OPERATING AND MAINTENANCE MANUAL

RESOLVER/SYNCHRO SIMULATOR

MODEL 530

NAI TM 5005

CN 3770

NORTH ATLANTIC *industries, inc.*

60 plant avenue, hauppauge, n.y. 11788 516-582-6500

SECTION 1

GENERAL DESCRIPTION

1.1 GENERAL

This manual contains general description, installation, operating instructions, maintenance and troubleshooting procedures, replacement parts lists, and schematic diagrams for the Resolver-Synchro Simulator, Model 530 (herein after referred to as the Model 530).

1.2 PHYSICAL DESCRIPTION

The Model 530 (fig. 1-1) is a 3-1/2-inch rack mounted unit.

1.3 FUNCTIONAL DESCRIPTION

The Model 530 is a dual-mode resolver-synchro simulator. It generates electrical data of angular shaft position of either three-wire synchros or four-wire resolvers to an accuracy of 2 seconds of arc.*

The unit meets all requirements for use in providing ideal inputs for testing of synchro and resolver receivers, or systems under test or evaluation which operate from synchro or resolver signals. In addition to its dual-mode capabilities, the unit provides switch selected line-to-line voltages of 11.8, 26, 90, or 115 volts, from either 26 V or 115 V input excitation. Consequently, the unit may be used for testing any standard synchros or resolvers, as well as systems utilizing these components. A complete description of its use in testing resolvers and synchros of various types is covered in Section 7.

The Model 530 is designed to provide full accuracy at any frequency from 400 to 800 Hz, and may be used up to 10 kHz with reduced accuracy. Specified accuracy is maintained for all angles over the complete range of readout. Similarly, loading errors which might arise from output impedance unbalance are minimized due to a high degree of impedance match coupled with a low output impedance.

The Model 530 has an in-line display for angular decimal readout, and is continuously switched through 360°.

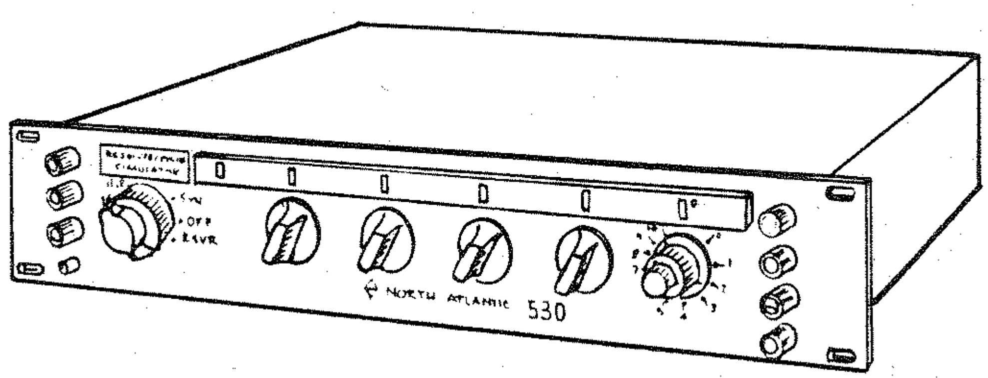

Figure 1-1. Synchro-Resolver Simulator, Model 530

*Accuracy of all North Atlantic Resolver-Synchro Simulators are verified by comparison to Ratio Standards which have records of calibrations traceable to the National Bureau of Standards.

1.4 SPECIFICATIONS

Table 1-1 provides characteristics and specifications for the Model 530.

Table 1-1. Specifications

Item	Specification
Excitation level	
26 volt terminals	0.07 f volt (f in Hz) 35 volts maximum
115 volt terminals	0.32 f volts (f in Hz) 150 volts maximum
Frequency range (within accuracy)	380 to 800 Hz
Frequency range (useful)	60 Hz to 10 kHz
Output voltage (line-to-line)	11.8, 26, 90, and 115 volts
Maximum load	500 mA
Accuracy (resolver and synchro modes)	±2 seconds of arc or ±0.00055°
Resolution	0.0001°
Maximum effective output impedance unbalance	0.05 + 0.03 ohm (max)
Output/input	All models are isolated
Size	3-1/2" panel x 19" W x 15-1/8" D
Weight	30 lbs. (approx.)

SECTION 2

INSTALLATION

The Model 530 is designed for either rack mounting or bench use. The compact 3-1/2" height and standard relay-rack width allows its installation into a large variety of test consoles with a minimum sacrifice of space. The all passive circuits used, generate no heat and, therefore, there need be no space allocated for cooling purposes.

An outline drawing of the Model 530 is illustrated in figure 2-1.

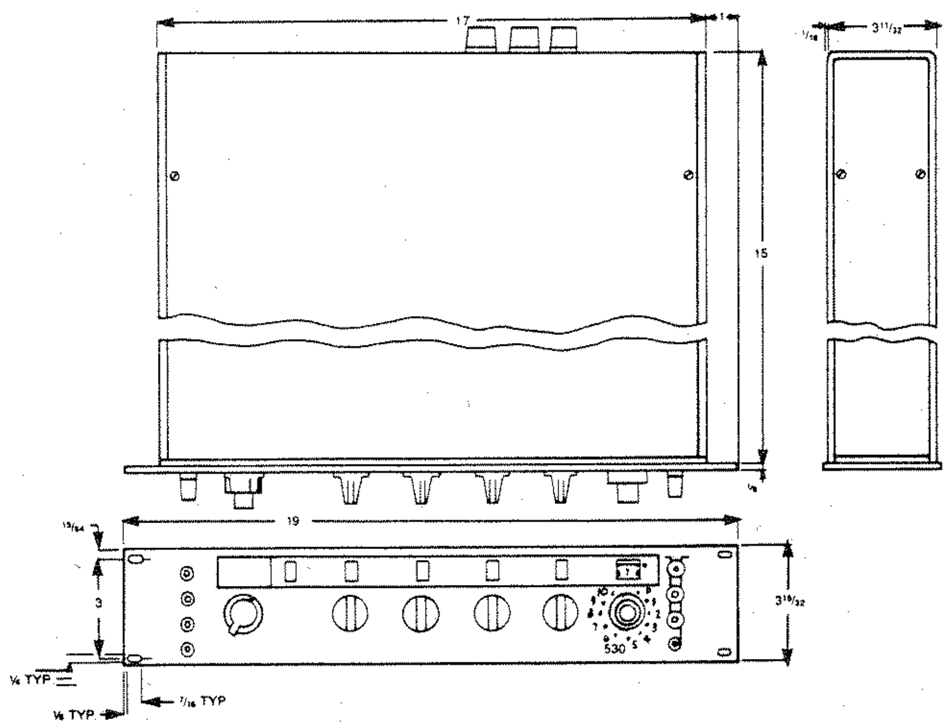

Figure 2-1. Model 530 Outline Drawing

SECTION 3

OPERATION

3.1 GENERAL

This section provides operating instructions for the Model 530.

