Performance of Current Source Converter Fed HVDC Transmission System for WECS

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ABSTRACT:

A series-connected current source converter (CSC)-based configuration has recently been proposed for offshore wind energy conversion systems. A big challenge exists for such a system that its maximum insulation level is the full transmission voltage due to its mono polar operation. This introduces significant burden to the system in terms of cost, reliability, and flexibility. To solve this issue, a bipolar operation giving a half insulation requirement is proposed and investigated in the present work. However, a unique challenge exists for the CSC-based system when operating under bipolar mode that is the dc-link current control. There are two equivalent paths for the dc-link current which introduces a concern for proper operation of the bipolar system. Accordingly, an optimized dc-link current control is developed in this study. In summary, the bipolar system with the help of the optimized dc-link current control features lower insulation requirement, higher reliability, higher efficiency, and higher flexibility.

Key Words: current source converter (CSC), Medium frequency rating transformer (MFT).

I. Introduction:

The role of electrical energy need is rapidly going day by day greater extent because of globalization and industrialization. Electrical Energy is highly needed for wide applications like agricultural applications, domestic application, and industrial applications. Without electrical energy no innovation is fulfilled. The greater challenge in front of every engineer is to reach the power demand. Power generation is by adopting conventional energy resources (produce power by combustion process) like coal, diesel, kerosene is causing environmental pollution and it may exhaust in future. So Now world looking about alternative methods to generate the power such as solar, wind, tidal and geo thermal *etc.* These renewable power generations wind energy is playing a vital role since a decade.

India is placed fifth position in renewable energy production across global, fourth position in wind energy and fifth position in solar power production. India is also registered for lowest ever wind tarrif of 2.4 rupees per unit in a tender of 500 MW project by government of gujarath in 2017. The total cumulative RES energy installed capacity has increased from 35.51 GW as of 31st March 2014 to 73.35 GW as of 31st October 2018 (increase about 106 percentage). Usage of wind energy is going high much year by year.

Power transmissions are broadly classified in ways like HVDC, HVAC and HVDC and HVAC. Beyond the breakeven point HVDC transmission is more economical [1]. In HVDC transmission network power electronics converters place a crucial role to exchange the power between the source and grid centers. HVDC transmission has more numerous advantages compare to other transmission techniques such as less cost, less maintenance, lower losses, lower environmental issues, deliver high amount of stable power to the load side. HVDC transmissions are mainly three ways like mono polar, bi polar and homo polar. In these techniques bi polar HVDC transmissions are more advantages, in this paper discussed about bipolar based HVDC transmission with WECS is discussed. The structure of Bi polar based HVDC transmission with WECS is shown in fig.1.

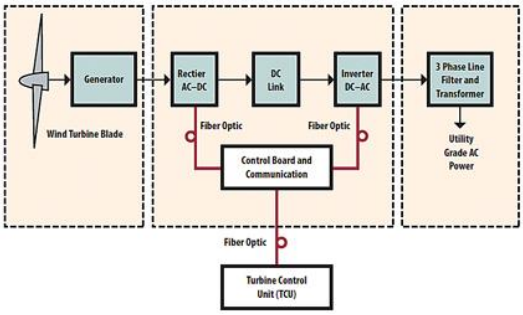


Fig.1. Structure of WECS with HVDC transmission

In literature available WECS with HVDC is available in shunt configuration and series configurations. Compare to voltage sources converters (VSC), current source converters (CSC) have significant features such as protects from the short circuits, improve power factor, control real & reactive power, and simple structure. The similarity in CSC employed series configurations is it can operate in mono polar mode. HVDC mono polar is suffered with system insulation; wind generator must require the neutral point. To handle this problem require transformer (low frequency) connection between generator and converter. This problem is also solved by medium frequency rating transformer (MFT) reported in []. Mon polar HVDC has still facing challenges in terms of economical and flexibility.

Existing method:

The existing method describes CSC-based series-connected configurations is they are all operating under monopolar mode leading significant challenge for system insulation. The wind generator that is farthest from the grounding point must be capable of withstanding a full transmission level which is impractical. To tackle this issue, a three-phase low-frequency high-power transformer is normally connected between the generator and the front-end converter. This transformer, however, is heavy and bulky increasing burden on offshore

construction because of the limited space either in the nacelle or in the tower of the wind turbine.

