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A New Way of Resolver to Digital Converter in a Steady System

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Abstract. This paper presents a simple method to detect the phase of a rotor based on the resolver equipped motor in a steady status. There are three pulses signals which are used to produce the phase edge at 0 degree, 90 degrees, 180 degrees and 360 degrees. This can be used to reset the integrator which is used to integrate the phase differences. Meanwhile the carrier edge can be used to counted as the phase angle of rotor. When the system is in a steady status it is easy to get the phase angle by using a digital counter.

Keywords: Resolver, phase detection, Rotor position, Synchronization pulse ADC.

1. Introduction

Resolvers are robust and reliable transducers comparing with other transducers. The non contact design between rotor and stator make it works well even in harsh environments like high temperature and high electrical magnetic noise. The resolver is basically a rotary transformer which has the rotor part fixed on the motor shaft and the reference signal coil and position-feedback orthogonal coils integrated on the stator part of the motor. The output of orthogonal coils signal is simply a multiplication of the rotation angle of rotor and the reference signal. To acquire the real-time phase and frequency information of rotor, we need to decode the feedback signal in the sine and cosine coils in a fast and appropriate way.

$$V_{ref} = Vsin(\omega_c t) \tag{1}$$

$$V_{cos} = g_v V_{ref} \cos(\theta) \tag{2}$$

$$V_{sin} = g_v V_{ref} \sin(\theta) \tag{3}$$

Where $g_v$is the transformation ratio between stator and rotor windings, $\theta_r = \omega_r t$ is the rotor position and ω_r is the rotor speed. The excitation signal is given by equation (1) in which the frequency of ω_c is a much higher than ω_r. For this, the edge can be detected in a much smaller period without influence the accuracy.

Fig.1 shows the stator and rotor parts of resolver from TE.

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Figure 1. TE resolver stator and rotor

2. Proposed method

Table 1. Reference signal, Sine/Cosine signals with the rotor in different position.

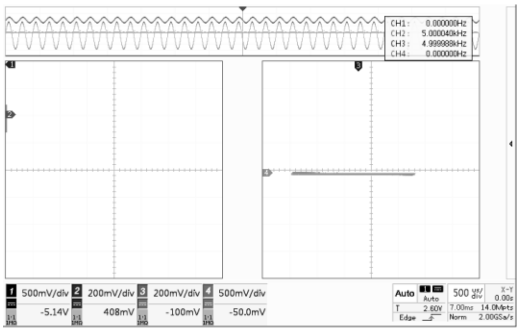
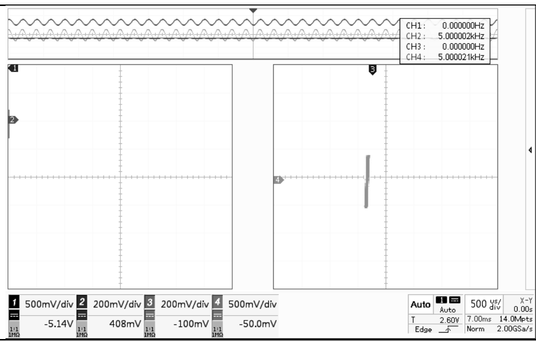
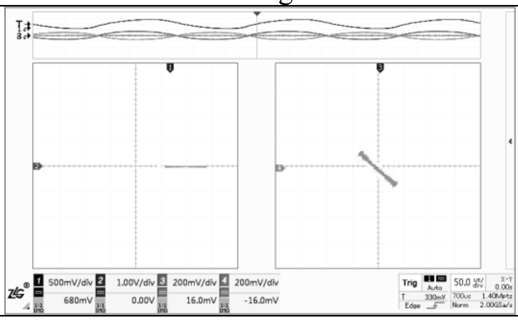
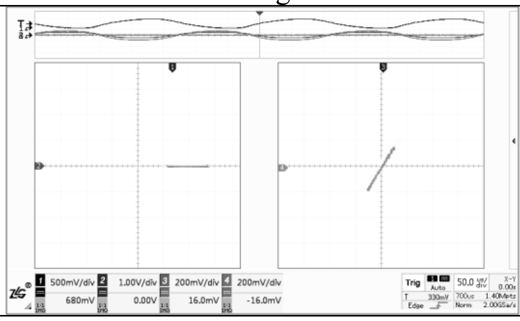
	
I zero degrees	II 90 degrees
	
III 135 degrees	IV 225 degrees

Table1 shows the traditional way of calculation the phase of rotor based on the sine and cosine signals. The reference signal is input through channel one. The scope is set to XY mode with the channel three and channel four set to sine coil input and cosine coil input. When the rotor is rotating, the angle of the plot will track the movement.

