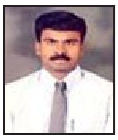
ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

A Method for Estimating and Easing of Voltage Flicker in STATCOM

R. Saiprasad Goud
M.Tech Student
Department of EEE
B V Raju Institute of Technology
Narsapur, Medak.



K.Ramakrishna
Associate Professor
Department of EEE
B V Raju Institute of Technology
Narsapur, Medak.

Abstract:

Many static synchronous compensators (STATCOMs) utilize multilevel converters due to the following: 1) lower harmonic injection into the power system; 2) decreased stress on the electronic components due to decreased voltages; and 3) lower switching losses. One disadvantage, however, is the increased likelihood of a switch failure due to the increased number of switches in a multilevel converter. A single switch failure, however, does not necessarily force an (2n + 1)-level STATCOM offline. Even with a reduced number of switches, a STATCOM can still provide a significant range of control by removing the module of the faulted switch and continuing with (2n − 1) levels. This project introduces an approach to detect the existence of the faulted switch, identify which switch is faulty, and reconfigure the STATCOM.

In this project, the method we propose requires only that the output dc link voltage of each phase be measured. This measurement is typically accomplished anyway for control purposes. If a fault is detected, the module in which the fault occurred is then isolated and removed from service. This approach is consistent with the modular design of cascaded converters in which the cells are designed to be interchangeable and rapidly removed and replaced. The proposed approach was able to accurately identify and remove the faulted module. In addition, the STATCOM was able to remain in service and continue to provide compensation without exceeding the total harmonic distortion allowances. Analytical expectations are verified using simulations in the MATLAB/SIMULINK environment, based on a detailed system model.

INTRODUCTION:

The static synchronous compensator (STATCOM) has been well accepted as a power system controller for improving voltage regulation and reactive compensation. There are several compelling reasons to consider a multilevel converter topology for the STATCOM. The well-known reasons include the following: 1) lower harmonic injection into the power system; 2) decreased stress on the electronic components due to decreased voltages; and 3) lower switching losses. Various multilevel converters also readily lend themselves to a variety of PWM strategies to improve efficiency and control.

An eleven-level cascaded multilevel STATCOM is shown in the below figure. This converter uses several full bridges in series to synthesize staircase waveforms. Because every full bridge can have three output voltages with different switching combinations, the number of output voltage levels is 2n + 1 where n is the number of full bridges in every phase. The converter cells are identical and therefore modular. As higher level converters are used for high output rating power applications, a large number of power switching devices will be used. Each of these devices is a potential failure point. Therefore, it is important to design a sophisticated control to produce a fault-tolerant STATCOM.A faulty power cell in a cascaded H-Bridge STATCOM can potentially cause switch modules to explode leading to the fault conditions such as a short circuit or an overvoltage on the power system resulting in an expensive down time. Subsequently, it is crucial to identify the existence and location of the fault for it to be removed. Several fault detection methods have been proposed over the last few years.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

Resistor sensing, current transformation and VCE sensing are some of the more common approaches. For example, a method based on the output current behavior is used to identify IGBT short circuits. The primary drawback with the proposed approach is that the fault detection time depends on the time constant of the load.

Therefore, for loads with a large RL time constant, the faulty power cell can go undetected for numerous cycles, potentially leading to circuit damage. Another fault detection approach proposed in is based on a switching frequency analysis of the output phase voltage. This method was applied to flying capacitor converters and has not been extended to cascaded converters. AI-based methods were proposed to extract pertinent signal features to detect faults. In sensors are used to measure each IGBT current and to initiate switching if a fault is detected. A reconfiguration system based on bidirectional switches has been designed for three-phase asymmetric cascaded H-bridge inverters. The fundamental output voltage phase shifts are used to rebalance a faulted multilevel cascaded converter.

In this paper, the method we propose requires only that the output dc link voltage of each phase be measured. This measurement is typically accomplished anyway for control purposes. If a fault is detected, the module in which the fault occurred is then isolated and removed from service. This approach is consistent with the modular design of cascaded converters in which the cells are designed to be interchangeable and rapidly removed and replaced. Until the module is replaced, the multilevel STATCOM continues to operate with slightly decreased, but still acceptable, performance.

In summary, this approach offers the following advantages:

- No additional sensing requirements.
- Additional hardware is limited to two by-pass switches per module.
- Consistent with the modular approach of cascaded multilevel converters.
- The dynamic performance and THD of the STATCOM is not significantly impacted.

FLEXIBLE A.C. TRANSMISSION SYSTEMS:

Flexible AC Transmission Systems, called FACTS, got in the recent years a well known term for higher controllability in power systems by means of power electronic devices. Several FACTS-devices have been introduced for various applications worldwide. A number of new types of devices are in the stage of being introduced in practice.

In most of the applications the controllability is used to avoid cost intensive or landscape requiring extensions of power systems, for instance like upgrades or additions of substations and power lines. FACTS-devices provide a better adaptation to varying operational conditions and improve the usage of existing installations. The basic applications of FACTS-devices are:

» Power flow control.

» Increase of transmission capability.

» Voltage control.

» Reactive power compensation.

» Stability improvement.

» Power quality improvement.

