www.ijramr.com

ISSN: 2350-0743

International Journal of Recent Advances in Multidisciplinary Research
Vol. 05, Issue 03, pp.3708-3712, March, 2018

RESEARCH ARTICLE

IMPLEMENTATION OF SINGLE PHASE NEUTRAL POINT CLAMPED GRID CONNECTED INVERTER WITH OPEN SWITCH FAULT DETECTION AND CORRECTION

Dr. Magesh, T., *Priyatharshini, G., Preethi, S. and Priyadharshini, R.

Department of Electrical and Electronics, R.M.K. Engineering College, Kavarapettai, Thiruvallur

ARTICLE INFO

Article History:
Received 18th December, 2017
Received in revised form
25th January, 2018
Accepted 09th February, 2018
Published online 30h March, 2018

Keywords:
NPC - Neutral Point Clamped,
3T - Three Terminal Topology,
THD - Total Harmonic Distortion.

ABSTRACT

The main aim of our project is to implement the 5 level neutral point clamped (NPC) inverter output using three terminal topology (3T) with open switch fault detection. Normally the grid coupled inverters to reduce the common mode leakage current we use the NPC inverter. In this type we need more number of components and to achieve the five level output. In our proposed system we use the 3T converter to achieve the 5 level output at reduced number of switches. In experimental result we use 5 level 3T converter with 4 switches. And achieve the THD at below 5% and correct the open switch fault in this system.

INTRODUCTION

Back-to-back power converters are applied in power conversion in wind turbine generation (WTG) systems (Jeong, 2010; Duan *et al*., 2011; Lu *et al*., 2009; Peuget *et al*., 1998; Estima, 2011; Sleszynski *et al*., 2009). Back-to-back power converters transfer power from a permanent-magnet synchronous generator (PMSG) to the grid. Back-to-back converters typically consist of two-level topologies; however, expensive switching devices with high specifications (in terms of voltage and current) are needed in medium- and high-power WTG systems (Ribeiro *et al*., 2003). Multilevel topologies have the advantages of little current distortion and reduced Collector - emitter voltage (VCE). It shows a back-to-back power converter using a neutral-point-clamped (NPC) topology. The grid- and machine-side topologies are the same and are known as the inverter and rectifier (according to the direction of power delivery). Interest in the reliability of these systems has increased, and much research into switch-fault detection is being performed to prevent additional problems of switch faults (Wang, 2013). These considerations improve the reliability of systems using the three-level topology. Short-circuited and open-circuited switch faults are possible. A short-circuited switch fault causes serious impacts on systems because a current larger than the rated current of the switch flows through the short-circuited switch. Moreover, other components can be destroyed. Therefore, in such a case, the system must stop to ensure the safety of all components.

Corresponding author: **Priyatharshini, G.,**
Department of Electrical and Electronics, R.M.K. Engineering College, Kavarapettai, Thiruvallur

Another fault is the open-switch fault, which is caused by thermal cycling, extremely high collector currents, or a gate driver fault (de Araujo Ribeiro, 2003). An open-switch fault causes a change in thecurrent pattern and can generate secondary problems that cause other parts to break down. Hence, the diagnosis of open switch fault is necessary to prevent the damage of other components and to improve the reliability of these systems.

Existing System

The existing system does not deal with fault localization and there is no enhancement with additional backup port for alternative switches. The open switch fault cannot be dealt with the existing system.

Proposed System

In this paper, the current distortions in the rectifier and inverter of a back-to-back converter using the NPC topology caused by different open-switch faults (at S1, S2, S3or S4) are analyzed. In particular, the specifications of PMSGs are considered to investigate both the current distortions in the rectifier and the cause of the current distortion. On the basis of our analysis, a fault diagnosis method is proposed for localizing the open-switch fault in the back-to back converter. Experiments are performed at a back-to-back converter using the NPC topology. The results characterize the proposed detection method. In this block diagram, DC source is converted to the AC source. In this system the 3T type converter is used with fault diagnosis circuit. The output voltage sensing unit is sense the output voltage.