In paper mainly focused on reduces the insulation of WECS system employing bi polar converters. In Mono polar need the transformer setup it may act as bulk on total system. In mono polar links current divides equally, in bi polar used dc link control method it helps to improve over system efficiency. The next sections of this paper is summarized as follows, configuration of CSC based WECS in Section –II, presented control scheme in section –III, MATLAB simulation results in section –IV and concluded in section-V.

II. Configuration of CSC based WECS:

The block diagram of PMSG based WECS with CSC is shown in fig.2. It mainly contains generator side converters it converts power produced by wind (A.C) into D.C act as rectifier. And grid side converter converts the D.C into A.C act as inverter and connected to grid.

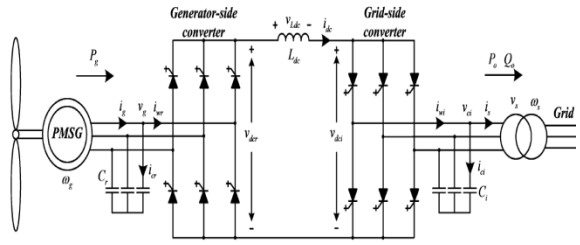


Fig.2. PMSG based WECS with CSC

The power produced from the wind i.e. captured energy from the wind, for an effective area *Ar* is given by

$P = 0.5\ \rho_{air} C_p A r v^3$

Where

ρair = Density of air [kg/m3],

vw = Speed of the wind

Cp = Coefficient of power

To receive maximum power from in WECS the rotor speed can be adjusted. Maximum power is acquired from WECS by controlling rotor speed of PMSG i.e. maximum power point tracking (MPPT) method, reported in literature widely [].

III. Control Scheme:

Various control schemes are available to operate the CSC such as direct torque control (DTC), direct power control (DPC), voltage oriented control and field oriented control techniques.

A. Generator Side Control scheme:

Field oriented control (FOC) technique is adopted to control the generator side and sinusoidal pulse width modulation is employed to operate the switching operation of current source converter. The block diagram of generator side control scheme is shown in figure.3.

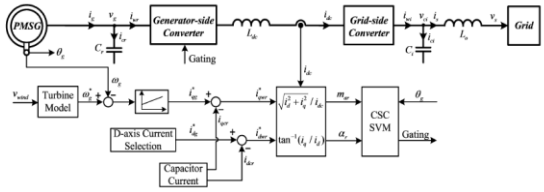


Fig.3. Configuration of generator side control scheme employing FOC control Scheme

B. Grid Side Control Scheme:

Voltage oriented control (VOC) technique is adopted to control the grid side and sinusoidal pulse width modulation is employed to operate the switching operation of current source

converter. The block diagram of generator side control scheme is shown in figure.4.

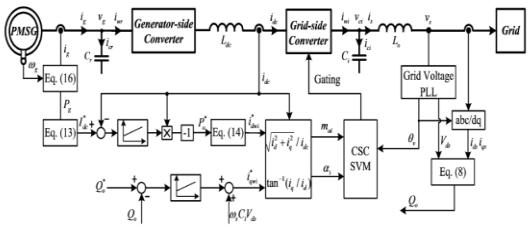


Fig.4. Configuration of generator side control scheme employing FOC control Scheme

The schematic diagram of dc link current control method is shown in figure.5. n. no. of wind power generations are connected to PCC to reach the power demand. This proposed bi polar HVDC transmission is equivalent of mono polar HVDC systems operates independently. It gives more flexible and high efficiency compare mono polar HVDC systems and reduces insulation greater extent.

