

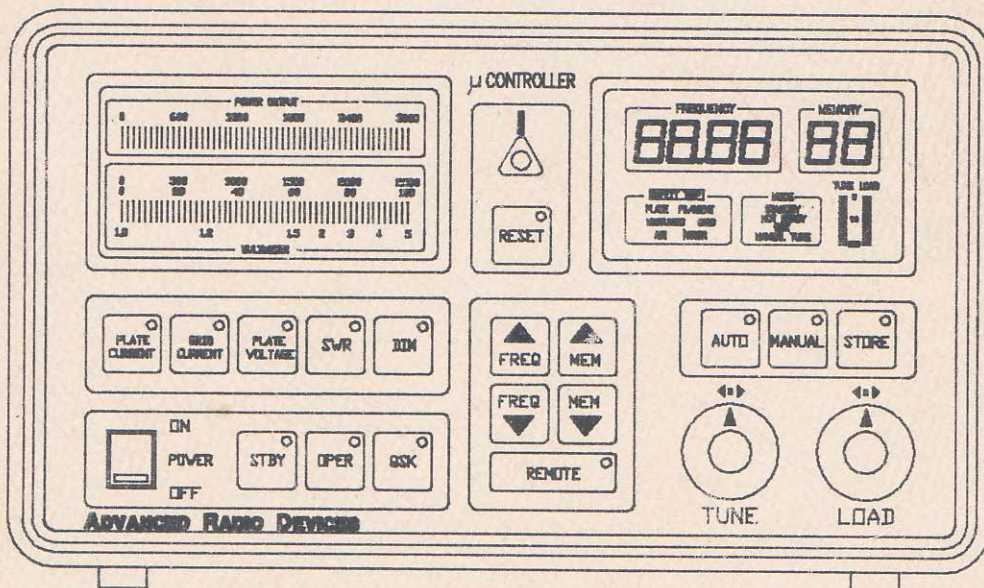
# ADVANCED RADIO DEVICES

RF LINEAR AMPLIFIER

INSTRUCTION MANUAL



MODEL 230A



103 Carpenter Drive, Sterling, VA. 22170 USA

F1 = 1/2 A on lights  
F2 = 2 A blower, LV P.S.  
F3 = 1/2 A out. switching  
25V

# WARNING

THIS AMPLIFIER INCLUDES POWER SUPPLIES  
THAT ARE CAPABLE OF CAUSING DEATH

ONLY QUALIFIED PERSONS SHOULD ATTEMPT  
MAINTENANCE AND THEN ONLY WHEN PROPER  
SAFETY PRECAUTIONS ARE TAKEN

# CAUTION

THIS EQUIPMENT CONTAINS SOLID STATE DEVICES  
THAT ARE VERY SENSITIVE TO ELECTROSTATIC  
DAMAGE IF PROPER HANDLING IS NOT OBSERVED.

WHEN PERFORMING MAINTENANCE ON THIS  
AMPLIFIER, ENSURE GOOD ESD PRACTICES ARE  
OBSERVED SUCH AS GROUNDING TECHNIQUES.

*Service: 9/18/94 Backlight on LCD displays dim. Replaced 5 new panels.*

## Table of Contents

1. Introductory Notice.....	1
2. General Information.....	2
2.1. Proprietary Information.....	2
2.2. FCC Certification.....	2
2.3. Copyright.....	2
2.4. Changes.....	2
2.5. Support.....	2
2.6. Instruction Manual.....	2
3. Warranty.....	3
4. General Description.....	4
4.1. Introduction.....	4
4.2. Specifications.....	5
4.3. Options.....	6
4.3.1. Controller Cable.....	6
4.3.2. 10-Meter Operation.....	6
4.4. Installation.....	6
4.4.1. Unpacking and Setup.....	6
4.4.1.1. RF/power supply deck.....	6
4.4.1.2. Input Voltage Selection.....	8
4.4.1.3. Power Transformer Installation.....	9
4.4.1.4. Microcontroller.....	9
4.4.1.5. KEY OUT Configuration.....	9
4.4.2. Equipment Placement.....	10
4.4.3. Input Voltage Considerations.....	10
4.4.4. Amplifier Interconnections.....	10
5. Operating Instructions.....	13
5.1. Introduction.....	13
5.2. Controls and Indicators.....	13
5.2.1. Microcontroller Controls and Indicators.....	13
5.2.2. Microcontroller Rear Panel Connectors.....	16
5.2.3. RF/Power Supply Connectors.....	16
5.3. Procedures.....	19
5.3.1. Quick Start.....	19
5.3.2. Automatic Operation.....	20
5.3.3. Semi-Automatic Operation.....	21
5.3.4. Manual Operation.....	22
5.3.5. Presets.....	23
5.3.6. Memories.....	23
5.3.6.1. Clearing a Memory Location.....	24
5.3.7. Remote Control.....	24
5.4. Protective Trips.....	24
5.4.1. Introduction.....	24
5.4.2. Pre-Trips (SOFT).....	25

5.4.3. Trips (HARD).....	25
5.5. Antenna Switching.....	26
5.6. Problems.....	27
5.7. Operational Notes.....	27
6. Theory of Operation.....	30
6.1. Functional Description.....	30
6.1.1. Power Supply Module.....	32
6.1.2. Amplifier Module.....	33
6.1.3. Input Module.....	34
6.1.4. Output Module.....	34
6.1.5. Control Module.....	35
6.1.5.1. I/O Board.....	35
6.1.5.2. Driver Board.....	38
6.1.5.3. Frequency counter.....	39
6.1.6. Microcontroller.....	39
6.1.6.1. CPU Board.....	39
6.1.6.2. Display Board.....	40
6.1.7. Software Description.....	40
6.1.7.1. General Description.....	40
6.1.7.2. Protection Logic.....	40
6.1.7.3. Manual Mode.....	41
6.1.7.4. Automatic Mode.....	42
6.1.7.5. Presets.....	43
6.1.7.6. User Memories.....	44
6.1.7.7. Tune/ Load Capacitor Control.....	45
6.1.7.8. Bandswitch/Relay Control.....	45
6.1.7.9. LCD Display Control.....	45
6.1.7.10. LED Control. See Table 3.....	46
6.1.7.11. Bias Control.....	46
6.1.7.12. Remote Control Operation.....	46
7. Maintenance.....	51
7.1. Introduction.....	51
7.2. Microcontroller.....	51
7.3. RF/power supply deck.....	51
8. Drawings.....	52

**Appendices**

A. Manual Tuning Procedure.....	68
---------------------------------	----

**List of Figures**

1. RF/Power Supply - covers removed.....	7
2. Interconnections.....	12
3. Front View - microcontroller.....	17
4. Rear View - microcontroller.....	17
5. RF/Power Supply Deck - Rear View.....	18
6. System Block Diagram.....	31

**List of Tables**

1. Accessories Furnished with Amplifier.....	8
2. Trip Value Summary.....	28
3. Troubleshooting Chart.....	29
4. Panel LED Control.....	48
5. Remote Control Commands.....	49

NOTE:

After page 69: TECHNICAL MANUAL ERRATA (3 pages total) - JUNE 1988.

## 230 Series Linear Amplifier

### 1. Introductory Notice

#### **IMPORTANT -- PLEASE READ**

Unpack all items very carefully and ensure that what you have agrees with the listing of furnished items for your amplifier.

The 230AX is shipped for operation on 230 VAC. If operation on 200 or 220 VAC is desired, please refer to paragraph 4.4.1.2 before attempting operation of the amplifier.

Before attempting to operate the amplifier, read over the operating instructions. There are a lot of unique features with the 230 and we want you to be able to take full advantage of them.

Call if you have any problems: 703 478 3100.

#### **WARNING**

**THIS EQUIPMENT PRODUCES VOLTAGES THAT CAN KILL YOU! SERVICE SHOULD ONLY BE PERFORMED BY QUALIFIED PERSONS. NEVER DEFEAT ANY OF THE SAFETY INTERLOCKS.**

## 230 Series Linear Amplifier

### 2. General Information

#### 2.1. Proprietary Information

Reproduction of any material in this manual for purposes other than personal is prohibited without specific written permission from Advanced Radio Devices.

#### 2.2. FCC Certification

The 230 amplifier complies with all applicable portions of FCC regulations pertaining to linear amplifiers and microprocessor based control systems.

#### 2.3. Copyright

This manual is copyrighted 1988.

#### 2.4. Changes

Advanced Radio Devices reserves the right to make changes to this product and/or its specifications. As part of our continuing effort to improve our products, changes to the design may occur. Some of these changes may be available to previous models. In order to be placed on our mailing list and receive notices concerning updates and other information of interest, you must return the WARRANTY REGISTRATION CARD.

#### 2.5. Support

We are always available to help you with problems should they occur. Call us during business hours at (703) 478 3100. Have your model type and serial number available when you call. Do NOT return your amplifier to the factory without prior return authorization.

#### 2.6. Instruction Manual

We guess no one likes to read manuals but please, please read through this one .. it will save you problems and will allow you to discover some of the really interesting features of your amplifier! We took our time to make the manual easy to read and did not include a lot of "junk" reading.

## 230 Series Linear Amplifier

### 3. Warranty

#### LIMITED WARRANTY

Advanced Radio Devices warrants to the original purchaser that the amplifier is free from material defects or workmanship for 12-months from the date of original purchase.\* To be eligible for warranty repair the warranty registration card must be returned to Advanced Radio Devices within 10-days of receipt of amplifier.

All shipping charges for returned amplifiers must be prepaid by the purchaser. It is suggested that all original packing material be retained in the event return is necessary.

This warranty does not apply to any defect that Advanced Radio Devices determines is caused by improper repairs, misuse, neglect, abuse, installation, accident or intentional damages.

Advanced Radio Devices is not responsible for damage to property or any other consequential or incidental damage of any kind whether based on negligence, contract, or liability. Maximum liability, in any case, shall not exceed the purchase price of the amplifier.

This warranty is Advanced Radio Device's entire obligation for this amplifier. The original purchaser and any user shall have no other remedy or claim for incidental or consequential damages.

\* The tubes are NOT covered by this warranty. The manufacturer's warranty is passed through to the purchaser.

#### NOTE

This warranty is void if the amplifier is shipped with the power transformer installed.



## 230 Series Linear Amplifier

### 4. General Description

#### 4.1. Introduction

The 230A and 230AX linear amplifiers manufactured by Advanced Radio Devices are the result of two years development work in hardware and software and represent a new dimension in linear amplifier technology and operating convenience.

The 230A, configured for amateur use, covers all amateur bands from 1.8 through 24 Mhz with a continuous power output rating of 1500 watts in all modes. 10 meter coverage is available to qualified users.

The 230AX is an export version of the 230A and will operate from 200/230 VAC, 50/60Hz power sources.

The amplifiers are completely automatic. The microprocessor control system continuously adjusts the amplifier for maximum efficiency using a sophisticated tuning algorithm in conjunction with gear-head driving motors for the band-switch, plate and loading capacitors. These amplifiers are NOT broadband compromises!

Both versions utilize the Eimac 3CX800A7 metal ceramic triode. The microprocessor control system is capable of completely automatic operation both locally and via an RS-232C control link. A small "microcontroller" contains all

metering and controls required for operation and setup and is all that is required at the operating position. If desired, the larger RF/power supply deck may be located up to 250-feet away.

The RF/power supply deck is heavy duty throughout to allow for 100% continuous duty operation.

The tubes are monitored by the microprocessor control system to ensure maximum operating efficiency but also to prevent tube damage by taking the amplifier off-line if a critical parameter is exceeded. A unique pre-trip feature is included to warn the operator of an impending trip so as to allow the amplifier to stay on the air by taking action before an actual trip occurs.

Attention has been paid in the design to ensure excellent RF immunity for the control system as well as minimizing emissions FROM the control system. A unique proprietary serial bus configuration is used between the microcontroller and RF/power supply deck.

## 230 Series Linear Amplifier

### 4.2. Specifications

Power Output: 1500 Watts

Duty Cycle: Continuous

Frequency (230A,AX):

1.75-2.0 Mhz  
3.1-4.3 Mhz  
5.8-8.0 Mhz  
13.4-15.1 Mhz  
18.5-21.6 Mhz  
24.8-25.0 Mhz \*  
28.0-30.0 Mhz \*

(\* Qualified users only  
for 230A)

Drive: 60-80 Watts

Input SWR: 1.5:1  
(Slightly higher on WARC)

Harmonic Suppression: -45dB

Intermod Products: -35dB

ALC: 0 to -10 VDC

AC POWER (230A): 230 VAC, 60Hz  
(230AX): 200/230 VAC,  
50/60Hz

Plate Voltage: 2250 Volts, Nom

Input/Output Impedance:  
50 ohms, unbalanced

Output Configuration: Pi-L

Motors: Gearhead DC

Interlocks: 3 cabinet and  
1 HV shorting

### Metering:

Power Output: 0-3000 watts  
Grid Current: 0-100 ma  
Plate Current: 0-2500 ma  
Plate Voltage: 0-2500 vdc  
VSWR: 1:1-5:1  
Reverse Power: 0-500 watts

### Safety Trips:

Plate Current: >1.3 amp  
Grid Current: >120 ma  
Filament volts: <12.8 vdc  
Reverse Power: >500 watts  
Mistuned: >1600 watts diss

### Microcontroller Connectors:

Key In	1/4" phone jack
Key Out	RCA
ALC	RCA
PTT	RCA
RS-232	Female D (25 pin)
RF Deck	Male D (25 pin)

### RF/Power supply Connectors:

RF In	BNC
RF Out	SO-239
Microcontroller:	Female D (25 pin)
Antenna Control:	Female D (9 pin)
Accessory:	Female D (15 pin)

AC Power: 8-foot cord with:  
230A: 20A plug  
230AX: stripped ends

### Dimensions (inches):

Microcontroller:  
10w x 8h X 9d

RF/Power supply deck:  
14w x 24h x 13d

## 230 Series Linear Amplifier

### 4.3. Options

#### 4.3.1. Controller Cable

The amplifier is supplied with a 15-foot cable to interconnect the microcontroller and the RF/power supply deck. Longer cables are available in 10-foot increments up to 250-feet. Write or call the factory for availability.

#### 4.3.2. 10-Meter Operation

Qualified users may obtain a conversion kit for 10-meter operation. The conversion consists of replacing the PROM within the microcontroller. If you desire the conversion, send a copy of your amateur license along with \$15.00 for postage and handling. (\$30.00 for non-USA).

\* \* \* \* \*

### 4.4. Installation

#### 4.4.1. Unpacking and Setup

The 230A and 230AX are shipped in 3 cartons containing the microcontroller, the RF/power supply deck and power transformer. Upon opening each carton, carefully examine the contents of each for any visible damage. If the amplifier has been damaged in shipment, save the cartons and packing materials and notify the manufacturer and shipping company promptly.

To unpack the amplifier, use the following procedures. As the amplifier is unpacked, check the contents with the equipment list provided in Table 1. Should any parts be missing, notify the manufacturer immediately.

##### 4.4.1.1. RF/power supply deck.

The large carton contains the RF/power supply deck. Carefully tip the carton on its side and open the bottom flaps. Remove the foam blocks. Tip the carton back upright and slowly slide the carton off the unit. Remove remaining packing material.

Move the RF/power supply deck to a convenient location and referring to Figure 1, remove the top cover. Use the special screwdriver furnished.

Remove the packing material located in the upper RF compartment and press down on each tube firmly to insure it is seated in its socket.

Replace the top cover.

230 Series Linear Amplifier

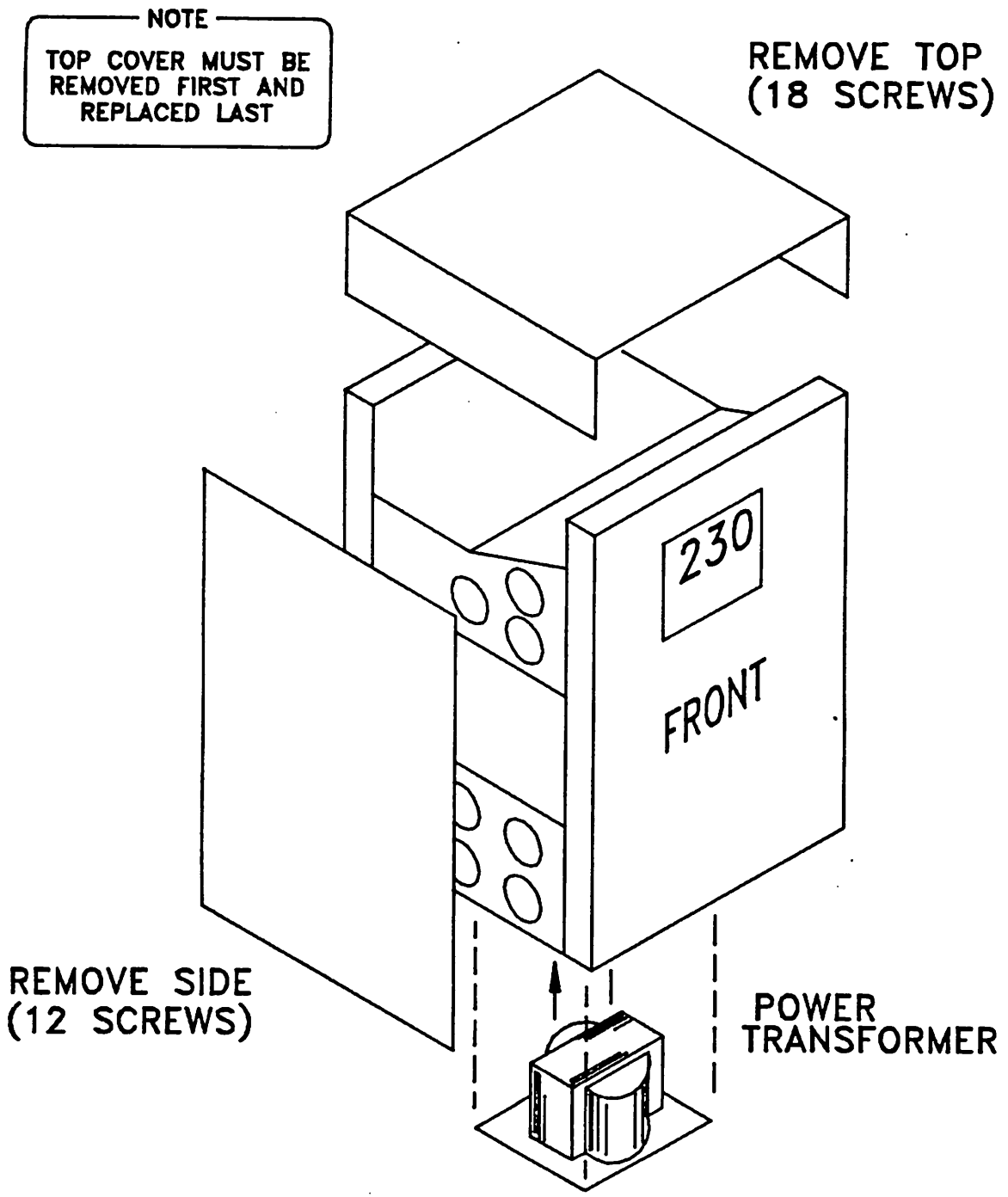


Figure 1. RF/Power Supply - covers removed

## 230 Series Linear Amplifier

**Table 1. Accessories Furnished with Amplifier**

NR.	CHECK	QTY	DESCRIPTION
1	( )	1	Microcontroller
2	( )	1	RF/power supply deck
3	( )	1	Spare .5 ampere fuse
4	( )	1	Spare 2 ampere fuse
5	( )	1	Spare 3 ampere fuse
6	( )	1	Cabinet screwdriver
7	( )	1	Instruction manual
8	( )	1	Warranty card
9	( )	2	Spare pilot lamp bulbs
10	( )	1	15-ft controller cable
11	( )	1	15-ft RG-58 cable
12	( )	2	6-ft RCA - RCA cable
13	( )	1	6-ft phone - RCA cable
14	( )	1	Power transformer

Items 1 is packaged in the small carton.  
 Items 3 through 12 are packaged with item 1 in this carton.