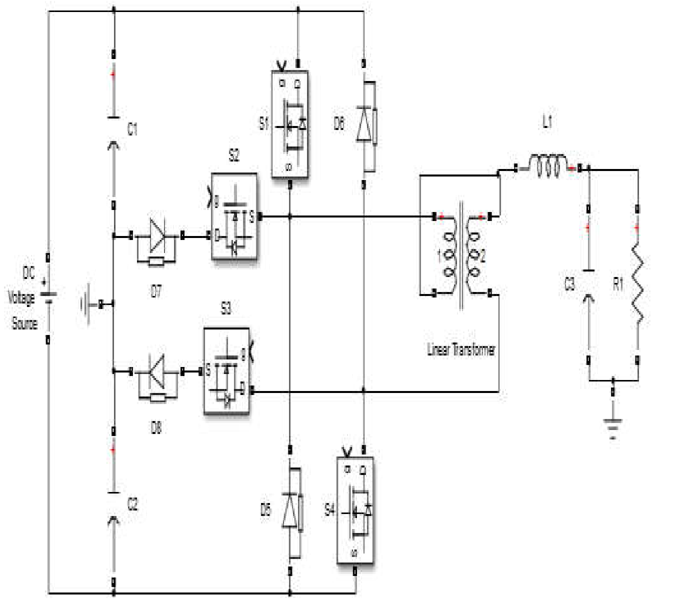

Fig. 1. Existing System

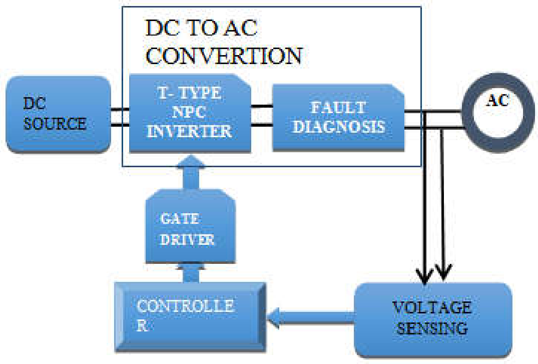

Fig 2. Block Diagram of the System

The Micro controller will be used to the control the output voltage. And control the open switch fault of the converter.

Modes of Operation

The NPC inverter consists of a transformer, a filter inductor and two bridge-legs. And it is a combination of vertically and horizontally orientated bridge-legs with coupled inductors. The power switches *S1* with diode *D1* is in series with power diode *D5*. This is the vertically orientated bridge-legs. Powerswitches *S2* with diode *D2* is in series with power diode D7.This is the horizontally orientated bridge-legs. The remaining power switches are placed in the similar orientations.

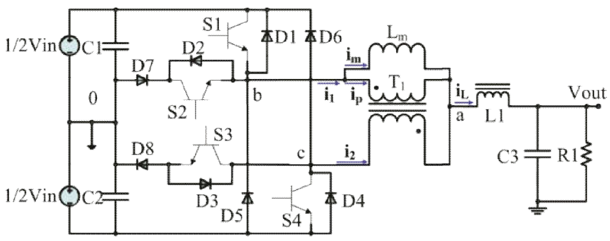

Fig. 3. Proposed Single-Phase T-Type 5-Level Inverter

In this way, both vertically and horizontally orientated bridge-legs are combined with the inter-cell transformer or coupled inductors and output filter inductor, where L1 represents the magnetizing inductance.

