Forest Technology Systems

OPERATING AND REFERENCE MANUAL FOR THE RM4000 RADIOMODEM

by

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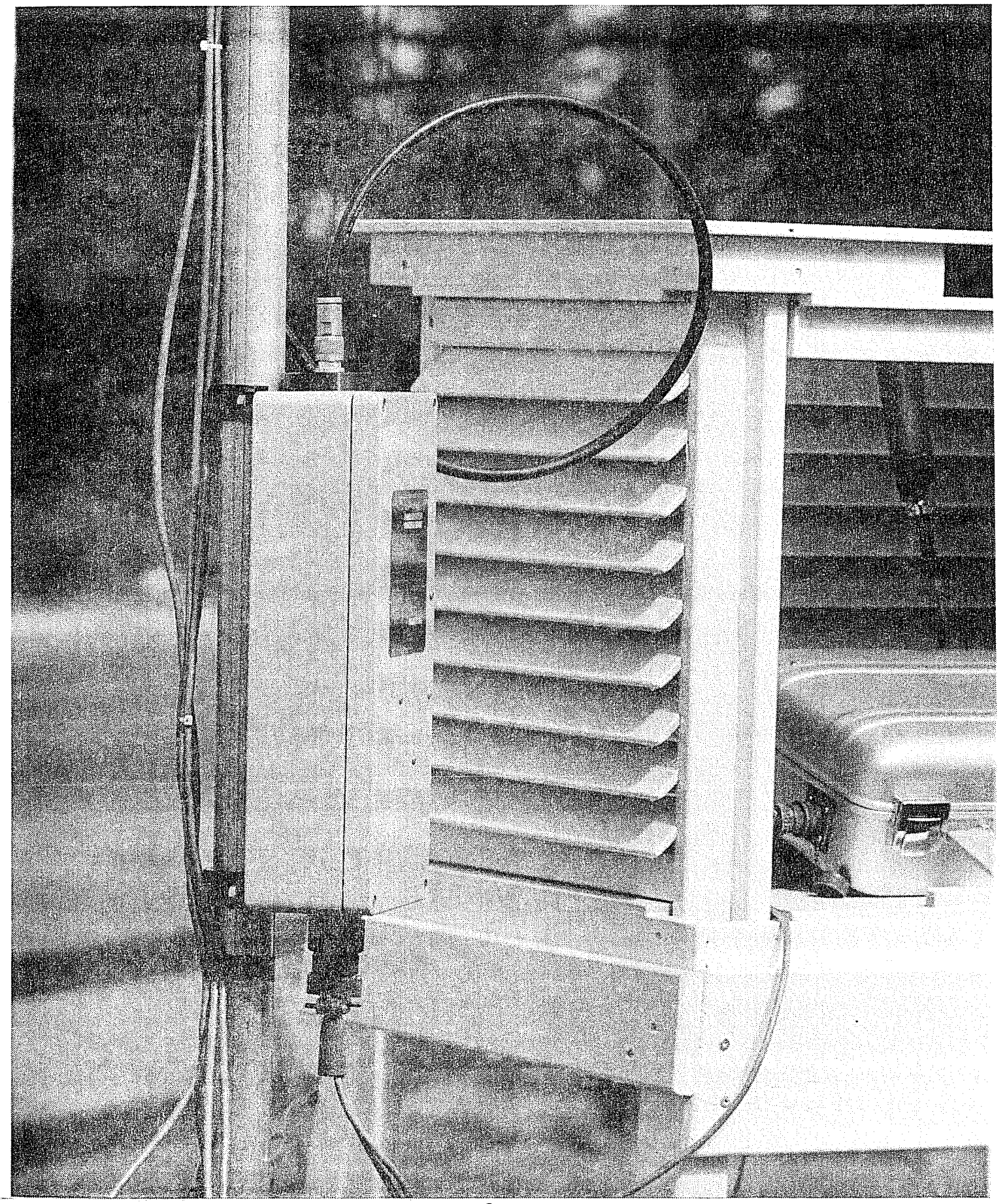
WARNING: This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions manual, may cause interference to radio communications. It has been tested and found to comply with the limits for a Class A computing device pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

CONTENTS



INTRODUCTION

The RM4000 radiomodem is ideally suited to transferring small amounts of data from remote locations with no AC power or telephone lines. It was designed to be easily licensed for use with virtually any mobile or portable transceiver working on any of the standard voice bands. It is also possible for a RM4000 data telemetry system to share a voice channel because it spends such a short period of time on the air. In short, the RM4000 is a very convenient way of collecting remote sensor readings.

The RM4000 operates as a polled data communications system. This means that all data being transferred is coordinated by a base station. In typical installations, the base station issues a request for data from the remote site, which then transfers its stored data to the base a short time later. Although it is possible to initiate a data transfer from the remote station, this requires the remote station to be intelligent enough to set up the commands for the RM4000 that cause it to route the data to the proper receiving RM4000. This would involve the proper programming of a sophisticated remote data logger.

In any case, the RM4000 itself takes no measurements directly from the sensors. This is the responsibility of the data logger, which may be a Forest Technology

Systems weather station, or any one of a variety of other units. The only common requirement is that the data logger must have a serial data port to mate with the one on the radiomodem.

The RM4000 has many features not found in other low cost radio operated data gathering equipment. Its low power consumption (less than 12 milliwatts not including transceiver), error detection and correction techniques, and rugged construction make it the best choice for remote, outdoor installations. Its frequency range simply depends on the transceiver that it is chosen to operate with. It may co-exist on normal voice channels, and operate through normal voice repeaters to extend coverage. Finally, we have tried very hard to make the RM4000 easy to operate and install, and we wish you success in your application.

***Note** - Before attempting to install this equipment, first read the appropriate sections in the manual at least once. That way, you will be best prepared to have with you all the equipment that will be needed in the installation and testing.

*** NOTE** - Recently, we were informed by one of our customers that the audio frequency tones used with this telemetry system sound much like the warning tones on certain helicopters. We are aware that most radiomodem systems are used on normal communications channels, and we urge you to make your pilots aware of this when they monitor these channels. Thank you.

INSTALLATION

1.1 Field Site Installation

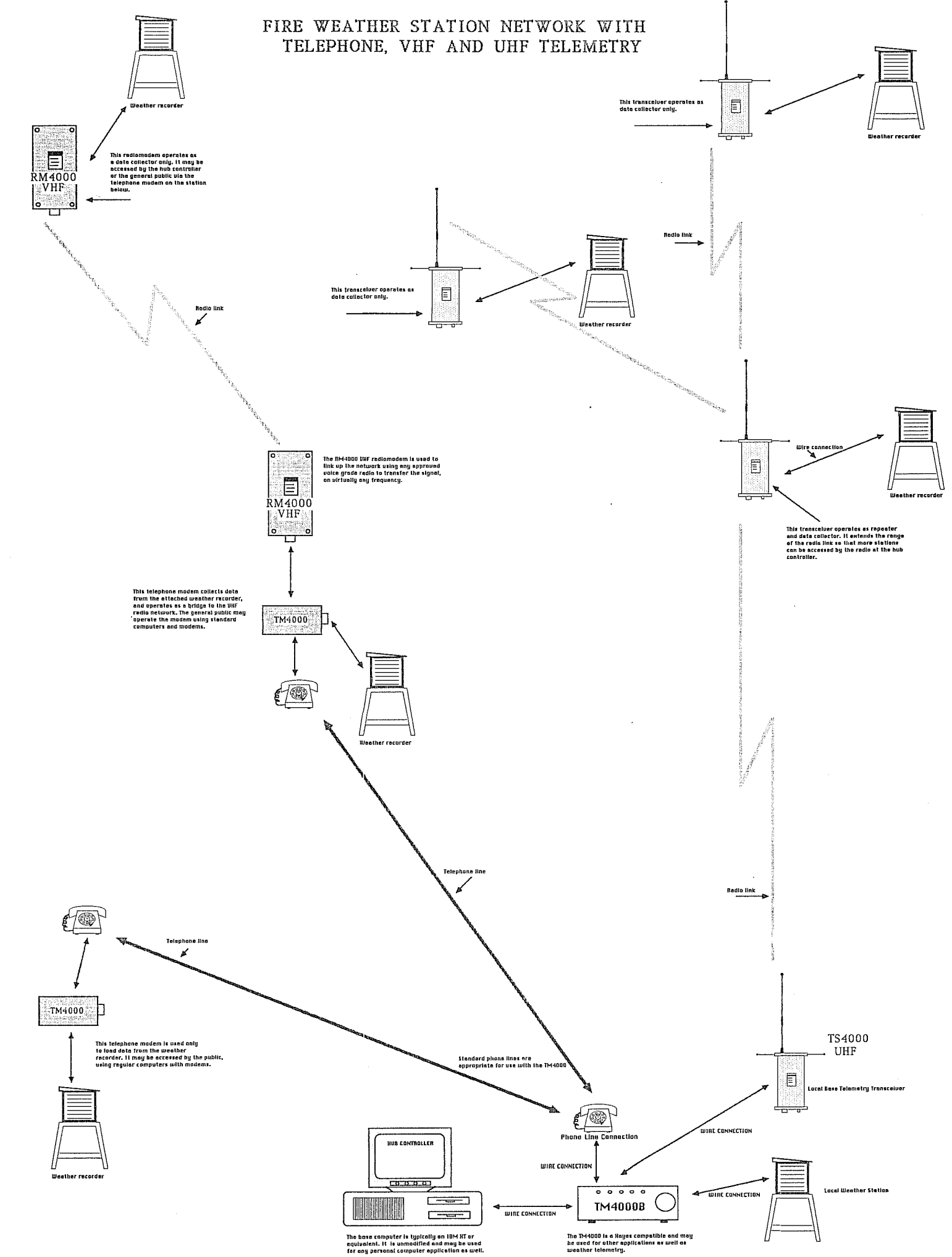
When installed with a WR62 FTS Fire Weather Station, the transceiver for the RM4000 is generally installed inside the RM4000 sealed enclosure prior to delivery. This makes installation much easier, but there are still some important things to remember.

BEFORE YOU HEAD TO THE FIELD...

1) Check the radio propagation first. Consult a radio communications expert if there is any doubt about the signal quality at your remote site. The range of the radiomodem depends mainly on the output power of the transceiver and the antenna system being used. Undoubtedly, by the time you read this manual, you will already have consulted with Forest Technology Systems as to the type of radio and antenna required, but if further information on the exact specifications is needed to estimate range, you may give us a call. It is also a good idea to double check your estimates with a portable transceiver at the remote site. Keep in mind that the power output of the portable should be similar to the power output of the radiomodem to make the test valid.

The most important signal is the one sent from the remote radiomodem since it is the one that is carrying the data, so make sure that the signal from the test portable gets through to the base loud and clear. Often

FIRE WEATHER STATION NETWORK WITH TELEPHONE, VHF AND UHF TELEMETRY



our customers have commented that the remote station answers the base station on every attempt, but that the base station receives the data without checksum errors intermittently. The reasons are twofold. First, the base station has a higher output power / antenna configuration causing the remote station to receive a relatively powerful signal, and secondly the outgoing message is very short so that the chances of error is relatively small.

2) Record the serial number on the outside label of the RM4000! Without this number, you have no access code to type into the computer at the base station, and you will have to make another trip to the field. (There are 65534 possible serial numbers) Also, you may have the transceiver mounted internally to the radiomodem for environmental protection. If it is a multichannel unit, make sure it is tuned to the channel that you will be using! You will have to open the cover of the RM4000 and set the channel selector on the transceiver to the channel you require.

3) Before you connect the cable harnesses, somehow label the new SP4000B (solar panel) 2 pin threaded connector to indicate that it is to connect to the external power plug on the weather recorder. This is already done for you on modern cable sets with color coding. Older cable sets do not have this feature. If it

is confused with the 2 pin anemometer connector when you are attaching the WR62, a fuse in the SP4000B may blow. If the cables are color coded, match the colors of the weather station connector and the cable connector.

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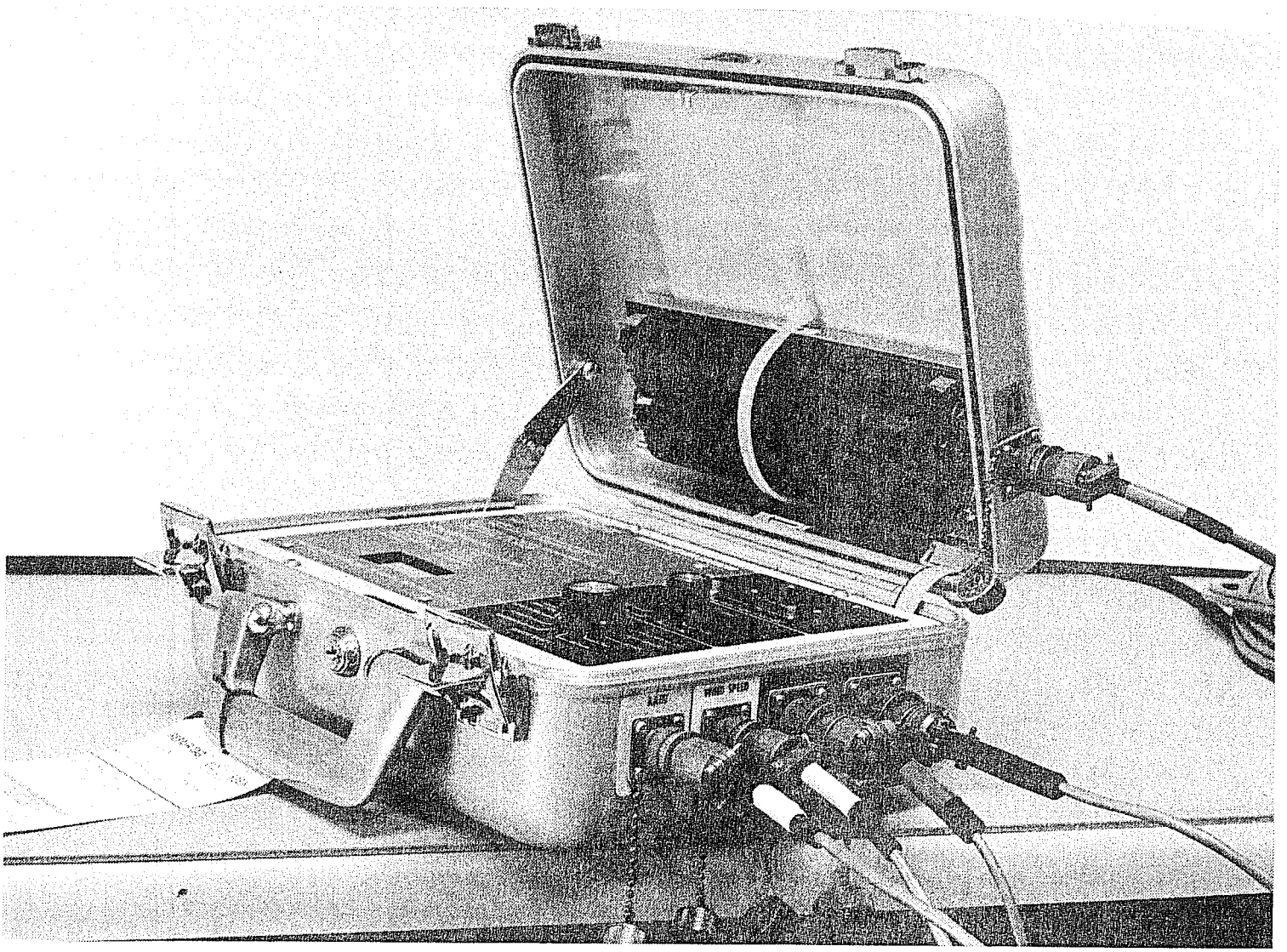

You are now ready to assemble. This description ASSUMES that your remote radiomodem is in the most common configuration, with an internal radio and a hermetically sealed "TYPE N" antenna connector. Sometimes, the radio will be mounted externally, especially withtransceivers in the 25 watt class.

With reference to the diagrams on the following pages, you can see that the standard mast extension we have used in the past to support the wind instruments has been lengthened and increased to one inch diameter. This spar is strong enough to support most antenna systems, and since it is solid, it will withstand any degree of clamping. (See installation card for the weather station for details on setting up the mast.)

The black anodized clamps on the bottom of the RM4000 are designed to fit around the largest diameter (bottom) section of the telescoping mast normally supplied with the weather station. With both the radiomodem and the SP4000B box mounted on the bottom section near the lowest set of guy wires, stability and strength of the mast is optimized.

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NEVER TILT UP AN EXTENDED TELESCOPING MAST WITH THE RADIOMODEM AND SOLAR PANEL ALREADY ATTACHED. YOU MIGHT HAVE BEEN ABLE TO GET AWAY WITH IT IN THE PAST WHEN THERE WERE ONLY WIND INSTRUMENTS, BUT THE INCREASED WEIGHT OF THE RADIO GEAR WILL BUCKLE THE MAST IF THIS IS ATTEMPTED. USE A LADDER AND EXTEND THE UPPER SECTIONS AFTER YOU HAVE BRACED THE FIRST ONE WITH THE GUY WIRES.

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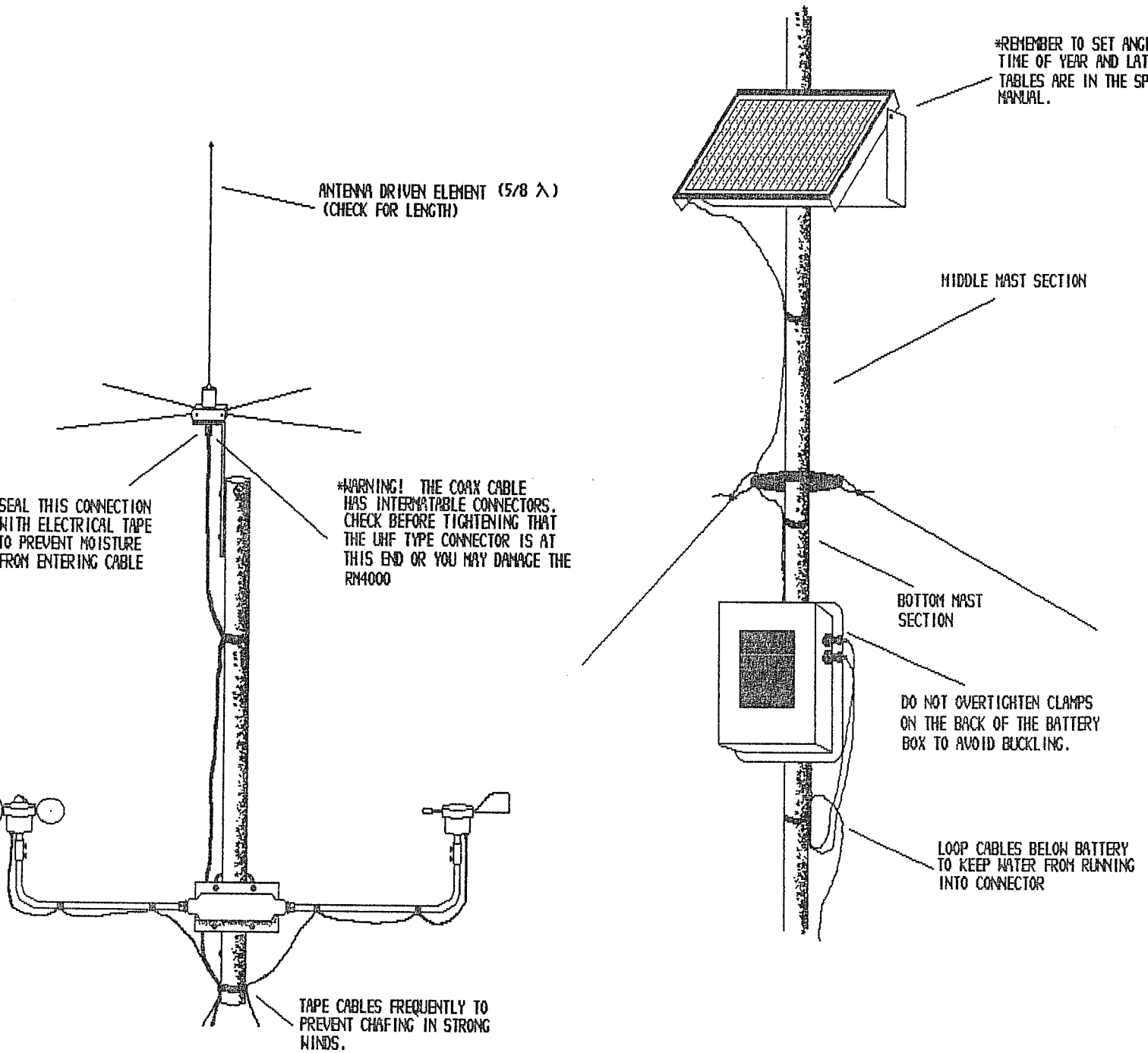
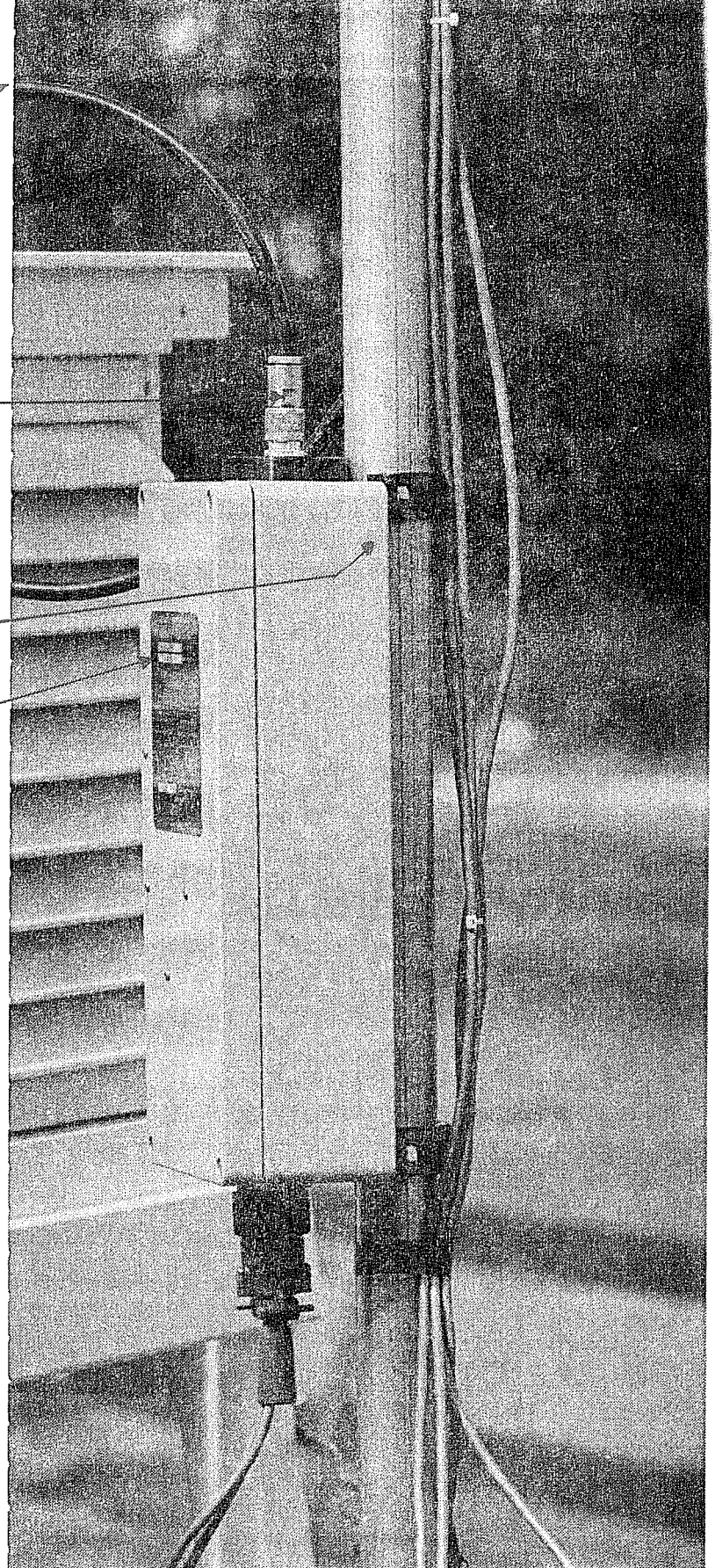

