Comparative Study of Diagnostic of Inverter Three and Five Levels Associated with Asynchronous Machine

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Abstract: ***This article presented a diagnostic of the inverters multi levels associates with the three-phase asynchronous squirrel-cage machines. That shows the faults of the switches for each inverter multi levels and their influence on the answers speed and torque.***

Keywords: asynchronous machine, diagnostic, inverters three states, inverter five levels.

1. Introduction

The voltage source inverters is consisting a non controllable function in the power electronic, it is used in the variable methods application. The strategy obtaining by this technique is based on the study of speed variation in induction machine. The strong evolution of this function was based, on the one hand, on the development of semi-conductor components entirely commandables, powerful, robust and fast, and on the other hand, on the quasi generalized use of the techniques known as pulse width modulated [1] [2].

2. Principle Operation of the Inverter Three Levels

The figure (1) represents the general diagram of the one of topologies of the three-phase inverters on three levels. The source of voltage continuous is consisted association in series of two groups of condensers of filtering delivering an intermediate potential with half voltage ($U_d/2=E$).

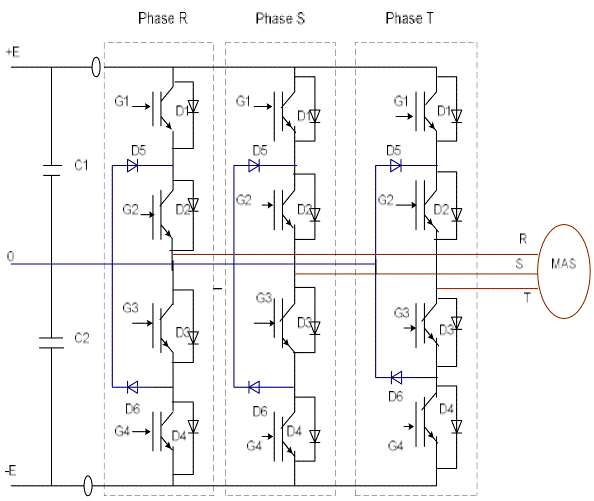


Figure 1: General diagram of the power circuit

Each half-arm of the inverter is composed of two switches in series with their common point connected by a diode in the middle of the source continuous. The direction of the diode depends on the polarity of the half-arm. To analyze the potentials generated by the three-phase inverter three states, it is interesting to show the whole of the combinations of potentials between the three phases like their evolutions during one period. The presentation of the intrinsic possibilities of this structure constitutes a reference of analysis for the strategies of piloting. The figure (2) has an equivalent structure of the three-phase inverter three states in which the functions of semiconductors are symbolized by switches. Each arm of the inverter is schematized by three switches independently making it possible to connect the three terminals R, S, T with the three potentials of the +E source, 0, - E. Thus, the full number of combinations of the operating conditions of this type of inverter is of 27 (3*3*3). This number is to be compared with that of the three-phase inverter in two states which is of 8 (2*2*2). [2] [4] [6]

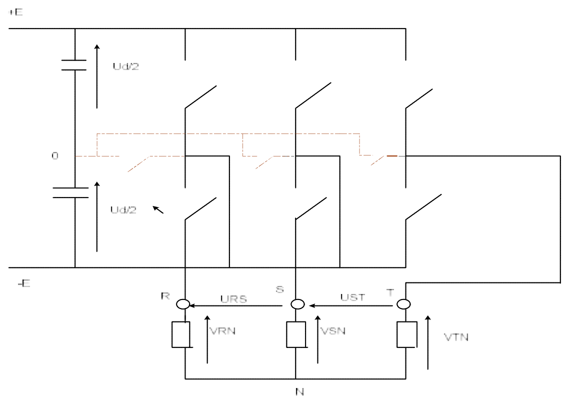


Figure 2: Equivalent structural of the three-phase inverter has three states.

