I/D QUAD CONVERTER BOARDS
TYPES 220100 and 220300

DESCRIPTION AND SPECIFICATIONS

Engineering Report 19801

January 22, 1998

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1. INTRODUCTION

An Inductosyn® transducer is a position measuring device consisting of two parallel plates with conductive patterns, separated by a small air gap. When one plate is driven by a suitable alternating current, the other produces analog output signals representing the relative position of the two plates. Linear Inductosyn® transducers measure translational position, while rotary Inductosyn® transducers measure angular position. Compared with a synchro resolver that may have one cycle per revolution of the input shaft, in an Inductosyn® transducer the cycles are usually small - for example one degree of rotation or 0.1 inch of linear motion. The transducer is excited with a sine wave signal at a high audio frequency and returns two signals from which the position within a transducer cycle is determined. The two outputs have a fixed relationship at each point of the transducer cycle and this relationship is repeated at the corresponding point of the next cycle.

A preamplifier is used to bring the transducer's low level analog sine and cosine output signals to the 2V rms level required at the input to the I/D Quad converter card. At the converter the two amplified sine/cosine position signals are translated to a digital value and any relative motion of the two transducer elements is converted to a serial stream of count signals that can be used to track the magnitude and direction of the change in position.

The I/D Quad Converter divides each transducer cycle into a fixed number of counts, referred to as the cycle division of the converter. Thus a smaller cycle length or a larger cycle division will result in a finer resolution. A wide range of cyclic division selections are available - typical values are 1000, 2000, 3600, 4000, or 10,000.

2. DESCRIPTION OF THE I/D QUAD CONVERTER

The I/D Quad Converter is a transducer to digital converter mounted on a single card. All power, inputs, and outputs come through a single edge connector. The board outputs a high audio frequency signal that is used to excite the transducer and receives back the resultant, position dependent sine and cosine output signals after amplification by an external preamplifier.

At the heart of the converter is an integrated circuit which converts the analog sine and cosine signals to a binary representation of position within the transducer cycle. This circuit divides the transducer cycle into 1024, 4096, 16,384 or 65,536 parts (2^{10}, 2^{12}, 2^{14} or 2^{16}). Additional circuitry on the Converter board is used to generate the desired cycle count - this is the stated cycle division of the board and can be at the full internal resolution of the board or modified to some lower value. The internal binary division selected for the card is usually determined by tracking speed requirements. For instance, unless limited by excitation frequency, reducing the internal binary division from 2^{12} to 2^{10} will increase the maximum tracking rate capability by a factor of four. Tracking rate and cyclic division data for typical systems are shown in section 3.21.

Output pulses are generated in one of three formats: A quad B, count and direction, or count up and count down.

The digital output can be used by a numerical display, a control system or a computer. The I/D Quad Converter can also be used with a synchro resolver.

Two types of card are available, as shown in section 4. The 220300 card differs from the 220100 in that it provides a loss of signal output and has automatic gain and phase correction. In all other respects the specifications of the two cards are identical. For the 220100 card potentiometers are provided for signal amplitude and phase adjustment.

The 220100 is designed as a direct replacement for the earlier 219100 converter card.

The 220300 provides the same functions that were previously implemented in the 219980 I/D Quad Converter and 219630 Connector board combination.

The I/D Quad converter can be used by itself, with all connections made to a card edge connector, or with a Farrand Connector Board that provides labeled screw terminations.

3. SPECIFICATIONS

Note: Unless otherwise stated, the features listed below apply equally to both the 220100 and 220300. The 220300 card incorporates all the functions of the 220100 and in addition provides a loss of signal output and has automatic gain and phase correction.

3.1 Input: 2V rms ± 10%
Use with a linear or rotary Inductosyn® transducer and Farrand Preamplifier 218891-X, 219200-X or 219594-X or with a resolver. See information drawings 218891-I, 219200-I and 219594-I included in this report. Depending on the application, preamplifier sine/cosine balance may be adjusted on site using an on-board potentiometer or preset at the factory using fixed high stability, precision resistors. In some applications, where the converter card is remote from the preamplifier, a second unity gain buffer amplifier with potentiometer balance or 220400 Connector board with input buffer option may be used to locate the balance adjustment close to the controller.

3.2 Output Count Types: The board can be jumpered to provide three different types of count signal. The selection is made by connecting the "CONTROL" inputs to ground or leaving them open as shown in the table on drawing 219216 or 220415 included in this report.
The following outputs are from RS-422-A standard differential drivers and provide up to 40 mA. into a 100 ohm differential load. The outputs are also TTL compatible.

3.2.1 Quadrature (**A** and $\overline{\mathbf{A}}$, **B** and $\overline{\mathbf{B}}$). This is the default setting, with no connection made to the "CONTROL" inputs. A count is considered to occur whenever there is a transition in either the A or B output signal. The phase relationship of the two signals indicates the direction of motion as shown in Figure 1.

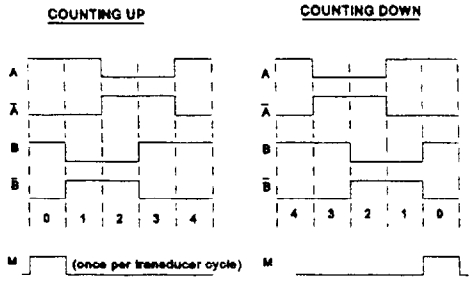


Figure 1. Quadrature Output Format

3.2.2 Count pulse and up/down level. (**RCT** and $\overline{\mathbf{RCT}}$, **U/D** and $\overline{\mathbf{U/D}}$). RCT is a positive pulse that occurs every time A or B change. It is 300 ± 100 nanoseconds wide with at least 200 nanoseconds between pulses. U/D indicates the direction of motion and is valid during RCT and at least 75 nanoseconds before the leading edge of RCT.

3.2.3 Count up and count down pulse. (**CU** and $\overline{\mathbf{CU}}$, **CD** and $\overline{\mathbf{CD}}$). CU and CD are negative pulses. When this output format is selected either a count up or a count down pulse will occur, depending on the direction of motion, whenever an RCT pulse would occur, and will have the same timing.

3.3 Marker Pulse Output. **M** and $\overline{\mathbf{M}}$. Marker is active once per Inductosyn® transducer cycle at the zero degree position.. In quadrature mode, the marker pulse occurs when A and B are both high. Output type is RS-422-A as for 3.2 above.

3.4 Loss of Signal Output (220300 only). **F** and $\overline{\mathbf{F}}$ This signal is active when the automatic amplitude adjustment circuit cannot drive the transducer to the level specified for correct operation of the converter board. If this is a transient condition, the "F" signal will remain active only as long as the transducer output cannot be driven to the required level. The user should interpret this as appropriate to his application. Output type is RS-422-A as for 3.2 above.

3.5 Velocity Output. This is a bipolar analog signal that is proportional to tracking rate. The output level is approximately 8.0 volts dc at the maximum tracking rate specified for the system. This is a buffered version of the output provided by the Analog Devices resolver to digital converter. For details of voltage offset, linearity, ripple etc. please refer to the Analog Devices AD2S80 or AD2S82 data sheet . See also 3.22.

3.6 Resolution: Output pulse resolution depends on the particular part number. Standard resolutions are shown on drawings 220100-I and 220300-I. For availability of other resolutions please consult the factory. In the quadrature output format a count pulse is considered to occur whenever there is a transition on either the A or B quadrature output and resolution is specified with the controller's quadrature detection in the "X4" mode. In the "X2" mode the resolution number (step size) is twice the value shown and in the "X1" mode it is four times the value shown.

3.7 Accuracy: Standard converter accuracy is ± 8 arc minutes. For a 360 pole (180 cycles per revolution) rotary transducer, the worst case error introduced by a ± 8 arc minute converter is ± 8/180 arc minutes (2.7 seconds) ± 1 converter count. This error is in addition to any other errors external to the 220100 or 220300 I/D Quad Converter board. Boards with ± 4 and ± 2 arc minute accuracies are available.

3.8 Indicator Lights:

220100 and 220300:

Count Indicators:
- "A" quadrature signal
- "B" quadrature signal
- "MARKER" sine zero signal

1/8 th. cycle indicators:
- "ABOVE" count just above octal value
- "BELOW" count just above octal value
  (at the exact octal point both indicators are lit)

Indicator Lights (continued) :

220300 only:

- "WARNING" signal level close to error level
- "ERROR" loss of signal

The "MARKER" indicator lights at the beginning of each transducer cycle. It is arranged to stay on long enough to be seen, even when moving at high speed. The "A" and "B" indicators display the quadrature signals even if a different output format is chosen.
Octal point indication is used to identify the exact 1/8 cycle points when setting the balance adjustment on the preamplifier. "Above" and "Below" light 4 times per cycle - at the 1/8, 3/8, 5/8, 7/8 cycle points (45, 135, 225 & 315 degrees).

3.9 Test Points:

The following test points are provided for use during installation. Additional test points, used during factory testing, are not listed.

a. COSINE "TPC". This is the same as the preamplifier "COS" output. It is monitored when adjusting the drive level and reference phase potentiometers on the 220100 board.
b. SINE "TPS". This signal is the same as the preamplifier "SIN" output.
c. PHASE "TPREF". This signal is the reference input to the converter's error detector, and is used in reference phase alignment for the 220100.
d. ANALOG GROUND. Ground return for "TPS", "TPC", and "TPREF".
e. OCTANT "TPO". Used to identify the exact 1/8 cycle points when setting the balance adjustment on the preamplifier. This point goes TTL High for one count 4 times per cycle at the 1/8, 3/8, 5/8, 7/8 cycle points.

3.10 Power Requirements:

(Outputs loaded with 75 ohms each)

+ 5V	± 0.25V d.c. 500 mA
+15V	± 0.25V d.c. 250 mA
-15V	± 0.25V d.c. 250 mA

Note: The +15V & -15V current is dependent on excitation current requirements. The specified 250 mA DC current provides 250 mA rms of excitation current.

3.11 Preamplifier Power:

Outputs of +12V and -12V at up to 50 mA are provided, and are to be used to power the external preamplifier.

3.12 Excitation Output:

A 10 KHz ± 10% sine wave output suitable for most Inductosyn® transducers.

1. Optional excitation frequencies from 1 KHz to 17KHz are available for the 220100 board. For some options an additional one-time engineering charge may be required.

3.13 Excitation Drive Capability:

Drive capability depends on load impedance which will vary with transducer type and cable length. The board includes a matching transformer for use when the load impedance is less than 15 ohms. The maximum outputs are:

(i) With direct output for impedances above 15 ohms:
Current 210 mA rms max.
Voltage 7V rms max (210 mA rms into 33 ohms)

(ii) Using transformer hook-up for a 4 to 15 ohm load.
1.5V rms @ 300 mA rms into 5 ohms

(iii) Using transformer hook-up for a load of 4 ohms or less.
1.0V rms @ 500 mA rms into 2 ohms

An optional output of 14V rms is available for driving long tape scales.

Note: The board is capable of supplying up to 500 mA rms of excitation current if forced air cooling is used to provide good air flow over the excitation power amplifier's heat sink and a 500 mA ± 15V power supply is used. In all cases the temperature at the case of the power amplifier should not be allowed to exceed 85 °C. If necessary a resistor can be added in series with the cable to reduce power dissipation in the amplifier or, if direct drive is used with long cable lengths, the matching transformer can be located near to the transducer.

3.14 Excitation Amplitude Adjustment:

220100: Adjusted by the user at installation, using an on-board potentiometer, so that peak sine and cosine inputs to the board are the required 2.0 volts rms (5.7 volts peak to peak) ± 5%.

220300: Excitation amplitude is automatically adjusted so that the peak sine and cosine inputs to the board are the required 2.0 volts rms (5.7 volts peak to peak) ± 5%.
The adjustment range is from zero excitation amplitude to the levels specified in 3.13 above.

