OPERATION AND MAINTENANCE MANUAL FOR MODEL 8300 ANGLE POSITION INDICATOR

NAI TM 5015

THE FOLLOWING PATENTS HAVE BEEN ISSUED FOR A NUMBER OF CIRCUITS IN THIS INSTRUMENT:
3,646,337 3,573,794 3,366,804 3,494,735 3,527,934

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CAUTION

High voltage exists at several points in the instrument. Normal precautions consistent with good practice should be taken to reduce shock hazard.

A potential shock hazard exists when ungrounded power source or ungrounded case operation is employed. Persons operating the instrument should be made aware of and take precautions against this condition.

North Atlantic Industries, Inc. cannot be held responsible for damage to person or property in the process of or as a result of maintenance, calibration, or setting up of the instrument.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

SECTION 1

GENERAL DESCRIPTION

1.1 GENERAL

This manual contains general description, installation and operating instructions, maintenance and troubleshooting procedures, replacement parts list, and schematic diagrams for the Angle Position Indicator, Model 8300 (API).

1.2 PHYSICAL DESCRIPTION

The API (fig. 1-1) is housed in a 9-½ inch rack panel with full programming via the rear connector (except off and channel select). It is primarily designed for computer controlled or fixed installation applications.

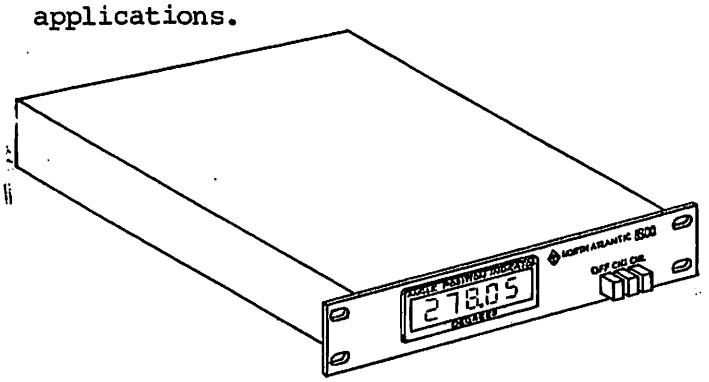


Figure 1-1. Angle Position Indicator

1.3 FUNCTIONAL DESCRIPTION

The API is a synchro/resolver-to-digital converter. It combines LSI technology, sophisticated transformers and a solid state front-end and VCO to insure the ultimate in analog-to-digital conversion.

The converted synchro or resolver data is presented in two forms.

- A front panel display using planar gas discharge information displays.
- BCD outputs on the rear panel connector.

1.4 CONFIGURATION

The Model 8300 is available in various configurations. Order a Model 8300 by specifying the model followed by a three-digit number as follows:

8300-F□□□

- Power line voltage 1 = 115V, 2 = 230V
- Accuracy & frequency
  - 1 = ±0.05°, 47-440Hz (std)
  - 2 = ±0.03°, 360-1200Hz
  - 3 = ±0.03°, 47-440Hz
- Display 1 = 0.00° - 359.99° (std)
  - 2 = +/- 179.99°
  - 3 = 0°00' - 359°59'

For instance, 8300-F321 is a degrees/minutes unit with ±0.03° accuracy @ 360-1200Hz with 115V power input.

1.5 SPECIFICATIONS

Table 1-1 provides characteristics and specifications for the standard API.

Table 1-1. Specifications

Item	Specification
Input specifications	
Input channels	2
Signal inputs	11.8 V, 26 V, or 90 V L-L, synchro or resolver, 47 to 440 Hz*
Signal input impedance	1MΩ (min)
Reference levels	26 V thru 115 V rms, 47 to 400 Hz*. (All synchro or resolver data must be derived from this reference.)
Reference input impedance	100 kΩ (min.)
Power requirements	115/230 V rms ±10% or 125/250 V rms ±10%, 47 to 440 Hz
Data freeze	Freeze / Track
$\overline{DF}$	+5 V / 0 V or open
DF	0 V / +5 V or open
Output specifications	
Decimal readout	5 decimal digits, 0.55-inch high (standard)*
Readout resolution	0.01°
Digital data output	5 decades of BCD digits (1, 2, 4, 8 code)
Digital output level	
Logic 1	+2.5 V min., LS TTL
Logic 0	0.5 V max., LS TTL
Converter busy	TTL compatible (pulses are present when converter is busy) (See paragraph 3.4.2.)
Performance specifications	
Angular accuracy	0.05°
Angular resolution	0.01°
Angular range	0.0° thru 359.99° in 0.01° steps continuous
Tracking speed	180°/S with no tracking error*
Settling time	1s (max.) for 180° step input
Operating mode	Track only
Mechanical specifications	
Front panel color	Semi-gloss gray, 26440 per Fed-Std-595
Markings	Semi-gloss black enamel, 27038 per Fed-Std-595
Size	9.5" W x 1.75" H x 12" D
Weight	4 lbs. (max.)
Operating temperature	0° to 70°C

*See paragraph 1.4 for variations from standard specifications.

SECTION 2

INSTALLATION

2.1 GENERAL

This section provides instructions for unpacking, inspecting, and installing the API.

2.2 UNPACKING AND INSPECTION

This instrument has been thoroughly tested, inspected, and evaluated at the factory before shipment. Care has been taken in the design of the wrapping and packaging material to insure no damage results from mishandling.

Inspect the instrument externally. Check the front panel for signs of damage to the switches and display. Check the switches for smooth operation. Switch buttons should be secure. Check the condition of the connector and fuse on the back panel. Check covers for damage and loose screws. If the instrument passes this inspection, install it and place it in operation. If damage is found, refer to the Warranty in the back of the manual.

2.3 INSTALLATION

2.3.1 Mounting Instructions

The API may be mounted on a bench or in a standard rack, in any physical position. It requires no special cooling equipment. Mount the unit so that air flows freely around it, particularly the rear panel used to transmit the power supply heat to the ambient. Figure 2-1 provides outline dimensions for the API.

2.3.2 Cabling Instructions

System interconnection to the S/D is through rear panel connector J1. Pin designations are given in table 2-1.

A 50-pin mating connector to J1 (NAI P/N 783718), consisting of the following components is available.

Qty	Description	AMP P/N
1	Shell	205211-1
1	Clamp	205732-1
2	Retainer	205980-1
50	Pins	66569-3

When the Model 8300 is used as a direct replacement for the Model 8025, an adapter cable is available to interface the Model 8300 to the S/D.

2.3.3 Grounding

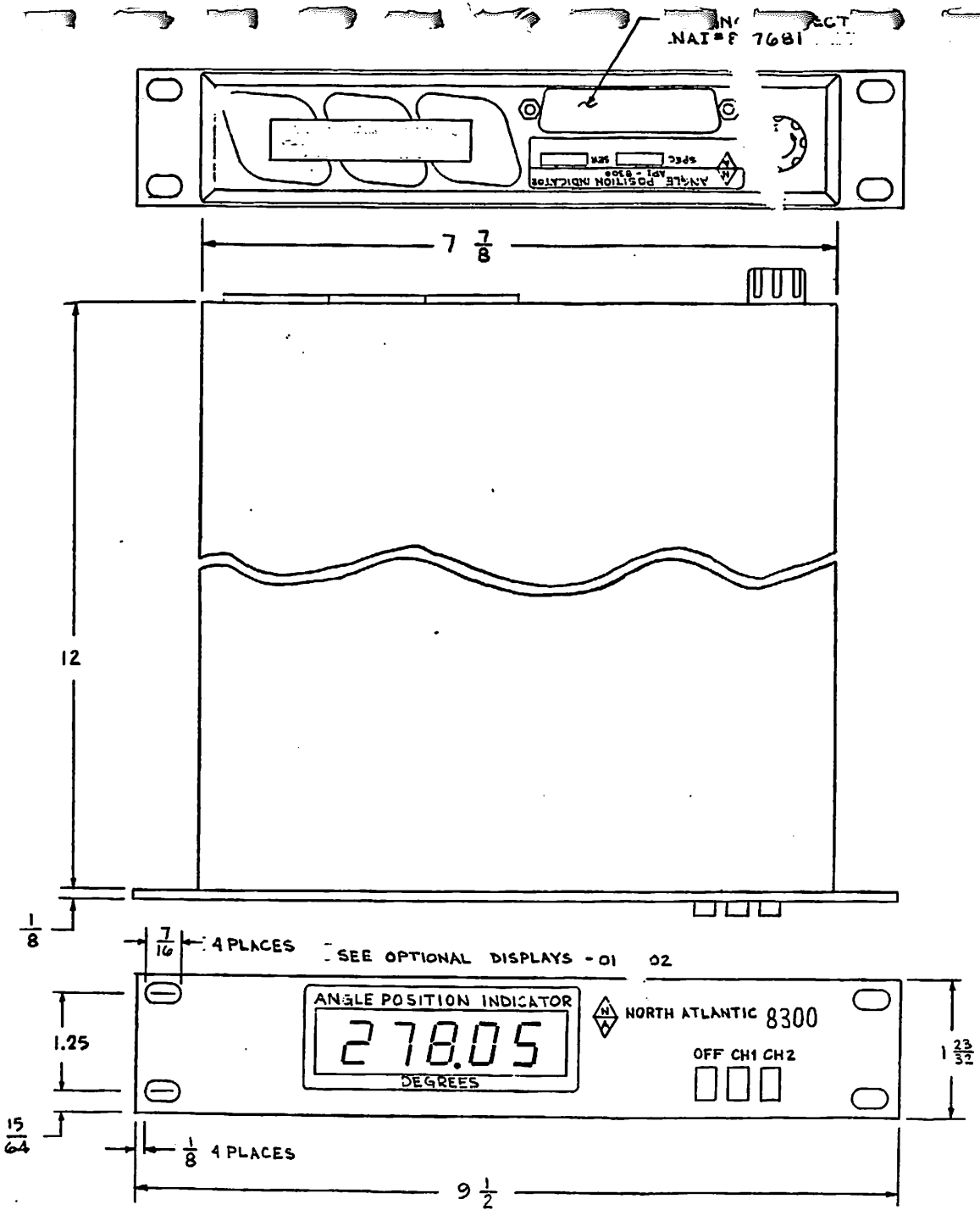
In a high-accuracy synchro/resolver-to-digital converter it is necessary for both chassis and signal ground to be tied together. Ground loops should be avoided in system applications. For this reason, chassis ground pin 3 and signal ground pin 4 are brought out separately.

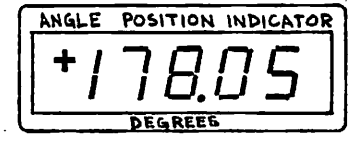
In bench applications, pins 3 and 4 should be tied together and connected to the low side of the signal source to the synchro or resolver.

In system applications, the separate pins make connections in other parts of the system possible. When not used, tie them together at the connector.

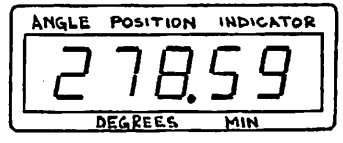
Table 2-1. J1 Pin Designations

Pin	Function
1	Power input Hi
2	Power input Lo
3	Case ground
4	Digital ground
5	S1 (CH 1)
6	S2 (CH 1)
7	S3 (CH 1)
8	S4 (CH 1)
9	R1 (CH 1)
10	R2 (CH 1)
11	Converter busy





OPTION -01
±180° DISPLAY



OPTION -02
DEGREES & MINUTES
DISPLAY

Figure 2-1. API Outline Drawing

Table 2-1. J1 Pin Designations (Continued)

Pin	Function	
12	.04° or 4'*	BCD outputs
13	.01° or 1'*	
14	.8° or not used*	
15	.2° or 20'*	
16	4°	
17	1°	
18	CH 2 synchro jumper	
19	CH 1 L-L programming	
20	CH 2 L-L programming	
21	S1	CH 2
22	S2	
23	S3	
24	S4	
25	R1	
26	R2	
27	Data freeze ($\overline{DF}$)	
28	.02° or 2'*	BCD outputs
29	.08° or 8'*	
30	.1° or 10'*	
31	.4° or 40'*	
32	2°	
33	8°	
34	CH 1 synchro jumper	
35	Scott-T center tap	
36	26 V L-L program line	
37	90 V L-L program line	
38	NC spare	
39		
40		
41		
42	Data freeze (DF)	
43	NC spare	
44	NC spare	
45	20°	BCD outputs
46	40°	
47	80°	
48	10°	
49	100°	
50	200° or + bit**	

*Degrees and minutes readout option.
** ±180° display option.

2.3.4 Signal Inputs

The API is designed to accept both synchro and resolver inputs and line-to-line programming through the rear connector (J1). See table 2-2 for signal input connections and pin programming.

Table 2-2. Signal Inputs and Programming

Signal	Signal input	CH 1 J1 pin	CH 2 J1 pin
Synchro	S1	5	21
	S2	6	22
	S3	7	23
Resolver	S1	5	21
	S2	6	22
	S3	7	23
	S4	8	24
Reference	R1	9	25
	R2	10	26

For CH 1 synchro, jumper pins 34 and 35 together.
For CH 2 synchro, jumper pins 18 and 35 together.

2.3.5 Line-to-Line Wiring

Table 2-3 provides voltage programming for both synchro and resolver operation.

Table 2-3. Line-to-Line Wiring

L-L voltage	CH 1 J1 pin	CH 2 J1 pin
11.8 V	19 open	20 open
26 V	Jumper 19 & 36	Jumper 20 & 36
90 V	Jumper 19 & 37	Jumper 20 & 37

2.3.6 Internal Power Connections

The API is designed to operate from 115 V, 125 V, 230 V, or 250 V, 47 to 440 Hz input power. It is normally set in the factory for 115 V operation. For 230 V operation, move Power switch S4 (fig..2-2) located on the main board near the power transformer to 230 V position. In order to operate the API at 125 V or 250 V, some lands must be cut and jumpers installed as shown in table 2-4 and figure 2-2.

Table 2-4. Operating Power Set-Up

Input voltage	S4 position	Jumpers/cuts (fig.2-2)
115 V	115 V	-
230 V	230 V	-
125 V	115 V	Cut land A and B.
250 V	230 V	Install jumpers C & D.

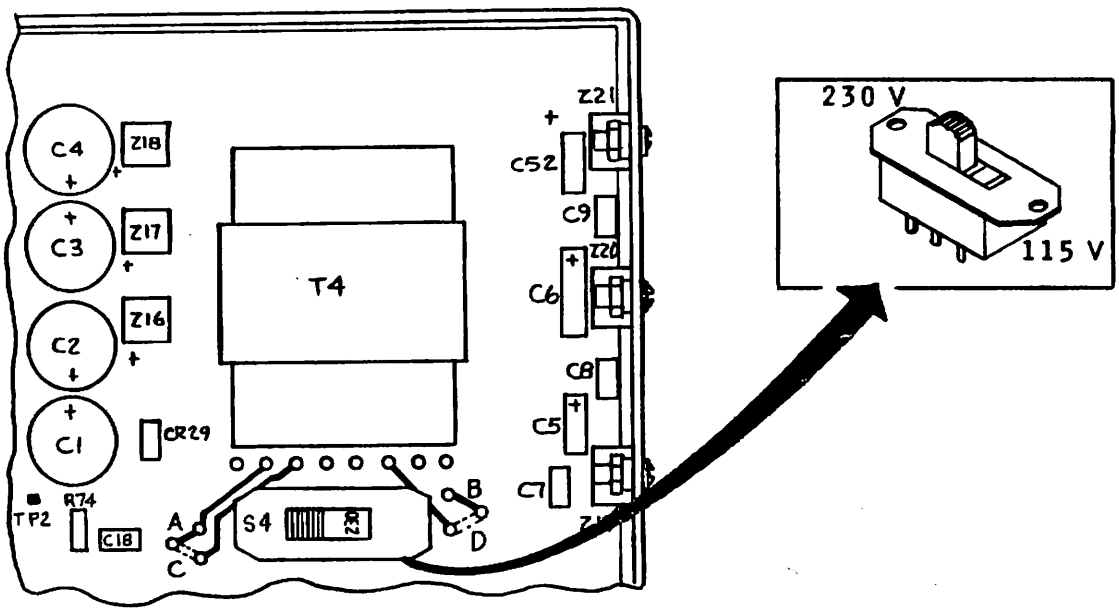


Figure 2-2. Power Programming

SECTION 3

OPERATION

3.1 GENERAL

This section provides operation procedures for the API.

3.2 SYNCHRO AND RESOLVER CONVENTIONS

Conventions for polarities, terminal designation and direction of shaft rotation for synchros and resolvers are most frequently defined in accordance with military specifications MIL-S-20708 (synchros) and MIL-R-21530(resolvers). The unit is provided with terminal designations and electrical characteristics to these specifications. In applying the conventions, exercise caution that:

- The manufacturer of the synchro or resolver has followed the MIL specification.
- The system use has not dictated a change in convention for a different characteristic (i.e., direction reversal or angular offset).

3.2.1 Synchro Transmitter Conventions

$$E(S1-S3) = -NE(R1-R2)\sin\theta$$
$$E(S3-S2) = -NE(R1-R2)\sin(\theta+120°)$$
$$E(S2-S1) = -NE(R1-R2)\sin(\theta+240°)$$

Where E(S1-S3) is the stator voltage S1 with respect to S3. Other stator and rotor voltages are similarly defined. N is the ratio of the maximum voltage across a pair of stator terminals to the voltage across the rotor terminals. θ is the shaft angle displacement from electrical zero which satisfies these equations. A schematic of the synchro transmitter is shown in figure 3-1.