Item 2 is packaged in the large carton.

Item 14 is packaged in its own carton.

\*\*\*\*\*

### 4.4.1.2. Input Voltage Selection

Input voltage selection is made by mating the proper connectors near the base of the power transformer assembly. Therefore, input voltage selection should be made prior to installation of the power transformer.

Only the 230AX requires input voltage selection. (The 230A only operates on 230 VAC nominal and no selection is required).

The 230AX input voltage may be selected to 200 VAC, 220 VAC or 230 VAC nominal. THE AMPLIFIER IS SHIPPED FOR 230 VAC OPERATION. If operation on other than 230 VAC is desired perform the following step:

Plug the connector labeled "LINE" into the connector labeled "200", "220", or "230" as desired. The connector may be inserted only one way .. do not force it!

## 230 Series Linear Amplifier

### 4.4.1.3. Power Transformer Installation

1. Select desired input voltage (230AX only). See previous paragraph.

2. Carefully lay the RF/power supply deck on its top. Use a carpeted surface or some of the packing material to avoid scratching the top surface.

3. Remove the four (4) 1/4-inch bolts from the bottom of the deck. The correct bolts are identified by a red mark and are located near the large cutout into which the transformer will be placed.

4. Cut the tie-wrap holding the large connector just inside the cutout. Discard the tie-wrap. Place the transformer on the bottom of the deck near the cutout and mate this connector to the one on the transformer. The connectors are keyed and can be inserted in only one position.

5. Carefully lift the transformer (use the slots in the bottom plate of the transformer) and slide it into the cutout observing the arrow on the bottom of the plate. This arrow should point towards the arrow on the amplifier.

6. Align the transformer with the four mounting holes and re-install the four 1/4-inch bolts. Make sure these bolts are tightened securely.

7. Lift the RF/power supply deck into its normal upright position. Be careful, the assembly now weighs approximately 80 pounds.

### 4.4.1.4. Microcontroller.

The smaller lighter carton contains the microcontroller. Remove the microcontroller from the carton as well as the accessories packaged with it.

### 4.4.1.5. KEY OUT Configuration

The microcontroller is configured for positive Key Out as shipped. This is satisfactory for nearly all transceivers. Some older units, such as the Drake T4XB, may require negative Key Out for proper operation. If this is the case, follow the following steps to change Key Out configuration from positive to negative:

1. Remove the top cover of the microcontroller (4 screws).

2. Locate 3-pin connector marked "KEY" on the printed circuit board (near the rear panel). Move the slip-on jumper to the end of the of the connector marked "-".

3. Reinstall the top cover.

## 230 Series Linear Amplifier

### 4.4.2. Equipment Placement

Equipment placement is not critical but some considerations are necessary to assure proper ventilation and access to antennas, AC power and ground connections.

The RF/power supply deck should be placed in a clean dry place with both AC power and good earth ground available within 6-feet of the unit. If a basement installation is used it is recommended a dehumidifier be used in the vicinity of the unit to keep humidity to less than 70%. Do not place anything within 6-inches of the air intake areas of the unit and DO NOT BLOCK the exhaust slots in the top of the unit. It is recommended nothing be placed on the top of the unit. Try to place the RF/power supply deck as close as possible to the antenna to reduce RF cable losses.

The microcontroller can be placed anywhere near the operating position at eye level or lower (If placed too high, the LCD displays will be difficult to read). Placement of the unit should provide the operator a clear view of the front panel and associated indicators.

### 4.4.3. Input Voltage Considerations

The 230A amplifier is designed to operate from 230 VAC, nominal, 60Hz and the 230AX

from 200, 220 or 230 VAC, 50/60Hz. The AC power line must be capable of supplying 15 amperes, continuous. Therefore, the wiring of the power line should be at least #12 AWG copper.

Whenever power is connected to the amplifier, the yellow pilot light ("POWER") on the front of the RF/power supply deck is illuminated. NEVER apply power to the amplifier with the covers removed!

### WARNING

**\*\*\* THIS AMPLIFIER PRODUCES VOLTAGES THAT CAN KILL YOU \*\*\***

**\*\*\* LET ONLY QUALIFIED PEOPLE SERVICE THE UNIT \*\*\***

**\*\*\* NEVER BY-PASS ANY OF THE CABINET INTERLOCKS \*\*\***

### 4.4.4. Amplifier Interconnections

Figure 2 illustrates the interconnections necessary for proper operation of the amplifier. After placing the microcontroller and RF/power supply deck in their respective permanent operating positions, carefully observe the following interconnect setup instructions:

1. Connect the control cable between microcontroller and RF/power supply deck.

## 230 Series Linear Amplifier

2. Install the RG-58 cable between the exciter and the RF IN jack on the RF deck. This cable is supplied with a PL-259 connector for the exciter and a BNC connector for the amplifier.

3. Connect a GOOD EARTH GROUND to the RF/power supply deck. If a water pipe connection is used be sure that the ground connection bypasses the water meter.

4. Connect the antenna to the RF OUT jack on the RF/power supply deck. At this point you should hear normal signal strengths in your receiver.

5. Connect the supplied RCA-RCA cable between your exciter and ALC input on the microcontroller. This is optional.

6. Connect the supplied RCA-RCA relay control cable between your exciter and the PTT input on the microcontroller,

7. It is recommended that the microcontroller be grounded along with your other station equipment.

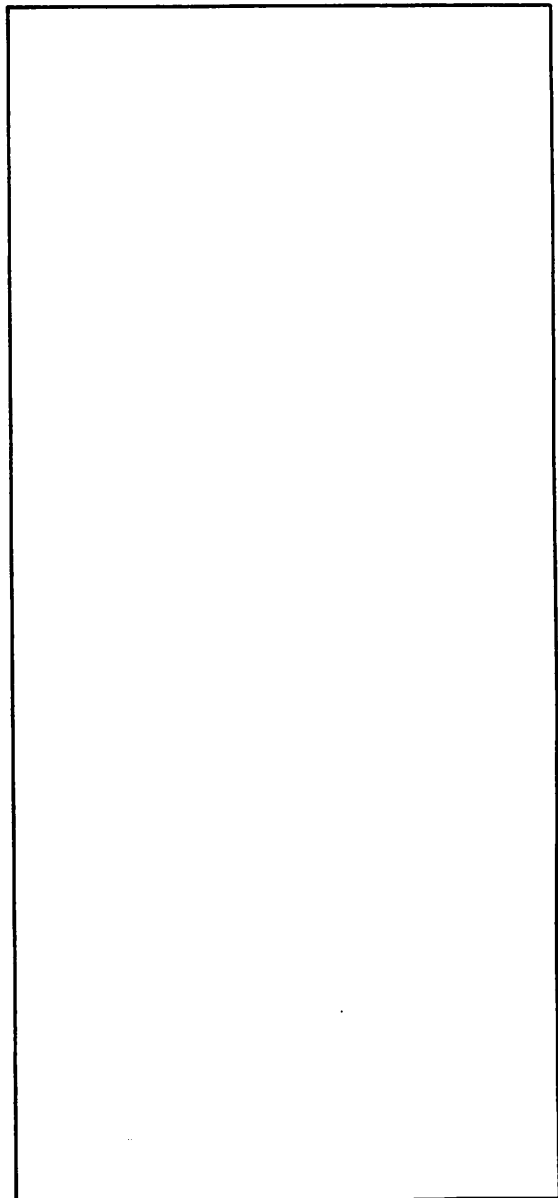
8. Plug the RF/power supply deck into the 230 VAC power source.

9. Turn on the main circuit breaker. The yellow light should immediately illuminate on the front of the RF/power supply deck. The RED LED in the POWER switch on the microcontroller should also be illuminated.

The amplifier is now ready to operate.

### NOTES

(Use this space for keeping notes on your specific installation)





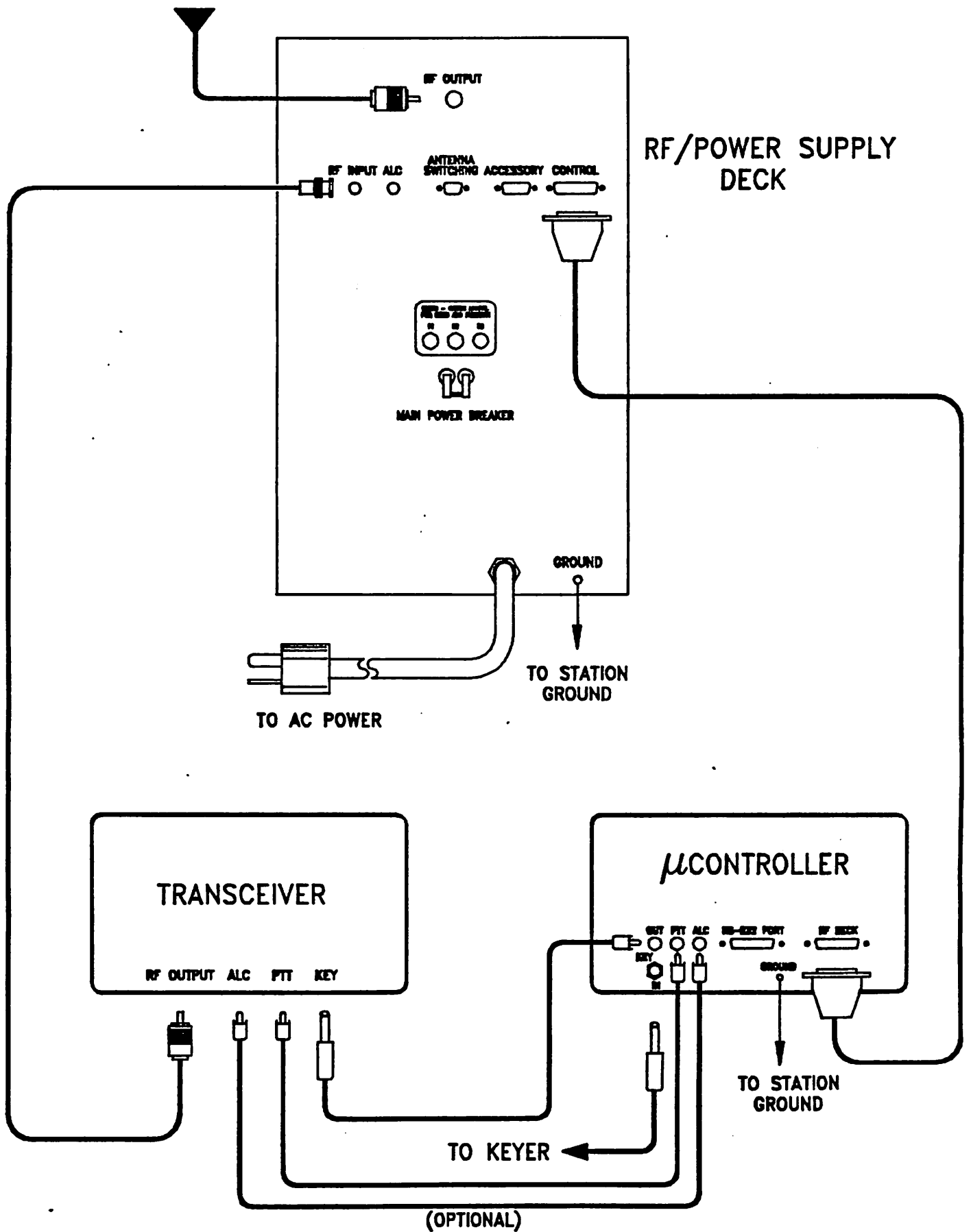


FIGURE 2. INTERCONNECTIONS

## 230 Series Linear Amplifier

### 5. Operating Instructions

#### 5.1. Introduction

This section covers the details of operating the amplifier. It is suggested you read the following paragraphs carefully in order to understand the features available and how to make the most of them.

For those who cannot bear the reading, there is a section following entitled "Quick Start". This will tell you how to get the amplifier on the air quickly.

#### 5.2. Controls and Indicators

Figures 3 and 4 are views of the front and rear of the microcontroller. Each control, switch, and connector is described in detail below.

##### 5.2.1. Microcontroller Controls and Indicators

(1) POWER. This switch controls the main relay in the RF/power supply deck. It will be illuminated when the main power breaker in the RF/power supply deck is closed indicating power is available for operation.

(2) STBY. This key switch, along with (3) and (4), controls the mode of operation. When STBY is depressed, all signals from the exciter are passed through the amplifier. The switch is illuminated when in STBY.

(3) OPER. This key switch, along with (2) and (4), controls the mode of operation. When OPER is depressed the amplifier is placed on-line and the switch illuminated. The STBY key switch is no longer illuminated.

(4) QSK. This key switch, along with (2) and (3), controls the mode of operation. When QSK is depressed the amplifier is set-up for full QSK operation for CW operation. This switch toggles QSK ON and OFF while in the OPER mode. When QSK is selected, it is indicated on LCD display legend area (16).

(5) & (6) FREQ UP & DOWN. These key switches are used to set the operating frequency of the amplifier. Only valid operating frequencies are displayed. The longer these key switches are held down, the faster the displayed frequency will slew.

The frequency selected is displayed in LCD display legend (20).

(7) REMOTE. This key switch is used to place the amplifier in the REMOTE mode of operation. When depressed, the LED within the switch will flash indicating REMOTE mode is active. All other panel key switches become inoperative. Control of the amplifier is now via an RS-232C port as described in paragraph 6.1.-

## 230 Series Linear Amplifier

7.12. Depressing REMOTE again will return the amplifier to normal (local) operation.

The LCD displays remain active in the REMOTE mode.

(8) & (9) MEMory UP & DOWN. These key switches are used to select a MEMory preset (1 through 20) as described in paragraph 5.3.5. The MEMory location selected, if any, is displayed on LCD legend (19).

(10) TUNE. This spring return to center switch is used to manually control the tune capacitor. This switch is only active if MANUAL tune is selected (See (13) below). The relative position of the tune capacitor is shown on LCD display legend (18).

(11) LOAD. This spring return to center switch is used to manually control the load capacitor. This switch is only active if MANUAL tune is selected (See (13) below). The relative position of the load capacitor is shown on LCD display legend (17).

(12) AUTO. This key switch places the amplifier in the AUTOMATIC mode of operation. When selected, the switch is illuminated. In this mode, automatic tuning is initiated by entering an operating frequency with the FREQ UP & DOWN keys; by selecting one of the 20 MEMory presets with the MEMory keys; or by talking or keying the amplifier through the exciter in which case ex-

citer frequency is determined by the processor and the amplifier quickly tuned accordingly.

Depressing this key a second time will cause the LED in this key switch to flash which indicates that the automatic tuning algorithm is not active. In this mode the fine tune algorithm is disabled but the amplifier will still tune according to its internal tables and interpolation algorithm.

(13) MANUAL. This key switch places the amplifier in the MANUAL mode of operation. When selected, the switch is illuminated. In this mode the TUNE (10) and LOAD (11) switches are active and the amplifier may be tuned manually. This mode is normally used to "customize" the tuning algorithm for the connected load (antenna's) or to enter settings into user memories.

(14) STORE. This key switch is used to save the desired MEMory presets. If the frequency displayed is a valid frequency for storage, the switch will be illuminated.

(15) - (20) These are the various legends within LCD display (21) and are described below:

(15) These legends are the various safety trips that can occur in order to protect the amplifier. If there are no trips or pre-trips in effect

## 230 Series Linear Amplifier

this area of the LCD is blanked out. If there is a pre-trip in effect, the appropriate legend will flash. If there is a trip in effect, the appropriate legend will be illuminated continuously.

(16) These legends show the operating state of the amplifier.

(17) This bargraph display shows the relative position of the load capacitor.

(18) This bargraph display shows the relative position of the tune capacitor.

(19) These two digits show the MEMORY preset in effect, if any.

(20) These digits show the operating frequency of the amplifier.

(21) This is one of the two custom LCD displays used to display all operating information.

(22) RESET. This keyswitch is depressed in order to reset a safety trip and place the amplifier back on-line. The switch will be illuminated to indicate a trip has occurred. This switch will not illuminate during a pre-trip condition.

(23) TRIP WARNING LED. This LED flashes when one of the various safety trip points is being approached. This allows the operator to take ap-

propriate action (such as reducing drive) to avoid being tripped off-line at an inconvenient moment. When a trip occurs, this LED will be on steady.

(24) This is one of the two custom LCD displays used to display various parameters.

(25) - (29) These are the various legends within LCD display (24) and are described below:

(25) This bargraph continuously displays output power (0 - 3000 watts PEP) except at initial turn-on when it becomes a 5-minute countdown timer.

(26) This scale (0-2500) is used in conjunction with bargraph (28) and is used for displaying plate voltage or current.

(27) This scale (0-100) is used in conjunction with bargraph (28) and is used for displaying grid current or reverse power (x5).

(28) This bargraph is used in conjunction with scales (26), (27), and (29) and meter switches (30) through (33) to display plate voltage or current, grid current, VSWR, or reverse power.

(29) This scale (1.0-5.0) is used in conjunction with bargraph (28) and is used for displaying VSWR.

## 230 Series Linear Amplifier

(30)-(33) MULTIMETER SELECT. These key switches are used to select the parameter displayed on the multimeter bargraph (28) in LCD display (24). The last key switch depressed will be illuminated and only the appropriate scale on the LCD display will be illuminated. These switches are electrically interlocked.

Toggling the SWR key switch will select SWR or reverse power for display. When reverse power is selected, the SWR key switch will flash and the 0-100 scale will be presented on the LCD. This scale is multiplied by 5 for the reverse power value.

(34) DIM. This switch is used to reduce the brightness of the panel LED's for ease of viewing in subdued lighting. When reduced brightness is selected, the two large LCD displays are back-lighted. This switch toggles brightness between normal and low.

### 5.2.2. Microcontroller Rear Panel Connectors.

(1) KEY OUT jack. This RCA jack is used to connect the amplifier to the exciter's key input.

(2) KEY IN jack. This 1/4-inch phono connector is used to connect a key or keyer to the amplifier.

(3) PTT jack. This RCA jack is used to control the amplifier on and off line. It is normally connected to a

"linear control relay" output on the exciter. (ground to transmit).

(4) ALC jack. This RCA jack is to connect an ALC control line between the exciter and amplifier if desired.

(5) GROUND. Connect to station ground !!

(6) RS-232 PORT. This connector is the control port for remote control via an external computer. It is a standard RS-232C interface.

(7) RF-DECK. This connector is used to interconnect the microcontroller and the RF/power supply deck.

### 5.2.3. RF/Power Supply Connectors

(1) RF OUTPUT. Amplifier out.

(2) RF INPUT. Exciter in.

(3) CONTROL. This connector is used to interconnect the RF/Power Supply deck to the microcontroller.

(4) ANTENNA SWITCHING. This connector is used for the control of antenna selection by band. See 5.5 for details.

(5) GROUND.

(6) ALC. Used to adjust the desired ALC threshold.

(7) ACCESSORY. For connection of accessories such as automatic antenna tuner, etc.

