A SIMPLE VELOCITY MEASUREMENT SIGNAL CONDITIONING CIRCUIT

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***Abstract*-This paper presents an approach in signal conditioning circuit design for velocity measurement. The goal of this project is to achieve an accurate measurement of the velocity using a rotational disc and a photodetector as a sensor. A signal conditioning circuitry is used to transform the input signal into a suitable output. The light from the light source is captured by a photodetector when the disc rotated. The signals captured are then transformed to the desired output that is in term of frequency, voltage and speed in meter per second.**

***Keywords*- rotational disc, signal conditioning circuitry, photodetector, frequency.**

1.0 Introduction

Sensors are devices used to measure the required signals using either contact or no contact techniques. Technology choices for sensors, include cable extension, magnetic induction, microwave, optical or laser, piezoelectric, radar or radio frequency, strain gauge, and ultrasonic. For cable extension devices, moving object is attached to a cable, which is typically connected to a potentiometer.

In several years ago researchers have attempted to develop a velocity measurement used several techniques such as Scintillation of laser beam [1], angular and frequency correlation [2] ,self-mixing laser diode using speckle correlation [3], and rotated split-firm sensor [4]. These techniques were applied for many types of velocity measurement included the air flow. The development of the techniques had been studied time to time in order to improve the system measurement.

1.1 Project overview

This paper presents an approached in using a rotational disc attached to an anemometer for velocity measurement. A photodetector detect a light signal from a light source when the slotted disc rotates. This information is processed through two stages; signal conditioning and signal conversion. A signal conditioning circuit is developed to process the data from the photodiode before the signal is converted into a voltage and speed. An effort had been spent in applying a new technique to bring out the conversion of the signal which was a Peripheral Interface Controller (PIC 16F873). The output signal is displayed on the oscilloscope and is measured through the digital voltmeter. This technique is suitable for further application such as interfacing and is an advantage in terms of the used of modern technology. Advantages of the PIC over other controller are that it has a faster response and be able to improve the signal.

2.0 The design

Figure 1 shows a block diagram of the measuring instruments which consists of the overall design of velocity measurement. The driver circuitry supplies a light source to the system. A photodetector act as a sensor which sense the incoming signals when the slotted disc rotated. These signals are then fed into the signal conditioning circuitry for further process. The signal conditioning circuitry consists of four major parts as shown in Figure 2.

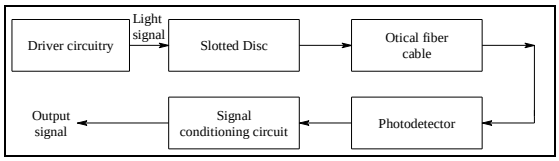

Figure 1: Block diagram of the measuring instrument.

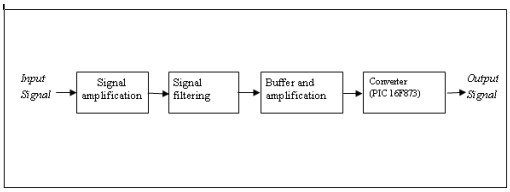

Figure 2: Block diagram of the signal conditioning circuitry.

2.1 Driver circuitry

A driver circuitry contains an ultra bright red LED, a transistor, and power supply. This circuit is very important to provide a light source to a photodiode. In order to control the current at the LED, the circuit is added a transistor to it.

2.2 Slotted disc

A slotted disc is designed to produce a light chopping signal. This slotted disc is supposed to be mounted to an anemometer in the process of detecting the wind speed. The mechanical part of the slotted disc is designed to have continuous rotation as the anemometer rotate. The design concept of the mechanical part of the slotted disc is shown in Figure 4. The propeller rotate when the wind flow and at the same time the slotted disc also rotate produces a light chopping.

It used a light beam interruption as the working principle. If the light beam interrupted, there will be no signal from the light source transmitted. This chopping process will produce a series of pulses signal. The principle of light chopping process is shown in Figure 5.

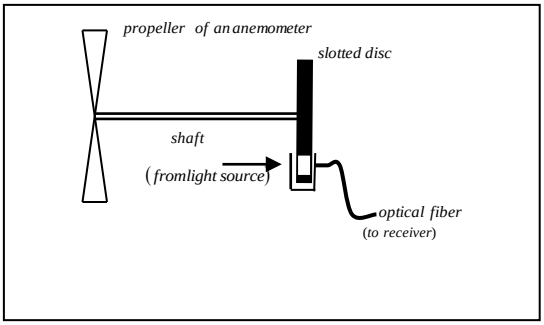

Figure 4: Mechanical design of the anemometer and a slotted disc.