ANTENNA DRIVEN ELEMENT (5/8 λ)
(CHECK FOR LENGTH)
SEAL THIS CONNECTION
WITH ELECTRICAL TAPE
TO PREVENT MOISTURE
FROM ENTERING CABLE
*WARNING! THE COAX CABLE
HAS INTERMATABLE CONNECTORS.
CHECK BEFORE TIGHTENING THAT
THE UHF TYPE CONNECTOR IS AT
THIS END OR YOU MAY DAMAGE THE
RN4000
TAPE CABLES FREQUENTLY TO
PREVENT CHAFING IN STRONG
WINDS.
*REMEMBER TO SET ANGLE FO
TIME OF YEAR AND LATITUDE
TABLES ARE IN THE SP4000
MANUAL.
MIDDLE MAST SECTION
BOTTOM MAST
SECTION
DO NOT OVERTIGHTEN CLAMPS
ON THE BACK OF THE BATTERY
BOX TO AVOID BUCKLING.
LOOP CABLES BELOW BATTERY
TO KEEP WATER FROM RUNNING
INTO CONNECTOR



Loop the cable as shown... The "Drip Loop" helps keep water out of the connector

Tape this connector after installation to keep out water.

Mast clamp (fits only bottom mast section)

Record this serial number before returning from the field

Bundle excess cable neatly and tape it to the mast out of the reach of rodents.

If the radiomodem is being attached to an existing weather recorder, you will need to collapse the mast and modify the "wind tee" that holds the wind instruments. The old mast extension should be unscrewed from the junction box that holds the two arms of the wind tee and discarded. Remove and discard the cover and screws from the junction box. Attach the square aluminum adaptor plate to the junction box with the two new, longer screws. The adaptor plate holds two U clamps which allow the wind tee to be securely clamped to the new 1 inch diameter solid mast extension. After the mast extension has been bolted to the top of the telescoping mast, tighten the wind tee clamps as near as possible to the bottom of the extension to avoid wind turbulence from the antenna. When you are finished, the top mast section should look like Figure 1.4, except for variations in the antenna system.

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CAUTION
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When you are connecting the antenna cable, carefully examine the two connectors at each end of the antenna cable. Usually they will be different. Because we were forced to use an expensive high quality "TYPE N" connector to insure the air tightness of the RM4000, we have often encountered problems when people get the antenna connector mixed up with the RM4000 connector. The threads on "PL259" connectors are the same as the threads on "TYPE N", but if the "PL259" is plugged into the "TYPE N", the latter will be ruined. Please beware.

The new SP4000B solar panel kit comes in two parts. First, there is the actual solar panel itself with its own tilting bracket. This should be mounted facing south

in the middle of the second section of the telescoping mast to avoid serious shadows from the guy wires. There is a chart in the back of its manual that is helpful for determining the optimum bracket angle based on the season and the latitude. The other half of the SP4000B contains a10 amp - hour lead acid battery and a regulator circuit. Because of its high weight, it is mounted on the bottom section of the mast. NEVER increase the length of the cable between the SP4000B battery box and the RM4000. If this is done, excessive voltage loss in the cable will affect the performance of the RM4000.

As you erect the mast, you should tape the cable bundle at regular intervals to prevent them from slapping against the mast in the wind. Electrical tape is provided in our tool kit for this purpose. Connect the two pin bayonet connector from the solar panel to the SP4000B battery box, and attach the cable harness for the radio-modem to both the battery box and the RM4000.

The radiomodem should now be functional, and it is a good time to give it a test, even without any of the weather equipment attached. One of the cables from the 14 pin bayonet connector ends in the "Telemetry Test Module". This box contains a tiny speaker, and a momentary push button. Before you press the button, listen carefully for the burst of radio static that should occur every 8 seconds.(This time may vary with some models). This static is heard because the radiomodem operates with

the squelch control turned off, and because it only checks for a data carrier intermittently to conserve power. If there are no bursts of static, read on. There is some limited troubleshooting you can still do in the field.

If there was no intermittent burst of static from the test module, then the most likely cause is a lack of power. If you have no voltmeter, remove the D cells from the weather recorder, if any have been installed yet, and then plug the solar panel's 2 pin screw connector into the external power connector to see if the weather recorder powers up. If not, recheck that you have cables coming out of both connectors on the SP4000B. If everything appears to be assembled correctly, the problem lies in one of the following areas, listed in order of probability:

1) Blown fuse in SP4000B
2) Discharged battery in SP4000B
3) Radio transceiver has squelch on(please leave squelch off)
4) Defective cables (check for rodent damage)
5) Defective RM4000 or radio transceiver

1.2 Using the Self Test Mode

If the bursts of static are identified, and the channel is clear, go ahead and press the button for about 8 seconds, or at least until a scratchy whistle is heard from inside the radiomodem. The sound you hear is the

radiomodem going through a rigorous self test. If you had a printer attached to the data output wire, it would print out a short test report for you. If the printer is not attached, it makes no real difference. Any failed test will cause the self test procedure to abort, and you will know thatsomething is wrong with the controller board circuitry. At the end of the test results printout, the transceiver is switched to transmit, and a universal response header is sent out. This will sound like a clear high pitched whistle that lasts for about 10 seconds, followed by a brief chirp which represents the test header. You can hear this activity both from within the radiomodem itself, or on a portable transceiver tuned to the radiomodem's channel. All stations REVISED TO SOFT-WARE VERSION 1.3 or above, will respond with alternating tones. These tones can be heard on the test module's speaker.

If you don't hear any tones, then this remote location is not in radio contact with the base, or any other remote radiomodem. Check the channel the transceiver is on with a portable radio if you experience difficulty. This will at least tell you if the unit is transmitting. There is another potential confusing point here. Many systems operate with existing voice repeaters which require that the transceiver transmit and receive on slightly different frequencies. In such cases, the high radio field strength from the radiomodem will more

than likely interfere with a portable's reception of the repeater at close range. If possible, tune your radio to the REPEATER's receive frequency. If this is not possible, separate your radio from the radiomodem by 1/4 mile so that the interference is reduced to the point that you can hear the repeater.

There is another useful test that can be performed now if the base station is operating. Attach the 4 pin female data connector from the radiomodem to the male socket on the weather recorder. This cable contains the wire that commands the weather recorder to send the telemetry unit all its stored data. Attach the solar panel power connector to the external power input of the weather recorder. It is not necessary to connect any sensors. The remote site should now be capable of sending the data stored in the weather recorder to the base. Call up the base on your mobile and ask someone there to use the base computer to call the remote station. You will need to have entered the particulars of the station into the base computer in advance.

Now that the mast is completely erected, bundle the excess cable length and tie it to the mast, well above ground level. This will help keep the soft vinyl wiring out of the reach of rodents. Run the connectors into the Stevenson Screen by unscrewing the louvered section from the support stand, and slipping the cable bundle through

the notch provided at the back of the shelter. Use the color coding, or whatever means you chose to identify the 2 pin weather recorder power connector to connect the various cables. (See warning on page 7) Check the weather recorder for reasonable readings in the "00" mode. (consult WR62 manual if necessary) Note that you will have to wait 10 minutes before the weather recorder will display a valid wind speed, since it computes the 10 minute average.

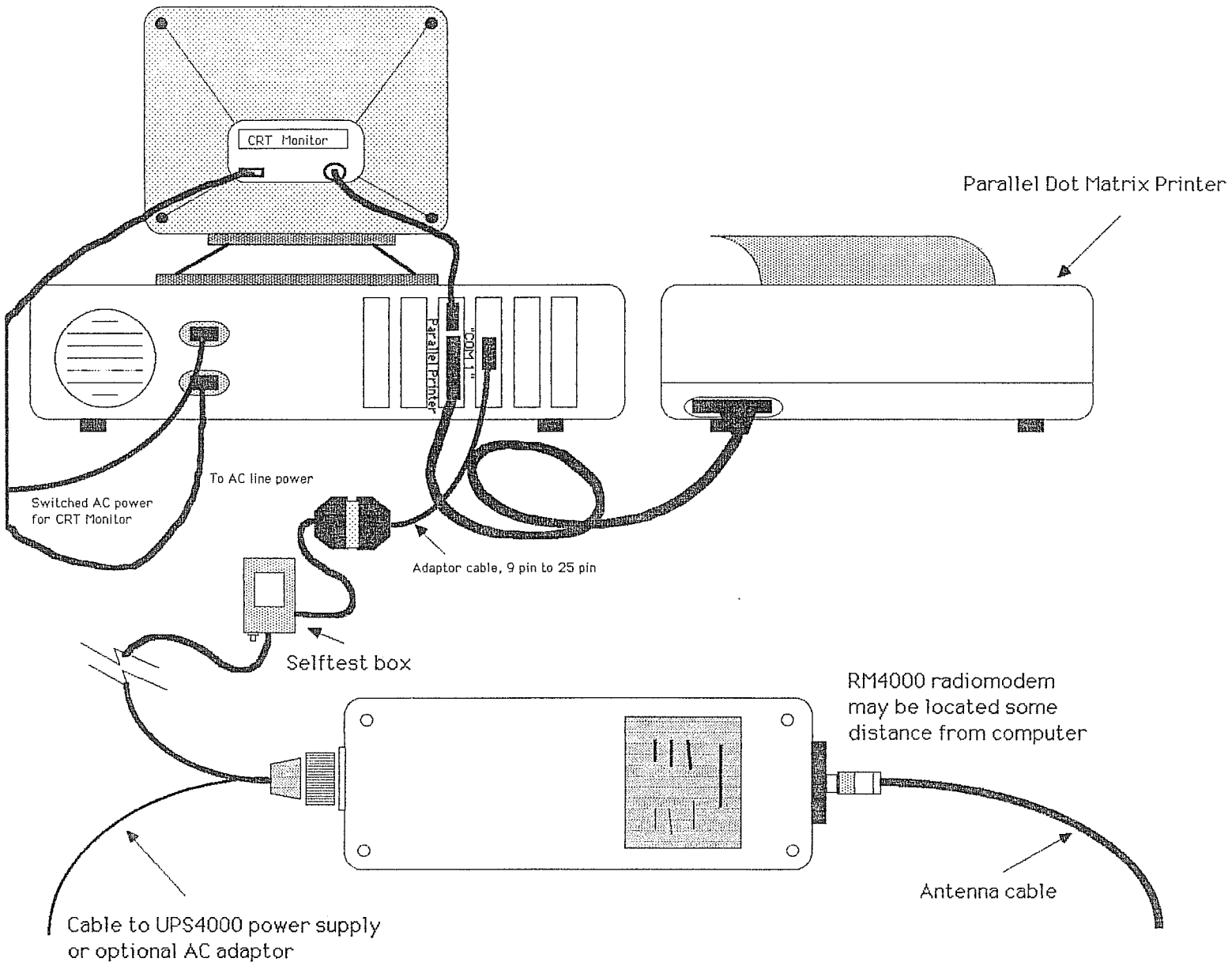
After the station has been completely assembled according to the instructions, either stake down the legs of the Stevenson Screen, or weight down the entire shelter to prevent it from being upset in high winds. As a final precaution, install a set of D cells in the weather recorder to provide backup for the SP4000B solar power supply in case a prolonged cloudy spell causes the main supply to go dead. This second set of batteries is never drained until the main SP4000B quits. The second set of batteries will preserve the weather recorder's operation until there is enough sunshine to make the SP4000B cut in again.

1.3 Base Station Installation

It is very difficult to produce a general description of how to set up the base station, because virtually every installation is different. Since most of the differences are in the connection to the radio equipment, some of the following information is quite technical. If this is not one of the rare installations where the base radio has been installed by FTS, you will need technical assistance to set up the radio equipment. The description will start with the straightforward part of the installation, which is common to all applications.

The base station comprises a controller - an unmodified dual disk drive IBM XT compatible personal computer, a dot matrix printer, and another radiomodem. Even though this radiomodem is called the base, it is identical to the ones installed in the remote sites, except for the radio interface. Here are some examples of base radiomodem configurations...

Unpack your "FTS XT", its companion printer and video monitor, each of which is provided with a cable. On the far left hand side of the computer, we will have installed an expansion card that has two connectors for these devices. Connect the monitor to the 9 pin female connector labelled "Video". Connect the printer to the 25 pin female connector labelled "Parallel/Printer". Finally, locate the short adaptor cable that was shipped with the computer which has a 9 pin female connector on one end and a 25 pin male connector on the other end. Plug this into the 9 pin connector labelled "RS232" on the back of the FTS XT. Connect the 25 pin female connector from the RM4000 cable harness to the dangling end of the adaptor cable. This completes the computer connections required for most installations.


CRT Monitor
Parallel Dot Matrix Printer
Parallel Printer
"COM 1"
To AC line power
Switched AC power
for CRT Monitor
Adaptor cable, 9 pin to 25 pin
Selftest box
RM4000 radiomodem
may be located some
distance from computer
Antenna cable
Cable to UPS4000 power supply
or optional AC adaptor

There are four basic ways in which RM4000 radiomodems have been used as base stations, and these will be decribed in three sections, from most frequently implemented to most obscure. The first is direct connection to a base radio transceiver with an antenna system on the same building as the radiomodem. The second is an indirect connection to a remote radio transceiver via a leased two wire or four wire telephone circuit. Finally, several base radiomodems have been installed in conjunction with the dial up telephone system, which use existing automatic radiotelephone services for the radio link.

1.4 Connecting a RM4000 to an External Transceiver

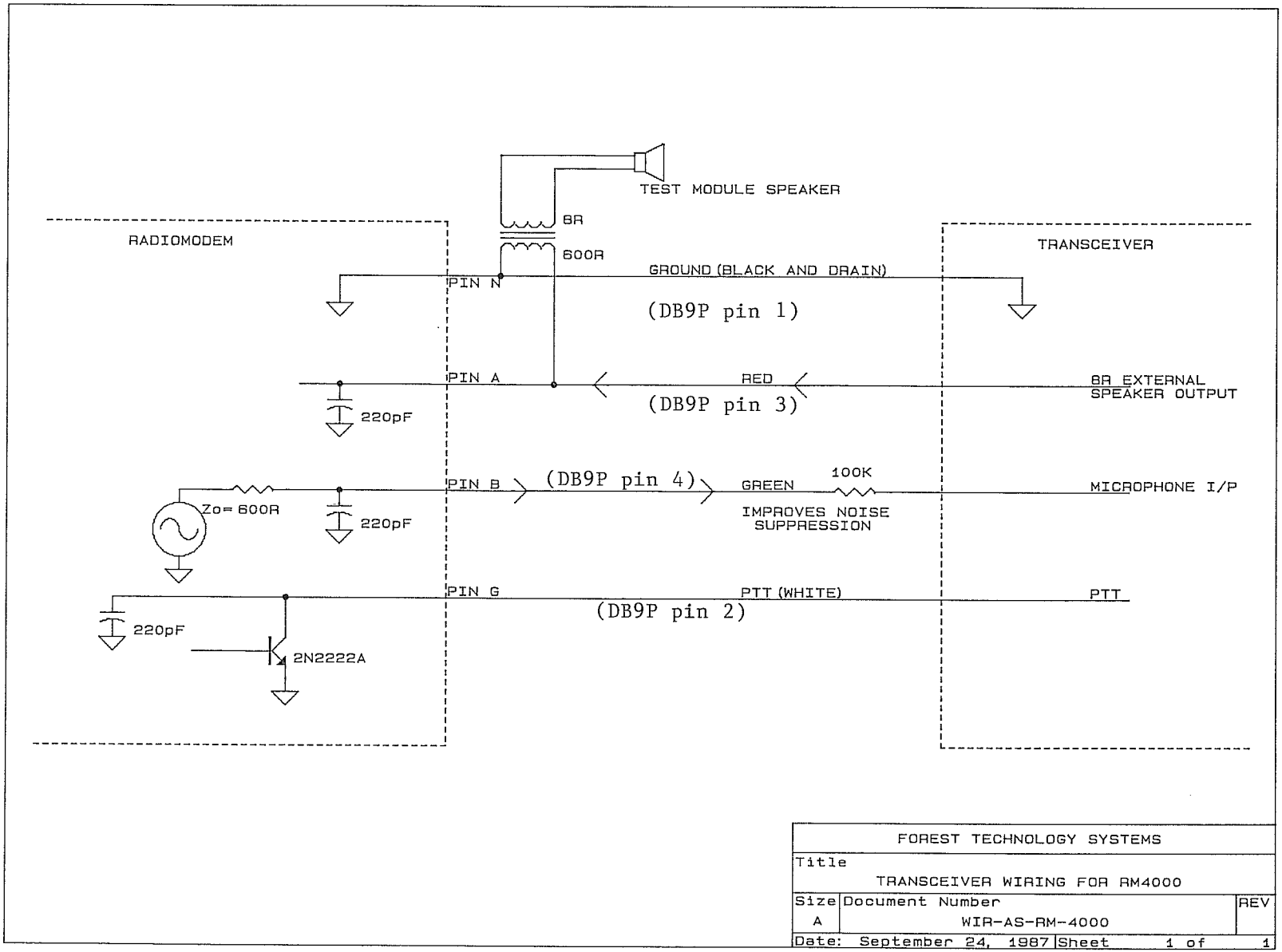
The RM4000 is equipped with a four wire radio interface that is directly compatible with the great majority of mobile transceivers. This provides audio output for transmit, a input line for receiver audio, and a open collector Push To Talk (PTT) line to control the mode of the transceiver. There is extensive overload protection on all lines except PTT. The PTT circuit should not be connected to any radio that requires more than 30 Volts across the microphone switch contacts, nor should it be required to shunt currents greater than 500 mA to ground. If this is the case with your transceiver, then a relay can be installed to handle the extra power. A relay is

also helpful with those transceivers that employ a positive ground.

One of the advantages of this interface is that the standard 600 ohm input and output impedances allow the radiomodem to be bridged across an existing microphone circuit. Refer to the circuit diagram on the next page. Color codes refer to the standard cable for base stations which ends in a DB9P connector. The numbers in brackets are the pin numbers. Since the PTT line is normally a high impedance in the idle state, it will not affect the operation of the microphone button. The 100 K resistor in the microphone audio line not only reduces noise pickup and ground loop problems when it is installed near the transceiver, it also prevents the radiomodem from loading the microphone circuit. Finally the effective 300 ohm impedance from the RM4000 and its selftest box monitor is a negligible load on the transceiver output line.

