Diagnostic of Inverter Three Levels Associated with Asynchronous Machine

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Abstract

This article presented the diagnostic of the inverter three level associate with the three-phase asynchronous squirrel-cage machines. Witch show the faults of the switches for this inverter and their influence on the answers speed and torque.

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 ($U_d/2=E$).

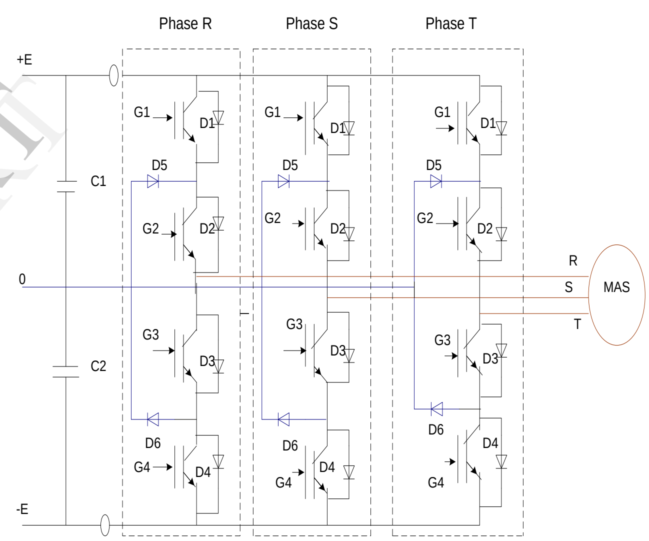


Figure1. General diagram of the power circuit

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]

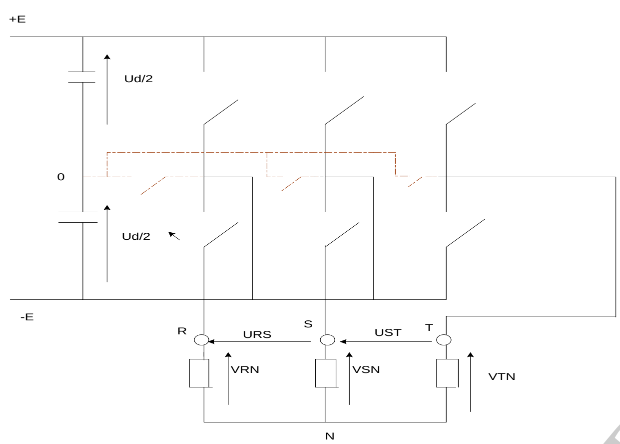


Figure2. Equivalent structural of the three-phase inverter has three states.

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]

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

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:

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

To describe the various configurations of operation of the converter, let us look at initially the values which can take a simple voltage, for example. The simple voltage is entirely defined by the state of the four switches of the first arm of the inverter, made up each one by a switch which can be a transistor, a GTO or an IGBT and a diode in parallel:

$$k_1 = [G_1 - D_1], k_2 = [G_2 - D_2], k_3 = [G_3 - D_3], k_4 = [G_4 - D_4] \quad (2)$$

The possible configurations of only one arm of switch is of 2^4=16 states which one can represent by a quadruplet of 0 or 1 following the state of the switches, k_1, k_2, k_3, k_4 only the three following configuration are implemented:

1st configuration $[G_1 G_2 G_3 G_4] = [1 \quad 1 \quad 0 \quad 0]$:

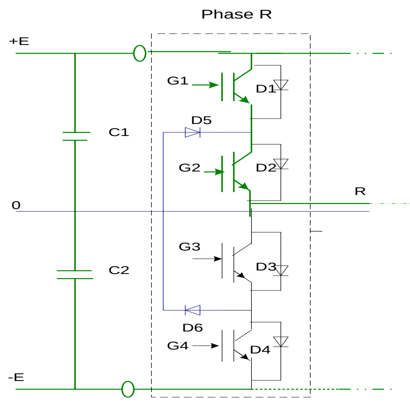
The figure (2.1-a) presents the state of the switches of first arm of the three-phase inverter of voltage has three levels. $G_1 \text{ and } G_2$ are opened, $G_3 \text{ and } G_4$ are blocked, the point R is connected to the noted higher point +, the voltage $V_{R0} = +E$

2nd configuration $[G_1 G_2 G_3 G_4] = [0 \quad 1 \quad 1 \quad 0]$:

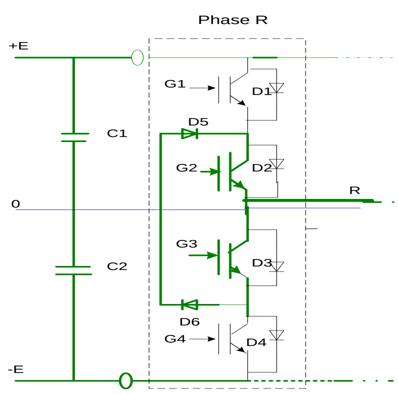
The figure (2.1-b) watch the setting has zero of the first arm of the inverter, $G_1 \text{ and } G_3$ are opened, $G_1 \text{ and } G_4$ are blocked, the point R is connected to the point medium 0, the voltage $V_{R0} = 0$.

