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Operation/Maintenance Manual

for

Model 8800 Angle Position Indicator

1. In section 1, paragraph 1.4, replace with the following information.

1.4 CONFIGURATION

The Model 8800 is available in various configurations. Order a Model 8800 by specifying the model followed by a number as follows:

8800-F ☐

Display and frequency - 1 = 0.000°-359.999°; 360-1200Hz
2 = 0.000°-359.999°; 47-440Hz

For instance, 8800-F1 is a 0.000°-359.999° unit with a frequency range of 360-1200 Hz.

2. In section 1, Replace Table 1-2 (Option Descriptions) with the following.

Short description	Full description
Standard	360-1200Hz, 0.001° resolution, 0-359.999° display
Low frequency	47-440Hz, 0.001° resolution, 0-359.999° display

Filename: 8800 ERRATA 2006-11-10.doc

1. In section 1, paragraph 1.4, replace with the following information.

1.4 CONFIGURATION

The Model 8800 is available in various configurations. Order a Model 8800 by specifying the model followed by a number as follows:

8800-F☐

Display and frequency - 1 = 0.000°-359.999°; 360-1200Hz
2 = 0.000°-359.999°; 47-440Hz
3 = ±179.995°; 360-1200Hz
4 = ±179.995°; 47-440Hz

For instance, 8800-F3 is a ±179.995° unit with a frequency range of 360-1200 Hz.

2. In section 1, Table 1-1 (Specifications), at the end of the table, replace existing information with the following.

Item	Specification
Operating Temperature	0° to 70° C

In section 5, replace paragraph 5.4.2 (alignment procedure) with the following information.

5-4.2 Procedure

a. Depress SYN push button on the API. Adjust the synchro/resolver simulator for 0.000° angle position indicator display and set the toggle switch to $\overline{DF}$ (data freeze). Adjust the synchro/resolver simulator for 0.0000°.

b. Connect the low side of the DVM to TP1 (ground) on the mother board and connect the high side to TP4. The voltage at TP4 should be between +0.5 mV dc and +3 mV dc.

c. Connect the high side of the DVM to TP2. Adjust R19 until the voltage at TP2 is the same as that measured at TP4 ± 100 μV.

d. Connect the high side of the DVM to TP3. Adjust R26 until the voltage at TP3 is the same as that measured at TP4 ± 100 μV.

e. Connect the high side of the DVM to TP5 and adjust R29 for 0 mV ± 100 μV. This is a preliminary adjustment. This is a preliminary adjustment.

f. Connect the high side of the DVM to TP7 and adjust R55 for 0 V ± 200 mV.

g. Remove data freeze. With the DVM at TP7, set the simulator to 10.000°. Manipulate the simulator so that the API display indi-cates 10.000°. Freeze the API. Set the simulator again to 10.000°. Note dc offset at TP7.

h. Remove data freeze. Manipulate the simulator so that the API display indicates 9.999° (9.995° for units with 0.005° resolution). Freeze the API and set the simulator to 9.999° (9.995° for units with 0.005° resolution). Read the dc offset at TP7. Readjust R29 until the offset is the same as that obtained in step g above. Repeat steps g and h to assure no change in dc offset.

i. Connect the low side of the scope to TP1 (GND) and the high side to TP10 (use an X10 probe).

j. Set the vertical sensitivity to 2V/division (pulse to be measured in 5 V pp) and the time base to 0.1 ms/ division. Adjust the scope time base and triggering so that the scope triggers on each successive pulse, displaying one pulse per sweep.

k. Adjust R65 so that pulses are of equal width (double edges on scope overlap and appear as a single edge). Disconnect scope.

l. Manipulate simulator so that the API display indicates 0.000°. Freeze the API. Connect the PAV to TP7. Adjust the simulator for an in-phase null at TP7 (angle on synchro/resolver simulator should be 0.000° ± .002°).

m. Connect the DVM to TP12 and adjust R103 for 0 mV ± 500 μV. This is a preliminary adjustment. Final adjustment will be made later.

n. Connect the DVM to TP14 and adjust R116 for 0V ± 200 mV.

o. Switch the Auto-phase switch on the main board from INT to EXT and note offset change at TP14. If there is, readjust R103 until there is no dc change at TP14 when the unit is switched from INT to EXT. Leave switch in the INT position.

p. Readjust R116 for 0 V ± 200 mV at TP14.

q. Connect the PAV to TP7. Remove data freeze. Set the simulator to 20.000°. Freeze the API. Adjust the simulator for an in-phase null at TP7. Record the simulator setting (20.000° ± 0.002°).

r. Remove data freeze. Manipulate the simulator so that the API display indicates 19.999° (19.9995° for units with 0.005° resolution). Freeze the API. Adjust the simulator for an in-phase null. Record the simulator setting.

s. Subtract the simulator setting of step r, above, from that of step q. The difference should be 0.001° (0.005° for units with 0.005° resolution). Adjust R63, if necessary, to obtain this difference. Remove data freeze.

t. Repeat steps q through s until desired result is obtained.

u. Advance the simulator through 360° in 10° steps, observing the API display. Ascertain that the largest angle errors are distributed as positive and negative errors. If maximum angle errors tend to be of the same sign (all positive or all negative), readjust R116 to minimize these errors.

In Section 2 paragraph 2-3.5, change the last sentence as follows:

For 125 V or 250 V operation, see schematic.

In SECTION 6 PARTS LISTS Chassis Assembly (787205, 783784) parts list change the following part number:

FROM: 807155-MOS
TO: 888068

In SECTION 6 - PARTS LIST table entitled Replacement Parts List: Model 8800 add the following:

Ref Des	Description	NAI P/N	FSCM	Mfr. P/N
	Mating Connector Kit Model 8300	783718	07342	783718
	Shell (1)		00779	205211-1
	Clamp (1)		00779	20732-1
	Retainer (2)		00779	205980-1
	Pins (50)		00779	66569-3

STATUS OF PUBLICATION

Original - August 1979
Change 1 - August 1980
Change 2 - November 1980
Change 3 - July 1981
Change 4 - March 1982
Change 5 - April 1982
Change 6 - December 1983
Change 7 - March 1986
Change 8 - March 1989
Change 9 - January 1997

NOTE 1

This manual describes the Model 8800 and its various standard options. For special options, see addenda attached.

NOTE 2

Units manufactured before May 1980, have a standard resolution of 0.005°. Units manufactured after May 1980 have option 06 (resolution of 0.001°, 400 to 1200 Hz) included as standard equipment.

CAUTION

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

A potential shock hazard exists with ungrounded power source or ungrounded case operation. Operators of the instrument should be aware of and take precautions against this condition.

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

MODEL 8800 (MM-I-5016) PRODUCT REVISION SHEET #26416 MARCH 7, 1989

A. ASSEMBLIES AND REVISION LEVELS AFFECTED:

±180° Display Circuit Card Assembly NAI P/N 783747 Revision B and higher.

B. CHANGES:

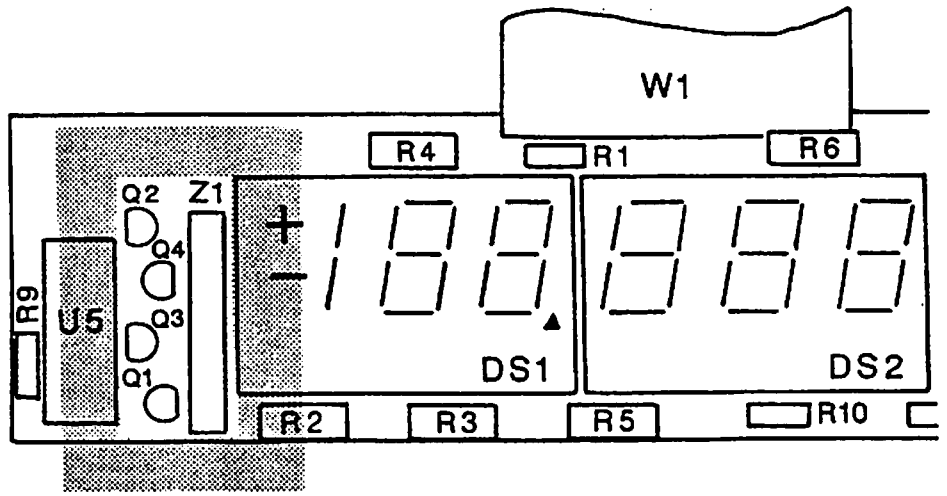
1. In SECTION 6 PARTS LIST change Replacement Parts List: ±180° Display Board - 783747 as follows:

a. Delete components Q1, R8, R15-R17, and U6

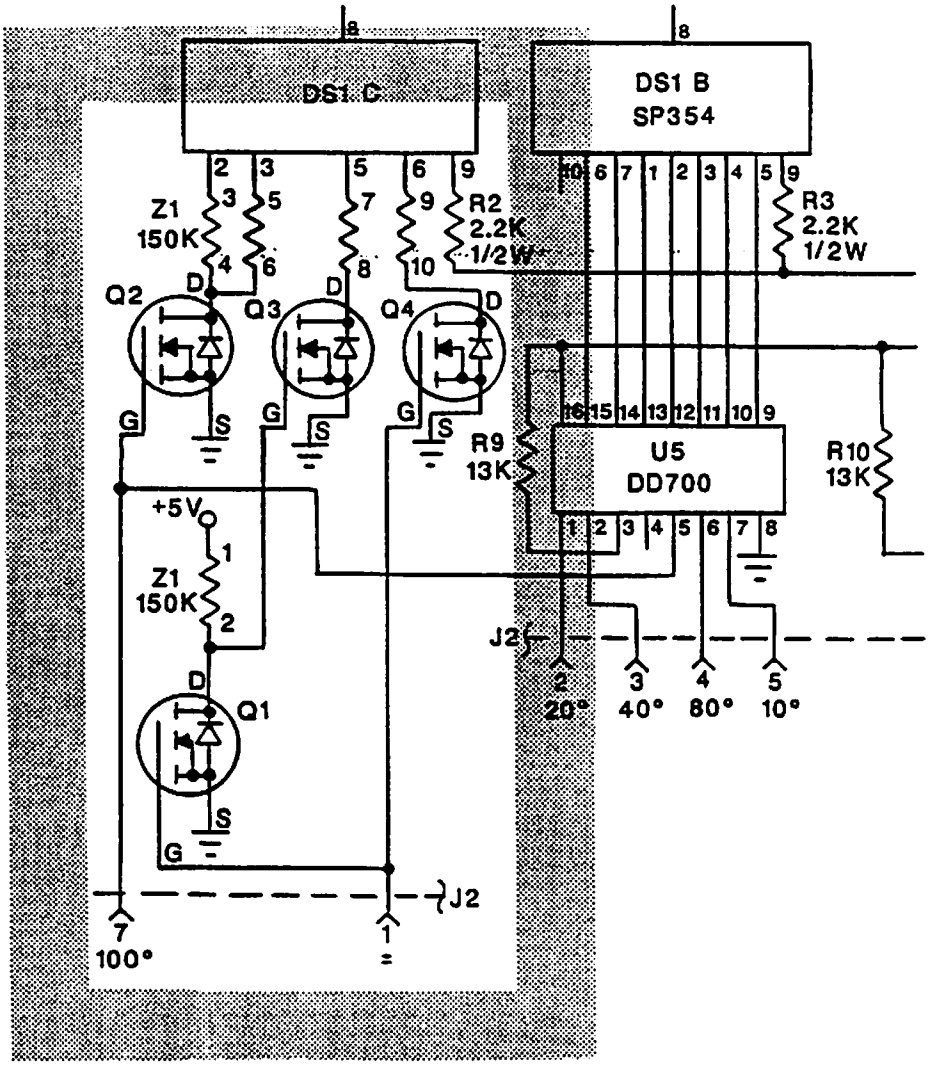
b. Add the following components:

Ref. Des.	Description	NAI P/N	Mfr. Code	Mfr. P/N	Total Qty
Q1	Transistor, MOSFET, 240 V, VDS, TO-92 Package	888114	17856	VM12420L	4
Q2	Same as Q1				
Q3	Same as Q1				
Q4	Same as Q1				
Z1	Resistor, Network, 10 Pin, 5 Resistor	888113	01121	110B153	1

c. Change Figure 6-8. ±180° Display Board, Parts Locator as shown:



2. In SECTION 7 SCHEMATIC DIAGRAMS change Figure 7-4. ±180° Display Board, Schematic as shown:



ADDENDUM TO NAI TM 5016

ANGLE POSITION INDICATOR, MODEL 8800

This addendum is for units with a clock delay board on the main chassis. The changes are as follows:

1. In the system and main board parts list, change the main chassis board part number from 783784 to 783784-1 and 787205 to 787205-I.

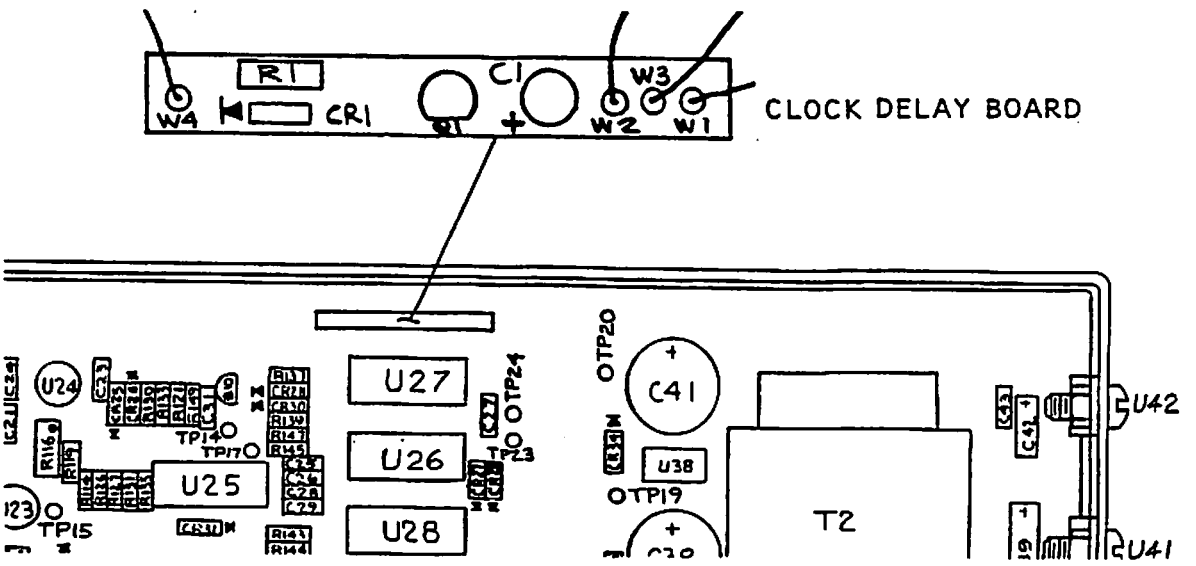
2. Add clock delay board, NAI P/N 787200 to the main chassis board parts list.

3. Add the following parts list to the end of the main chassis board parts list.

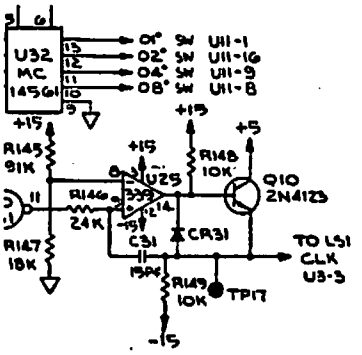
Replacement Parts List: Clock Delay Board - 787200

Ref.	Description	NAI P/N	Code	Mfr. P/N	Qty
C1	Capacitor, Elect. Tant. 10uf, 25V, +-10%	808270	90303	TDC106K025FL	1
CR1	Diode	808974	07263	1N4148	1
Q1	Transistor	885532	Supertex Inc.	VN0104N3	1
R1	Resistor, Composition 33k, 1/4W, +-5%	880097	01121	CB3335	1

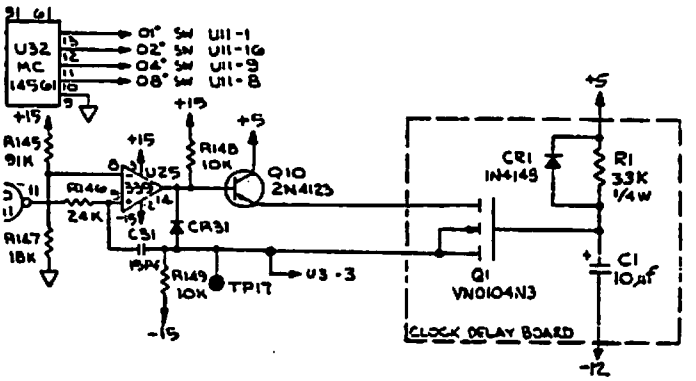
4. Add a clock delay board to the main chassis board parts locators as shown below:



5. Change main chassis schematic diagrams (sh. 5 of 5) as shown below:



WAS



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LIST OF TABLES

INFORMATION FOR UNITS SOLD WITHIN THE EUROPEAN UNION

GENERAL

Information contained within the following paragraphs supplements and in some cases supersedes information contained throughout this Manual. Where there is a conflict between information contained in these paragraphs and information contained elsewhere in the manual, these paragraphs take precedence for units sold within the European Union.

SPECIFICATIONS

Add to the list of specifications the following information:

Environmental	
Temperature, operating	0° to 70° C, standard
Temperature, non-operating	-55° to 75° C
Relative Humidity	95%, non condensing
Altitude	3050 Meters operating, 12,000 Meters non-operating
Overvoltage/Installation Category	Category II
Pollution Degree	Degree 1
Fuses	115V operation - 0.50 amp. FAST-BLO 230V operation - 0.25 amp. FAST-BLO

INSTALLATION AND MAINS INPUT

The Model 8800 API is designed for permanent rack-mount installation. It is not recommended that the Model 8800 be used in bench-top applications. When the Model 8800 is used in a permanent rack-mount installation with only the front panel accessible to the operator and mains supply applied to the 50-pin D-subminiature connector, there is no high quality safety (earth) ground provided for the chassis. If such a ground is desired in your application, connect safety (earth) ground to one of the jackscrews for the 50-pin connector using an AWG 16 wire and lug.

For continued safe operation of the model 8800 API, observe the following:

a. Mains input wiring to 50-pin D-subminiature connector must include a disconnect device such as a switch (2 pole), or circuit breaker easily accessible to the operator.

b. Insulation rating for all wires connected to 50-pin D-subminiature connector must be consistent with the applied mains supply .

c. Mains supply may not be applied to the 50-pin D-subminiature connector for bench-top use.

LINE VOLTAGE SELECTION

Selection of power line voltage is to be accomplished by Maintenance personnel only and is not to be done by the OPERATOR. When the line voltage selection is changed, the proper label must be affixed to the rear panel and the proper fuse must be installed. Refer to Manual section 2.3.5.

IMPROPER USAGE

If the equipment is installed or used in a manner not specified safety may be impaired.

MAINTENANCE

The OPERATOR only has access to the exterior of the unit. All maintenance, including any procedures that require removal of covers, must be referred to qualified maintenance personnel

TECHNICAL ASSISTANCE

Contact your local Sales Representative for any technical assistance. Alternately, contact the Factory at:

North Atlantic Instruments, Incorporated
170 Wilbur Place
Bohemia, NY 11716 USA

Telephone: **(516) 567-1100**
Fax: **(516) 567-1823**

WARNING

SAFETY SUMMARY

GENERAL SAFETY NOTICES

The following general safety notices supplement the specific warnings and cautions appearing elsewhere in this manual. They are recommended precautions that must be understood and applied during operation and maintenance of the equipment covered herein.

DO NOT REPAIR OR ADJUST ALONE

Under no circumstances should repair or adjustment of energized equipment be attempted alone. The immediate presence of someone capable of rendering aid is required.

HIGH VOLTAGE IS USED IN THE OPERATION OF THIS EQUIPMENT

DEATH ON CONTACT may result if personnel fail to observe safety precautions. Learn the areas containing high voltage on this equipment. Be careful not to contact high-voltage connections when installing, operating, or maintaining this equipment.

SECTION 1

GENERAL DESCRIPTION

1.1 GENERAL

This manual contains general description, installation, operating instructions, maintenance and troubleshooting procedures, replacement parts lists, and schematic diagrams for the Angle Position Indicator, Model 8800 (API).

1.2 PHYSICAL DESCRIPTION

The API (fig. 1-1) replaces the Synchro-to-Digital Converter, Model 545/100. The API is housed in a 9-1/2-inch rack panel.

1.3 FUNCTIONAL DESCRIPTION

The API is an extension of the instrument product line using the exclusive LSI TRIG-LOGIC™ processor.

It is a full tracking type II servo which follows synchros or resolvers to speeds of 1000°/second without velocity errors. It accepts any standard line-to-line level without pre-selecting or pre-programming the input signals. The converted synchro or resolver data is presented in two forms:

- Front-panel display using planar gas dishcarge information displays
- BCD outputs on the rear panel connector

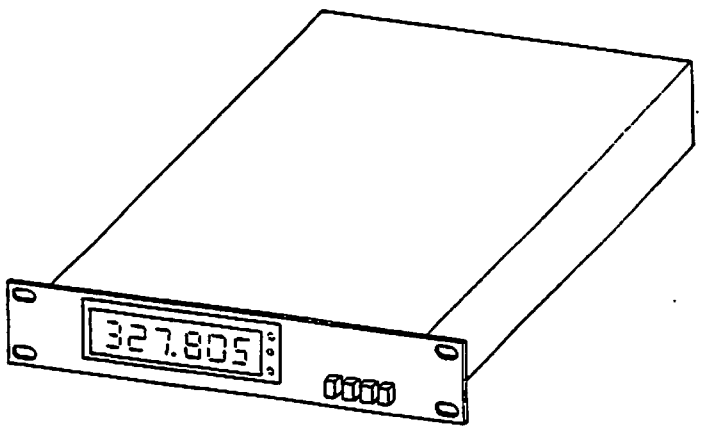

Figure 1-1. Angle Position Indicator

1.4 CONFIGURATION

The Model 8800 is available in various configurations. Order a Model 8800 by specifying the model followed by a three-digit number as follows:

8800-F□□□

- Temperature range: 0 = 0-50°C; 1 = 0-70°C
- Power line voltage: 1 = 115 V; 2 = 230 V
- Display and frequency: 1 = 0.000°-359.999° 360-1200Hz; 2 = 0.000°-359.999° 47-440Hz; 3 = ±179.995°; 360-1200Hz; 4 = ±179.995°; 47-440Hz

For instance, 8800-F310 is a ±179.995° unit with a frequency range of 360-1200 Hz, with a power line input of 115 V and a temperature range of 0-50°C.