» Power conditioning.

» Flicker mitigation.

» Interconnection of renewable and distributed generation and storages.

Figure 1.1 shows the basic idea of FACTS for transmission systems. The usage of lines for active power transmission should be ideally up to the thermal limits. Voltage and stability limits shall be shifted with the means of the several different FACTS devices. It can be seen that with growing line length, the opportunity for FACTS devices gets more and more important.The influence of FACTS-devices is achieved through switched or controlled shunt compensation, series compensation or phase shift control. The devices work electrically as fast current, voltage or impedance controllers. The power electronic allows very short reaction times down to far below one second.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

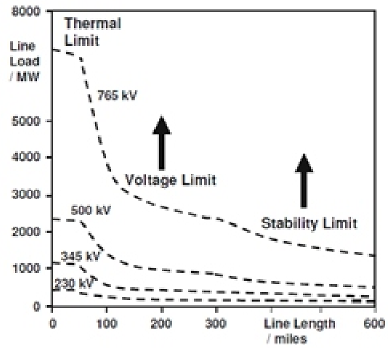
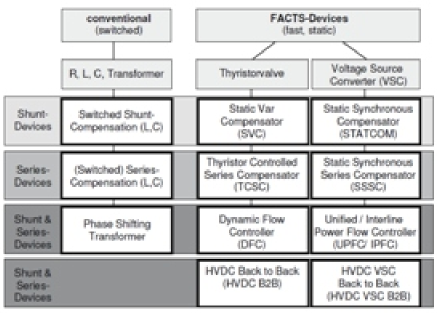


Fig. 1.1. Operational limits of transmission lines for different voltage levels

The development of FACTS-devices has started with the growing capabilities of power electronic components. Devices for high power levels have been made available in converters for high and even highest voltage levels. The overall starting points are network elements influencing the reactive power or the impedance of a part of the power system. Figure 1.2 shows a number of basic devices separated into the conventional ones and the FACTS-devices.

For the FACTS side the taxonomy in terms of 'dynamic' and 'static' needs some explanation. The term 'dynamic' is used to express the fast controllability of FACTS-devices provided by the power electronics. This is one of the main differentiation factors from the conventional devices. The term 'static' means that the devices have no moving parts like mechanical switches to perform the dynamic controllability. Therefore most of the FACTS-devices can equally be static and dynamic.



The left column in Figure 1.2 contains the conventional devices build out of fixed or mechanically switch able components like resistance, inductance or capacitance together with transformers. The FACTS-devices contain these elements as well but use additional power electronic valves or converters to switch the elements in smaller steps or with switching patterns within a cycle of the alternating current.

The left column of FACTS-devices uses Thyristor valves or converters. These valves or converters are well known since several years. They have low losses because of their low switching frequency of once a cycle in the converters or the usage of the Thyristors to simply bridge impedances in the valves.

The right column of FACTS-devices contains more advanced technology of voltage source converters based today mainly on Insulated Gate Bipolar Transistors (IGBT) or Insulated Gate Commutated Thyristors (IGCT). Voltage Source Converters provide a free controllable voltage in magnitude and phase due to a pulse width modulation of the IGBTs or IGCTs.

STRUCTURE OF STATCOM:

Basically, STATCOM is comprised of three main parts (as seen from Figure) a voltage source converter (VSC), a step-up coupling transformer, and a controller. In a very-high-voltage system, the leakage inductances of the step-up power transformers can function as coupling reactors. The main purpose of the coupling inductors is to filter out the current harmonic components that are generated mainly by the pulsating output voltage of the power converters.

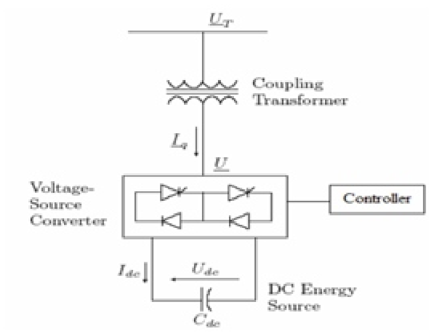


Fig. Reactive power generation by a STATCOM

MULTILEVEL STATCOM:

A cascaded multilevel STATCOM contains several H-bridges in series to synthesize a staircase waveform. The inverter legs are identical and are therefore modular. In the eleven-level STATCOM, each leg has five H-bridges. Since each full bridge generates three different level voltages (V, 0, –V) under different switching states, the number of output voltage levels will be eleven. A multilevel configuration offers several advantages over other converter types.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

1) It is better suited for high-voltage, high-power applications than the conventional converters since the currents and voltages across the individual switching devices are smaller.

2) It generates a multistep staircase voltage waveform approaching a more sinusoidal output voltage by increasing the number of levels.

3) It has better dc voltage balancing, since each bridge has its own dc source.

To achieve a high-quality output voltage waveform, the voltages across all of the dc capacitors should maintain a constant value. Variations in load cause the dc capacitors to charge and discharge unevenly leading to different voltages in each leg of each phase. However, because of the redundancy in switching states, there is frequently more than one state that can synthesize any given voltage level.

