Chapter 8

# Synchros

TEC / NOT / 011

This paper introduces angle and angular velocity measurement using synchros.

The following topics are discussed:



## 8.1 Overview

Synchros have been available since the 1930s. They are electromechanical devices consisting of a stator with three windings and a rotor with one winding. The rotor carries an ac signal and induces a different ac signal on each of the stator windings depending on the angle.

By monitoring the signals on the stator windings, the angle (and hence angular velocity) can be deduced. This method is robust and is arguably the most accurate way of measuring angle.

## 8.2 Synchro theory

Synchros are cylindrical and resemble small ac motors as illustrated in the following figure. The size of a synchro is specified by rounding the diameter to the nearest tenth of an inch.

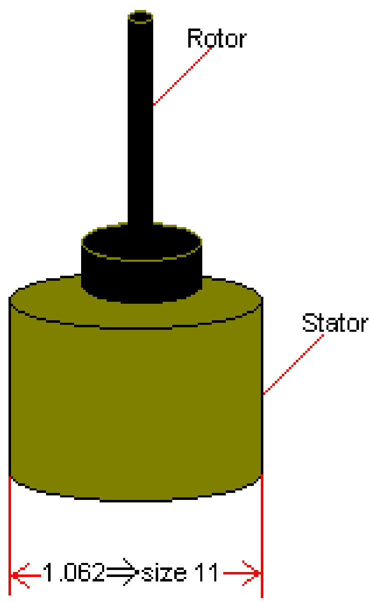


*Figure 8-1: A typical synchro outline*

An exploded view of a synchro is shown in the following figure.

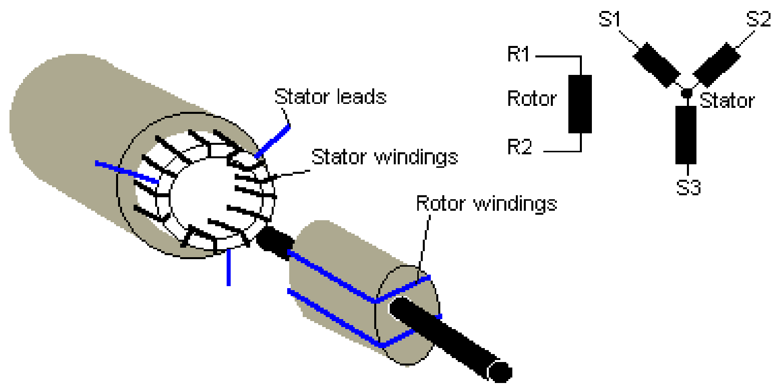


*Figure 8-2: Exploded view of synchro*

An ac signal (typically 60 or 400 Hz) is applied to the rotors (usually via carbon brushes), inducing a voltage on the stator leads that is a function of the shaft angle (θ). In particular, if the voltage on the rotor is:

$$R = A \cdot Sin(360° \cdot t \cdot 60Hz)$$

The signals that appear across the stator terminals are:

$$V_{s1-s3} = K \cdot Sin(360° \cdot t \cdot 60Hz) \cdot Sin(\theta)$$

$$V_{s3-s2} = K \cdot Sin(360° \cdot t \cdot 60Hz) \cdot Sin(\theta + 120°)$$

$$V_{s2-s1} = K \cdot Sin(360° \cdot t \cdot 60Hz) \cdot Sin(\theta + 240°)$$

These voltages are known as synchro format voltages and are graphed in the following figure for a shaft angle (θ) of 15°. Essentially there are three equations with two unknowns (*K* and θ), where *K* is a gain factor that may vary with time and temperature and from synchro to synchro. To solve for two unknowns, two equations are normally sufficient. However when the shaft angle (θ) is 0°, the amplitude of the voltage $V_{S1\text{-}S2}$ is 0 and therefore cannot be used so instead the other two are used.

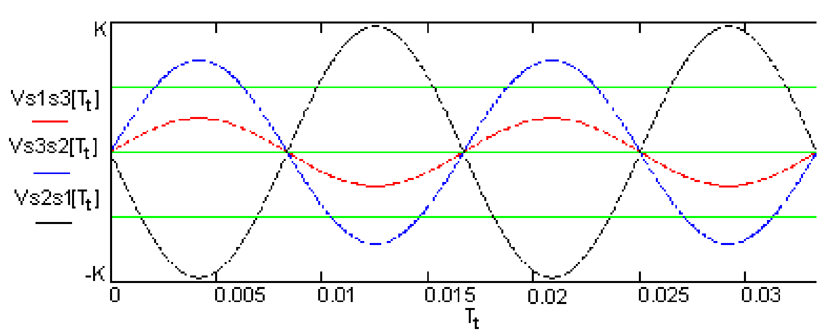


*Figure 8-3: Synchro format voltages for a shaft angle of 15º*

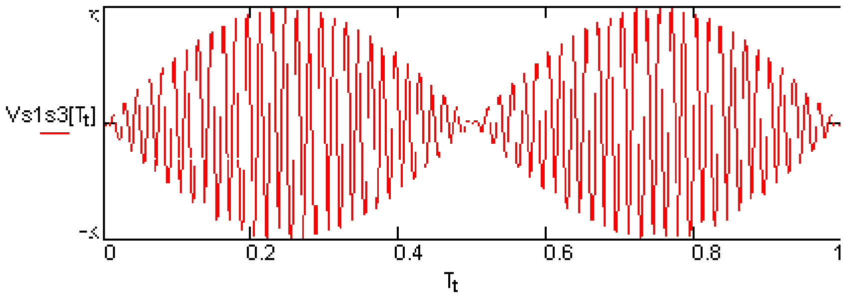


*Figure 8-4: One of the three synchro format voltages for a 360º/sec. angular velocity*

## 8.3 Conclusion

This paper described basic synchro theory, and examined angle and angular velocity measurement using synchros.

## 8.4 References


*Synchro & Resolver Conversion*

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