Digital Contact Tachometer Using a Rotary Encoder Input Signal for AC Induction Motor

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***Abstract*—Speed measuring equipment knows as Tachometer is a vital device in a wide range of research; accuracy is the most important for the use of speedometer devices in terms of reliability. This paper is a study of the operation including the control device of the Tachometer and develops the digital contact tachometer compare with the speedometer used in the market in term accuracy and percentage of errors and then compared to the theoretical values. The results show that the accuracy of the proposed equipment is high accuracy and low tolerances and able in practical works, can be applied in industrial applications such as engine control, speed control, mechanical speed control in industrial applications.**

Keywords—AC induction motor, instrument, digital contact tachometer.

I. Introduction

The motor speed control system, in addition to the electric motor, also requires an electronic control set or called an inverter to adjust the motor speed. In the past, motor speed control was mainly used in DC motors because the electronic control units used rectifiers and processing as well as analog controls using Silicon Control Rectifier (SCR) to control and regulate the voltage. Moreover, controlling the speed of the DC motor is more comfortable, more accurate, and more accessible to control.

However, the DC motor has a High initial expense and need more maintenance cost due to the presence of commutator and brush gear. Therefore, the use of an AC induction motor, which has a lower price, high reliability, and uncomplicated structure and many factors which makes AC induction motors more advantageous compared to the DC.

Many pieces of research bring the Tachometer to use as a control device and evaluate the stability of the system. In [1] Tazwar M. and Thomas B. studied and proposed the DC motor model and design the experiment that focuses on an IR sensor tachometer designing in microcontroller platform which performs digital to analog conversion, the results show that the system has reasonably priced and straightforward to use, but there is a limitation of sensors that cannot measure speeds up to 6000 rpm. In [2] Zhan S. et al. proposed a tachometer using magnetoelectric composites, magnets, and steel gear as an assemble, the meter performed very stable and very high sensitivity under the low-speed range. They claimed that electromagnetic substances able to make an adequate speedometer.

Honghong G. et al. introduced the test system for motorcycle speedometer in [3], the administrator can control motorcycle speed at any resolute value with a speed adjustment box without testing staff, the result indicates the reduction of the working intensity of the operator, simplifies test process and improves test performance and precision. In [4], Sun Y. Et al. designs the method of the self-correction frequency calculating, online measuring rotational speed device providing a high degree of accuracy and high anti-interference, the principle established, increasing precision, developing the capacity of anti-interference, and satisfying organization requirement. Also, the study by Wiwik B. et al. discovered the position of the speedometer that minimizes distraction and workload while driving to maintain security and convenience in driving, and the results suggested using a speedometer located behind steer because it has a faster glance and fewer workloads [5].

This article is a study of the operation including the control device of the Tachometer and develops the digital contact tachometer compare with the speedometer used in the market in term precision and percentage of distortion and then compared to the theoretical values.

II. The Operation of AC Induction Motors

AC induction motors operation is similar to the transformers. The stator coils when energized create a rotating magnetic field equal to the frequency of the power supply. The effect of the magnetic field that cuts through the air gap between stator and rotor causes current shuttled in the rotor coil, creating a magnetic force on the rotor conductor rod.

The reaction from a combination of the current flowing and changing in the magnetic field allow the rotor to rotate. This result from the impulses of the magnetic field caused by induction in the rotor rod. However, if the rotation of the rotor is equal to the speed of the rotating magnetic field, there would be no intersection of the rotating magnetic field and the rotor conductor rod cause no current to flow in the conductor. For this reason, the rotor must rotate rotated in a bit slower speed than the speed of the magnetic field to have the intersection of the magnetic field and the speed of the rotor called slip. The motor action is detailed in Fig. 1.

