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ERROR CORRECTION TERMINAL

870-01000

December, 1987, Printing

ARQ1000A ERROR CORRECTION TERMINAL

CONTENTS:

INTRODUCTION

This manual describes the installation and operation of the HAL ARQ1000A Error Correction Terminal. The ARQ1000A has been designed for convenient and straightforward customer use. Many features are self-explanatory from a close examination of the ARQ1000A front and rear panels. However, like many sophisticated electronic devices, there are some features and operator techniques which you may not understand until you have read this manual. You should plan to devote some time becoming familiar with the ARQ1000A before using it on the air.

NOTE! The ARQ1000A will NOT work correctly until the correct I/O switch settings have been made. Please read Chapter 2 carefully and make the appropriate switch selections before attempting operation.

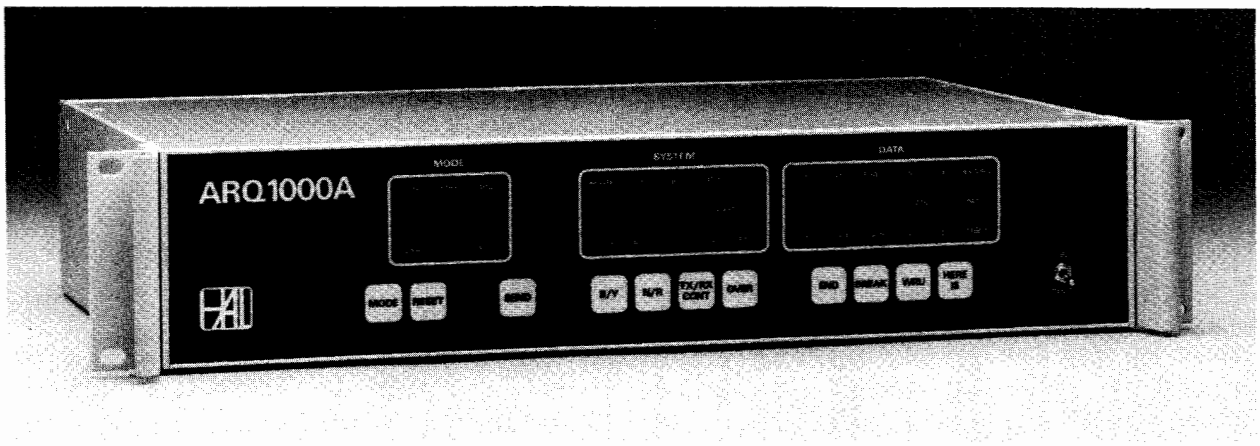


Figure 1 The ARQ1000A

CHAPTER 1

UNPACKING AND INSPECTION

When unpacking the ARQ1000A, carefully inspect the shipping carton and the cabinet for shipping damage. Any evidence of shipping damage should be immediately reported to your supplying dealer or shipping carrier. Be sure to save all packing materials if damage is found - the shipping carrier will want to inspect them for any insurance claim. Before discarding the packing materials check that all parts and accessories are accounted for. Check the accessories against the following list. If any are found missing, double-check the packing for loose parts and then notify either your dealer or HAL Communications Corp. of the shortage. Please specify the HAL part number!

Accessory parts:

Accessories Packed With ARQ1000A:

1 -	770-05001	1/2 Amp Slow-blow Fuse
1 -	333-17250	AC Power Cord
1 -	870-01000	ARQ1000A OPERATOR's MANUAL
1 -	333-10250	DB-25S External Modem Connector
1 -	333-20250	DB-25P Terminal Connector
2 -	333-51228	25-pin Connector Shell
3 -	333-74564	D Connector Hardware
1 -	333-20090	DE-9P Radio Connector
1 -	333-51218	9-pin Connector Shell

Additional Options Available for ARQ1000A:

M1700 Modem Option for 1700 Hz +/- 85 Hz; installs inside ARQ1000A. Includes receive demodulator and transmit tone generator. All external connections are made to DE-9 connector on ARQ-1000A rear panel. User installable option.

LP1200A High voltage loop power supply. Neutral or polar (0-120V or -60/+60V), 20 or 60 ma. Optically isolated RS232C I/O. Separate cabinet; 3.5-inch high rack mount design. User installable.

In addition to these accessories, you will need the following items to complete the ARQ station:

1. An RTTY modulator/demodulator capable of operation at a data rate of 100 baud. This unit may be a HAL ST-8000, ST6000, or the M1700 accessory demodulator board installed in the ARQ1000A. The standard tone frequencies used in marine ARQ service are 1700 Hz, +/-85 Hz. The M1700 is normally supplied for these frequencies and the ST6000 can be supplied for these frequencies on special order. The ST-8000 is a fully tunable modem and can be set by the user to any tone set. Other high quality modulator/demodulator systems may also be used with the ARQ1000A if they (1) interface to TTL or RS232C data circuits, (2) have totally separate data connections for transmit and receive data, and (3) have bandwidth and low pass filter sufficient to process 100 baud data. A good tuning indicator is also recommended, especially if the system is to be used with a variable tuning receiver. This will aid in determining if the receiver is set on the exact frequency. ARQ systems must typically be tuned very accurately in order to operate correctly. The ST-8000 and ST6000 each include a tuning oscilloscope. The SPT-1 Spectra Tune tuning indicator is highly recommended when the M1700 or other modem without a tuning indicator is used.

2. A teleprinter or video terminal that can operate using the Baudot or ASCII code at data rates between 45 and 300 baud. The ARQ1000A can be directly connected to the HAL DS3200 Communications Terminal. Any high quality Baudot or ASCII terminal may also be used with the ARQ1000A if the following conditions are met: (1) data rate of 45, 50, 57, 74, 110, 134.5, 150, or 300 baud; (2) Baudot (ITA No. 2) or ASCII code; and (3) interface to RS232C or TTL voltage levels. If a high voltage loop terminal is to be used, the LP1200A Loop Power Supply should be used. The ARQ1000A terminal "echo" may be selected on or off so that a terminal with or without local echo may be used. A data inhibit control line (CTS in RS-232 systems) is also desirable for tape and other automated message transmitting systems.

3. A transmitter and receiver system that is capable of rapid switching between transmit and receive conditions. In general, delays in switching must all be 20 ms or less for satisfactory ARQ mode operation. Many transceivers will NOT meet these requirements. Some modifications or a change in equipment may be required to use the ARQ1000A with transceivers in particular. HAL may be able to provide some additional information about equipment capabilities, but it is the user's responsibility to assure that switching times are adequate. Of course, the transmitter must also be capable of operation with a 100% duty cycle when the FEC and SEL-FEC modes are used.

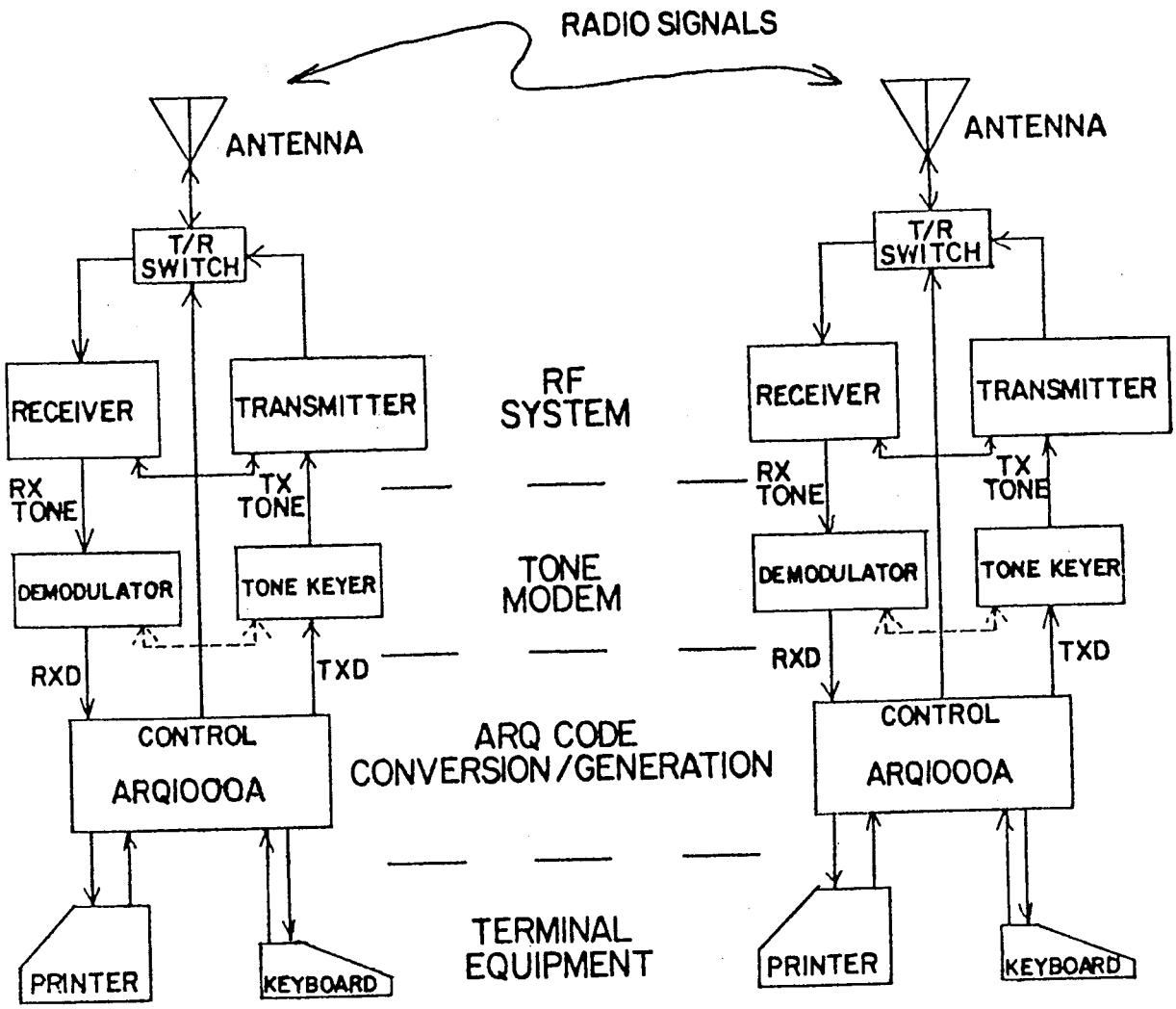


Figure 2. A typical ARQ communications system.

CHAPTER 2

INSTALLATION

2.1 PRELIMINARY INSTALLATION CONSIDERATIONS.

The HAL ARQ1000A is a versatile instrument that may be used to adapt a radio communications sytem for transmission and reception of the Moore/ARQ 7-unit error correcting digital code. The basic radio communications system consists of a radio transmitter, radio receiver, antennas, tone demodulator for received data, tone encoder for transmit data, a keyboard and printer (TTY terminal), and the ARQ1000A Error Correction Terminal. The transmit-receive functions of the tone demodulator and encoder devices are often combined into a single unit that may be called a "modem", "demodulator", or "terminal unit". The ARQ1000A may be interfaced directly to external "demodulators" or a circuit board option, the M1700 Demodulator, may be installed in the ARQ1000A cabinet. Since the interfacing requirements of each demodulator and keyboard/printer terminal may be different, a number of user-selectable switches are provided in the ARQ1000A to match the specific I/O requirements of your equipment. The majority of this chapter will discuss the possible interface selections in detail. The ARQ1000A will be ready for operation only after all interface requirements have been determined and the appropriate switch settings selected. Before the I/O selection is discussed, a few preliminary installation details should be defined.

2.1.1 MECHANICAL REQUIREMENTS.

The ARQ1000A is housed in a cabinet that may be used in either table-top or rack-mounting applications. The basic cabinet measures 3.5" high (8.9 cm) by 16.75" wide (42.5 cm) by 10.0" deep (25.4 cm). The complete unit weighs 8 lbs (3.6 kg). Addition of the M1700 option adds no dimension and approximately 1 lb to the weight. The ARQ1000A may be rack mounted in a standard 19" wide equipment rack or mounted on a table top as required. When rack mounted, the ARQ1000A requires 3.5" of vertical panel space. Since the ARQ1000A consumes little power, cooling requirements are not stringent. However, when installing in a rack, try to avoid blocking airflow to the top and bottom surfaces of the cabinet.

2.1.2 ELECTRICAL REQUIREMENTS.

The ARQ1000A may be operated from AC power mains with voltages between 105 to 130 or 210 to 250 volts, 50 or 60 Hz. It requires approximately 30 watts of AC power. The unit is

furnished factory wired for 120 VAC, 60 Hz. The ARQ1000A can be supplied from the factory with 220 VAC, 50 Hz wiring if specified. In either case, the unit may be be modified by the user for operation from 105 to 130 VAC or 210 to 250 VAC, as described in APPENDIX A of this manual. If a mains voltage other than 120 VAC is set at the factory, it will be so noted on a small label on the rear panel, near the AC power input connector. The AC power input connector is the international standard for three conductor non-captive power cords. As will be discussed in Chapter 3, all programmable features such as selective call codes, etc. are stored in an EEPROM so that they are not lost if ac power fails. The initial power-on start-up mode is also programmable so that the ARQ1000A may be set to always return to a preset mode when power is restored. No internal or external support batteries are required for the ARQ1000A. The ARQ1000A has a full front panel with 30 indicators and 12 switches. Although all front panel switch functions may be remotely set by keyboard programming on the TTY terminal, it will be advantageous in most installations to mount the ARQ1000A in such a location that the indicators may be observed by the operator from time to time. When the ARQ1000A is mounted an appreciable distance from the TTY terminal, demodulator, or transmitter and receiver, it is strongly advised that shielded cabling be used to minimize RF and noise induction onto the data signals. If cable distances greater than 50 ft. are required, it may be advisable to consider use of balanced line drivers and receivers to minimize RF and noise problems. In particular, use of TTL data connections for long cables is NOT advised.

2.1.3 REAR PANEL CONNECTIONS

The rear panel of the ARQ1000A is shown in Figure 3. With the exception of the AC power input, ALL I/O connections are made to the three "D" style connectors. When the ARQ1000A is used with an external receive demodulator and transmit tone keyer, all connections are made to the two 25-pin connectors. The 9-pin connector is only used when the M1700 modem option is installed.

When connecting the ARQ1000A, be sure to use grounding style of AC power distribution as this provides the required safety ground system. In addition, since the ARQ1000A will be used with radio transmitters and receivers, a good RF ground system should also be installed. A low-inductance, short length RF ground lead should connect between all equipment in the system. A .25" or wider shield braid or copper strap is highly recommended for the RF ground return; attach it directly to the ground binding post on the ARQ1000A rear panel. If problems with RF interference to or from the ARQ1000A are encountered, please request the HAL application note "R.F. Induced Problems And Solid-State RTTY Terminals."

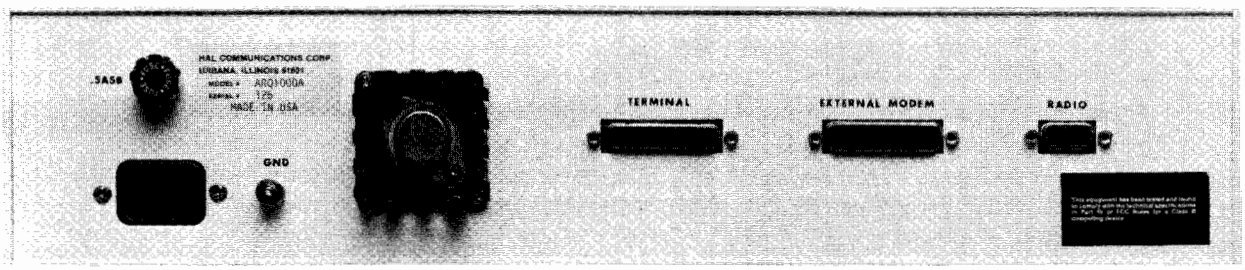


FIGURE 3. ARQ1000A REAR PANEL DETAILS

Interfacing the ARQ1000A to the rest of the system invloves two steps: (1) making the physical wire connections and (2) making the proper internal switch settings to match the required I/O interface of your equipment. Switch settings will be discussed in sections 2.2 and 2.3 of this chapter. The rear panel connections and their uses are outlined below:

TERMINAL CONNECTOR:

PIN 1 - FRAME GROUND: Direct Connection to the ARQ1000A cabinet for grounding of a shielded cable between the terminal and the ARQ1000A.

PIN 2 - KEYBOARD DATA INPUT: Input signal from terminal or from keyboard, if separate keyboard and printer units are used. Accepts standard RS232 Transmit Data (TXD) line or TTL signal. TX/RX DATA switches must be set properly. (See Section 2.2.)

PIN 3 - PRINTER DATA OUTPUT: Output signal from ARQ1000A to terminal or printer. Drives standard RS232 Receive Data (RXD) line or TTL device. TX/RX DATA switches must be set properly.

PIN 4 - REQUEST TO SEND (RTS): Input from terminal to ARQ1000A. Can be used as Transmitter PTT control when ARQ unit is in OFF mode by setting jumper J3 to the RTS position. (See Section 2.2.)

PIN 5 - KEYBOARD WAIT: Control signal from ARQ1000A to terminal or keyboard which provides flow control for data being transmitted. This signal is active when the first 80 characters of the ARQ1000A buffer are filled. Drives standard RS232 Clear to Send (CTS) line or TTL device. Highly recommended if terminal has the capability!

PIN 7 - SIGNAL GROUND: Provides standard RS232 signal ground connection to terminal.

PIN 19 - TERMINAL KOS: Input signal from the terminal to the ARQ1000A to key the transmitter if the ARQ unit is to be used in the OFF mode for standard ASCII or Baudot teleprinter operations. Not normally used in SITOR operations.

PIN 20 - PRINTER WAIT: Control signal from terminal or printer to inhibit data coming from the ARQ1000A. Normally set for No Connection in most systems, as virtually all terminals and printers are able to receive the effective throughput of approx. 50 b/s in SITOR. Accepts standard RS232 Data Terminal Ready (DTR) signal or TTL.

EXTERNAL MODEM CONNECTOR: (NOTE: This connector is typically used only if an external modem is connected; not normally used if the M1700 Modem option is installed.)

PIN 1 - FRAME GROUND: Direct connection to the ARQ1000A cabinet for grounding of a shielded cable between the terminal and ARQ1000A.

PIN 2 - TRANSMIT DATA (TXD): Data output from ARQ1000A to modem for transmission. Can be RS232 or TTL signal.

PIN 3 - RECEIVE DATA (RXD): Receive data from modem to ARQ1000A. Can be RS232 or TTL signal.

PIN 7 - SIGNAL GROUND: Provides standard RS232C signal ground between modem and ARQ1000A.

PIN 19 - TX/RX CONTROL: Provides transmit-receive switching to external modem if required; either open NPN collector (O.C., low=transmit) or TTL (high= transmit); factory set to O.C. (Jumper J6).

PIN 22 - TRANSMITTER PTT: Push-To-Talk control from the ARQ1000A to the modem, if modem is so equipped, for controlling the transmitter PTT circuit. If no PTT connection is made through external modem, then the PTT control line on the Radio Connector (PIN 4) may be used.

PIN 23 - EXTERNAL SCOPE MARK: For use when M1700 internal modem is installed. Output from ARQ1000A which can be used with an external oscilloscope (along with pin 24) to provide a visual presentation of the received signal. This signal is normally fed to the "x" axis input of an x-y input oscilloscope. (Nominal 1000 ohms, 1.0 v P-P)

PIN 24 - EXTERNAL SCOPE SPACE: For use when M1700 internal modem option is installed. Output from ARQ1000A which is fed to the "y" axis of an x-y input oscilloscope (used along with pin 23). (Nominal 1000 ohms, 1.0 v P-P)

RADIO CONNECTOR:

PIN 1 - AUDIO INPUT: Input from receiver audio.

PIN 2 - AUDIO IN GROUND: Second audio input terminal for balanced audio connection to receiver. NOTE: If only a single receive audio terminal is provided on the receiver (unbalanced audio), this pin should be connected to ground.

PIN 4 - TRANSMITTER PTT: Push-To-Talk control from the ARQ1000A to the transmitter. Carries the same signal as pin 22 on the External Modem connector, but designed for direct connection to the transmitter PTT line when the M1700 is installed.

PIN 6 - SELCAL OUTPUT: Control line from ARQ1000A which becomes active (low) when the Selective Call loaded into the ARQ1000A (parameter "LC") is received in ARQ or SEL FEC modes.

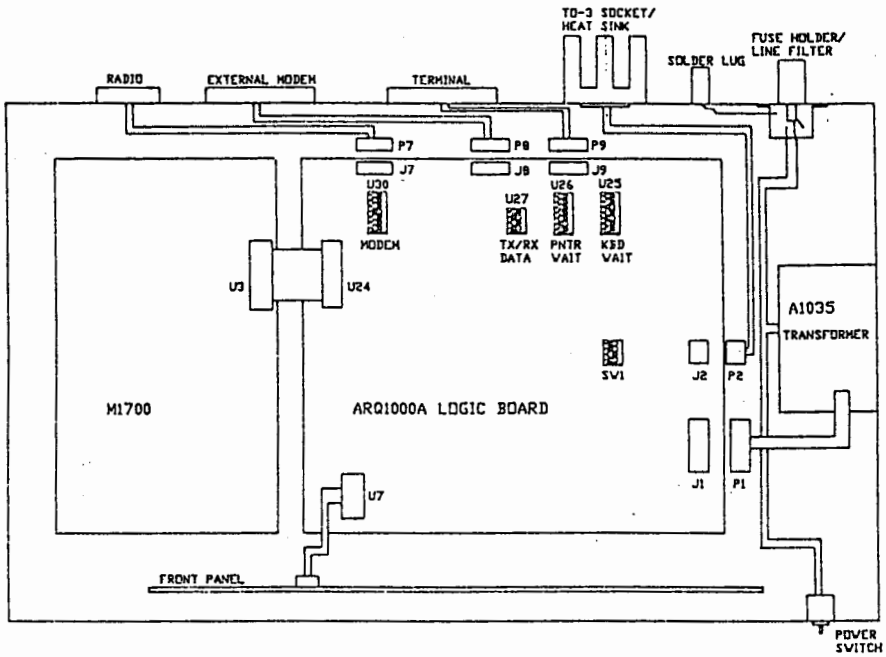
PIN 7 - GROUND

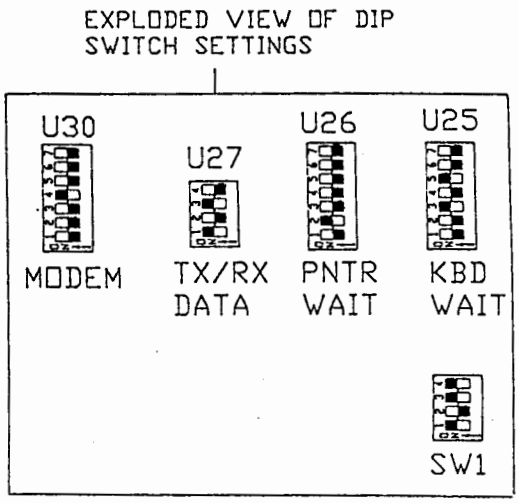
PIN 8 - AUDIO OUT: Output to transmitter audio connections.

PIN 9 - AUDIO OUT GROUND: Second audio output terminal for balanced audio connections to transmitter. This pin is to be grounded if the transmitter supports only unbalanced (single wire) audio.

The I/O interface standards used on the ARQ1000A connections are:

RS232C:	Mark voltage = -5 to -12 VDC
	Space voltage = +5 to +12 VDC
	Source resistance = 300 ohms maximum
	Load resistance = 3000 to 7000 ohms
	Load capacitance = 2500 pF maximum
TTL:	Mark voltage = +3.5 to + 5 VDC
	Space voltage = 0 to + 1.5 VDC
	Output capability = 20 mA (7408)
	Input loading = 1 mA (7408)
OPEN COLLECTOR: (O.C.)	NPN transistor (2N5655)
	Open-circuit voltage = 10 to 200 VDC
	Open-circuit resistance = 10,000 ohms min.
	Closed-circuit current = 10 to 100 mA
	Closed-circuit resistance = 10 ohms max.
	Will ONLY switch positive voltage circuits.





Settings shown for: RS232 Terminal (Keyboard and Printer)
RS232 Keyboard Wait
N/C Printer Wait
M1700 Internal Modem selected
Code & Data Rate = 50 Baud Baudot

FIGURE 4. I/O SWITCH LOCATIONS

2.2 TTY TERMINAL INTERFACE.

The ARQ1000A with the M1700 Demodulator option requires only a teleprinter or video terminal and the transmitter-receiver to make a complete ARQ communications system. Conversely, the ARQ1000A without the M1700 Option may be used as a code conversion device to convert a standard Baudot or ASCII radio teleprinter station into an ARQ station. In either case, the data code, rate, and electrical interface parameters of the terminal and ARQ1000A must first be matched.

The ARQ1000A may be set with internal switches to interface the following terminal parameters:

Data Code:	ASCII or Baudot (ITA No. 2 or U.S. Baudot)
Data Rate:	45, 50, 57, 74, 110, 134.5, 150, or 300 baud
Interface:	RS232C or TTL; separate connections for keyboard and printer.
Control:	Printer Wait (RS232C or TTL, either polarity) Keyboard Wait (RS232C, TTL, or open-collector; either polarity)

These parameters are chosen by switches inside the ARQ1000A. The location of these switches is shown in Figure 4.

2.2.1 SELECTION OF TTY TERMINAL.

Either an ASCII or Baudot encoded TTY terminal may be used with the ARQ1000A at any of the data rates shown above. The terminal should have an I/O interface for RS232C or TTL data circuits. If a high voltage loop terminal is to be used, a loop interface such as the LP1200A is required. Most commercial terminals and personal computers can be interfaced to the ARQ1000A with little trouble. If the ARQ1000A is to be used in a commercial "SITOR" system, it is recommended that your terminal use 50 baud Baudot as this will then work directly for normal RTTY when "SITOR" type communications are not required. Otherwise, you may want to use 110 or 300 baud Baudot or ASCII for the terminal since this will noticeably improve the speed at which the ARQ1000A may be reprogrammed. 45 baud Baudot may be used, but may give some confusing situations on receive because the printer operates slower than the ARQ code through-put (no error or FEC conditions).

Control or "handshaking" connections are provided on the ARQ1000A. These control signals are:

1. PNTR WAIT: A signal from the printer to the ARQ1000A that indicates a printer busy condition.
2. KBD WAIT: A signal from the ARQ1000A to the keyboard or data transmit device that indicates that the ARQ1000A input buffer is full and data input should temporarily halt.

The PNTR WAIT signal may be either RS232C or TTL, of either polarity. The PNTR WAIT signal will not be required for any but the slowest of printers. Since the maximum through-put of the ARQ communications system is 6.67 characters per second, few printers will require this control signal. It may be useful, however, in computer storage applications where disk operations must temporarily interrupt data collection.

The KBD WAIT signal is most advantageous when an electronic data message storage device is used. The KBD WAIT signal may be RS232C, TTL, or open-collector of either polarity. The Open-collector connection may be used to switch positive DC voltages to ground within the maximum limitations of 200V open-circuit and 0.1 amp. closed circuit. Use a control relay if your keyboard control requires voltages or currents beyond these limitations. It is recommended that you now review your terminal's specifications and fill-out the following form which will be used in selection of proper jumpers on the I/O plugs. IF you are using a HAL DS3200, specific settings will be presented later in this chapter.