Therefore, there exists a "best" state among all the possible states that produces the most balanced voltages. Since there are multiple possible switching states that can be used to synthesize a given voltage level, the particular switching topology is chosen such that the capacitors with the lowest voltages are charged or conversely, the capacitors with the highest voltages are discharged.

This redundant state selection approach is used to maintain the total dc link voltage to a near constant value and each individual cell capacitor within a tight bound. Different pulse width modulation (PWM) techniques have been used to obtain the multilevel converter output voltage. One common PWM approach is the phase shift PWM (PSPWM) switching concept. The PSPWM strategy causes an cella-tion of all carrier and associated sideband harmonics up to the (N – 1)th carrier group for an N-level converter. Each carrier signal is phase shifted by

$$\Delta\phi = \frac{2\pi}{n}$$

Where n is the number of cells in each phase. Fig. 2 illustrates the carrier and reference waveforms for a phase leg of the eleven-level STATCOM. In this figure, the carrier frequency has been decreased for better clarity. Normally, the carrier frequency for PWM is in the range of 1–10 kHz.

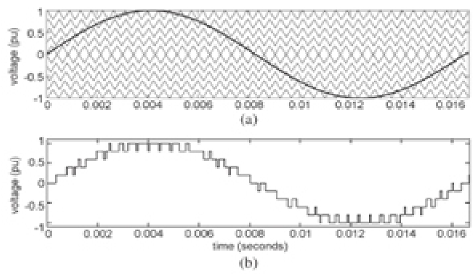


Fig. 2. (a) Carrier and reference waveform for PSPWM. (b) Output waveform.

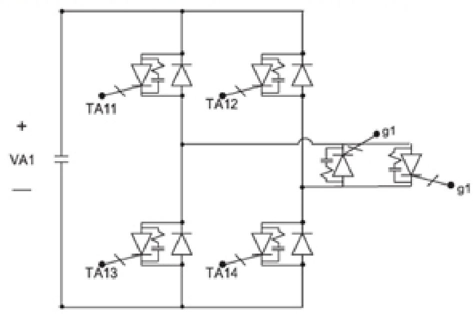


Fig. 3. Cell with fault switch.

Fig. Cascaded H Bridge inverter with output waveform

The above configuration system based on bidirectional switches has been designed for three phase asymmetric cascaded H bridge inverters. The fundamental output voltage phase shifts are used to rebalance a faulted multilevel cascaded converter. In this method requires only that the output dc link voltage of each phase is measured.

This measurement is typically accomplished anyway for control purposes. If a fault is detected, the module in which the fault occurred is then isolated and removed from service. This approach is consistent with modular design of cascaded converters in which the cells are designed to be interchangble and rapidly removed and replaced. Until the module is replaced, the multilevel STATCOM continues to operate with slightly decreased, but still acceptable, performance.

FAULT ANALYSIS FOR THE MULTILEVEL STATCOM:

A converter cell block, as shown in Fig.4.3, can experience several types of faults. Each switch in the cell can fail in an open or closed state. The closed state is the most severe failure since it may lead to shoot through and short circuit the entire cell.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

An open circuit can be avoided by using a proper gate circuit to control the gate current of the switch during the failure. If a short circuit failure occurs, the capacitors will rapidly discharge through the conducting switch pair if no protective action is taken. Hence, the counterpart switch to the failed switch must be quickly turned off to avoid system collapse due to a sharp current surge. Nomenclature for the proposed method is given in Table I.

TABLE I
NOMENCLATURE

E_{out}	STATCOM output voltage (V)
$\hat{E}_{out}$	Filtered STATCOM output voltage (RMS) (V)
E'	STATCOM threshold voltage (constant) (V)
S_{j1}, S_{j2}	Switching signal of the j-th cell (0, 1)
f_i	possible STATCOM output voltage (V)
x_i	difference between possible and actual STATCOM output (V)
g_j	bypass signal for j-th cell (0, 1)

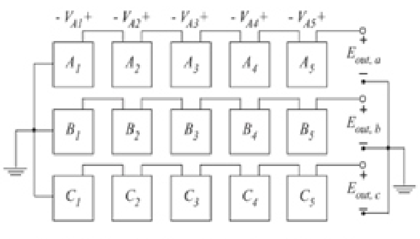


Fig. 4. Simplified eleven-level cascaded multilevel STATCOM.

Fig. Eleven-level cascaded multilevel STATCOM

The staircase voltage waveform shown in Fig. is synthesized by combining the voltages of the various cells into the desired level of output voltage. At the middle levels of the voltage waveform, due to the switching state redundancy, there are more than one set of switching combinations that may be used to construct the desired voltage level.

Therefore, by varying the switching patterns, the loss of any individual cell will not significantly impact the middle voltages of the output voltage. However, the peak voltages require that all cells contribute to the voltage; therefore, the short circuit failure of any one cell will lead to the loss of the first and (2n + 1) output levels and cause degradation in the ability of the STATCOM to produce the full output voltage level. Consider the simplified eleven-level converter shown in Fig. The process for identifying and removing the faulty cell block is summarized in Fig. The input to the detection algorithm is ˆEout for each phase, where ˆEout is the STATCOM filtered RMS output voltage. If the STATCOM RMS output voltage drops below a preset threshold value (E), then, a fault is known to have occurred (see Fig.). Once a fault has been detected to have occurred, then, the next step is to identify the faulty cell. By utilizing the switching signals in each converter cell, (i.e., S1 and S2), it is possible to calculate all of the possible voltages that can be produced at any given instant as illustrated in Table. Thus, the output voltage of a cell is

$$v_{ax} = v_{ax} + -v_{ax}^{-}$$

and since the cells of the STATCOM are serially connected, the total output voltage per phase is

$$v_{y0} = \sum_{x=1}^{n} v_{yx}, \qquad y \in [a, b, c]$$

where n is the number of blocks.