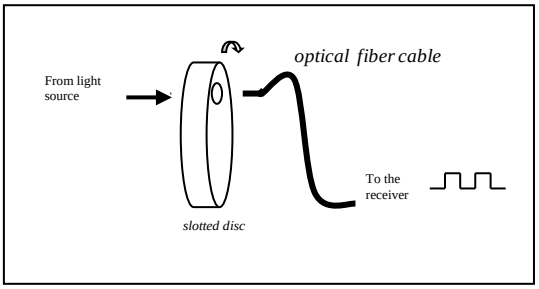

Figure 5: The principle of light chopping.

2.3 Photodetector

A pin photodiode is a type of optical receiver which detects the optical signal. It changes its electrical conductivity according to the intensity and the wavelength of light. The photodiode detect the light signal and transformed the signal back to an electrical signal. It provides current as an output signal.

2.4 Signal conditioning circuit

The signal conditioning circuitry consists of signal amplification circuitries, filtering circuitry and converter. The signal from the optical receiver was very small (μA). Thus it is important for the signal to be amplified to get the desirable output signal for the next process. However, during the amplification, there is a noise or signal distortion occurred. Noise is a disturbance that obscures or reduces the quality of the signal. Noise effected and limitations of the signal conditioning circuits cause the distortion of the receiver's electrical output signal. Thus, the filtering circuitry is introduced to reduce or eliminate the possible noise that

occurred. A low- pass filter and a high- pass filter are used. A buffer required to get a proportional output voltage as the slotted disc rotation increased.

2.5 Signal conversion

A converter in this project used a PIC 16F873 where it is programmed to convert the input frequency in the range of 0- 255HZ into voltage. Table 1 shows the relationship of input frequency and the output voltage. The maximum output voltage that can be measured is 5 volt at the maximum frequency of 255Hz. If the frequency exceeds the maximum range, the output voltage will maintain at 5 volts.

Input Frequency (Hz)	Output Voltage (Vo)
0	0.00
20	0.43
40	0.79
60	1.15
80	1.51
100	1.87
120	2.23
140	2.59
160	2.95
180	3.31
200	3.67
220	4.03
240	4.39
260	5.00

Table 1: Relationship between input frequency and the output voltage.

The operation of this PIC is continuous for continuous input signal fed through it. A flow chart of the operation is shown in Figure 6.

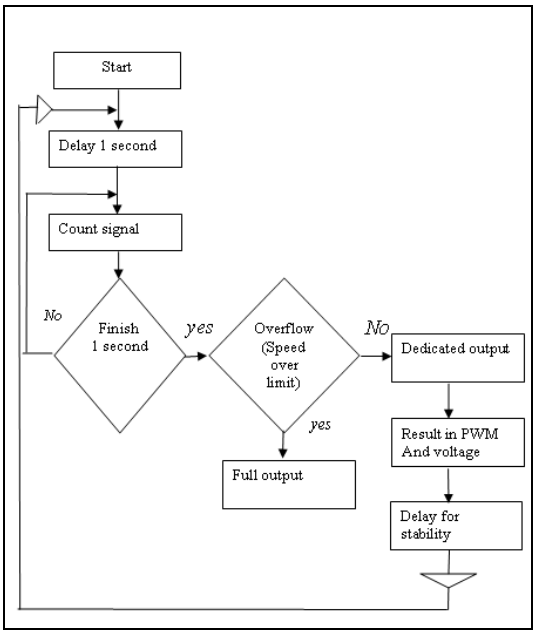

Figure 6: Operation flow chart.

This technique is suitable for further application such as interfacing and is an advantage in terms of the used of modern technology. Advantages of PIC over other controller are, it has a faster response and be able to improve the input signal. The speed is then calibrated by its relationship between the PWM which can be observed from the oscilloscope.

3. Result

3.1 Signal conditioning measurement

Figure 7 shows the output of the signal conditioning circuit when the motor was rotate. The output signal was in pulses as a photodiode detected the light entered to the slotted disc. It just like ON and OFF signals. The ON condition was when a light signal passed to the photodiode through the slotted disc. The OFF condition was when the light can not pass through the disc.

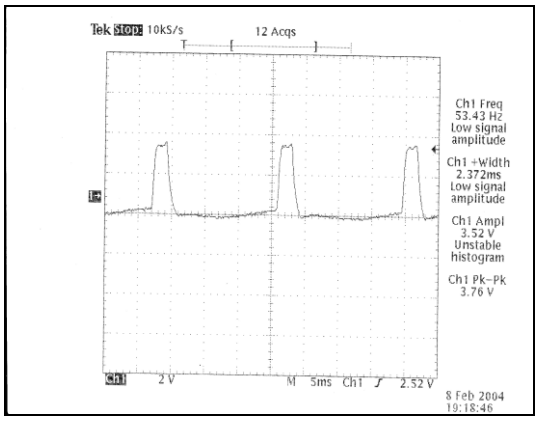

Figure 7: Signal conditioning output.