3.2 CONTROLS AND INDICATORS

The controls and indicators for the Model 530 are described in table 3-1 and illustrated in figure 3-1.

Table 3-1. Controls and Indicators

Control or indicator	Function
115 V, 26 V front and rear terminals	115 or 26 V excitation input applied to either front or rear of unit (high side).
COM	Low side of excitation input applied to front or rear terminal. (CASE should be placed at ground by either rack-mounting connection or a jumper from the COM terminal.)
Mode Selector switch	Selects synchro or resolver mode of operation.
SYN	Selects synchro mode of operation.
RSVR	Selects resolver mode of operation.
OFF	Turns unit on or off.
Line-to-Line Level Selector switch	Selects one of four line-to-line operating levels (11.8, 26, 90, 115 V) regardless of mode of operation. These levels are obtained with either 26 or 115 V excitation (applied to the terminals).
Angle Select controls and In-line Decimal Readout	The electrical angular setting of the Model 530 is adjusted by means of the Angle Selector controls. The angle is read directly above these controls. The first switch controls the most significant digit and advances the angle in 10° steps. This control is continuous (no stops) enabling the user to go directly from 350° to 0°. The second control controls the units of degrees from 0° to 9°. The third and fourth switches control tenths and hundredths of degrees, respectively. The fifth control consists of two concentric switches; the inner for increments of 0.001° with its readout in the window above the switch and an outer knob for increments of 0.0001° with its indicated setting screened on the panel.

Table 3-1. Controls and Indicators (Continued)

Control or indicator	Function
SYN and RSVR terminals (front and rear panel)	Three-wire synchro and four-wire resolver data available (front and rear panel) when Mode Selector switch is in SYN and RSVR position, respectively. By utilizing the rear panel terminals, the unit can be alternately switched from resolver to synchro operation without changing terminal connections.
1 and 5 A Slow Blow fuses	The unit is protected by a 1 A and a 5 A fuse which are in-series with the 115 V and 26 V excitation lines, respectively. These fuses are located on the rear panel.

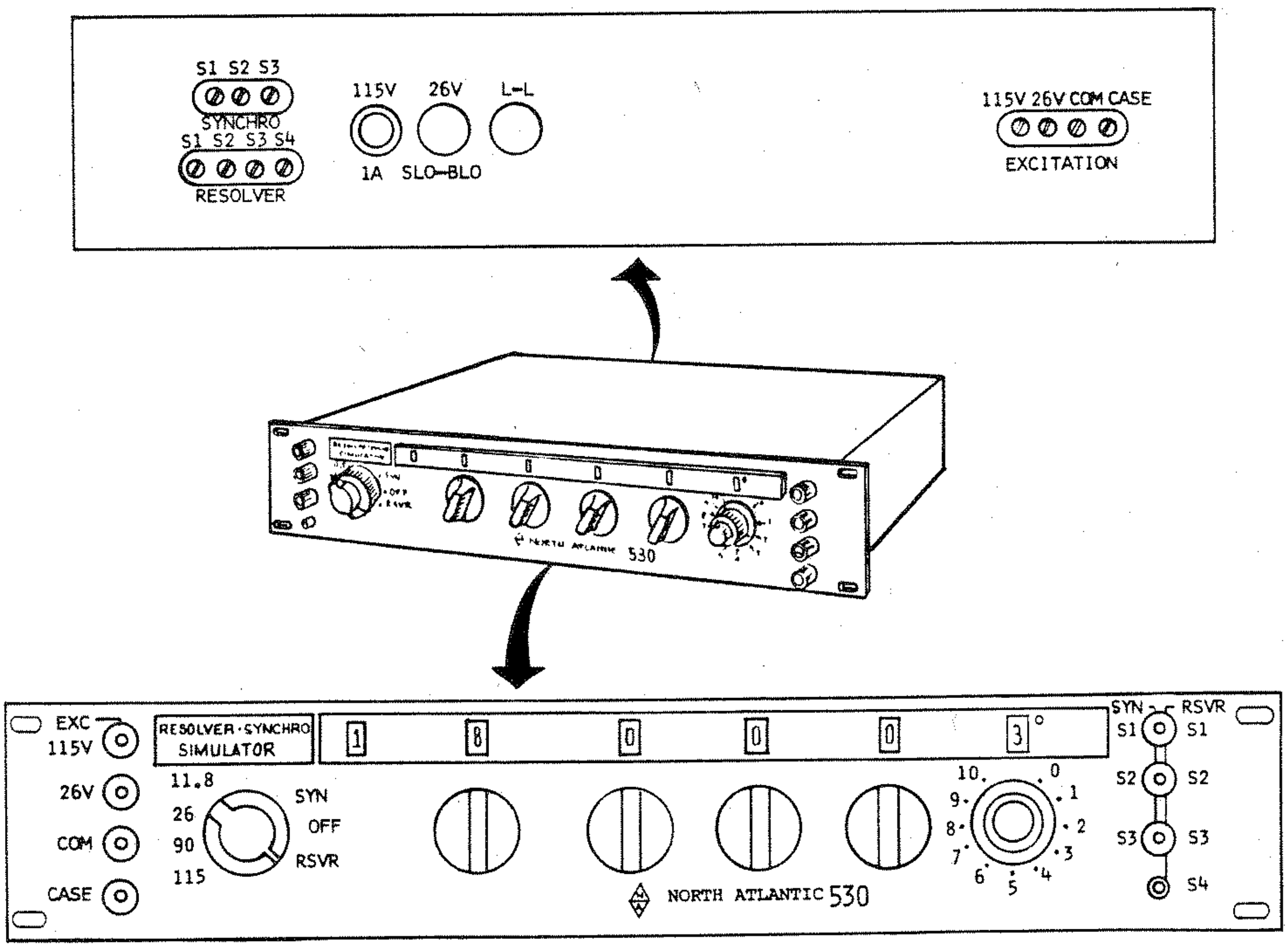

Figure 3-1. Controls and Indicators

3.3 APPLICATIONS

There are many methods in which the Model 530 can be used as a test instrument for evaluation, calibration, and alignment of resolver and synchro components, as well as systems employing these components. The following examples are meant to serve as a guide only. Many other applications in such areas as control circuit, phase shifters, etc., will no doubt occur to the user once familiar with the instrument's capability.