TABLE 1

TTY TERMINAL PARAMETERS

TERMINAL MFGR AND MODEL: _____

DATA RATE CHOSEN: _____
DATA CODE: ASCII ____ BAUDOT ____

PNTR I/O: RS232C __ (mark = negative voltage)

TTL __ (mark = logic high: +V)

KBD I/O: RS232C __ (mark = negative voltage)

TTL __ (mark = logic high)

PNTR WAIT: REQUIRED? ___ (yes/no)

RS232C __ WAIT = __ (mark or space)

TTL __ WAIT = __ (high or low)

KBD WAIT: REQUIRED? ___ (yes/no)

RS232C __ WAIT = __ (mark or space)

TTL __ WAIT = __ (high or low)

OPEN COLLECTOR __ POSITIVE VOLTAGE __ (yes or no)
VOLTAGE LESS THAN 200 VDC __ (yes or no)
CURRENT LESS THAN 100 ma __ (yes or no)
(if any of the above are "NO", use a relay for control)

WAIT = ____ (open or closed circuit)

2.2.2 TERMINAL CONNECTIONS.

Now that the parameters of your TTY terminal have been defined in Table 1, the required switch selections for the ARQ1000A can be made. Two 7-position and two 4-position DIP switches must be set for the proper terminal I/O parameters. Refer to Figure 4 for the location of the switches. In addition, you may select either standard RS232 RTS (Request To Send) or terminal KOS (Keyboard Operated Switch) to be used for transmitter PTT control when in the off mode for standard TTY.

DATA CODE AND RATE:

The data code and rate are set with the four switches on SW1 located near the right hand side of the main circuit board (see Figure 4.). The four switches are set as defined in Table 2 below:

TABLE 2. TERMINAL CODE AND RATE SWITCHES

Switch	Function	BAUD RATE	SWITCHES ON or CLOSED
1	set code	45	2,3, 4
2		50	3, 4
3	set data	57	2, 4
4	rate	74	4
		110	2, 3
		134.5	3
		150	2
		300	(2,3, and 4 all OFF)

Turn no. 1 "ON" for Baudot, turn "OFF" for ASCII

TERMINAL INTERFACE (TX/RX DATA):

The data connections to the terminal are set by the Switches of U27 labelled "TX/RX DATA". The switches are set according to Table 3 below:

TABLE 3. TERMINAL TX/RX DATA SWITCHES

I/O INTERFACE	SWITCHES ON
RS232	1, 3
TTL	2, 4

PRINTER WAIT CONTROL SIGNAL:

This control signal will generally not be required. However, if your system has need of this signal, set the switches as shown below in Table 4. NOTE! Switch 2 is required if PNTR WAIT is not used!

TABLE 4. PNTR WAIT CONTROL SWITCHES

PNTR WAIT SIGNAL	SWITCHES ON
RS232C (-V = wait)	3, 5
RS232C (+V = wait)	1, 5
TTL (high = wait)	3, 7
TTL (low = wait)	1, 7
No PNTR WAIT req'd	2

KBD WAIT CONTROL SIGNAL:

The KBD WAIT signal is used to control the flow of characters from the terminal into the ARQ1000A. This is most helpful when transmitting a stored buffer from an electronic terminal where the number of characters exceeds 80. When conditions are poor on the radio frequency link, traffic flow may be slowed and a risk of lost text exists if the text is lengthy. The KBD WAIT signal avoids this by inhibiting text transmission from the terminal to the ARQ1000A when the 80 character initial buffer of the ARQ unit is full. The ARQ1000A allows a great deal of flexibility for this control signal so that many variations may be accommodated. Switch selections for the KBD WAIT signal are shown in Table 5.

TABLE 5. KBD WAIT CONTROL SWITCHES

KEYBOARD WAIT SIGNAL	SWITCHES ON
RS232C (-V = wait)	3, 5
RS232C (+V = wait)	1, 5
TTL (high = wait)	3, 6
TTL (low = wait)	1, 6
O.C. (open ckt = wait)	3, 7
O.C. (closed ckt = wait)	1, 7

RTS/KOS TRANSMITTER CONTROL:

If the system will be used to transmit standard Baudot or ASCII code with the ARQ1000A in the OFF mode, you may choose whether RTS or KOS from your terminal will be used to turn on the transmitter PTT for automatic switching to transmit from receive. This is done by selecting the proper location for jumper J3. J3 is located near the right side of the main circuit board (the side nearest the transformer). It labelled RTS and KOS indicating the appropriate positions for the jumper supplied. Factory standard is to set J3 for RTS. If your terminal is equipped with an automatic KOS which is designed to ground the PTT line of a transmitter, you may wish to switch this jumper to the KOS position. The factory-supplied RTS setting is standard for most RS232 terminals.

It now remains to connect the physical wires between the ARQ1000A and the TTY terminal equipment. Since a radio system is involved, it is recommended that shielded cabling be used for these connections. All terminal connections to the ARQ1000A are made to the DB-25 TERMINAL connector on the rear panel.

2.2.3 CONNECTION TO THE HAL DS3200 RADIO COMMUNICATIONS TERMINAL

The HAL DS3200 is ideally suited for use as an ARQ I/O terminal. RS232 connections are used between the ARQ1000A and the DS3200 as shown in figure 5. The DS3200 makes use of the KBD WAIT signal but does not require the PNTR WAIT signal.

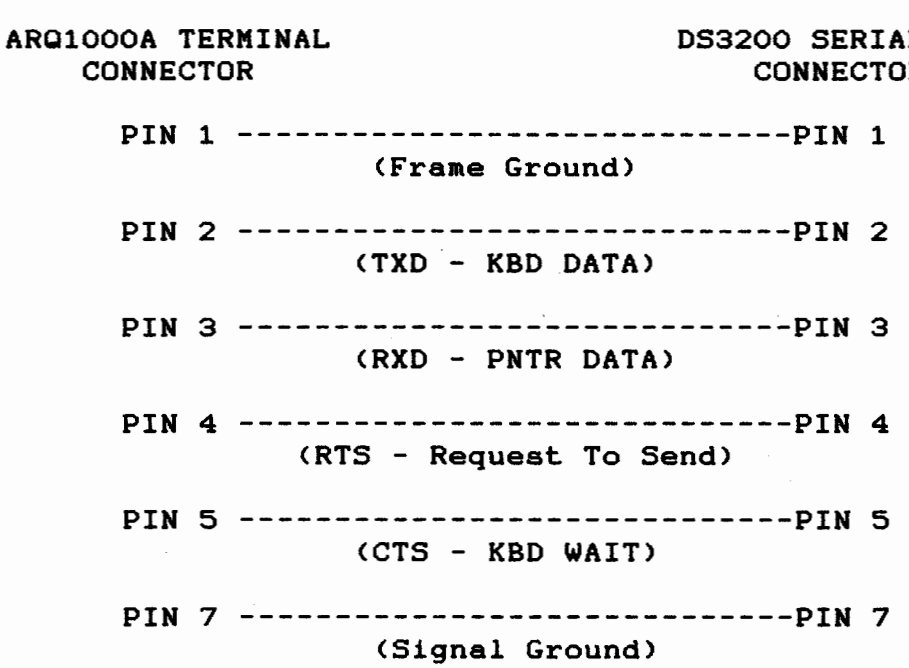


FIGURE 5. DS3200 TERMINAL CONNECTIONS TO ARQ1000A

2.3 DEMODULATOR CONNECTIONS.

The ARQ1000A may be used with its own M1700 Optional internal demodulator or with any high quality RTTY demodulator. When the M1700 demodulator option is used, the M1700 board mounts in the ARQ1000A cabinet and plugs into the main circuit board at socket location U24. Switch 4 of the Modem switches (U30) should be on and all others off when the M1700 is installed. With the M1700 installed, connections may be made directly between the ARQ1000A Radio Connector and the transmitter-receiver system. This connector is ONLY used when the M1700 modem option is installed.

2.3.1 DEMODULATOR SWITCH SELECTION

Connection of a demodulator to the ARQ1000A requires setting of switches on the MODEM 7-position DIP switch (location U30), in a manner similar to that used for the TTY terminal I/O selections. Separate selection may be made for transmit data to the tone generator and for receive data from the demodulator. The switch selections are made as shown in Table 6. below.

TABLE 6. MODEM I/O SWITCH SELECTION

DATA	I/O	SWITCH ON
TX DATA	RS232C	5
	TTL	7
RX DATA	RS232C	1
	TTL	3
For M1700 Installed		4

By choosing the proper switches, it should be possible to interface virtually any high performance modulator/demodulator system. If it is necessary to interface the modem directly through a high-voltage loop circuit, it is recommended that optical loop isolation devices be obtained. Such devices are available from HAL Communictions Corp. at a modest cost.

2.3.2 ARQ1000A CONNECTIONS TO HAL DEMODULATORS.

The HAL ST8000 and ST6000 demodulators, as well as earlier models, can be easily connected to the ARQ1000A for use in an ARQ system. Diagrams of the connections to both the ST8000 and ST6000 Demodulator follow, along with appropriate switch settings for both demodulators for operation in ARQ mode.

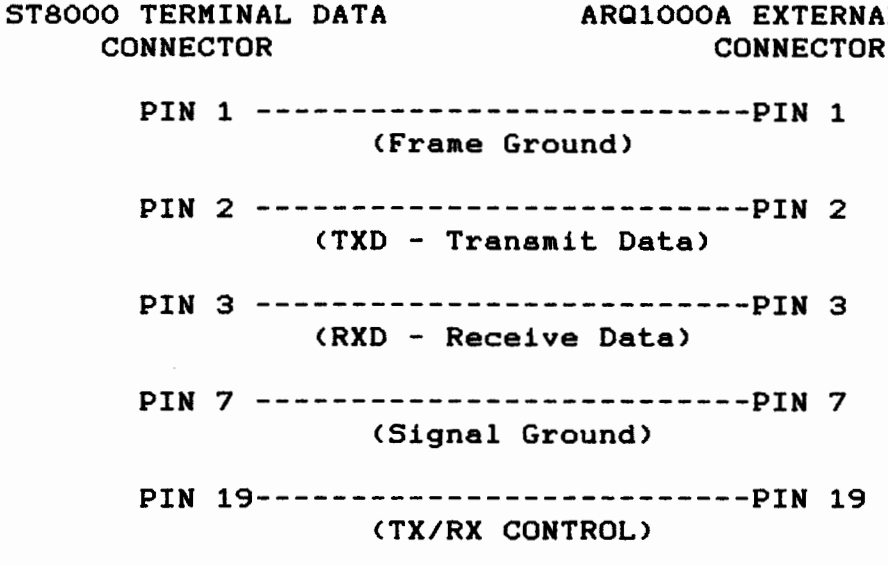


FIGURE 6. ARQ1000A CONNECTIONS TO ST8000 HF MODEM

In ARQ mode the transmitter PTT line and the tones from the modem are activated at different times. Pin 22 on the External Modem connector or pin 4 on the Radio connector of the ARQ1000A can be used to key the transmitter PTT. The Pin 19 connection between the ARQ1000A and the ST8000 then controls the On/Off condition of the ST8000 transmit tone keyer. Other connections to the ST8000 are at RS232 logic levels. Switch number S4-5 of the ST8000 should be set to ON so that AFSK tones are present only during the transmit condition. (See ST8000 manual.) The ST8000 should be left in RX mode, REGEN OFF, ANTISPACE OFF, POLARITY NORM, PRINT SQUELCH counter-clockwise, Data Rate 100 Baud, and set to the proper tones for the intended use (for SITOR normally 1615 Hz Mark, 1785 Hz Space).

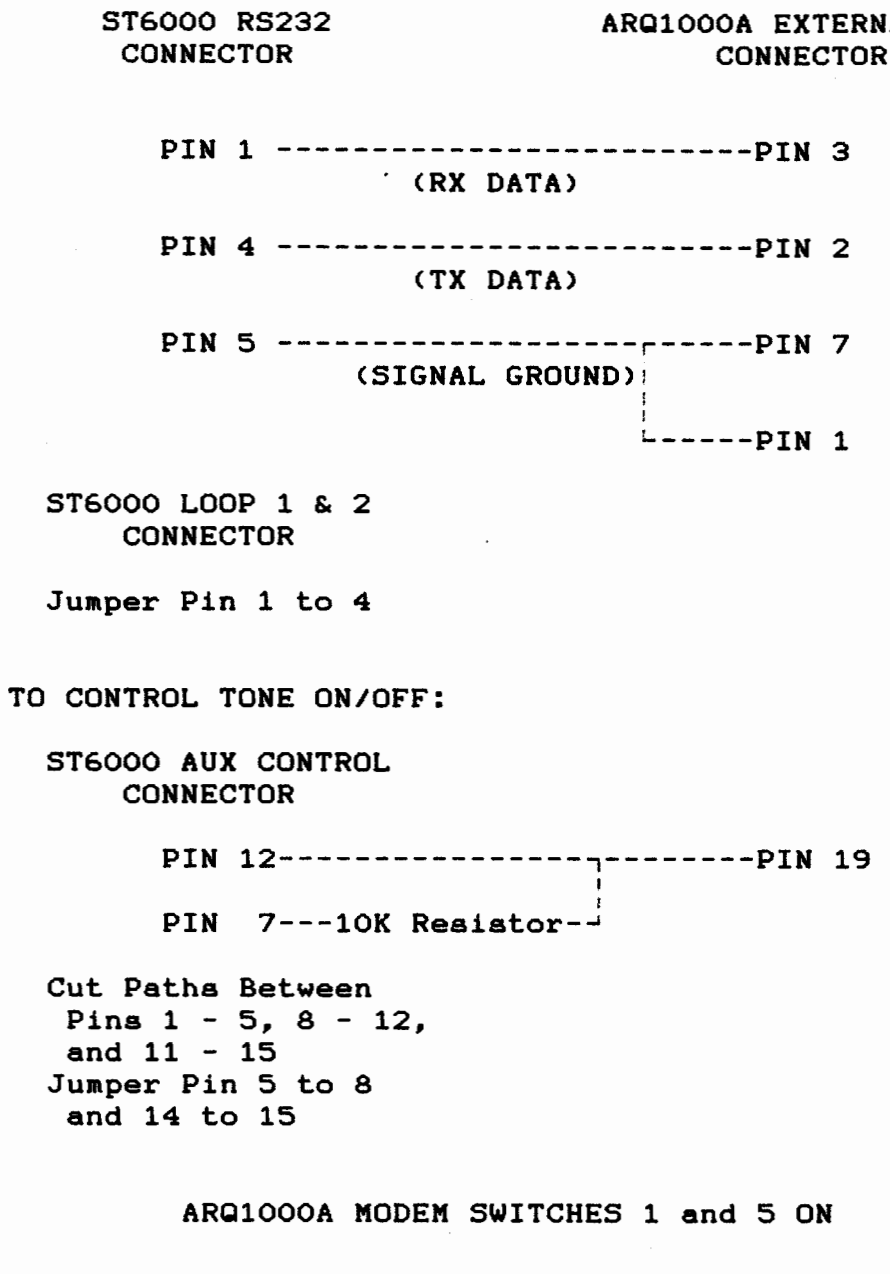


FIGURE 7. ARQ1000A CONNECTIONS TO ST6000 DEMODULATOR

When connected to the ARQ1000A, the ST6000 loop circuit must be jumpered (Loop 1 & 2 Conn.) and no connections should be made to the loop circuit. Serious damage to the ARQ1000A may occur if direct loop connections are made. All data connections are RS232. The modifications shown to the Aux. Control Connector of the ST6000 are necessary if tone on/off control is required. The ST6000 should be set as follows: LIMITER ON, NORMAL Polarity, ATC OFF, DTH OFF, LINE Selected, KOS OFF, AUTOSTART OFF, 170 Hz shift.

2.4 TRANSMITTER AND RECEIVER CONSIDERATIONS

The transmitter, receiver and their associated antenna(s) finish the ARQ radio communications system. Use of the ARQ mode in particular imposes stringent switching time requirements on the transmitter and receiver. As will be discussed in detail in Chapter 4, the ARQ mode requires burst-type communications between the two stations involved. An appreciation of the switching problem involved can be grasped by careful study of the timing diagram in Figure 8.

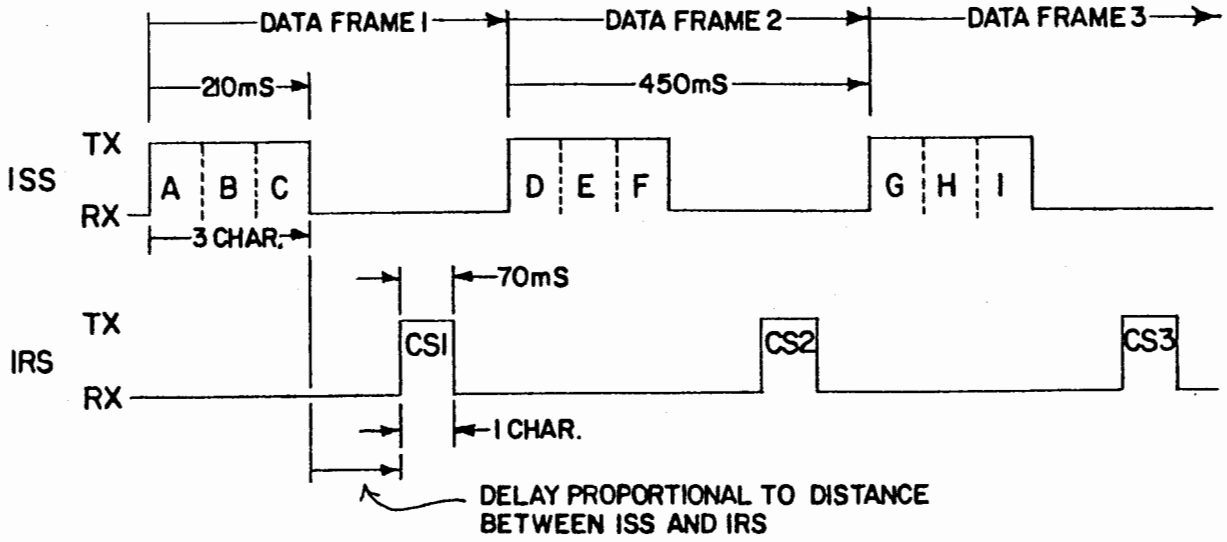


FIGURE 8. ARQ MODE TIMING

In ARQ mode, the Information Sending Station (ISS) transmits a burst of three characters in a 210 millisecond (ms) period and the Information Receiving Station (IRS) then responds with a 70 ms control signal burst. The cycle repeats itself every 450 ms. The time delay between the end of the ISS burst and the beginning of the IRS response is critical. This time will vary with the distance between the two stations due to the finite propagation time required. The delay will be short for closely spaced stations and long for greatly separated stations. Theoretically, this delay could be between 0 and 170 ms, corresponding to a range of 0 to 26,000 km, more than half-way around the earth. However, delays created by less than ideal switching characteristics of the transmitter and receiver tend to reduce both the minimum and maximum range over which the ARQ system will operate.

All real transmit-receive system delays can be expressed in terms of four times: (1) transmitter turn-on, (2) transmitter turn-off, (3) receiver turn-on (or recovery), and (4) receiver turn-off delay. Of these four possible sources for system errors, the transmitter turn-off and receiver turn-on are usually the most damaging. These delays may be measured on your transmitter and receiver system with a triggered-sweep oscilloscope. Trigger the start of the sweep from either the leading or trailing edge of a pulse applied to the transmit-receive control circuit (PTT). Observe the RF output envelope of the transmitter to measure transmitter delays. Tune the receiver to produce a mark audio tone and observe the audio output envelope to determine the receiver delays. These time delays are shown graphically in Figure 9.

In general, transmit-receive switching delays are usually caused by relays, switching circuit time constants, receiver gating and AGC time constants, and receiver recovery from blocking by the transmitter itself. In practice, it has been noticed that systems with transmitter on and off delays of 10 ms or less and a receiver recovery delay of 30 ms or less work well over most usable communications paths. Receive turn-off delay is rarely a problem. Delay problems are most severe when simplex ARQ communications are used (same frequency for transmitting and receiving). Transceivers also seem to have more delay problems than separate units, particularly when duplex operation is used (separate frequencies for transmit and receive). Some transceivers may be capable of adequate ARQ simplex communications but may have excessive delays when used in a duplex system due to the delays introduced by relay switching between frequency bands. Some transceivers may appear to pass the oscilloscope timing test but still prove unsuccessful due to synthesizer settling time as the internal local oscillator is switched between transmit and receive frequencies.

When choosing a new piece of equipment for ARQ operation, try to pick one that is rated for ARQ service. If such a rating is not available, a transceiver rated for "QSK" (fast break-in CW) use will usually have very fast switching times, but some modifications may still be required for optimum ARQ operation. In general, transceivers that do NOT require relays for transmit-receive switching will be noticeably better suited to ARQ operation: equipment that uses multiple relays for transmit-receive control rarely work well for ARQ use. Since the ARQ mode is inherently error correcting, high powered amplifiers are seldom needed and their associated transmit-receive switching relays usually preclude use for ARQ communications. Most ARQ communications is conducted on the high frequencies with transmitter output powers of 100 watts or less.

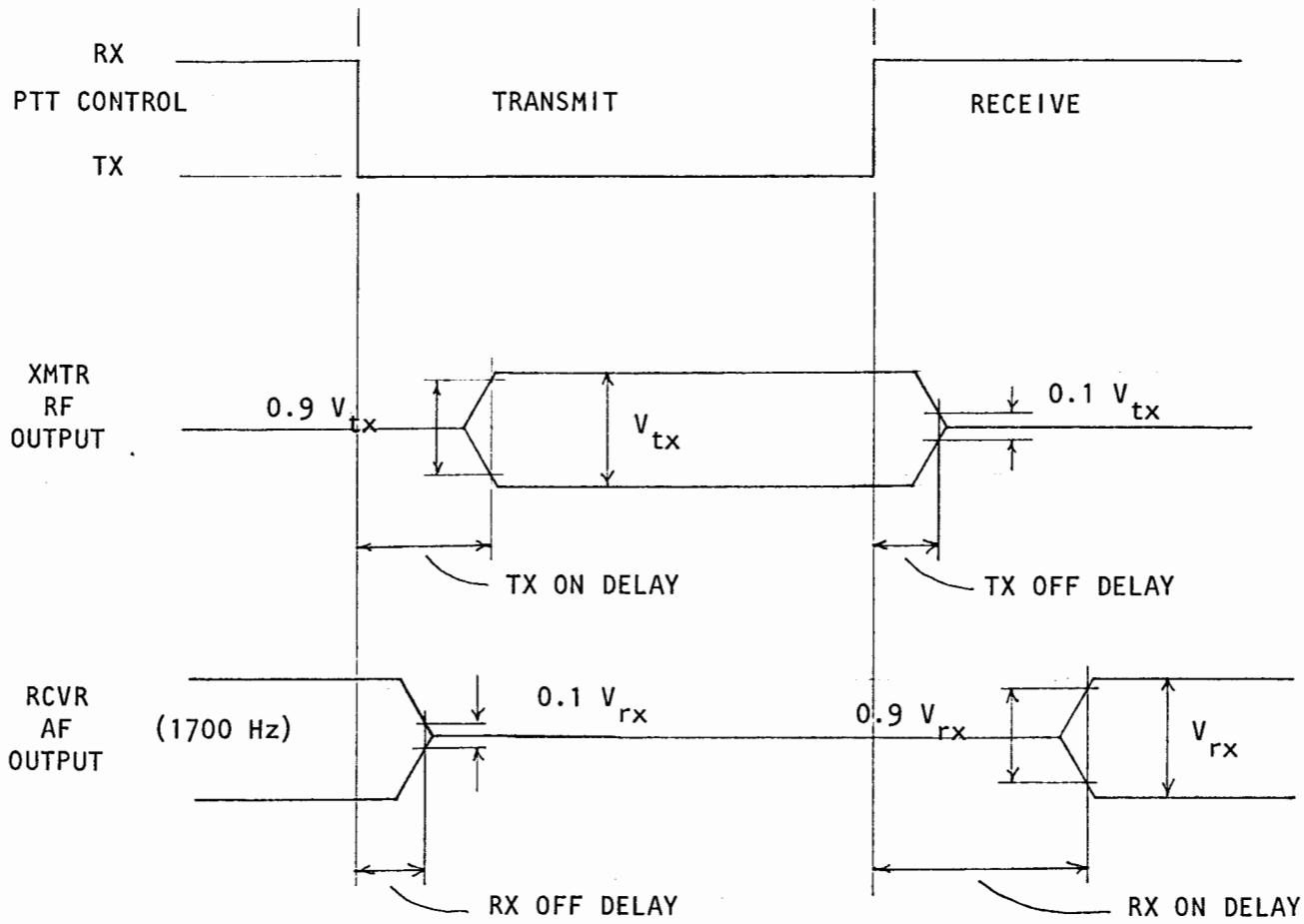


FIGURE 9. ARQ TX/RX TIMING

The other considerations for choosing a transmitter-receiver system for ARQ communications are: (1) stability, (2) duty cycle, and (3) flexibility. ARQ communications use 170 Hz shift or difference between the mark and space (or Y and B) signal pulses. As little as 20 Hz drift in frequency may prevent adequate communications. If unattended monitoring of an ARQ communications channel is desired, the long-term stability of the transmitter and receive system should be no worse than +/- 20 Hz. If the station is continuously manned by an operator, stabilities as poor as +/- 100 Hz can be made to work, but only with constant operator attention.

The duty cycle of ARQ mode communications is 47% (ISS condition), similar to that required for Morse code or voice transmissions. However, when the station transmits text in FEC or SEL-FEC modes, the transmitter is turned on continuously, a 100% duty cycle. Therefore, to take advantage of all the capabilities of the ARQ1000A, the transmitter must be capable of continuous output. The continuous output power rating of the transmitter should be checked closely and the recommendations of the manufacturer followed. This is particularly important if the transmitter is designed for primary use for SSB voice communications. In general, the power output rating for a SSB/CW transmitter will be less when used for continuous output.

The job of the radio operator will be much simpler if flexible receiver features are available. An RIT or clarifier control will allow the operator to offset his receiver frequency from the transmitter frequency and thus adjust for a drifting transmitter at the other station. Also, passband tuning, adjustable receiver bandwidth, and tunable notch filters will provide ways of continuing communications even when interference is strong. A line audio output from the receiver that is not controlled by the front panel volume control allows the operator to turn-down the speaker volume without affecting ARQ system performance (connect demodulator to line output when possible).

Finally, consider the power rating of the antenna itself. Often, antennas using loading coils may perform quite adequately in SSB and CW service, but melt when the same RF power is used in 100% duty cycle communications such as RTTY and FEC or SEL-FEC.

CHAPTER 3

OPERATING THE ARQ1000A

The HAL ARQ1000A is a self-contained communications processor that will convert send and receive RTTY data into the 7-unit ARQ (Moore) data code. It is designed to offer a great deal of versatility to the user and to simplify the sometimes complicated operation of an ARQ system as much as possible. The feature of menu operation from the terminal makes operation of the ARQ1000A very simple. This will be discussed in detail in section 3.3. As was discussed in Chapter 2, the I/O interface of a great variety of terminals and modems can be sucessfully met with the user-settable switches inside the ARQ1000A. It is recommended that, before attempting operation as described in this Chapter, the user should have connected his radio modem and TTY terminal as described in Chapter 2. Even though all functions of the ARQ1000A may be controlled from the terminal keyboard, a discussion of the ARQ1000A Front Panel is presented here to thoroughly aquaint the operator with the unit.

3.1 ARQ1000A FRONT PANEL

The ARQ1000A front panel includes 30 indicator lamps, 11 control switches, and a power switch. Although not all of the indicators and switches may be considered absolutely essential for good ARQ communications, they do provide a great deal of operator information and flexibility.

3.1.1 MODE CONTROL SWITCHES/INDICATORS

The left end of the front panel provides selection and indication of the mode of operation of the system. The six indicators within the MODE area may be thought of as switch positions of a rotary switch. The rotary switch is pulsed one position clockwise each time the MODE switch is pressed. The control switches on the ARQ1000A front panel are all membrane, pressure-sensitive switches. A small "beep" will be heard whenever a switch has been pressed. The MODE switch will step the ARQ1000A through the following modes:

OFF — ARQ1000A is logically off: RTTY data is connected directly between the modem and TTY terminal.

