



Diagnosis of Induction Motor Rotor Faults Based on Finite Element Evaluation of Voltage Harmonics of Coil Sensors

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2012 IEEE

SENSORS APPLICATIONS SYMPOSIUM

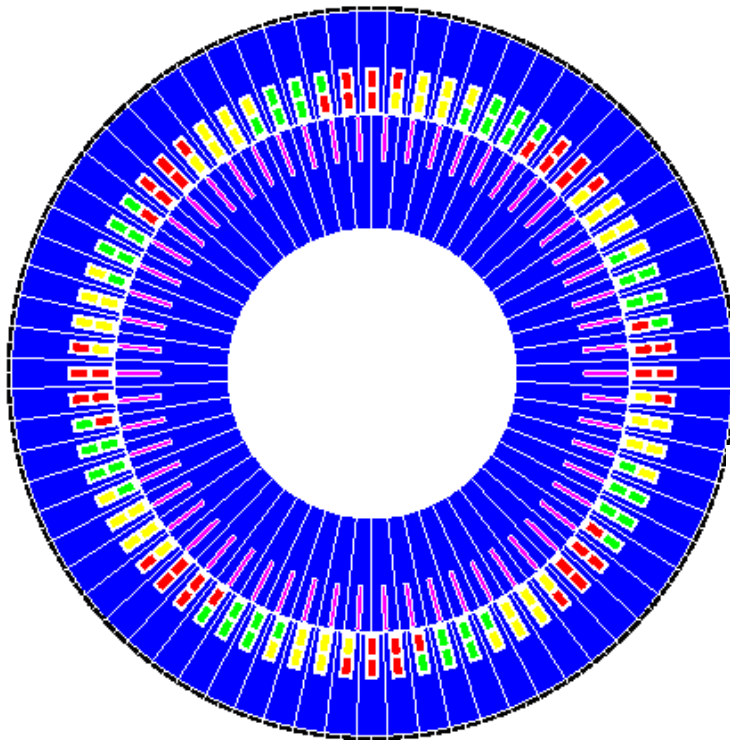
February 7-9 2012 - University of Brescia, Italy

Paper content

- **Introduction. Finite element model**
- **Effects of rotor faults on motor operation parameters**
- **Influence of rotor faults on the magnetic field outside the motor**
- **Non-invasive diagnosis of rotor faults**
- **Conclusions**

Introduction. Finite element model

Electromagnetic field model Computation domain



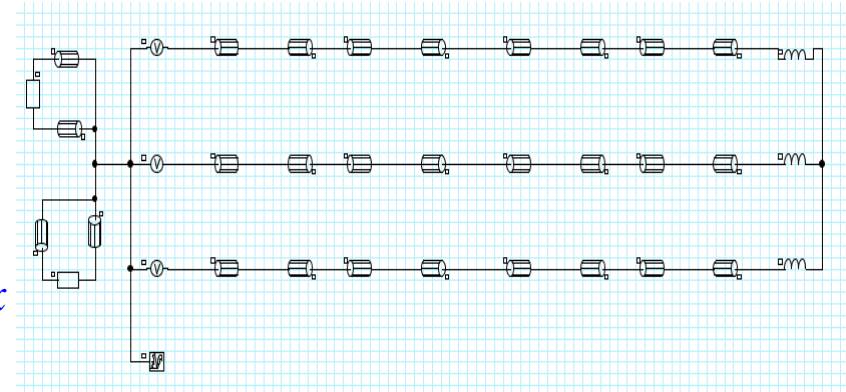
SensorOx



SensorOy



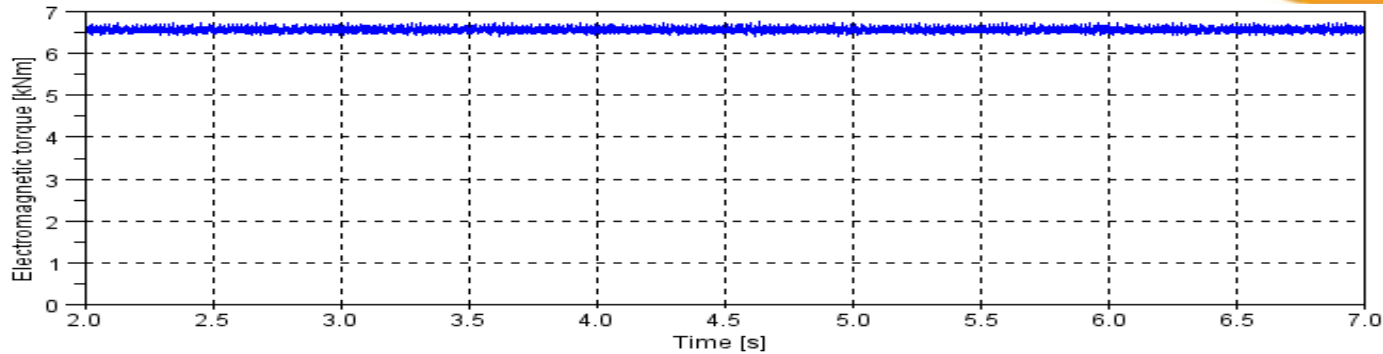
Electric circuit model



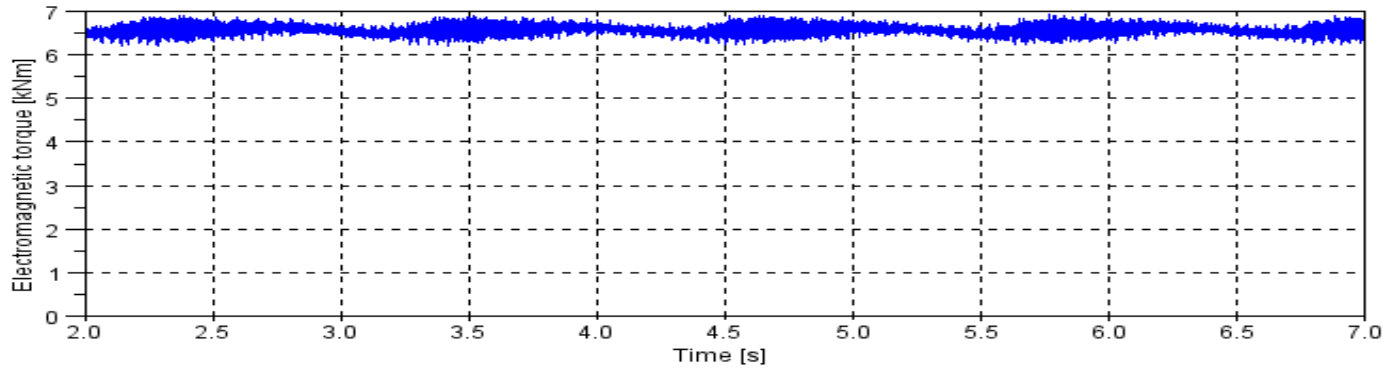
Induction motor data

- 500 kW
- 750 rpm
- 3 x 6000 V, 50 Hz
- coper squirell cage

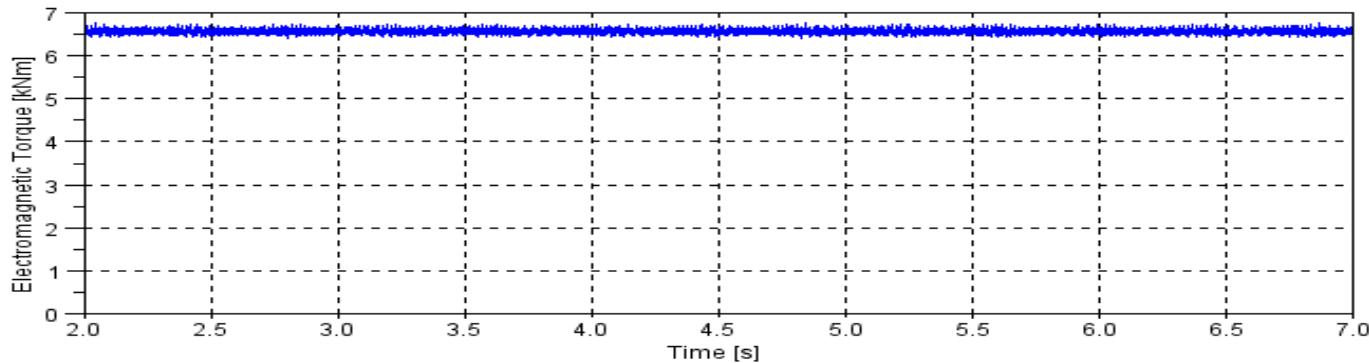
Effects of rotor faults on electromagnetic torque