3.15 Size:

The I/D Quad Converter fits in a 4 ½ in. card cage. It is 6 ½ in. long, 0.062 in. thick, 1.2 in. in overall height and weighs 8 ounces.

3.16 Connector

The I/D Quad converter can be used by itself, with all connections made to a card edge connector, or with a Farrand Connector Board that provides labeled screw terminations.
The mating connector is an industry standard 22 position dual readout card edge connector with 0.156 in. contact spacing, such as the Cinch 50-44SN.

3.17 Temperature Rating:

The I/D Quad Converter will operate form 0°C to 70 °C, provided the temperature of power amplifier heat sink does not exceed 85 °C. See 3.13 above.

3.18 Cable Lengths:

Farrand drawing A218000, included with this report, supplies information on recommended cables and wiring techniques. Provided that these recommendations are complied with, the following cable lengths are possible:

(i) Transducer to preamplifier: The preamplifier should be mounted as close as possible to the transducer. The recommended maximum distance is 6 ft but greater lengths are possible depending on the noise environment and wiring method.

(ii) Preamplifier to I/D Quad Converter Card: 400 ft

• For the excitation signal, maximum cable length is usually determined by voltage drop in the cable. A 400 ft. run of 24 AWG cable, for instance, has a nominal resistance of 20 ohms compared with the resistance of an Inductosyn® scale that may be as low as 1 or 2 ohms. Excitation current and, therefore, voltage drop can be reduced by using a higher gain preamplifier or, in some cases, by locating a matching transformer close to the scale.
Section 3.13 gives information on excitation drive capacity for different load impedances.

• For the sine/cosine signals, attenuation in the cable is low because of the high input impedance of the I/D Quad Converter board and external noise pickup , either EMI or ground induced, is the controlling factor.

(iii) RS422-A output connections: Cable lengths of at least 100 ft. are practical using a 24 AWG twisted pair terminated with 100 ohms. This is conditional on acceptable common mode noise levels, for instance ground potential differences between the I/D Quad board and receiving electronics. For a detailed analysis please refer to National Semiconductor's application note AN214, August 1993 "Transmission Line Drivers for TIA/EIA Standards RS422 and RS423".

3.19 Tracking Speed:

Maximum tracking speed is determined by two factors, as shown in the table below:
(i) The internal resolution (number of bits) selected for the converter - either ÷ 2^{10}, 2^{12}, 2^{14} or 2^{16}.
(ii) The excitation frequency - this becomes the limiting factor for smaller internal resolution selections (for example 2^{10}.)

Note: The internal resolution that is chosen must be greater than or equal to the selected transducer cycle division. Selecting a high internal resolution may give a better accuracy in some applications but at the expense of tracking speed.

Table 1. Tracking Speed Versus Internal Resolution and Excitation Frequency

Internal Bits (Divide By)	Speed in transducer cycles per second at various excitation frequencies		
	17 KHz	10 KHz	1 KHz
10 (÷1,024)	1000	600	60
12 (÷4,096)	250	250	60
14 (÷16,384)	62.5	62.5	60
16 (÷65,536)	15.6	15.6	15.6

3.20 Calculation of Maximum Tracking Speed:

The specifications for many typical applications are listed in section 3.21. The following examples show how the data in Table 1 can be used to calculated maximum tracking speed.

Example 1. ÷ 500 at 10 KHz. excitation frequency using a rotary 720 pole transducer: The standard internal divide by for a cycle division of 500 is 1024. From table 1, with an internal divide by of 1024 and excitation frequency of 10 KHz. the maximum tracking rate is 600 transducer cycles per second.
The number of transducer cycles per revolution is 720 ÷ 2 = 360
Therefore, the maximum tracking rate is 600 ÷360 = 1.67 revolutions/second (100 rpm)

Example 2. ÷ 2000 at 17 KHz. excitation frequency using a linear transducer with 0.2" cycle length. The standard internal divide by for a cycle division of 1,000 is 4096. From table 1, with an internal divide by of 4096 and excitation frequency of 17 KHz. the maximum tracking rate is 250 transducer cycles per second. Therefore, the maximum tracking rate is 250 x 0.2" = 50 inches/second (3,000 inches/minute).

Note: As the examples show, maximum tracking rate depends on the internal resolution setting and not on cycle division. For a given cycle division number, it may be possible to increase tracking speed by selecting a smaller internal divide-by, however, this can result in a lower resolution.

3.21 Resolution & Tracking Rate for Typical Applications:

DASH NO. Where -X = frequency option	CYCLE DIVISION	INTER-NAL RESO-LUTION (bits)	EXAMPLES				
			Transducer	Overall Resolution	Speed at 17 KHz	Speed at 10 KHz	Speed at 1 KHz
-X100	1,024	10	256 pole	2^{-17} rev	450 rpm	280 rpm	28 rpm
-X110	256	10	256 pole	2^{-15} rev	450 rpm	280 rpm	28 rpm
-X120	32	10	256 pole	2^{-12} rev	450 rpm	280 rpm	28 rpm
-X130	360	10	720 pole	10 arc sec	160 rpm	100 rpm	10 rpm
-X140	500	10	0.1 inch	200 µin.	6000 ipm	3600 ipm	360 ipm
			360 pole	0.004°	320 rpm	200 rpm	20 rpm
-X200	4,096	12	512 pole	2^{-20} rev	56 rpm	56 rpm	14 rpm
-X210	1,000	12	0.2 in	200 µin	3000 in/min	3000 in/min	720 in/min
			0.1 in	100 µin	1500 in/min	1500 in/min	360 in/min
			2 mm	2 µm	30 m/min	30 m/min	7.2 m/min
			720 pole	0.001°	40 rpm	40 rpm	10 rpm
-X220	2,000	12	0.2 in	100 µin	3000 in/min	3000 in/min	720 in/min
			0.1 in	50 µin	1500 in/min	1500 in/min	360 in/min
			2 mm	1 µm	30 m/min	30 m/min	7.2 m/min
			360 pole	0.001°	80 rpm	80 rpm	20 rpm
-X230	3,600	12	720 pole	1 arc sec	40 rpm	40 rpm	10 rpm
-X240	128	12	256 pole	2^{-14} rev	112 rpm	112 rpm	28 rpm
-X250	2,540	12	0.1 in	1 um	1500 in/min	1500 in/min	360 in/min
-X290	720	12	720 pole	5 arc sec	40 rpm	40 rpm	10 rpm
-X300	16,384	14	256 pole	2^{-21} rev	28 rpm	28 rpm	28 rpm
-X310	10,000	14	0.2 in	20 µin	750 in/min	750 in/min	720 in/min
			0.1 in	10 µin	375 in/min	375 in/min	360 in/min
			2 mm	0. 2 µm	7.5 m/min	7.5 m/min	7.2 m/min
			720 pole	0.0001°	10 rpm	10 rpm	10 rpm

3.21 Resolution & Tracking Rate for Typical Applications (continued):

DASH NO. Where -X = frequency option	CYCLE DIVISION	INTER-NAL RESO-LUTION (bits)	EXAMPLES				
			Transducer	Overall Resolution	Speed at 17 KHZ	Speed at 10 KHZ	Speed at 1 KHZ
-X320	4,000	14	0.2 in	50 µin	750 in/min	720 in/min	720 in/min
			0.1 in	25 µin	375 in/min	375 in/min	360 in/min
			2 mm	0. 5 µm	7.5 m/min	7.5 m/min	7.2 m/min
-X330	3,600	14	720 pole	1 arc sec	10 rpm	10 rpm	10 rpm
-X340	7,200	14	360 pole	1 arc sec	20 rpm	20 rpm	20 rpm
-X510	20,000	16	0.2 in	10µin	187 in/min	187 in/min	187 in/min
			0.1 in	5 µin	93 in/min	93 in/min	93 in/min
			2 mm	0. 1 µm	1.9 m/min	1.9 m/min	1.9 m/min
			720 pole	0.00005°	2.5 rpm	2.5 rpm	2.5 rpm

3.22 Connector Board Options:

Connector Boards are available with labeled screw terminals for hooking up signal input, output and power connections.

The 200100 and 220300 I/D Quad Boards can be used with Connector Board types 219215 or 220400. However, the 220400 Connector board must be used if connections are required for a "Loss of Signal" output (220300 only) or "Velocity" output (220100 and 220300).

Versions of the 220400 Connector Board are also available with the following additional circuits installed:

- Input Buffer Option: This option is useful in two situations:

(i) In an electrically noisy environment where its differential input stage can help in reducing common mode noise signals picked up on the cabling between the preamplifier and the I/D Quad Converter Board.

(ii) Where the I/D Quad Converter Board is a long distance from the Inductosyn® transducer and it is more convenient to make the sine/cosine balance adjustment at the Converter Board's location.

The input buffer stage has a gain of 1.29

- Velocity Adjust Option:

This option provides a gain and DC level adjustment for the Converter's velocity signal. When this option is not present the velocity output signal is a buffered version of the AD2S82 converter's velocity output signal. This is a bipolar signal with a peak amplitude of approximately 8 volts at the maximum specified tracking rate and a DC offset voltage of up to 38 mV (at 25 °C). The velocity adjust option provides DC offset adjustment and a voltage gain adjustable from 1 to 10.

For catalog numbers refer to drawings 220400-I and 219215-I.

3.23 Static Sensitivity and Handling:

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.