3.3.1 Finding the Unknown Data Angle of a Receiver Type Component Using a Full Resolution Simulator

a. With a hookup similar to that shown in figure 3-2, adjust the Model 530 Angle Select knobs to produce an approximately in-phase null on the phase angle voltmeter. The null meter phase shifter should be set at 0°.

b. Since the resolver or synchro receiver under test will have two positions which yield an in-phase null, it is necessary to remove this ambiguity as follows:

(1) While in the region of an approximate null, increase the angle setting of the Model 530. This will produce a more positive deflection on the phase angle voltmeter, if the correct angle has been found and if conventions are in accordance with Section 4 of this manual. If the reading is negative, increase the setting of the Model 530 by 180° and verify that the correct gradient polarity now occurs.

(2) Proceed with the nulling process by using the highest increment knobs first and continuing to the least significant knob. It will be necessary to down-scale the

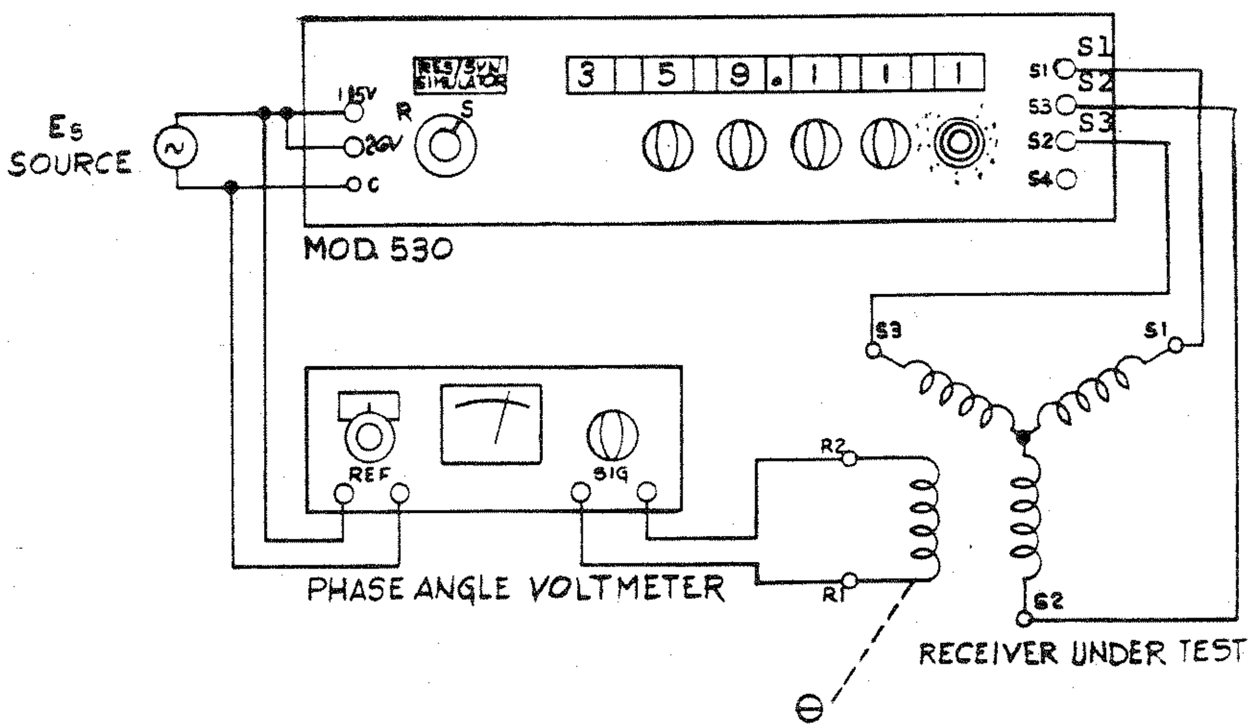

Figure 3-2. Typical Test Hook-up for Testing a Synchro Circuit

Phase Angle Voltmeter while these adjustments are being made in order to obtain maximum sensitivity.

(3) In the above measurement, it was indicated that the phase shifter of the null meter was set at 0° so as to produce a null in-phase with the line excitation. This method is consistent with the procedures of MIL-S-20708A.

c. An alternate null detector phase setting is sometimes used when the source of the null detector reference has an arbitrary phase relation to the synchros resolver excitation or where the component usage requires phasing in relation to the actual output signals. This procedure which is required by definition in MIL-R-21530C Resolvers, is as follows:

(1) With a (0° phase) null achieved as above, switch the Simulator to maximum output (90° + reading). Up range the null meter and observe the quadrature component at as large a meter deflection as possible. Now, offset the Model 530 by a large angle, but not enough to light the meter OVERLOAD lamp and observe that the quadrature reading changes slightly. The phase dial is now repositioned so as to restore the original quadrature reading. This, in effect, aligns the system to make measurements in-phase with the output. Since the actual setting would vary somewhat with mechanical position of the component under test, this procedure is usually done at zero mechanical degrees of electrical zero.

