TEGAM INC.

MODEL DSRB-5CDA
DECADE SYNCHRO / RESOLVER BRIDGE

Instruction Manual

PN# 500783-350

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REV. B

NOTE: This user’s manual was as current as possible when this product was manufactured. However, products are constantly being updated and improved. Because of this, some differences may occur between the description in this manual and the product received.

Warranty:

TEGAM, Inc. warrants this product to be free from defects in material and workmanship for a period of 1 year from the date of shipment. During this warranty period, if a product proves to be defective, TEGAM, Inc., at its option, will either repair the defective product without charge for parts and labor, or exchange any product that proves to be defective.

TEGAM, Inc. warrants the calibration of this product for a period of 1 year from date of shipment. During this period, TEGAM, Inc. will recalibrate any product, which does not conform to the published accuracy specifications.

In order to exercise this warranty, TEGAM, Inc., must be notified of the defective product before the expiration of the warranty period. The customer shall be responsible for packaging and shipping the product to the designated TEGAM service center with shipping charges prepaid. TEGAM Inc. shall pay for the return of the product to the customer if the shipment is to a location within the country in which the TEGAM service center is located. The customer shall be responsible for paying all shipping, duties, taxes, and additional costs if the product is transported to any other locations. Repaired products are warranted for the remaining balance of the original warranty, or 90 days, whichever period is longer.

Warranty Limitations:

The TEGAM, Inc. warranty does not apply to defects resulting from unauthorized modification or misuse of the product or any part. This warranty does not apply to fuses, batteries, or damage to the instrument caused by battery leakage.

Statement of Calibration:

This instrument has been inspected and tested in accordance with specifications published by TEGAM, Inc. The accuracy and calibration of this instrument are traceable to the National Institute of Standards and Technology through equipment, which is calibrated at planned intervals by comparison to certified standards maintained in the laboratories of TEGAM, Inc.

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FIGURE 1-1. MODEL DSRB-5CDA DECADE SYNCHRO/RESOLVER BRIDGE

Section I
GENERAL DESCRIPTION

1.1 PURPOSE

The Model DSRB-5CDA combines the functions of a decade synchro bridge and a decade resolver bridge into a single unit. A front panel switch changes the unit from one mode of operation to the other. The unit is designed for testing control transmitters, differentials (rotors), and torque transmitters as components or for simulating an incremental control transformer in a servo loop.

The increased versatility of this high resolution unit provides additional applications as follows:

a. As a distinctly superior system-error bridge, for measuring the output angle of synchros or resolvers which are an integral part of a system or sub-system; e.g., servos, radar antennas, inertial platforms, aircraft indicators, vertical and directional gyroscopes, etc. (See Figure 1-2).

b. For trouble shooting sources of error in data transmission systems such as cable loading, gearing, dial readout, component angular accuracy, receiver (z_{so}) impedance unbalance, transmitter (Z_{ss}) impedance unbalance, voltage and frequency deviations, etc.

c. To simulate precision synchro or resolver transmitters, by using the decade bridge to calibrate an ordinary synchro or resolver transmitter at any desired angle. A vernier dial assembly, or a dividing head is required to null the transmitter, under load, against the bridge at each desired angle. This technique is ideal for simulating small errors in transmitters, generating accurately known system inputs to autopilots, servos, aircraft indicators, navigational computers, etc. This technique can also be used to check the response of a servo loop, and to investigate areas of particular interest very minutely. In multiple-speed systems a high-resolution transmitter is particularly useful.

d. For measuring and recording the drift or stability of vertical or directional gyros, servos, inertial platforms, etc. When using the PAV in conjunction with the decade bridge, the angular drift or stability about any desired angular position may be read directly on the meter of the PAV, in terms of angular units. This error is also available in the form of a dc voltage, form the rear of the PAV for recording purposes.

e. As a conventional 5° synchro or resolver bridge, to perform angular accuracy tests on transmitters and differentials (rotor). The unique feature here is that the bridge may be used to obtain a null, instead of the dividing head (Proportional Voltage Nulling Method).

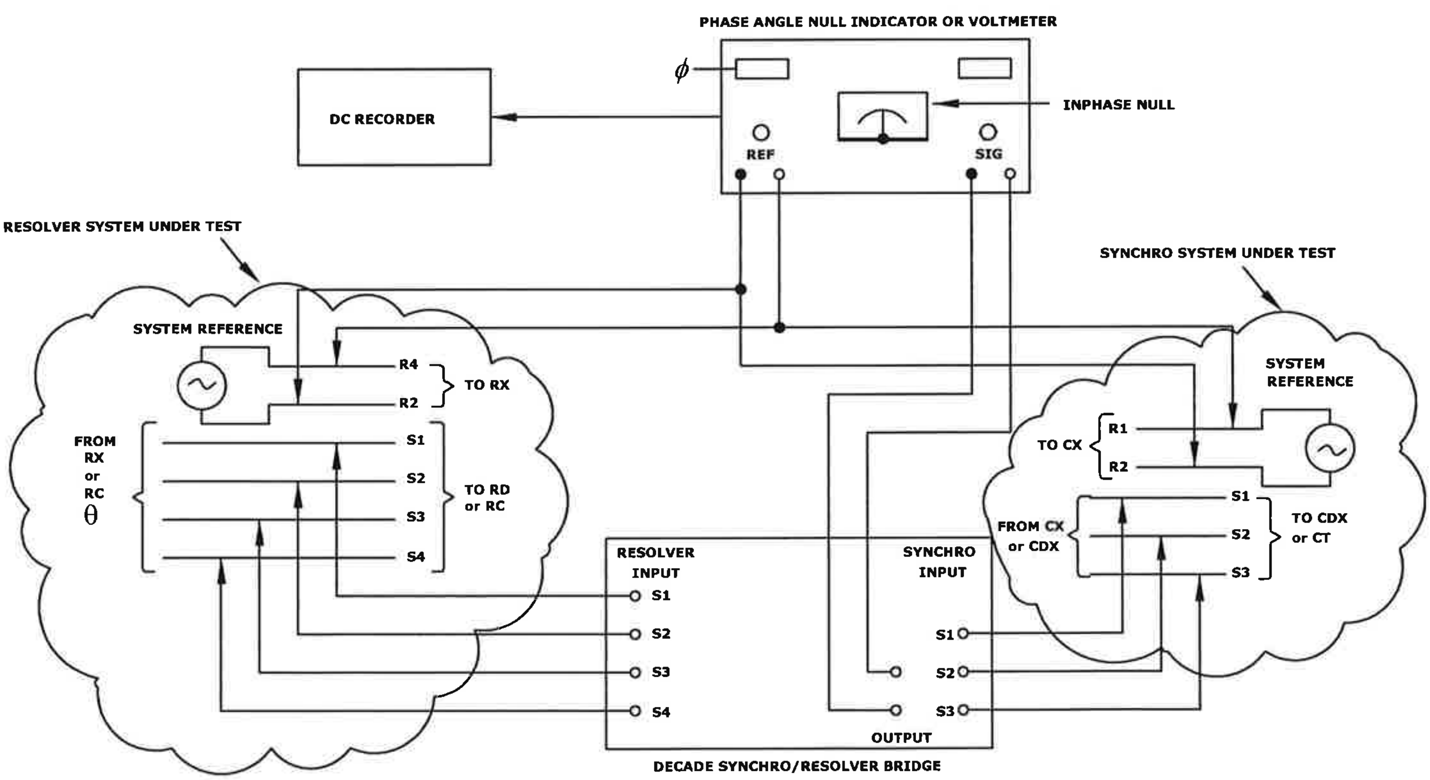


Figure 1-2. Typical System-Error Measurement

1.2 GENERAL DESCRIPTION

1.2.1 Resolver Mode

The decade resolver bridge uses precision transformers to form a voltage comparator bridge as shown in Figure 1-3. The two voltage signals into the bridge bear a precise voltage ratio relationship which is determined by the angular position of the unit under test. The two signals are applied across Ratiotransformers and movement of the ratio transformer arms is equivalent to change in the angular position of a control transformer. When the equivalent angular positions of the bridge and the input signals are identical, the output of the bridge (R1 and R3) is null (Zero volts).

When the equivalent angular positions of the bridge and the input signals differ, the bridge produces an error voltage. This error voltage is directly related to the angular difference but without compensation the error voltage is not constant throughout the 0° to 360° range. To provide an equal error voltage gradient at all increments, all models of the bridge are inherently compensated. With compensation, the electrical error of a component under test may be determined without the necessity of obtaining an exact null at each increment (proportional voltage gradient method).

Two input isolation transformers provide complete isolation between the sine and cosine inputs and also reduce the secondary to primary reflected impedance. An isolation transformer is also included in the bridge output circuit.

The ratio accuracy, equivalent to 4 seconds-of-arc, is based upon the use of a toroidal transformer which is not affected by age or normal environmental condition. Because of the low output impedance, the bridge is essentially insensistive to pickup and loading errors. The high input impedance allows an actual load to be connected in parallel with the bridge input, providing a test of the component under actual load conditions.

1.2.2 Synchro Mode

In the synchro mode, the three wire input is converted to two voltage signals in a Scott-tee transformer arrangement. After conversion, the voltage comparator operates in the same manner as in the resolver mode.

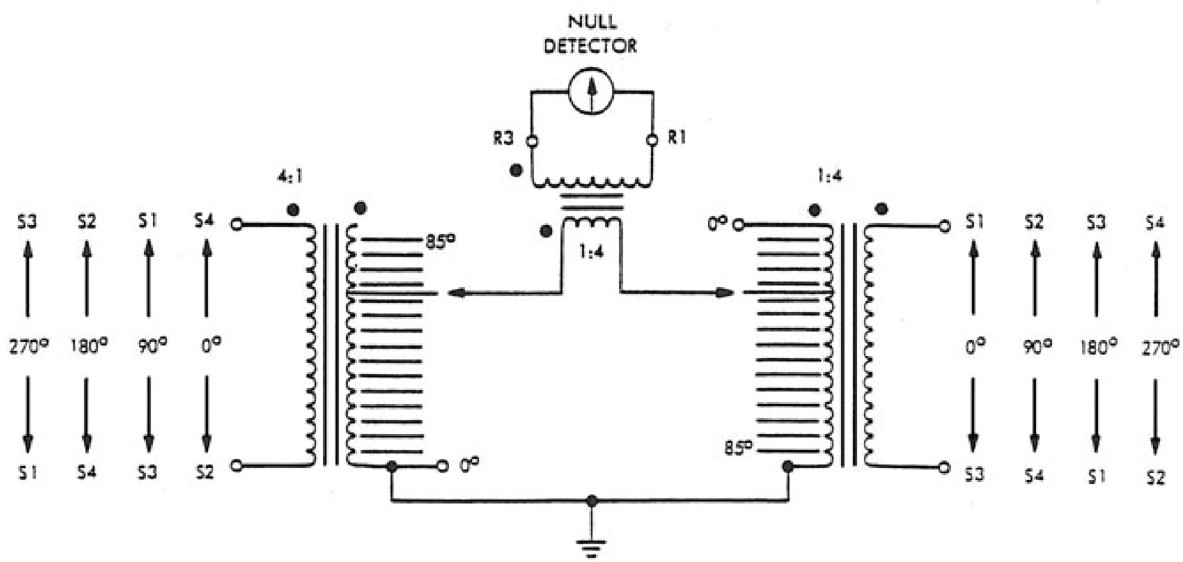


Figure 1-3. Ratio Transformer Resolver Bridge

1.2.3 Specifications

Refer to Table 1-1 for general specifications and to Table 1-2 for Detailed Specifications.

Table 1-1. General Specifications

1.	Angular Range quad. 0-360° direct 0-400°
2.	Error Voltage Gradient $4.85 \times 10^{-6} E_S$(max) V/second ±1%
3.	Max. Input Voltage: Frequency dependent, see table. Absolute maximum, all models, 170 volts.

Table 1-2. Detailed Specifications

MODEL	Angular accuracy at nom freq. (seconds of arc) RB	SB	Angular resolution (degrees)	Nom. freq. (HZ)	Freq. range (HZ)	Max. rms input voltage (Fin HZ)	Input impedance at nom. freq. (Ohms) RB	SB	Output impedance at nom. freq (Ohms)
DSRB-5CDA 4	4	4	CONT	400	300-800	.35F	750K	1 Meg	300-J50
DSRB-5CDA 8	4	4	CONT	800	400-1200	.35F	750K	1 Meg	300-J100
DSRB-5CDA 24	4	5	CONT	2400	±10%	.17F	200K	200k	200-J500
DSRB-5CDA 20	20	120	.001	10K	±10%	.05F	50K	50k	100-J500

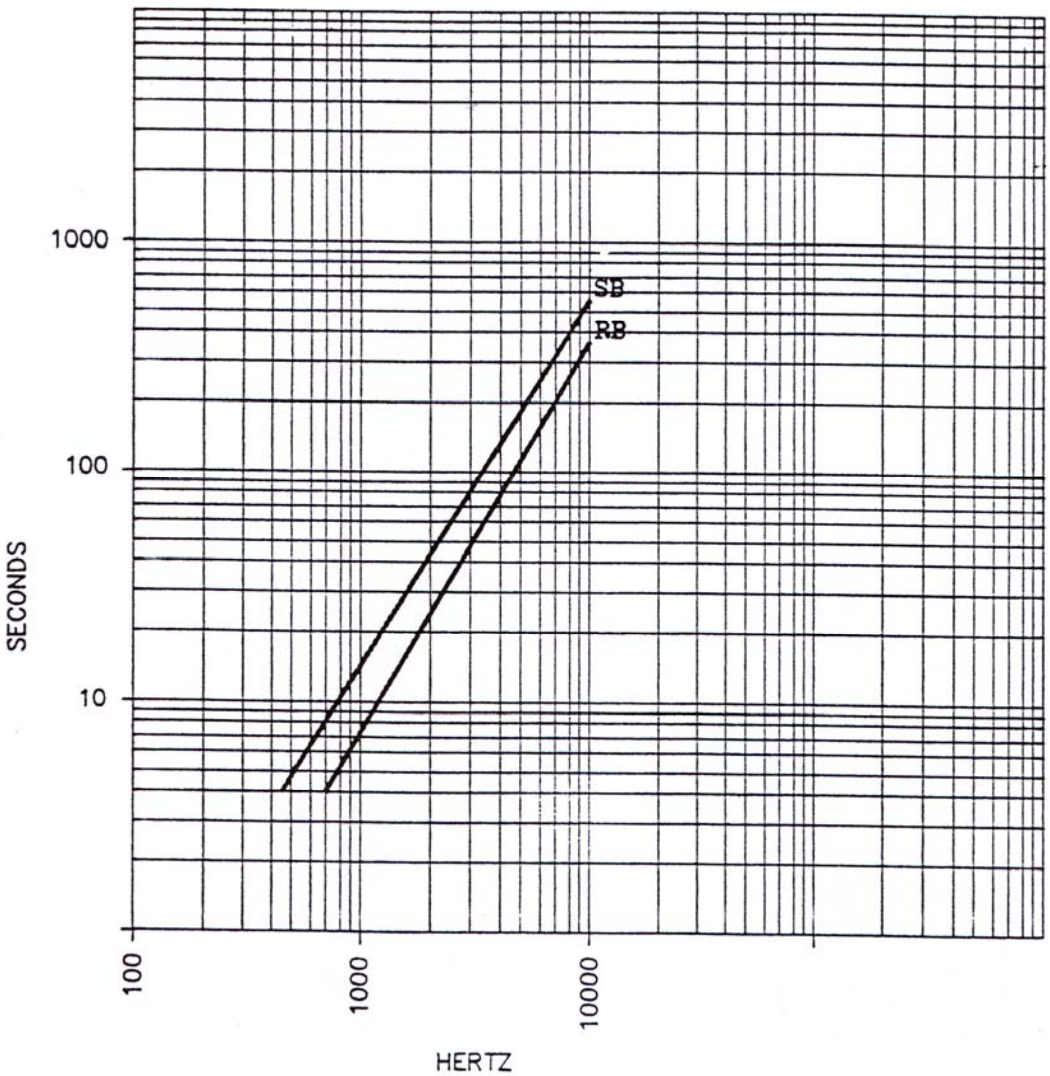


FIGURE 1-4. ACCURACY (IN SECONDS) VERSES FREQUENCY FOR ALL 400 HZ UNITS (TYPICAL CURVE)

Section II
INSTALLATION

2.1 UNPACKING

No special handling or unpacking procedures are required. After unpacking, inspect units for any evidence of damage.