4. BOARD OUTLINE & LOCATION OF MAJOR COMPONENTS:

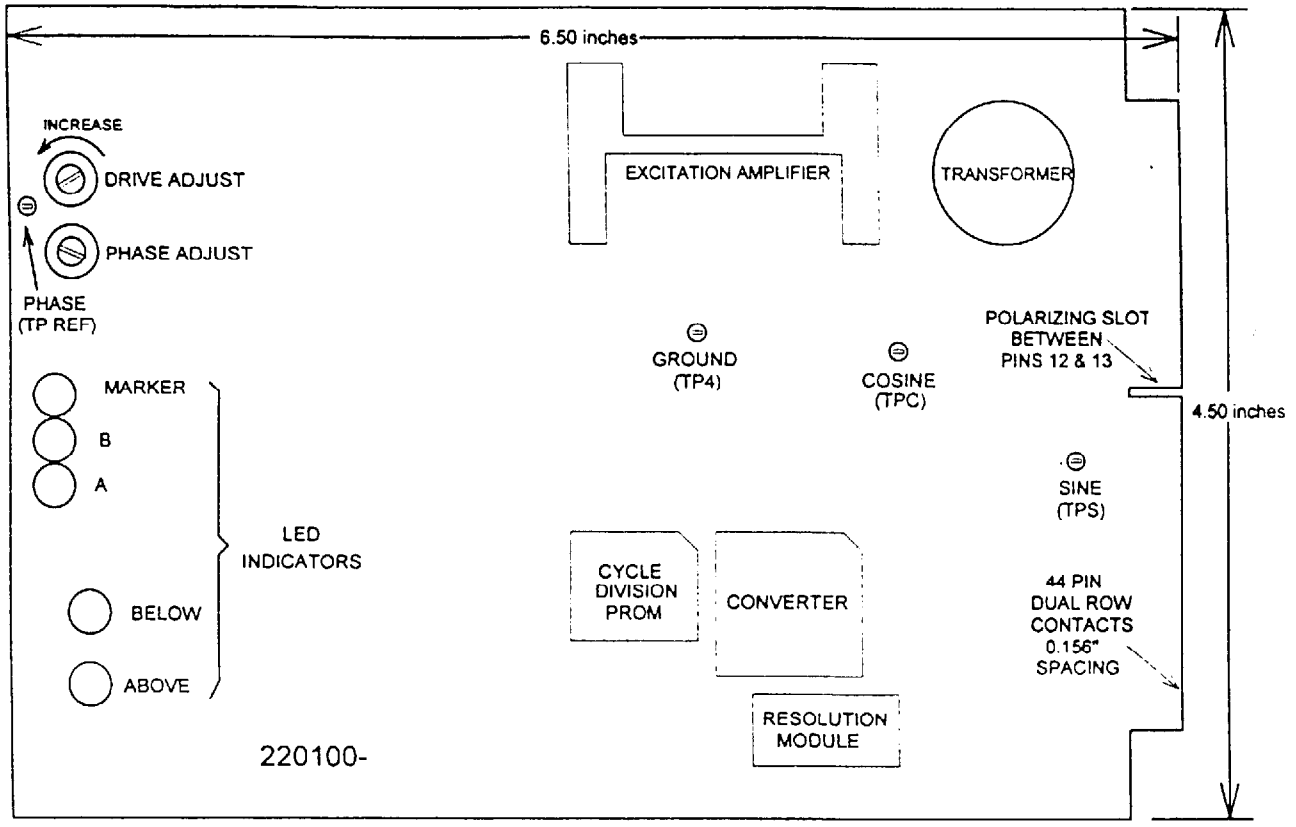


Figure 2. I/D Quad Converter Assembly Type 220100

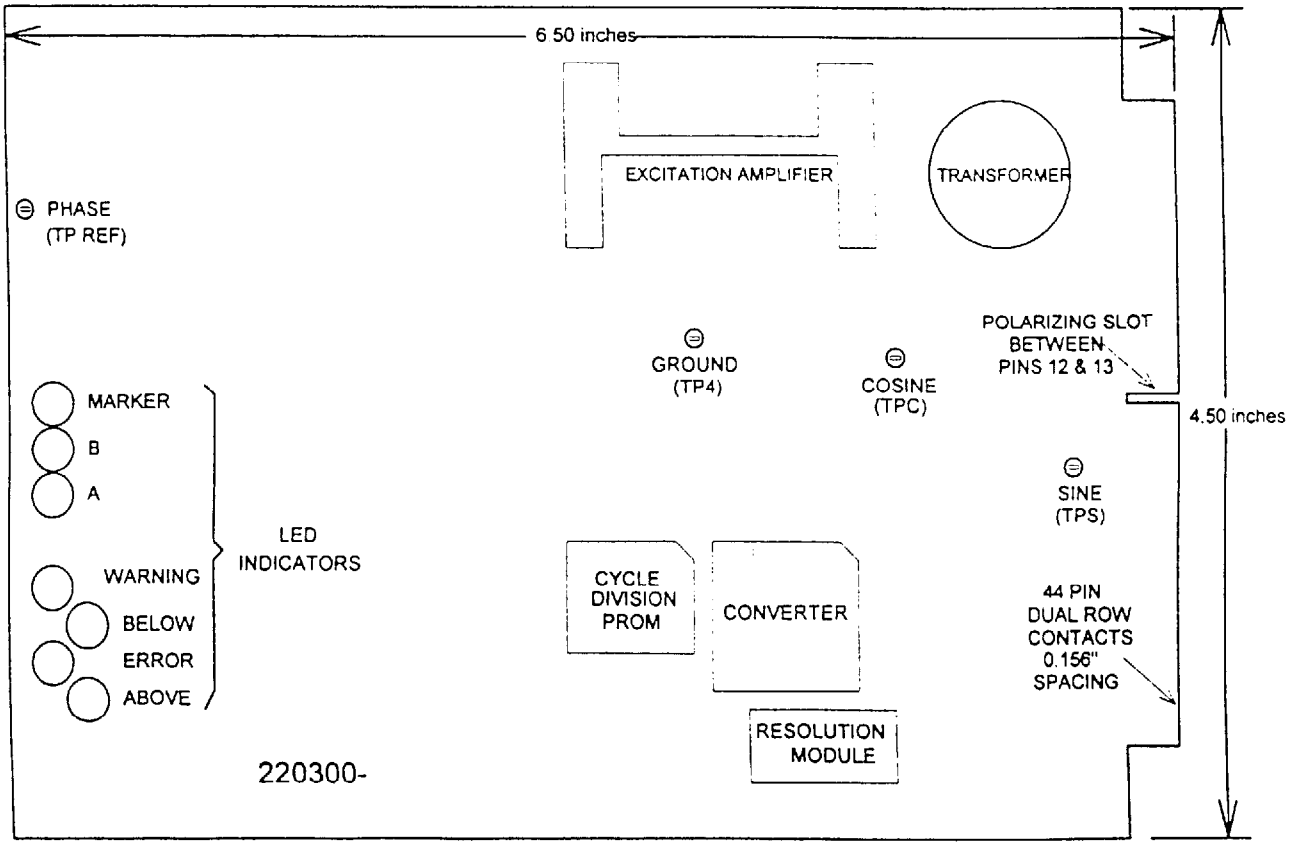
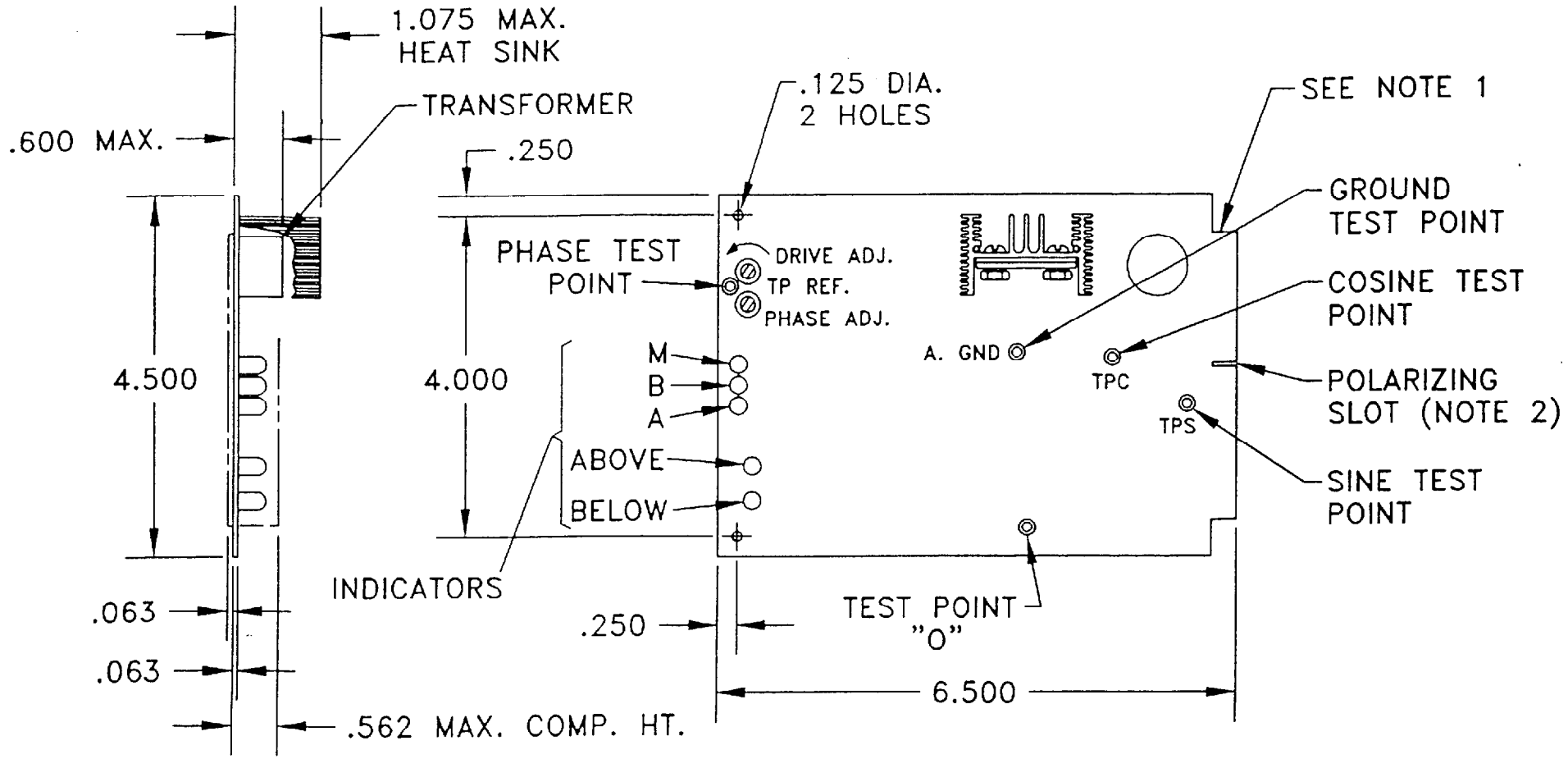


Figure 3. I/D Quad Converter Assembly Type 220300



NOTES:

1. FITS INDUSTRY STANDARD 22 POSITION DUAL READOUT CARD EDGE CONNECTOR WITH 0.156 IN. CONTACT SPACING, SUCH AS THE CINCH 50-44SN.
2. POLARIZING SLOT BETWEEN CONTACTS 12 & 13.

MATERIAL								
FINISH								
DRAWN RSG	1/20/98	RELEASED JTB	2/5/98					
MECH. ENG JTB	2/5/98					ITEM	DWG. NO.	REQ.
ELECT. ENG. BC	2/5/98	APPROX. SCALE	1/2	NEXT ASSEMBLY				

UNLESS OTHERWISE SPECIFIED FOLLOWING TOLERANCES APPLY
FRACTIONS | DECIMALS | ANGLES

FARRAND CONTROLS
DIVISION OF RUHLE COMPANIES, INC.
99 WALL STREET
VALHALLA, N.Y., U.S.A.

INFORMATION DWG
I/D QUAD CONVERTER
WITH 2S82

DWG SIZE A | 220100-I | SHEET 1 OF 2

REV	CHANGES	DATE CHECKED	DATE RELEASED
A	ISSUED	JTB 2/5/98	TLC 2-10-98

C74 USED ON 584

STANDARD 220100, 10KHz MODELS:

CYCLE DIVISION	220100 CATALOG NUMBER	CROSS REFERENCE		INTERNAL RESOLUTION (bits)
		TO 220300**	TO 219100	
32	220100-F120	220300-F120	219100-12	10
128	220100-F240	220300-F240	219100-24	12
256	220100-F110	220300-F110	219100-11	10
360	220100-F130	220300-F130	219100-13	10
500	220100-F140	220300-F140	219100-14	10
720	220100-F290	220300-F290	219100-29	12
1000	220100-F210	220300-F210	219100-21	12
1024	220100-F100	220300-F100	219100-10	10
2000	220100-F220	220300-F220	219100-22	12
2540	220100-F250	220300-F250	219100-71	12

CYCLE DIVISION	220100 CATALOG NUMBER	CROSS REFERENCE		INTERNAL RESOLUTION (bits)
		TO 220300**	TO 219100	
3600	220100-F230	220300-F230	219100-23	12
3600	220100-F330	220300-F330	219100-33	14
4000	220100-F320	220300-F320	219100-32	14
4096	220100-F200	220300-F200	219100-20	12
7200	220100-F340	220300-F340	219100-34	14
10,000	220100-F310	220300-F310	219100-31	14
16,384	220100-F300	220300-F300	219100-30	14
20,000	220100-F510	220300-F510	219100-51	16
65,536	220100-F500	220300-F500	219100-50	16

NOTES: 1. **THE 220300 MODEL HAS AUTOMATIC GAIN AND PHASE CORRECTION AND PROVIDES A LOSS OF SIGNAL OUTPUT.
2. INDUCTOSYN CYCLE DIVISION IS SPECIFIED FOR QUADRATURE DETECTION IN THE "X4" MODE.

