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# Detection of Electrical Faults by the Time-Frequency Approach

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**Abstract**— This paper argues that detection of electrical drives faults, especially the process of failure will be characterized, containing induction machines. First, the context of the study is keeping the faults which might occur in a rotating electrical body in mind, and the research in detection of fault. Second, the development of diagnostic of the machine will be shown. The signal processing in known operating phases (fixed speed), considering and locating malfunctions. In this context, we proposed a new approach for diagnosis electrical defects based on the value of rotor resistance as fixed for condition monitoring. MATLAB/SIMULINK simulation is used in this work.

**Keywords**— asynchronous machine, modeling, signal processing, stator fault, inverter fault, stator current pattern.

## I. INTRODUCTION

Fault diagnosis of induction machine has become a central problem in power industry over the past decade. In fact, it is to be found in all the industrial fields and, particularly, in the growth industries like chemistry, nuclear power, aeronautic, or railway transports. The possibility of faults is inherent in converting electrical energy to mechanical energy. Therefore, there has been a substantial amount of research into the creation of new monitoring techniques for induction motor drives [1]. One of the main maintenance efforts is to detect faults occurring in electrical machinery [2,3]. The failures of asynchronous machine are divided into various types of faults; broken rotor bars, shorted stator turns, shaft misalignments, loads vibrations, torque oscillations, gearbox, and bearing faults. Approximately (45%) of the failures are due to the bearing faults [4-6], followed by stator (37%) and rotor faults (10%). These different techniques are appropriate responses to various challenges and constraints encountered during diagnosis, such as load level and the disruption of the power supply. The approach system, on the contrary, allows complete automation of the fault diagnosis process from the acquisition and data processing to decision making [7,8]. This paper proposes then a fault detection technique that takes into account some of the above discussed aspects. The proposed technique is based on stator current frequency spectral subtraction [9]. This paper is organized as follows: part II describes the induction machine model under simplifying assumptions. Part III, presents digital simulation results, the obtained results prove the effectiveness of the proposed monitoring method based on .

## II. THE INDUCTION MACHINE MODEL UNDER

### A. Overview of the Drive

The block diagram consists of an induction machine, pulse width inverter, rotor - directed flow control, a current measurement loop and a speed control loop. Fig. 1 shows the simplified diagram of the servo.

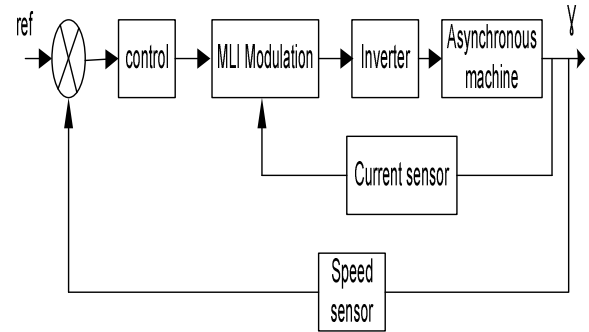


Fig. 1. Schematic of the control system studied.

The faults we are considering in such a drive:

In the machine a bar or the ring breaks down in the rotor.

## III. RESULTS AND DISCUSSIONS

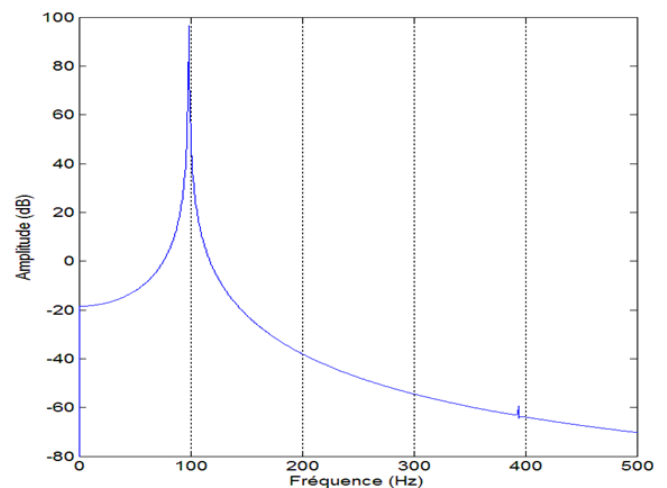
The test parameters are following [1]:

- From  $t=0$  to  $t=0.3s$ , flux application
  - From 0.3 to 1.8s, liner increase of the speed reference
  - From 1.6s constant speed
  - At  $t=3s$ , fault in the machine
- The observers are enabled from beginning.

