I/D QUAD CONVERTER BOARDS
TYPES 220100 and 220300
INSTALLATION

Engineering Report 19802

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CONTENTS

REFERENCES

ER19801 Engineering Report Description and Specifications I/D Quad Converter Boards 220100 & 220300

Note: ER19801 includes the following drawings:

220100-I & 220300-I Information Drawings for the 220100 & 220300 I/D Quad Converter Boards
219400-I & 219215-I Info Drawing for Connector Boards type 220400 & 219415
220415 & 219216 Hook-up drawings for Connector Boards type 220400 & 219415
218891-I, 219200-I & 219594-I Info Drawings for suitable Preamplifiers
218000 Wiring Techniques and Materials

1. INTRODUCTION

This report describes how to install the 220100 and 220300 I/D Quad Converter Boards. It should be used in conjunction with Engineering Report ER19801 which contains technical specifications and associated drawings.

The 220300 differs from the 220100 in that it provides loss of signal detection and automatic gain and phase adjustment. In all other respects the two assemblies are identical. The following text, therefore, applies equally to both boards unless otherwise indicated.

2. INSTALLATION

STATIC SENSITIVE
The integrated circuits on the board are static sensitive. Whenever the board is not plugged into its socket it should be protected by a static dissipating bag such as the one it was shipped in, or be handled at a static protected work station. Boards returned to the factory must be repackaged using anti-static material or any applicable warrantee will be voided.

2.1. Installation of Inductosyn® Data Element

For transducer installation information, consult the installation drawing for your unit and the appropriate Farrand report. Stated accuracies will not be obtained unless the Inductosyn® data element is installed with the correct mechanical tolerances. The transducer air gap should be set to the proper value.

2.2 Mechanical Installation of I/D Quad Board

Farrand Connector Boards are available with labeled screw terminals for easy hook up of signal and power connections. Drawings 220400-I and 219215-I show the options that are available. The 220400 Connector Board must be used if screw terminal connections are required for the "loss of signal" output provided with the 220300 Converter Board or for a velocity output signal, otherwise the 219215 Connector Board may be used.

Alternatively, the board can be installed in a card cage or mounted to a plate using the two mounting holes provided. If the two mounting holes are used, care must be taken that the mounting hardware does not short to the board's printed circuit pattern.

For direct connection via a card edge connector, pin-out information is given later in this report.

Note: If the 220400 Connector Board is used a 220100 system can be easily upgraded later to add loss of signal detection and automatic gain and phase adjustment by replacing its 220100 Converter Board with a 220300 model.

2.3 Electrical Hook up

2.3.1 Wiring Information

The following supporting documentation is included with Engineering Report ER18901:

- Drawing 218000 "Wiring Techniques and Materials". To insure full accuracy, wiring must meet these requirements and the appropriate hookup drawing should be followed exactly.
- Hook-up Drawing 220415 for the 220400 Connector Board
- Hook-up Drawing 219216 for the 219215 Connector Board

2.3.2 Load Resistance.

To prevent damage to the I/D Quad Converter the resistance driven by the excitation signal when no transformer is used must be at least 15 ohms. If the scale or rotor resistance is less than this value, a two watt resistor should be connected between terminals OUT and HI on the 220400 or 219215 Connector Board in place of the jumper shown on drawings 219216 and 220415. This is not necessary when using the matching transformer (terminals T4, T5, T6, & T7) or when using a rotary transducer with integral rotary transformer. The drive capability of the excitation amplifier is also dependent on ambient temperature and air flow over the power amplifiers's heat sink . For further details refer to Engineering Report ER19801.

2.3.3 Power Supply Reversal

Mis-wiring of the power supplies to the board will almost certainly result in damage. It is very important that the power supply voltages are checked before the Converter Board is installed. Also, power should be turned off during board installation.

2. INSTALLATION (continued)

2.4 Preamplifier Options

Some Inductosyn® spars and cassette assemblies are supplied with the proper preamplifier and may include an internally mounted series resistor or matching transformer in the excitation supply. For all other installations one of the preamplifiers 218891, 219200 or 219594 should be used. Farrand drawings 218891-I, 219200-I and 219594-I (included with ER18901) should be consulted for details of these preamplifiers. Each preamplifier is supplied in several gain settings; consult the factory for the proper model. For best results, power for the preamplifier should be taken from the terminals provided for that purpose on the Connector Board or the Converter Board's edge connector.

2.5 Cable Lengths

The Preamplifier Assembly should be mounted as close to the transducer as possible. The Converter Board may be up to 400 feet from the preamplifier. Please refer to Engineering Report ER19801 for further information on cable lengths.

2.6 Master/Slave Operation

Some applications may involve a rotary transducer with two independent sets of rotor and stator patterns or a linear transducer where two or more sliders are installed on a common scale. For these applications separate preamplifiers are used and the Converter Boards can be set up in a "Master/Slave" configuration with one Converter supplying the excitation to the transducer and feeding a reference signal to the other Converter(s). For hook-up information consult the factory.

3. EXCITATION LEVEL AND PHASE ADJUSTMENT

3.1 Outline

Correct operation requires the following conditions:

a. Balanced (equal) sine and cosine peak input voltages of 2.0 volts rms (5.7 peak to peak) ±10%. This level is set by adjusting the excitation voltage to the transducer.

b. Correct phasing of the reference signal to the converter.

For the **220300** Converter Board the signal amplitude and reference phase adjustments are controlled automatically and it is only necessary to check that the circuit is functioning correctly and the excitation voltage setting is within specification.