1.5 SPECIFICATIONS

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

1.6 EXPLANATION OF OPTIONS

Throughout this manual the various options are differentiated by a shortened description. For an equivalent full description, refer to table 1-2.

Table 1-1. Specifications

Item	Specification
Input specifications	
Signal inputs	11.8 V, 26 V, or 90 V L-L, synchro or resolver, 200 to 1200 Hz
Signal input impedance	1 MΩ (min.) at 400 Hz
Reference levels	3 V thru 115 V rms, 200 to 1200 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 DF $\overline{DF}$	Freeze / Track +5 V / 0 V or open 0 V / +5 V or open
CH 1 remote programming	0 V or Gnd = CH 1; +5 or open = CH 2
Output specifications	
Decimal readout	6 decimal digits, 0.55-inch high (standard); 5-1/2 decimal digits, 0.55-inch high (±180° option)
Readout resolution	0.001° (standard) 0.005° (± 180° option)
Digital data output	6 decades of BCD digits (standard) 1, 2, 4, 8 code; 5-1/2 decades of BCD digits (±180° option)
Digital output level Logic 1 Logic 0	 +5 V (+0.25 V -2.5 V) 0 V (+0.6 V -0 V) at 10 TTL loads
Converter busy	TTL compatible, positive-going pulse approximately 1 µS wide. Data changes on the falling edge of the busy pulse. (See paragraph 3.4.2.)
Performance specifications	
Angular accuracy	0.003° +1 LSB resolution error (standard) 0.005° +1 LSB resolution error (±180° option)
Angular resolution	0.001° (standard) 0.005° (±180° option)
Angular range	0.0° thru 359.999° in 0.001° steps continuous (standard); 0.0° thru 179.995° in 0.005° steps continuous (±180° option)
Tracking characteristics (type II servo)	200°/S with no tracking error (standard) 1000°/S with no tracking error (±180° option) 75°/S with no tracking error (low frequency option)

Table 1-1. Specifications (Continued)

Item	Specification
Settling time	Less than 1.5 seconds (standard) Less than 400 mS (±180° option) Less than 3 seconds (low frequency option)
Operating mode	Track only
L-L selection	Automatic L-L determination, 11.8 V, 26 V, or 90 V L-L displayed at front panel
Auto phase correction	Automatically corrects for signal phase shift up to ±30° (max.)
Mechanical specifications	
Front panel color	Semi-gloss gray, 26440 per Fed-Std-595
Markings	Semi-gloss black enamel, 27038 per Fed-Std-595
Size	7.88" W x 1.72" H x 12.5" D
Operating temperature	0° to 50°C (standard) 0° to 70°C (high temperature option)

Table 1-2. Option Descriptions

Short description	Full description
Standard	360-1200Hz, 0.001° resolution, 0-359.999° display
±180°	360-1200Hz, 0.005° resolution, 179.995° display
Low frequency	47-440Hz, 0.001° resolution, 0-359.999° display
Low frequency, 0.005° resolution	47-440Hz, 0.005° resolution
High temperature	0-70°C temperature

SECTION 2

INSTALLATION

2.1 INTRODUCTION

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 ambience. 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.

API parallel I/O 50-pin mating connector J1 is supplied by North Atlantic Industries (NAI P/N 783718) but cable assembly must be made by operator. It consists of the following parts:

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

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	CH1
6	S2	
7	S3	
8	S4	
9	R1	
10	R2	

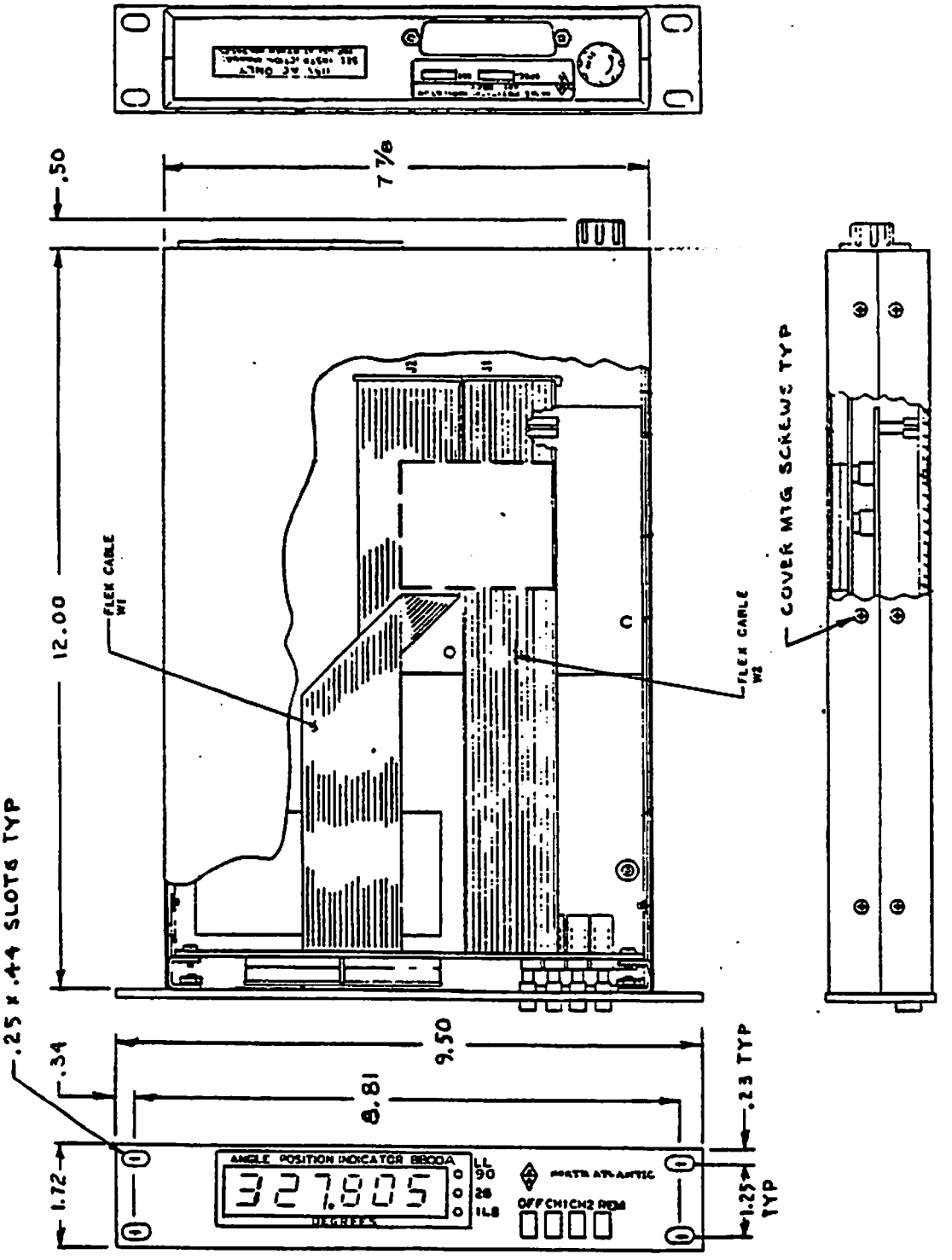

Figure 2-1. API Outline Drawing (with 180° Digital Board)

Table 2-1. J1 Pin Designations (Continued)

Pin	Function
11	Converter busy
12	.04° ┐
13	.01°
14	.8°
15	.2° ├ BCD outputs
16	4°
17	1° ┘
18	CH 2 synchro jumper
19	Spare
20	REM
21	S1 ┐
22	S2
23	S3
24	S4 ├ CH2
25	R1
26	R2 ┘
27	Data freeze ($\overline{DF}$)
28	.02°
29	.08°
30	.1°
31	.4°
32	2°
33	8°
34	CH 1 synchro jumper
35	Scott-T center tap
36	Spare
37	Spare
38	.008°* ┐
39	.002°* ├ BCD outputs
40	.001°* ┘
41	Spare
42	Data freeze (DF)
43	Remote program
44	.004°*
45	20° ┐
46	40°
47	80°
48	10° ├ BCD outputs
49	100°
50	200°** ┘

* On 0.005° resolution units, pins 40 and 44 are connected internally and act as the 0.005° bit. Pins 38 and 39 are grounded.

** + bit (±180° option)

2.3.4 Signal Inputs

The API is designed to accept both synchro and resolver inputs 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
	S3	7	23
	S2	6	22
	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 Internal Power Connections

The API is designed to operate from 115 V or 230 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 (figure 2-2), located on the standard board near the power transformer, to 230 V position. For 125 V or 230 V operation, see schematic.

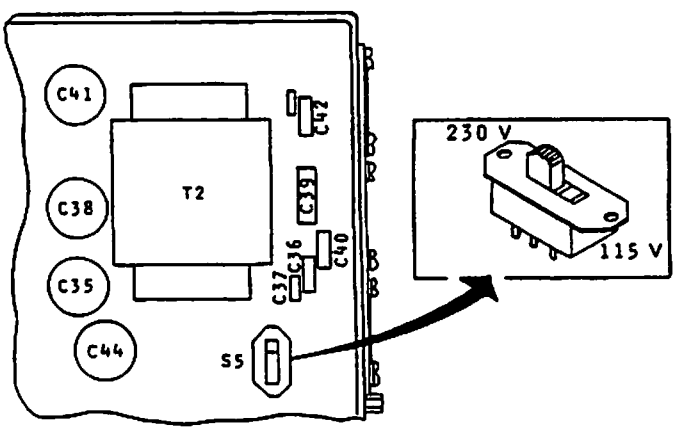

Figure 2-2. Power Programming

SECTION 3

OPERATION

3.1 GENERAL

This section provides operating 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-2153 (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

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

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.

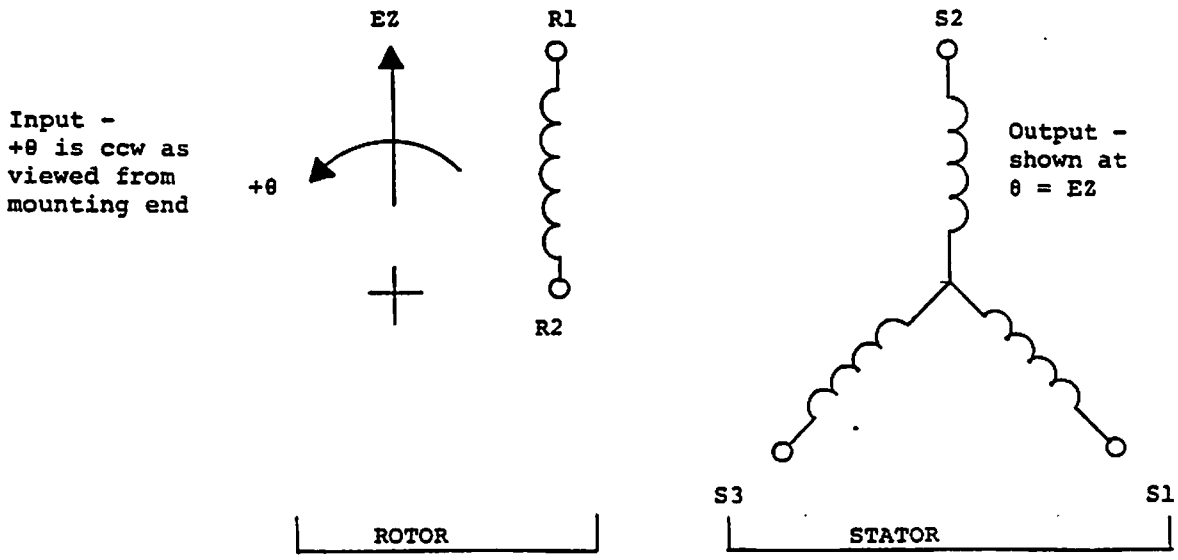

Figure 3-1. Synchro Transmitter, Schematic

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.

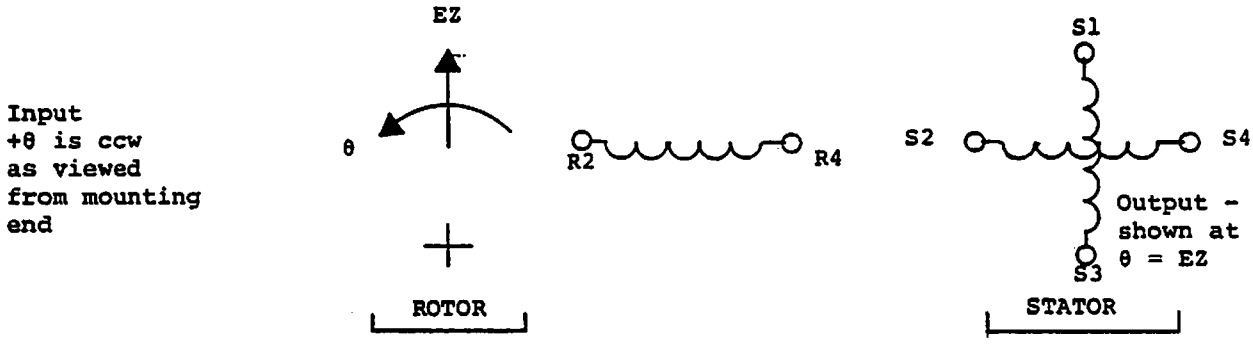

Figure 3-2. Resolver Transmitter, Schematic

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.
REM push button	Allows remote programming of channel 1 or channel 2 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.
EXT-INT Reference switch (located on main board)	Provides a means of switching reference as required in calibration procedure. Normally is set to INT.
L-L 90 V LED	When lit, indicates that input signal is 90 V L-L.
L-L 26 V LED	When lit, indicates that input signal is 26 V L-L.
L-L 11.8 V LED	When lit, indicates that input signal is 11.8 V L-L.

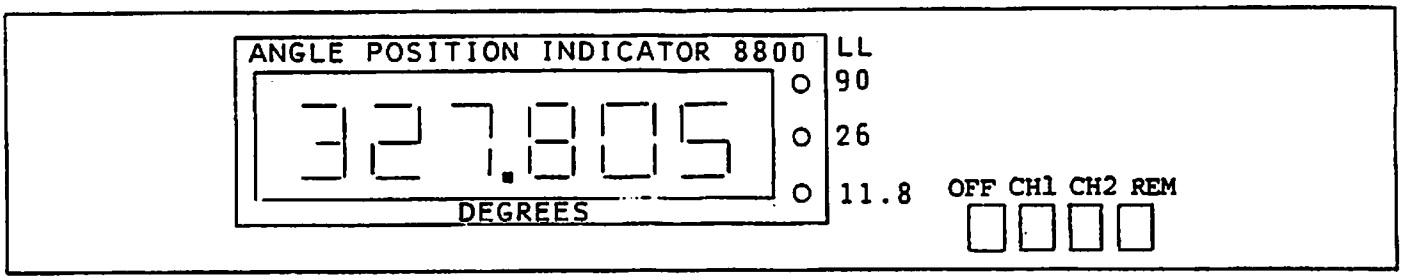

Figure 3-3. Controls and Indicators

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 is a 1 µs-wide Logic 1 pulse and indicates output data changes.

It is necessary to transfer data 2 µS after the trailing edge of the converter Busy. The data will be stable for a minimum of 5.5 µS when the converter is tracking at its maximum rate of 200°/S.

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.

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 an angular input rate of 0.25 rps (90°/S).

Application of the inhibit for less than 3 µS will produce a maximum peak transient error of less than 1 LSB at an angular input rate of 2.5 rps (900°/S).

NOTE

At slower angular input rates the converter can be frozen for much longer periods with no appreciable error buildup. In addition, the change allows for a reasonable capacitive load on the digital output lines (500 pF or less). Special precautions must be taken for capacitive charge and discharge for applications with excessive capacitive loads.

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/DN 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 40° 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 (θ-αc) error signal and Cos (θ-αc) 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 40° intervals, θ-αc will be somewhere between 0° and ±20°, depending upon the value of the input angle θ. The error signal Sin (θ-αc) is then balanced out in the interpolation circuit, using Cos (θ-αc) 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 range of the interpolation section is 20°. When interpolating angles larger than αc, the output of the interpolation ladder is added to αc. When interpolating angles less than αc, the interpolation bits are complemented, the CEF switch is closed and the interpolation ladder subtracts from αc. This allows the interpolation section to cover a total span of 40°.

Since the Sin function is not a linear one, interpolating a full 20° would result in rather large errors. Several methods are used to reduce the interpolation error. The first is to break up the 20° interpolation span into two 10° segments. From 0° to 9.999°, the PRG supplies Sin 10° to ladder for interpolation. From 10° to 19.999°, the Sin 10° is applied to a resistor at the summing amplifier, and the Sin 20° to Sin 10° is applied to the interpolation ladder. This reduces the interpolation error to about ±0.005°. This error is further reduced by three analog switches which perform slight amplitude changes in the ladder reference. The final mathematical error is less than ±0.001°. The result of the bridging process is an ac error signal at the output of U13 proportional to Sin (θ-αc) Cos αf Cos (θ-αc).

This equals Sin (θ-αc-αf), where αf is the digitally generated angle in the interpolation circuit.

The output of summing amplifier U13 is fed to amplifier U17 for further amplification.

Since the ac scale factor changes with coarse bridge angles, it is necessary to normalize this scale factor to maintain constant sensitivity throughout the entire 360° span. Resistor R94 is switched in and out to eliminate this change. (The change would be 40% without this normalization). In addition, gain changes to U17 are performed for line-to-line voltage changes.

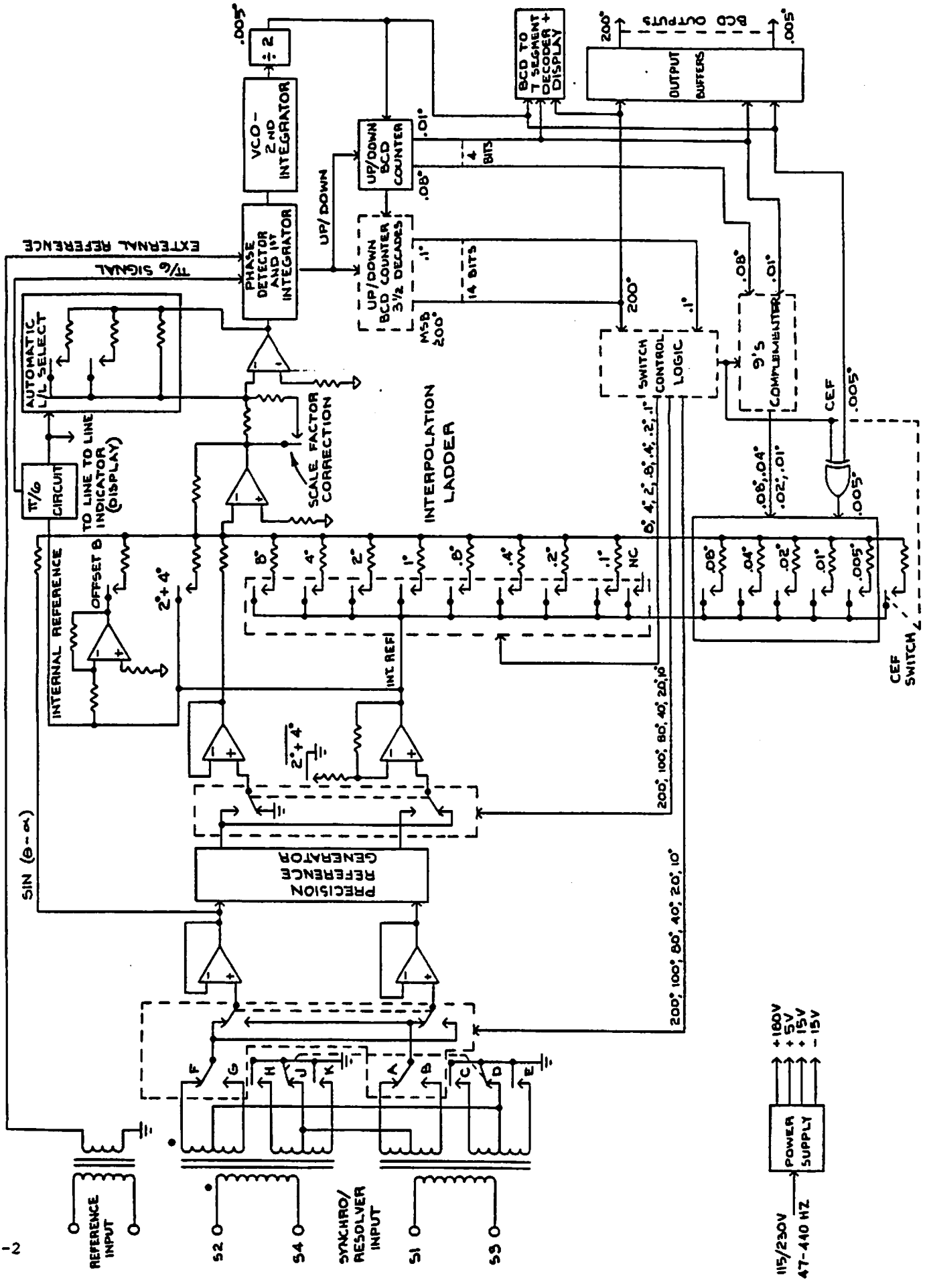

Figure 4-1. API, Block Diagram

At 11.8 V L-L, resistor R92 is the feedback. R91 is in parallel with R92 for 26 V L-L operation. For 90 V L-L operation, R90 and R91 are in parallel with R92. The ac scale factor at the output of U17 (TP7) is 2.5 V rms/degree at all three line-to-line levels.

In most S/D converters, reference to the null circuit is supplied externally from the same source exciting the synchro. Since all synchros generate phase shift, their output signal is phase shifted in respect to the reference, usually 5° to 10°. For optimum performance, the reference applied to an S/D converter should be phase shifted by the same angle as the synchro signal. The API contains an auto-phase circuit which eliminates the need for external reference phase correction. This circuit is able to correct for maximum phase shift of ±30°. Reference phase correction is accomplished by sampling the interpolation ladder reference. Since this signal is derived directly from the synchro input signal, it is in-phase with the synchro signal.