her



brb fault

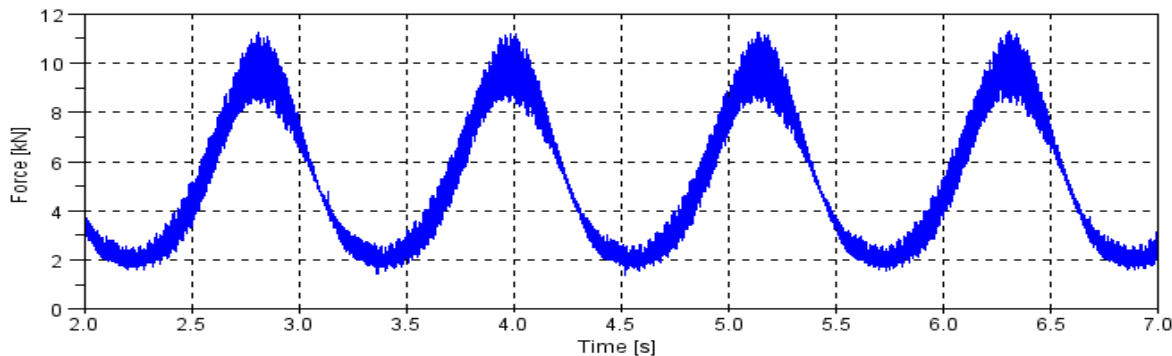


ecc fault

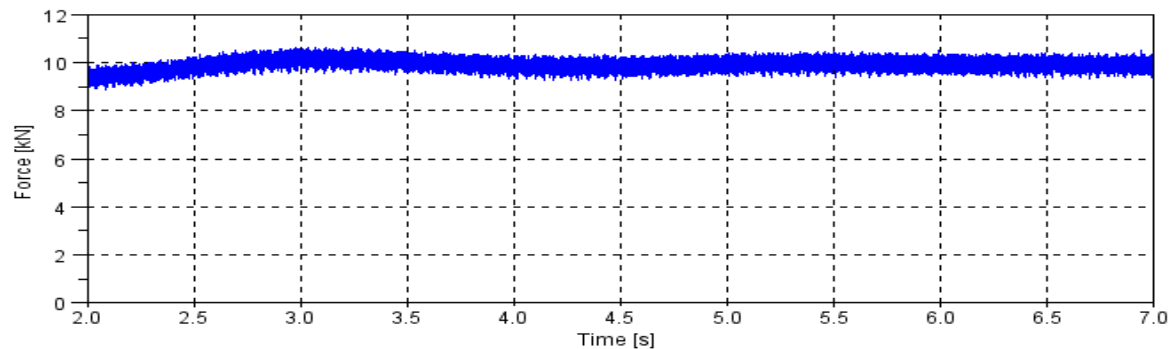
Effects of rotor faults on electromagnetic force