DASH NUMBER: CYCLE DIVISION, EXCITATION FREQUENCY AND INTERNAL RESOLUTION ARE DETERMINED BY APPENDING A FIVE CHARACTER DASH NUMBER TO THE BASE CATALOG NUMBER AS SHOWN BELOW:

CATALOG NUMBER	FREQUENCY OR SPECIAL OPTION	INTERNAL RESOLUTION	CYCLE DIVISION (DIVIDE BY)	CONVERTER ACCURACY
220100-	X	X	XX	X
	F=10KHz	1=10 bit	ASSIGNED 2 DIGIT CODE	J OR NONE =8 ARC MIN
	A=17KHz	2=12 bit		
	C=2.4KHz	3 OR 4=14 bit		K=4 ARC MIN
		5 OR 6=16 bit		L=2 ARC MIN
		7, 8 OR 9=SPECIAL		

REFERENCES:
FOR FULL TECHNICAL SPECIFICATIONS REFER TO ENGINEERING REPORT ER19801.
FOR INSTALLATION INSTRUCTIONS REFER TO ENGINEERING REPORT ER19802.

AVAILABILITY:
1. FOR FREQUENCIES OTHER THAN 10KHz A NON RECURRING ENGINEERING CHARGE MAY APPLY.
2. PLEASE CONSULT THE FACTORY IF REQUIRED CYCLE DIVISION IS NOT LISTED.

REV	CHANGES	DATE CHECKED	DATE RELEASED
A	ISSUED	JTB 2/5/98	JLC

MATERIAL
FINISH
DRAWN RSG 1/31/98 RELEASED JTB 2/8/98
MECH. ENG. JTB 2/8/98
ELECT. ENG. BC 2/5/98 APPROX. SCALE
ITEM | DWG. NO. | REQ.
NEXT ASSEMBLY

UNLESS OTHERWISE SPECIFIED FOLLOWING TOLERANCES APPLY
FRACTIONS | DECIMALS | ANGLES

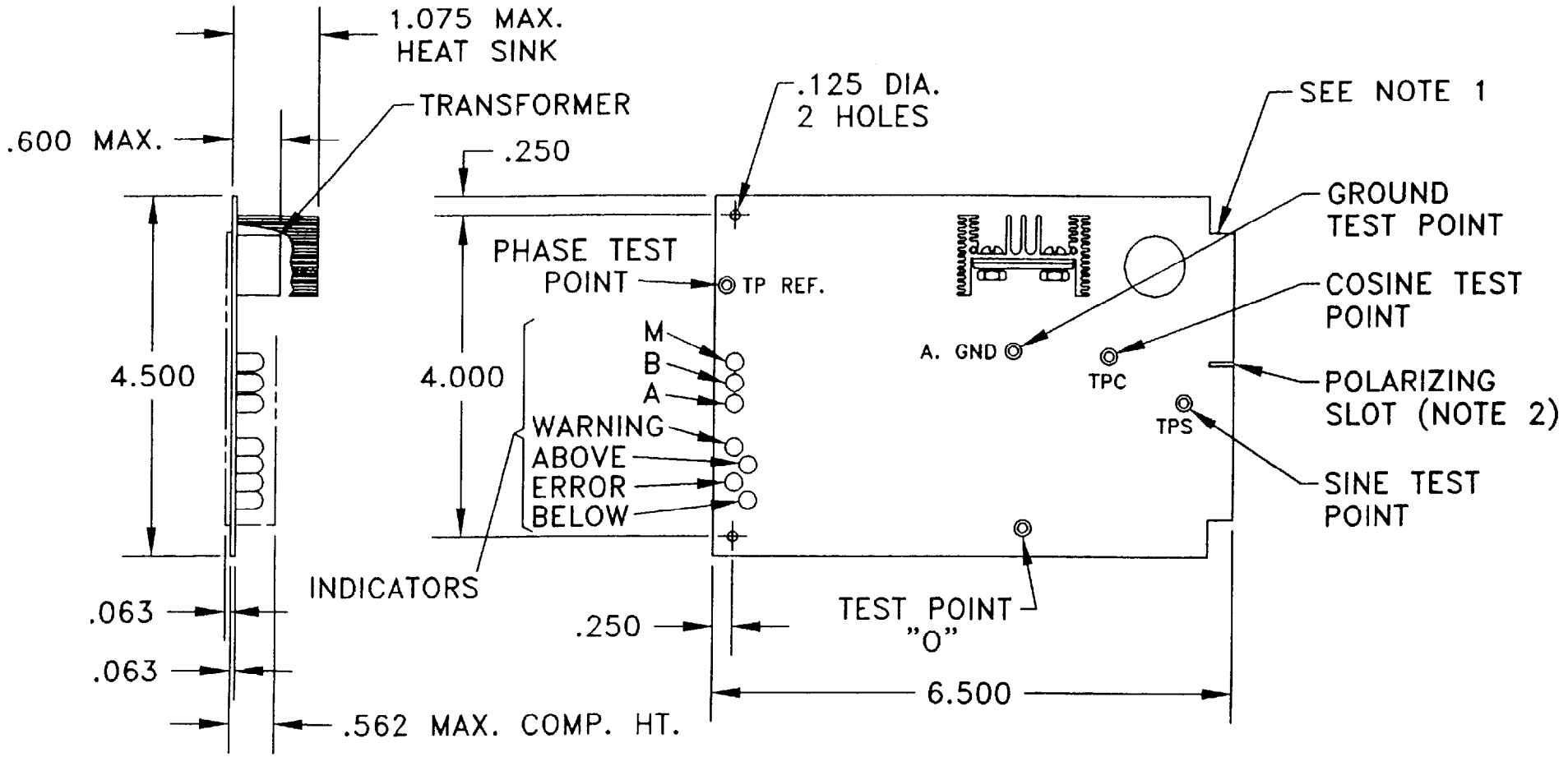
FARRAND CONTROLS
DIVISION OF RUHLE COMPANIES, INC.
99 WALL STREET
VALHALLA, N.Y., U.S.A.

INFORMATION DWG
I/D QUAD CONVERTER
WITH 2S82

DWG. SIZE A

220100-I
SHEET 2 OF 2

C74 USED ON 584



NOTES:
1. FITS INDUSTRY STANDARD 22 POSITION DUAL READOUT CARD EDGE CONNECTOR WITH 0.156 IN. CONTACT SPACING, SUCH AS THE CINCH 50-44SN.
2. POLARIZING SLOT BETWEEN CONTACTS 12 & 13.

MATERIAL							
FINISH							
DRAWN RSG	1/20/98	RELEASED JTB	2/8/98				
MECH. ENG JTB	1/29/98			ITEM	DWG. NO.	REQ.	
ELECT. ENG. BC	2/5/98	APPROX. SCALE	1/2	NEXT ASSEMBLY			

UNLESS OTHERWISE SPECIFIED FOLLOWING TOLERANCES APPLY
FRACTIONS | DECIMALS | ANGLES

FARRAND CONTROLS
DIVISION OF RUHLE COMPANIES, INC.
99 WALL STREET
VALHALLA, N.Y., U.S.A.

INFORMATION DWG
I/D QUAD CONVERTER WITH
2S82 & AUTO GAIN/PHASE ADJ.

DWG. SIZE A

220300-I
SHEET 1 OF 2

REV.	CHANGES	DATE CHECKED	DATE RELEASED
A	ISSUED	JTB 2/10/98	JLC. 2-10-98

C74 USED ON 584

NOTE:
THE DRAWING SHOWS A PARALLEL MOUNTING CONFIGURATION USING THE 220400 CONNECTOR BOARD.
FOR PERPENDICULAR MOUNTING USE THE 220400-1 BOARD.

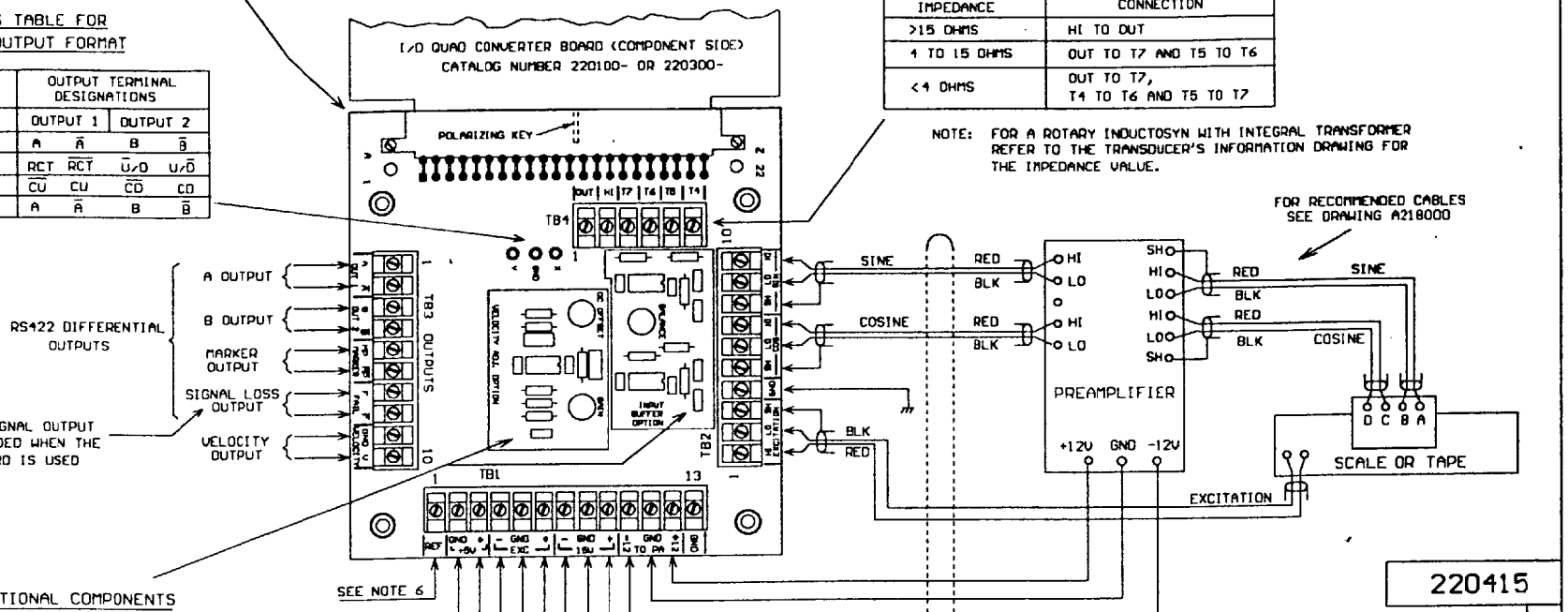
OPTIONS TABLE FOR DIGITAL OUTPUT FORMAT

CONTROL INPUT CONNECTION		OUTPUT TERMINAL DESIGNATIONS			
X	Y	OUTPUT 1		OUTPUT 2	
OPEN	OPEN	A	$\overline{A}$	B	$\overline{B}$
GND	OPEN	RCT	$\overline{RCT}$	U/D	$\overline{U/D}$
OPEN	GND	$\overline{CU}$	CU	$\overline{CD}$	CD
GND	GND	A	$\overline{A}$	B	$\overline{B}$

EXCITATION SUPPLY TERMINAL BLOCK HOOK UP TABLE

ROTOR OR SCALE IMPEDANCE	TERMINAL CONNECTION
>15 OHMS	HI TO OUT
4 TO 15 OHMS	OUT TO T7 AND T5 TO T6
<4 OHMS	OUT TO T7, T4 TO T6 AND T5 TO T7

NOTE: FOR A ROTARY INDUCTOSYN WITH INTEGRAL TRANSFORMER REFER TO THE TRANSDUCER'S INFORMATION DRAWING FOR THE IMPEDANCE VALUE.