The interpolation reference is coupled through C10 and applied to full wave rectifier circuit U14. FET switch Q8 switches the gain of the rectifier when the interpolation reference changes amplitude so that the rectified signal at TP9 is a constant amplitude (fig. 4-2). The output of the rectifier drives the inverting input (pin 6) of comparator U15. The output of the rectifier is divided and filtered by components R73, R74, and C12. This network applies exactly 50% of the peak value of the full wave rectified signal which corresponds to the Sin of 30°. This develops a $\pi/6$ (±30°) signal at the output of the comparator (TP10). The $\pi/6$ signal is applied to the phase detector which is discussed later.

After scale factor correction is made with Q8, the output voltage of the rectifier is directly proportional to the input line-to-line voltage. The filtered voltage at C12 is buffered by voltage follower U14, and the output (TP11) is connected to two comparators. The dc voltage (TP11) is approximately 1/20th of input line-to-line voltage (rms). The two comparators sense the voltage amplitude at TP11. When the voltage is less than 0.9 V, the outputs of both comparators are low. This sets the gain of U16 for 11.8 V L-L. When the voltage is between 0.9 V and 1.8 V, the output of U15, pin 13, goes high, and switches the API to 26 V L-L. When the voltage at TP11 exceeds 1.8 V, both comparator outputs go high, switching the API to 90 V L-L. The outputs of the comparators are decoded by U16 to drive the line-to-line indicator LEDs on the front panel.

The null circuit receives the $\pi/6$ signal, the external reference, and the ac error signal from U17. This circuit performs three discrete functions: (1) phase-sensitive detection, (2) clock pulse generation, and (3) count up/count down signal. In addition, an Auto-phase defeat switch is provided so that, if necessary, the synchro information may be referenced to the external reference. With the Auto-phase switch in the external position, the phase detector operates as a normal full wave detector. This mode of operation is explained first.

The external reference applied to J1 is isolated and stepped down by transformer T3. This signal is squared by comparator U15. At this point the signal splits. One side is connected to U21, pin 6, the other inverted by U20. This inverted signal connects to U21, pin 8. Since the $\pi/6$ signal is grounded by S6, the NAND gates function as inverters. This two-phase reference signal is buffered and drives the phase detector switches. The third grounding switch remains open.

The ac error signal from U17 is coupled through C15 to U18. With the Auto-phase switch in the external position, U18 operates as a non-inverting unity gain buffer. The signal at TP8 is identical to that at TP7, except that any dc offset present at TP7 is blocked by C15. This signal is applied to one of the phase detector switches. The ac error signal at TP8 is also inverted by U19 and fed to another phase detector switch. These two switches alternately open and close in phase with the external reference and form a phase-sensitive full wave detector. The output of the phase

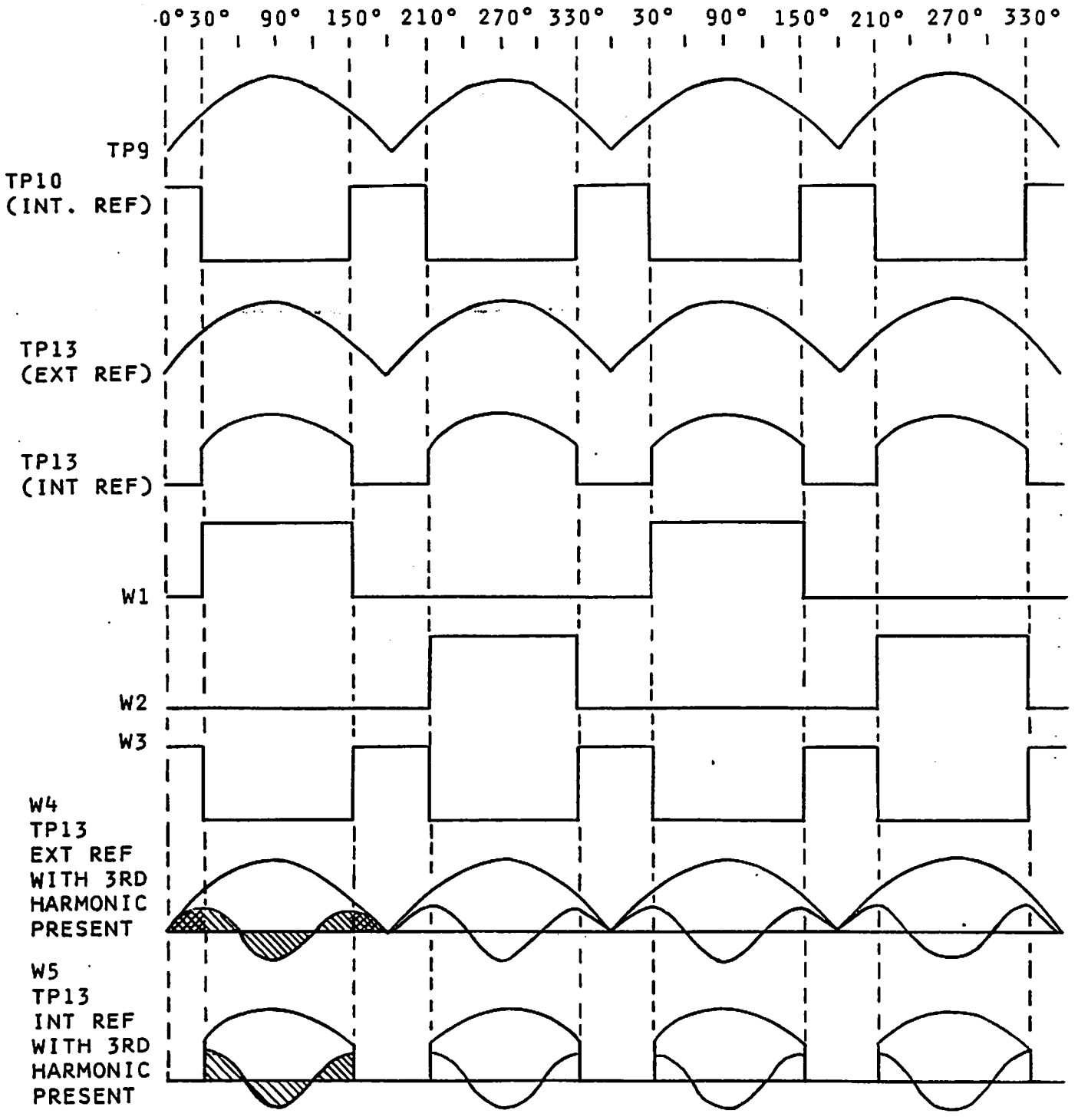

Figure 4-2. Null Circuit Waveforms

detector is a dc signal whose amplitude is proportional to the in-phase portion of the ac error signal. Polarity depends on whether the ac error signal is in-phase or 180° out-of-phase with the reference. U23 integrates the phase detector output.

When the Auto-phase switch is in the INT position, the π/6 signal is digitally combined with the external reference square wave. The π/6 signal removes 30° of the leading and trailing edges which reduces the switch closure angle from 180° to 120° (waveforms W1 and W2, fig. 4-2). Grounding switch Z22, pin 2 is closed when the other switches are both open to insure no signals leak through to the integrator during the π/6 interval (waveform W3, fig. 4-2). Since this reduces the gain of the phase detector, resistor R97 is grounded by the Auto-phase switch, increasing the gain of U18 proportionately.

In addition to automatic phase correction, the π/6 null circuit provides complete rejection of the third harmonic and all multiples of the third harmonic. A normal full wave detector provides a 3:1 attenuator of 3rd harmonics and an attenuation of all other odd harmonics proportional to the ratio of the harmonic to the fundamental (i.e., 7th harmonic 7:1, etc.). For all odd harmonics, not a multiple of the third harmonic, the π/6 phase detector provides the same attenuation as the full wave phase detector. Both types provide complete rejection of even harmonics.

A circuit in the null circuit, not mentioned, consists of a half-wave rectifier and filter, comprising of CR20, R104, R107, and C16. Comparator U14 monitors the voltage across C16 and trips when the ac error is greater than 10 V rms. This occurs when the angular error between the API and synchro exceeds 4°. This will cause the internal signal supplied to the π/6 circuitry randomly to change amplitude until the converter slews closer to the input angle. This results in a momentary disruption of the π/6 signal applied to the phase detector. To insure proper operation of the phase detector, the π/6 signal is disabled by comparator U14, pin 10 until the error is reduced. The API uses a Type II servo, which does not require a continuous error signal to generate clock pulses. Depending upon the phase relationship with the reference and the direction of the synchro rotation, an ac error signal will either accelerate or decelerate the clock until clock rate matches the rate of the incoming synchro data. At this point, the ac error signal drops to zero and the clock continues to run at its present rate until an ac error signal again appears to accelerate or decelerate it.

The VCO consists of integrator U24 and two sections of comparator U25. In operation, a dc voltage from U23 charges C23 through R117 and R118 until the output of U24 reaches the trip point of one of the comparators. When this occurs, CR25 or CR26 is forward biased and C23 discharged until the comparator flips back to its original state. The cycle is then repeated. The up clock pulses are derived from U25, pin 1 and the down clock pulses are derived from U25, pin 2. The output of U24 is also fed to comparator U25, pin 10 to develop an up/down signal for the LSI counter.

The clock lines drive the BCD up/down counter. The counter outputs (decoded and complemented) close the loop with the coarse bridge and interpolation circuits. 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.

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.

CAUTION

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

U3 - LSI	*U201 - 74C192
U16 - 4011	*U202 - 74C902
U21 - 4011	*U203 - 14561
U26 - 4011	Z1 - 74C00
U27 - 4027	Z2,5,8,11,14 - MC14519
U28 - 4030/14070	
U29 - 4069	Z3,6,9,12,15 - MC14560
U30 - 4011	
U31 - 74C192/34192	Z4,7,10,13,16 - MC14561
U32 - 14561	

*0.001° resolution units only.

5.2 CLEANING

No special cleaning procedures or fluids are required. Apply good housekeeping rules to maintain the instrument free of dust nad 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 frequency range is determined by the options selected (para. 1-4).

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.

Table 5-1. Test Equipment Required

Item	Minimum use/critical specifications	Manufacturer and model
Synchro/resolver simulator	Frequency: 400 Hz Range: 00.0000 to 359.9990 Accuracy: 2 arc seconds Modes: Synchro or Resolver. Synchro conventions meet MIL-S-20708A. Resolver conventions meet MIL-R-21530 (para. 3.2).	North Atlantic Industries, Model 530 -S741 Synchro Resolver Simulator

Table 5-1. Test Equipment Required (Continued)

Item	Minimum use/critical specifications	Manufacturer and model
Mating connector	Connector wired for the functions to be tested.	North Atlantic Industries mating connector kit Qty — AMP P/N 1 shell — 205211-1 1 clamp — 205732-1 2 retainer — 205980-1 50 pins — 66569-3
Ac power source	Frequency: 400 Hz Range: 0 V to 120 V rms Distortion: 0.6% Output rating: 20 VA Load regulation: ±1% Phase: Single	Elgar, Model 121 with Model 401V plug-in
Phase angle voltmeter	Frequency: 400 Hz Sensitivity: 300 V to 0.003 V Mode: In-phase Voltage accuracy: ±2% full scale Phase accuracy: ±1°	North Atlantic Industries, Model 213C 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 ±2% approx. 33 pf	Tektronix, Model 422
DVM	Range: 199.9 mV Z in: 100 MΩ Accuracy: ± 0.05% Resolution: 3-1/2 digits	Weston, Model 4449

5.3.2 Set-up

a. Set the synchro/resolver simulator MODE switch to OFF to avoid damage to the equipment and to prevent dangerous voltages from existing at the output terminals when Power switches are turned on.

b. Turn all Power switches (with the exception of the API) on and allow the test equipment to stabilize.

c. Wire up the test connector and connect the equipment as shown in figure 5-1.

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

e. Program channel 1 of the API mating connector for resolver by leaving pin 34 open.

f. Program channel 2 of the API mating connector for synchro by jumping pins 18 and 35.

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

5.3.3 Channel 1 Accuracy Test

a. On API turn power on and depress CH 1 push button. The 11.8 V LED lights.

b. Advance the synchro/resolver simulator in 10° steps (00.000° through 350.000°).

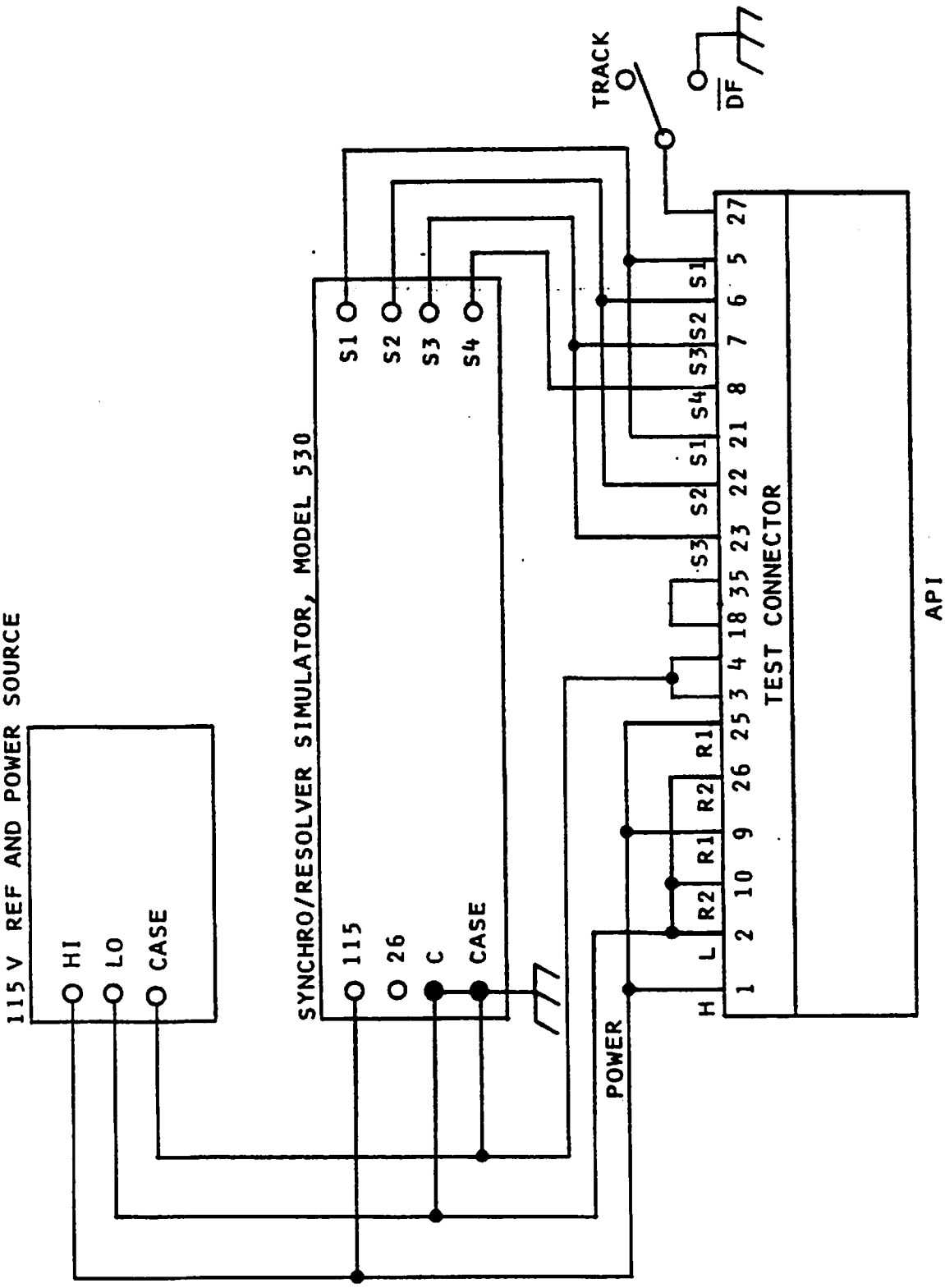

Figure 5-1. Test Set-up

API should read within ±0.004° of the input angle for standard and low frequency option units, and within ±0.01° for ±180° option units.

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 ±0.004° of the input angle for standard and low freuqency option units, and ±0.01° for ±180° option units.

5.3.4 Channel 2 Accuracy Test

a. Depress CH 2 push button on the API.

b. Set the synchro/resolver simulator for 26 V L-L output. The 26 V LED on the API lights.

c. Set the synchro/resolver simulator for 90 V L-L synchro output. The 90 V LED in the API lights.

d. Advance the synchro/resolver simulator in 10° steps (00.000° through 350.000°). API should read within ±0.004° of the input angle for standard and low frequency units, and within ±0.01° for ±180° option units.

e. Advance the synchro/resolver simulator in 1° through 9°, 0.1° through 0.9°, and 0.01° through 0.09° steps, respectively. API should read within ±0.004° of the input angle for standard and low frequency option units, and within ±0.01° for ±180° option units.

5.4 ALIGNMENT PROCEDURE

This procedure describes the alignment sequence and test equipment required to align the API. The unit is aligned by adjusting eight 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 Set-up

a. Set Mode switch on synchro/resolver simulator to OFF to avoid damage to the equipment and to prevent dangerous voltages from existing 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.

c. Wire up the test connector and connect the equipment as shown in figure 5-1.

d. Set the synchro/resolver simulator for 11.8 V L-L, 400 Hz synchro output at 0.000°.

5.4.2 Procedure

a. Depress CH 1 push button on the API. Adjust the synchro/resolver simulator for 0.000° angle position indicator display and set the toggle switch to DF. Adjust synchro/resolver simulator for 0.0000°.

b. Connect the low side of the DVM to TP1 (ground) on the mother board and connect the high side to TP4. The voltage at TP4 should be between +0.5 mV dc and +3 mV dc.

c. Connect the high side of the DVM to TP2. Adjust R19 until the voltage at TP2 is the same as that measured at TP4 ±100 µV.

d. Connect the high side of the DVM to TP3. Adjust R26 until the voltage at TP3 is the same as that measured at TP4 ±100 µV.

e. Connect the high side of the DVM to TP5 and adjust R29 for 0 mV ±100 µV.

f. Connect the high side of the DVM to TP7 and adjust R55 for 0 V ±200 mV.

g. With the DMV at TP7, set the simulator to 10.000°. Manipulate the simulator so that the API display indicates 10.000°. Freeze the API. Set the simulator again to 10.000°. Note dc offset at TP7.

h. Remove data freeze. Manipulate the simulator so that the API display indicates 9.999° (9.995° for units with

0.005° resolution). Freeze the API and set the simulator to 9.999 (9.995° for units with 0.005° resolution). Read the dc offset at TP7. Readjust R29 until the offset is the same as that obtained in step g above. Repeat steps g and h to assure no change in dc offset.

i. Remove data freeze and connect the low side of the scope to TP1 (GND) and the high side to TP10 (use an X10 probe).

j. Set the vertical sensitivity to 2 V/division (pulse to be measured is 5 Vpp) and the time base to 0.1 ms/division. Adjust the scope time base and triggering so that the scope triggers on each successive pulse.

k. Adjust R65 so that pulses are of equal width (double edges on scope overlap and appear as a single edge).

l. Connect the DVM to TP12 and adjust R103 for 0 mV±500μV. This is a preliminary adjustment. Final adjustment will be made later.

m. Connect the PAV to TP7. Adjust the simulator for an in-phase null at TP7 (angle on synchro/resolver simulator should be 0.000° ±.002°).

n. Connect the DVM to TP14 and adjust R116 for 0 V ±200 mV.

o. Switch the Auto-phase switch on the main board from INT to EXT and note offset change at TP14. If there is, readjust R103 until there is no dc change at TP14 when the unit is switched from INT. to EXT.

p. Readjust R116 for 0 V ±200 mV at TP14.

q. Connect the PAV to TP7. With data freeze removed, set the simulator to 20.000°. Freeze the API. Adjust the simulator for an in-phase null at TP7. Record the simulator setting (20.000° ± 0.002°).

r. Remove data freeze. Manipulate the simulator so that the API display indicates 19.999° (19.995° for units with 0.005° resolution). Freeze the API. Adjust the simulator for an in-phase null. Record the simulator setting.

s. Subtract the simulator setting of step r, above, from that of step q. The difference should be 0.001° (0.005° for units with 0.005° resolution). Adjust R63, if necessary, to obtain this difference.

t. Repeat steps q through s until desired result is obtained.

u. Advance the simulator through 360° in 10° steps, observing the API display. Ascertain that the largest angle errors are distributed as positive and negative errors. If maximum angle errors tend to be of the same sign (all positive or all negative), readjust R116 to minimize these errors.