2.2 BENCH OPERATION

The DSRB-5CDA is shipped ready for use as a bench-operated instrument. A folding support that is attached to the feet under the front of the instrument may be pulled down to elevate the front of the instrument for ease of operation.

2.3 RACK MOUNTING

A set of adapter brackets and attaching screws (Option 11) permits mounting of the DSRB-5CDA into a standard 19-inch rack. To prepare the instrument for rack mounting, proceed as follows:

a. Remove the six screws that attach the four feet and folding support to the bottom of the instrument. Retain the screws, feet and support for future use.

b. Attach rack mount bracket kit (Part No. OPT-11) using hardware provided.

2.4 OPERATING POWER

No operating power is required.

2.5 INSTALLATION CHECKOUT

Refer to Paragraph 6.1.

Section III
OPERATING INSTRUCTIONS

3.1 GENERAL

Actual operation of the decade synchro/resolver bridge is simply at matter of connecting the input and output, turning the mode switch to the required position, and selecting the required angle. Precautions to be observed in setting up tests and operating the equipment are listed below. Suggested tests setups and applications are given in Appendix C.

The color coding of the binding posts and the phase relations of the output voltage relative to input voltages conform to the requirements of Military Specification MIL-R-21530 (resolver mode) or to the requirements of Military Specification MIL-S-20708 (synchro mode). To convert the terminal identifications to the Aeronautical Radio, Inc. (ARINC) system, refer to Table 3-1 (for the synchro mode). The conversions given in the table apply for 0 degree index reference and positive rotation reference.

Table 3-1. Binding Post Identifications

Color Code	Identification	ARINC System
Red	R1	H
Black	R2	C
Blue	S1	X
Black	S2	Z
Yellow	S3	Y
White	Case Gnd	

3.2 TEST BINDING POSTS

The compensated models are furnished with four green binding posts and two shorting links. For operation as a standard unit, the two shorting links must be installed as shown in Figure 3-1. To operate the unit without the output isolation transformer, remove the shorting links and connect the output circuit to the “B” set of green binding posts. Connect R1 to the B post of the NO. 1 TEST set and connect R3 (or R2) to the B post of the NO. 2 TEST set.

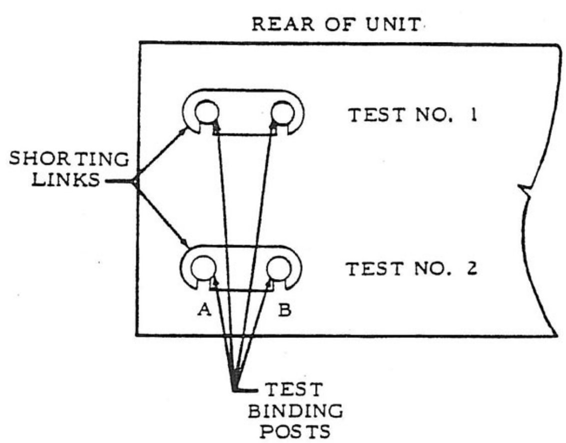


Figure 3-1. Test Binding Posts

3.3 SPECIAL PRECAUTIONS

To obtain maximum accuracy, observe the following precaution:

a. Avoid subjecting the bridge to large off-null signals if the output is shorted. If it is suspected that large off-null signals have been applied, check bridge calibration as outlined in Section VI.

To avoid damage to the equipment, observe the following precautions:

a. Make certain that the input voltage does not exceed the voltage rating of the unit. For all units, the voltage should not exceed 0.35 times the frequency in cps. The input voltage should never exceed 170 vrms.

b. Make certain that the input voltage does not contain a dc component. DC currents of more than a few microamperes will cause saturation of the input winding If dc voltage is accidentally applied, degauss the unit as outlined in Section V.

c. Do not apply voltage to the output terminals.

At true null, the error signal will be 180° out-of-phase (-) at a bridge angle greater than the null angle and in-phase (+) at a bridge angle less than the null angle. At false null (180° from true null), the phase relationships of the error signals are reversed. This applies only to the resolver mode; synchro mode is just the opposite.

Section IV

THEORY OF OPERATION

4.1 GENERAL

This section includes a general theory of operation for the resolver bridges. For a complete analysis refer to TEGAM Synchro/Resolver Ratio Instrumentation Application Notes.

4.2 GENERAL THEORY, RESOLVER BRIDGE

The electrical position of a resolver transmitter can be determined from the ratio of the two output voltages to each other. One of the output voltages is proportional to the sine of the rotational angle and the second output voltage is proportional to the cosine. At 0°, the sine output voltage approaches 0. At 45°, the two output voltages are equal and approach a 0.707 ratio to the input voltage.

In the Tegam resolver bridge as shown in Figure 4-1, the sine output voltage is applied across one ratio transformer and the cosine voltage is applied across a second. The ratio transformer with the sine voltage input is tapped to provide an output voltage proportional to the cosine. The second ratio transformer is tapped to provide an output voltage proportional to the sine.

With a resolver under test and the resolver bridge both set to 0°, both output voltages of the bridge approach 0 and a null detector would detect a null. The sine output voltage of the resolver under test approaches 0 and its ratio transformer is set to unity output. The cosine output voltage approaches a maximum but its ratio transformer is set to zero output. Thus both voltages approach zero.

For any angle between 0 and 90°, both voltage outputs of the bridge are proportional to a sine and a cosine product; therefore, the two voltages are equal. Any voltage detected across the output terminals indicates a different ratio between the output voltages of the resolver and therefore a different electrical angle.

4.2.1 Decade Increments

Refer to Figures 4-2 and 7-1. When the incoming signal is not an exact 10° increment, the SIN θ x COS θ_1 product is larger than the COS θ x SIN θ_1 product. To compensate for this difference, decade transformers T3 through T5B, with their controlling switches, are included. The applicable switches select a precise portion of the input voltage and this selected portion is added to the COS θ x SIN θ_1 voltage supplied by transformer T2. At null, this summed voltage is exactly equal to the SIN θ x COS θ_1 voltage supplied by transformer T1.

The voltage supplied to the primary of transformer T3 is a sum of two voltages: a SIN θ x SIN θ_1 voltage from transformer T1 and a COS θ x θ_1 voltage from transformer T2. By trigonometric identities, this summed voltage may be expressed as COS (θ - θ_1). The voltage selected by the 1° switch is equal to COS (θ - θ_1) TAN θ_2.

Any voltage across transformer T6 may be expressed by the following formula:

1. $V = \text{SIN}\ \theta\ \text{COS}\ \theta_1 - (\text{COS}\ \theta\ \text{SIN}\ \theta_1 + \text{COS}\ (\theta - \theta_1)\ \text{TAN}\ \theta_2)$

2. $V = \text{SIN}\ \theta\ \text{COS}\ \theta_1 - \text{COS}\ \theta\ \text{SIN}\ \theta_1 - \text{COS}\ (\theta - \theta_1)\ \text{TAN}\ \theta_2$

3. $\text{SIN } \theta \text{ COS } \theta_1 - \text{COS } \theta \text{ SIN } \theta_1$ by trigonometric identities, may be expressed as $\text{SIN } (\theta - \theta_1)$

4. $V = \text{SIN } (\theta - \theta_1) - \text{COS } (\theta - \theta_1) \text{ TAN } \theta_2$

5. $\text{TAN } \theta_2 = \frac{\text{SIN } \theta_2}{\text{COS } \theta_2}$. Multilply through to eliminate $\text{TAN } \theta_2$.

6. $V \text{ COS } \theta_2 = \text{SIN } (\theta - \theta_1) \text{ COS } \theta_2 - \text{COS } (\theta - \theta_1) \text{ SIN } \theta_2$

7. $\text{SIN } (\theta - \theta_1) \text{ COS } \theta_2 - \text{COS } (\theta - \theta_1) \text{ SIN } \theta_2$, by trigonometric identities, may be expressed as $\text{SIN } (\theta - \theta_1 - \theta_2)$

8. $V \text{ COS } \theta_2 = \text{SIN } (\theta - \theta_1 - \theta_2)$

9. $V = \frac{\text{SIN } (\theta - \theta_1 - \theta_2)}{\text{COS } \theta_2}$

10. When the angular setting of the switches (θ_1, θ_2, etc.) exactly equals the incoming angle θ, $\theta - \theta_1 - \theta_2 = 0$.

11. The SIN 0° = 0 and therefore the voltage equals zero.

Transformer T4 (see Figure 7-1) receives its input from transformer T3 and is tapped to correspond to the .1° increments. The voltage selected by the .1° switch is added to the voltage on the 1° switch arm. This addition process continues through all the decades. A potentiometer provides continuous resolution and angular readout to the .0001° level.

4.2.2 Direct Readout

Refer to Figure 7-1. In the DSRB-5CDA, quadrant switching is accomplished through the 100° and 10° switches.

4.2.3 Synchro Mode

Refer to Figure 4-3. The electrical position of a synchro can be determined from the ratio of the stator output voltages to each other. As shown in Figure 4-4, each of the three output voltages is a sine function.

In the 0° to 90° quadrant, the voltage from S1 to S3 is a SIN θ voltage and this is applied to the cosine ratio transformer. This ratio transformer operates the same as in the resolver mode with a SIN x COS output.

To derive a cosine input for the sine ratio transformer, the primaries of transformers T1 and T2 are interconnected as shown in Figure 4-3. In this Scott-tee transformer arrangement, the voltage from the center tap of T1 to S2 is equal to COS 60° COS θ. This voltage is inserted at the COS 60° tap and therefore the voltage across the full transformer is equivalent to a COS θ input.This ratio transformer then operates the same as in the resolver mode with a COS x SIN output.