STBY — Normal "rest" position of ARQ1000A. When receiving, ARQ1000A will automatically step to ARQ, FEC, or SEL-FEC mode when recognized. When reception has automatically switched, both the STBY and selected mode (ARQ, FEC, SEL) lamps will be lit.

ARQ — Indicates that the ARQ mode is being used for communications. When both the ARQ and STBY lamps are on, the ARQ1000A has detected a valid ARQ call and automatically switched to ARQ mode. If ARQ mode is originated at this unit, only the ARQ lamp will be on.

FEC — Indicates that FEC mode is being used. If both FEC and STBY lamps are on, ARQ1000A has switched automatically for reception of an FEC signal. When transmitting FEC only FEC lamp is on.

SEL — Indicates that SEL-FEC mode is being used. Since selective FEC is a subset of FEC, both the SEL and FEC lamps will be on. If the STBY lamp is also on, this indicates reception of a valid SEL-FEC signal. As before, only the SEL and FEC lamps will be on while transmitting.

MON — Indicates selection of MONitor mode. MON is a receive-only mode. When a valid ARQ, FEC, or SEL signal is received, the appropriate indicator will turn on in addition to the MON lamp.

RESET SWITCH: When pressed, does a full reset of all ARQ1000A logic circuitry. All internal buffers are cleared and the ARQ1000A is returned to the default mode as defined in program mode.

3.1.2 TRANSMISSION CONTROL SWITCHES

Several of the front panel switches may be used to control the transmission mode or condition. These switches are: SEND, OVER, and END. The functions of these switches are as follows:

SEND SWITCH: To initiate transmission from the front panel, the desired mode is first selected with the MODE switch. Pressing the SEND switch will then start transmitting in the desired mode.

OVER SWITCH: When pressed during ARQ mode communications, an OVER operation is initiated. The ISS and IRS stations exchange roles.

END SWITCH: When pressed, causes the sending of the correct END transmission sequence.

3.1.3 SYSTEM INDICATION AND CONTROL

The center group of indicators are used to show the current ARQ system status. These are informative to the operator and often a quick glance at these indicators can resolve otherwise confusing behavior.

MASTER: Indicates that this ARQ1000A has originated the transmission and is the MASTER station in ARQ mode. This lamp will always be on when sending FEC or SEL-FEC data. The transmission timing is always set by the MASTER station.

SLAVE: In ARQ mode, indicates that the ARQ1000A responded to or is waiting for a call from another station. This lamp is always on when receiving FEC or SEL-FEC data and in all of the MONITOR modes. The timing of the SLAVE is always locked to that of the originating MASTER station.

ISS: Information Sending Station. When lit, shows that this station is presently sending data. In ARQ mode, this condition changes with the OVER command. In other modes, the ISS lamp will only be on when traffic is being transmitted by this station.

IRS: Information Receiving Station. When lit, shows that this station is presently receiving data or is waiting for a call. In ARQ mode, this condition changes with the OVER command. In other modes, the IRS lamp will be on when traffic is being received by this station.

B/Y: Indicate data state of the transmitted and received signal. Proper system operation is shown by alternate flashing of these lamps.

NORM/REV: Indicates polarity of ARQ1000A transmission. All transmission (including SEL-FEC) should show NORM polarity if the standard of Y=lower radio frequency is used, as in Marine Telex operations. However, polarity may be reversed (with N/R switch) if a reverse signal is desired as in amateur radio use.

TX/AUTO/RX: Indicates status of transmit-receive control signal. During ARQ communications, AUTO lamp will be on and TX and RX lamps will show instantaneous state of the radio system. The TX/RX CONT switch may be used to set either AUTO control or continuous transmit or receive condition. The AUTO lamp is extinguished when either continuous receive or transmit is selected.

B/Y SWITCH: When pressed, sets the ARQ1000A to transmit alternate B and Y signal conditions for 450 ms each state. Used for channel testing; turn off with RESET switch or by entering program mode with BREAK. The ARQ1000A will NOT send correct ARQ code or respond to a call when the B/Y test mode is active.

N/R SWITCH: Changes polarity of both receive and transmit data as indicated by the NORM/REV lamps. One press selects REV, second press returns NORM polarity. Leave in NORM condition unless a non-standard signal is to be used.

TX/RX CONT SWITCH: Controls operation of transmit-receive signal. Set to AUTO for normal ARQ, FEC, and SEL-FEC operations. May be set to TX for continuous transmit (as when testing) or to RX to prevent automatic ARQ1000A response to an ARQ call (as when performing equipment maintenance). Three step action - first press sets RX, second press TX, and third press back to AUTO.

BREAK SWITCH: Enter Program mode(see section 3.2); has same effect as pressing the keyboard BREAK key or entering BRK (CR).

3.1.4 DATA INDICATORS

The right section of the ARQ1000A panel is devoted to 13 indicators that show what type of data is being received and transmitted. The indications of these lamps will vary somewhat as the mode and transmit or receive condition of the terminal changes. The TFC, IDLE, RQ, and ERR lamps are particularly useful to the operator when signal conditions are poor. The nature of the ARQ mode of transmission is such that no characters will be printed (on receive) or sent (in transmit) while errors are being corrected. Under such conditions, the ARQ system may require many repeats of text or control signals until the errors are resolved. These four lamps will at least inform the operator that communications are still being made, even though no receive text is being printed or the transmitting of text has halted. The data indicators show the following information:

TFC: In ARQ mode as ISS, shows when traffic is being transmitted. Does not indicate in IRS ARQ mode. In FEC and SEL-FEC mode shows transmission and reception of traffic (ISS and IRS).

IDLE: In ARQ mode as ISS, shows when idle signals are being transmitted. Does not indicate in ARQ IRS mode. In FEC and SEL-FEC mode, shows transmission and reception of idle signals (PS1/PS2 in FEC or beta in SEL-FEC).

RQ: In ARQ mode, shows request for error correction in either ISS or IRS condition. Shows idle condition in FEC mode.

ERR: In ARQ mode, shows reception of a character in error in either ISS or IRS condition. Shows reception of errors in both DX and RX sets of data in FEC and SEL-FEC modes.

PHAS: In ARQ mode shows reception of signals and that the ARQ1000A is trying to establish the communications link.

OVER: In ARQ mode, shows that one station (ISS or IRS) has requested a turn-around in the channel. No indication in FEC or SEL-FEC mode.

CS1: CS2: In ARQ mode as IRS, shows transmission of (CS1) and (CS2) control signals. No indication in ARQ ISS mode or in FEC or SEL-FEC modes.

(ALPHA): In ARQ mode, shows transmission of 3 - alpha end of transmission signal; also shows when alpha of the (beta-alpha-beta) OVER signal is transmitted in ARQ mode. In FEC and SEL-FEC ISS mode, shows transmission of phasing signal 1.

(BETA): In ARQ ISS mode shows transmission of idle state (3-beta); also shows reception of (beta-alpha-beta) OVER signal. In SEL-FEC mode shows transmission of idle (3-beta) signal.

WRU: In ARQ IRS condition, shows reception of the WRU character (FIGS D = $ in U.S. Baudot). When received, an OVER operation is executed, the contents of the ARQ1000A HERE IS buffer is sent, and a second OVER is executed.

SEL-CAL: IN ARQ IRS and SEL-FEC IRS modes shows reception of the local (ARQ) or group (SEL-FEC) selective call identifier code. Also indicates that SEL-CAL output on rear panel has switched to the "on" state to activate a signal bell, turn on the printer, or stop receiver scan.

INPUT INHIBIT: Indicates that text will not be accepted from the keyboard. Active in all IRS conditions (ARQ ISS, FEC, and SEL-FEC SLAVE). Also shows status of rear panel KBD WAIT signal.

3.1.5 WRU AND HERE IS SWITCHES

The ARQ1000A includes provision for either manual or automatic transmission of the radio station's call letters. The call sign is stored in the programmable HERE IS memory. Any text, up to 32 characters in length may be stored in the HERE IS memory. The HERE IS message will be transmitted whenever the operator presses the front panel HERE IS switch. If the station is in ARQ ISS condition, the HERE IS message is

simply attached to the end of current transmit text in the transmit buffer. If, the station is in ARQ IRS mode, an OVER command is first issued to turn the channel around, the HERE IS text sent, and then a second OVER issued to restore the original ISS/IRS alignment. The HERE IS message may also be inserted at any time into transmitted text when sending FEC or SEL-FEC data. The HERE IS switch has no effect when the station is receiving FEC or SEL-FEC messages.

The WRU switch causes the ARQ WRU code to be transmitted. In the case of the ITA No. 2 Baudot, this corresponds to "FIGS D". In the U.S. Baudot code, the "FIGS D" is usually interpreted as "$". The ASCII translation of the ARQ1000A converts "$" into "FIGS D". If an ARQ station is equipped with a WRU (Who aRe yoU) answer-back feature, reception of the FIGS-D code will cause the IRS to issue an OVER command, transmit its HERE IS message, and then issue a second OVER command. The sending station (ISS) may therefore request identification of the other station by simply sending "FIGS D" ("$" on U.S. Baudot machines). The WRU feature is only active when in ARQ mode and may be turned on or off by programming the ARQ1000A as explained in section 3.2.8.

The BREAK front panel switch performs the same function as pressing the keyboard BREAK key or typing BRK (CR). This feature is used to enter programming mode of the ARQ1000A.

3.2 PROGRAMMABLE FEATURES OF THE ARQ1000A

The ARQ1000A contains several features which may be programmed from the terminal keyboard. Included among these features are station identifiers, timing parameters, terminal interface features, and conditions for boot-up after a RESET. The ARQ1000A has non-volatile storage of all programmable features and they will therefore not be lost if AC power is interrupted. Programmed items stay in storage until they are changed by the next entry.

3.2.1 ENTERING PROGRAM MODE

The programming mode of the ARQ1000A is entered in one of three ways:

1. Press the front panel BREAK button for 1/2 second or longer.
2. Press the special BREAK key on your keyboard,if so equipped. This is usually designed to send a 1/2 sec. or longer space condition from the keyboard.
3. Type "BRK" and a carriage return (CR) on your keyboard.

After the BREAK has been entered from the keyboard or front panel, all front panel lights except "B", "Y", and "INPUT INHIBIT" turn off and the ARQ1000A responds with the following output to the terminal printer (or video screen):

```
ENTER HE: FOR COMMAND LIST
CMD ?
```

The question mark is the prompt for you to enter programming data. It is also the operator's clue that the ARQ1000A is in programming mode and will NOT be usable for ARQ communications until the mode has been exited.

Note that the time it takes for the printer to print a response is controlled by the data rate selected for the printer. When video terminals are used, programming is faster if a moderately high data rate is used (110 baud Baudot or ASCII, for example). In the maritime service, it is recommended that the terminal rate be kept at 50 baud Baudot so that direct traffic may be passed to/from public coast stations in the OFF mode.

3.2.2 PROGRAMMING COMMANDS AND FORMAT

After the ARQ1000A programming response, you may wish to type HE: (CR) to obtain a complete list of the programming commands of the ARQ1000A. This will take some time to print out, especially if the terminal data rate is slow.

> NOTE: If you wish to avoid having to wait for the entire programming command list to be printed, you may stop printing of the command list by hitting the space bar on your keyboard. This may be useful if you wish to get out of the programming mode quickly to make or receive a call.

Two types of programming commands are used on the ARQ1000A; (1) those that require no operand and (2) those commands that do have an operand. For example, to specify programming of the HERE IS message, you need to first state that the HERE IS message is to be programmed and then enter the text to be stored. On the other hand, if you just want to list the current status of the programmable features, only a status command is required. The command set used on the ARQ1000A always involves a colon after the command followed by the operand and then terminated with a CR/LF entry. The list of programming commands is:

```
HI:[32 characters of text maximum] = HERE IS message
LC:[4 or 5 characters]  = local call identifier
RC:[4 or 5 characters]  = remote call identifier
GC:[4 or 5 characters]  = group call identifier
CS:X or CS:1            = ARQ IRS control signal sequence
EC:ON or OFF            = terminal echo on or off
WR:ON or OFF            = WRU response on or off
TO:ON or OFF            = retry time-out on or off
CF:ON or OFF            = Conversational FEC on or off
BC:ON or OFF            = Buffer Clear on or off
CD:[2 digits]           = Control Delay in milliseconds
TD:[2 digits]           = Transmit Delay in milliseconds
AD:[2 digits]           = Audio delay in milliseconds
```

```
Default after RESET parameters:
  SD:ON  or OFF            = go to SEND after RESET
  NR:NORM or REV           = go to NORM after RESET
  TR:AUTO or TX or RX      = go to AUTO after RESET
  BY:OFF or ON             = turn BY test on or off after RESET
  MD:OFF                   = set mode as indicated after RESET
     STB
     ARQ
     FEC
     SEL
     MON

  ST:  =  print out status of programmed features
  HE:  =  print the complete command list
  SH:  =  print an abbreviated version of the command list
  EX:  =  exit from programming mode
```

ALL program commands are entered in the format:

[command]:[argument]CR
where "CR" = carriage return or other end of line sequence

For example: "EC:ON CR" or "LC:1234 CR"

3.2.3 PROGRAMMING THE HERE IS MESSAGE

The ARQ1000A will accept any of the ARQ code characters in the HERE IS program area. The storage is limited to a maximum of 32 characters, excluding carriage control (CR,LF) which cannot be used as part of the HERE IS text. If more than 32 characters are entered, only the first 32 are stored. To program the HERE IS message, first enter a BREAK command from the keyboard or front panel. After the "?" prompt is printed, enter the following:

HI:[here is text, up to 32 characters]CR

Additional characters following the CR may be entered (such as LF and LTRS), but they are not essential and are ignored by the ARQ1000A.

The ARQ1000A will again respond with "?", indicating that it is ready for the next programming feature. If you wish, you may check that the program has been stored by typing "ST:CR" to get the new status list. If no program is desired for the HERE IS message, enter a non-printing character such as the Baudot blank character. The entry of a new program erases and replaces the previous entry.

3.2.4 PROGRAMMING THE IDENTIFIER CODES

There are three different identifier codes to be programmed in the ARQ1000A. These are:

1. The LOCAL CALL (LC:) identifier. This is the identifier that your station will respond to when called in ARQ mode.

2. The REMOTE CALL (RC:) identifer. This is the identifier code of the other station you are calling in ARQ mode.

3. The GROUP CALL (GC:) identifier. This is the identifier used when you transmit or receive a SEL-FEC message. It should correspond to the identifier of the group of stations you wish to address when transmitting in SEL-FEC mode or to the group call issued by the desired transmitting station when you are receiving.

In all three cases, the identifier code consists of four letters. However, commercial practice as defined in CCIR Rec. 491 is to specify identifer codes as four or five digit numbers. The tables of 491 then define the corresponding letters that are used to represent these numbers. The ARQ1000A will accept EITHER all numbers (4 or 5 digits) or letters (4 letters) for the programming of the three identifier codes. However, each entry must be self-consistent. If a number is entered as the first character, the other three (or four) characters should also be numbers. If a letter is entered as the first character, the remaining three characters should also be letters. When numbers are entered, they are immediately converted and stored as the equivalent letters so that a subsequent use of the status command (ST:) will show only the letter equivalents of the numbers entered. The translation tables of CCIR 491 are shown in APPENDIX C.

A unique feature of the ARQ1000A is that, although the CCIR 491 definition only recognizes 20 of the 26 letters of the alphabet (G,H,J,L,N, and W excepted), all 26 are allowed in the ARQ1000A programming, lending extra flexibility.

To program the identifier codes, use the following procedure:

1. Enter program mode with BREAK or BRK (CR)
2. After "?" prompt type
3. LC:[4 char]CR
   or RC:[4 char]CR
   or GC:[4 char]CR

You may check that your entries have been stored by typing "ST: CR" to get the status list of all programmed items.

3.2.5 CS:X/CS:1 CONTROL SIGNAL PARAMETER

There is an observed difference in the transmission of control signals in some existing commercial SITOR/TOR equipment. The difference comes about in ARQ mode when the OVER (+?) command is used. When the OVER command is sent, the relative positions of the ISS and IRS stations exchange. As discussed in section

3.3.2, the IRS equipment responds to each received 3-character block with either the (CS1) or (CS2) control signals, alternating if there are no errors. When an OVER command is executed, the new IRS then starts response with either (CS1) or (CS2). CCIR 476-2 does not specify which of the two characters should be transmitted first (CS1 or CS2). Some existing equipment always has the new IRS start with the (CS1) signal. To be compatible with this equipment, enter "CS:1 CR" in program mode.

Other commercial equipment has the IRS start with whatever the next sequential control signal would have been prior to the OVER command; (CS1) if (CS2) was last sent before the OVER or (CS2) if (CS1) preceded the OVER. To be compatible with this equipment, enter "CS:X CR" in program mode.

The ARQ1000A itself will actually accommodate either format when communicating with another ARQ1000A. However, it may not be possible to maintain communications with equipment of another manufacturer unless this parameter is set correctly. This may be particularly noticeable when the communications channel is noisy and errors interrupt the "OVER" process. The factory standard is to set "CS:X."

3.2.6 EC:ON/EC:OFF TERMINAL ECHO PARAMETER

The ARQ1000A includes an internal echo feature that may be turned on or off. The correct setting of this parameter depends upon how the terminal is constructed and connected to the ARQ1000A. Terminal echo is a feature that allows the printer or video screen to show not only received text but also that which will be transmitted. When a full duplex terminal is used with the ARQ1000A, the text typed on the keyboard will not normally be displayed unless the external device (ARQ1000A) provides the feed-back or "echoes" the text to the printer. In such cases, it is recommended that you turn the EC feature on with the "EC:ON CR" command when programming.

Many video terminals include an internal echo feature that automatically displays both receive text and typed text as it is transmitted. In this case, you will want to turn the echo feature off with the "EC:OFF CR" command when programming. This feature need usually be set only once when first connecting a terminal and will remain the same for as long as particular terminal is used.

The following settings are recommended for common terminal connections:

DS3200 (FDX mode): (recommended)	echo ON (EC:ON)
DS3200 (HDX mode):	echo OFF (EC:OFF)

When using a FDX terminal notice that the echoed transmit text is not sent to the printer (or receive video screen) until it is actually transmitted from the terminal. This means that if

you send a precomposed text such as the QUICK BROWN FOX... message you will not see the full message until it is sent from the terminal to the ARQ1000A. When a terminal with hardware flow control, such as the DS3200, is used, it is highly recommended that you also connect the KBD WAIT (CTS on an RS232 terminal) control to prevent over-running of the ARQ1000A input buffer. The split screen capability of the DS3200 is particularly useful in this application in that you may observe both keyboard entered text and progress of transmitted text.

If the echo is turned ON and the terminal has local echo, you may see no printer or screen response to typed characters, double characters, or completely garbled response. If the echo is turned off and the terminal has no local echo, you will see no printer or screen response to typed characters. In all cases, the solution is to change the echo parameter.

3.2.7 TIME OUT (TO) PARAMETER

In ARQ mode communications, the signal conditions may become so poor that communication between the two stations is temporarily lost. The ARQ1000A includes provision so that the MASTER station will attempt to re-establish contact in such a condition, even to the point of returning itself to ISS if signal was lost while serving as IRS, and then initiating the original selective-call sequence if necessary. The ARQ1000A can be set to re-call the lost station either continuously or for a set period of time after communication is broken. The time out parameter may be set to "TO:OFF" or "TO:ON" for "time-out off or time-out after 64 call-cycles (TO:ON). To program this parameter, enter programming mode and then type either "TO:OFF" or "TO:ON" as desired. The factory standard setting is "TO:ON".

3.2.8 WR:ON/WR:OFF WRU CONTROL COMMAND

The ARQ1000A includes an automatic Who aRe yoU (WRU) answerback feature. When it is active, reception of the WRU code (FIG-D) will cause the receiving ARQ1000A to issue an OVER sequence, send the contents of its HERE IS buffer, and issue a second OVER sequence. This feature allows the sending station to confirm the identity of the receiving station in ARQ mode. Unfortunately, the FIGS-D character is also used to represent the dollar sign ($), particularly on United States terminals. If the WRU feature is ON, each reception of "$" (FIGS-D) will trigger the WRU sequence. Therefore, do not use "$" in messages sent by SITOR.

3.2.9 DEFAULT AFTER RESET PARAMETERS

The ARQ1000A programming mode also allows presetting of a default mode of operation that will occur after each operation of the RESET switch and upon completion of program mode. The parameters and commands used are:

PARAMETER	COMMAND	ACTION
MODE	"MD:OFF CR"	Return to OFF mode upon RESET
	"MD:STB CR"	Return to STBY mode upon RESET
	"MD:ARQ CR"	Return to ARQ mode upon RESET
	"MD:FEC CR"	Return to FEC mode upon RESET
	"MD:SEL CR"	Return to SEL-FEC upon RESET
	"MD:MON CR"	Return to MON upon RESET
SEND	"SD:ON CR"	Return to SEND upon RESET
	"SD:OFF CR"	Return to receive upon RESET
	(SENDS when reset to ARQ, FEC, or SEL modes or when manually stepped to ARQ mode after reset to OFF, STBY, or MON.)	
TX/RX	"TR:AUTO CR"	Return to AUTO upon RESET (AUTO required for response to ARQ calling signal)
	"TR:TX CR"	Return to TX upon reset (not same as SEND)
	"TR:RX CR"	Return to RX upon RESET
B/Y	"BY:OFF CR"	Return to B/Y test off upon reset
	"BY:ON CR"	Return to B/Y test on upon reset (may only be stopped by re-entering program mode and re-programming)

The normal default programming supplied from the factory is:

```
HI:TEST
LC:TEST
RC:TEST
GC:TEST
CS:X        EC:ON       WR:ON       SD:OFF      NR:NORM
TR:AUTO     BY:OFF      TO:ON       CF:OFF      BC:ON
CD:50       TD:10       AD: 5
MD:STB
```

Obviously, you will have to reprogram the ARQ1000A to match your requirements for the HERE IS and identifier messages.

3.2.10 CONVERSATIONAL FEC (CF:)

Conversational FEC mode produces the same output coding as used in FEC mode, but allows the RTS (Request To Send) or KOS (Keyboard Operated Switch) feature of the terminal to control the SEND and END format of the FEC transmission, simplifying operation. This mode is convenient for use by stations which wish to pass two-way traffic in the FEC mode. The Conversational FEC mode can be turned on or off by program control with the "CF:_" command as follows:

CF:OFF CR = Normal FEC mode. Transmissions must start with setting to FEC mode, and pressing SEND or entering FEC through keyboard command.

CF:ON CR = Conversational FEC mode. Step to FEC mode with front panel switch on ARQ1000A. RTS or KOS from the terminal will automatically begin and end transmissions.

As with other programmable features, the selected mode will remain active until reprogrammed. Note that when operating Conversational FEC, you must first select FEC mode with the mode switch to send text with RTS or KOS control. Also, jumper J3 on the main circuit board of the ARQ1000A must be set for either RTS or KOS to match the terminal being used. A receiving terminal in STBY mode will automatically step to STBY-FEC mode and print the received text. If the receiving terminal also wishes to then transmit in Conversational FEC mode, he should also step to FEC mode with the MODE switch. If Conversational FEC mode is selected, the ARQ1000A will remain in FEC receive condition after text has been transmitted, awaiting the FEC reply of the other station.

3.2.11 TRANSMIT DELAY (TD:)

The ARQ1000A includes the capability of programming the minimum transmitter turn-on delay. This delay allows the user to compensate for transmitter turn-on and relay transition times as the radio system is switched from receive to transmit condition. The action of the TX PTT output is now separated from that of the MODEM TX/RX CONTROL signal and the start of transmit data. The sequence of operation is as follows:

A: Initial call by Master ISS:
1. TX PTT turns ON - start of 450 ms data frame
2. Wait for transmit delay time
3. Set MODEM TX/RX CONTROL to TX condition and start transmit text.

B: After communications are established:
1. TX PTT turns ON immediately after completion of received CS1/CS2 (when ISS) or received data block (as IRS).
2. MODEM TX/RX CONTROL goes to TX and text starts at beginning of next data frame.

Notice that the transmitter delay parameter simply sets the minimum time that occurs upon the first call by the Master ISS station. The transmitter delay is then adjusted to the maximum available after communications are established. As illustrated in Figure 8, the total time available for reception of the other station's response is REDUCED by the amount of the transmit delay setting. Therefore, avoid setting too high a value for the transmit delay as this will cause reduction of the maximum distance over which ARQ communications may be made. The transmit delay feature is only applicable to ARQ mode

operations and will not affect FEC or SEL-FEC operation. Program the transmit delay as follows:

TD:[2 digit number]CR - 2 digits represent transmit delay in ms (Range = 0 to 99 ms)

Example: TD:10 CR - sets a 10 ms transmit delay

It is recommended that you first try a TD setting of 10 ms and only increase this if required by your equipment. Insufficient transmit delay is usually evidenced by failure of the receiving station to correctly print an intial selective-call code. To test, be sure to work with a receiving station whose ARQ equipment is known to work correctly! Have the receiving station select MONITOR mode and send an ARQ call to him for several minutes. The receiving station should print the 4 characters your have programmed in your RC: storage. If, after several tries, these characters cannot be printed at the receiving station, try increasing TD: at the transmitting station (5 ms increments recommended). Use the MINIMUM setting of TD that gives satisfactory results. One setting of TD: should work for ALL receiving stations, regardless of distance or equipment used by the receiving station.

3.2.12 CONTROL DELAY (CD:)

The Control Delay in ARQ mode is keyboard programmable. This delay also affects ONLY ARQ mode transmissions. The Control Delay is shown in the timing diagrams of Figure 11. This delay applies ONLY to a called IRS station (SLAVE condition) and is the time delay between the END of a received text block and the start of the IRS response character (CS1/CS2). There are conflicting constraints on both the minimum and maximum settings of the control delay that depend upon the switching times of BOTH the transmitting AND receiving station equipment AND on the distance separating the two stations. The optimum setting of CD: may therefore vary somewhat with each station contacted! The constraint considerations are:

CD: - minimum: Must be GREATER than the transmitter turn-off PLUS receiver turn-on delay of the TRANSMITTING (ISS) station. Also, must be GREATER than receiver turn-off PLUS transmitter turn-on delay of the RECEIVING station (IRS).

CD: - maximum: Must be LESS than propagation time delay for the communication distance PLUS transmitter turn-off delay of IRS.

Practical experience has shown that IF both the ARQ stations are equipped with transmitters and receivers with fast switching times, the CD: may be set to 85 ms or less for distances up to 1000 miles. The delay should be correspondingly reduced as the distance increases to approximately 20 ms for very long distances. A setting of 50

ms has proven to be a good compromise setting for normal HF radio communications. Note, however, that the system performance over long distances is very much dependant upon individual station parameters and settings that work for one pair of stations may not work for others, particularly if the radio equipment is different at either end. The control delay is programmed as follows:

CD:[2 digits] CR - Set 2 digits equal to delay in ms.
(Range = 00 to 99 ms)

Example - CD:50 CR - Set CD to 50 ms.

3.2.13 AUDIO DELAY (AD:)

AD is the amount of time that tones are applied to the transmitter before data begins. This is useful in a system where audio tones are used to modulate an SSB transmitter. AD allows a certain amount of time for stabilization of the transmitter under power before transmitting the data. AD is factory set to 5 milliseconds and should not require adjustment for most SSB transmitters. If AD is changed, it should be programmed as follows:

AD:[2 digits] CR - Set 2 digits equal to delay in ms.
(Range 0 to TD ms)

IMPORTANT: AD must be set from 0 ms to TD ms. If AD is set longer than TD, problems may arise with the timing cycle of the ARQ1000A. Otherwise, AD does not affect the timing cycle, nor does it add to either the Control Delay or Transmit Delay.