Let us specify that the Neutral N of the receiver should not be connected to the point of the source. The potentials of the terminals R, S, T referred compared to the point medium 0 are noted as follows: [2] [6]

$$V_{R0}, V_{S0}, V_{T0} \; with \; V_{R0} + V_{S0} + V_{T0} \neq 0$$

Let us recall that the respective sums of the simple voltage is made up of the receiver are null. According to its potentials, the relations of the receiver are written.

Simple voltage:

$$\begin{bmatrix} V_{RN} \\ V_{SN} \\ V_{TN} \end{bmatrix} = \frac{2}{3}\begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ -\frac{1}{2} & 1 & -\frac{1}{2} \\ -\frac{1}{2} & -\frac{1}{2} & 1 \end{bmatrix}\begin{bmatrix} V_{R0} \\ V_{S0} \\ V_{T0} \end{bmatrix} \quad (1)$$

Phase voltage:

$$\begin{bmatrix} V_{RN} \\ V_{SN} \\ V_{TN} \end{bmatrix} = \begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{bmatrix}\begin{bmatrix} V_{R0} \\ V_{S0} \\ V_{T0} \end{bmatrix}$$

3. Structure Of The Inverters Has Five Levels

In order to go up in voltage and power, the conventional inverter on two levels starts with uses replaced by the inverters multi levels in the industrial applications most varied, requiring a great power. The judicious exploitation of the point medium of the continuous source appreciably improves quality of the wave of voltage with dimensions receiver what is advantageous to reduce the torque pulsatory and the losses in the induction machines. An advantage which rises from this structure consists with the best controls constraints in the components voltage, the amplitude of the terminal voltage is limited to the half voltage of the source raised of has overpressure due to the commutation of the switches.

This topology is able to generate a simple voltage on five levels (between the arm of inverter and the point medium). In this paragraph we study the structure of the inverter to five levels (figure 3). This structure is composed of three symmetrical arms consisted each of six switches of series and two others in parallels G_7 and G_8. More two diodes, noted D_9, D_{10} allowing obtaining level zero of the voltage V_{k0} (k=R, S, T). Each one of these switches is composed of a semiconductor bi-commandables and of a diode assembled in teat digs. [1] [4] [6].

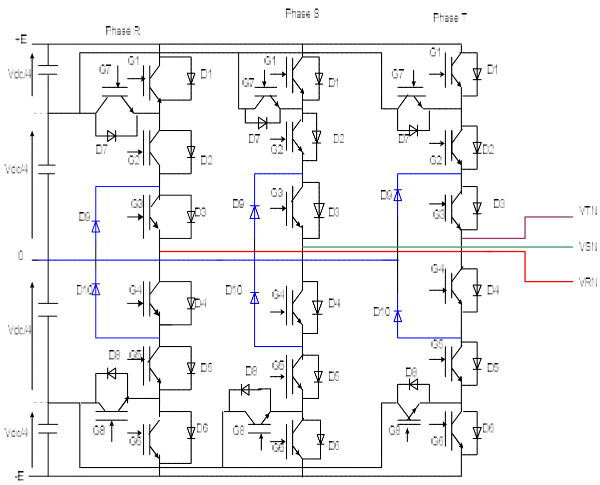


Figure 3: The inverter five levels structural

4. Diagnostics Faults of Inverter Multi Levels

The application domains of the three-phase inverters of voltage most known in industry are undoubtedly that of the electric drives at variable speed. The three-phase inverters, in spite of their qualities, which have pusses to reach thanks to the development of the power electronics, and the use quasi-generalized of the techniques known as of "pulse width modulation", can present a structural fault such as the fault of closing of the semiconductors. This type of induced dysfunction of the constraints can be damages for the systems of production if the personnel are not informed and that a spurious shutdown is produced. Since, the equipment of protection intervenes only at the last stage of fault; it is thus obvious, that the investment in the field of the detection of the dysfunctions appears a solution impossible to circumvent.

Many faults of the inverters multi levels is detected by using overpressures and the over currents of current system. However, the detection of fault of the elements of commutation is very difficult because the voltage and the current according to each fault of commutation decrease quickly compared to the normal functioning. The disequilibrium of the continuous voltage at the input of the inverter multi levels, as the faults occur, causes serious problem for the protection and the reliability of the system [2] [3] [5].