3.3.2 Adjusting a Receiver or System to a Predetermined Angle

a. With the Simulator connected to provide an input to the receiver under test, set the Angle Selector knobs so as to adjust the Model 530 to the desired angle. Then adjust the receiving resolver or synchro to obtain a null on the output of the receiver as evidenced either by an external phase angle Voltmeter (fig. 3-2) or by some pre-established output of the system being aligned. For example, if a servo such as a North Atlantic API-8025 were being tested, the counter readout would be used to indicate the null position of the receiver shaft.

b. At this point, increasing the Model 530 angle will cause a positive change in resolver or synchro data and in the case of a system under test will cause the system output to increase providing the system or components are wired in accordance with the conventions of Section 4. If an opposite deflection occurs, the receiver being aligned is 180° in error and should be repositioned by this amount.

c. Note that in systems incorporating resolvers and synchros, the conventions of Section 4 are frequently altered to provide fixed offset angles or to reverse direction of rotation. The user must, therefore, verify the nature of the system's performance requirements before interpreting the results of the foregoing test.

3.3.3 Using the Phase Angle Voltmeter for Measuring Receiver Angular Error

This method is frequently used in testing synchro or resolver receivers where the inputs are in the form of discreet shaft angle increments. Typically, a component under test would be mounted in a device such as a dividing head. The Model 530 and dividing head would be set to 0° and the component positioned to 0° angle in the manner described in the previous paragraphs or by the electrical zero method of the applicable military specifications. Both the Model 530 and the dividing head are then advanced in the desired increments. The amplitude of the null voltage as measured on the output of the receiving component is related to the error angle as follows:

$$E_{out} = K \sin(\theta - \phi)$$

$$\cong K(\theta - \phi), \text{ where}$$

K is gradient of device under test

$(\theta - \phi)$ is error angle of component

Since this relationship holds for small deviations at all angular settings whether the component is a resolver or a synchro, the null meter can easily be used to read a voltage which is proportioned to degrees, minutes, or seconds of arc.

As a matter of added convenience, a phase angle voltmeter, having a variable range attenuator, will permit the user to scale the null meter sensitivity such that the error angle can be read directly in degrees, minutes, or seconds from the meter itself.

SECTION 4

CONVENTIONS

4.1 GENERAL

Conventions for polarities, terminal designation, and direction of shaft rotation for synchros and resolvers are most frequency defined in accordance with military specifications MIL-S-20708A (synchros) and MIL-R-21530 (resolvers).

North Atlantic bridges and simulators all have terminal designations and electrical characteristics consistent with these same specifications. Thus, a bridge is used as though it were a receiving component such as a control transformer (CT or RC). Likewise, a simulator is comparable to a transmitting component (CX or RX).

In applying the conventions, caution must be exercized that:

- The manufacturer of the synchro or resolver followed the MIL SPEC conventions.
- System use of the component has not dictated a change in convention in order to achieve a difference in characteristic, such as direction reversal or mechanical shaft offset.

4.2 SYNCHRO TRANSMITTER CONVENTIONS

4.2.1 Synchro Transmitter (CX)

The equations describing an ideal Synchro Transmitter (CX) apply as well to the Model 530. They are:

$$E_{(S1-S3)} = NE_{(R2-R1)} \sin \theta$$

$$E_{(S3-S2)} = NE_{(R2-R1)} \sin (\theta + 120°)$$

$$E_{(S2-S1)} = NE_{(R2-R1)} \sin (\theta + 240°)$$

Where: $E_{(R2-R1)}$ is the voltage between rotor leads R1 and R2.

$E_{(S3-2)}$ is the voltage between stator leads S1 and S2. Other voltages are similarly defined.

N is the ratio of the maximum rms voltage between the secondary terminals (stator) and the primary rotor voltage.

θ is the shaft angle displacement from electrical zero which satisfies these equations.

The schematic representation for a Synchro Transmitter (CX) is shown in figure 4-1.

NOTE

Synchro is shown at $\theta = E_Z$ (electrical zero). This is defined as that angle for which coupled voltage between the rotor and $E_{(S1-S3)}$ is a minimum.

4.2.2 Synchro Simulator

The input and output terminals of the Model 530 in the synchro mode correspond to figure 4-1 and are indicated in figure 4-2.

4.3 SYNCHRO RECEIVER CONVENTIONS

4.3.1 Synchro Receiver (CT)

The equations describing an ideal synchro receiver or control transformer (CT) apply as well to all Series 540 Bridges. They are:

$$E_{(R2-R1)} = N[E_{(S3-2)} \sin\theta - E_{(S1-S3)} \sin(\theta+120)]$$

$$\theta = E_{(S1-S3)} + E_{(S3-S2)} + E_{(S2-S1)}$$

Where, symbols have meaning defined in paragraph 4.2.1.

The schematic representation for a synchro-receiver (CT) is shown in figure 4-3.