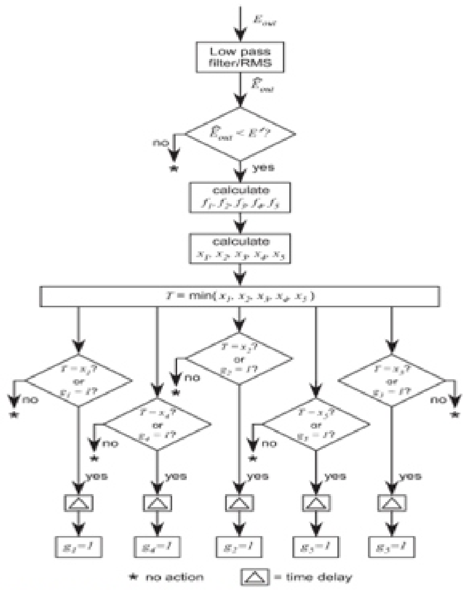


Fig. 5. Flowchart for eleven-level converter.

Fig. Flowchart for eleven-converter

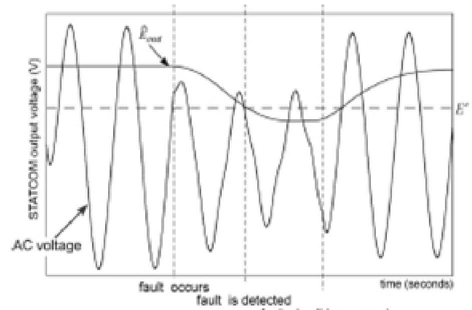


Fig. Filtered output voltage & threshold value of STATCOM

Fig. 6. STATCOM-filtered output voltage and threshold value.

By utilizing the switching signals in each converter cell, (i.e., Sj1 and Sj2, j is the cell number), it is possible to calculate all of the possible voltages that can be produced at any given instant.

TABLE II
SWITCHING STATE AND OUTPUT VOLTAGE OF AN H-BRIDGE

S_1	S_2	v_{ax}^{+}	v_{ax}^{-}	v_{ax}
0	0	0	0	0
0	1	0	v_{dc}	$-v_{dc}$
1	0	v_{dc}	0	v_{dc}
1	1	v_{dc}	v_{dc}	0

When there is a fault in the multilevel converter, the capacitor at the faulty block will rapidly discharge. This discharge results in a phase shift in the output ac voltage as well as a change in amplitude of voltage. The set of all possible phase fault voltages for an eleven-level converter is given by

$$f_1 = V_{dc0}(S_{21} - S_{22} + S_{31} - S_{32} + S_{41} - S_{42} + S_{51} - S_{52}) \quad \text{(cell 1 faulted)}$$

$$f_2 = V_{dc0}(S_{11} - S_{12} + S_{31} - S_{32} + S_{41} - S_{42} + S_{51} - S_{52}) \quad \text{(cell 2 faulted)}$$

$$\vdots$$

$$f_5 = V_{dc0}(S_{11} - S_{12} + S_{21} - S_{22} + S_{31} - S_{32} + S_{41} - S_{42}) \quad \text{(cell 5 faulted)}$$

or more succinctly as

$$f_i = V_{dc0}\sum_{j=1}^{n}(S_{j1} - S_{j2}), \qquad i = 1, \ldots, n \qquad (3)$$

$$f_1 = V_{dc0}(S_{21} - S_{22} + S_{31} - S_{32} + S_{41} - S_{42} + S_{51} - S_{52}) \quad \text{(cell 1 faulted)}$$

$$f_2 = V_{dc0}(S_{11} - S_{12} + S_{31} - S_{32} + S_{41} - S_{42} + S_{51} - S_{52}) \quad \text{(cell 2 faulted)}$$

$$\vdots$$

$$f_5 = V_{dc0}(S_{11} - S_{12} + S_{21} - S_{22} + S_{31} - S_{32} + S_{41} - S_{42}) \quad \text{(cell 5 faulted)}$$

or more succinctly as

$$f_i = V_{dc0}\sum_{\substack{j=1 \\ j \neq i}}^{n}(S_{j1} - S_{j2}), \qquad i = 1, \ldots, n \qquad (3)$$

Fault diagnosis in multilevel converters:

Since a multilevel converter is normally used in medium to high power applications, the reliability of the multilevel converter system is very important. For instance industrial drive applications in manufacturing plants are dependent upon induction motors and their inverter systems for process control. Generally, the conventional protection systems are passive devices such as fuses, overload relays, and circuit breakers to protect the inverter systems and the induction motors.