Interaction rotor – stator electromagnetic force

healthy rotor
negligeable



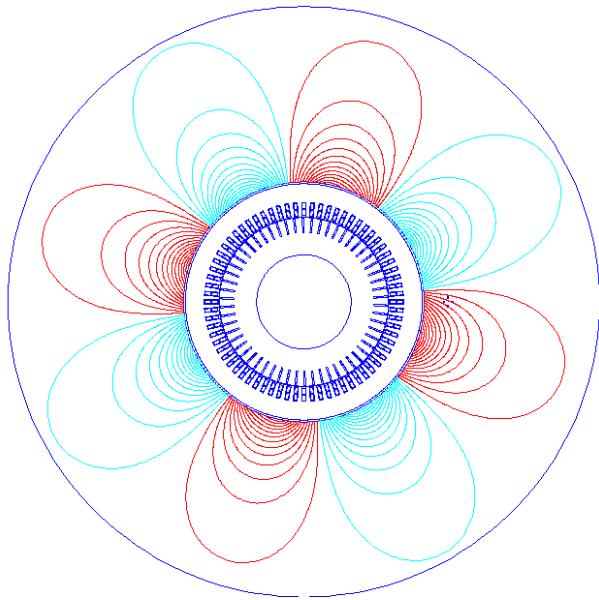
one broken bar
fault



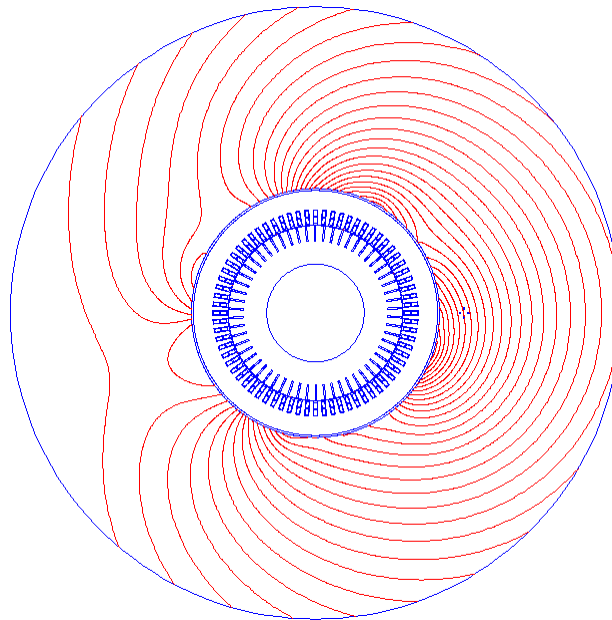
eccentricity
fault

Influence of rotor faults and magnetic field lines

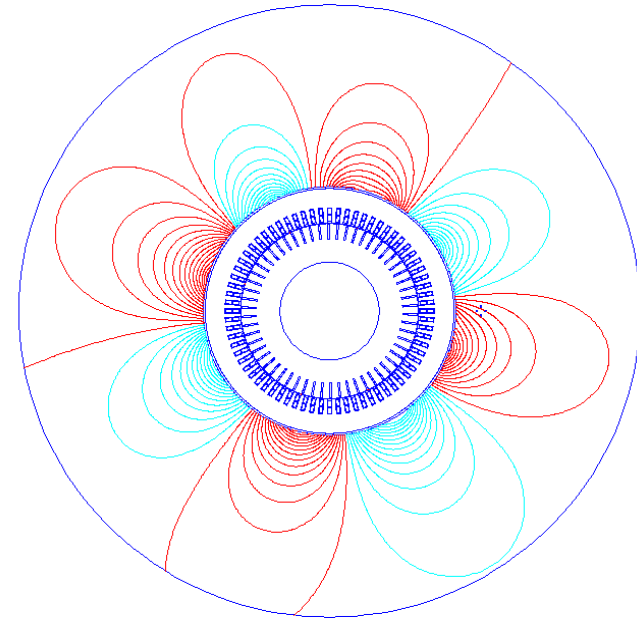
Magnetic field lines outside the motor



**healthy
rotor**

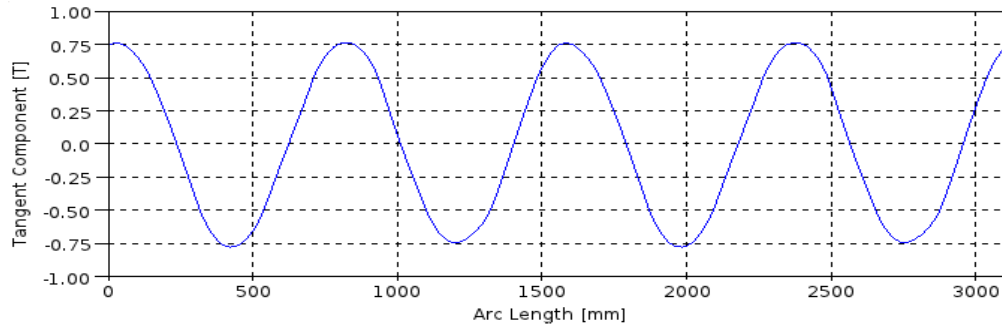


**one broken bar
fault**

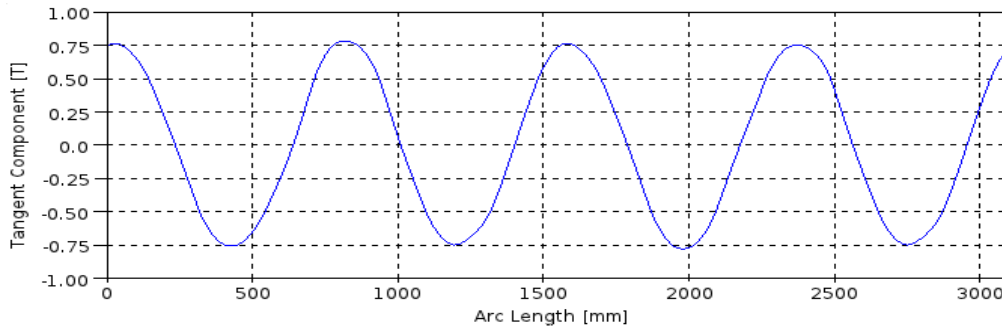


**eccentricity
fault**

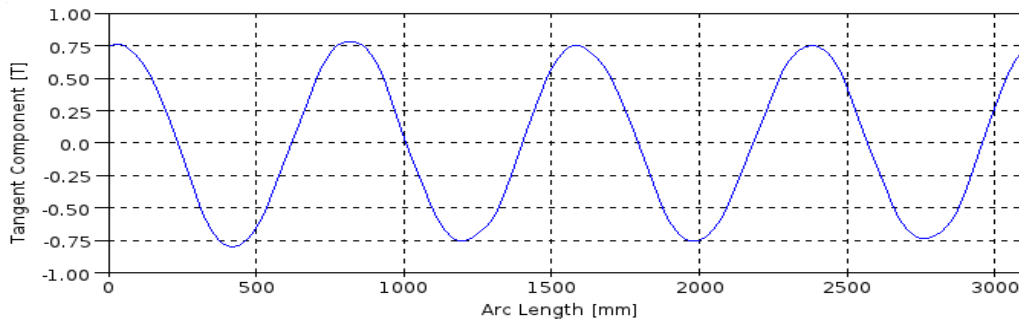
Tangent component of magnetic flux density



healthy rotor

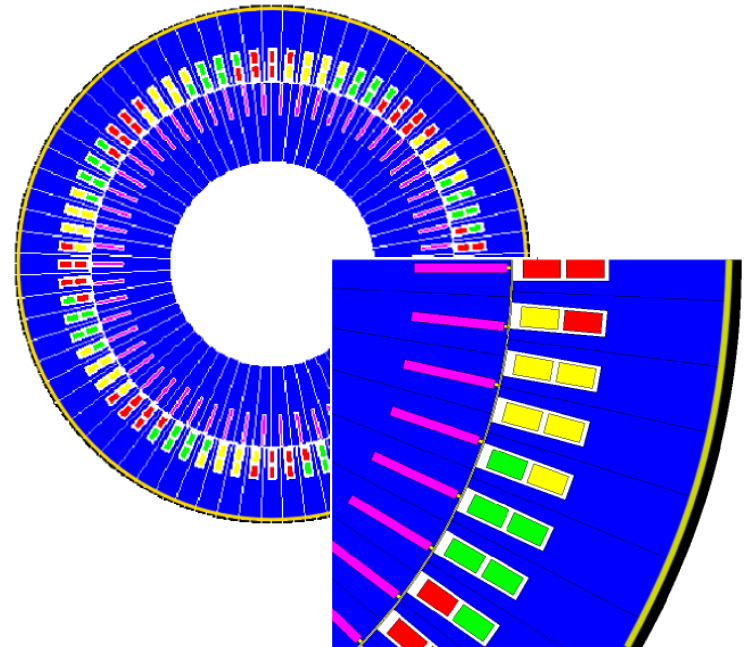


one broken bar fault

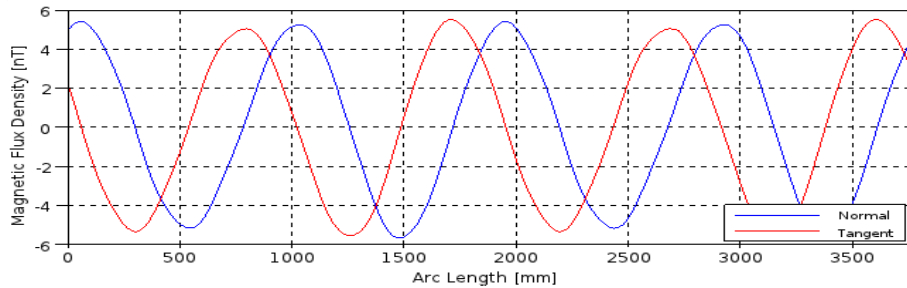


eccentricity fault

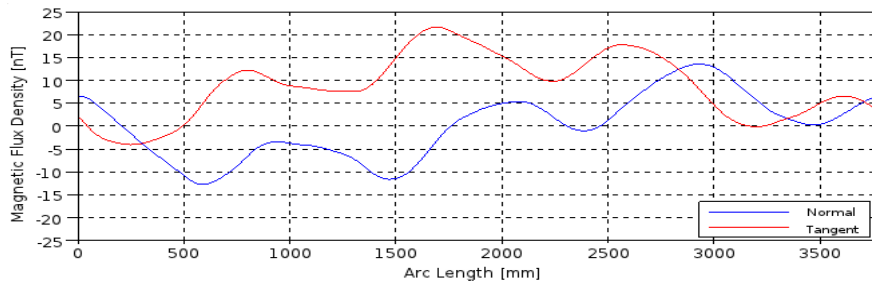
**Along the circle
of magnetic
core – casing
interface**



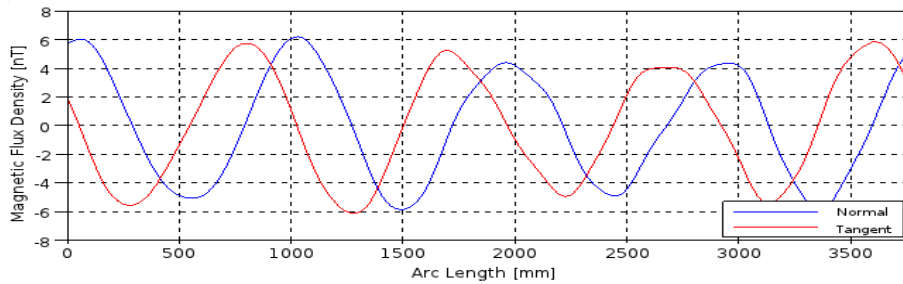
Tangent component of magnetic flux density



healthy rotor

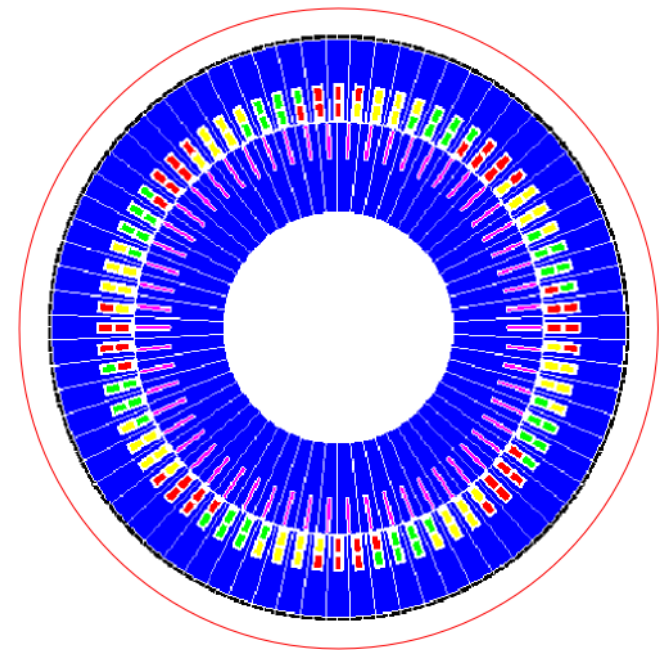


one broken bar fault

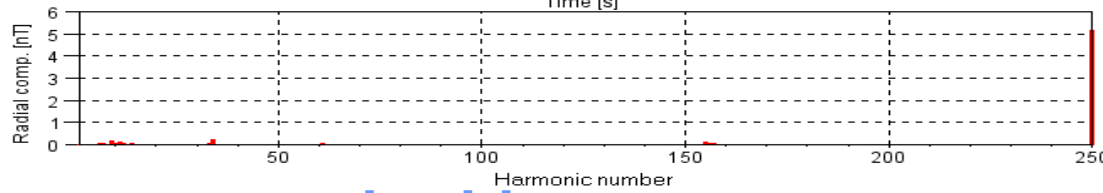
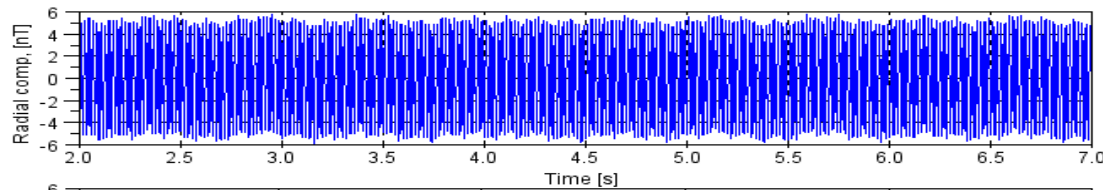


