Effect of Length and Position Relative to the Rotor of the Magnetostrictive Amorphous Wire in Motor Speed Sensing

A. M. Muhia, J. N. Nderu, P. K. Kihato and C. K. Kitur

Abstract—**The performance of the magnetostrictive amorphous wire in motor speed sensing has been shown to match that of conventional motor speed sensors. The sensor is based on Large Barkhausen Jump, a unique feature of the wire, which occurs at a given critical length of the wire. A permanent magnet is also used and therefore depending on the strength of the magnet used, the position of the sensor relative to the rotor is expected to influence the results. This paper presents experimental results on the influence of length and position of the magnetostrictive amorphous wire on the performance of the sensor. A close observation on the signal waveforms indicate that there is a critical length and optimal positioning of the wire from the magnet for which the performance of the sensor is satisfactory.**

Index Terms—**Length, Magnetostrictive Amorphous Wire, Position, Speed sensing**

I. Introduction

Magnetostrictive amorphous wires have been shown to posses useful characteristics for sensing such as Large Barkhausen Jump and Matteucci effect [1]. In our previous work [2], we compared the performance of the magnetostrictive amorphous wire in motor speed sensing with conventional speed sensors such as tachometer. The principle of operation of the sensor is based on Large Barkhausen Jump, a unique feature of the wire. Large Barkhausen Jump is only observed in wires which are longer than a certain critical length, which depends on the diameter of the wire [3]. The length of the wire used is, therefore, of importance so as to obtain satisfactory results. The use of a permanent magnet in speed sensing means that the results obtained will to some extent depend on the strength of the magnet used. However, for any magnet used, the position of the wire relative to the rotor is also expected to influence the results since effects of the magnetic fields are strong in certain regions and weaken with distance from the magnet.

II. Experimental Procedure

A single phase induction motor (3000W, 240V, 50Hz, 2920rpm) is used in this work. A permanent magnet is attached on one end of the rotor, well secured to prevent it from flying away as the rotor rotates. A pick-up coil of 3000 turns, with the amorphous wire placed inside, is then placed at a chosen distance from the rotor. The ends of the coil are connected to a digital oscilloscope.

A. Length of wire

Different lengths (x cm) of the wire (4cm, 5cm, 6cm, 7 cm) are used and observations made on the signal waveforms obtained to determine the optimal wire length at which stable pulses are generated as shown in Fig 1.

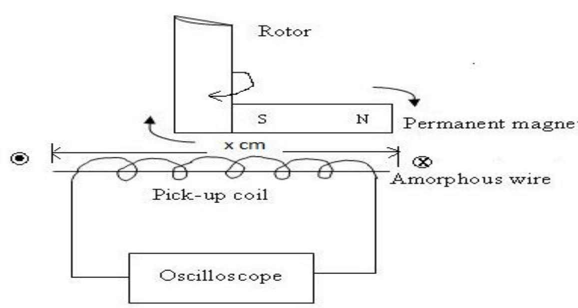

Fig. 1: Setup for determining the critical length of the wire

B. Positioning of the wire

A wire of optimal length (7cm) as obtained above is used in this case. At this optimal length, stable pulses are generated

Horizontal position: The wire is centered and placed at different positions (y cm) from the rotor and observations made on the the signal waveforms obtained as shown in Fig 2. The optimal horizontal position of the wire at which stable pulses are generated is determined.

Vertical and sideways position: The wire is centered at the optimal horizontal position determined previously and placed at different vertical or sideways positions from the rotor and observations made on the the signal waveforms obtained.The optimal vertical and sideways position of the wire at which stable pulses are generated is determined.

A. M. Muhia, Department of Electrical and Electronic Engineering, JKUAT (phone: +254723928227; e-mail: ammuhia@gmail.com).
J. N. Nderu, Department of Electrical and Electronic Engineering, JKUAT (e-mail: djainderugac@gmail.com. jkuat.ac.ke).
P. K. Kihato, Department of Electrical and Electronic Engineering, JKUAT (e-mail: kamitazv@yahoo.co.uk).
C. K. Kitur, Department of Electrical and Electronic Engineering, JKUAT (e-mail: cleophaskitur@gmail.com).

