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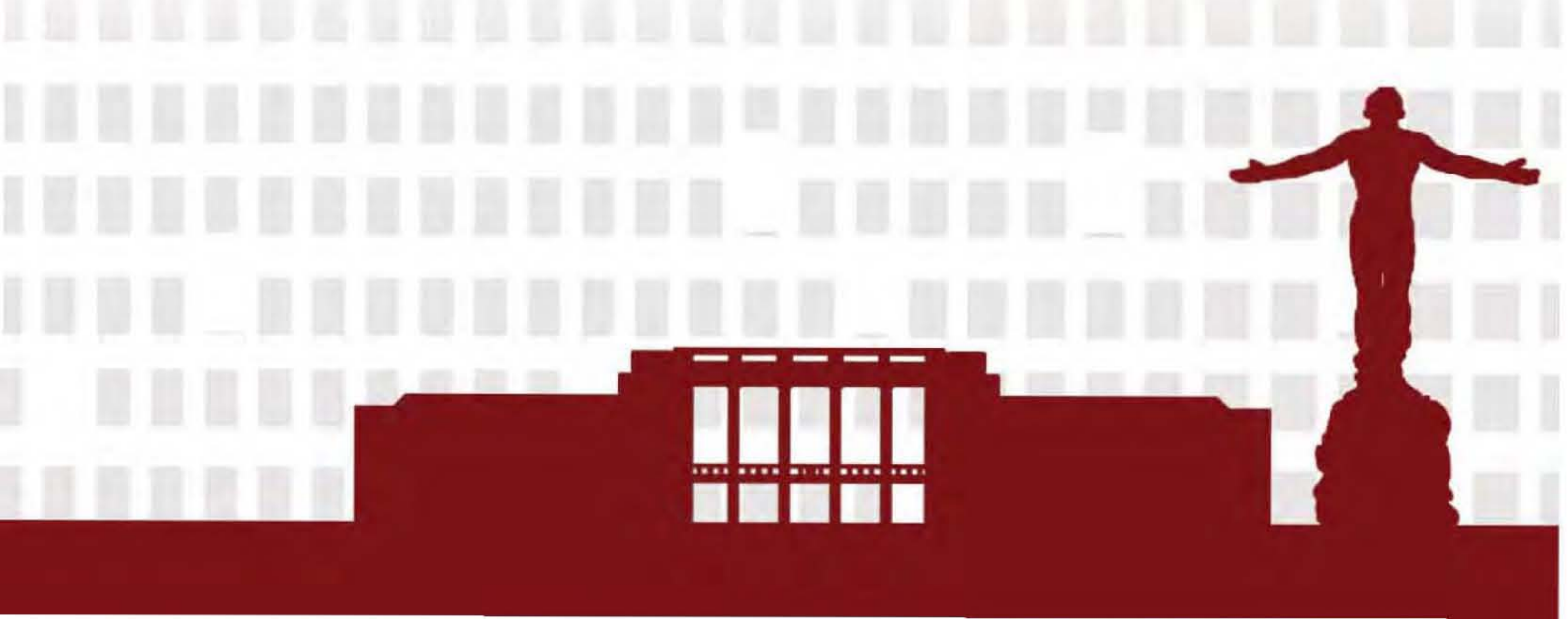

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DETERMINATION SHORT CIRCUIT FAULT AND UNBALANCE VOLTAGE SOURCE OF INDUCTION MOTOR USING PARK VECTOR MODULUS AND WAVELET TRANSFORM

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ABSTRACT

In this study, winding short circuit fault and unbalance voltage source in induction motor are detected. Stator current is recorded and converted into a Park's Vector Modulus (PVM) signal. PVM signal is then processed using the Discrete Wavelet Transform (DWT). Power Details Density (PDD) signal of wavelet transform is used to detect disturbances that occur in stator. The result shows that the proposed method is able to detect short circuit fault and unbalance voltage source. Winding short circuit is detected as higher value of PDD level D1, D2 and D3, while unbalanced voltage source is detected from D6, D7 and D8

Keywords : Short Circuit fault, Unbalance voltage, DWT, PDD.