3.2.14 BUFFER CLEAR (BC:)

The ARQ1000A includes a two-step transmit text buffer between the TTY terminal and the ARQ code conversion. This buffer allows text to be typed or otherwise entered at a faster rate than it is transmitted. This prevents loss of characters that would otherwise occur when a TTY terminal rate greater than 50 baud is used or when conditions require a lot of repeats. The first step in this keyboard buffer occurs at 80 characters. When 80 characters have accumulated in the keyboard buffer, the KBD WAIT signal is turned on and the INPUT INHIBIT front panel lamp is turned on. IF the TTY keyboard has been connected to KBD WAIT, further input text is inhibited at the keyboard until some of the buffered characters have been sent. This is the normal connection when the DS3200 is used. However, some terminals do not have a KBD WAIT control feature. If the KBD WAIT signal is ignored by such a terminal, the ARQ1000A will continue to accumulate text to be transmitted until a total of 1024 characters are stored. At this time, the buffer is full and some over-run characters will indeed be lost unless the keyboard input is stopped manually. In practice, buffer over-run has not proven to be a common problem even when

a terminal without KBD WAIT (or CTS) is operated at 110 baud (1024 characters = approximately 1:50 of text ahead of transmitted output).

Clearing or non-clearing of this keyboard buffer in the ARQ1000A is programmable. Such a situation only arises when an "OVER" command is forced while text is still in the keyboard buffer of the ARQ1000A. The most usual occurance being a forced "OVER" by the receiving station for a "quick break". Program the buffer clear feature as follows:

BC:ON CR - Keyboard buffer CLEARS after each OVER operation

BC:OFF CR - Keyboard buffer does NOT clear after each OVER

Unless you have a specific need to retain the buffer contents during an OVER operation, it is recommended that the ARQ1000A be operated with the buffer clear feature turned ON (BC:ON).

3.2.15 ST: LIST STATUS COMMAND

The status of all programmable features can be easily determined by first entering program mode with the BREAK SWITCH or the keyboard BREAK key and then typing "ST: CR". The ARQ1000A will list the whole set of features on the printer or video screen. A typical listing for the ST: command is:

```
HI:M/V COMMUNICATOR
LC:YYYY
RC:XXXX
GC:ZZZZ

CS:X     EC:ON     WR:ON     SD:OFF     NR:NORM
TR:AUTO  BY:OFF    TO:ON     CF:OFF     BC:ON
CD:50    TD:10     AD: 5

MD:STB
CMD ?
```

3.2.16 EX: EXIT PROGRAMMING COMMAND

After all programming has been set by the procedures outlined above, you may return to normal operation of the ARQ1000A by typing "EX: CR". The ARQ1000A now executes a full reset of all features and responds with the message:

```
HAL ARQ1000A VX.X
ENTER HELP FOR ARQ COMMANDS
```

The unit now returns to the default conditions just programmed. Once in program mode, the ARQ1000A will NOT operate in any other mode UNTIL the EX: command has been entered. The programming mode may also be terminated by simplying pressing the front panel RESET switch. This has the SAME effect as using the EX: command.

3.3 OPERATING INSTRUCTIONS

After you have interfaced the terminal, modem, and transmitter and receiver (Chapter 2), and programmed the HERE IS and identifier codes (section 3.2), you are now ready to start operating the ARQ1000A.

When the ARQ1000A is turned on, it responds to the printer or terminal screen with:

```
HAL ARQ1000A Vx.x
ENTER HELP FOR ARQ COMMANDS
```

The first line of the response gives the ARQ1000A version number. This is the number following the V. After this two line message the operator may begin operation by keyboard commands or by using the front panel switches of the ARQ1000A. Operating instructions are summarized in APPENDIX E, the "QUICK ORERATOR'S GUIDE."

3.3.1 HELP PAGE

The operator may obtain a quick look at the commands available through the keyboard. Simply type "HELP" followed by a CR, or "?" followed by a CR and the ARQ1000A will respond with:

```
ARQ1000A COMMANDS

ARQ (CR) - SEND ARQ
FEC (CR) - SEND FEC
OFF (CR) - OFF MODE

ZZZZ (CR) - END
//// (CR) - HERE IS
HELP (CR) OR ? (CR) - HELP PAGE

BRK (CR) - ENTER PROGRAM MODE
(BRK) (CR) - ENTER PROGRAM MODE
```

As explained before, (CR) means a carriage return or ENTER key on the HAL DS3200. The HELP Page gives all the options which the operator may exercise using only the terminal keyboard.

3.3.2 TO RECEIVE AN ARQ OR FEC MESSAGE

Receiving an ARQ or FEC message is very simple. The operator simply sets the radio receiver on the proper frequency and turns on the terminal (or keyboard and printer). After that he turns on the ARQ1000A and should get the turn on message as described in the beginning of section 3.3. The ARQ1000A should have been programmed with the proper calls as described in section 3.2, and should be in STBY mode. Any time the ARQ1000A hears a general FEC signal, the FEC lamp will light in addition to the STBY lamp. The ARQ1000A will synchronize with the transmitting station and will copy the traffic and send it to the terminal or printer.

If the ARQ1000A hears its LC or local call being used in an ARQ call-up it will begin to transmit responses back to the station originating the call. Once the two stations have synchronized, the originating station may pass traffic to the ARQ1000A and its associated terminal or printer.

3.3.3 TO SEND AN ARQ MESSAGE WITH THE ARQ1000A

There are two ways to start an ARQ transmission with the ARQ1000A. The easiest is through keyboard control, in which case the operator never has to touch the ARQ1000A. The other is by using the front panel switches on the ARQ1000A.

To send ARQ from the keyboard:

Type ARQ (CR). The response is:
CALLING (TEST) Y/N? (Where TEST is the RC as programmed by the operator.)
Type Y (CR) to begin sending if TEST is the correct call of the remote station. The response is:
SENDING (TEST) (The ARQ1000A will begin keying the transmitter.)
Or, type N (CR) to change the call. The response is:
NEW CALL -

Now enter the new call and (CR). The response is:
SENDING (XXXX) (Where XXXX is the new call as entered in letters, or as changed to letters from numbers by the unit according to the CCIR 491 table in Appendix C.)
(The ARQ1000A will begin keying the transmitter.)

To send ARQ from the front panel:

Step the ARQ1000A to ARQ mode with the MODE switch.
Press SEND. (The ARQ1000A will begin keying the transmitter using the Remote Call as programmed in the RC parameter)

Once the link has been established with the station being called the idle lamp will come on. This is the indication that the link is up and that traffic may be passed.

Answerbacks may now be exchanged with the other station. To send the HERE IS message, the operator may either press the HERE IS switch on the ARQ1000A or type //// (CR) on the terminal. (//// is a special feature of the ARQ1000A which lets the operator send the HERE IS without touching the ARQ1000A.) The WRU code may be generated by pressing the WRU switch on the ARQ1000A or by sending a FIGS D ($ in U.S. Baudot) from the keyboard. This will cause the link to over temporarily for the other station to send its identification.

Traffic may be passed to the other station when the ARQ1000A indicates ISS and the Idle light is on. If your terminal is connected to the KBD WAIT control signal, you may load up to 80 characters in the ARQ1000A input buffer before the INPUT INHIBIT light comes on and further input is prevented by KBD WAIT. As characters are transmitted and space becomes available in the 80 character buffer, more characters will be accepted from the terminal. If your terminal is not connected to the KBD WAIT control, INPUT INHIBIT will still come on when input text exceeds transmitted text by 80 characters. However, your terminal may continue to send characters into a secondary buffer which will store up to 1024 characters. Once both buffers are full, characters can no longer be stored and will be lost if sent from the terminal.

CAUTION: If a transmission is interrupted by an OVER generated by the other station or by a restart due to poor signal conditions, all text beyond the 80 character buffer may be lost. It is highly recommended that you use the KBD WAIT connection if your terminal will accept it.

During the link, the operator may turn the link over with the +? sequence ("? in U.S. Baudot) or by pressing the OVER switch on the ARQ1000A. At this time the ISS light will go out and the IRS light will come on indicating that the ARQ1000A is now the receiving unit.

After all traffic has been passed, the link may be ended by typing ZZZZ (CR) from the keyboard or by pressing the END switch on the ARQ1000A IF you are the ISS. If you are the IRS, then you must end the link with the END switch on the ARQ1000A front panel.

3.3.4 TO SEND AN FEC MESSAGE WITH THE ARQ1000A

As in ARQ mode there are two ways to enter the FEC sending mode with the ARQ1000A.

To send FEC from the keyboard:

Type FEC (CR). The response is:
ALL STATIONS? Y/N

Type Y (CR) if this is a general FEC call. The response is:
SENDING (The ARQ1000A keys the transmitter.)

Or, type N (CR) if this is to be a selective FEC message. The response is:
CALLING (TEST)? Y/N (TEST is the programmed Group Call.)

Type Y (CR) if the group call is correct. The response is:
SENDING (TEST) (The ARQ1000A keys the transmitter.)

Or, type N (CR) to enter a new Group Call. The response is:
NEW CALL -

Now enter the new Group Call and (CR). The response is:
SENDING (XXXX) (Where XXXX is the new Group Call.)
(The ARQ1000A keys the transmitter.)

To send FEC using the front panel:

Step the ARQ1000A to FEC mode with the MODE switch.
If this is a general FEC call simply press the SEND switch.

If this is a selective FEC call, the operator must insure that the Group Call is programmed right before entering FEC. With the proper Group Call programmed, step the ARQ1000A to SEL FEC mode and press the SEND switch.

When sending an FEC transmission, allow at least 30 seconds of idle signal transmission before sending traffic. This will allow ample time for the receiving station(s) to synchronize with the transmission. Traffic may then be passed. There will be no two-way communications in an FEC transmission, as this is a broadcast mode.

During the transmission of traffic, you may wish to send the HERE IS message to identify the station. This may be done by pressing the HERE IS switch on the ARQ1000A or by typing //// (CR) on the keyboard. There is no way to request the identification of the listening station(s) since FEC is a one way transmission.

As before, if the KBD WAIT signal is used, automatic protection against input character overflow is assured. If KBD WAIT is not used, the ARQ1000A buffer will overflow when more than 1100 characters in advance of those transmitted have been entered.

3.3.5 CONVERSATIONAL FEC MODE

Conversational FEC operates the same as normal FEC except that the KOS (Keyboard Operated Switch) or RTS (Request to Send) signal of the TTY terminal will now control the SEND and END operations of the transmission. This makes FEC operation very similar to that of normal RTTY but with the advantage of the error-correction of FEC mode. To operate Conversational FEC, first be sure that the feature has been selected in programming mode with the "CF:ON CR" command. Next step the mode lamps to FEC and then start typing. The terminal KOS or RTS will automatically turn on the transmitter, send the required PS1/PS2 sequence and then transmit the text in FEC format. When all text has been typed, the terminal KOS or RTS returns to receive and, after all typed text has been transmitted, the required END sequence is appended and the transmitter is turned off. The ARQ1000A will the then remain in FEC mode and be able to either receive or send further FEC data. This is a difference between CFEC and normal FEC operation: normal FEC operation returns to STBY after an FEC END sequence is transmitted.

3.3.6 MONITOR MODE

The MON (monitor) mode of the ARQ1000A allows the station to listen and print all three modes of ARQ transmission. Select MON mode by repeated presses of the MODE switch until the MON lamp is on. The monitor mode does not require reception of a selective call identifier for either ARQ or SEL-FEC modes and will print whatever text is being received if it matches one of the three modes (ARQ, FEC, or SEL-FEC). As in STBY mode, the ARQ1000A will automatically advance to reception of whatever mode is being received.

MON is a receive-ONLY mode and therefore cannot offer the error correction features of the ARQ mode. It does not participate directly in the error-correction exchange process. However, MON mode will take advantage of any error corrections requested by the IRS that is communicating with the ISS and correct any similar errors received. It also suppresses multiple printings of repeats caused by errors between the two communicating stations. No transmit features including WRU and HERE IS are available in MON mode.

3.3.7 OFF MODE

OFF mode of the ARQ1000A may be entered by typing OFF (CR) from the keyboard or by pressing the OFF switch on the front panel. The OFF mode is really just a logical pass-through between the terminal and data modem. This mode allows use of normal RTTY communications. The data code and rate are determined only by the settings of the terminal and the capabilities of the modem used. If the M1700 option is installed, data rates up to 110 baud may be used for ASCII, Baudot, or any other serial code. The M1700 is, however, restricted to 170 Hz shift at the center frequency supplied (normally 1700 Hz; others available on special order).

When the ARQ1000A is in the OFF mode, the KOS (Keyboard Operated Switch) or the RTS (Request To Send) output of the TTY terminal controls the transmit-receive control line (PTT) of the radio system. The TX-AUTO-RX control, NORM/REV, WRU, HERE IS, and all other features of the ARQ1000A do NOT operate in OFF mode. The ARQ1000A will not automatically switch into other modes when OFF is selected. To exit the off mode, step the unit into STBY mode with the mode switch.

3.4 OPERATION WITH DS3200 AND ST8000

The DS3200 and ST8000 should be connected to the ARQ1000A as described in Chapter 2. The combination of these three units gives a great deal of operator flexibilty to the ARQ station. The following settings are recommended for this system:

DS3200:	110 baud Baudot FDX (full duplex) WORD or CONT modes SYNC IDLE turned off	USOS turned off
ST8000:	Marine tones: 1615 Hz Mark 1785 Hz Space 100 Baud Print Squelch counter-clockwise	Antispace off Polarity norm Regen off TX-KOS-RX switch to RX
ARQ1000A:	110 baud Baudot EC:ON (echo ON)	all jumpers = RS232C (except PNTR WAIT = 2)

When these settings are used, text may be typed on the DS3200 without regard to the ISS/IRS status of the ARQ1000A; the KBD WAIT signal connection will prevent ARQ1000A buffer over-running. To enter program mode, you can either use the ARQ1000A BREAK switch or type BRK (CR) on the DS3200 keyboard. The program responses will be much faster if you choose to operate the ARQ1000A and DS3200 at the higher data rate (110 baud). Since the typed text shows on the lower portion of the screen, you have a continuous monitor of the ARQ1000A input buffer. The bright-dim receive-transmit character display in the receive section does NOT function in this case since the echo is generated in the ARQ1000A and appears to the DS3200 as received text.

The DS3200 may also be interfaced using lower data rates such as 45 bd Baudot. However, a confusing set of circumstances may occur if the receive data rate is less than the through-put rate of the ARQ system. With good propagation, no errors are corrected and the ARQ system will pass 6.67 characters per second in ARQ, FEC, or SEL-FEC modes. However, the character rate for 45 bd Baudot is only 6 characters per second - text is received faster than it is displayed in the receive buffer. The ARQ1000A 250 character receive buffer will usually prevent any lost characters due to this difference, but an interference situation may arise after an OVER operation, particularly when KBD WAIT is used and transmit text is pretyped while receiving. The ARQ1000A in this case is functioning correctly, but the remnants of the receive text interfere with the echoed transmit text. The solution is to change the DS3200 data rate to 50 bd or higher in Baudot or 74 bd or higher in ASCII.

Since the OVER sequence ("?) is used quite often in ARQ communications, it is convenient to use one of the DS3200 HERE IS messages to store these characters. Normal RTTY operation is restored to the DS3200 and ST8000 by placing the ARQ1000A in the OFF mode.

3.5 OPERATION WITH DS3200 AND ST6000

The DS3200 and ST6000 should be connected to the ARQ1000A as described in Chapter 2. These three units also give a great deal of operator flexibility to the ARQ station. The following DS3200 and ST6000 settings are recommended for this system:

DS3200:	110 baud Baudot	USOS turned off
	FDX (full duplex)	
	WORD or CONT modes	
	SYNC IDLE turned off	
ST6000:	170 shift	DTH off
	Limiter on	Line selected
	NORMAL polarity	KOS off
	ATC off	AUTOSTART off
ARQ1000A:	110 baud Baudot	all switches = RS232C
	EC:ON (echo on)	(except PNTR WAIT = 2)

When these settings are used, text may be typed on the DS3200 without regard to the ISS/IRS status of the ARQ1000A; the KBD WAIT signal connection will prevent ARQ1000A buffer over-running. To enter program mode, you can use the ARQ1000A BREAK switch or enter BRK (CR) from the keyboard. The program responses will be much faster if you choose to operate the ARQ1000A and DS3200 at 110 baud. Since the typed text shows on the lower portion of the screen, you have a continuous monitor of the ARQ1000A input buffer. The bright-dim receive-transmit character display in the receive section does NOT function in this case since the echo is generated in the ARQ1000A and appears to the DS3200 as received text.

The same conditions concerning data rate as stated in section 3.4 apply when using the DS3200, ST6000, and ARQ1000A.

CHAPTER 4

THEORY OF OPERATION

This Chapter will discuss how the ARQ communications system works. It is recommended reading if you do not have a working knowledge of the ARQ data communications system. APPENDIX D contains a list of reference materials.

4.1 THE ARQ COMMUNICATIONS SYSTEM - AN OVERVIEW

Throughout this manual, the term "ARQ" is used with reference to the particular error correction system as defined by CCIR Recommendations 476-2, 476-3, and CCIR 491. There exist several other codes and communications system which also use an error detection and repeat-request correction system. The ARQ1000A is only capable of operation with stations using the ARQ code defined by CCIR 476-2, and 476-3. This code is also sometimes called the "Moore 7 bit Error Correcting Code" and may be called by the trade names "TOR" and "SITOR".

4.2 COMPARISON BETWEEN ARQ AND RTTY

When radios and transmitters are used to transmit text data between teleprinter machines, this is normally called "RTTY" or "RATT". The use of radio for such text transmission dates back to the late 1930's. Many advances have been made in the design of RTTY demodulators in particular to minimize errors between the transmitter and receiver, but since propagation is rarely optimum, errors will be found in all but the best propagation conditions. This problem is particularly noticeable when the high frequencies between 3 and 30 MHz are used, as they must be for very long distance communications. Recent advances in satellite communications using microwave frequencies have greatly reduced this problem, but there are still conditions under which it is more practical and economical to use direct high frequency transmissions. One of these commercial applications is communications between ships at sea and land stations. Transmitter on-off keying with hand-sent Morse code has been and is still used very extensively. However, the faster text transmission offered by RTTY circuits is very attractive. Both Morse code and RTTY can, however suffer from errors caused by poor propagation conditions. In the 1960's and 1970's, another form of RTTY transmission has become accepted where errors are detected and corrected by an automatic repeat-request system. This code was first defined internationally by the CCIR Recommendation 476, followed by the up-dates of 476-1, 476-2, and 476-3.

Standard RTTY transmissions using mechanical teleprinters are usually sent using the Baudot (also know as Murray) code with some modern use of the ASCII data code. Both the Baudot and ASCII serial codes are known as "asychronous" codes; synchronizing pulses are included in the transmission of each character of text. Thus, if the receiving printer should become unsynchronized with the incoming text, it may then re-synchronize with the loss of only a few characters of text. If propagation conditions are particularly poor, this loss and regaining of text can result in a considerable loss of intelligibility in the printed copy. The Baudot code uses a start pulse to initiate machine decoding, 5 data pulses, and a stop pulse to signal the end of a character. The ASCII code uses a start pulse, 8 data bits (including parity), and one or two stop pulses, depending on data rate. Serial Baudot and ASCII codes may be sent at several data rates, the most common of which are 45, 50, 57, 74, 110, 150, or 300 baud. Because the error rate increases considerably at the faster data rates, 45 to 110 baud are the most commonly used rates for high frequency communications. The format and code definition of the Baudot and ASCII codes are shown in Tables 7 and 8.

The ARQ code, defined by 476-2, uses 7 data pulses to represent each character and has NO start or stop pulse. This is known as a "synchronous" communications code. Sent in serial fashion, the 7 data pulses (or bits) of one character follow the previous 7 pulses with no start or stop synchonizing pulses. The receiving station must therefore have some system of knowing where the first character started and then keeping track of the end of one character and the beginning of the next. This is accomplished with precise timing of both the receive and transmit data equipment and with an automatic timing tracking and correction circuit. The equipment is adjusted so that momentary fades in signal strength or bursts of interference do not disturb the timing and characters are again found at their correct time location when the disturbance is over. The 476-2 ARQ code is ALWAYS sent at a data rate of 100 baud, each data pulse is 10 milliseconds (ms) long.

The ARQ (Moore) code used is arranged so that each character always has 4 pulses of one polarity ("B" = higher radio frequency) and 3 pulses of the other polarity ("Y" = lower radio frequency). Errors may therefore be fairly easily detected by checking for the 4/3 ratio between B and Y pulses in each character. In comparison with standard RTTY practice, the "Y" is similar to a MARK condition and the "B" to a SPACE condition. The character set for ARQ code is quite similar to that of the Baudot code in that it allows use of only upper case letters and some punctuation: lower case letters are NOT supported by the 7-unit ARQ code. The 7-unit ARQ code is shown in Table 9; Figure 10 shows a timing diagram comparison between Baudot, ASCII, and the 7-unit ARQ code. The polarity relationships between MARK, SPACE, Y, B, and wire data circuits are shown in APPENDIX B.

TABLE 7. BAUDOT DATA CODE

Bit Number 5 4 3 2 1	Letters Case	U.S. Figures Case	CCITT#2 Figures Case	
0 0 0 0 0	blank	blank	blank	
0 0 0 0 1	E	3	3	
0 0 0 1 0	LF	LF	LF	
0 0 0 1 1	A	-	-	
0 0 1 0 0	space	space	space	
0 0 1 0 1	S	bell	'	<<
0 0 1 1 0	I	8	8	
0 0 1 1 1	U	7	7	
0 1 0 0 0	CR	CR	CR	
0 1 0 0 1	D	$	WRU	<<
0 1 0 1 0	R	4	4	
0 1 0 1 1	J	'	bell	<<
0 1 1 0 0	N	,	,	
0 1 1 0 1	F	!	!	
0 1 1 1 0	C	:	:	
0 1 1 1 1	K	(	(	
1 0 0 0 0	T	5	5	
1 0 0 0 1	Z	"	+	<<
1 0 0 1 0	L	)	)	
1 0 0 1 1	W	2	2	
1 0 1 0 0	H	#	***	<<
1 0 1 0 1	Y	6	6	
1 0 1 1 0	P	0	0	
1 0 1 1 1	Q	1	1	
1 1 0 0 0	O	9	9	
1 1 0 0 1	B	?	?	
1 1 0 1 0	G	&	&	
1 1 0 1 1	FIGS	FIGS	FIGS	
1 1 1 0 0	M	.	.	
1 1 1 0 1	X	/	/	
1 1 1 1 0	V	;	=	<<
1 1 1 1 1	LTRS	LTRS	LTRS	

NOTES: 1. "<<" symbols denote differences between U.S. FIGS and CCITT No. 2 FIGS characters. HAL terminals follow U.S. conventions.
2. *** = FIGS-H may be used for "#", " ", or for MOTOR STOP function. "#" is used on HAL terminals.
3. "1" = Mark condition = loop current on, neg. RS232 voltage, or TTL logic high (> 3.5 V).

TABLE 8. ASCII DATA CODE

BITS	7	0	0	0	0	1	1	1	1
	6	0	0	1	1	0	0	1	1
4 3 2 1	5	0	1	0	1	0	1	0	1
0 0 0 0		NUL	DLE	SPC	0	@	P		p
0 0 0 1		SOH	DC1	!	1	A	Q	a	q
0 0 1 0		STX	DC2	"	2	B	R	b	r
0 0 1 1		ETX	DC3	#	3	C	S	c	s
0 1 0 0		EOT	DC4	$	4	D	T	d	t
0 1 0 1		ENQ	NAK	%	5	E	U	e	u
0 1 1 0		ACK	SYN	&	6	F	V	f	v
0 1 1 1		BEL	ETB	'	7	G	W	g	w
1 0 0 0		BS	CAN	(	8	H	X	h	x
1 0 0 1		HT	EM	)	9	I	Y	i	y
1 0 1 0		LF	SUB	*	:	J	Z	j	z
1 0 1 1		VT	ESC	+	;	K	[	k	{
1 1 0 0		FF	FS	,	<	L	\	l	|
1 1 0 1		CR	GS	-	=	M	]	m	}
1 1 1 0		SO	RS	.	>	N	^	n	~
1 1 1 1		SI	US	/	?	O	_	o	RBO

NOTES:
Mark = "1"
= loop on
= -RS232 V
= TTL high

Space = "0"
= loop off
= +RS232 V
= TTL low

Transmisson bit order = 1 to 8

bit 8 = "0" or
= parity

acknowledge
BEL = signal bell
BS = back space
CAN = cancel
CR = carriage return
DC1 = device control 1
DC2 = decive control 2
DC3 = device control 3
DC4 = device control 4
DLE = data link escape
ENQ = enquiry = WRU
EM = end of medium
EOT = end of transmission
ESC = escape
ETB = end of block
ETX = end of text
FF = form feed

FS = form separator
GS = group separator
HT = horizontal tab
LF = line feed
NAK = not acknowledge
NUL = null
RS = record separator
RBO = RUB OUT = DEL
SI = shift in
SO = shift out
SOH = start of heading
SPC = space bar
STX = start of text
SUB = substitute
SYN = synchronous idle
US = unit separator
VT = vertical tab

TABLE 9. 7-UNIT ARQ DATA CODE

LETTER CASE	FIGURES CASE	BAUDOT CODE	7-UNIT ARQ CODE
A	-	ZZAAA	BBBYYYB
B	?	ZAAZZ	YBYYBBB
C	:	AZZZA	BYBBBYY
D	WRU ($)	ZAAZA	BBYYBYB
E	3	ZAAAA	YBBYBYB
F	! (**)	ZAZZA	BBYBBYY
G	& (**)	AZAZZ	BYBYBBY
H	# (**)	AAZAZ	BYYBYBB
I	8	AZZAA	BYBBYYB
J	BELL (')	ZZAZA	BBBYBYY
K	(	ZZZZA	YBBBBYY
L	)	AZAAZ	BYBYYBB
M	.	AAZZZ	BYYBBBY
N	,	AAZZA	BYYBBYB
O	9	AAAZZ	BYYYBBB
P	0	AZZAZ	BYBBYBY
Q	1	ZZZAZ	YBBBYBY
R	4	AZAZA	BYBYBYB
S	' (bell)	ZAZAA	BBYBYYB
T	5	AAAAZ	YYBYBBB
U	7	ZZZAA	YBBBYYB
V	= (;)	AZZZZ	YYBBBBY
W	2	ZZAAZ	BBBYYBY
X	/	ZAZZZ	YBYBBBY
Y	6	ZAZAZ	BBYBYBY
Z	+ (")	ZAAAZ	BBYYYBB
Carriage Return		AAAZA	YYYBBBB
Line Feed		AZAAA	YYBBYBB
Letters Shift		ZZZZZ	YBYBBYB
Figures Shift		ZZAZZ	YBBYBBY
Space Bar		AAZAA	YYBBBYB
Unperforated Tape		AAAAA	YBYBYBB

ARQ MODE	FEC MODE	7-UNIT ARQ CODE
Control Signal 1		BYBYYBB
Control Signal 2		YBYBYBB
Control Signal 3		BYYBBYB
Idle Signal Beta		BBYYBBY
Idle Signal Alpha	Phasing Signal 1	BBBBYYY
Signal Repetition (RQ)	Phasing Signal 2	YBBYYBB

NOTES:
1. (**) = Characters not defined by CCIR 476-2.
2. Differences are shown between CCITT No. 2 and U.S. Baudot code used on HAL terminals.
3. "Z" = Mark, "A" = space in Baudot wire line; "Y" = mark, "B" = space in ARQ radio circuit.