For the **220100** Converter Board the signal amplitude and reference phasing are adjusted on-site using on-board potentiometers.

3.2 Excitation Power Limits

For both the 220100 and 220300 Converter Boards it is important to make sure that:

a. The output is matched correctly to the load using, if necessary, the on board transformer or a series resistor.

b. The maximum excitation power ratings listed in Engineering Report ER19801 are not exceeded.

Notes:
(i) For transformer options see drawing 220415 or 219216.

(ii) When the load resistance is below 33 ohms and the transformer is not used, the excitation level should not be adjusted to deliver more than the 210 ma rms maximum rating. However, output currents of up to 500 mA are possible with forced air cooling and ±15 V supplies power supplies rated at 500 mA. The maximum recommended operating temperature on the case of the power amplifier is 85EC (185 EF).

(iii) If the excitation drive level is too high, a preamplifier with higher gain may be required.

3.3 Excitation Level Adjustment

For both the 220100 and 220300 boards it is important that the maximum sine and cosine signals should be 2.0 V rms (5.7 volts peak to peak) ±5 % and undistorted. If the Sine or Cosine waveforms displayed on the oscilloscope are distorted, or if the voltage level stated above cannot be obtained, it is probably due to a mismatch between the transducer input impedance and the excitation power amplifier on the Converter Board. Drawings 220415 and 219216 show the three excitation hookup possibilities. The first is direct output from the driver and the other two use the step-down transformer on the board for matching the load impedance. In difficult installations it may be necessary to try all three to determine which hookup meets the voltage requirement without distortion.

3.3.1 220300 Excitation Level Check

Please skip this section if you are installing a 220100 Board and proceed to section 3.3.2

Since the 220300 Board automatically adjusts the excitation level to maintain the correct 2.0 V rms input level , it is only necessary to check that the circuit is functioning correctly.

a. Check that the maximum Cosine input at test point "TPC", as the transducer moves, is an undistorted 2.0 V rms ±5 %.

b. Check that the excitation power level specified in section 3.2 is not exceeded.

3. EXCITATION LEVEL AND PHASE ADJUSTMENT (continued)

3.3.1 220300 Excitation Level Check (continued)

c. Check that the excitation voltage is within its automatic control range and safely below the level where a spurious loss of signal “FAIL” output might be generated. The excitation voltage control range, driving directly without transformer, is from 0 V rms up to the maximum output of the Converter Board of 7 V rms (20 V p-p). Therefore, a maximum excitation voltage of 5.7 V rms (17 V p-p) is recommended.

Notes:

(i) The “warning” indicator on the board lights when the excitation voltage reaches the maximum control value. The loss of signal ”FAIL” output is not generated until the input to the board falls to around 10% below its nominal 2.0 V rms value.

(ii) The excitation voltage can be reduced by using a smaller air gap, higher gain preamplifier or matching the excitation power amplifier more efficiently into its load.

3.3.2 220100 Excitation Level Adjustment

Please skip this section if you are installing a 220300 board and refer to section 3.3.1.

a. Adjust the “DRIVE” potentiometer on the Converter Board. so that the maximum cosine input at test point "TPC", as the transducer moves, is an undistorted 2.0 V rms ± 5 %.
Note: Counterclockwise rotation increases the drive level.

b. Check that the excitation power level specified in section 3.2 is not exceeded.

3.4 <u>Phase Adjustment</u>

The phase of the reference signal to the converter must be adjusted to match the phase shift of the particular transducer. Inductosyn® transducers have input to output phase shifts in the range of 0° to 90° leading. Since the phase of the sine and cosine signals switches by 180° at some points of the cycle, the system is in phase when the signal at the phase test point "TPREF" is either in phase or 180° out of phase with sine and cosine.

For the 220100 board this adjustment is made using the “PHASE” potentiometer on the Converter Board. For the 220300 the adjustment is automatic.

3.4.1 220300 System Phase Check

Please skip this section if you are installing a 220100 board and refer to section 3.4.2.

The automatic phase adjustment can be verified by using a two channel oscilloscope to compare the signals at the phase test point "TPREF" and at either the sine test point "TPS" or the cosine test point "TPC" on the Converter Board. These signals should be either in phase or 180º out of phase

3.4.2 220100 System Phase Adjustment

Please skip this section if you are installing a 220300 board and refer to section 3.4.1.

Procedure:

a. Using a dual channel oscilloscope, connect one input to the COSINE test point "TPC" on the Converter Board.
(or the COS output of the preamplifier assembly).

b. Connect the other input to the phase test point "TPREF".

c. Display both oscilloscope inputs together using the "chopped" mode.

d. Position the transducer so that the COSINE signal is near its maximum amplitude.

e. Synchronize the oscilloscope to the COSINE signal.

f. Adjust the "PHASE" potentiometer until the two signals are either in phase or 180º out of phase.

g. The system is now properly phased.

4. SINE/COSINE GAIN BALANCE ADJUSTMENT

4.1 Outline

To achieve the expected system accuracy, the total gain of the sine channel must be closely matched to the gain of the cosine channel. The gain balance adjustment on the preamplifier compensates for differences in the resistance of the transducer's sine and cosine patterns and cabling, as well as for the characteristics of the particular preamplifier. Any difference in gain directly affects the position error within the transducer cycle. The type of error produced is shown in figure 1.

A number of methods can be used to set the preamplifier gain balance:

C Factory balance - see section 4.2 below.