When the RM4000 is attached to the transceiver, its audio levels will have to be adjusted to achieve proper sensitivity and modulation. The RM4000 can produce audio over a range of -40 to -6 dBm in 600 ohms. The 100 K resistor at the microphone jack end of the cable serves to reduce this to the level required for 3 KHz of peak deviation in the transceiver. The fine adjustment is made by adjusting the trimmer potentiometer labelled "Audio O/P Deviation" (RV201).

When a radio data transfer is being received, RV202 is adjusted so there is no clipping on pin 14 of U216.



FOREST TECHNOLOGY SYSTEMS		
Title: TRANSCEIVER WIRING FOR RM4000		
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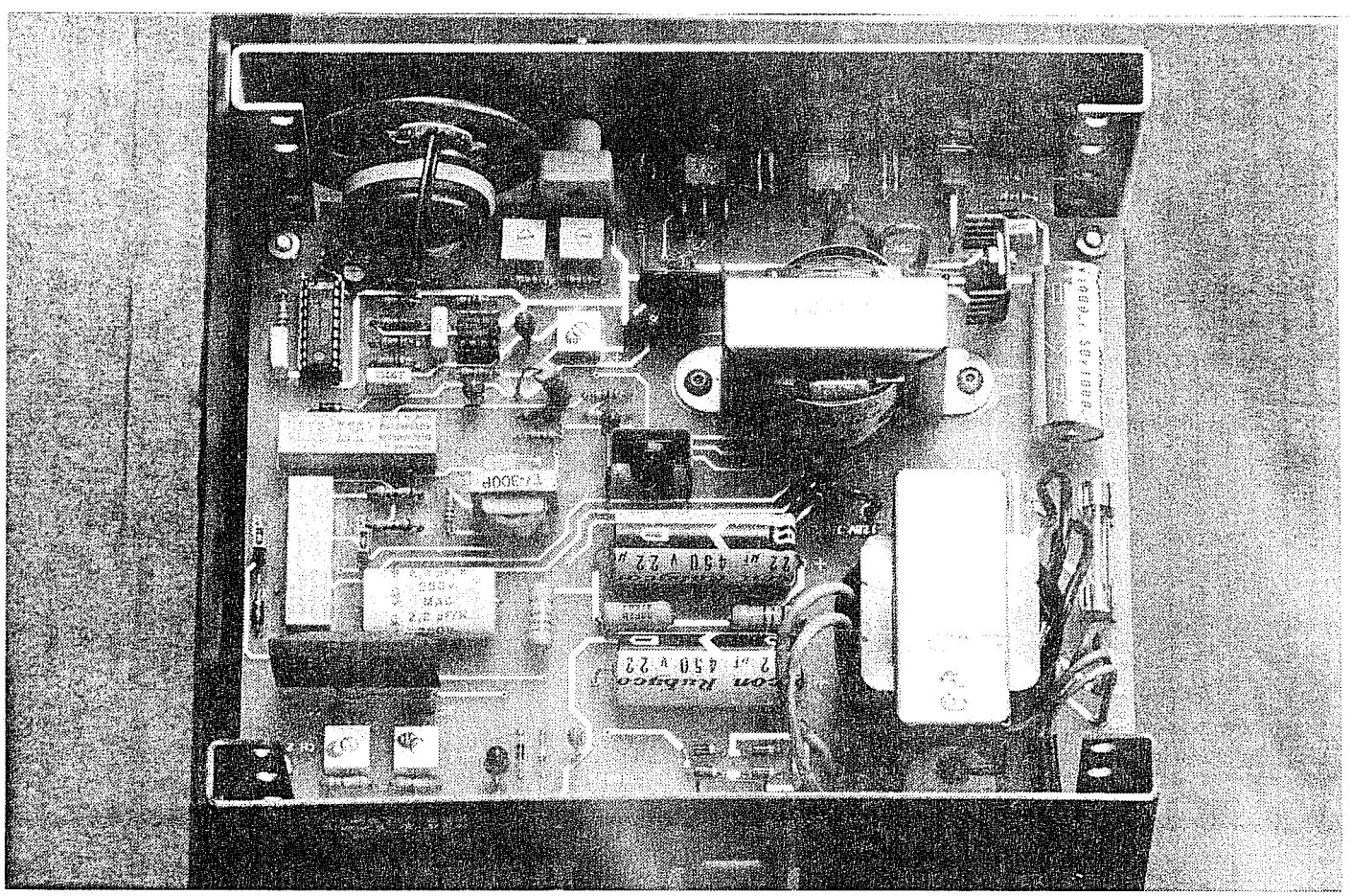
Date: September 24, 1987	Sheet 1 of 1	

1.5 Connecting the RM4000 to a Remote Transceiver

Often, radio network base stations operate their transceivers by remote control over leased telephone lines so that the radio transceiver can be placedin a high spot for best coverage. Forest Technology Systems has designed a interface for one popular system, called the "Descon 2". The only difference in the RM4000 base radiomodem is that its cable is shipped pre-wired for direct connection to the CA4000 interface. The CA4000 acts exactly like a regular Descon 2 station, except that the microphone is interfaced to the RM4000.



Interior view of the CA4000 remote radio interface (Schematic on page 62)

1.6 Connecting the RM4000 to the Public Switched Telephone System

Because the RM4000 uses higher frequencies than standard telephone modems, 1200 baud operation through the public switched telephone network will not work reliably. If the RM4000 is to operate on telephones, it must be ordered so that it is set to 600 baud, and is equipped with a special interface called the TEL4000.

The RM4000 will be shipped with a special connector on the four wire external radio interface that plugs into the TEL4000. This gives the RM4000 control over the phone line when it is necessary to place a radio call. The TEL4000 also has two telephone jacks. A regular telephone is connected to one of the jacks, and a telephone extension cord is plugged into the other. When the RM4000 is not operating, the telephone can be used normally.

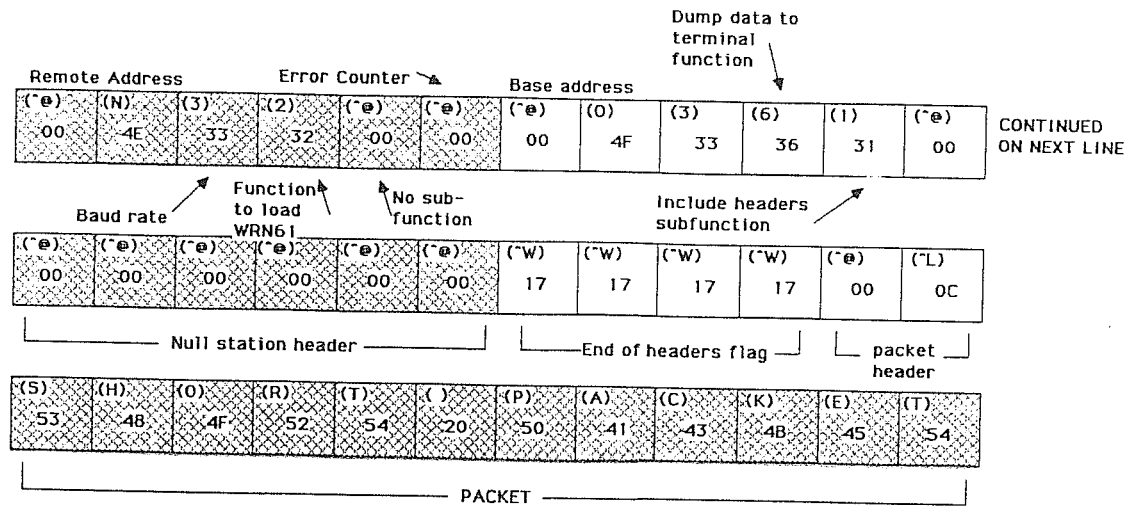
When the RM4000 is used, the telephone is used to place the call to the remote radio repeater, and once access to the repeater has been granted, the return key on the computer is used to tell the RM4000 to take over the phone line.

2.1 Introduction to FTS Packet Switching

Not all the software in the telemetry system is in the XT hub controller. Unlike most modems, or radiomodems for that matter, the RM4000 Packet Switched Radiomodem contains its own microprocessor which runs built - in ROM routines or special application programs that can be downloaded from the base station. This software, in fact, is the only truly distinguishable factor in this telemetry system.

This telemetry system usually operates in the "polled" mode. This means that data is only sent from the remote sites on request from a base station. In normal applications, an operator sends a long series of control characters to the base radiomodem from his base computer (often called the hub controller). In our system, these control characters form short, concise, headers for each radiomodem station the message will pass through (See Figure 2.1 below).

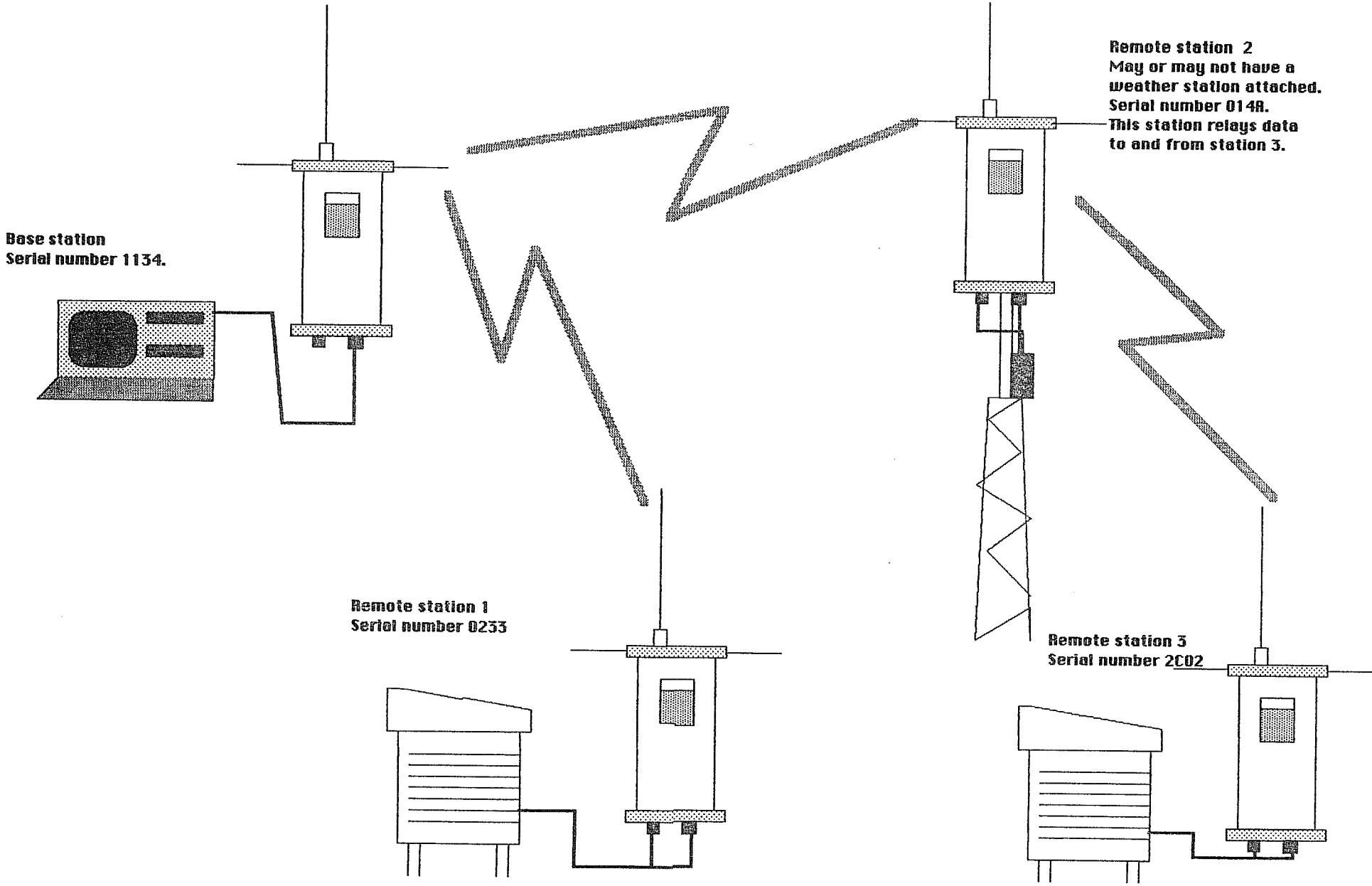
Header Example -



Note that all the boxes represent one character. The number represents the hexadecimal value. The character itself is in brackets.

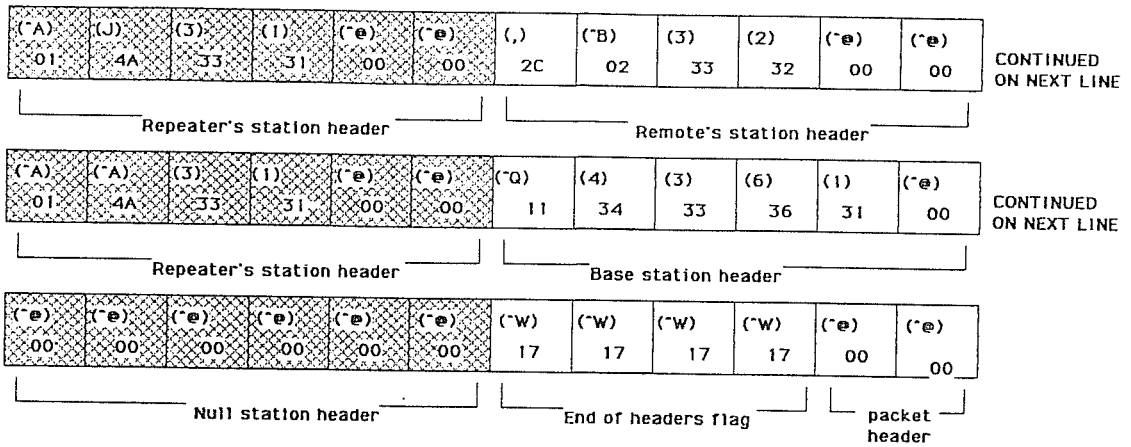
Each station header starts with the address of the station to be accessed, followed by the baud rate to be used, followed by the task to be performed, followed by two variable codes to be explained later. At the end of the station headers is a null station header which prevents infinite loops, and a flag to delimit the station header code section. Finally there is a packet header, followed by packets of data or programs, or whatever information is to be sent through the network. At the very end of the header is a checksum which the telemetry system uses to identify flawed data. This checksum is generated by the radiomodem itself, and never appears in data sent to or from the controller.

To understand exactly how several stations can operate on one channel without interfering with each other, the headers must be examined more closely. It is the base computer's job to place the station headers in the proper order for the transmission to take place. Consider a base station surrounded by 3 remote radiomodems (Figure 2.2). One is in direct radio range of the base, while another is only in range when propagation is good. To reach it reliably, the message has to be relayed though a "repeater".

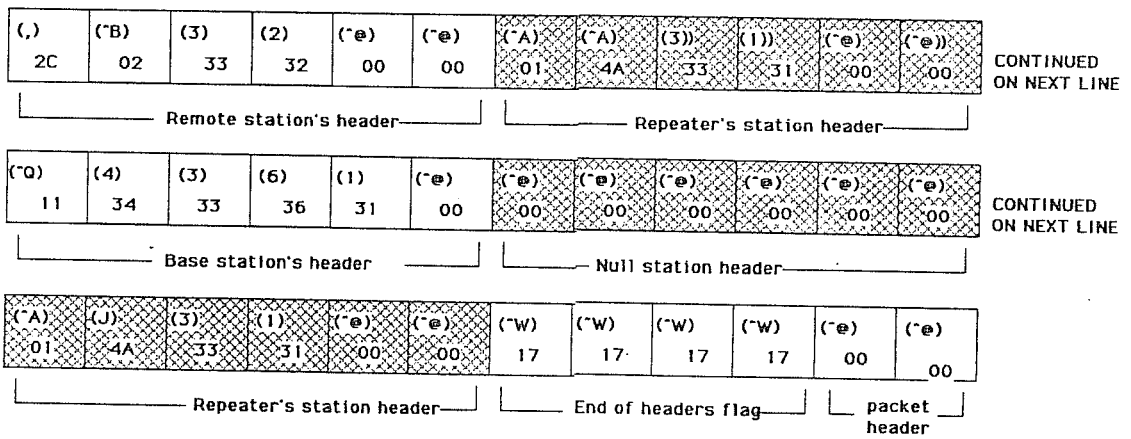

Base station
Serial number 1134.
Remote station 2
May or may not have a
weather station attached.
Serial number 014A.
This station relays data
to and from station 3.
Remote station 1
Serial number 0233
Remote station 3
Serial number 2C02

Accessing Station 3 via Station 2

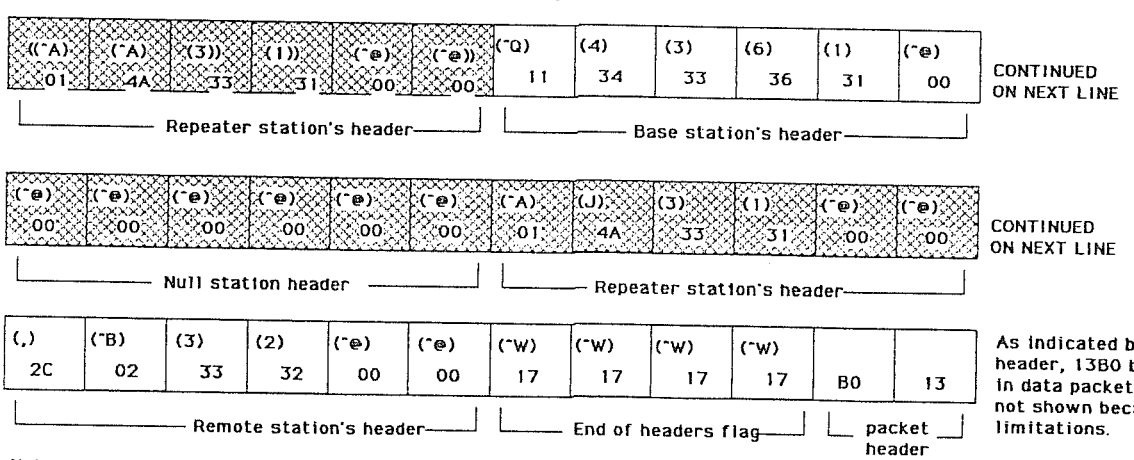
Stage 1 – User's computer sends the base telemetry unit the header with routing information and commands.



Stage 2 – Repeater rotates station headers one position, and retransmits. As a result, the next station to respond will be the remote site.



Stage 3 – The remote station, having examined its control function, will load data from the weather recorder. It then creates a series of data packets and a packet header. Once again, the station headers are rotated one position, and the entire message is transmitted to the next station, in this case, it is the repeater that will respond next. There is no room on this page to continue, but the station headers are rotated again, and eventually the message gets back to the base station.



As indicated by the packet header, 13B0 bytes follow in data packets, which are not shown because of space limitations.

Note that all the boxes represent one character. The number represents the hexadecimal value. The character itself is in brackets.

Referring to the diagrams in the Figure 2.3 let's get a printout of the data from remote station 3 via remote station 2. First the base sends out all the station headers in precise order, with the first station to be accessed (station 2) first in line. At the end of the station headers is a flag composed of four "end transmission block" ASCII control characters which tells the base radiomodem to expect the packet header next. Since the base station is not sending a packet of data to the remote station, the packet header is set to zero characters.

When station 2 receives the long 10 second wake up tone that preceeds the headers when the base station transmits, it locks onto the tone and decodes the first two characters of the first station header. It compares the value to its own address and begins to input the rest of the station headers. Station 1 will have also locked onto the tone, but when it decoded the first two characters, they will not have matched its internal address, and it will have started strobing again, looking for the next 10 second tone.

Station 2 then inputs all the station headers, the flag, and finally the packet header. Since the packet header indicated 0000 bytes to follow, it stops the input mode, and searches the function field in its own header to find out what it has been told to do. In this case,

the 31 is the code to become a repeater, so it rotates the headers one header length to the left and repeats the headers. After the rotation of the headers, the station header for station 3 becomes first, and station 2 becomes last.

Station 3 locks onto the tone from station 2, and after decoding its address, inputs the headers in the same way as station 2 did. This time, the function field tells it to load data from the attached weather station, and transmit it to the next station. The data is loaded, a packet header is calculated, the headers are rotated one position to the left, and it relays the data to station 2.

Station 2 inputs all the headers, but when it comes to the packet header, it begins waiting for 13B0 bytes to follow. Once it has received all these, it performs a check on the data to see if any uncorrectible errors have occurred, and follows the repeater function in its function field. The data is then relayed to the base.

The base station inputs all the headers and the data, but when it searches its function field, it finds that it is to dump the data to the computer. Furthermore, its function field also contains a subfunction code which tells it to include the headers in the data being sent to the computer, and to use a baud rate of 1200 bits per second. When this is done, the data has been transferred,

and all stations are back to the receive mode.

