundant lines and the maximum allowable conductor temperature in emergency operation.

When comparing HVDC and EHVAC lines from a transmission capacity point of view, the HVDC lines are principally limited only by the thermal loading capability since there are no reactive power constraints.

3.9. Transformer

Transformers are commonly used in applications which require the conversion of AC voltage from one voltage level to another. There are two broad categories of transformers: electronic transformers, which operate at very low power levels, and power transformers, which process thousands of watts of power. Electronic transformers are used in consumer electronic equipment like television sets, VCRs, CD players, personal computers, and many other devices, to reduce the level of voltage from 220V (available from the AC mains) to the desired level at which the device operates. Power transformers are used in power generation, transmission and distribution systems to raise or lower the level of voltage to the desired levels. The basic principle of operation of both types of transformers is the same. In this chapter, we will first review some of the basic concepts of magnetic circuits, which are fundamental building blocks in transformers and electric machinery. In order to understand how a transformer operates, we will examine two inductors that are placed in close proximity to one another. The concepts of such magnetic coupled circuits will be extended to the development of transformers. After understating the relationships between voltages and currents, we will look at some practical considerations regarding the use of transformers.

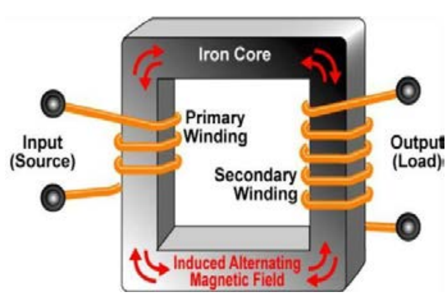

Fig. 3.9: Transformer

3.10. The Main Learning Objectives of this Chapter are listed below

Learning Objectives

- Understand concept of mutual inductance
- Understand operation of ideal transformers
- Use equivalent circuits to determine voltages and currents.
- Analyze the operation of the transformer for different transformation ratios.
- Understand the concept of a reflected load in a transformer and its application in impedance matching.
- Study the application of transformers in electrical energy distribution and power supplies.

3.10.1. Applications of Transformers

- Transformers have many applications in power transmission and electronics
- They may be used to minimize energy losses due to voltage drop in transmitting electricity over long distances.
- They match loads with internal resistance so that there is maximum power transfer.

3.11. Losses in Transformers

- All transformers have copper and core losses, and flux leakage.

Copper loss is ohmic power lost in the primary and secondary windings of a transformer due to the ohmic resistance of the windings. Copper loss, in watts, may be found using the following equation

Copper Losses = IpRp + Is

- Rs Where Ip is the primary current, Is is the secondary current, Rp is the primary resistance, and Rs is the secondary resistance. Core losses are caused by two factors: hysteresis and eddy current losses. Hysteresis loss is that energy lost by reversing the magnetic field in the core as the magnetizing AC rises and falls and reverses direction. Eddy current loss is a result of induced currents circulating in the iron core. It can be used by laminations.

3.12. Results and Discussion

The result shows that the system is studied include 2 EHV/UHV transmission lines states. Zero sequence parameters of double-circuit EHV/UHV transmission lines with mutual inductance based on distribution parameter Model transmission line equations and distributed parameter model, a new approach is proposed to accurately measure the zero sequence parameters of long-distance double-circuit transmission lines using voltages and currents measured at the ends of lines.

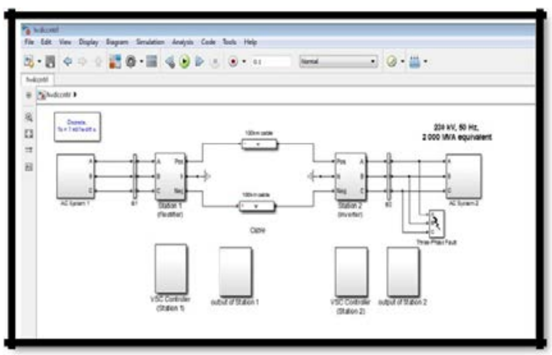

Fig. 3.12.1: Simulation Diagram for Proposed System

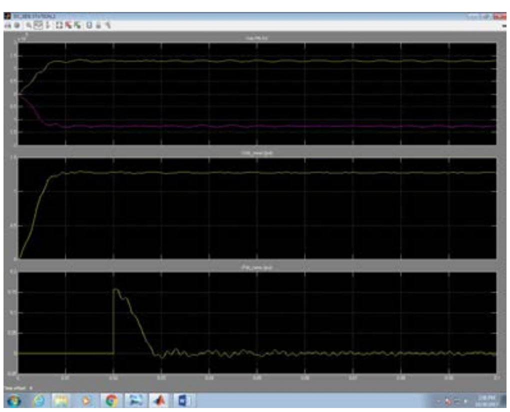

Fig 3.12.2: DC Side Station Power Variations

Consists of 3 traces upper trace shows the dc side station voltage variations from positive (0-1.2) negative (0-1.2). Middle trace shows measured dc-voltage 1.2v will increase at the time of 0.3t. The lower trace shows the power measured and the saturation of the voltage is increased 0.02 time period at the voltage of 0.15v.

