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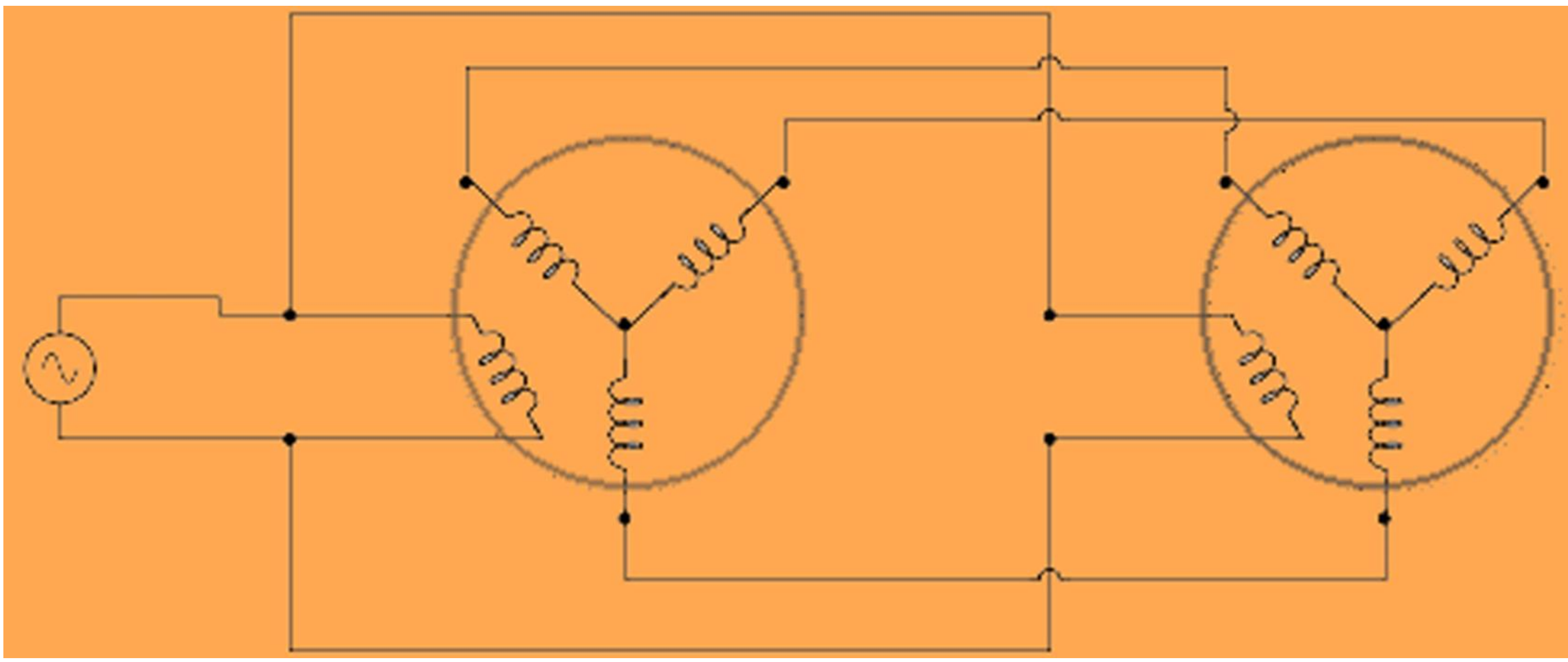
CONTROL SYSTEM HOW-TO GUIDE

# Synchro Transmitter and Receiver



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# SYNCHRO TRANSMITTER / RECEIVER

## INTRODUCTION

The term synchro is a generic name for a family of inductive devices which works on the principle of a rotating transformer (Induction motor). The trade names for synchronous are Selsyn, Autosyn and Telesyn. Basically they are electro mechanical devices or electromagnetic transducer which produces an output voltage depending upon angular position of the rotor.

A Synchro system is formed by interconnection of the devices called the synchro transmitter and the synchro control transformer. They are also called as synchro pair. The synchro pair measures and compares two angular displacements and its output voltage is approximately linear with angular difference of the axis of both the shafts. They can be used in the following two ways.

i. To control the angular position of load from a remote place / long distance.
ii. For automatic correction of changes due to disturbance in the angular position of the load.

## SPECIFICATIONS

| | | |
|---|---|---|
| Transformer | - | 230/50V AC |
| Digital Voltmeter | - | (0-300V)AC |

### Synchro Transmitter

| | | |
|---|---|---|
| Input Rotor voltage | - | 50VAC |
| Output Stator Voltage | - | 34VAC (max) |

### Synchro Receiver

| | | |
|---|---|---|
| Stator Voltage | - | 34V AC (max) |
| Rotor Voltage | - | 35VAC |

## SYNCHRO TRANSMITTER

The constructional features, electrical circuit and a schematic symbol of synchro transmitter are shown in figure-2. The two major parts of synchro transmitters are stator and rotor.The stators identical to the stator of three phase alternator. It is made of laminated silicon steel and slotted on the inner periphery to accommodate a balance three phase winding. The stator winding is concentric type with the axis of the three coil 120° apart. The stator winding is star connected(Y - connection).