C Field balance by accuracy measurement - recommended if suitable accuracy measurement is available and described in section 4.3 below.

C Field balance without accuracy measurement - the system is positioned to a precise 315E point by temporarily rewiring the hookup to the sine and cosine windings and moving to a position where the output is a null. The preamplifier's balance potentiometer is then adjusted for the correct reading. This method is described in section 4.4 below.

C Indirect balance method. - the preamplifier is balanced by itself and the slider, or stator, sine and cosine resistances are balanced using a Wheatstone bridge with series resistance added as necessary to balance the bridge. This method is used at the factory to balance Inductosyn® Spars and is described in section 4.5 below.

4.2 Gain Balance Method 1: Factory balance

Spar systems and cassettes which have internal preamplifiers are balanced at the factory and need no further adjustment.

4.3 Gain Balance Method 2: Field Balance by Accuracy Measurement

In this method the actual error of the measurement total system including the transducer, preamplifier, Converter Board and wiring is measured over one transducer cycle by comparison with an accuracy standard. For a linear system this standard can be a laser interferometer, step gage, or gage blocks; for a rotary system it can be a tangent arm or autocollimator with angle gage blocks. This is the preferred method whenever the necessary measurement equipment is available. The balance potentiometer on the preamplifier is adjusted, if necessary, to give the minimum error and the measurements are repeated to verify that the balance in now properly set.

a. Set up the accuracy measuring equipment.

b. Make an initial balance adjustment using a digital voltmeter. Measure the peak voltage of the cosine output and adjust the potentiometer to bring the sine output to the same peak value. Note: Preamplifiers are usually balanced before shipment so this adjustment may not be necessary.

c. Position the Inductosyn® transducer so that the MARKER indicator on the Converter Board is lit. This occurs at one of the two points in the transducer cycle where the signal at the SINE test point "TPS" (or the SIN output of the preamplifier) is zero. This is the starting point for the following error measurements.

d. Starting at this point, make eight moves, each equal to 1/8 of a transducer cycle, as measured by either the converter or the accuracy measuring equipment.

Transducer Cycle	Spacing for Readings
0.2 in	0.0250 in
0.1 in	0.0125 in
2. mm	0.0098425 in (0.25 mm)
720 pole	0.125 degree (7' 30.0")
512 pole	0.1758 degree (10' 32.8")
360 pole	0.25 degree (15' 00.0")
256 pole	0.3516 degree (21' 5.6")

At each of these points, record the distance from the starting point both as measured by the Converter Board and by the accuracy standard. The position as indicated by the converter minus the position measured by the accuracy standard is the error. Plot this error as a function of position on graph paper. A curve like Figure 1 with two positive peaks and two negative peaks located at 1/8, 3/8, 5/8, and 7/8 of the cycle shows a gain balance error. The curve might be inverted from

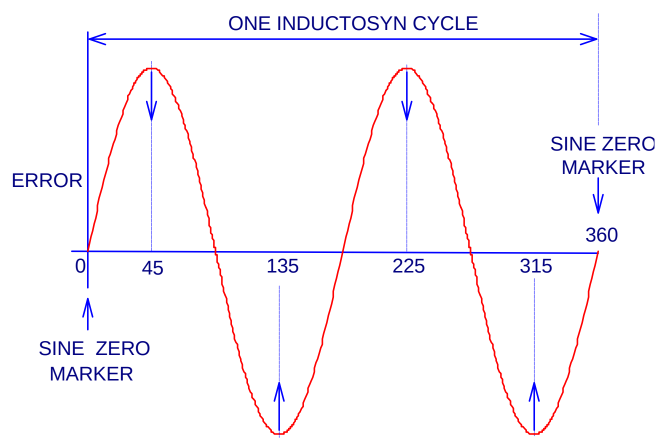

FIGURE 1 BALANCE ERROR

that shown.

4.3 Gain Balance Method 2 (continued)

e. Return the Inductosyn® transducer to the first peak. Remove the RTV silicone rubber from the balance potentiometer on the preamplifier assembly and adjust the potentiometer to reduce the position error to zero.

f. Repeat the procedure starting at (c). Note that when the first and third peaks go more negative the second and fourth peaks go more positive. If the curve is not exactly as shown in figure 1, a compromise adjustment should be made to minimize the overall error. When the error measured in Step (d) is within acceptable limits, the gain balance procedure is complete.

g. Secure the shaft of the potentiometer on the preamplifier with RTV.

h. If the error curve has a different shape, refer to section 7 or Engineering Report ER387A.

4.4 Gain Balance Method 3: <u>Field Balance Without Accuracy Measurements</u>

In this method, the position of an exact 1/8 cycle point is determined by temporarily connecting the sine and cosine windings in series, as shown in Figure 2, and moving the transducer to null their combined outputs. Normal wiring is then restored and the balance potentiometer on the preamplifier is adjusted if necessary until the lights on the Converter Board indicate an exact 1/8 cycle point.

a. Make an initial balance adjustment using a digital voltmeter. Measure the peak voltage of the Cosine output and adjust the potentiometer to bring the Sine voltage to the same peak value. Note: Preamplifiers are usually balanced before shipment so that this adjustment may not be necessary.

b. Synchronize an oscilloscope (on external sync) to the excitation input to the transducer or to the signal at the Phase Test Point ("TPREF") on the I/D Quad Converter Board. Display the Sine signal (test point "TPS" or "SIN" output of preamplifier). Position the transducer so that at least 1 volt peak to peak is displayed. Adjust the horizontal position so that either the positive or negative peak of the displayed signal is at the exact center of the display. Do not change these settings until the balance adjustment is finished.