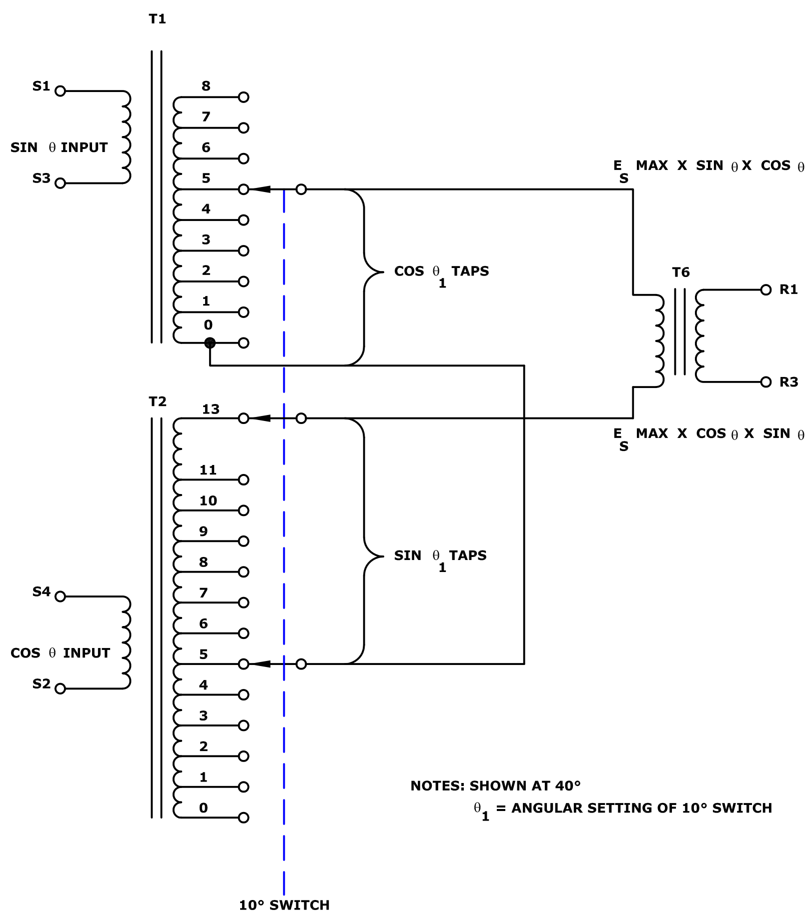


Figure 4-1. Simplified Diagram. 10° Increments

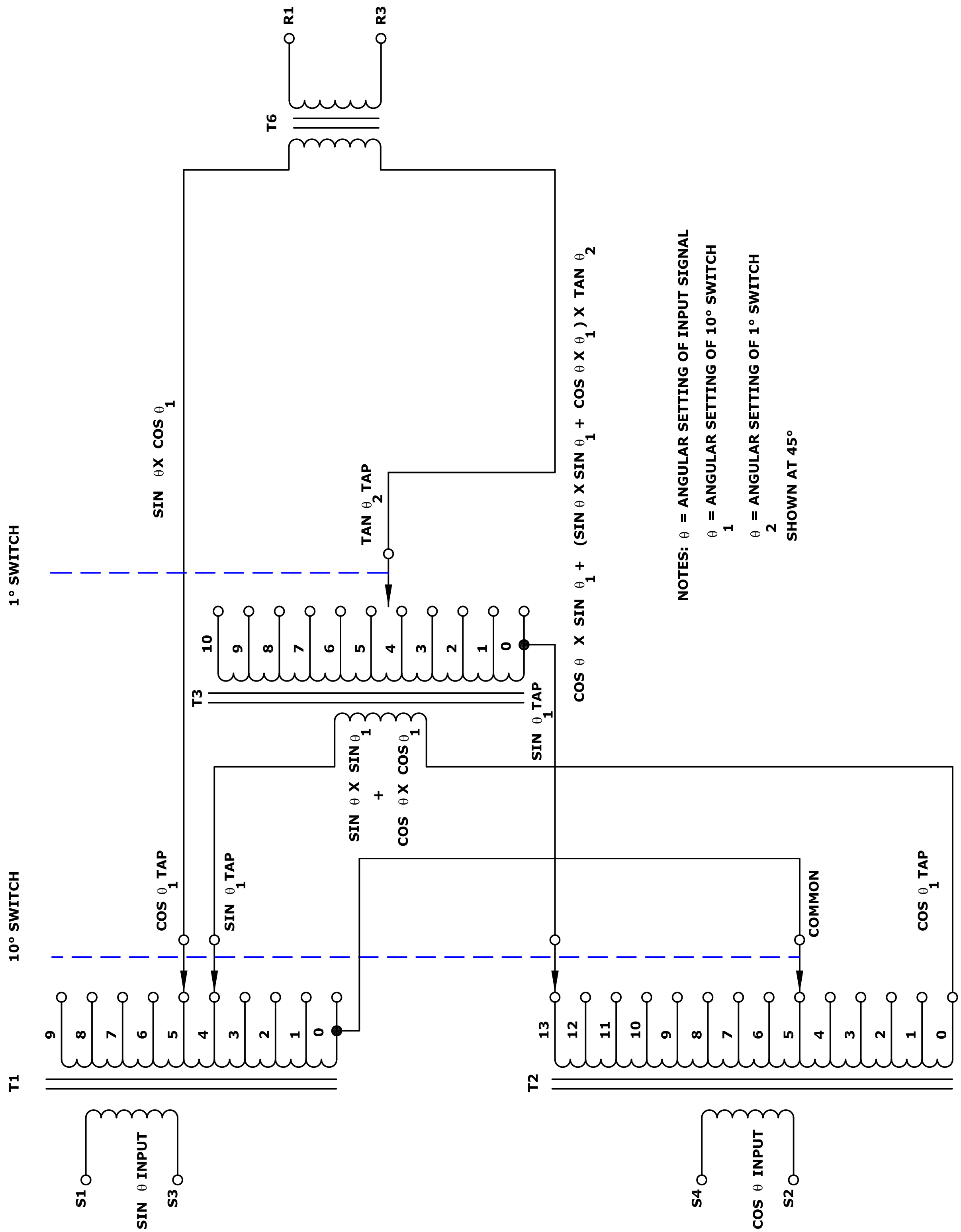


Figure 4-2. Simplied Diagram, Decade Increments

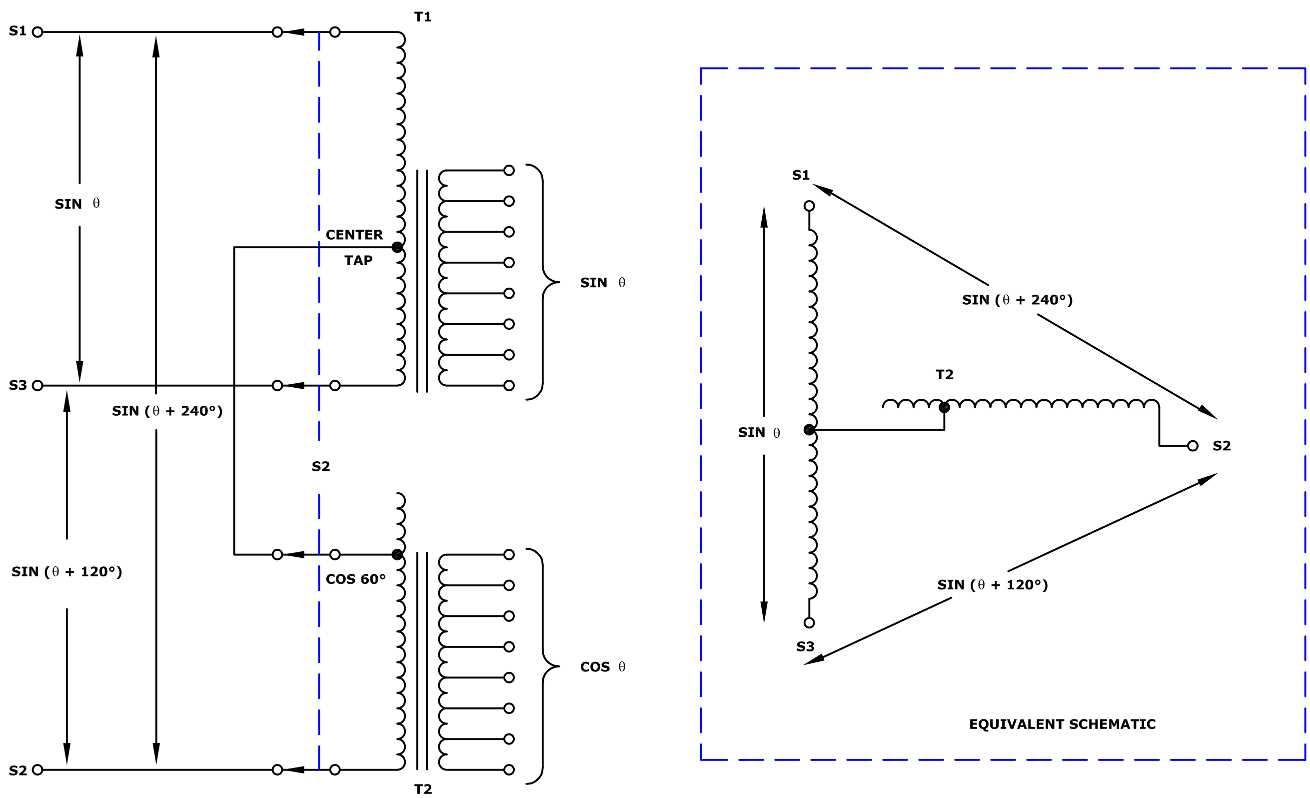


Figure 4-3. Simplified Diagram, Decade Synchro Bridge

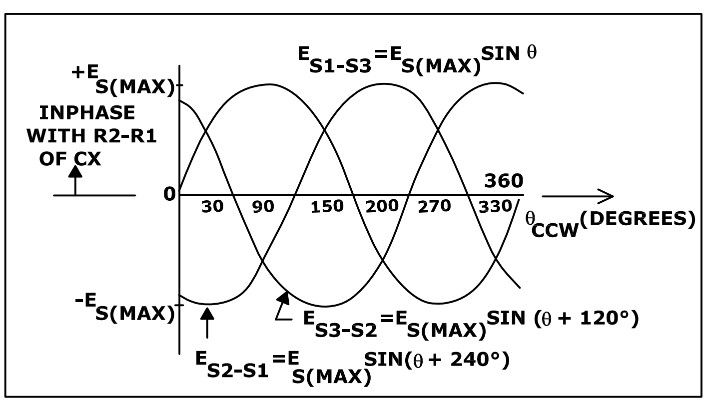


Figure 4-4. Standard Synchro Control Transmitter (CX) Outputs

Section V

MAINTENANCE

5.1 GENERAL

Since the bridge is a passive device, a minimum of maintenance is required. With the exception of cleaning switch contacts, no maintenance on a regularly scheduled basis is required. Moving parts are lubricated at the factory and should require no further lubrication.

5.2 SWITCH CONTACTS

During calibration intervals, clean switch contacts with a good grade of solvent such as alcohol or acetone. Relubricate contacts with a layer of Vaseline.

5.3 DEGAUSSING

If dc voltage is accidentally applied to the input terminals, degauss the unit as follows:

a. Turn mode switch to resolver.
b. Connect a 1K resistor in series with input connector S1.
c. By means of a variac or other suitable voltage control, apply a 60 cps signal between the open end of the 1K reisistor and input terminal S3.
d. Starting with the voltage control at zero, increase voltage to 40 vrms.
e. Slowly decrease the voltage to zero. The period of time to reduce the voltage from 40 vrms to zero should be between 10 and 15 seconds.
f. Repeat steps a through e with input terminals S2 and S4.

5.4 REPAIRS

If any repairs are made on the unit or if any parts are replaced, check the accuracy of the unit as outlined in Section VI. If any transformer problems are encountered, it is recommended that the unit be returned to the factory for overhaul and recalibration.

Section VI
CALIBRATION

6.1 GENERAL

The 4 second-of-arc accuracy of the bridge should be maintained for *a* period of not less than three years, provided that the unit is kept in a normal laboratory environment, has clean low resistance contacts, and does not suffer injury or insulation damage. Under these conditions, the unit should only require recalibration every three years. Under more severe conditions, the calibration period should be shortened.

This section includes two calibration checks:

a. A 4 second-of-arc Functional test which may be used for a rough field check. (See Paragraph 6.2)

b. A 4 second-of-arc accuracy test which may be used as a complete test of the unit. (See paragraph 6.3)

6.2 4 SECONDS-OF-ARC FUNCTIONAL TEST

6.2.1 <u>Input Impedance Test</u>

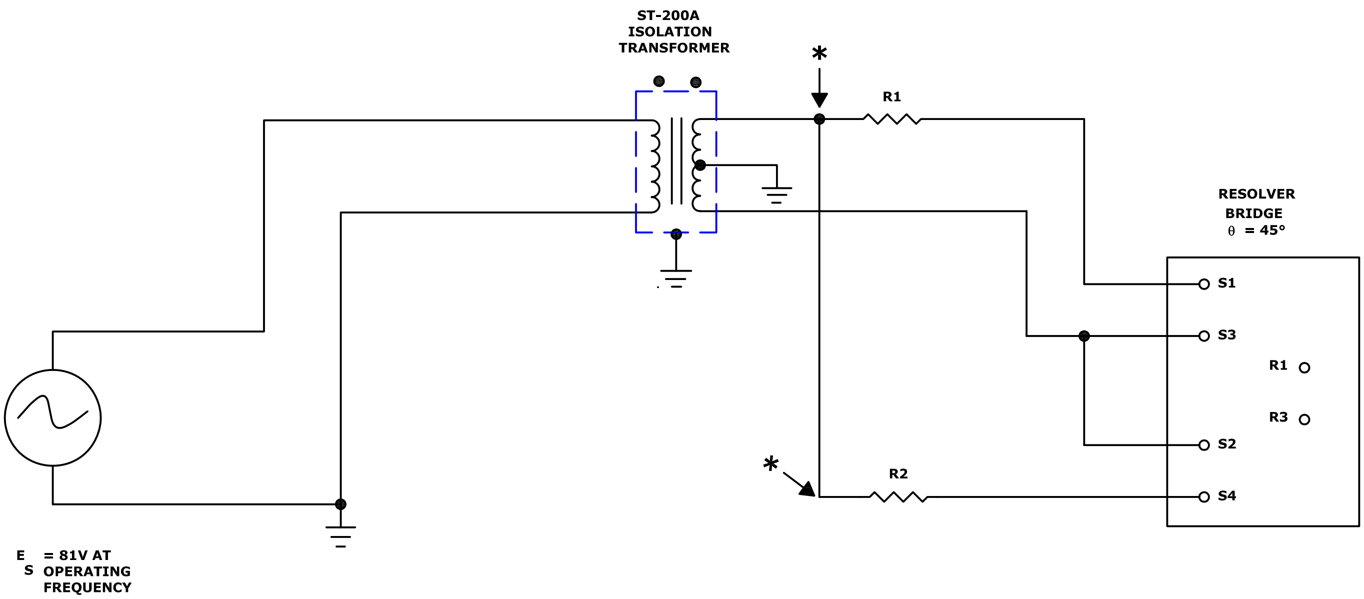
The following test equipment (or equivalent) is required:

Isolation Transformer	Model ST200A
Resistors (Rl, R2)	50 ohms +1%
Voltmeter, AC, 1 mV RMS	
FS Sensitivity Battery Operated	

Use the following test procedure:

a. Connect resolver bridge into test setup as shown in Figure 6-1.

b. Turn mode switch to resolver.
c. Adjust input voltage (E_s) to 81 volts at the normal operating frequency of the bridge.
d. Set the bridge controls to a 45° angle.
e. Measure voltage drop across resistors R1 and R2.
f. The voltage drop shall be 0.008 volts or less (representing an input impedance of 500K or more).
g. The input impedance in the synchro mode is theoretically equal to 1.5 x the input impedance in the resolver mode.



*** LOW (CASE) SIDE OF VOLTMETER INPUT**

Figure 6-1. Input Impedance Test Setup

6.2.2 Angular Accuracy Test, Resolver Mode

The following test equipment (or equivalent) is required:

Resolver Standard	Model DSRS-5DA
Phase Angle Voltmeter	Model PAV-4B or C

Use the following test procedure:

a. Connect resolver bridge into test setup as shown in Figure 6-2.

b. Turn mode switch to resolver.

c. Make certain the two shorting straps are installed across the test binding posts.

d. Adjust phase angle voltmeter to measure in-phase voltage.

e. Calculate the voltage output of the resolver bridge which is equivalent to a 4 seconds-of-arc error by the following formula:

$$V_{R1-R2} = 4.85 \times 10^{-6} \times E_s \times 4 \text{ (seconds-of-arc)}$$

Where E_s = maximum stator output voltage of resolver standard

EXAMPLE:

1. E_s = 90 volts

   $V_{R1-R2} = 4.85 \times 10^{-6} \times 90 \times 4$

   $V_{R1-R2} = 1.75$ millivolts

2. E_s = 11.8 volts

   $V_{R1-R2} = 4.85 \times 10^{-6} \times 11.8 \times 4$

   $V_{RI-R2} = .23$ millivolts

NOTE: 1 sec = 4.85×10^{-6} Radians.

3. E_s = 115 volts

$V_{R1\text{-}R2} = 4.85 \times 10^{-6} \times 115 \times 4$

$V_{R1\text{-}R2} = 2.23$ millivolts

f. The voltage output, as measured by the phase angle voltmeter shall not exceed the voltage calculated in step e.

g. Repeat voltage check at each 5° step of the bridge with the standard set to the same angle.

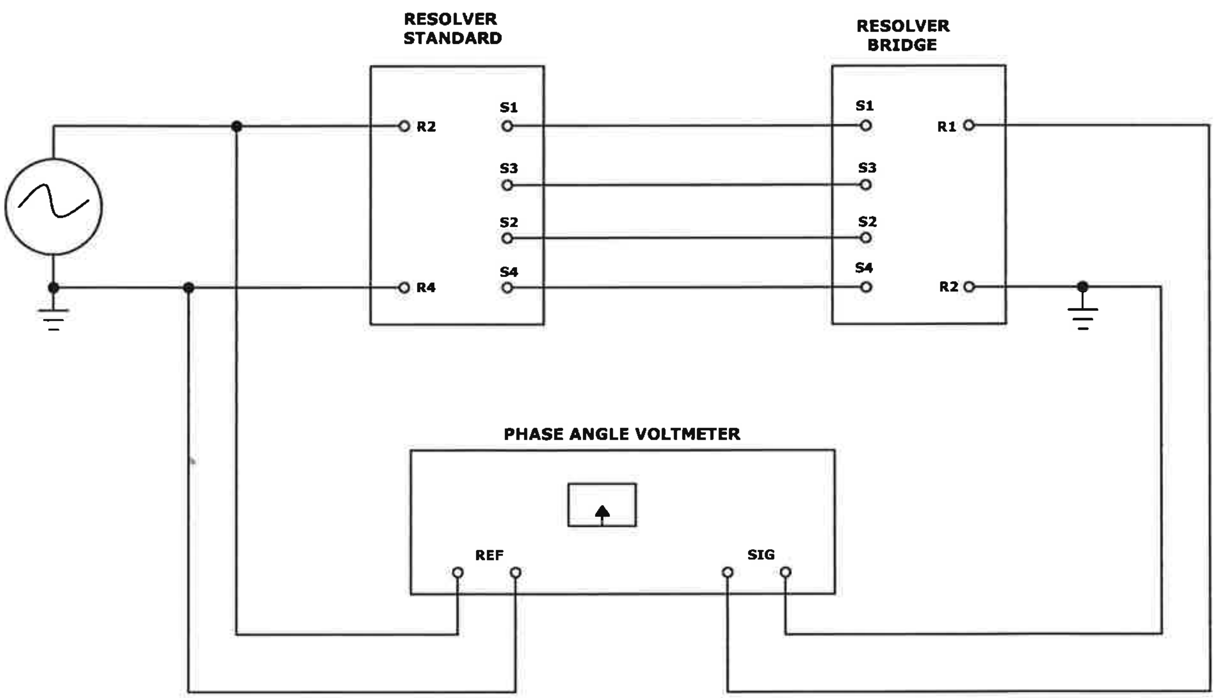


Figure 6-2. Angular Accuracy Test Setup, Field Test, Resolver Mode

6.2.3 Voltage Gradient Test

The same test equipment and test setup as used in the angular accuracy test are required.