Fig.2. shows two multipliers are used to animate the resolver signal from the SINE and COSINE coils. The carrier frequency is set to 3.6k HZ and the ROTOR frequency is set to 100HZ. It is intentionally set this way for the angle phase calculation scaled to 0-360°. When the Rotor frequency and carrier frequency is set to other frequency. It still works with this methodology. A demodulation method has been talked in[1],but due to the precision of circuit, there will be distortion around the crossing zero area. The upper part is a rising edge generator to sample the pulses level for the output of three comparators. For a normal way to acquiring the rotor phase based on the resolver encoder, ADCs, Demodulation circuit, Inverse tangent function and Look up table would be included. The system is much more expensive and very complicated to be built. Here a pure digital method is proposed and the speed of this circuit is quite satisfied. A SVPWM method based segment distribution can be extended from the present research. Fig.3 shows the 3 input to 6 output logic circuit to produce the four quadrant

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period signal based on the output pulses from the three comparators. There are many papers have presented circuit diagram to get the resolver processed signals which include a lot of amplifiers.[2-4].Here a simpler 3-8 decoder has been used to reduce the cost.

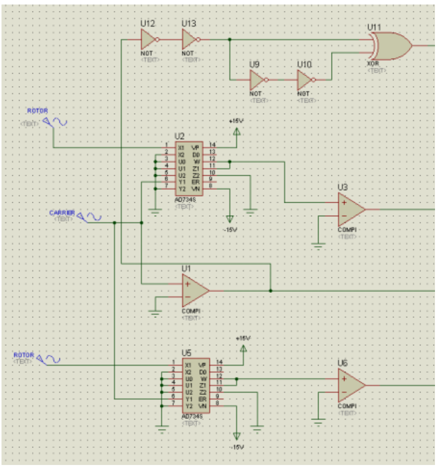

Figure 2. Resolver signal animation and the reference pulse generation

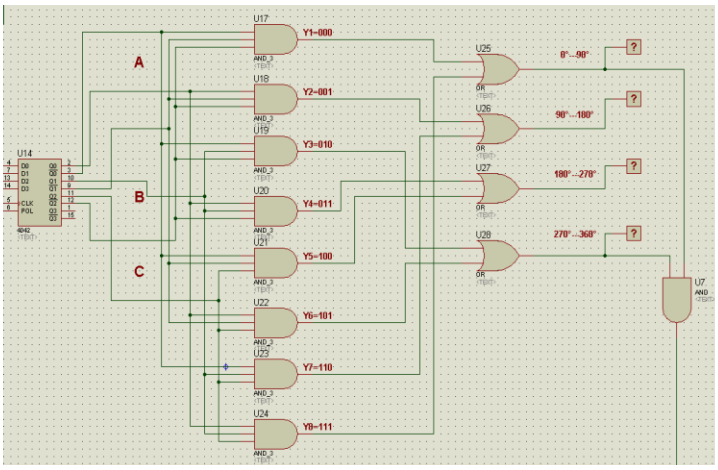

Figure 3. The phase angle edge generation

Fig.4 shows the TTL decade counter which is used to accumulate the phases from the comparator pulse. A PE12016G chip can also placed here for direction or displacement of an axis determination based on the demodulated two orthogonal signals in Fig.5. Alternatively, the pulse width can be measured by the known fixed carrier clock rate. The reset pulsed is generated from the 0-90 quadrant and the 270-360 quadrant when the rotor position is right at 360 degrees.

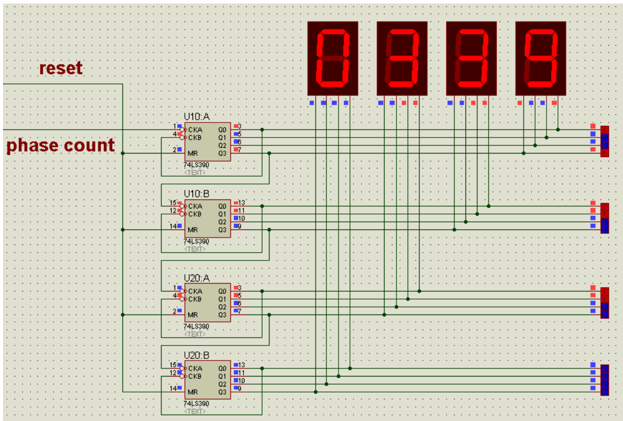

Figure 4. Angle generation

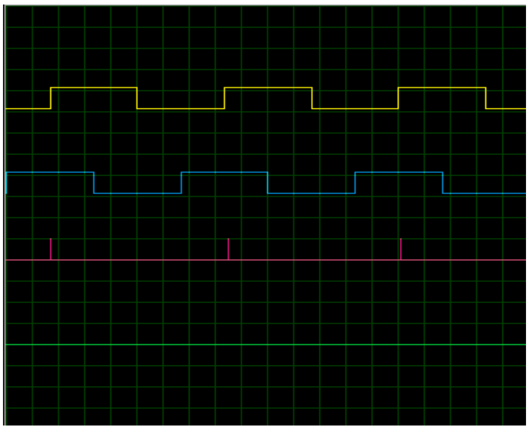

Figure 5. Demodulated signal generated orthogonal pulses

3. Experiment

Based on the circuits presented in the previous section, the simulation is performed on the Proteus. Fig.6 shows the animated resolver output signal from sine coil and the other three output pulse from the comparators. Fig.7 shows the four quadrants period signal which is also realized in [5].The comparators were constructed by precise comparator EL2018B. The multiplier is constructed by using AD734S.The TTL decade counter is built by 74LS390.The Schmitt triggers and XOR gates which can be chosen from general components as long as they can fit for the time requirement. A further experiment to this circuit can be application of a dynamic resolver signal to acquire the dynamic performance of this design.