The two windings of the transformer, are inversely coupled and are connected to two middle-points of vertically orientated bridge-legs respectively. Therefore, this new topology can be considered as a variation of T-type 5-level or dual-buck inverter with coupled inductors. In this operation range, the single-phase T-type 5-level inverter has four switching modes in a complete switching period as shown in Fig 5, where *SS1*, *SS2*, *SS3* and *SS4* are the drive signals of 4 active power switches.

t0~t1: The power switches *S1*, *S2* and *S3* are switched on in the mode 1. Although *S2* has been turned on, there is no current on it. As the point “b” is connected to the positive pole of input voltage V_{in} while the point “c” is connected to the point “0” of the middle-point of dc bus capacitor, the voltage between two terminals of inverse coupled transformer T1 isVbc = Vin/2. As a result, imis increased with the rate of (Vin/4.Lm).t linearly because the voltage betweenLm isVbc/2=+Vin/4. On the other hand, the voltage difference from the point “a”, connected another terminal of T_1 with filter inductor, to the middle-point of dc bus capacitor “0”, is Vao=+Vin/4. Thus,the current through the filter inductor is increased linearly.

t1~t2: The power switches *S2* and *S3* are continuously on while power diodes *D7* and *D8*are conduct in the mode 2, As both of the point “b” and “c” are connected to the point “0”, the voltage between two terminal of the transformer T1 is Vbc=0,im remains no change.As the inverter middle point voltage Vao=0iLis decreased linearly s the output voltage is available.

t2~t3: The power switches *S2* is continuously on while power diodes *D6* and *D7* conduct in the mode 3. As the point “b” is connected to the point “0” while the point “c” is connected to the positive pole of the input voltage Vin, the voltage between two terminals of inverse coupled transformer T1 isVbc = -Vin/2.As a result, im is decreased with the rate of (Vin/4.Lm).t linearly. The inverter middle point voltage is expressed as Vao=+Vin/4. Hence iLis increased linearly.

t3~t4: The power switches *S2* are continuously on and *S3* is turned on while power diodes *D7* and *D8* conduct in the mode 4. As both point “b” and “c” are connected to the point “0”, the voltage between two terminal of the transformer T1 is Vbc=0, im remains no change. As the inverter middle point voltage is Vao=0, iL is decreased linearly as the output voltage is available.

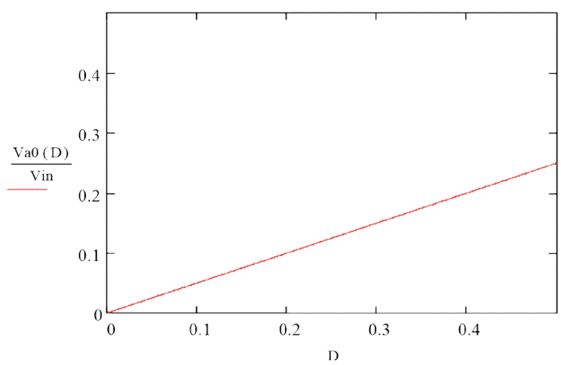

Fig. 4. Relationship Between Vao, D, And Vin (D<0.5)

From the above analysis, the inverter middle-point voltage is with two levels of 0 and +Vin/4.

Table. Switching combinations

Condition	Mode	S1	S2	S3	S4	Vbc	Va0
D < 0.5	1	1	1	1	0	+Vin/2	+Vin/4
	2	0	1	1	0	0	0
	3	0	1	0	0	-Vin/2	+Vin/4
	4	0	1	1	0	0	0
D > 0.5	1	1	1	0	0	0	+Vin/2
	2	1	1	1	0	+Vin/2	+Vin/4
	3	1	1	0	0	0	+Vin/2