Using the following test procedure:

a. Connect resolver bridge into test setup as shown in Figure 6-2.

b. Turn mode switch to resolver.

c. Adjust phase angle voltmeter to measure in-phase voltage.

d. Adjust resolver standard to 5°.

e. Adjust resolver bridge to 0°.

f. Measure output voltage of the bridge.

g. The error voltage shall be approximately 9% of E_s, maximum stator output voltage of the standard.

h. Repeat error voltage measurement at each 5° increment throughout the 0° to 90° range of the bridge. The standard shall be adjusted to maintain a constant 5° error at each increment.

i. The error voltage shall be constant within ±2% for each increment in the 0° to 90° range. (1% for the RS and 1% for the RB)

6.2.4 Functional Accuracy Test, Synchro Mode

The following test equipment (or equivalent) is required:

Synchro Standard	Model DSRS-5DA
Phase Angle Voltmeter	Model PAV-4B or 4C

Using the following test procedure:

a. Connect synchro bridge into test setup as shown in Figure 6-3.
b. Turn mode switch to synchro.
c. Install shorting straps on the test binding posts.
d. Adjust phase angle voltmeter to measure in-phase voltage.
e. Calculate the voltage output of the synchro bridge which is equivalent to 4 seconds-of-arc by the following formula:

$$V_{R1\text{-}R2} = 4.85 \times 10^{-6} \times E_s \times 4 \text{ (seconds-of-arc)}$$

where:

E_s = maximum stator output voltage of synchro standard

EXAMPLES:

1. $E_s = 90$ volts

   $V_{R1-R2} = 4.85 \times 10^{-6} \times 90 \times 4$

   $V_{R1-R2} = 1.75$ millivolts

2. $E_s = 11.8V$

   $V_{R1-R2} = 4.85 \times 10^{-6} \times 11.8 \times 4$

   $V_{R1-R2} = .23$ millivolts

3. $E_s = 115V$

   $V_{R1-R2} = 4.85 \times 10^{-6} \times 115 \times 4$

   $V_{R1-R2} = 2.23$ millivolts

f. The voltage output, as measured by the phase angle voltmeter, shall not exceed the voltage calculated in step e.

g. Report voltage check at 0°, 105°, 210°, and 330° with the synchro bridge and synchro standard set to the same angle.

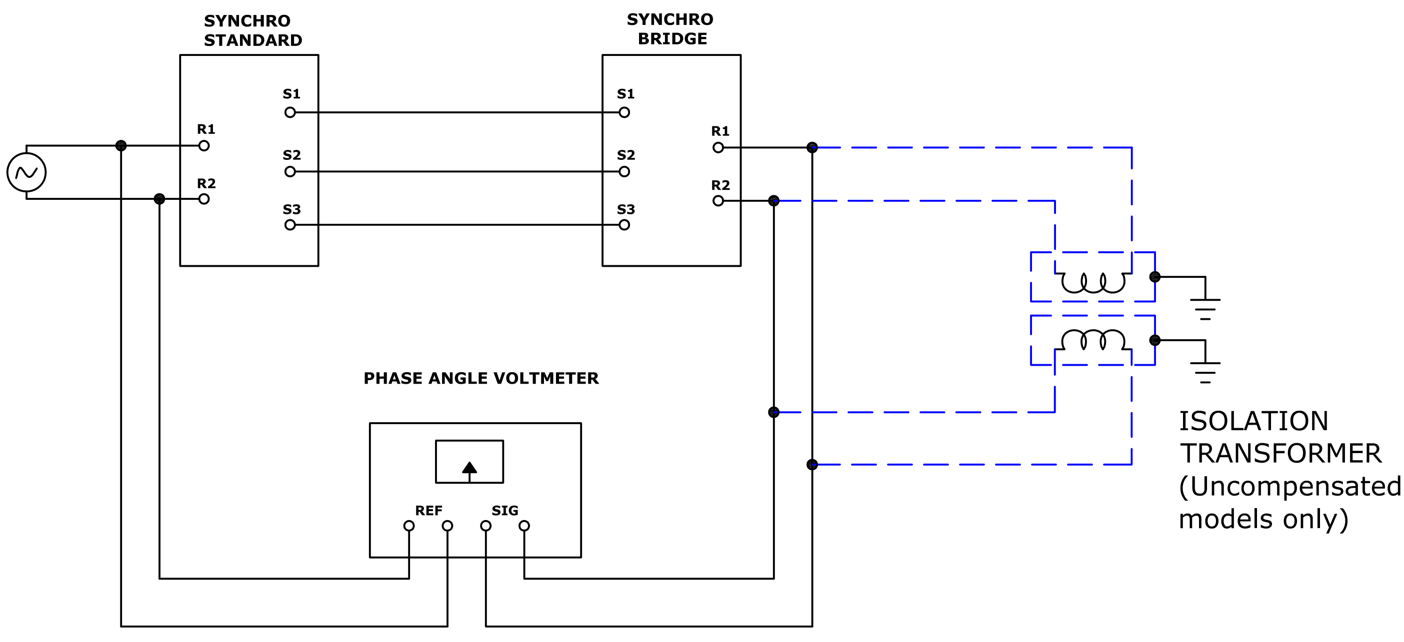


Figure 6-3. Angular Accuracy Test Setup, Field Test, Synchro Mode

6.3 4 SECONDS-OF-ARC TEST

6.3.1 Input Impedance Test

Perform this test as outlined in Paragraph 6.2.1.

6.3.2 Angular Accuracy Test, Resolver Mode

The following test equipment (or equivalent) is required:

AC Ratio Standard (T2, T3)	Model 1011A
Ratio Transformer (T1)	Model RT-60
Phase Angle Voltmeter (V1, V2)	Model PAV-4B or 4C
Isolation Transformer (1)	Model ST200
Isolation Transformer (2)	Model ST200AM (Matched to 2 ppm)
Swith (S1, S2, S3)	DPDT

Use the following test procedure:

a. Connect resolver bridge into test setup as shown in Figure 6-4.
b. Turn mode switch to resolver.
c. Make certain that the two shorting straps are installed across the test binding posts.
d. Adjust resolver bridge to 0°.
e. Adjust phase angle voltmeters V1 and V2 to measure in-phase voltage.
f. Set switch S1 to the No. 2 position.
g. Set switches S2 and S3 to the No. 1 position.
h. Set Ratio Transformer T1 to a ratio of 1.00.
i. Adjust AC Ratio Standard T2 as required to obtain a null on phase angle voltmeter V2. The approximate ratio at which a null will be obtained is given in the theoretical ratio column of Table 6-1.

SWITCH POSITIONS

ANGLE	S1	S2	S3
0-40°	2	1	1
45-85°	1	1	1
90-130°	1	1	2
135-175°	2	1	2
180-220°	2	2	2
225-265°	1	2	2
270-310°	1	2	1
315-360°	2	2	1

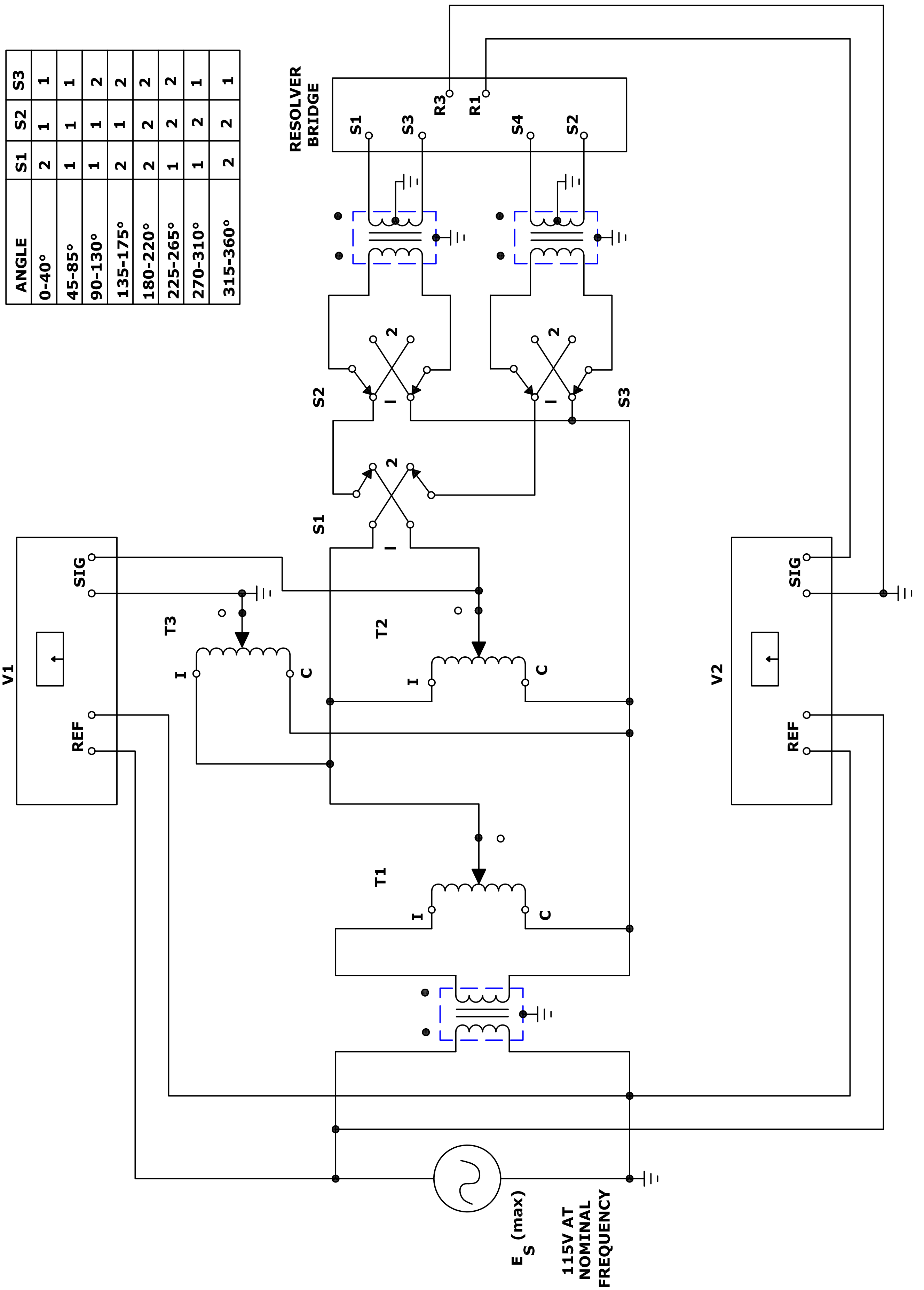


Figure 6-4. Angular Accuracy Test Setup, Resolver Mode

j. Adjust AC Ratio Standard T3 as required to obtain a null on phase angle voltmeter V1.

k. AC Ratio Standard T3 shall indicate the theoretical ratio given in Table 6-1 within the limits set by the maximum deviation column.

l. Report test at each 5° increment of the bridge. Set Ratio Transformer T1 to the values specified in Table 6-1. Operate switches S1, S2, and S3 as noted in Figure 6-4. Refer to Table 6-1 for the theoretical ratio settings of AC Ratio Standard T3 and maximum allowable deviations.

m. Repeat test at each increment listed in Table 6-3. Set Ratio Transformer T1 to the values specified in Table 6-3. Refer to Table 6-3 for the theoretical ratio settings of AC Ratio Standard T3 and maximum allowable deviations.

6.3.3 Voltage Gradient Test

The same test equipment and setup used in the angular accuracy test are required, refer to Paragraph 6.3.2.

Use the following test procedure:

a. Adjust bridge and test equipment as outlined in steps a through i of Paragraph 6.3.2.

b. Advance resolver bridge to 5°.

c. The error voltage measured by phase angle voltmeter V2 shall be approximately 9% of E_s (10.4 volts).

d. Repeat error voltage measurement at each 5° increment throughout the 0° to 90° range setting T1 and T2 in accordance with Table 6-1 and the resolver bridge 5° ahead.

e. The error voltage shall be constant within ± 1% for each increment in the 0° to 90° range.

6.3.4 Angular Accuracy Test, Synchro Mode

To perform the angular accuracy test, the following test equipment (or equivalent) is required:

AC Ratio Standard (T2, T3)	Model 1011A
Ratio Transformer (T1)	Model RT-60
Isolation Transformer (T4)	Model ST200A
Switch (S1)	DPDT
Switch (S2)	3 pole, 3 position
Phase Angle Voltmeter (V1, V2)	Model PAV-4B or -4C

Use the following test procedure:

a. Connect snychro bridge into test setup as shown in Figure 6-5.

b. Turn mode switch to snychro.

c. Install shorting straps on the test binding posts.

d. Adjust snychro bridge to 0°.

e. Adjust phase angle voltmeter V1 and V2 to measure in-phase voltage.

f. Set switches S1 and S2 to the No. 1 position.

g. Set Ratio Transformer T1 to a ratio of 0.87.

h. Adjust AC Ratio Standard T2 as required to obtain a null on phase angle voltmeter V1. The approximate ratio at which a null will be obtained is given in the theoretical ratio column of Table 6-2.

i. Adjust AC Ratio Standard T3 as required to obtain a null on phase angle voltmeter V2.

j. AC Ratio Standard T3 shall indicate the theoretical ratio given in Table 6-2 within the limits set by the maximum deviation column.

k. Repeat test at each angle given in Table 6-2. Set Ratio Transformer T1 to the values specified in Table 6-2.