eccentricity fault

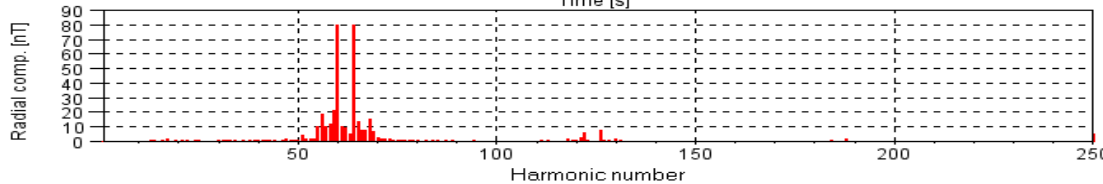
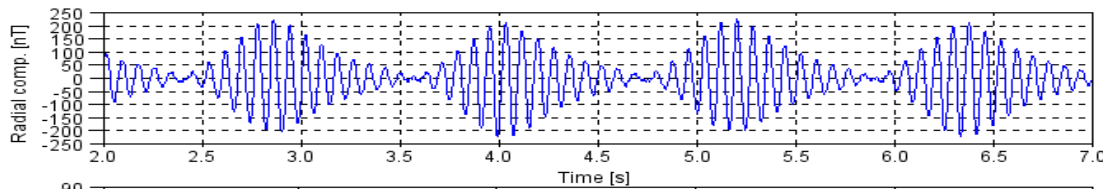
Along a
circle
outside
the motor



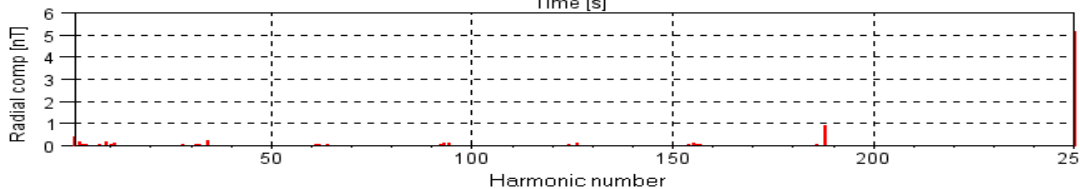
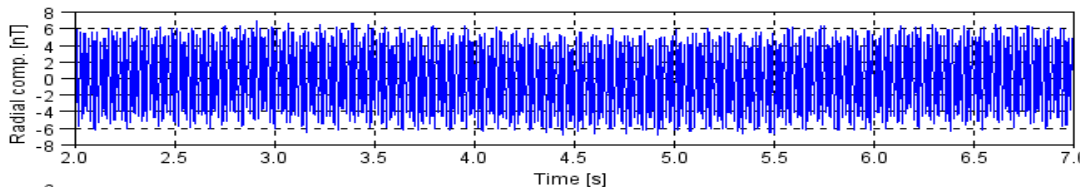
Radial component of magnetic flux density B_x



healthy rotor

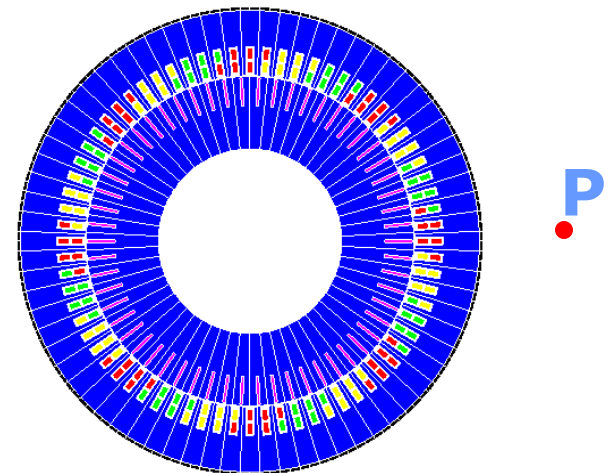


one broken bar fault



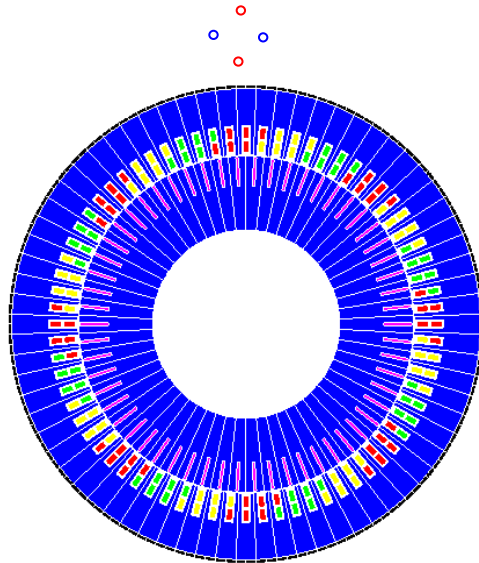
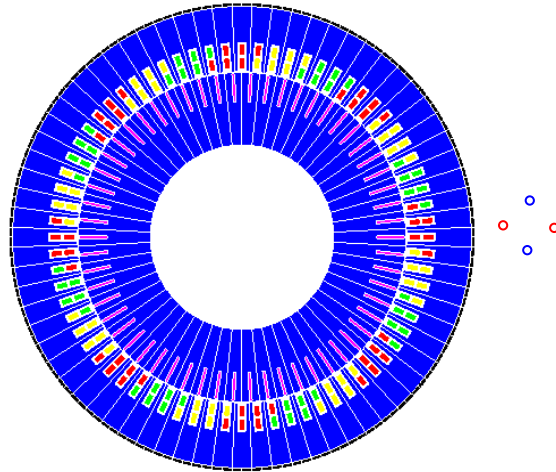
eccentricity fault

Time variation and harmonics of B_x in a point P outside the motor

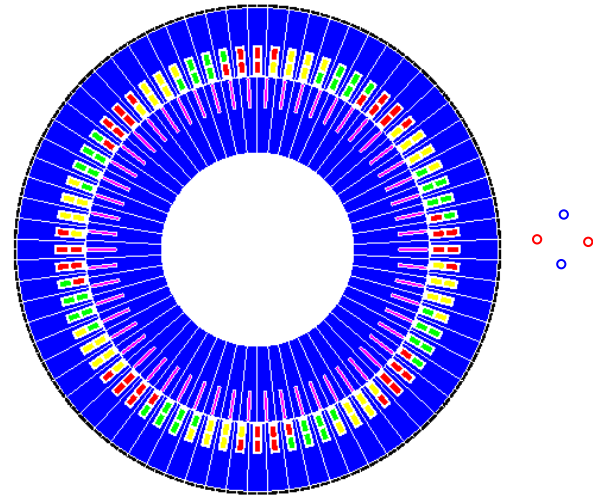


Coil sensors for rotor faults diagnosis

SNZ1 scheme

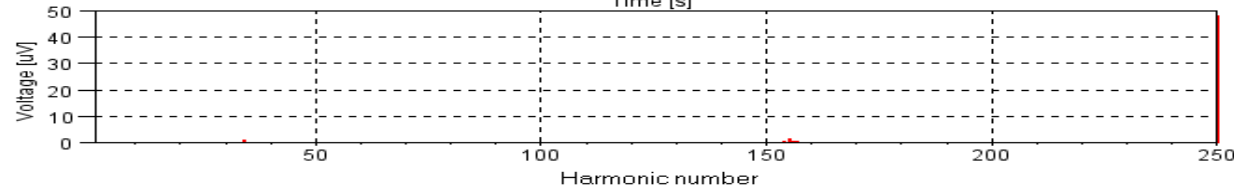
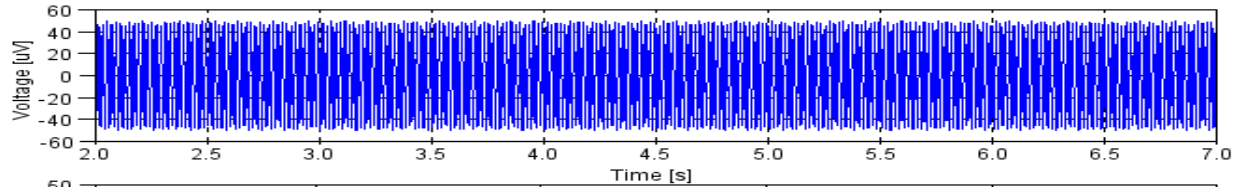