NOTE:
A LOSS OF SIGNAL OUTPUT IS NOT PROVIDED WHEN THE 220100 BOARD IS USED

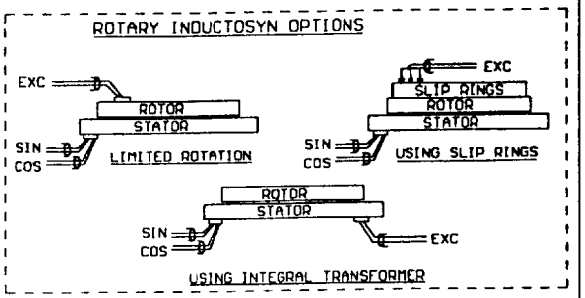
OPTIONAL COMPONENTS

1. INPUT BUFFER OPTION: PROVIDES SINE/COSINE BALANCE ADJUSTMENT AND DIFFERENTIAL INPUT CONNECTION.
2. VELOCITY ADJUST OPTION: PROVIDES GAIN AND DC OFFSET ADJUSTMENT FOR THE CONVERTER'S VELOCITY OUTPUT SIGNAL.
3. FOR CATALOG NUMBERS SEE DRAWING 220400-I

CABLE PART # 214458 RECOMMENDED FOR LONG CABLE RUNS

220415
B

ROTARY INDUCTOSYN OPTIONS



NOTES:

1. RUN TWO SETS OF +15V, -15V & GROUND LINES FROM THE POWER SUPPLY FOR EXCITATION AND COMPUTATION POWER AS SHOWN.
2. THE GROUNDS OF THE +5V & ± 15V POWER SUPPLIES MUST BE CONNECTED TOGETHER AS SHOWN.
3. POWER REQUIREMENTS:
   +5V ± 0.25V DC @ 500 mA
   +15V ± 0.25V DC @ 250 mA
   -15V ± 0.25V DC @ 250 mA *
   * NOTE: THIS IS THE DC CURRENT REQUIRED TO SUPPLY 250 mA RMS OF EXCITATION CURRENT.
4. WIRE ACCORDING TO DRAWING A218000. COLOR CODE IS SUGGESTED.
5. SUITABLE PREAMPLIFIERS ARE: 218891-, 219200-, 219594-
6. THE REFERENCE OUTPUT IS NOT NORMALLY USED. IT IS PROVIDED FOR THE CASE WHERE ONE I/O QUAD CONVERTER BOARD IS USED TO PROVIDE EXCITATION POWER TO TWO TRANSDUCERS.

GND +5V — +5V POWER SUPPLY — SEE NOTE 2
GND +15V -15V — +15V, -15V POWER SUPPLY — SEE NOTE 1

REV.	CHANGES	DATE CHECKED	DATE RELEASED
B	+ & - 15V PSU WIRING CORRECTED		
A	ISSUED	2-10-98	2-10-98

MATERIAL							
FINISH							
DRAWN	BC	1-21-98	APPROVED	JTB	2-10-98		
MECH ENG.	JTB	2-10-98	RELEASED	JLC	2-10-98	ITEM	DWG. NO. / REQ.
ELECT. ENG.	BC	2-6-98	APPROX. SCALE	1X		NEXT ASSEMBLY	

UNLESS OTHERWISE SPECIFIED FOLLOWING TOLERANCE APPLY
FRACTIONS | DECIMALS | ANGLES

FARRAND CONTROLS
DIVISION OF RUHLE COMPANIES INC.
99 WALL STREET
VALHALLA, N.Y., U.S.A.

HOOK UP DWG. - CONNECTOR BD. FOR 220100 AND 220300 I/O QUAD BOARDS

DWG. SIZE C — 220415

CAT USED ON 584

STANDARD 220300, 10KHz MODELS:

CYCLE DIVISION	220300 CATALOG NUMBER	CROSS REFERENCE TO 220100**	INTERNAL RESOLUTION (bits)
32	220300-F120	220100-F120	10
128	220300-F240	220100-F240	12
256	220300-F110	220100-F110	10
360	220300-F130	220100-F130	10
500	220300-F140	220100-F140	10
720	220300-F290	220100-F290	12
1000	220300-F210	220100-F210	12
1024	220300-F100	220100-F100	10
2000	220300-F220	220100-F220	12
2540	220300-F250	220100-F250	12

CYCLE DIVISION	220300 CATALOG NUMBER	CROSS REFERENCE TO 220100**	INTERNAL RESOLUTION (bits)
3600	220300-F230	220100-F230	12
3600	220300-F330	220100-F330	14
4000	220300-F320	220100-F320	14
4096	220300-F200	220100-F200	12
7200	220300-F340	220100-F340	14
10,000	220300-F310	220100-F310	14
16,384	220300-F300	220100-F300	14
20,000	220300-F510	220100-F510	16
65,536	220300-F500	220100-F500	16

NOTES: 1. **THE 220100 MODEL DOES NOT PROVIDE AUTOMATIC GAIN AND PHASE CORRECTION OR A LOSS OF SIGNAL OUTPUT.
2. INDUCTOSYN CYCLE DIVISION IS SPECIFIED FOR QUADRATURE DETECTION IN THE "X4" MODE.

DASH NUMBER: CYCLE DIVISION, EXCITATION FREQUENCY AND INTERNAL RESOLUTION ARE DETERMINED BY APPENDING A FIVE CHARACTER DASH NUMBER TO THE BASE CATALOG NUMBER AS SHOWN BELOW:

CATALOG NUMBER	FREQUENCY OR SPECIAL OPTION	INTERNAL RESOLUTION	CYCLE DIVISION (DIVIDE BY)	CONVERTER ACCURACY
220300-	X	X	XX	X
	F=10KHz	1=10 bit	ASSIGNED 2 DIGIT CODE	J OR NONE =8 ARC MIN
		2=12 bit		
		3 OR 4=14 bit		K=4 ARC MIN
		5 OR 6=16 bit		L=2 ARC MIN
		7, 8 OR 9=SPECIAL		

REFERENCES:
FOR FULL TECHNICAL SPECIFICATIONS REFER TO ENGINEERING REPORT ER19801.
FOR INSTALLATION INSTRUCTIONS REFER TO ENGINEERING REPORT ER19802.

AVAILABILITY:
1. FOR FREQUENCIES OTHER THAN 10KHz A NON RECURRING ENGINEERING CHARGE MAY APPLY.
2. PLEASE CONSULT THE FACTORY IF REQUIRED CYCLE DIVISION IS NOT LISTED.

REV.	CHANGES	DATE CHECKED	DATE RELEASED
A	ISSUED	JTB 2/10/98	JLC 2-10-98

MATERIAL
FINISH
DRAWN RSG 1/31/98 RELEASED JTB 2/10/98
MECH. ENG. JTB 2/10/98
ELECT. ENG. BC 2/5/98 APPROX. SCALE
ITEM | DWG. NO. | REQ. | NEXT ASSEMBLY

UNLESS OTHERWISE SPECIFIED FOLLOWING TOLERANCES APPLY
FRACTIONS | DECIMALS | ANGLES

FARRAND CONTROLS
DIVISION OF RUHLE COMPANIES, INC.
99 WALL STREET
VALHALLA, N.Y., U.S.A.

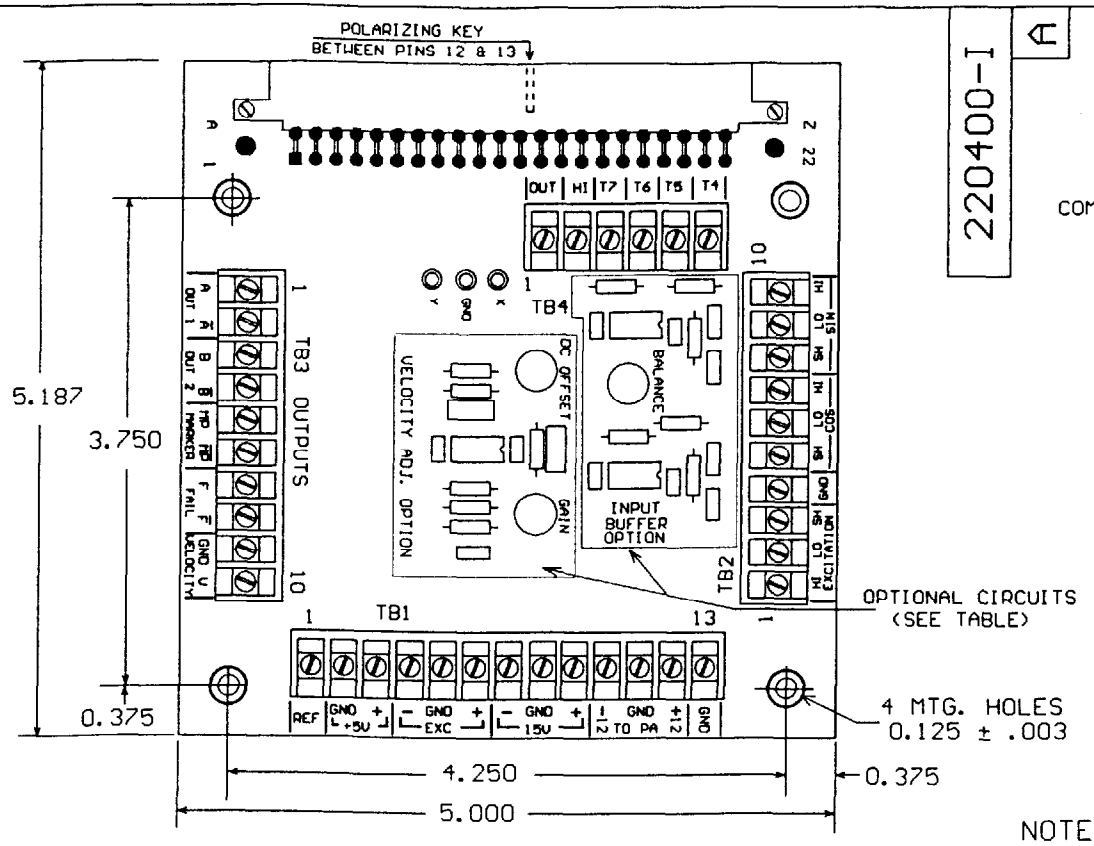
INFORMATION DWG
I/D QUAD CONVERTER WITH 2S82 & AUTO GAIN/PHASE ADJ.

DWG. SIZE A

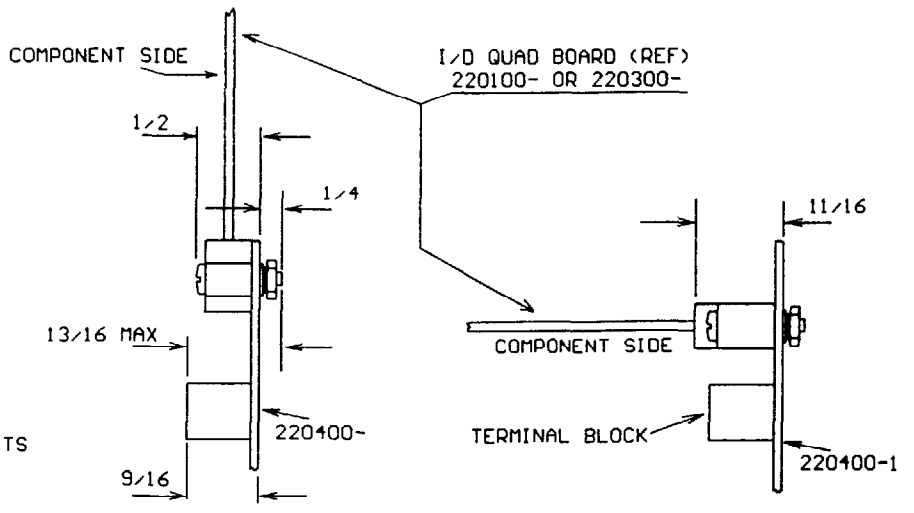
220300-I
SHEET 2 OF 2

C74 USED ON 584

220400-I A



MOUNTING OPTIONS



220400
PARALLEL MOUNT OPTION
(RIGHT ANGLE CONNECTOR)

220400-1
PERPENDICULAR MOUNT OPTION
(FLUSH MOUNT CONNECTOR)

DASH NUMBER	I/O QUAD BD. ORIENTATION	INPUT BUFFER OPTION	VELOCITY ADJUST OPTION
-	PARALLEL	NO	NO
- B	PARALLEL	YES	YES
- V	PARALLEL	NO	YES
- 1	PERPENDICULAR	NO	NO
- 1V	PERPENDICULAR	NO	YES
- 1B	PERPENDICULAR	YES	YES

NOTES:

1. FOR HOOK UP SEE DRAWING C220415
2. FOR FURTHER INFORMATION ON BUFFER & VELOCITY OPTIONS REFER TO ENGINEERING REPORT ER19801

REV.	LET.	CHANGES	DATE CHECKED	DATE RELEASED
A		ISSUED		

MATERIAL

FINISH

DRAWN	BC	2/5/98	APPROVED				
MECH. ENG.	JE	2/8/98	RELEASED	JLC	2-10-98	ITEM	DWG. NO.	REQ.
ELECT. ENG.	BC	2/6/98	APPROX. SCALE	1X		NEXT ASSEMBLY	

UNLESS OTHERWISE SPECIFIED FOLLOWING TOLERANCES APPLY
FRACTIONS | DECIMALS | ANGLES

FARRAND CONTROLS
DIVISION OF RUHLE COMPANIES INC.
99 WALL STREET
VALHALLA, N.Y., U.S.A.