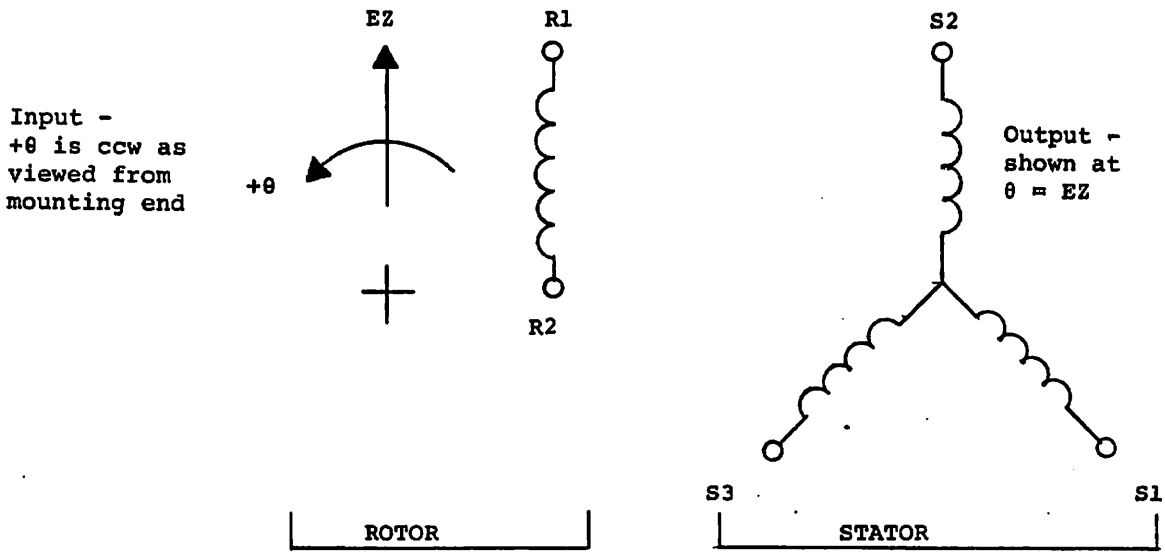


Figure 3-1. Synchro Transmitter, Schematic

3.2.2 Resolver Transmitter Conventions

For rotor energized resolvers:

$E(S1-S3) = NE(R1-R3)\cos\theta - NE(R2-R4)\sin\theta$
$E(S2-S4) = NE(R2-R4)\cos\theta + NE(R1-R3)\sin\theta$

A rotor energized resolver transmitter schematic is shown in figure 3-2. Input and output may be reversed for stator energized devices.

Since the NAI standard assumes an R2R4 energized resolver, the resolver outputs become:

$E(S1-S3) = -NE\ (R2-R4)\ \sin\theta$
$E(S2-S4) = +NE\ (R2-R4)\ \cos\theta$

3.3 CONTROLS AND INDICATORS

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

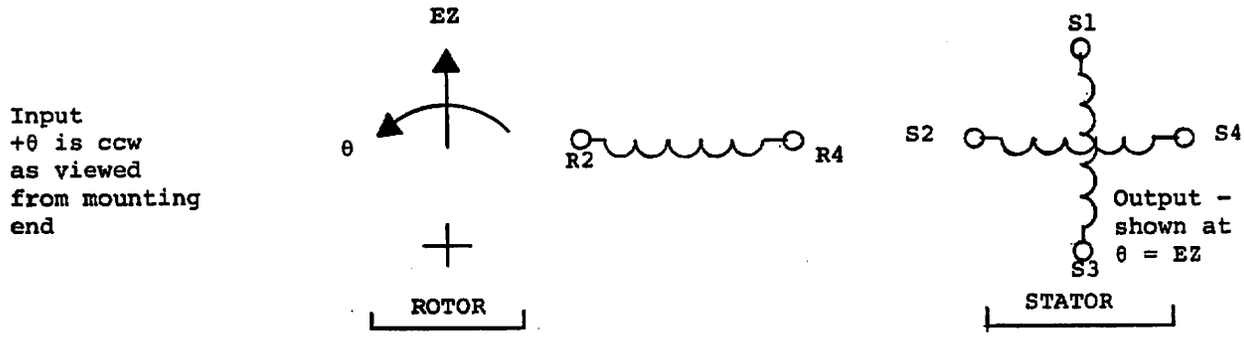


Figure 3-2. Resolver Transmitter, Schematic

Table 3-1. Controls and Indicators

Control or indicator	Function
OFF push button	Turns power off.
CH 1 push button	Selects channel 1 operation and turns on power.
CH 2 push button	Selects channel 2 operation and turns on power.
Indicator	Displays, digitally, information.
115 V - 230 V Power switch (located on main board)	Allows unit to operate from either 115 V or 230 V power source.

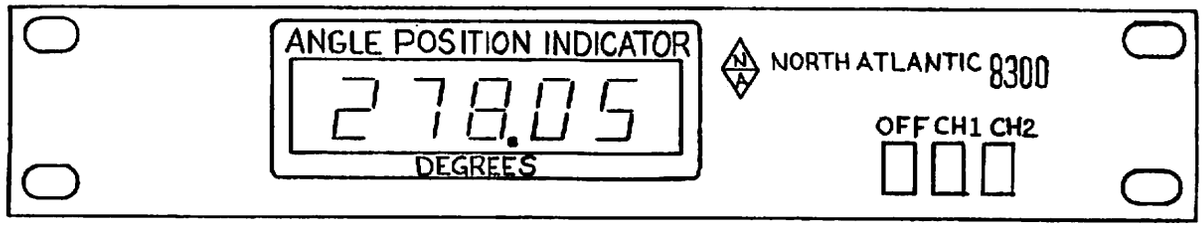


Figure 3-3. Controls and Indicators

3.4 DATA TRANSFER CONSIDERATIONS

3.4.1 Timing

The S/D converter output changes in discrete 1 LSB steps. To prevent data from changing during the time it is transferred into the system or computer, provisions have been made to insure data stability during this transfer.

3.4.2 Converter Busy

The first method of transferring converter output data into the system is to monitor the Busy signal supplied by the S/D converter. This signal indicates output data changes.

It is necessary to transfer data 2 µs after the trailing edge of the converter Busy (fig. 3-4). The data will be stable for a minimum of 30 µs when the converter is tracking at its maximum rate of 0.5 rps.

NOTE

For units designed to operate at 400 Hz and above, the converter Busy minimum period is 5.5 µs and min/max delay for data transfer is 2 µs.

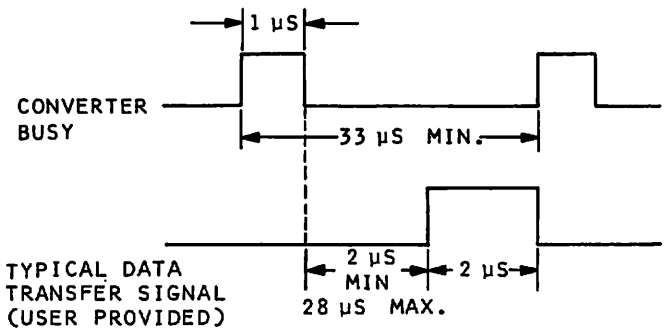


Figure 3-4. Converter Busy

3.4.3 Data Freeze

The second method of transfer is to freeze the data output with an externally supplied inhibit signal. The inhibit should be applied for a minimum of 2 µs before transferring the data into the system (fig. 3-5).

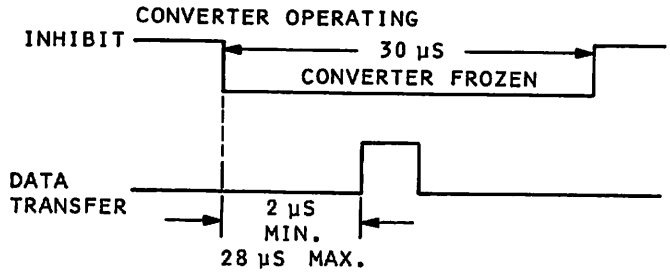


Figure 3-5. Data Freeze

Since the inhibit signal stops the S/D converter output from tracking, it should be applied for as short a time as necessary, otherwise large errors will accumulate under high angular rate conditions. When this occurs, time will have to be allowed for the converter to settle. In general, application of the inhibit for less than 30 µs will produce a maximum peak transient error of less than 1 LSB at the maximum angular input rate of 0.5 rps.

For units designed to operate at 400 Hz and above, application of the inhibit for less than 6 µs will produce a maximum peak transient error of less than 1 LSB at a maximum angular input rate of 5 rps.

NOTE

At slower angular input rates the converter can be frozen for much longer periods with no appreciable error build-up. In addition, the change makes allowance for a reasonable capacitive load on the digital output lines (500 pf or less). For applications with excessive capacitive loads, special precautions have to be taken for capacitive charge and discharge.

3.5 DEGREES AND MINUTES READOUT OPTION

The displayed angle is in degrees (00.00 through 359.00) and minutes (00 through 59).

To perform this conversion a degrees-to-

minutes conversion board (P/N 783726) is furnished.

This assembly takes the .1 and .01 BCD information from the TRIG LOGIC™ processor and .01 counter and converts it to minutes information. This conversion is accomplished by using a pre-programmed PROM. The output data from the PROM goes to the display board and the angle displayed is in degrees and minutes. Table 3-2 provides conversion data from degrees to minutes.

Table 3-2. Degrees-to-Minutes Conversion

Degrees	Minutes	Degrees	Minutes
.01°	1'	.1°	6'
.02°	1'	.2°	12'
.03°	2'	.3°	18'
.04°	2'	.4°	24'
.05°	3'	.5°	30'
.06°	4'	.6°	36'
.07°	4'	.7°	42'
.08°	5'	.8°	48'
.09°	5'	.9°	54'

SECTION 4

THEORY OF OPERATION

4.1 GENERAL

This section contains theory of operation for the API.

4.2 DETAILED DESCRIPTION

The API is designed with NAI's closed servo loop (refer to block diagram, fig. 4-1). This system continuously tracks the analog input data with a precision Scott-T transformer, resistive bridge, phase detector, integrator, and clock generator, driving a counter which updates the bridge to the synchro data angle input.

The heart of the system is a custom LSI TRIG LOGIC™ processor. This LSI contains analog switches, an Up/Down counter and trigonometric digital circuitry for processing the input signals.

The input signal, whether synchro (three wire) or resolver (four wire) goes directly into the precision transformer assembly, which outputs a Sin θ signal and a Cos θ signal to the coarse bridge. Both signals drive analog switches which are turned at 20° intervals. These points are referred to as αc. The signals produced within the coarse bridge circuit are Sin θ Cos αc, Sin θ Sin α, Cos θ Cos αc, and Cos θ Sin αc. These four functions are combined to derive Sin $(\theta-\alpha c)$ error signal and Cos $(\theta-\alpha c)$ interpolation signal, implementing the following trigonometric relationships:

$$\text{Sin}(\theta-\alpha c) = \text{Sin}\ \theta\ \text{Cos}\ \alpha c - \text{Cos}\ \theta\ \text{Sin}\ \alpha c$$
$$\text{Cos}(\theta-\alpha c) = \text{Sin}\ \theta\ \text{Sin}\ \alpha c + \text{Cos}\ \theta\ \text{Cos}\ \alpha c$$

Since αc takes on values at only 20° intervals, $\theta-\alpha c$ will be somewhere between 0° and +20°, depending upon the value of the input angle θ. The error signal Sin $(\theta-\alpha c)$ is then balanced out in the interpolation circuit, using Cos $(\theta-\alpha c)$ as an interpolation reference signal.

The interpolation circuit contains a precision resistor network to bridge the error signal against the interpolation reference signal. The precision resistor network as well as the analog switches of the coarse bridge are driven digitally by the counter. The result of the bridging process is an ac error signal proportional to:

$$\text{Sin}\ (\theta-\alpha c)\ \text{Cos}\ \alpha f\ \text{Cos}\ (\theta-\alpha c)$$

This equals Sin $(\theta-\alpha c-\alpha f)$, where αf is the digitally generated angle in the interpolation circuit.

The output of the interpolation circuit is connected to the null circuit which performs two discrete functions - phase-sensitive detection and clock pulse generation. The phase-sensitive detector combines the ac error signal with the input reference signal to produce a bi-polar dc signal proportional to the in-phase portion of the ac error signal. This dc error signal is integrated and then applied to the input of two comparators, one with a positive, the other with a negative threshold voltage. These comparators, along with a common charging and discharging circuit, produce clock pulses with frequency proportional to the magnitude of the dc error signal.

The two clock lines go into a BCD Up/Down counter. The counter outputs digitally, closing the loop with the coarse bridge and interpolation circuits. In addition to the counter, there is also a 1s complementing circuit for the lower order bits in the interpolation circuitry.

The digital word in BCD form from the LSI goes to the output buffers. These buffers isolate the LSI and drive the rear connector for external use. They also go to the display board for decoding to drive the seven segments of the Beckman Planar Gas Discharge Information Display.

In operation, whenever the input synchro or resolver is turned, an ac error builds up,

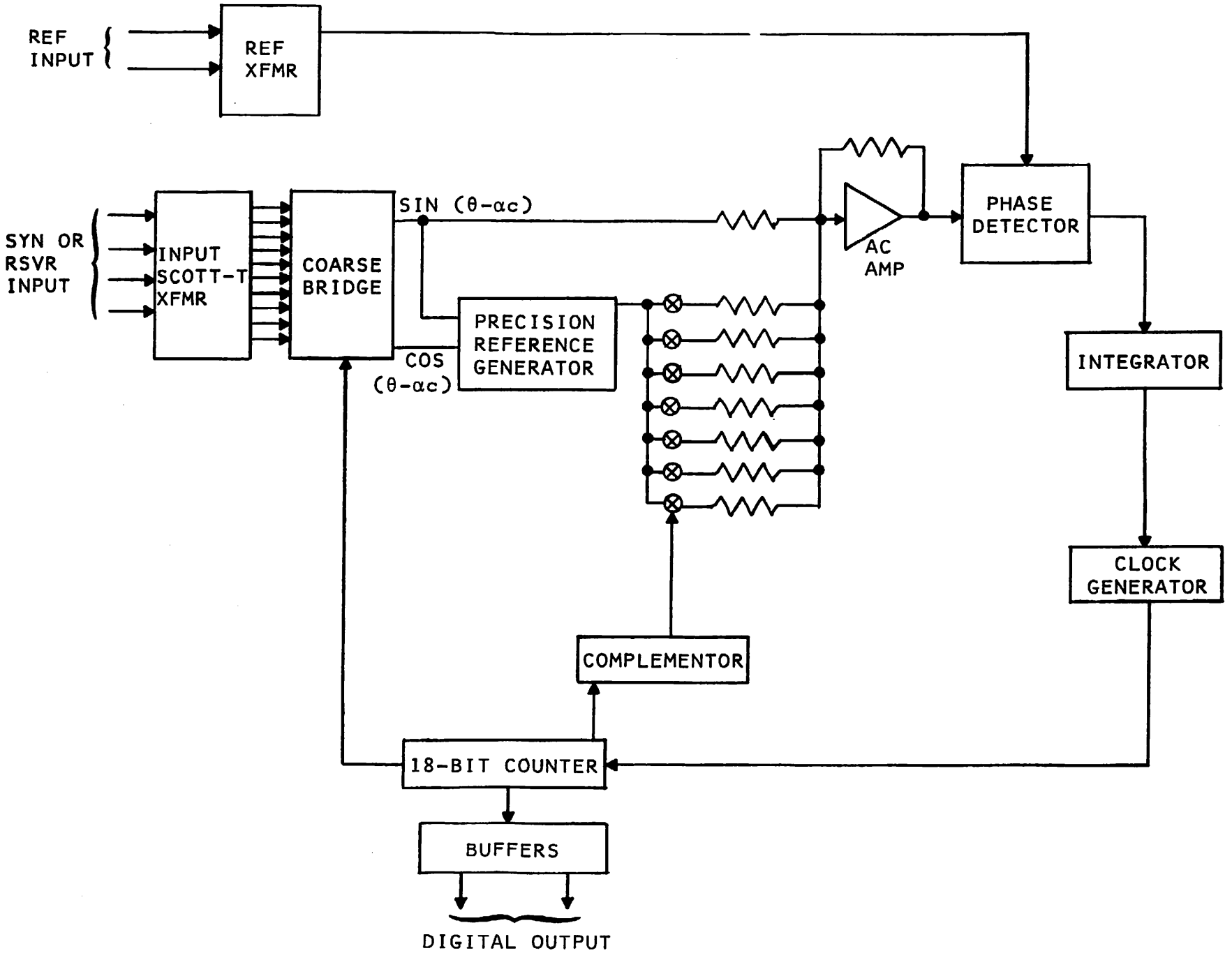


Figure 4-1. API Block Diagram

causing a corresponding dc error. The dc error causes clock pulses to appear in the proper direction to reduce the magnitude of the error signals. When the error signals are reduced to zero, plus or minus the threshold voltages, the digital output then equals the new input synchro or resolver angle.

During a tracking condition or jitter of the synchro (resolver) angle, the LAZY EIGHT™ ambiguity indicator is illuminated (the decimal point in the far right corner of the display). Due to the seven segment display construction in a moving data situation, the digits displayed appear as eights 8's (LAZY EIGHT™) and should be disregarded. The BCD data available at the rear connector is valid for rates to 0.5 rps (180°/second).

SECTION 5

MAINTENANCE

5.1 GENERAL

This section contains cleaning, performance tests, and alignment procedures for the API.

WARNING

High voltages exist at several points in this instrument. Normal precautions should be taken to avoid shock hazard.

5.2 CLEANING

No special cleaning procedures or fluids are required. Apply good housekeeping rules to maintain the instrument free of dust and dirt.

5.3 PERFORMANCE TEST

The API is designed to operate as a solid state, two-channel, synchro or resolver-to-digital converter with a built-in display. This display is a gas discharge type located on the front panel. The synchro or resolver input data may have a frequency range of 47 to 440 Hz and a line-to-line voltage of either 11.8, 26, or 90 V.