2.2 RS232C Hardware Handshake

The previous discussion of how the radiomodem relays messages was simplified. If you intend to write software that is compatible with the radiomodem, then there are some aspects you must be aware of. First, since all radiomodems are hardware and software identical, even the base radiomodem spends most of its time powered down. It "wakes up" every 8 seconds to see if there is a radio call being made to it, but otherwise it is turned off. Therefore, before you can send it a group of headers to get it to do something for you, you must first get its attention. This is done using the "request to send" hardware handshaking line on the RS232c port of your terminal (computer).

The inactive voltage level of RTS (request to send) is -5 to - 25 Volts. When this line is active, it becomes positive, and causes the radiomodem to power up. The radiomodem is capable of sensing that the power up was due to RTS, and will expect data to be sent to it within 1/2 second, at 1200 baud. If no data is sent, it powers down and resumes "strobing". Also - RTS is only edge sensitive, therefore, you should reset RTS after you have accomplished the wake - up. It has no other handshaking function in the radiomodem. Finally, there is a 2% chance that the radiomodem will be busy checking the radio when

you initiate the RTS pulse, which means that RTS and all your data will be ignored. However, since RTS is only edge sensitive, and is latched, you may assert RTS twice before sending data and thereby get the radiomodem's attention in spite of a radio check coincidence. Follow the timing chart on the timing diagram (Figure 2.4).

The only other handshaking line implemented on the radiomodem is the clear to send from the computer. If this is not active, the radiomodem will not send any data. This is marginally useful for computers which cannot accept data at high rates. Note that if a large amount of data is being transferred, there is only just enough time to receive, decode and transmit the data at 1200 baud before the hardware timeout resets the radiomodem. Therefore, if you hooked up the radiomodem to a 15 character per second printer, you cannot expect to get a full printout before the timeout occurs.

DETAILED TIMING DIAGRAM

DIAGRAM 1 - TWO NORMAL STROBE INTERVALS FOLLOWED BY TRANSFER OF HEADER INFORMATION

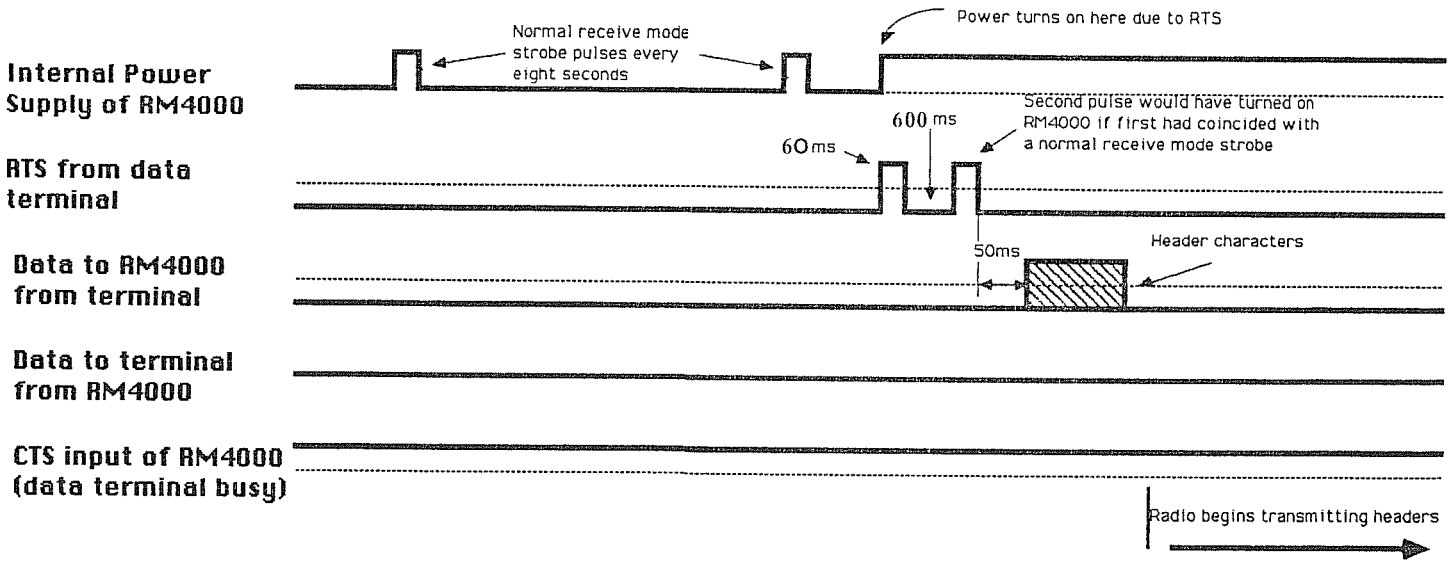


DIAGRAM 2 - ONE NORMAL STROBE PERIOD FOLLOWED BY RECEIPT OF DATA FROM REMOTE STATION

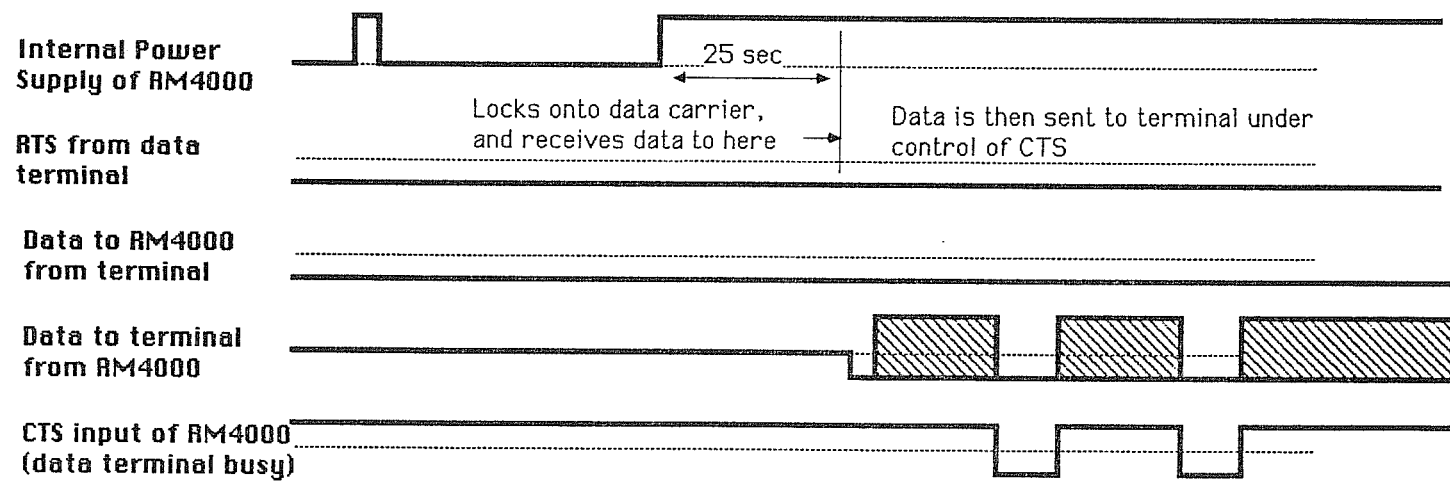
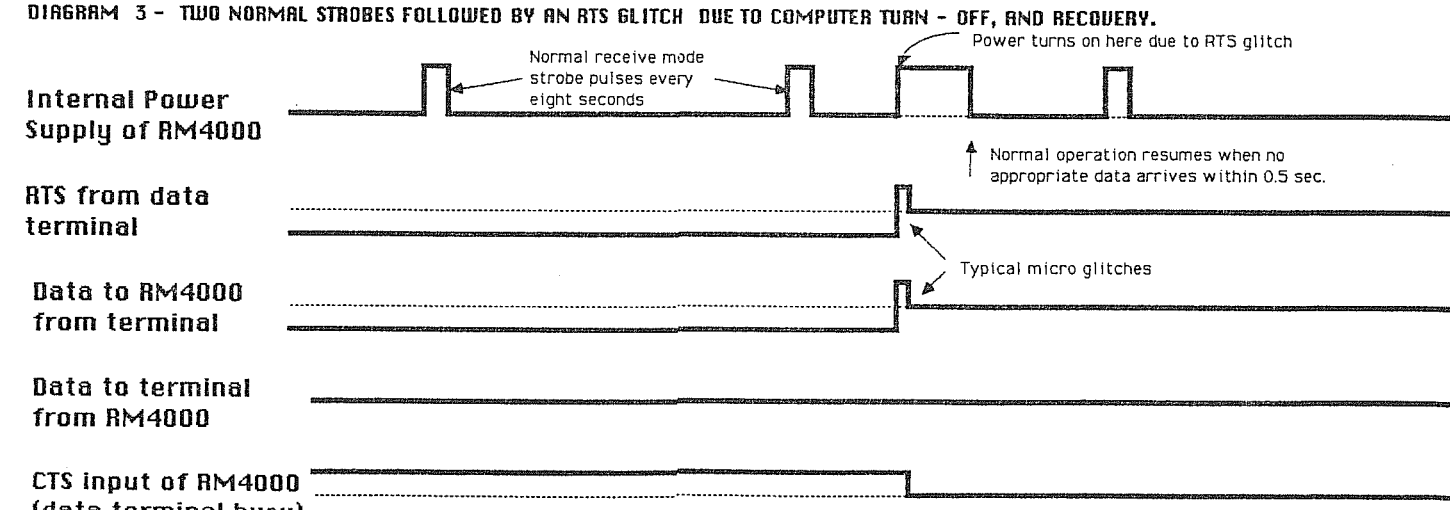


DIAGRAM 3 - TWO NORMAL STROBES FOLLOWED BY AN RTS GLITCH DUE TO COMPUTER TURN - OFF, AND RECOVERY.



If you choose to have the radiomodem dump the headers to the computer as well as the data, you can retrieve information about the signal quality from the headers. The radiomodem uses an error correcting scheme to eliminate errors in transmission over the radio. For each radio link, the number of errors corrected is totalled and placed in the error counter in the 6th byte of the receiving station's header. Therefore, if a radio link is becoming marginal, you will notice that the error counter is not zero before the link fails.

The packet switching protocol software provides protection from some omissions in the header. If the command field is left out or contains an invalid function, the radiomodem defaults to being a repeater. If the null header is missing, it is automatically reinserted. If the packet header is missing, it defaults to zero, and is reinserted.

If an uncorrectible error occurs during any radio link, the radiomodem that encounters the error will abort the data, and simply send a message through the RS232c output port reading: "Checksum error in received data, try again." This message is preceeded by the standard pattern of 6 nulls, then a tilda ("~").

The number of repeaters permitted is up to 128, but you must realize that the time to receive data increases with the number of repeaters that you chain together, and

the amount of memory free for transferring data decreases at the rate of 12 bytes per station header. Please note that the type of repeater being referred to is a store - and - forward repeater, not an existing duplex analog repeater. When chaining repeaters together, it is not necessary to follow the same path back from the remote site as it took to send the commands to the remote site. Since all radiomodems are identical, any radiomodem may be used as a repeater - even base stations.

2.3 Other Features of RM4000 Software

This is one of the first packet switched data communications devices to use advanced error correction techniques to provide resistance to noise and static. Certainly, this makes it unique among normal narrowband radio equipment. Our units can correct up to 3 one bit errors in any two characters worth of transmitted data. The actual error correction theory is the same as was used to send back the video from the mariner space probes, which share many of the same communications problems we were faced with - low power, noise, and low duty cycle. This technique is part of the protocol conversion from ordinary asynchronous ASCII that is universal in usage to our particular synchronous packet switched encoded radio protocol. This protocol is specially tailored for:

a) Low power, low data rate applications
b) Narrowband voice type radio channels with noise
c) Half Duplex, polled operation

In addition to the error correction, there is error checking. It is not acceptable for any errors to be passed by the telemetry system, but it is possible for more than three errors to occur in two bytes in bad conditions. Whenever data is being handled, therefore, all the data bytes are added together, and the resulting sum is placed at the end of the packets before they are encoded with the 32 X 16 error correction matrix. This checksum is encoded together with the data, and is decoded at the receiving end. An independent sum is calculated at the receiver using the decoded data, and compared to the decoded checksum that was generated at the transmitter. If the two do not match, the data is assumed to be flawed, and aborted. A message reading "CHECKSUM ERROR IN RECEIVED DATA - TRY AGAIN" is sent down the serial lines of whatever radiomodem the error is detected at the default baud rate, but the transmitter cannot be activated after a flaw has been detected.

Direct Connection to Serial Printers

Version 1.4 of the radiomodem software was the first to allow direct connection to 1200 baud serial printers. The station headers referred to in the previous sections are stored in the EPROM (Erasable, Programmable, Read Only Memory) inside the radiomodem. There is a small two pin jumper on the controller circuit board which tells the radiomodem whether to operate normally or in the

"Autocall" mode (See figure 2.5). When the jumper is installed, the following sequence will occur every time the printer is turned on:

1)When the printer is turned on, the RS232c handshaking line called RTS (pin 4) or DSR (pin 6) goes positive. This causes the power supply in the radiomodem to turn on and puts the controller in the "terminal handling" mode.

2)The controller board in the radiomodem then "reads" the Autocall jumper, and finding it to be active, loads into the transmit buffer memory the header which was stored in EPROM at location $1F00. This header is identical in construction to those in the previous section, except that it has an ASCII "D" in the function field of the base station header.

3)When the "D" function is executed, the raw binary data from the weather station is titled, converted to standard units, and formatted for printing. Handshaking with the printer is done through the standard "External Ready" handshaking line (pin 20). If the printer can achieve at least 30 characters per second, all data can be printed before the hardware timeout occurs. Slower printers will print out only a part of the data.

Forest Technology Systems can produce a custom header in the ROM of any length on request. Normally,

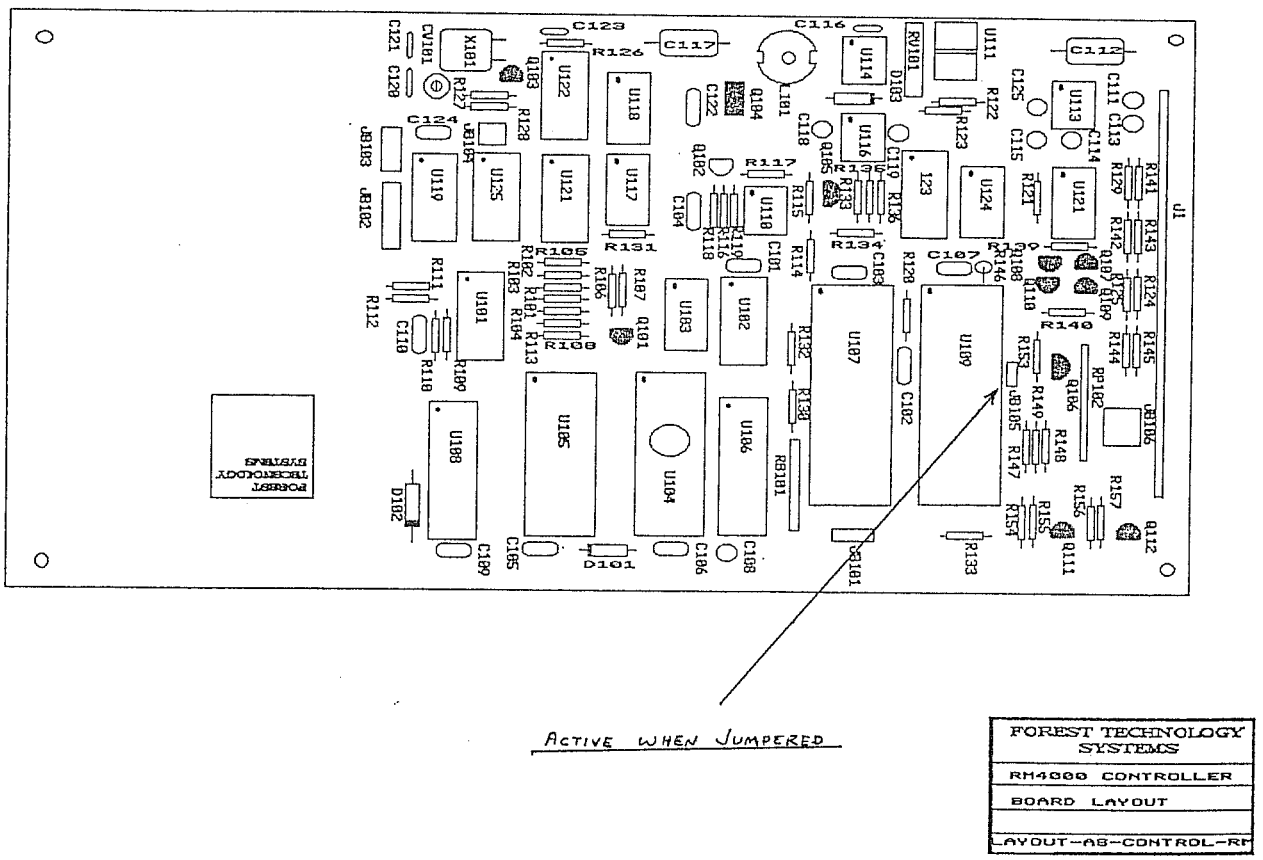


Figure 2.5 - Autocall jumper

units are shipped with the EPROM default value in the locations above $1F00, which is $FF. If you have the equipment for "burning in" 2764 EPROMS, you can make a copy of the ROM in your unit and add a custom Autocall header of your own design. The rules in the previous sections apply, but add a "$" (Hexadecimal 24) to the end of the header. This tells the program that it has reached the end of the custom header. A sample header follows on the next page...

Sample Header:

Location	Data	Comments
1F00	00	MOST SIGNIF BYTE OF REMOTE STATION ADD.
1F01	4E	LEAST SIGNIF BYTE
1F02	33	CHOOSE 1200 BAUD DATA RATE
1F03	32	FUNCTION IS TO UPLOAD DATA FROM WRN61
1F04	00	THERE IS NO SUBFUNCTION
1F05	00	INITIALLY SET THE ERROR COUNT TO ZERO
----------END OF REMOTE STATION HEADER----------		
1F06	00	MOST SIGNIF BYTE OF BASE STATION ADDRESS
1F07	4F	LEAST SIGNIF BYTE
1F08	33	CHOOSE 1200 BAUD DATA RATE
1F09	44	FUNCTION TO PRINT FORMATTED DATA
1F0A	00	NO APPLICABLE SUBFUNCTION
1F0B	00	INITIALLY SET THE ERROR COUNT TO ZERO
----------END OF BASE STATION HEADER----------		
1F0C	00	NULL STATION HEADER
1F0D	00	
1F0E	00	
1F0F	00	
1F10	00	
1F11	00	
----------END OF NULL STATION HEADER----------		
1F12	17	END TRANSMISSION BLOCK CHARACTER
1F13	17	
1F14	17	
1F15	17	
1F16	00	SET PACKET HEADER TO #BYTES = 0
1F17	00	
----------END OF FLAG AND PACKET HEADER----------		
1F18	24	END OF HEADERS CHARACTER ($)

This header contained no repeaters, but if required, they could be added to a depth of five or six. The biggest disadvantage to the Autocall approach to radiomodems is that the radiomodems can only call one station, and extensive networking is not possible.

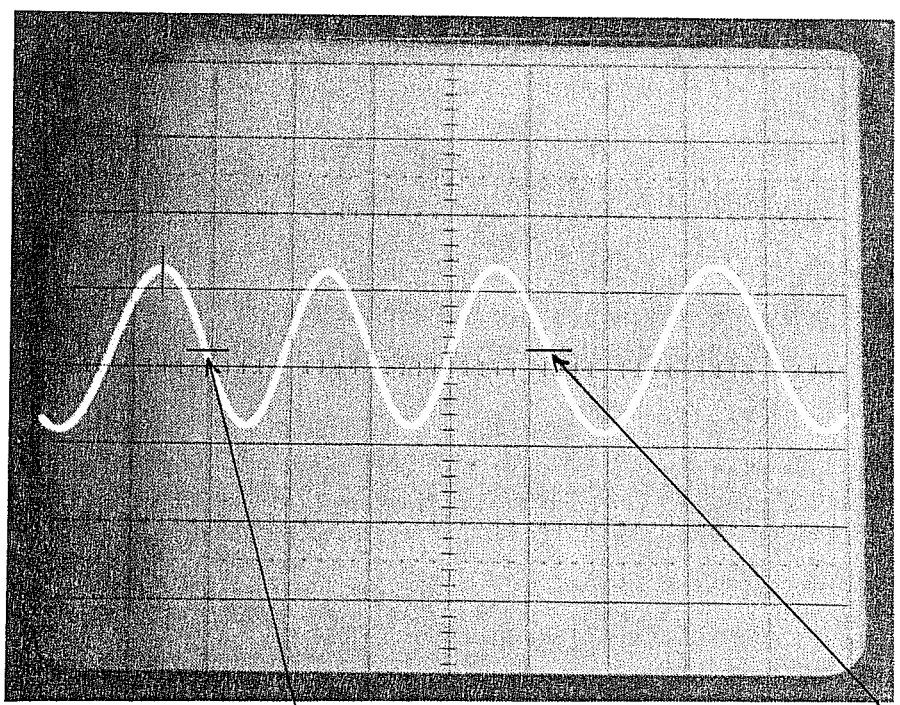
2.4 COMMAND LIBRARY - Version 3.0

Function	Subfunction	Description
31H	N/A	Repeater Function
32H	N/A	Load all available data from WR62 and send it back
33H	N/A	transfer the program in the packets to RAM, beginning at the address in the first two bytes, and run it.
36H	31H	Send the returned header and packets at 1200 Baud
36H	32H	Send the returned header and packets at 2400 Baud
36H	33H	Send the packets only at 1200 Baud
36H	34H	Send the packets only at 2400 Baud
37H	N/A	Load and return the first 160 data points from a CR21
38H	N/A	Load and return the second 160 data points from a CR21
39H	N/A	Load and return the third 160 data points from a CR21
41H	N/A	Load and return the fourth 160 data points from a CR21
42H	N/A	Transfer and return data from and Aanderra recorder
43H	N/A	Clear the battery backed RAM, if installed
44H	N/A	Assume the packets contain FTS weather data, decode it, title it, and print daily and hourly readings
45H	N/A	Load only the most recent 24 hours of WR62 data, and send it back. (can work directly with serial printers)
46H	N/A	Set the clock in a CR21X to new time, or read clock
47H	N/A	Return CR21X data in ASCII format
48H	N/A	Return CR21X data in binary format
49H	N/A	Download new programming to CR21X
50H	N/A	Assume the packets contain FTS weather data, decode it, title it, and print only the last 24 hours
51H	N/A	Change protocol to "BC QUICKCALL" conventions
58H	N/A	Return the Version and Revision of internal software.