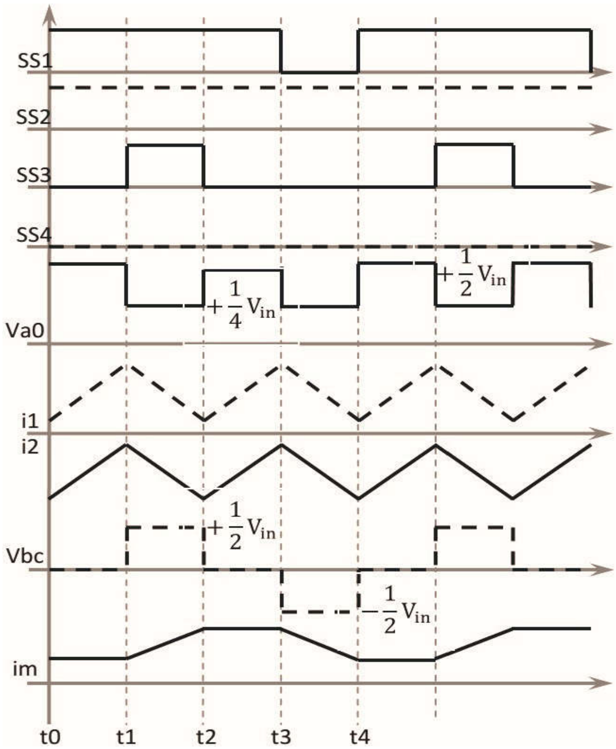

Fig 5. waveform of the single phase npc inverter,d>0.5

Based on the theory of volt-second balance in the inductor, the averaged output voltage can be obtained by the integration calculation.

$$v_{out} = \frac{2}{T}\left[\int_{t0}^{t1}\frac{1}{4}\cdot V_{in}\cdot dt + \int_{t1}^{t2} 0\cdot dt\right] = \frac{V_{in}}{2}\cdot D$$

Meanwhile, the magnetising current im of T1 is with bidirectional circulation, the transformer can be reset reliably. Thus, back to back converter gives the output voltage as half of the input voltage. The output voltage can be controlled by changing the amplitude of the sine wave by varying the duty cycle.

Simulation of single phase npc inverter

The simulation block consists of 3 subsystems.The substem1 consists of four different carrier pulses of different phases are given to the relational operator which compares the pulses with the reference sine wave. The technique which is used is called sine pulse width modulation (SPWM). For switches S1 and S3, if the amplitude of the sine wave is greater than the amplitude of the carrier wave, then the switches turn ON and if the amplitude of the sine wave is less than that of the carrier wave the switches remain in OFF condition.