4.1 Diagnostics Faults of Inverter Three Levels

In the inverter three levels, the voltage of phase, nine levels exist under normal functioning, but their levels of voltage seem to be different with each fault from commutation.

In the event of fault of commutation of K_{11}, the voltage of phase for the positive period has only $+\frac{V_{dc}}{3}$ $(V_{dc} = 2E)$ it because the current of phase crosses the K_{12} switch in the state of P (positive). When the faults of the inverter three levels occur, the current overflowing in the point medium poses a great effect in the radial force/discharge of the condensers.

4.2 Diagnostics Faults Of Inverter Five Levels

In the inverter five levels, the voltage of phases have fifteen levels under symmetrical functional, but their levels of voltage seem to be different with each fault from commutation. The voltage of phase for the positive period has only five levels because the current of phase crosses the K_{17} switch instead of k_{11} in the state of P (positive). In the event of fault of commutation of k_{12}, the voltage of phase for the positive period has only three levels because the current of phase crosses the K_{13} switch in the state of P (positive). Consequently when each fault of commutation occurs, the voltage of fictitious phase differently appeared between them. The fault of K_{17} and k_{12} induces a disequilibrium in the three phases, which translates by the discharge of the lower condensers of the arm R of the inverter five levels [2] [3].

5. Result Simulation

The simple tension of the inverter three levels (three states) takes the values ±2E, ±E, 0 what can be translated by the improvement of the form of wave of the output voltage of the inverter three states. For a fault of the K_{11} switch of the inverter 3 states, the figure (4) illustrates the control of voltage disequilibrium when the fault of commutation occurs, but the currents I_{ra}, I_{sa} resulting from the faults of the switches K_{11} represented by the figure (6), that show disequilibrium of this currents. The figure (5) represents leads of asynchronous machine before and during the fault, which are translated by an augmentation of speed and the oscillations of the torque. After this oscillation the torque augments but the speed dominated. For the inverter five levels the form of V_{an} voltage and currents I_{sa}, I_{ra} resulting from the faults of the K_{12} switches for inverter five level illustrated by the figure (7) and figure(9), which shows the effect of these faults on disequilibrium of the currents.

During the fault of the K_{12} switch we remark an augmentation of speed and oscillations of the torque but after this oscillation the speed dominated, which illustrated by the figure (8). In results that more goes up from the levels of inverters will have some more of the improvements of the shape of wave of the current.

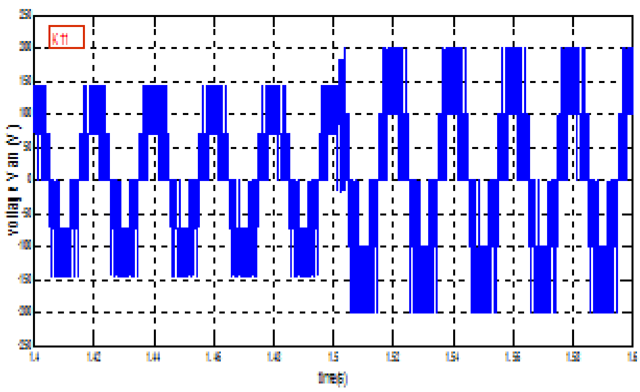
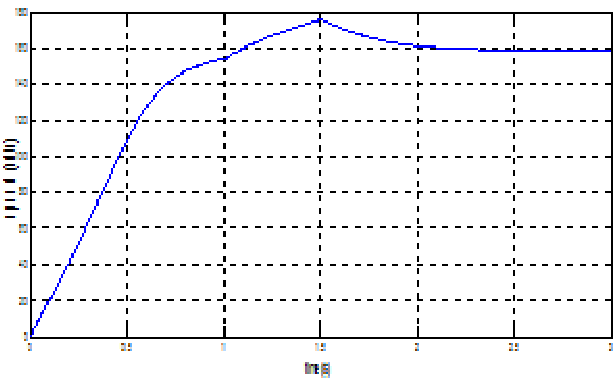
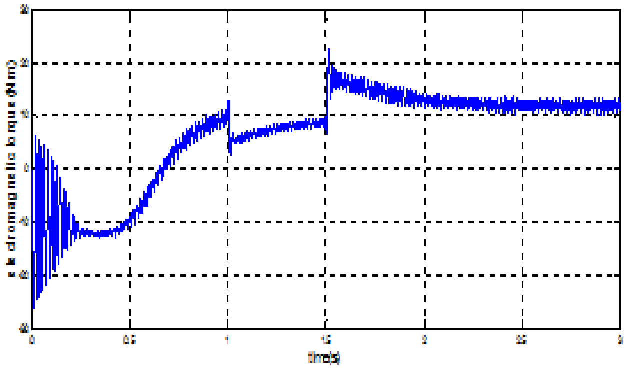