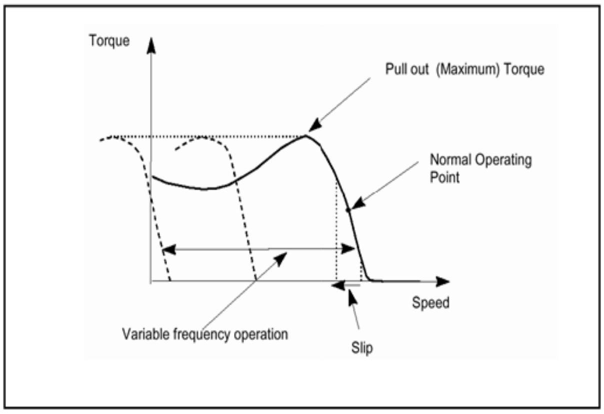

Fig. 1. Characteristics of torque to the speed of AC motors.

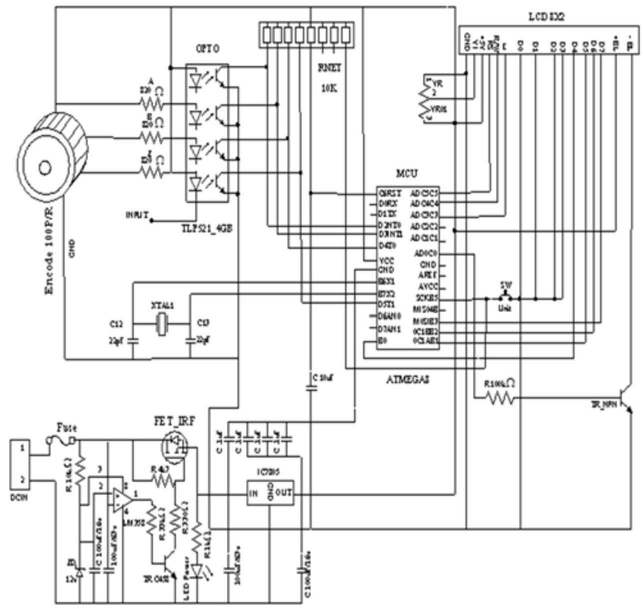

Fig. 2. The contact tachometer circuit

III. Circuit Design and Operating Principle

The circuit, as shown in Fig. 2, IC Micro controller ATMEGA8-16PU use 5 Volts as a power supply. All operations operate on the MCU which the input signal port from is receiving the information from Rotary Encoder 100P. / R. The pulse signal contributed from the phototransistor using an optical intersection, resulting in a pulsed image. When the input signal is received, it compared with the external pulse signal obtained from XTAL1 and then processed via the port connected to the LCD.

The operation of the program begins by defining the initial variable value using the acquired input signal comparing to the external pulse signal, then convert incoming pulse signals to RPM (RPM). The operation of the Voltage Regulator circuit using DC power as input, control the voltage and current to be constant at +5 VDC utilizing IC number 7805 and LM 358 working together in parallel, the block diagram of contact tachometer depicted in Fig. 3.