SNZ1-2 scheme



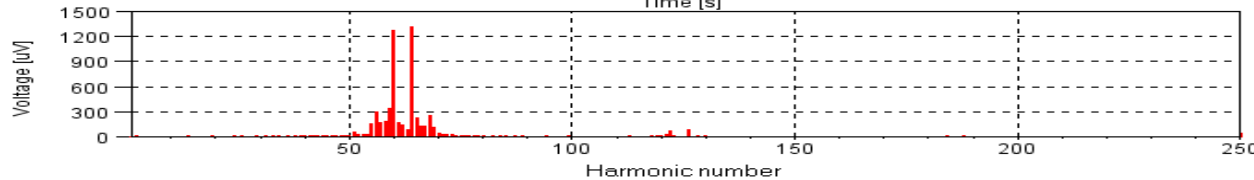
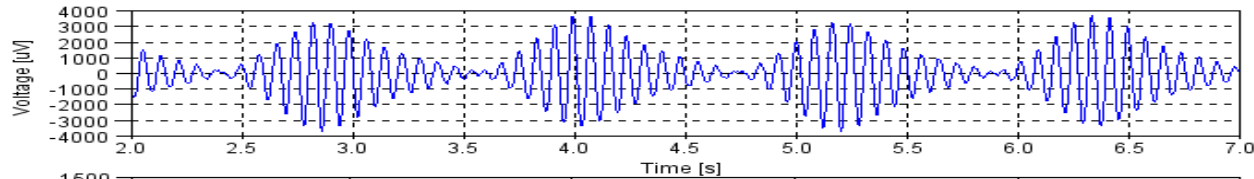
SNZ1-3 scheme

SensorOx output voltage – SNZ1 scheme

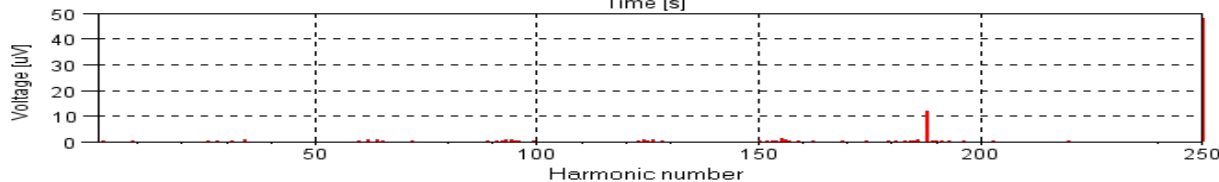
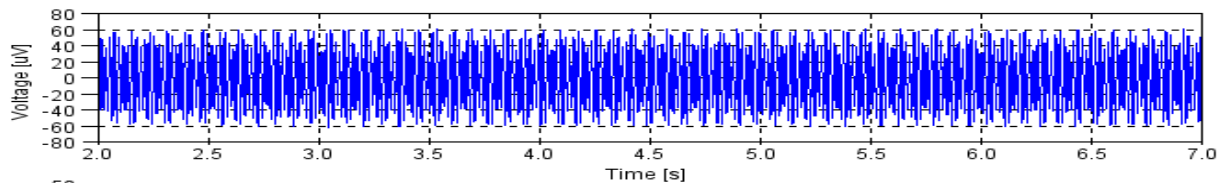