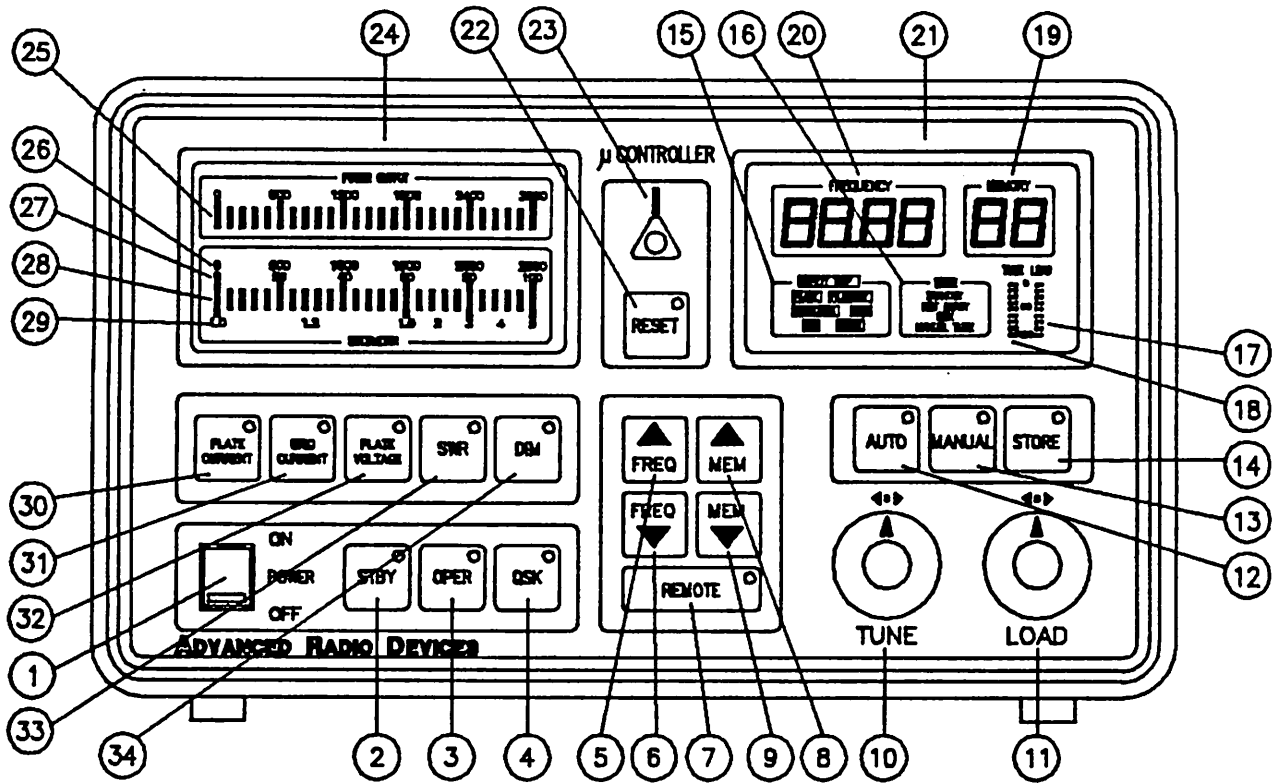


Figure 3. Front View - Microcontroller

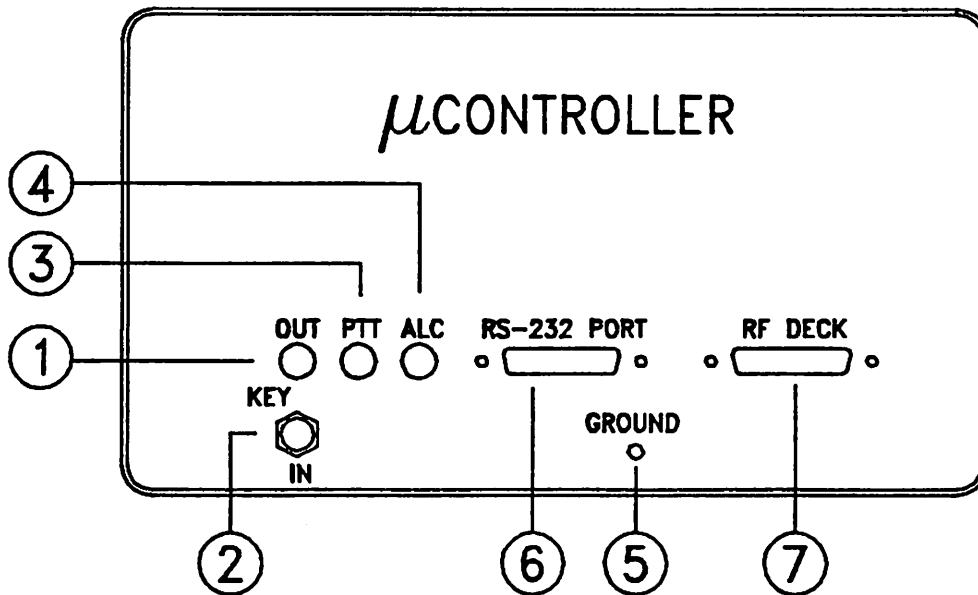


Figure 4. Rear View - Microcontroller

# 230 Series Linear Amplifier

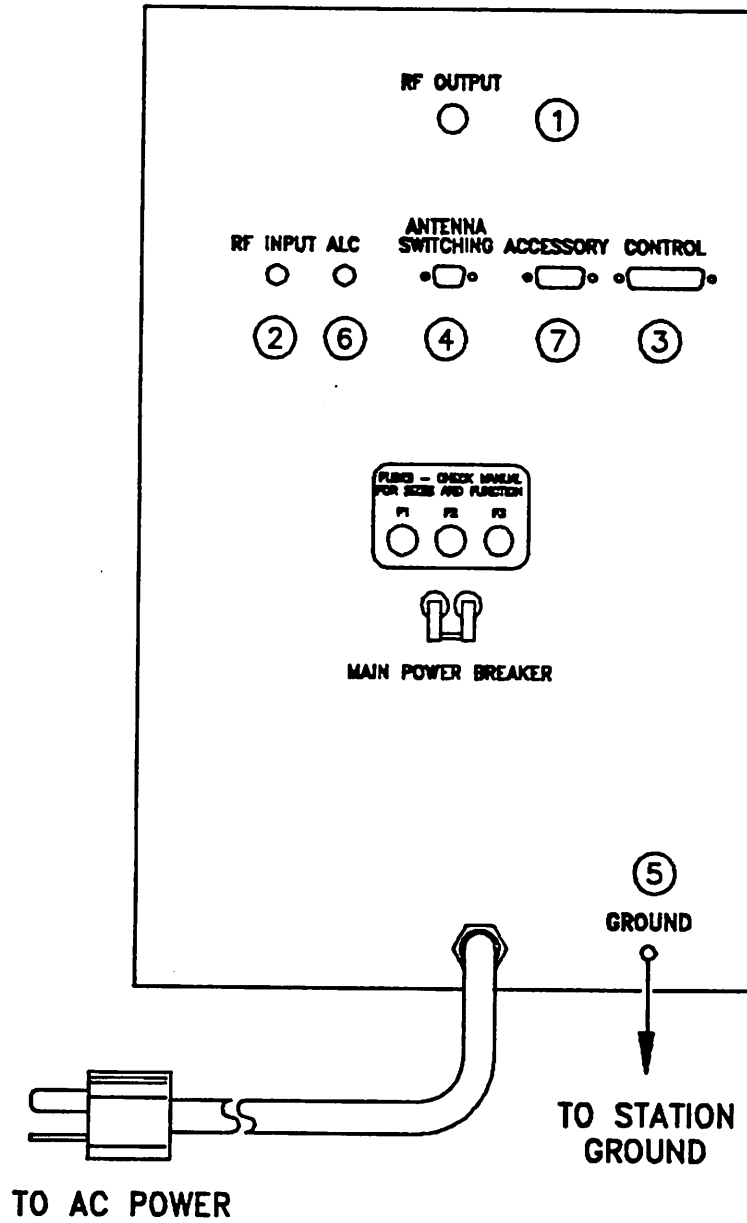


Figure 5. RF/Power Supply Deck - Rear View

## 230 Series Linear Amplifier

### 5.3. Procedures

#### 5.3.1. Quick Start

This section will explain how to get your amplifier on-the-air as quickly as possible. (But please read the manual later !!)

It is assumed that all interconnections have been made and checked. (It is suggested a dummy load be connected for this procedure).

1. Close the breaker on the RF/power supply deck. The "POWER" light should light and the small LED within the power switch on the microcontroller should light.

2. Turn the amplifier on with the POWER switch on the microcontroller. Observe that the blower is running inside the RF/power supply deck. It is normal to hear the tuning motors run for 1-2 seconds at initial turn-on.

3. The upper bargraph display labeled POWER OUTPUT should be full scale and slowly start to "count down". This is the 5-minute warm-up delay timer.

#### CAUTION

The 3CX800A7's require a full 5 minutes to warm-up to prevent cathode damage, according to their manufacturer. For your convenience, a feature has been included that allows for a 15-second restart delay in case of a short AC

power drop-out. DO NOT USE THIS FEATURE TO BYPASS THE WARM-UP TIMER FROM A "COLD" START !!

4. The following key switches should be illuminated: GRID CURRENT, STBY, AUTO.

5. The FREQUENCY display should indicate "14.20" and the MEMORY display should be blank.

6. The MODE area of the LCD display should indicate NOT READY and STANDBY.

7. After the 5-minute delay, the POWER OUTPUT bargraph should read zero, the MODE display should indicate STANDBY.

8. Key your exciter or talk into the microphone briefly and the FREQUENCY display should change to a value very near your exciter's frequency.

9. Select OPERate. The STANDBY indication in the LCD should extinguish.

10. Watch the GRID CURRENT and the POWER OUTPUT bargraphs while talking and adjusting your microphone gain or power output control for the desired power level. Keep grid current below 60 ma. (If you exceed 100 ma., the PRE-TRIP LED will begin to flash to warn you are approaching the grid current trip point (120 ma.)



## 230 Series Linear Amplifier

11. Change frequency and observe the frequency display. It should follow the exciter's frequency closely. You will hear motors tuning the plate and load capacitors as well as moving the bandswitch when required. (If you select a frequency which is not valid (outside the band), the amplifier will trip off-line and indicate a MISTUNED trip. The RESET key must be depressed to recover)

12. The NOT READY indication may briefly illuminate while the amplifier tunes to the new frequency.

### CAUTION

If you use a solid-state exciter, it is a good idea to switch the amplifier to STANDBY when switching bands since the exciter will briefly see a high SWR before the bandswitch occurs. Changing frequency within a band may be done in OPERate without a problem.

13. That's all there is to it in the AUTOMATIC mode. Connect your antenna and operate!

### NOTE 1

If you manually select a frequency, the frequency of the exciter is ignored for 5-seconds after the last change in frequency.

### NOTE 2

The frequency presets (see paragraph 5.3.4) are set for a 50-ohm load. If your antenna is not close to this value, the amplifier will not be properly tuned for maximum power. However, the tuning algorithm will tune the amplifier for maximum but it may take a few seconds. This delay will be eliminated when you "trim" the presets to your antenna (see 5.3.4).

### 5.3.2. Automatic Operation

This mode of operation is the most interesting. All tuning is accomplished by the amplifier. The frequency of the exciter is monitored to allow the amplifier to "follow" the exciter's frequency.

1. Select ON with POWER switch. If the amplifier has not been on, the POWER OUTPUT bargraph will count down the 5-minute warm-up delay.

2. If the LED within the AUTO keyswitch is not illuminated, depress the switch to select AUTO.

3. Keying the exciter or talking into the microphone briefly will cause the amplifier to automatically switch to the exciter's frequency.

## 230 Series Linear Amplifier

### NOTE

If you manually select a frequency, the frequency of the exciter is ignored for 5-seconds after the last change in frequency.

### CAUTION

If you are using a solid state exciter it is suggested you keep the linear in STBY if a band change is being made. The exciter sees a high SWR for a brief moment before the band change is made. After the band change has been made switch to OPER (or QSK). Frequency changes within a band are not a problem.

4. Select AUTO or QSK.

5. Observe grid current and power output to determine the amount of drive required. If the "!" LED begins to flash, reduce drive to prevent a trip on excessive grid or plate current.

6. You may elect to store the operating frequency in a memory. See paragraph 5.3.5.

7. Should a trip occur, note the type of trip on the LCD display, determine the cause, and depress the RESET key-switch to resume operation.

In the automatic mode, the amplifier will tune for maximum efficiency taking into consideration the load and power level. It is possible

therefore, to achieve a maximum efficiency at a lower than desired power level. If this occurs, and you then increase excitation, trips may occur before the amplifier has time to retune.

If this becomes bothersome, consider semi-automatic operation as described in the next paragraph.

### 5.3.3. Semi-Automatic Operation

This mode of operation is quite similar to the automatic mode described in the previous paragraph in that the frequency of the exciter is still monitored by the amplifier but the automatic tuning process is slightly different.

The fine tuning algorithm is not operational in this mode. The amplifier is tuned by using its internal tuning tables and interpolation process. This tuning process assumes a 50-ohm load and therefore tuning may not be optimal for your antenna(s). This may be corrected by trimming the tuning tables (presets) as described in paragraph 5.3.4.

The advantage of this mode is that the amplifier will always be tuned for maximum efficiency without the need for "finding it" first which in some cases may take a few seconds and/or if excitation

## 230 Series Linear Amplifier

is too high, unwanted trips may occur. See paragraph 5.7 for additional comments on this mode of operation.

1. Select ON with POWER switch. If the amplifier has not been on, the POWER OUTPUT bargraph will count down the 5-minute warm-up delay.

2. If the LED within the AUTO keyswitch is not illuminated, depress the switch TWICE to select semi-automatic (LED in the switch will flash) The AUTO keyswitch toggles between off, automatic, and semi-automatic.

3. Keying the exciter or talking into the microphone briefly will cause the amplifier to automatically switch to the exciter's frequency.

(Recall the NOTE and CAUTION from the previous paragraph)

4. Select AUTO or QSK.

5. Observe grid current and power output to determine the amount of drive required. If the "!" LED begins to flash, reduce drive to prevent a trip on excessive grid or plate current.

6. You may elect to store the operating frequency in a memory. See paragraph 5.3.6.

### 5.3.4. Manual Operation

Manual operation allows for changing frequency and tuning the amplifier from its front

panel. Manual is also used to store data in memory (See paragraph 5.3.5).

1. Select ON with POWER switch. If the amplifier has not been on, the POWER OUTPUT bargraph will count down the 5-minute warm-up delay.

2. Depress MANUAL keyswitch. MANUAL TUNE will be displayed in the LCD display.

3. Select a frequency with either the FREQ keys or the MEM keys. Holding a FREQ key down will cause the displayed frequency to slew faster.

4. Tune the amplifier with the TUNE and LOAD switches. These switches spring return to center and directly operate the motors that rotate the tune and load capacitors. The TUNE and LOAD scales on the LCD display show the relative positions of these capacitors.

Tuning should be accomplished by observing both grid and plate current. If you observe a pre-trip condition, reduce drive while continuing to tune.

Once tuned to a frequency you may elect to store this data into a memory position. See paragraph 5.3.5.

5. Select OPER or QSK as desired.

## 230 Series Linear Amplifier

### 5.3.5. Presets

In order to speed up the auto-tuning algorithm the amplifier makes use of a number of stored data points which consist of a frequency and positions of the tune and load capacitors for proper operation into a 50-ohm load. These data points are termed "presets".

The amplifier is delivered with presets approximately every 100 KHz over all the bands (3.50, 3.60, .. 7.00, 7.10, etc., etc.). These presets are used by the processor to determine starting points for the fine-tuning algorithm.

It is suggested that these presets be trimmed to your antennas. Although not necessary, this trimming will speed up the auto-tune feature of the amplifier. To trim a preset, simply select MANUAL operation, tune the amplifier at one of the preset frequencies (when a preset frequency is selected, the LED in the STORE key will be illuminated), and then save the new values by depressing the STORE keyswitch.

If your antenna(s) are close to 50-ohms, no trimming will be necessary. If you are happy with the output obtained at any given frequency, leave the presets as they were.

### 5.3.6. Memories

Twenty memory positions are available which can be used to recall a frequency and its tune parameters quickly.

The amplifier is delivered with all memories empty. When AUTO is selected, pressing MEM up or down keyswitches causes the next or previous non-empty MEM number and its associated frequency to be displayed on the LCD display. If all memory positions are empty, pressing a MEM keyswitch will result in an audible beep.

If a non-empty MEM is selected while in AUTO mode of operation for more than 1-second, the amplifier will tune to this memory position by changing the bandswitch and position of the tune and load capacitors as required.

You may store a frequency into memory as follows:

1. Select MANUAL mode of operation.
2. Select the frequency desired using the FREQ key switches.
3. Select a MEMORY location using the MEM keyswitches.

#### NOTE

As the memory locations are scrolled, the MEM number flashes and the frequency display blanks if that MEM is

## 230 Series Linear Amplifier

empty. Otherwise, you will see the MEM number and its associated frequency displayed.

If a MEM up or down keyswitch is not pressed after 2-seconds, the original frequency that the amplifier was tuned to returns to the LCD display.

4. If necessary, tune the amplifier with the TUNE and LOAD switches.

5. Press STORE. The new setting will be stored in the MEMORY position selected.

### 5.3.6.1. Clearing a Memory Location

1. Select MANUAL.

2. Select the memory to be cleared with the MEM up and down keyswitches.

3. Press the STORE key three times in quick succession. the MEMORY indication in the LCD display will blank and the memory will be cleared.

### 5.3.7. Remote Control

Remote control operation is available by depressing the REMOTE keyswitch. The LED within this keyswitch will flash indicating remote operation and all remaining key switches on the panel will be rendered inoperative. All control is via the RS-232C interface available at the rear of the microcontroller.

Normal operation is returned by depressing the REMOTE keyswitch again.

Refer to paragraph 6.1.7.12 for details of remote operation.

## 5.4. Protective Trips

### 5.4.1. Introduction

The 230 amplifier has a unique protection arrangement. Numerous parameters are monitored in order to protect the expensive 3CX800A7's. However trips can be a nuisance if they occur at an unwanted time but on the other hand, NOT tripping may cause damage.

A two-step trip arrangement has been incorporated into the design of the 230: PRE-TRIPS ("Soft trips") that will warn you of an impending trip but will keep you on the air and TRIPS ("Hard trips") that will immediately shut-down the amplifier to prevent damage.

In the event of a pre-trip, you can take corrective action before you are actually taken off the air.

Pre-trips are indicated by a flashing LED marked "!" on the microcontroller. The cause of the pre-trip is announced on the right side LCD indicator.

## 230 Series Linear Amplifier

Trips are indicated by the "!" LED illuminating steadily. The cause of the trip is announced on the right hand LCD indicator.

The various pre-trip and trip values for the monitored parameters are shown in Table 2.

### 5.4.2. Pre-Trips (SOFT)

Pre-trips are available in order to warn of a possible trip.

Pre-trips are indicated by the "!" LED flashing along with the appropriate indication flashing on the LCD display. A pre-trip can be caused by improper plate or grid current, excessive reverse power, low efficiency (mistuned), or high temperature.

If the monitored parameter returns to a value less than the pre-trip value, the LED and LCD indications disappear and operation continues.

A pre-trip on PLATE CURRENT or GRID CURRENT is an indication of an overdrive condition. Corrective action would be to reduce drive quickly (talk softly!)

A pre-trip on REVERSE POWER would indicate an antenna or antenna tuner problem. Make sure you have the correct antenna connected and/or the antenna tuner is correctly adjusted.

A MISTUNED pre-trip would indicate that the amplifier is improperly tuned in the manual mode of operation OR that a frequency has been selected that is not in an amateur band.

### 5.4.3. Trips (HARD)

A trip will occur when the monitored parameter approaches a value to possibly damage the 3CX800A7's.

Trips are indicated by the "!" LED illuminating steadily along with the appropriate indication in the LCD display. The amplifier is immediately biased off and the RESET switch LED illuminated. A trip can be caused by excessive plate or grid current, excessive reverse power, low efficiency (mistuned), temperature or filament voltage.

In order to return the amplifier to operation, it is necessary to depress the RESET key switch. If the trip condition has not been corrected, the amplifier will immediately trip again.

A trip on PLATE CURRENT or GRID CURRENT is an indication of a severe overdrive condition or improper amplifier loading.

A trip on REVERSE POWER would indicate an antenna or antenna tuner problem.

## 230 Series Linear Amplifier

A trip on EFFICIENCY would indicate that the amplifier is improperly tuned in the manual mode of operation or an improper frequency has been selected.

In the AUTOMATIC mode of operation, a trip on reverse power or mistuned condition under the following two conditions may not require the operator depress RESET to return the amplifier to operation:

1. If the amplifier was switched to the incorrect band based on the drive frequency and a reverse power trip occurs, the processor will make a second attempt at operation to give the bandswitch time to rotate.

2. If the amplifier's displayed frequency is at least .5Mhz away from the drive frequency and a mistuned trip occurs, the processor will make a second attempt at operation to give the amplifier time to tune.