c. Disconnect the wires connected to the slider or stator from the preamplifier SIN LO and COS HI and LO terminals ("B", "C", and "D-J"). Connect the two transducer windings in series to the SINE input terminals as shown in Figure 2.

d. With the Converter Board providing excitation to the scale or rotor, position the Inductosyn® transducer manually to produce a minimum signal on the oscilloscope. If this signal is not zero, the minimum occurs when the displayed signal crosses the zero axis of the oscilloscope display at the exact center of the display (as located in (b) above). At this point the remaining signal out of the preamplifier is 90° out of phase with the normal preamplifier output. The minimum signal at the center of the display should be within 0.5 mV of 0 volts.

e. Clamp the slider or rotor in this position.

f. Check to make sure that the null condition achieved in step (d) above has not been disturbed.

g. Reconnect the wires from the slider or stator to the preamplifier assembly in the normal way as shown in drawing 220415 or 219216.

h. The Converter Board should now be close to a 1/8 th cycle point and either the “ABOVE” or “BELOW” indicators should be lit.

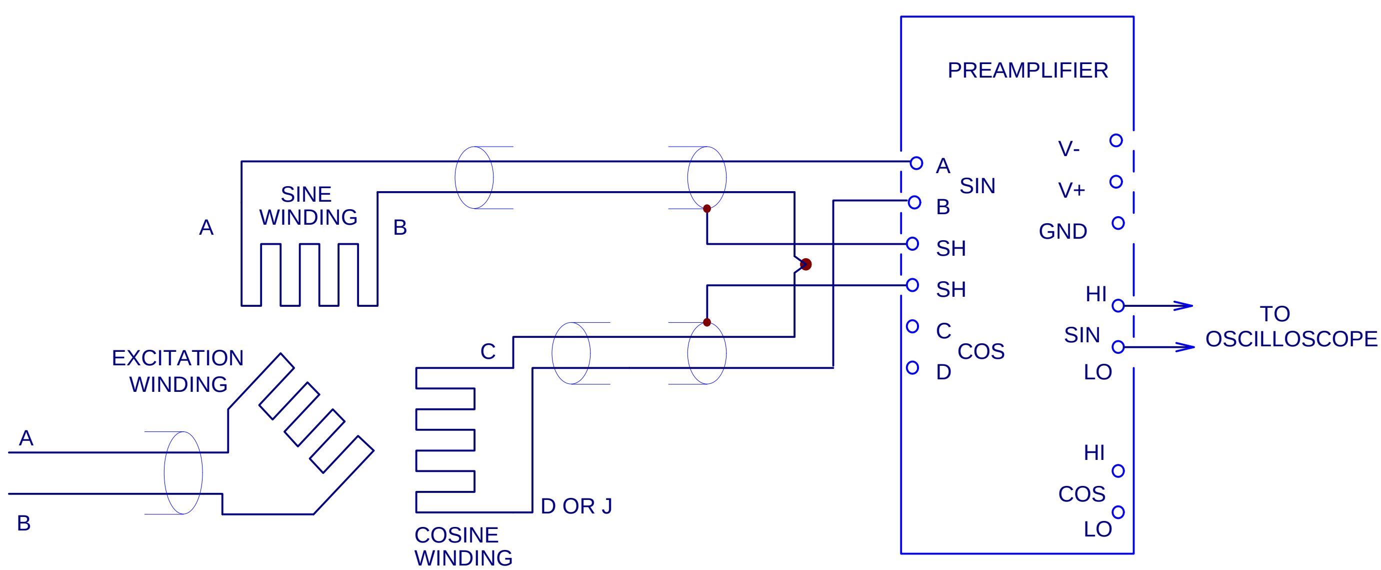

FIGURE 2. CONNECTION FOR LOCATING A PRECISE 1/8 CYCLE POINT

4.4 Gain Balance Method 3 (continued)

h. Remove any RTV from the potentiometer on the preamplifier assembly and adjust the potentiometer until the "ABOVE" or "BELOW" indicators are both lit. At this point the signal on test point "TPO" goes high and the SIN and COS signals at "TPS" and "TPC" should be equal.

j. When the adjustment is complete, secure the potentiometer on the preamplifier with RTV.

k. Remove the clamp from the rotor or slider.

4.5: Gain Balance Method 4: <u>Indirect Balance</u>

The indirect balance method consists of balancing the slider or stator and the preamplifier separately and does not involve positioning the transducer elements in any particular relationship to each other. This method is used at the factory to balance Inductosyn® transducer spars.

4.5.1 <u>Preamplifier Balance</u>

The preamplifier is connected as shown in Figure 3. The oscillator amplitude is adjusted for a preamplifier output of approximately 5V peak to peak. The potentiometer on the preamplifier is then adjusted for a minimum output into the oscilloscope terminals.

Note: The transformer must provide excellent electrostatic shielding between input and output, the correct end of the output winding should be grounded and the input and output leads should be separated. Suitability of the setup can be checked by connecting both ends of the input winding to the same preamplifier output. The output signal, divided by the turns ratio of the transformer, should be less than 0.05% of the preamplifier output. After the adjustment is completed, the test circuit should be removed.