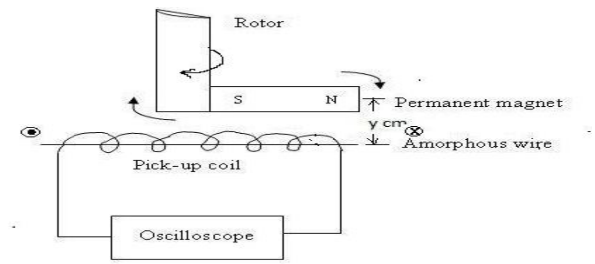

Fig. 2: Setup for determining the optimal positioning of the wire relative to the rotor

III. Results and Discussion

A. Effects of Length of the wire

Figures 3 to 6 show the signal waveform with 4cm, 5cm, 6cm and 7cm length of the wire respectively. With the 4cm wire, the signal waveform is weak. The signal waveform strength improves with 5cm, 6cm and 7cm. At about 7cm the signal obtained becomes stable. This due to the fact that Large Barkhausen Jump occurs at a given critical length of wire.

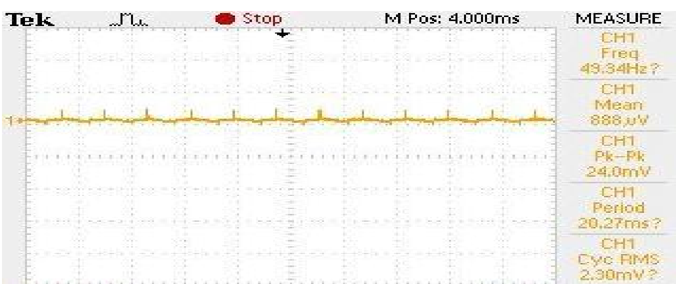

Fig. 3: With 4 cm wire

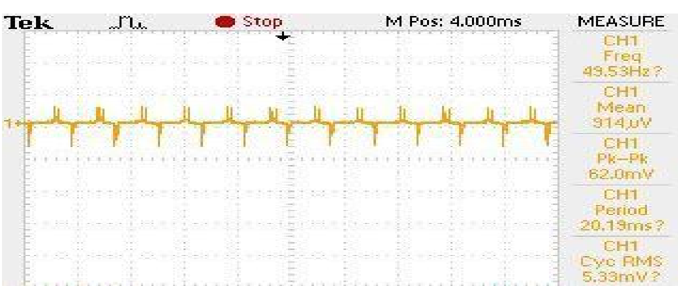

Fig. 4: With 5 cm wire

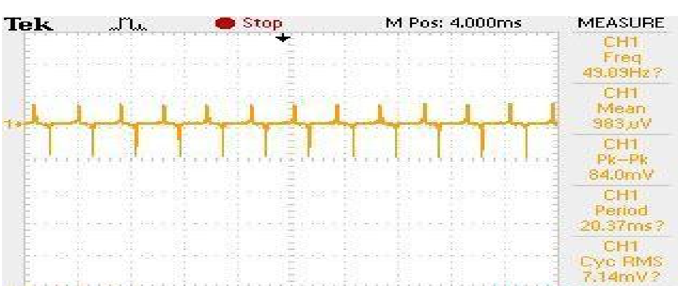

Fig. 5: With 6 cm wire

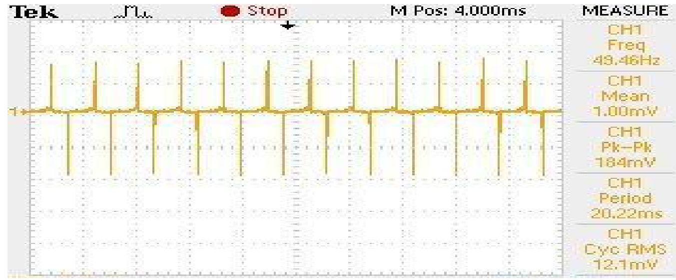

Fig. 6: With 7 cm wire

B. positioning of the wire

1) Horizontal position: Figures 7 to 11 show the signal waveform with the wire 7cm long placed at 4cm, 5cm, 6cm, 7cm and 8cm, respectively. The signal waveform is weak at 4cm from the rotor and improves with increase in distance up to at 7cm. At 8cm, the signal is completely lost since beyond this distance, effect of magnetic fields is very weak.

