OPEN-CIRCUIT FAULT DIAGNOSIS IN VSI BY SIMPLE DIRECT CURRENT METHOD

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ABSTRACT

Failures in the Power device of inverter can be mainly divided as open circuit faults and short circuit faults. This type of failure will not necessarily cause the system shutdown and can remain undetected for an extended period of time. This can cause to another faults in the converter or in the remaining component, resulting total system shutdown and high repairing cost. For these reason, development of online methods that can detect open-circuit fault in voltage source inverter has become important. This paper focus on method of open-circuit fault diagnosis is current spectrum analysis technique which is based on the study of harmonic analysis of load current or output current of the inverter. Zero-order harmonics /DC component present in the signal when open-circuit fault occurs. The amplitude and the argument of each harmonics are used for open-circuit fault detection and localisation.

Keywords- Voltage source inverter (VSI), Simple Direct Current Method.

I. INTRODUCTION

In general, Power device failure in the power electronic system can be broadly classified as short circuit faults and open circuit faults. The protection against short circuit has become standard feature for industrial drives; the open circuit failures have not received so much attention. Open circuit fault will not necessarily cause the system shutdown and can remain undetected for an extended period of time. This may lead secondary faults in the converter or in the remaining drive components, resulting total system shutdown and high repairing cost. This is not desirable for many applications such as military, aerospace etc. Therefore, there is increase in demand of reliability and safety of industrial system against abnormalities or component faults. To prevent the unscheduled shutdown, real-time fault tolerant operation must be implemented.

Some real-time diagnostic technique based on real time depends on complicated artificial fault analysis and some technique based on voltage or current of power electronic device. They are applicable for fault detection of switch component such as IGBT and MOSFET.

Other technique based on artificial intelligence, data driven method such as artificial neural network which diagnosis typical component fault based on measured voltage and current signal and they only applicable for

ISSN: 2394-3696, Website: www.ijiert.org, June, 2022

specific fault and device condition. There is another one method which is based on neural network. In this technique first needed to train sample data based on historical fault free signal and faulty signal. Depend on this value diagnosis of fault is done.

II. PROPOSED METHOD FOR FAULT DIGNOSIS

There are various methods used for open-circuit fault detection in voltage source inverter feeding RL load such as neural network, fuzzy network, spectrum analysis, etc. but they are not reliable and fault detection time is more, so that we go through Simple Direct Current Method approach. By using these methods, fault detection of system shown in fig. (1) is done.

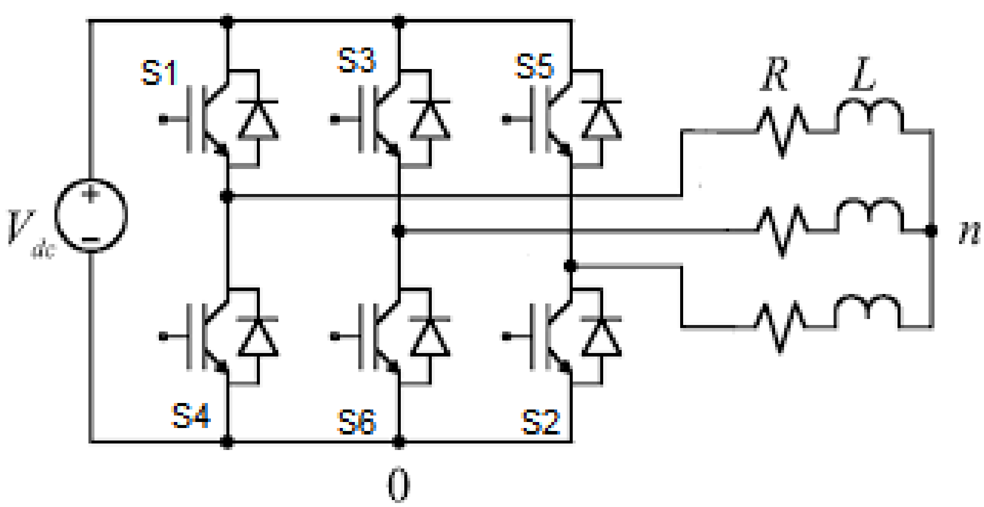

Fig.1- VSI with R-L Load

III. Methodology

A straight forward and easy to implement fault detection scheme is the simple direct current method. The Simple DC Current method uses the direct component encountered in faulty phases same as Normalized Park's Vector Approach, but does not use a Park's Vector transformation or normalization. Direct component of each phase is compared to a threshold value 0.45 to localize the faulty switch as displayed in table1. Simple direct current method uses mean value of phase current for fault detection. The largest of three phase dc current value (absolute) is compared with threshold 0.45 to identify faulty leg. Faulty switch is localised from polarity of mean value. By using this method only single IGBT open-circuit fault diagnosis is done.