4.5.2 <u>Slider or Stator Balance</u>

The resistive balance of the sine and cosine windings of the slider or stator together with cable resistance is checked using a DC Wheatstone bridge. Imbalance between the two source resistances should be less than 0.05%. Provision has been made for mounting balancing resistors on slider mounted preamplifiers (R3 and R9 on 218891-X). If preamplifier 219200 or 219594 is used, balance resistors must be supplied and mounted by the user. Resistors used for balance should be wire wound, metal film, or equivalent temperature stable type.

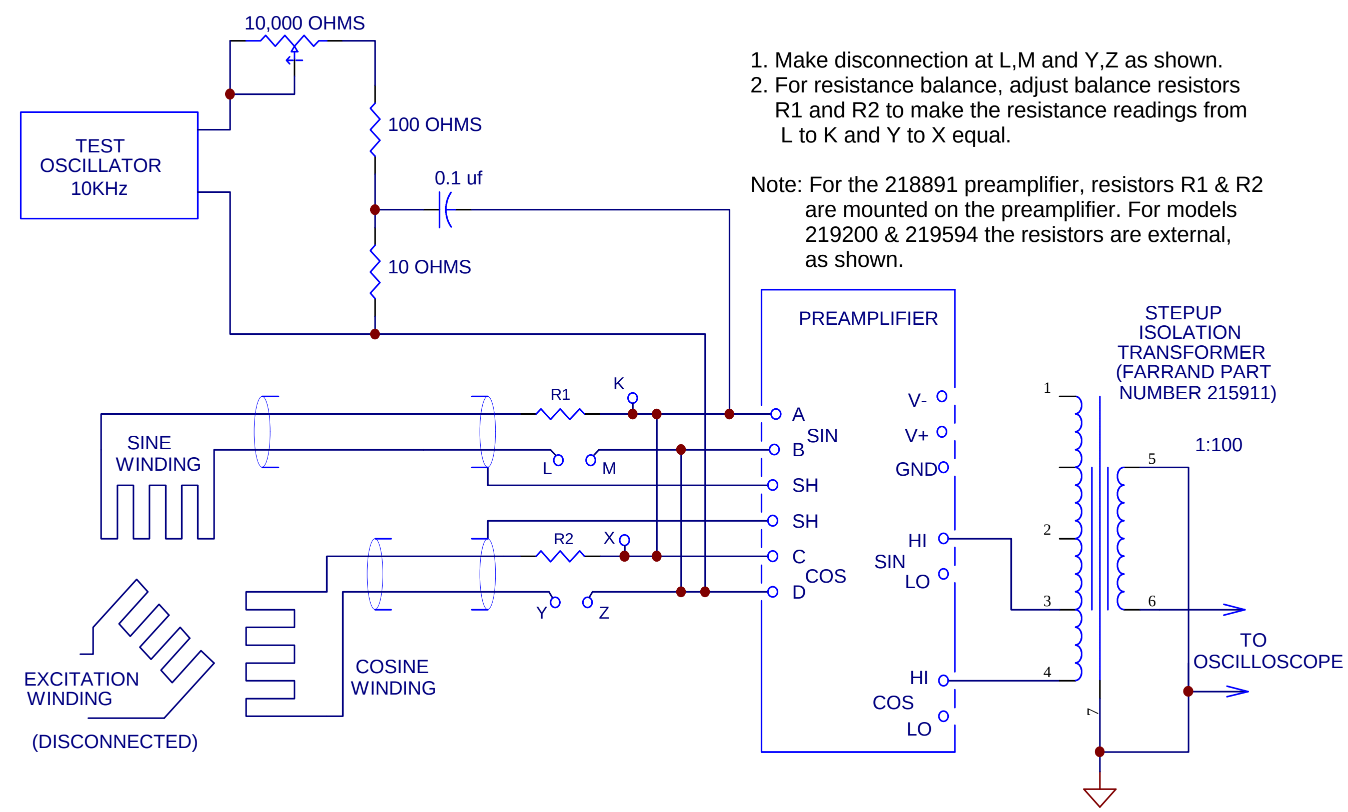

FIGURE 3. SET UP FOR PREAMPLIFIER BALANCE AND SOURCE RESISTANCE BALANCE PROCEDURES

5. CONNECTOR BOARD SIGNAL LISTING

Note: The connections listed below are also shown on the Connector Board hookup drawings 220415 and 219216 supplied with Engineering Report ER19801.

5.1 Power Input Terminals

SIGNAL	CONNECTOR BD. LABEL		DESCRIPTION	PIN
+15V DC	+	15V	Power for analog circuits	2
Analog Ground	GND			1 & A
-15V DC	-			B
+5V DC	+	+5V	Power for digital circuits	10 & L
Digital Ground	GND			8 & J
+15V DC for excitation	+	EXC	Power for excitation oscillator and driver	20 & X
Excitation Ground	GND			22 & Z
-15V DC for excitation	-			21 & Y

Notes: 1. All ground connections to be tied to machine ground at power supplies.
2. The same power supply can be used for the ± 15 V analog and excitation supplies but two sets of +15V, -15V and GND leads should be used to prevent excitation signals from coupling into the analog circuits.