SECTION 6

PARTS LIST

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

LIST OF MANUFACTURERS

Code	Manufacturer's Name and Address
00779	AMP, Inc., Harrisburg, Pennsylvania 17105
01121	Allen-Bradley Company, Milwaukee, Wisconsin 53204
01295	Texas Instruments, Dallas, Texas 75265
02111	Spectrol Electronics, City of Industry, California 91745
03508	General Electric Company, Auburn, New York 13021
04713	Motorola Semiconductor, Phoenix, Arizona 85008
06751	Components Inc., Phoenix, Arizona
06776	Robinson Nugent, New Albany, Indiana 47150
07187	Sperry Corporation, Albuquerque, New Mexico 87119
07263	Fairchild Camera, Mountain View, California 94042
07342	North Atlantic Industries, Hauppauge, New York 11788
12040	National Semiconductor, Danbury, Connecticut 06810
16299	Corning Glass Works, Raleigh, North Carolina 27604
28480	Hewlett Packard Co., Palo Alto, California 94304
30870	Republic Machinery Co., Carson, California 90749
56289	Sprague Electric Company, North Adams, Massachusetts 01247
72982	Murata Erie North America, Inc., Erie, Pennsylvania 16512
73138	Beckman Industrial Corporation, Fullerton, California 92634
74840	Illinois Capacitors, Inc., Lincolnwood, Illinois 60645
75915	Tracor Littelfuse, Inc., Des Plaines, Illinois 60016
79727	C-W Industries, Southampton, Pennsylvania 18966
91637	Dale Electronics Corporation, Columbus, Nebraska 06861

Replacement Parts List: Model 8800

Description	NAI P/N
Chassis	787205, 783784
Front Panel	783734
Cover, Top & Bottom	500891
360° Display Board	783739
Option 01	
Delete - 360° Display Board	783739
Add - 180° Display Board	783747
180° Digital Board	783719
Circuit Board Support	808167
Connector, 22-pin	808168
Damper Strip	205878

Replacement Parts List: Chassis Assembly (787205, 783784)

Ref. Des.	Description	NAI P/N	Mfr. Code	Mfr. P/N	Total Qty
C1[2]	Capacitor, Mica, 15pf, 200V, ±10%	807269		CK05BX150K	9
C2[2]	Same as C1[2]				
C3[2]	Same as C1[2]				
C4[2]	Same as C1[2]				
C5	Same as C1[2]				
C6[2]	Same as C1[2]				
C7	Capacitor, Ceramic, .1µf, 100V, ±10%	805154		CK06BX104K	24
C8	Same as C7				
C9	Same as C7				
C10	Capacitor, Tantalum, 10µf, 15V, ±10%	805643	06751	TS2K-15-106K	2
C11	Same as C1				
C12	Same as C10				
C13	Same as C7				
C14	Same as C7				
C15	Capacitor, Ceramic, 1µf, 50V, ±10%	805155		CK06BX105K	2
C16	Same as C15				
C17	Same as C7				
C18[4-8]	Capacitor, Ceramic, .39µf, 50V, ±10%	808193	56289	5CX7R394X9100C5	1
C19[4-8]	Same as C18				
C19[6]	Capacitor, Ceramic, .33µf, 50V, ±10%	882457		CKR06BX334KP	1
C20[6]	Capacitor, Ceramic, .068µf, 100V, ±10%	805468		CK06BX683K	1
C20[4-8]	Capacitor, Ceramic, .082µf, 100V, ±10%	808405		CK06BX823K	1
C21	Same as C7				
C22[6]	Capacitor, Ceramic, .056µf, 100V, ±10%	805454		CK06BX563K	1
C22[4]	Capacitor, Ceramic, .82µf, 50V, ±10%	805076		CK06BX824K	1
C22[8]	Same as C18				
C23[6]	Capacitor, Ceramic, 100pf, 200V, ±10%	805210		CK05BX101K	1
C23[4]	Capacitor, Ceramic, 390pf, 200V, ±10%	805284		CK05BX391K	1
C23[8]	Capacitor, Ceramic, 1000pf, 200V, ±10%	805788		CK05BX102K	1

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[2] - 783784 units only.
[4] - Low frequency option .001°
[6] - Standard & 180° option.
[8] - Low frequency option .005°

Replacement Parts List: Chassis Assembly (787205, 783784) (Continued)

Ref. Des.	Description	NAI P/N	Mfr. Code	Mfr. P/N	Total Qty
C24	Same as C7				
C25	Capacitor, Ceramic, 27pf, 200V, ±10%	808401		CK05BX270K	2
C26	Same as C25				
C27	Same as C7				
C28	Capacitor, Ceramic, 100pf, 200V, ±10%	805210		CK05BX101K	2
C29	Same as C28				
C30	Same as C7				
C31	Same as C1				
C32	Same as C7				
C33	Same as C7				
C34	Same as C7				
C35	Capacitor, Aluminum, 470µf, 35V, ±10%	807685	56289	503D477G035ER	2
C36	Capacitor, Tantalum, .22µf, 35V, ±20%	801297	56289	150D224X0035	2
C37	Same as C7				
C38	Same as C35				
C39	Capacitor, Tantalum, 2.2µf, 35V, ±10%	802914	56289	150D225X8035B2	1
C40	Capacitor, Tantalum, 1µf, 35V, ±20%	801343	56289	150D105X0035A2	1
C41	Capacitor, Aluminum, 1000µf, 16V, ±10%	807686	56289	503D108G016ER	1
C42	Same as C36				
C43	Same as C7				
C44	Capacitor, Aluminum, 10µf, 250V	885188	74840	106RAR-250APX	1
C45	Same as C1				
C46	Same as C7				
C47	Same as C7				
C48	Same as C7				
C49	Same as C7				
C50	Same as C7				
C51	Same as C7				
C52[2]	Capacitor, Ceramic, 220pf, 200V, ±10%	805156		CK05BX221K	1
C53	Capacitor, Ceramic, 4700pf, 200V, ±10%	805153		CK06BX472K	2
C54	Same as C53				

2- 783784 units only.

Replacement Parts List: Chassis Assembly (787205, 783784) (Continued)

Ref. Des.	Description	NAI P/N	Mfr. Code	Mfr. P/N	Total Qty
C55	Same as C7				
C56[2]	Capacitor, Mica, 2pf, ±1pf	806241	72136	DM5-020	1
C201	Same as C7				
C201[4]	Same as C7				
CR1[2]	Diode, Signal 1N	808974	07263	1N4148	28
CR2[2]	Same as CR1				
CR3[2]	Same as CR1				
CR4[2]	Same as CR1				
CR5[2]	Same as CR1				
CR6[2]	Same as CR1				
CR7	Same as CR1				
CR8	Same as CR1				
CR9	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[1]	Diode, Signal	883449		1N6263	3
CR18[1]	Same as CR17[1]				
CR19	Same as CR1				
CR20	Same as CR1				
CR21[1]	Same as CR1				
CR22[1]	Same as CR17[1]				
CR23	Transistor	807607	04713	2N4123	5
CR24	Same as CR23				
CR25	Same as CR1				
CR26	Same as CR1				
CR27	Same as CR1				
CR28	Same as CR1				
CR29	Same as CR1				
CR30	Same as CR1				
CR31	Same as CR1				
CR32	Diode	804477	04713	1N4001	3
CR33	Same as CR32				
CR34	Same as CR32				
CR35	Diode, 190V, 500mW, ±5%	808157	04713	1N5280B	1

[1] - 787205 units only.
[2] - 783784 units only.
[4] - Low frequency option .001°

Replacement Parts List: Chassis Assembly (787205, 783784) (Continued)

Ref. Des.	Description	NAI P/N	Mfr. Code	Mfr. P/N	Total Qty
F1	Fuse, .5A, 3AG (115V units)	802900	75915	312.500	1
	Fuse, .25A, 3AG (230V units)	802530	75915	312.250	1
	Fuseholder (3AG) for F1	800137	75915	342004	1
J1	Connector, 50-pin	808198	00779	206971-1	1
J2	Socket, 25-pin	808363	06776	SB-25-T	4
J3	Same as J2				
K1	Relay	808015	00779	53451-1	2
K2	Same as K1				
Q1	Transistor	804583	01295	TIS73	7
Q2	Same as Q1				
Q3	Same as Q1				
Q4	Same as Q1				
Q5	Same as Q1				
Q6	Same as Q1				
Q7	Same as CR23				
Q8	Same as Q1				
Q9	Same as CR23				
Q10	Same as CR23				
Q11	Transistor	807690	04713	MPSA43	1
R1[1]	Resistor, Composition, 100k, 1/8W, ±5%	805104		RC05GF104J	6
R1[2]	Resistor, Composition, 47k, 1/4W, ±5%	801638	01121	CB4735	8
R2[1]	Same as R1[1]				
R2[2]	Same as R1[2]				
R3	Resistor, Composition, 24k, 1/4W, ±5%	801393	01121	CB2435	8
R4	Same as R3				
R5[1]	Same as R1[1]				
R5[2]	Same as R1[2]				
R6[1]	Same as R1[1]				
R6[2]	Same as R1[2]				
R7	Same as R1[2]				
R8[1]	Same as R1[1]				

[1]- 787205 units only.
[2]- 783784 units only.

Replacement Parts List: Chassis Assembly (787205, 783784) (Continued)

Ref. Des.	Description	NAI P/N	Mfr. Code	Mfr. P/N	Total Qty
R8[2]	Same as R1[2]				
R9	Resistor, Composition, 510k, 1/4W, ±5%	802086	01121	CB5145	7
R10	Same as R9				
R11	Same as R9				
R12	Same as R9				
R13	Same as R9				
R14	Same as R9				
R15	Resistor, Matched Set	807726-3	07342	807726-3	
R15[5]	Resistor, Matched Set	808160-3	07342	808160-3	
R16	Resistor, Matched Set	807726-1	07342	807726-1	
R16[5]	Resistor, Matched Set	808160-1	07342	808160-1	
R17	Resistor, Matched Set	807726-2	07342	807726-2	
R17[5]	Resistor, Matched Set	808160-2	07342	808160-2	
R18[1]	Resistor, Composition, 180k, 1/4W, ±5%	882398		RCR07G184JP	2
R18[2]	Resistor, Composition, 2MΩ, 1/4W, ±5%	807094	01121	CB2005	2
R19	Potentiometer, 100k	807625	02111	62-1-1-104	4
R20[1]	Resistor, Composition, 160Ω, 1/4W, ±5%	804078	01121	CB1625	3
R20[2]	Resistor, Composition, 1.6k, 1/4W, ±5%	804078	01121	CB1625	3
R21	Resistor, Matched Set	807727-3	07342	807727-3	
R21[5]	Resistor, Matched Set	808161-3	07342	808161-3	
R22	Resistor, Matched Set	807727-1	07342	807727-1	
R22[5]	Resistor, Matched Set	808161-1	07342	808161-1	
R23	Resistor, Matched Set	807727-2	07342	807727-2	
R23[5]	Resistor, Matched Set	808161-2	07342	808161-2	
R24[1]	Same as R18[1]				
R24[2]	Same as R18[2]				
R25[1]	Same as R20[1]				
R25[2]	Same as R20[2]				
R26	Same as R19				
R27	Resistor, Metal Film, 158k, 1/10W,±1/2%	808359	01121	CC1583D	1

[1] - 787205 units only.
[2] - 783784 units only.
[5] - High temperature option.

Replacement Parts List: Chassis Assembly (787205, 783784) (Continued)

Ref. Des.	Description	NAI P/N	Mfr. Code	Mfr. P/N	Total Qty
R28	Resistor, Metal Film, 750Ω, 1/10W,±1/2%	808360	01121	CC7500RD	1
R29	Potentiometer, 20kΩ(square)	808229	02111	RT-24C2X	2
R30	Resistor, Metal Film, 20k, 1/10W,±.5%	808226	16299	NC5-20K,1/10W,.5%	2
R31	Resistor, Composition, 10kΩ, 1/4W, ±5%	801006	01121	CB1035	14
R32	Same as R30				
R33	Resistor, Metal Film, 2.10M, 1/10W,±1%	808107	01121	CC2104	1
R34	Resistor, Metal Film, 698K, 1/10W,±.5%	808108	16299	NC5-698K,1/10W,.5%	1
R35	Resistor, Matched Set	807728-3	07342	807728-3	1
R35[5]	Resistor, Matched Set	808162-3	07342	808162-3	1
R36	Resistor, Matched Set	807728-4	07342	807728-4	
R36[5]	Resistor, Matched Set	808162-4	07342	808162-4	
R37	Resistor, Matched Set	807728-5	07342	807728-5	
R37[5]	Resistor, Matched Set	808162-5	07342	808162-5	
R38	Resistor, Matched Set	807728-6	07342	807278-6	
R38[5]	Resistor, Matched Set	808162-6	07342	807162-6	
R39	Resistor, Matched Set	807728-7	07342	807728-7	
R39[5]	Resistor, Matched Set	808162-7	07342	808162-7	
R40	Resistor, Matched Set	807726-8	07342	807726-8	
R40[5]	Resistor, Matched Set	808162-8	07342	808162-8	
R41	Resistor, Matched Set	807728-9	07342	807728-9	
R41[5]	Resistor, Matched Set	808162-9	07342	808162-9	
R42	Resistor, Matched Set	807727-10	07342	807727-10	
R42[5]	Resistor, Matched Set	808162-10	07342	808162-10	
R43	Resistor, Metal Film, 250k, 1/10W,±.5%	806106	16299	NC5-250K,1/10W,.5%	1
R44	Resistor, Metal Film, 499k, 1/10W,±1%	806929	16299	NC5-499K,1/10W,1%	1
R45	Resistor, Metal Film, 1MΩ, 1/10W,±1%	807692	91637	DC-1/8, 1M	2
R46	Resistor, Metal Film, 2MΩ, 1/10W,±1%	807691	91637	DC-1/8, 2M	1
R47[3-8]	Resistor, Metal Film, 4.02MΩ, 1/10W,±1%	808095	01121	CC4024F	2
R48	Same as R47[3-8]				
R49	Resistor, Metal Film, 976k, 1/10W,±1%	808097	01121	CC9763F	1

[3] - 180° option
[5] - High temperature option.
[8] - Low frequency option .005°.

Replacement Parts List: Chassis Assembly (787205, 783784) (Continued)

Ref. Des.	Description	NAI P/N	Mfr. Code	Mfr. P/N	Total Qty
R50	Resistor, Matched Set	807728-2	07342	807728-2	
R50[5]	Resistor, Matched Set	808162-2	07342	808162-2	
R51	Resistor, Metal Film, 1.05MΩ, 1/10W,±1%	808144	01121	CC1054F	1
R52	Resistor, Metal Film, 26.7k, 1/10W,±1%	807634	01121	CB4315	1
R53	Same as R9				
R54	Resistor, Composition, 430Ω, 1/4W,±5%	801399	01121	CB4315	1
R55	Resistor, Variable, 100k	808690	32997	3279-1-104	1
R56	Resistor, Composition, 270Ω, 1/4W,±5%	802190	01121	CB2715	1
R57	Resistor, Composition, 470Ω, 1/4W,±5%	880567	01121	CB4715	1
R58	Resistor, Matched Set	807728-1			
R58[5]	Resistor, Matched Set	808162-1			
R59[1]	Resistor, Metal Film, 4.02k,1/10W,±1%	808316		RN55C4021F	2
R59[2]	Resistor, Metal Film, 20k, 1/10W,±1%	807049		RN55D-2002F	7
R60[1]	Resistor, Metal Film, 59k, 1/10W,±1%	808184	01121	CC5902F	2
R60[2]	Same as R59[2]				
R61[1]	Same as R60[1]				
R61[2]	Same as R59[2]				
R62[1]	Same as R59[1]				
R62[2]	Resistor, Composition, 13k, 1/4W,±5%	802186	01121	CB1335	4
R63	Potentiometer, 200k	808362	01121	A2A204	1
R65	Potentiometer, 100k	807062	32997	3299W-104	1
R66[1]	Resistor, Composition, 3.9Ω, 1/4W,±5%	807480	01121	CB3955	1
R66[2]	Resistor, Composition, 10MΩ, 1/4W, ±1%	803389	01121	CB1065	1
R67[1]	Resistor, Metal Film, 30.1k, 1/8W,±1%	880646		RNR55C3012FM	2
R67[2]	Resistor, Metal Film, 10k, 1/10W,±1%	806103	16299	NC4-10K,1/10W,1%	3
R68[1]	Same as R67				
R68[2]	Same as R59				
R69[2]	Resistor, Composition, 6.8K, 1/4W,±5%	802189	01121	CB6825	8
R70[1]	Resistor, Metal Film, 24.9K,1/10W,±1%	808096	01121	CC2492F	2
R70[2]	Resistor, Metal Film, 243K, 1/10W, ±1%	808186	01121	CC2433	2

[1] - 787205 units only.
[2] - 783784 units only.
[5] - High temperature option.

Replacement Parts List: Chassis Assembly (787205, 783784) (Continued)

Ref. Des.	Description	NAI P/N	Mfr. Code	Mfr. P/N	Total Qty
R71[1]	Same as R70[1]				
R71[2]	Same as R70[2]				
R72[1]	Resistor, Metal Film, 40.2k, 1/10W,±1%	884538		RN55C4022F	1
R72[2]	Resistor, Metal Film, 402k, 1/10W,±1%	808187	01121	CC4023F	1
R73	Resistor, Metal Film, 27.4k, 1/10W,±1%	808098	01121	CC2742F	1
R74	Resistor, Metal Film, 100k, 1/10W,±1%	806992		RN55D1003F	3
R75	Same as R69				
R76	Same as R3				
R77	Resistor, Metal Film, 49.9k, 1/10W,±1%	807635	01121	CC4992F	6
R78	Same as R31				
R79	Resistor, Metal Film, 3.32k, 1/10W,±1%	807631	01121	CC3321F	6
R80	Same as R31				
R81	Same as R79				
R82	Same as R31				
R83	Same as R66				
R84	Same as R66				
R85	Same as R31				
R86[1]	Resistor, Composition, 5.1k, 1/4W,±5%	880089	01121	CB5125	1
R86[2]	Resistor, Composition, 100k, 1/4W,±5%	801986	01121	CB1045	8
R87[2]	Same as R3				
R88	Same as R31				
R89	Same as R1[2]				
R90	Same as R77				
R91	Resistor, Metal Film, 221k,1/10W,±1%	808099	01121	CC2213F	1
R92	Resistor, Metal Film, 267k, 1/10W ±1%	807641	01121	CC2673F	1
R93	Resistor, Metal Film, 4.99k,1/10W,±1%	808182	01121	CC4991F	1
R94	Resistor, Metal Film, 16.2k, 1/10W,±1%	806559	16299	NC4-16.2K,1/10W,1%	1
R95	Same as R1[2]				
R96	Same as R69[2]				
R97	Resistor, Metal Film, 634k, 1/10W,±1%	808146	01121	CC6343F	1
R98	Same as R74				

1 - 787205 units only.
2 - 783784 units only.

Replacement Parts List: Chassis Assembly (787205, 783784) (Continued)

Ref. Des.	Description	NAI P/N	Mfr. Code	Mfr. P/N	Total Qty
R99	Same as R86[2]				
R100	Same as R59[2]				
R101	Same as R59[2]				
R102	Same as R31				
R103	Potentiometer 20K (round)	808110	73138	62P-R-20K	2
R104	Same as R67				
R105	Same as R31				
R106	Resistor, Metal Film, 78.7K,1/10W,±1%	807288		RN55D7872F	1
R107	Same as R77				
R108	Same as R45				
R109	Same as R77				
R110	Same as R69[2]				
R111	Same as R31				
R112	Resistor, Metal Film, 90.9K,1/10W,±1%	808185	01121	CC9092F	1
R113	Resistor, Metal Film, 133K,1/10W,±1%	807639	16299	C4-133K,1/10W,1%	1
R113[3]	Resistor, Metal Film, 59K,1/10W,±1%	808184	01121	CC5902F	1
R113[4]	Resistor, Metal Film, 232K,1/8W,±2%	806937	16299	C4-232K, 2%	1
R114	Same as R86[2]				
R115	Resistor, Metal Film, 100Ω,1/10W,±1%	808143	01121	CC1000F	1
R116	Same as R29				
R117	Same as R31				
R118	Same as R74				
R119	Resistor, Metal Film, 100K,1/10W,±1%	806992	16299	C4-100K,1/10W,1%	1
R119[3]	Resistor, Metal Film, 41.2K,1/10W,±1%	807695	01121	CC4122F	1
R119[4]	Resistor, Metal Film, 100K,1/10W,±1%	806992	16299	C4-100K,1/10W,1%	1
R120	Same as R86[2]				
R121	Same as R3				
R122	Same as R69[2]				
R123	Same as R3				
R124	Resistor, Composition, 130K, 1/4W,±5%	801394	01121	CB1345	1
R125	Same as R3				

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[2] - 783784 units only.
[3] - ±180° option
[4] - Low frequency option .001°

Replacement Parts List: Chassis Assembly (787205, 783784) (Continued)

Ref. Des.	Description	NAI P/N	Mfr. Code	Mfr. P/N	Total Qty
R126	Same as R52				
R127	Same as R59[2]				
R128	Resistor, Metal Film, 13.3K, 1/10W,±1%	807633	01121	CC1332F	2
R129	Same as R79				
R130	Same as R79				
R131	Same as R77				
R132	Same as R128				
R133	Same as R79				
R134	Same as R79				
R135	Same as R77				
R136	Same as R69[2]				
R137	Same as R62[2]				
R138	Same as R69[2]				
R139	Same as R62[2]				
R140	Same as R62[2]				
R141	Same as R86[2]				
R142	Same as R86[2]				
R143	Resistor, Composition, 18K, 1/4W,±5%	802183	01121	CB1835	3
R144	Same as R143				
R145	Resistor, Composition, 91K, 1/4W,±5%	803240	01121	CB9135	1
R146	Same as R3				
R147	Same as R143				
R148	Same as R31				
R149	Same as R31				
R150	Same as R31				
R151	Same as R86[2]				
R152	Same as R31				
R153	Resistor, Composition, 330Ω, 1/4W, ±5%	880080	01121	CB3315	1
R154[2]	Same as R69[2]				
R155	Same as R86[2]				
R156[2]	Resistor, Composition, 510K, 1/8W,±5%	807623		RC05GF514J	1
R162	Same as R67[2]				

[2] - 783784 units only.

Replacement Parts List: Chassis Assembly (787205, 783784) (Continued)

Ref. Des.	Description	NAI P/N	Mfr. Code	Mfr. P/N	Total Qty
R163	Same as R67[2]				
R201[7]	Same as R48[7]				
R202[7]	Resistor, Composition, 10MΩ, 1/4W,±5%	803389	01121	CB1065	1
R203[7]	Resistor, Metal Film, 4.99MΩ, 1/10W,±1%	808254	16299	C4-4.99M,1/10W,1%	1
R204[7]	Resistor, Metal Film, 2.49MΩ,1/10W,±1%	808255	16299	C4-2.49M,1/10W,1%	1
S1	Switch, Pushbutton, DPDT	808111	07342	808111	1 set
S2	Same as S1				
S3	Same as S1				
S4	Same as S1				
S5	Switch, Slide, DPDT	808112	79727	GF126	2
S6	Same as S5				
T1[6]	Transformer, Scott-T	783741	07342	783741	1
T1[4-8]	Transformer, Scott-T	783740-1	07342	783740-1	1
T2	Transformer, Power	807659	07342	807659	1
T3[1-3]	Transformer, Reference	807570	07342	807570	1
T3[2-4-6-8]	Transformer, Reference	808148	07342	808148	1
U1	Integrated Circuit	807626	12040	LM339N	4
U2	Same as U1				
U3	Integrated Circuit, LSI	888068	55261	2201N	1
U4	Integrated Circuit	807797	12040	LF356C	7
U5	Same as U4				
U6	Integrated Circuit	807530	07263	uA4136PC	4
U7	Same as U4				
U8	Integrated Circuit	808089	12040	LF13203(N)	4
U9	Same as U6				
U10	Same as U6				
U11	Same as U8				
U12	Same as U8				

[1] - 787205 units only.
[2] - 783784 units only.
[3] - 180° option.
[4] - Low frequency option .001°
[6] - Standard & 180° option
[7] - Standard & low frequency option
[8] - Low frequency option .005°

Replacement Parts List: Chassis Assembly (787205, 783784) (Continued)

Ref. Des.	Description	NAI P/N	Mfr. Code	Mfr. P/N	Total Qty
U13	Integrated Circuit	808145	12040	LF357C	3
U14	Same as U6				
U15	Same as U1				
U16	Integrated Circuit	808092-MOS	04713	MC14011BF	4
U17	Same as U13				
U18	Same as U4				
U19	Same as U4				
U20	Integrated Circuit	808188	12040	DM78L04N	1
U21	Same as U16				
U22	Same as U8				
U23	Same as U4				
U24	Same as U4				
U25	Same as U1				
U26	Same as U16				
U27[3,8]	Integrated Circuit	808093-MOS	04713	4027	1
U28	Integrated Circuit	808091-MOS	04713	MC14070BP	1
U29	Integrated Circuit	808092-MOS	04713	MC14069BP	1
U30	Same as U16				
U31	Integrated Circuit	807700-MOS	12040	74C192	1
U32	Integrated Circuit	807702-MOS	04713	MC14561	1
U33	Integrated Circuit	808357	12040	DM81LS95N	4
U34	Same as U33				
U35	Same as U33				
U36	Same as U33				
U37	I.C., Diode Bridge, 50V	807704	30870	VM08	2
S38	Same as U37				
U39	I.C., Diode Bridge, 400V	807705	30870	VM48	1
U40	Integrated Circuit	808388	12040	LM340T-15	1
U41	Integrated Circuit	808390	12040	LM320T-15	1

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3 - ±180° option
8 - Low frequency option .005°

Replacement Parts List: Chassis Assembly (787205, 783784) (Continued)

Ref. Des.	Description	NAI P/N	Mfr. Code	Mfr. P/N	Total Qty
U42	Integrated Circuit	808389	12040	LM340T-15	1
U43[1]	Operational Amplifier, Dual	885063	12040	LF-353H	1
U43[2]	Same as U13				
U201[7]	Integrated Circuit	807700-MOS	12040	74C192	1
U203[7]	Integrated Circuit	807702-MOS	04713	14561	1
U204[7]	Integrated Circuit	808089	12040	LF13202	1
VP1	Varistor	807699	03508	V130LA10A	2
VP2	Same as VP1				
XU3	Same as J2				

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[1] - 787205 units only.
[2] - 783784 units only.
[7] - Standard & low frequency option.