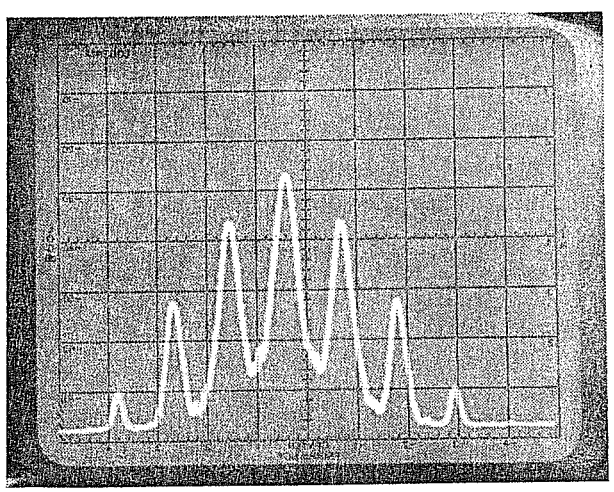
RM4000 HARDWARE

3.1 Theory of Operation

The RM4000 is a FSK (Frequency Shift Keyed) modem that can operate up to 1200 bits per second. The frequency that represents a "one" is 2400 Hz and the frequency that represents a "zero" is 1800 Hz. If the RM4000 has been configured to operate at 600 Baud, the frequencies are exactly divided by two. To eliminate jitter, a bit synchronous format is used, where a "one" takes two cycles (720 degrees) and a zero takes 1.5 cycles (540 degrees). That means frequency changes always occur at the same phase points.



When the RM4000 is operated at its full data rate, it occupies a section of the audio spectrum between 1400 and 2700 Hz. This is above the DTMF (Dual Tone Multi Frequency) band and subaudio control tones, and below some of the high frequency control tones used in repeater networks. Assuming that the maximum bandwidth coincides with the maximum data rate, the bandwidth may be estimated by assuming a bit stream composed of alternating ones and zeros. This forms a standard FM carrier at the geometric mean of 2400 and 1800 Hz, or 2080 Hz. Since the bit stream is actually a squarewave of 600 Hz, sidebands are produced around this carrier at $\pm$ 600 Hz. Real data has significant sidebands within this 1200 Hz bandwidth.



Spectrum Analyzer Photo. Center frequency 2080 Hz, 500 Hz / division

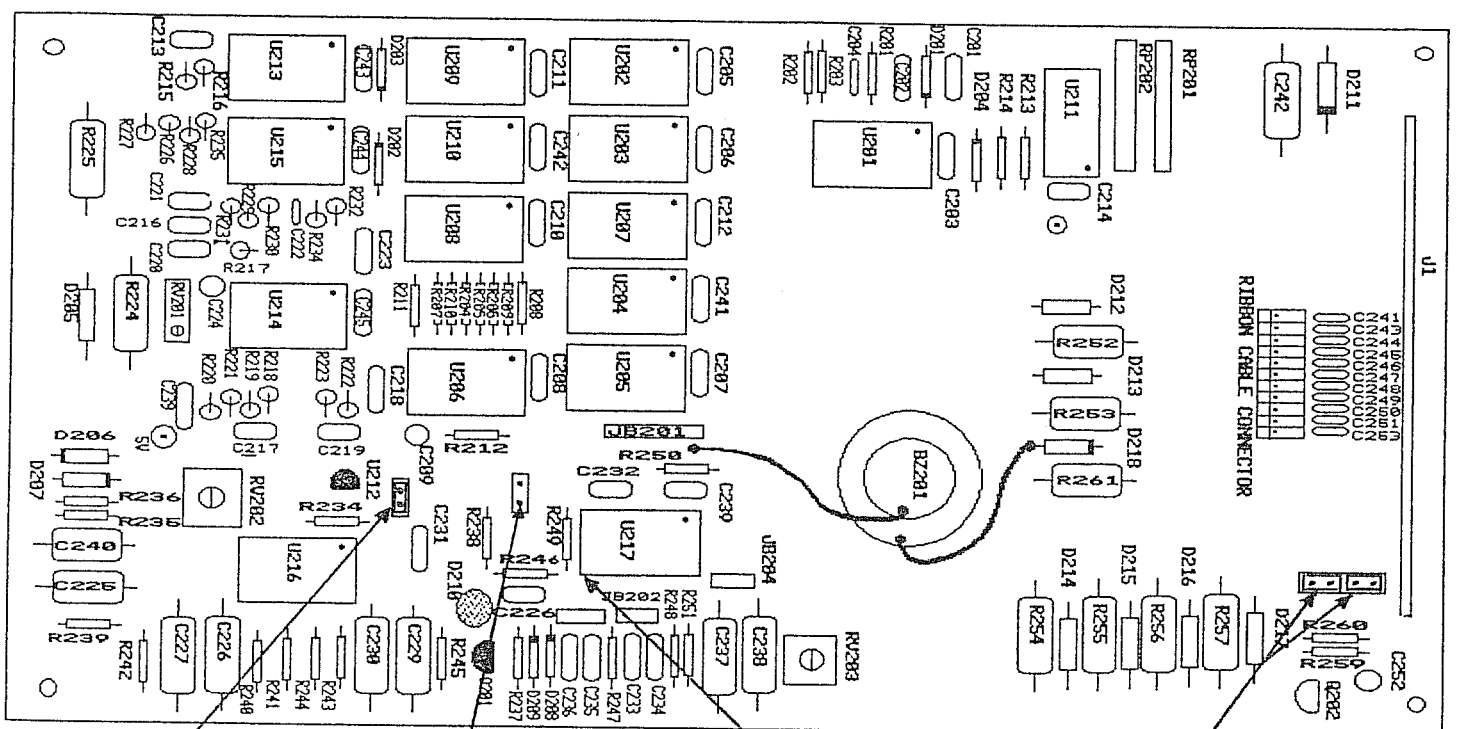
Figure 3.2

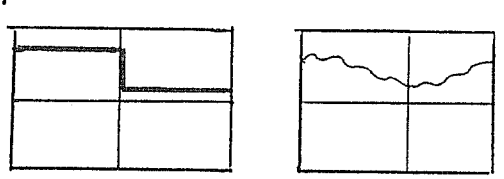
Each sideband contains information about 1's and 0's in the modulation. So does the carrier. In audio terms, the 3 dB bandwidth is about 1200 Hz, but in radio terms,

where occupied bandwidth is defined by the 26 dB bandwidth, it is nearer 17 KHz, at 5KHz FM deviation. This deviation is excessive, since many borderline transmitters will introduce considerable distortion due to the limiting action they are required by law to apply to overdriven inputs. At Forest Technology Systems, we normally set the deviation to 3KHz peak deviation, which is a good compromise. The important design consideration is that regardless of the deviation, the occupied bandwidth is within legal limits. For your information, the type of emission is designated as 16K0F2DCN on DOC license applications.

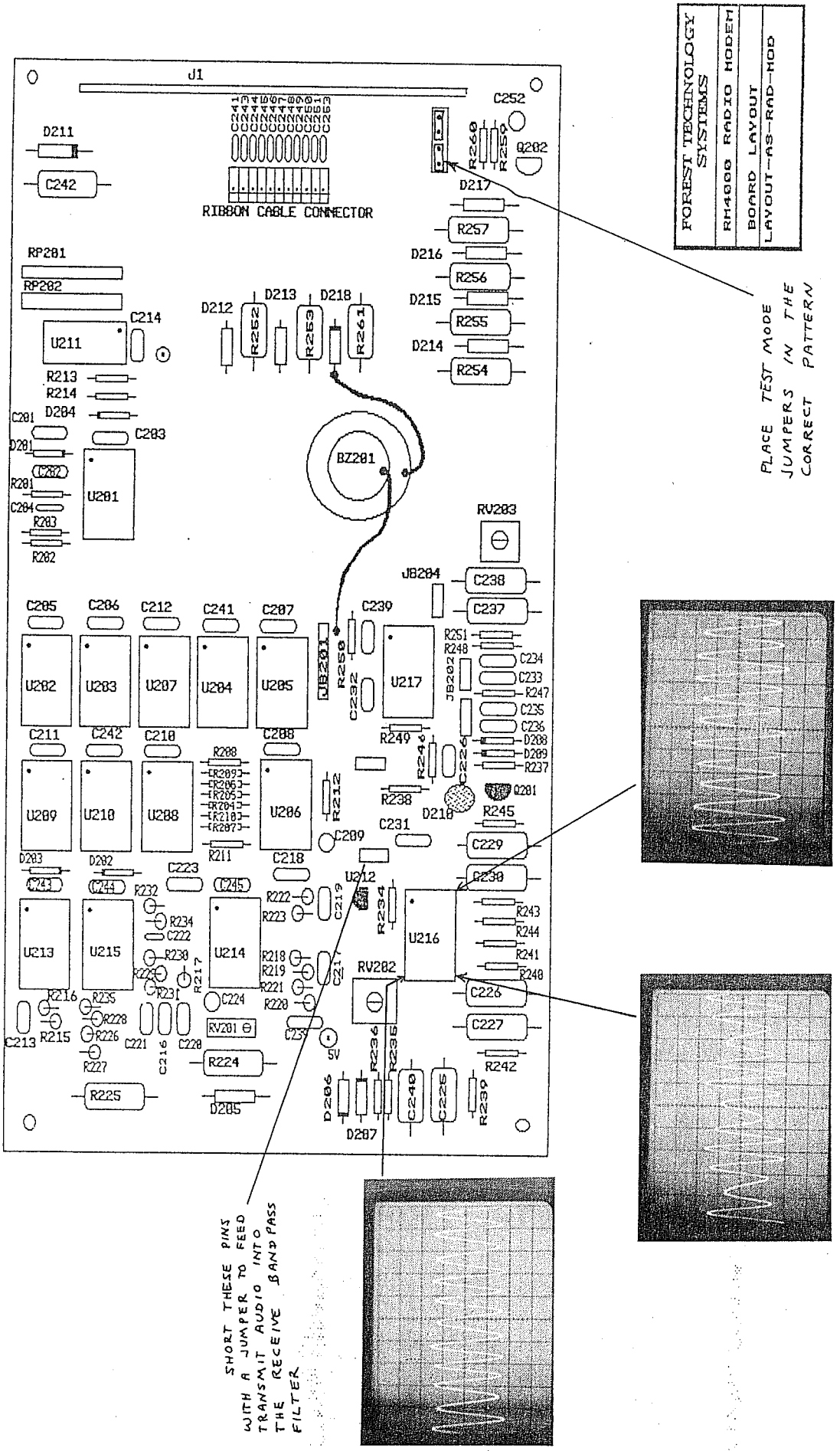
The information density as far as the modem is concerned lies between 1400 and 2700 Hz in the voice channel. To increase the signal to noise ratio, a bandpass filter is used to isolate this data subchannel from the ever present noise in the rest of the audio channel. Note that we have set the energy density ABOVE the DTMF tone matrix frequencies and the subaudio control tones which are usually used in commercial two way radio service. This will help these systems tolerate the relatively high modulation level we place on the carrier. Some repeater systems are tone controlled by bursts of high frequency tones. These systems are more of a problem, and we have got around this by issuing the PTT signal 250 ms before we begin modulating the carrier so that the control tones can get through.

The receive bandpass filter is centered on the geometric mean of the two most significant sidebands in the audio spectrum. The filter is 6th order and was designed to have maximum 1 dB ripple in the passband. You should be able to observe the following waveforms when the RM4000 is put in the "transmit test mode", and the output of the modem is tied to the input. This is called the "local analog loopback test".



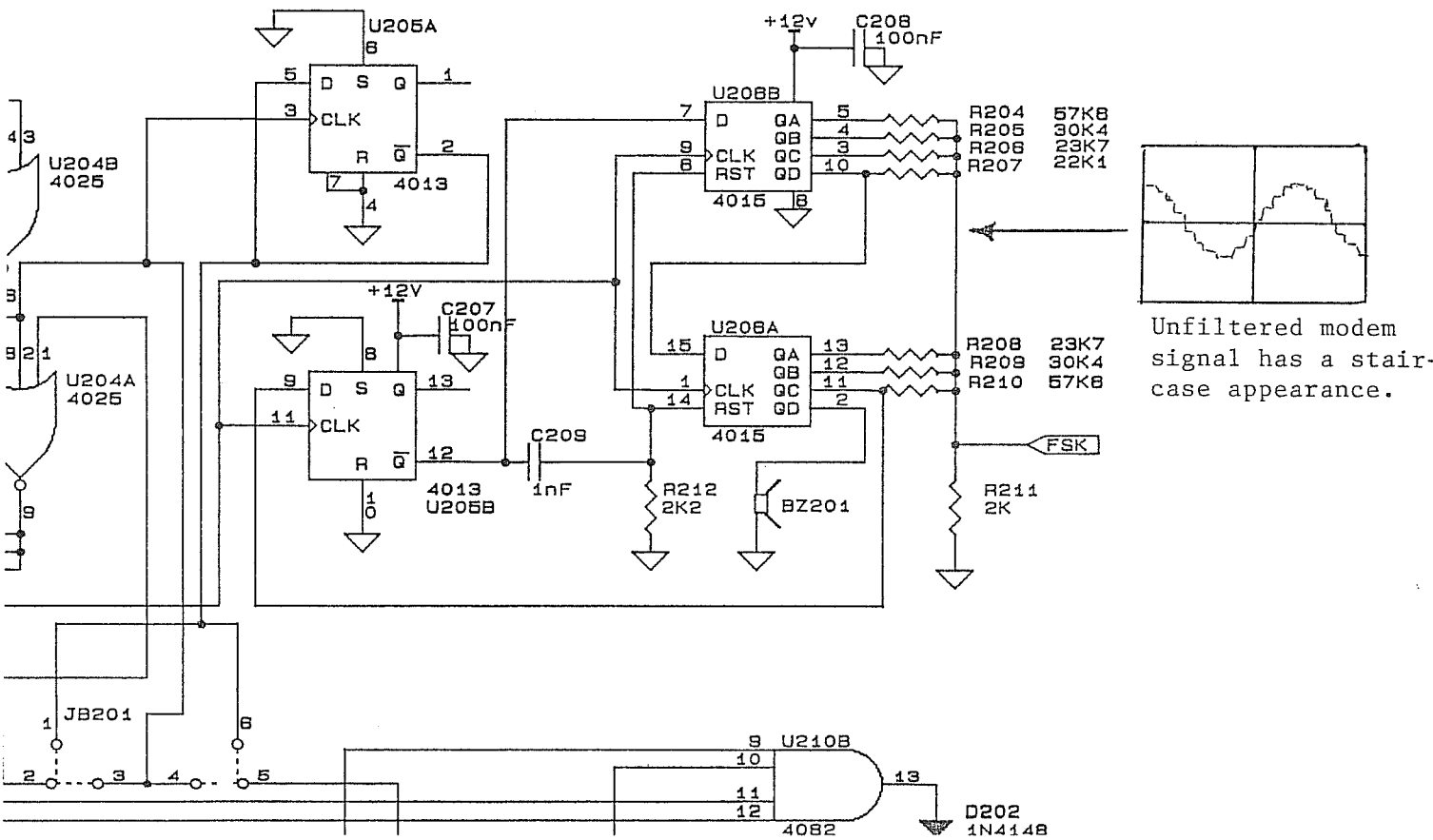


FOREST TECHNOLOGY SYSTEMS
RM4000 RADIO MODEM
BOARD LAYOUT
LAYOUT-AS-RAD-MOD



Data receiver bandpass filter operation and waveforms.

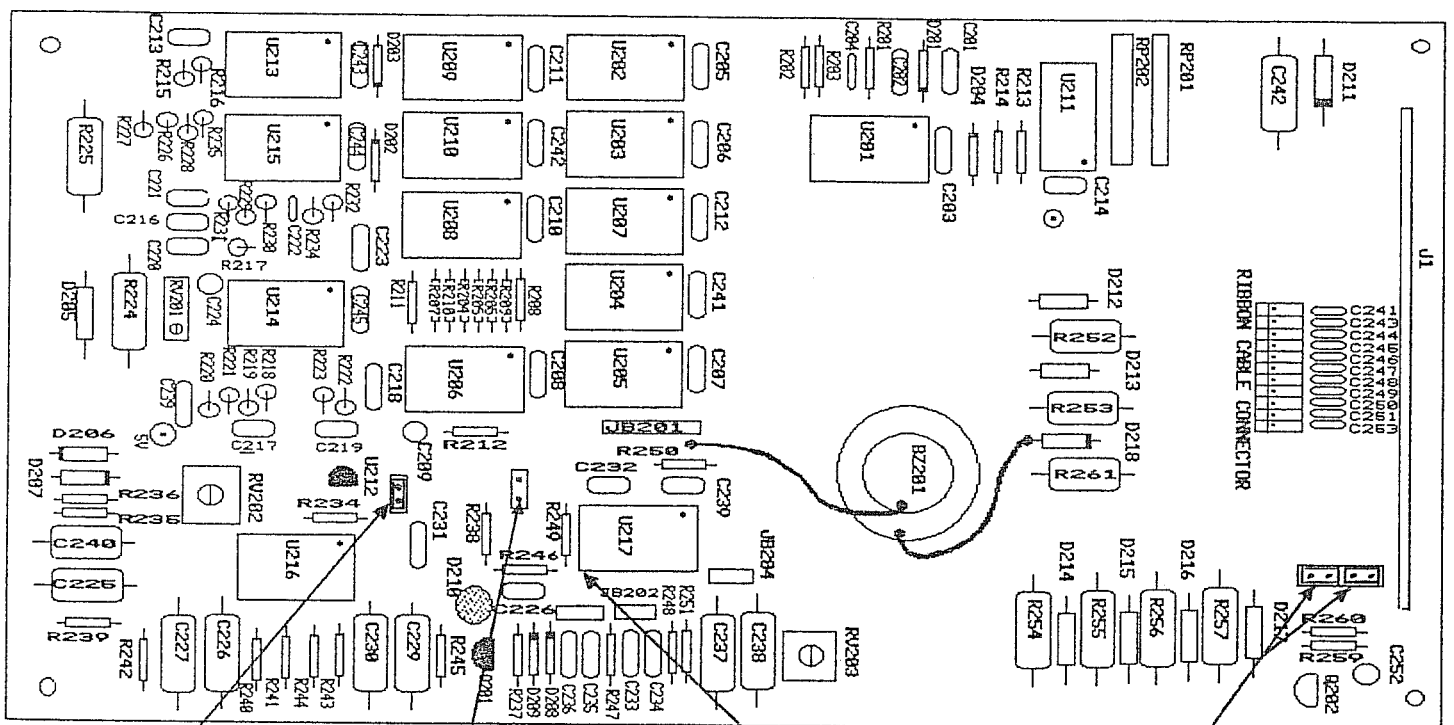
The transmitter section of the modem starts with a phase locked frequency tripler (U201 and U202) coupled to a divide by 3 or divide by 4 digital counter (U203, U204, and U207), which divides down the CPU clock to 38400 Hz and 28800 Hz as the serial data output of the CPU changes from 1 to 0. A jumper block allows this signal to be further divided by two (U205A) to easily convert the RM4000 to 600 Baud. From the jumper block, the signal is converted to a sine wave with a shift register and summing resistor network (U206 and R204 - 210). The final output frequency is 1/16 th of the 38400/28800 Hz driving squarewave, or 2400 Hz and 1800 Hz. A smoothing filter, (U214) is used to eliminate higher order harmonics from the final signal.



Unfiltered modem signal has a stair-case appearance.