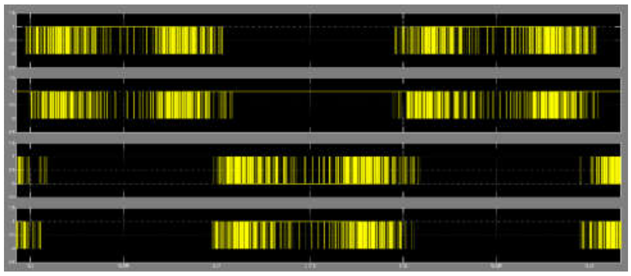

Fig. 6. Four Different Carrier Pulses

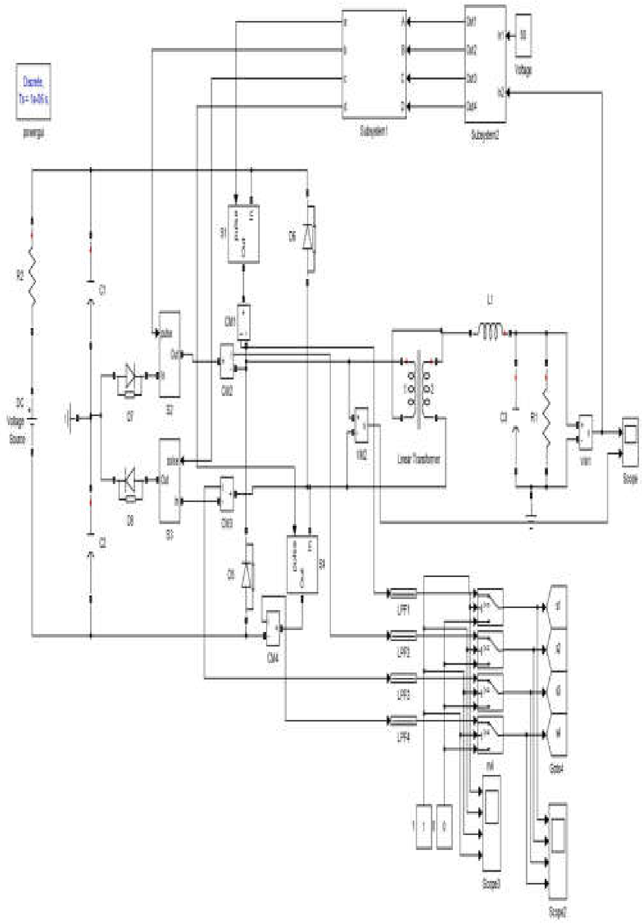

Fig. 7. Simulation Diagram of Proposed System

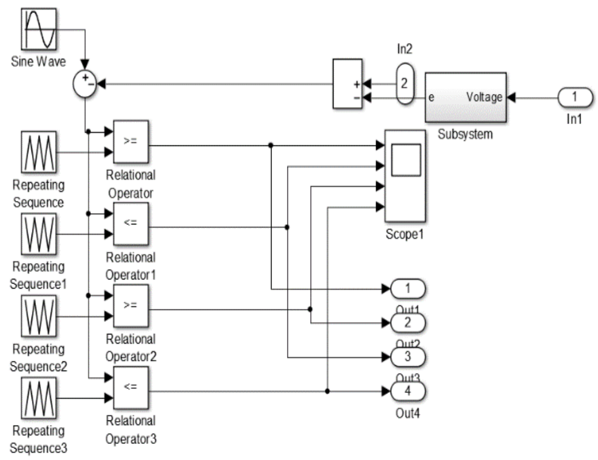

Fig. 8. Subsystem 1

Conversely, for switches S2 and S4, if the amplitude of the sine wave is less than the amplitude of the carrier wave, then the switches turn ON and vice versa.