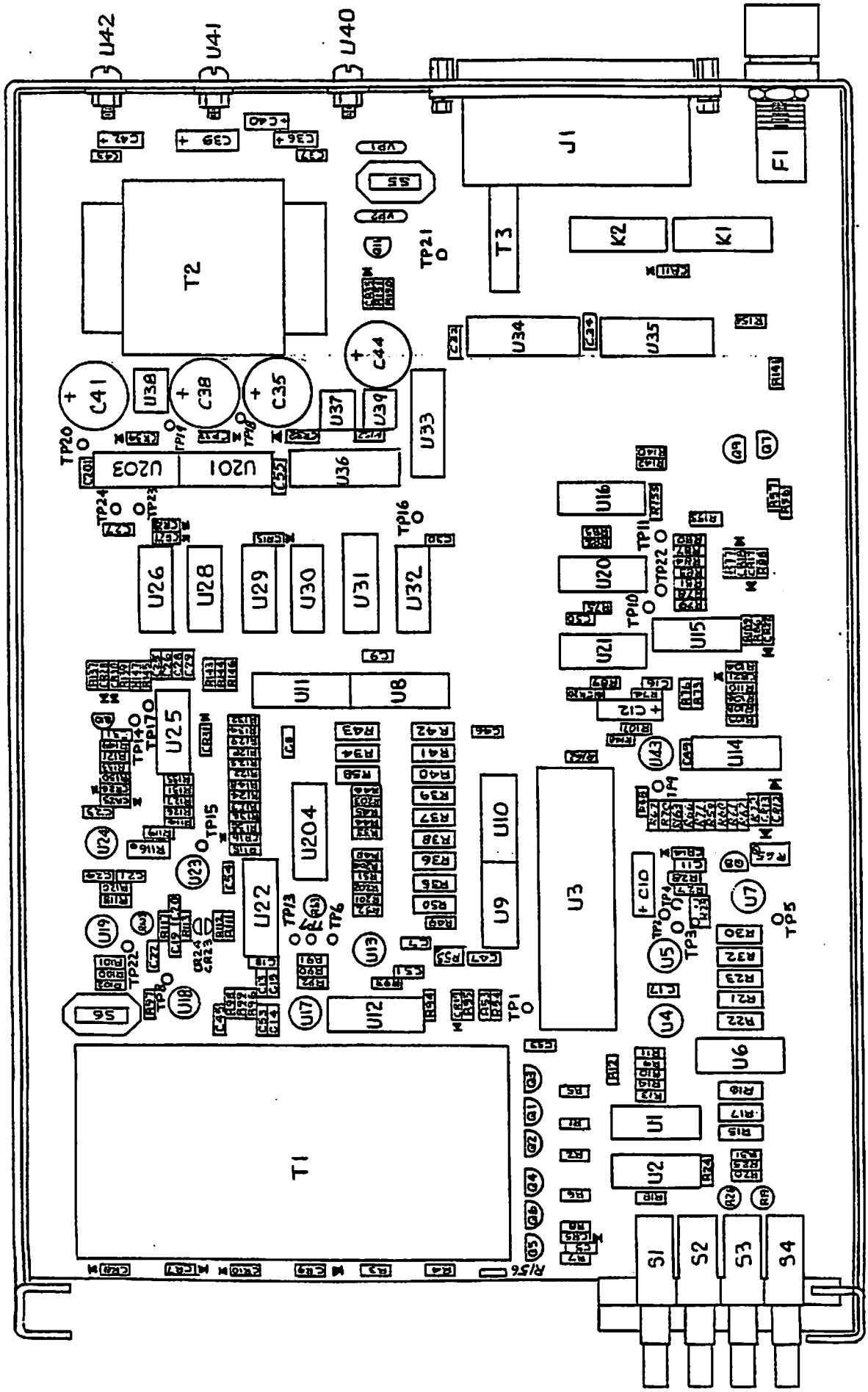


Figure 6-1. Main Chassis (Standard and Low Frequency Option) (787205), Parts Locator

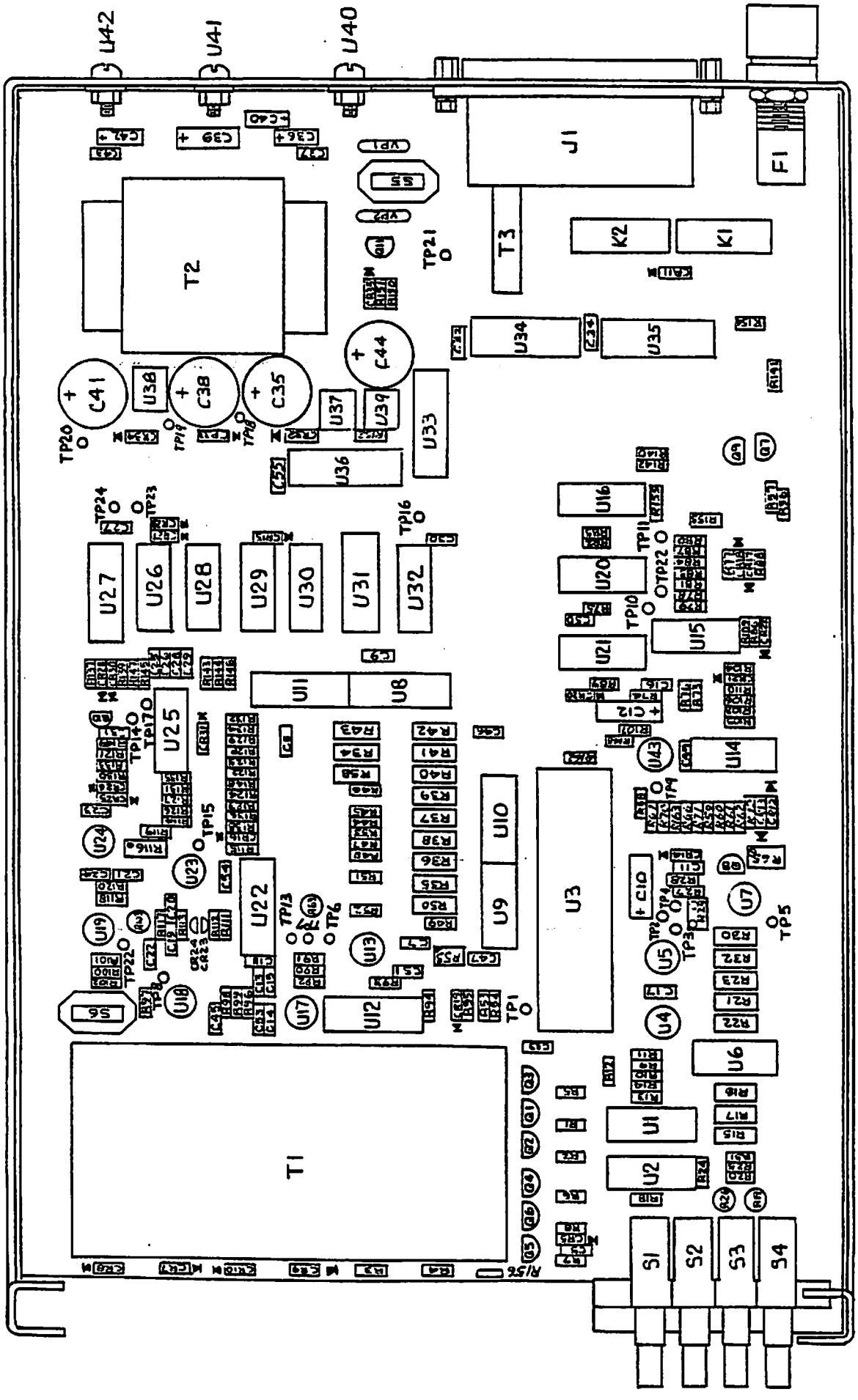


Figure 6-2. Main Chassis (±180° Option) (787205), Parts Locator

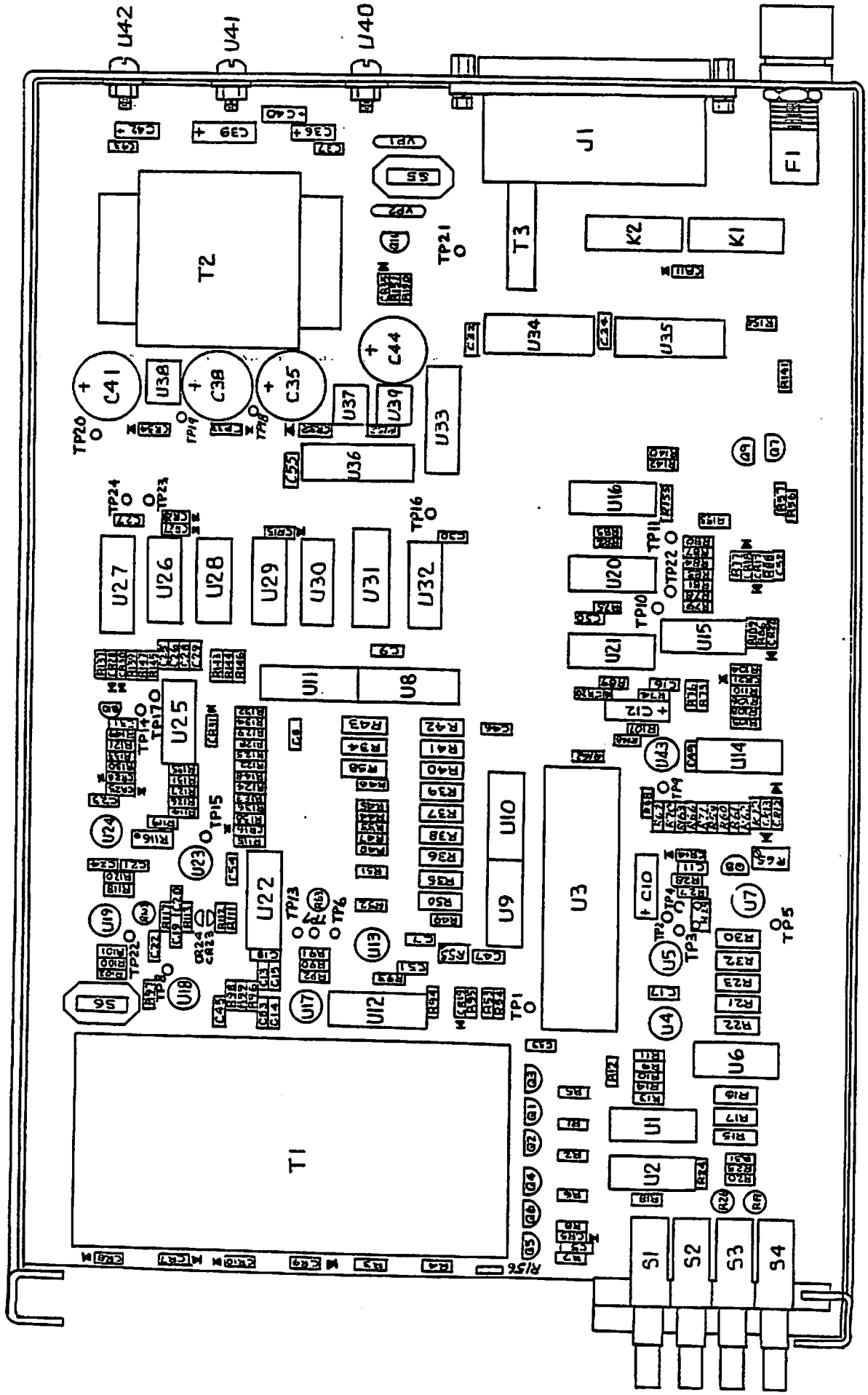


Figure 6-3. Main Chassis (0.005° Resolution) (787205), Parts Locator

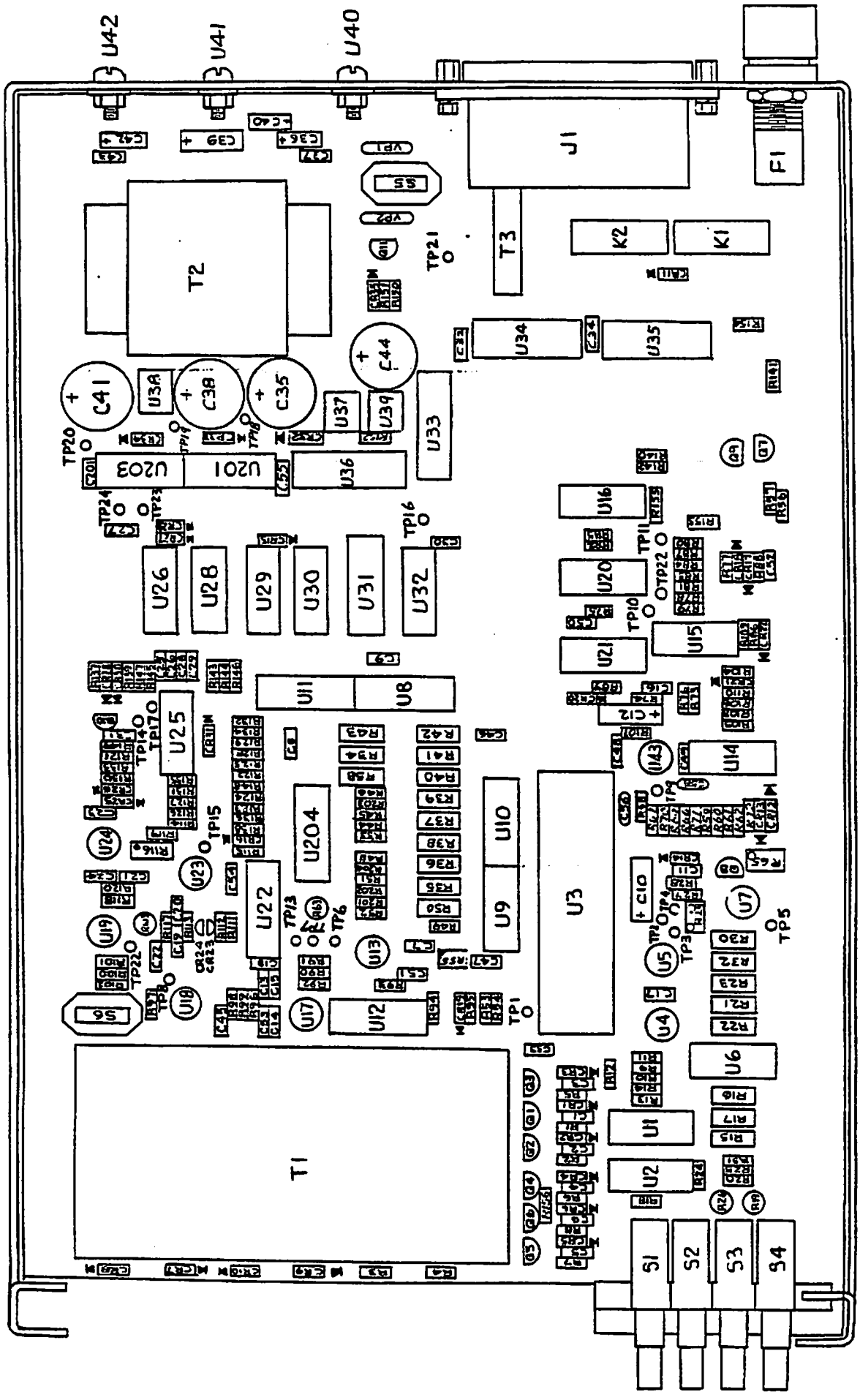


Figure 6-4. Main Chassis (Standard and Low Frequency Option) (783784), Parts Locator