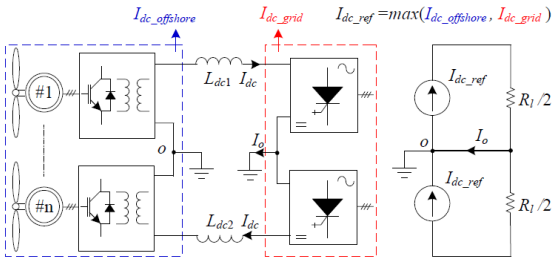
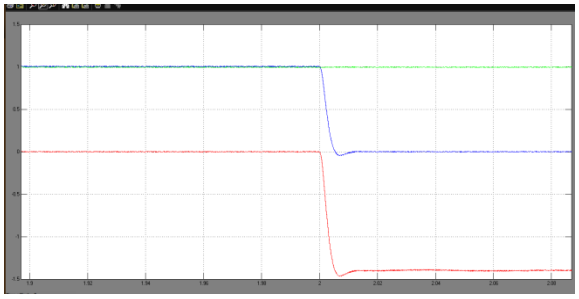
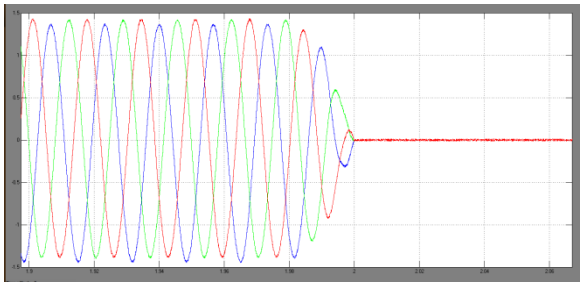


Fig.5. Bipolar HVDC transmission configuration with DC link current control

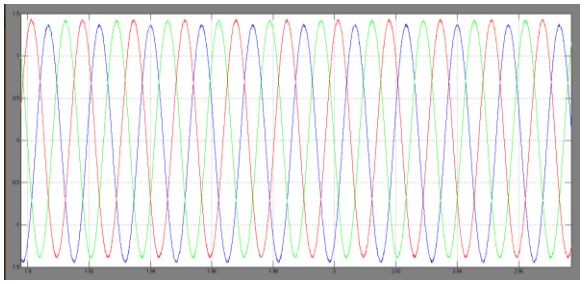
IV. Simulation Discussions:



(a)Dc-link currents (pu)

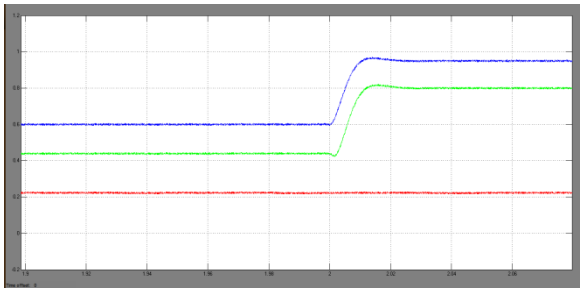


(b)Load Currents for #1 (pu)

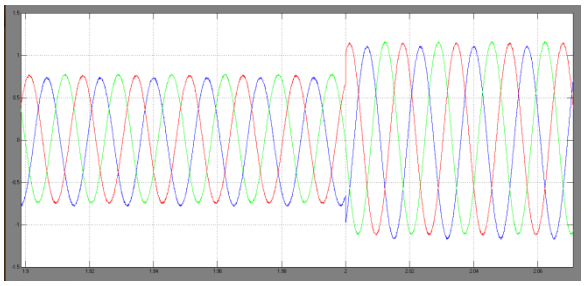


(c) Load Currents for #2 (pu)

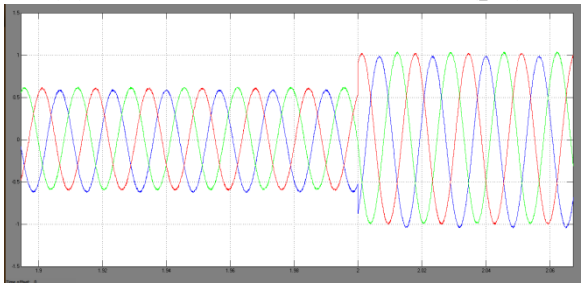
Fig: Simulated performance of the bipolar system when one module is by passed.



(a) Dc-link currents (pu)



(b) Load Currents for #1 (pu)



(c) Load Currents for #2 (pu)

Fig. Simulated performance of the bipolar system under stepped dc-link Current.

V. Conclusion:

In this paper, the modeling of bi polar HVDC transmission based WECS is investigated. MATLAB simulations results are proven that bipolar mode hvdc transmission system gave reduce insulation level compared to mono polar HVDC transmission system. Bipolar HVDC has lower cost and simple operating. In design Bi polar HVDC optimized dc link current control is employed, in simple words it is combination of two single mono polar systems operates independently. The performance of overall system is investigated proposed dc link current control method provides better simulation results compared to conventional dc-link current control, Proposed control provides more reliable and high efficiency.

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