The following paragraphs provide performance test procedures. Perform these tests periodically to ensure proper equipment operation.

5.3.1 Equipment Required

Table 5-1 lists the test equipment required to test and align the API. The minimum use/critical specification column lists the parameters required for alignment and are not for the purpose of alternate equipment selection. Satisfactory performance of alternates should be verified before use.

5.3.2 API Test Characteristics

Table 5-2 lists the various API characteristics and the methods which are used to test them.

Table 5-1. Test Equipment Required

Item	Minimum use/critical specifications	Manufacturer and model
Synchro/resolver simulator	Frequency: 60 to 400 Hz Range: 00.000° to 359.999° Accuracy: 10 arc second Modes: Synchro or resolver Synchro conventions meet MIL-S-20708A Resolver conventions meet MIL-R-21530 (para. 3.2).	North Atlantic Industries, Model 530/20 Synchro/ Resolver Simulator
Mating connector	Connector wired for the functions to be tested (fig. 5-1)	North Atlantic Industries mating connector kit P/N 783718) Qty — AMP P/N 1 shell — 205211-1 1 clamp — 205732-1 2 retainers — 205980-1 50 pins — 66569-3

5.3.3 Preliminary Operations

Perform the following preliminary steps.

a. Verify that all power switches are off and connect equipment to appropriate power souce.

b. Verify that the mating connector has been wired for proper line-to-line and function to be tested. Refer to figure 5-1.

5.3.4 Grounding

In a high-accuracy synchro/resolver-to-digital converter, it is necessary for both chassis and signal ground to be tied together. It is also important to avoid ground loops in system applications. For this reason, both chassis ground (pin 3) and signal ground(pin 4) are brought out separately.

In bench applications, pins 3 and 5 should be tied together and connected to the low side of the signal source to the synchro or resolver.

In system applications, the separate pins make it possible to connect to other parts of the system. If they are not connected, however, they should be tied together at the connector.

5.3.5 Set-Up

Set-up equipment as shown in figure 5-1 and perform the following.

a. Set all auxiliary equipment controls as necessary to avoid damage to the equipment and to prevent dangerous voltages at the output terminals when power switches are turned on.

b. Turn all power switches, with the exception of the API, on and allow time for the auxiliary equipment to stabilize. (The API does not require warm-up time.)

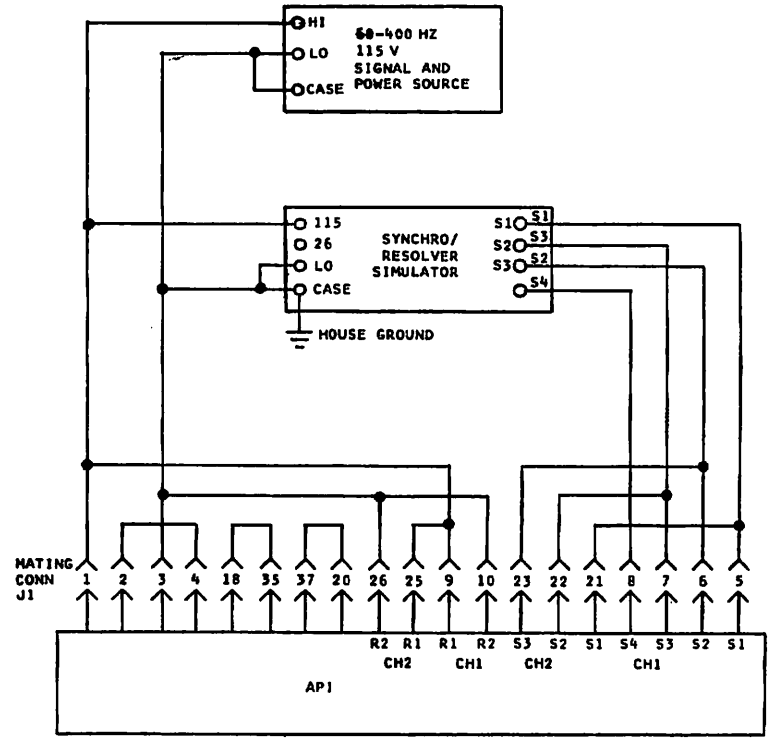


Figure 5-1. Performance Test Set-Up

Table 5-1. Test Equipment Required (Continued)

Item	Minimum use/critical specifications	Manufacturer and Model
Ac power source	Frequency: 60 to 400 Hz Range: 0 to 120 V rms Distortion: 0.6% Output rating: 20 VA Load regulation: ±1% Phase: Single	Elgar, Model 121 with Model 401 V plug-in
Phase angle voltmeter	Frequency: 60 and 400 Hz Sensitivity: 10 V to 0.003 V Voltage accuracy: ±2% full scale Phase accuracy: ±1°	North Atlantic Industries, Model 321 or 225 Phase Angle Voltmeter
Oscilloscope	Horizontal sweep time: 1 µs Vertical sensitivity: 1 V/cm Rise time: 24 ns Input R and C: 1 MΩ paralleled by approx. 33 pf	Tektronix, Model 422
DVM	Range: 199.9 mV Zin: 100 MΩ Resolution: 3-1/2 digits	Weston, Model 4449

Table 5-2. API Test Characteristics

Characteristic	Performance specification	Test method
Line voltage	The line voltage may range from 47 to 440 Hz, 102 to 125 V.	Not tested.
Signal inputs	11.8 V, 26 V, or 90 V, L-L synchro or resolver at 47 to 440 Hz. Signal input impedance 250 kΩ, minimum.	Not tested.
Reference input	10 V thru 115 V rms, 47 to 400 Hz. Input impedance 100 kΩ, minimum.	Not tested.
Angular accuracy	±0.05° (standard)	Accuracy is tested by injecting known synchro or resolver angles and observing them on the display.
Angular resolution	0.01° (standard)	None
Angular range	0.00° thru 359.99° in 0.01° steps, continuous (standard)	Not tested.
Tracking characteristics	Up to 0.5 rps (180°/sec)	Not tested.
Settling time	1 second (maximum) for 180° step	This test is accomplished by applying Data Freeze, offsetting the input angle by 180.10°; releasing Data Freeze for one second, then reapplying. The API must slew to within 0.05° of new input angle.

c. Set the synchro/resolver simulator for 11.8 V L-L, 400 Hz resolver output (00.000°).

d. Adjust the variable power and reference source for 400 Hz ±10 Hz, 115 V ±2 V output.

5.3.6 Channel 1 Accuracy Test

a. On the API front panel depress CH1 push button.

b. Advance the synchro/resolver simulator in 10° steps (00.000° through 350.000°). API should read within ±0.05° of the input angle.

c. Advance the resolver/synchro simulator in 1° through 9°, 0.1° through 0.9°, and 0.01° through 0.09° steps, respectively. API should read within ±0.05° of the input angle.

5.3.7 Channel 2 Accuracy Test

a. Depress CH2 push button on the API.

b. Set the synchro/resolver simulator for 90 V L-L, 60 Hz synchro output.

c. Adjust the variable power source for 60 Hz ±5 Hz, 115 V ±2 V output.

d. Advance the synchro/resolver simulator in 10° through 9°, 0.1° through 0.9°, and 0.01° through 0.09° steps, respectively. API should read within ±0.05° of the input angle.

5.3.8 Settling Time Test

The following test insures proper settling time up and down in all four quadrants.

a. Data Freeze the API by applying a ground to pin 27 of the mating connector.

b. Advance the synchro/resolver simulator to 180.10° and release Data Freeze for one second. The unit must slew to within ±0.05° of the new input angle.

c. Repeat this process for:

0°	to 180.10°
180°	to 0.10°
90.10°	to 270.00°
270.10°	to 90.00°

5.4 ALIGNMENT PROCEDURE

This procedure describes the alignment sequence and test equipment required to align the API. The unit is aligned by adjusting four potentiometers for proper dc offsets at various test points. Periodic alignment is unnecessary and should not be attempted unless the performance test reveals a misaligned condition.

5.4.1 Test Equipment

Minimum use specifications are the principal parameters required for performance of the alignment procedure and are included to assist in the selection of alternate equipment, which may be used at the discretion of the aligning activity. Satisfactory performance of alternate items shall be verified before use. All applicable equipment must bear evidence of current calibration. See table 5-1 for equipment requirements.

5.4.2 Calibration Set-Up

a. Set all auxiliary equipment controls as necessary to avoid damage to the equipment and to prevent dangerous voltages from existing at the output terminals when power switches are turned on.

b. Set-up equipment as shown in figure 5-1. Tie the auxiliary equipment to house ground at only one point to avoid ground loops.

c. Turn all power switches, with the exception of the API, on and allow time for the auxiliary equipment to stabilize. (The API does not require warm-up time.)

d. Set the synchro/resolver simulator for

11.8 V L-L, 400 Hz synchro output at 0.000°.

5.4.3 Calibration Procedure

a. Depress CH1 push button on the API front panel. Adjust the synchro/resolver simulator for 0.00° angle position indicator display and data freeze the unit by grounding pin 27.

b. Connect the low side of the DVM to the ground test point on the mother board and connect the high side to TP7. Adjust R30 for 0 V ±1 mV dc.

c. Connect the high side of the DVM to TP6 and adjust R36 for 0 V ±1 mV dc.

d. Connect the high side of the DVM to TP1 and adjust R120 for 1 V ±50 mV dc.

e. Connect the high side of the DVM to TP8 and the high side of the PAV to TP1, low side to the ground test point. Use the system reference as the reference input to the PAV. Adjust the synchro/resolver simulator for an in-phase null on the PAV, then adjust R70 for 0 V ±50 mV dc.

NOTE

This voltage should be adjusted to swing symmetrically about 0 V dc on a dc coupled oscilloscope.

f. Check the plus and minus threshold by monitoring TP4 with the oscilloscope and advancing the simulator setting from null in 0.001° steps until the clock just appears. Record the difference in this angle from null. The threshold should be 0.027° ±.003°. Return the synchro/resolver simulator to ac null and monitor Z9, pin 1 (TP5) down clock. Decrease the synchro/resolver simulator setting in 0.001° steps until the clock just appears. Record the difference in this angle from null. The threshold should be 0.027° ±.003°. It should be split symmetrically by adjusting R70 slightly and rechecking to within 0.002°.

SECTION 6

TROUBLESHOOTING

6.1 GENERAL

This section contains troubleshooting procedures for the API.

WARNING

High voltages are present at several points in the API. Observe normal precautions consistent with good practice to avoid shock hazard.

CAUTION

The API contains the following CMOS integrated circuits. Handle these ICs with extreme care. Never remove any integrated circuit with the power on. Use only properly grounded test equipment.

Z8 - 74C192
Z9 - 74C00
Z10- MC14561
Z14- LSI
±180° digital board
(Z1 thru Z16)

6.2 VISUAL INSPECTION

After removing the API cover, the unit should be thoroughly inspected. Some obvious causes of trouble could be.

- Cable connectors not properly seated.
- IC's not properly seated in their sockets.
- Broken wires or loose components.
- Burnt components indicating thermal overload. The cause should be located and corrected.
- Metallic particles shorting adjacent lands on PC board. Both sides of boards should be inspected (where convenient) and all exposed boards completely brush cleaned to remove dust particles.
- Input signals and power levels are not at their proper levels and frequencies.
- Programming to rear connector J1 is incorrect.
- The unit is not properly grounded.
- S4 is not in the proper position for power input.

Table 6-1 provides a list of test points and the signals to be checked during troubleshooting. Refer to table 5-1 for required test equipment.

Table 6-1. Troubleshooting Points

Test point	Signal
TP1	Ac null from Z2-10
TP2	Dc null from Z7-12
TP3	Clock to LSI from Q13 emitter
TP4	Up clock to .01° decade from CR16 anode
TP5	Down clock to .01° decade from CR19 anode
TP6	Analog signal from Z1-10
TP7	Analog signal from Z1-12
TP8	Integrator output from Z4-6
+15 V	Dc power supply level from Z19-2
-15 V	Dc power supply level from Z20-2
+ 5 V	Dc power supply level from Z21-2
+180 V	Dc power supply level from Q1 emitter

6.3 TROUBLESHOOTING POWER SUPPLY

Check the power supply for correct levels as the first step in troubleshooting. These levels should be measured between the ground test point and the designated power supply level test point (table 6-1). They are as follows:

+15 Vdc	±0.5 V
-15 Vdc	±0.5 V
+ 5 Vdc	±0.25 V
+180 Vdc	±20 V

For detailed troubleshooting procedure of the power supply, refer to table 6-2.

Table 6-2. Troubleshooting Power Supply

Symptom	Possible cause	Remedy
No or low +15V	1. Defective T4, pins 7 thru 10 2. Loose screw on Z19. 3. Z19 defective 4. Integrated circuit loading 5. Z16 defective	1. Replace T4. 2. Tighten screws. 3. Replace Z19. 4. Remove Z1 thru Z7 one at a time and replace shorted IC. 5. Replace Z16.
+15V low with high ripple	C1 open	Replace C1.
No or low -15V	1. Defective T4, pins 7 thru 10 2. Loose screw Z20 3. Z20 defective 4. Integrated circuit loading 5. Z16 defective	1. Replace T4. 2. Tighten screws. 3. Replace Z20. 4. Remove Z1 thru Z7 and Z14, one at a time and replace shorted IC. 5. Replace Z16.
-15V low with high ripple	C2 open.	Replace C2.
No or low +5V	1. Defective T4, pins 11 and 12 2. Loose screw Z21 3. Z21 defective 4. Integrated circuit loading. 5. Z17 defective. 6. Display board defective	1. Replace T4. 2. Tighten screws. 3. Replace Z21. 4. Remove Z8 thru Z14, one at a time, and replace shorted IC. 5. Replace Z17. 6. Remove display cable W1 from J2. Recheck power supply level. If good, troubleshoot display board.
+5V low with high ripple	C3 open	Replace C3.
No or low +180V	1. Defective T4, pins 13 and 14 2. Z18 defective 3. Q1 defective 4. Display board defective	1. Replace T4. 2. Replace Z18. 3. Replace Q1. 4. Remove display cable W1 from J2. Recheck power supply level. If good, troubleshoot display board.
-180V low with high ripple	C4 open.	Replace C4.

6.4 TROUBLESHOOTING DISPLAY BOARD

Table 6-3 provides a display board troubleshooting procedure.

6.5 TROUBLESHOOTING MAIN BOARD

Table 6-4 provides main board troubleshooting procedure.

Table 6-3. Troubleshooting Display Board

Symptom	Possible cause	Remedy
No display	1. Fuse F1 blown 2. No +180 Vdc 3. W1 not installed in J2	1. Determine what caused F1 to blow and replace. 2. Power supply (table 6-2). 3. Install W1 in J2.
One or more segments of the display always on.	1. Defective decoder driver on display board 2. Defective buffer 3. Defective Z8 (.01° decade only)	1. Replace decoder driver. 2. Replace buffer. 3. Replace Z8.
Segments of the display partially on.	1. Low +180 Vdc supply 2. Defective readout panel 3. Low +5 V supply	1. Repair power supply (table 6-2). 2. Replace readout panel. 3. Repair power supply (table 6-2).
One readout panel not lit.	Defective readout panel	Replace readout panel.
Letters A, B, C, D, E, or F displayed	1. Defective decoder driver 2. Defective buffer	1. Replace decoder driver. 2. Replace buffer.

Table 6-4. Troubleshooting Main Board

Symptom	Possible cause	Remedy
API does not track input data. Display frozen at one angle.	1. Data Freeze line grounded 2. No ac error signal (TP1), Z1 or Z2 are defective 3. No dc error signal (TP2), Z7 defective 4. No error signal from integrator (TP8). Defective Z4. 5. No clock pulses (UP TP4 or DOWN TP5), Z3 or Z9 defective. 6. .01° counter, Z8 defective	1. Float Data Freeze line (J1-27). 2. Replace defective IC. 3. Replace defective IC. 4. Replace defective IC. 5. Replace defective IC. 6. Replace Z8.
.01° decade only	No clock to LSI, Z9 defective; Z3 (TP3) defective; or Z14 LSI defective.	Replace defective IC.

Table 6-4. Troubleshooting Main Board (Continued)

Symptom	Possible cause	Remedy
API free runs, will not settle at any angle.	Loss of precision reference generator (TP6 or TP7) Z1 defective; ac amplifier (TP1), Z2 defective; phase detector (TP2), Z7 defective; integrator (TP8), Z4 or Z3 (TP4 or TP5) defective.	Replace defective IC.
API displays large angular errors.	1. S2 or S3 defective. 2. Open input data line: loss of reference signal; TP3, Z3, or Q12 defective; Precision reference generator Z1; ac amplifier Z2; phase detector Z7; integrator Z4 or Z3; .01° counter; Z10, 9's complementer defective; Z5 or Z6 BCD ladder booster amplifiers Z14 LSI; defective component in any of these positions will result in large errors.	1. Repair defective switch. 2. Replace defective component.

6.6 TROUBLESHOOTING AID

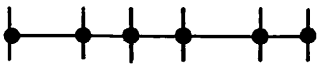
Use the following information as an aid in troubleshooting the API. It provides voltage levels and signal waveforms at various test points of the API.

TEST CONDITION 1

API at Null 0.00°; Input Angle 0.00°; 90 V L-L Synchro; Data Freeze Off.

TP6 -200 mV in-phase  clean sine wave

TP7 -200 mV in-phase  clean sine wave

TP1 ±5 mV in-phase  noise spikes

TP2 ±10 mVdc

TP8 ±50 mVdc

TP4 0 Vdc

TP5 0 Vdc

TP3 -14.5 V ±.5 V

TEST CONDITION 2

API at 0.00°; Input Angle 0.10°; 90 V L-L Synchro; Data Freeze On.