3.2 PIC 16F873 calibration

In this experiment, the range of input frequency from the frequency generator was fed into the PIC16F73.The output PWM and output voltage was observed and was plot in a graph as shown in Figure 8 and Figure 9.

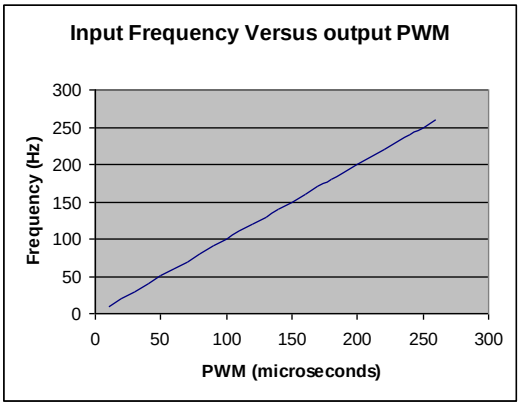

Figure 8: Relationship between input frequency and the PWM.

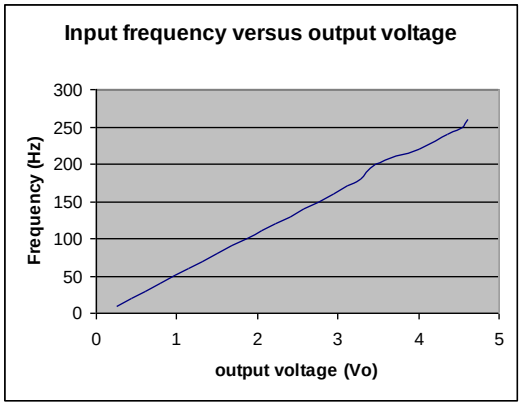

Figure 9: Relationship between input frequency and output voltage.

From the observation, a PWM output was the same as the input frequency value while the output voltage was increased by 0.18Volts. The output voltage however was 4.61 volt when the input frequency reached the maximum (255Hz).

3.3 The system output

The output signal from the overall system was shown in Figure 10.

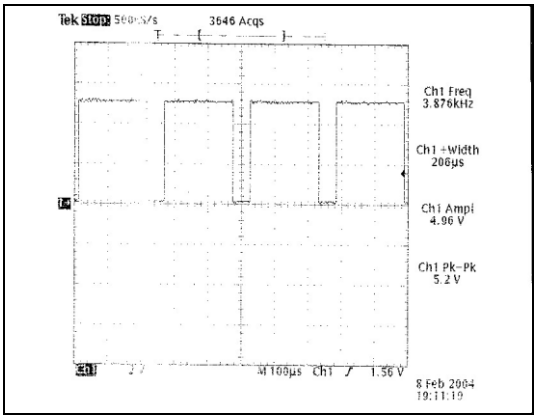

Figure 10: System output.

As the speed of the motor increased, the width of the output PWM also increased, as well as the output voltage. The speed of the motor was equal to the output PWM. The output voltage and the speed are shown in Table 2.

Output Voltage (Vo)	Speed (rps)
0.16	5
0.29	12
0.61	30
0.97	50
1.89	100
2.24	124
4.24	223

Table 2: Output voltage and the speed

4. Discussion and Conclusion

The signal conditioning has an improvement pulses signal after filtered. However the signal can be improved much better if a better filtering technique was applied and it required a detail study on filtering.

For the converter circuit, the signal was much more stable, and by the used of PIC the output signal was more stable and easier to measure.

As for the whole system, the output signal was measured and observed. This signal however could be improved to be more accurate by creating more slots on the disc.

Thus it can be conclude that the stable and improved signal could be measured from this project.

5. Future development

A modification on the system design of this project can be made to improve its accuracy and sensitivity. This can be done by design an optical fiber with a dome to converge the light so that there is more light immersion into the receiver.

By adding an interfacing to the output signal, the value of the measurement can be display on the computer. Visual basic programming can be used through RS232. Besides that, this project can expanse to detect not only the speed of the wind but also its direction. However, more modification on the mechanical design of the anemometer is going to be done and the circuitry of the signal conditioning also need to be design properly to get the reading of the direction.

6. Acknowledgement

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7. References

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