### A. Frequency characterization of the faults

The purpose of the frequency characterization of faults consists, as a function of the fault considered, in determining the frequency (or frequencies) related to the fault and in discriminating the most relevant variable (measured or calculated) in which this frequency can be isolated.

### B. Good performance



(a)

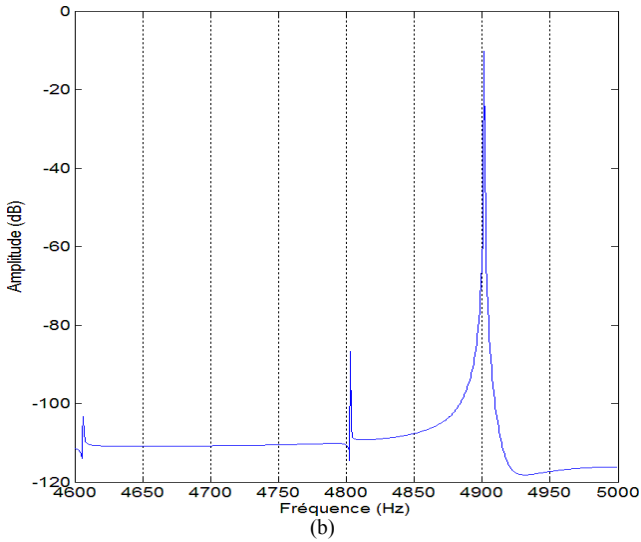
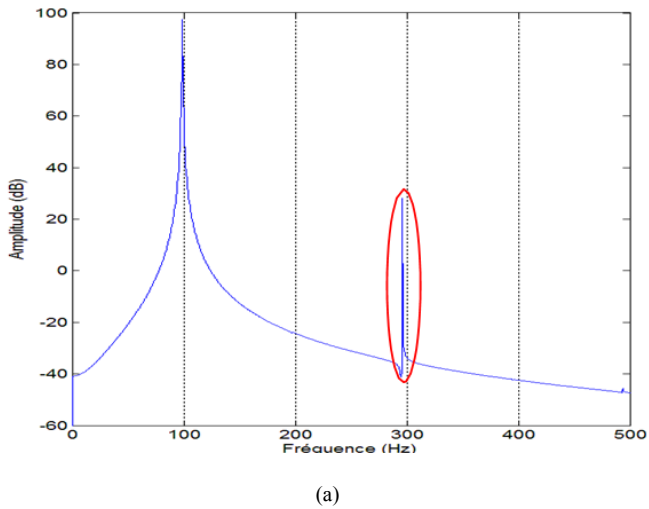


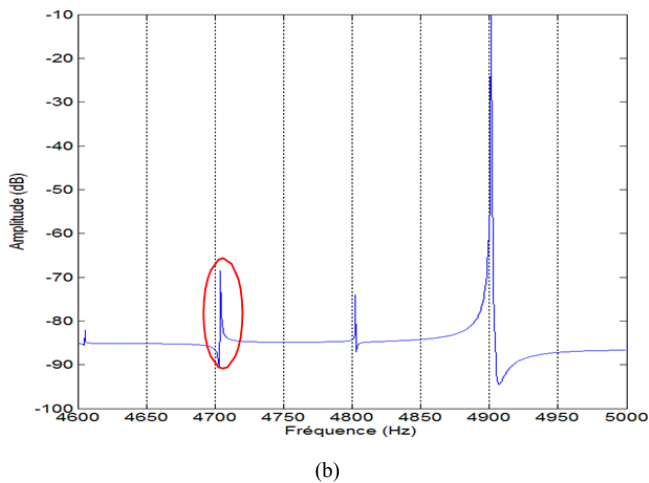
Fig. 2. Stator current spectrum of phase a in BF and HF.