Figure 4: the voltage results Van of inverter three levels with fault in switch K_{11} a t (1.4, 1.6)



(a)



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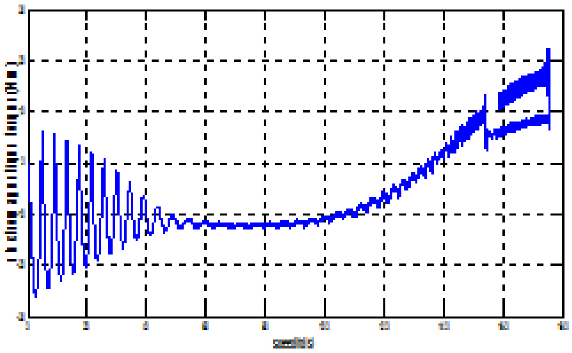
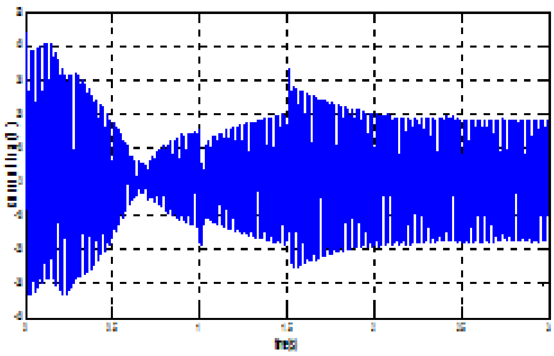


(c)

Figure 5: speed, electromagnetic torque and speed (torque) results of inverter three levels with fault in switch K_{11} at t (1.4, 1.6)



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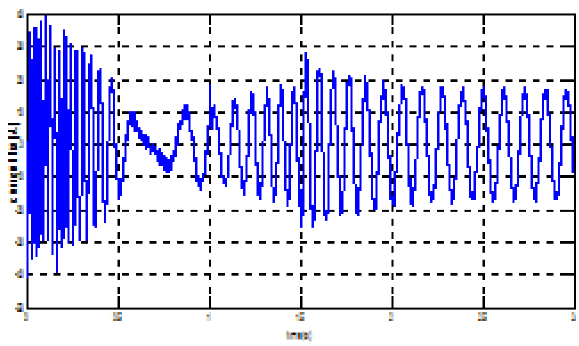


(b)

Figure 6: The current I_{sa}, I_{ra} result of inverter three levels with fault in switch K_{11} at t (1.4, 1.6).