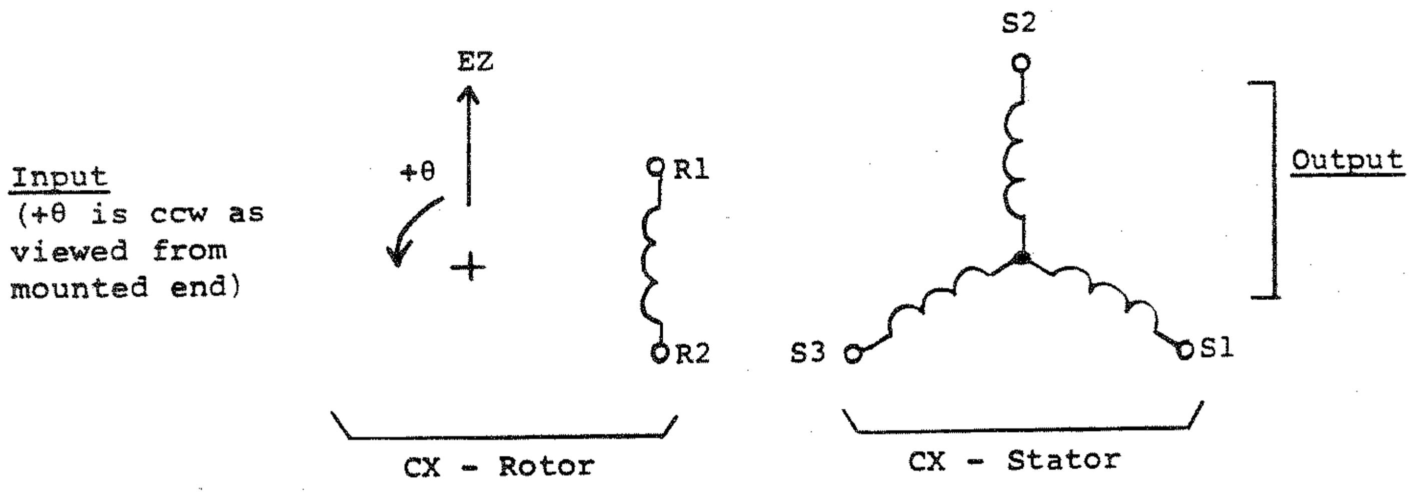

Figure 4-1. Synchro Transmitter (at EZ) - CX

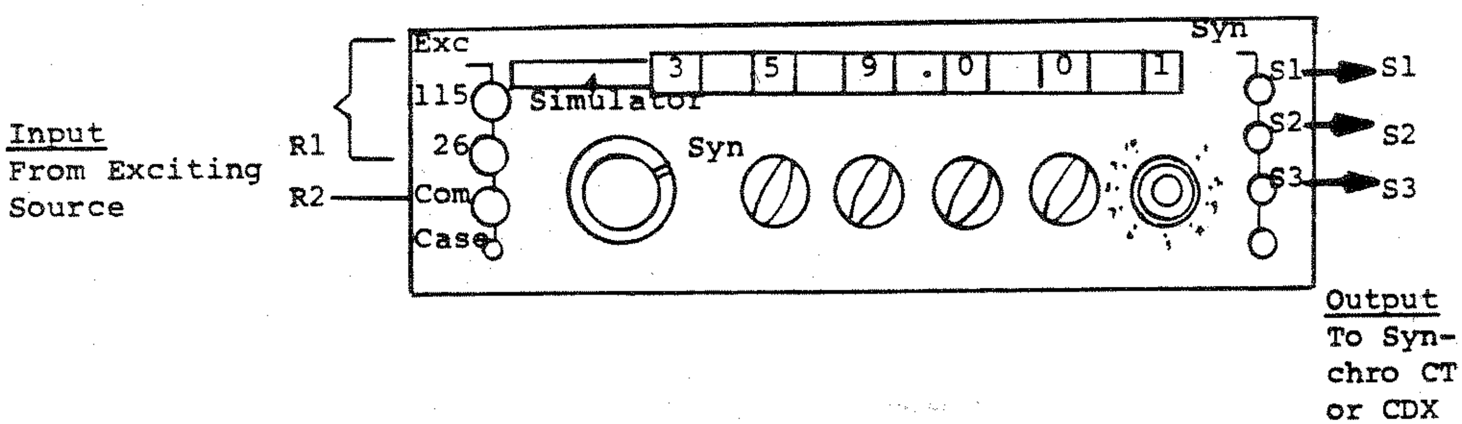

Figure 4-2. Model 530 - Synchro Mode

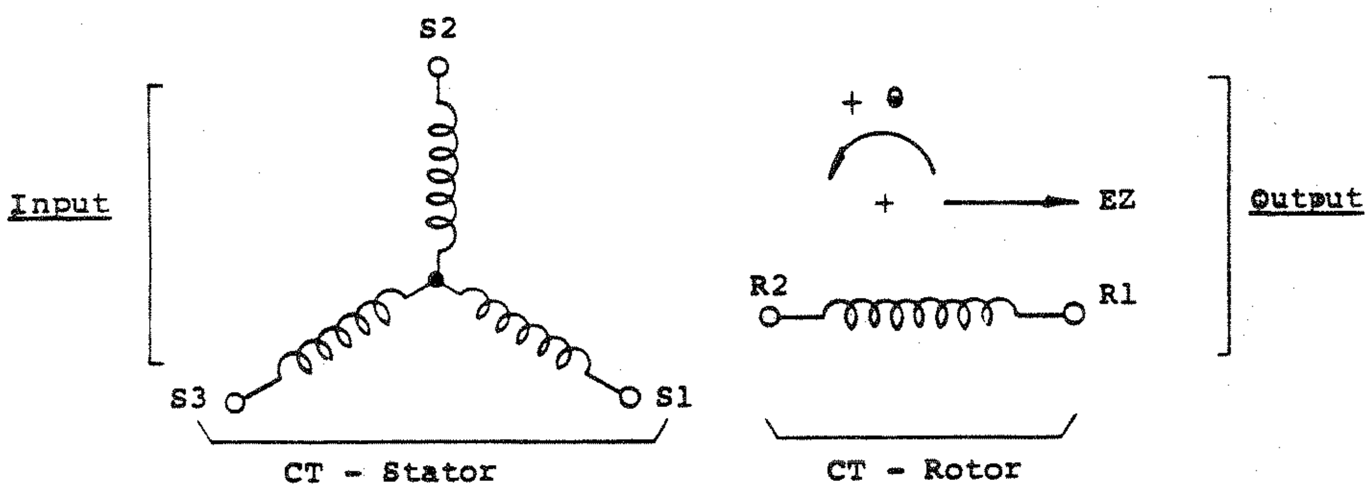

Figure 4-3. Synchro Receiver (at EZ) - CT

NOTE

Synchro is shown at $\theta = \theta_Z$ (electrical zero). This is defined as that angle for which the coupled voltage to the rotor is a minimum when the stators are excited between S2-S1, S3.

4.3.2 Synchro Bridge

The input and output terminals of a North Atlantic Series 540 Bridge in the synchro mode are analogous to those of a synchro receiver (CT). The connections which correspond to figure 4-3 are shown in figure 4-4.

