Krishna Institute of Engineering & Technology

# *PRACTICAL MANUAL*

# *Control System Lab*

## EXPERIMENT NO. 8

To study the synchro-transmitter and receiver and obtain output v/s input characteristics

SIGNATURE OF HOD

SIGNATURE OF LAB INCHARGE

# EXPERIMENT: - 8

**OBJECT:** - To study the synchro-transmitter and receiver and obtain output v/s input characteristics.

**APPARATUS REQURIED: -**

1. Experimental kit with pair of transmitter-receiver synchro motor
2. CRO

**THEORY: -**

**Synchro error detector**: Synchro transmitter and synchro control transmitter arrangement for converting angular position difference into a proportional a.c.

The winding on the rotor of a synchro transmitter is connected to an a.c. supply voltage and this rotor is held fixed at a desired angular position any θr The stator winding of synchro transmitter and also that the synchro control transformer is wound at 120° in space on the stator. The two stator winding are connected together.The location of transmitter and control transformer can be away from each other.The rotor of synchro transmitter is salient pole type and that of synchro control transformer is cylindrical type.

The rotor of control transformer is coupled to the output shaft of the control system .If the position of the output shaft is indicated as θ this results in as angular error $\theta_e = (\theta_r - \theta_0)$ between the position of the input reference and the output shafts.

The process of conversion of the angular difference in to a proportional voltage is explained below,

A single-phase arc voltage

$$e_i(t) = E_m \sin(2\pi f t)$$

Is applied to the rotor winding of the synchro transmitter, then if θr = 0 the corresponding voltage induce by transformer action across the stator winding $e_{1n}$ is given by

$$e_{1n} = KE_m \sin(2\pi f t)$$

Where *K* is proportionality constant

As the stator winding 2*n* and 3 *n* are 240 ° and 120 ° a part (angle measured as positive in anti-clockwise direction) w.r.t. The winding 1n the voltage induce across them are,

$$e_{2n} = K\,Em\,\sin(2\pi f t)\cos(240°)$$
$$= -0.5\,K\,Em\,\sin(2\pi f t)$$

$$e_{3n} = K\,Em\,\sin(2\pi f t)\cos(120°)$$
$$= -0.5\,K\,Em\,\sin(2\pi f t)$$

Now if the rotor of the synchro transmitter shifts in anticlockwise direction through an angle $\theta_r$ the voltage in the stator coil are,

$$e_{1n} = K\,Em\,\sin(2\pi f t)\cos\theta_r°$$
$$e_{2n} = K\,Em\,\sin(2\pi f t)\cos(240° - \theta_r)$$
$$e_{3n} = K\,Em\,\sin(2\pi f t)\cos(120° - \theta_r)$$

Equation reveal that the magnitudes of the voltage $e_{1n}$, $e_{2n}$, and $e_{3n}$vary sinusoidal w.r.t. $\theta_r$.

SIGNATURE OF HOD SIGNATURE OF LAB INCHARGE

The three-voltage $e_{1n}$ , $e_{2n}$, and $e_{3n}$ are connected consecutively to three stator winding of the control transformer and produce a resultant flux in the air gap of the rotor winding of the control transformer. The magnitude of this induce voltage depend on the difference $(\theta_r-\theta_0)$ If the difference $(\theta_r-\theta_0)$ is zero, the induce voltage across the rotor winding terminal of the control transformer is zero, maximum for $(\theta_r-\theta_0)=90°$ and again zero when $(\theta_r-\theta_0)=180°$. After 180° the phase of the induce voltage reverses.

The magnitude being again maximum with a reversed phase and finally zero for $(\theta_r-\theta_0)=360°$. The variation of the amplitude of induce voltage across the rotor of control transformer w.r.t. $(\theta_r-\theta_0)$.

Therefore, the magnitude of the output induces voltage *e* developed across rotor of control transformer is given by the following relation:

$$e = K_s \sin(\theta_r-\theta_0)$$

Where Ks is a constant of proportionality

It is to be noted that the frequency of the voltage *e* is the same as that of supply and the magnitude is proportional to the $\sin(\theta_r-\theta_0)$.

In control system the angular error *i.e.*$(\theta_r-\theta_0)$is usually small and since $(\theta_r-\theta_0)$ is expressed in radian, therefore,

$$\text{Sin}\ (\theta_r-\theta_0) \cong (\theta_r-\theta_0)$$

Hence, $\quad e=K_s(\theta_r-\theta_0)$

And $(\theta_r-\theta_0)$ is expressed in v/rad.

The above equation indicates that angular error is converted into a proportional voltage. Laplace transform of the above equation is,

$$\boldsymbol{(Es)=K_s\theta e(s)}$$

The block diagram representation of synchro error detector is shown in fig.1, *Ks* are known as the sensitivity or the gain of synchro-error detector.