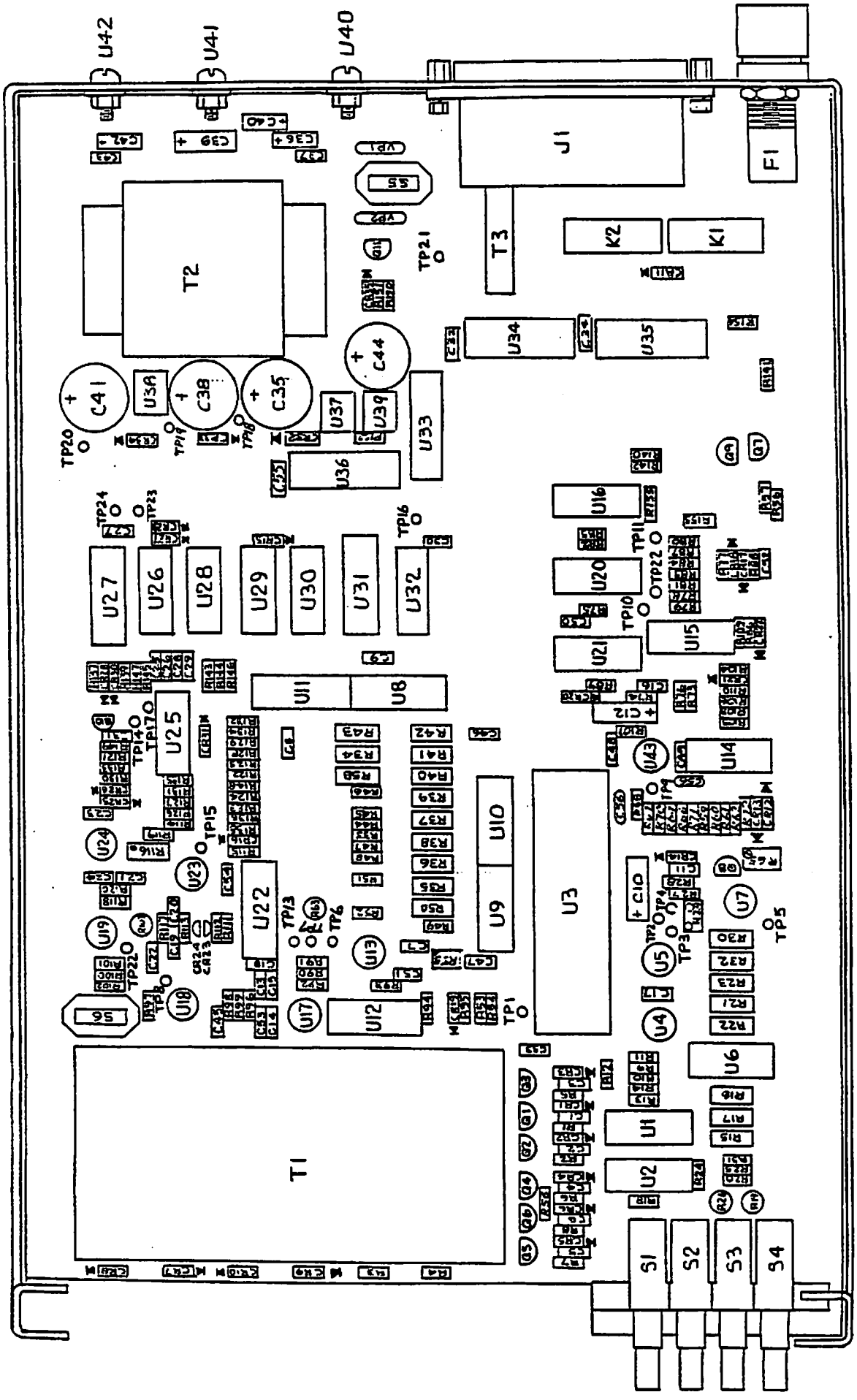


Figure 6-5. Main Chassis (±180° Option) (783784), Parts Locator

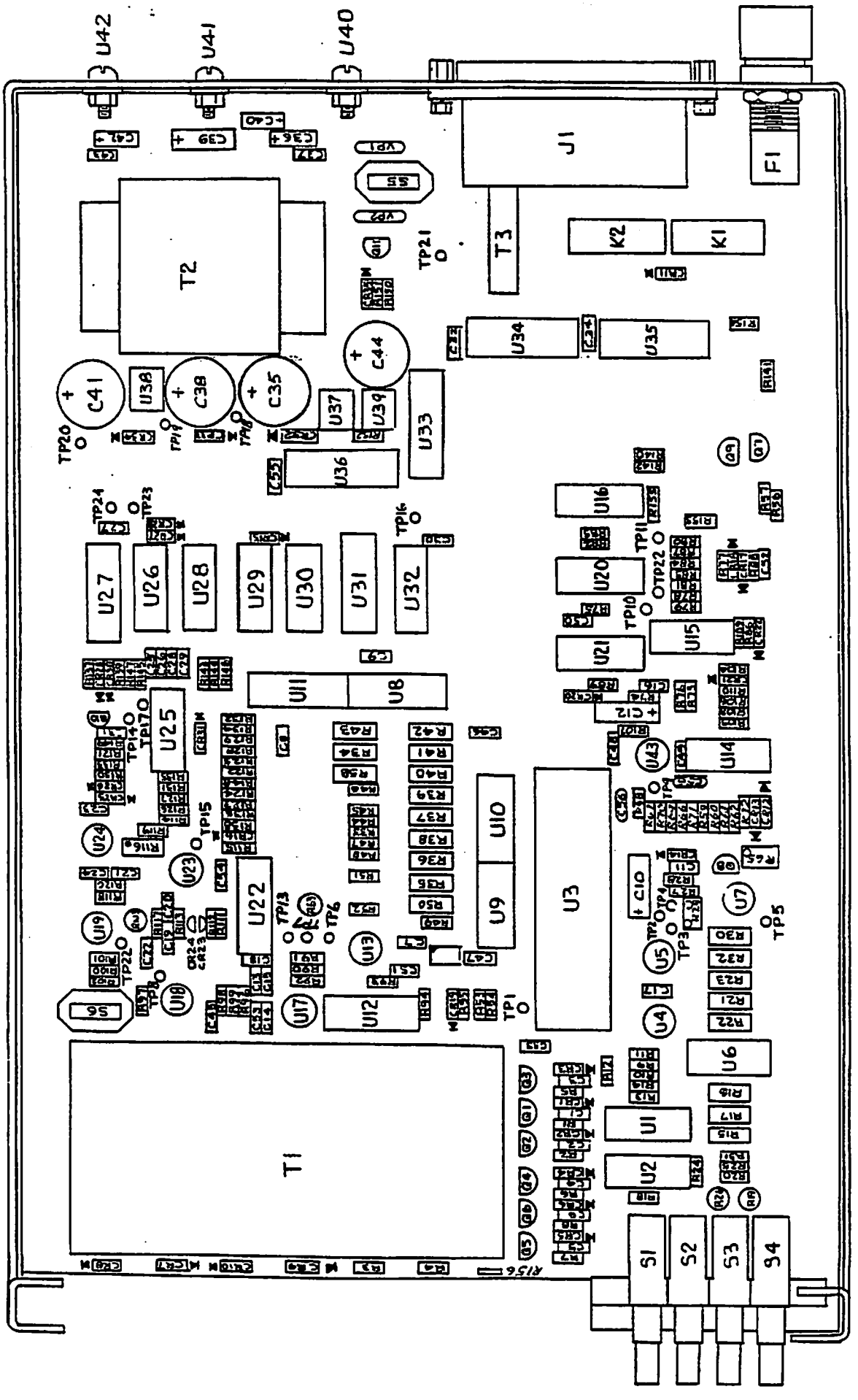


Figure 6-6. Main Chassis (0.005° Resolution Option)(783784), Parts Locator

Replacement Parts List - 360° Display Board, 783739

DESIGNATION	DESCRIPTION	NAI PART NO.	MFR CODE	MFR PART NO.	TOTAL QTY
DS1, DS2	Display, Readout	807670	73138	SP353	2
XDS1, XDS2	Socket, Readout	807672	73138	CS353	2
DS3, 4, 5	LED	807493	28480	5082-4484	3
R1	Resistor, Composition, 430kΩ, 1/4W ±5%	802519	01121	CB4345	1
R2-7	Resistor, Composition, 2.2kΩ, 1/4W ±5%	800079	01121	EB2225	6
R8-13	Resistor, Composition, 13kΩ, 1/4W ±5%	880094	01121	CB1335	6
R14	Resistor, Composition, 150Ω, 1/4W ±5%	880200	01121	CB1515	1
U1-U6	Integrated Circuit	806945	07187	DD700	6
W1	Cable, Flat-Flex, 16 conductor	808117	00779	5107-651-74	1
W2	Cable, Flat-Flex, 14 conductor	808116	00779	5107-651-157	1

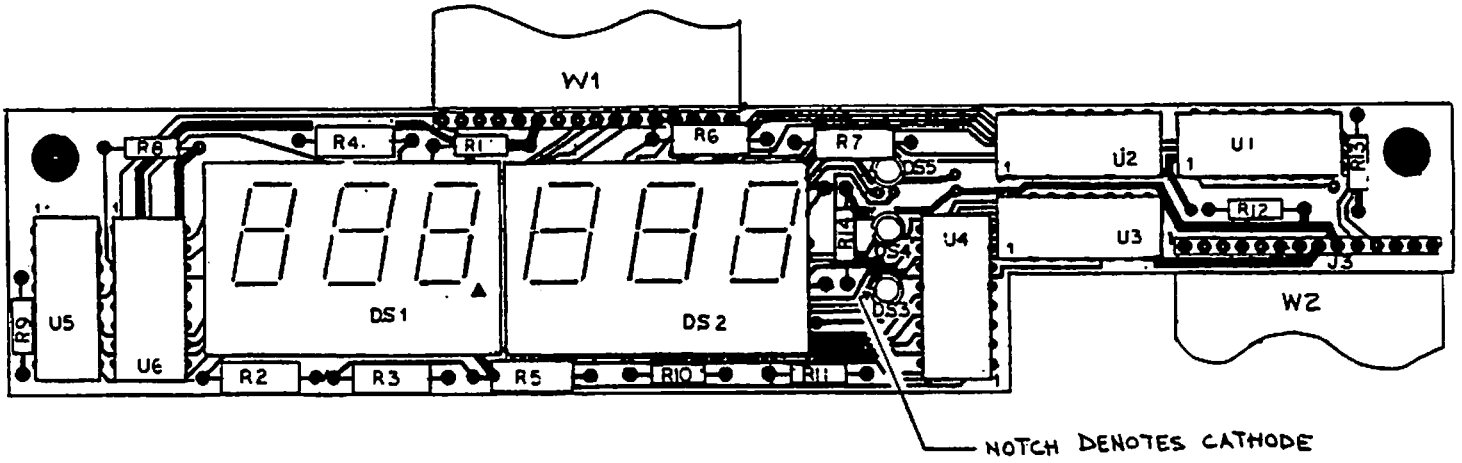


Figure 6-7. 360° Display Board (Standard), Parts Locator

Replacement Parts List - ±180° Display Board - 783747

DESIGNATION	DESCRIPTION	NAI PART NO.	MFR CODE	MFR PART NO.	TOTAL QTY
DS1	Display Readout	808279	73138	SP354	1
DS2	Display, Readout	807670	73138	SP353	1
XDS1,XDS2	Socket, Readout	807672	73138	CS353	2
DS3, 4, 5	LED	807493	09182	5082-4484	3
Q1	Transistor, Signal	804088	04713	2N4123	1
R1	Resistor, Composition, 430kΩ, 1/4W ±5%	802519	01121	CB4345	1
R2 thru R7	Resistor, Composition, 2.2kΩ, 1/2W ±5%	800079	01121	EB2225	6
R8 thru R13	Resistor, Composition, 13kΩ, 1/4W ±5%	802186	01121	CB1335	6
R14	Resistor, Composition, 150kΩ, 1/4W ±5%	803672	01121	CB1515	1
R15	Resistor, Composition, 27kΩ, 1/8W ±5%	808278	01121	BB2735	1
R16	Resistor, Composition, 10kΩ, 1/8W ±5%	880830	01121	BB1035	1
R17	Resistor, Composition, 4.7kΩ, 1/8W ±5%	880829	01121	BB4721	1
U1 thru U5	Integrated Circuit	806945	07187	DD700	5
U6	Integrated Circuit	807761	07187	DD702	1
W1	Cable, Flat Flex, 16 Conductor	808117	00779	5107-651-74	1
W2	Cable, Flat Flex, 14 Conductor	808116	00779	5107-651-157	1

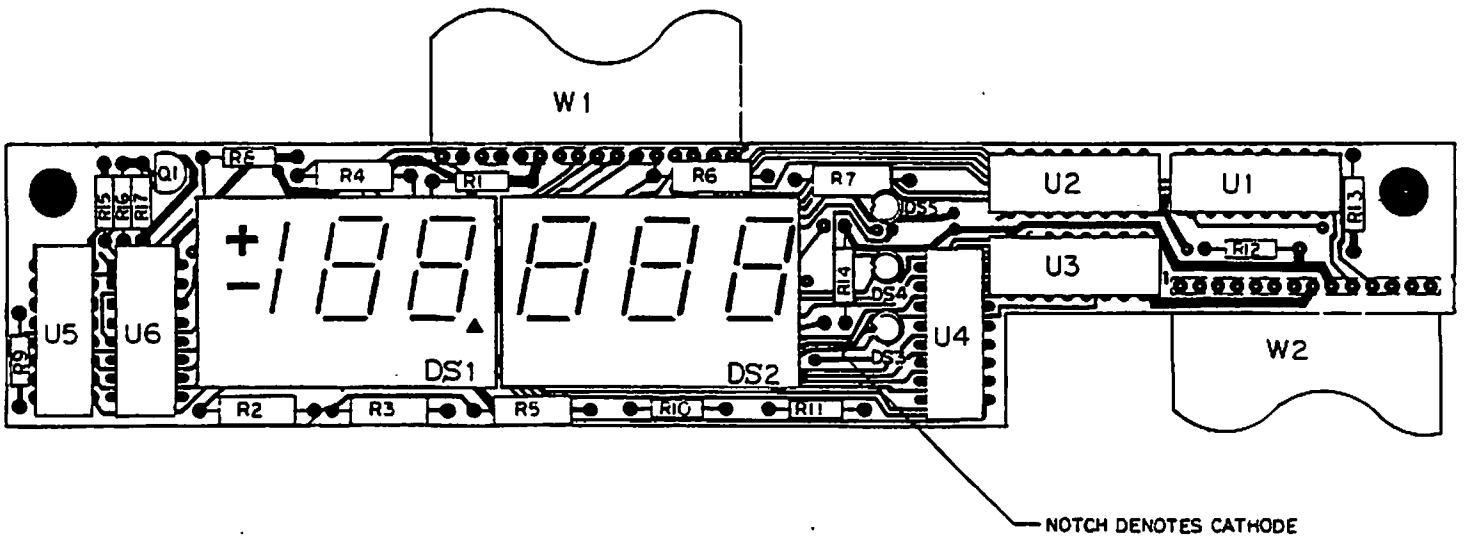


Figure 6-8. ±180° Display Board , Parts Locator

Replacement Parts List - 180° Digital Board - 783719

C1,C2	Capacitor, Ceramic, .01μF, 25V +80-20%	803406	72982	5835	2
Z1	Integrated Circuit	807701-MOS	12040	74C00	1
Z2,5,8,11 14	Integrated Circuit	807780-MOS	04713	MC14519CP	5
Z3,6,9,12, 15	Integrated Circuit	807779-MOS	04713	MC14560CP	5
Z4,7,10,13 16	Integrated Circuit	807702-MOS	04713	MC14561	5
XZ1,4,7,10, XZ13,16	Socket, IC, 14 Pin	807473	01295	C931402	6
XZ2,3,5,6, XZ8,9,11,12, XZ14,15	Socket, IC, 16 Pin	807474	01295	C931602	10