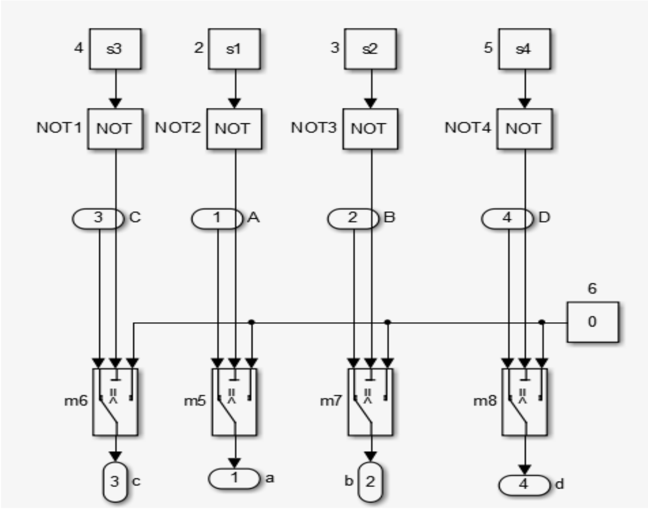

Fig. 9. Subsystem 2

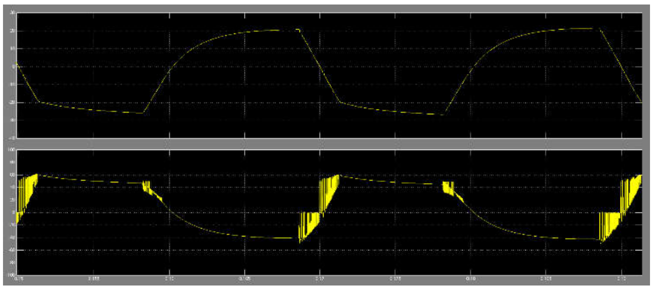

Fig 10: Output During Fault Condition

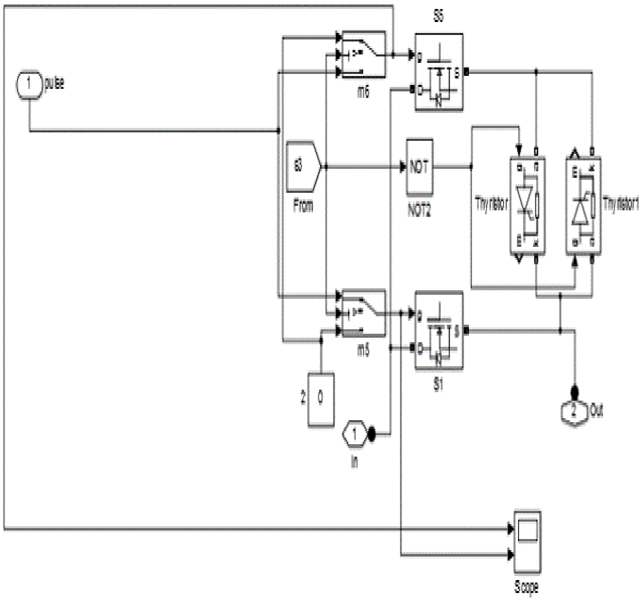

Fig. 11. Bypass Switch

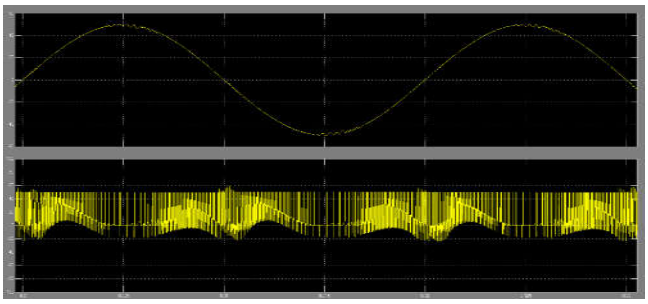

Fig 12. Output after Fault Rectification

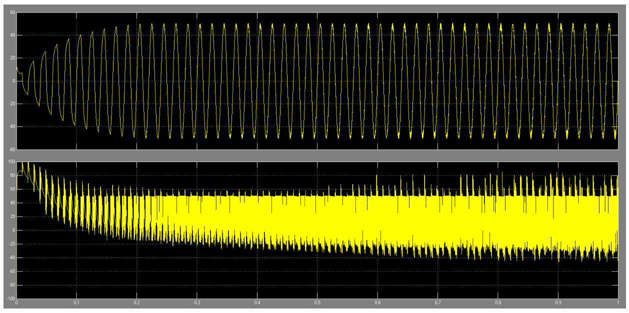

Fig. 12. Output After Fault Rectification

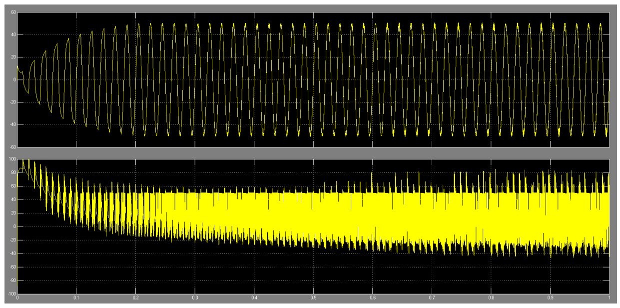

Fig. 13. Output Voltage

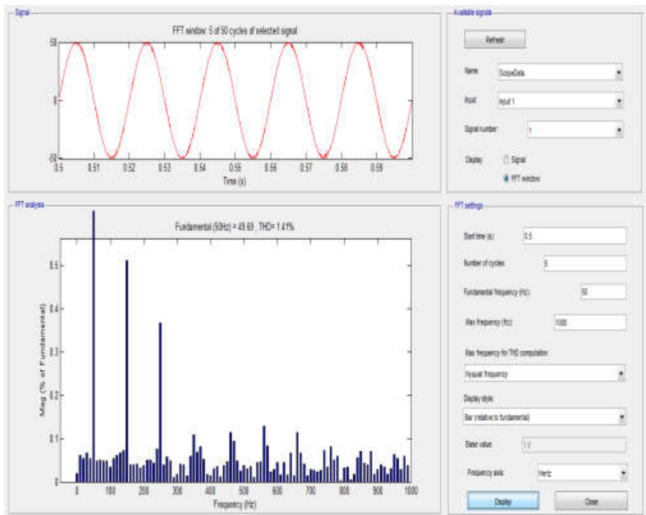

Fig. 14. Thd of the Inverter

Fault localization and correction

For analysis purpose, fault is artificially created in a subsystem2 by blocking the pulses to the switches. The NOT gate which when activated blocks the incoming pulses from the subsystem1 and gives 0 as input to switches. This creates the fault in the respective switch. The open switch fault diagnosis is depicted as subsystem2 in which the gate pulse for a particular switch is blocked and the switch gets opened. Then in the closed loop system, the voltage and the current are continuously sensed. If the current sensed across any switch is zero. Then the switch has the influence of open switch fault. After the fault is being localized across the switch, the current flow is bypassed by using another switch which acts as a backup. Because of this backup or bypass switch, there is no discontinuity in the current flow. The bypass path is shown below in the fig.11 To sum up, if the current pulse is one then the current flows as usual through the switch in the circuit and if it is zero the gate pulse is given to bypass switch. This way there is continuity in flow of current and the output is obtained without any discontinuity.

Conclusion

An open-switch fault detection method for a back-to-back converter using an NPC topology has been proposed in this paper. The proposed detection method just uses the phase current without requiring additional devices. In fault detection and localization method under the open fault in multiple switches in three-phase AC/DC PWM converter for wind power generation system. Various kinds of fault may occur in AC/DC PWM converter, which decreases the generator output power and degrades the stability in wind power generation system. In this paper, multiple as well as