### 5.5. Antenna Switching

Provisions are included for controlling external antenna switching relays from the rear of the RF/power supply deck via the ANTENNA SWITCHING connector. The connections for the 9-pin DB connector are shown below:

<u>PIN #</u>	<u>FUNCTION</u>
1	Band 1
2	Band 2
3	Band 3
4	Band 4
5	Band 5
6	Band 6
7	+28VDC
8	Ground
9	Ground

There are 6 band outputs, one of which is energized according to the following table:

<u>FREQUENCY</u>	<u>BAND</u>
1.75 - 2.0	1
3.1 - 4.3	2
5.8 - 8.0	3
13.4 - 15.1	4
18.5 - 25.0	5
24.8 - 25.0	6
28.0 - 30.0	6

The outputs, pins 1 through 6 are "pull-downs" which are capable of sinking 300 ma. 24 VDC is available at pin 7 and is fused by F3 at the rear of the RF/power supply deck.

Connect antenna relays between pins 1 and 7, 2 and 7, 3 and 7, etc. Make sure they are 24 VDC relays.

Since the outputs are pull-downs, relay's may be used with other than 24 VDC coils and an external power supply. Connect DC supply NEGATIVE to

## 230 Series Linear Amplifier

pin 8 or 9 and POSITIVE to one end of each relay coil. Return the coils to the appropriate band output pins 1 through 6.

### CAUTION

If an external supply is used, do NOT exceed 25 volts DC.

### 5.6. Problems

The 230 is a complicated piece of equipment and therefore it is quite possible that one of the operating details may be overlooked which can result in abnormal indications, tuning problems, etc. Table 3 lists some common problems and their cause. Refer to this table if you experience difficulty in operating your amplifier.

If you are having a problem also refer to the appropriate section(s) in the manual and make sure you understand the correct procedure(s) involved.

### 5.7. Operational Notes

1. All microcontroller switch settings are retained at power down and will be available the next time the amplifier is turned on. However, in order to increase EEPROM life, the amplifier does NOT retain the last frequency setting after power down. This should not be an inconvenience since the appropriate frequency setting will be returned at the first

moment excitation is applied. Prior to excitation, the frequency displayed will be that of MEMORY 1 or to the approximate center of the last band selected if no frequency is stored in MEMORY 1.

2. Selecting the Semi-Automatic mode of operation as described in paragraph 5.3.3. is useful in some instances. In this mode, (LED in the AUTO switch flashing), the internal tuning tables are still active and the amplifier monitors exciter frequency. Tuning is via presets as described in paragraph 5.3.5.

In a contest for example, with short transmission times on different frequencies, the fine-tuning algorithm will not have a change to "complete" with the result that output may not be maximized. The tuning presets will do a better job especially if you have adjusted them for your antenna(s).



## 230 Series Linear Amplifier

Table 2. Trip Value Summary

<u>PARAMETER</u>	<u>PRE-TRIP</u>	<u>TRIP</u>
Plate Current	>1.2 amp	>1.3 amp
Grid Current	>100 ma	>120 ma
Filament Volts	None	<12.8 v
Reverse Power	>400 watts	>500 watts
Mistuned (Plate dissipation)	>1400 watts	>1600 watts >1400 watts for 5-seconds
Temperature	None	>160 F

### NOTES:

1. The parameters are sampled and checked 30 times per second. The only exception is the dissipation calculation (Mistuned trip) which occurs approximately 8 times per second.
2. The Filament Current and Mistuned trips contain a .5-second delay to prevent spurious trips.
3. The Mistuned trip will occur within .5-second if dissipation exceeds 1600 watts. If dissipation remains between 1400-1600 watts for greater than 5-seconds, a trip will occur.
4. If the drive frequency is greater than 50 Khz from a valid amateur band (see table of allowed operating frequencies), the amplifier will trip off-line, MISTUNED. The RESET key must be depressed to recover.

## 230 Series Linear Amplifier

**Table 3. Troubleshooting Chart**

<u>SYMPTOM</u>	<u>CAUSE(S)</u>
1. Cannot tune in MANUAL	Antenna impedance not close enough to 50-ohms.  Improper tuning technique. See Appendix A.
2. LED does not light in POWER switch; amplifier does not power up.	Main breaker tripped or off. No AC power available.
3. No power output	5-minute time delay not completed.  Amplifier in hard-trip.
4. TUNE & LOAD switches do not operate.	MANUAL mode not selected.
5. Frequency does not change	5-second delay not completed Wait for 5-seconds before attempting to change frequency
6. Grid pre-trip or trip	Drive too high. Reduce drive.
7. None of the key-switches operate.	REMOTE operation selected.
8. LED in SWR keyswitch flashing.	This keyswitch toggles between VSWR and reverse power indication. When indicating reverse power, the keyswitch flashes.
9. Amplifier does not follow exciter frequency.	AUTO mode not selected.
10. Microcontroller powers-up but LCD's are blank.	One of the RF/power supply cabinet interlocks not engaged.

## 230 Series Linear Amplifier

### 6. Theory of Operation

#### 6.1. Functional Description

Refer to Figure 8 for a functional block diagram of the amplifier. The microcontroller provides all control and indication functions and communicates with the larger RF/power supply deck through a highly noise immune proprietary serial data bus. These two units may be separated by up to 250-feet.

The amplifier is designed around the EIMAC 3CX800A7 in a class AB2 grounded grid configuration in order to provide high efficiency, low distortion operation. The amplifier is rated at 1500 watts with no duty cycle restrictions.

The microcontroller continuously monitors the basic operating parameters of the amplifier and displays all pertinent information. It also provides the control necessary for monitoring the excitation signal to the amplifier and then to automatically tune the amplifier for maximum efficiency. The microcontroller consists of a display board and a CPU board both of which will be described in detail later in this section.

The RF/power supply deck consists of five major functional modules:

1. The POWER SUPPLY module, located at the bottom of the enclosure, provides all operating voltages for the amplifier including HV, filament, LV control, relay power, and a separate LV power supply for the digital circuits.

2. The AMPLIFIER module, located at the top of the enclosure, consists of an RF chassis which houses the input module, output module and the 3CX800A7 triodes, and a subassembly containing the plate tank components, drive motors, and related circuitry.

3. The INPUT module, mounted inside the RF chassis, contains the tuned input networks, an rf sampler, ALC detector, and a high speed input RF relay.

4. The OUTPUT module, mounted above the RF chassis, contains a high power vacuum relay, and a second broadband rf wattmeter used to measure output and reflected amplifier power.

5. The CONTROL INTERFACE module which consists of a pair of printed circuit boards located inside the RF chassis, and serve to interface to the microcontroller and provide all internal control signals for the amplifier. This module also contains circuitry for bias switching and high speed QSK operation.

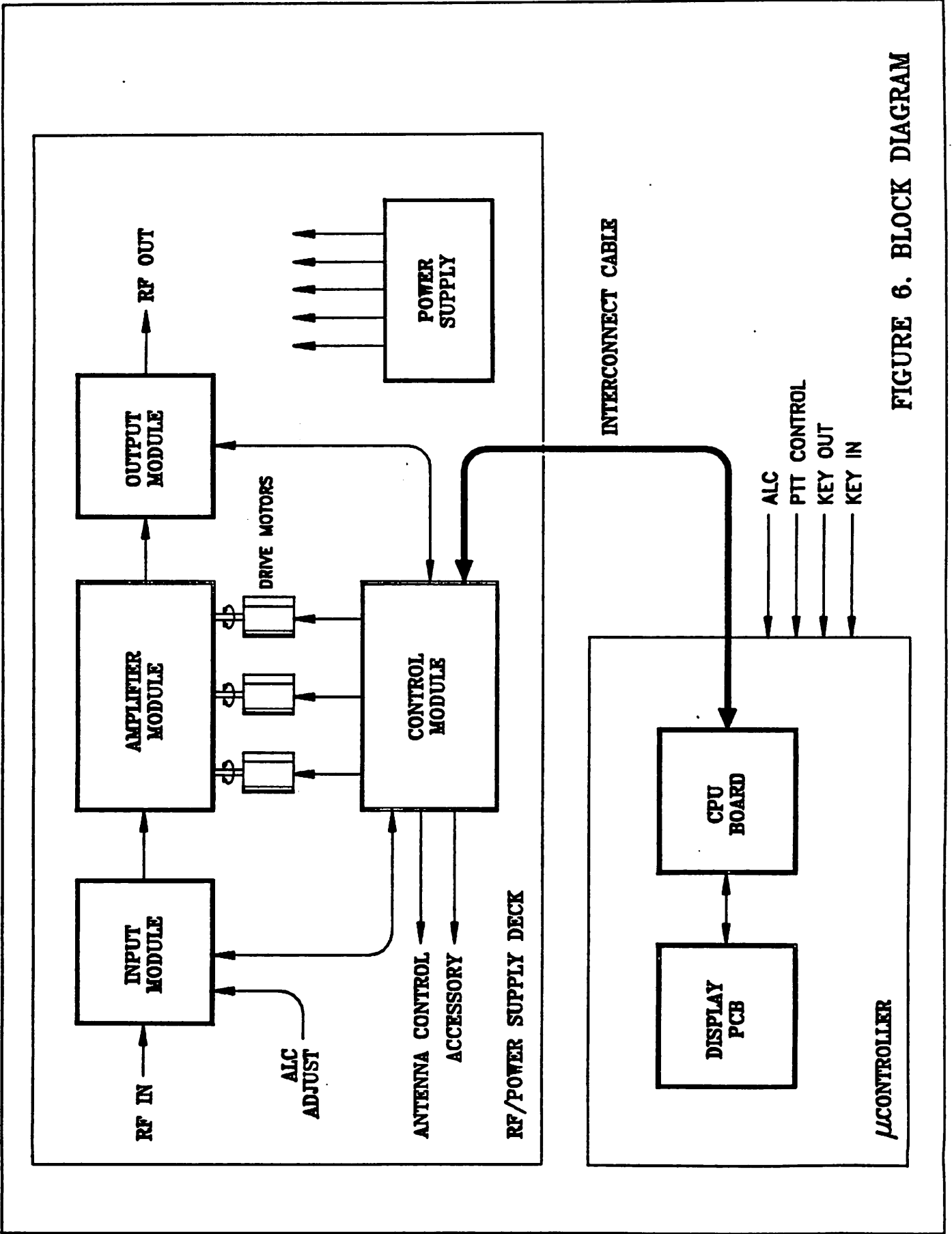


FIGURE 6. BLOCK DIAGRAM

## 230 Series Linear Amplifier

### 6.1.1. Power Supply Module

The power supply components are mounted on a heavy sub-plate located at the bottom of the enclosure. Refer to Schematic T7001 for a schematic of the power supply.

230 VAC (or 200VAC for the 230AX) line voltage is connected through main circuit breaker CB1, with a trip rating of 20 amperes. (Because of the high current demands of the amplifier in key-down applications, no provisions have been included for 120VAC operation). Relay 1M, when closed, connects primary power to plate transformer T1 through power resistor R102. Suppressor Z102 protects the diode bank from transient spikes on the power lines. The purpose of R102 is to limit inrush current of the filter capacitor bank. After plate voltage reaches 2000 volts, the microcontroller closes relay 2M which shorts R102 and allows full plate current to be drawn from the high voltage supply.

The secondary voltage of plate transformer T1 is bridge rectified by CR102-105 and filter by capacitors C103-110. Each of these capacitors is shunted by two 150Kohm resistors to equalize voltage drops across the capacitors and to bleed the capacitors after power is switched off. The high voltage output is nominally 2250 VDC at 1.2 amperes. The resistor network consisting of

R115-118 and zener diode CR108 is used to provide a low voltage for the high voltage measuring circuits. U100 and 101 serve as instrumentation amplifiers to provide inputs to the microcontroller circuitry.

The +18 volt supply, used for powering the control circuits in the microcontroller, consists of transformer T3, bridge rectifier CR100, and filter capacitor C100. This voltage is regulated down to +5 volts within the microcontroller. This power supply is protected by fuse F1 and transient suppresser Z100, and is energized whenever the main circuit breaker is closed.

A second low voltage supply provides +28 volts for relays and tube cut-off bias and +17 volts for control circuitry and is energized only when power relay 1M is closed. This supply consists of transformer T2, bridge rectifier CR101, and capacitors C101 and C102. The 28 volt output to the antenna switching connector is protected by fuse F3. A second winding on T2 provides filament voltage for the 3CX800A7 triodes, with series resistor R100 used for monitoring filament voltage. Interlocks S1, S2, and S3 prevent relay 1M from closing whenever the cabinet top or sides are removed and hence no high voltages may be produced.

## 230 Series Linear Amplifier

The power light LT1 is energized whenever breaker CB1 is closed to indicate power is available for operation. Light LT2, "Power" is energized whenever relay 1M is energized to indicate the amplifier is operational.

The majority of small components are mounted on a printed circuit assembly for ease of maintenance.

### 6.1.2. Amplifier Module

The amplifier module consists of an RF chassis and output network base plate assembly located in the upper part of the enclosure. The RF chassis contains the 3CX800A7's and houses the printed circuit boards comprising the interface module described below. The base plate assembly contains the bandswitch, output tank coils, drive motors, and associated components. Drawing T7002 is the amplifier schematic.

RF drive power is applied through the input module to the cathode of parallel connected triodes V1 and V2 via C12. These tubes are connected in a standard grounded grid configuration with the RF voltage at the cathodes of V1 and V2 isolated from the bias circuitry by cathode choke L3.

High voltage is applied to the anodes of V1 and V2 through plate chokes L3 and L4. Choke L4 is intended to suppress VHF

frequencies along with parasitic suppressers Z1 and Z2. Power resistor R1 limits the peak current to a level that will not damage the tubes, should a flashover in the plate circuit occur.

RF currents in the plate circuit are coupled by blocking capacitors C5-7 to the plate tank circuit. The tank circuit is configured as a Pi-L network, with an input impedance of 2000 ohms, an output impedance of 50 ohms, and a nominal loaded Q of seven. The tank circuit components consist of tuning capacitor C1, plate inductor L1, loading capacitor C2, and L-network inductor L2. In addition, fixed capacitors C8, 13, 16 - 19 are added to C1 and C2 on the lower frequency bands, where additional capacitance is required to achieve resonance.

Band switch S1 is a custom Radio Switch type 86 to ensure long life at the high RF currents encountered at the high power levels of the amplifier.

A safety high voltage interlock is provided at the plate choke L4 to short the high voltage if the top cover is removed.

Drive motors are coupled to the bandswitch, tuning capacitor, and loading capacitor and are mounted to the lower side of the base plate assembly along with the blower.

## 230 Series Linear Amplifier

### 6.1.3. Input Module

Drawing T7003 is the schematic for the input module. This module is located within the RF chassis near the base of amplifier tubes V1 and V2.

It consists of relay actuated input networks for each of the frequency bands of the amplifier, an input RF relay, an RF wattmeter, and an RF sensing circuit for driving a frequency counter located on one of the Interface module circuit cards to be described later.

RF drive is applied at the input BNC connector J16 and coupled to the input network switching relays.

Relay RL107 is a high speed keying relay which is used to bypass the amplifier circuitry when the amplifier is offline. When online, RL107 couples the exciter RF to the appropriate input network which is selected by the microcontroller. Each input network consists of a relay and a pi-network. These networks are designed with an input impedance of 50 ohms and an output impedance of 27 ohms which is the nominal cathode input impedance of the amplifier tubes in full power operation. The loaded Q of each network is nominally one. An expansion connector is used for adding additional input networks should they be desired.

The RF sensing circuit consists of Q100-Q102, inverter U101, and associated circuitry. RF voltage is coupled through C104 to the gate of JFET Q102. Q102, connected as a source follower, buffers the RF signal. CR101 and 102 limit voltage to Q100 to a safe value. R102 prevents these diodes from loading the input. The output of Q100 is amplified by Q101 and 102 and applied to U101 which generates a square wave equal to the excitation signal frequency. This output is coupled to the microcontroller inputs circuits for use in the automatic mode of operation.

RF voltage is sampled by voltage divider C111 and C113 and applied to diode CR106 and associated components to provide a DC signal which is used as an ALC control voltage. The ALC voltage level is adjustable by R112 which is available at the rear of the cabinet.

### 6.1.4. Output Module

Drawing T7005 is the schematic of the output module. This module is located at the top of RF chassis near the RF out connector.

It consists of a high speed, high power vacuum relay and a broadband RF wattmeter. The outputs of the wattmeter are used by the microcontroller to provide power output indication and protective trip signals. The microcontroller

## 230 Series Linear Amplifier

also uses these outputs to calculate VSWR for display, if desired. Outputs from this wattmeter and the wattmeter located on the input module are used by the microcontroller to calculate amplifier efficiency for use by the automatic tuning algorithm.

R102 and 103 are used to calibrate the wattmeter and C102 and 103 are used for balance adjustment. L100 prevents high voltage from appearing at the output in the event of a plate blocking capacitor failure.

### 6.1.5. Control Module

The control module consists of three printed circuit boards located inside the RF chassis in a completely shielded compartment. Two of boards (the I/O board and the Driver board) are used to provide communications to and from the microcontroller and various A/D conversion functions. The third printed circuit board is piggy-backed to the Driver board and provides a frequency counter function.

The major functions of this module are bias control, QSK and PTT control, communications control with the microcontroller, frequency counter, and motor drive circuitry.

Drawing T7600 is the schematic for the I/O board containing bias control, QSK circuits,

and A/D conversion for various parameters within the amplifier. Drawing T7610 is the schematic for the Driver board containing motor control, PTT and keying control, and low voltage power supplies. Drawing T7620 is the schematic for the frequency counter.

Portions of the I/O and Driver boards are not included due to the proprietary nature of the bus structure used to communicate with the microcontroller.

All inputs and outputs to these boards are isolated by ferrite chokes and monolithic bypass capacitors to ensure high RF immunity. To further enhance RF immunity these boards utilize their own isolated +5 and +12 volt power supplies.

The following paragraphs describe the function of these boards in detail.

#### 6.1.5.1. I/O Board

##### 1. QSK and bias control.

This circuitry is located on one of the control module boards. Refer to drawing T7600.

The bias voltage for the cathodes of the 3CX800A7's is controlled by bias switching transistor Q306. This transistor can be driven into saturation by a positive output at inverter U301, which is controlled by the QSK circuit.



## 230 Series Linear Amplifier

The bias clamp input BM26, in conjunction with Q307, provides a mechanism for inhibiting this control voltage in the event the micro-controller detects any out of range operating parameters. When Q306 is in the off state, +28 volts is applied through R317 to the cathodes of V1 and V2. This voltage serves to bias the tubes to cutoff.

When Q307 is switched on, the anode of zener CR300 is clamped to ground via R322. In this state, the +28 volt supply, in conjunction with R317, provides approximately 4 ma of quiescent bias current for CR300. This current is sufficient to fix the voltage at the cathode of V1 and V2 at approximately 8.2 volts, which is appropriate for class AB2 operation. The resting plate current of V1 and V2 under this condition is about 70 ma. When RF drive is applied to V1 and V2, the DC grid current, maximum of 70 ma, flows through CR300, Q306, and R322. The voltage developed across R322 is utilized by the micro-controller to calculate grid current. Resistor R325 provides isolation between R322 and the measuring circuit.

The QSK circuit ensures that the amplifier is brought on-line in the proper sequence by closing the output relay, bias switch, and input relay appropriately. The QSK circuit also protects the relay from damage due to "hot switching".

Q302 and bias resistors R301, 302 and 308 comprise a constant current source of approximately 1.6 ma. Ignoring Q304 and 305 for the moment, the main function of this current source is to charge capacitor C303 at a linear rate of 1.6mv/msec until it reaches 5.7 volts. It takes 3msec for the voltage across V1 to stabilize, at which point Q302 is driven into saturation.

The rising voltage across C303 is sensed by U302, a bargraph generator, which sequentially grounds LED outputs L1-10. Three of these outputs L1, 2, and 10 sequentially turn on, via inverters U301b, c, and d, the switching transistors Q301, 303 and 306 which control the output relay, the input relay, and the amplifier bias respectively. By adjusting the ramp time constant and the choice of outputs L1-10, the sequencing circuit can compensate for the settling time of the relay contacts to insure the proper sequence.