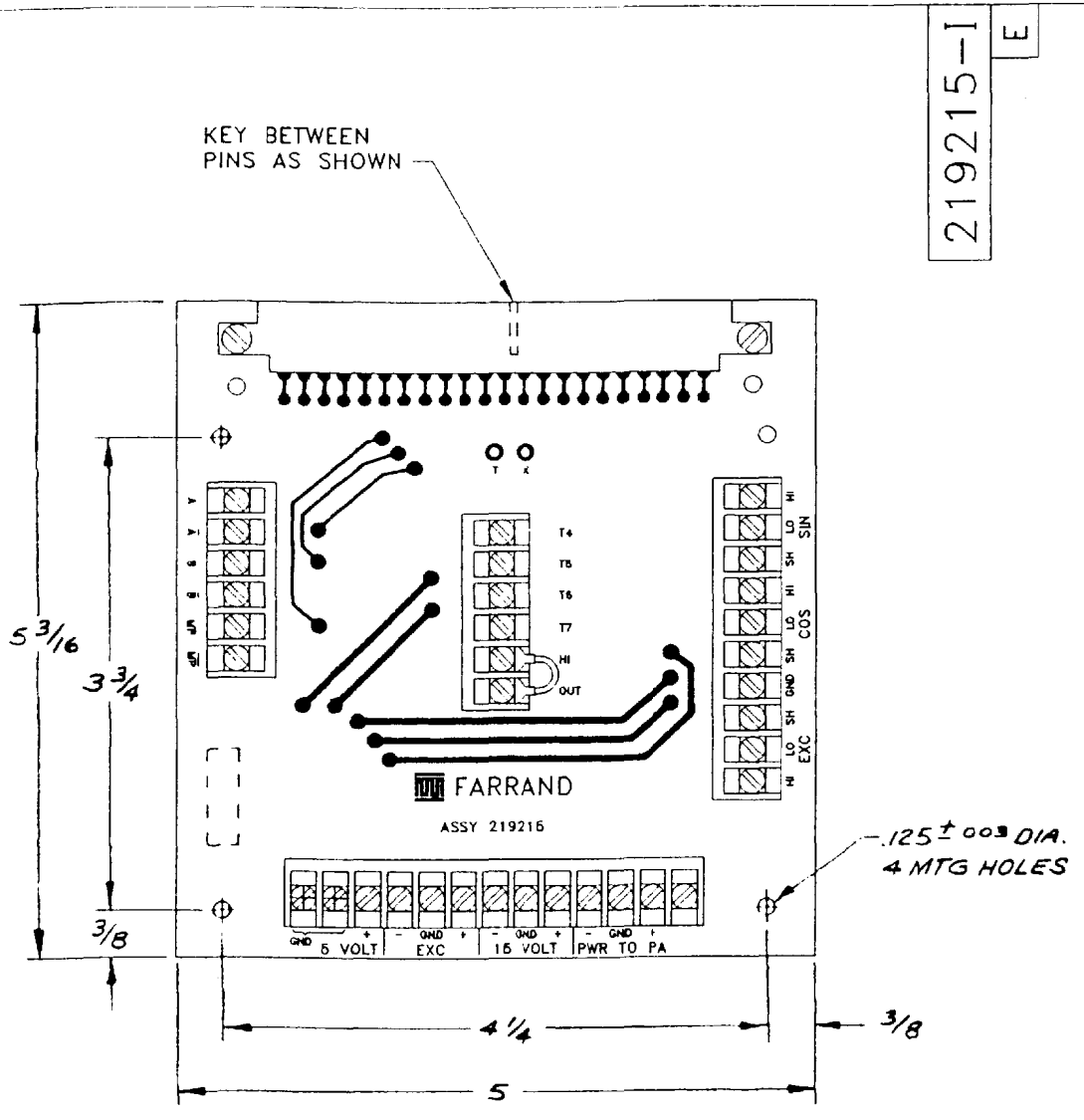
INFORMATION DRAWING
CONNECTOR BOARD
FOR 220100 AND 220300 BDS.

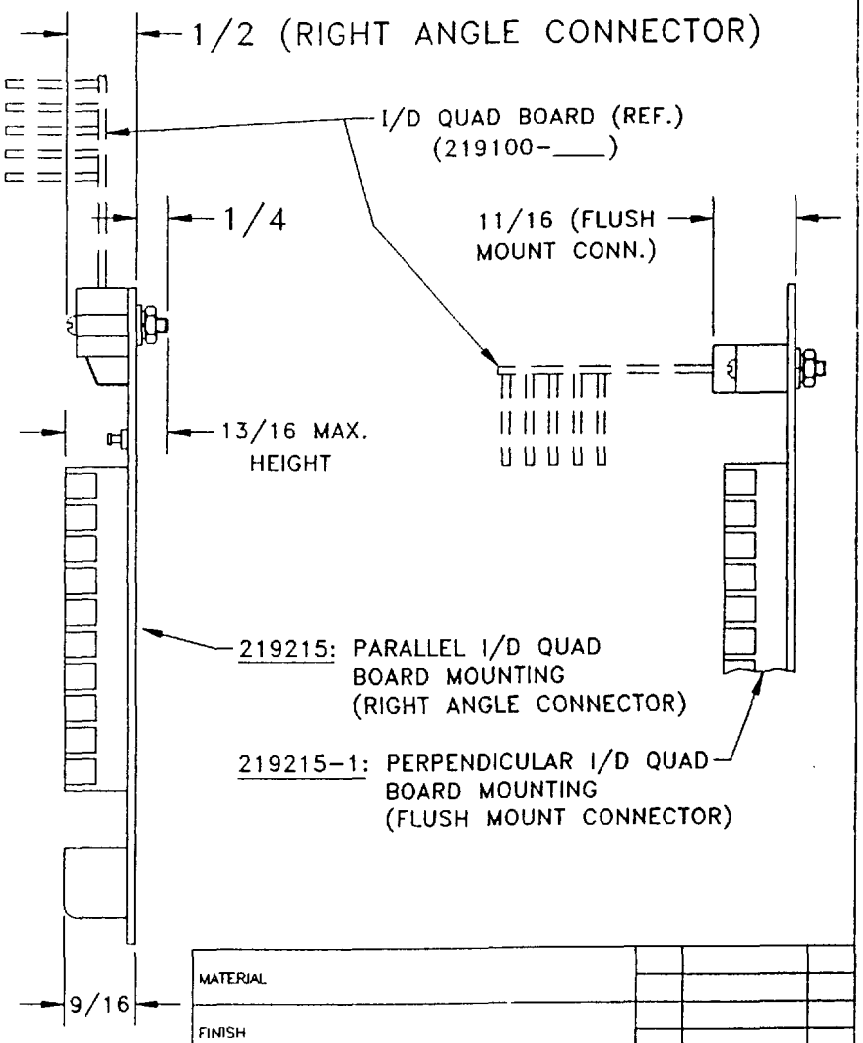
DWG. SIZE B

220400-I

C74 USED ON 584

219215-1 E





NOTES
1. FOR HOOK UP SEE DWG C219216.

LET.	NO	CHANGES	DATE	C'K'D
E		CHANGED DESCRIPTION OF 219215 & 219215-1	5-19-95	NC
D		PICTURE CHANGED TO SHOW BOTH FLUSH & RIGHT ANGLE CONNECTORS	11/3/94	
C		ROTATED CENTER TERMINAL BLOCK		

MATERIAL							
FINISH							
DRAWN RSG	7/13/94	APPROVED					
CHECKED		RELEASED PAV	5-18-95	ITEM	DWG. NO.	REQ.	
PROJ ENG		APPROX. SCALE	1/1		NEXT ASSEMBLY		

UNLESS OTHERWISE SPECIFIED FOLLOWING TOLERANCES APPLY
FRACTIONS | DECIMALS | ANGLES

FARRAND CONTROLS
DIVISION OF RUHLE COMPANIES, INC.
99 WALL STREET
VALHALLA, N.Y., U.S.A.