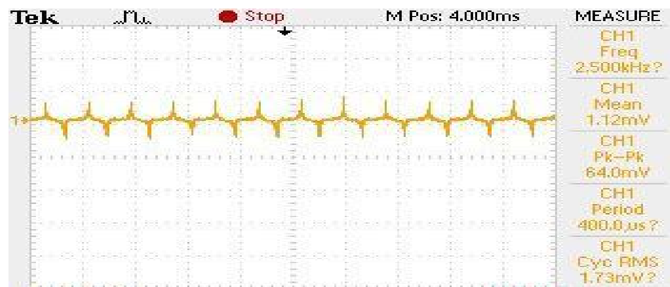

Fig. 7: With the wire at 4cm from the rotor

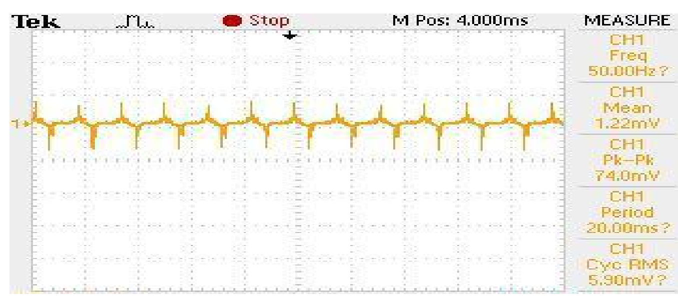

Fig. 8: With the wire at 5cm from the rotor

Fig. 9: With the wire at 6cm from the rotor

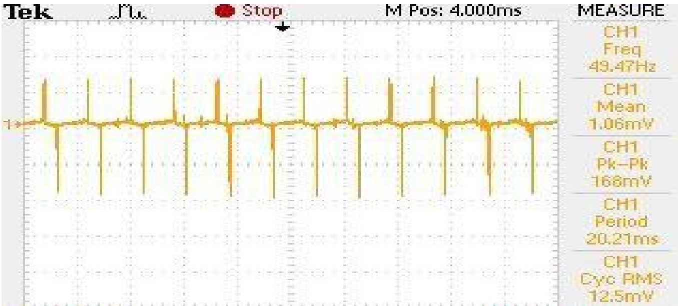

Fig. 10: With the wire at 7cm from the rotor

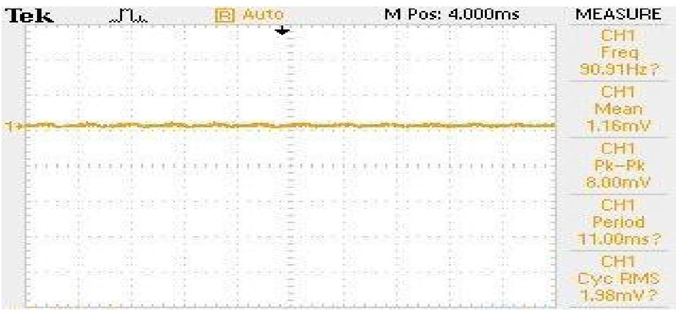

Fig. 11: With the wire at 8cm from the rotor

2) Vertical Position: Figures 12 to 15 show the signal waveform with the wire placed at different vertical positions from the center of the rotor. With the wire at the same vertical position with the rotor the, the signal is strong and weakens with increase in distance due to weakening magnetic fields. At 3cm above the rotor, the signal is completely lost.