SWITCH POSITIONS		
ANGLE	S1	S2
0° - 60°	1	1
60° - 120°	2	2
120° - 180°	1	3
180° - 240°	2	1
240° - 300°	1	2
300° - 360°	2	3

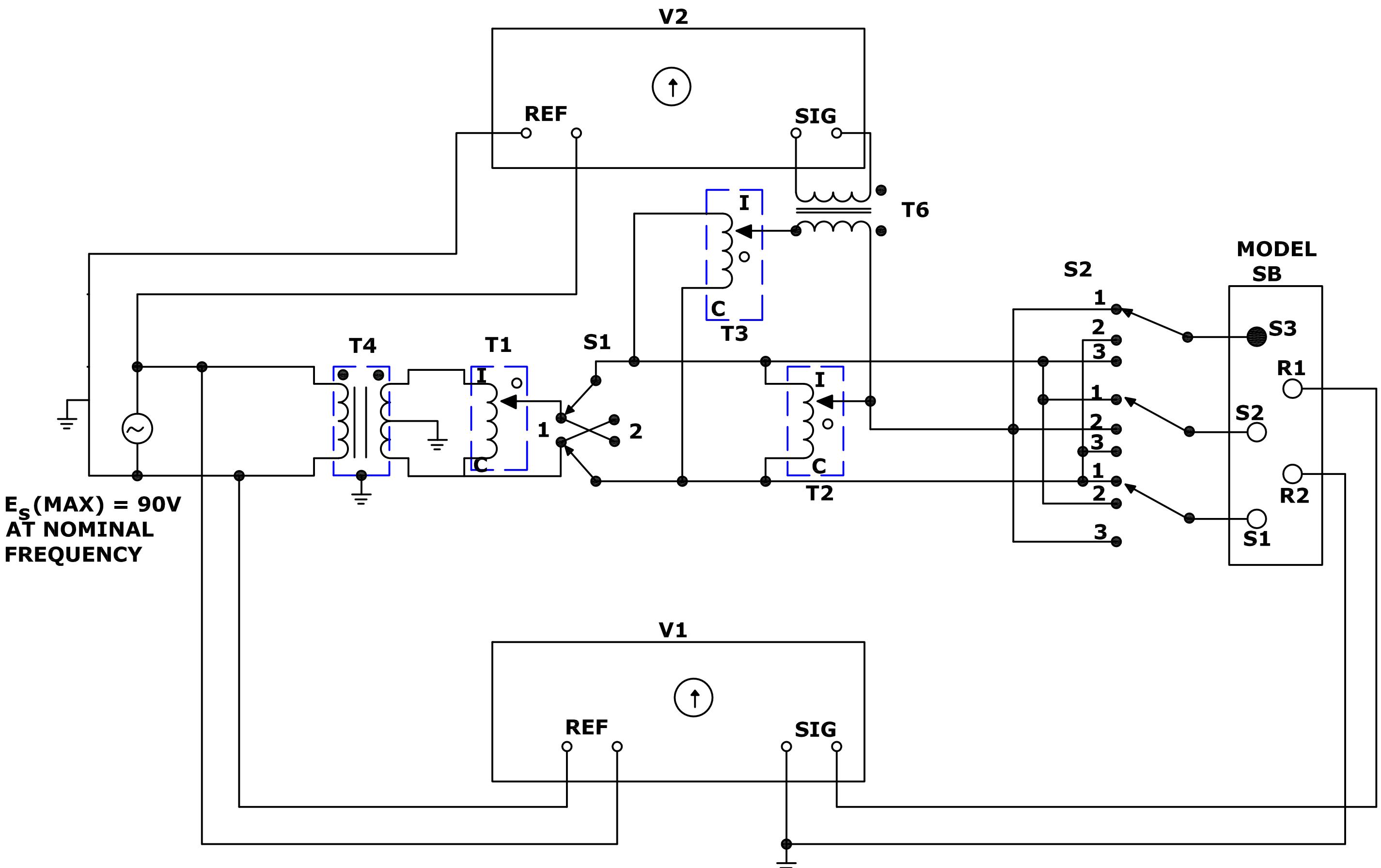


Figure 6-5. Angular Accuracy Test Setup, Synchro Mode

Operate switches S1 and S2 as noted in Figure 6-5.
Refer to Table 6-3 for theoretical ratio settings of
AC Ratio Standard T3 and maximum allowable deviation.

TABLE 6-1. Angular Accuracy, 5° Increments, Resolver Mode

RESOLVER BRIDGE ANGULAR SETTING				T1	THEORETICAL RATIO	MAXIMUM DEVIATION (±)
0	90	180	270	1.00	0.0000000	.0000194
5	95	185	275	1.00	0.0874887	.0000196
10	100	190	280	0.98	0.1763270	.0000200
15	105	195	285	0.97	0.2679492	.0000208
20	110	200	290	0.94	0.3639702	.0000220
25	115	205	295	0.91	0.4663077	.0000236
30	120	210	300	0.87	0.5773503	.0000260
35	125	215	305	0.82	0.7002075	.0000290
40	130	220	310	0.77	0.8390996	.0000330
45	135	225	315	0.71	1.000000	.0000388
50	140	230	320	0.77	0.8390996	.0000330
55	145	235	325	0.82	0.7002075	.0000290
60	150	240	330	0.87	0.5773503	.0000260
65	155	245	335	0.91	0.4663077	.0000236
70	160	250	340	0.94	0.3639702	.0000220
75	165	255	345	0.97	0.2679492	.0000208
80	170	260	350	0.98	0.1763270	.0000200
85	175	265	355	1.00	0.0874887	.0000196

TABLE 6-2. Angular Accuracy, Synchro Mode

SYNCHRO BRIDGE ANGULAR SETTING	T1	THEORETICAL RATIO	MAXIMUM DEVIATION (±)
0	.87	0.0000000	.0000224
135	0.97	0.2679492	.0000180
210	1.00	0.5000000	.0000168
345	0.97	0.7320508	.0000180

TABLE 6-3. Angular Accuracy, Decade Increments, Resolver Mode

ANGULAR SETTING	T1	THEORETICAL RATIO (TAN)	MAXIMUM DEVIATION±
0.001	1.00	0.0000175	0.0000194
0.002	1.00	0.0000349	0.0000194
0.003	1.00	0.0000524	0.0000194
0.004	1.00	0.0000698	0.0000194
0.005	1.00	0.0000873	0.0000194
0.006	1.00	0.0001047	0.0000194
0.007	1.00	0.0001222	0.0000194
0.008	1.00	0.0001396	0.0000194
0.009	1.00	0.0001571	0.0000194
0.01	1.00	0.0001745	0.0000194
0.02	1.00	0.0003491	0.0000194
0.03	1.00	0.0005236	0.0000194
0.04	1.00	0.0006981	0.0000194
0.05	1.00	0.0008727	0.0000194
0.06	1.00	0.0010472	0.0000194
0.07	1.00	0.0012217	0.0000194
0.08	1.00	0.0013963	0.0000194
0.09	1.00	0.0015708	0.0000194

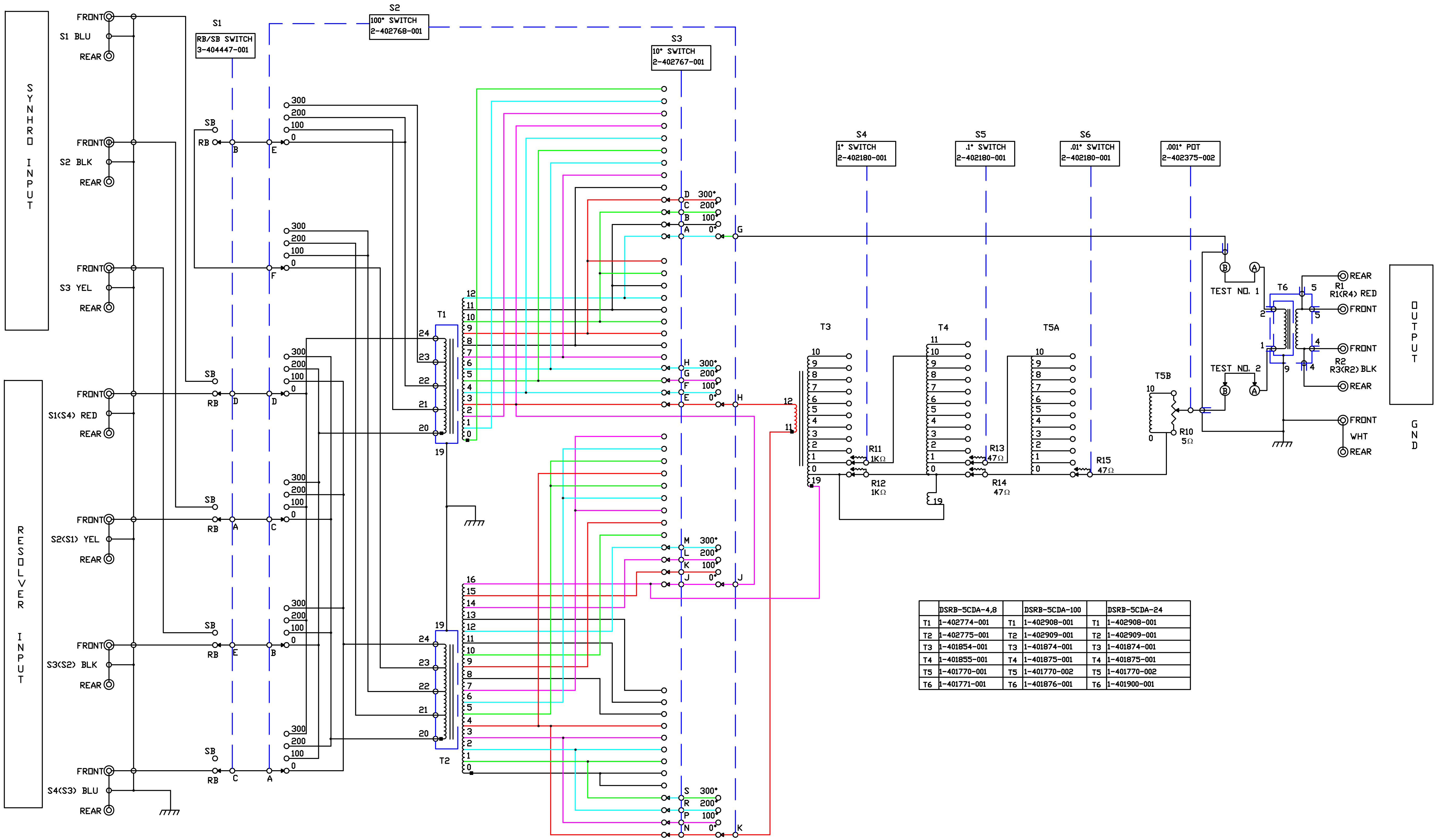
ANGULAR SETTING	T1	THEORETICAL RATIO (TAN)	MAXIMUM DEVIATION±
0.1	1.00	0.0017453	0.0000194
0.2	1.00	0.0034907	0.0000194
0.3	1.00	0.0052360	0.0000194
0.4	1.00	0.0069814	0.0000194
0.5	1.00	0.0087269	0.0000194
0.6	1.00	0.0104724	0.0000194
0.7	1.00	0.0122179	0.0000194
0.8	1.00	0.0139635	0.0000194
0.9	1.00	0.0157093	0.0000194
1	1.00	0.0174551	0.0000194
2	1.00	0.0349208	0.0000194
3	1.00	0.0524078	0.0000194
4	1.00	0.0699268	0.0000196
5	1.00	0.0874877	0.0000196
6	1.00	0.1051042	0.0000196
7	1.00	0.1227846	0.0000196
8	1.00	0.1405408	0.0000200
9	1.00	0.1583844	0.0000200

Section VII

SCHEMATIC DIAGRAMS

2.1 INTRODUCTION

This section contains the Model DSRB-5CDA schematic that applies equally to Models DSRB-5CDA 4, 8, 24, or 100. The difference between these models is the part number of the Transformer Assembly. The Transformer Assembly consists of T1 thru T6.



	DSRB-5CDA-4,8		DSRB-5CDA-100		DSRB-5CDA-24
T1	1-402774-001	T1	1-402908-001	T1	1-402908-001
T2	1-402775-001	T2	1-402909-001	T2	1-402909-001
T3	1-401854-001	T3	1-401874-001	T3	1-401874-001
T4	1-401855-001	T4	1-401875-001	T4	1-401875-001
T5	1-401770-001	T5	1-401770-002	T5	1-401770-002
T6	1-401771-001	T6	1-401876-001	T6	1-401900-001

Figure 7-1. Typical Schematic, Direct Readout

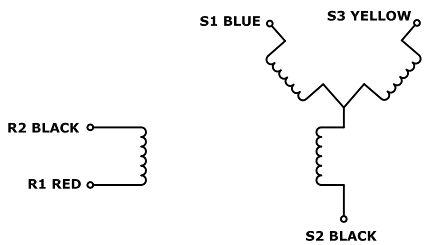
APPENDIX A

Synchro and Resolver Testing

Component Description

Synchros and resolvers transmit mechanical angular data via electrical means. The angular position is converted to an electrical signal by a control transmitter. The electrical signal is transmitted to a receiver which then converts the electrical signal to a mechanical position. The mechanical position determines the amplitude of the output signal or signals and thus synchros and resolvers may be viewed as variable transformers.

SYNCHRO CONTROL TRANSMITTER (CX). In a synchro control transmitter, the system reference voltage is applied across a single rotor winding which functions as a primary. Three stator windings (secondaries) are displaced 120 degrees from each other and are star connected.



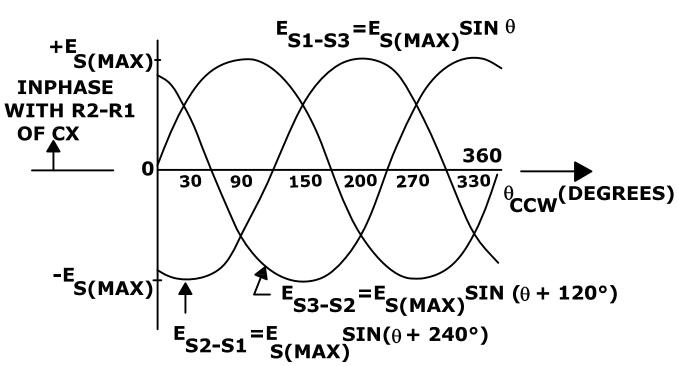
The induced voltage in each stator winding is either in-phase or 180 degrees out-of-phase with the input voltage. The magnitude of the voltage depends upon the rotor position relative to that specific winding. The output voltages relative to the input vary according to the following formula:

$$E_{S1\text{-}S3} = N\ E_{R2\text{-}R1} \sin\theta$$

$$E_{S3\text{-}S2} = N\ E_{R2\text{-}R1} \sin(\theta + 120\text{ degrees})$$

$$E_{S2\text{-}S1} = N\ E_{R2\text{-}R1} \sin(\theta + 240\text{ degrees})$$

where N is the transformation ratio and θ is positive for CCW rotation from electrical zero (EZ) as viewed from the shaft end.



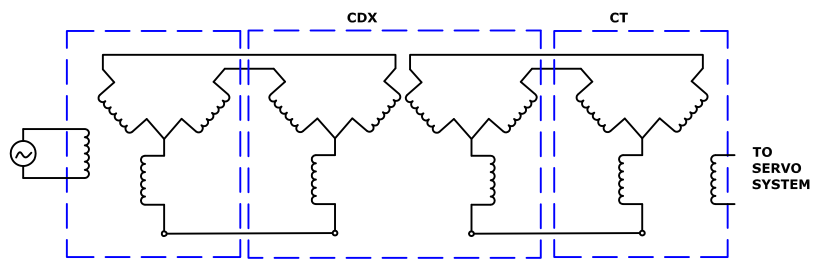
$$E_S(max) = N\ E_{R2\text{-}R1}$$

Standard Synchro Control Transmitter (CX) Outputs as a Function of CCW Rotation From Electrical Zero (EZ).

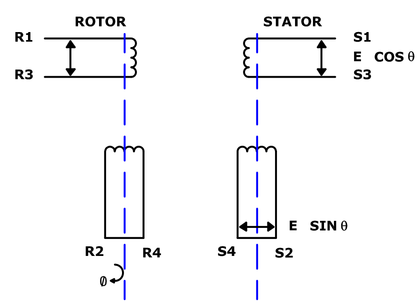
These three voltages completely and uniquely define an angular position and this data is normally supplied to a control transmitter (CT) or a control differential transmitter (CDX).

CONTROL TRANSFORMER (CT). In a control transformer, the three stator windings function as the primary and the single rotor winding functions as the secondary. When the angular positions of the rotor and the electrical signal are the same, the output of the rotor winding is a null voltage. Any difference in angular position produces a voltage output which, in turn, is used to drive a servo system.

CONTROL DIFFERENTIAL TRANSMITTER (CDX). A control differential transmitter includes three rotor and three stator windings. It is used to modify a three-wire signal from a control transmitter. The three-wire output corresponds to the sum or difference of the input angle and the mechanical angle of the rotor.



RESOLVER CONTROL TRANSMITTER (RX). Resolvers normally include two stator and two rotor windings. In a resolver control transmitter, the reference voltage is applied to one of the stator windings which functions as the primary. The secondaries produce two separate voltages: one voltage is proportional to the sine of the rotational angle and the second is proportional to the cosine.