Fig. 2(a,b) illustrates the spectrum of the stator current ( $I_{sa}$ ) of the phase an asynchronous machine without short circuit. In low frequency, note the presence of the fundamental frequency ( $f_e$ ). In high frequency, we note the presence of the frequency  $f_{MLI} - f_e$  and  $f_{MLI} - 2f_e$ .

### C. Motor operation with stator fault on one phase



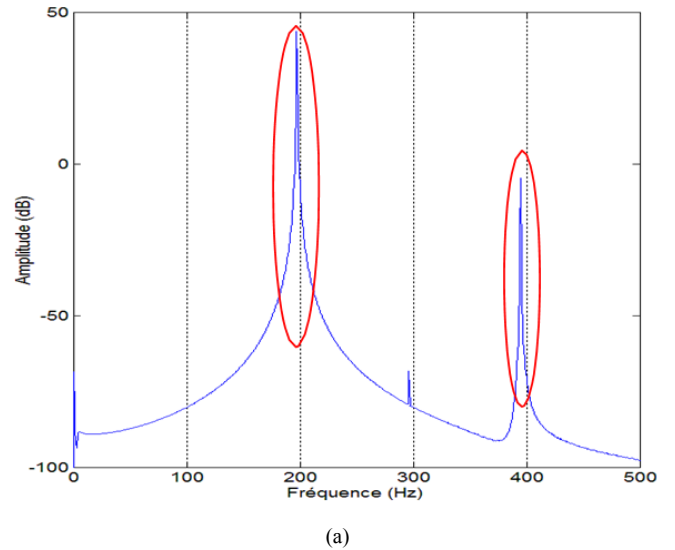
(a)



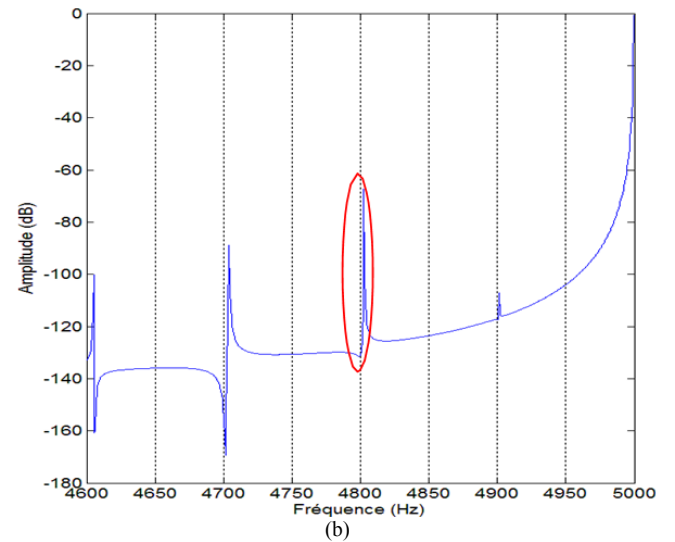
(b)

Fig. 3. Spectrum of the stator current ( $I_{sa}$ ).

Fig. 3(a,b) illustrates the spectrum of the stator current ( $I_{sa}$ ) of the asynchronous machine without short circuit. In low frequency, note the appearance of the frequency of the defect ( $3f_e$ ). In high frequency, we note the presence of the frequency  $f_{MLI} - f_e$  and  $f_{MLI} - 3f_e$ .



(a)



(b)

Fig. 4. Stator current spectrum of the faulty machine on a stator phase in the reference frame (d, q).