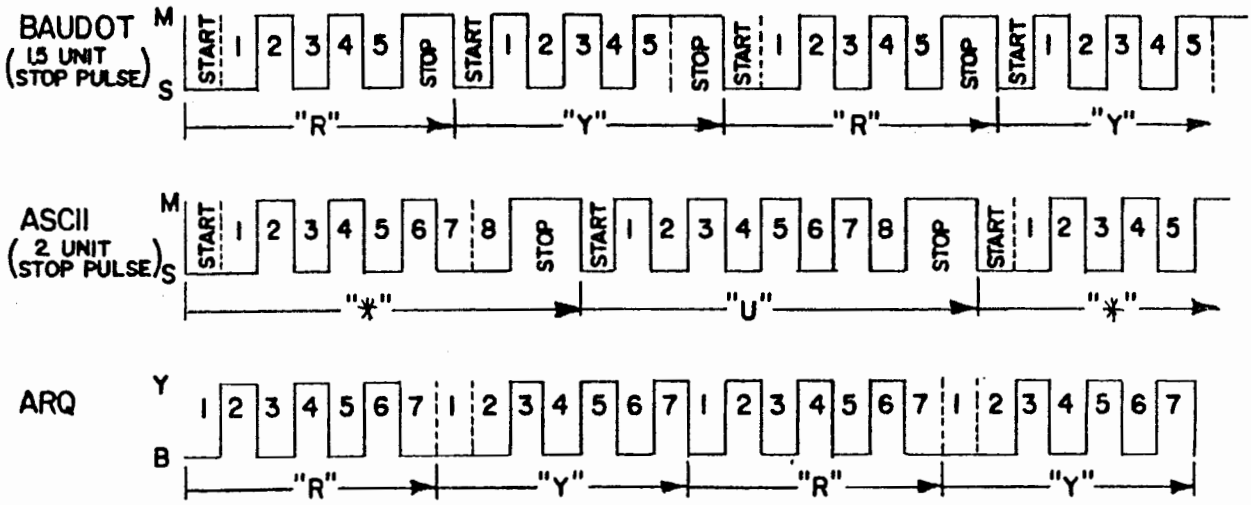


FIGURE 10. TIMING OF BAUDOT, ASCII, AND ARQ CODES

It is important to recognize that one of the funtions of the ARQ1000A is to act as a code conversion device. Although the 7-unit Moore ARQ code is transmitted and received in the radio circuit, it is processed and converted by the ARQ1000A to either the 5-unit Baudot or 8-unit ASCII serial asychronous codes so that standard radio teleprinters and video terminals may be used for data entry and output.

There are three modes which can be used to send text in ARQ communications: ARQ (also called "Mode A"); FEC (for Forward Error Correction, also know as "Mode B" or "Collective Broadcast" (CB)); and SEL-FEC (for Selective Forward Error Correction, also known as "Selective Mode B" or "Selective Broadcast" (SB)). The ARQ1000A also includes a fourth mode, "MONITOR" which is a receive-only mode that allows printing of transmissions in any of the three primary modes. MONITOR mode is NOT defined by CCIR 476-2 and is an operator convenience of the ARQ1000A only. Because it is a receive-only mode, the error correction features of ARQ mode are not possible.

Another feature of the ARQ1000A is the addition of "Conversational FEC" mode which is essentially the same as the FEC mode except that the start and end sequence of a transmission are triggered by the terminal's KOS (Keyboard Operated Switch) or RTS (Request To Send) output.

4.3 ARQ MODE

ARQ or Mode A is the most commonly used mode of transmission. This mode requires rapid on-off switching of the transmitter and receiver at each station for the error correction to function properly. Text is transmitted from the Information Sending Station (ISS) in groups of three characters, requiring a total of 210 ms for transmission. After the three characters have been sent, the Information Sending Station (ISS) turns off its transmitter and listens for the other station. The Information Receiving Station (IRS) receives the three characters, analyzes them for errors and transmits one of two different control characters to indicate "reception good - go ahead" or "error detected - please repeat". The transmission of the control signal by the IRS requires 70 ms. Each 450 ms, the ISS starts a new cycle, sending either the next three characters of the message or repeating the previous three if requested by the IRS. As mentioned previously, the IRS can check for errors by checking for the 4/3 ratio between B and Y pulse conditions in each character.

Even though the transmitters and receivers of both stations are turned on and off, it is important to consider that information may flow in only one direction at a time; from the Information Sending Station (ISS) to the Information Receiving Station (IRS). This is, in fact parallel to the way in which messages are normally sent using RTTY simplex circuits. The IRS will normally only transmit one of two characters, used to either acknowledge good reception or to request a repeat. If a message must be transmitted in the other direction, a special character sequence must first be transmitted so that the relative roles of ISS and IRS are reversed. Either station may be the ISS or IRS, depending upon the direction the traffic is flowing. This process of reversing the direction of the communications channel is called an "OVER" and is usually initiated by the ISS sending the character sequence "plus query" (+?) on an ITA No. 2 Baudot or ASCII terminal. Since the U.S. Baudot alphabet does not include the "plus" character, its equivalent, the "quote" (") must be sent. Thus on a U.S. Baudot terminal (HAL terminals or Model 15, 19, and 28 machines), the OVER is sent with "quote query" ("?). A special combination of control signals allows the current IRS to gain control of the channel for break-in response. When all traffic has been passed between the two stations, another special combination of control signals is sent to signify "END" and to break the two-way exchange.

ARQ mode communications may ONLY be made between TWO radio stations. The error detection and correction system depends upon the accept/reject response from the IRS; a third or fourth station may NOT participate in such communications. The MONITOR mode of the ARQ1000A may be used by a third (or fourth, etc) station to monitor the transmissions of the other two stations. However, since the third station cannot participate in the repeat-request format, the

correction of errors feature is not available to the monitoring station. The ARQ1000A MONITOR mode does feature automatic repeat suppression so that if the IRS requests repeats that the monitoring ARQ1000A copied correctly, the repeated characters are not output to the printer. Thus, the ARQ1000A Monitor mode may participate "vicariously" in the corrections for the IRS only to the extent that errors happen to coincide.

When a station initiates communications in ARQ mode, it becomes what is known as the "MASTER" station. When the called station responds, it is known as the "SLAVE" station. The positions of MASTER and SLAVE do NOT change with the direction of traffic flow. The original calling station is always the MASTER station for as long as the ARQ communication is maintained. The positions of "ISS" (Information Sending Station) and "IRS" (Information Receiving Station) do change with direction of information flow. The ARQ1000A front panel includes indicators for both MASTER/SLAVE and ISS/IRS conditions for operator convenience. The reason that the MASTER/SLAVE designation never changes is that the MASTER (or originating station) always maintains fixed timing, regardless of propagation conditions. The SLAVE station adjusts its timing so that it always maintains synchronization with the pulses of the MASTER station.

4.3.1 SELECTIVE CALLING IN ARQ MODE

Each station in an ARQ communications system has a four character identifier. When a transmission is initiated by the MASTER station in ARQ mode, the first step is to transmit the identifier of the desired second station. Many stations may be monitoring the radio frequency and receive the transmissions of the MASTER station but ONLY the called station will respond. In commercial usage, these identifiers are 4 or 5 digit numbers assigned to the vessel or land station by an international authority. However, the way in which the selective call is formatted does not allow transmission of the actual numbers themselves in the call-up routine. Therefore, the 4- or 5-digit numbers are translated into 4 letters according to look-up tables defined by CCIR Recommendation No. 491. This table uses 20 of the available 26 characters of the alphabet. The programming feature of the ARQ1000A will accept either ALL numbers or ALL letters for the selective call identifiers. If numbers are specified, the indicated translation to letters is made.

The initial selective call by the MASTER station takes a special format so that it may be distinguished from text transmission. The four identifier characters are sent in two three-character groups with the "signal repetition" signal (called "RQ"). If the calling identifier is "1234", this translates by Rec. 491 to the letters "XQKM". This will be transmitted as "X (RQ) Q" for the first three character group and "K M (RQ)" for the second group. The calling sequence of two groups of three will be repeated until the desired

station answers or a preset time passes (approximately 1 minute for the ARQ1000A with time-out enabled (TO:ON). When the desired station recognizes its call identifier, it responds by transmitting a control signal (CS1). It continues responding with the control signal until one complete "X (RQ) Q" plus "K M (RQ)" sequence has been acknowledged. The exchange between the MASTER and SLAVE stations will appear as follows:

MASTER (and ISS)		SLAVE (and IRS)
X (RQ) Q		
		(no response)
K M (RQ)		
	(CS1)	(contact established)
X (RQ) Q		
	(CS1)	
K M (RQ)		
	(CS1)	(complete call acknowledged)
A B C		
	(CS2)	(text transmission starts)
D E F		
	(CS1)	

etc.

4.3.2 TEXT TRANSMISSION AND ERROR CORRECTION

Once communication has been established through the above calling format, the MASTER station starts transmitting straight text, without the insertion of the special (RQ) character. The IRS (also SLAVE) now responds with alternate (CS1) and (CS2) control signals if no errors are detected. If one or more characters in the three character group are received in error (B/Y ratio is not 4/3), the IRS repeats the previous control signal rather than alternating. For example, suppose it is desired to send the text "TESTING 123". If no errors are detected, the signals transmitted by the ISS and IRS would be:

ISS: T E S T I N G (SP) (FIGS) 1 2 3

IRS: (CS1) (CS2) (CS1) (CS2)

The alternating of (CS1) and (CS2) by the IRS will continue as long as no errors are detected. However, for an example, suppose that an error was received on the letter "I" and that it took two repeats to correct the error. The exchange would now appear as:

ISS: T E S T I N T I N T I N G (SP) (FIGS)

IRS: (CS1) (CS1) (CS1) (CS2) (CS1)

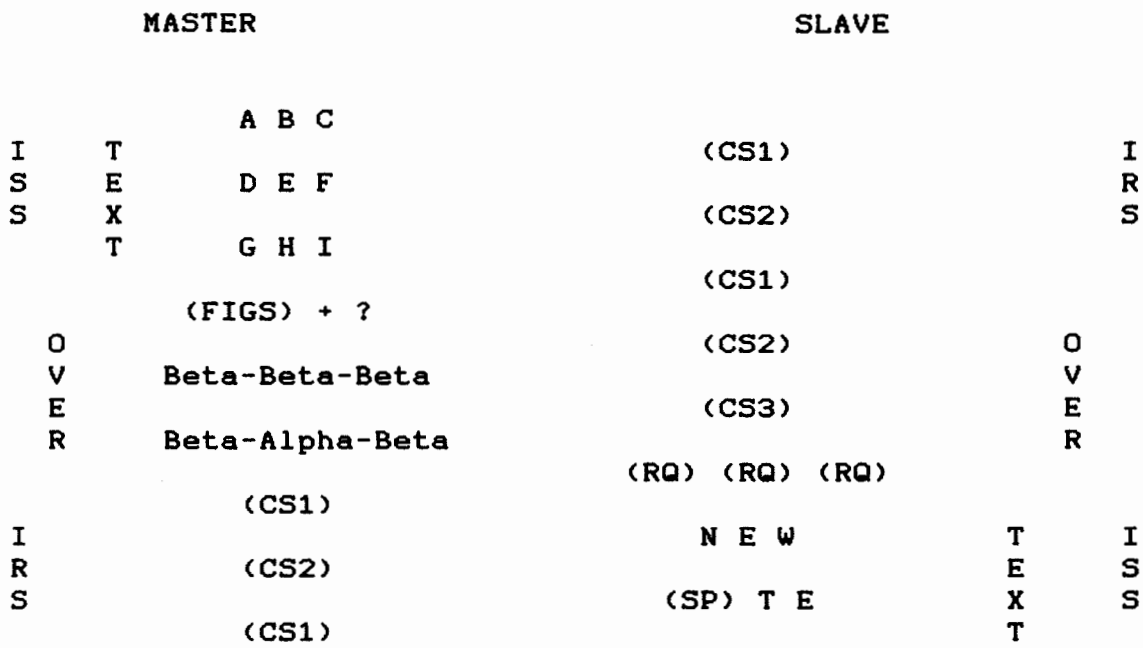
The ARQ1000A will not print the "TIN" sequence until all three letters have been correctly received. The communications system will keep repeating the three characters until they do meet the 4/3 = B/Y ratio requirement. Note that the ARQ system is NOT completely infallible; it is possible that two bits of the same character may have been changed to maintain the 4/3 ratio. It does not occur frequently! Because of this repeat-until-correct feature, the ARQ1000A may seem to be "stalled" or not processing the data, particularly under noisy conditions. Have patience, the text will appear eventually! If the Information Sending Station (ISS) detects an error in the reception of either (CS1) or (CS2), the ISS then sends a block of three (RQ) characters that signal the IRS to repeat its last sent control signal (CS1 or CS2).

4.3.3 "OVER" - CHANGING DIRECTION OF TRANSMISSION.

As mentioned previously, the information in ARQ mode flows in only one direction at a time even though there is a continuous back-and-forth transmission between the two stations. The direction of information transmission may be changed by two different techniques, depending upon whether it is requested by the ISS or IRS. Consider first that the Information Sending Station (ISS) has finished his traffic and wants to turn the channel around for a reply. To do this, he sends the sequence "(FIGS) + ?" ("OVER" command). If the normal sequence of transmission is such that these three characters do NOT complete a three character ARQ block, one or more "Idle Signal Beta" ( ) will be used to complete the block. It is common practice to insert three beta characters even if the OVER sequence forms the end of a block. Upon reception of the OVER and beta sequence, the IRS now transmits a new control signal, (CS3). The ISS responds with the sequence "Beta-Alpha-Beta" and the IRS responds with (RQ) characters (three if the new ISS is also the SLAVE and one (RQ) if the new ISS is also the MASTER station). The channel is now turned around and the former ISS is now IRS and vice versa.

The example on the next page will help clarify this situation. The MASTER station starts as the ISS and sends the text "ABCDEFGHI". Then the ISS initiates the OVER with (FIGS + ?) followed by three beta idle signals. The IRS responds with (CS3), the ISS sends beta-alpha-beta, the IRS sends (RQ) (RQ) (RQ) and the channel is now reversed with the MASTER as IRS and the SLAVE as ISS. The SLAVE ISS station now sends the characters "NEW TEXT ".

This is the normal full sequence for changing the direction of the information flow. Note that the block containing the three beta idle signals could include only one or two beta signals, depending upon when the sequence (FIGS + ?) was entered.



The IRS can also initiate an over operation by simply responding with (CS3) instead of the normal (CS1) or (CS2) control signal. In this case, the ISS responds with beta-alpha-beta, the channel turns around, and the new ISS starts with (RQ) character(s). After an over, the new ISS always begins three character block transmissions with three (RQ) characters. Notice that even though the relative positions of ISS and IRS have interchanged, the MASTER and SLAVE status of the two stations remain unchanged. MASTER status remains with the station that placed the original call.

In the ARQ1000A, the Information Sending Station (ISS) can intiate an OVER operation in two ways: (1) entering (FIGS + ?) from the keyboard, or (2) pressing the front panel OVER switch. The front panel switch electronically inserts the required (FIGS + ?) sequence. The IRS (Information Receiving Station) can initiate the OVER squence by pressing his front panel OVER switch. In this case, the required (CS3) response is electronically inserted. Note that when a HAL terminal is used in Baudot, the (FIGS) character will be automatically inserted when the plus (+) or quotes (") character is typed. You need NOT manually enter the (FIGS) on a HAL Baudot terminal. When an ASCII terminal is selected, the (FIGS) character is automatically inserted when the (+ ?) characters are typed.

4.3.4 END OF COMMUNICATIONS

When all of the traffic has been passed between the two stations, a special END sequence is transmitted to break the link and turn-off the transmitters. An END sequence consists of the three control characters "alpha-alpha-alpha". The END sequence may ONLY be sent by the ISS (Information Sending

Station). If the IRS wishes to end communications, it must first initiate an OVER sequence and then send END after the channel has turned around.

On the ARQ1000A, either ISS or IRS can end communications by pressing the front panel END switch. If the station is the ISS, this switch causes the "alpha-alpha-alpha" sequence to be transmitted. If the station desiring the END is the IRS, pressing the END button causes first an OVER operation, followed by the END sequence.

4.3.5 IDLE CHANNEL SIGNALS

There are conditions in teleprinter communications when communications are established, but the ISS may temporarily not have text to send. This conditon may occur if the teleprinter operator is interrupted or when changing paper tapes. In this case, it is desired to maintain the ISS status and keep the radio link intact, but without sending printed text. To do this, the ARQ1000A automatically inserts the sequence "beta-beta-beta" as idle signals until there is traffic to be sent. These idle signals preserve the communications link but do not result in any printed output at the IRS.

4.4 FORWARD ERROR CORRECTION (FEC) MODE

The ARQ mode works very well for direct communications between two stations and provides very good error correction. However, there are many situations in which it is desirable to transmit a message to several ARQ-equipped stations simultaneously. Such broadcast situations arise when transmitting weather reports, a traffic list for many stations, or a general call (CQ). Of course, standard RTTY techniques could be used, but without the benefit of some error correction. The definition of CCIR 476-2 allows two slightly different forms of a broadcast mode of transmission with error correction, Forward Error Correction (FEC), and Selective Forward Error Correction (SEL-FEC). These modes may also be called "Collective Broadcast" (CB) and "Selective Broadcast" (SB) or also by "Collective Mode B" and "Selective Mode B". Transmission is always done by the MASTER station in FEC or SEL-FEC modes. The transmitting station in FEC mode is sometimes called the "CBSS", for "Collective Broadcast Sending Station". Similarly, the receiving station is sometimes called the "CBRS", for "Collective Broadcast Receiving Station". The FEC mode will be discussed first as the SEL-FEC mode is quite similar.

4.4.1 TEXT TRANSMISSION IN FEC MODE

When FEC mode is selected, the MASTER station transmits data continuously and there is no switching between transmit and receive condition. Therefore, there is no chance for use of the repeat-request transmission from the receiving station(s). Because the data is broadcast from the master

station, the system is not limited to just one sending and one receiving station: several receiving stations may listen to the broadcast simultaneously. The error correction scheme of FEC mode relies on simple repetition of all transmitted text. The repetition is made with a time-shift so that effects of propagation fades are minimized. The message is sent twice with the two sets of characters interleaved and offset by 5.

The first set of text characters is called the "DX" set and the second set is called the "RX" set. For example, the text "TESTING 1234" would be sent as follows:

```
 MASTER

DX    RX

 T
      (1)   (= Phasing Signal No. 1)
 E
      (1)
 S
       T
 T
       E
 I
       S
 N
       T
 G
       I
(SP)
       N
(FIGS)
       G
 1
      (SP)
 2
      (FIGS)

  etc.
```

The (1) symbol is used to represent transmission of the Phasing Signal No. 1. A similar Phasing Signal No. 2 (2) is used for the DX set characters. For clarity, the DX and RX sets have been shown in separate columns. However, the transmission from the MASTER station is linear and interleaved as follows:

T (1) E (1) S T T E I S N T G I (SP) N (FIGS) G 1 (SP) 2 (FIGS) 3 etc.

4.4.2 ERROR CORRECTION IN FEC MODE

The receiving station ARQ1000A recognizes reception of the FEC mode and automatically separates the DX and RX character sets. Since the same 7-unit code is used in FEC as in ARQ mode, the receiving station again checks each character received for the correct 4/3 = B/Y ratio. If the first character (DX set) is received correctly, the second set (RX) is ignored and the correct character is saved for printing. If the first character has the incorrect B/Y ratio, it is discarded and the second character (RX set) is examined. If correct, this character is saved for printing. If NEITHER character has the correct B/Y ratio, both are discarded and the ARQ1000A substitutes a space character for printing. Therefore, the receiving station has only two opportunities to receive a correct character and one opportunity for error correction. The error rate for a given radio path and conditions will therefore always be greater for FEC mode than for ARQ mode. However, the FEC mode allows broadcast of general interest messages to more than one receiving station.

4.4.3 BEGINNING OF TRANSMISSION & IDLE SIGNALS

The transmission of text in FEC mode is always initiated by a period of transmission of phasing signals. This is necessary to assure that the receiving station equipment correctly phases or "locks-onto" the signal of the MASTER station. There are two phasing signals associated with FEC transmission, called "Phasing Signal 1" (abbreviated by (1)), and Phasing Signal 2 (abbreviated by (2)). If you study the ARQ code in Table 12, you will notice that the phasing signals carry the same Y/B codes as the ARQ signals "Idle Signal Alpha", and "Signal Repetition" (RQ). Since neither of these signals are used in FEC mode, there is no conflict. Phasing Signal (1) is always transmitted as part of the RX set of text and Phasing Signal (2) is always transmitted as part of the DX set.

Transmission of an FEC broadcast ALWAYS starts with a period of alternate (2) and (1) phasing signals. The CCIR Rec. 476-2 specifies that a minimum of four sets of phasing signals be transmitted before any text is transmitted. However, because some receiving stations may take longer than others to acquire a good lock on the MASTER signal, it is common practice to transmit a long sequence of phasing signals before text is released. The ARQ1000A will send a minimum of 6 sets of phasing signals before text transmission begins. It is a good idea to allow 30 or 60 seconds of phasing signal transmission before text transmission is started. This gives some lee-way to stations who may have tuned-in late or have poor propagation conditions.

The two phasing signals are also transmitted whenever there is a pause in the input of text to the ARQ1000A. As in the case of ARQ mode, this feature serves to maintain the communications channel and assure good lock by the receiving stations. Also,

six pairs of idle signals are automatically inserted by the ARQ1000A prior to the end of each line to assure that the IRS equipment has the opportunity to regain correct phase at the end of each line.

4.4.4 END OF FEC TRANSMISSION

When the complete FEC broadcast message has been sent, the MASTER station may end the transmission and return receive units to standby condition by sending a sequence of three Idle Signal Alpha (same as Phasing Signal (1)) in the DX character set ONLY. Since, when used as a phasing signal, this character is always in the RX set, appearance in the DX character set is a signal to the receiving station that the transmission is over. There is also an automatic time-out feature in the ARQ1000A so that if it is receiving FEC text and the signal becomes unreadable (or the receiving station misses the END signal), the ARQ1000A reverts to STANDBY mode after a preset time (approximately 10 seconds).

4.4.5 CONVERSATIONAL FEC MODE

ARQ1000A terminals include a semi-automatic form of the FEC mode, called "CONVERSATIONAL FEC" (CFEC). This is mode operates in the same manner as the FEC mode except that the beginning and end of a transmission are automatically controlled by the TTY terminal TX/RX control signal or KOS (Keyboard Operated Switch) output. This feature allows the error correction of FEC mode to be used for normal two-way simplex transmissions using standard RTTY operating techniques. The sending operator thus types the message to be sent and the KOS signal from the terminal causes the ARQ1000A to select FEC mode, turn on the transmitter, send the initial phasing signals, and then send the text. When the operator is done sending the message and the KOS signal returns to "receive" condition, the ARQ1000A first continues to send any text that may still be in its transmit buffer and then adds the necessary Phasing Signal (1) codes at the end before turning off the transmitter.

CFEC mode automatically inserts 32 pairs of PS1/PS2 phasing signals at the beginning of each transmission. This is generally more than sufficient to assure a good lock at the receiving station. However, under some noisy conditions, the receiving station may still not receive the required 4 uniterrupted pairs of PS1/PS2 signals and therefore not lock. When this happens, the receiving station will either not print the signal or print a badly garbled version. The most common cause of this failure to synchronize is usually CW interference close to either the mark or space (Y or B) frequencies. When this happens, you should probably switch to ARQ mode to gain the full advantage of the error correcting system. CONVERSATIONAl FEC mode is selected through a programming selection as discussed in section 3.3.5 of this manual.

4.5 SEL-FEC MODE

The third mode included in the CCIR Rec. 476-2 is for selective broadcast to one or more stations. This is a mode very similar to FEC except that it is intended to restrict reception to a station or group of stations whose selective call identifier matches that transmitted by the MASTER station. This mode is known as "SEL-FEC", "Selective Broadcast", or "Selective Mode B". The MASTER or transmitting station is sometimes called "SBSS" for "Selective Broadcast Sending Station" and the SLAVE or receiving station is sometimes called the "SBRS", for "Selective Broadcast Receiving Station".

The SEL-FEC is very similar in operation to that of the FEC mode with two important differences. First, as in ARQ mode, a transmission of a selective call identifier begins the transmission. Only receiving stations whose identifiers agree with the one transmitted will respond to the broadcast. Secondly, starting with the selective call indentifier transmission, ALL further transmissions use an inverted B/Y ARQ code. The error detection and correction algorithms are the same for FEC and SEL-FEC modes except that the code is inverted in SEL-FEC mode.

As in the case with the ARQ mode, a four letter identifier is used to selectively identify the station called. Again, the tables of CCIR 491 are used commercially to translate the assigned number into four letters. In the ARQ1000A, the transmit identifier for SEL-FEC mode may be specified separately and is called the "Group Call" (GC). This identifier is used both when transmitting SEL-FEC data as MASTER ISS and also as the selective call identifer when receiving SEL-FEC broadcasts (SLAVE, IRS).

The transmission of a SEL-FEC message starts like the FEC transmission with 6 or more groups of (2) (1) phasing signals (four minimum, more recommended). To this point in time, the transmission is similar to that of FEC mode. The call identifier characters (4) are then transmitted with inverted polarity and FEC-type DX/RX set spacing. The sending station now transmits a "Beta Idle signal" and then sends the call identifier again, followed by another "Beta Idle Signal", all inverted with a 3/4 Y/B ratio. Text then follows, again inverted. If there is an idle time between messages or for operator pauses, the "Beta Idle Signal" is used in both DX and RX character sets. Again, to END a SEL-FEC mode transmission, the sending station sends the "Alpha Idle Signal" in the DX character set, as in FEC mode.

4.6 STANDBY MODE

The ARQ1000A terminal rest state is STANDBY mode. In this mode, all received signals are continuously examined to determine if they meet the criteria for ARQ, FEC, or SEL-FEC modes. If the received signal has the characteristics of an

ARQ signal, the ARQ1000A will lock its timing circuitry to that signal. However, it will NOT initiate the transmitted (CS1) and (CS2) response UNLESS the local selective identifier programmed into the ARQ1000A matches that received. If the correct local identifier is received, the ARQ1000A automatically switches from STBY to ARQ mode and begins transmission of the (CS1) and (CS2) responses.

If the received signal is determined to be an FEC signal, the ARQ1000A will automatically switch to FEC mode and begin collecting text for printing. However, during this time, the ARQ1000A is also examining the first four characters for an inverted B/Y ratio and will automatically switch into SEL-FEC mode if the characters are inverted AND the correct selective-call identifier is receievd.

When reception of any mode is completed with an END signal, the ARQ1000A returns to STANDBY mode to be ready for any further transmission in any of the three modes.

4.7 MONITOR MODE

The MONITOR mode ("MON") of the ARQ1000A is NOT specified by the CCIR Rec. 476-2. However, it is included as an operator convenience so that transmissions of other ARQ-equipped stations may be monitored. The MONITOR mode operates in much the same manner as STANDBY mode except that transmission of the (CS1) and (CS2) control signals is NOT allowed; MONITOR mode is strictly a receive-only mode. The ARQ1000A will automatically switch to reception of ARQ, FEC, or SEL-FEC transmissions as indicated and return to MONITOR when the transmission is ended. However, because there is no two-way communications between sending and receiving stations in MONITOR ARQ mode, no error correction is available in this mode. When a character is received in error, its position on the printer output is represented by a space character. The ARQ1000A does not require reception of any selective call indentifiers in MONITOR mode and will print all valid ARQ, FEC, and SEL-FEC signals received, regardless of indentifier codes transmitted. The identifier codes themselves will also be printed in monitor mode (letter characters equivalents).