The rotor is of dumb bell construction with a single winding. The ends of the rotor winding are terminated on two slip rings. A single phase AC excitation voltage is applied to the rotor through the slip rings.

## Working Principles

When the rotor is excited by AC voltage, the rotor current flows, and a magnetic field is produced. The rotor magnetic field induces an emf in the stator coil by transformer action. The effective voltage induced in any stator coil depends upon the angular position of the coils axis with respect to rotor axis.

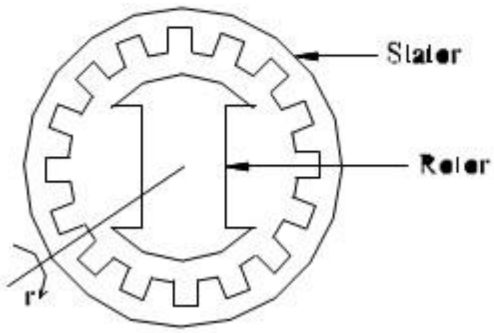


**Figure - Constructional Features of Synchro Transmitter**

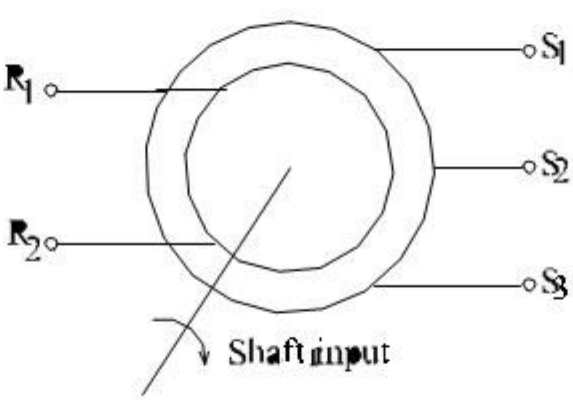

**Figure - Schematic symbol of a synchro transmitter**

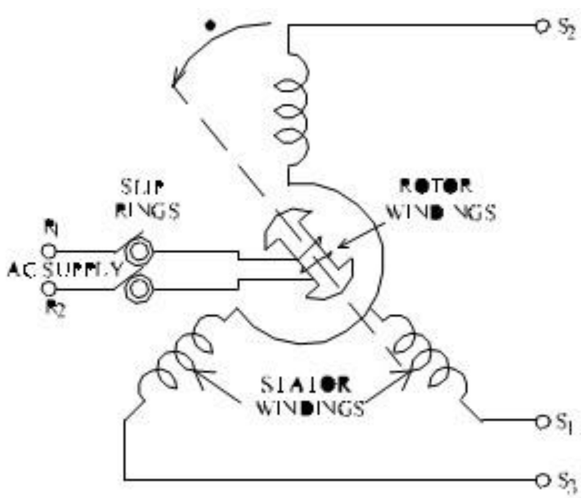


**Figure - 2c Electrical Circuit (Synchro Transmitter )**Where,

Let $e_r$ = Instantaneous value of AC voltage applied to rotor.

e ,e ,$e_{s1}$s2 s3 = Instantaneous value of emf induced in stator coils

S ,S , S with respect to$_1$2 3 neutral respectively.

$E_r$ = Maximum value of rotor excitation voltage.

T = Angular frequency of rotor excitation voltage.

Kt = Turns ratio of stator and rotor winding.

$K_c$ = Coupling coefficient.

2 = Angular displacement of rotor with respect to reference.

The instantaneous value of excitation voltage , e = Er sin$_r$Tt ---(1)

Let the rotor rotates in antic lock wise direction. When the rotor rotates by an angle, 2 emfs are induced in stator coils. The frequency of induced emfs is same as that of rotor frequency. The magnitude of induced emfs are proportional to the turns ratio and coupling coefficient. The turns ratio , K is a constant, but a coupling coefficient, K is a function of rotor angular position.$_t$c

Induced emf in stator coil = K K E sin$_c$e r$^T$t ------(2)

## SYNCHRO TRANSMITTER / RECEIVER

Let e be reference vector. With reference to figure 2, when 2 = 0, the flux linkage of coil s i.

zero. Hence the flux linkage of coil S is function of cos$_2$2 (K = K ) Cos $_c$1 2 for coil S ). The flux$_2$ linkage of coil S will be maximum after a rotation of 120°in anti-clock wise direction and that$_3$ of S after a rotation of 240°.$_1$