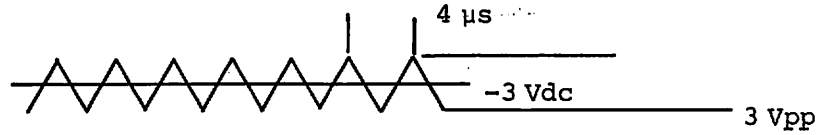
TP6 -200 mV

TP7 -200 mV

TP1 +200 mV in-phase

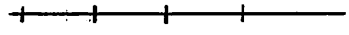
TP2 +14.4 Vdc ±1 V

TP8



TP4

TP5



TP3 -14.5 V ±.5 V

TEST CONDITION 3

API at 45.00°'; Input Angle 44.90°'; 90 V L-L Synchro; Data Freeze On.

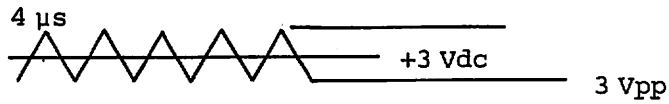
TP6 -265 mV in-phase

TP7 -270 mV in-phase

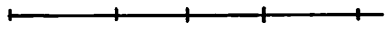
TP1 -235 mV in-phase

TP2 +14.5 V ±1 Vdc

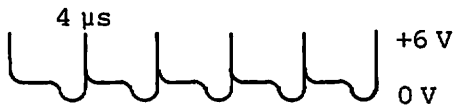
TP8



TP4



TP5



TP3 -14.4 V ±.5 V

NOTE

When the API is tracking, TP3 should have -15 V to +5 V clock pulses 1 µs in width.

SECTION 7

PARTS LIST

This section provides a vendor codes list, parts lists, and parts locator diagrams for the API.

LIST OF MANUFACTURERS

00779	AMP P.O. Box 3608 Harrisburg, Pennsylvania 17105
01121	Allen Bradley Company 1201 South 2nd Street Milwaukee, Wisconsin 53204
01295	Texas Instrument Semiconductor Components Div. 13500 North Central Expressway Dallas, Texas
02111	Spectrol Electronic Corp. 17070 East Gale Avenue City of Industry, California
03508	General Electric Semiconductor Electronics Park Syracuse, New York 13201
04713	Motorola Semiconductor Products Inc. 5005 East McDowell Road Phoenix, Arizonia 85008
07342	North Atlantic Industries, Inc. 60 Plant Avenue Hauppauge, New York 11787
12040	National Semiconductor Commerce Drive P.O. Box 443 Danbury, Connecticut 06810
16299	Corning Glass Works Electronic Component Div. 3900 Electronics Drive Raleigh, North Carolina 27604
18324	Signetics Corp. 811 East Argues Ave. Sunnyvale, California 94086
30870	Republic Machinery Company Los Angeles, California
31918	I.E.E./Schadow 8081 Wallace Road
49956	Raytheon Company Lexington, Massachusetts 02173
56232	Sperry Gyroscope Div. Sperry Rand Corp. Marcus Ave. & Lakeville Road Great Neck, New York 11020
56289	Sprague Electric Company 335 Marshall Street North Adams, Massachusetts 01247
71785	Cinch Manufacturing Co., Inc. 1026 South Homan Avenue Chicago, Illinois 60624
72136	Elmenco Electro Motive Mfg. Co. South Park & John Streets Willimantic, Connecticut 06226
72982	Erie Technological 644 West 12th Street Erie, Pennsylvania 16512
73138	Beckman Instruments Helipot Division 2500 Harbor Blvd. Fullerton, California 92634
75915	Littlefuse, Inc. 800 E.N.W. Highway Des Plaines, Illinois 60016
79727	Continental Wirt Elect. 550 Davisville Road Warminster, Pennsylvania 19874
84171	Arco Electronics Community Drive Great Neck, New York 10222
91506	Augat Inc. 33 Perry Avenue Attleboro, Massachusetts 02703
91637	Dale Electronics Inc. P.O. Box 609 Columbus Nebraska 68601

Replacement Parts List - API, Model 8300 and Model 8300A

Description	Part No.
Chassis Assembly	783783
Chassis Assembly	783684
Display Board (Standard & Degrees & Minutes Option)	783685
±180° Display Board Option	783716
Degrees-to-Minutes Converter Option	783725
±180° Digital Board Option	783719

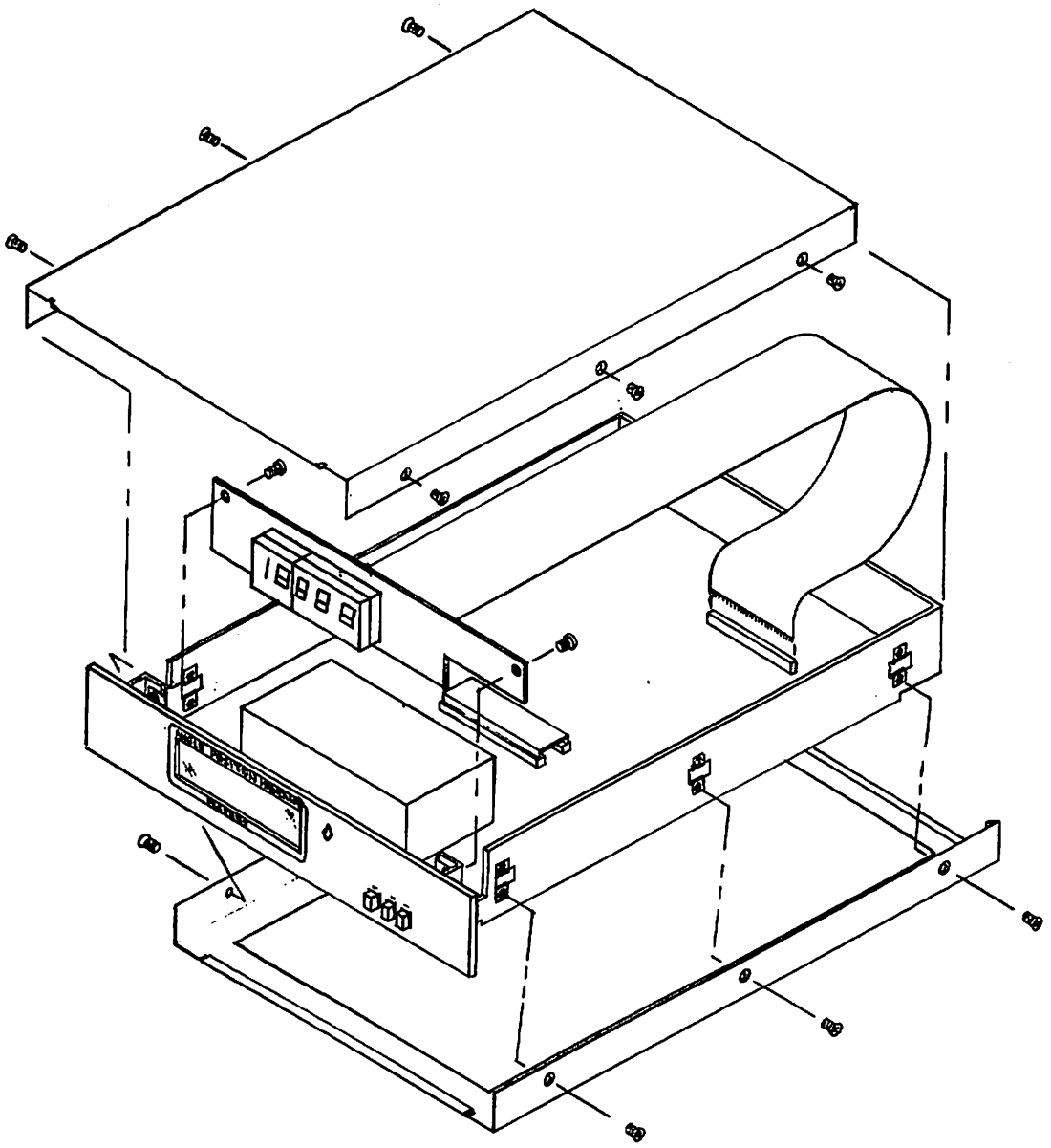


Figure 7-1. API Exploded View

Replacement Parts List: Chassis Assembly (783783, 783684)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C1	Capacitor, Aluminum 470µf, 35V, ±10%	807685	56289	503D477G035ER	2
C2	Same as C1				
C3	Capacitor, Aluminum 1000µf, 16V, ±10%	807686	56289	503D108G016ER	1
C4[1]	Capacitor, Aluminum 20µf, 250V	807676	56289	TVA-1508	1
C4[2]	Capacitor, Aluminum 10µf, 250V	808189	56289	Type R*	1
C5	Capacitor, Tantalum .22µf, 35V, ±20%	801297	56289	105D22X0035A2	2
C6	Capacitor, Tantalum 2.2µf, 35V, ±10%	802914	56289	105D225X9035B2	1
C7	Capacitor, Ceramic .1µf, 100V, ±10%	805154		CK06BX104K	3
C8	Capacitor, Tantalum 1µf, 35V, ±20%	807192	56289	196D105X9035HA1	1
C9	Same as C8				
C10[1]	Capacitor, Mica 15pf, 500V, ±5%	802497	72136	DM10-150J	3
C11[1]	Capacitor, Mica 220pf, 500V, ±10%	802341	84171	DM15-221K	4
C12[1]	Same as C11[1]				
C13[1]	Same as C11[1]				
C14[1]	Same as C11[1]				
C15	Capacitor, Tantalum 6.8µf, 35V, ±10%	801091	56289	150D685X0035B2	1
C18	Capacitor, Mica 150pf, 500V, ±5%	801365	72136	DM15F-151J	1
C20[1]	Capacitor, Mica 27pf, 500V, ±5%	801925	72136	DM15-270J	2
C20[2]	Capacitor, Ceramic 27pf, 500V, ±10%	808401	72982	CK05BX270K	2
C21[1]	Same as C20[1]				
C21[2]	Same as C20[2]				

[1] 783684 units only.
[2] 783783 units only.
* Represents type part numbers that require full description when ordering replacement parts from true manufacturer.

Replacement Parts List: Chassis Assembly (783783, 783684) (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C22	Capacitor, Mica 10pf, 500V, ±5%	802561	72136	DM15-100	1
C23	Capacitor, Mica 240pf, 500V, ±5%	803745	72136	DM15-241J	1
C24	Same as C7				
C25[1]	Same as C10[1]				
C26[1]	Same as C10[1]				
C27	Capacitor, Ceramic .01µf, 25V	803406	72982	5835-000-Y5U-103	
C28	Same as C27				
C29	Same as C27				
C30	Same as C27				
C31	Same as C27				
C32	Same as C27				
C33	Same as C27				
C52	Same as C5				
CR1	Diode	808974		1N4148	34[1] 18[2]
CR2	Same as CR1				
CR3	Same as CR1				
CR5[1]	Same as CR1				
CR6[1]	Same as CR1				
CR7[1]	Same as CR1				
CR8[1]	Same as CR1				
CR9[1]	Same as CR1				
CR10	Same as CR1				
CR11	Same as CR1				
CR12	Same as CR1				
CR13	Same as CR1				
CR14	Same as CR1				
CR15	Same as CR1				
CR16	Same as CR1				
CR17	Same as CR1				
CR18	Same as CR1				

[1] 783684 units only
[2] 783783 units only.

Replacement Parts List: Chassis Assembly (783783, 783684) (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
CR19	Same as CR1				
CR20	Same as CR1				
CR21[1]	Same as CR1				
CR22	Same as CR1				
CR23	Same as CR1				
CR24	Same as CR1				
CR25[1]	Same as CR1				
CR26[1]	Same as CR1				
CR27	Diode	804477	04713	1N4720	3
CR28	Same as CR27				
CR29	Same as CR27				
CR30[1]	Diode	807689	04713	1N5279B	1
CR30[2]	Diode	808157	04713	1N5280B	1
CR31	Same as CR1				
CR32	Same as CR1				
CR33	Same as CR1				
CR34	Same as CR1				
CR35	Same as CR1				
CR36	Same as CR1				
CR37	Same as CR1				
CR38	Same as CR1				
F1	Fuse, .5A, 3AG, 115 V	802900	75915	312.500	1
	Fuse, .25A, 3AG, 230 V	802530	75915	312.250	
	Fuseholder (for F1)	800137	75915	342004L	1
J1	Connector, 50-pin	807676	00779	205869-1	1
J2	Connector, 22-pin	807675	00779	1-5837730	1
Q1	Transistor, NPN	807690	04713	MPS-A43	1
Q2[1]	Transistor	805808	01295	TIS75	7
Q3[1]	Transistor	804136	04713	2N4125	7
Q4[1]	Same as Q2				
Q5[1]	Same as Q3				

[1] 783684 units only.
[2] 783783 units only.

Replacement Parts List: Chassis Assembly (783783, 783684) (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
Q6[1]	Same as Q2[1]				
Q7[1]	Same as Q3[1]				
Q8[1]	Same as Q2[1]				
Q9[1]	Same as Q3[1]				
Q10[1]	Same as Q2[1]				
Q11[1]	Same as Q3[1]				
Q12	Transistor	804137	49956	R51182	1
Q13	Transistor	807607	04713	2N4123	1
Q14	Transistor	807406	04713	2N5550	1
Q15[1]	Same as Q2[1]				
Q16[1]	Same as Q3[1]				
Q17[1]	Same as Q2[1]				
Q18[1]	Same as Q3[1]				
R1[1]	Resistor, Composition 110kΩ, 1/2W, ±5%	800682	01121	EB1145	1
R1[2]	Resistor, Composition 180kΩ, 1/2W, ±5%	801260	01121	EB1845	1
R2	Resistor, Composition 11kΩ, 1/4W, ±5%	802255	01121	CB1135	1
R3[1]	Resistor, Composition 47kΩ, 1/4W, ±5%	801638	01121	CB4735	16[1] 3[2]
R4[1]	Resistor, Composition 330kΩ, 1/4W, ±5%	803553	01121	CB3345	9
R5[1]	Same as R3[1]				
R6	Resistor, Metal Film 2MΩ, 1/8W, ±1%	807691	91637	DC-1/8*	2
R7[1]	Same as R3[1]				
R8[1]	Same as R4[1]				
R9[1]	Same as R3[1]				
R10	Same as R6				
R11[1]	Same as R3[1]				
R12[1]	Same as R4[1]				

[1] 783684 units only.
[2] 783783 units only.

Replacement Parts List: Chassis Assembly (783783, 783684)
(Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R13[1]	Same as R3[1]				
R14	Resistor, Metal Film 1MΩ, 1/8W, ±1%	807692	91637	DC-1/8*	1
R15[1]	Same as R3[1]				
R16[1]	Same as R4[1]				
R17[1]	Same as R3[1]				
R18	Resistor, Metal Film 499kΩ, 1/10W, ±1%	806929	16299	NC-5*	1
R19[1]	Same as R3[1]				
R20[1]	Same as R4[1]				
R21[1]	Same as R3[1]				
R22	Resistor, Metal Film 249kΩ, 1/10W, ±1%	807693		RN55C2493F	1
R23[1]	Resistor, Composition 2.2kΩ, 1/4W, ±5%	802230	01121	CB2225	2
R24[1]	Same as R23[1]				
	Resistor, Matched Set	807614	07342	807614	1
R25		807614-3			
R26		807614-2			
R27		807614-1			
R28	Resistor, Composition 1.6kΩ, 1/4W, ±5%	804078	01121	CB1625	1
R29	Resistor, Composition 2MΩ, 1/4W, ±5%	807094	01121	CB2055	2
R30	Resistor, Potentiometer 100k	807625	02111	62-1-1-104	3
	Resistor, Matched Set	807615	07342	807615	1
R31		807615-3			
R32		807615-2			
R33		807615-1			
R34	Same as R28				
R35	Same as R30				
R36	Same as R29				
R37[1]	Resistor, Composition 750Ω, 1/4W, ±5%	803229	01121	CB7515	10

[1] 783684 units only.
[2] 783783 units only.

Replacement Parts List: Chassis Assembly (783783, 783684) (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R38[1]	Same as R37[1]				
	Resistor, Matched Set Interpolation Bridge	807616	07342	807616	1
R39		807616-1			
R40		807616-2			
R45		807616-8			
R47		807616-7			
R49		807616-6			
R51		807616-5			
R53		807616-4			
R55		807616-3			
R41	Resistor, Metal Film 200kΩ, 1/10W, ±1%	807694		RN55C2003F	1
R42[1]	Same as R37[1]				
R43	Resistor, Metal Film 100kΩ, 1/10W, ±1%	806992		RN55D1003F	2
R44[1]	Same as R37[1]				
R46[1]	Same as R37[1]				
R48[1]	Same as R37[1]				
R50[1]	Same as R37[1]				
R52[1]	Same as R37[1]				
R54[1]	Same as R37[1]				
R56[1]	Same as R37[1]				
R57	Resistor, Composition 8.2kΩ, 1/4W, ±5%	802080	01121	CB8225	1
R58	Resistor, Metal Film 267kΩ, 1/10W, ±1%	807641	91637	MF-1/10*	1
R59	Resistor, Metal Film 66.5kΩ, 1/10W, ±1%	807636	91637	MF-1/10*	2
R60	Same as R3[1]				
R61	Same as R59				
R62	Resistor, Metal Film 107kΩ, 1/10W, ±1%	807638	91637	MF-1/10*	1
R63	Resistor, Metal Film 26.7kΩ, 1/10W, ±1%	807634	91637	MF-1/10*	3
R64	Same as R63				

[1] 783684 units only.
[2] 783783 units only.