Jumper block for Baud rate selection

After the signal has passed through the receive bandpass filter, it is demodulated by a single chip PLL (Phase Locked Loop). The XR2211 contains three separate blocks, an input amplifier / limiter, a PLL, and a data level comparator. The single adjustment, RV203, sets the center frequency of the internal VCO, and is used to set the duty cycle of the data output test point to 50 % when the RM4000 is in the local analog loopback test mode. You should be able to observe the following waveforms:



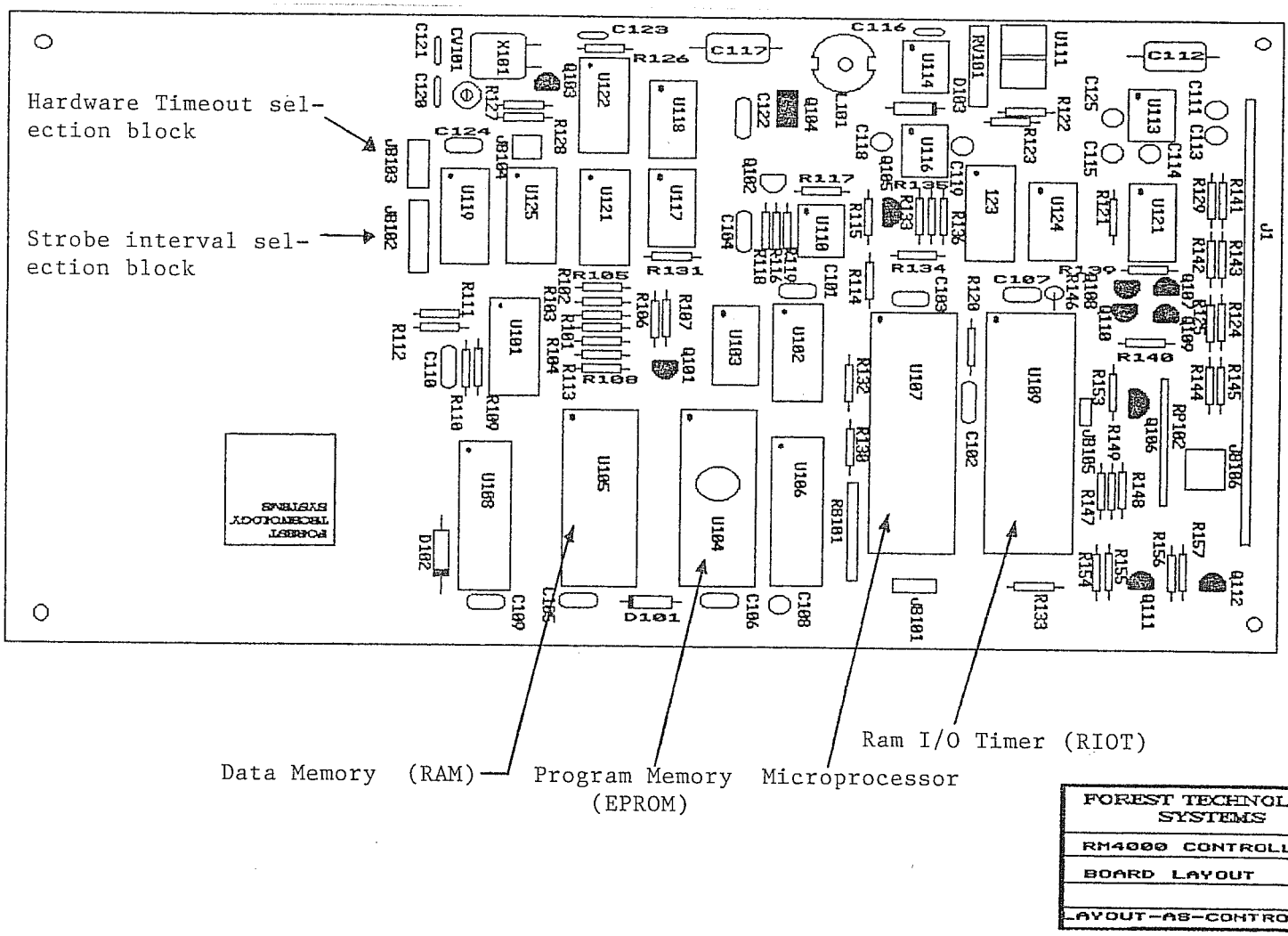
The RM4000 also has the decoder part of a CVSD CODEC which is used to generate DTMF tones, signalling tones, and voice station identification. CVSD CODEC is an abbreviation for "Continuously Variable Slope Delta modulated COder - DECcoder". This is simply a device for converting analog signals to a binary data stream and vice versa in the most efficient way. The CVSD decoder on the RM4000 only converts stored digital data to analog levels, and provides two digitizing rates - 19200 bits per second and 38400 bits per second. The higher rate provides excellent quality speech and DTMF signalling, while the lower rate is only suited to speech.

The CVSD hardware includes a four bit shift register used as a digital compander (U208, U209, and U210), a companding level integrator (R215 and C213), a slope switch (U215B and U213D), an approximating integrator (U215C) and finally, an output smoothing filter (U215D). Unfortunately, there is no simple self test procedure to exercise this hardware for troubleshooting purposes.

If the CVSD hardware is used at all, prior arrangements have to be made with FTS to have the EPROM on the controller board custom programmed for CVSD output, since this requires the use of a CVSD encoder and special EPROM programmer.

3.2 CONTROLLER BOARD DESCRIPTION

The controller board of the RM4000 is located underneath the modem board discussed in the previous section. It holds the power supply sections and all the digital circuitry. Referring to the block diagram below, the central component is the microcontroller block which contains the 80C85 microprocessor, 81C55 RIOT (Ram/Input-Output/Timer), 27C256 program EPROM, and the 4464 RAM. It controls all the functions of the RM4000 whenever it receives a "strobe on" signal from the Timer block.



The Timer block is a logical place to start the description of the controller board. It runs continuously from the 5 Volt switchmode power supply (U114). The reference for the Timer block is a 6.144 MHz crystal oscillator (Q103). Its output drives the 80C85 microprocessor through a NOR gate (U118A) whenever the microprocessor section is powered up. It also is fed to a divide by 10 counter (U122) and a 14 stage binary counter. The 38.4 KHz tap on this binary counter (U119) is sent to the modem board as the reference for the modem tones (interboard connector pin 5). It is also buffered and provided to the external connector as a reference frequency for the weather station's serial data port.(Interboard connector pin 27).

After the 6.144 MHz signal has passed through both U122 and U119, it has been divided down to 37.500 Hz. This frequency is sent to both U120 and U119. U120 is a 14 stage binary counter that functions as a RTC (Real Time Clock). Although its "Ticks" are 109.2267 seconds long, there is a software routine in the EPROM that converts the time to the nearest minute. The clock is "read" when the RIOT is instructed to input the data on pins 1,2, and 3 of U120 every time the microprocessor is powered up by a "strobe on" command.

The "strobe on" commands themselves are generated by U119. Six jumper (JB101) selectable taps on this 14 stage binary counter allow you to choose a strobe

interval of 0.2133 sec, 0.4267 sec, 0.8533 sec, 1.707 sec, 3.413 sec, or 6.827 sec. Position A is for the shortest time, and position F is the longest. RM4000 radiomodems are usually set to a 6.827 second strobe interval. When combined with the proper high speed compatible EPROM, choosing a shorter strobe interval allows faster polling of the radiomodems. The tradeoff is average idle power consumption, which increases dramatically at short strobe interval selections. The "strobe on" signal is sent to a flip flop (U117A) that simply turns on a FET switch (Q104). This applies power to the microprocessor block which will then begin to run its program. Normally, when the program is finished running, it will instruct the RIOT to set pin 5 of U118B high, which then resets the microprocessor power supply by clearing the flip flop. This could be considered a "strobe off" signal.

There is another possible way of generating strobe on signals. If the "RTS input" pin on the external connector is brought high, U117B will sense the rising edge and turn on Q104 in the same manner as if U119 had been the source of the "strobe on" signal. The microprocessor senses the difference by instructing the RIOT to read the state of pin 9 of U117B. If this signal is found to be high, it means that an external device is trying to gain the attention of the RM4000.

There is also another way of generating "strobe off" signals. There is a second jumper block (JB103) attached to U119 that has three "timeout" positions. This defines the maximum amount of time that any program can run before the hardware "times out" and shuts down the microprocessor power supply. This is a safety feature in case the software instuctions ever get missequenced and the microprocessor block latches up. Because of the nature of RM4000 operation, there is never a case where the software needs to be run continuously. The timeout periods are 109.2 sec, 218.5 sec, and 436.9 sec. As in the case of the strobe interval jumper block, position A is the shortest interval, and B and C provide the longer times.

As mentioned in the Timer description, the microprocessor section only operates intermittently, to conserve power. When power is applied, the buffered clock signal is sent to the external clock input of the 80C85 microprocessor. This is done to make the 80C85 start faster and more reliably than if it used its own independent clock crystal. Because of this feature, the restart timing components (R120 and C102) are designed to start the microprocessor executing its program in only 1 millisecond after the power is applied.

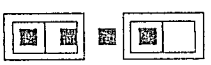
The program that directs the operation of the RM4000 starts by setting the programmable RIOT to the correct frequency and settings, so that the default Baud

rate is set to 1200 Baud. Next, it checks for the condition of the self - test jumper block. This jumper block has two sense pins, and four possible selections:

Selftest Mode Jumper Block

Normal Operation 

Analog loopback test mode

Same function as button on selftest box 

Receiver on only.

After checking for test mode conditions, the microprocessor then turns on the 12 Volt regulator, which applies power to the modem board and the internal radio transceiver. The microprocessor then waits for a short period of time for the transceiver to warm up and stabilize on the radio channel, and begins to check the received audio for a data carrier. The exact timing depends on the transceiver and the custom programmed EPROM that is matched to that brand of transceiver. Some synthesized transceivers actually take a couple of seconds to stabilize, while the more conventional crystal controlled units usually stabilize within a fraction of a second. External radios are assumed to run continuously, and may have a warm up time of zero. The data carrier sensing is done by examining the output of the data demodulator (interboard connector pin 13). If there is voice or simply static coming from the transceiver, then

this output will be switching states randomly. If there is a data carrier that is good enough for reception, then 90% or more of the bits will be "ones", and the program will proceed to examine the station headers. Otherwise, it issues a "strobe off" command to the Timer section, and the RM4000 resumes it low current idle state.

This data carrier sensing technique requires that the transceiver's squelch control is set to OFF. If the squelch is left on, there may not be enough audio output to make the modem's data demodulator operate when there is no signal present, and therefore the microprocessor will waste time and power trying to decode non - existent headers. The static from an unsquelched radio will actually reduce average current drain.

The hardware in the microprocessor section is quite simple. The 80C85 is capable of addressing 64K of memory, and 256 I/O ports. Our system makes use of 6 I/O ports and all 64 K of the memory space. The memory map is divided into 4 pieces as follows:

Memory Address	I/O Address	Devices Represented	Detailed Description
0000 H 7FFF H	N/A	27C256 standard EPROM or 27C64 Optional	Holds programs (Firmware) and digitized audio
8000 H 9FFF H	N/A	uPd 4464 -15 RAM	Battery backed data memory and clock registers
A000 H BFFF H	N/A	Optional DAC1008LCN 10 bit D-A Converter	Not installed in the RM4000
C000 H FFFF H	C0 to C5	81C55A Ram/I/O/Timer	256 bytes of non-battery backed Ram for stack, arithmetic and control registers. Also holds I/O ports.

The largest RAM chip is battery backed. That means that power is maintained to it even when the rest of the

microprocessor is turned off in order to preserve its contents. This is a necessary feature for remotely downloaded programs and to keep track of real time. The RAM must be protected from inadvertent write commands as the microprocessor is powered down. This done using the secondary RAM chip select, pin 28 on U105. When the power supply of the microprocessor fails after a "strobe off" command, and reaches the 88% of the normal level, U101D turns ON Q101, which deactivates U105. U105 is then protected from inadvertent writes, and all its address and data lines become tri-stated so that there is no conflict with the rest of the microprocessor section which is powered down.

The I/O map is laid out on the diagram on the next page. Note that all the pin numbers for the I/O functions refer to the RIOT (Ram Input -Output Timer) chip, U109. The 80C85 also equipped with its own serial I/O channel, labelled SID (Serial Input Data) and SOD (Serail Output Data). It is not adressed as an I/O device, but is acessed with a special software instruction.

The SID line is multiplexed with U124 so that data can be selected from either the output of the modem board's data demodulator (interboard connector pin 13), or the data output of the external device (external connector pin I). If the data from the external device is selected, the RIOT is instructed to place a "one" on pin 6 of U124B and data is then allowed to flow from external

connector pin I to the SID terminal. This also turns OFF Q105, which allows data from the 80C85 SOD pin to flow through U123 to the external connector pin D. Usually, when the microprocessor is "talking" to the external device, it also intructs the RIOT to place a "one" on the RTS line (external connector pin E), to signal the external device that it now ready for data.

If the microprocessor is "talking" to the modem board, it will usually place a zero (inactive) level on the RTS line (external connector pin E) and place a "one" on pin 8 of U124C. The inactive RTS signal tells the external device that the RM4000 is no longer able to accept data, and data is received from the modem board instead. Of course, the RIOT also places a "zero" on pin 6 of U124B to prevent interference from the external device. Output data from the SOD pin is always sent to the modem board whether it is meant for the modem or not.

The microprocessor section also has some other minor functions. There is a multiplexer on the modem board that provides audio levels to the output driver. The RIOT can select no input, causing the transceiver to produce a simple carrier (interboard connector pins 8 and 9 grounded), or modem tones (pin 8 high, pin 9 low), or CVSD synthesized audio (pin 8 low, pin 9 high). The circuit diagrams also show a simple Analog to Digital converter (U110) and a 10 bit Digital to Analog converter

(U108). These sections are never installed on RM4000 controller boards, and are provided so that the board can be used in one of our other products.

The only other section on the controller board is the regulated 12 Volt power supply. This uses a special low drop - out regulator, U111. It will provide proper regulation with battery voltages right down to 12.5 Volts. It can be placed in the OFF position by the RIOT applying a "zero" to the input of U121C. When this is done, the LM2931T consumes only 80 microamps.

ASCII CODE CHART:

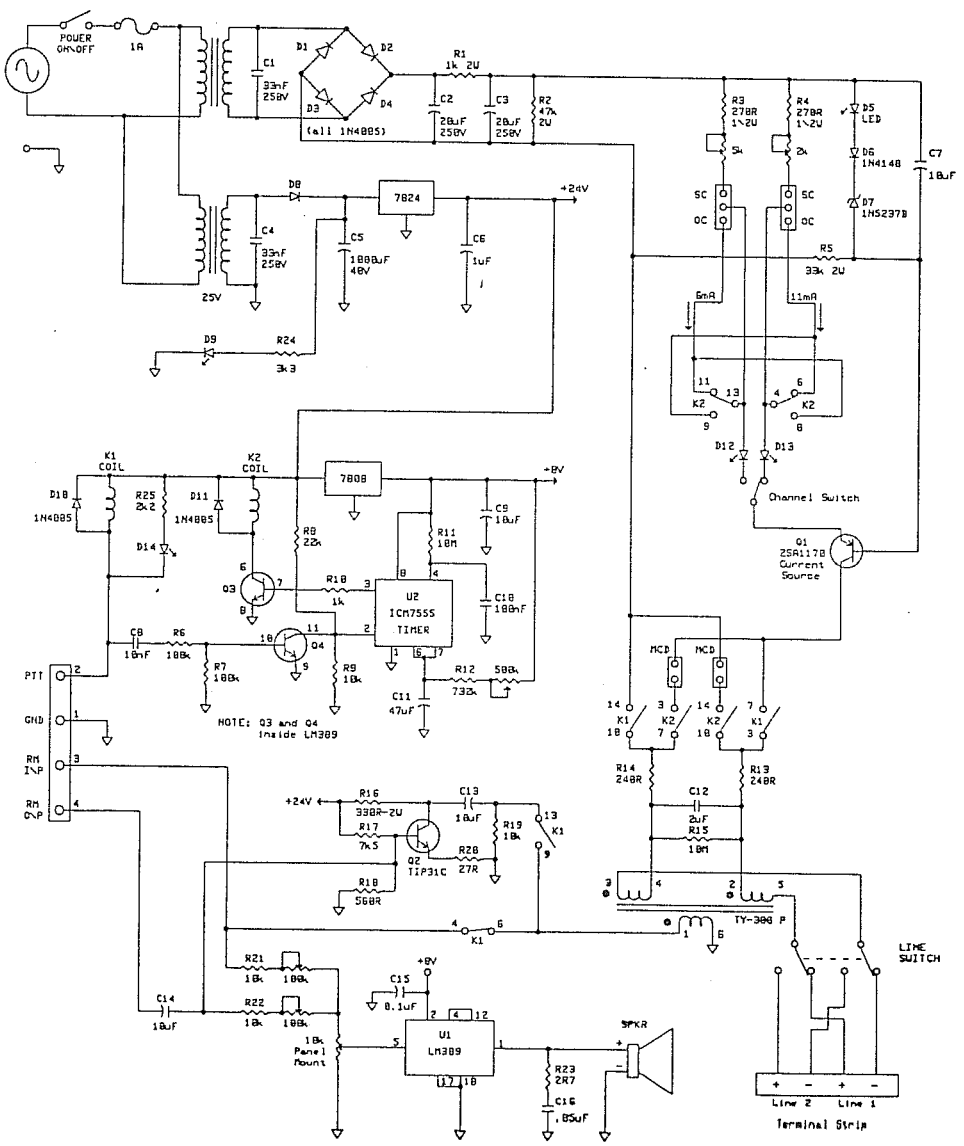
Hexadecimal Value		Name	Description
00	or ^@**	NUL	An all zero character used for synchronization or as a filler
01	or ^A	SOH	Start of Heading - Used before a control segment ahead of data
02	or ^B	STX	Start of Text - Indicates text will follow
03	or ^C	ETX	End of Text
04	or ^D	EOT	End of Transmission
05	or ^E	ENQ	Enquiry - Request for response often sent at the end of polling
06	or ^F	ACK	Acknowledge
07	or ^G	BEL	Rings the terminal's bell
08	or ^H	BS	Backspace code
09	or ^I	HT	Horizontal tab
0A	or ^J	LF	Line feed
0B	or ^K	VT	Vertical tab
0C	or ^L	FF	Form Feed
0D	or ^M	CR	Carriage return
0E	or ^N	SO	Shift Out - Means that all successive characters may be interpreted outside normal meanings until an SI is received
0F	or ^O	SI	Shift In - see SO
10	or ^P	DLE	Data Link Escape - Used to change the meaning of at least one of the following characters or controls
11	or ^Q	DC1	Device control 1
12	or ^R	DC2	Device control 2
13	or ^S	DC3	Device control 3
14	or ^T	DC4	Device control 4
15	or ^U	NAK	Negative acknowledgement
16	or ^V	SYN	Synchronous idle - Used to identify a synchronizing bit sequence.
17	or ^W	ETB	End Transmission Block - Used by the radiomodem to identify the end of the transmission header
18	or ^X	CAN	Cancel - Ignore the previous block
19	or ^Y	EM	End of medium - ie: disk full
1A	or ^Z	SUB	Substitute - to replace invalid characters
1B	or ^[	ESC	Escape - modifies the meaning of the folowing characters to extend the control character set
1C	or ^\	FS	File Separator |
1D	or ^]	GS	Group Separator |
1E	or ^^	RS	Record Separator | for file ops
1F	or ^_	US	Unit Separator |

20	Space	40	@	60	`
21	!	41	A	61	a
22	"	42	B	62	b
23	#	43	C	63	c
24	$	44	D	64	d
25	%	45	E	65	e
26	&	46	F	66	f
27	'	47	G	67	g
28	(	48	H	68	h
29	)	49	I	69	i
2A	*	4A	J	6A	j
2B	+	4B	K	6B	k
2C	,	4C	L	6C	l
2D	-	4D	M	6D	m
2E	.	4E	N	6E	n
2F	/	4F	O	6F	o
30	0	50	P	70	p
31	1	51	Q	71	q
32	2	52	R	72	r
33	3	53	S	73	s
34	4	54	T	74	t
35	5	55	U	75	u
36	6	56	V	76	v
37	7	57	W	77	w
38	8	58	X	78	x
39	9	59	Y	79	y
3A	:	5A	Z	7A	z
3B	;	5B	[	7B	{
3C	<	5C	\	7C	|
3D	=	5D	]	7D	}
3E	>	5E	^	7E	~
3F	?	5F	_	7F	Delete

ADAPTING THE RADIOMODEM TO REMOTE RADIO EQUIPMENT:

This circuit diagram is an example of how the radiomodem was adapted for use with a "DESCON 2" remote radio console which operated a 2 channel base station through a two wire telephone twisted pair. The channel was selected by the current sent down the twisted pair, and the audio was superimposed on the DC current.