ISSN: 2394-3696, Website: www.ijiert.org, June, 2022

Table 1- Diagnostic variables of Simple direct current method for the faulty switch identification

Faulty Switches	en			<InN>		
	Ea	eb	ec	<IaN>	<IbN>	<IcN>
S1	+Ve	-	-	-Ve	-	-
S2	-	-	+Ve	-	-	+Ve
S3	-	+Ve	-	-	-Ve	-
S4	+Ve	-	-	+Ve	-	-
S5	-	-	+Ve	-	-	-Ve
S6	-	+Ve	-	-	+Ve	-

IV. MATLAB Simulation and Results

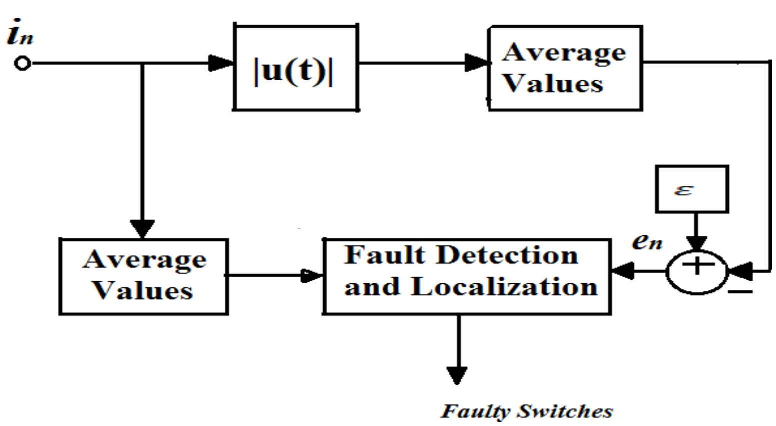

Fig.2- Proposed fault diagnostic Simple direct current method for VSI

Results of Simple direct current method performance under different failure configuration are given below.

Time domain waveform of the three phase inverter current (load current) in fig.(3), diagnostic variables (ea) fig.(4) and average value of current fig.(5) for single power switch open-circuit fault in IGBT S1 is shown below. Open-circuit fault in switch S1 is introduced by removing its gate signal at t=0.5. When open circuit fault occurs in S1 e a become positive. As ea is nothing but diagnosis variable of a-phase i.e. a-Phase of the inverter is open.

As fault occurs in S1, current flowing through S1 is zero but current flow through lower switch S4 i.e. negative current. By calculating mean value of this faulty switch is localized.

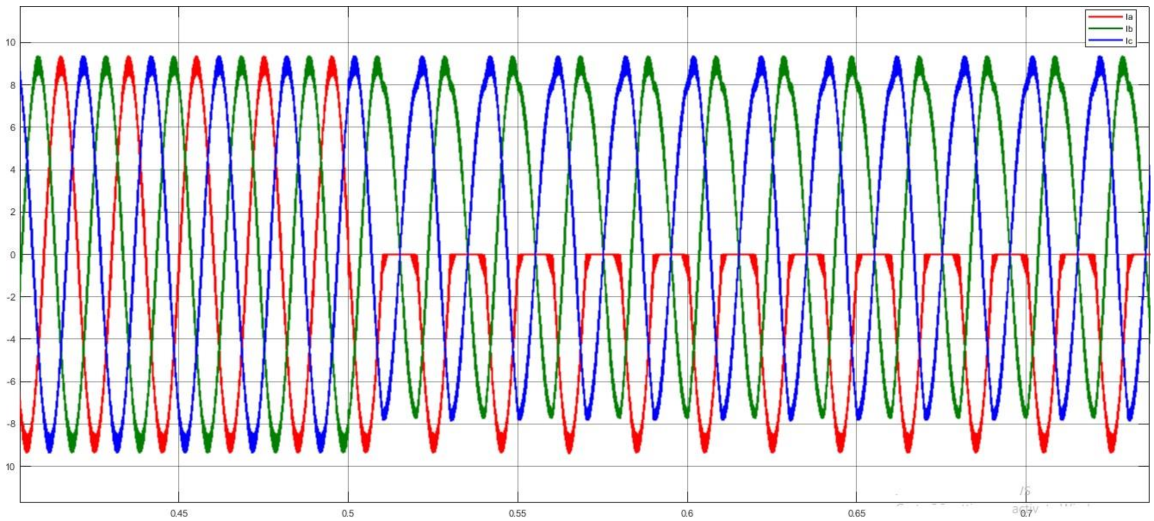

Fig. 3 Time domain waveform of load currents (Ia,Ib,Ic) when open-circuit fault occur in IGBT S1