The variation of the magnitude of the output voltage *e* of synchro-error detector is a function of time.

It is to be noted that the phase of *e* (the output voltage) reverses at the points a and b as the error detector$\theta_e(t)$ Changes its sign.

**PROCEDURE:**

A). To study of remote position indication system using synchro transmitter/ receiver. Release the damping keeping knob to counter-clockwise.

1. Connect the circuit as shown in figure-**1** keep Tx dial at 0° position. Watch the Rx dial position. If there is an error than try it to remove gently positioning the Rx dial.
2. Increase the Tx dial position to 30° and note the Rx dial position. In actual practice increase Tx dial position 35° than bring it back to 30° to minimize the error.
3. Proceed with same increments and note Rx dial position each time. Tabulate the observation. Find out the tracking difference between two-. In practice the error rate should be with in ±2°.
4. Change the connection between Rx, rotor as connect Tx, $R_1$ with Rx, $R_2$ and Tx, $R_2$ with Rx, $R_1$.
5. Repeat the step 3 and observe the tracking direction with its displacement.

6. Bring Tx, Rx, rotor connection as before. Change the connection between Tx, Rx as given below

| Tx | | Rx |
|---|---|---|
| $S_1$ | ------------------- | $S_2$ |
| $S_2$ | ------------------- | $S_3$ |
| $S_3$ | ------------------- | $S_1$ |
| $R_1$ | ------------------- | $R_1$ |
| $R_2$ | ------------------- | $R_2$ |

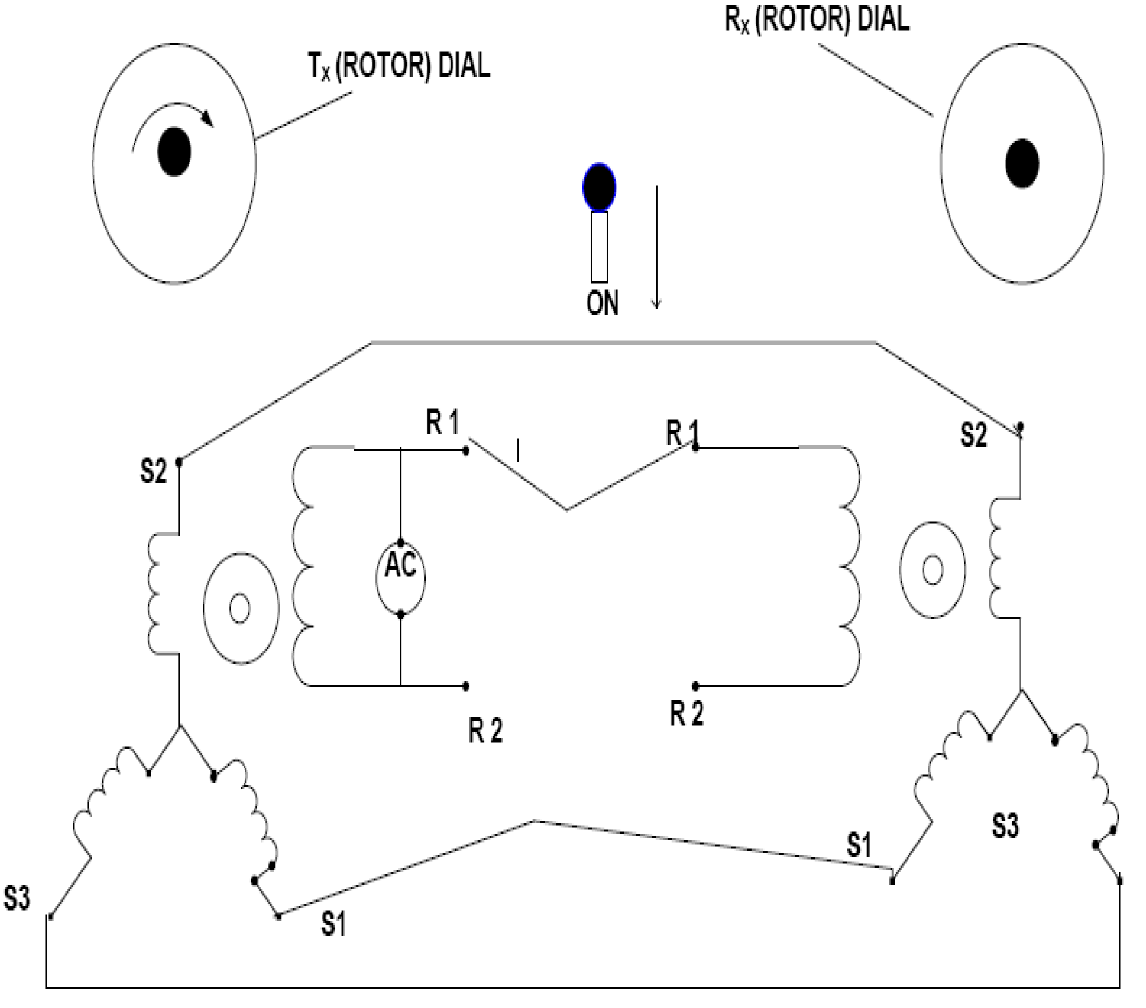
7. Repeat step 3. Tabulate the observation. Conclude the result as given in the text.