4.8 "OFF" MODE

The ARQ1000A also includes a mode position labeled "OFF". In this condition, the ARQ1000A itself is logically off and it no longer attempts to translate ARQ code. Rather, data is passed directly between the demodulator and printer and from the keyboard to the tone keyer. This allows use of the system for standard RTTY operations without changing cables or using additional external switches. The transmit-receive control circuit is also switched from control by the ARQ1000A to control by the terminal KOS (Keyboard Operated Switch) circuit. The ARQ1000A will NOT automatically switch to the correct ARQ mode when in the OFF mode.

4.9 PROGRAMMABLE DELAYS

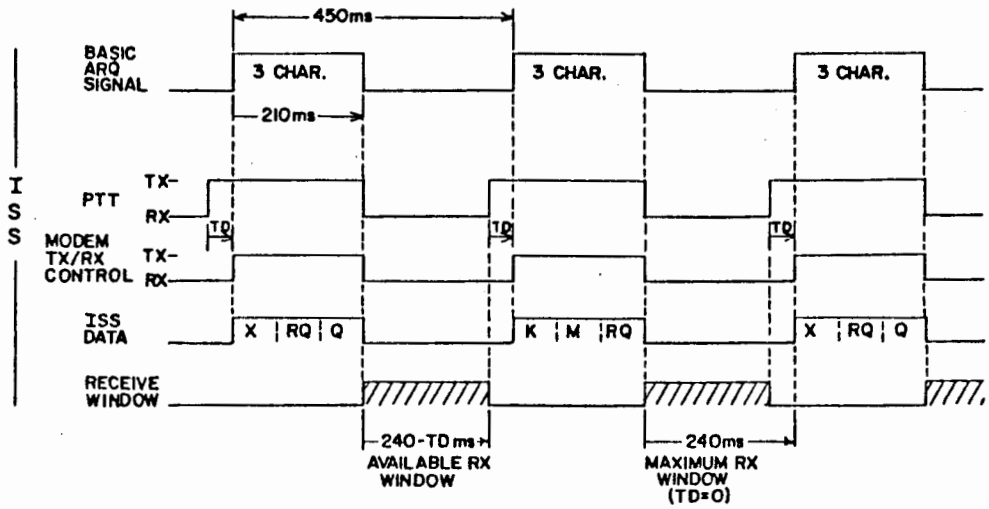
ARQ1000A terminals include provision for user programming of two delays that may be used to compensate for imperfections in the transmitting and receiving equipment. The delays are (1) minimum delay between activation of the transmitter PTT line and the beginning of transmit text; and (2) delay in the IRS slave station between the end of the received 3-character text block and the transmission of the CS1/CS2 response. Both delays may be adjusted over a wide range so that variations between different models of equipment may be compensated.

The transmit delay (TD:) parameter allows compensation for transmitter turn-on and relay switching (such as antenna relays). The action of the XMTR PTT output signal and the MODEM TX/RX CONTROL signals are split so that the XMTR PTT is first switched "ON" and then, after the TD delay, the MODEM TX/RX CONTROL is switched "ON" and the transmit data is started. Thus, if the modem transmit tones are controlled by the MODEM TX/RX signal, a tone-driven SSB transmitter will not develop RF output until after the relays are switched and the delay period has passed. Adjustment of this delay is discussed in section 3.2.11 of this manual.

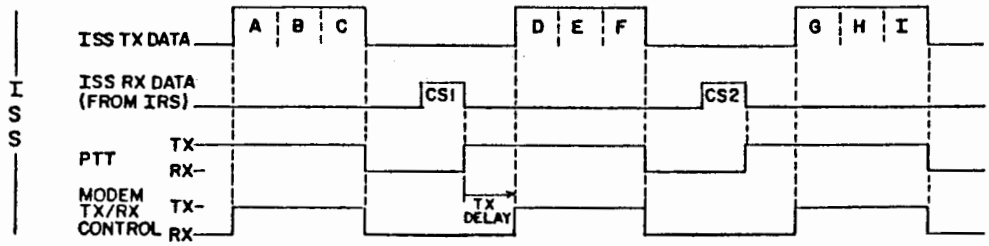
The control delay parameter (CD:) allows the slave receiving station to set when his CS1/CS2 response start. For best long-range distance, this delay should be as short as possible. However, transmitter turn-off and receiver turn-on delays in either station will interact with this aetting and some experimentation may be necessary. This delay is ONLY important when the station is in ARQ mode and is the called (SLAVE) receiving station (IRS). Adjustment of this delay is discussed in section 3.2.12 of this manual.

The effects of these two delays are shown in the diagrams of Figure 11. Notice that the transmit delay (TD) is a minimum delay parameter when the first call is made (Figure 11a). After communications are established, the transmit delay time increases to the maximum available and XMTR PTT is switched "ON" immediately after text is received. Also, notice that both the transmit delay (TD) and control delay (CD) consume part of the available 450 ms time "window". Thus, the effect of both delays tends to be additive and both will reduce the time and therefore the distance range available for reception.

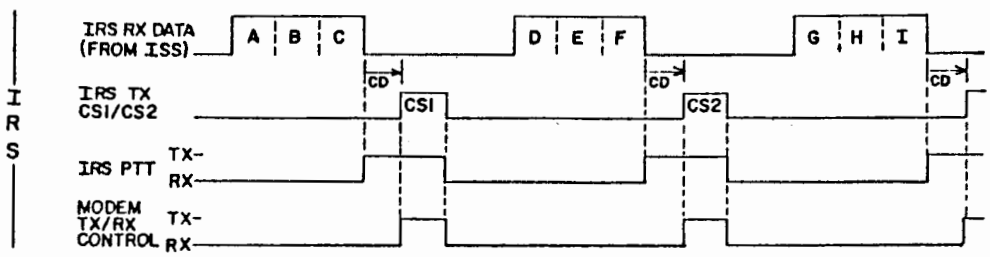
A third delay, the Audio Delay (AD), is also used in the ARQ1000A. AD is the time between the start of audio tones and the beginning of data transmission. It allows a short time of tone transmission for transmitter stabiliization before data begins. AD must be set from 0 to TD milliseconds. The AD parameter does not add to the TD and CD delays and therefore does not affect the range available for reception.



a. MASTER TIMING ON CALL-UP SHOWING TD
(ACCESS CODE=1234=XQKM)



b MASTER ISS TIMING OF PTT AFTER ARQ LINK IS ESTABLISHED
(PTT KEYS ON END OF RX DATA: TX DELAY ≥ TD)



c. SLAVE IRS TIMING OF CSI/CS2 AND PTT

Figure 11. Effects of Setting TD: and CD:

CHAPTER 5

IN CASE OF DIFFICULTY

This section of your user's manual will discuss in general terms how to keep your ARQ1000A in top operating condition and describe typical operating problems you might encounter (and some solutions).

5.1 CARE OF YOUR ARQ1000A

Your ARQ1000A is the latest of many generations of terminals sold by HAL Communications. In every way, it has been designed, constructed, and tested to assure years of trouble-free operation. However, there are a number of simple procedures that you, the user, can follow to further improve the reliability, performance, and useful life of the terminal. The following suggestions are offered to help preserve a long operating life for your ARQ1000A.

Environment:

Electric equipment is very susceptible to variations in temperature, relative humidity, and to dust and dirt accumulations. The ARQ1000A will operate in normal room-temperature environments and should be as tolerant of temperature extremes as you are while operating it. However, inadvertent blockage of the ventilating holes in the cabinet will cause the INTERNAL temperature of the terminal to rise considerably above the ambient room temperature and may in fact cause circuit failure. Also, accumulations of dust or dirt, particularly when accompanied by high humidity conditions, can also cause overheating and may result in long-term corrosion of the internal circuitry. Therefore, try to position the terminal so that its ventilating holes are not obstructed and try to avoid extremely dusty or dirty environments. On the other hand, the solid-state components in the ARQ1000A are designed to operate at considerably higher temperatures than we humans: do not be overly disturbed if the cabinet of the ARQ1000A (particularly the right side) operates quite warm to the touch. This internal heat often helps to "dry-out" humidity in the cabinet.

Electrical Connection:

All electrical connection points of the ARQ1000A have maximum voltage and current ratings as given in this manual. If these ratings are exceeded for even a short period of time,

considerable damage to the terminal may result. Therefore, be very careful -- KNOW the ratings of the ARQ1000A and the characteristics of any other equipment before making connections. Some common causes of electrical failures have been found to be:

A. Inadequate grounding, causing RF interference problems as well as sensitivity to AC power line transients.

B. Damage from lightning, or other transients on the power line or station antenna system. A good lightning protection system may help, as will disconnecting the terminal during electrical storms. However, such things are unpredictable and the ARQ1000A is no more susceptible to such problems than other electronic equipment in the station.

C. Direct connections to high voltage devices or to equipment with inadequate safety grounds. The ARQ1000A is not designed for connection to high voltage loop devices. Connection to such devices should be made only through a proper loop interface such as the LP1200A. Be sure that all devices plugged into the AC mains have safety grounds attached to them. AC line by-pass capacitors in a piece of equipment may cause the cabinet of that equipment to "float" at an AC potential sufficiently high enough to damage the ARQ1000A when the equipment is connected. CONNECT THE GROUNDS FIRST - THEN CONNECT TO POWER!

5.2 TYPICAL OPERATIONAL PROBLEMS

Because a large number of features are offered in the ARQ1000A, it is by nature a complicated device. Therefore, there may be times when it first appears that the terminal has either quit completely or gone off to "do its own thing". If some of the circuitry has failed, you may well get such symptoms. However, most often when a new owner finds the terminal "unresponsive", it is actually doing what it has been instructed to do. Familiarity with the ARQ1000A controls will quickly reduce the chances of "cockpit error" during terminal operation.

The front panel lamps are the best keys to what is happening in the ARQ1000A. Some of the more confusing conditions you may encounter are:

1. If the echo parameter is set wrong for your terminal, you may get some very confusing lamp indications when the ARQ1000A power is first turned on. The correct power-on response is indicated if the message "HAL ARQ1000A Vx.x" ("x.x" = current software version) is printed on the terminal. If the echo parameter is not set correctly, you may see all the mode lights turn on or all the ARQ1000A lamps may be off. To correct this problem, press the front panel BREAK switch to enter program mode. Refer to section 3.2 of this manual and enter the "ST:"

command to get a list of the programmed parameters. Change the echo parameter to its opposite (EC:ON: if EC:OFF is found, etc.). Exit program mode with "EX:" and then you should get the "HAL ARQ1000A Vx.x" prompt on the printer. Now, cycle the ARQ1000A power switch and be sure you get this response again.

2. A similar condition to (1) will be caused if the ARQ1000A and terminal are not set for the same code (Baudot or ASCII) and same data rate (45 to 300 baud). The power-on prompt message ("ARQ1000A Vx.x") is a good test of printer interfacing. You should get this result before proceding to other trouble-shooting steps.

3. If you cannot get the ARQ1000A to accept transmit text, make sure that the interfacing and data code and rate are correctly set. The code and rate of the printer and keyboard MUST be the same. If you are using the KBD WAIT signal, make sure that you have chosen the correct polarity and interface for your equipment. Also, make sure that your station is the Information Sending Station as shown by the ISS lamp: you cannot transmit data unless you are the ISS! If you are using a DS3200, be sure that the transmit function is enabled (activated by ALT-F10).

4. Sometimes, it may take some time to achieve a correct lock when using MON mode. The key in this case is to have patience. Use a good tuning indicator (like the SPT-1) and BELIEVE it! After correct tuning is made, leave the receiver frequency alone and let the ARQ1000A synchronize. It may take a lot longer than you think, particularly in FEC or SEL-FEC modes. Once an FEC transmission has started, you will only be able to synchronize once at the end of each line of text. This may require 10 seconds or more. The ARQ modes will NOT produce instant printing as on a standard RTTY circuit.

5. Sometimes you may find that when using ARQ mode, the communications link drops out a minute or so after the initial successful communications. This may be due to a very noisy communications circuit. However, if this occurs often with strong signals, this drop-out is usually an indication of poor transmitter or receiver switching times. Review the discussions of section 2.5 of this manual and measure the times of your equipment. You may have to modify or change the equipment to get satisfactory results. The manufacturer of the equipment is the best source to consult if this is found to be a problem. Some equipment delays may be compensated for by adjusting the TD:, CD:, and AD: programmable delays as explained in section 3.2.11 through 3.2.13 However, these adjustments will not allow all makes of transceivers to work without some modifications to the transceiver itself. The transceiver manufacturer or the sales depatment at HAL may be able to offer some advice about such modifications.

6. If your ARQ1000A can be used sucessfully as MASTER station but will not maintain synchronization when called as SLAVE station, try reducing the setting of CD:. This effect has been noticed over communications paths between the U.S. and Europe. Try using 30 to 50 ms for the CD: setting.

7. Be sure to disable any autostart or autoprint feature on your demodulator. The switching times of the ARQ mode are not compatible with the standard time constants used in RTTY demodulator autostart circuits. The autostart will usually not turn-on to an ARQ signal.

8. Be sure the POLARITY of BOTH the demodulator and ARQ1000A are set correctly. For USB transmitters, this means NORMAL polarity on both the demodulator and ARQ units. The polarities should also be NORMAL when the FSK or RTTY modes of transceivers are used. When using the direct FSK circuit of these transceivers, be sure that the correct polarity of TX DATA signal is conneced to the FSK or RTTY input. The polarity and voltage of FSK circuits varies with model and manufacturer - check your manual!

9. If your demodulator has selectable filter bandwidths or data rates such as the ST8000, set it for 100/110 baud signals (50 Hz minimum bandwidth). All current ARQ transmissions use 170 Hz shift. HAL ST6000 demodulators should require no LP filter modifications for ARQ operation.

10. Do NOT use linear amplifiers! The ARQ mode has error correction and power levels of 50 to 100 watts are generally adequate for world-wide communications. If it is necessary to use higher power, consult with manufacturers of the transmitter or amplifier to determine delays involved and techniques to be used to prevent damage due to switching transients.

11. The ARQ1000A has been designed to work with transmitters and receivers. However, normal grounding and shielding precautions must be taken to prevent RFI problems in a radio system. If you experience RFI problems, techniques for prevention are presented in the HAL application note "RF Induced Problems and Solid State Terminals", free upon request.

12. A good RTTY tuning indicator is ESSENTIAL to proper tuning of the ARQ signal when not using channelized radios, and can be very valuable in any case for determining frequency accuracy. The HAL SPT-1 Spectra Tune tuning indicator is recommended if you are not using an external demodulator with oscilloscope tuning.

13. Most intial hook-up problems are caused by incorrect settings of the I/O switches or by incorrect control settings. Double check your connections and controls before assuming that something is wrong!

14. The OFF mode is an active pass-through mode to allow operation of normal RTTY. The ARQ1000A AC power MUST be turned ON to operate RTTY. Power consumption of the ARQ1000A is low and it should be turned ON whenever RTTY or ARQ operation is desired.

15. Be sure that the AD parameter is set no longer than TD. If AD is set to a longer time than TD, it is possible that the framing time for ARQ transmission will be affected making ARQ communications impossible.

5.3 REPAIR PROCEDURES

In the event that your ARQ1000A develops a malfunction, the first step is to carefully note all of the symptoms of the problem. Statements such as "BROKEN" or "DOESN'T WORK" are of little help to the service technician, and usually lead to longer repair times than might otherwise be required. Try to provide as much information concerning the failure as you can before you contact your dealer. By all means, consult your dealer before calling the factory; he may be able to fix the unit locally and avoid the shipping and delay times.

The following are some of the things that will concern the dealer or factory:

1. Model number
2. Serial number
3. Software Version Number? (Vx.x - where x.x is the version number.)
4. How long have you owned it?
5. Where did you purchase it (dealer's name)?
6. If purchased used, who was the previous owner? (Used to refer to any previous repair history on that unit.)
7. What modes and conditions are associated with the failure?
8. Are there extenuating circumstances? (Lightening, spilled liquids, dropped unit?)
9. Is there anything else you can add to the description that you think might be useful?

AFTER you have determined answers to the above, contact your dealer and discuss the problem with him. If he indicates that he will be unable to assist you, the unit should be returned to the HAL factory for repair. Before returning the unit to the factory, either you or the dealer should call and receive factory return authorization so that we may expect the unit in shipping and be prepared to work on it when it arrives. Whenever possible, return the unit via UPS to the factory address below, insuring it for the full value. The shipping cost to the factory should be paid by you: the return shipping costs from the factory (48 contiguous states only) are paid by HAL (warranty repairs only). The factory "ship-to" address is:

HAL COMMUNICATIONS CORP
1201 W. KENYON ROAD
URBANA, ILLINOIS 61801
ATTENTION: REPAIR DEPARTMENT

The one-year limited warranty (listed in full at the end of this manual) provides for repair of the ARQ1000A for a full year after purchase. The purchase invoice date from your dealer marks the beginning of the warranty period - save your copy of the invoice! Please read the warranty carefully to determine the full extent of the privileges and limitations.

5.4 USER ADJUSTMENTS

Because of the complexity of the circuitry used in the ARQ1000A, we do NOT recommend that you personally undertake repairs of the terminal circuit board. There are a number of user-selectable I/O interface switches as outlined in Chapter 2 of this manual. However, there are NO adjustments in the ARQ1000A itself. Adjustments on the M1700 Modem option circuit board are discussed in its manual. The ARQ1000A is a fully microprocessor-controlled digital device. Unless you are very familiar with such circuitry, we recommend that all repairs be done at the factory or at an authorized service location.

CHAPTER 6

TECHNICAL DATA

This chapter presents a brief discussion of the circuitry used in the ARQ1000A and a full set of schematic and mechanical diagrams.

6.1 CIRCUIT DESCRIPTION

Circuitry of the ARQ1000A is contained entirely on a single printed circuit board, with the exception of the power transformer, the voltage regulator for the five-volt power supply, and the front panel lights and switches. The heart of the ARQ1000A is a type Z80-A, silicon-gate, N-channel MOS, 8-bit microprocessor IC. This is combined with Read-Only Memory (ROM), Random-Access Memory (RAM), Electrically Eraseable Read-Only Memory (EEROM), programable interval timer, Universal Synchronous/Asynchronous Receiver/Transmitter (USART) and I/O interface circuitry to produce the ARQ1000A.

CPU:

All operations of the ARQ1000A are performed by the Z80-A CPU as it performs steps in the system program. This program, which contains all necessary instructions the CPU must carry out, is contained in two type 2732 Erasable Programmable ROMs (EPROMs). This program (software) is installed in plug-in sockets, assuring simple replacement if future software updates are made available.

Data Storage:

The p.c. board contains 2048 bytes of RAM, which is used for the storage of terminal input (keyboard) and output (printer) data, ARQ input (receive) and output (transmit) data, and all the necessary supervisory data required to establish and maintain ARQ communications. In addition to the RAM, the board includes 2048 bytes of EEPROM (the data in which remains intact during power-down cycles) which is used to contain all the default modes power-up information as well as the HERE-IS message, the Local, Remote, and Group call signs.

Communications:

A type 8251 USART IC provides the serial-to-parallel conversion of the terminal data received, and vice-versa for transmitted data. It also determines the character length of the serial I/O (5-unit for Baudot or 8-unit for ASCII) and inserts start and stop bits as required. The type 8253 programmable interval timer provides the USART clock and thereby determines the data

rate to the terminal. Additionally, it provides to the CPU a non-maskable interrupt every 1 millisecond, so that the CPU can calculate when to send and receive data to and from the radio system in the various modes of ARQ communications. The p.c. board also contains the ICs to provide all of the various interface options such as high voltage loop, RS23C2, and TTL for all the inputs and outputs.

Front Panel:

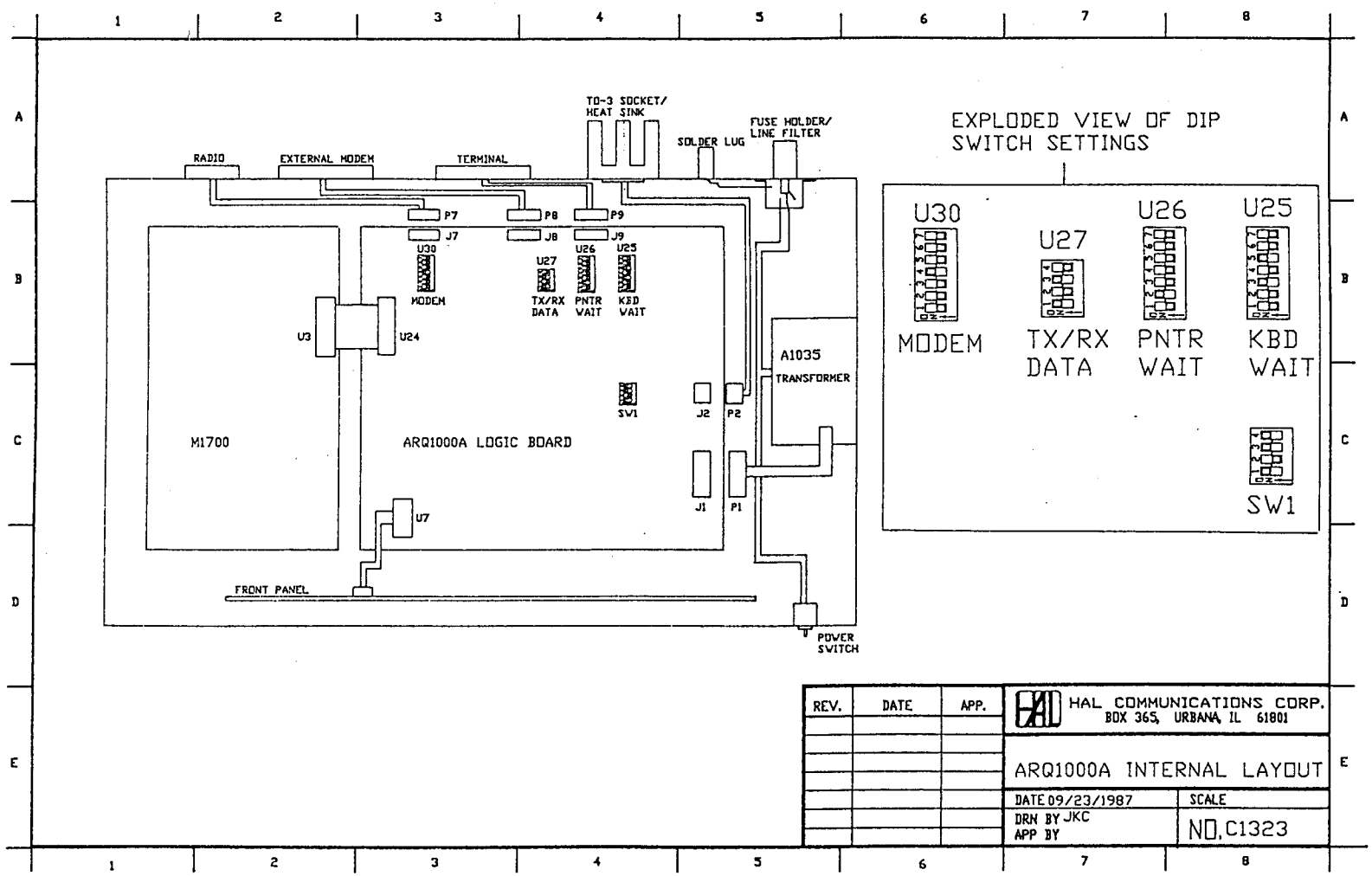
The front panel contains a large part of the circuitry to access the 11 switches, and to decode and drive the 30 lights, as +well as the "beeper." It communicates with the main board over a specially defined nine-pin bus consisting of four data lines, and five supervisory lines, and with the exception of the RESET button, is completely controled by the main board.

Power Supply:

The p.c. board accepts low voltage AC from the cabinet-mounted transformer, and provides three regulated voltages to the main and front-panel boards through the use of three three-terminal voltage regulators, one each for the following voltages: +12V, -12V, and +5V. The +5V is used to power all the boards in the unit, while the +12V and -12V are used to generate the voltages required to support the RS232 communications interface. All three voltages are also used by the optional M1700 modem board.

6.2 CIRCUIT DIAGRAMS

Following are circuit diagrams of the ARQ1000A for reference. These diagrams include the internal layout, rear panel detail, front panel schematics, and main board schematics.