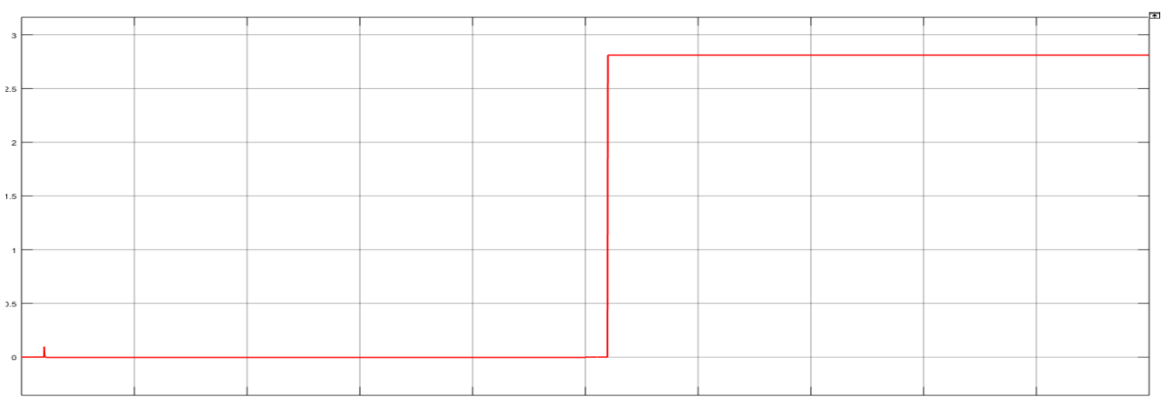

Fig.4 Time domain waveform of diagnostic variables (ea) when open-circuit fault occur in IGBT S1

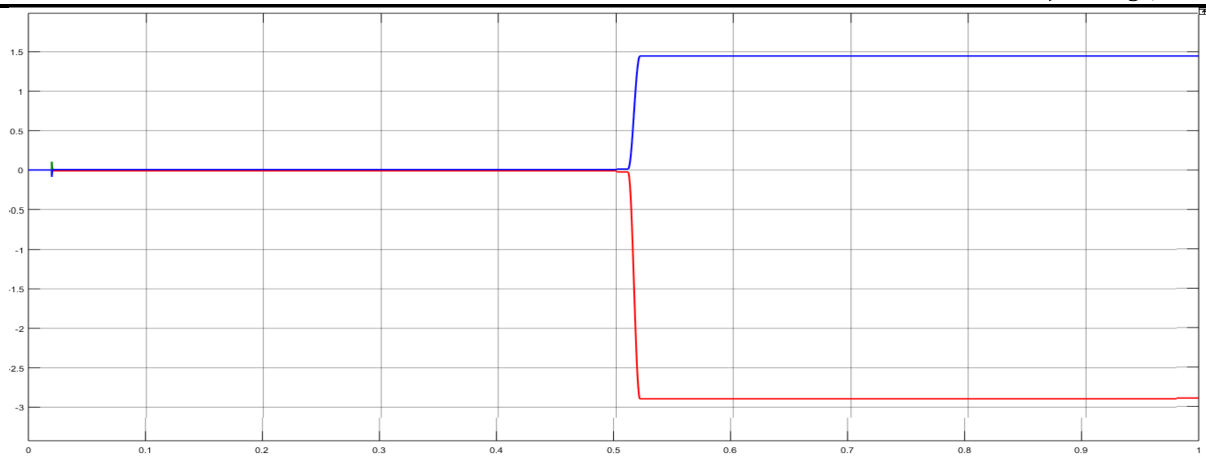

Fig. 5 Time domain waveform of average value of current when open-circuit fault occur in IGBT S1

Time domain waveform of the three phase inverter current (load current) in fig.(3.6), diagnostic variables (ea) fig.(3.7) and average value of current fig.(3.8) for single power switch open-circuit fault in IGBT S4 is shown below. Open-circuit fault in switch S4 is introduced by removing its gate signal at t=0.5. When open circuit fault occurs in S4, ea become positive. As ea is nothing but diagnosis variable of a-phase i.e. a-Phase of the inverter is open.