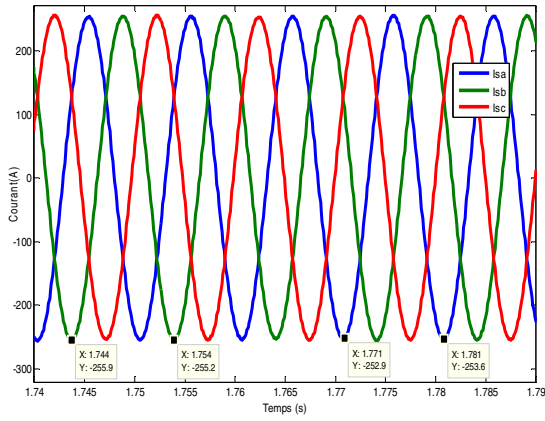
Fig. 4(a,b) illustrates in low frequency the frequency of the fault ( $2f_e$ ) and in high frequency we note the presence of the frequency  $f_{MLI} - 2f_e$ . The table below summarizes the results of simulation of the machine with defect on a phase to the stator.

TABLE 1. FREQUENCY OF FAULT ON A STATOR PHASE

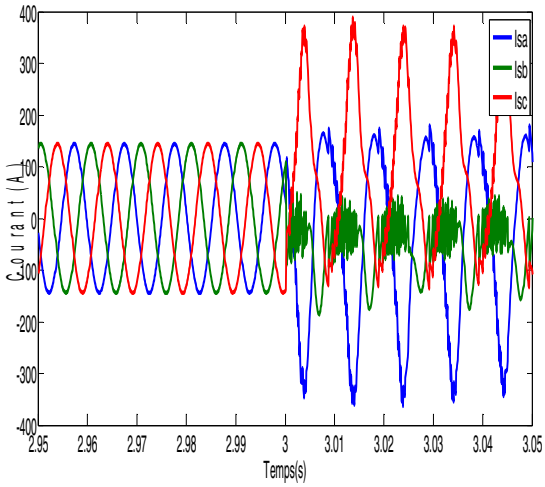
	<i>BF</i>	<i>HF</i>
Current	$3f_e$	$f_{MLI} - 3f_e$
Referentiel (d,q)	$2f_e$	$F_{MLI} - 2f_c$

### D. Fault in the inverter

We chose to consider the effects of an open component. For this, we have included a block to block the control orders arriving at the switch considered to be defective.



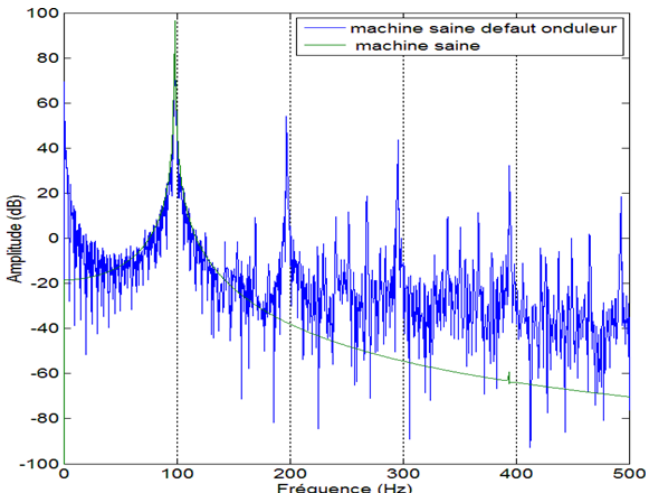
(a)



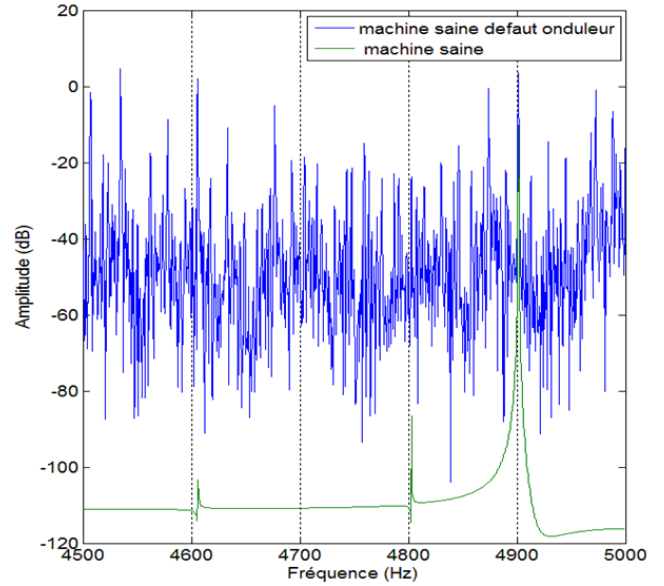
(b)

Fig. 5. Speed of the stator currents and the spectrum of the machine with inverter fault.