U300a and Q304 are used to turn on the ramp circuit when the key is depressed or, alternately, when the PTT line is closed. When the key line is open, R320 and R321 force Q304 into saturation (provided the control input of U300a is high), diverting the current sourced by Q302 away from C303 and clamping the voltage across C303 to near zero. When the key line is closed,

## 230 Series Linear Amplifier

Q304 is switched off, allowing the ramp to begin and the relay to sequence closed.

The L10 output of U302 is used to indicate whether the amplifier is in the ON state (relay sequencing completed) or OFF state (relays open or sequencing not completed), the latter condition indicated by a high on pin 10 of U302. This output serves three functions: (1) It controls the lockout circuit, which keeps the amplifier offline if RF is sensed before the relay sequencing is completed, (2) It controls the lockon circuit, which keeps the amplifier online if RF is present; and (3) it controls the KEY OUT line, insuring that the keyed output to the exciter cannot be closed until the amplifier is ready to receive RF. This last function precludes the possibility of a race between the amplifier relay contacts and the keying circuits of the exciter. The details of these functions follow.

The lockout circuit consists of U300b and Q305. If the amplifier sequence is not yet completed AND RF is sensed on the RF sense line, then U300b receives a high at both inputs. The resulting high output of U300b turns on Q305, clamping the voltage at the signal input to U302 to zero and thus locking the amplifier offline.

The lockon circuit consists of U300a, c, U301a, and f. If the amplifier is online AND RF is present, then U300c receives a high at both inputs which results in switching Q304 off, thus keeping C303 charged and locking the amplifier online irrespective of whether the key is open or closed.

The KEY OUT circuit consists of U301e, U300d, and Q307. When the key is closed, the input to inverter U301a is low resulting in a high at the input of U300d. If the amplifier is online when this occurs, then the control input of U300d is high and the output keying transistor Q307 is switched on. If the amplifier is offline when the key is closed, then U300d will delay the switching of Q307 until the amplifier comes online.

### 2. A/D Conversion

Multiplexing A/D converter U207 provides digital outputs from a number of inputs.

Grid current, plate current, power output forward and reverse are monitored via U202, a four section operational amplifier. Power input forward and reverse are monitored via U203. The outputs of these amplifiers are applied to the multiplexed inputs of A/D converters U207 and U210.

## 230 Series Linear Amplifier

U206 and associated components provide the voltage reference for the A/D converters. U203 is a buffer for this reference voltage.

Other inputs to the A/D converters include plate voltage, plate current, and motor feedback potentiometer voltages. These inputs are via U203 and are multiplexed on the driver board (see paragraph 6.1.5.2).

### 6.1.5.2. Driver Board

#### 1. Motor Control

The motor drivers for the three control motors are identical (tune and load capacitors and bandswitch). All three utilize a full bridge motor driver IC. The circuit receives control information from U106 and 108. Each motor is controlled by three lines which select on/off, hi/low speed, and direction. Low speed operation is provided by gating the motor on/off signal with a low duty cycle square wave using U100 and 102.

The motor driver which drives the bandswitch has an additional gating signal which prevents motor energization while operating bias is applied to the tubes. This prevents the possibility of moving the bandswitch with RF present.

#### 2. PTT and Keying Control

The PTT (push-to-talk) and keying control circuit consists of U106, U200, U201, and Q200. Outputs from U106 select the mode of operation: standby, operate, or QSK. In standby only signal line STBCTL is active and the amplifier cannot be keyed. However, the key input signal is routed directly to the key out jack through U201.

In operate, both signal lines KEYCTL and PTTCTL are active which allows either the PTT input or the key input to key the amplifier.

In QSK only signal line KEYCTL is active which allows key input control only for full break-in QSK operation.

Antenna relay control is provided by U103 whose outputs are open collectors which ground the output corresponding to the current bandswitch position. Relays up to 28VDC and 250 ma. may be driven by these outputs.

This board also includes an analog multiplexer, U104, to select between plate current, plate voltage, and capacitor position feedback potentiometers.

## 230 Series Linear Amplifier

### 3. Power Supplies

This board contains regulators for local generation of +5 and +12 volt power for the circuitry within the Interface Module.

U202 is a 12 volt regulator and U203 a 5 volt regulator.

#### 6.1.5.3. Frequency counter

This board, which is connected to the I/O board, provides a digital output based on a sampling of the excitation signal.

This output is used by the microprocessor's fine tuning algorithm (see paragraph 6.1.5.3).

The circuit consists of 4 elements; a time base comprised of U102 and Y1; control circuit U100 and 101; counters U103, 105, 106, 108, and 109; and output registers U104 and 107.

#### 6.1.6. Microcontroller

The microcontroller is housed in a small enclosure that contains all operating controls and indicators. It consists of two printed circuit boards.

A CPU board which is located inside a completely shielded enclosure within the unit for high RF immunity and a Display board which contains all display electronics including the custom LCD's and indicating LED's.

#### 6.1.6.1. CPU Board

The CPU board consists of the processor and input/output buffers. The processor is a Z80 (U111) running at approximately 2.5Mhz with 32K ROM (U109), 4K RAM (U110), and 2K EEPROM (U108).

The primary I/O is through U104, a dual serial receiver transmitter which provides communications through a RS-232 style port buffered by U114 to the I/O board in the RF/power supply deck.

Additional outputs are provided by U106 and 107 which drive the display board. These chips buffer and latch data bus information so that communications to the display board can be accomplished at low speeds. Keyboard input is provided by U201 which scans the multiplexed front panel keyswitches. The tune and load switches are read through U104.

The CPU board also provides several auxiliary functions:

U202, 203, 204, and 101 provide control for the communications to the RF/power supply deck.

Q200 and 201 provide a tone for key and alarm beeps.

U200 provides on-board 5 VDC regulation for CPU logic.

## 230 Series Linear Amplifier

U100 provide for early power loss detection so that current operating parameters may be stored in EEPROM before power is lost.

U102 and 103 provide 150Hz interrupts for the CPU.

U100 and Q100 provide power loss reset control.

### 6.1.6.2. Display Board

The major portion of this board is comprised of the two custom LCD displays and their drivers, U101 and 102. These surface mounted driver chips are completely self-contained, generating all voltages and waveforms necessary to drive the 3-way multiplexed LCD displays along with memory to store the segment on/off states for each segment of the LCD. These drivers are controlled by the CPU through the low speed data bus which is buffered on the CPU board.

INV1 is a high voltage inverter for powering the back lighting for the LCD displays.

U104 and 105 are latches to hold the state of front panel LED's.

### 6.1.7. Software Description

#### 6.1.7.1. General Description

This section is essentially the "software functional specification" for the amplifier. It describes, from a

software perspective, all the operating and control functions of the amplifier.

The software monitors all amplifier parameters and keeps the operator constantly informed via LCD and LED displays as well as providing automatic protective action in the event parameters exceed recommended values. The software also provides both automatic or manual operation.

The operator may store 20 frequency, tune, and load settings for future recall or may simply provide an excitation signal in which case fine-tuning logic will optimize amplifier gain dynamically.

#### 6.1.7.2. Protection Logic

The software constantly monitors operating parameters looking for PRE-TRIP and/or TRIP conditions.

Parameters monitored include plate current, filament voltage, plate dissipation (see "\*" below), grid current, air-flow, and reflected power.

If a parameter is detected exceeding a pre-trip value, it is considered a SOFT-TRIP and the following occurs: TRIP LED ("!") blinks, SAFETY TRIP lights up in the LCD display, TRIP type blinks in the LCD display, and the amplifier

## 230 Series Linear Amplifier

bias circuit is enabled. (viz., no effect on normal amplifier operation).

If the value returns to lower than its pre-trip value, the LCD and LED warnings disappear and operation continues. If the value exceeds the trip value, it is considered a HARD TRIP and the following occurs: Trip LED ("!") lights solid, SAFETY TRIP lights up the the LCD display, TRIP type lights in the LCD display, NOT READY indication lights in the LCD display, LED is the RESET key lights, and the amplifier is biased off (viz., normal amplifier operation is terminated).

The amplifier remains biased off on a HARD TRIP until the user presses the RESET key. At that point, all warnings are extinguished, the amplifier is biased back on and operation resumes. If the cause of the trip has not been corrected, the amplifier will again trip immediately.

However, there are two exceptions to the requirement that the RESET key be pressed to recover from a hard trip: Hard reverse power trip and hard mistuned trip.

In the AUTOMATIC mode the amplifier attempts to recover from these two HARD TRIPS. The requirements for a recovery attempt from the HARD reverse power trip are: drive power sufficiently high at the time of trip and amplifier was

in the wrong band based on drive frequency. The requirements for a recovery attempt from the HARD mistuned trip are: drive power sufficiently high at time of trip, amplifier tune and load capacitors have reached their "table settings", and displayed frequency is at least .5Mhz away from drive frequency.

In these cases, the following occurs immediately after the trip is detected: The amplifier is biased off, amplifier is retuned to the drive frequency, and then biased back on again.

\*\*\* If the drive frequency is not in a valid amateur band, the amplifier will trip off-line, MISTUNED. The RESET key must be depressed to recover.

### 6.1.7.3. Manual Mode

The MANUAL mode is selected by pressing the MANUAL key. The LED in the MANUAL key as well as the MANUAL TUNE legend on the LCD display are lighted. In both MANUAL and AUTOMATIC modes, the bandswitch, band relays, and antenna relays are set by the software based on the selected frequency. This frequency is displayed on the LCD display. In MANUAL, the only way for the user to change the selected frequency is by using the FREQUENCY UP and DOWN keys. The frequency of the excitation signal is ignored in the MANUAL mode.

## 230 Series Linear Amplifier

In MANUAL, the TUNE and LOAD capacitors are controlled by the front panel TUNE and LOAD knobs. The software looks at the positions of these knobs and controls the motors appropriately. See section 6.1.7.7.

The MEMORY keys work differently in MANUAL and AUTOMATIC. The differences are explained in section 6.1.7.6.

### 6.1.7.4. Automatic Mode

The amplifier is placed in AUTOMATIC by depressing the AUTO key. When in AUTO, the LED in the AUTO key is lighted and MANUAL TUNE in the LCD is extinguished. In AUTOMATIC, as in MANUAL, the software controls bandswitch and band relays based on the displayed frequency. In the AUTOMATIC mode, the software performs 4 additional functions:

1. Monitors the frequency of the drive signal when sufficiently high and updates the displayed frequency accordingly. This allows the amplifier to "follow" the exciter's frequency. Whenever the user changes exciter frequency, the amplifier will immediately adjust the bandswitch, band relays, and TUNE and LOAD capacitors based on table settings and then enable the fine tuning algorithm.

2. Positions the TUNE and LOAD capacitors automatically based on displayed frequency.

There are two methods used by the software to determine the appropriate positions of these capacitors:

- (a) If the displayed frequency is NOT one of the 20 stored in user memories, it uses an internal table (PRESETS) to determine the values. Linear interpolation is used if the exact frequency is not in the table. These PRESET TABLES can be changed by the user. See also section 6.1.7.5.

- (b) If the displayed frequency is one of the 20 user memories, the TUNE and LOAD capacitors are positioned from values in the user memory tables.

3. Lets the user change displayed frequency by using the MEMORY keys. See section 6.1.7.6.

4. Uses a fine-tune algorithm to adjust TUNE and LOAD capacitors to optimize amplifier gain. Once the bandswitch, band relays, TUNE and LOAD capacitors have been positioned, the NOT READY indication in the LCD is extinguished. The amplifier is now operational. At this moment, the fine-tune algorithm is initiated. The fine-tune algorithm is disabled during a HARD TRIP.

The AUTOMATIC TUNING of the amplifier proceeds in the following manner:

## 230 Series Linear Amplifier

1. The user selects a frequency via the MEMORY or FREQ keys or by changing the frequency of the exciter.

2. If the frequency requires a different band setting, NOT READY indication is given in the LCD, the amplifier is biased OFF, and the bandswitch starts to move. If the frequency does not require a band change, the amplifier remains biased on.

3. Movement of the TUNE and LOAD capacitors is delayed until the user has stayed off the FREQ and/or MEM keys for two seconds.

4. The TUNE and LOAD capacitor positions are looked up in tables (in user memory tables, if applicable). These values are referred to as TABLE positions.

5. TUNE and LOAD capacitor motors are started to move the capacitors to the TABLE positions. NOT READY indication is given until the capacitors reach their TABLE positions.

6. The NOT READY indication is extinguished.

7. The amplifier is biased ON if it was off.

8. The fine-tune algorithm is initiated.

9. The frequency of the exciter is ignored for 5-seconds prior to the start of fine tuning.

10. This series of events repeats from 1. above.

The FINE-TUNE algorithm is proprietary in nature and is therefore not discussed in detail herein.

### 6.1.7.5. Presets

PRESETS are tables in PROM and EEPROM which relate frequencies to default TUNE and LOAD settings. They are used only when the amplifier is in AUTO. The displayed frequency is looked up in the PRESET table. If found, the corresponding values of TUNE and LOAD are used. If not found, linear interpolation is used to derive approximate values.

The PRESETS are initialized at the time of manufacture but may be changed by the user. An appendix to this section contains these values.

The following steps are followed to change a PRESET:

1. Press MANUAL.

2. Press FREQ up or down until the desired frequency appears on the LCD display (The LED in the STORE key will light).

3. Use the TUNE and LOAD knobs to adjust as desired.



## 230 Series Linear Amplifier

### 4. Press STORE.

MANUAL is selected in order to set, change, or clear a MEM location.

### 6.1.7.6. User Memories

The amplifier contains 20 user memories (MEMS), numbered 1 through 20 in which the user may store a frequency and corresponding TUNE and LOAD settings for fast access. All the MEMS are empty when the amplifier is delivered. These tables are referenced in both AUTO and MANUAL modes but in quite different ways:

#### AUTOMATIC MODE:

Pressing MEM up or down causes the next or previous non-empty MEM number and its associated frequency to appear in the LCD display. If all the MEMS are empty, pressing the MEM key will result in an audible "beep".

If a frequency is reached which requires a bandswitch change, the bandswitch will start to move immediately. If the MEM keys are not depressed for two-seconds, both TUNE and LOAD capacitors will move to their values stored in the MEM selected. When both the bandswitch and the TUNE and LOAD capacitors get to their respective locations, the NOT READY indication will extinguish and the amplifier is operational and fine tuning begins.

#### MANUAL MODE:

The following procedure is used to set or change a MEM location:

1. Depress the MANUAL key.
2. Use the FREQ up/down keys until the desired frequency is displayed on the LCD.
3. Use the MEM up/down keys until the desired MEM location is displayed on the LCD.

NOTE: As the MEM location are scrolled, the MEM number blinks and the frequency display blanks if that MEM is empty. Otherwise, you will see the MEM number and its associated frequency displayed. The TUNE and LOAD settings are also displayed on the TUNE and LOAD bargraphs on the LCD.

4. After not pressing a MEM up/down key for 2-seconds, the original frequency that the amplifier was tuned to returns to the LCD display as well as the current positions of the TUNE and LOAD capacitors.
5. Tune the amplifier using the TUNE and LOAD switches.
6. Press STORE. The new setting will be stored in the MEM selected.

To clear a MEM, select MANUAL mode, use MEM up/down keys to display the MEM that is to be

## 230 Series Linear Amplifier

cleared and quickly press the STORE key 3-times. The MEM indication will blank.

If the STORE key is pressed (while in MANUAL) and the displayed frequency is in the PRESET table, the current settings of TUNE and LOAD capacitor settings will update the preset table.

### 6.1.7.7. Tune/ Load Capacitor Control

In MANUAL, the TUNE and LOAD capacitors only move with the TUNE and LOAD knobs on the front panel. When a knob is turned right or left, the corresponding drive motor immediately starts at low speed and switches to high speed after 5 seconds. Protection is provided to stop the capacitors at the "end of rotation" limit.

In AUTO, whenever the displayed frequency is changed with the FREQ up/down keys, there is a 2-second delay before the TUNE and LOAD capacitors start to move. This gives the user an opportunity to continue changing frequency before motors start moving. This is especially important when the user used the MEM key and has frequencies installed in a haphazard order. The motors run a high speed until they get close to their target setting at which point they are switched to low speed to reach the target. If the displayed

frequency changes due to FREQ or MEM key input, the motors are stopped immediately and restarted after the 2-second delay. If the input frequency becomes at least 20khz different from the displayed frequency, the motors are started immediately.

### 6.1.7.8. Bandswitch/Relay Control

Tables in PROM relate displayed frequency to bands. This enables "skipping over" discontinuities in band coverages and to determine which of the 6 bands is appropriate for a given frequency.

At power up, the bandswitch is moved at high speed forward until its starting position becomes known. The frequency and corresponding TUNE and LOAD settings that were in use at last power down are then loaded.

After power up, the bandswitch is moved as soon as it is determined to be in the incorrect position for the displayed frequency. Software determines the shortest distance to move (CW or CCW) to get to the correct band position. The bandswitch then moves at high speed to the correct position and switches to slow speed to "center" the bandswitch contacts.

## 230 Series Linear Amplifier

The band relays and antenna control output lines are closed just prior to the bandswitch motor starting.

### 6.1.7.9. LCD Display Control

1. **POWER OUTPUT BARGRAPH.** At power on, this scale becomes a 5-minute countdown timer (right to left). Normally, power output, forward, is displayed.

2. **MULTIMETER BARGRAPH.** Either plate current, plate voltage, grid current, or VSWR is displayed with the appropriate scale illuminated.

The SWR key toggles the display to read either VSWR (LED in SWR key is illuminated) or POWER OUTPUT, REVERSE (LED in SWR key flashes and the 0-500 scale is illuminated).

3. **FREQUENCY.** Normally displays amplifier frequency. This display is blanked if a MEM up/down input causes a empty memory location to be displayed.

4. **MEMORY.** Blinks in MANUAL when an empty MEM location is selected. Blank if the displayed frequency is not a MEM. Normally displays the selected MEMORY location.

5. **SAFETY TRIPS.** See Paragraph 6.1.7.2.

6. **MODE.**

**STANDBY.** On at startup and when STBY key is depressed.

**NOT READY.** On in AUTO before bandswitch and TUNE and LOAD capacitors reach target positions.

**QSK.** On when QSK key is depressed. (toggles between QSK and OPER).

**MANUAL TUNE.** On when MANUAL is selected.

**TUNE BARGRAPH.** Shows relative position of TUNE capacitor.

**LOAD BARGRAPH.** Shows relative position of LOAD capacitor.

6.1.7.10. **LED Control.** See Table 3.

### 6.1.7.11. Bias Control

The amplifier is biased off during the 5-minute warm-up period, whenever the bandswitch is moved, and during any HARD TRIP.

The amplifier is biased on in MANUAL when the bandswitch reaches the correct band and in AUTO when the bandswitch, TUNE and LOAD capacitors reach their correct table positions, or when the RESET key is pressed to clear a HARD TRIP.

### 6.1.7.12. Remote Control Operation

Remote Control is through a standard RS-232C interface at the microcontroller. This allows complete monitoring and control via an external computer.

## 230 Series Linear Amplifier

To engage REMOTE operation, press the REMOTE key. The LED in the REMOTE key will light and all other panel keys will become inoperative.

The remote port runs at 1200 baud, 1 stop bit, and no parity. The user controls the amplifier by inputting ASCII commands into the port. The amplifier provides feedback by sending messages out the port. Error messages (from illegal commands) are also sent through the port.

All commands to the amplifier are terminated with a carriage return. A software switch allows the amplifier to echo or not echo commands received.

See Table 5 for commands.