As fault occurs in S4, current flowing through S4 is zero but current flow through upper switch S1 i.e. positive current. By calculating mean value of this faulty switch is localized.

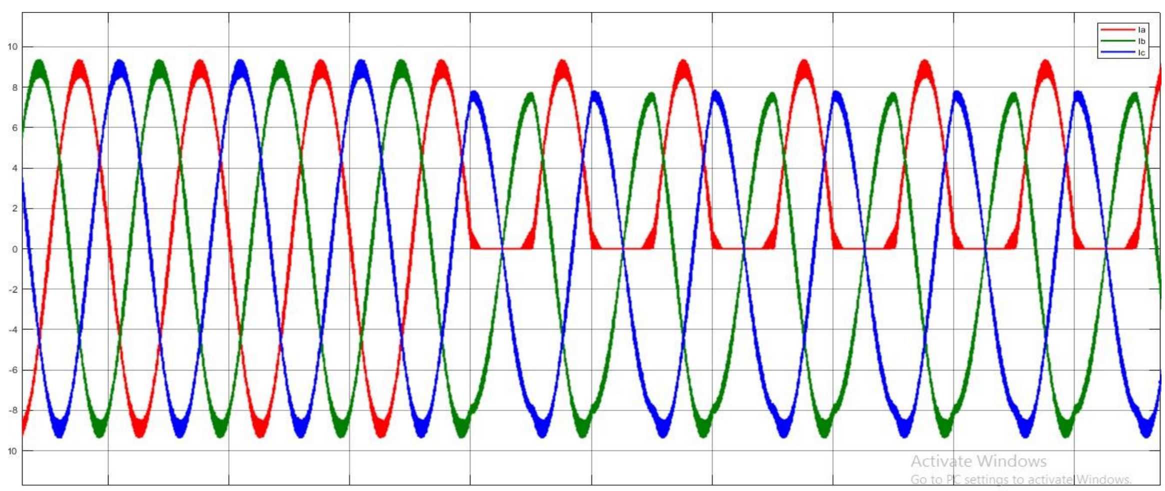

Fig.6 Time domain waveform of load currents (Ia,Ib,Ic) when open-circuit fault occur in IGBT S4

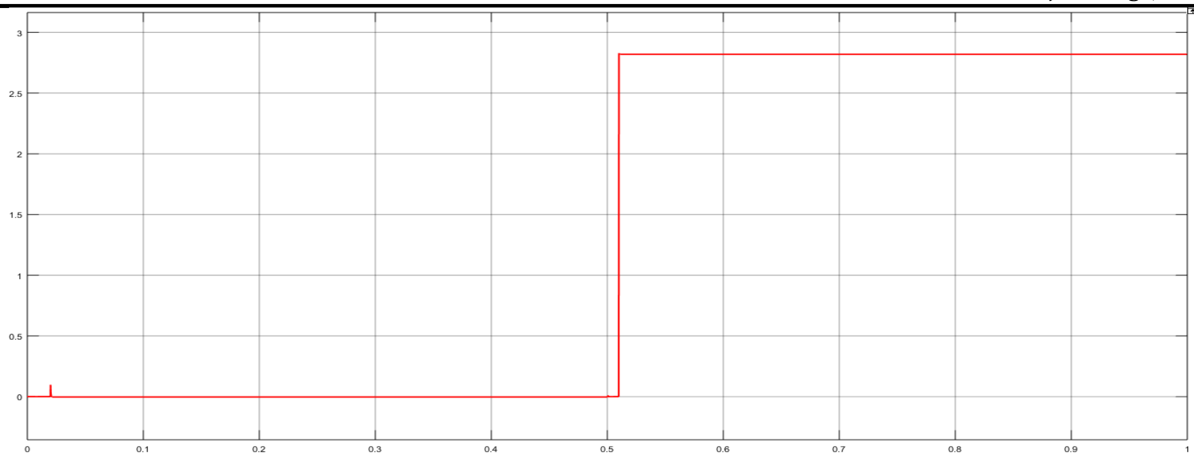

Fig. 7 Time domain waveform of diagnostic variables (ea) when open-circuit fault occur in IGBT S4

