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Multilevel STATCOM Using Cascaded Two Level Inverter for High Power Transmission Line

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Abstract:
In this paper, a STATCOM using cascaded two level inverter is proposed. The topology consists of two standard two level inverters connected in cascaded manner. The dc link voltages of inverter are observed at different levels to obtain four level operations. The simulation study is carried out in MATLAB/SIMULINK at fault condition. The STATCOM compensate during the fault condition and gives stable voltage and current.

Keywords: DC-link voltage balance, multilevel inverter, power quality (PQ), static compensator (STATCOM).

I. INTRODUCTION

Power systems today are highly complex and the requirements to provide a stable, secure, controlled and economic quality of power are becoming vitally important with the rapid growth in industrial area. To meet the demanded quality of power in a power system it is essential to increase the transmitted power either by installing new transmission lines or by improving the existing transmission lines by adding new devices. Installation of new transmission lines in a power system leads to the technological complexities such as economic and environmental considerations that includes cost, delay in construction as so on. Considering these factors power system engineers concentrated the research process to modify the existing transmission system instead of constructing new transmission lines. Later they came up with the concept of utilizing the existing transmission line just by adding new devices, which can adapt momentary system conditions in other words, power system should be flexible. In this research process, in late 1980s Electric Power Research Institute (EPRI) came up with the concept of Flexible AC Transmission Systems (FACTS) technology, which enhances the security, capacity and flexibility of power transmission systems. It was the new integrated concept based on power electronic switching device and dynamic controllers to enhance the system utilization and power transfer capacity as well as the stability, security, reliability and power quality of AC transmission Systems. The controllers designed based on the concept of FACTS technology known as FACTS controllers. The controllers that are designed based on the concept of FACTS technology to improve the power flow control; stability and reliability are known as FACTS controllers. These controllers were introduced depending on the type of power system problems. Some of these controllers were capable of addressing multiple problems in a power system but some are limited to solve for a particular problem. All these controllers grouped together as a family of FACTS controllers categorized as follows:

First Generation of FACTS Controllers: Static Var Compen sator (SVC) and Thyristor Controlled Series Compensator (TCSC)

Second Generation of FACTS Controllers: Static Synchronous Series Compensator (SSSC) and Static Synchronous Compensator (STATCOM)
Third Generation of FACTS Controllers: Unified Power Flow Controller (UPFC)
Fourth Generation of FACTS Controllers: Interline Power Flow Controller (IPFC) and Generalized Power Flow Controller (GUPFC)
This paper is organized as follows: The proposed control scheme is presented in Section II. Proposed controller strategy is discussed in Section III. Simulation results are presented in Sections IV.

II. CASCADED TWO-LEVEL INVERTER -BASED MULTILEVEL STATCOM

Fig. 1 shows the power system model considered in this paper. Fig. 2 shows the circuit topology of the cascaded two-level inverter-based multilevel STATCOM using standard two-level inverters. The inverters are connected on the low-voltage (LV) side of the transformer and the high-voltage (HV) side is connected to the grid. The dc-link voltages of the inverters are maintained constant and modulation indices are controlled to achieve the required objective. The proposed control scheme is derived from the ac side of the equivalent circuit which is shown in Fig. 3. In the figure, Va’, Vb’, Vc’ are the source voltages referred to LV side of the transformer, Ra, Rb and Rc are the resistances which represent the losses in the transformer and two inverters, La, Lb and Lc are leakage inductances of transformer windings, ea1, eb1, ec1 and ea2, eb2, ec2 are the output voltages of inverters 1 and 2, respectively. r1, r2 are the leakage resistances of dc-link capacitors C1 and C2, respectively. Assuming ra = rb = rc = r , La = Lb = Lc and applying KVL on the ac side, the dynamic model can be derived using as

$$\begin{bmatrix} \frac{di'_{ia}}{dt} \\ \frac{di'_{ib}}{dt} \\ \frac{di'_{ic}}{dt} \end{bmatrix} = \begin{bmatrix} \frac{-r}{L} & 0 & 0 \\ 0 & \frac{-r}{L} & 0 \\ 0 & 0 & \frac{-r}{L} \end{bmatrix} \begin{bmatrix} i'_a \\ i'_b \\ i'_c \end{bmatrix} + \frac{1}{L} \begin{bmatrix} v'_a - (e_{a1} - e_{a2}) \\ v'_b - (e_{b1} - e_{b2}) \\ v'_c - (e_{c1} - e_{c2}) \end{bmatrix} \quad (1)$$