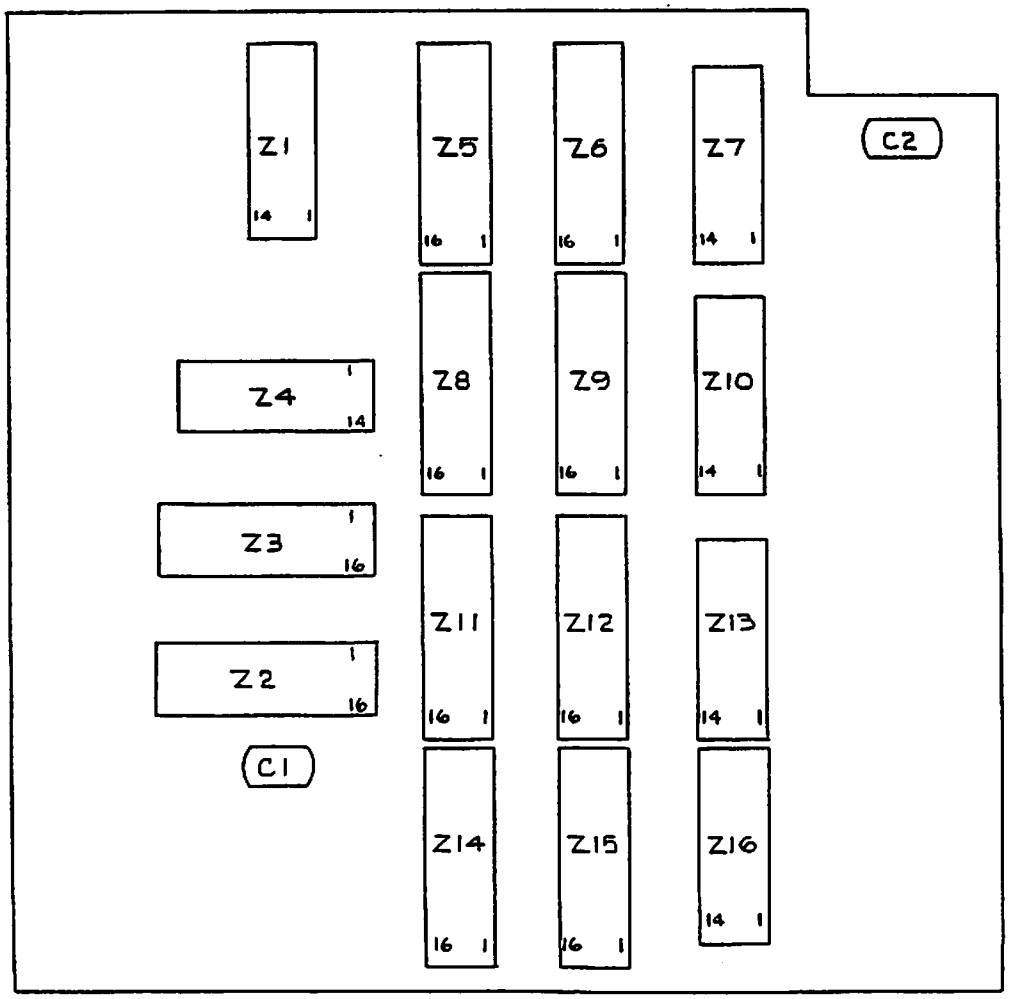


Figure 6-9. ±180° Digital Board , Parts Locator

SECTION 7

UNIT SCHEMATICS

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

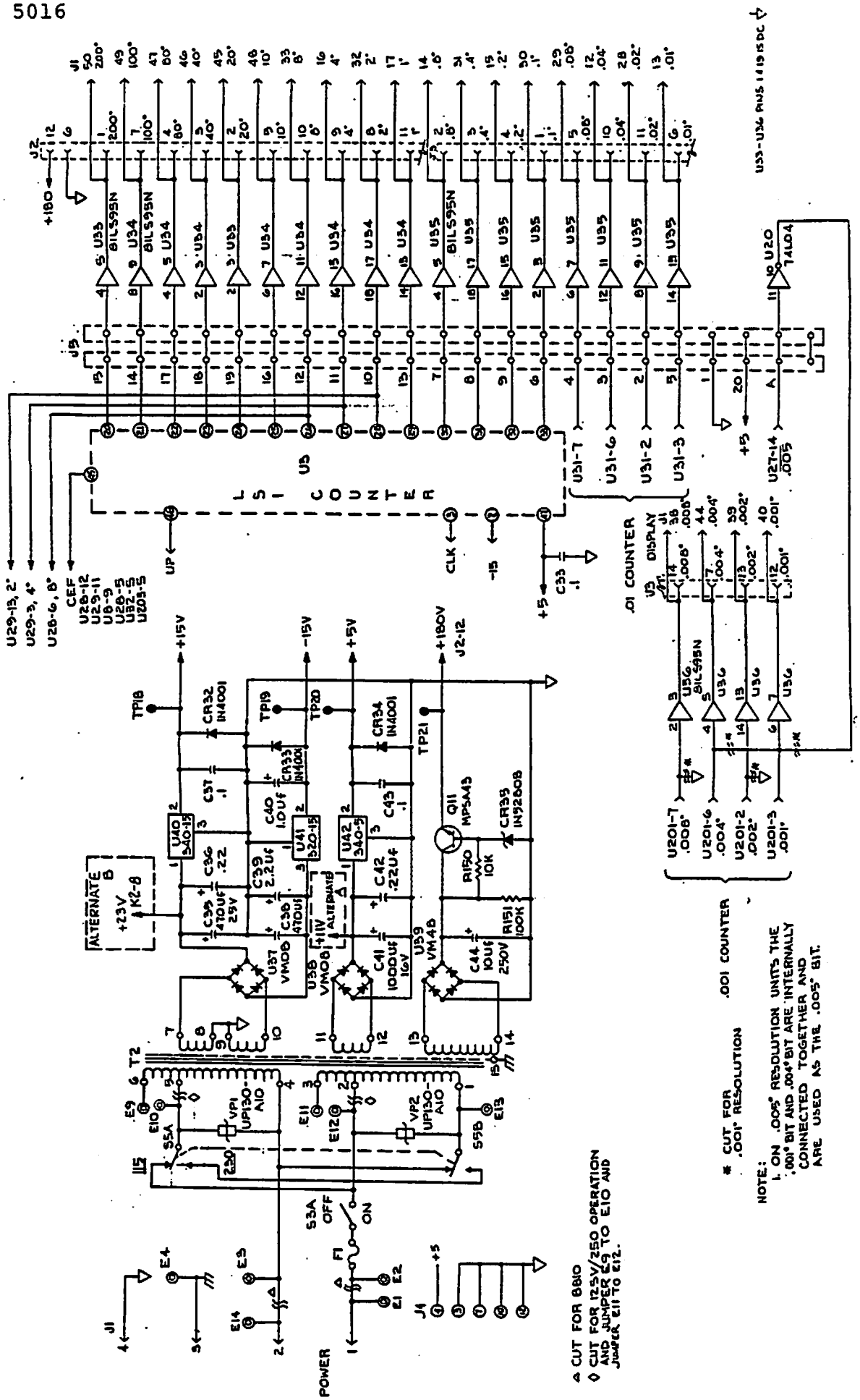


Figure 7-1. Main Chassis (783784) (Sh 1 of 5), Schematic

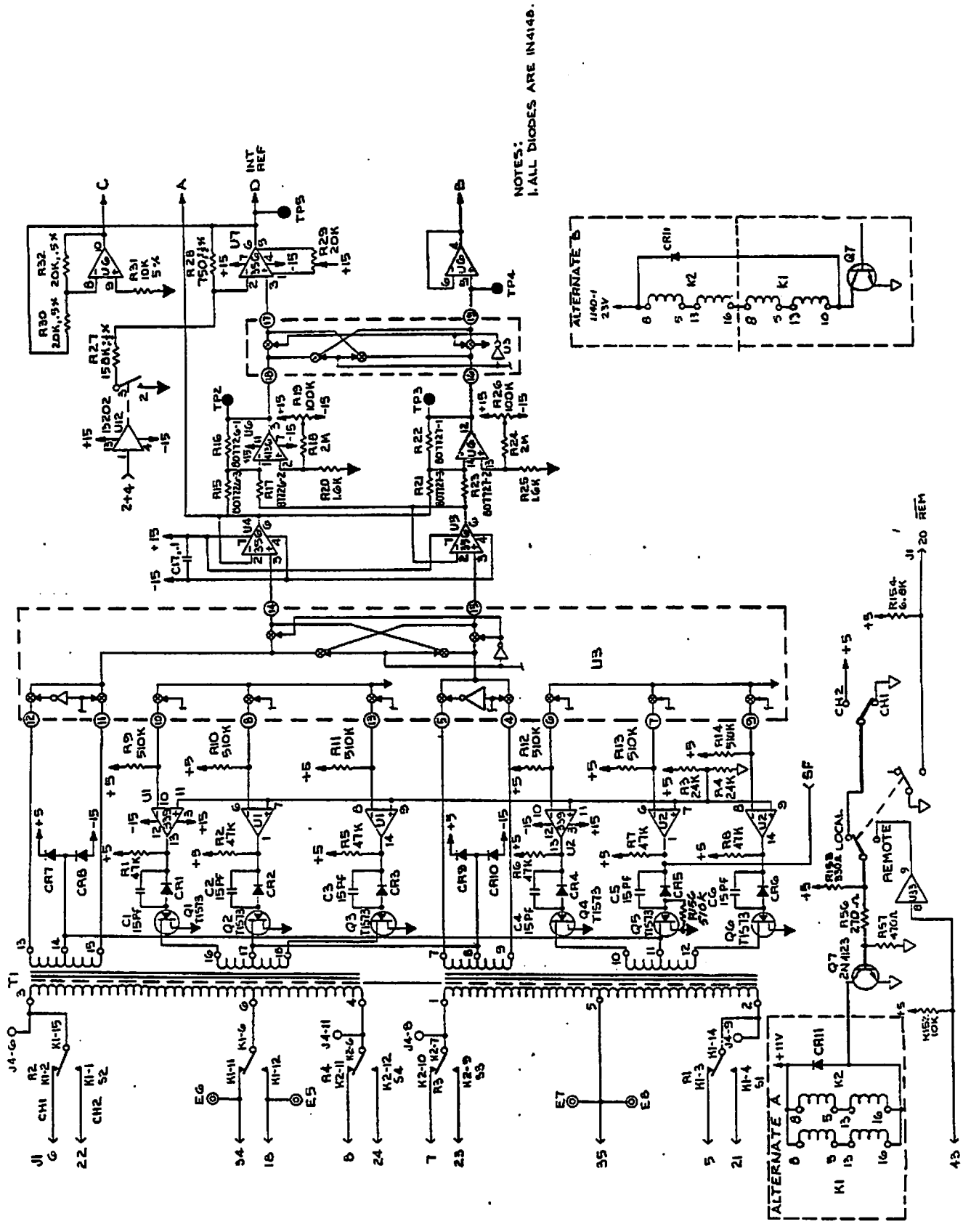


Figure 7-1. Main Chassis, (783784) (Sh 2 of 5), Schematic

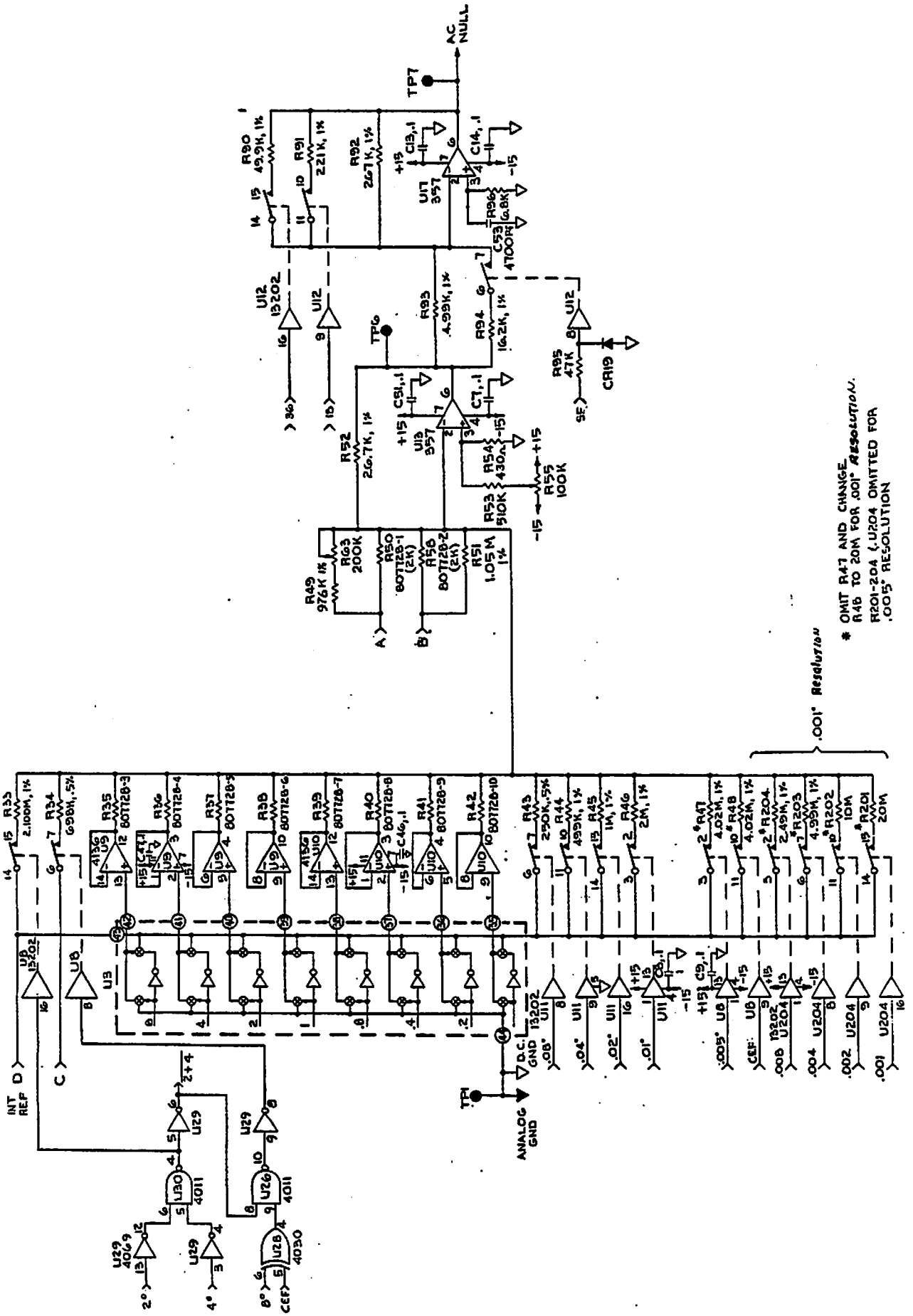


Figure 7-1. Main Chassis (783784) (Sh 3 of 5), Schematic

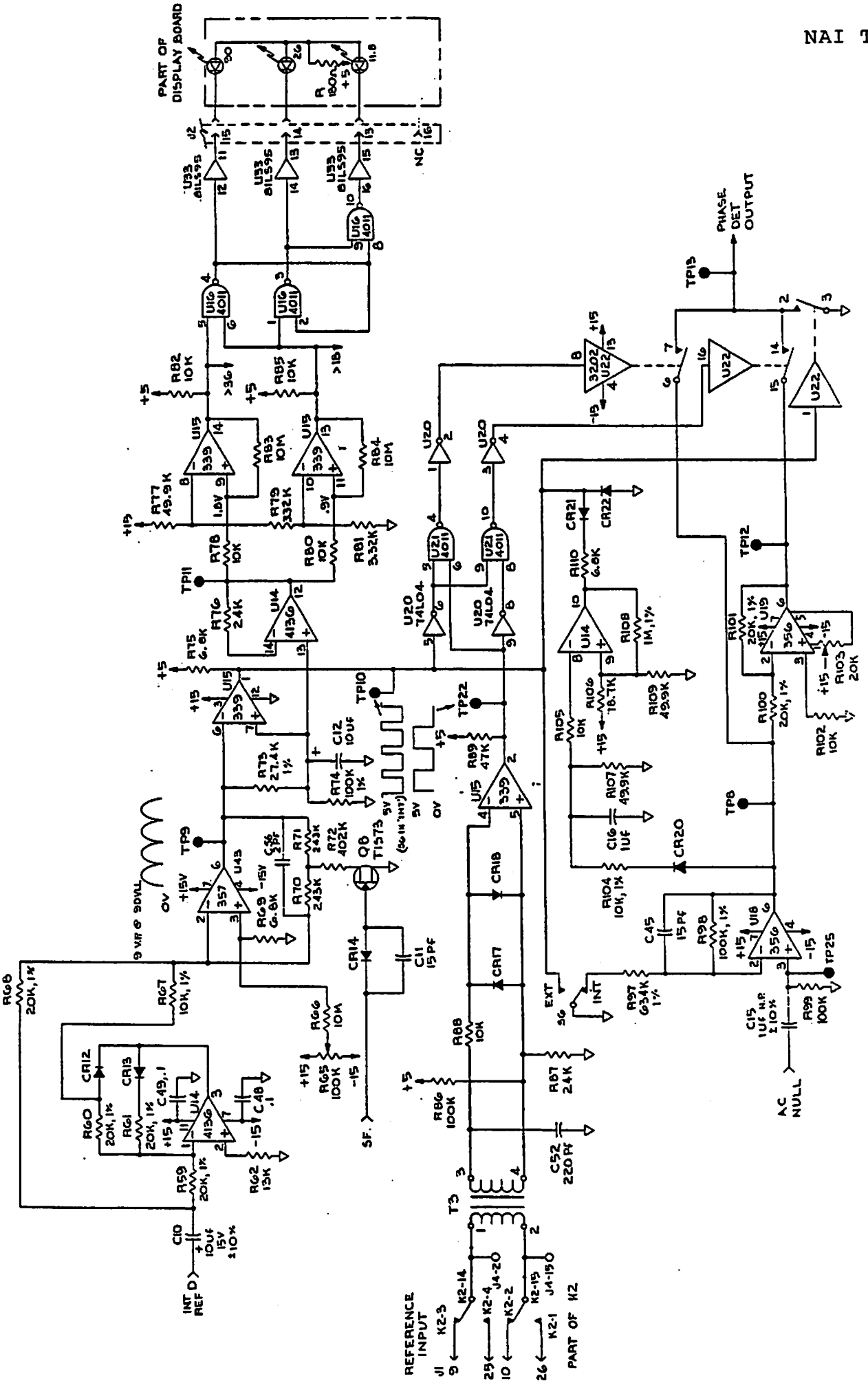


Figure 7-1. Main Chassis (783784) (Sh 4 of 5), Schematic

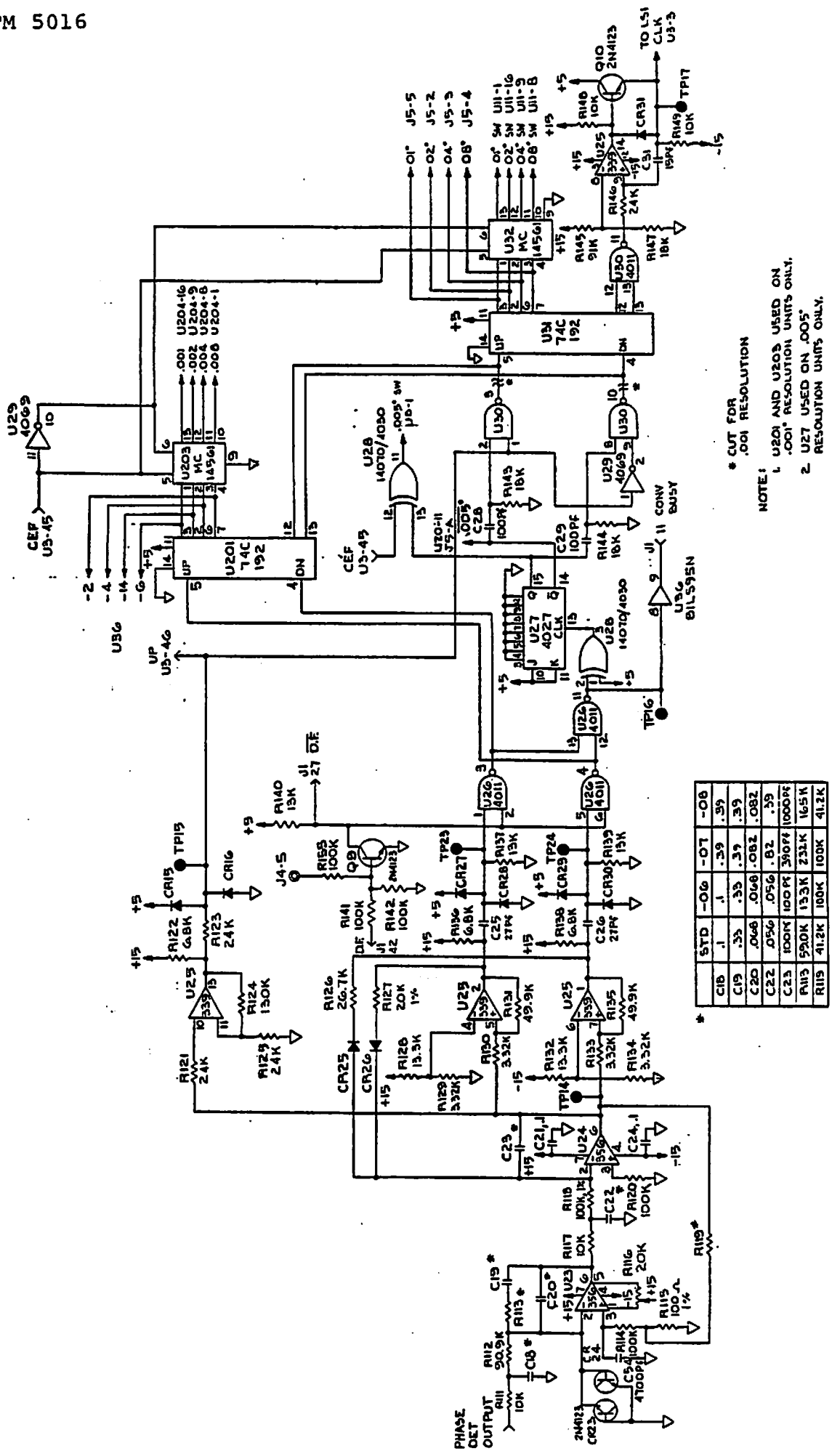


Figure 7-1. Main Chassis (783784)(Sh 5 of 5), Schematic

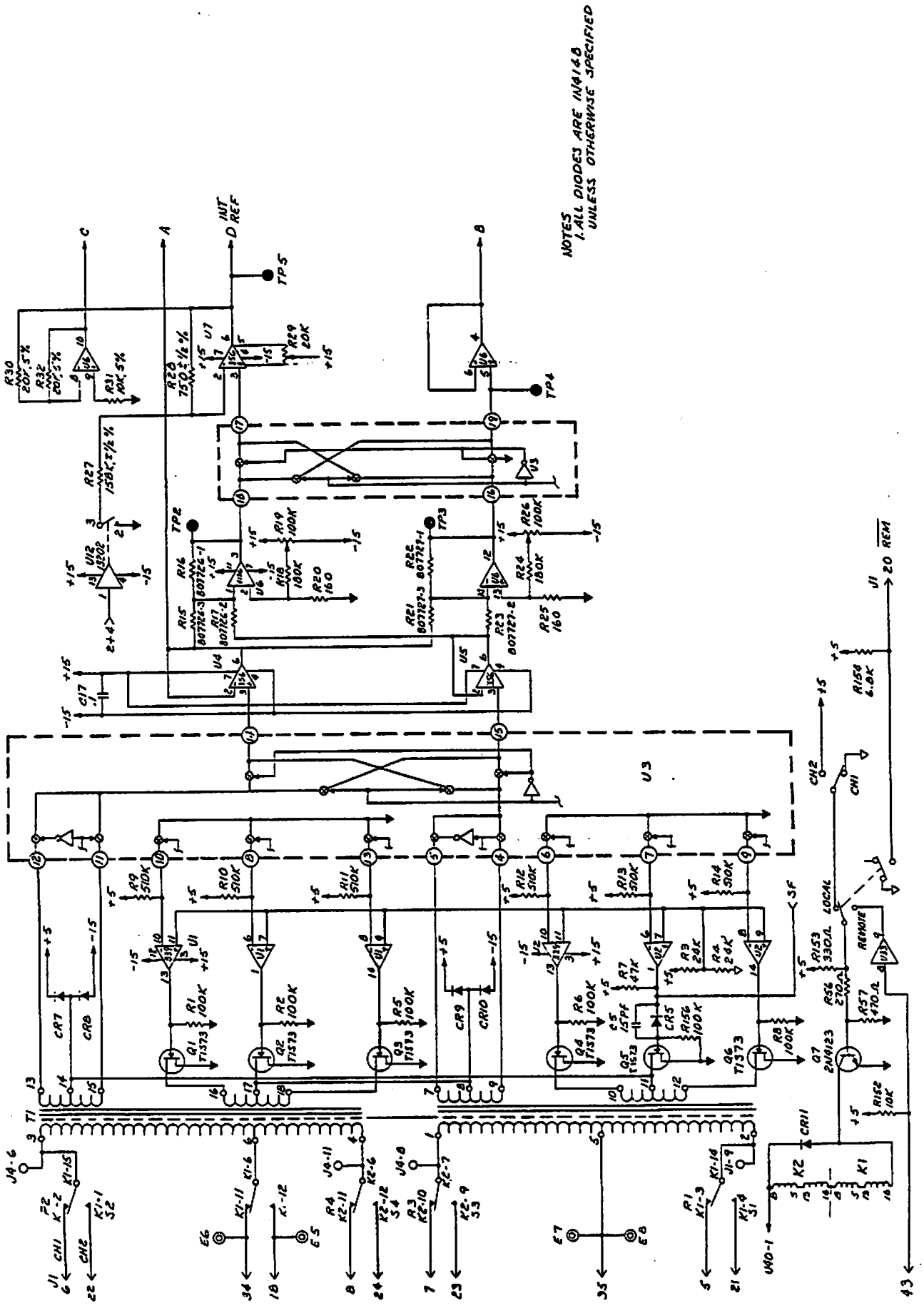


Figure 7-2. Main Chassis (787205) (Sh 1 of 5), Schematic

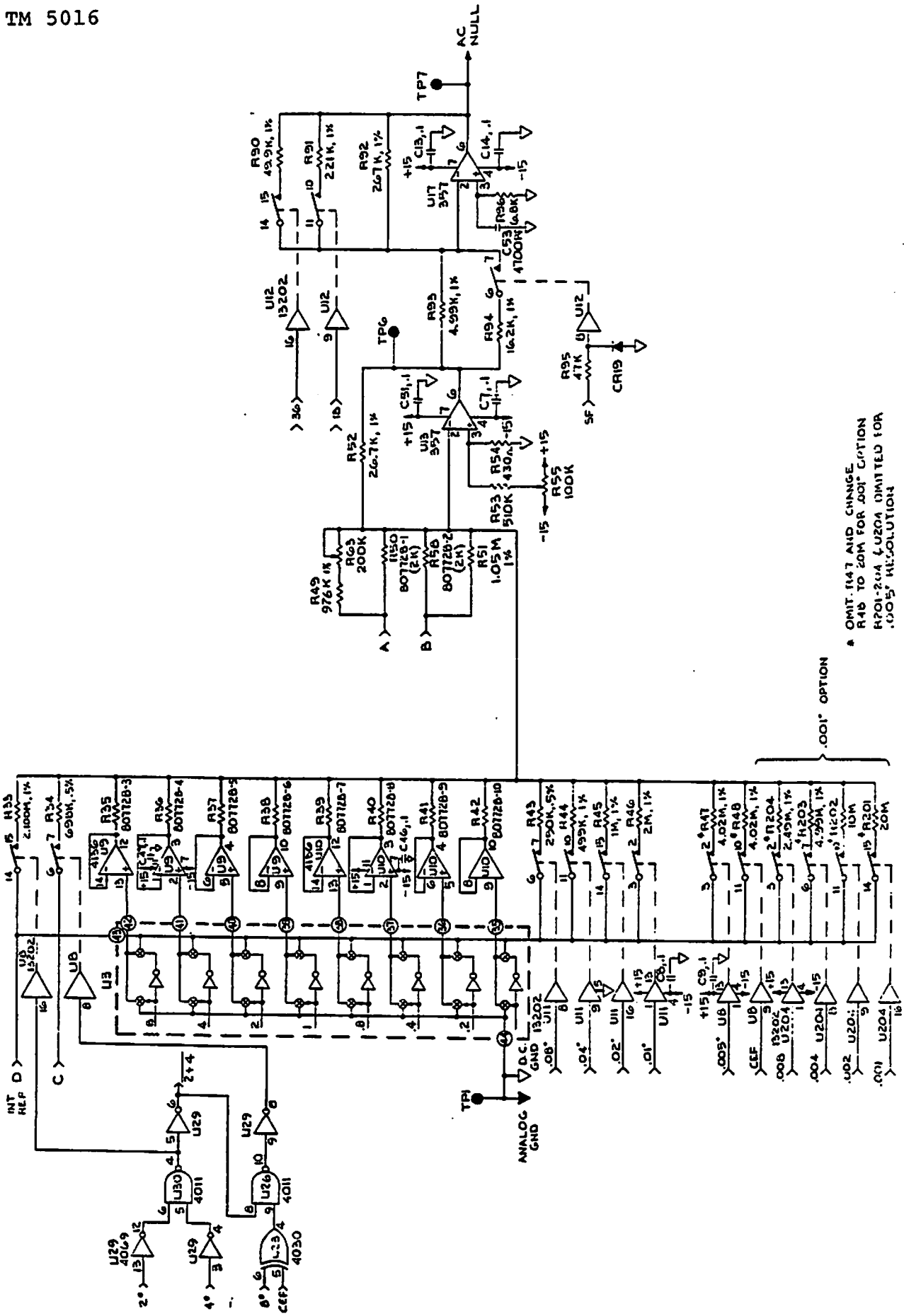


Figure 7-2. Main Chassis (787205)(Sh 2 of 5), Schematic

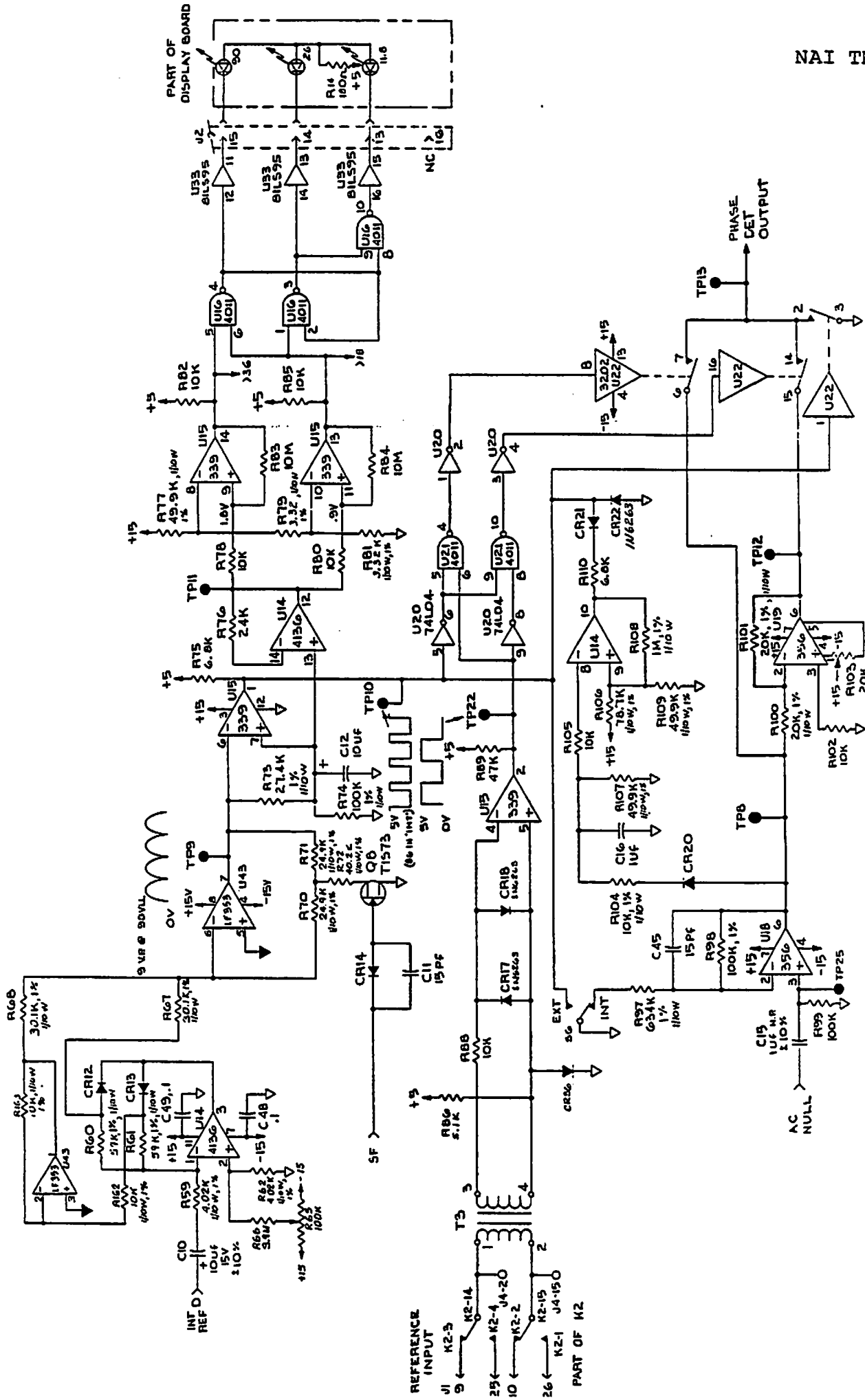


Figure 7-2. Main Chassis (787205)(Sh 3 of 5), Schematic

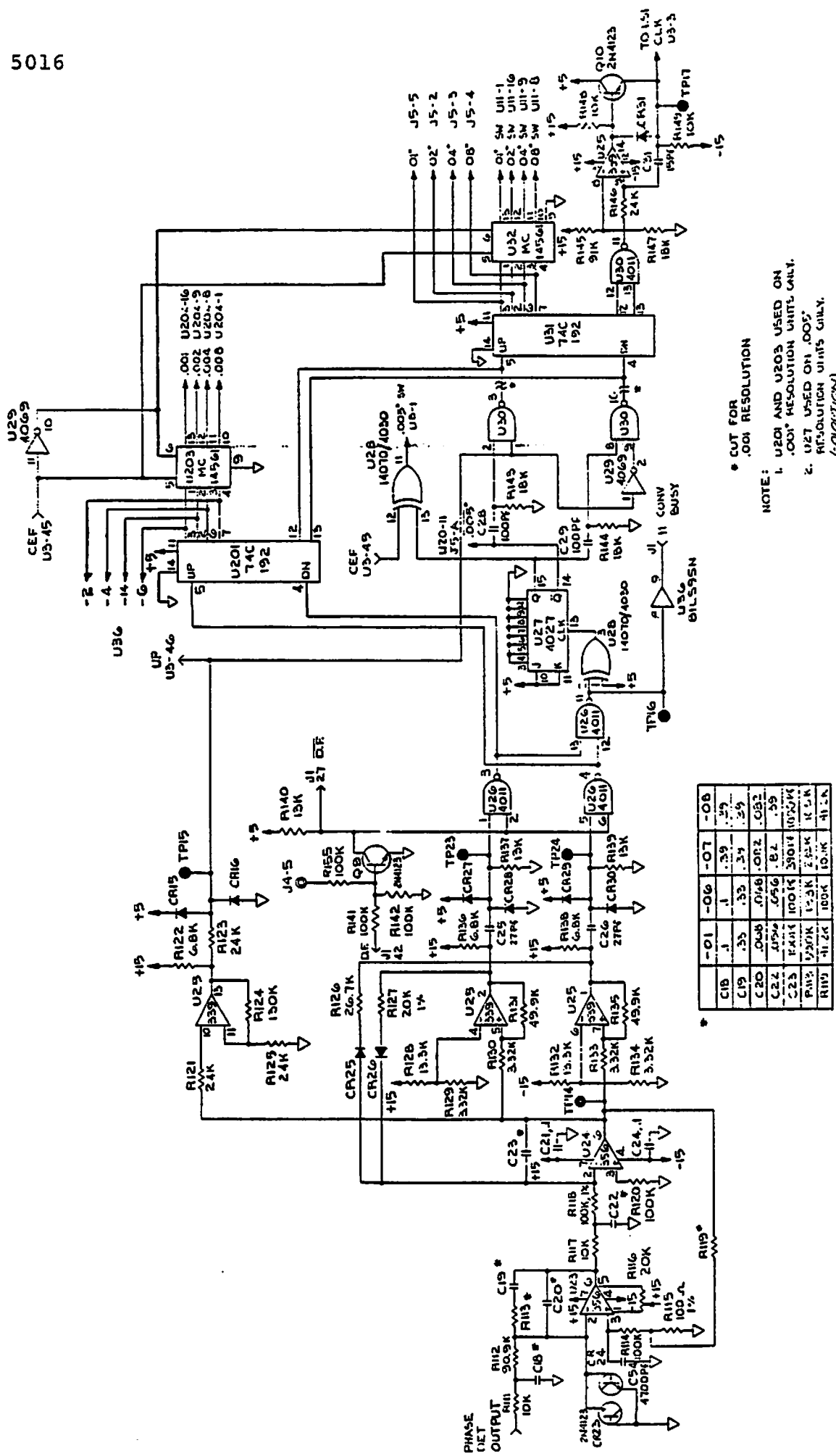


Figure 7-2. Main Chassis (787205) (Sh 4 of 5), Schematic

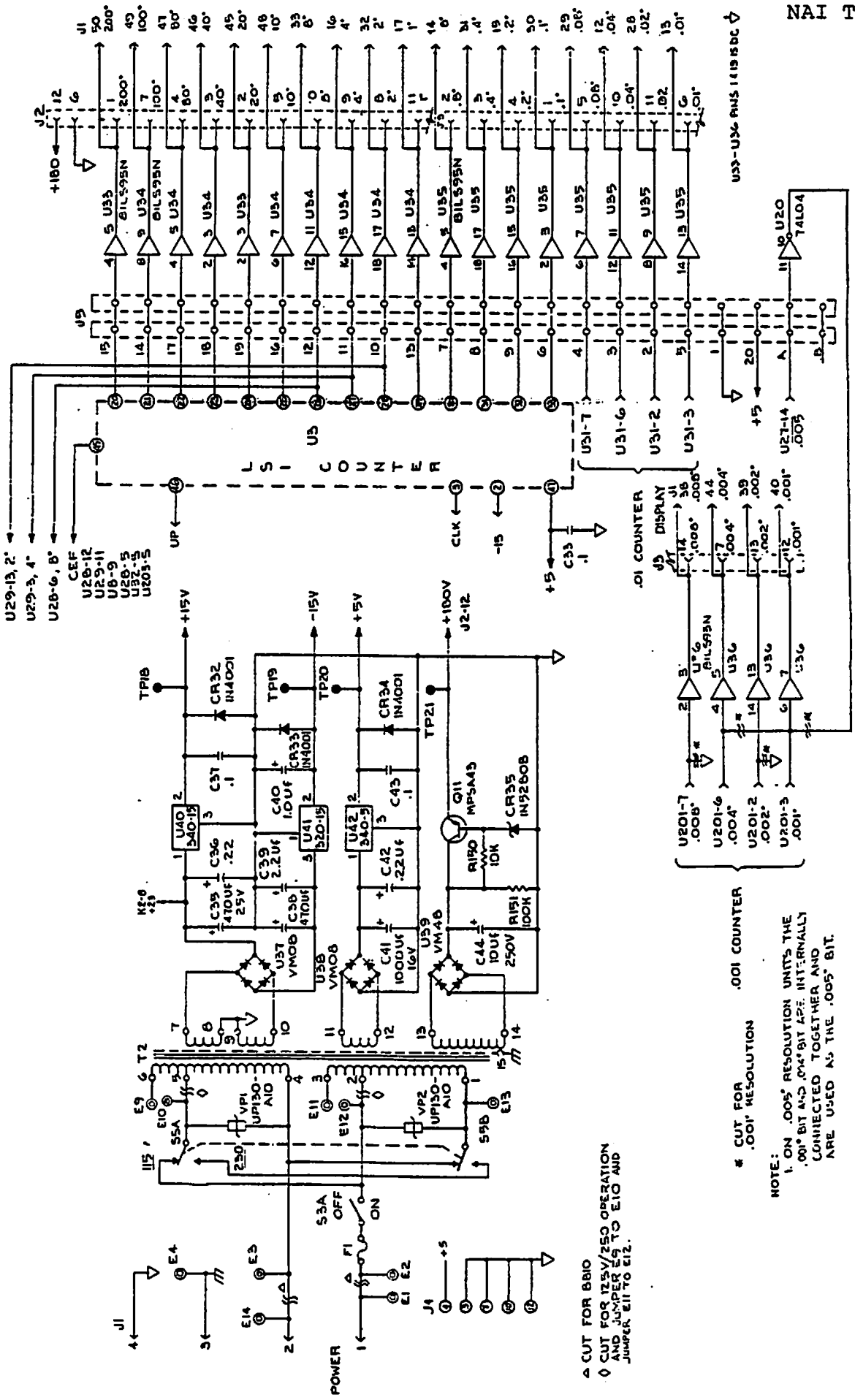


Figure 7-2. Main Chassis (787205) (Sh 5 of 5), Schematic

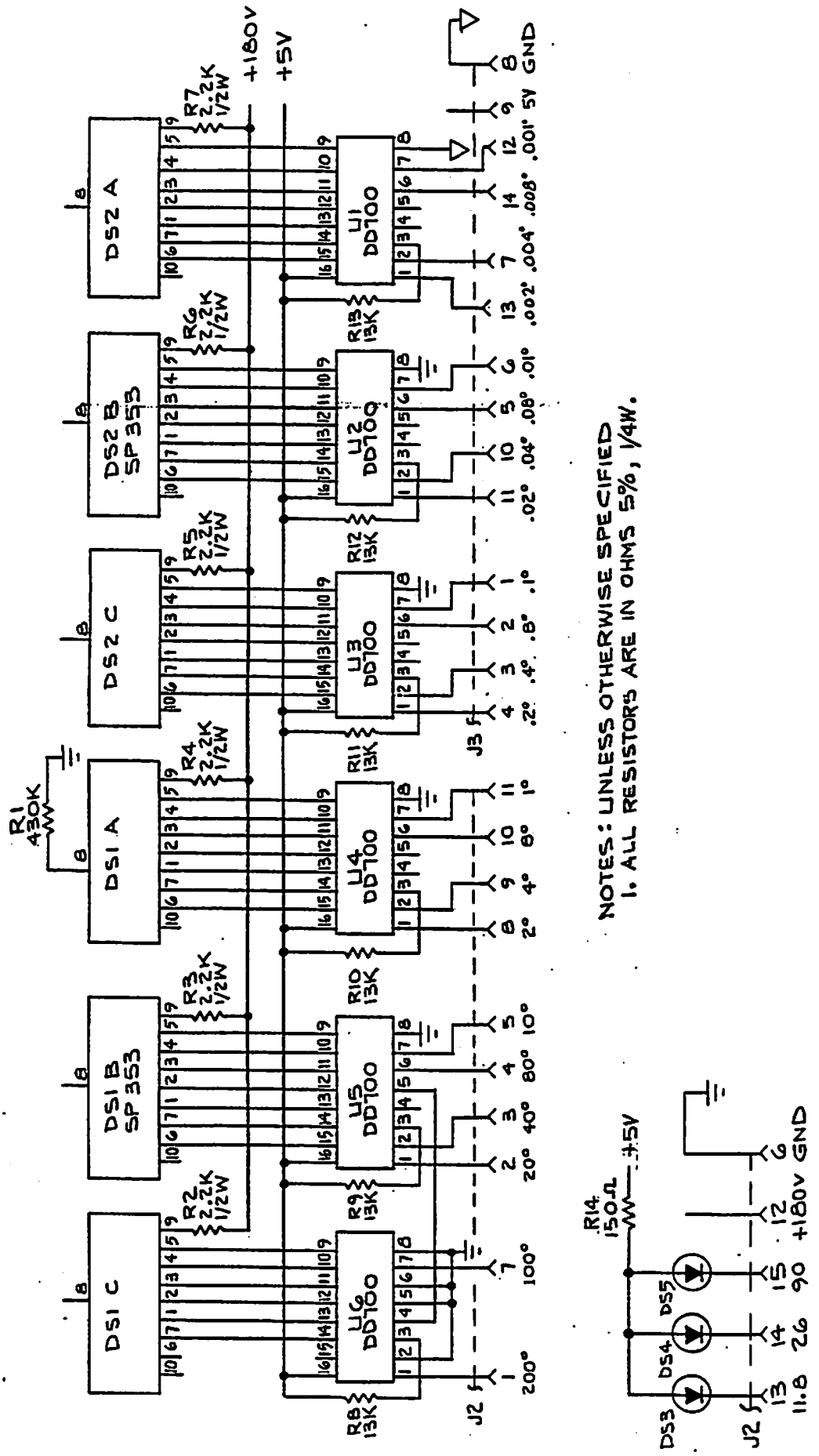


Figure 7-3. 360° Display Board, Schematic

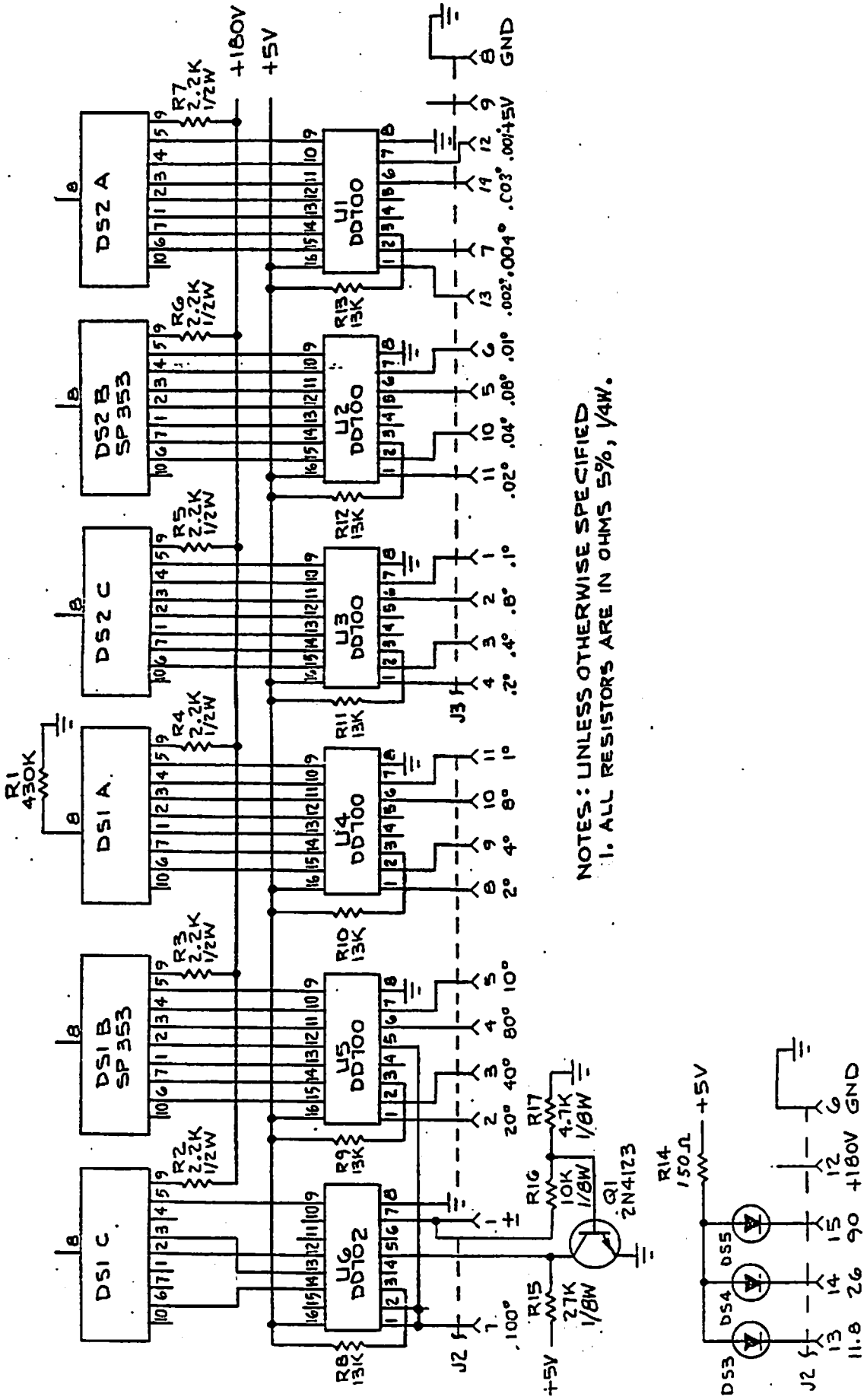


Figure 7-4. ±180° Display Board, Schematic

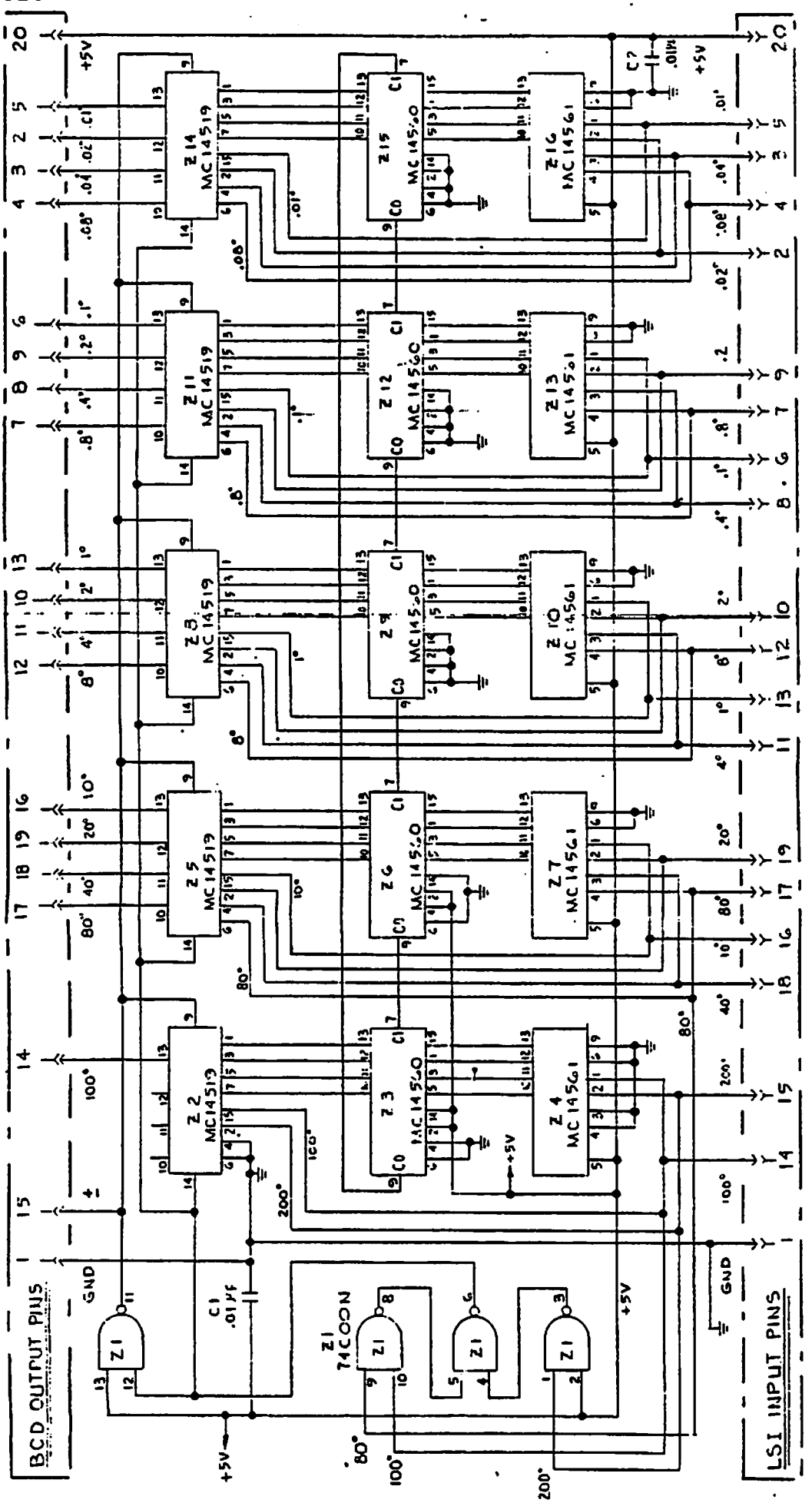


Figure 7-5. ±180° Digital Board, Schematic

APPENDIX A

MANUAL CHANGE DATA

A.1 INTRODUCTION

This appendix contains information necessary to backdate the manual to conform with earlier assembly configurations. To identify the configuration of the assembly used in your unit, refer to the revision letter on the solder side of each assembly. Table A-1 defines the assembly revision levels documented in this manual with an X.

A.2 NEWER UNITS

As changes and improvements are made to the unit they are identified by incrementing the revision letter or number marked on the affected assembly. These changes are documented on a Product Revision Sheet which, when applicable, is inserted at the front of the manual.