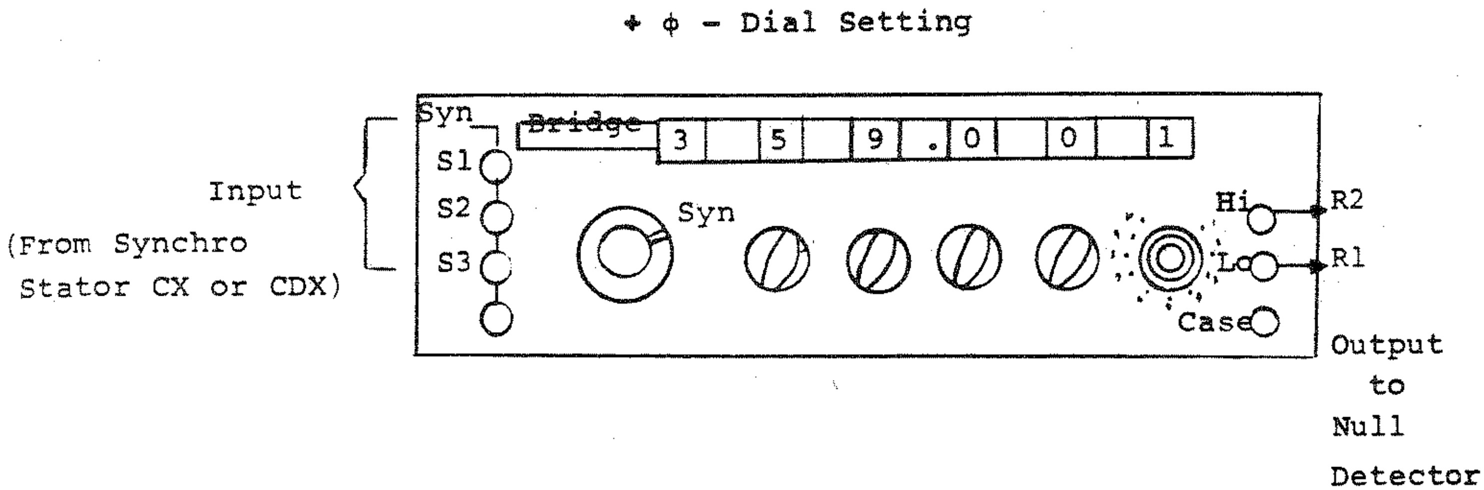

Figure 4-4. Model 540 Bridge - Synchro Mode

4.4 RESOLVER CONVENTIONS

4.4.1 Resolver Transmitter (RX), Control Transformer (RC), and Differential Resolver (RD)

The equation describing an ideal resolver apply as well to all Series 540 Bridges and 530 Simulators. They are:

For Rotor Energized Resolvers:

$$E_{(S1-S3)} = NE_{(R1-R3)} \cos\theta - NE_{(R2-R4)} \sin\theta$$

$$E_{(S2-S4)} = NE_{(R2-R4)} \cos\theta + NE_{(R1-R3)} \sin\theta$$

For Stator Energized Resolvers:

$$E_{(R1-R3)} = NE_{(S1-S3)} \cos\theta + NE_{(S2-S4)} \sin\theta$$

$$E_{(R2-R4)} = NE_{(S2-S4)} \cos\theta - NE_{(S1-S3)} \sin\theta$$

Where, symbols have meaning defined in paragraph 4.2.1.

The schematic representation for a Resolver Transmitter (RX), Resolver Control Transformer (RC), or a Differential Resolver (RD) with the rotor excited is shown in figure 4-5. Input and output can be reversed for stator excited schematic.

NOTE

Resolver is shown at θ = EZ (electrical zero). This is defined as a minimum coupling from (R1-R3) to (S2-S4) for rotor excited case. For stator excited resolver EZ is defined for minimum coupling from (S1-S3) to (R2-R4).

4.4.2 Resolver Simulator

The input and output terminals of the Model 530 simulator in the resolver mode is analogous to that of a rotor excited Resolver Transmitter (RX). The connections which correspond to those shown in figure 4-5 are illustrated in figure 4-6 for a Model 530 Simulator in the resolver mode.