## 230 Series Linear Amplifier

Table 4. Panel LED Control

<u>LED DESIGNATION</u>	<u>ACTION REQUIRED TO LIGHT</u>
PLATE CURRENT	Press PLATE CURRENT key (last)
GRID CURRENT	Press GRID CURRENT key (last)
PLATE VOLTAGE	Press PLATE VOLTAGE key (last)
SWR	Press SWR key (last)
STBY	Power up Press STBY key (Amplifier is biased OFF)
OPER	Press OPER key (Amplifier is biased ON when READY)
QSK	Toggles with QSK key
TRIP ("!")	Blinks in PRE-TRIP state On solid at HARD TRIP
RESET	HARD TRIP
REMOTE	Blinks when REMOTE key pressed
AUTO	Press AUTO key
MANUAL	Press MANUAL key
STORE	Ready to store a frequency

## 230 Series Linear Amplifier

### Table 5. Remote Control Commands

**Kn** Simulate a KEY stroke as follows:

K1	STORE
K3	DIM
K5	MANUAL
K6	REMOTE (disables REMOTE operation)
K7	SWR
K8	FREQ (UP)
K9	FREQ (DOWN)
K10	STBY
K11	PLATE CURRENT
K12	MEM (UP)
K13	MEM (DOWN)
K14	OPER
K15	GRID CURRENT
K16	RESET
K17	AUTO
K18	QSK
K19	PLATE VOLTAGE

Errors: \*\*Invalid key number

**Fnnnn** Set FREQUENCY to nnnn.

nnnn must be a valid frequency. The frequency is input with no decimal point. If the amplifier is in AUTO, it will tune to that frequency. For example F180 is 1.80Mhz, F2400 is 24.00Mhz.

Errors: \*\*Invalid frequency

**Mnn** Tune to MEMORY n. (n must be between 1 and 20)

Errors: \*\*Invalid user memory number

**T\*** Move TUNE capacitor for 1-second at slow speed  
\* = + to increase setting  
\* = - to decrease setting

**L\*** Move LOAD capacitor for 1-second at slow speed  
\* = + to increase setting  
\* = - to decrease setting

Errors: \*\* Can't manual tune while in AUTO  
\*\* Invalid command (+ or - missing)

## 230 Series Linear Amplifier

**DMn** Display contents of user MEMory n.  
If n = 0, all 20 user MEMories are displayed.

Errors: \*\* Invalid user memory number

**Dn** Display the value of operating parameter n.  
In n = 0, all parameters are displayed.  
Each parameter displayed is prefixed by its ASCII  
parameter name and followed by carriage return & Line

**Feed.**

D1	DISPLAYED FREQUENCY
D2	INPUT FREQUENCY
D3	BAND
D4	TUNE CAPACITOR
D5	LOAD CAPACITOR
D6	TUNE MODE
D7	OPERATING MODE
D8	MULTIMETER SETTING
D9	GRID CURRENT
D10	PLATE CURRENT
D11	FILAMENT VOLTAGE
D12	PLATE VOLTAGE
D13	POWER OUT, FORWARD
D14	POWER OUT, REVERSE
D15	POWER IN, FORWARD
D16	POWER IN, REVERSE
D17	VSWR
D18	PROTECTION STATUS (TRIPS AND PRE-TRIPS)

Errors \*\* Invalid display item

**Bn** Same as Dn above, but values are returned without their  
parameter names and suffixed by a comma.

Errors \*\* Invalid display item

## 230 Series Linear Amplifier

### 7. Maintenance

#### 7.1. Introduction

Although the 230 amplifier is designed to give years of trouble-free service, it is a complicated piece of equipment and as such requires some attention to maintenance in order to perform satisfactorily over long periods of time and heavy service.

#### 7.2. Microcontroller

No preventive maintenance is required except for an occasional cleaning of the cabinet exterior. Use only non-abrasive materials.

#### 7.3. RF/power supply deck

The chart below suggests maintenance items and their periodicity:

<u>PERIODICITY</u>	<u>ITEM</u>
Monthly	Check air input and output slots for blockage.
6-Months	Remove the top cover and inspect the interior of the RF deck for heat damage. (look for areas of discoloration).
Yearly	Remove top cover and side covers and carefully clean any accumulation of dust and other foreign matter.

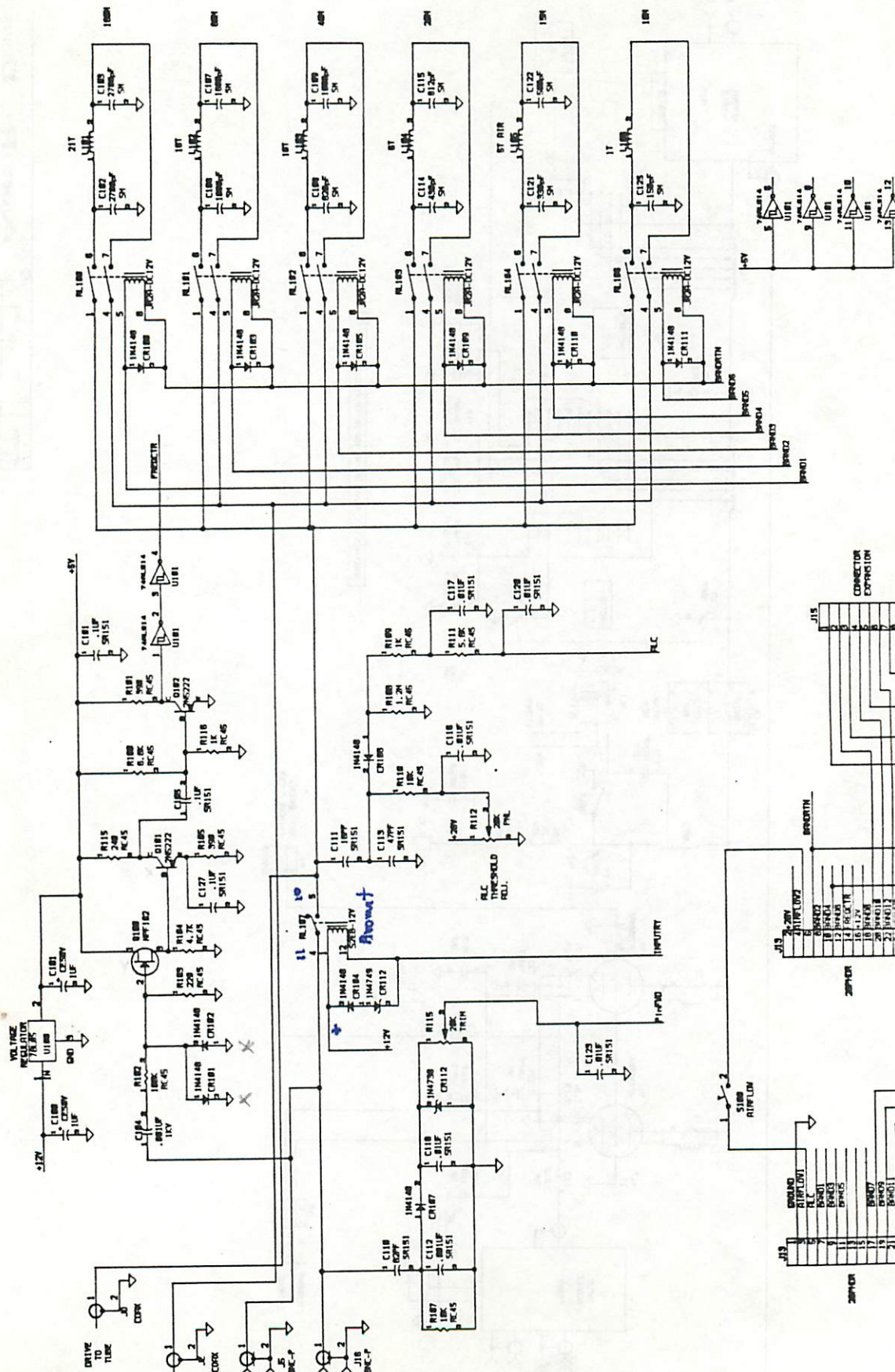


## 230 Series Linear Amplifier

### 8. Drawings

1. T7000 Interconnections
2. T7001 Power Supply
3. T7002 Amplifier
4. T7003 Input Board
5. T7005 Output Board
6. T7008 Drive Motor Circuitry
7. T7500 Microcontroller CPU Board (2 sheets)
8. T7510 Microcontroller Display Board
9. T7600 Control Module I/O Board (3 sheets)
10. T7610 Control Module Driver Board (2 sheets)
11. T7620 Control Module Frequency Counter Board



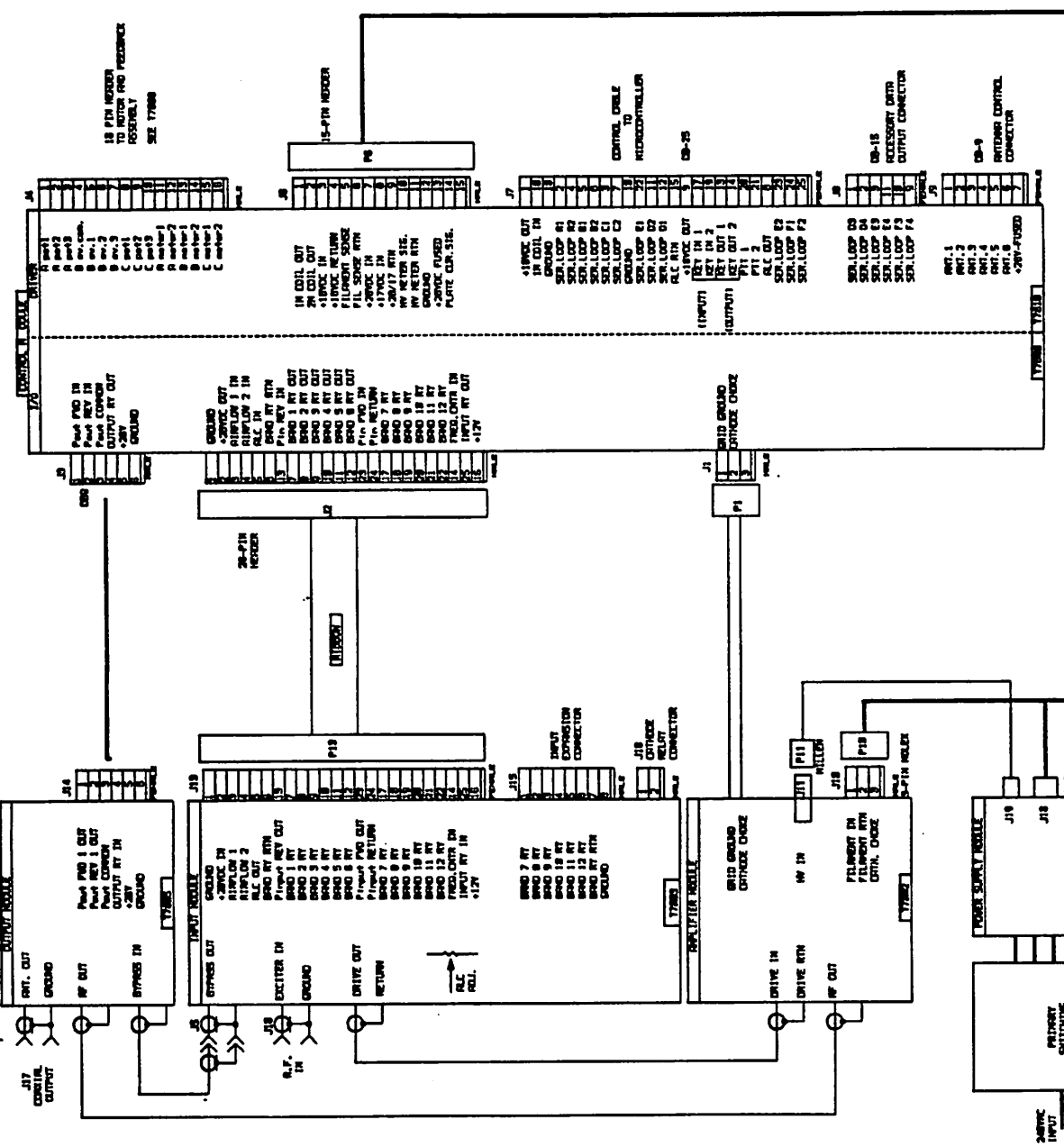


APPROVAL	BY	DATE	TITLE
DRWEN	WHITE	11 JAN 68	2300A INPUT MODULE
CHECKED			
ENGRG			

ADVANCED RADIO DEVICES  
 2300A INPUT MODULE  
 NUMBER 17803

SHEET 1 OF 1	SCALE	NUMBER	REV
3		2	1

REV. 1 DATE REVISIONS THRU  
 REV. 2 DATE REVISIONS THRU  
 REV. 3 DATE REVISIONS THRU  
 REV. 4 DATE REVISIONS THRU

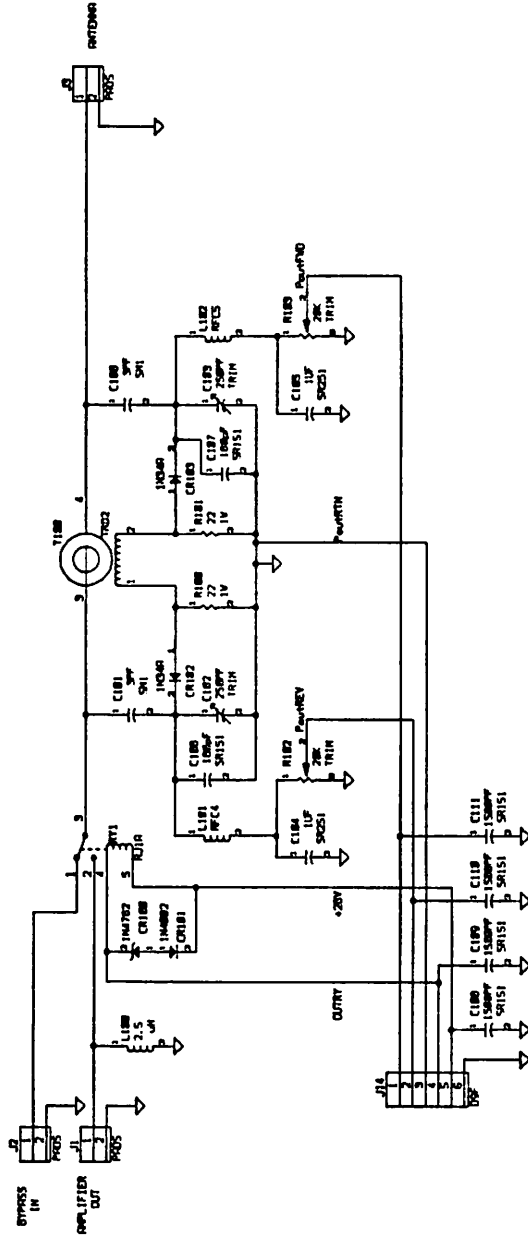


APPROVAL	BY	DATE
DESIGN	WHITE	28 APR 87
CHECKED		
ENGINEER		
SHEET 1 OF 1	SCALE:	
NUMBER	3	177880
TITLE	RF / POWER SUPPLY INTERCONNECTIONS-- 230A	
REV.	4	

ADVANCED RADIO DEVICES

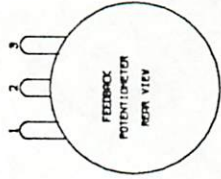
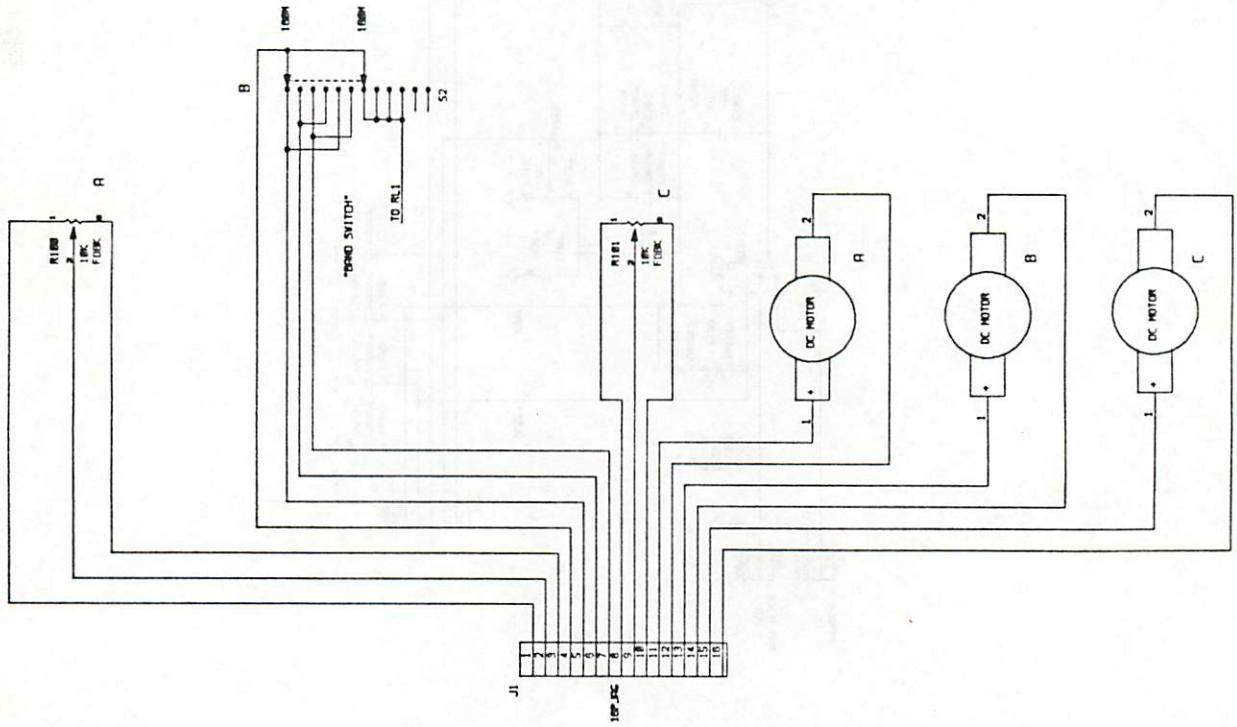


REV. 1 GEN'L. REVISIONS 21DEC1967  
 REV. 2 BYPASS CAPS ADDED 5/6/70



APPROVAL	BY	DATE
DESIGN	WHITE	17 JUNE 1967
CHECKED		
ENG'G		
TITLE		
LINEAR OUTPUT BOARD SCHEMATIC		
NUMBER		
17605		
SHEET 1 OF 1		
SCALE:		
2		

ADVANCED RADIO DEVICES



"A" = TUNING  
 "B" = BANDSWITCH  
 "C" = LOADING

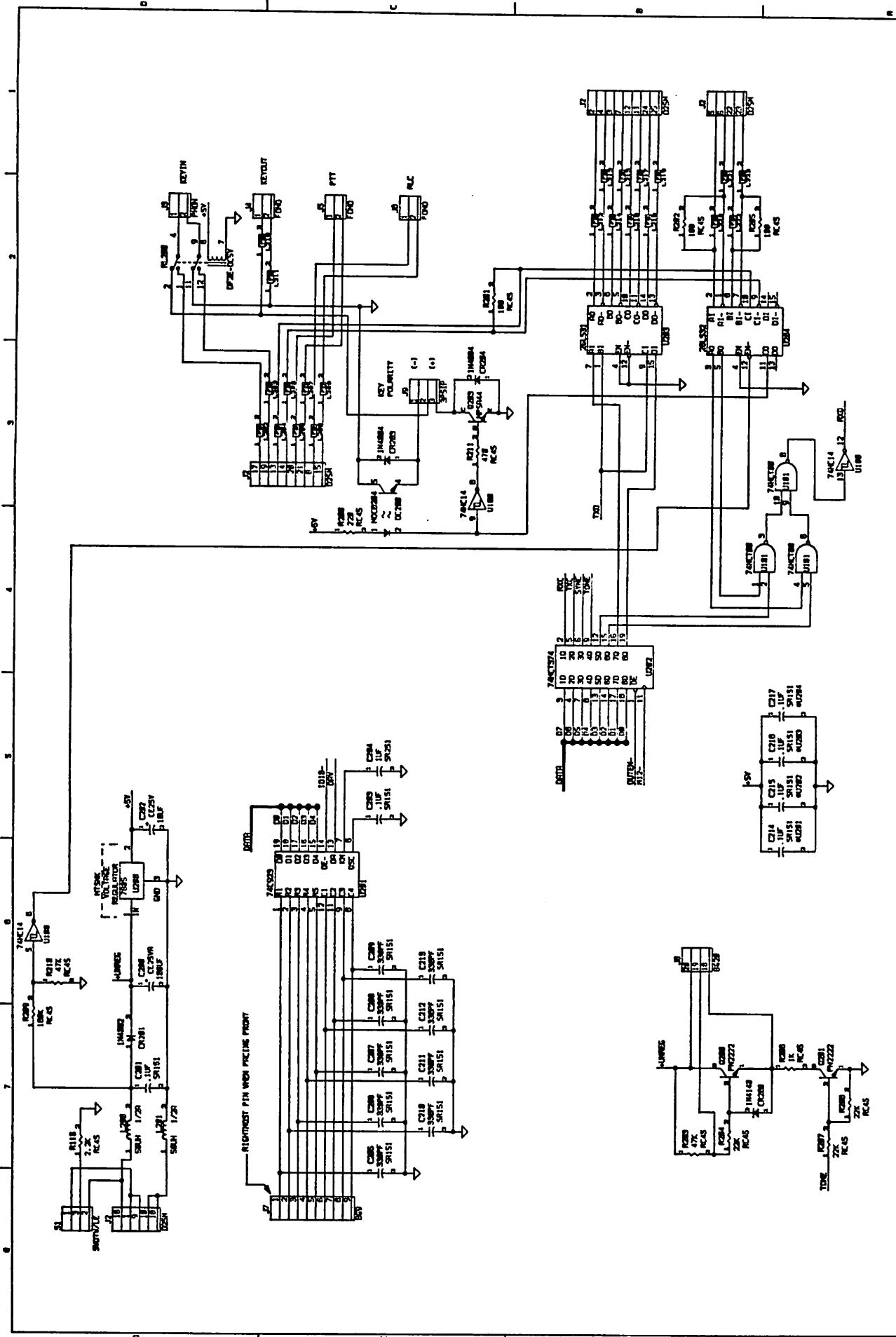
APPROVAL	BY	DATE	©
DRAWN	DESIGNED	APPROVED	TITLE
CHECKED			
ENG'G			
SHEET 1 OF 1	SCALE:	NUMBER	REV. B
		7700A	