The protection devices will disconnect the power sources from the multilevel inverter system whenever a fault occurs, stopping the operated process. Downtime of manufacturing equipment can add up to be thousands or hundreds of thousands of dollars per hour, therefore fault detection and diagnosis is vital to a company's bottom line.

In order to maintain continuous operation for a multilevel inverter system, knowledge of fault behaviors, fault prediction, and fault diagnosis are necessary. Faults should be detected as soon as possible after they occur, because if a motor drive runs continuously under abnormal conditions, the drive or motor may quickly fail.

The possible structure for a fault diagnosis system is illustrated in Figure . The system is composed of four major states: feature extraction, neural network classification, fault diagnosis, and switching pattern calculation with gate signal output.

The feature extraction performs the voltage input signal transformation, with rated signal values as important features, and the output of the transformed signal is transferred to the neural network classification.

The networks are trained with both normal and abnormal data for the MLID; thus, the output of this network is nearly 0 and 1 as binary code. The binary code is sent to the fault diagnosis to decode the fault type and its location. Then, the switching pattern is calculated to reconfigure the multilevel inverter.

Switching patterns and the modulation index of other active switches can be adjusted to maintain voltage and current in a balanced condition after reconfiguration recovers from a fault.

The MLID can continuously operate in a balanced condition; of course, the MLID will not be able to operate at its rated power. Therefore, the MLID can operate in balanced condition at reduced power after the fault occurs until the operator locates and replaces the damaged switch

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

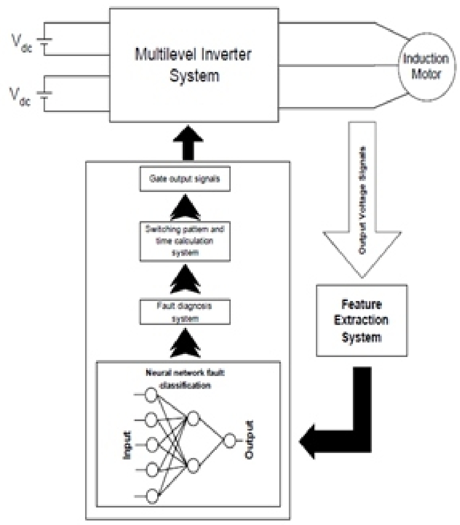
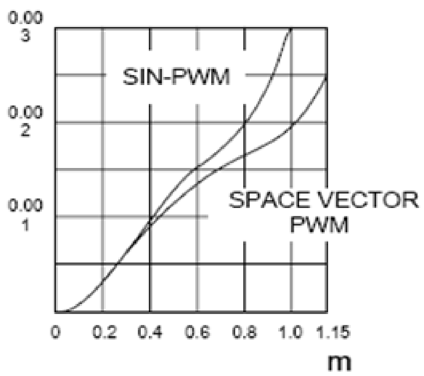
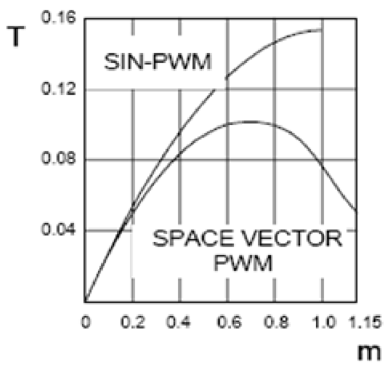


Fig. Structure of fault diagnosis system of a multilevel cascaded H-bridges inverter.