Fig. 6 illustrates the current spectrum ( $I_{sa}$ ) of the healthy machine with inverter fault (open component) and the sound machine, noting the appearance of the lines around the electric frequency  $f_e$  and the frequency  $f_{MLI}-f_e$ .



(a)



(b)

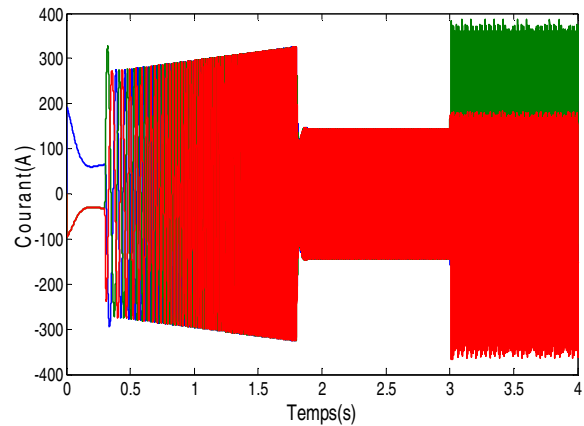
### E. Sensor faults

The sensor fault considered consists of an offset on the measured size (50A or about 15% of the size).

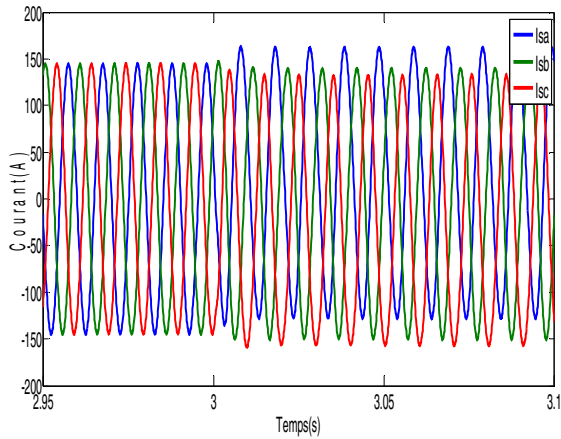
#### 1) Current sensor fault

For this fault (a measurement offset on phase a), the analysis of the spectral content of the current can be effective. Indeed, the vector control will require that the measured currents follow the reference. It will then appear, by composition of the signals, multiple frequencies of the fundamental frequency, in particular the double frequency. Fig. 7 shows the spectrum of the current measured when the sensor fails.

Noting that this line can also be detected in the controls variables (reference voltages in the Park reference system). These data being continuous the line will then be at the fundamental frequency of currents.



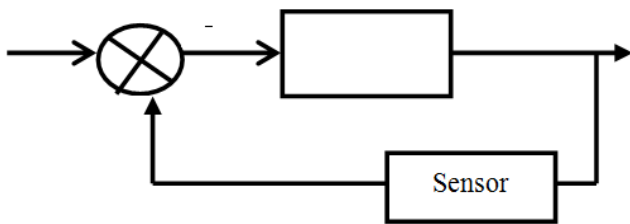
(a)