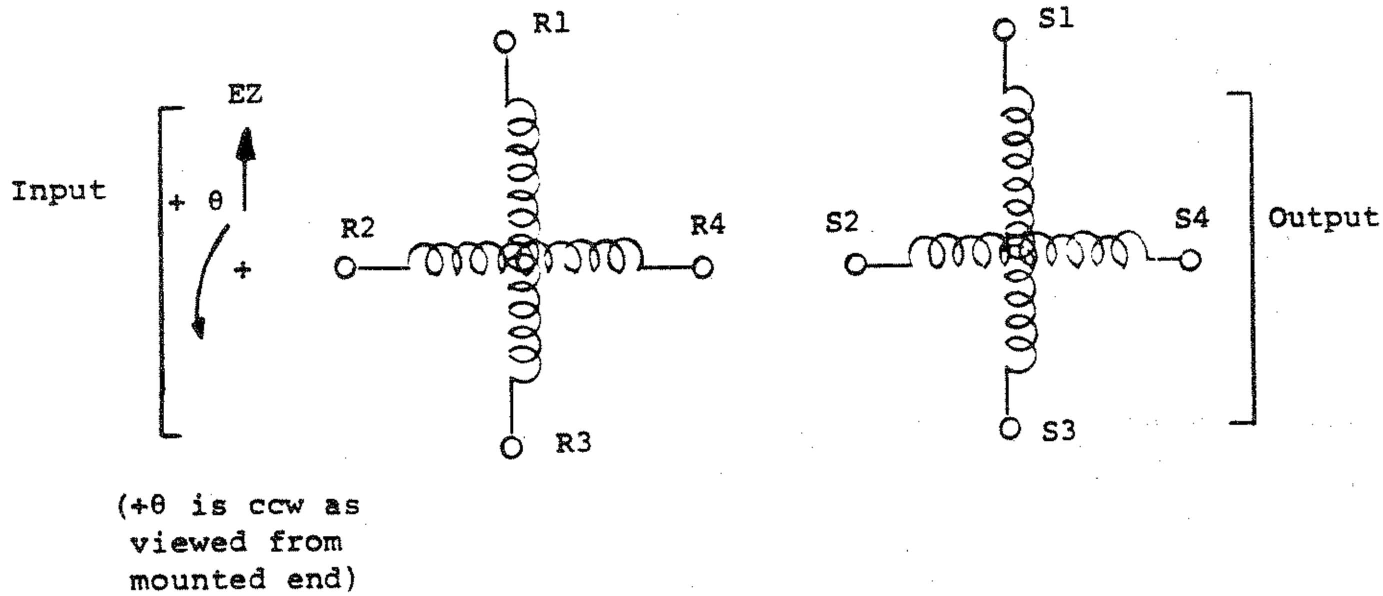

Figure 4-5. Rotor Excited Resolver at EZ, RX, RC, or RD

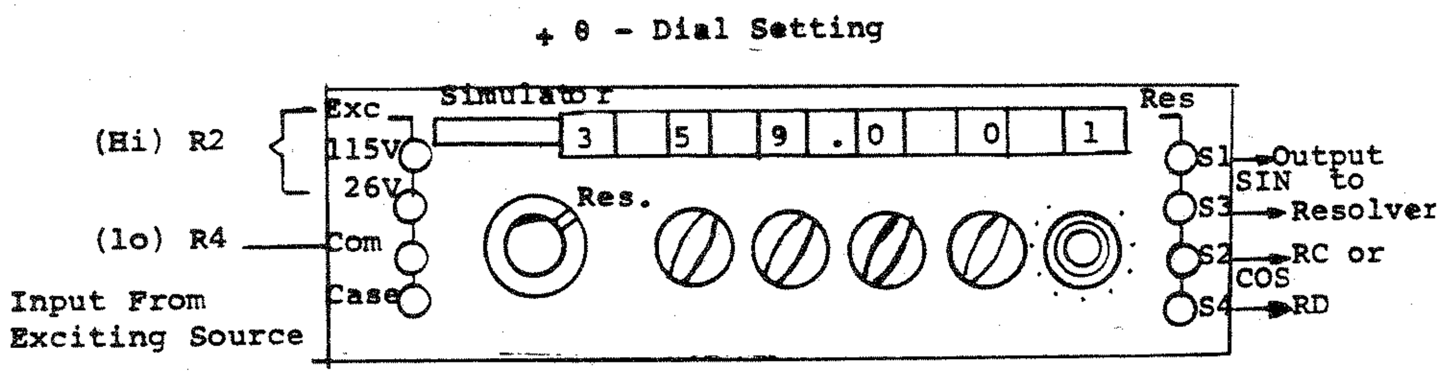

Figure 4-6. Model 530 Simulator - Resolver Mode

Alternate Resolver Simulator conventions (all assume CCW is positive rotation) are shown in figure 4-7.

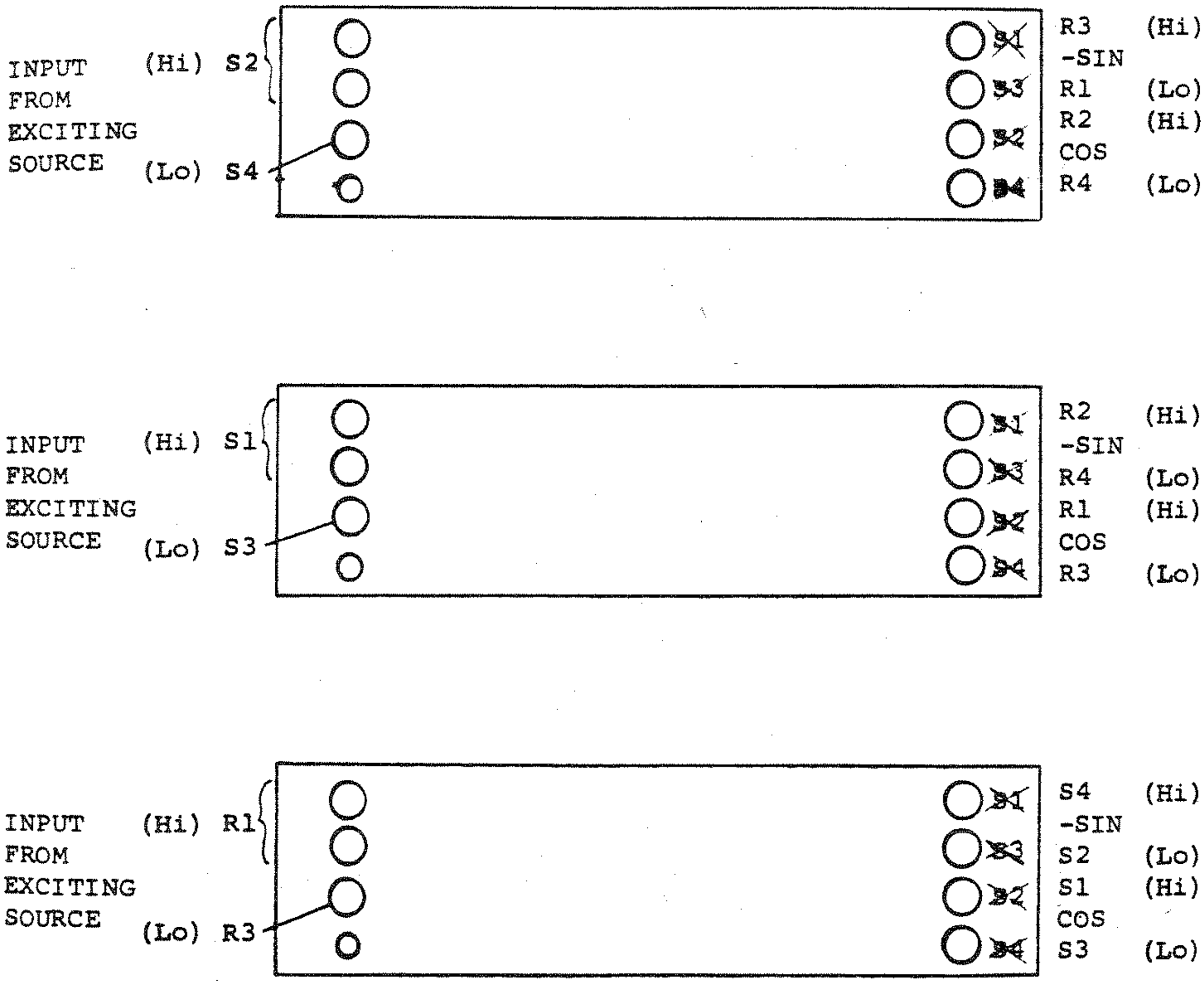

Figure 4-7. Model 530 Simulator - Resolver Mode (Alternate Convention)

4.5 RESOLVER BRIDGE

The input and output terminals of the North Atlantic Series 540 Resolver Bridge in the resolver mode are analogous to those of a stator excited resolver Control Transformer (RC). The connections which correspond to those shown in figure 4-5 are illustrated for a Model 540 Bridge in figure 4-8.