Fig.8 shows the sampling pulse for the three output pulses. Fig.9 shows the one integrator can be used to integrate the phase signal for 0-360°Saw tooth wave generation.

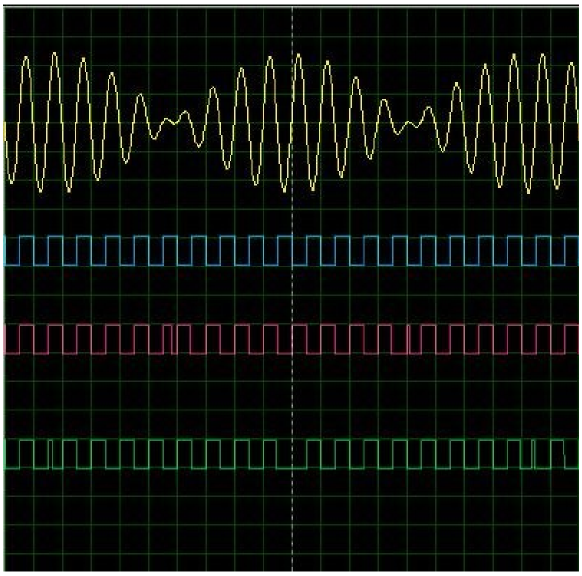

Figure 6. Sine coil output signal and three pulses

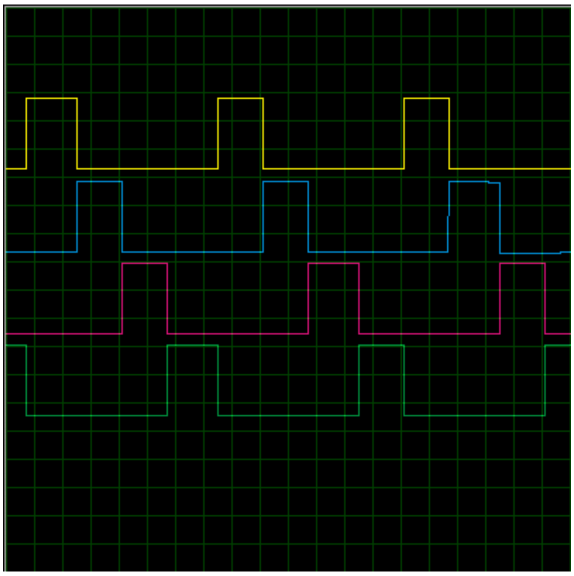

Figure 7. Four quadrants period signal

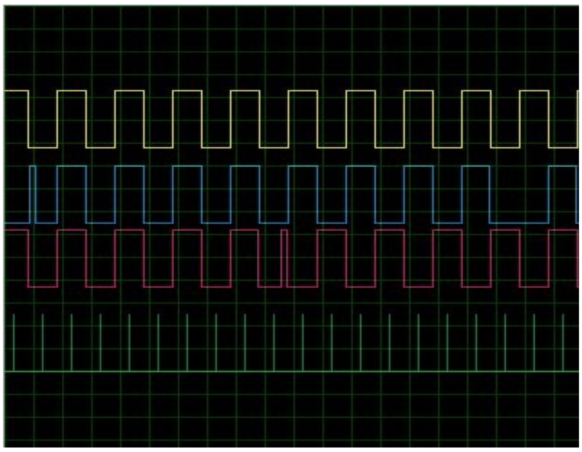

Figure 8. Sampling pulse and the resolver to digital pulse signal

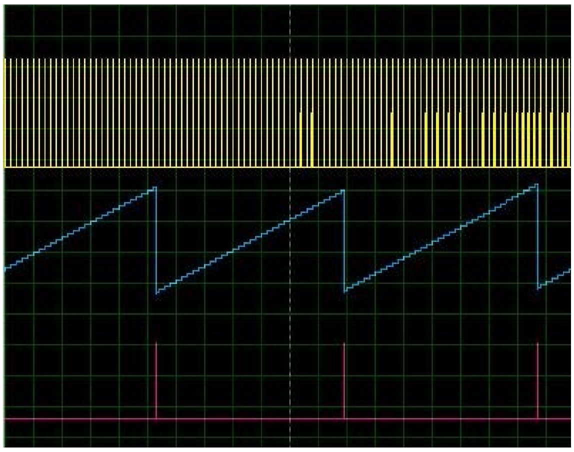

Figure 9. Integrator used for saw tooth wave generation

4. Conclusion

In this paper, a new simple resolver to digital conversion method is proposed. This circuit can apply to different frequency and have a fast response to it. The digital segments give the degree of the rotor in a steady system. The system character due to the frequency step and phase step will illustrate in a future study.

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