Equation (1) represents the mathematical model of the cascaded two-level inverter-based multilevel STATCOM in the stationary reference frame. This model is transformed to the synchronously rotating reference frame [14]. The – axes reference voltage components of the converter as

$$e_d^* = -x_1 + \omega L i_q^{'} + v_d^{'} (2)$$
$$e_q^* = -x_2 - \omega L i_d^{'} + v_q^{'} (3)$$

The -axis reference current Id* is obtained as

$$i_d^* = \left(k_{p3} + \frac{k_{i3}}{s}\right)[(V_{dc1}^* + V_{dc2}^*) - (V_{dc1} + V_{dc2})] (4)$$

Where Vdc1*, Vdc2*and Vdc1,Vdc2 are the reference and actual dc-link voltages of inverters 1 and 2, respectively. The – axis reference current is Iq* obtained either from an outer voltage regulation loop when the converter is used in transmission-line voltage support or from the load in case of load compensation.

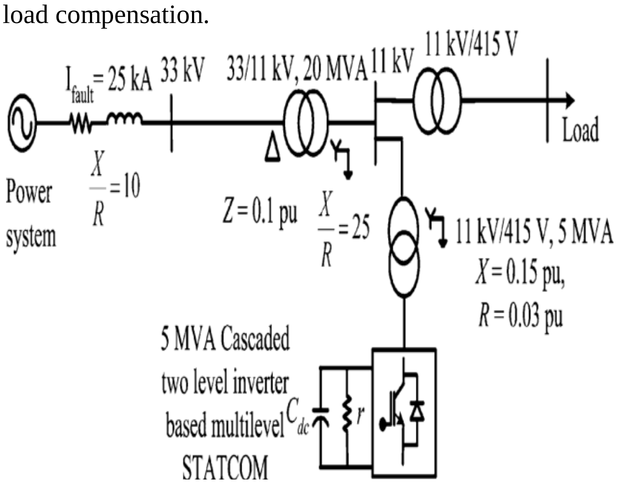

Figure.1. Power system and the STATCOM model.

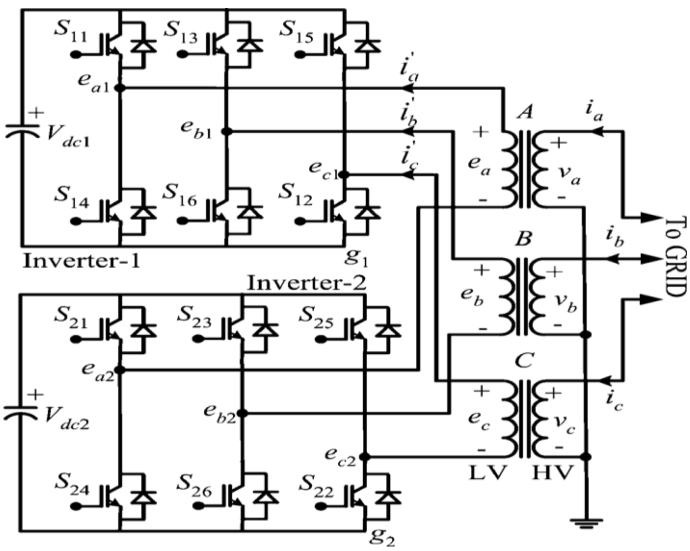

Figure.2. Cascaded two-level inverter-based multilevel STATCOM.

III. PROPOSED CONTROL STRATEGY

A. Control Strategy

The control block diagram is shown in Fig. 4. The unit signals Coswt and sinwt are generated from the phase-locked loop (PLL) using three-phase supply voltages [14]. The converter currents are transformed to the synchronous rotating reference frame using the unit signals. The switching frequency ripple in the converter current Iq* loops, the controller generates – axes reference voltages, eq* and ed* for the cascaded inverter. With these reference voltages, the inverter supplies the desired reactive current and draws required active current to regulate total dc-link voltage. However, this will not ensure that individual dc-link voltages are controlled at their respective reference values. Hence, additional control is required to regulate individual dc-link voltages of the inverters.