Coupling coefficient, K for coil – S1

Coupling coefficient, K for coil – S2

Coupling coefficient, K for coil – S3

$$e_{S1S2} = e_{S1} - e_{S2} = \sqrt{3}\ KE_r \sin(\theta + 240^\circ)\ \sin\omega t$$

$$e_{S2S3} = e_{S2} - e_{S3} = \sqrt{3}\ KE_r \sin(\theta + 120^\circ)\ \sin\omega t$$

$$e_{S3S1} = e_{S3} - e_{S1} = \sqrt{3}\ KE_r \sin\theta\ \sin\omega t$$

$$e_{S1S2} = e_{S1} - e_{S2} = KE_r \cos(\theta - 240^\circ)\ \sin\omega t - K E_r \cos\theta\ \sin\omega t$$

$$= KE_r \left[ \cos\theta\ \cos 240^\circ + \sin\theta\ \sin 240^\circ - \cos\theta \right] \sin\omega t$$

$$= KE_r \left[ \cos\theta\ (-0.5) + \sin\theta \left(-\frac{\sqrt{3}}{2}\right) - \cos\theta \right] \sin\omega t$$

$$= \sqrt{3}\ KE_r \left[ \sin\theta \left(-\frac{1}{2}\right) + \cos\theta \left(-\frac{\sqrt{3}}{2}\right) \right] \sin\omega t$$

$$= \sqrt{3}\ KE_r \left[ \sin\theta\ \cos 240^\circ + \cos\theta\ \sin 240^\circ \right] \sin\omega t$$

$$= \sqrt{3}\ KE_r \sin(\theta + 240^\circ)\ \sin\omega t$$

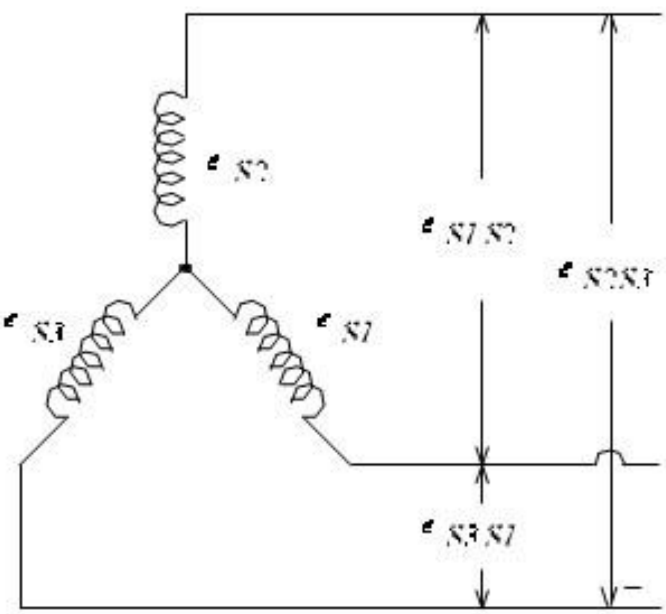


**Figure -3 Induced emf in stator coils**

When 2 = 0, from equation 3 we can say that maximum emf is induced in coil S. But from$_2$ equation 8, it is observed that the coil - to coil voltage ES3S1 is zero. This position of the rotor is defined as the electrical zero of the transmitter.

$$e_{S2S3} = e_{S2} - e_{S3} = K\,E_r \cos\theta \,\sin\omega t - KE_r \cos(\theta - 120^\circ)\,\sin\omega t$$

$$e_{S3S1} = e_{S2} - e_{S3} = KE_r \cos(\theta - 120^\circ)\,\sin\omega t - K\,E_r \cos(\theta - 240^\circ)\,\sin\omega t$$

$$= KE_r \left[\cos\theta - \cos\theta \cos 120^\circ - Sin\,\theta\, Sin\, 120^\circ\right] \sin\omega t$$

$$= \sqrt{3}\,KE_r \left[\sin\theta \cos 120^\circ + \cos\theta\, Sin\, 120^\circ\right] \sin\omega t$$

$$= \sqrt{3}\,KE_r \left[\sin\theta\left(-\frac{1}{2}\right) + \cos\theta\left(\frac{\sqrt{3}}{2}\right)\right] \sin\omega t$$

$$= \sqrt{3}\,KE_r \sin(\theta + 120^\circ)\,\sin\omega t$$

## SYNCHRO TRANSMITTER / RECEIVER

$$= KE_r \left[\cos\theta\, cos120^\circ + Sin\,\theta\, Sin120^\circ - \cos\theta \cos 240^\circ - Sin\,\theta\, Sin240^\circ\right] \sin\omega t$$

$$= KE_r \left[\cos\theta\,(-0.5) + \sin\theta\left(\frac{\sqrt{3}}{2}\right) - \cos\theta\,(-0.5) - \sin\theta\left(-\frac{\sqrt{3}}{2}\right)\right] \sin\omega t$$

$$= KE_r \left[\cos\theta - \cos\theta\,(-0.5) - \sin\theta\left(\frac{\sqrt{3}}{2}\right)\right] \sin\omega t$$

$$= \sqrt{3}\,KE_r \sin\theta\, \sin\omega t$$

angular position of its rotor shaft and the output is a set of three stator coil-to-coil voltages. By measuring and identifying the set of voltages at the stator terminals, it is possible to identify the angular position of the rotor. [A device called synchro / digital converter is available to measure the stator voltages and to calculate the angular measure and then display the direction and angle of rotation of the rotor].

