Simple Resolver Demodulation

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Abstract

A simple method to demodulate the resolver signal is introduced in this article. The proposed method can provide the demodulated resolver quadrature signals, sine and cosine, without requiring the resolver excitation signal as the carrier signal. Therefore, the phase delay between the stator winding and the rotor winding is avoided. The configuration of this approach consists of commercial avariable circuit building blocks such as comparator, simple and hold (S/H) and monostable multivibrators. Thus, the proposed approach is obtained to the economical attraction. The operation of the proposed demodulator and its performances are confirmed by simulation and experimental results.

Keywords – resolver, demodulation, suppressed carrier, sample and hold

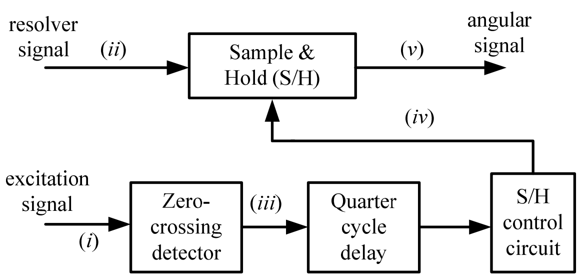
1 Introduction

Resolver is an importance transducer in measurement and control systems. Its applications are in the form of angular position measurement such as robot, aircraft, CNC and satellite tracking antenna [1]-[3]. The interesting for using resolver in these applications is due to the fact that resolver provides the benefit in term of high reliability, robustness and maintenance free [4]. The configuration of resolver is a kind of rotary transformer where rotor winding is a primary and two stator windings placed on right angle are secondaries. The resolver operating requires an excitation signal for rotor winding. The output signals from two secondaries are produced by the modulation of excitation signal at primary and the rotor shaft angle. The modulated signals from resolver are results in function of sine and cosine. These output signals are generated in form of amplitude modulated signals with double side-band suppressed carrier. Traditionally, a synchronous demodulator is used to remove the carrier or excitation signal and produce the angular of the rotor shaft. The use of synchronous demodulator requires a low-pass filter, which is phase sensitive device to reject high frequency component. To determine the rotor shaft angular, both output signals of resolver are used [3]-[5]. However, the inaccuracy of the shaft angular readout is due to the mismatch of synchronous demodulators used to detect angular signals from secondaries. In general, a low-pass filter provides phase shift of output signal. Therefore, low-pass filters used for two synchronous demodulators of resolver secondaries must be perfectly matched for high accuracy. Unfortunately, two perfectly matched low-pass filters are improbable for implementation. In addition, the inaccuracy of traditional synchronous demodulator is also disturbed by phase shift between the excitation signal and carrier presented in secondaries of the resolver. This is due to that the synchronous demodulator requires an excitation signal to remove the carrier presented in the secondaries. There are several techniques to demodulate the resolver signals with more accurately results [6], [7]. Nevertheless, these techniques provide large configuration and inconvenience for implementation. In this article, a simple technique to demodulate the resolver signals is presented. The excitation signal is used to provide the time-sequence control signal. Therefore, the inaccuracy due to the phase shift between excitation signal and carries is avoided. The output signals can be produced without low-pass filter. Thus, the phase errors of the resulting signals from secondaries are eliminated. The proposed resolver demodulator circuit shows the benefits in the terms of small in size, high performance and low cost.