Replacement Parts List: Chassis Assembly (783783, 783684) (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R65	Resistor, Composition 24kΩ, 1/4W, ±5%	801393	01121	CB2435	5
R66	Same as R65				
R68	Resistor, Composition 33kΩ, 1/4W, ±5%	802259	01121	CB3335	3
R69[1]	Resistor, Composition 620kΩ, 1/4W, ±5%	805326		RCR07G624JP	1
R69[2]	Resistor, Composition 390kΩ, 1/4W, ±5%	801987	01121	CB3945	1
R70	Resistor, Potentiometer 100kΩ	807786	73138	68WR100K	1
R71	Resistor, Metal Film 412Ω, 1/10W, ±1%	807630	91637	MF-1/10*	1
R72	Resistor, Metal Film 150kΩ, 1/4W, ±1%	807332	16299	C4*	1
R73	Same as R43				
R74	Same as R65				
R75	Resistor, Composition 150Ω, 1/4W, ±5%	803672	01121	CB1515	1
R76	Same as R65				
R77	Resistor, Composition 18kΩ, 1/4W, ±5%	802183	01121	CB1835	1
R78	Same as R68				
R79	Resistor, Composition 6.8kΩ, 1/4W, ±5%	802189	01121	CB6825	4[1] 3[2]
R80	Same as R65				
R81	Same as R63				
R82	Resistor, Metal Film 13.3kΩ, 1/10W, ±1%	807633	91637	MF-1/10*	2
R83	Resistor, Metal Film 3.65kΩ, 1/10W, ±1%	807632	91637	MF-1/10*	2
R84	Resistor, Metal Film 3.32kΩ, 1/10W, ±1%	807631	91637	MF-1/10*	2
R85	Resistor, Metal Film 49.9kΩ, 1/10W, ±1%	807635	91637	MF-1/10*	2
R86	Same as R84				

[1] 783684 units only.
[2] 783783 units only.

Replacement Parts List: Chassis Assembly (783783, 783684) (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R87	Same as R85				
R88	Same as R82				
R89	Same as R83				
R90	Resistor, Metal Film 20kΩ, 1/8W, ±1%	806544	16299	NC4*	1
R91	Same as R79				
R92	Same as R79				
R93	Resistor, Composition 12kΩ, 1/4W, ±5%	801721	01121	CB1235	3
R94	Same as R93				
R95	Same as R93				
R96	Resistor, Composition 10kΩ, 1/4W, ±5%	801006	01121	CB1035	3
R97	Same as R96				
R98	Same as R68				
R99	Resistor, Composition 91kΩ, 1/4W, ±5%	803240	01121	CB9135	1
R100	Same as R77				
R101[1]	Same as R79				
R102	Resistor, Composition 1.3MΩ, 1/4W, ±5%	803657	01121	CB1355	1
R103[1]	Resistor, Composition 20kΩ, 1/4W, ±5%	801636	01121	CB2035	1
R103[2]	Resistor, Composition 5.1kΩ, 1/4W, ±5%	801397	01121	CB5125	1
R104	Resistor, Composition 100kΩ, 1/4W, ±5%	801986	01121	CB1045	4
R105	Same as R3[1]				
R106	Resistor, Metal Film 10kΩ, 1/8W, ±1%	806103	16299	NC4*	1
R107[1]	Same as R4[1]				
R107[2]	Resistor, Composition 330kΩ, 1/4W, ±5%	803553	01121	CB3345	2
R108	Resistor, Composition 620Ω, 1/4W, ±5%	804598	01121	CB6215	1

[1] 783684 units only.
[2] 783783 units only.

Replacement Parts List: Chassis Assembly (783783, 783684)
(Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R109	Resistor, Metal Film 53.6kΩ, 1/10W, ±1%	807696		RN55C5362F	1
R110	Resistor, Metal Film 22kΩ, 1/10W, ±1%	807697		RN55C2263F	1
R111	Resistor, Metal Film 41.2kΩ, 1/10W, ±1%	807695		RN55C4122F	1
R112[1]	Same as R4[1]				
R112[2]	Same as R104				
R113[1]	Same as R3[1]				
R113[2]	Same as R104				
R114[1]	Same as R3[1]				
R114[2]	Same as R104				
R115[1]	Same as R3[1]				
R116[1]	Same as R4[1]				
R117[1]	Same as R3[1]				
R118	Same as R96				
R119[1]	Same as R4[1]				
R119[2]	Same as R107[2]				
R120	Same as R30				
R121	Same as R3[1]				
S1[1]	Switch, PB 3-section	807698	31918	3G10FSCBLK-4UGR	1
S1[2]	Switch	808692	07342	808692	1
S2[1]	Same as S1[1]				
S2[2]	Same as S1[2]				
S3[1]	Same as S1[1]				
S3[2]	Same as S1[2]				
S4	Switch, Voltage Select	806675	79727	GF-326UL	1
T4	Transformer, Power	807659	07342	807659	1
VP1	Varistor	807699	03508	V130LA10A	2
VP2	Same as VP1				
XZ1	Socket, I.C. 14-pin	807473	01295	C931402	11[1] 9[2]

[1] 783684 units only.
[2] 783783 units only.

Replacement Parts List: Chassis Assembly (783783, 783684)
(Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
XZ2	Same as XZ1				
XZ3	Same as XZ1				
XZ4	Socket, I.C. 8-pin	805671	71785	8 ICS	1
XZ5	Same as XZ1				
XZ6	Same as XZ1				
XZ7	Same as XZ1				
XZ8	Socket, I.C. 16-pin	807474	01295	C931602	3
XZ9	Same as XZ1				
XZ10	Same as XZ1				
XZ11[1]	Same as XZ1				
XZ11[2]	Socket, I.C. 20-pin	808358	01295	C93-20-02	3
XZ12[1]	Same as XZ1				
XZ12[2]	Same as XZ11[2]				
XZ13[1]	Same as XZ1				
XZ13[2]	Same as XZ11[2]				
XZ14	Socket, Strip	807733	91506	325-AG10	2
XZ22[2]	Same as XZ1				
XZ23	Same as XZ8				
XZ24	Same as XZ8				
Z1	Integrated Circuit	807530	49956	RC4136	3
Z2	Integrated Circuit	807784	07342	807784	1
Z3	Integrated Circuit	807626	12040	LM339N	1
Z4	Integrated Circuit	806347	12040	LM301A	1
Z5	Same as Z1				
Z6	Same as Z1				
Z7	Integrated Circuit	808394	01295	TL075CN	1
Z8	Integrated Circuit	807700-MOS	12040	74C192N	1
Z9	Integrated Circuit	807701-MOS	12040	74C00N	1
Z10	Integrated Circuit	807702-MOS	04713	MC14561	1
Z11[1]	Integrated Circuit	807703-MOS	12040	74C902	3

[1] 783684 units only.
[2] 783783 units only.

Replacement Parts List: Chassis Assembly (783783, 783684) (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
Z11[2]	Integrated Circuit	808357	12040	DM81LS95N	3
Z12[1]	Same as Z11[1]				
Z12[2]	Same as Z11[2]				
Z13[1]	Same as Z11[1]				
Z13[2]	Same as Z11[2]				
Z14	LSI Trig Logic Processor	807155-MOS	07342	807155	1
Z15[1]	Diode, Bridge Rectifier	807704	30870	VM08	3[1] 2[2]
Z16	Same as Z15[1]				
Z17	Same as Z15[1]				
Z18	Diode, Bridge Rectifier	807705	30870	VM48	1
Z19[2]	Voltage Regulator	808388	12040	LM340T-15	1
Z20[2]	Voltage Regulator	808390	12040	LM320T-15	1
Z21[2]	Voltage Regulator	808389	12040	LM340T-5	1
Z22[2]	Integrated Circuit	808043	01295	74L00	1
Z23[2]	Integrated Circuit	808089	12040	LF13202N	2
Z24[2]	Same as Z23[2]				
J5*	Connector, 22-pin	808168	00779	87334-9	2
J6*	Same as J5				

[1]783684 units only.
[2]783783 units only.
*Used with ±180° or degrees & minutes option.

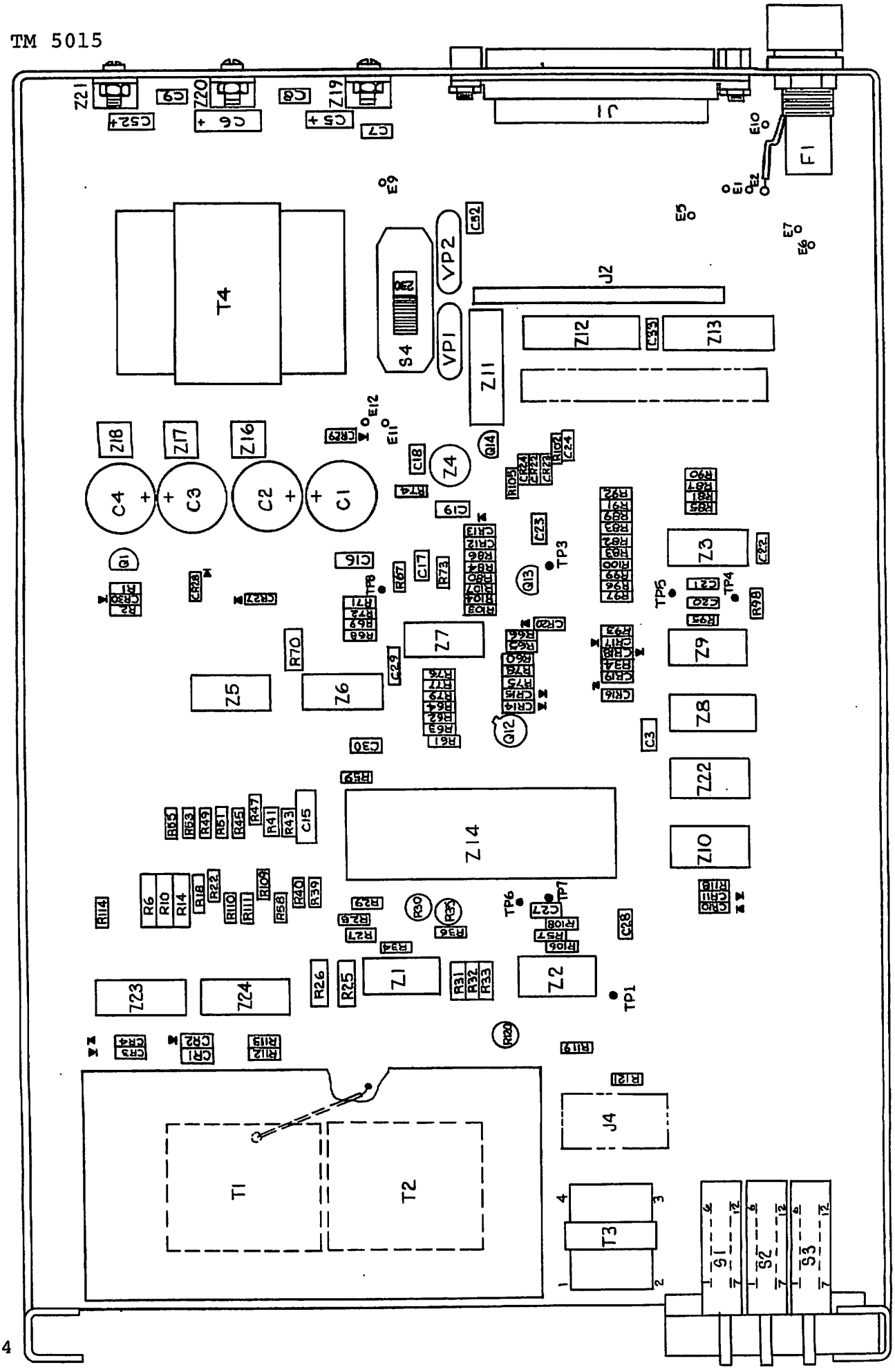


Figure 7-2. Main Chassis (783783), Parts Locator

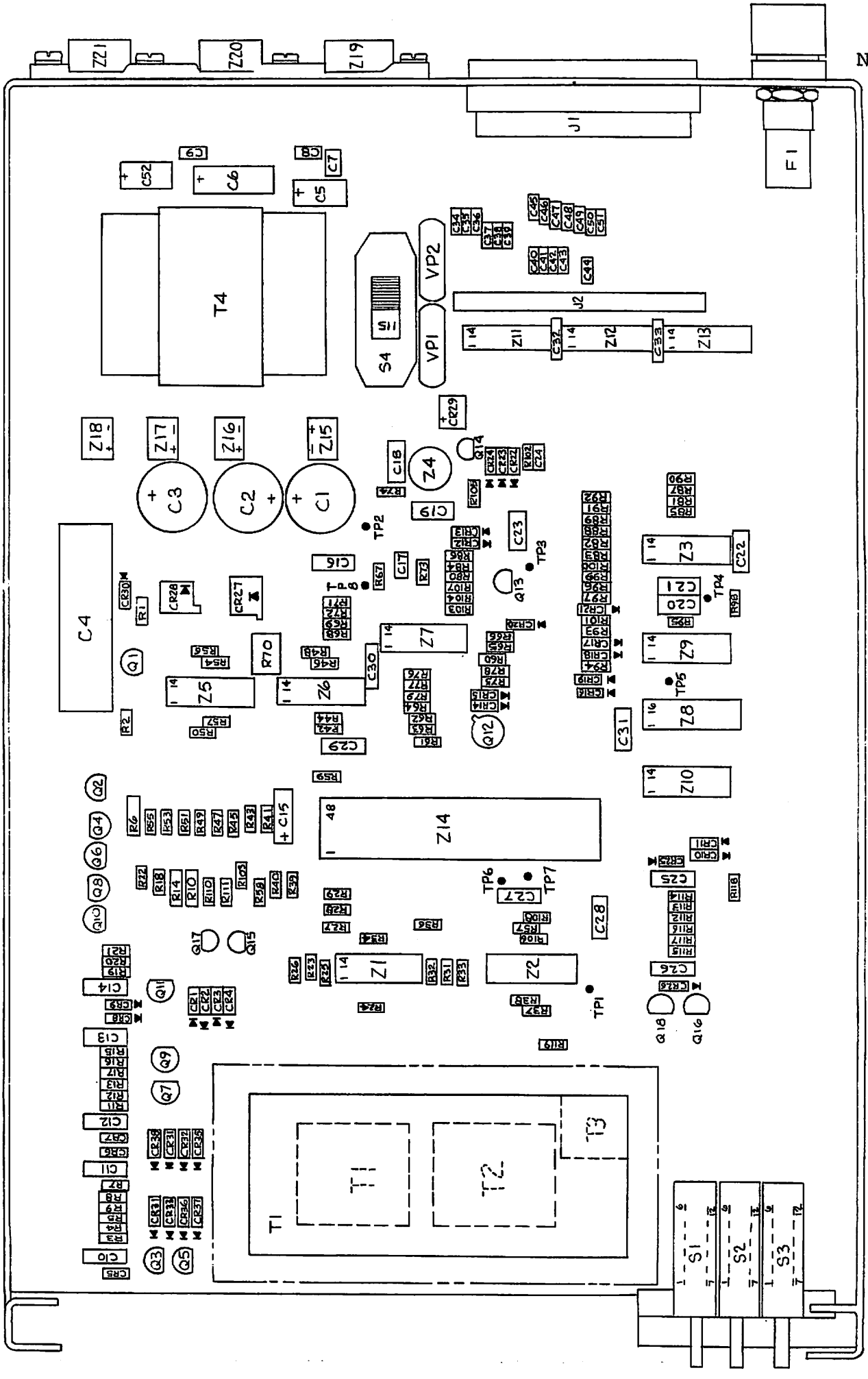


Figure 7-3. Main Chassis (783684), Parts Locator

Replacement Parts List - Standard Model ONLY (47 Hz to 440 Hz)
(Part of Main Chassis)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C16	Capacitor, Ceramic .47µf, 50V, ±10%	805075		CK06BX474KP	1
C17	Capacitor, Ceramic .1µf, 100V, ±10%	805154		CK06BX104K	1
C19	Capacitor, Mica 1500pf, 100V, ±5%	807363	72136	DM15FA152J	1
R67	Resistor, Composition 120kΩ, 1/4W, ±5%	802438	01121	CB1245	1
T1[1]	Transformer	807653	07342		1
T1[2]	Transformer, Scott-T	808261	07342		1
T2[1]	Same as T1[1]				
T2[2]	Same as T1[2]				
T3[1]	Same as T1[1]				
T3	Transformer, Reference	808148	07342		1

Replacement Parts List - (±.03° Accuracy, 360-1200Hz Option)
(Part of Main Chassis)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C16	Capacitor, Ceramic .47µf, 50V, ±10%	805075		CK06BX474KP	1
C17	Capacitor, Ceramic .1µf, 100V, ±10%	805154		CK06BX104K	1
C19	Capacitor, Mica 150pf, 500V, ±5%	801365	72136	DM15F151J	1
R67	Resistor, Composition 62kΩ, 1/4W, ±5%	802082	01121	CB6235	1
R72	Resistor, Metal Film 226kΩ, 1/10W, ±1%	807697		RN55C2263F	1
T1	Transformer, Scott-T	808029	07342	783741	1
T2	Same as T1				
T3[1]	Transformer, Reference	807570	07342		1
T3[2]	Transformer, Reference	808148	07342		1

[1] 783684 units only.
[2] 783783 units only.

Replacement Parts List - (.03° Accuracy, 47-440Hz Option)
(Part of Main Chassic)

Ref. Des.	Description	NAI Part-No.	Mfr. Code	Mfr. Part No.	Total Qty
C16	Capacitor, Ceramic .47µf, 50V, ±10%	805075		CK06BX474KP	1
C17	Capacitor, Ceramic .1µf, 100V, ±10%	805154		CK06BX104K	1
C19	Capacitor, Mica 1500pf, 100V, ±5%	807363	72136	DM15FA152J	1
R67	Resistor, Composition 120kΩ, 1/4W, ±5%	802438	01121	CB1245	1
T1	Transformer, Scott-T	807799	07342	783740	1
T2	Same as T1				
T3	Transformer, Reference	808148	07342	808148	1

Replacement Parts List - (400Hz only Option)
(Part of Main Chassis)

C16	Capacitor, Ceramic .47µf, 50V, ±10%	805075		CK06BX474KP	1
C17	Capacitor, Ceramic .1µf, 100V, ±10%	805154		CK06BX104K	1
C19	Capacitor, Mica 150pf, 500V, ±5%	801365	72136	DM15-F151J	1
R67	Resistor, Composition 62kΩ, 1/4W, ±5%	802082	01121	CB6235	1
T1[1]	Transformer Set	807660	07342		1
T1[2]	Transformer Set	808261	07342		1
T2[1]	Same as T1[1]				
T2[2]	Same as T1[2]				
T3[1]	Same as T1[1]				
T3[2]	Transformer, Reference	808148	07342		1

[1] 783684 units only.
[2] 783783 units only.