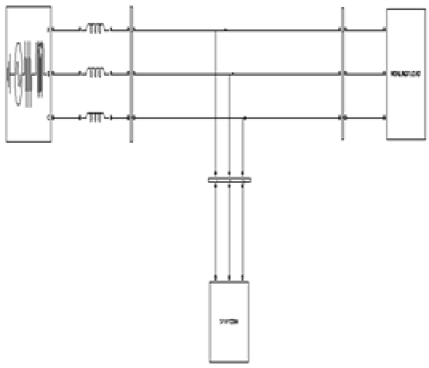
(a)rms harmonic current



(b) torque harmonics

Fig. Harmonic wave forms

RESULTS WITH CIRCUIT DIAGRAMS CIRCUTE DIAGRAM



Fig, SINGLE LINE DIAGRAM OF ARC FURNACE LOAD

PULSE GENERATOR

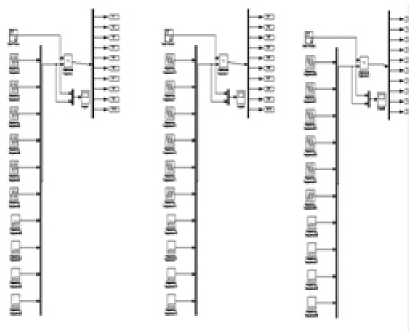


Fig. Pulse Generator Circuits

Controller

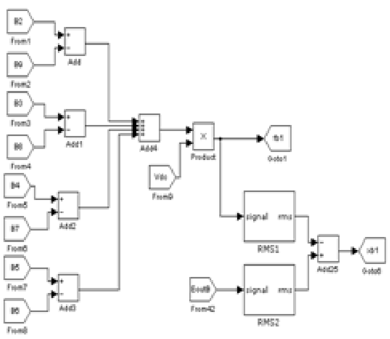


Fig. Controller Circuits

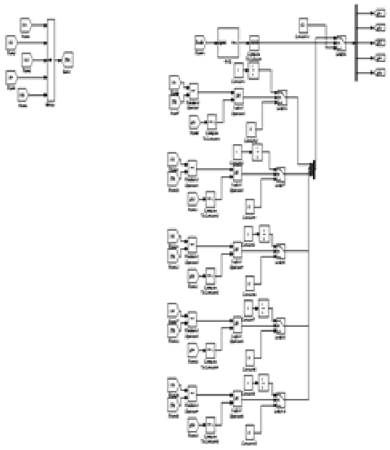


Fig. Proposed fault detection and module removal

OUTPUTS

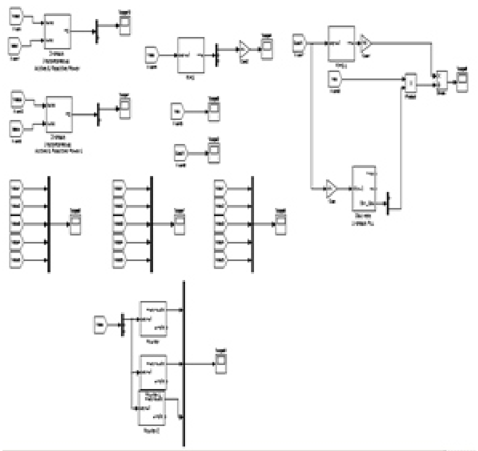


Fig. Outputs of the arc furnace load

Active power at load

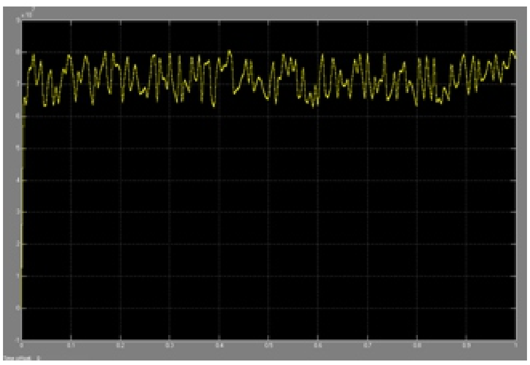


Fig. Active power drawn by the arc furnace load

Active power at source

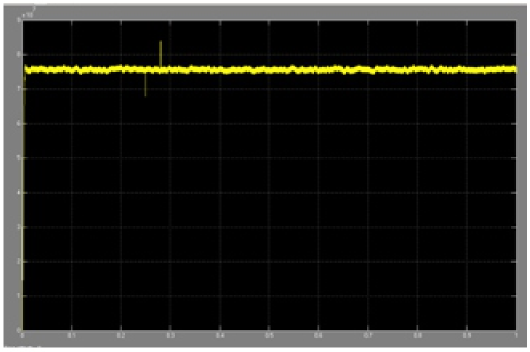


Fig. line active power drawn by the arc furnace load

Dc voltages across level

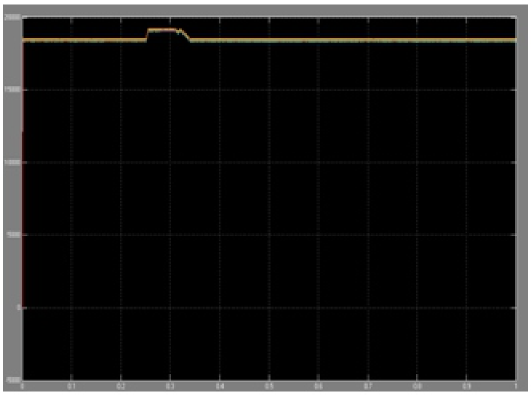


Fig. Individual module capacitor voltage before, during and after fault in phase –a

Voltage rms

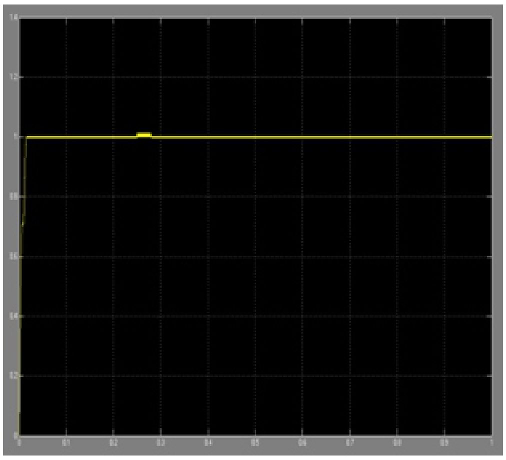


Fig. RMS voltage of STATCOM

VDC:

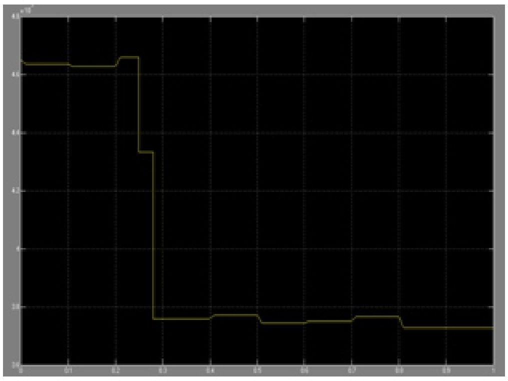


Fig. DC voltage before, during and after fault

VDC o/p from inverter

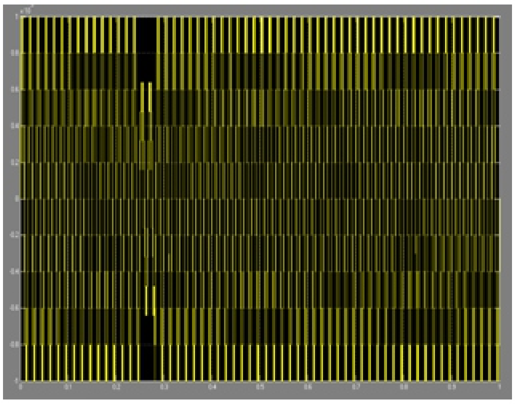


Fig. Converter output with faulted cell

EOUT:

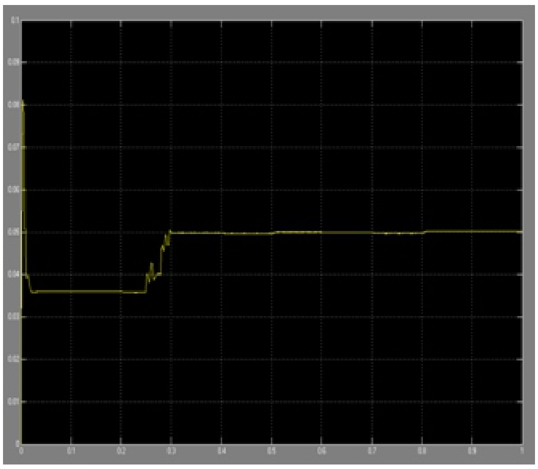


Fig. Modulation gain before, during and after fault

Voltages

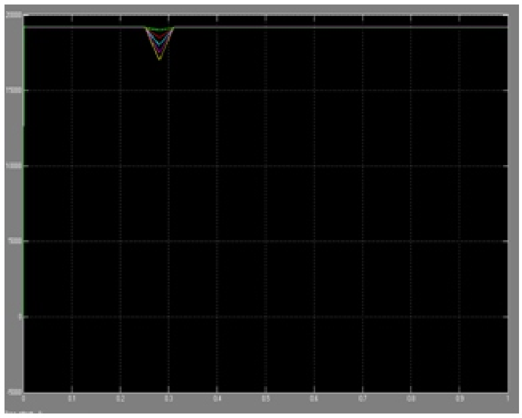


Fig. Individual module capacitor voltage gain before, during and after fault in phase-b

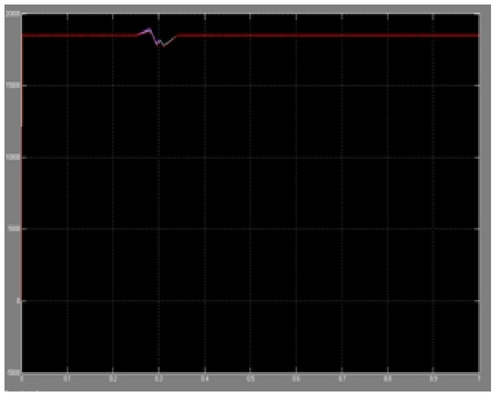


Fig. Individual module capacitor voltage gain before, during and after fault in phase-c

Vabc:

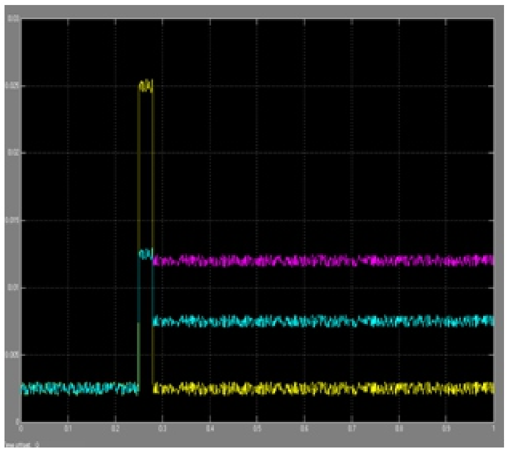


Fig. Percent harmonic content of the faulty phase before, during and after fault

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

CONCLUSION:

In this paper, a fault detection and mitigation strategy for a multilevel cascaded converter has been proposed. This approach requires no extra sensors and only one additional bypass switch per module per phase. The approach has been validated on a 115-kV system with a STATCOM compensating an electric arc furnace load. This application was chosen since the arc furnace provides a severe application with its non sinusoidal, unbalanced, and randomly fluctuating load. The proposed approach was able to accurately identify and remove the faulted module. In addition, the STATCOM was able to remain in service and continue to provide compensation without exceeding the total harmonic distortion allowances.

REFERENCES:

[1]V. Dinavahi, R. Iravani, and R. Bonert, "Design of a real-time digital simulator for a D-STATCOM system," IEEE Trans. Ind. Electron., vol. 51, no. 5, pp. 1001–1008, Oct. 2004.