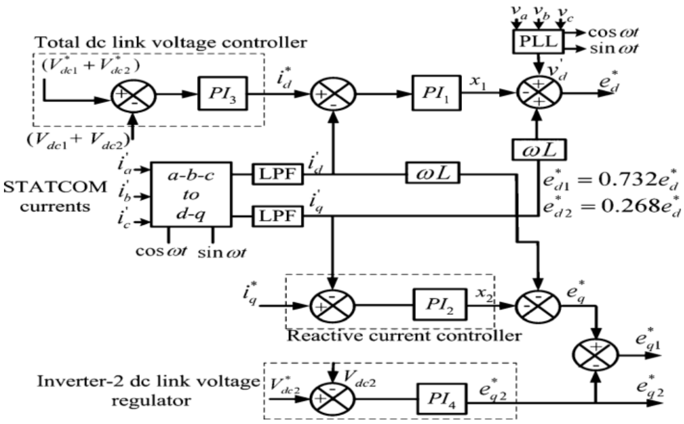

Figure.3. Control block diagram.

$$V_{dc1} = 0.732V_{dc} (7)$$
$$V_{dc2} = 0.268V_{dc} (8)$$

C. Unbalanced Conditions

Network voltages are unbalanced due to asymmetric faults or unbalanced loads [16]. As a result, negative-sequence voltage appears in the supply voltage. This causes a double supply frequency component in the dc-link voltage of the inverter. This double frequency component injects the third harmonic component in the ac side [17]. Moreover, due to negative-sequence voltage, large negative-sequence current flows through the inverter which may cause the STATCOM to trip [16]. Therefore, during unbalance, the inverter voltages are controlled in such a way that either negative-sequence current flowing into the inverter is eliminated or reduces the unbalance in the grid voltage. In the latter case, STATCOM needs to supply large currents since the interfacing impedance is small. This may lead to tripping of the converter.