3rd configuration $[G_1 G_2 G_3 G_4] = [0 \quad 0 \quad 1 \quad 1]$:

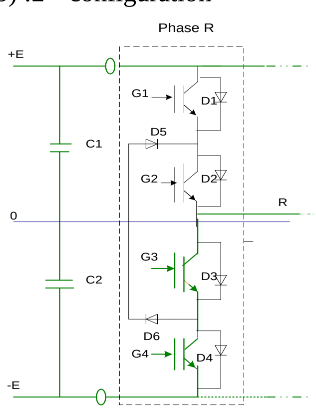
The figure (2.1-c) illustrates the state of the switches for the third configuration of operation of the inverter three levels, $G_1 \text{ and } G_2$ are blocked, $G_3 \text{ and } G_4$ are opened, the point R is connected to the noted lower point -, the voltage $V_{R0} = -E$



(a):1st configuration.



(b) :2nd configuration



(c) :3rd configuration

Figure 2. The differents configurations for1sd arm of inverter three levels.

Other sequences to be avoided because: Is they **cause short-circuit of the continuous voltage:**

Short-circuit of $E_1 and E_2$: $[1\ 1\ 1\ 1], [1\ 0\ 0\ 1]$

Short-circuit of E_1 : $[1\ 1\ 1\ 0], [1\ 0\ 0\ 0], [1\ 0\ 1\ 0]$

Short-circuit of E_2 : $[0\ 1\ 1\ 1], [0\ 0\ 0\ 1], [0\ 1\ 0\ 1]$

Is they cause the disconnection of a phase of the engine: $[0\ 0\ 0\ 0]$

Either they do not make it possible to ensure the connection of the phase of medium point some or direction of the current circulating in this phase: $[0\ 1\ 0\ 0], [0\ 0\ 1\ 0]$

3. 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. [2] [3] [5]

3.1. 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. 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. The figures (3) show the voltage waveforms simple and phase at the exit of the inverter three states; one notice a clear improvement of the form of the voltage V_{an} in the shape of staircase compared to the conventional inverter then figure (5) represented the result of statoric and rotoric current without fault. The figure (4) represents the speed then the torque which can have variations in permanent regime then stabilization in transitory regime. For a fault of the K_{11} switch of the inverter 3 states, the figure (6) illustrates the control of voltage disequilibrium when the fault of commutation occurs.

The figure (7) 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 and we have a diminution of speed. The currents I_{sa}, I_{ra} resulting from the faults of the K_{11} switches illustrated by the figure (8) that show how the faults of this switches, induces a disequilibrium on these currents.

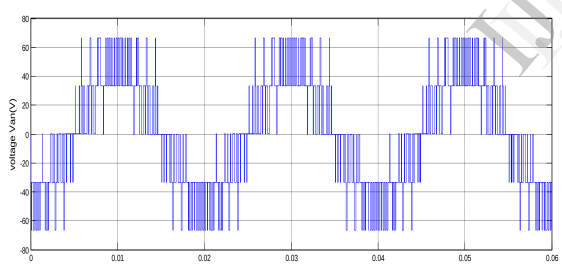
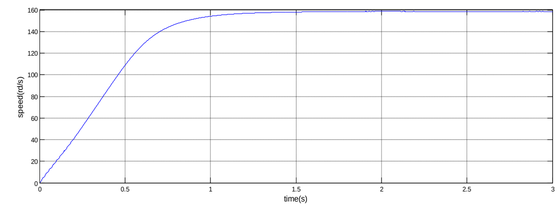
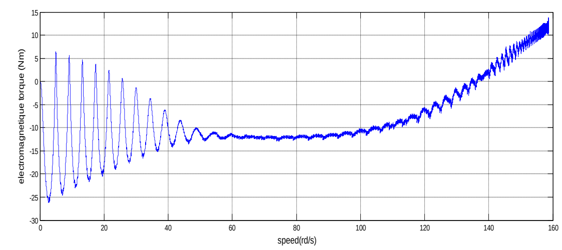


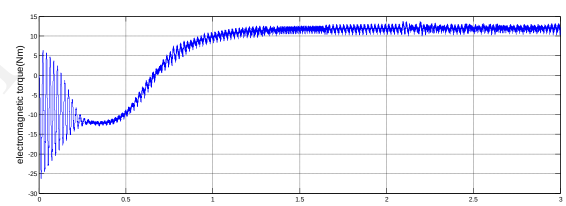
Figure3. The voltage results V_{ab} and V_{an} of inverter three levels without fault