RESOLVER CONTROL TRANSFORMER (RC). In an RC, the stator windings function as the primary and one of the rotor windings functions as the secondary. When the angular positions of the rotor and the electrical signal are the same, the output is a null voltage. Any difference in angular position produces a voltage output which, in turn, drives a servo system.

RESOLVER DIFFERENTIAL TRANSMITTER (RDX). An RDX includes two rotor and two stator windings. It is used to modify the two separate voltage signals from a resolver control transmitter (RX). The two voltage outputs correspond to the sum or difference or the input angle and the mechanical angle of the rotor.

COMPONENT TESTING

Test	Angular Accuracy	Null Voltage	Transformation Ratio	Phase Shift
CX	DH, PAV, SB	DH, PAV	DH, PAV, RT	DH, PAV
CDX	DH, PAV, SB, SS	DH, PAV	DH, PAV, RT	DH, PAV
CT	DH, PAV, SS	DH, PAV	DH, PAV, RT	DH, PAV
RX	DH, PAV, RB	DH, PAV	DH, PAV, RT	DH, PAV
RD	DH, PAV RB, RS	DH, PAV	DH, PAV, RT	DH, PAV
RC	DH, PAV, RS	DH, PAV	DH, PAV, RT	DH, PAV

DH - Dividing Head
PAV - Phase Angle Voltmeter
RT - Ratio Transformer

SS - Synchro Standard
SB - Synchro Bridge
RS - Resolver Standard
RB - Resolver Bridge

NOTE: Also see Engineering Bulletins No. 1, 2, 3, and 4.

Angular Accuracy

The angular accuracy of a data-transmission synchro or resolver is briefly defined as the difference between the mechanical and the electrical position. The difference is referred to as the electrical error and is expressed in angular units.

The DH is the precision angular positioning device used to mechanically rotate a unit under test. An SB, an SS, an RS or an RB, is used to measure the electrical position of the unit under test. All components may be tested at 5 degree increments through out the 0 to 360 degree range. When the dividing head and the bridge or standard are set to the same angular position, the output of the test setup should be a null voltage. Any voltage output indicates electrical error and, in the test method used, the amount of voltage output is directly related to angular error (proportional voltage gradient method). The fine zero control of the DH provides the means for introducing an exact angular error. With the test setup set to null, the DH may be offset by the maximum allowable angular error. This will produce a maximum allowable error voltage which is applied to the PAV. The variable range control of the PAV may be adjusted to provide full scale deflection on the voltmeter. Less than full scale deflection may be calculated as a percentage of the maximum allowable angular error.

Null Voltage

Null voltage is the voltage component of the minimum output signal. Fundamental null voltage is synonymous with quadrature voltage since the in-phase output voltage at this point is zero.

A 0 degree excitation voltage is applied to the primary of the unit under test and the PAV is connected across the secondary. The unit under test is adjusted to produce an in-phase null voltage and then the fundamental and total null voltages are measured with the PAV.

With the PAV set to the TOTAL function, the PAV indicates the total null voltage including harmonics and noise. With the PAV set to the FUND function, a band-pass filter is switched into the circuit to eliminate noise and harmonics. The PAV therefore indicates the fundamental component of the selected frequency.

Transformation Ratio

Transformation ratio (N) is the ratio of the fundamental component of the no-load secondary voltage to the fundamental voltage applied to the primary. The ratio is measured at the first position of maximum coupling in the positive direction (CCW as viewed from the shaft end) from electrical zero. For these tests, the excitation voltage is applied across the primary of the unit under test and across an RT. The PAV is connected between the high side of the secondary and the arm of the RT and functions as a phase sensitive null indicator.The RT is adjusted until a null is indicated. The output to input ratio of the unit under test may then be read from the setting of the ratio controls. The ratio controls indicate the ratio of the fundamental components only at 90 degrees. Since there may be phase shift through the unit under test, the ratio is divided by the cosine of the phase shift angle ($\emptyset$) to obtain the total transformation ratio.

Phase Shift

Phase shift ($\emptyset$) is the difference between the time phase of the fundamental component of the primary and secondary voltages. Phase shift is measured at the first position of maximum coupling in the positive direction from electrical zero (EZ).

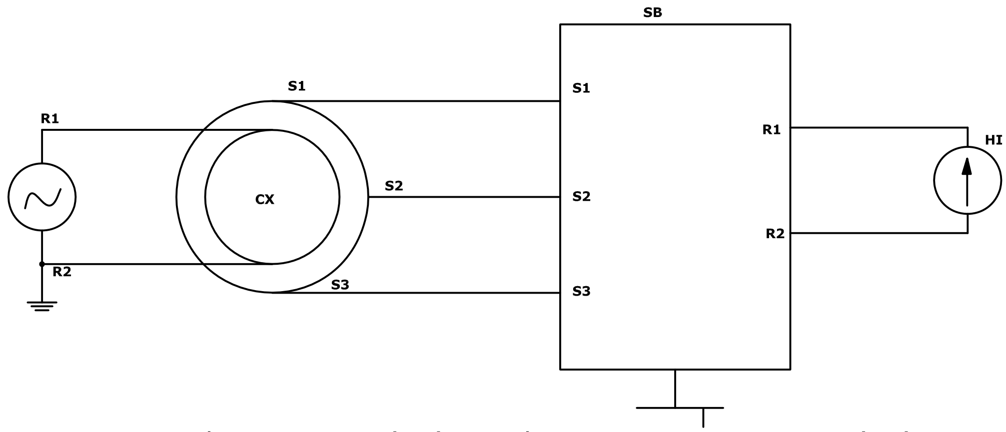
For this test, the PAV is used as a phase angle measuring device. The excitation voltage is applied across the primary and the PAV is connected across the secondary. The unit under test is rotated to the first position of maximum coupling and the PAV is adjusted to measure phase angle.

The phase sensitive detector of the PAV indicates a peak deflection when the instrument is set to the exact phase shift angle and a null when the instrument is set 90 degrees from the exact phase shift angle. Since null indications are more precise than peak deflections, the PAV is adjusted to measure the quadrature null. In reading $\emptyset$, the 90 degree setting of the PAV FUNCTION switch is ignored and $\emptyset$ is read directly from the setting of the DEGREES dial.

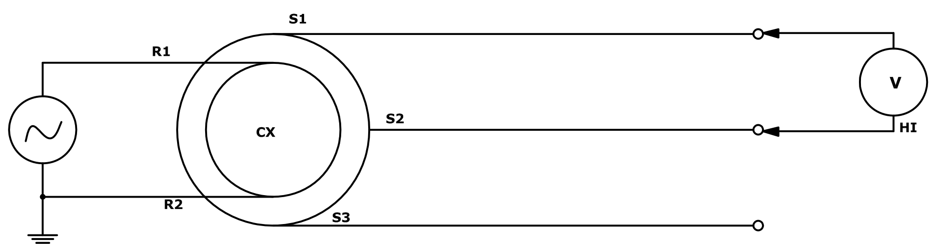
Synchro Control Transmitter (CX) Tests

The electrical output of the control transmitter (S1, S2, S3) is applied to a synchro bridge (SB). The synchro bridge is a precision transformer instrument which produces an error voltage (across R1 and R2) when its angular position differs from the equivalent angular position of the three-wire signal applied to the input.

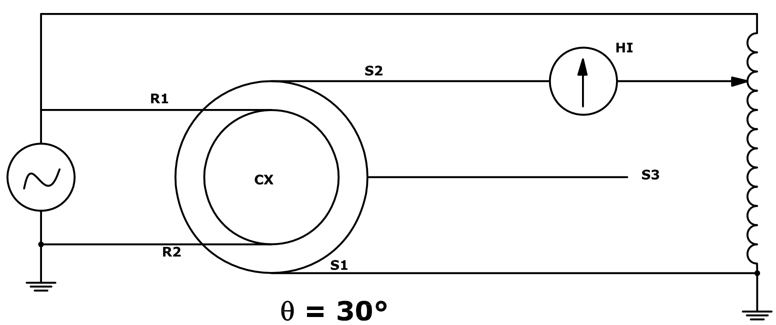
The error voltage is directly related to the angular difference but is not constant throughout the 0 to 360 degree range of the bridge. To provide an equal error voltage (voltage gradient) at all increments, a scaling transformer is included as the compensating network. With the addition of the compensating network, the electrical error may be determined without the necessity of obtaining an exact null.



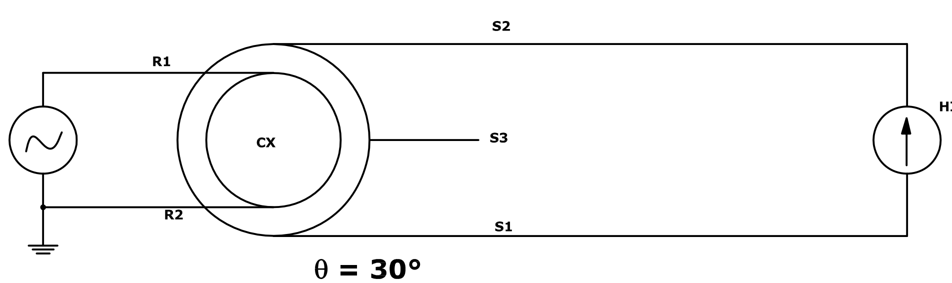
Control Transmitter (CX) Angular Accuracy Test Circuit (AA)



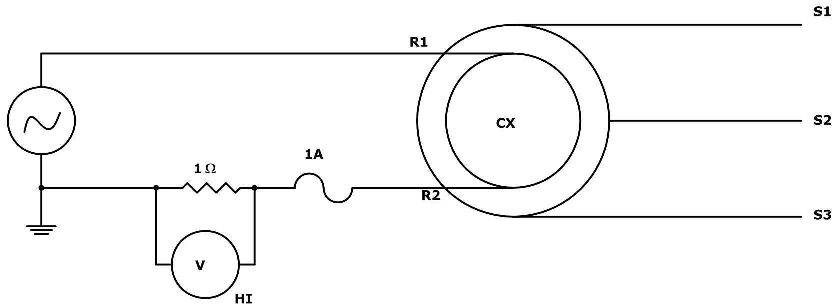
Control Transmitter (CX) Angular Null Voltage Test Circuit



Control Transmitter (CX) Transformation Ratio Test Circuit (N)



Control Transmitter (CX) Phase Shift Test Circuit (Ø)



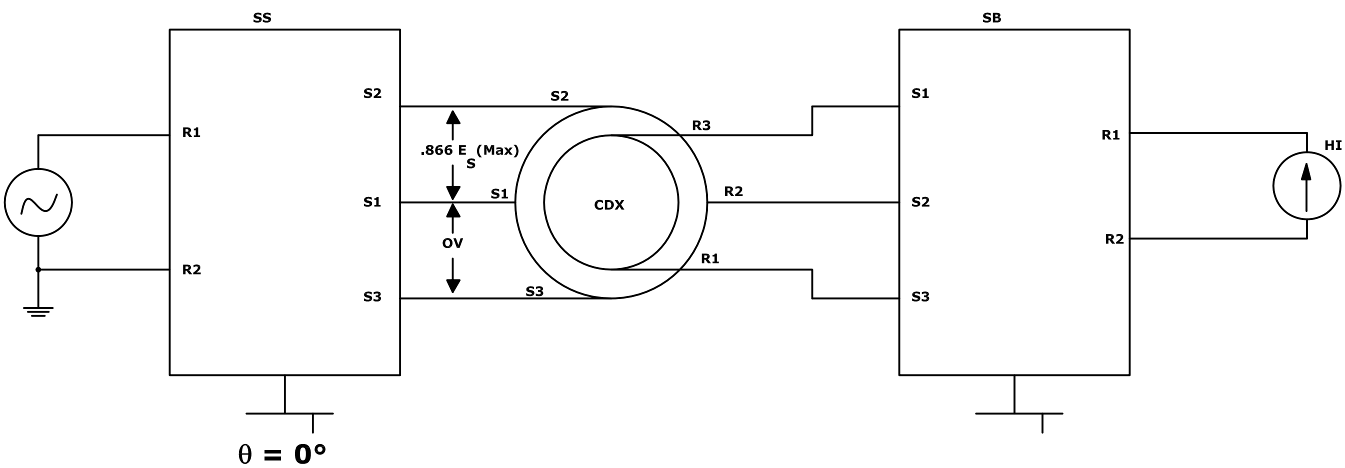
Control Transmitter (CX) Input Current Test Circuit (Ip)

Synchro Control Differential Transformer (CDX) Tests

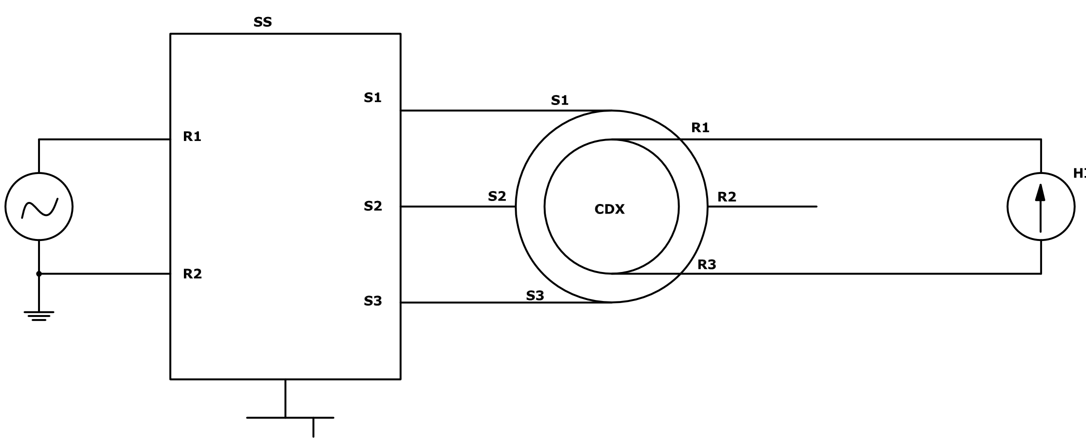
ROTOR TESTS. The two wire excitation voltage is converted to a three wire signal in a synchro standard (SS). The three wire output of the SS is applied to the stator (S1, S2, S3) of the CDX and functions as the 0 degree reference voltage. The electrical output of the CDX (R1, R2, R3) is applied to a synchro bridge (SB). For this test, the SS is set to 0 degrees for all tests and the DH and SB are rotated.

The synchro standards is a precision transformer instrument which simulates the ideal outputs of a synchro control transmitter (CX). The SS produces three output voltages "120 degrees in amplitude" from each other. One of the three voltages is directly related to the sine of the angle displayed by the unit.