5.2 Preamplifier Power

SIGNAL	CONNECTOR BD. LABEL		DESCRIPTION	PIN
+12V DC out to preamp	+	TO PA	These outputs provide a regulated +V and -V supply to the preamplifier. Analog ground is the common return.	3
-12V DC out to preamp	-			C
Analog Ground	GND			1 & A

5.3 Signal Inputs

SIGNAL	CONNECTOR BD. LABEL		DESCRIPTION	PIN
Sine HI	HI	SIN	Analog input signals from the preamplifier. When the transducer is positioned for maximum on Sin HI or on Cos HI, the corresponding signal should be 2V rms ± 5% at the excitation frequency.	9
Sine LO	LO			K
Sine shield	SH			M
Cosine HI	HI	COS		12
Cosine LO	LO			N
Cosine shield	SH			11
Excitation Drive HI	HI	EXC	Excitation output to scale or rotor. ** Note: connection to card edge connector depends on excitation terminal block hookup.	**
Excitation Drive LO	LO			W
Excitation Shield	SH			

5. CONNECTOR BOARD SIGNAL LISTING (continued)

5.4 Outputs

SIGNAL	CONNECTOR BD. LABEL		DESCRIPTION	PIN
OUT1	A	OUT 1	Format can be A quad B, pulse and direction (RCT & U/D) or count up & count down pulses (CU & CD) as selected by appropriate jumpers to pins or terminals X and Y.	6
/OUT1 (inverse)	$\bar{A}$			F
OUT2	B	OUT 2		5
/OUT2 (inverse)	$\bar{B}$			E
MP	M	MARKER	Index marker - occurs once per transducer cycle when A & B are both high.	4
/MP (inverse)	$\bar{M}$			D
F	F	FAIL	Loss of signal indication - 220300 board only.	7
/F (inverse)	$\bar{F}$			H
V	V	VELOCITY	Analog velocity output - 220100 & 220300	R
GND	GND			1 & A
REF	REF		Provided for use with "Master/slave" operation	13

Note: Signals OUT1, OUT2, MARKER and FAIL are provided as complimentary pairs. The signals are TTL compatible and each pair meets the requirements of EIA specification RS-422-A.

5.5 Control Inputs (on terminal posts)

SIGNAL	CONNECTOR BD. LABEL		DESCRIPTION	PIN
Control X	X	TERMINAL POSTS	The TTL levels on these pins select the data format on OUT1 and OUT2 - see drawings 220515 and 219216.	15
Control Y	Y			S

6. PIN-OUT FOR 44 PIN CARD EDGE CONNECTOR

NUMBERED PINS				LETTERED PINS		
FUNCTION	LABEL	PIN		PIN	LABEL	FUNCTION
Analog ground	AGND	1		A	AGND	Analog ground
Analog +15V input	+15V	2		B	-15V	Analog -15V input
+12V output to preamp	+12V	3		C	-12V	-12V output to preamp
Marker output (RS422-A hi)	M	4		D	/M (inverse)	Marker output (RS422-A low)
Count Output 2 (RS422-A hi)	B	5		E	/B (inverse)	Count Output 2 (RS422-A low)
Count Output 1 (RS422-A hi)	A	6		F	/A (inverse)	Count Output 1 (RS422-A low)
Loss of Signal (RS422-A hi) see note** below	F	7		H	/F (inverse)	Loss of Signal (RS422-A low) see note** below
Digital Ground	DGND	8		J	DGND	Digital Ground
Sine Input - high	SIN.HI	9		K	SIN.LO	Sine Input - low
Digital +5V Supply	+5V	10		L	+5V	Digital +5V Supply
Analog ground	AGND	11		M	AGND	Analog ground
Cosine Input - high	COS.HI	12		N	COS.LO	Cosine Input - low
KEY						
Converter Reference Output	REF	13		P		No Connection
No Connection		14		R	VEL	Velocity Output
Output Control 'X'	X	15		S	Y	Output Control 'Y'
Oscillator Output		16		T		Oscillator Output - phase shifted
Transformer Tap 'T5'	T5	17		U	T4	Transformer Tap 'T4'
Transformer Tap 'T6'	T6	18		V	T7	Transformer Tap 'T7'
Excitation Oscillator Power Output	OSC.HI	19		W	OSC.LO	Excitation Oscillator Output Return
+15 V Excitation Supply	+15V.EXC	20		X	+15V.EXC	+15 V Excitation Supply
-15 V Excitation Supply	-15V.EXC	21		Y	-15V.EXC	-15 V Excitation Supply
Ground Return For Excitation Supply	EGND	22		Z	EGND	Ground Return For Excitation Supply

** **Note:** Provided on 220300 board only.

7. CYCLIC ACCURACY ANALYSIS

The error curve, plotted in section 4.3, for sine/cosine gain balance may differ from the ideal curve shown in figure 5 below. This is because other error sources with different characteristics may be contributing to the overall result. These sources include the converter integrated circuit (see ER19801 for accuracy options) and the error sources discussed below. The overall error curve will, therefore, be a sum of the individual error contributions. These errors can be minimized by using the wiring techniques and materials recommended in drawing A218000.

7.1 Cross Coupling between Excitation and Sine or Cosine

This is a first harmonic error - it completes one cycle as the Inductosyn® travels through one cycle. The polarity of the error signal may be inverted from that shown and may be phase shifted. The phase shift occurs because, for an Inductosyn® transducer, the sine and cosine signals lead the Excitation signal by 0 to 90 degrees.
This type of cross coupling is often electromagnetically induced and can be minimized by keeping the excitation cable well separated from the sine and cosine cables and by maintaining a tight twist on all unshielded sections of wiring. The sine and cosine signals prior to amplification are

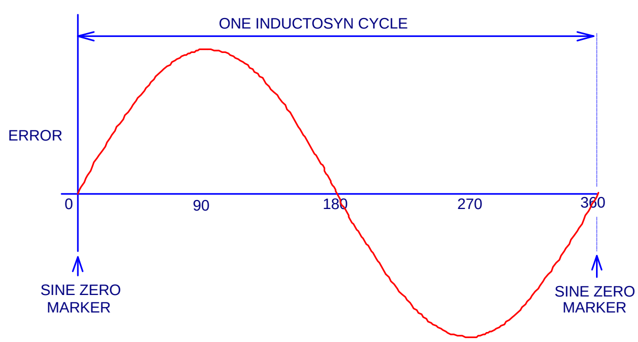

FIGURE 4 CROSS COUPLING: EXCITATION TO SINE OR COSINE

very sensitive to pick up and special care is necessary if these signals are routed through the same connector as the excitation signal. In general, and especially for high accuracy systems, it is adviseable to use a separate connector for the excitation signal - see also drawing A218000.