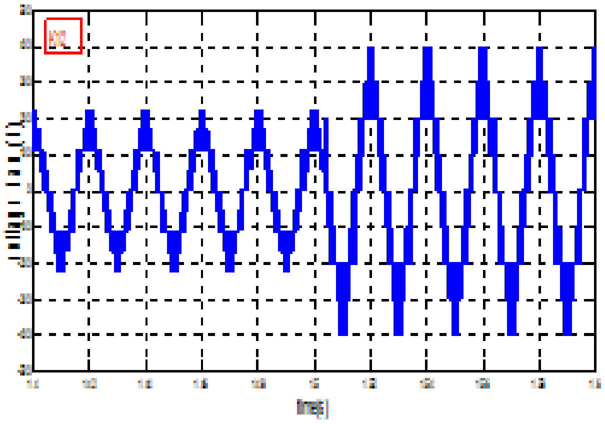
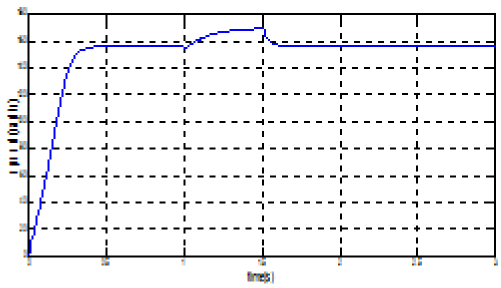


Figure 7: The voltage results Van of inverter five levels with fault in switch K_{12} a t (1.4, 1.6)



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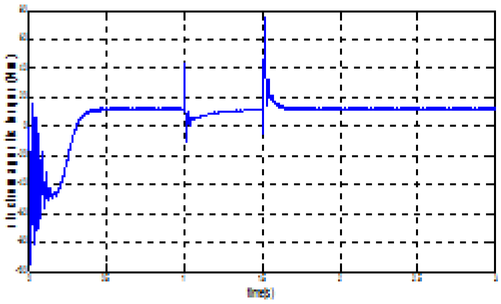

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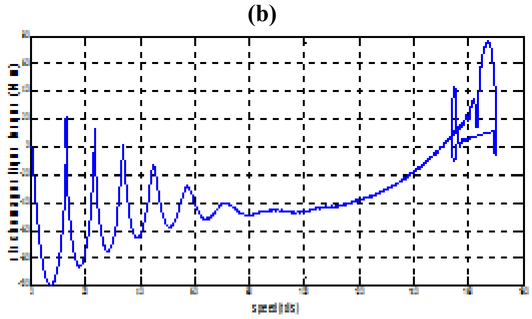
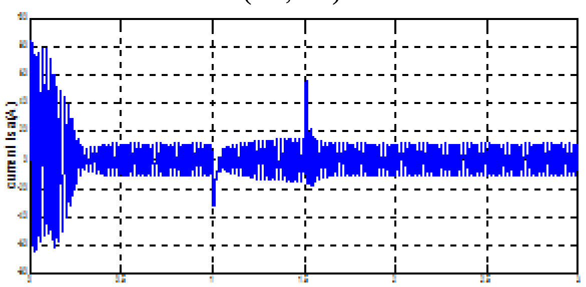


(c)

Figure8: Speed, electromagnetic torque and speed=t (torque) results of inverter five levels with fault in switch K_{12} at t (1.4, 1.6)



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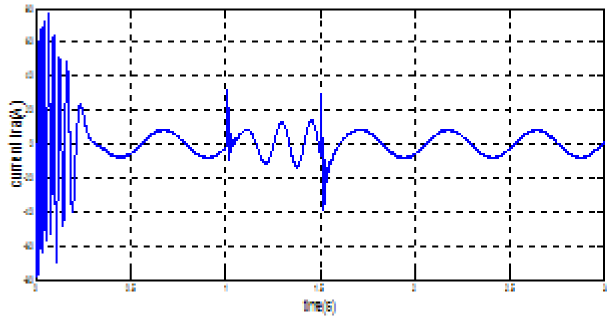

(b)

Figure 9: The current Isa, Ira result of inverter five levels with fault in switch K_{12} at t (1.4, 1.6)

6. Conclusion

We developed a new structure of the voltage inverters with three levels, like their principle of operation associated with an asynchronous machine, one notes according to the results obtained a clear improvement of the performances of the unit inverter machine compared to the conventional inverter. Then we elaborate a new functional model of the three-phase inverter with five levels. The results obtained show well the contribution of the inverters multi levels for the improvement of the performances of the asynchronous machine. After proposed the diagnosis method of fault of the inverter three and five levels which proposes the following advantage, the diagnostic of fault can easily identifies each fault of commutation.

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