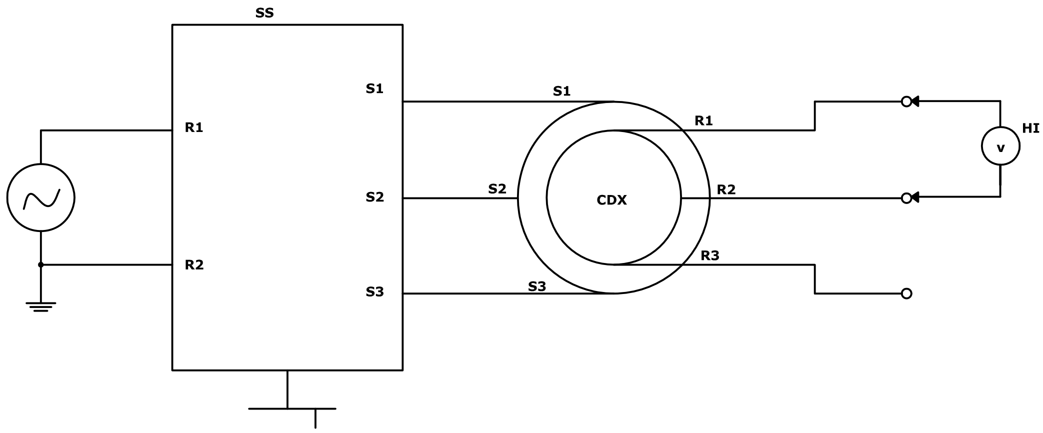
STATOR TESTS. As with the rotor tests, the two wire excitation is converted to a three wire signal in the SS and applied to the stator (S1, S2, S3). For this test, the SS and the DH are rotated and the error voltage is measured across the rotor (R1, R3).



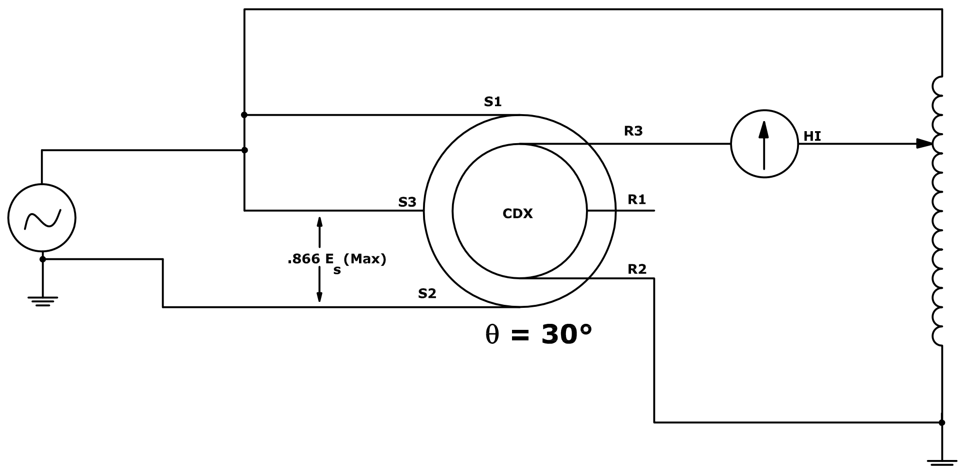
Control Differential Transformer (CDX) Rotor Angular Accuracy Test Circuit (AA)



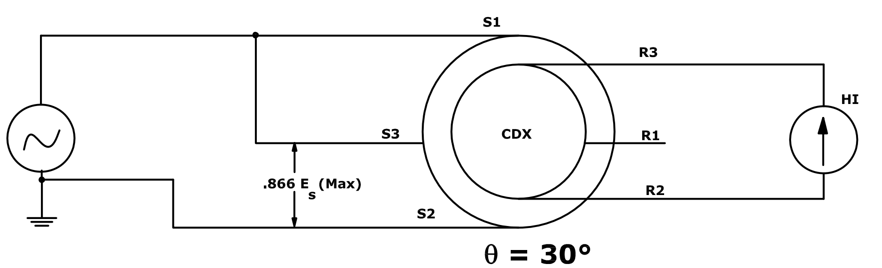
Control Differential Transmitter (CDX) Stator Angular Accuracy Test Circuit (AA)



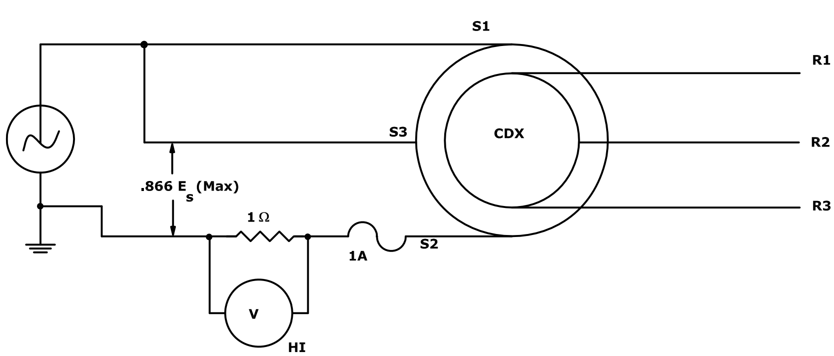
Control Differential Transformer (CDX) Null Voltage Test Circuit



Control Differential Transformer (CDX) and Transformation Ratio Test Circuit (N)



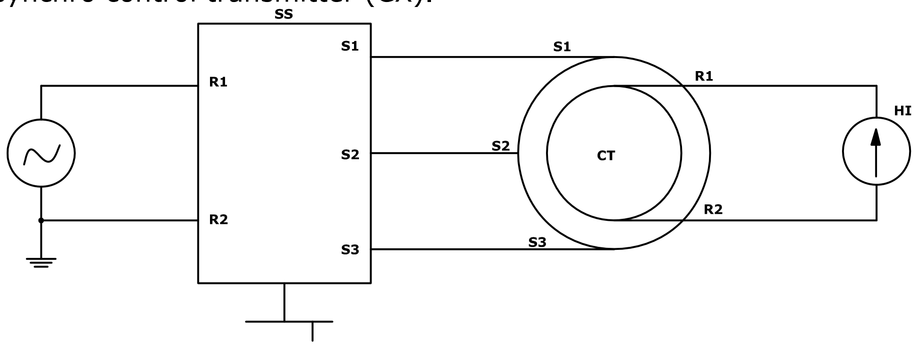
Control Differential Transformer (CDX) Phase Shift Test Circuit (∅)



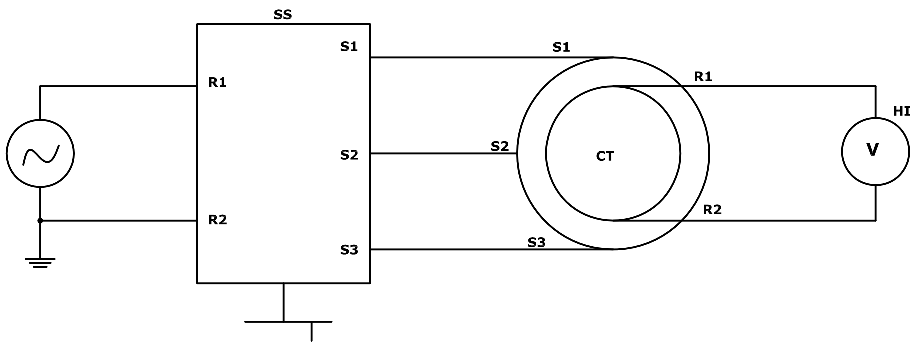
Control Differential Transformer (CDX) Input Current Test Circuit (Ip)

Synchro Control Transformer (CT) Tests

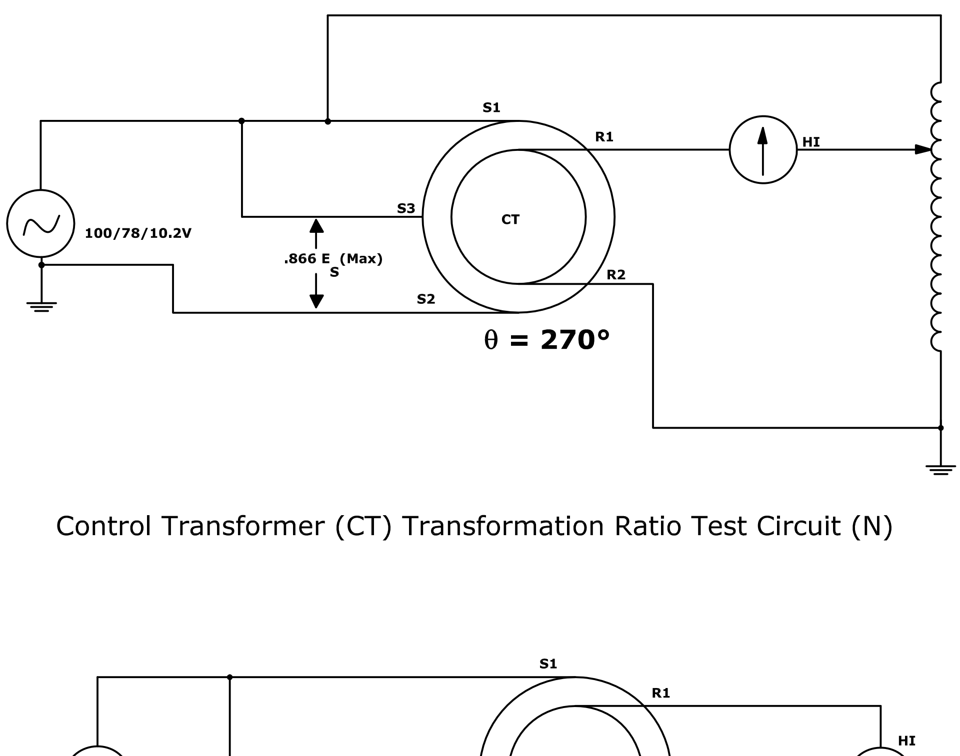
The two wire excitation voltage is converted to a three wire signal in a synchro standard (SS). The three wire output of the SS is applied to the stator (S1, S2, S3) of the CT. The SS and the DH are rotated and the error voltage is measured across the rotor (R1, R2).
The synchro standard is a precision transformer instrument which simulates the ideal outputs of a synchro control transmitter (CX).



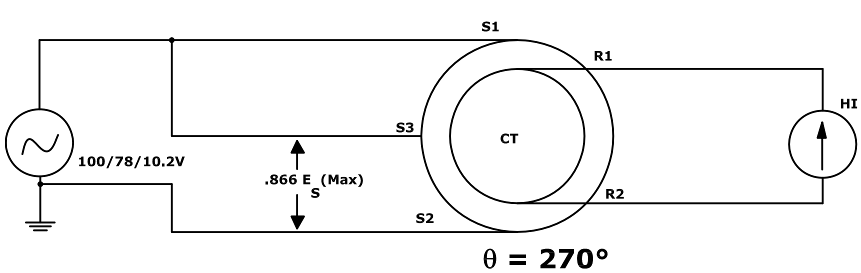
Control Transformer (CT) Angular Accuracy Test Circuit (AA)



Control Transformer (CT) Null Voltage Test Circuit



Control Transformer (CT) Transformation Ratio Test Circuit (N)



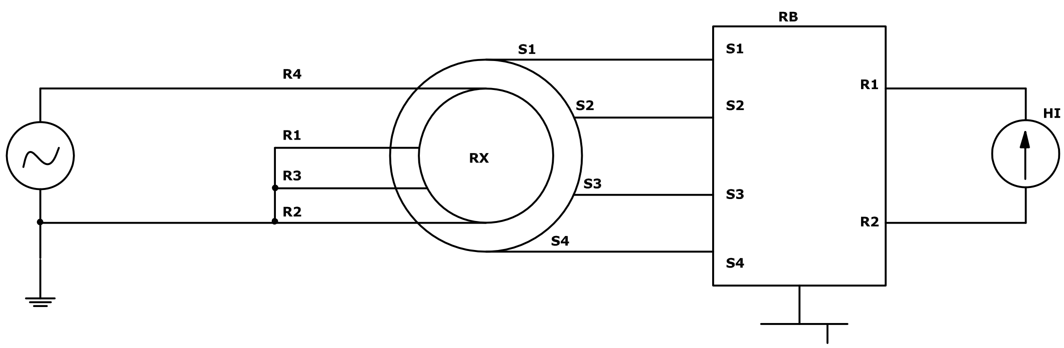
Control Transformer (CT) Phase Shift Test Circuit (Ø)

Control Transmitter (RX) Tests

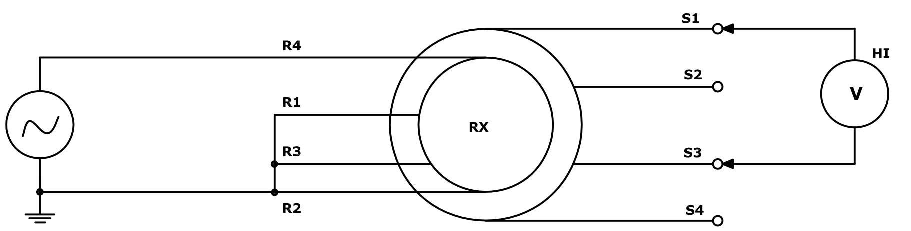
The two wire excitation voltage is applied to the rotor (R2, R4) of the unit under test. The unit produces two signals which are applied to a resolver bridge (RB).

The resolver bridge uses precision transformers to form a voltage comparator bridge. The two voltage signals into the bridge bear a precise voltage ratio relationship which is determined by the angular position of the unit under test. Each signal is applied across a ratio transformer and movement of the ratio transformer arms is equivalent to change in the angular position of a control transformer. When the equivalent angular positions of the bridge and the input siganls are identical, the output of the bridge (R1, R3) is null.

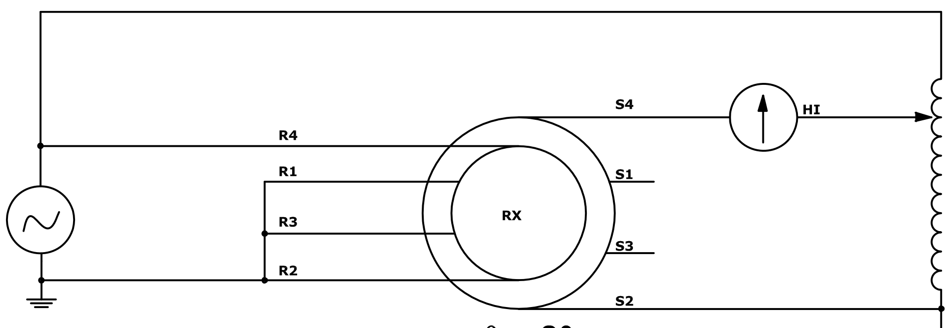
When the equivalent angular positions of the bridge and the input signals differ, the bridge produces an error voltage. This error voltage is directly related to the angular difference but is not constant at each increment. To provide an equal error voltage gradient at all increments, the bridges are inherently compensated. With compensation, the electrical error of a component under test may be determined without the necessity of obtaining an exact null at each increment (proportional voltage gradient method).