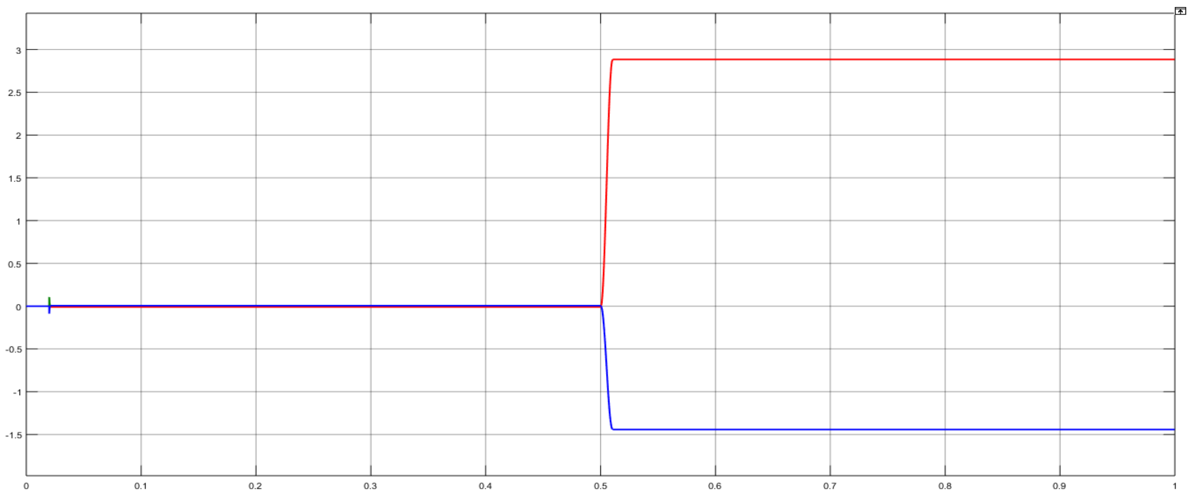

Fig. 8 Time domain waveform of average value of current when open-circuit fault occur in IGBT S4

V. CONCLUSION

In simple direct current method, transformation or normalisation of current is not required. Measured value of current directly compared with threshold value which is equal to 0.45. From this comparison, open-circuit fault produced in VSI can be detected. The fault detection time is nearly equal to 9 msec which is very less.

The simulation parameter used for proposed system are listed in Table 2

Table 2- Simulation parameter for proposed system

Parameters	Value
Input voltage (V_{DC})	400 V
Switching frequency (f_s)	10 KHz
Load (R(ohm), L(mH))	20 ohm, 5mH

REFERENCES

1] Bin Lu, Santosh K. Sharma, “A literature review of IGBT fault diagnostic and protection methods for power inverters,” *IEEE Transaction on Industry Application*, vol.45, no. 5, September/October 2009.

2] F. W. Fuchs, “Some diagnosis methods for voltage source inverters in variable speed drives with induction machines—A survey,” in *Proc. 29th Annu. Conf. IEEE Ind. Electron. Soc.*, Nov. 2–6, 2003, vol. 2, pp. 1378–1385.

3] A. M. S. Mendes, A. J. M. Cardoso, and E. S. Saraiva, “Voltage source inverter fault diagnosis in variable speed AC drives, by Park’s vector approach,” in *Proc. 7th Int. Conf. Power Electron. Variable Speed Drives*, 1998, pp. 538–543.

4] R. Peuget, S. Courtine, and J. P. Rognon, “Fault detection and isolation on a PWM inverter by knowledge based model,” *IEEE Industry Applications Society Annual Meeting New Orleans, Louisiana*, October 5-9 1997.

5] H.-K. Cho, S.-S. Kwak, and S.-H. Lee, “Fault diagnosis algorithm based on switching function for boost converters,” *Int. J. Electron.*, vol. 102, no. 7, pp. 1229–1243, 2015.

6] E. Ribeiro, A. Cardoso, and C. Boccaletti, “Fault-tolerant strategy for a photovoltaic DC–DC converter,” *IEEE Trans. Power Electron.*, vol. 28, no. 6, pp. 3008–3018, Jun. 2013.

7] S. Nie, X. Pei, Y. Chen, and Y. Kang, “Fault diagnosis of PWM DC-DC converters based on magnetic component voltages equation,” *IEEE Trans. Power Electron.*, vol. 29, no. 9, pp. 4978–4988, Sep. 2014.