Replacement Parts List - (400-1200Hz, Low Voltage Option) (5V, 11.8V, 26V)
(Part of Main Chassis)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C16	Capacitor, Ceramic .47µf, 50V, ±10%	805075		CK06BX474KP	1
C17	Capacitor, Ceramic .1µf, 100V, ±10%	805154		CK06BX104K	1
C19	Capacitor, Mica 150pf, 500V, ±5%	801365	72136	DM15-F151J	1
R58	Resistor, Metal Film 187kΩ, 1/10W, ±1%	808083	01121	Type CC*	1
R67	Resistor, Composition 62kΩ, 1/4W, ±5%	802082	01121	CB6235	1
R110	Resistor, Metal Film 137kΩ, 1/10W, ±1%	808084	01121	Type CC*	1
R111	Resistor, Metal Film 44.2kΩ, 1/10W, ±1%	808085	01121	Type CC*	1
T1[1]	Transformer Assembly	807763	07342	807763	1
T1[2]	Transformer Assembly	808150	07342	808150	1
T2[1]	Same as T1[1]				
T2[2]	Same as T1[2]				
T3[1]	Same as T1[1]				
T3[2]	Transformer, Reference	808148	07342	808148	1

[1] 783684 units only.
[2] 783783 units only.

Replacement Parts List - Standard Model 8300 Display Board & Degrees & Minutes Option)
-783685-

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
DS1	Display Readout	807671	73138	SP352	1
DS2	Display Readout	807670	73138	SP353	1
R2	Resistor, Composition 13kΩ, 1/4W, ±5%	802186	01121	CB1335	5
R3	Resistor, Composition 2.2kΩ, 1/2W, ±5%	800079	01121	EB2225	5
R5	Same as R2				
R6	Same as R3				
R8	Same as R2				
R9	Same as R3				
R10	Resistor, Composition 430kΩ, 1/4W, ±5%	802519	01121	CB4345	1
R12	Same as R2				
R13	Same as R3				
R15	Same as R2				
R16	Same as R3				
R17	Resistor, Composition 330kΩ, 1/4W, ±5%	803553	01121	CB3345	1
W1	Cable, Flat-Flex	807674	00779	86948-3	1
XZ1	Socket, I.C., 16-pin	807474	01295	C931602	5
XZ2	Same as XZ1				
XZ3	Same as XZ1				
XZ4	Same as XZ1				
XZ5	Same as XZ1				
Z1	Integrated Circuit	806945	56232	DD-700	5
Z2	Same as Z1				
Z3	Same as Z1				
Z4	Same as Z1				
Z5	Same as Z1				

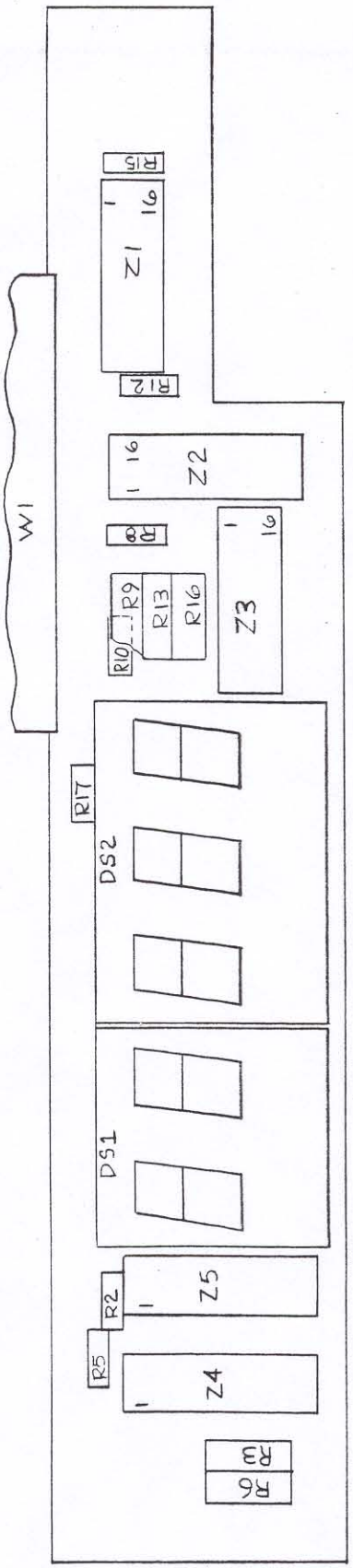


Figure 7-4. Display Board (Standard and Degrees & Minutes Option), Parts Locator

Replacement Parts List - ±180° Display Board - 783716

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
CR1	Diode	805805		1N4148	2
CR2	Same as CR1				
DS1	Display Readout	807669	73138	SP352	1
DS2	Display Readout	807670	73138	SP353	1
Q1	Transistor	807607		2N4123	1
R2	Resistor, Composition 13kΩ, 1/4W, ±5%	802186	01121	CB1335	5
R3	Resistor, Composition 2.2kΩ, 1/2W, ±5%	800079	01121	EB2225	5
R5	Same as R2				
R6	Same as R3				
R8	Same as R2				
R9	Same as R3				
R10	Resistor, Composition 430kΩ, 1/4W, ±5%	802519	01121	CB4345	1
R12	Same as R2				
R13	Same as R3				
R15	Same as R2				
R16	Same as R3				
R17	Resistor, Composition 330kΩ, 1/4W, ±5%	803553	01121	CB3345	1
R18	Resistor, Composition 27kΩ, 1/4W, ±5%	802256	01121	CB2735	1
R19	Resistor, Composition 100kΩ, 1/4W, ±5%	801986	01121	CB1045	1
W1	Cable, Flat-Flex	807674	00779	86948-3	1
XZ1	Socket, I.C., 16-pin	807474	01295	C931602	5
XZ2	Same as XZ1				
XZ3	Same as XZ1				
XZ4	Same as XZ1				
XZ5	Same as XZ1				
Z1	Integrated Circuit	806945	56232	DD700	4
Z2	Same as Z1				
Z3	Same as Z1				
Z4	Same as Z1				
Z5	Integrated Circuit	807761	56232	DD702	1

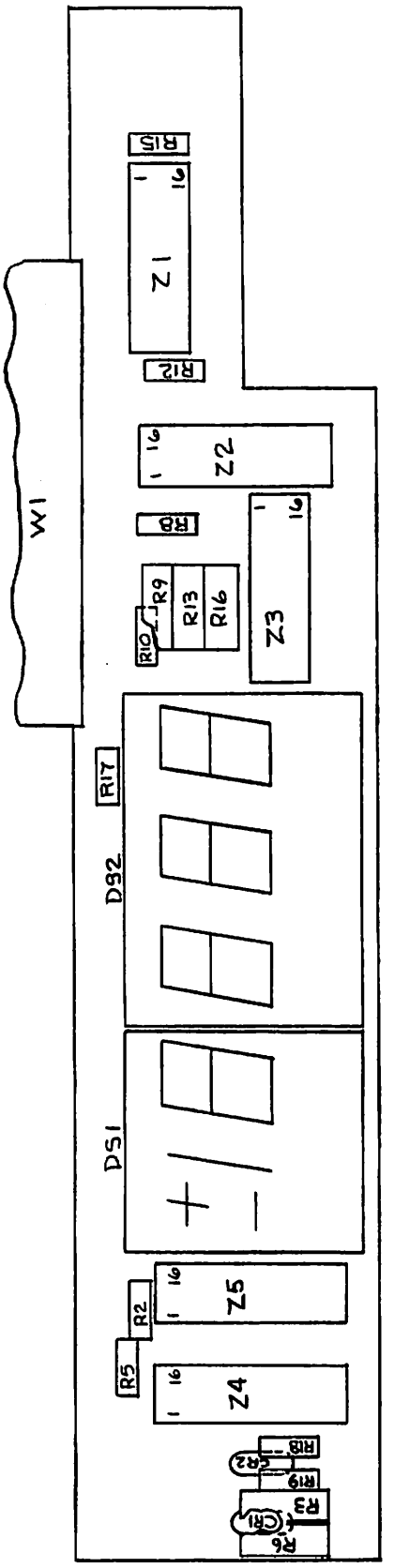


Figure 7-5. ±180° Display Board Option, Parts Locator

Replacement Parts List - Degrees-to-Minutes Converter Option - 783725

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C1	Capacitor, Ceramic .01µf, 25V, +80-20%	803406	72982	5835-000-Y5U-1032	1
XZ1	Socket, I.C., 24-pin	808004	00779	530195-1	1
Z1	Integrated Circuit	808003	18324	N82S114	1

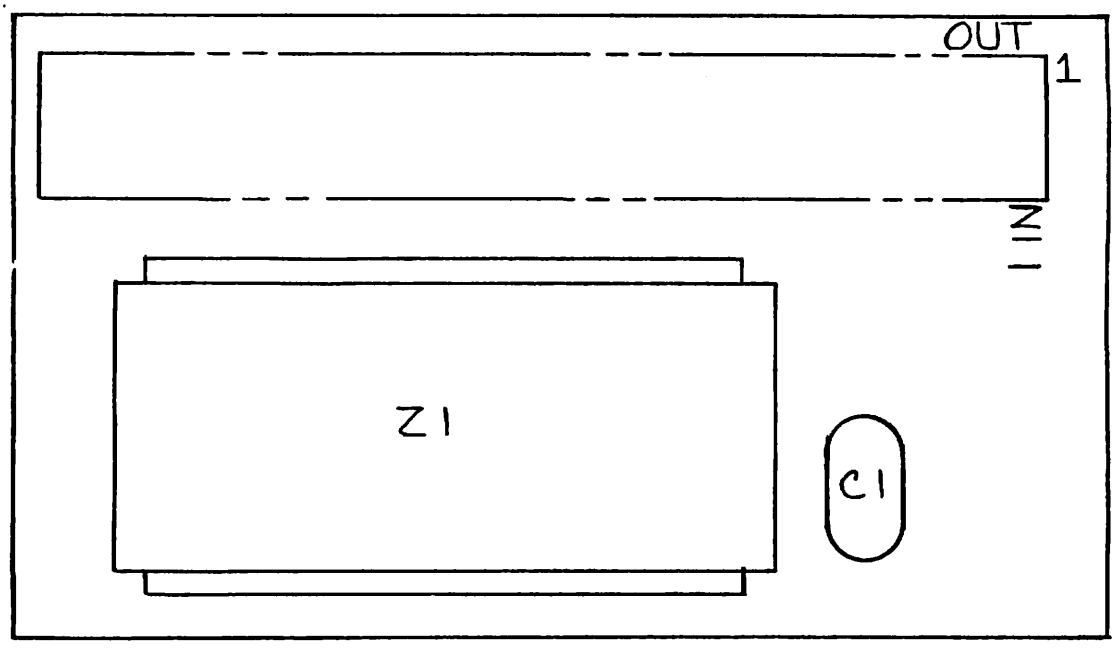


Figure 7-6. Degrees-to-Minutes Converter Option, Parts Locator

Replacement Parts List - ±180° Digital Board Option - 783719

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C1	Capacitor, Ceramic .01µf, 25V, +80-20%	803406	72982	5835-000-Y5U-1032	2
C2	Same as C1				
XZ1	Socket, I.C., 14-pin	807473	01295	C931402	6
XZ2	Socket, I.C., 16-pin	807474	01295	C931602	10
XZ3	Same as XZ2				
XZ4	Same as XZ1				
XZ5	Same as XZ2				
XZ6	Same as XZ2				
XZ7	Same as XZ1				
XZ8	Same as XZ2				
XZ9	Same as XZ2				
XZ10	Same as XZ1				
XZ11	Same as XZ2				
XZ12	Same as XZ2				
XZ13	Same as XZ1				
XZ14	Same as XZ2				
XZ15	Same as XZ2				
XZ16	Same as XZ1				
Z1	Integrated Circuit	807701	12040	74C00N	1
Z2	Integrated Circuit	807780	04713	MC14519	5
Z3	Integrated Circuit	807779	04713	MC14560	5
Z4	Integrated Circuit	807702	04713	MC14561	5
Z5	Same as Z2				
Z6	Same as Z3				
Z7	Same as Z4				
Z8	Same as Z2				
Z9	Same as Z3				
Z10	Same as Z4				
Z11	Same as Z2				
Z12	Same as Z3				
Z13	Same as Z4				
Z14	Same as Z2				
Z15	Same as Z3				
Z16	Same as Z4				

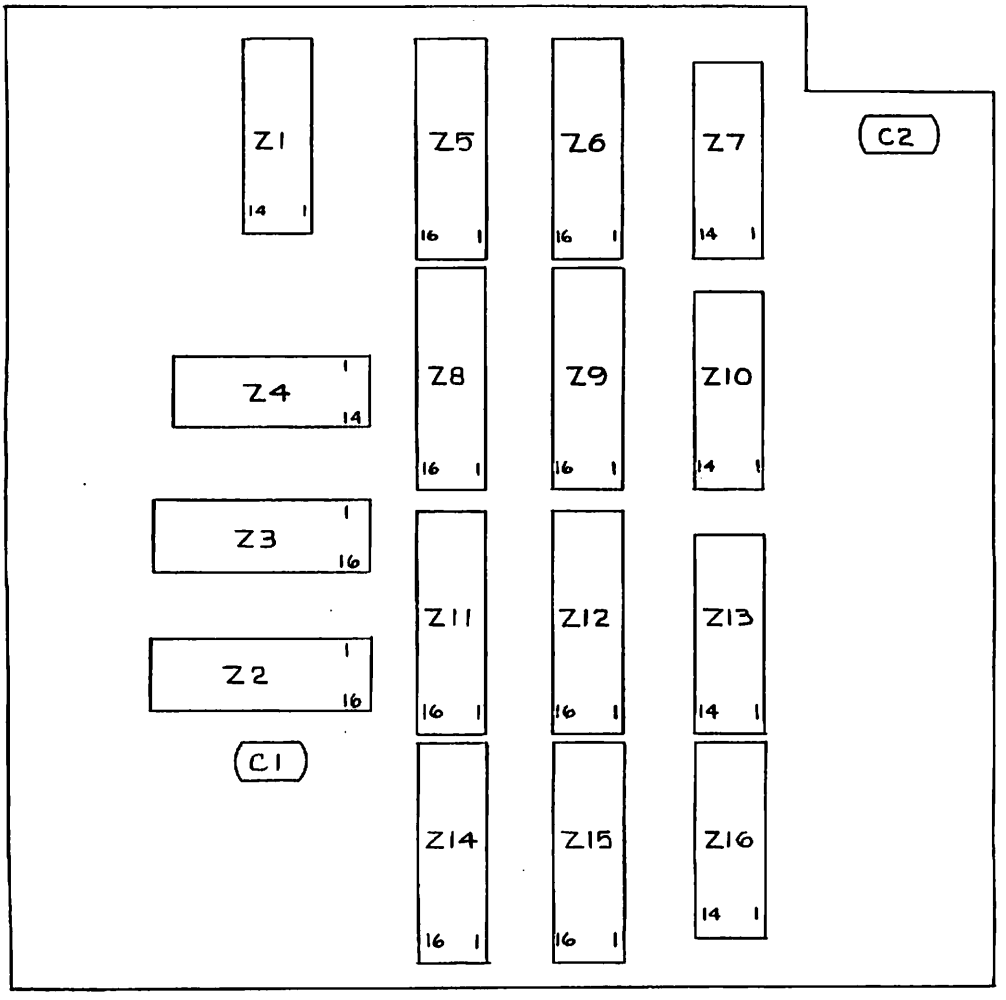
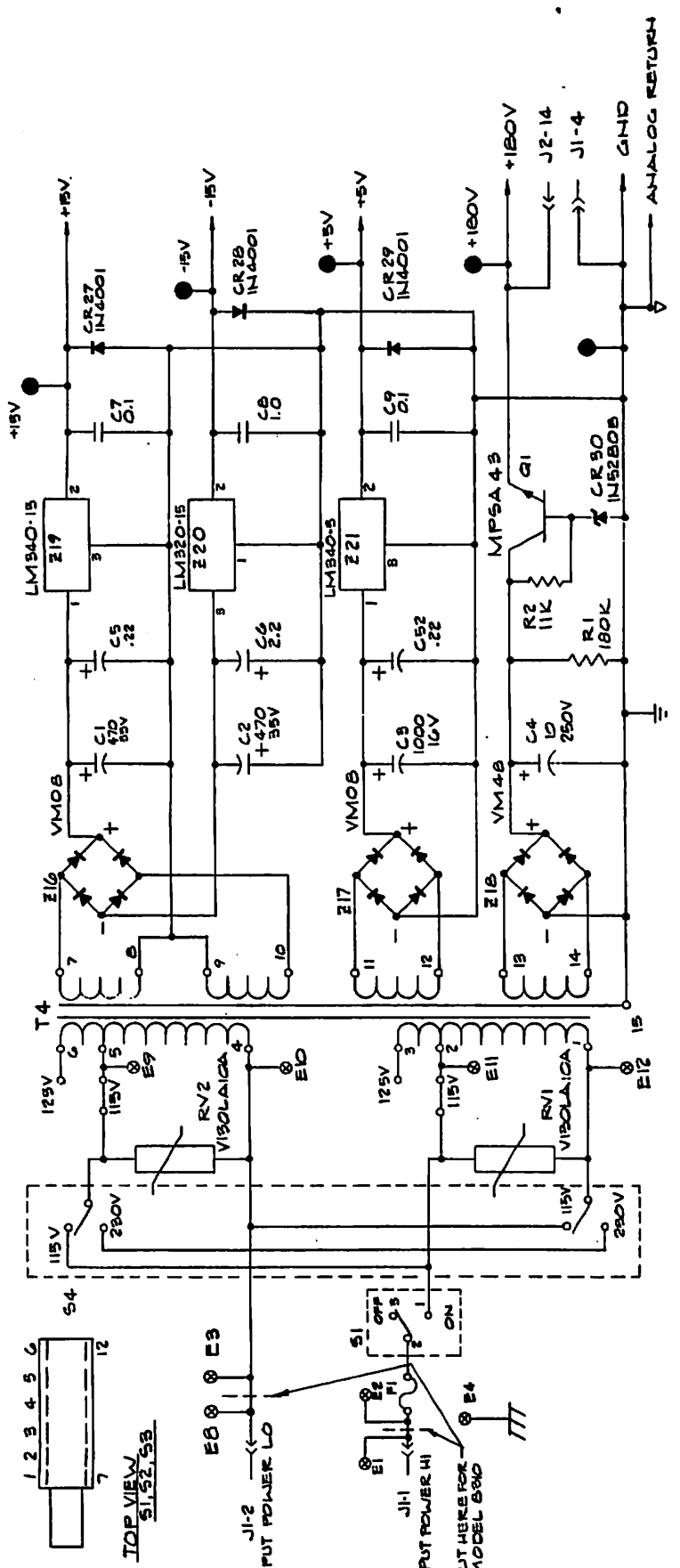


Figure 7-7. ±180° Digital Board Option, Parts Locator

SECTION 8

UNIT SCHEMATICS

This section contains schematic diagrams for the basic and optional units of the API.