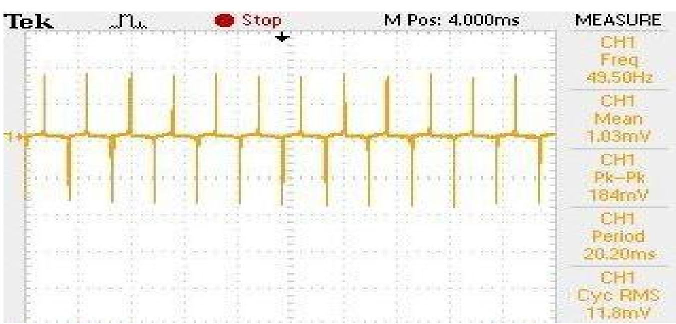

Fig. 12: With the wire at same vertical position as the rotor

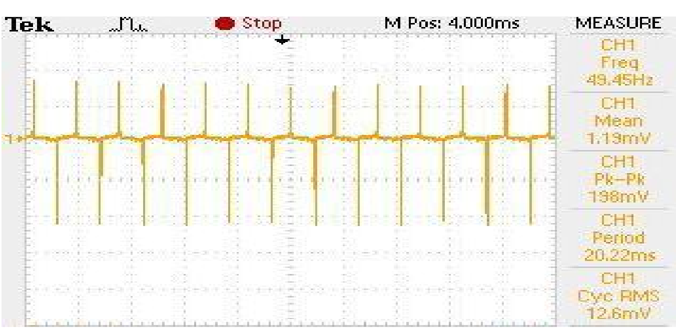

Fig. 13: With wire at 1cm above the rotor

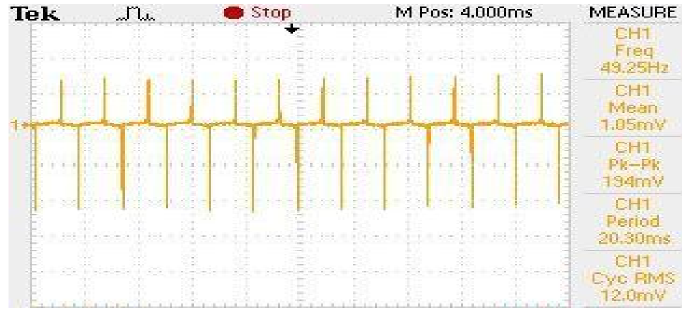

Fig. 14: With wire at 2cm above the rotor

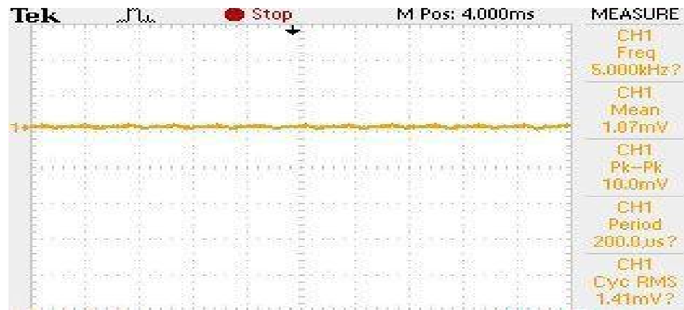

Fig. 15: With wire at 3cm above the rotor

3) Distance sideways from center of the rotor: Figures 16 to 19 show the signal waveform with the wire placed at different positions to the right from the center of the rotor. At the center, the signal is strong and weakens with increase in distance due to weakening fields. At 3cm, the signal is completely lost.