ADVANCED RADIO DEVICES

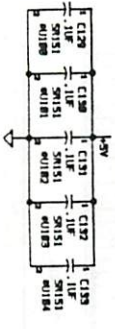
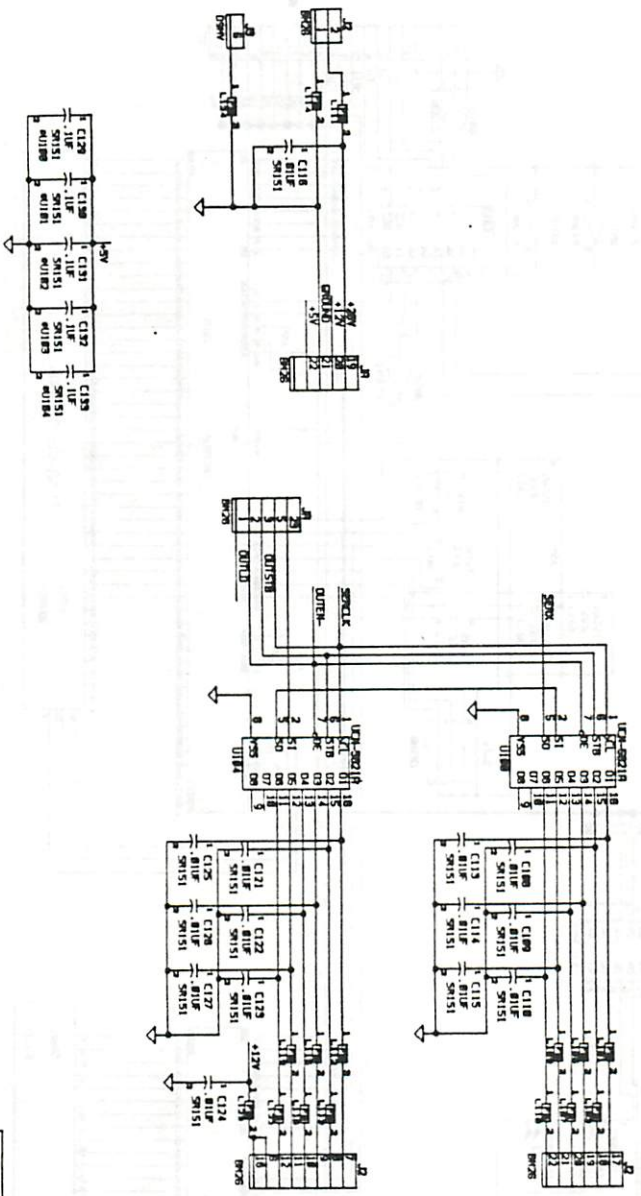
230 AMPLIFIER— MOTOR WIRING SCHEMATIC



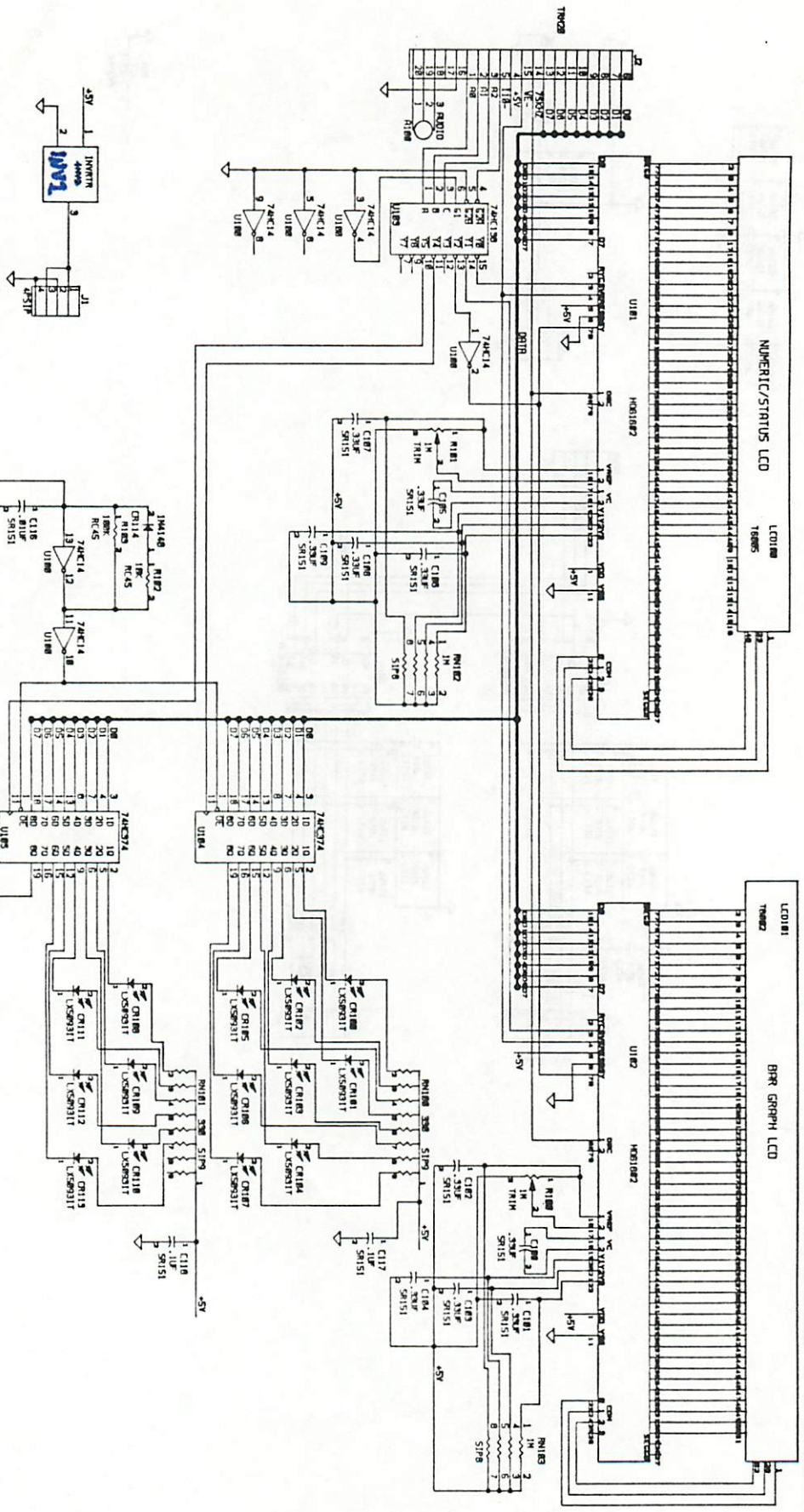




APPROVAL	BY	DATE	<b>ADVANCED RADIO DEVICES</b> LINEAR CONTROL CPU SCHEMATIC NUMBER 17580
DRAWN	TILDEN	8-11-1967	
CHECKED			
ENGINEER			
SHEET 2 OF 2	SCALE		



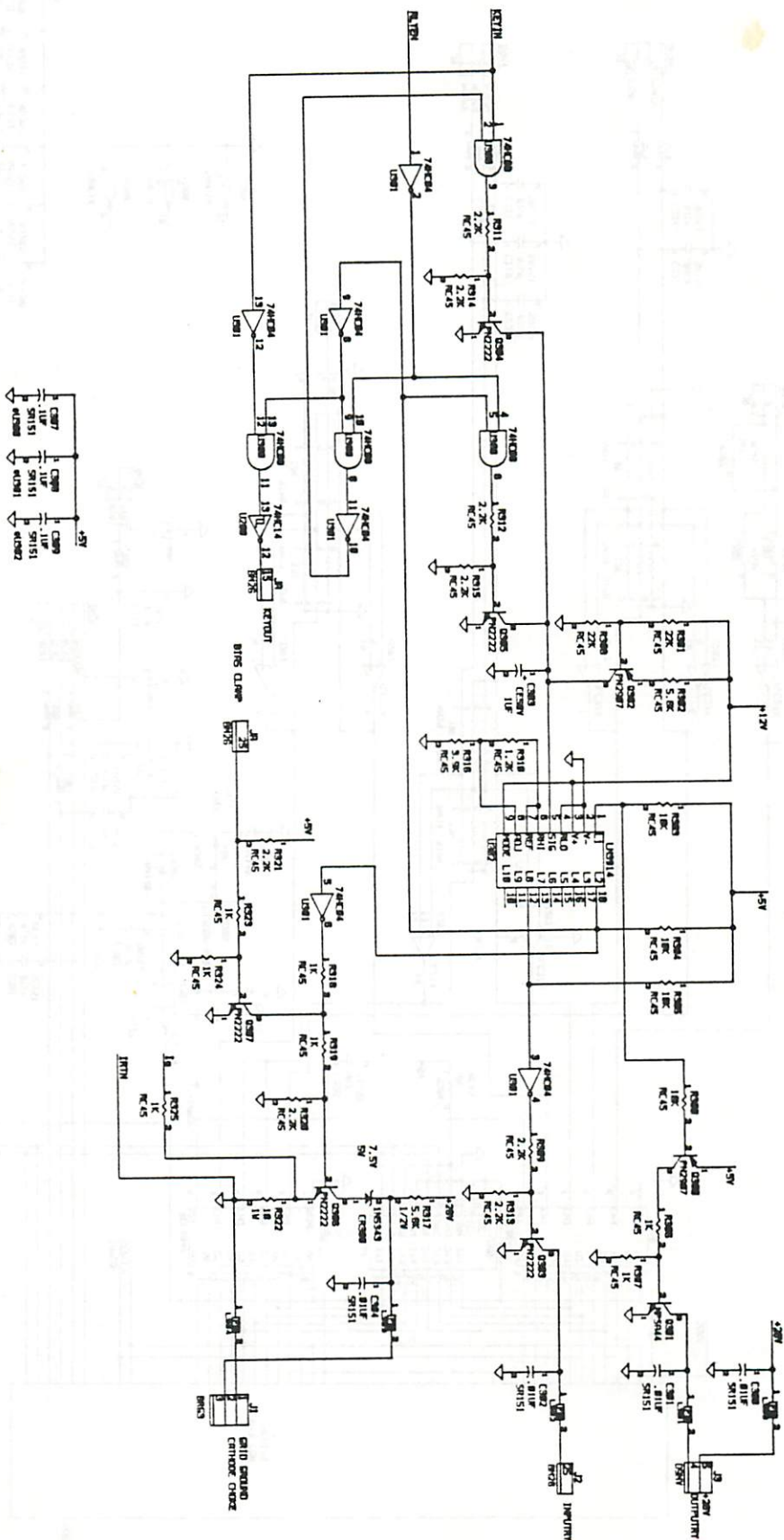
APPROVAL	BY	DATE	<b>ADVANCED R1010 DEVICES</b> TITLE LINEAR CONTROL I/O BOARD SCHEMATIC
DESIGN	TILLEN	5-27-1987	
CHECKED			
ENGR.			
SHEET 1 OF 3			NUMBER 17500



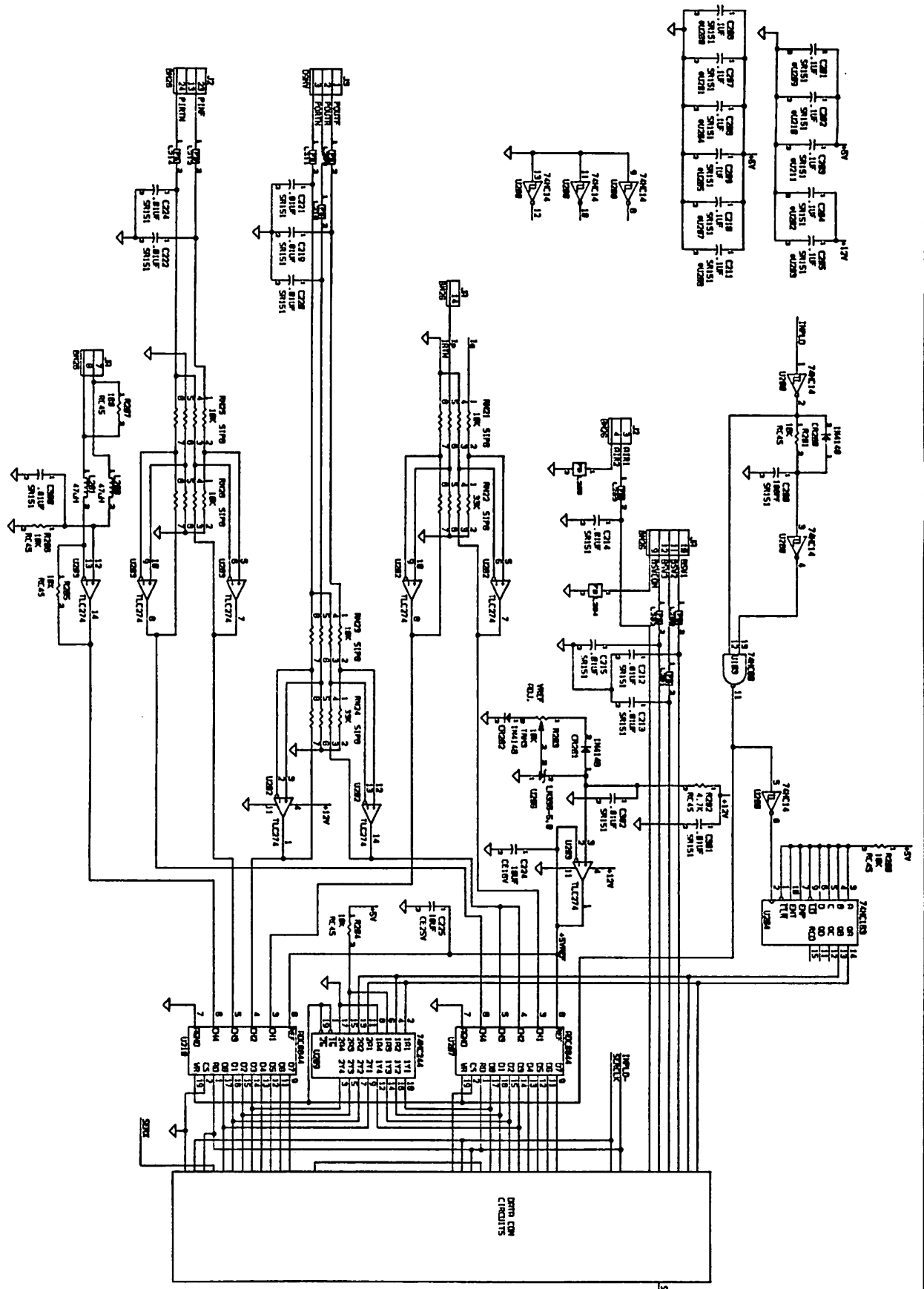
IC	QTY	REF
U100	14	7
U101	1	11
U102	1	11
U103	1	11
U104	1	11
U105	28	18
U106	1	18
U107	1	18
U108	1	18
U109	1	18
U110	1	18
U111	1	18
U112	1	18
U113	1	18
U114	1	18
U115	1	18

IC	QTY	REF
C100	1	11
C101	1	11
C102	1	11
C103	1	11
C104	1	11
C105	1	11
C106	1	11
C107	1	11
C108	1	11
C109	1	11
C110	1	11
C111	1	11
C112	1	11
C113	1	11
C114	1	11
C115	1	11

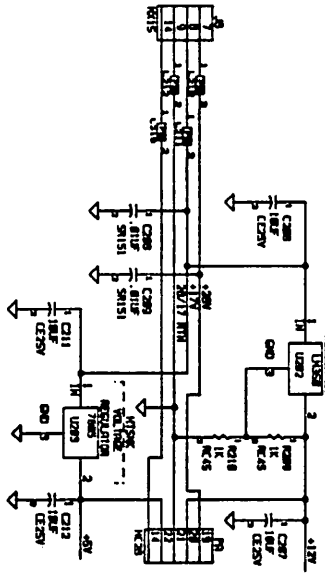
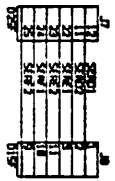
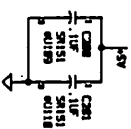
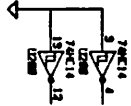
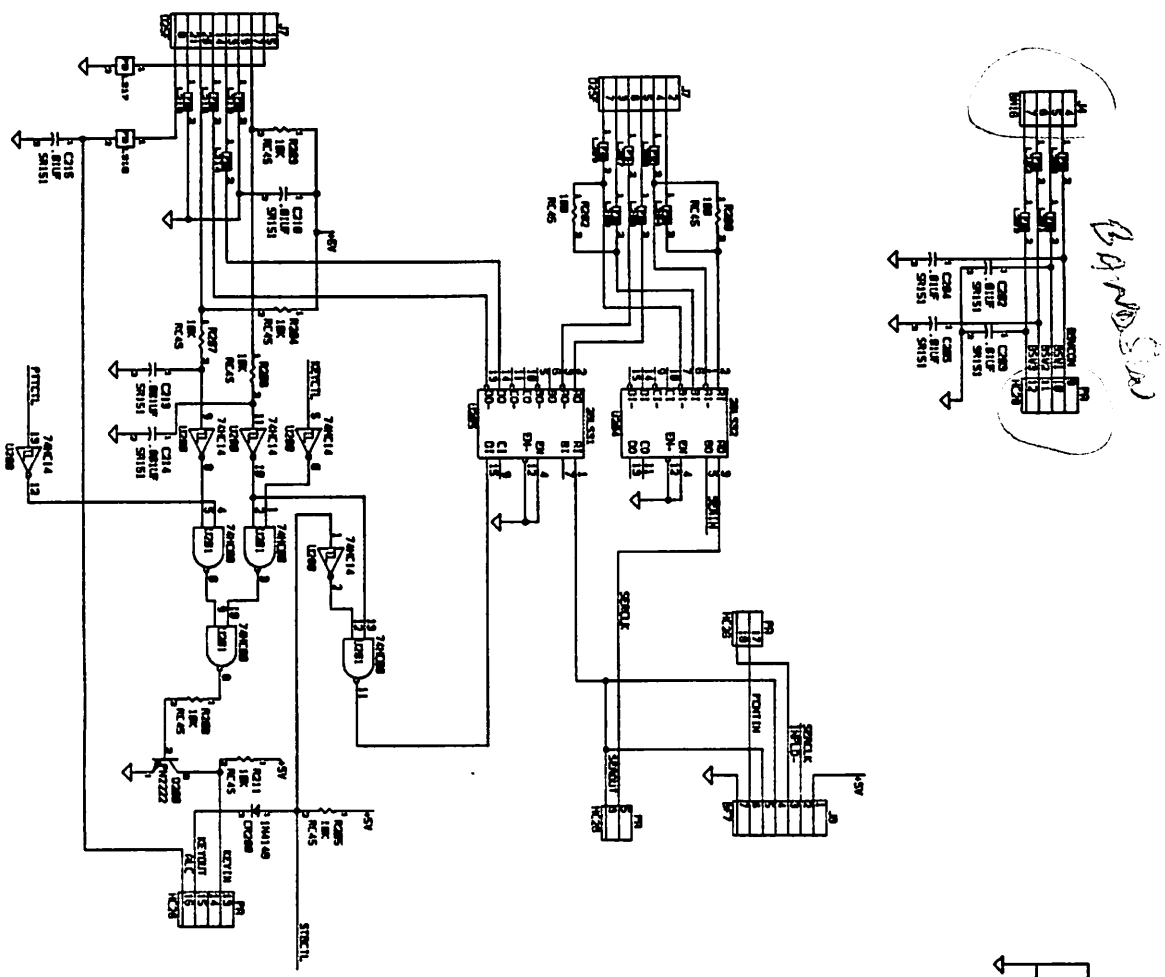
APPROVAL	BY	DATE	<p><b>ADVANCED RAYON DEVICES</b></p> <p>TITLE LINEAR CONTROL DISPLAY SCHEMATIC</p>
DRAWN	TILDEH	7-15-1987	
CHECKED			
EMC			
SHEET 1	OF 1	SCALE:	
NUMBER	2		