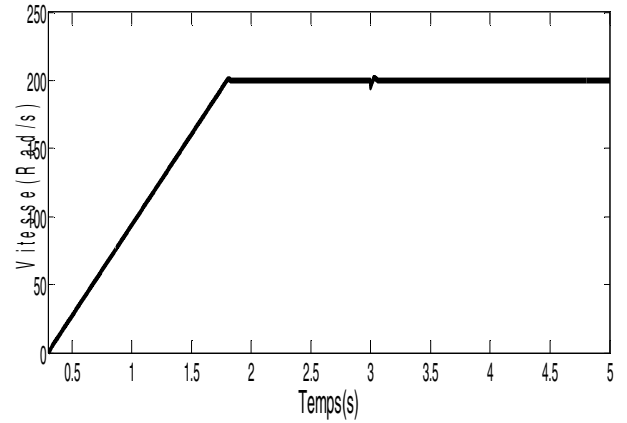
(b)

## 2) Speed sensor fault

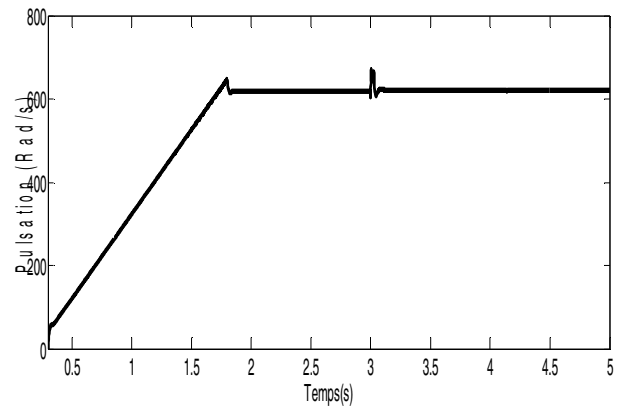
We present this type of defect to emphasize the importance of detecting it, but as the variables concerned are continuous, there is, to our knowledge, no characteristic frequency for this defect. As in the previous case, the measured speed follows the imposed reference. It is therefore necessary to study the evolution of another quantity or to reconstruct the speed to compare it with the speed measured. Fig. 8 shows the different variables to be taken into account.



We all propose first to follow the evolution of the stator pulsation imposed by the vector control. Indeed, this magnitude is an image (with a slip close) of the actual speed of the machine. If there is a significant difference between the stator pulsation and the electrical speed ( $p\Omega$ ), this may result from an error in the measured speed. Indeed, during the application of the defect (the default type offset), the speed control will react by changing the torque reference. By means of the equations of the vector control, this means that the stator pulsation imposed by the command will evolve. Fig. 9 shows the measured speed of a sensor error of 5 Rad / s (2.5% of the reference value). Note that speed control responds to compensate for the offsets that appear on the measured speed.



This compensation of the speed therefore produces an increase in the stator pulsation as shown in Fig. 10.



It should be noted, however, that the position and speed information measured is supplied to the control in order to place the rotating marker. However the orientation of the magnetic quantities in the machine differs from those of the control, there is a risk of stalling the machine if the error is too strong between the two marks.

From  $I_{sa}$  phase current:

TABLE 2. CHARACTERISTICS OF THE SET

	<i>Stator</i>	<i>Rotor</i>	<i>Inverter</i>	<i>Current sensor</i>
$f_{MLI-3fe}$	x		x	
$f_{MLI-2fe}$			x	x
$3fe$	x		x	
$2fe$			x	x
$fe$			x	x

From vector control outputs:

$2f_e$	x		x	
$f_e$			x	

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#### IV. CONCLUSION

The study presented in this paper contributes, in the diagnostic faults in electric machines, with specially, in the detection of asynchronous machines. The impact of fault electrical was studied. The majority of recent research was oriented towards the monitoring of the state of an asynchronous machine by using the stator current (its spectrum) as a variable allowing the detection and the diagnosis of some defects. This work focused on the simulation of an electrical drive based on asynchronous machine. After having shown, in the context of the study, the inadequacy of the traditional methods of maintenance and diagnosis, we endeavored to make the most of the information available on the application. This information, first of all in the form of knowledge, allowed the establishment of simulation models. We underlined the influence of the control on the choice of the variable to be considered to detect the characteristic frequency signature of the defect we presented the frequency characteristics of the defects concerning our application. They are summarized in the following table.

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