A.3 OLDER UNITS

To backdate this manual to conform with earlier assembly revision levels, perform the changes indicated in table A-1 in descending order.

Table A-1. Manual Status and Backdating Information

Assembly Name	NAI Part No.	To adapt manual to earlier rev configurations perform change numbers in descending order (by no.), ending with change under desired rev letter.						
		-	A	A1	C	E	L	L1
Chassis Assy.	783784					1	3	X
Chassis Assy.	787205		X					
360° Display Bd.	783739			2	X			
±180° Display	783747	X						
±180° Digital	783719		X					

X=the assembly revision levels documented in this manual.
Numbers represent changes described in the following pages.

CHANGE 1 - CHASSIS ASSEMBLY 783784 (PCR 22334)

In the chassis assembly parts list, change CR22 from NAI P/N 808974 to NAI P/N 883449.

CHANGE 2 - 360° DISPLAY BOARD 783739 (PCR 22538)

In the 360° display board parts list, change R8 through R13 from NAI P/N 880094 to NAI P/N 802186 and R14 from NAI P/N 880200 to NAI P/N 803672.

CHANGE 3 - CHASSIS ASSEMBLY 783784 (PCR 22762)

In the chassis assembly parts list, change C44 from NAI P/N 885188 (epoxy sealed) to NAI P/N 808189.

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.

DECLARATION OF CONFORMITY

We **NORTH ATLANTIC INSTRUMENTS, INC.**
170 WILBUR PL.
BOHEMIA, NY 11716-2416

declare under our sole responsibility that the product

8800 SERIES ANGLE POSITION INDICATOR

to which this declaration relates is in conformity with the following standard(s) or other normative document(s):

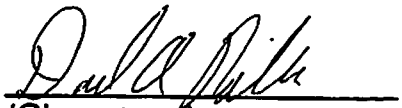
EN 50081-1: 1992 EN 55022; CONDUCTED EMISSIONS
EN 55022; RADIATED EMISSIONS

EN 50082-1: 1992 IEC 801-2; 1984 ESD
IEC 801-3; 1984 RADIATED IMMUNITY
IEC 801-4; 1988 EFT BURST

EN 61010-1: 1993/A2: 1995 SAFETY

following the provisions of COUNCIL DIRECTIVE 89/336/EEC
73/23/EEC

Place Bohemia, NY, U.S.A.


(Signature)

Date 9-10-97

Daniel A. Palladino
(Full Name)

Quality Analyst
(Position)

FORM007.B