healthy rotor

**Time
variation
and
harmonics**

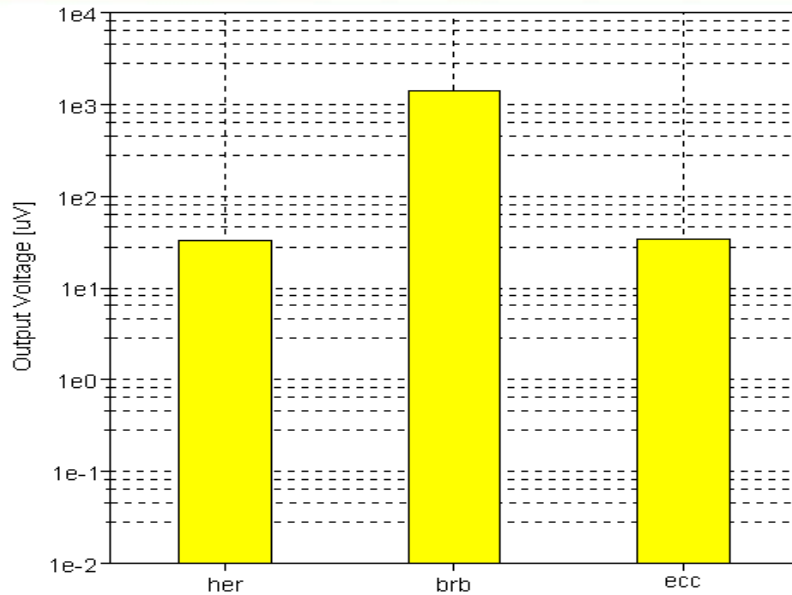


**one broken bar
fault**

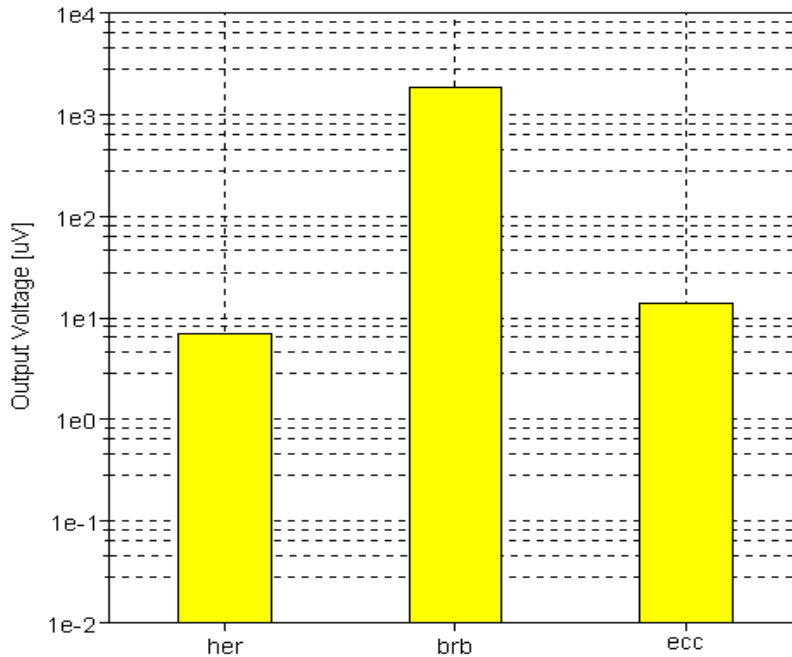


**eccentricity
fault**

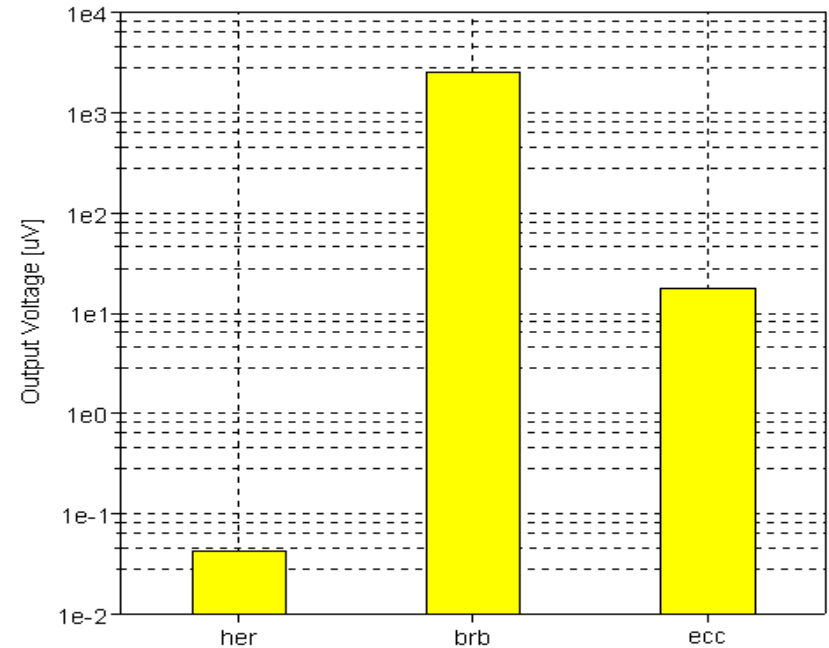
Rms values of the output voltage



**SNZ1
scheme**



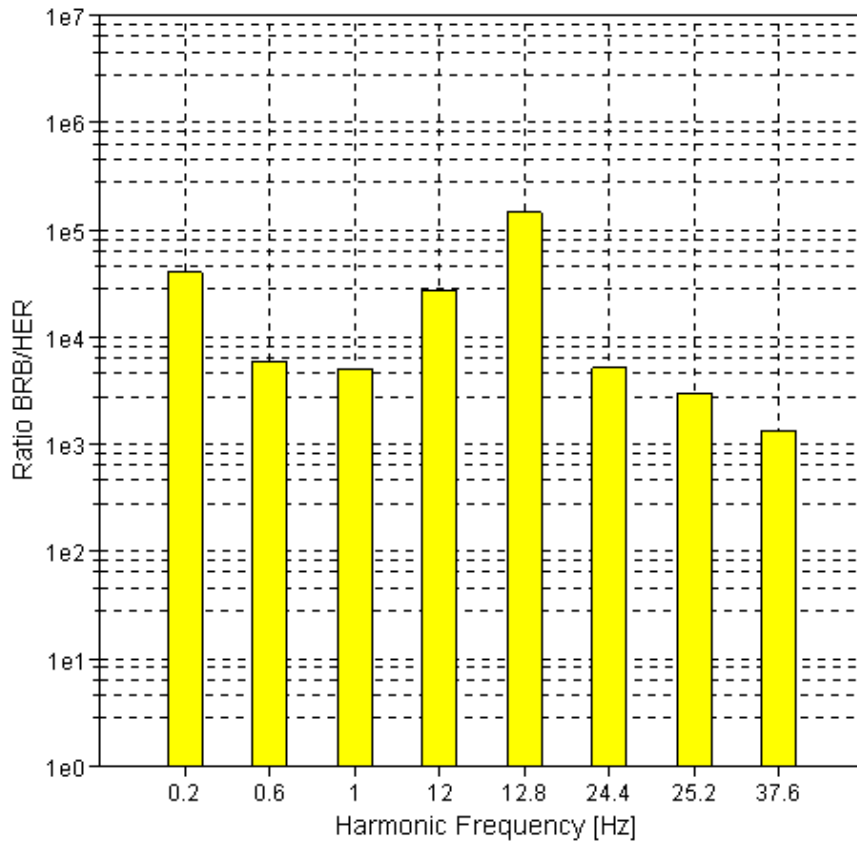
**SNZ1-2
scheme**



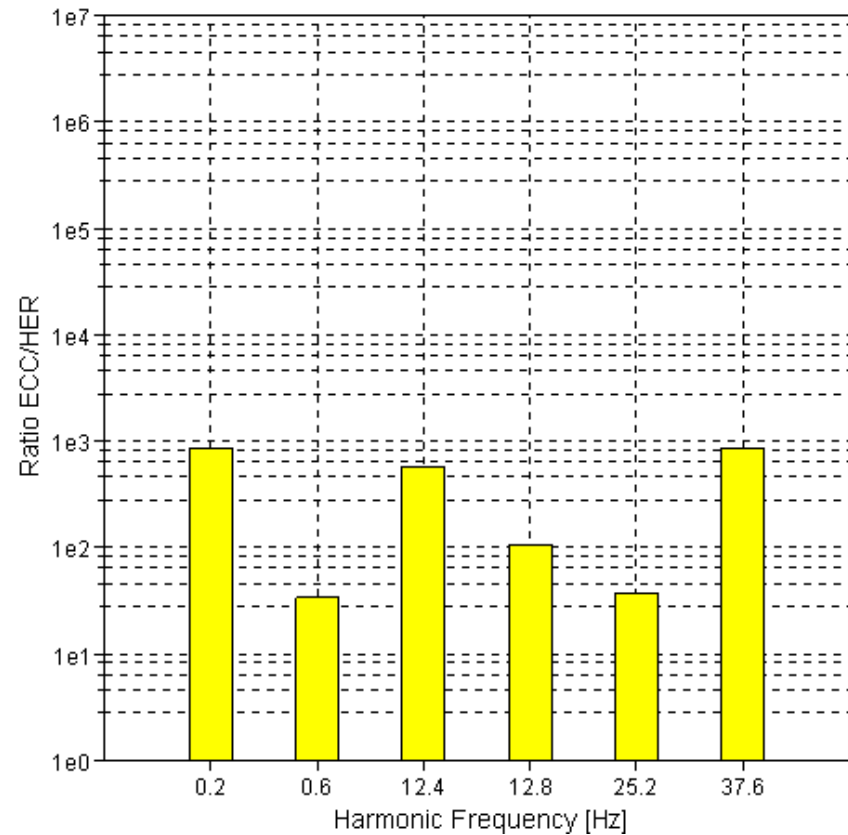
**SNZ1-3
scheme**

Efficiency of rotor faults diagnosis/1

SNZ1 scheme



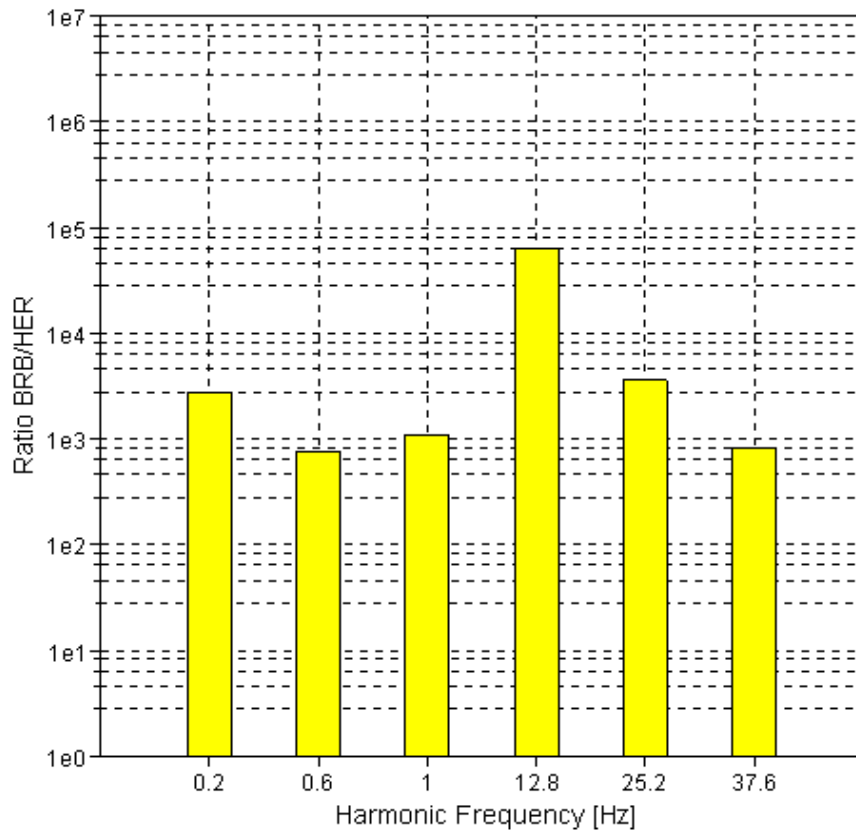
one broken bar fault



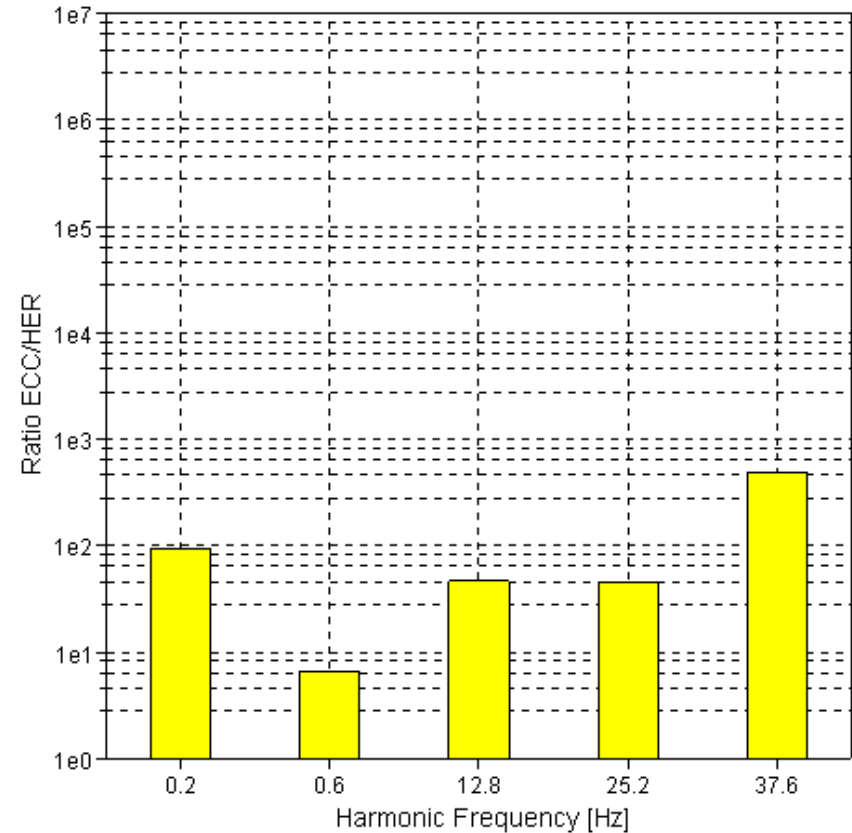
eccentricity fault

Efficiency of rotor faults diagnosis/2

SNZ1-2 scheme



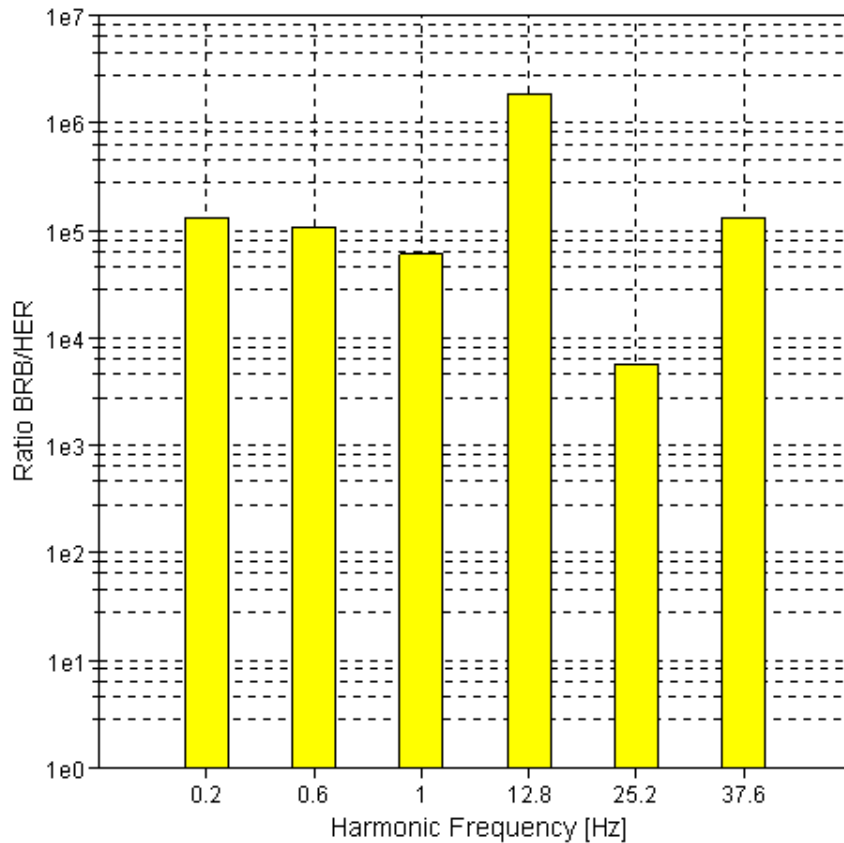
one broken bar fault



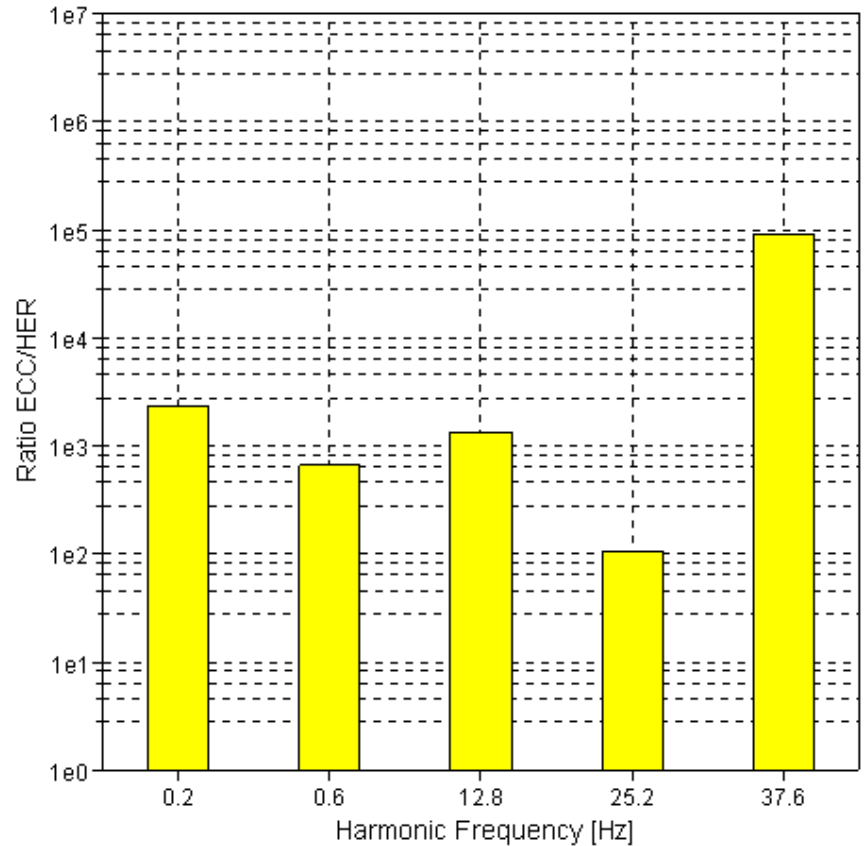
eccentricity fault

Efficiency of rotor faults diagnosis/3

SNZ1-3 scheme