(a)



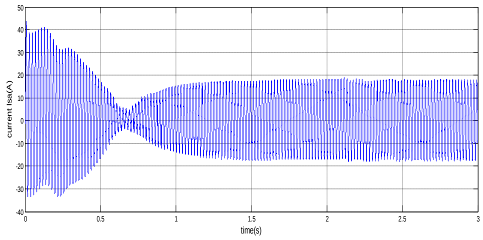
(b)



(c)

Figure4. Speed, electromagnetic torque and speed=t (torque) results of inverter three levels without fault

(a)



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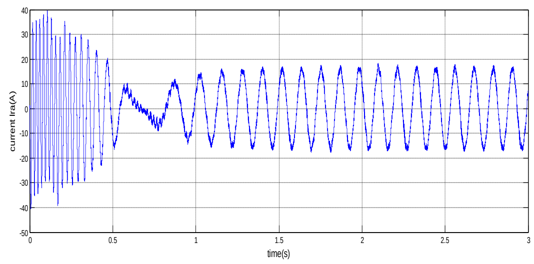


Figure5. The current I_{sa}, I_{ra} result of inverter three levels without fault

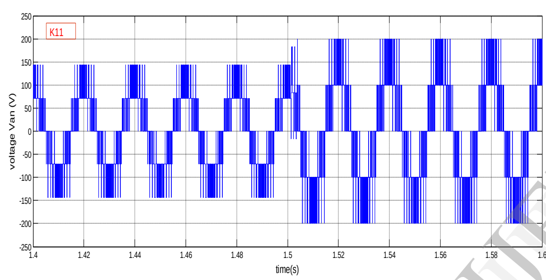
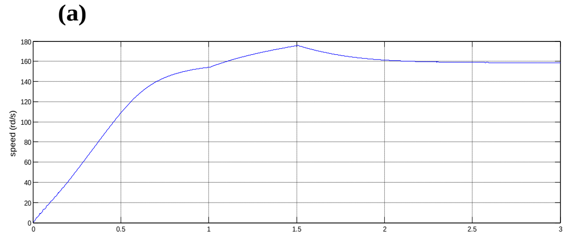
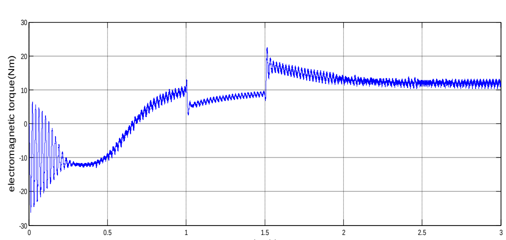


Figure 6. The voltage results Van of inverter three levels with fault in switch K_{11} a t (1.4, 1.6)

(a)





(b)

(c)

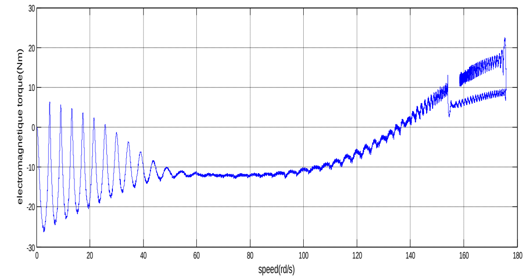
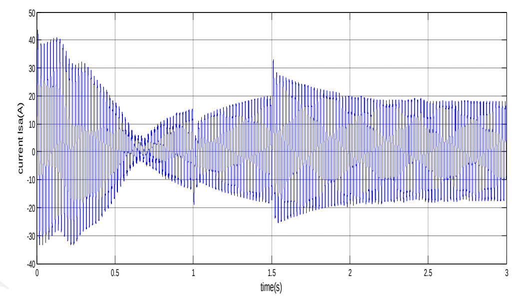


Figure7. Speed, electromagnetic torque and speed=t (torque) results of inverter 3 level with fault in switch K_{11} at t (1.4, 1.6)

(a)



(b)

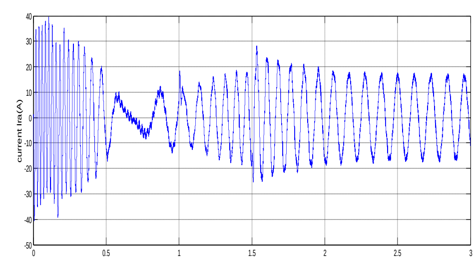


Figure 8. The current I_{sa}, I_{ra} result of inverter 3 level with fault in switch K_{11} at t (1.4, 1.6).

Conclusion

The developed of a new structure of the voltage inverters with three levels, like their principle of operation associated with an asynchronous machine, show that the results obtained give a clear improvement of the performances of the unit inverter machine compared to the conventional inverter. After proposed the diagnosis method of fault of the inverter three, which proposes the following advantage, the diagnostic of fault can easily identifies each fault of commutation.

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