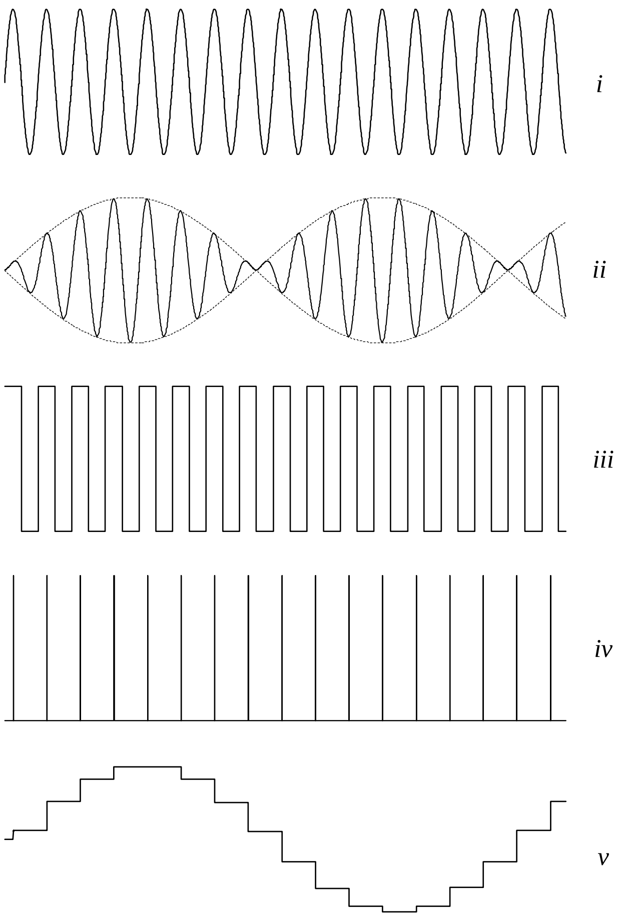
2 Circuit description

2.1 Principle

Principle of the proposed resolver demodulator is shown in Fig. 1(a). The configuration of proposed principle comprises four-circuit building blocks i.e. sample and hold (S/H) circuit, zero-crossing detector, quarter cycle delay circuit and S/H control circuit. The operation of the principle in Fig. 1(a) can be explained as follow. From Figs. 1(a) and 1(b), zero-crossing detector converts the excitation signal (curve *i*) to square wave (curve *iii*), which is used to generate time sequence for control the operations of each circuit building blocks. The quarter cycle delay circuit delays the obtained square wave signal to one fourth of time period of the excitation signal. The output signal of the quarter cycle delay circuit is sent to S/H control circuit to control the operation mode of S/H (curve *iv*) where logic level "1" means sampling and logic level "0" means hold. The resolver signal (curve *ii*) and S/H control signal (curve *iv*) are simultaneously applied to S/H in Fig. 1(a). The S/H is controlled by S/H control signal to produce demodulation of resolver signal to the angular signal (curve *v*). It can be seen that the proposed technique can detect angular signal from resolver signal without using phase sensitive device that requires in the traditional resolver demodulator.



(a)



(b)

Fig.1. Proposed resolver demodulation technique.
(a) Basic principle
(b) Signal waveforms of each point

2.2 Proposed circuit

The proposed technique for Fig. 1(a) is depicted in Fig. 2. All devices used are commercial available components. Therefore, the circuit is easily setting up and low cost. From circuit in Fig. 2, opamp A1 functions a comparator to compare the excitation signal with ground potential. The excitation signal in the form of sinusoidal wave is converted to square waveform with 50% duty cycle. The positive going edge of square wave is passed to trig the monostable multivibrator MN1 to generate a positive single pulse. The pulse width of the output pulse from MN1 is assigned to the quarter of the excitation signal time period. The falling edge of the output pulse from MN1 will transfer to trig the S/H control circuit formed by the monostable multivibrator MN2 to provide sample signal for S/H. The time period of sample signal is set to minimum time requirement for ability of sampling to hold of S/H. Consequently, the S/H will sample the resolver signal at the peak amplitude of carrier signal and hold. The angular signal or demodulation signal is occurred in the hold stage. It should be noted that the operation of the circuit in Fig. 2 is agreed with the proposed principle in Fig. 1.

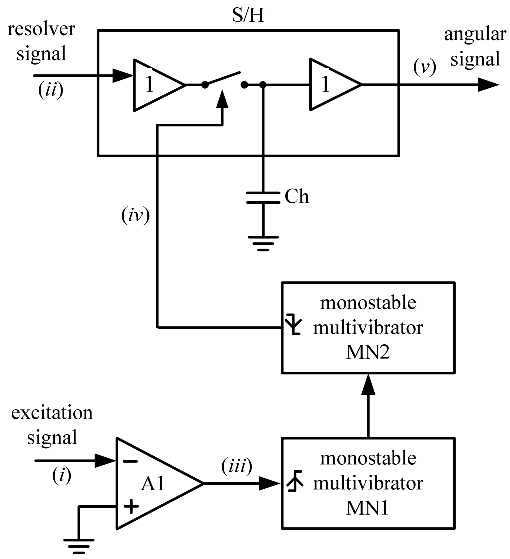


Fig. 2. Block diagram of the proposed resolver demodulation.