CA 4000B



PIN - OUT OF THE RADIOMODEM

PIN A - Audio input to the radiomodem (-30 to +10 dBm 600 ohms)

PIN B - Audio output from radiomodem (-40 to +1 dBm 600 ohms)

PIN C - RTS (request to send) pseudo RS232 input (TTL OK)

PIN D - Transmitted data from radiomodem (RS232 output)

PIN E - RTS O.C. output and/or DSR (data set ready)

PIN F - Testmode sense pin for "Telemetry Test Module"

PIN G - PTT line to transceiver. This line is connected to a 2N2222A NPN transistor collector and is a high impedance in the receive mode, and able to sink up to 500 mA in the transmit mode. Standoff is +30 V

PIN H - CTS (clear to send) input from terminal

PIN I - Data input to radiomodem (pseudo RS232)

PIN J - Timer / Clock output - TTL level

PIN K - 13.8V battery input to the radiomodem

PIN L - Ground, signal and chassis

PIN M - Ground, signal and chassis

PIN N - Ground, signal and chassis

- -

Weather recorder 4 pin telemetry/printer interface socket:

Pin A - TTL level clock input at 16X the data rate
Pin B - RTS input
Pin C - Data output (TTL)
Pin D - Ground, signal

- -

COLOR CODE CONVENTIONS:

Power cables: Black and drain wire, if present = GROUND
White or clear = +13.8V fused

Data cables to weather station:	Black and drain	= GROUND
	TTL level clock	= RED
	RTS input	= GREEN
	Data output	= WHITE
Audio cables to external radio:	Black and drain	= GROUND
	PTT line	= WHITE
	Input to radio	= GREEN
	Output from radio	RED
Data cables to computer :	Drain wire	= GROUND
	RTS	= BLACK
Data output	from radiomodem	= RED
Data input	to radiomodem	= GREEN
	CTS	= WHITE
	Audio from rec.	= BROWN
	Testmode sense	= BLUE
Selftest cable to Test Module:	Audio from rec.	= BLACK
	Testmode sense	= CLEAR
	Ground	= Drainwire

- -

IBM PC RELEVENT PINOUT: (Refers to male DB25P connector)

PIN 1 - IBM chassis ground (to radiomodem pins L,M,N)
PIN 2 - Transmit Data (to radiomodem pin I)
PIN 3 - Receive Data (from radiomodem pin D)
PIN 4 - RTS (output to radiomodem pin C)
PIN 5 - CTS (jumper to pin 6 and 8)
PIN 6 - DSR (jumper to pin 5 and 8)
PIN 7 - IBM signal ground (connected to pin 1 inside) (jumper to pin 1)
PIN 8 - DCD input (jumper to pin 5 and 6)
PIN 20 - DTR (output to radiomodem pin H)

For the serial printer port, the pinout is the same, except it is wired as data terminal equipment and therefore has pins 2 and 3 swapped.

SPECIFICATIONS

******** NOT INCLUDING TRANSCEIVER *********

POWER: 12 TO 16 VOLTS, < 3 mA average drain, 50 mA peak

OPERATING ENVIRONMENT: -20C TO +60C ; CAST ALUMINUM CASE IS WATERPROOF

CASE DIMENSIONS: L 36 cm, W 16 cm, H 9 cm

MODEM TYPE: 1200 baud coherent FSK, half duplex operation

OCCUPIED BANDWIDTH: 1200 Hz equivalent noise bandwidth centered on 2078 Hz

MINIMUM PERFORMANCE: No errors over full temperature range for a 7 dB unweighted S/N ratio over entire voice channel

RADIO INTERFACE: 500 mA open collector PTT transmitter keying line
Audio input 600 ohms, -30 dBm to +1 dBm
Audio output 600 ohms, -40 dBm to 0 dBm

ERROR CONTROL: Reed Muller error correction for up to 3 random errors in any two consecutive characters.

PROTOCOL: Custom HDLC packet switched control to allow up to 65533 sites to be monitored on one channel, and to allow the unit to act as repeater, base or data platform as required. External communications is asynchronous, but all radio transmission is synchronous and securely coded with Reed Muller technique.

TYPE OF EMISSION: This specification varies with the radio, but according to international designations on FM narrowband radio license applications it is called: 16K0F2DCN. 16K0 means that the bandwidth is within 16 KHz limits. F2 means that the main carrier is frequency modulated with digital information on an audio sub-carrier. D stands for data transmission. CN means the data is carried by a two state code with error correction.

SPECIAL INSTRUCTIONS CONCERNING RADIOMODEMS USING 25 WATT RADIOS

Powerful transceivers in the 25 watt and greater class pose several problems in remote installations. Pay careful attention to these special instructions so that your radio installation will operate properly, and reliably over the long term. The problems are associated with the following differences between low power transceivers and the higher power versions:

1) High power transceivers are too large and dissipate too much heat to be used inside the sealed radiomodem enclosure.

2) High power solid state transceivers are always less efficient at producing RF energy, and therefore large currents are required from the battery. This poses very unexpected problems in low voltage systems, and even makes audio connections more difficult.

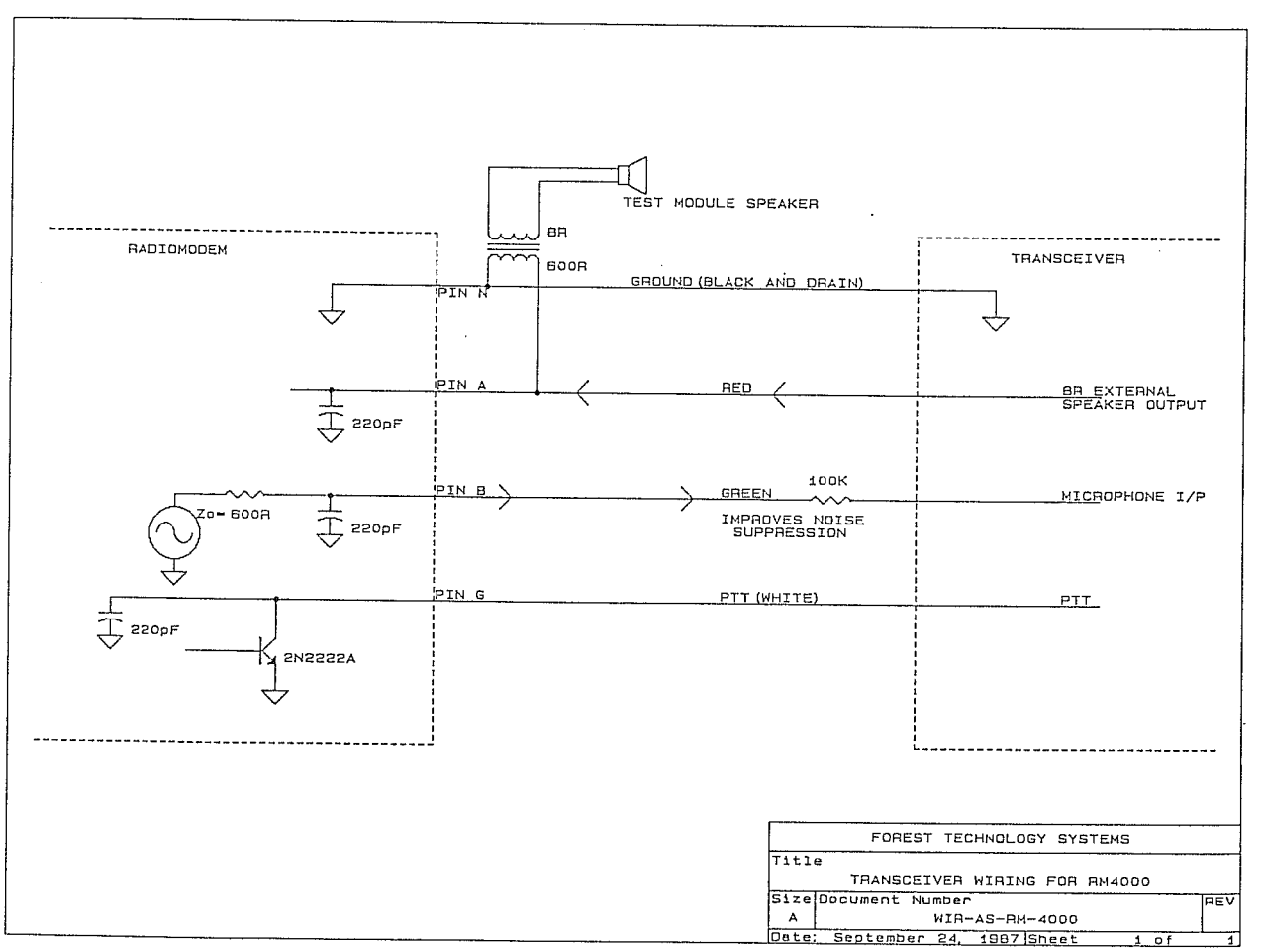
3) If power strobing is used to decrease the standby power consumption of the transceiver, expect huge surge currents in the power supply lines which may interfere with other electronic equipment on the same power source.

4) Since high power transceivers are mounted externally, and are designed to operate with external antennas, antenna cable problems must be dealt with, and the selection of an appropriate antenna must be made.

CONNECTING AN EXTERNAL RADIO:

The radiomodem was designed to operate with external radios using an audio patch into the external speaker output and the microphone input. The transceiver is normally assumed to run continuously in the receive mode, unsquelched. If the receiver consumes too much current for your needs, we can usually strobe the power supply to the receiver to decrease the AVERAGE power consumption. If you have this option in your installation, be aware of the problems described in the third section.

Audio connections:



Connecting an external radio con't:

No radio for mobile use will tolerate operation in environments with excessive humidity. If any dew setting is possible, the radio must be placed in a SEALED enclosure, with dessicant. If this precaution is not taken, frequency drift, and intermittent operation will occur. If the transceiver is sealed, make sure the enclosure is large enough to provide air circulation around the heat sink.

SPECIAL PRECAUTIONS FOR HIGH CURRENT CONNECTIONS:

With solid state radio transmitters, efficiency decreases with output power. This means that a 25 watt transceiver operating at around 25% efficiency will consume 100 watts while it is transmitting. This is a tough problem when you are using battery power supplies. Mobiletransceivers are DESIGNED to operate on an automotive system where the alternator will maintain the battery voltage at around 13.8 Volts. A wet shallow cycle maintainance-free battery will supply about 12.25 Volts at the 50% discharge point. This is a very bad operating voltage for mobile transceivers, but for most of our installations, it is the normal voltage of the power supply as the solar panels stop charging the battery when the sun goes down.

To further complicate the problem, there is a voltage loss in the power supply leads when the transmitter draws a heavy current through them. There is

an additional voltage loss at every mechanical connection. Some fuses that have a high voltage rating have a significant voltage drop as well.

The point, therefore, is to eliminate all voltage drops as best you can, since operation on battery power is marginal to begin with. The radiomodem will fail outright at 11.5 Volts. Mobile radios vary in their performance, but never assume they can operate below 11.5 Volts. A typical automotive style connector is good for about 0.2 V of loss in new condition, with a 25 Watt transceiver. Three meters of #14 gauge wire (2 conductors) will drop about 0.5 Volts. A 10 Amp low voltage fuse and its holder contribute about 0.2 Volts of losses.

How to reduce voltage drops:

1) Keep the power leads to the radio as short as possible, and use heavy gauge wire. Gauge 14 is suitable for 1 meter runs. Guage 10 is better for longer runs of cable.

2) Solder all your terminals, or else they must be considered mechanical connections. When there is a mechanical connection, such as a fuse holder or power plug, use electrical tape to seal the connection from corrosion. Corrosion in a mechanical connection will ruin the performance of your installation.

3) When you have a metal frame, use it as a negative ground. Most transceivers are negative ground frames, or provide for this option. Then you can eliminate the voltage drops in the negative lead by sending the current through the frame.

4) Use only one fuse, and place it in the POSITIVE supply lead.

5) Use a separate wire connection to the battery for the radiomodem itself. Therefore voltage drops in the transceiver supply cable will not affect the voltage delivered to the radiomodem.

6) Make sure that you have a reasonably powerful battery. The maximum voltage that can be delivered at 10 Amps varies with the type of battery you are using. Make conservative choices, and base your decision on a 50% discharged battery. A 45 Amp Hour car battery is suitable for most transceivers in the 25 Watt class.

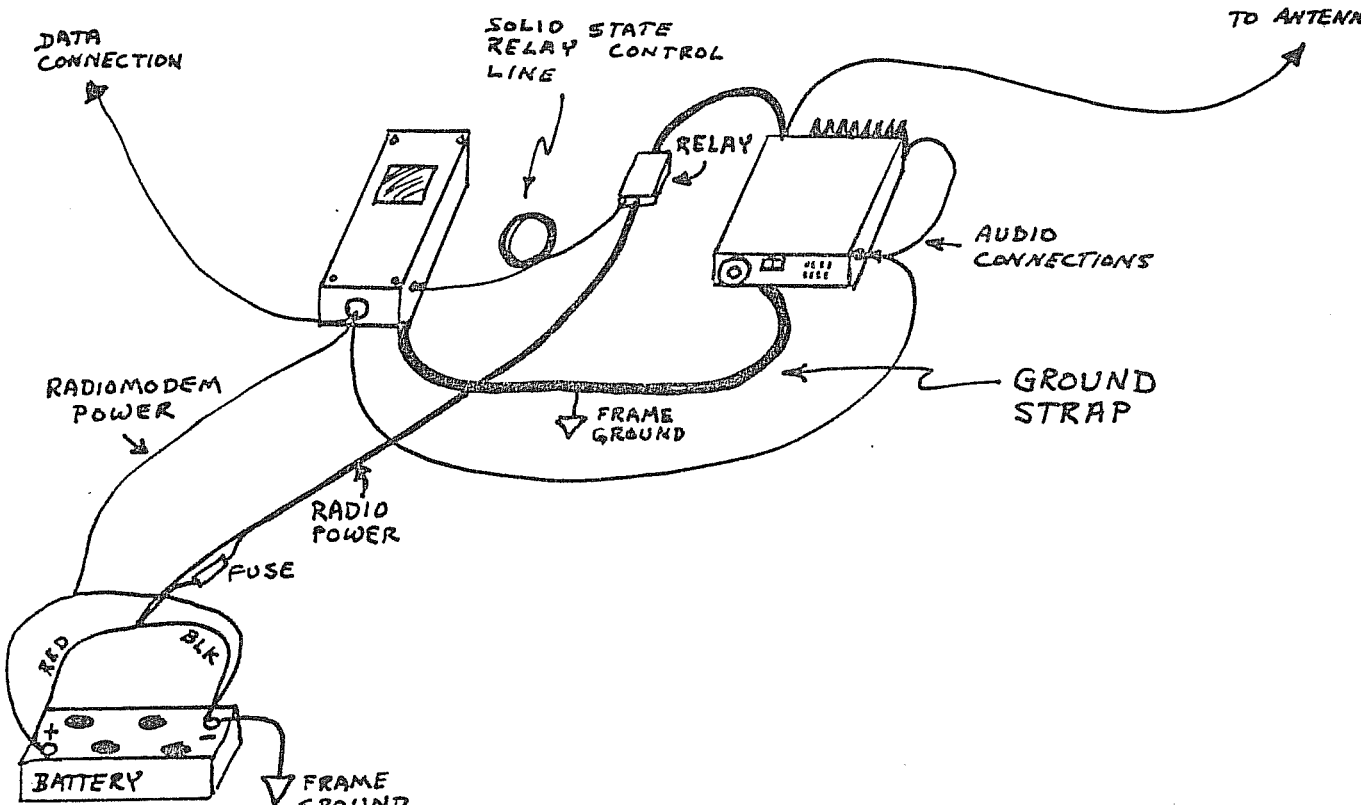
7) There is another nasty problem associated with voltage drops relating to the audio connections. The radiomodem uses ground potential to refer all its audio voltages. A voltage drop in the ground connection is essentially added to the audio voltage. If you have a loose connection, or a noisy power source, there will be interference with the transmitted audio from the radiomodem. You MUST make sure that there is a HEAVY ground strap connection between the frame of the

radiomodem and the frame of the transceiver to eliminate these voltage drops. CAUTION ! You often only notice this problem AFTER vibration or corrosion of connections makes it apparent. It is best to take precautions. The heavy copper braid from RG8 coaxial cable is a suitable ground strap material.

Special precautions for strobed receivers

The strobed receivers use an external solid state relay to turn the receiver on during the strobe interval. Different transceivers stabilize in different times, but the overall effect of strobing is to reduce the average current consumption of the transceiver. If you have this option installed in your radiomodem, be aware that most high power transceivers consume huge surge currents the moment they are turned on.

The surge current will be on the order of 30 to 50 Amps using our solid state relay. This causes a instantaneous voltage drop in low capacity batteries. The terminal voltage of a fully charged 10 Amp Hour gelled cell has been observed to drop 4 Volts at the beginning of each strobe period. This short loss of voltage will cause havoc in other electronic equipment sharing the same battery. Solution: - Use a higher capacity battery.



CHOOSING ANTENNAS AND CABLES FOR 25 WATT TRANSCEIVERS:

Yet more problems can be experienced with antenna systems. This seems to be the most common radio problem since the antenna is always exposed to weathering. No compromise should be made in the selection of the antenna. It must be corrosion proof and allow for sealing the coaxial feedline. If the specifications of the antenna do not exactly say that the coax is sealed, check with the manufacturer to make sure. The slightest amount of water in the braid of coax operating at UHF will destroy the performance of the radio.

Most common RG8 style cable is appropriate, but it is up to the installer to purchase the correct cable for the application. When the station is licensed, you must be able to provide details on the feedline losses and the antenna gain. Coaxial cable deteriorates, and UHF installations will need feedline replacement every year to maintain peak performance, using common grades of RG8 coaxial cable.

Wherever radio regulations permit, use an antenna with gain, such a directional yagi, or a collinear array. For UHF, collinear whips offer up to 5 dB gain at little expense. They are rugged, convenient, and omnidirectional. There are now teflon coated versions produced by Larsen for use in corrosive environments. Make sure the plastic parts can withstand ultraviolet light. Caulking compound should be clear silicone to

avoid RF losses. Avoid enclosed loading coils, since most of them will eventually leak.

As a final note, the following formulas can be used to compute the approximate energy drain based on several common variables:

For strobed systems:

$$\left[\left(2.9\left(\frac{Sp}{Si}\right)+24\,I_R\right)+\frac{(0.8\,I_R+I_T)(1+N_S(2))\left(P_D+\frac{N_B}{200}\right)}{3600}\right](13.8)=\frac{\text{WATT-HOURS}}{\text{DAY}}$$

For normal systems:

$$\left[\left(2.9+24\,I_R\right)\left(\frac{Sp}{Si}\right)+\frac{(0.8\,I_R+I_T)(1+N_S(2))\left(P_D+\frac{N_B}{200}\right)}{3600}\right](13.8)=\frac{\text{WATT-HOURS}}{\text{DAY}}$$

Sp -Strobe period: The amount of time the radiomodem applies power to its circuitry.

Si -Strobe interval: The period (in seconds) between the commencement of the strobe periods.

con't...

Pi -Polling interval: The period in hours between polls by the base station.

Nb -Number of bytes being transferred.

Pd -Data carrier period: The number of seconds the stations send a clear data carrier to lock on remote stations.

Ns -Number of stations which use the unit in question as a repeater.

Ir -Radio's receiver current drain.(Amps)

It -Radio's transmitter current drain.(Amps)

5/5
beyond
this pt

I/O MAP

PORTC0 - This is an internal register for controlling the 81C55A

---

bits 7 and 6 - timer control - 00 = no change, 01 = stop now, 10 = stop at end, 11 = starts count.
bits 5 and 4 - 81C55A interrupt. conrtol - not used at present, see data sheets.
bits 3 and 2 - port C3 mode conrol - 11 means both set to output which is normal.
bit 1 - port C2 mode control. 1 = output, 0 = input.
bit 0 - port C1 mode control. 1 = output, 0 = input.

PORTC1 - This is an input port on the 81C55a. Pin number are included.

---

bit 7, pin 28 - real time clock
bit 6, pin 27 - real time clock
bit 5, pin 26 - real time clock
bit 4, pin 25 - autocal sense for version 1.4 and above. Active low
bit 3, pin 24 - PTT sense, active low. Also self test pin.
bit 2, pin 23 - Voice Mode sense. Active low.
bit 1, pin 22 - RTS wake-up indicator. Active high.
bit 0, pin 21 - Ready signal from IBM. Active high.

PORTC2 - This is an output port on the 81C55A. Pin numbers are include.

---

bit 7, pin 36 - Voice mode enable. Active high.	0
bit 6, pin 35 - Modem enable. Active high.	0
bit 5, pin 34 - Synthesize, low = receive, high = transmit.	0
bit 4, pin 33 - RTS sent when high.	0
bit 3, pin 32 - not committed.	0
bit 2, pin 31 - Voice synthesis, CVSD mode high.	0
bit 1, pin 30 - Terminal blocked when low.	0
bit 0. pin 29 - Radio data blocked when low.	0

PORTC3 - This is an output port on the 81C55A. Pin numbers are included.

---

bit 5, pin 5 - High resets the A/D converter.	1
bit 4, pin 2 - High enters sleep mode.	0
bit 3, pin 1 - High for radio power.	1
bit 2, pin 39 - not committed.	0
bit 1, pin 38 - High sets XMIT/RCV relay to XMIT.	1
bit 0, pin 37 - not committed.	0

PORTC4 - This is an internal register to the 81C55A. it is used to set timer.