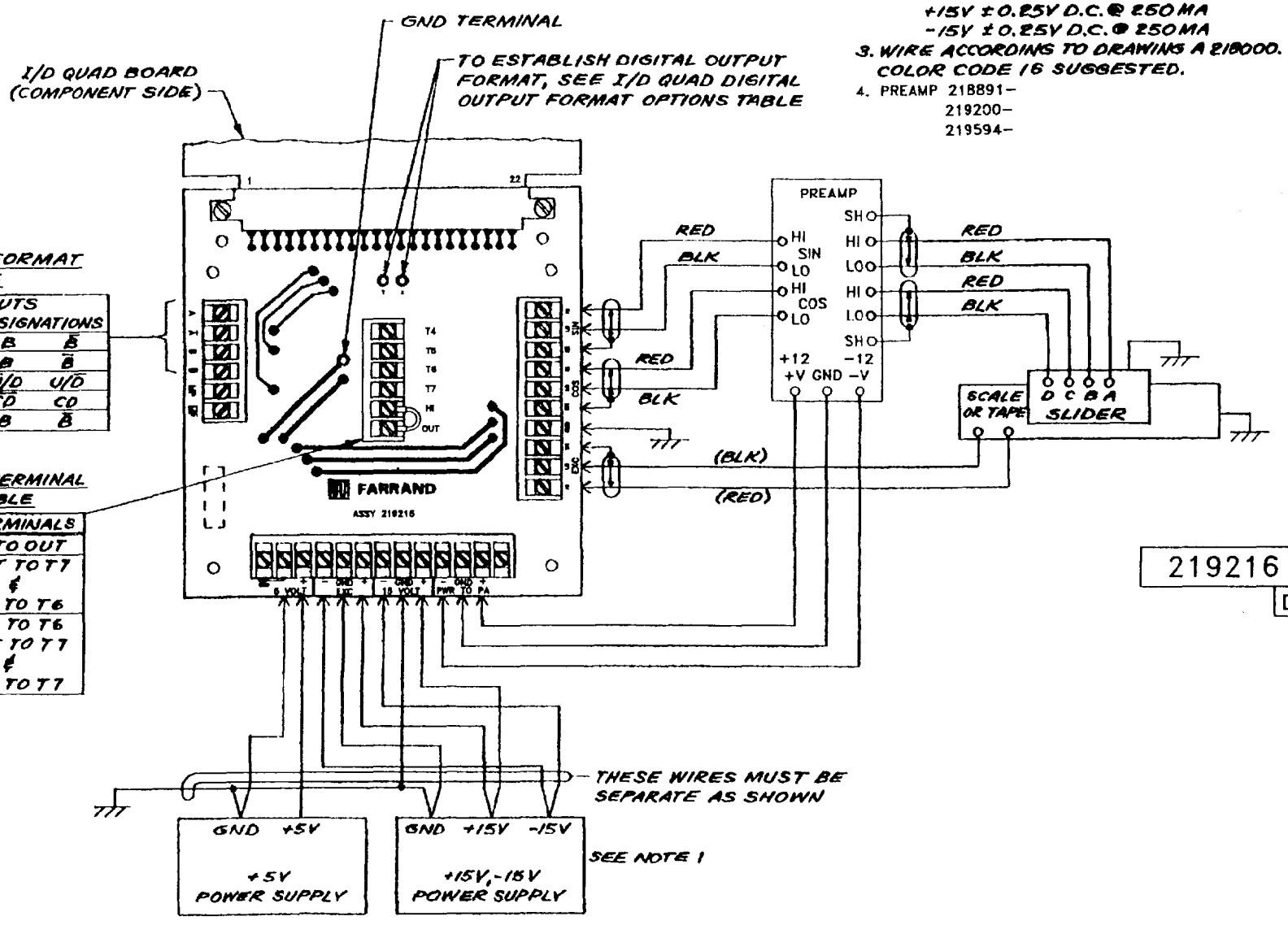
INFO DWG-I/D QUAD CONNECTOR BOARD

DWG SIZE B

219215-I

C74 USED ON 584

NOTES:
1. SUPPLY TWO SETS OF +15V, -15V & GROUND LINES FROM POWER SUPPLY FOR EXCITATION & COMPUTATION POWER.
2. POWER REQUIREMENTS:
   +5V ± 0.25V D.C. @ 1.0A
   +15V ± 0.25V D.C. @ 250MA
   -15V ± 0.25V D.C. @ 250MA
3. WIRE ACCORDING TO DRAWING A 218000. COLOR CODE 16 SUGGESTED.
4. PREAMP 218891-
   219200-
   219594-



I/D QUAD DIGITAL OUTPUT FORMAT OPTIONS TABLE

CONTROL INPUTS TURRET TERMINALS		OUTPUTS TERMINAL DESIGNATIONS			
X	Y	A	$\bar{A}$	B	$\bar{B}$
GND	GND	A	$\bar{A}$	B	$\bar{B}$
GND	OPEN	RCT	$\overline{RCT}$	U/D	$\overline{U/D}$
OPEN	GND	CU	$\overline{CU}$	CD	$\overline{CD}$
OPEN	OPEN	A	$\bar{A}$	B	$\bar{B}$

EXCITATION SUPPLY TERMINAL BLOCK HOOK-UP TABLE

ROTOR OR SCALE	TERMINALS
>15Ω	HI TO OUT
4Ω TO 15Ω	OUT TO T7 & T5 TO T6
<4Ω	T4 TO T6 OUT TO T7 & T5 TO T7

219216
D

LET	NO	CHANGES	DATE	CK'D
D		ROTATED CENTER TERMINAL BLOCK		
C		PREAMP SECTION REVISED		

MATERIAL
FINISH
DRAWN RSG 12/21/93 APPROVED
CHECKED RELEASED PAV
PROJ. ENG. APPROX. SCALE —— NEXT ASSEMBLY

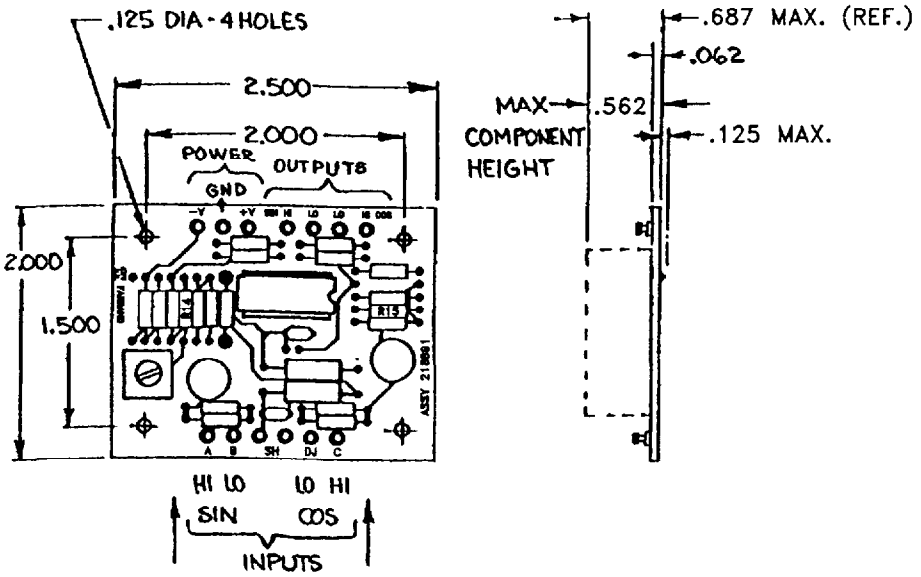
FARRAND CONTROLS
DIVISION OF RUHLE COMPANIES, INC.
99 WALL STREET
VALHALLA, N.Y., U.S.A.

I/D QUAD CONNECTOR BOARD HOOK-UP

DWG. SIZE C 219216

218891-I G

NOTES:
1. R14 & R15 ARE GAIN RESISTORS.



DASH NO.	GAIN ±10%	POWER	
−1 &−11	5600	+V, −V	NOT FOR CVU CONVERTER
−2 &−12	3000		
−3 &−13	1250		
−4 &−14	520	+V, GND	USE WITH CVU CONVERTER
−5 &−15	286		
−6 &−16	136		
−7 &−17	520	+V, −V	NOT FOR CVU CONVERTER
−8 &−18	286		
−9 &−19	136		

OUTPUT
SIGNAL − 2.5 VOLTS RMS MAX
D.C. COMPONENT − LESS THAN 50 mV

GAIN
SIN, ADJUSTABLE ± 5% OF COS,
COS, SEE TABLE

INPUT IMPEDANCE
GREATER THAN 18 OHMS

POWER SUPPLY, +V & −V
+V 11 TO 16V DC 25 mA
−V −11 TO −16V DC. 25 mA
MAGNITUDE +V AND −V MUST NOT DIFFER BY MORE THAN 1 VOLT.

POWER SUPPLY, +V, GND
11 TO 16 Vdc 25mA

TEMPERATURE RANGE
0° TO 70° C −1 TO −9
−55° C TO 125° C −11 TO −19

REFERENCE:
HOOK-UP DWG. 218918 & SCHEMATIC 218929

LET.	NO.	CHANGES	DATE	C'K'D
G		REVISED & REDRAWN	11-19-96	NC

MATERIAL							
FINISH							
DRAWN RSG	3/30/93	APPROVED JTB	10-31-96				
CHECKED		RELEASED PAV	4/25/93	ITEM	DWG. NO.	REQ.	
PROJ. ENG.		APPROX. SCALE	———	NEXT ASSEMBLY			

UNLESS OTHERWISE SPECIFIED FOLLOWING TOLERANCES APPLY
FRACTIONS | DECIMALS | ANGLES

FARRAND CONTROLS
DIVISION OF RUHLE COMPANIES, INC.
99 WALL STREET
VALHALLA, N.Y., U.S.A.

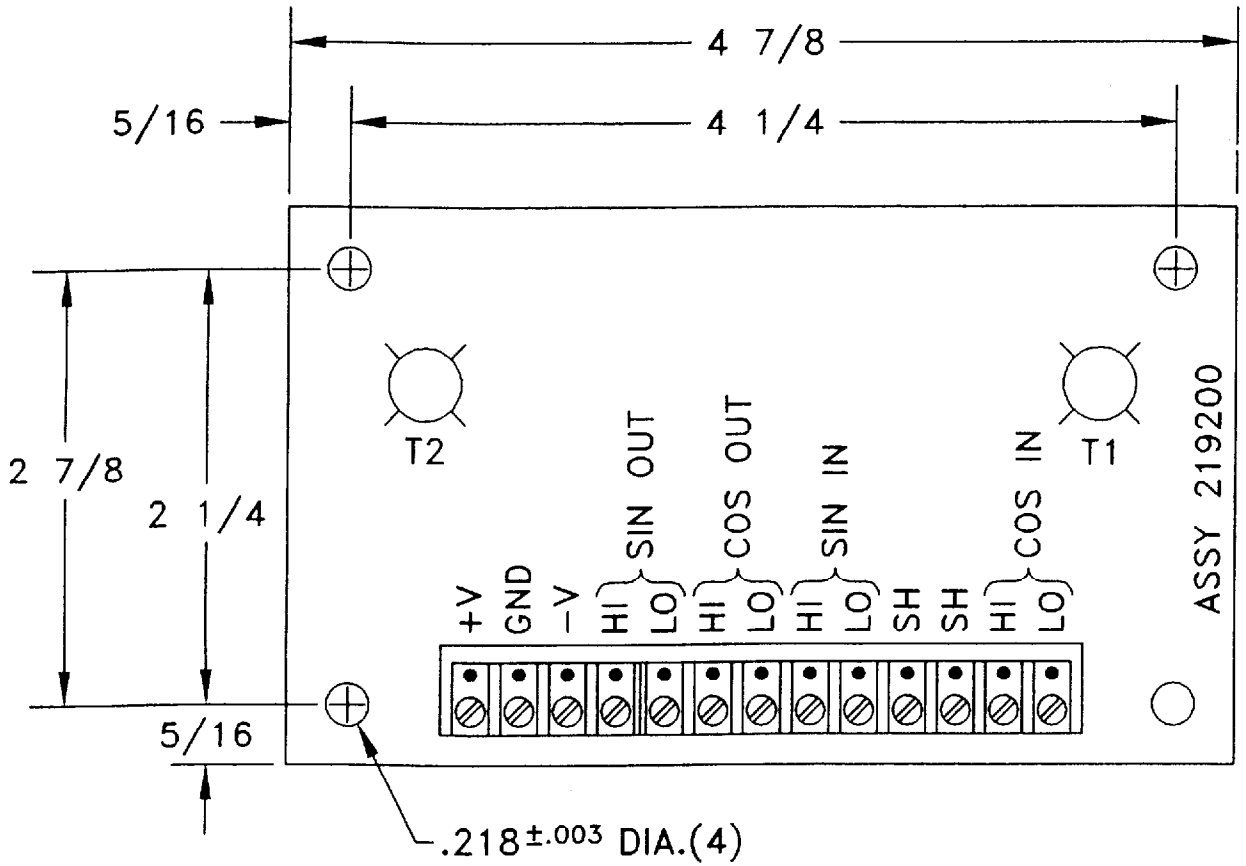
INFO DWG TWO CHANNEL PRE-AMP BOARD ASSY 218891

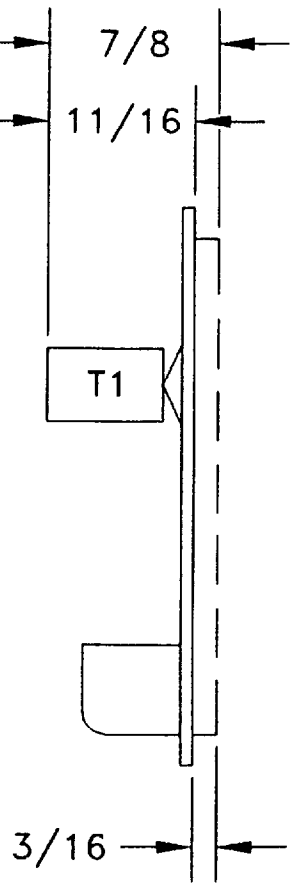
DWG. SIZE B

218891-I

C74 USED ON 584

219200-I E





DASH NO.	GAIN ±10%
-1	5600
-2	3000
-3	1250
-4	520
-5	286
-6	136
-7	UNITY
-8	286
-9	136
-10	520

NOTES:
1. -4,-5 & -6 ARE DESIGNED FOR USE WITH MODEL CVU CONVERTER

GAIN SINE CHANNEL-ADJUSTABLE ±5% OF COSINE,
COSINE CHANNEL-SEE TABLE.
OUTPUT SIGNAL-2.5V RMS MAX.
DC COMPONENT-LESS THAN 50mV.
POWER +11 TO +16V 25 mA AND -11 TO -16V 25mA
MAGNITUDE OF PLUS AND MINUS VOLTAGES NOT TO DIFFER BY MORE THAN 1 VOLT. EXCEPT -4, -5 & -6 +11 TO +16V 25mA & GND.
TEMPERATURE RANGE 0° TO 70° C.