Another possible cause for this error is a lack of grounding to the transducer elements, particularly on the slider or stator.

7.2 Sine/Cosine Balance Error

This is a second harmonic error - it completes two cycles as the Inductosyn® travels through one cycle. It is caused by unequal amplification in the sine and cosine channels. The procedure for sine/cosine gain balance adjustment is given in section 4 above.

The accuracy required for sine/cosine gain balance adjustment depends on the accuracy requirements of the system. For example: in a 180 speed system a 0.1% gain balance error will
introduce a peak to peak cyclic error of one arc second and for a linear system with a 0.1 inch pitch, a 0.1% gain balance error
will introduce a peak to peak cyclic error of 16 micro inches.

7.3 Cross Coupling Between Sine and Cosine Wiring

This is a second harmonic error like the sine/cosine balance error of figure 5 - it completes two cycles as the Inductosyn® travels through

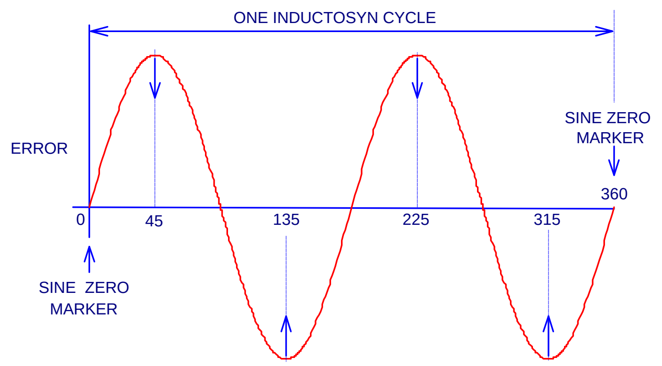

FIGURE 5 BALANCE ERROR

one cycle. It differs from the sine/cosine balance error in its phasing - it peaks at 0, 90, 180 and 270 degrees compared with the balance error curve which peaks at 45, 135, 225 and 315 degrees.
This type of error is not usually a problem. It can be eliminated by correct shielding and by keeping all unshielded sections of wiring well separated and as short as possible, with the twist maintained as close to the termination point as possible.

7.4 Fourth Harmonic Errors.

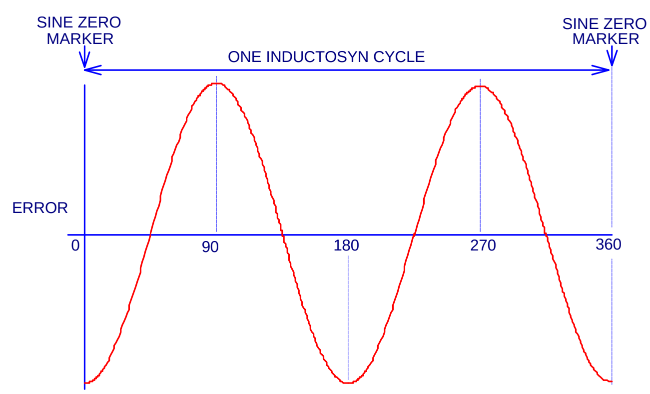

FIGURE 6 CROSS COUPLING: SINE TO COSINE

In this case the error curve completes four cycles as the Inductosyn® travels through one cycle. It is caused by a nonlinearity in the preamplifier or, more likely, by over driving the excitation amplifier so that the peaks of the excitation signal are clipped. The converter is very insensitive to signal distortion and this type of error is very unusual.

8. TROUBLE SHOOTING

8.1 The most common causes of problems are:

(i) Mis-wiring of the power supplies to the Connector Board or preamplifier. The wiring hookup should always be checked with a voltmeter before plugging in the Converter Board. (ii) No connection between the + 5V supply common and the ± 15V supply common. This causes a failure of the TTL output signals. (iii) Mounting the board so that the mounting hardware shorts circuit traces together or to ground.

8.2 No Signal at the Sine and Cosine Test Points.

8.2.1 Is there a large DC offset at the preamplifier's sine and cosine output terminals ?

Yes - there is a large DC offset: Possible causes are:

a. The ± 12V power supply wiring to the preamplifier is incorrect. Measure each supply voltage with respect to the common (ground) terminal at the preamplifier terminals and check that the amplitude and polarity of the supplies is correct.

b. There is a problem on the Converter Board or wiring that is forcing a voltage back into the preamplifier's output terminals. Try disconnecting the wiring to the Sine and Cosine "HI" output terminals on the preamplifier and check to see if the DC offset is corrected.

c. The preamplifier's balance potentiometer has been turned so that it has zero resistance - nominal setting is about 4.3 ohms. If the above measures do not locate the problem then there may be a fault on the preamplifier assembly.