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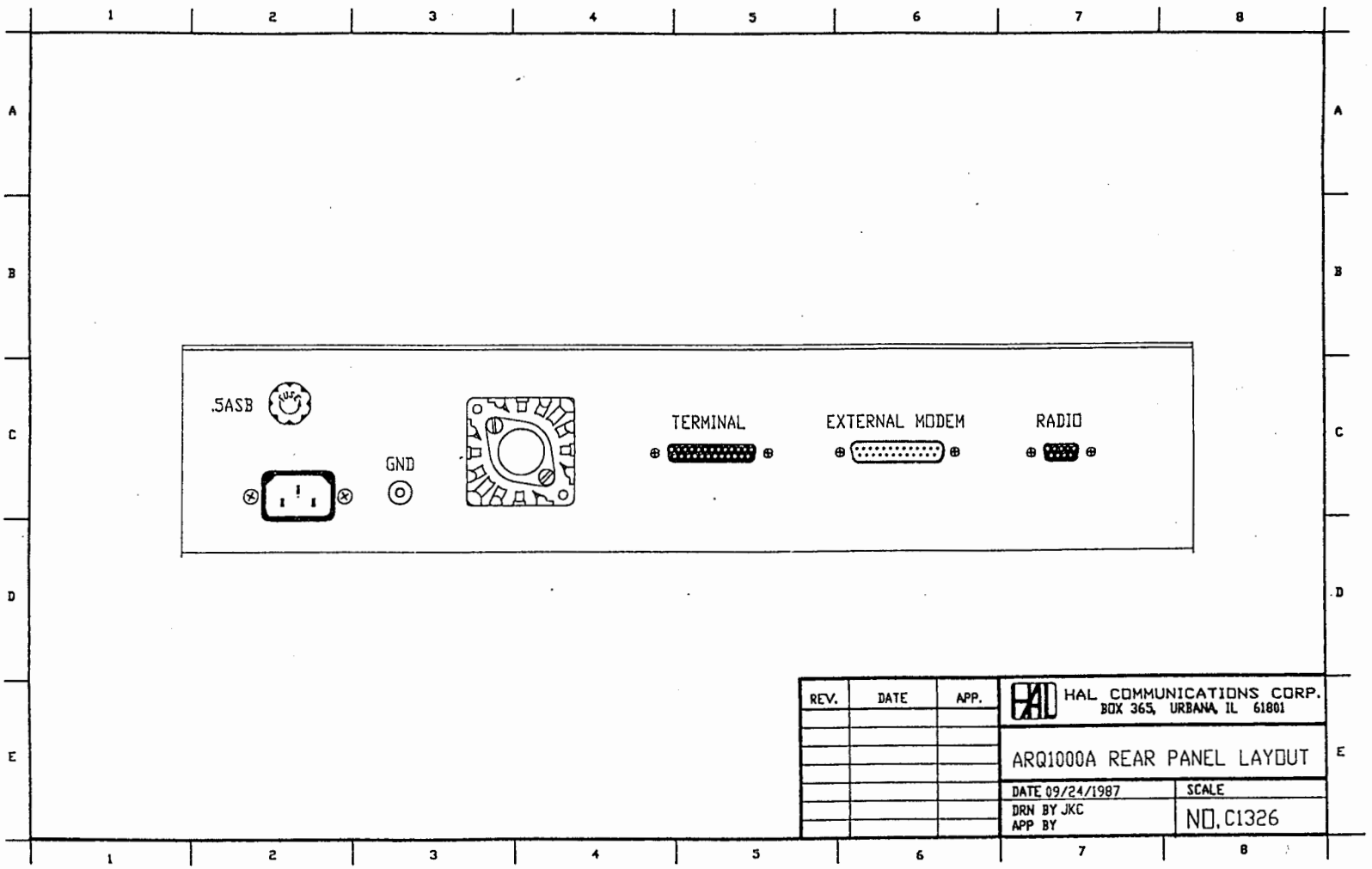
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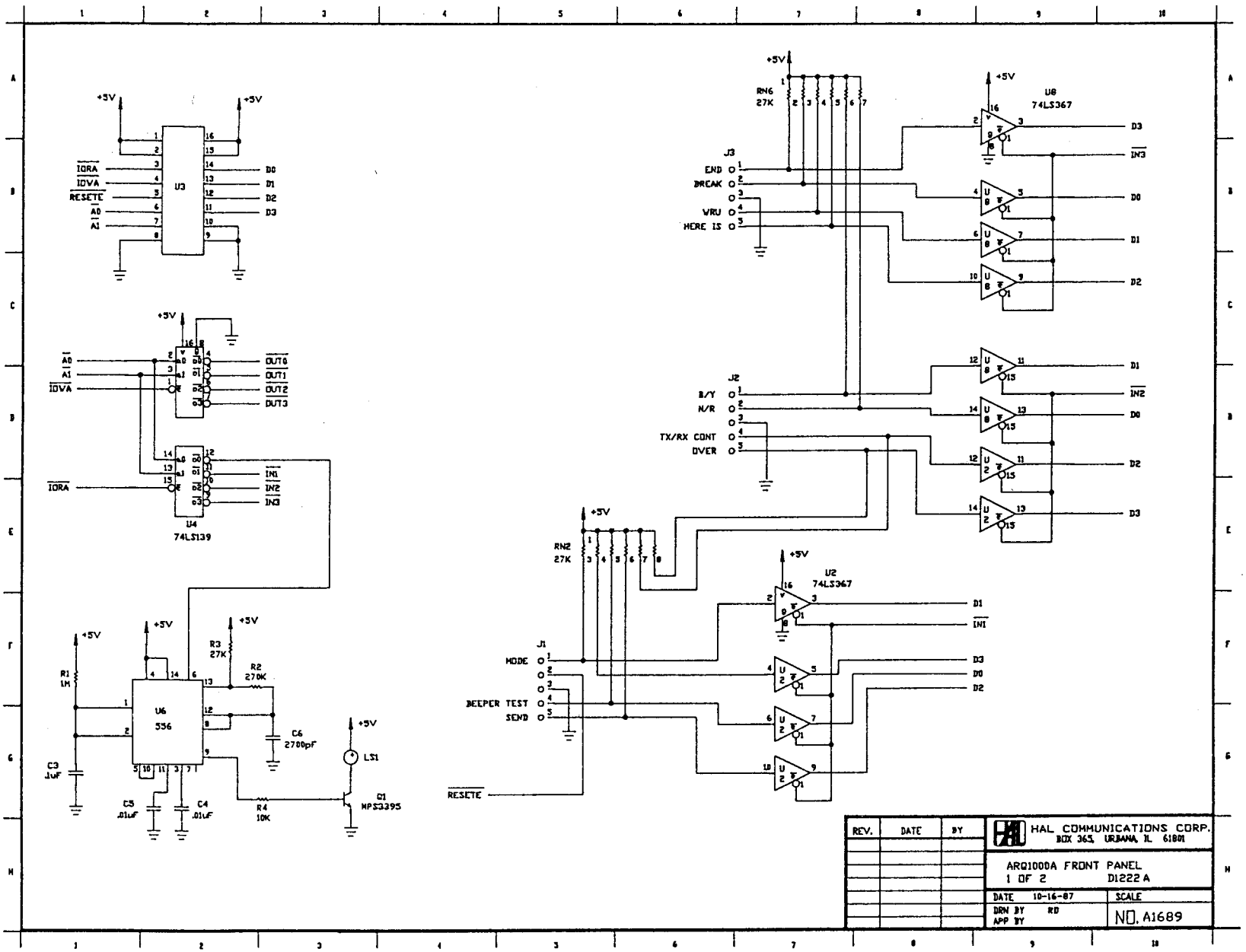

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ARQ1000A FRONT PANEL
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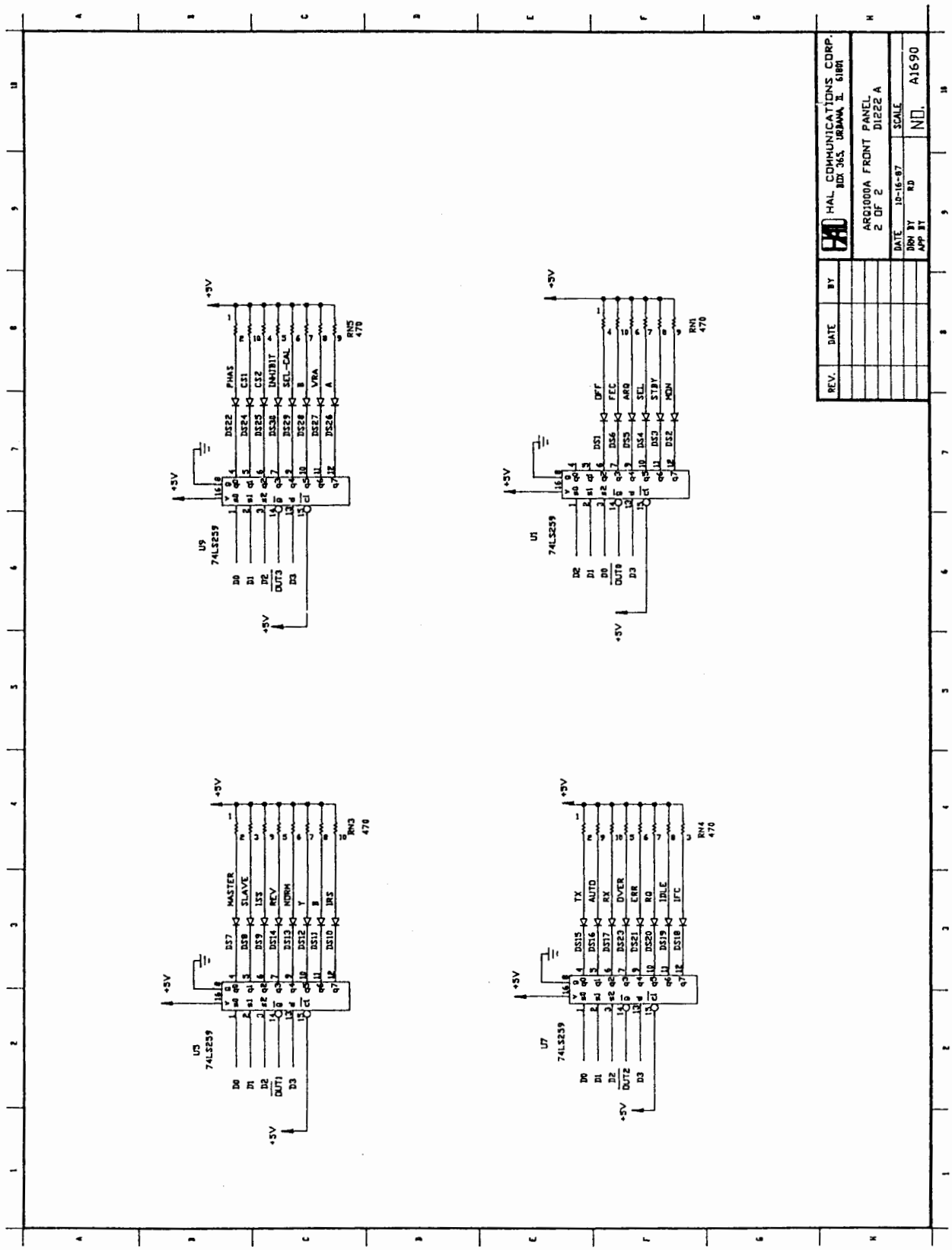
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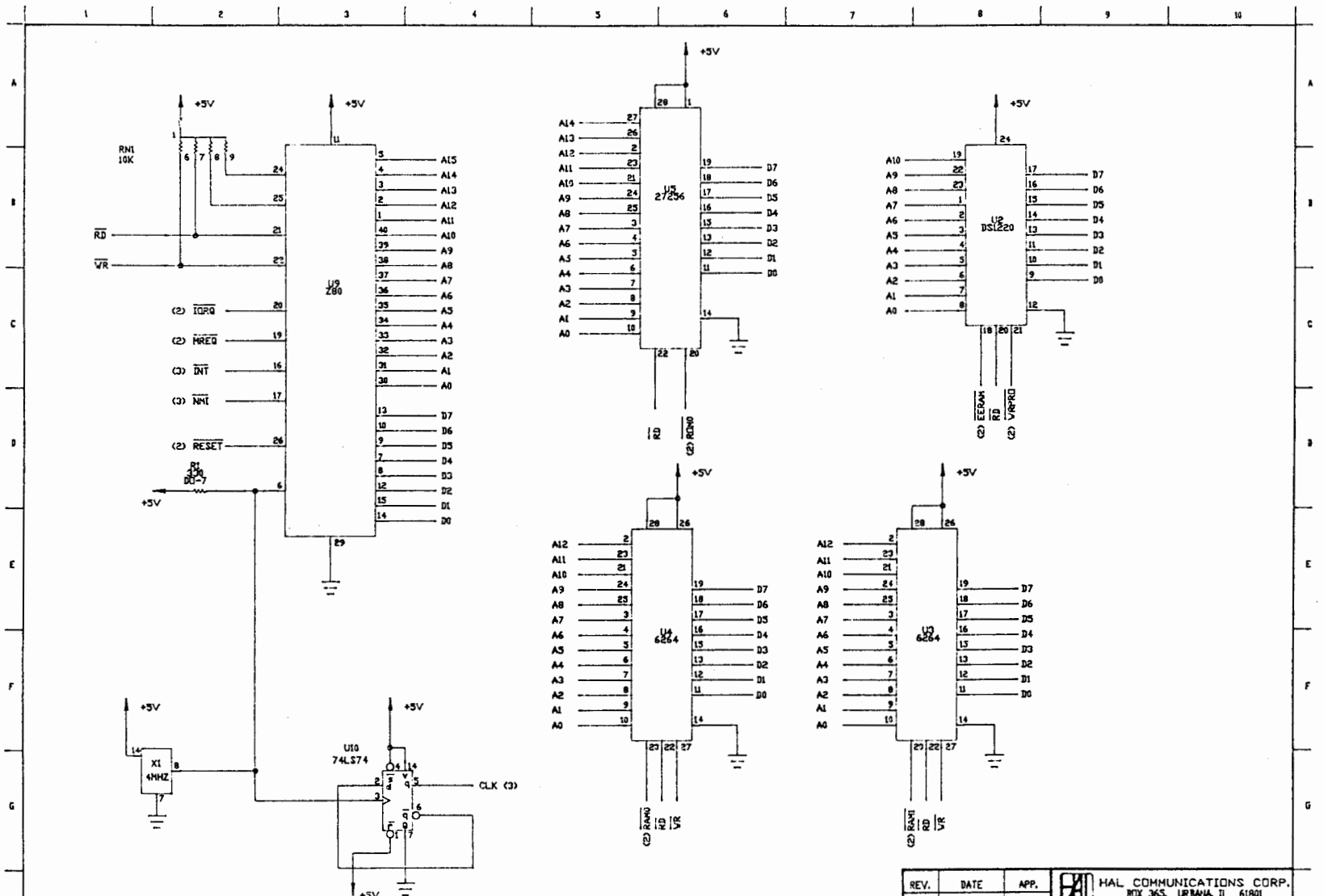
U1 74LS259
U5 74LS259
U7 74LS259
RN5 470
RN1 470
RN3 470
RN4 470
+5V
MASTER
SLAVE
TX
AUTO
RX
OVER
ERR
RQ
IDLE
IFC
PHAS
CS1
CS2
UNKNOT
SEL-CAL
VRA
OFF
FEC
ARQ
STBY
MON


+5V
RN1
10K
U1
Z80
RD
WR
(2) IORQ
(2) MREQ
(3) INT
(3) NMI
(2) RESET
R1
4.7K
DC-7
A15
A14
A13
A12
A11
A10
A9
A8
A7
A6
A5
A4
A3
A2
A1
A0
D7
D6
D5
D4
D3
D2
D1
D0
X1
4MHZ
U10
74LS74
CLK (3)
U5
27256
(2) ROM0
U2
DS1220
(2) EERAM
(2) ARRD
U4
6264
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U3
6264
(2) RAM1
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ARQ1000A MAIN BOARD
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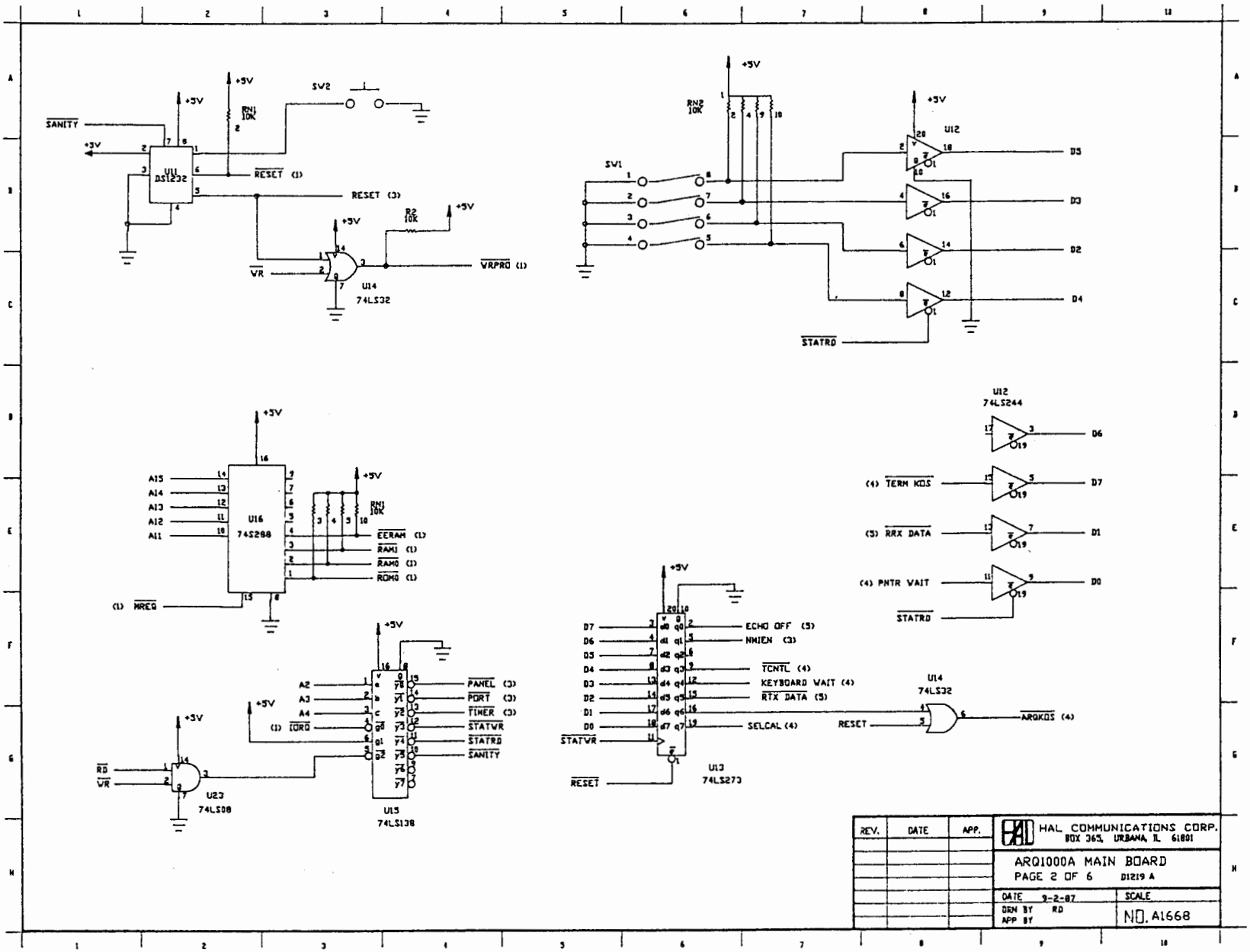

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ARQ1000A MAIN BOARD
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SCALE
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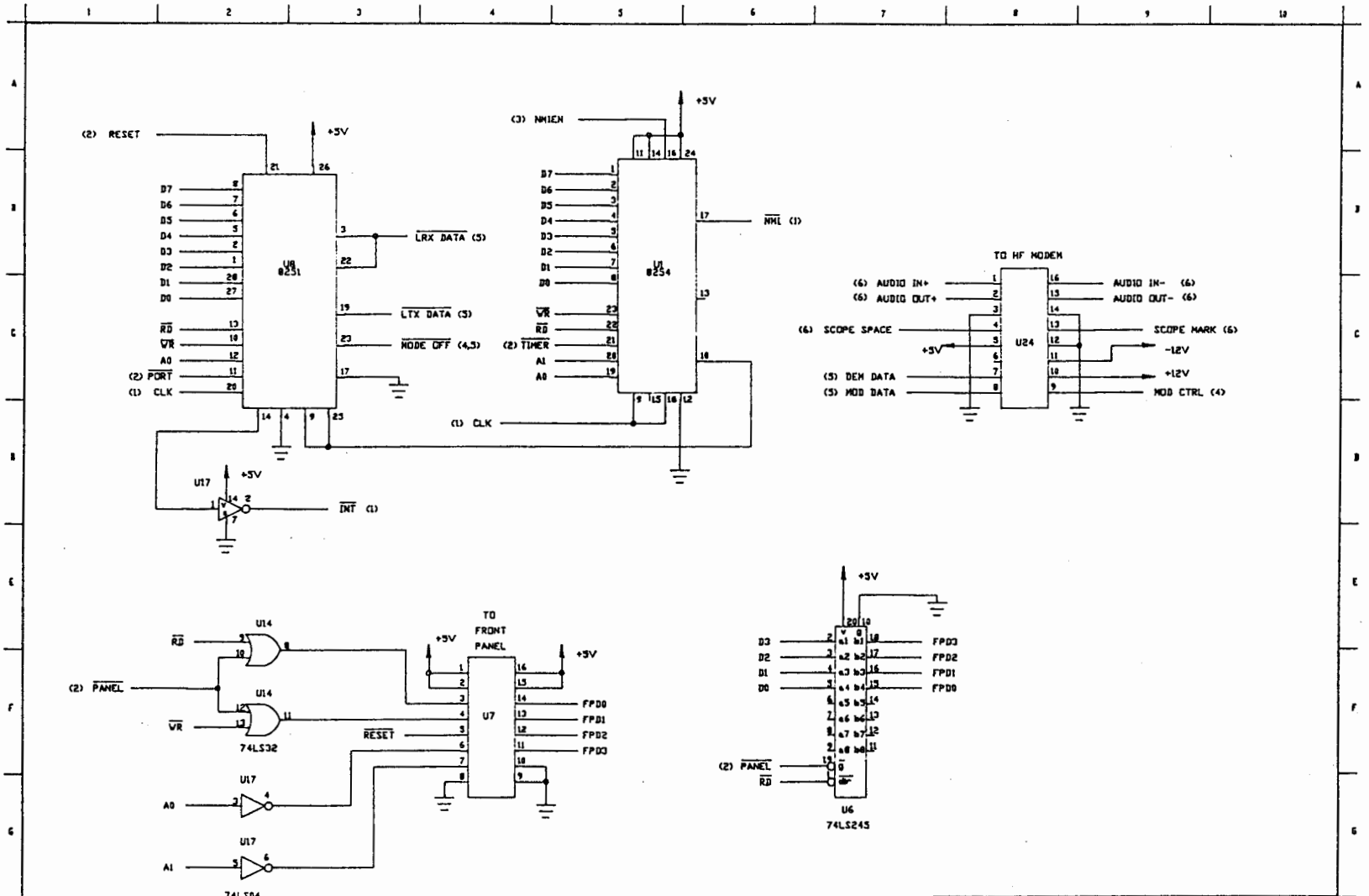

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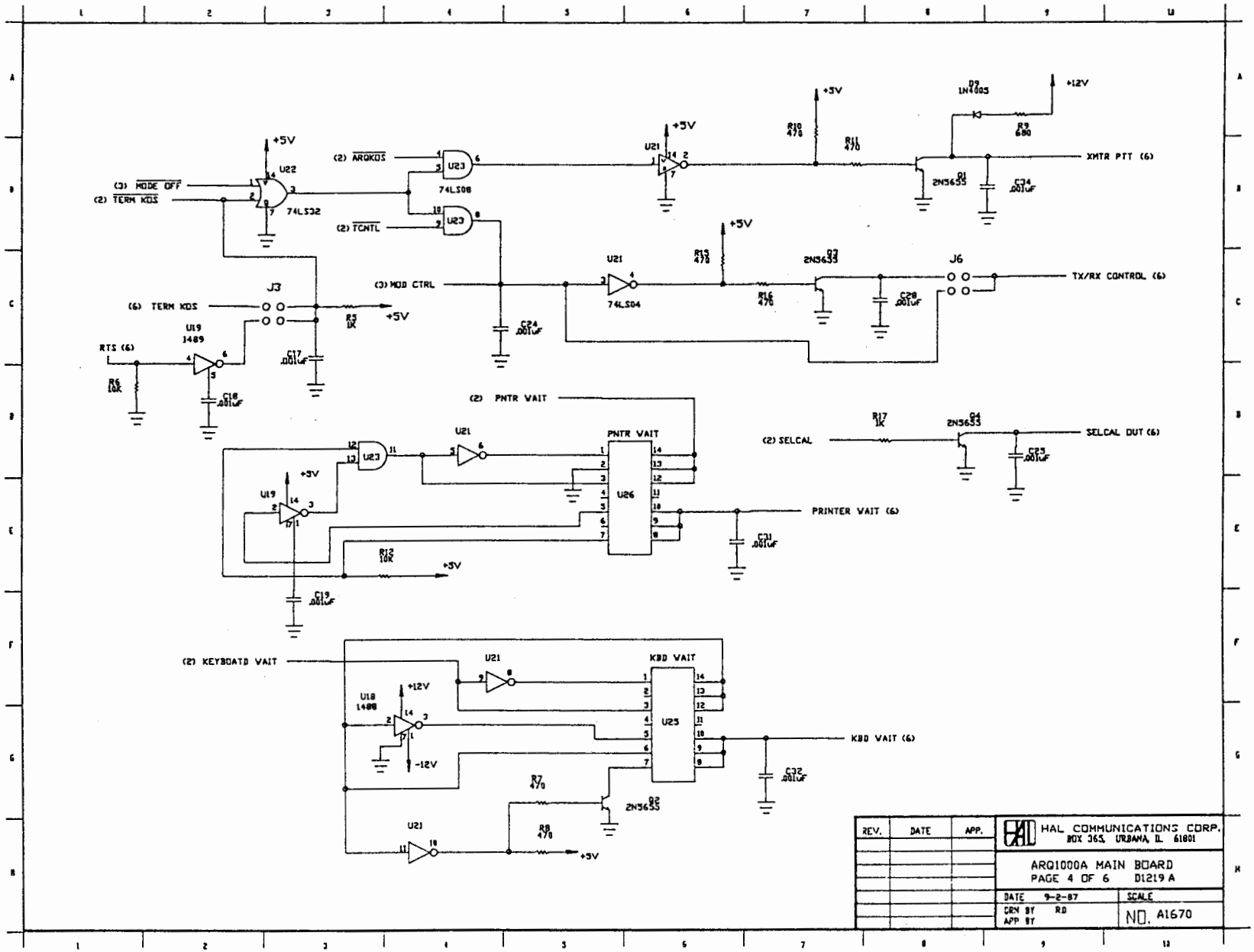
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(2) TERM KDS
(2) AROKDS
(2) TCNTL
(3) MOD CTRL
(6) TERM KDS
RTS (6)
(2) PNTR WAIT
(2) SELCAL
(2) KEYBOARD WAIT
XMTR PTT (6)
TX/RX CONTROL (6)
SELCAL OUT (6)
PRINTER WAIT (6)
KBD WAIT (6)
+5V
+12V
-12V
74LS32
74LS08
74LS04
1489
1488
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1N4005
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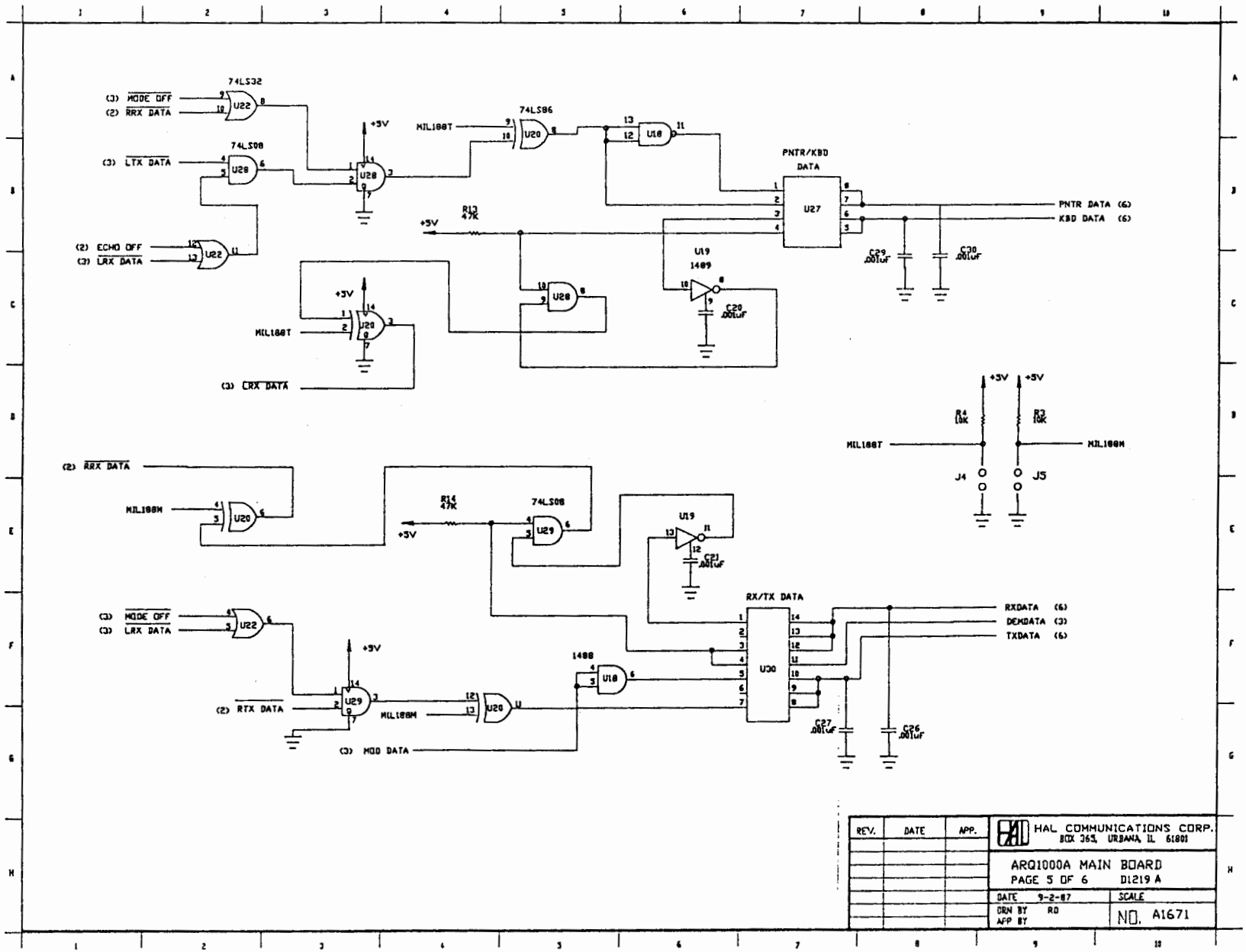

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			DATE 9-2-87 SCALE
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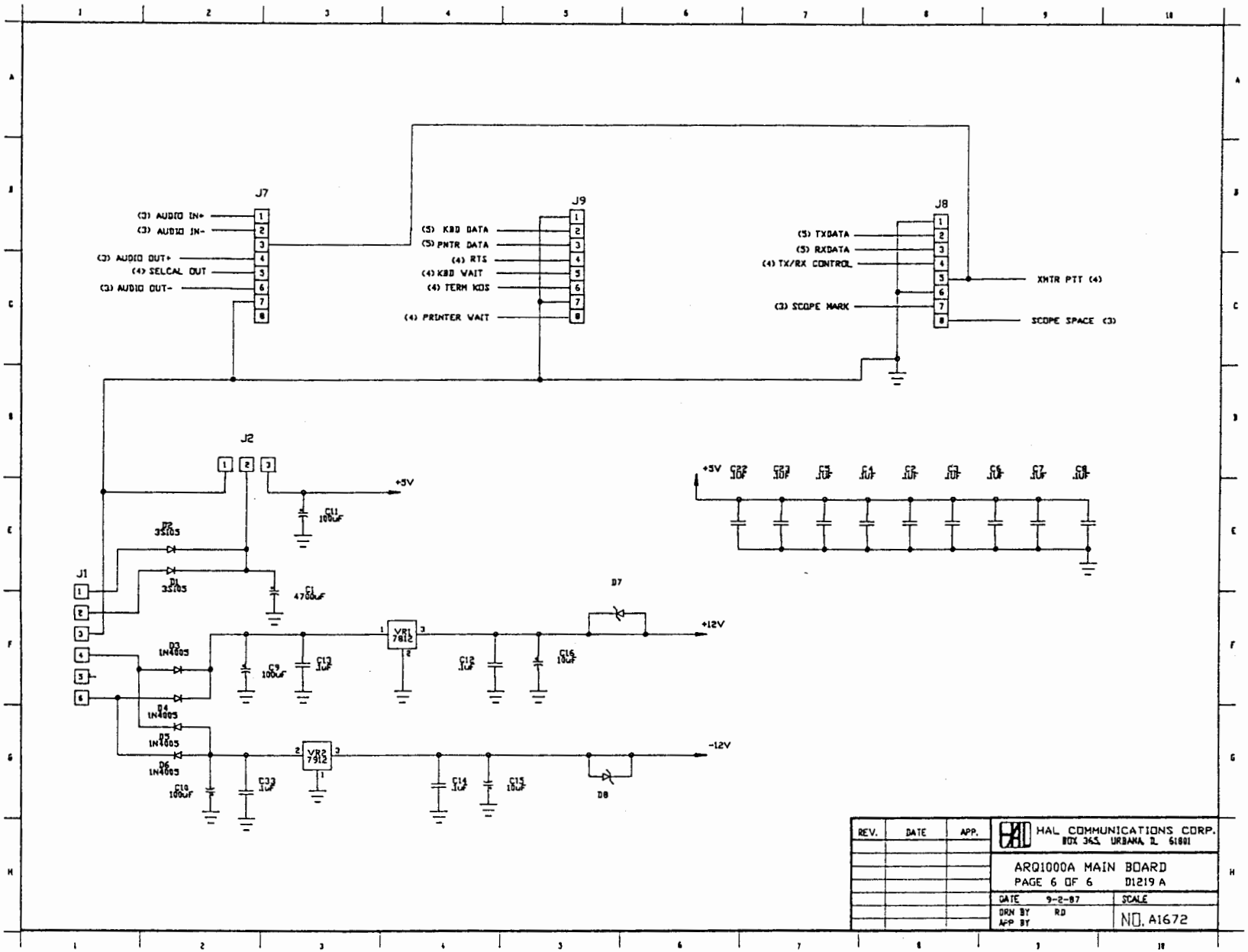
			APP BY



REV.	DATE	APP.