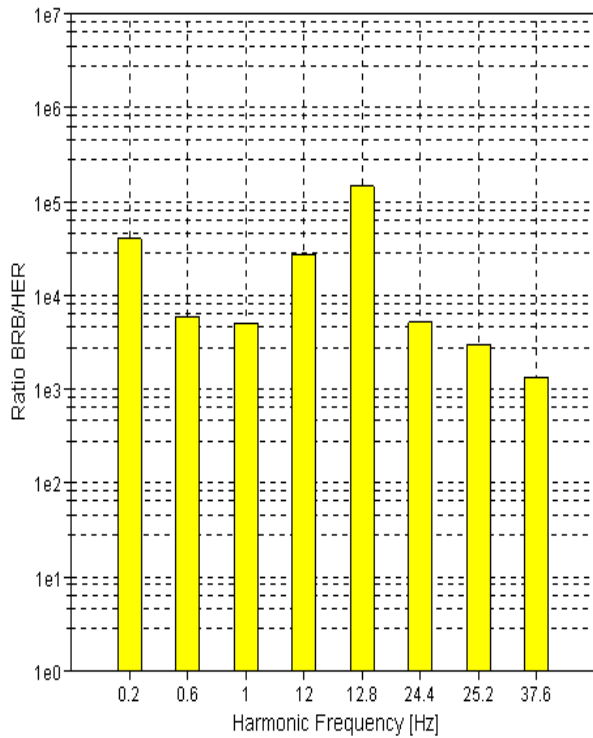
one broken bar fault



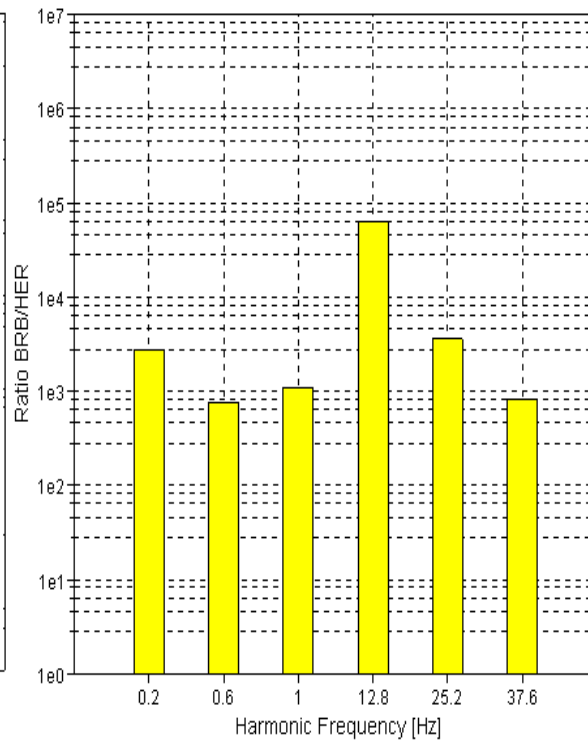
eccentricity fault

One broken bar fault diagnosis

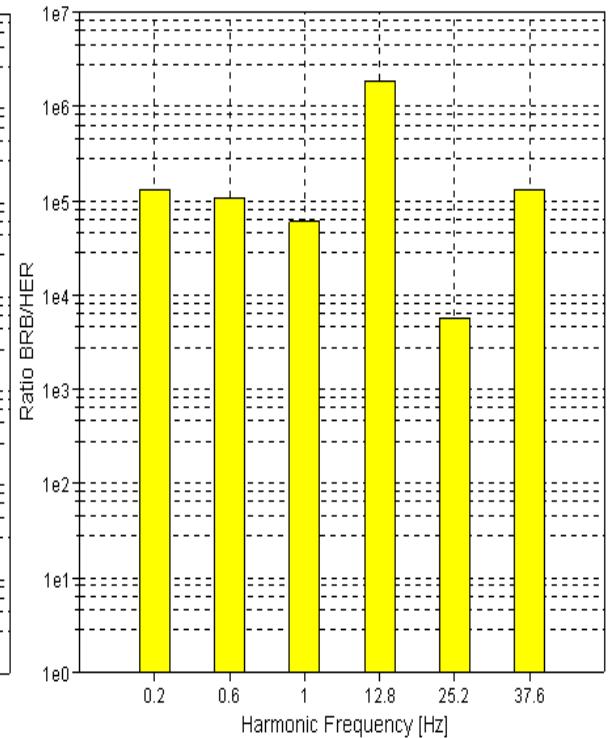
Diagnosis efficiency with different schemes



SNZ1



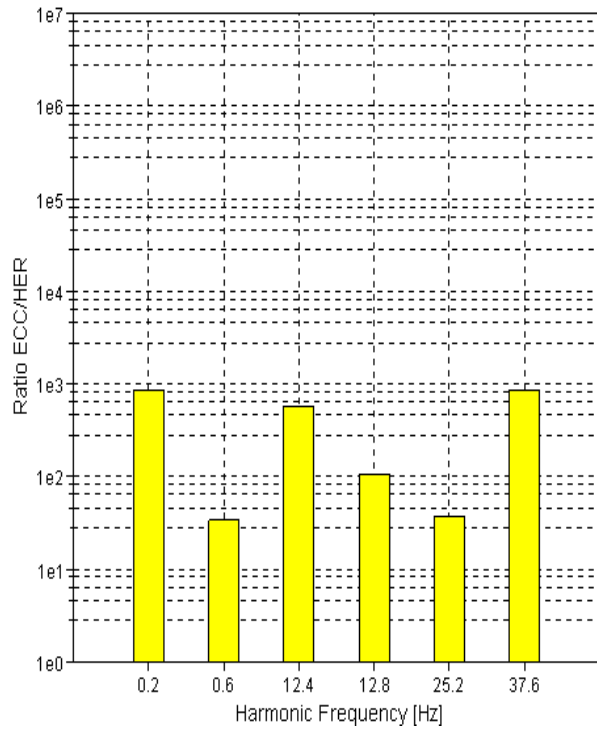
SNZ1-2



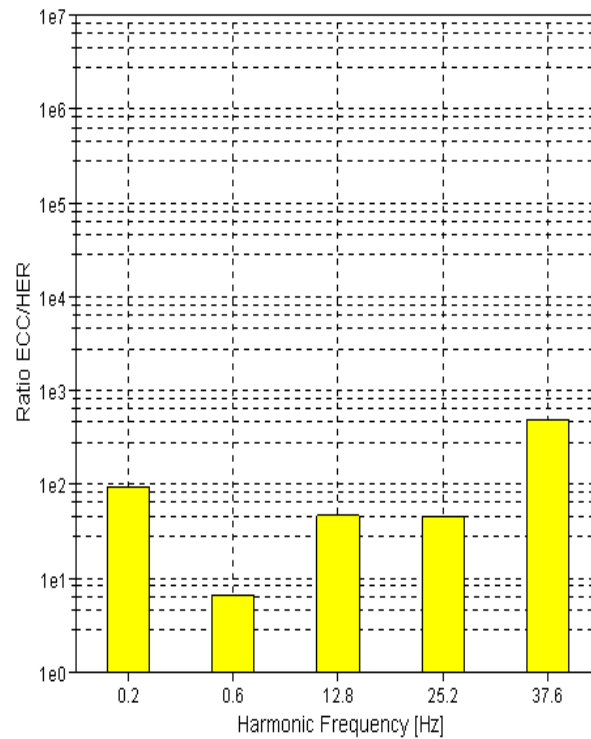
SNZ1-3

Rotor eccentricity fault diagnosis

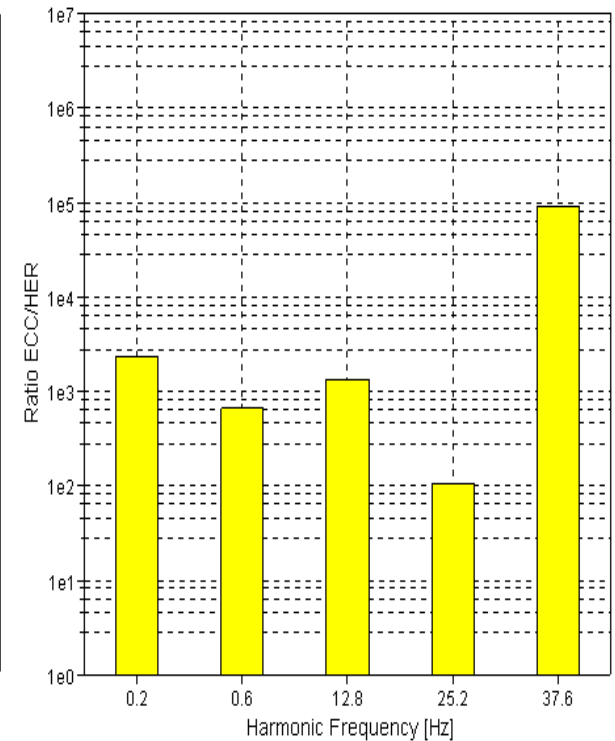
Diagnosis efficiency with different schemes



SNZ1



SNZ1-2



SNZ1-3

Conclusions

- The existence of faults like squirrel cage broken bars or rotor eccentricity can drastically affect the lifetime of the induction motors due to low frequency oscillations of the electromagnetic torque and to the important values of the electromagnetic force acting on the rotor.
- Based on the influence of faults influence on the near magnetic field, noninvasive diagnosis of the motor healthy state can use the output voltage of coil sensors.
- The amplitude of some harmonics of the output voltage presents important or very important increase when the faults appear.
- The faults diagnosis can take into account harmonics with frequency around an integer number of the rated frequency divided by two and by the number of motor poles and harmonics with frequency around the frequency of the rotor currents.
- The diagnosis efficiency, which is the ratio between the harmonic amplitude in the presence of fault and the amplitude of the same harmonic in case of the healthy motor depends on the frequency of the harmonic, on the coil sensors scheme and on the fault type.



THANK YOU



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