No - there is not a large DC offset: Proceed to 8.2.2.

8.2.2 Is the excitation signal present at the transducer?

Yes - the excitation signal is present:

a. Check that the ± 12V feeds to the preamplifier are present and wired correctly.

b. Check that the preamplifier's output cables are wired correctly. The "LO" (black) signal lead is usually grounded and will short out the preamplifier output if connected to the "HI" terminal.

c. Check that the transducer elements are gapped correctly.

d. Check that the gain of the preamplifier, indicated by its dash number, is correct.

No - there is no excitation signal.

a. Check that the ± 15V excitation supply is wired correctly.

b. For the 220100 board, try turning the "drive" potentiometer <u>counterclockwise</u> to increase the excitation output signal. For the 220300 board the adjustment is automatic and if the Sine and Cosine inputs to the board are missing the excitation voltage should increase to its maximum level and the "error" indicator should be lit.

c. Check for a signal on the phase test point "TPREF". A signal here at the excitation frequency signal confirms that the on board oscillator is functioning correctly. This signal is sinusoidal for a 220100 board and a squarewave (TTL) for the 220300.

d. If a 220400 or 219215 Connector Board is being used, check that the excitation terminal block is jumpered correctly.

e. Unhook the excitation "HI" signal to check for a short circuit. If this restores the excitation signal then there is a short in the cabling or in the transducer.

If the measures above fail to locate the problem then there may be a fault on the Converter Board.

8.3 The sine and cosine gain balance cannot be set correctly.

The cosine channel has a fixed gain and the gain of the sine channel is adjusted to match it. There should be adequate adjustment to swing the signal output of the sine channel above or below that of the cosine channel.

a. Check for physical damage to the stator or slider. Disconnect the wiring to the sine and cosine patterns and check that the pattern resistances are approximately equal and are not shorted to ground or to each other.

b. Move the transducer to peak the cosine signal and measure this peak amplitude using a digital voltmeter. Now move the transducer to peak the sine output and adjust the balance potentiometer on the preamplifier checking that the sine peak amplitude can be adjusted to be less than or greater than the sine peak amplitude. If the adjustment range is incorrect disconnect the "HI" cable connections to the sine and cosine outputs of the preamplifier and recheck to see if the signals are being affected by the Converter Board.

Notes:
(i) The Converter Board has a 10 Kohm input impedance and should have a negligible loading affect on the preamplifier output.
(ii) The preamplifier's balance potentiometer is multi-turn and its adjustment range is non-linear.
(iii) There may be other forms of cyclic error present - see section 7 above. The balance adjustment should be adjusted for the lowest overall peak to peak error.

8.4 The output count appears to have hysteresis when the system is checked with a laser

This usually occurs because the laser beam of the measuring equipment is not centered on the axis of the transducer and an abbe offset error is created. The hysteresis value for the I/D Quad Converter Board is less than one internal resolution count. For instance, for a 0.1 inch scale and a converter with an internal resolution of 14 bits, the converter's hysteresis level is less than $0.1/2^{14}$ = 6 micro inches.This hysteresis value is true for all cycle division values generated from this 14 bit internal divide by.

8. TROUBLE SHOOTING (continued)

8.5 The controller does not respond correctly to the A quad B output signal

The most likely causes are:

a. The 0V common (GND) of the +5V supply is not tied to the 0V common (GND) of the ± 15V supply.

b. The 0V common (GND) of the Converter Board's power supply is not connected to the ground reference of the controller.

c. The tracking speed of the controller does not match the output data rate from the Converter Board. The maximum data rate of the Converter Board will vary with model number. The maximum rate is approximately 1.3 MHZ. - measured for a transition on the A output to the next transition on the B output. This is the “internal” data rate of the converter. For most models the internal cyclic division is modified so that several “internal” counts are used to generate one external count so that the final data rate at the output less than the “internal” data rate. The listing of “internal” and “overall” divide by figures given Engineering report ER18901 can be used to calculate the maximum expected data.

Notes:

(i) If the controller is signaling an A quad B failure the manufacturer of the controller may be able to advise on what type of fault is being detected. For instance, loss of signal, incorrect signal level or invalid A quad B sequence.

(ii) The A quad B output signals from the Converter Board are both TTL and RS422 compatible. The preferred method of interfacing is to a controller that uses an RS422 compatible receiver.

C For a differential (**RS422**) hookup, the A quad B signals are received differentially, typically with 100 ohm resistors connected between the A & $\overline{A}$ and B & $\overline{B}$ inputs at the controller. Using this method long cable lengths can be used and the data transmission has a very good rejection of common mode noise signals - for instance voltage differences between the ground voltage at the Converter Board and the ground voltage at the controller. Unless the controller's inputs are opto- isolated, a ground connection is still required between the Converter Board and the controller. Also, the voltage difference between the two ground references must be kept within RS422 specifications.

C For non-differential, **TTL** hookups , noise immunity is very much reduced. A very small voltage difference between the grounds of the Converter Board and controller can produce a false TTL high or TTL low signal. If there is a problem, a pull-up resistor of 1K ohm to + 5V at the controller may help in some cases.

8.6 The cyclic division (resolution) of the system is not as expected

The most likely cause is that the controller is not set to X4 mode. The resolution (cycle division) of the Converter Board is specified for a count at every transition of the A or B output.

The recommended method for checking the cyclic division is to position the system so that the “marker” (sine zero) indicator on the Converter Board is lit and then measure the counts for a movement to the next position that the “marker” indicator is lit.