single open-switch fault conditions are investigated. By analyzing various information current waveforms, the proposed scheme is able to detect the open-switch fault and find the faulty switch in multiple switches as well as in single switch irrespective of operating conditions. The proposed fault detection and localization algorithms do not require any additional sensors or hardware since they use only the information on measured phase currents. The proposed algorithms require only simple mathematical operations with the reduced computational efforts, which makes the proposed diagnosis quite simple and cost-effective. It can be easily implemented into the main controller without any complexity to improve the reliability of the practical three-phase AC/DC PWM converter. Twenty-one cases of open faults in multiple switches as well as in single switch are used for test conditions. The simulation results under different operating conditions have been presented to prove the effectiveness of the proposed scheme and its independence on operating conditions.

REFERENCES

Duan, P., Xie, K., Zhang, L.and Rong, X. 2011. "IEEE Trans. on Power Electronics", Open-switch Fault Diagnosis and System Reconfiguration of Doubly fed Wind Power Converter Used in a Microgrid, vol. 26, no. 3.

Estima, J. O. and Cardoso, A. J. M. 2011. "IEEE Trans. on Industry Applications", A New Approach for Real-time Multiple Open-circuit Fault Diagnosis in Voltage-source Inverters, vol. 47, no. 6.

Jeong, H. G., Lee, K. B. S., Chio, and Choi, W. 2010. "Performance improvement of LCL-filter-based grid-connected inverters using PQR power transformation," *IEEE Trans. Power Electron.*, vol. 25, no. 5, pp. 1320–1330, May.

Lu, B. and Sharma, S. K. 2009. "IEEE Trans. on Industry Electronics" A Literature Review of IGBT Fault Diagnostic and Protection Methods for Power Inverters, vol. 45, no.5.

Peuget, R., Courtine, S. and Rognon, J. P. 1998. "IEEE Trans. on Industry Applications", Fault Detection and Isolation on a PWM Inverter by Knowledge-based Model, vol. 34, no. 6.

Sleszynski, W., Nieznanski, J. and Cichowski, A. 2009. "IEEE Trans. on Industrial Electronics", Open-Transistor Fault Diagnostics in Voltage-source Inverters by Analyzing the Load Currents, vol. 56, no. 11.