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE 1/4W, ±5%.
2. ALL CIRCLED NOS ARE Z14 PIN NO'S.
3. UNLESS OTHERWISE SPECIFIED ALL CAPACITORS ARE IN MICROFARADS. *P/O FOR DICOFARAD.
4. **SEE PARTS LIST FOR VALUE OF C16, C17, C19, R67

Figure 8-1. Main Chassis (783783) (Sh 1 of 3), Schematic

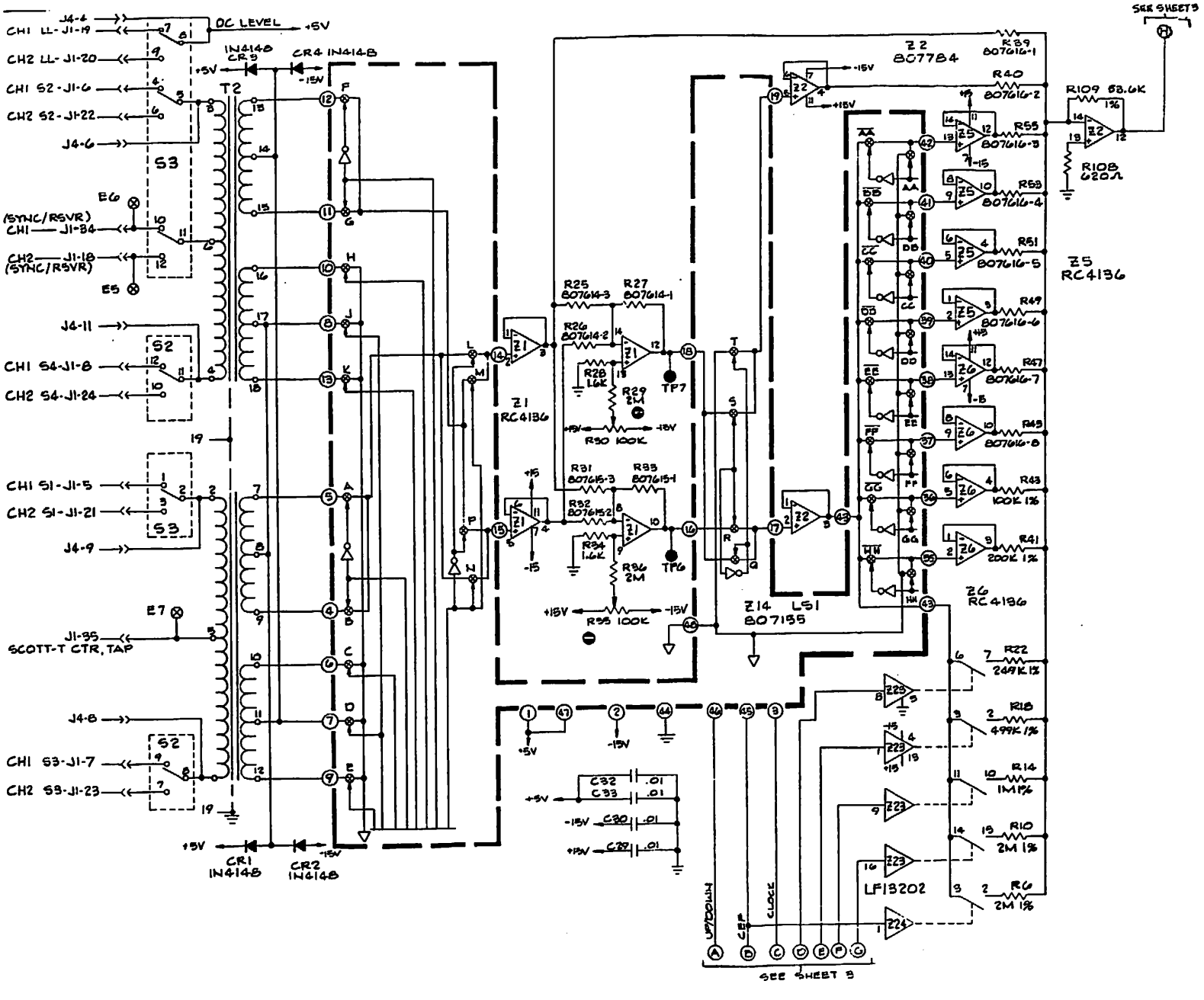


Figure 8-1. Main Chassis (783783)(Sh 2 of 3), Schematic

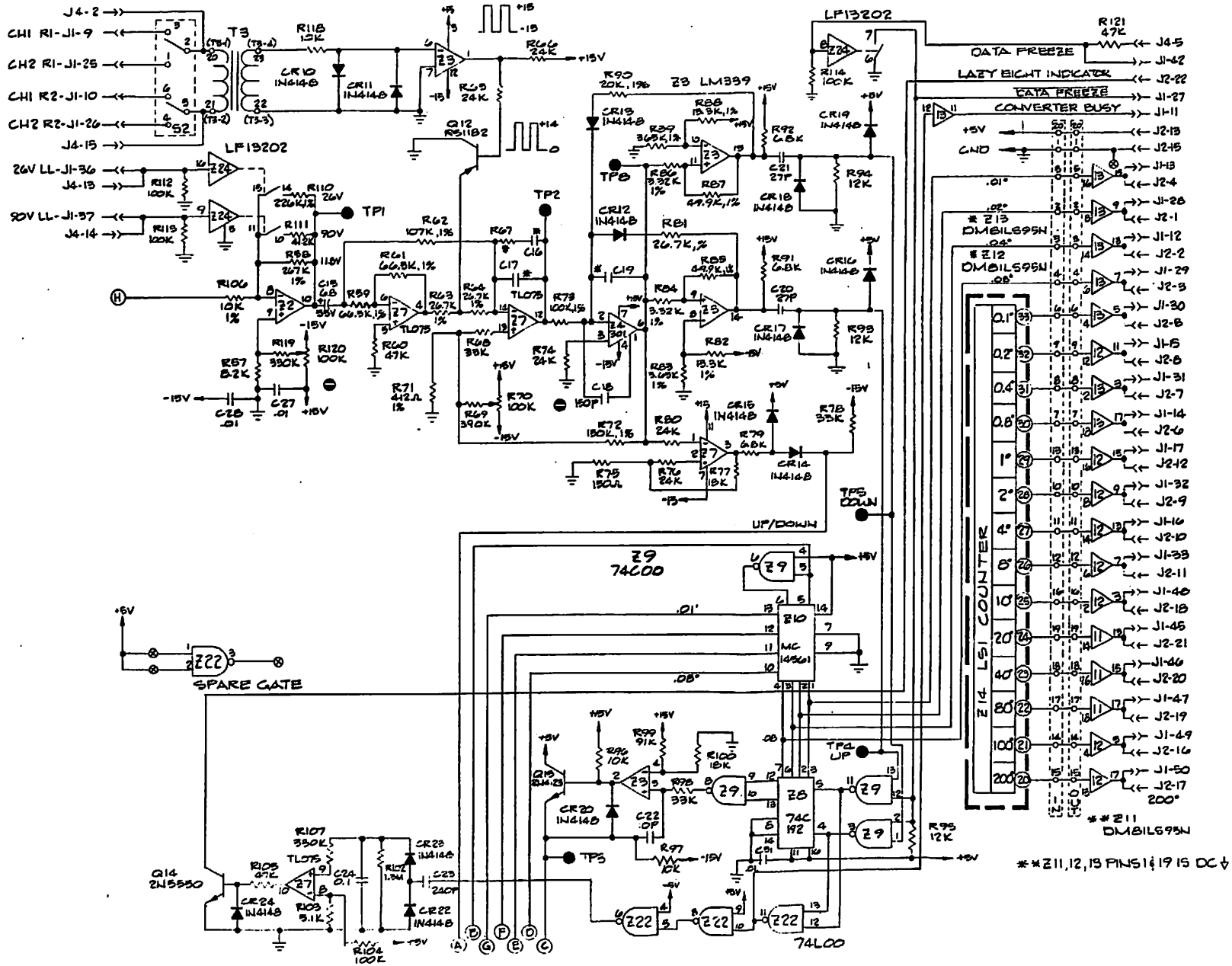


Figure 8-1. Main Chassis (783783)(Sh 3 of 3), Schematic

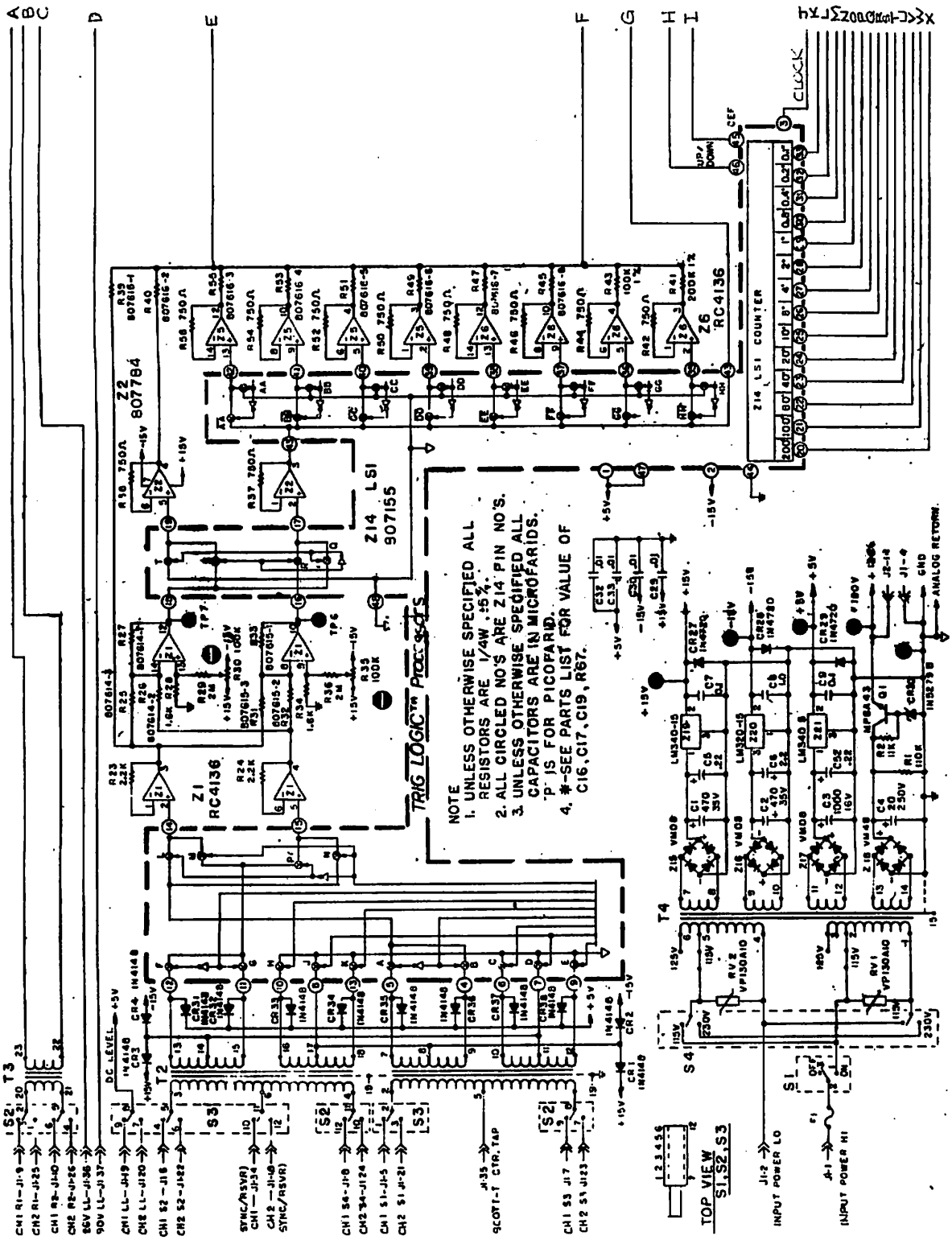


Figure 8-2. Main Chassis (783684)(Sh 1 of 2), Schematic

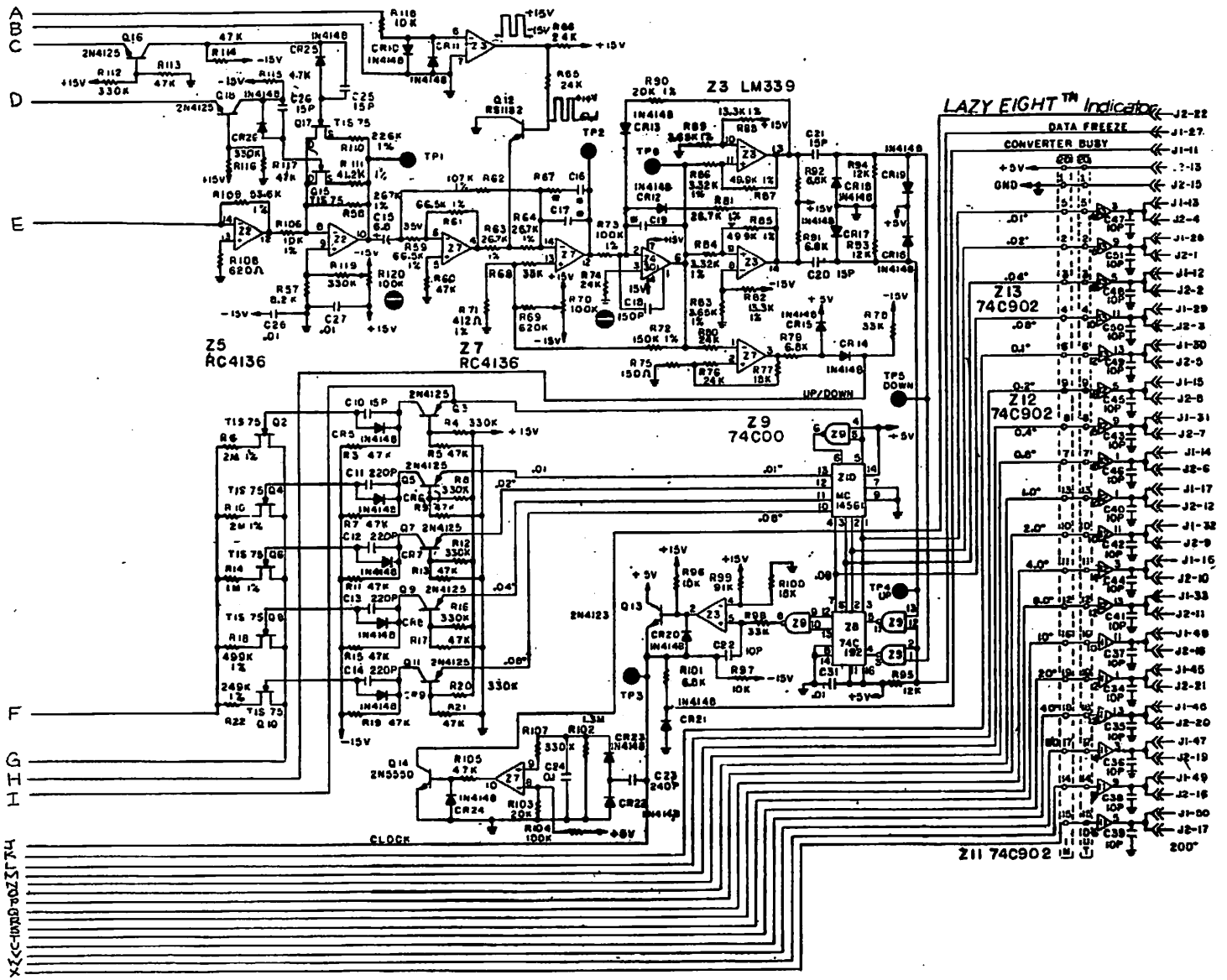
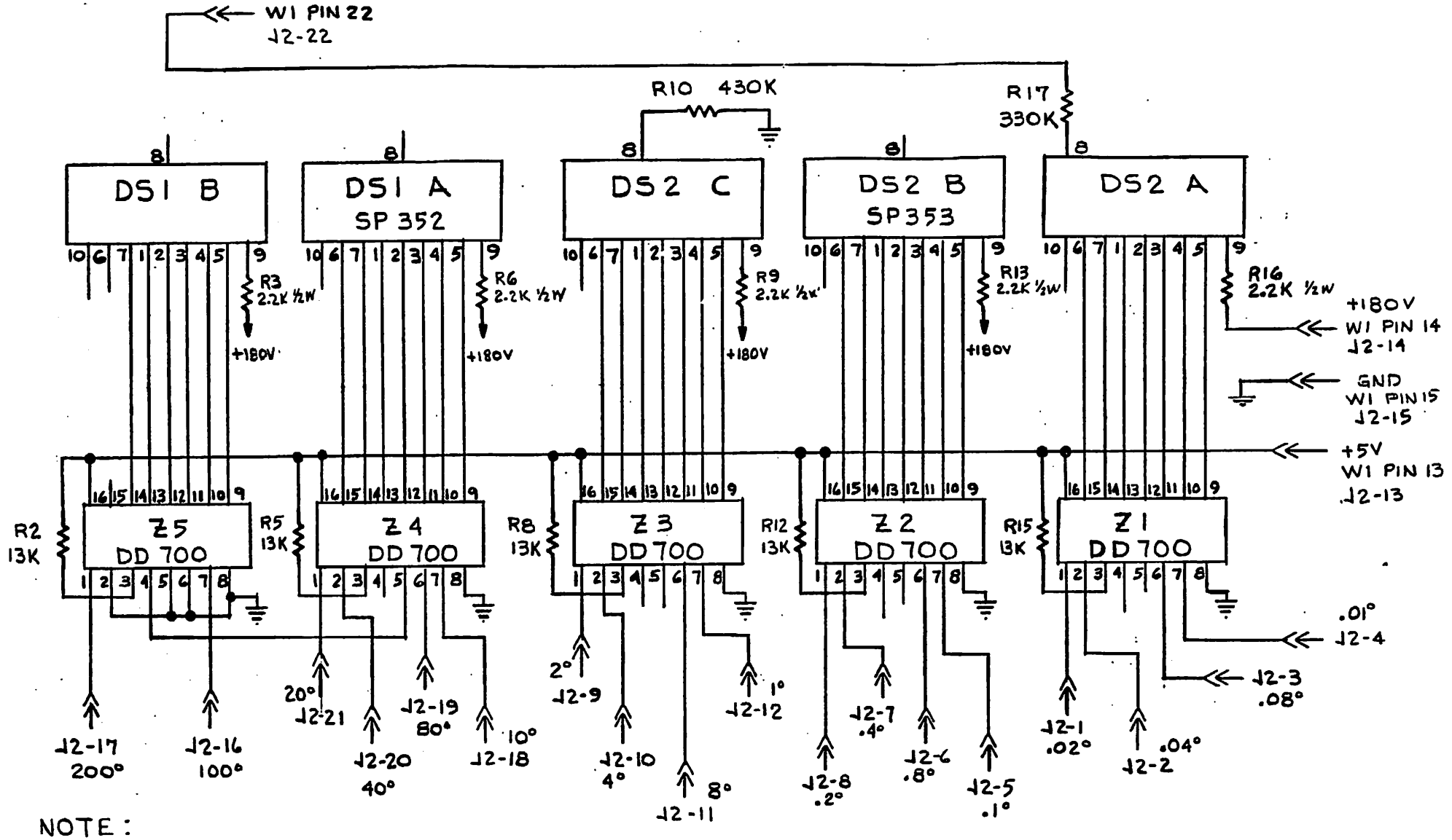