B). To study of synchros transmitter in term of position v/s phase and voltage magnitude withrespect to rotor voltage magnitude / phase.

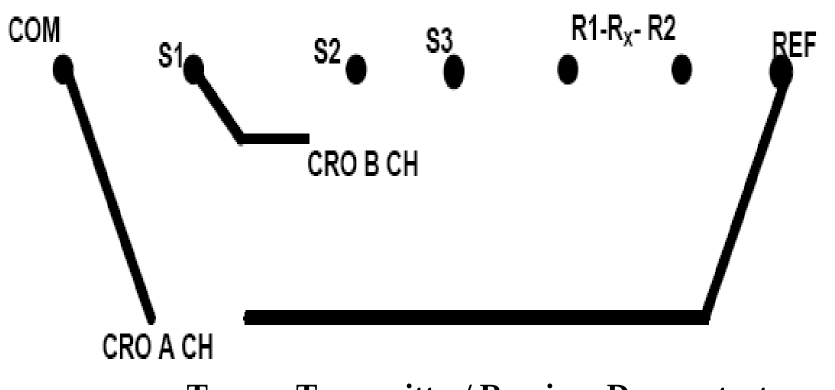
1. Connect the CRO one channel with the provided sockets Com and REF as shown in figure-**2.** The ground of CRO should be connected with COM. The reference sockets as attenuated 1: 10, voltage of Tx, $R_2$ with respect to $R_1$.
2. Connect the CRO other channel, say B channel with output of $S_1$, $S_2$ and $S_3$ alternately while kept Tx dial to certain position say 0°. Note the output in Vpp and its phase angle either same as REF output of phase or each stator winding.
3. Rotate Tx dial in 30° increment step and note voltage magnitude and phase w.r.t. input as REF.
4. Prepare a table as given in reference from observations. Conclude the results from your experiment.