3 Simulation and experimental results

To demonstrate the principle of Fig. 1(a), MATLAB SIMULINK program was used. The results of each stage can be shown in Fig. 3.

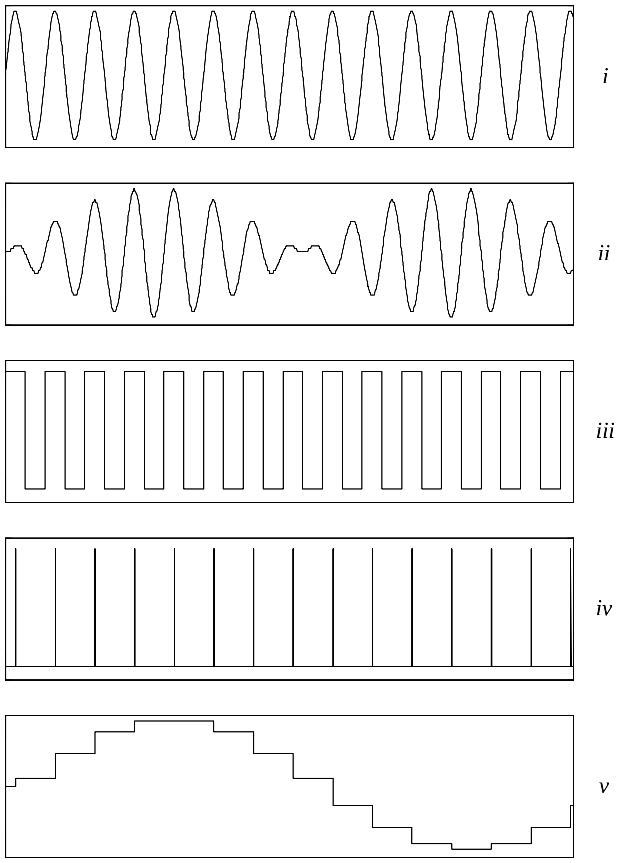
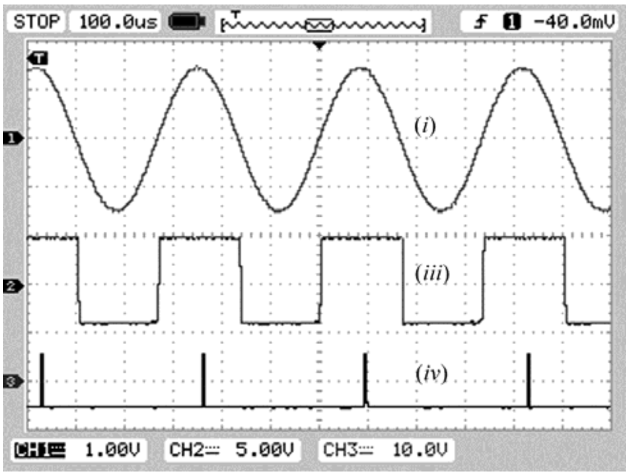
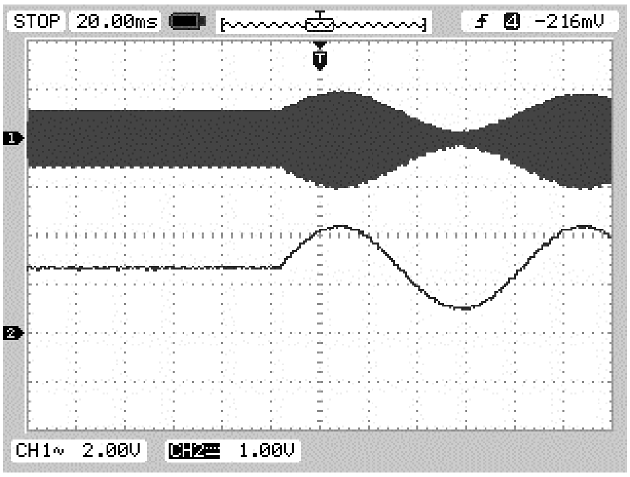


Fig.3. Simulation results from MATLAB.