[2]B. Singh, S. Murthy, and S. Gupta, "STATCOM-based voltage regulator for self-excited induction generator feeding nonlinear loads," IEEE Trans. Ind. Electron., vol. 53, no. 5, pp. 1437–1452, Oct. 2006.

[3]A. Luo, C. Tang, Z. Shuai, J. Tang, X. Xu, and D. Chen, "Fuzzy-PI-based direct-output-voltage control strategy for the STATCOM used in utility distribution systems," IEEE Trans. Ind. Electron., vol. 56, no. 7, pp. 2401– 2411, Jul. 2009.

[4]M. Molinas, J. Suul, and T. Undeland, "Extending the life of gear box in wind generators by smoothing transient torque with STATCOM," IEEE Trans. Ind. Electron., vol. 57, no. 2, pp. 476–484, Feb. 2010.

[5]C.-H. Liu and Y.-Y. Hsu, "Design of a self-tuning PI controller for a STATCOM using particle swarm optimization," IEEE Trans. Ind. Elec-tron., vol. 57, no. 2, pp. 702–715, Feb. 2010.

[6]D. Soto and T. C. Green, "A comparison of high-power converter topolo-gies for the implementation of FACTS controllers," IEEE Trans. Ind. Electron., vol. 49, no. 5, pp. 1072–1080, Oct. 2002.

[7] J. A. Barrena, L. Marroyo, M. Á. Rodríguez Vidal, J. R. Torrealday Apraiz, "Individual voltage balancing strategy for PWM cascaded H-bridge converter-based STATCOM," IEEE Trans. Ind. Electron., vol. 55, no. 1, pp. 21–29, Jan. 2008.

[8]Y. Liu, A. Q. Huang, W. Song, S. Bhattacharya, and G. Tan, "Small-signal model-based control strategy for balancing individual DC capacitor voltages in cascade multilevel inverter-based STATCOM," IEEE Trans. Ind. Electron., vol. 56, no. 6, pp. 2259–2269, Jun. 2009.

[9]T. A. Meynard, M. Fadel, and N. Aouda, "Modeling of multilevel convert-ers," IEEE Trans. Ind. Electron., vol. 44, no. 3, pp. 356–364, Jun. 1997.

[10]C. Turpin, P. Baudesson, F. Richardeu, F. Forest, and T. A. Meynard, "Fault management of multicell converters," IEEE Trans. Ind. Electron., vol. 49, no. 5, pp. 988–997, Oct. 2002.

[11]S. Wei, B. Wu, F. Li, and X. Sun, "Control method for cascaded H-bridge multilevel inverter with faulty power cells," in Proc. Appl. Power Electron. Conf. Expo., Feb. 2003, vol. 1, pp. 261–267.

[12]S. Li and L. Xu, "Fault-tolerant operation of a 150 kW 3-level neu-tral point clamped PWM inverter in a flywheel energy storage system," in Conf. Rec. 36th IEEE IAS Annu. Meeting, Chicago, IL, Oct. 2001, pp. 585–588.

[13]F. Richardeau, P. Baudesson, and T. Meynard, "Failure-tolerance and remedial strategies of a PWM multicell inverter," IEEE Trans. Power Electron., vol. 17, no. 6, pp. 905–912, Nov. 2002.

[14]S. Khomfoi and L. Tolbert, "Fault diagnosis and reconfiguration for multilevel inverter drive using AI-based techniques," IEEE Trans. Ind. Electron., vol. 54, no. 6, pp. 2954–2968, Dec. 2007.

[15]M. Ma, L. Hu, A. Chen, and X. He, "Reconfiguration of carrier-based modulation strategy for fault tolerant multilevel inverters," IEEE Trans. Power Electron., vol. 22, no. 5, pp. 2050–2060, Sep. 2007.

[16]S. Ceballos, J. Pou, E. Robles, I. Gabiola, J. Zaragoza, J. L. Villate, and D.Boroyevich, "Three-level converter topologies with switch breakdown fault-tolerance capability," IEEE Trans. Ind. Electron., vol. 55, no. 3, pp. 982–995

Authors Details:

R. SAIPRASAD GOUD

received B.Tech degree from TRR college of engineering & technology, Patancheru, Medak, Telangana in 2010. And currently pursuing M.Tech in Electrical power system at Padmasri Dr. B V Raju Institute of Technology, Narsapur, Medak, Telangana. His area of interest in Electrical inspection field. He had an experience of 2years as a Quality Control Inspector.

K.Ramakrishna

obtained his BE (EEE) degree from GU Gulbarga in 1998, M.Tech.(Power Systems) from JNTU Hyderabad in 2004, pursuing Ph.D in JNTU Hyderabad .He worked as Asst. Prof. in Adams Engineering collegePalvoncha and Associate Professor at Vardhaman Engineering college Hyderabad. He has been working as a Associate Professor in dept. of EEE at Dr. B. V. Raju Inst. of Technology since 2008. His areas of interest include power system operation & control, distribution studies and optimization techniques in power system operation. He is also LMISTE. He is having 12 years teaching experience.