SIGNATURE OF HOD SIGNATURE OF LAB INCHARGE

**CIRCUIT DIAGRAM:-**

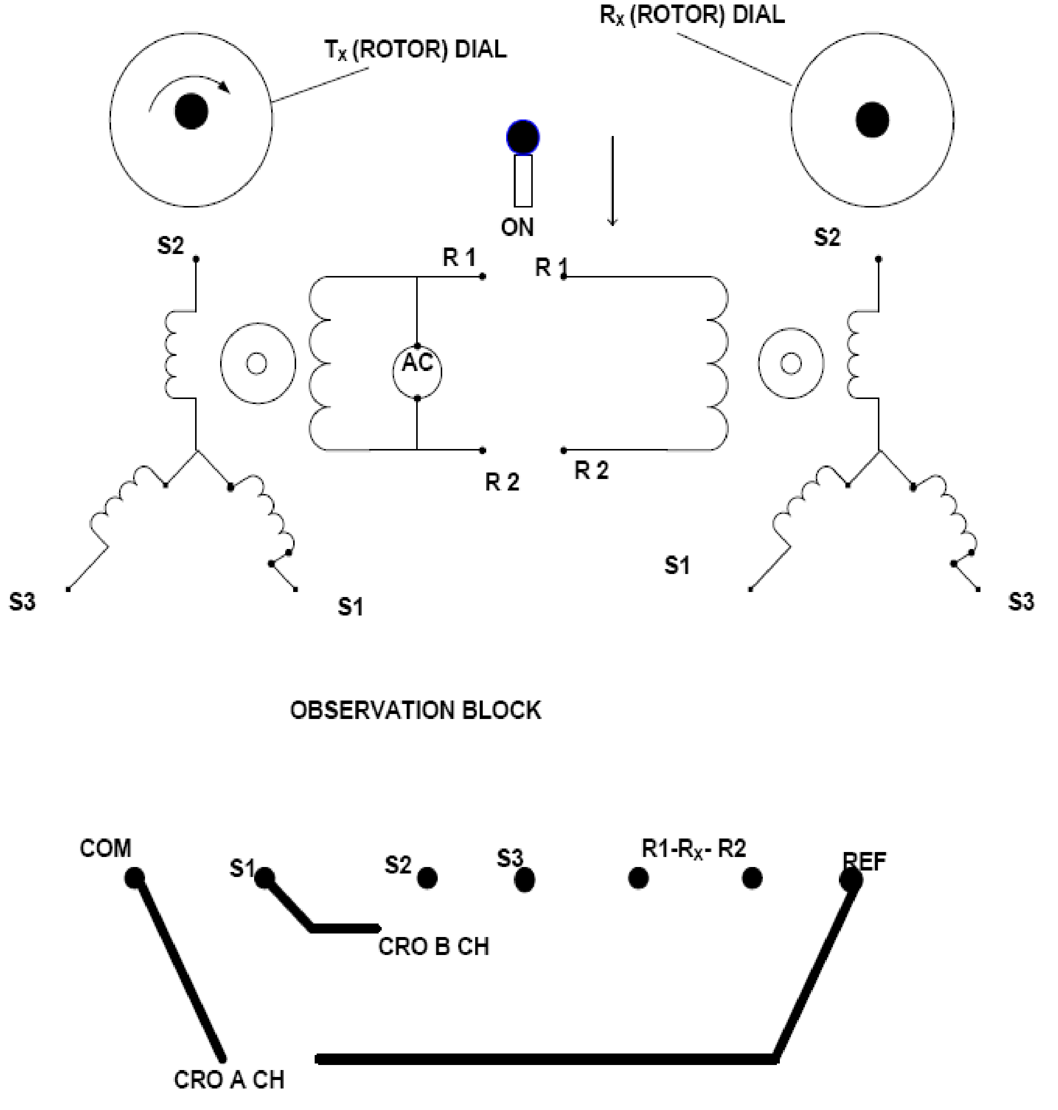



OBSERVATION BLOCK




**Torque Transmitter/ Receiver Demonstrater**

**Fig1: Study of Tx to Rx (as error detector) waveforms in term of magnitude v/s phase w.r.to input**




**Torque Transmitter/ Receiver Demonstrater**
**Fig2: Study of motor waveforms in term of magnitude v/s phase w.r.to input**

SIGNATURE OF HOD SIGNATURE OF LAB INCHARGE

**Conclusion:** It is observed that synchro-transmitter has produced electrical signals in its stator, which are magnitude and phase related with rotor position. There is always one stator winding voltage is out of phase with other .The electrical zero appeared at each 60°, with respect to stator winding.

**C.** To study of synchro transmitter / receiver as an error detector.
Note: During the experiment receiver shaft should be constant position say 0° in this case.

1. Connect the circuit as shown in fig **2** Note that Rx, R2 socket is left open and R1 is connected with R1 of Tx for common mode. Rotate damping knob situated nearby Rx dail toward arrow direction.
2. Connect CRO one channel with REF and COM socket as experiment connect other channel socket with R2 of Rx provided at the observation block.
3. Start from 00 of Tx dial note the voltage magnitude in Vpp and phase in respect to REF.
4. Rotate Tx dial to all around in 60° or 90° note the Rx, R2 output voltage and phase.
5. Plotting th magnitude and phase response of Rx shows the phase / magnitude response. Conclude the result from experiment.

The system can be track the position of transmitter rotor. The phase and output voltage is $e(t) = KVr\cos\phi \sin \omega c(t)$, where K is constant,Vr is the reference voltage, $\phi$ is the angle between two rotor and $\omega$ c is the reference signal frequency.

**OBSERVATION TABLE:**

| Angular position In degree Tx | Angular position In degree Rx | Difference in Degree Tx – Rx |
|---|---|---|
| 0 | | |
| 30 | | |
| 40 | | |
| .. | | |
| …. | | |
| 330 | | |

**RESULT:-**

**PRECAUTIONS:-**

1 Read operating manual before working on the kit.
2 Check the connection before switching power supply.
3 Don’t change the connection without switching off the supply of the experiment kit.
4 Draw the traces from CRO properly
5 Keep the connecting lead and ancillary equipment at proper

SIGNATURE OF HOD SIGNATURE OF LAB INCHARGE

**VIVA VOICE QUESTIONS:-**

1) How Synchro error detector works?
2) What is the difference between servo motor and synchros?
3) What are the main parts of Synchro error detector?
4) What is the use of synchros?

**INDUSTRIAL APPLICATIONS:-**

Positioning servomechanisms were used in military fire-control and marine navigation equipment.Nowadaysservomechanism is used in automatic machine tools, satellite-tracking antennas, remote control airplanes, automatic navigation systems on boats and planes, and antiaircraft-gun control systems. Other examples are fly-by-wire systems in aircraft which use servos to actuate the aircraft's control surfaces, and radio-controlled models which use RC servos for the same purpose. In industrial machines, servos are used to perform complex motion.

SIGNATURE OF HOD SIGNATURE OF LAB INCHARGE