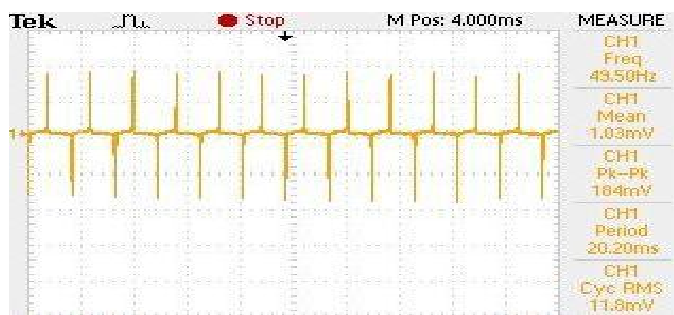

Fig. 16: With wire centered

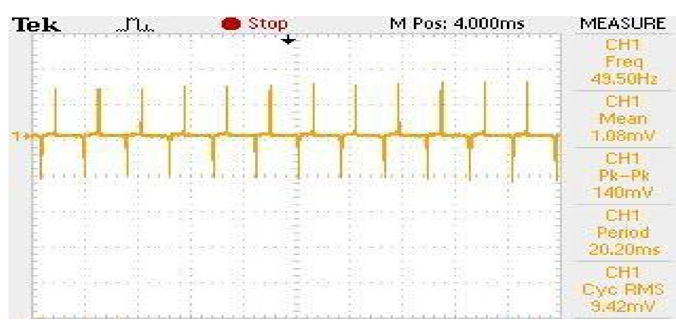

Fig. 17: With wire at 1cm to the right from the center of the rotor

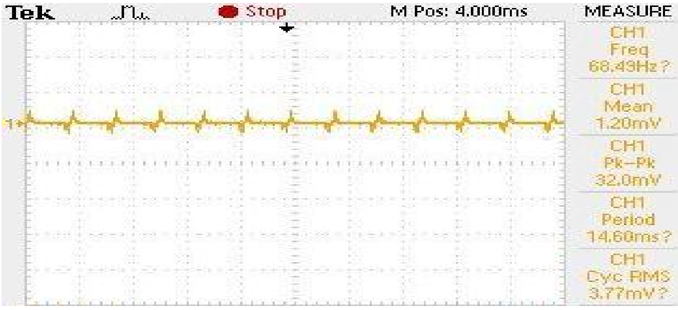

Fig. 18: With wire at 2cm to the right from the center of the rotor

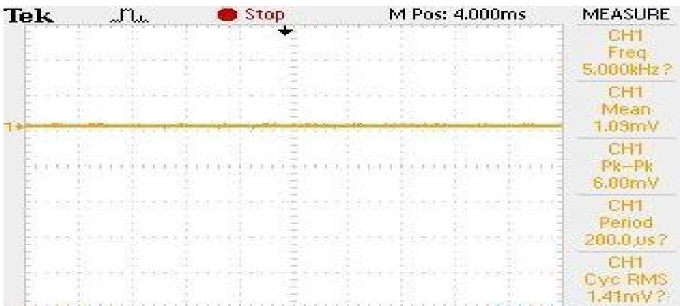

Fig. 19: With wire at 3cm to the right from the center of the rotor

IV. Conclusion

In this work, we have shown that the length and positioning of the amorphous wire senor affects the speed sensing ability. In conclusion:

1) There is a critical wire length at which desirable results are obtained. This length is is approximately 7 cm for the wire used in this work.
2) There is an optimal horizontal position from the rotor at which the wire should be placed to give satisfactory results which depends on the strength of the magnet used. In this work the distance is 7 cm beyond which the signal is completely lost.
3) The vertical position of the wire with respect to the rotor affects the results. In this work, it has been shown that the wire should be placed at the same vertical position as the rotor. At a distance of 3 cm above or below the vertical position of the rotor, the signal is completely lost.
4) Finally, the position of the wire with respect to the center of the rotor also influences the results. In this work, it has been shown that the wire should be centered with respect to the rotor. At a distance of 3 cm to the right or left from the center of the rotor, the signal is completely lost.

References

[1] P. K. Kihato, J. N. Nderu, and G. M. Hinga, "Motor speed measurement using magnetostrictive amorphous wire," *Proceedings of 2007 JKUAT Scientific, Technological and Industrialization Conference*, pp. 315–319, October 2007.

[2] A. M. Muhia, J. N. Nderu, P. K. Kihato, and C. K. Kitur, "Performance of magnetostrictive amorphous wire in motor speed measurement," *Proceedings of the KSEEE Annual Conference*, November 2011.

[3] Nderu J. N. and Ruirii P. K., "Speed sensing by amorphous magnetostrictive metal wires," *Proceedings of the 5th International Annual Mechanical Engineering Seminar (JKUAT)*, June 2000.