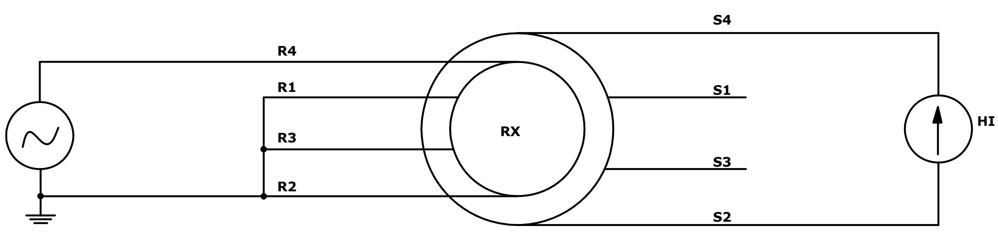
Control Transmitter (RX) Angular Accuracy Test Circuit (AA)



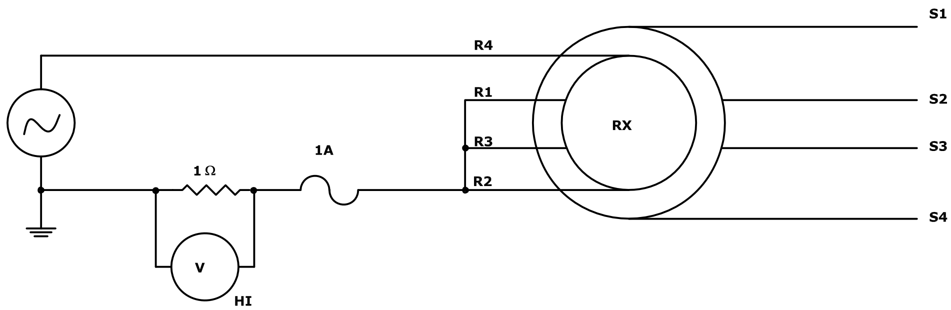
Control Transmitter (RX) Null Test Circuit



Control Transmitter (RX) Transformation Ratio Test Circuit (N)



Control Transmitter (RX) Phase Shift Test Circuit (∅)



Control Transmitter (RX) Input Current Test Circuit (Ip)

Control Differential Transmitter (RD) Tests

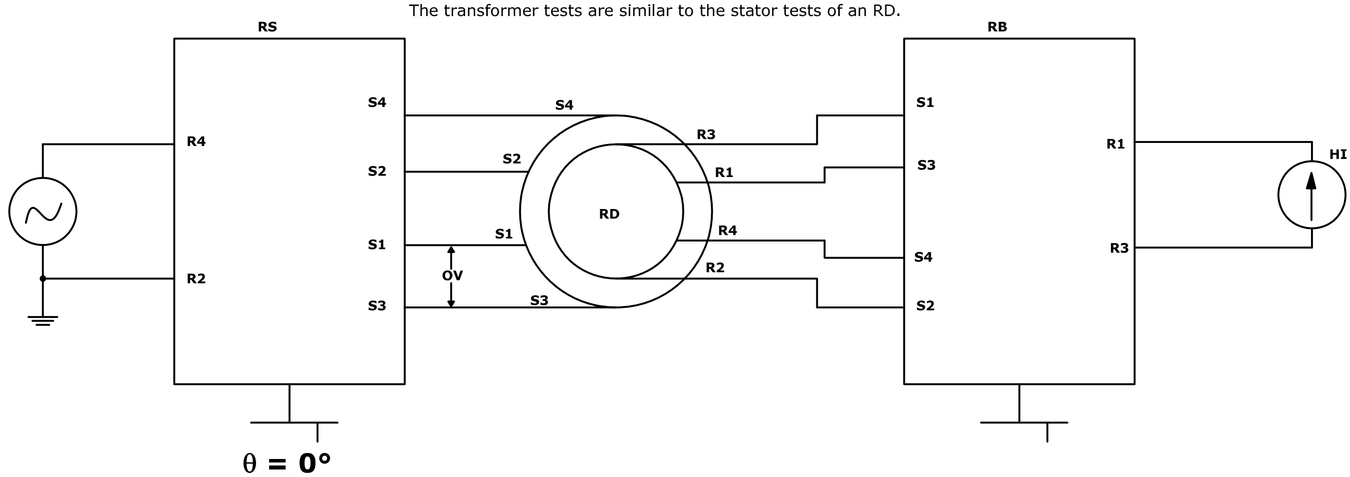
ROTOR TESTS. The two wire excitation voltage is converted to two separate (four wire) signals in a resolver standard (RS). The four wire output of the RS is applied to the stator (S1, S2, S3, S4) of the RD and functions as the 0 degree reference voltage. The electrical output of the RD (R1, R2, R3, R4) is applied to a resolver bridge. For this test, the RS is set to 0 degrees for all tests and the DH and RB are rotated.

The resolver standard is a precision transformer instrument which simulates the ideal outputs of a resolver control transmitter (RX). The RS produces two output voltages, one of which is related to the sine of the angle displayed on the unit and the other is related to the cosine.

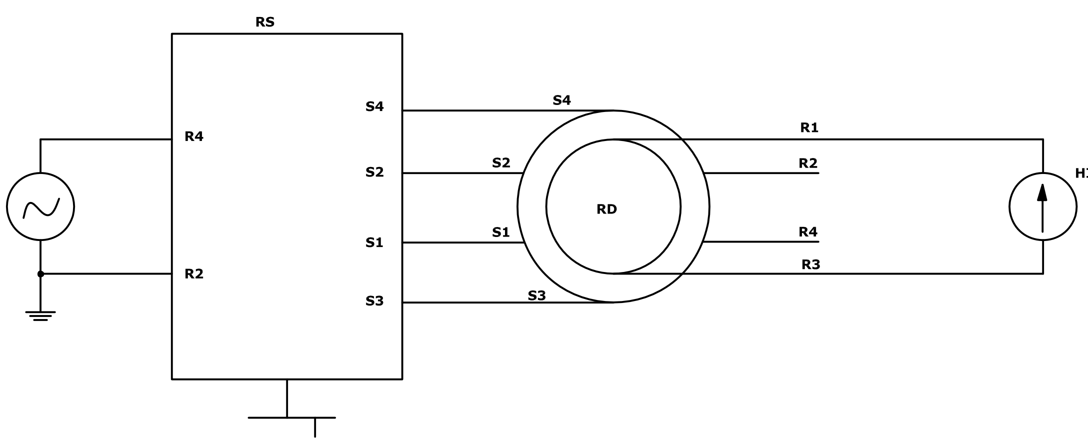
STATOR TESTS. As with the rotor tests, the two wire excitation voltage is converted to two separate signals in the RS and applied to the stator of the RD. For this test, the RS and the DH are related and the error voltage is measured across the rotor (R1, R3).

Control Transformer (RC) Tests

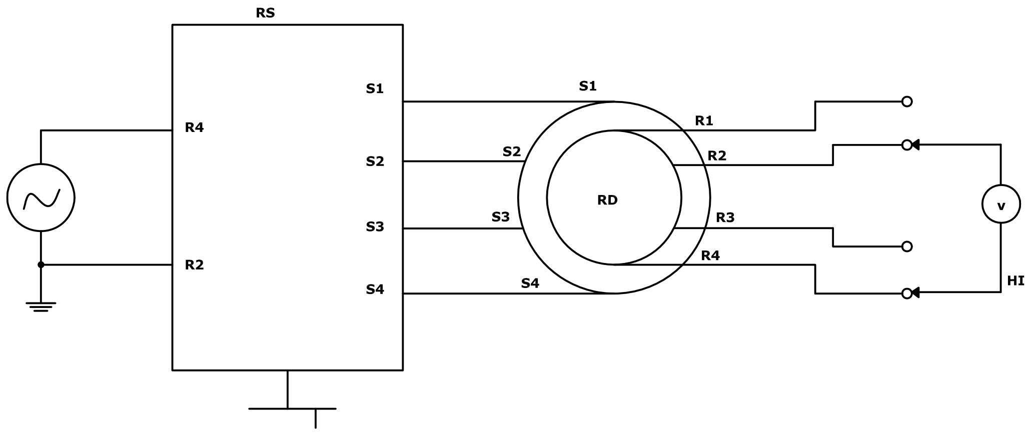
The transformer tests are similar to the stator tests of an RD.



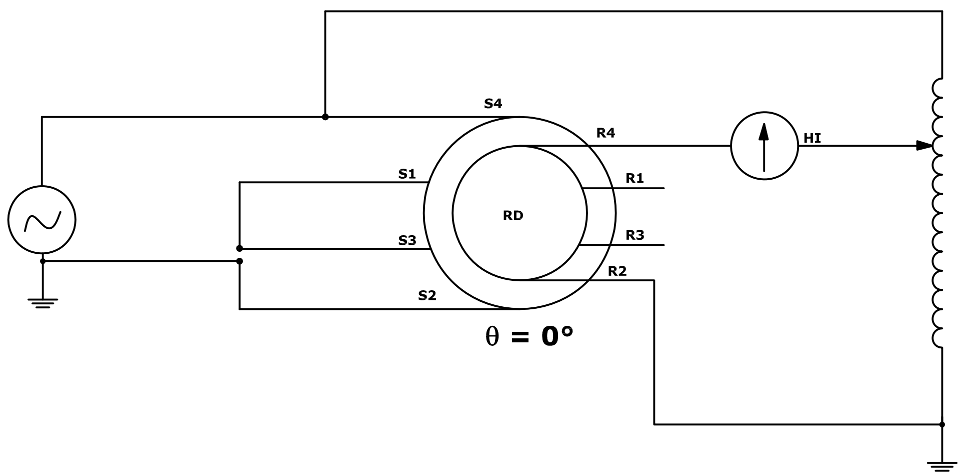
Control Differential Transmitter (RD) Rotor Angular Accuracy Test Circuit (AA)



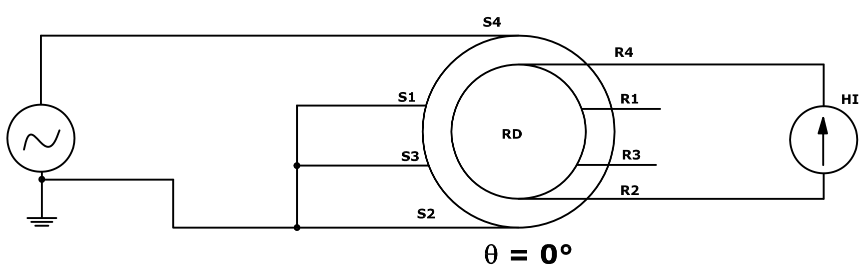
Control Differential Transmitter (RD) Stator and Transformer (RC) Angular Accuracy Test Circuit (AA)



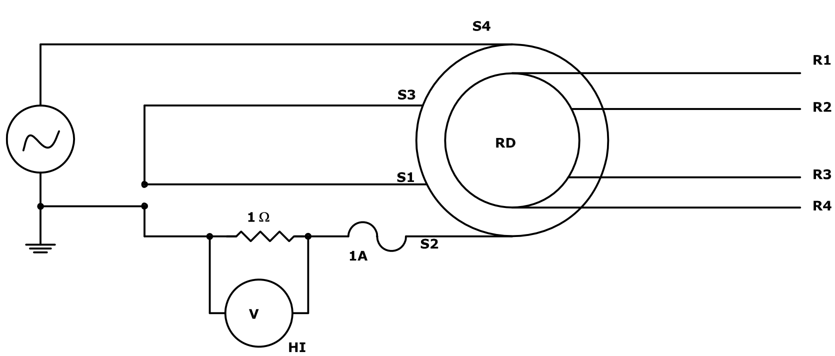
Control Differential Transmitter (RD) and Transformer (RC) Null Test Circuit



Control Differential Transmitter (RD) and Transformer (RC) Transformation Ratio Test Circuit (N)



Control Differential Transmitter (RD) and Transformer (RC) Phase Shift Test Circuit (∅)



Control Differential Transmitter (RD) Transformer (RC) Input Current Test Circuit (Ip)

APPENDIX B

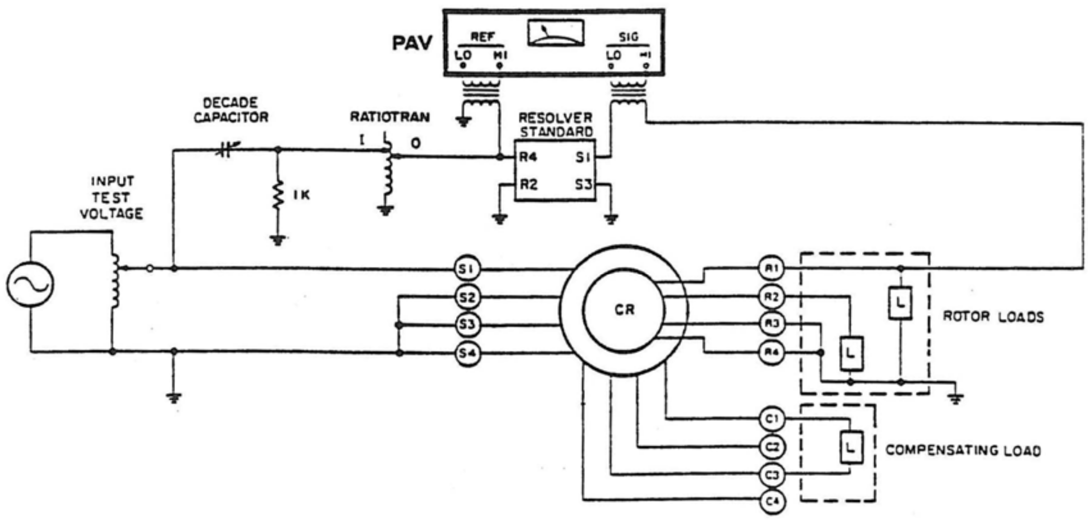
Computational Resolver Tests

Functional Accuracy

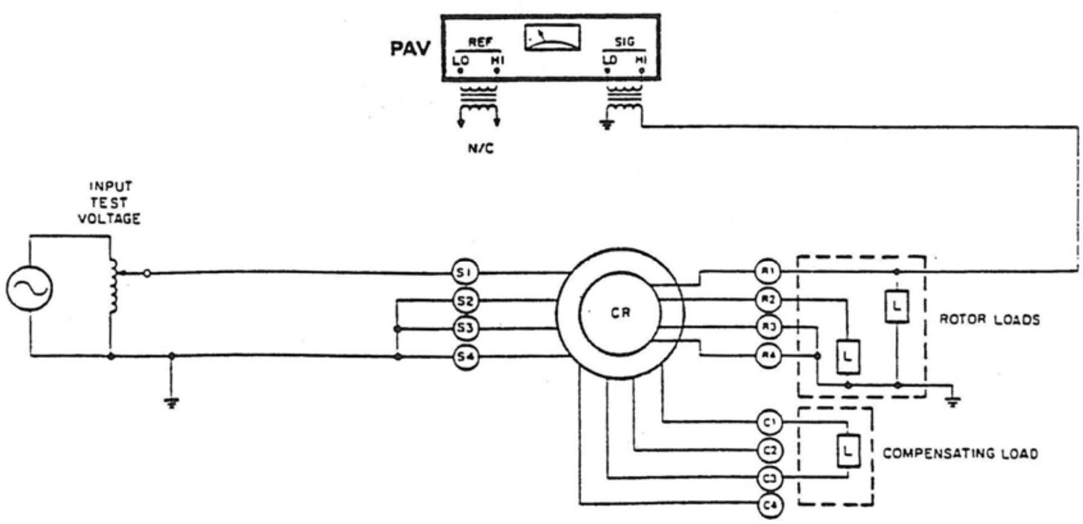
Functional accuracy is a measure of the accuracy with which a computational resolver computes a trigonometric equation. This accuracy is generally expressed as a percentage of the output at the point of maximum coupling. The output of a .1% computational resolver is maximum at 90 degrees for the sine function. The accuracy is therefore .001 times the voltage (E_sMAX) at 90 degrees ($\sin\theta = 90$ degrees).

A dividing head is the precision angular positioning device used to mechanically rotate a unit under test. A resolver standard produces a sin θ reference voltage to measure the computed output of the unit under test. All components may be tested at 5 degree increments throughout the 0 to 360 degree range.

The decade capacitor and the 1K resistor are used to compensate for any phase shift through the unit under test. These components are used to shift the phase of the reference input to the phase angle voltmeter and the resolver standard. The Ratio Tran by the same process compensates for any variation in transformation ratio through the unit under test.



Functional Accuracy Test (S1-S3/R1-R3)



Null Voltage Test (S1-S3/R1-R3)