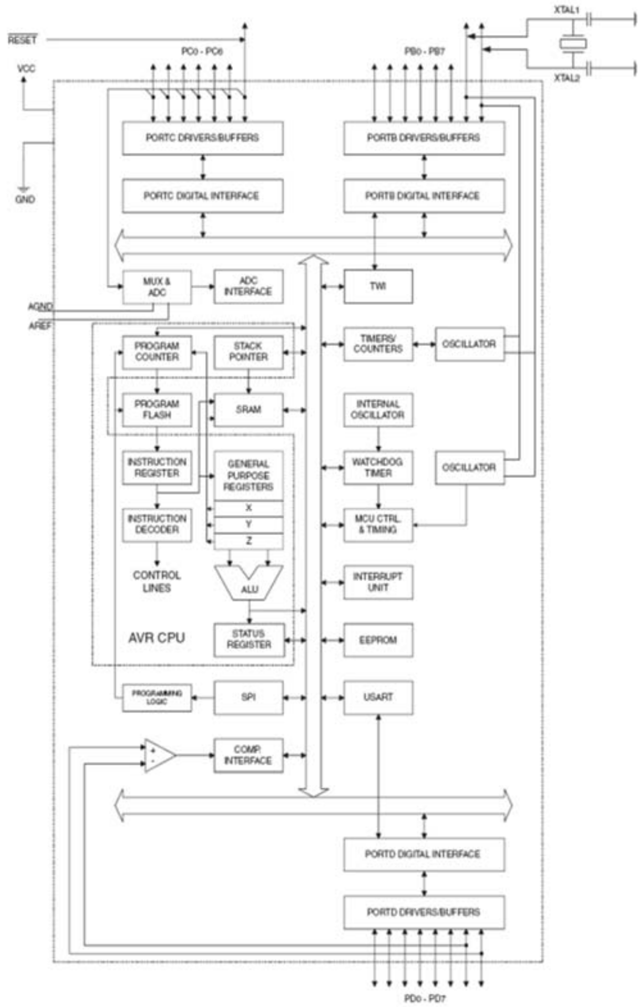

Fig. 3. Block diagram of contact tachometer

IV. Experimental Setups

The experiments of speed measurement in this paper have measured the speed of the AC induction motor in a no-load condition. The available measuring instruments in the market held to the experiment to compare the performance and the error percentage. The instrument used in the experiment consists of a light-speed meter, commercial contact tachometer, and the proposed tachometers. The experiment was carried to measure motor speed ten times per measuring instruments type. The speed of the motor increase when increasing the supplying voltage. Moreover, find the average value to record the results in the experimental results table compare to calculation values.

The equipment used in the experiment shows in Fig.2 as follows: Motor 60 watts, 3000 rpm, 24 volts, and 3.3 amps, 24 VDC power supply, voltmeter, light speed meter, commercial contact tachometer, and the proposed tachometers. Table 1 shows a comparison of the results of each type of speed measuring instruments comparing to calculation value.

Fig. 4. Equipment composition in the experiment.

V. EXPERIMENTAL RESULTS

The speed measurement on the rotary machine in the experimental setup to compare the accuracy between the proposed unit and two types of Tachometer with speed from the calculation. The speed of the motor when varying the supply voltage can be summarized as shown in Table 1, and the average error of compare to calculation speed can be summarized, as shown in Table 2.

TABLE I. THE MOTOR SPEED MEASUREMENT USING DIFFERENT TYPE OF TACHOMETER

Voltage (V)	**Speed of Motor**			
	Calculation	***Laser Tachometer***	***Contact Tachometer***	***Proposed Unit***
24	3000	3656	3543	3432
20	2500	2577	2561	2544
16	2000	2074	2023	2040
12	1500	1421	1572	1594
8	1000	1097	1089	1074
6	750	784	786	774
3	375	386.8	372.2	360

TABLE II. THE AVERAGE ERROR OF DIFFERENT TYPES OF TACHOMETER

Average Error (%)		
Laser Tachometer	***Contact Tachometer***	***Proposed Unit***
±8%	±7%	±6%

The result from the table shown that the proposed Tachometer can achieve a better accuracy compared to other types of Tachometer with an average error of around 6%

VI. CONCLUSION

This paper proposes the development of contact motor tachometer by receiving input signals from rotary encoders connecting to various types of motors. MCU controlled all devices and processed by displaying the numbers in RPM (Revolutions Per Minute) units by LCD. The maximum speed is 4,000 rpm with ± 6% error compared to products in the commercial sector. It can be concluded that the proposed speedometer has accuracy and reasonable price, an error is caused by the contact axis between the motor and the speedometer, resulting in a loss of approximately 3-6% of the contact axis, including faulty processing and loss within the circuit as well. It appears that it can be used and applied in industrial applications such as motor revolutions or mechanical speed control in industrial applications.

The problems found in the experiment are that when measuring the motor speed, the contact of the motor and the Tachometer may be tilted or slippery, and the contact axis is impacted, causing the damaged surface of the contact, resulting in the distorted measured value. The guidelines for the further development of contact tachometers is increasing the capacity of the circuit to be able to measure the high speed of the circuit to be more sensitive and accurate and to improve the device to be more compact, to be easy to carry and accessible to users.

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