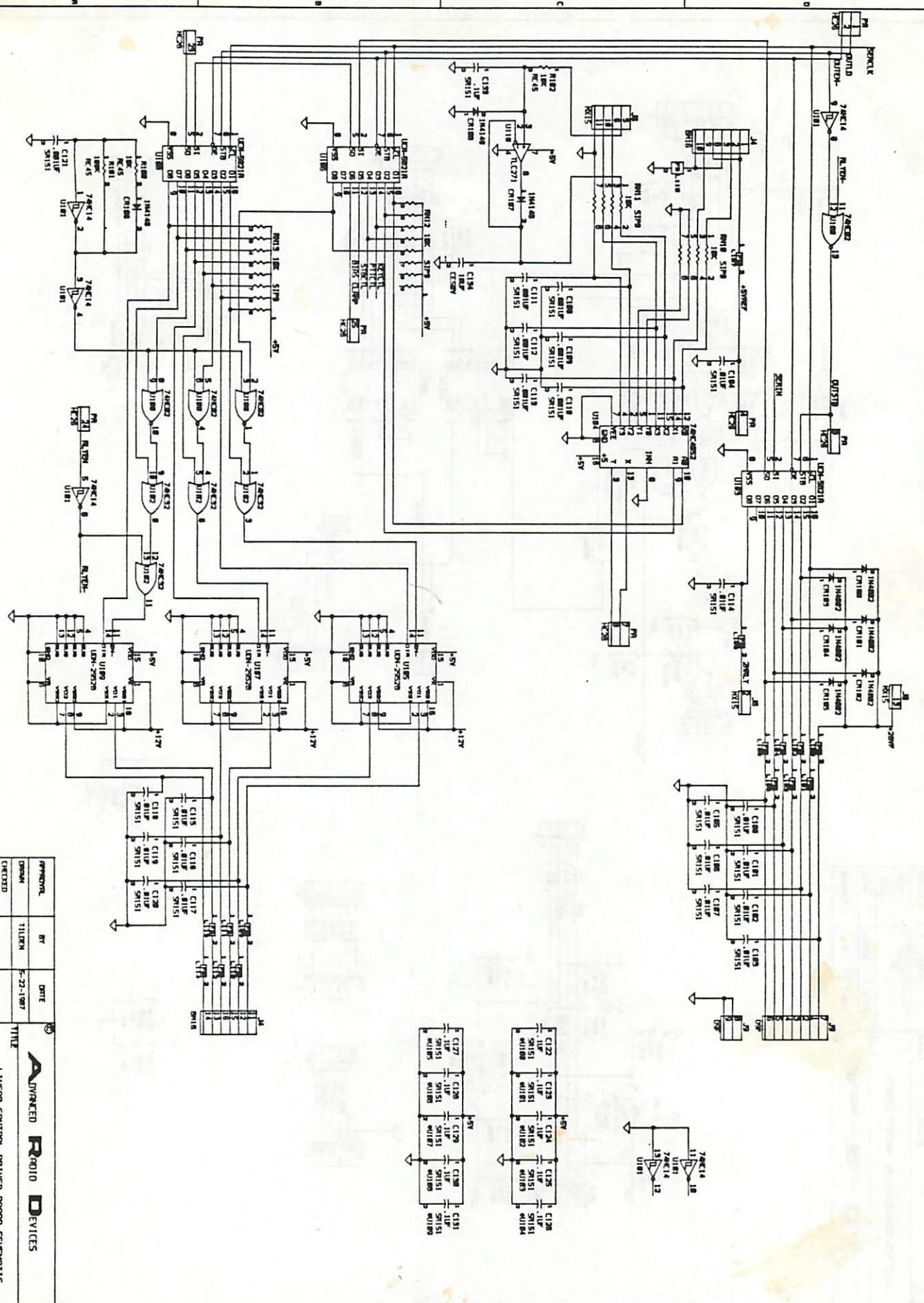
APPROVAL	BY	DATE	<b>ADVANCED RAIID DEVICES</b> TITLE LINEAR CONTROL I/O BOARD SCHEMATIC
DRAWN	WHITE	11/14/87	
CHECKED			
ENGR.			
SHEET 3 OF 3			SCALE:
NUMBER			17/500
			REV B



APPROVAL	BY	DATE	<b>ADVANCED RADIO DEVICES</b> 2300 CONTROL I/O BOARD SCHEMATIC
DRAWN	TILDEN	5-22-1987	
CHECKED			
ENGR.			
SHEET 2 OF 3	SCALE:	NUMBER 2	17688



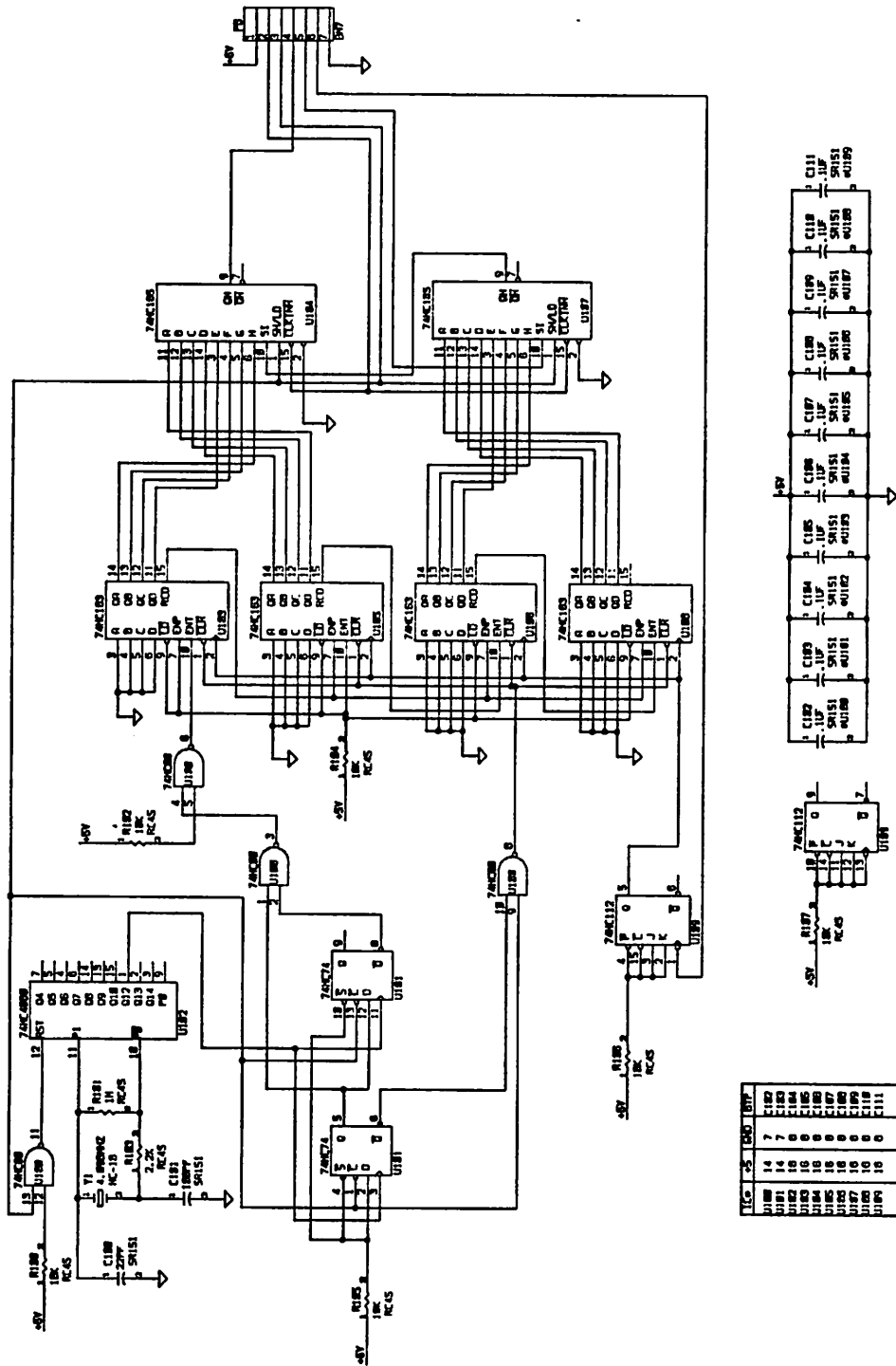
APPROVAL	BY	DATE	<b>ADVANCED RAYO DEVICES</b> LINEAR CONTROL DRIVER BOARD SCHEMATIC
CHECKED	TILBEN	5-23-1967	
ENGINE			
SHEET 3 OF 3 SCALE			NUMBER 17618



APPROVAL	BY	DATE
DESIGN	TILLEN	5-22-1987
CHECKED		
ENGINEER		

**ADVANCED RADIO DEVICES**  
 TITLE  
 LINEAR CONTROL DRIVER BOARD SCHEMATIC

SHEET 1 OF 2	SCALE
NUMBER 3	17618



UIC	QTY	REF	QTY
U100	1	1	1
U101	1	2	1
U102	1	3	1
U103	1	4	1
U104	1	5	1
U105	1	6	1
U106	1	7	1
U107	1	8	1
U108	1	9	1
U109	1	10	1
U110	1	11	1
U111	1	12	1
U112	1	13	1
U113	1	14	1
U114	1	15	1
U115	1	16	1
U116	1	17	1
U117	1	18	1
U118	1	19	1
U119	1	20	1
U120	1	21	1
U121	1	22	1
U122	1	23	1
U123	1	24	1
U124	1	25	1
U125	1	26	1
U126	1	27	1
U127	1	28	1
U128	1	29	1
U129	1	30	1
U130	1	31	1
U131	1	32	1
U132	1	33	1
U133	1	34	1
U134	1	35	1
U135	1	36	1
U136	1	37	1
U137	1	38	1
U138	1	39	1
U139	1	40	1
U140	1	41	1
U141	1	42	1
U142	1	43	1
U143	1	44	1
U144	1	45	1
U145	1	46	1
U146	1	47	1
U147	1	48	1
U148	1	49	1
U149	1	50	1
U150	1	51	1
U151	1	52	1
U152	1	53	1
U153	1	54	1
U154	1	55	1
U155	1	56	1
U156	1	57	1
U157	1	58	1
U158	1	59	1
U159	1	60	1
U160	1	61	1
U161	1	62	1
U162	1	63	1
U163	1	64	1
U164	1	65	1
U165	1	66	1
U166	1	67	1
U167	1	68	1
U168	1	69	1
U169	1	70	1
U170	1	71	1
U171	1	72	1
U172	1	73	1
U173	1	74	1
U174	1	75	1
U175	1	76	1
U176	1	77	1
U177	1	78	1
U178	1	79	1
U179	1	80	1
U180	1	81	1
U181	1	82	1
U182	1	83	1
U183	1	84	1
U184	1	85	1
U185	1	86	1
U186	1	87	1
U187	1	88	1
U188	1	89	1
U189	1	90	1
U190	1	91	1
U191	1	92	1
U192	1	93	1
U193	1	94	1
U194	1	95	1
U195	1	96	1
U196	1	97	1
U197	1	98	1
U198	1	99	1
U199	1	100	1

APPROVAL	BY	DATE
DESIGN	TLUDEN	5-11-1967
CHECKED		
ENGINE		
TITLE	FREQUENCY COUNTER BOARD SCHEMATIC	
NUMBER	17628	
SHEET	1 OF 1	SCALE:



## 230 Series Linear Amplifier

### Appendix A. Manual Tuning Procedure

This appendix is written especially for the user who is not familiar with tuning a pi-L type of linear output circuit. Those who are familiar with tuning a pi-type output configuration will find that the LOAD control has a more pronounced effect in the pi-L. In fact, if TUNE and LOAD are sufficiently misadjusted, it is possible that the inexperienced user may not be able to tune for any output at all! However, if the following procedure is followed tuning the amplifier is quite easy.

Tuning the amplifier involves adjusting the TUNE and LOAD controls with exciter drive to obtain the correct relationship between grid current, plate current, and power output.

#### NOTE

The 3CX800A7 tubes are durable devices when properly treated. Given proper care, they will run for years. The 230's have been designed to ensure the safety of the tubes while not interfering with normal operation. However, while practicing manual tuning you are likely to invoke one or more of the safety trips. Don't let it bother you, these trips are protecting your investment!

Tune the amplifier using the following procedure:

1. Turn on and warm-up the amplifier.
2. Select STBY and AUTO.
3. Enter the desired frequency using the FREQ up and down keyswitches or simply transmit some RF from the exciter. The amplifier will read this frequency and change to the proper band and frequency.
4. Select OPERate and MANUAL.
5. Select PLATE CURRENT on the multimeter.
6. With the exciter drive at a minimum, apply drive slowly until about 500ma plate current is indicated. Adjust the TUNE control to peak POWER OUTPUT. If a peak is NOT found, set the TUNE capacitor to half scale.(90 on bargraph) and search for an output peak with the LOAD control. When the peak is found, adjust TUNE for maximum output.
7. Select GRID CURRENT on the multimeter. The meter should be indicating about 60 ma. Increase drive while observing grid current. It will increase quite rapidly. (If you go too far, a grid trip will occur. If this happens, simply reduce drive and press the RESET keyswitch and continue).

## 230 Series Linear Amplifier

### CAUTION

If you experience a MISTUNED trip you have been sitting too long in an untuned condition and have exceeded the plate dissipation of the tubes. No problem .. simply remove the drive, depress RESET, lower the drive a bit, and continue at a lower drive level.

As drive is increased, increase LOADING (LOAD switch to the CW position) to reduce grid current to less than 60 ma. Re-peak POWER OUTPUT with the TUNE control. (Notice that grid current peaks with peak output).

Continue this process of increasing drive and loading and peaking output until you achieve 1500 watts POWER OUTPUT with approximately 60 ma grid current and 1200 ma plate current.

### CAUTION

Don't overLOAD the amplifier to run a high plate current. This only increases input DC power and does nothing for POWER OUTPUT. Tune for maximum efficiency as described above.

8. You may save the settings of TUNE and LOAD at the selected frequency by simply depressing the STORE key-switch. (See Paragraph 5.3.5)



## 230 Series Linear Amplifier

### TECHNICAL MANUAL ERRATA - JUNE 1988 (Three pages)

\*\*\* REPLACE AS INDICATED WITH THE FOLLOWING \*\*\*

PAGE 1: Replace the 2nd paragraph starting "The 230AX is shipped..." with the following:

"You must select the input voltage for the 230AX amplifier. Please refer to paragraph 4.4.1.2 before attempting operation of the amplifier."

PAGE 8: Replace paragraph 4.4.1.2 with the following:

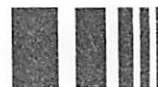
#### "4.4.1.2. Input Voltage Selection

Input voltage selection is made by mating the proper connectors to the power transformer (The 230A has only one choice) as the transformer is being installed. See the following paragraph for details.

The 230AX input voltage may be selected to 200, 220, or 230 VAC nominal.

To select input voltage, perform the following:

1. Plug the large black connector labeled "LINE" into the transformer connector labeled "200", "220", or "230" (there is only one plug on the 230A transformer labeled "230"). Remove the protective "dummy plug" first. The connector may be inserted only one way .. do not force it!
2. Plug the small white connector labeled "CONTROL" into the corresponding white plug on the transformer labeled "200", "220", or "230" (there is only one plug on the 230A transformer labeled "230").
3. Check to see that BOTH black (LINE) and white (CONTROL) connectors are connected as desired. Ensure that the same voltage is selected for both plugs!
4. Proceed to install the power transformer."



PAGE 9: Replace paragraph 4.4.1.3 with the following:

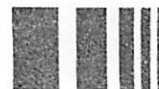
"4.4.1.3. Power Transformer Installation.

1. Carefully lay the RF/power supply deck on its top. Use a carpeted surface or some of the packing material to avoid scratching the top surface.
2. Remove the four (4) 1/4-inch bolts from the bottom of the deck. The correct bolts are identified by a red mark and are located near the large cutout into which the transformer will be placed.
3. Cut the tie-wrap holding the two connectors (labeled "LINE" and "CONTROL") just inside the cutout. Discard the tie-wrap.
4. Place the transformer on its side near the cutout on the bottom of the deck (the two red leads (HV) should be down). Connect the high voltage side connector (two red leads) to its mating connector inside the amplifier located at the top of the filter capacitor/high voltage rectifier bank. Then mate the connectors as described in paragraph 4.4.1.2 Input Voltage Selection. The connectors are keyed and can only be inserted one way.

### CAUTION

Each large black plug on the transformer contains a "dummy plug" to avoid accidental contact when unused. Ensure this plug is removed before attempting to mate the connectors. Further, ensure that a "dummy plug" is in place on each connector unused.

5. Carefully lift the transformer (use slots or handles as provided) and slide it into the cutout observing the arrow on the bottom of the plate which should point towards the corresponding arrow on the amplifier. Guide the leads and connectors into the cutout as the transformer is lowered. For the 230AX transformer only, bend the unused transformer leads so that the ends of the plugs are resting on the top of the transformer windings. This allows easy passage of the transformer through the access cutout. BE CAREFUL NOT TO PINCH ANY OF THE LEADS AS THE TRANSFORMER IS LOWERED INTO PLACE.
6. Align the transformer plate with the four mounting hole's and re-install the four 1/4-inch bolts. Make sure these bolts are tightened securely.
7. Lift the RF/power supply deck into its normal upright position. Be careful, the assembly now weights approximately 80 pounds."



PAGE 9. Add the following new paragraph 4.4.1.3A:

"The 230AX is shipped without a line plug due to the various standards in different countries. When installing a line plug ensure it is rated for at least 20 amperes and connect as follows:

GREEN: Safety (chassis) ground  
BLACK: Line  
WHITE: Line

The GREEN wire must be grounded for safety considerations."

PAGE 47. Change "1200" to "2400" in the second paragraph.

PAGE 6, Section 4.4.1.1. Delete the last three (3) paragraphs.

(It is not necessary to remove the top cover since no packing material is located within the upper RF compartment. Furthermore, there is no danger of the tubes lifting out of their sockets .. they are held tightly in place by an O-ring)

DRAWING T7001. Correct as follows: Change F1 size to 2A  
Change F2 size to 3A

230AX OWNERS ONLY: Replace Drawing T7001 with T7001AX.