Introduction

This paper is examined the differences of fault caused by the stator winding short circuit and unbalanced voltage source in induction motor. This study is interesting because both of faults are produces similar stator current spectrum. Therefore we need further analysis to identify the fault so that the appropriate corrective actions can be planed [1]. Experiments are carried out on two conditions; the motor with a modified stator windings to create a short circuit conditions and induction motors supplied by unbalanced voltage source.

Proposed Method

Park transformation is used to transform the three-phase stator current induction motor into two-phase (Id, Iq). The formula of Park transformation is shown in following equation [1].

$$Id = \sqrt{\frac{2}{3}}\, Ia - \frac{1}{\sqrt{6}} Ib - \frac{1}{\sqrt{6}} Ic \quad ; Iq = \frac{1}{\sqrt{2}} Ib - \frac{1}{\sqrt{2}} Ic \tag{1}$$

The next process is calculates PVM signal,

$$\text{PVM} = \sqrt{Id^2 + Iq^2} \tag{2}$$

While the wavelet transformation of signal PVM can be calculated as

$$d_j(k) = SVM \cdot W_k^j \;, c_j(k) = SVM \cdot V_k^j \tag{3}$$

where $d_j\,(k)$ and $c_j\,(k)$ are high and low signal of wavelet decomposition at level j respectively. W_j^k is high pass filter, while V_j^k is low pass filter wavelet transform. The next step is calculate power detail density of high frequency signal as follow.

$$Dj = \frac{\Sigma_1^k \left(d_j(k)\right)^2}{HPF}. \tag{4}$$

HPF is high pass filter represent to j level transformation of wavelet transform. Induction motor that used in experiment is a three-phase induction motor 1 hp, 1390 rpm, 4 pole, 380 V. Table 1 shows the cases variation of laboratory testing.

Table 1. Experimental Case variation

Phase			Variation	Load (%)	Number of cases
R	S	T	Normal	0,20,40,60,80,100	6
R_{unb}	S	T	225,230,235,240	0,20,40,60,80,100	24
R_{unb}	S	T_{unb}	225,230,235,240	0,20,40,60,80,100	24
R_{unb}	S	T	215,210,205,200	0,20,40,60,80,100	24
R_{unb}	S	T_{unb}	215,210,205,200	0,20,40,60,80,100	24
R_{short}	S	T	3-N,5-N,15-N	0,20,40,60,80,100	18
R_{short}	S	T_{short}	3-3,5-5,15-5	0,20,40,60,80,100	18
Total Data					138

Result

Unbalance condition can be detected in the low frequency range, namely at the level of detail D6 (312.5-156.25Hz), D7 (156.25-78.12 Hz) and D8 (78.12-39.06 Hz) which have a significant difference value of the spectrum to the normal condition. Conversely, when short circuit occurs, a significant difference in the value of the spectrum in high frequency range can be found, namely at the level of detail D1 (10000-5000Hz), D2 (5000-2500Hz), and D3 (2500-1250Hz). Based on this result, the level of detail decomposition PDD is used as a reference for detecting fault occurrence.

Considering loading level, short circuit in stator winding can be accurately detected by PDD at the level of decomposition of D1, D2 and D3 on load level higher than 60%. The unbalanced of voltage source of induction motor can be detected from the high value of the PDD at the level of decomposition D6, D7 and D8 on load level is less than 40% as shown in Table 2.

Table 2. Fault detection considering load level

Loading level (%)	Effectiveness of short circuit detection (%)			Effectiveness of unbalanced detection (%)		
	D1	D2	D3	D6	D7	D8
0	100	33,3	83,3	100	100	100
20	83,3	66,7	66.7	100	100	93,7
40	50	0	83,3	68,7	68,7	75
60	100	100	100	93,7	81,2	87,5
80	100	100	100	31,2	31,2	37,5
100	100	100	100	31,2	31,2	62,5

Reference

[1] P. Purkait, Santanu "*Separating Induction Motor Current Signature Winding Faults from that due to Supply Voltage Unbalances,"IEEE Trans. Ind. Appl.*, 978-1-4673-1669-9/12, 2012.