IV. SIMULATION MODEL

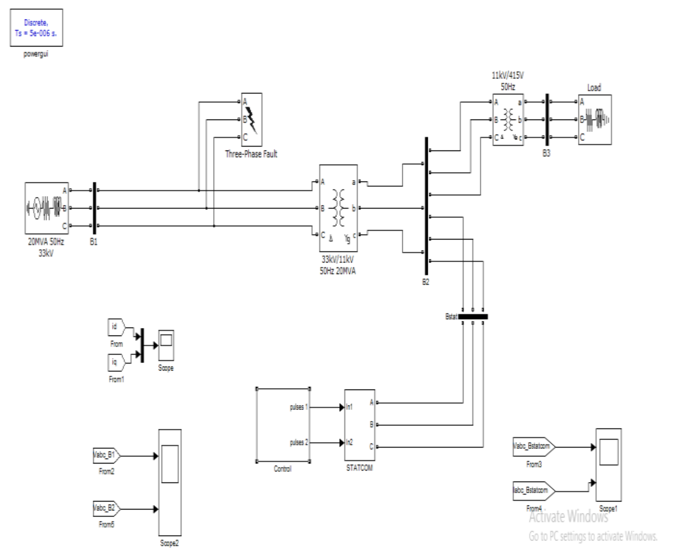

Figure.4. Main Model with unsymmetrical fault

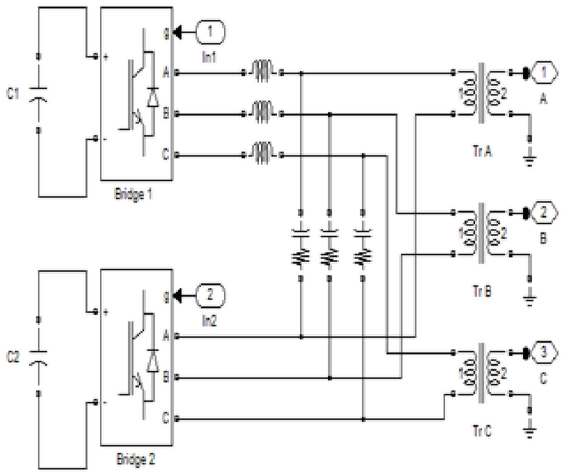

Figure.5. STATCOM model

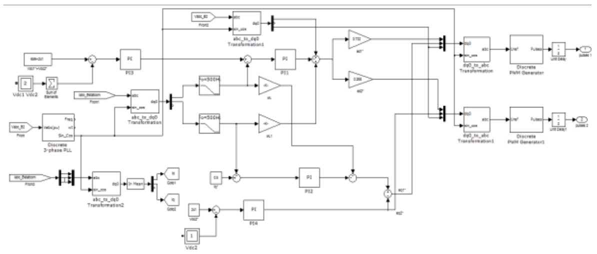

Figure.6. Controller

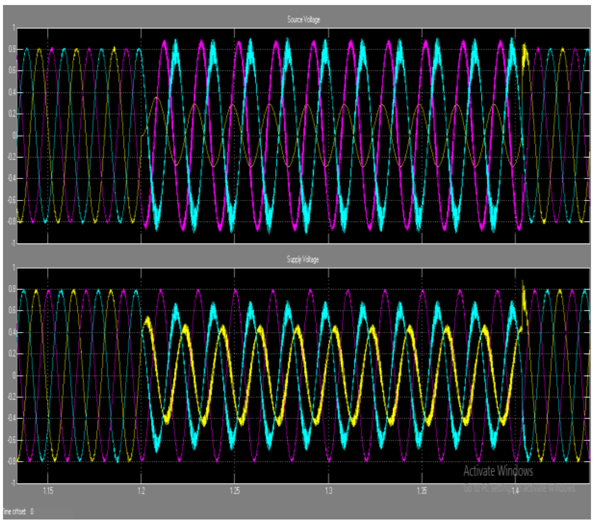

Figure.7. Source Voltage and Supply Voltage

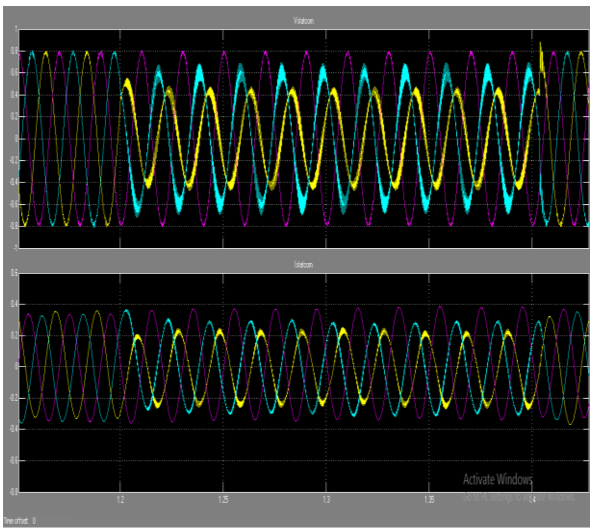

Figure.8. STATCOM Voltage and STATCOM Current

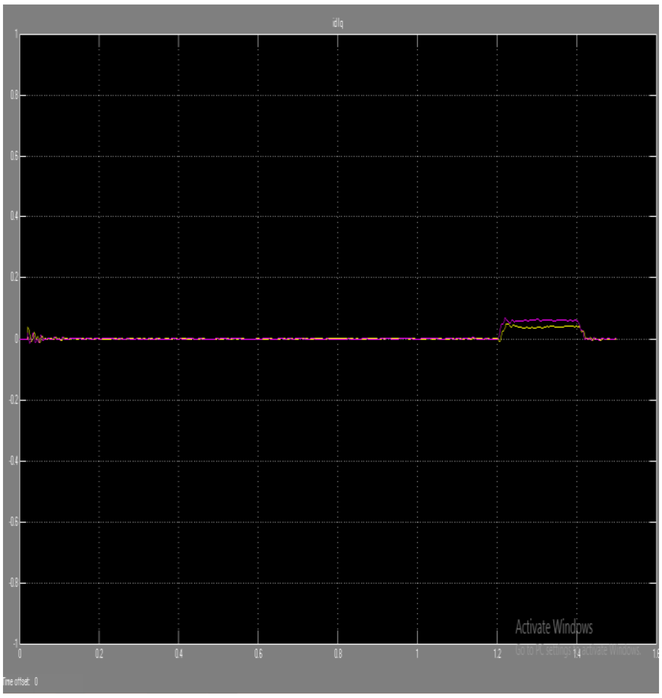

Figure.9. iq and id current

V. CONCLUSION

The MATLAB/ Simulink model is designed for cascaded two level inverter based multilevel STATCOM for fault condition. The STATCOM compensate during the fault condition. It gives stable Supply voltage and STATCOM Current and STATCOM voltage

VI. REFERENCES

[1].N. G. Hingorani and L. Gyugyi, Understanding FACTS. Delhi, India: IEEE, 2001, Standard publishers distributors.

[2].N.N.V. SurendraBabu and B.G. Fernandes, "Cascaded two level inverter based multilevel statcom for high power applications," IEEE Trans. Power Del., vol.29, no.3, June-2014.

[3]. M. Satyanarayana, "Atransformerless cascaded H bridge multilevel statcom for power quality applications," IJRASET vol.4, issue XI, Nov 2016.

[4]. H. Akagi, H. Fujita, S. Yonetani, and Y. Kondo, "A 6.6-kV transformer less STATCOM based on a five-level diode-clamped PWM converter: System design and experimentation of a 200-V 10-kVA laboratory model," IEEE Trans. Ind. Appl., vol. 44, no. 2, pp. 672–680, Mar./Apr.2008.

[5]. A. Shukla, A. Ghosh, and A. Joshi, "Hysteresis current control operation of flying capacitor multilevel inverter and its application in shunt compensation of distribution systems," IEEE Trans. Power Del., vol. 22, no. 1, pp. 396–405, Jan. 2007.