## SYNCHRO CONTROL TRANSFORMER

### Construction

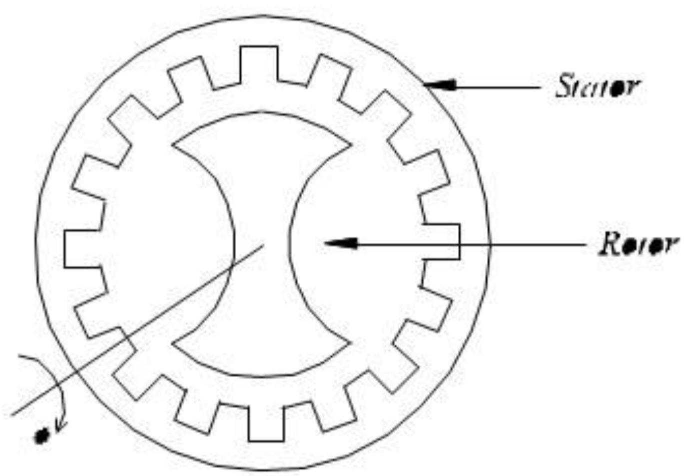


**Figure - 4a Constructional Features**

The constructional features of synchro control transformer are similar to that of synchro transmitter, except the shape of rotor. The rotor of the control transformer is made cylindrical so that the air gap is practically uniform. This feature of the control transformer minimizes the changes in the rotor impedance with the rotation of the shaft. The constructional features, electrical circuit and a schematic symbol of control transformer are shown in figure 4.

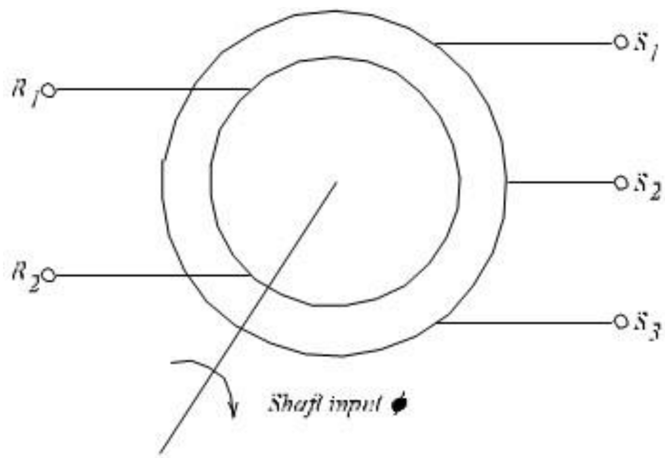


**Figure - 4b Schematic Symbol of synchro control transformer**

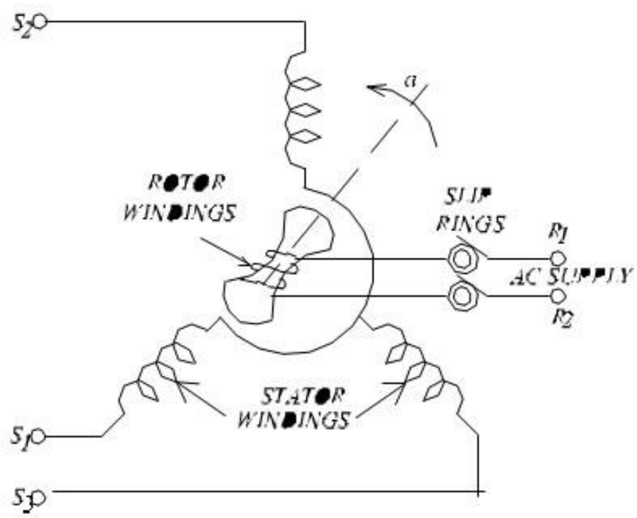


**Figure - 4c Electrical Circuit of synchro control transformer**

## Working

The generated emf of the synchro transmitter is applied as input to the stator coils of control transformer. The rotor shaft is connected to the load whose position has to be maintained at the desired value.

Depending on the current position of the rotor and the applied emf on the stator, an emf is induced on the rotor winding. This emf can be measured and used to drive a motor so that the position of the load is corrected.

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