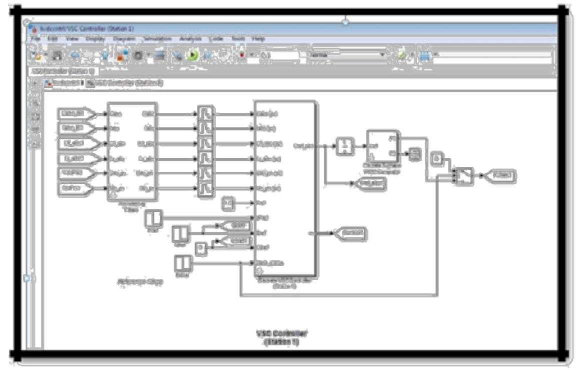

Fig. 3.12.3: Simulation Diagram for Voltage Controller Station 1

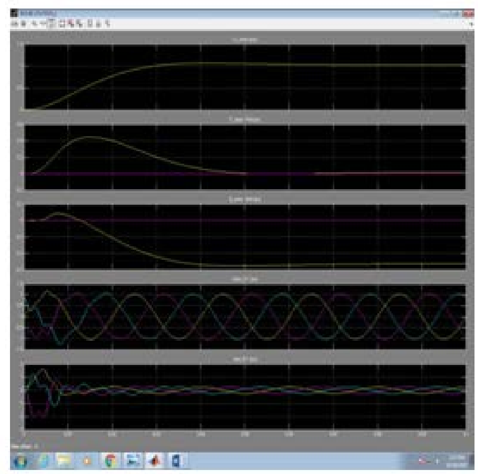

Fig. 3.12.4: Output Waveform for Bus Sub-Station 1

The bus station 1 power(p) reactive power (q) bus voltage (b1) bus current (bi) can be described. In the substation 1 power value is (0-0.4v) and then reactive power is(0-0.3)v and then bus voltage is (0-1) and (0-(-0.1) and bus current(0-1) and (0-(-0.1)

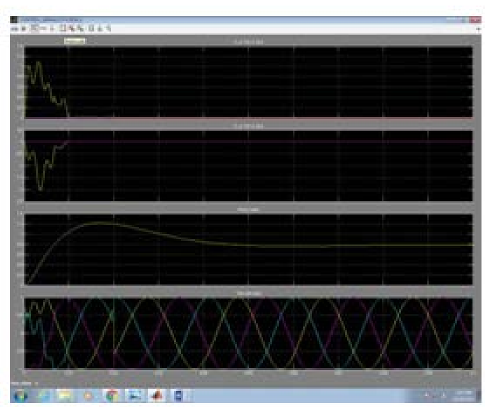

Fig. 3.12.5: Control Signal Station1

There are three control signal ivd, ivq, vref input voltage of control signal is (0-1) input voltage reactive power (0-0.2) and the reference voltage of the bus station (0-1) and (0-(-1).

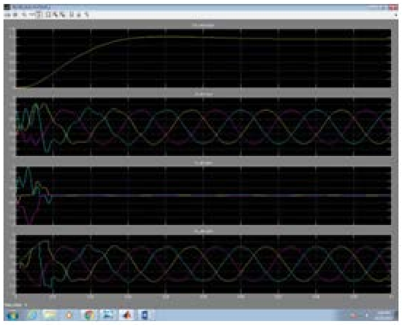

Fig. 3.12.6: Filter Bus Station 1

In the bus station VSC (voltage source controller) it has some of the input and output error signals .so filter is implemented in this project where power frequency filter will reduce (0-1.2) frequency. The stabilized output voltage (0-0.02) v. after the filtrations the current (0-0.1)I the current goes stabiles. Final all the filtrations process the output voltage is maintained constant.

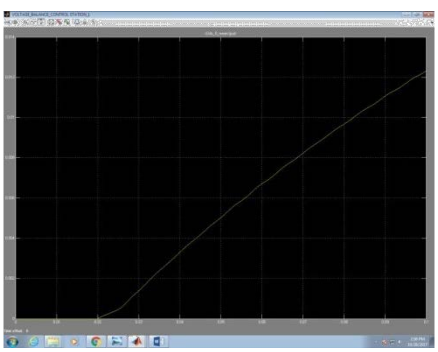

Fig. 3.12.7: Voltage Balance Control Station 1

In the control station balance voltage is saturated between (0.02-0.12).

IV. CONCLUSION

The power frequency parameters of EHV/UHV transmission lines are zero sequence parameter measurement of long-distance double-circuit EHV/UHV AC transmission lines and in the zero sequence parameter measurement of long-distance UHV bipolar DC transmission lines. Can measure zero sequence resistances, zero sequence inductances and zero sequence capacitances simultaneously.

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