The performance of the proposed circuit in Fig. 2 was confirmed by experimental implementation. All devices used in the proposed circuit are commercially available. The devices of LF398, LM339 and CD4528 are used as S/H, comparator and monostable multivibrator, respectively. The excitation signal was set to 3 kHz sinusoidal wave with $5V_{pp}$. The resolver signal is provided from SANYO DENKI 101-4100 resolver. The pulse width of the monostable multivibrator MN1 is set to quarter of the excitation signal time period as 83µs. The S/H control pulse width is assigned to 5µs for S/H (LF398). The sequential curves from excitation signal to S/H control signal are shown in Fig. 4(a). It can be seen that the output curves of each building block are similar to the curves in Fig. 1(b). The resolver was driven to the speed of 1,800 rpm. The resolver signal was applied to the input of S/H. The results of the angular signal are shown in Fig. 4(b). In addition, the sine and cosine signals of resolver can also be achieved by including another S/H as shown in Fig. 5(a). Fig. 5(b) shows two demodulated signals obtained from secondaries of resolver.

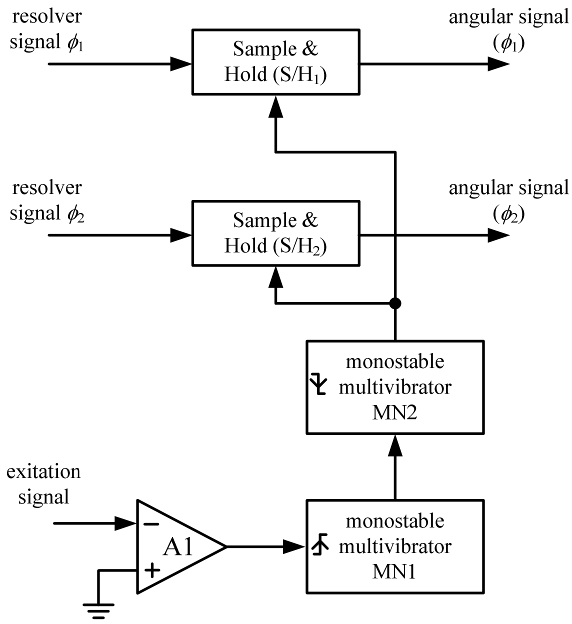


(a)

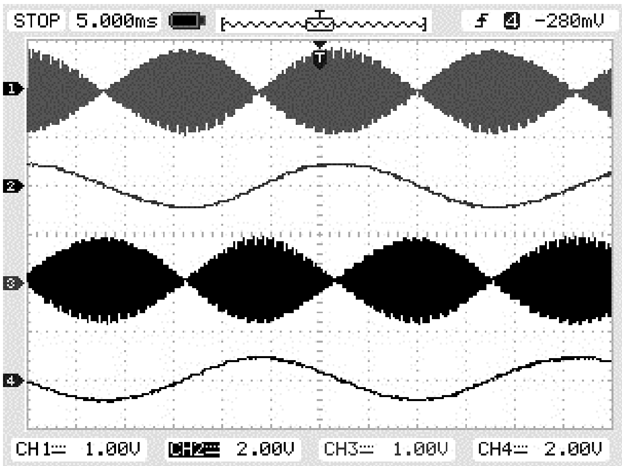


(b)

Fig. 4. Measured results of the proposed demodulation.
(a) Signals of each building block
(b) The obtained angular signal from resolver



(a)



(b)

Fig.5. Measured results of two demodulated signals, sine and cosine.
(a) Block diagram for two signals demodulation
(b) Modulated and demodulated signals of the resolver driven at 1,800 rpm

4 Conclusions

A simple technique to implement a demodulator for resolver has been presented. The components used for the demodulator are only the commercial available devices, i.e. comparator, sample and hold, monostable multivibrator. Two angular output signals, sine and cosine signals, can be simultaneously provided using same S/H control signals for two S/Hs. The advantage of the proposed demodulator is that the phase sensitive devices are without requirement. Simulation and experimental results demonstrated the circuit performances are included.

References

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