Figure 8-2. Main Chassis (783684)(Sh 2 of 2), Schematic

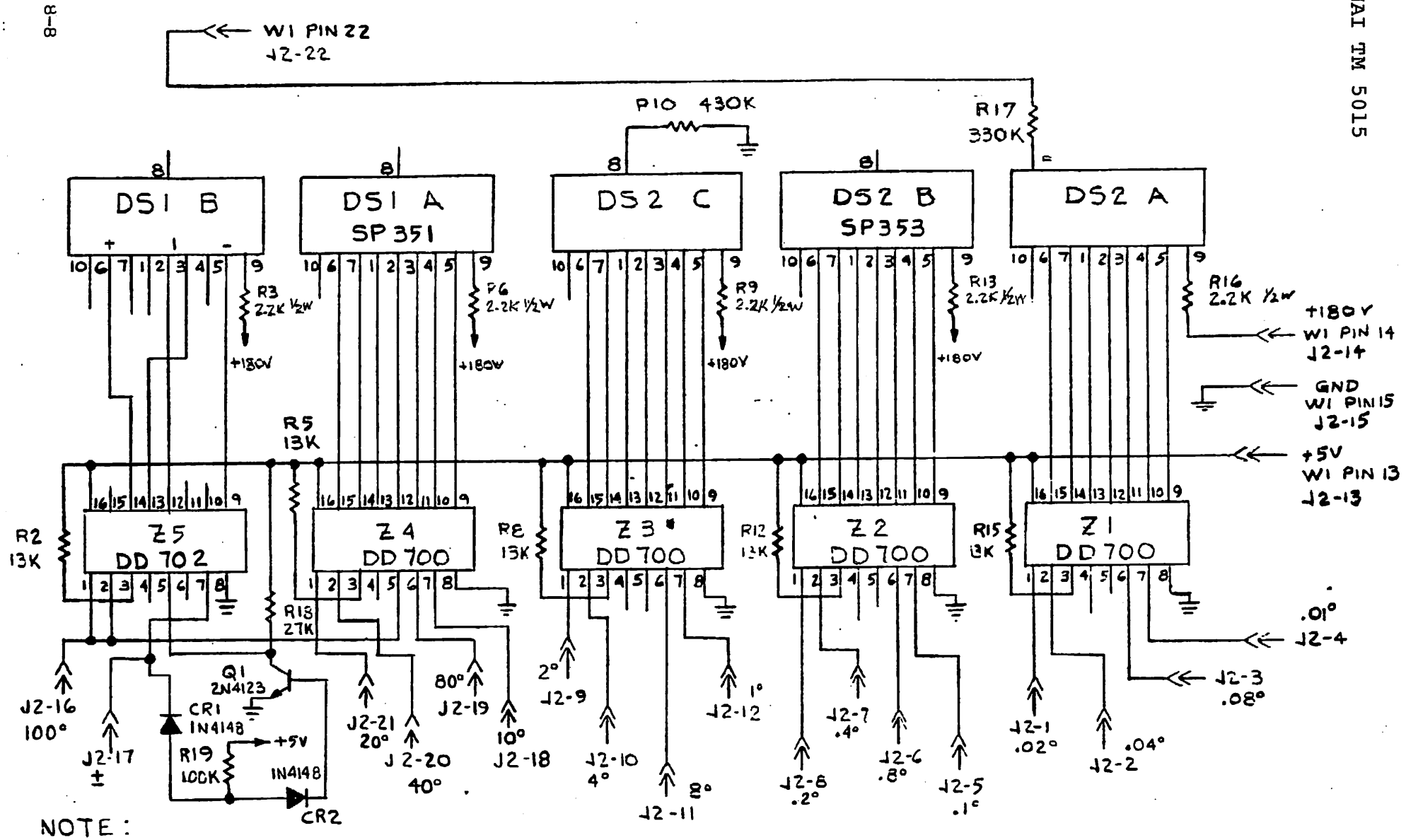


NOTE:

1 - UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE 1/4W, ±5%.

2 - PIN NUMBERS FOR W1 AND J2 ARE INTERCHANGEABLE.

Figure 8-3. 360° Display Board (Standard and Degrees & Minutes Option), Schematic



NOTE:

1 - UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE 1/4W, ±5%.

2 - PIN NUMBERS FOR W1 AND J2 ARE INTERCHANGEABLE.

Figure 8-4. ±180° Display Board Option , Schematic

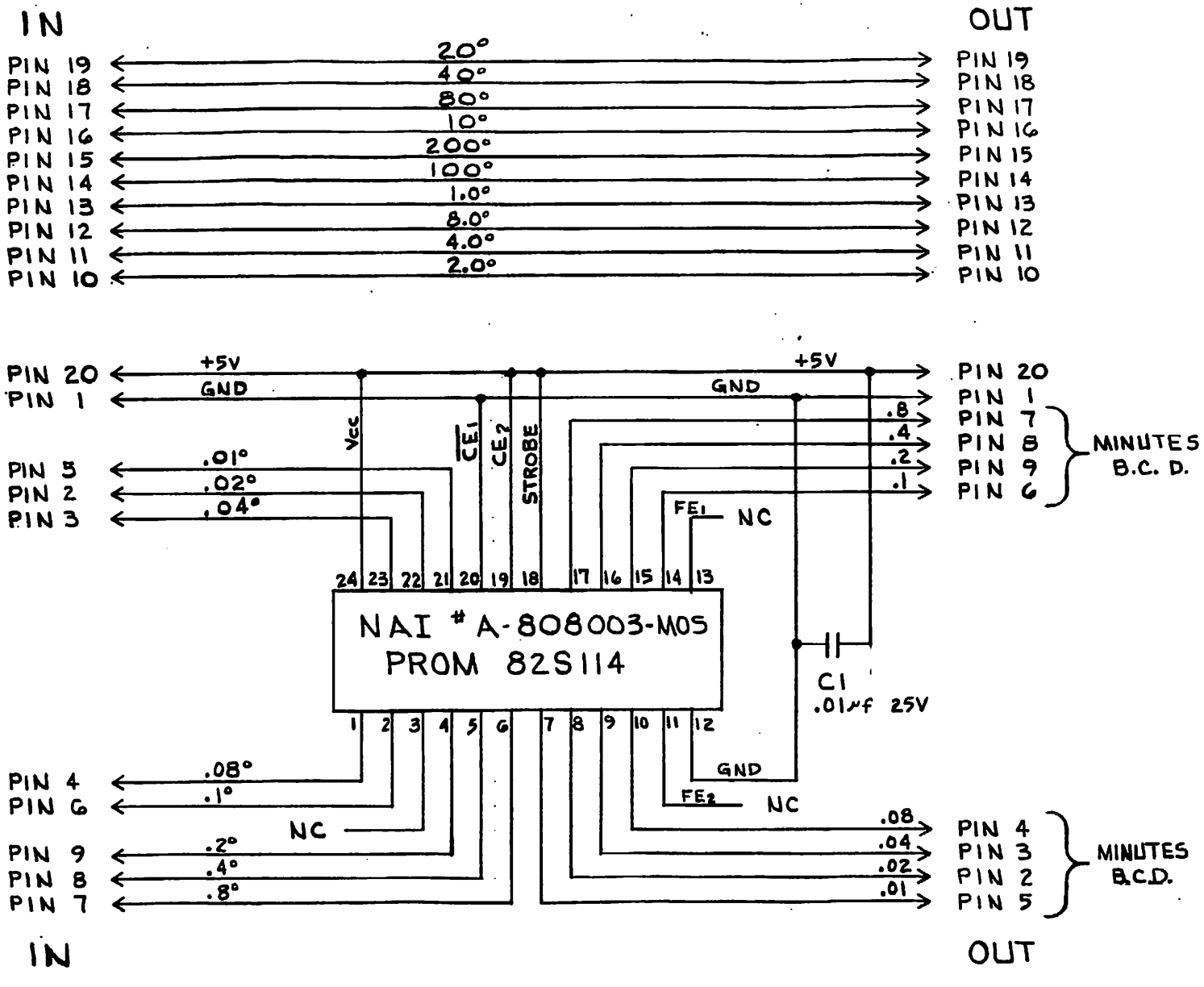


Figure 8-5. Degrees-to-Minutes Converter Option, Schematic

NOTE:
1- Z1 (74C00N), AND Z4, 7, 10, 13 AND 16 (MC14561) ARE 14 PIN IC'S WITH PIN 7 TO GND AND PIN 14 TO +5V.
2- Z2, 3, 5, 6, 8, 9, 11, 12, 14, AND 15 ARE 16 PIN IC'S WITH PIN 8 TO GND AND PIN 16 TO +5V.

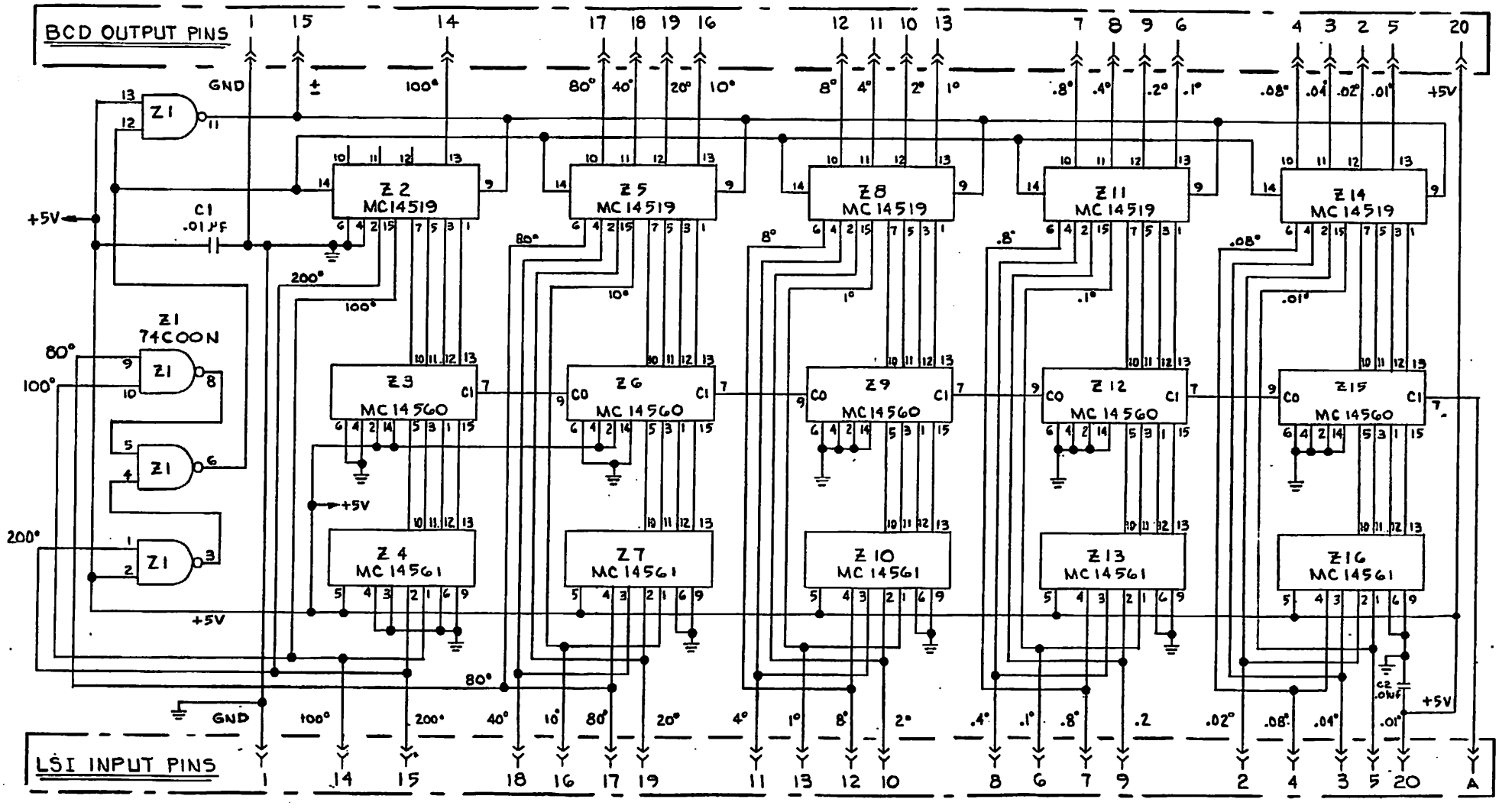


Figure 8-6. ±180° Digital Board Option, Schematic

WARRANTY

A. The seller warrants products against defects in material and workmanship for one year from the date of original shipment. The seller's liability is limited to the repair or replacement of products which prove to be defective during the warranty period. There is no charge under the warranty except for transportation charges. The purchaser shall be responsible for products shipped until received by the seller.

B. The seller specifically excludes from the warranty 1) calibration, 2) fuses, and 3) normal mechanical wear, e.g.: end-of-life on assemblies such as switches, relays, gear trains, etc. is dependent upon number of operations or hours of use, and end-of-life may occur within the warranty period.

C. The seller is not liable for consequential damages or for any injury or damage to persons or property resulting from the operation or application of products.

D. The warranty is voided if there is evidence that products have been operated beyond their design range, improperly installed, improperly maintained or physically mistreated.

E. The seller reserves the right to make changes and improvements to products without any liability for incorporating such changes or improvements in any products previously sold, or for any notification to the purchaser prior to shipment. In the event the purchaser should require subsequently manufactured lots to be identical to those covered by this quotation, the seller will, upon written request, provide a quotation upon a change control program.

F. No other warranty expressed or implied is offered by the seller other than the foregoing.

CLAIMS FOR DAMAGE IN SHIPMENT

The purchaser should inspect and functionally test the product(s) in accordance with the instruction manual as soon as it is received. If the product is damaged in any way, including concealed damage, a claim should be filed immediately with the carrier, or if insured separately, with the purchaser's insurance company.

SHIPPING

On products to be returned under warranty, await receipt of shipping instructions then forward the instrument prepaid to the destination indicated. The original shipping containers with their appropriate blocking and isolating material is the preferred method of packaging. Any other suitably strong container may be used providing the product is wrapped in a sealed plastic bag and surrounded with at least four inches of shock absorbing material to cushion firmly, preventing movement inside the container.