HAL COMMUNICATIONS CORP.
BOX 365, URBANA IL 61801

ARQ1000A MAIN BOARD
PAGE 6 OF 6 D1219 A

DATE	9-2-87	SCALE
DRN BY	RD	NO. A1672
APP BY		

CHAPTER 7
SPECIFICATIONS

CONTROLS AND RELATED INDICATORS:

CONTROL	INDICATOR	
MODE:	OFF:	By-pass ARQ conversion; connect TTY to demodulator
	STBY:	"Rest mode" for automatic switching to ARQ, FEC, and SEL transmit-receive modes.
	ARQ:	Select normal ARQ transmit-receive mode.
	FEC:	Select FEC collective broadcast mode
	SEL:	Select SEL-FEC selective broadcast mode
	MON:	"Rest mode" for automatic switching to ARQ, FEC, and SEL receive-only modes.
RESET:		Force full reset of ARQ1000A processing.
SEND:		Manual initiation of transmission; may also be made by keyboard control.
B/Y:		Force transmission of alternate 450 ms B and Y ARQ code to the demodulator for testing.
N/R:	NORM:	Reverse modem TX/RX data sense.
	REV:	
TX/RX	TX:	Transmit continuously until switched off
CONT:	AUTO:	Automatic TX/RX control (normal)
	RX:	Receive only until switched off
OVER:		Force change in direction of traffic; also made by keyboard control.
END:		Signal end of message to other station.
BREAK:		Force terminal keyboard continuous space condition; used to indicate entry to program mode for ARQ and SEL-FEC codes; also made by keyboard BREAK key.
WRU:	WRU:	Send WRU call to other station in ARQ mode.
HERE IS:		Manually transmit WRU response message to identify station.

INDICATORS:

MASTER:	Station that originated communications.
SLAVE:	Original receiving station.
ISS:	Information Sending Station at a given time.
IRS:	Informatio Receiving Station at a given time.
TFC:	Normal traffic is being processed.
IDLE:	Idle signals are being sent or received.
RQ:	Repeat request in ARQ mode.
ERR:	A reception error has been detected.
PHAS:	ARQ1000A synchronizing with remote station.
OVER:	ARQ system is changing direction.
CS1: CS2: alpha: beta:	Show reception of indicated ARQ control code.
SEL-CAL:	Show reception of programmed SEL-CAL code.
INPUT INHIBIT:	Indicate keyboard/TD wait control signal.

INTERFACE SPECIFICATIONS:

Data To/From Demodulator:

Code, Rate:	100 Baud ARQ code as defined by CCIR 476-2.
Levels:	RS232C, TTL.
Control:	Tone enable when transmitting.

Data To/From Terminal (TTY):

Codes:	Baudot (CCITT No. 2) or ASCII.
Rates:	45, 50, 57, 74, 110, 134.5, 150, 300 baud.
Connection:	Full duplex.
Levels:	RS232C, TTL.
Control:	Printer busy input and keyboard wait output; input from terminal KOS control or RTS.

Data to Transmitter/Receiver:

Control:	Transmit/receive control (KOS)

I/O Connections: DB25 connectors for Terminal and External Modem. DE-9 for Radio connection with optional M1700 Modem.

GENERAL:

SIZE:	3.5" H x 16.75" W x 10.375" D (8.9 x 42.5 x 26.4 cm)
WEIGHT:	8 lbs net; 12 lbs shipping (3.6 kg net; 5.5 kg shipping)

COLOR:	Light gray cabinet with black front panel.
STYLE:	Table mounting with tilt bail or 19" rack mounting.
POWER:	105-130, 210-250 VAC, 50/60 Hz; 30 Watts.

OPTIONAL M1700 INTERNAL DEMODULATOR:

The M1700 demodulator circuit board installs in the ARQ1000A and provides high-performance demodulation of the received signal. The transmit tones are also generated on the M1700 board. Power for the M1700 is obtained from the ARQ1000A. It is easily field-installed in the ARQ1000A. Rear panel and internal connections for the M1700 are included in all ARQ1000A units.

SHIFT:	170 Hz
TONES:	1700 Hz +/- 85 Hz standard 1500 Hz +/- 85 Hz, 2125/2295 or 1275/1445 on special order. Transmit tones crystal controlled.
RECEIVE CIRCUITS:	Multi-pole input bandpass, discriminator, low-pass filters; wide-range limiter.
POLARITY:	Controlled by ARQ1000A N/R switch
RX AF IN:	600 ohm, 4 ohm, or high impedance; -40 to +10 dBm.
TX AF OUT:	600 ohm with or without DC isolation; -40 to +6 dBm adjustable.
TUNING SCOPE:	Output of mark and space filters to external X-Y oscilloscope; 1 V p-p, 1K.
POWER:	Derived from ARQ1000A.
CONNECTIONS:	10-terminal barrier strip.
MECHANICAL:	Installs in ARQ1000A. Adds less than 2 lbs.

FURTHER ACCESSORIES AVAILABLE FOR ARQ1000A:

DS3200: Radio Communications Terminal. Complete with 640K RAM, 2 - 360K Floppy Disk Drives (or 1 Floppy and 1 - 20MB hard disk in DS3200HD version), AT-style keyboard, high resolution video monitor, serial and parallel I/O, and terminal operating software. DS3200 is fully PC-compatible and rack-mountable. Software allows function as full or half duplex terminal with message storage.

ST8000: Demodulator for RTTY. Variable frequency shift. Mark and space tones settable from 400-4000 Hz. Includes transmit tone generator and tuning oscilloscope. RS232C and MIL188 interfaces, full or half duplex. 100-120 / 200-240 Vac, 50/60 Hz. 3.5 " high, table or 19" rack mounting.

ST6000: Demodulator for RTTY. Three shifts standard (170, 425, 850 Hz); 2125 or 1275 Hz standard mark tones. Includes crystal-controlled transmit tone generator, internal 175 V, 60 ma neutral loop supply. Loop, RS232C, CMOS I/O interface; full or half duplex. 105-130 / 210-250 Vac, 50/60 Hz. 3.5" high, table or 19" rack mounting.

LP1200A: High voltage loop power supply. Provides conversion to high voltage loop circuits for mechanical TTY machines. Also provides the loop supply to drive teleprinter. Neutral (0 to +120 VDC) or Polar (-60 to +60 VDC, 20 or 60ma loop current. RS232 I/O to ARQ1000A. 19" rack mounting cabinet standard.

SPT-1: Spectra-Tune tuning indicator. Calibrated LED bar graph displays received tones in range from 300 - 3000 Hz. 6.125W x 2.5H x 6.25D (inches). 12-15 VDC, 90 ma.

APPENDIX A

POWER TRANSFORMER CONNECTIONS

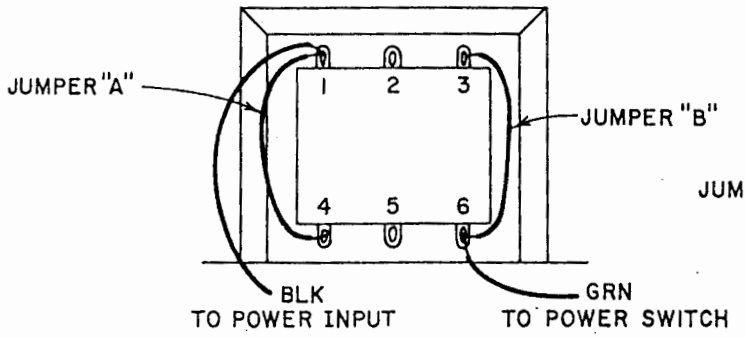
The ARQ1000A can be connected for operation from either 95-125 VAC, or 190-250 VAC power lines. It will operate on 50 or 60 Hz AC power with no changes being required. The ARQ1000A is normally supplied from the factory set for 120 VAC, but can be supplied for 220 VAC upon request.

> CAUTION! DO NO MAKE ANY CHANGES IN TRANSFORMER CONNECTIONS UNLESS THE TERMINAL HAS BEEN DISCONNECTED FROM THE POWER LINE AND OTHER EQUIPMENT.

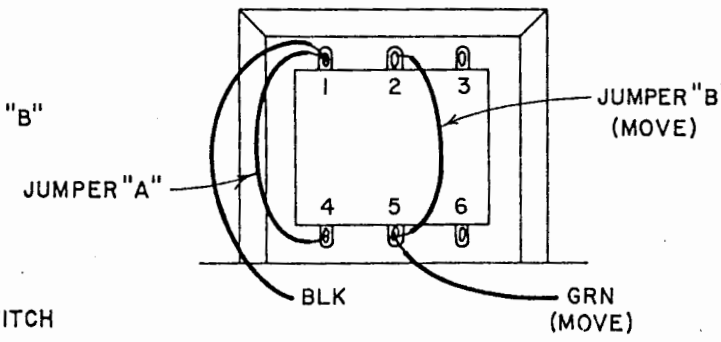
Connections to the power transformer primary windings must be changed to match the available AC power line voltage. Refer to Figure 24 for the various possibilities.

The ARQ1000A is normally shipped from the factory with one of two settings. ALL orders shipped to U.S. customers are supplied for 110-125 VAC operation usless specifically requested otherwise. All export units are supplied with 220-250 VAC connections unless otherwise specified. If the ARQ1000A is factory wired for 220-250 VAC, it will be so indicated by a rear panel label near the AC power line connector. If this label is not present on your cabinet, assume that your ARQ1000A is wired for 110-125 VAC operation.

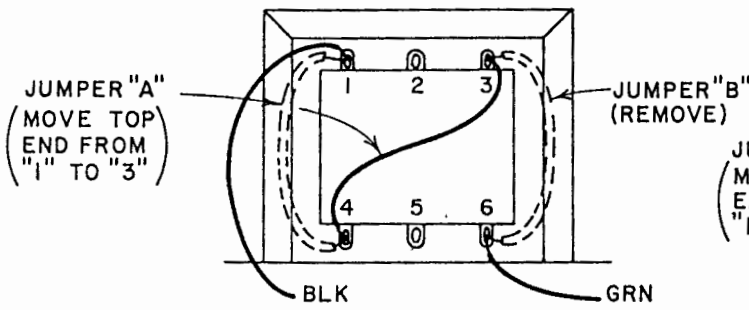
Two additional settings are provided for installations in which the AC power line voltage is CONSISTENTLY lower than the 110-125 or 220-250 VAC ranges. ONLY use these connections if your voltages are always lower than the standard ranges. Use of the low voltage connections will not cure problems due to poor AC line regulation and damage may be done to the ARQ1000A if low voltage taps are used and the line voltage then increases much above 110 or 220 VAC. Use of a saturable-reactor type of line voltage regulator is NOT recommended. Switching spikes generated by such devices may cause improper operation of the ARQ1000A.



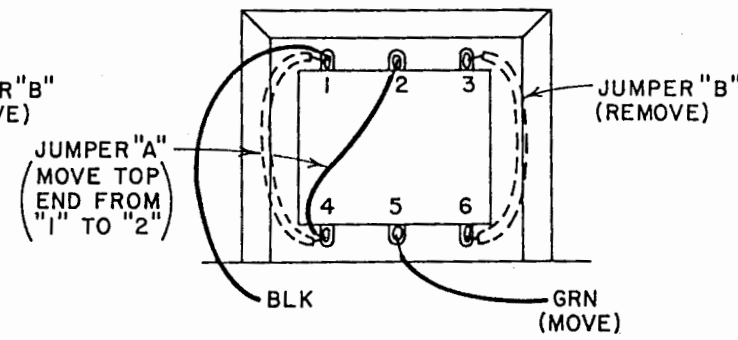
(a) 110 - 125 VAC Connection (Standard)



(b) 95 - 110 VAC Connection



(c) 220 - 250 VAC Connection



(d) 190 - 220 VAC Connection

FIGURE 24. POWER TRANSFORMER VOLTAGE TAP CONNECTIONS

APPENDIX B

DEFINITION OF SIGNAL POLARITIES

The following tables apply to commercial applications of radio teleprinters.

RF OUTPUT	TELEPRINTER DATA	SYNC	TAPE	WIRE	7-UNIT ARQ	TELEX LINE
Higher Radio Frequency	SPACE	START	No Perf.	A	B	Free Line Condx.
Lower Radio Frequency	MARK	STOP	Perf.	Z	Y	Idle Circuit Condx.

NOTE: Above radio frequency polarity corresponds to both CCIR Recommendation 490 and to FCC Rules and Regulations for marine service (Parts 81 and 83). If tones are used with a SSB transmitter, USB should be used with a 1615 Hz mark and 1785 Hz space tone.

I/O SIGNAL POLARITIES

DATA	* LOOP CURRENT	RS232C VOLTAGE	TTL VOLTAGE
MARK	ON	-5 to -25V	+3.5 to +5.0V
SPACE	OFF	+5 to +25V	0.0 to +1.5V

* NOTE: The ARQ1000A does not support loop devices directly. Normal loop polarity is shown for reference and for those who intend to use an external loop power supply and converter like the LP1200A Loop Power Supply.

APPENDIX C

CCIR 491 SEL-CAL INDENTIFICATION TABLE

5 DIGIT NUMBERS

1st digit		0	1	2	3	4	5	6	7	8	9
	0	T	V	V	V	T	T	T	V	V	V
	1	B	X	X	X	B	B	B	X	X	X
	2	U	Q	Q	Q	U	U	U	Q	Q	Q
	3	E	K	K	K	E	E	E	K	K	K
2nd digit	4	O	M	M	M	O	O	O	M	M	M
	5	I	P	P	P	I	I	I	P	P	P
	6	R	C	C	C	R	R	R	C	C	C
	7	Z	Y	Y	Y	Z	Z	Z	Y	Y	Y
	8	D	F	F	F	D	D	D	F	F	F
	9	A	S	S	S	A	A	A	S	S	S

3rd digit											
	0	V	T	V	V	T	V	V	T	T	V
	1	X	B	X	X	B	X	X	B	B	X
	2	Q	U	Q	Q	U	Q	Q	U	U	Q
	3	K	E	K	K	E	K	K	E	E	K
	4	M	O	M	M	O	M	M	O	O	M
	5	P	I	P	P	I	P	P	I	I	P
	6	C	R	C	C	R	C	C	R	R	C
	7	Y	Z	Y	Y	Z	Y	Y	Z	Z	Y
	8	F	D	F	F	D	F	F	D	D	F
	9	S	A	S	S	A	S	S	A	A	S

4th digit											
	0	V	V	T	V	V	T	V	T	V	T
	1	X	X	B	X	X	B	X	B	X	B
	2	Q	Q	U	Q	Q	U	Q	U	Q	U
	3	K	K	E	K	K	E	K	E	K	E
	4	M	M	O	M	M	O	M	O	M	O
	5	P	P	I	P	P	I	P	I	P	I
	6	C	C	R	C	C	R	C	R	C	R
	7	Y	Y	Z	Y	Y	Z	Y	Z	Y	Z
	8	F	F	D	F	F	D	F	D	F	D
	9	S	S	A	S	S	A	S	A	S	A

5th digit											
	0	V	V	V	T	V	V	T	V	T	T
	1	X	X	X	B	X	X	B	X	B	B
	2	Q	Q	Q	U	Q	Q	U	Q	U	U
	3	K	K	K	E	K	K	E	K	E	E
	4	M	M	M	O	M	M	O	M	O	O
	5	P	P	P	I	P	P	I	P	I	I
	6	C	C	C	R	C	C	R	C	R	R
	7	Y	Y	Y	Z	Y	Y	Z	Y	Z	Z
	8	F	F	F	D	F	F	D	F	D	D
	9	S	S	S	A	S	S	A	S	A	A

4 DIGIT NUMBERS

ALL digits

0	V
1	X
2	Q
3	K
4	M
5	P
6	C
7	Y
8	F
9	S

Examples:

32610 = QCXT

1234 = XQKM

APPENDIX D

REFERENCES

The following documents and definitions are referenced in this ARQ1000A manual:

American National Standards Institute, Inc.
1430 Broadway
New York, NY 10018

ANSI X3.4 -1977 American National Standard Code for Information Interchange

ANSI X3.15-1976 American National Standard for Bot Sequencing of the American National Standard Code for Information Interchange in Serial-By-Bit Data Transmission.

ANSI X3.38-1976 American National Standard Procedures for the Use of Control Characters of American National Standard Code for Information Interchange in Specified Data Communications Links.

Electronic Industries Association
EIA Engineering Department
Standards Orders
2001 Eye Street
Washington, D.C. 20006

EIA Standard RS232C Interface Between Data Terminal Equipment and Data Communications Equipment Employing Serial Binary Data Interchange.

International Telecommunications Union
CCIR International Radio Consultive Committee
Recommendations and Reports of The CCIR, 1978
XIVth Plenary Assembly
Kyoto, 1978

CCIR Recommendation 476-2 Direct-Printing Telegraph Equipment in the Maritime Mobile Service (ARQ, FEC, and SEL-FEC 7-unit code)

CCIR Recommendation 490 The Introduction of Direct-Printing Telegraph Equipment in the Maritime Mobile Service; Equivalence of Terms.

CCIR Recommendation 491 Direct-Printing Telegraph Equipment in the Maritime Mobile Service. (Selective-call translation tables)

CCIR Recommendation 492-1 Operational Procedures for the Use of Direct Printing Telegraph Equipment in the Maritime Mobile Service. (WRU and calling procedures)

Recommendations and Reports of The CCIR, 1982
XVthe Plenary Assembly
Nairobi, 1982

CCIR Recommendation 476-3 Direct-Printing Telegraph Equipment in the Maritime Mobile Service

Recommendations and Reports of The CCIR, 1986
XVIth Plenary Assembly
Dubrovnik, 1986

CCIR Recommendation 476-4 Direct-Printing Telegraph Equipment in the Maritime Mobile Service

Federal Communications Commission
Washington, D.C. 20400

Rules and Regulations Volume IV
Part 81 Stations on Land in the Maritime Services and Alaska-Public Fixed Stations.
Part 83 Stations on Shipboard in the Maritime Services.

APPENDIX E

QUICK OPERATOR'S GUIDE

This guide is offered as a quick reminder of what steps are used to operate the ARQ1000A. It assumes that the operator has read and understands the discussions of Chapters 2 and 3 and that he has made the correct I/O connections described in Chapter 2.
NOTE: A carriage return is represented by the symbol "↵".
PROGRAMMING:

ENTER PROGRAMMING:	BREAK (BRK ↵,switch,or keyboard BREAK key)
PROGRAM PROMPT:	?
LIST STATUS:	ST: ↵
PROGRAM HERE IS:	HI:[32 characters maximum] ↵
PROGRAM LOCAL CALL:	LC:[4 letters or 4/5 numbers] ↵
PROGRAM REMOTE CALL:	RC:[4 letters or 4/5 numbers] ↵
PROGRAM GROUP CALL:	GC:[4 letters or 4/5 numbers] ↵
CONTROL SIGNAL:	CS:1 ↵ or CS:X ↵
TERMINAL ECHO:	EC:ON: ↵ or EC:OFF ↵
TIME OUT:	TO:ON ↵ or TO:OFF ↵
WRU:	WR:ON ↵ or WR:OFF ↵
CONVERSATIONAL FEC:	CF:ON ↵ or CF:OFF ↵
BUFFER CLEAR:	BC:ON ↵ or BC:OFF ↵
CONTROL DELAY:	CD:[2 digits] ↵ (digits = delay in ms)
TRANSMIT DELAY:	TD:[2 digits] ↵ (digits = delay in ms)
AUDIO DELAY:	AD:[2 digits] ↵ (digits = delay in ms)
DEFAULT AFTER RESET:	
SEND:	SD:ON ↵ or SD:OFF ↵
NORM/REV:	NR:NORM ↵ or NR:REV ↵
TX/RX CONTROL:	TR:AUTO ↵ or TR:RX ↵ or TR:TX ↵
B/Y TEST:	BY:OFF ↵ or BY:ON
MODE:	MD:OFF ↵ or MD:STB ↵ or MD:ARQ ↵ or MD:FEC ↵ or MD:SEL ↵ or MD:MON ↵
LEAVE PROGRAM MODE:	EX: ↵ (goes to default mode after reset)

OPERATING:

OPERATE RTTY:	Set to OFF mode; terminal KOS controls transmit-receive control line.
STANDBY FOR CALL:	Set to STBY mode; ARQ call using LC will start ARQ reception. FEC call or SEL-FEC call using GC will be printed.
TRANSMIT ARQ MSG:	Set to ARQ mode, program RC of desired station, press SEND switch; or type ARQ ↵ and confirm or change RC.

"OVER" IN ARQ MODE:	Press OVER switch or type ("?) or (+?) on keyboard.
TRANSMIT FEC MSG:	Set to FEC mode, press SEND switch; or type FEC ↵, answer Y ↵.
TRANSMIT CONV. FEC:	Set CF:ON in programming,select FEC mode, use terminal with RTS or KOS, type text.
TRANSMIT SEL-FEC MSG:	Set to SEL mode, program GC of desired station(s), press SEND switch; or type FEC ↵, answer N ↵, confirm or change GC.
END ARQ, FEC or SEL:	Press END on front panel; or type ZZZZ ↵ when ARQ or FEC sending station.
MONITOR ONLY:	Set to MON mode; will automatically select ARQ, FEC or SEL-FEC to match received signal. Selective call codes in ARQ and SEL-FEC modes will be printed (letter format only).
SEND HERE IS MSG:	Press HERE IS front panel switch or type //// ↵ while sending as ISS.
REQUEST WRU:	Press WRU front panel switch or enter "$" from keyboard. Turns channel around, causes other station to send HERE IS MSG, and returns channel as before WRU call.
RESET ARQ1000A:	Press front panel RESET switch or exit program mode, or cycle power to ARQ1000A.
SEND B/Y TEST:	Press B/Y panel switch or program default mode. Can only be returned to normal operation with RESET or by entry into program mode with BREAK.
MANUAL TX/RX CONTROL:	TX/RX CONT. front panel switch; cycles from AUTO to RX to TX to AUTO. Condition indicated by TX, AUTO, and RX lamps.
REVERSE DATA:	N/R front panel switch; condition shown by NORM and REV panel lamps.

LIMITED WARRANTY

HAL Communications Corp. of Urbana, Illinois, hereby warrants to the original retail purchaser only that the product herein described and sold shall be free from defects in materials and workmanship for a period of one year from the date of sale to the original retail purchaser.

In the event of a defect in materials or workmanship during the warranty period, HAL Communications Corp. will, at its own expense, repair the defective unit and replace any defective parts. Cost of shipping the unit to HAL Communications Corp. shall be paid by the purchaser, as well as costs of removal and reinstallation of the unit. HAL Communications Corp. will bear the shipping costs incurred in returning the unit to the purchaser (48 contiguous states only).

To obtain service under this warranty, the original purchaser should do the following:

1. Notify, as soon as possible, the Customer Service Departmenmt of the original selling dealer or HAL Communications Corp., Box 365, Urbana, Illinois, 61801, either in writing or by telephone, of the existence of a possible defect.
2. At the time of notification, identify the model and serial number, date of purchase, place of purchase, and the possible defect.
3. Hold the unit until a written return authorization is received.
4. Return the unit, freight prepaid, upon the receipt of the written return authorization with a copy of the original bill of sale for the equipment.

Correct installation, use, maintenance, and repair are essential for proper performance of this product. The purchaser should carefully read the technical manual. The purchaser will be billed for labor and shipping charges on any unit determined by HAL to be in working order when received for repair.

This warranty does not apply to any defect which HAL Communications Corp. determines is due to any of the following:

1. Improper maintenance or repair, including the installation of parts or accessories that do not conform to the quality and specifications of the original parts;
2. Misuse, abuse, neglect, improper installation, or improper operation (including operation without a proper safety ground connection);
3. Accidental or intentional damage.

All implied warranties, if any, are limited in duration to a period of one year from the date of purchase by the original retail purchaser. (Some states do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you.)

HAL Communications Corp. disclaims any liability for incidental or consequential damages arising out of the use of, or inability to use, this product. (Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.)

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.