Alternate Resolver Bridge conventions (all assume CCW is positive rotation) is illustrated in figure 4-9.

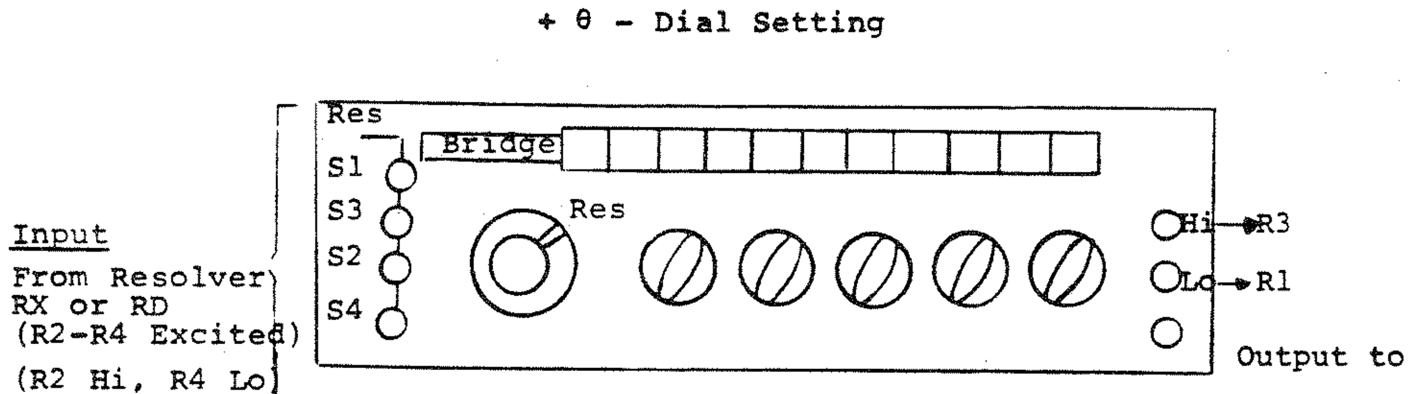

Figure 4-8. Model 540 Bridge - Resolver Mode

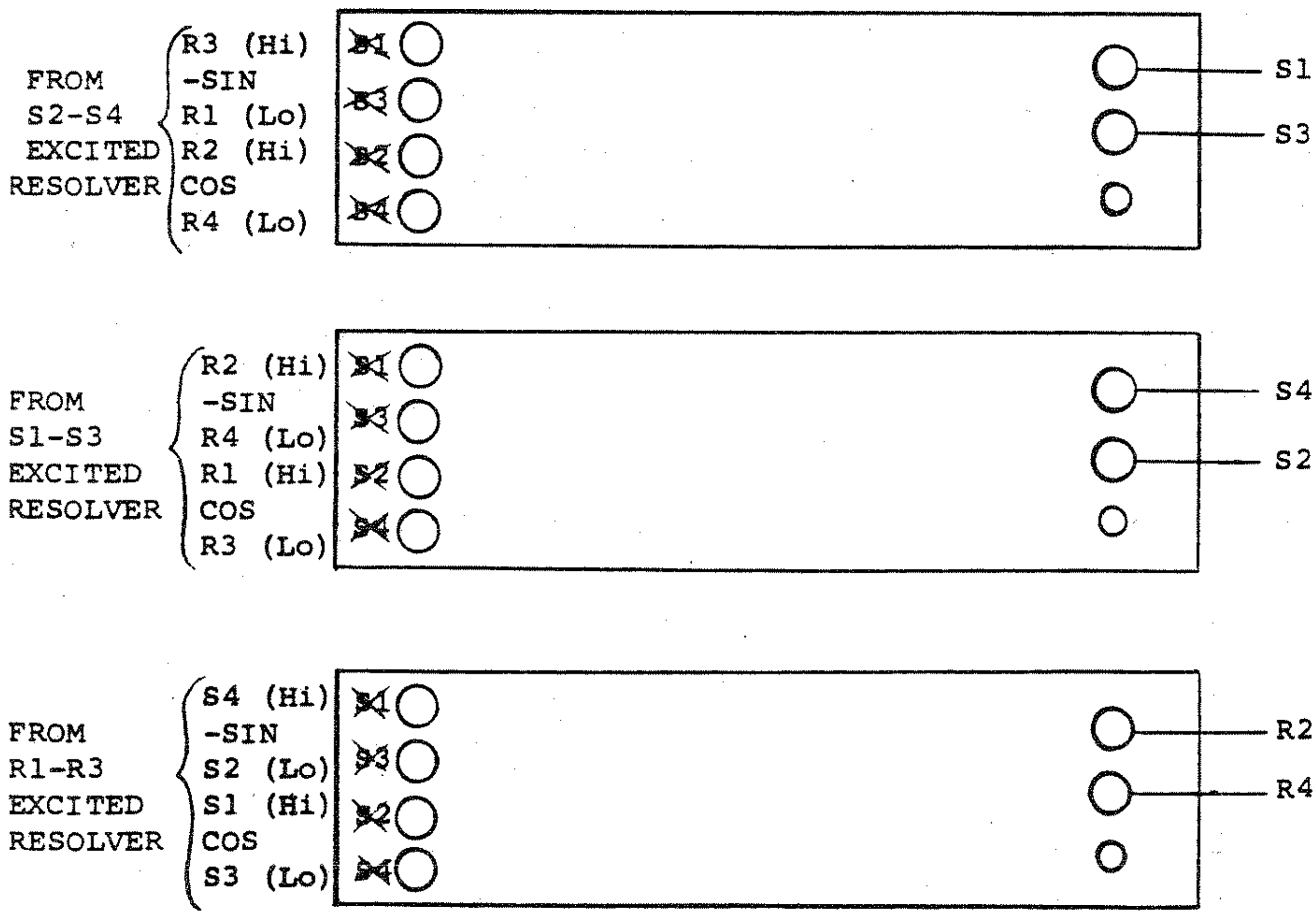

Figure 4-9. Model 540 Bridge - Resolver Mode (Alternate Convention)