REFERENCE: HOOK-UP DWG. 219159,
SCHEM. 219201

LET.	NO.	CHANGES	DATE	C'K'D
E		REVISED POWER INFORMATION	11/21/96	NC

MATERIAL							
FINISH							
DRAWN RSG	4/7/95	APPROVED JHB	11/20/96				
CHECKED		RELEASED PAV	4/7/95	ITEM	DWG. NO.	REQ.	
PROJ. ENG.		APPROX. SCALE	1/1	NEXT ASSEMBLY			

UNLESS OTHERWISE SPECIFIED FOLLOWING TOLERANCES APPLY
FRACTIONS | DECIMALS | ANGLES

FARRAND CONTROLS
DIVISION OF RUHLE COMPANIES, INC.
99 WALL STREET
VALHALLA, N.Y., U.S.A.

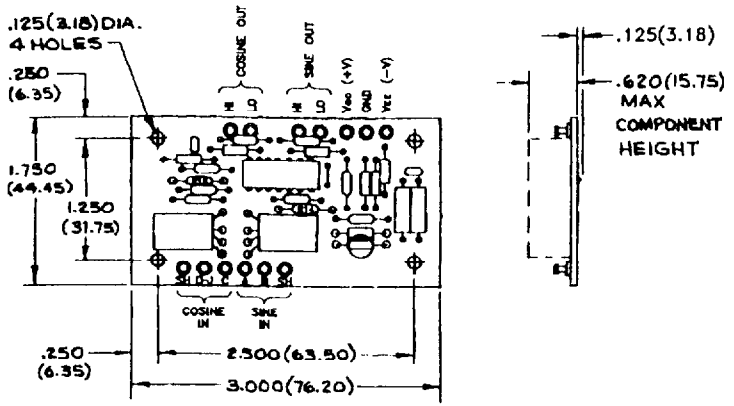
INFORMATION DRAWING
DUAL CHANNEL PREAMP

DWG. SIZE A

219200-I

C74 USED ON 584

NOTES:
1. R14 & R15 ARE GAIN RESISTORS.
2. -31 THRU -39 ARE FOR SYSTEMS WHERE THE BALANCE ADJUSTMENT IS PROVIDED ON A REMOTE BUFFER AMPLIFIER.



OUTPUT
SIGNAL-2.5 VOLTS RMS MAX.
D.C. COMPONENT-LESS THAN 50 mV

GAIN, ADJUSTABLE BALANCE
SIN, ADJUSTABLE ±5% OF COS, COS, SEE TABLE

GAIN, FIXED BALANCE
SIN & COS-SEE TABLE

INPUT IMPEDANCE
GREATER THAN 18 OHMS AT 10 KHZ

TEMPERATURE RANGE
-55° TO +125° C

1. POWER SUPPLY, +V, -V VERSION
+V 11 TO 16 VDC 25 mA
-V -11 TO -16 VDC 25 mA
MAGNITUDE +V AND -V MUST NOT DIFFER BY MORE THAN 1 VOLT.

2. SINGLE SUPPLY (CVU) VERSION
+V 11 TO 16 VDC 25 mA
-V NOT CONNECTED

CHANNEL BALANCE METHOD	DASH NUMBER: POTENTIOMETER	PRECISION FACTORY SELECTED RESISTORS	FIXED RESISITORS NOT TRIMMED FOR PRECISION BALANCE	GAIN ±10%	POWER	
	-1	-11	-31	5600	+V, -V	NOT FOR CVU CONVERTER
	-2	-12	-32	3000		
	-3	-13	-33	1250		
	-1C	-11C	-31C	5600	+V, GND	USE WITH CVU CONVERTER
	-2C	-12C	-32C	3000		
	-3C	-13C	-33C	1250		
	-4	-14	-34	520		
	-5	-15	-35	286		
	-6	-16	-36	136		
	-7	-17	-37	520	+V, -V	NOT FOR CVU CONVERTER
	-8	-18	-38	286		
	-9	-19	-39	136		

219594-I
D

REFERENCE:
HOOK-UP DWG. 218918 & SCHEMATICS 219596 & 219596-3X

REV	CHANGES	DATE CHECKED	DATE RELEASED
D	CHANGED DASH NO. CHART & POWER SUPPLY INFORMATION & TEMP. RANGE		
C	REVISED & REDRAWN	11/18/88	

MATERIAL
FINISH
DRAWN RSG 3/30/83 RELEASED JTB 10/31/88
MECH. ENG.
ELECT. ENG.
APPROX. SCALE
NEXT ASSEMBLY

UNLESS OTHERWISE SPECIFIED FOLLOWING TOLERANCES APPLY
FRACTIONS DECIMALS ANGLES

FARRAND CONTROLS
DIVISION OF RUHLE COMPANIES, INC.
99 WALL STREET
VALHALLA, N.Y., U.S.A.

INFO DWG TWO CHANNEL PREAMP BOARD ASSY

DWG. SIZE C

219594-I

A. RECOMMENDED WIRING TECHNIQUES FOR INDUCTOSYN® TRANSDUCERS

In order to minimize undesired coupling, the following wiring techniques should be employed. When these recommendations are properly executed, the full accuracy of the Inductosyn® system can be realized.

1. Wiring From Transducer To Preamplifier (or Balance Board if used)

1.1 Cable: Wire each of the three transducer signal leads (sine, cosine & excitation/error) using a twisted pair, electrostatically shielded cable. The three shields must be electrically isolated from each other and the cable should have a tight twist of at least 4 turns per inch - an "audio twist" is not satisfactory. A list of suitable cables is provided in section B.

1.2 Shielding: Carry each shield independently through connectors and terminal strips and ground at one point in the system.

1.3 Cable Separation: Separate the sine and cosine cables from the excitation/error cable by at least one inch. If this is not possible, enclose all three cables in separate magnetic shields. It is not necessary to ground the magnetic shields but if the shields are grounded, care must be taken to avoid ground loops. A list of magnetic shields is provided in section C.
Note: Magnetic shielding, in addition to preventing cyclic errors caused by cross coupling, will also protect against interference from external low level magnetic fields.

1.4 Use of Connectors: Take care in the location of leads passing through a connector or junction box. Often overlooked is the fact that most connectors consist of unshielded parallel connecting pins. Care must be taken to isolate the pairs of transducer signal wires from each other and from any other wires carrying signals of the same frequency. Since electromagnetic coupling is the major source of error, the selected pair pins should be as close together as possible - if necessary, co-axial connector pins may be used.
It is recommended that the excitation/error cable is run in a separate connector from the sine and cosine cables. However, this is not necessary if the pairs of pins are spaced one or more inches apart.

1.5 Wiring Details:
a. For all twisted pairs, maintain the twist to within 1/4 inch of all connectors and terminal boards.
b. Do not strip shields back more than 3/4 inch at any connector or terminal board.
c. If two or three leads pass through a small hole in a magnetic material protect them with individual magnetic shields.

2. Wiring From Preamplifier (or Balance Board if used) to the Converter

After amplification, cross coupling between cables is not as critical as for the low level transducer signals, however, the same general rules apply. Cables should be tightly twisted and electrostatically shielded as specified above, but additional magnetic shielding is not necessary unless protection is required from high levels of external radiation. In connectors, the locations of the pairs of pins for the three twisted pairs should still be chosen to minimize cross coupling but the spacing between pairs can be closer than the one inch specified above for the transducer to preamplifier cables.

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B. RECOMMENDED CABLES

• Between Transducer and Preamplifier (or balance board if used)

1. Farrand P/N 216858 - recommended for use where cable diameter is not a restriction.
   Specification: Two conductor shielded cable, 22 AWG with PVC insulation.
   Conductors - red & black, twisted together with a nominal lay of 4 turns per inch.
   Shield - braided copper providing 85% coverage.
   Outer jacket - gray PVC. Temperature range -54°C to 105 °C. Nominal O.D. is 0.165".

2. Farrand P/N 219288 - increased flexibility and smaller O.D. than P/N 216858.
   Specification: Two conductor shielded cable, 24 AWG with PVC insulation.
   Conductors - red & black, twisted together with a nominal lay of 4 turns per inch.
   Shield - 38 AWG tinned copper spiral shield.
   Outer jacket - white PVC. Temperature range -54°C to 105 °C. Nominal O.D. is 0.130".

3. Farrand P/N 77830237 - for use where a small wire with high flexibility is required
   Specification: Two conductor shielded cable, 29 AWG with silicon insulation.
   Conductors - white & grey, twisted together with a nominal lay of 4 turns per inch.
   Shield - tinned copper spiral shield..
   Outer jacket - dark gray silicon. Temperature range -65°C to 200 °C. Nominal O.D. is 0.103".

• Between Preamplifier (or balance board if used) and the Converter

1. Farrand P/N 214458 - this is a single, 11 conductor cable with the following specification:
   - Three twisted , shielded insulated pairs, 24 AWG, 19/36 tinned copper - red and black twisted together with a nominal lay of 4 turns per inch.
   - Four single wires, 24 AWG, tinned copper - red, black, brown and orange.
   - One single wire, 16 AWG, tinned copper - green.
   - Insulation: PVC.
   - Overall braided shield providing 85% coverage.
   - Outer jacket - black PVC with nominal O.D. of 0.460".
   - Maximum temperature rating: 105 °C.

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C. RECOMMENDED MAGNETIC SHIELDING

If mechanical protection is desired, the cables should be encased in galvanized magnetic shield tubing, such as Anaconda part number DSL3 made by Anaconda American Brass Co. and available from electrical distributors.

If both mechanical protection and flexibility are important magnetic spring shielding may be used. This is available in a wide range of sizes as listed below.

If dampness is present, "Greenfield" conduit cover, plain or vinyl covered, may be used.

Note: The excitation/error signal cable from the transducer to the preamplifier should not be run in the same tubing as the sine and cosine cables unless it is individually shielded with a magnetic spring shield or tubing.

Listing of Standard Magnetic Spring Shields Available from Farrand

Farrand Part No.	Spring Dimensions		Wire Size	
	Nominal I.D. in inches	Nominal O.D. in inches	Wire Gauge	Wire Diameter in inches
209969-AXXX	0.075	0.095	30	0.0100
209969-BXXX	0.125	0.145	30	0.0100
209969-CXXX	0.140	0.160	30	0.0100
209969-DXXX	0.075	0.100	28	0.0126
209969-EXXX	0.132	0.157	28	0.0126
209969-FXXX	0.163	0.195	26	0.0159
209969-GXXX	0.185	0.236	22	0.0253
209969-HXXX	0.108	0.133	28	0.0126
209969-JXXX	0.262	0.313	22	0.0253

Last three characters of dash number indicate length in inches.
For example: 209969-D016 is 16 inches long and has an I.D. of 0.075" .

Recommended spring shields: cable part No. 216858 - spring shield Part No.209969-GXXX
cable part No. 77830237 - spring shield Part No. 209969-BXXX

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