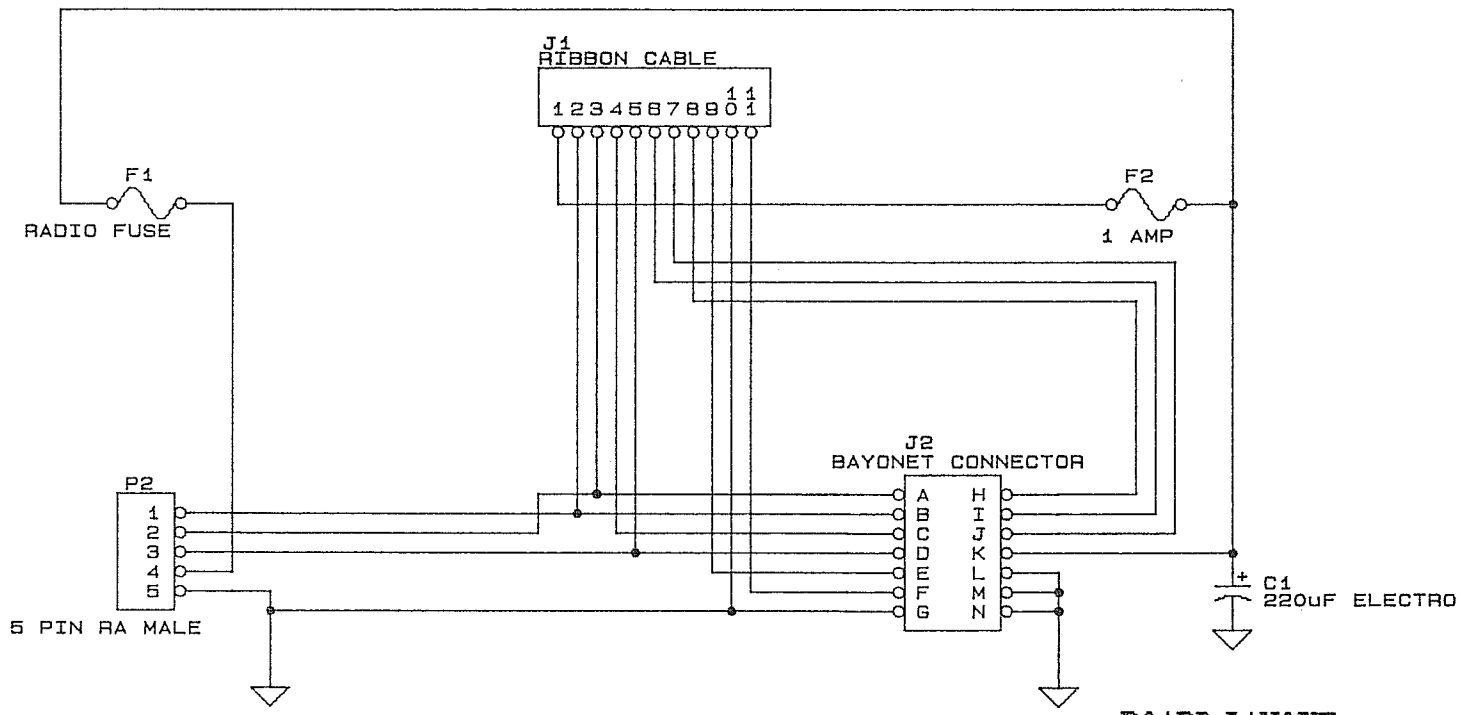
---

bits 7 thru 0 - These are the 8 low order timer delay bits. They may be set at any time

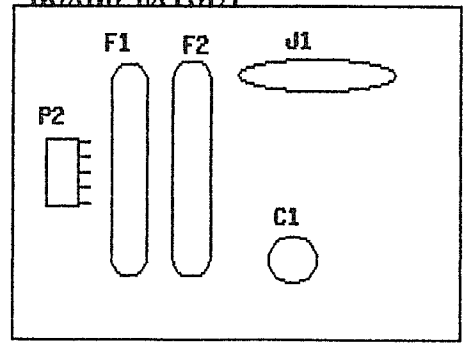
PORTC5 - This is an internal register to the 81C55A. It is used to set part of the delay value for the timer and to set the time function.

---

bits 7 and 6 - 00 = 50% single shot, 01 = CS square wave, 10 = pulse single shot, 11 = CW pulses.
bit 5 - bit 13
bit 4 - bit 12
bit 3 - bit 11
bit 2 - bit 10
bit 1 - bit 9
bit 0 - bit 8



BOARD LAYOUT



P2

PIN #	DESCRIPTION
1	AUDIO OUTPUT
2	AUDIO INPUT
3	PTT
4	13.8V BATTERY
5	GND

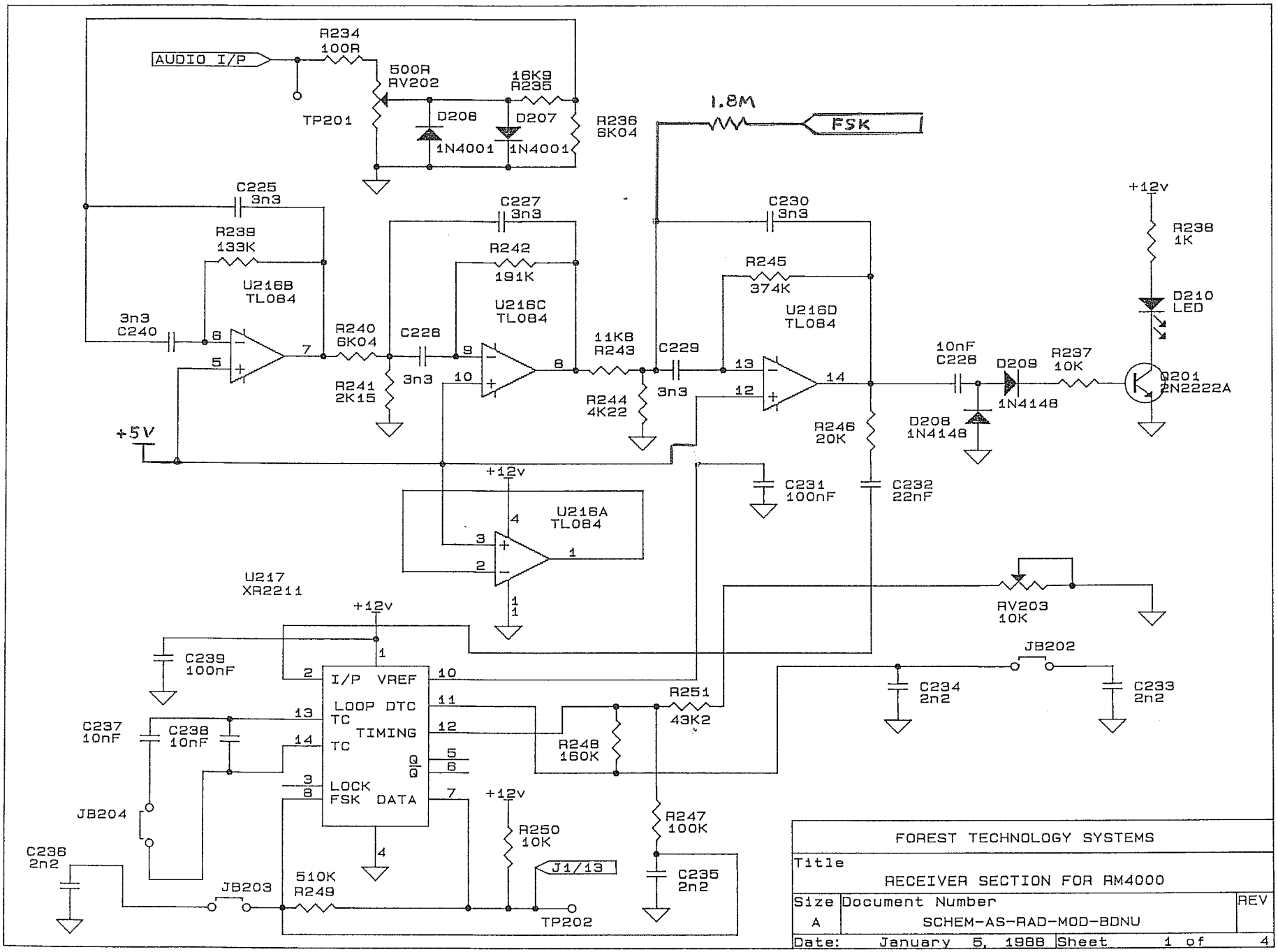
J1

PIN #	DESCRIPTION
1	13.8V BATTERY
2	AUDIO AOUTPUT
3	AUDIO INPUT
4	RTS INPUT
5	DATA OUTPUT
6	DATA INPUT
7	CLOCK
8	CTS INPUT
9	RTS OUTPUT
10	PTT
11	SELFTEST

J2

PIN #	DESCRIPTION
A	AUDIO INPUT
B	AUDIO OUTPUT
C	RTS INPUT
D	DATA OUTPUT
E	RTS OUTPUT
F	SELFTEST
G	PTT
H	CTS INPUT
I	DATA INPUT
J	CLOCK OUTPUT
K	13.8V BATTERY
L, M, N	GND

FOREST TECHNOLOGY SYSTEMS		
Title: RADIO MODEM FUSE BOARD		
Size: A	Document Number: SCHEM-AS-RADMOD-FUSE	REV
Date: December 18, 1987	Sheet 1 of 1	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R234
100R
500R
RV202
16K9
R235
TP201
D206
1N4001
D207
1N4001
R236
6K04
1.8M
FSK
C225
3n3
C227
3n3
C230
3n3
R239
133K
R242
191K
R245
374K
U216B
TL084
U216C
TL084
U216D
TL084
3n3
C240
R240
6K04
C228
11K8
R243
C229
R241
2K15
3n3
R244
4K22
3n3
+5V
+12v
R238
1K
D210
LED
10nF
C226
D209
R237
10K
Q201
2N2222A
1N4148
D208
1N4148
R246
20K
C231
100nF
C232
22nF
U216A
TL084
U217
XR2211
RV203
10K
JB202
C239
100nF
I/P
VREF
LOOP DTC
TC
TIMING
TC
LOCK
FSK DATA
Q
Q
C234
2n2
C233
2n2
R251
43K2
C237
10nF
C238
10nF
R248
160K
JB204
R247
100K
R250
10K
J1/13
C236
2n2
JB203
510K
R249
TP202
C235
2n2
FOREST TECHNOLOGY SYSTEMS
Title
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Size
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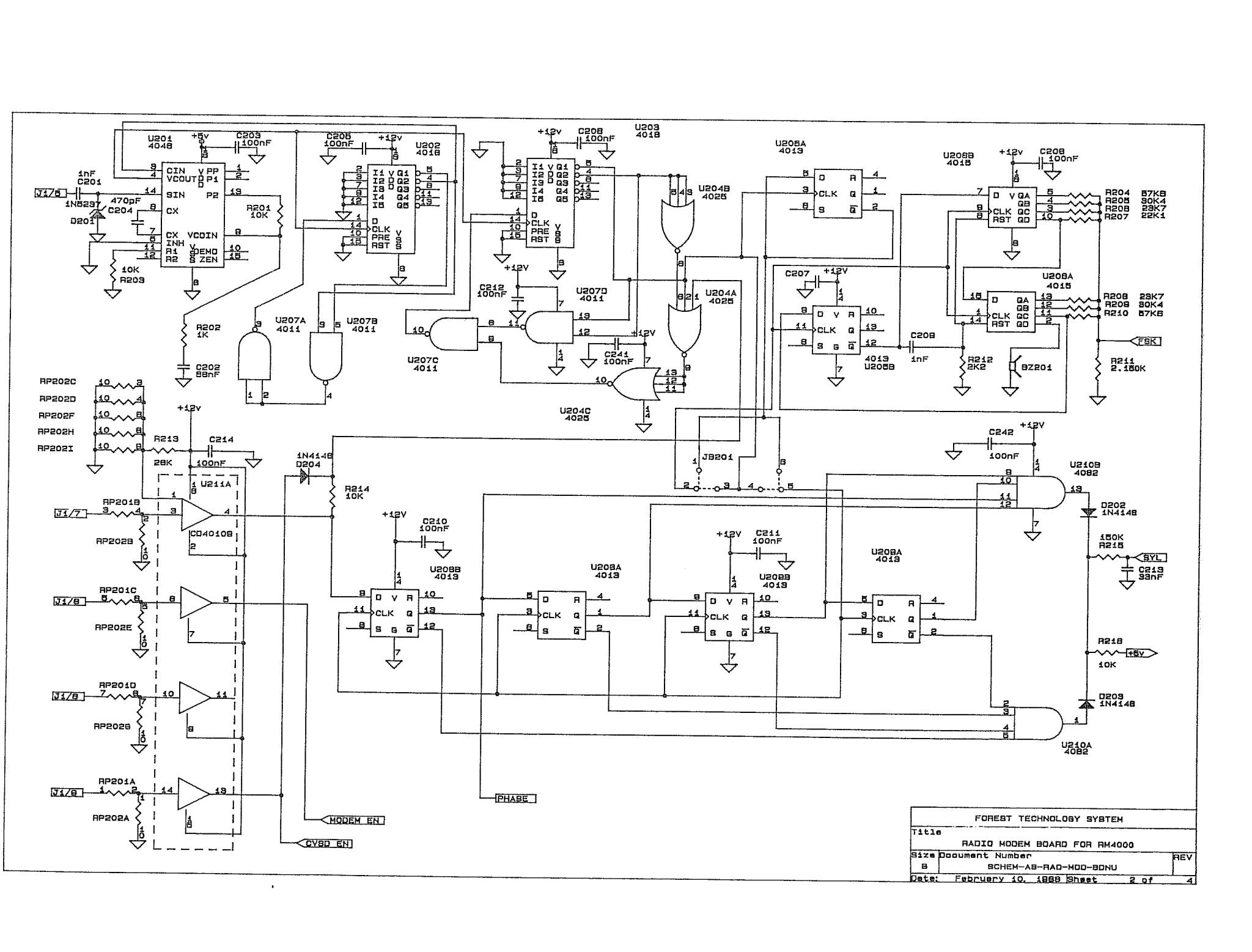
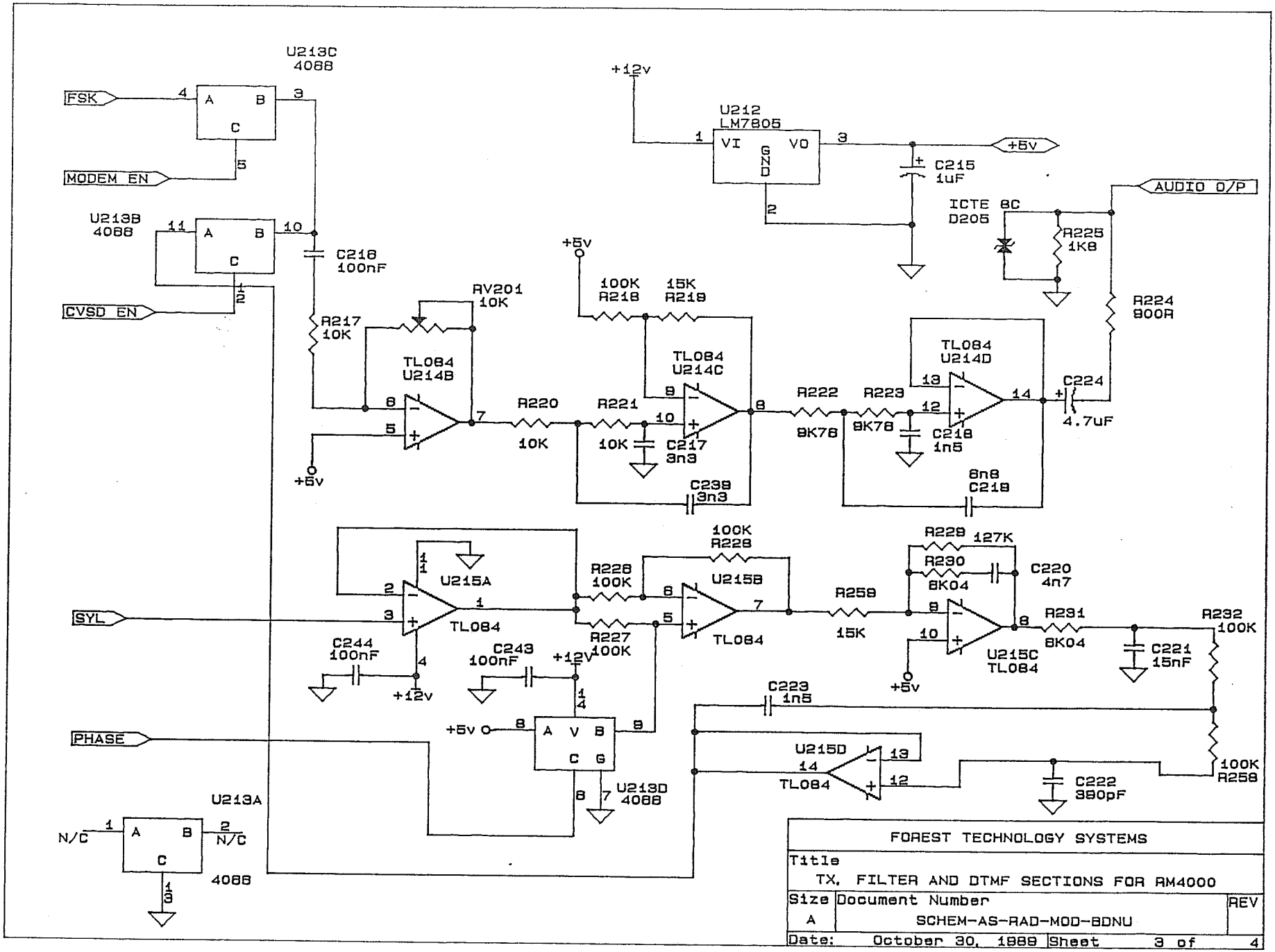
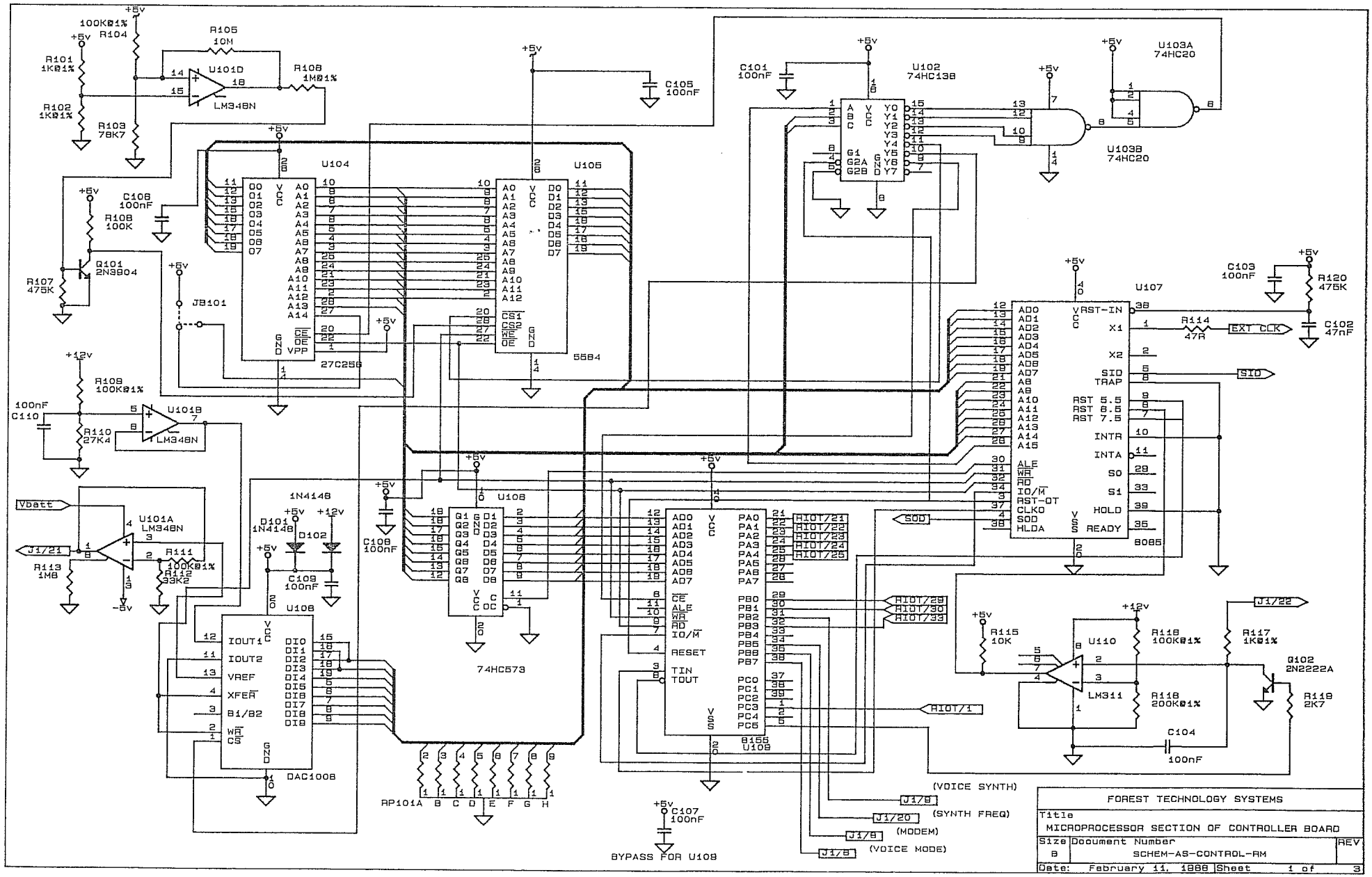
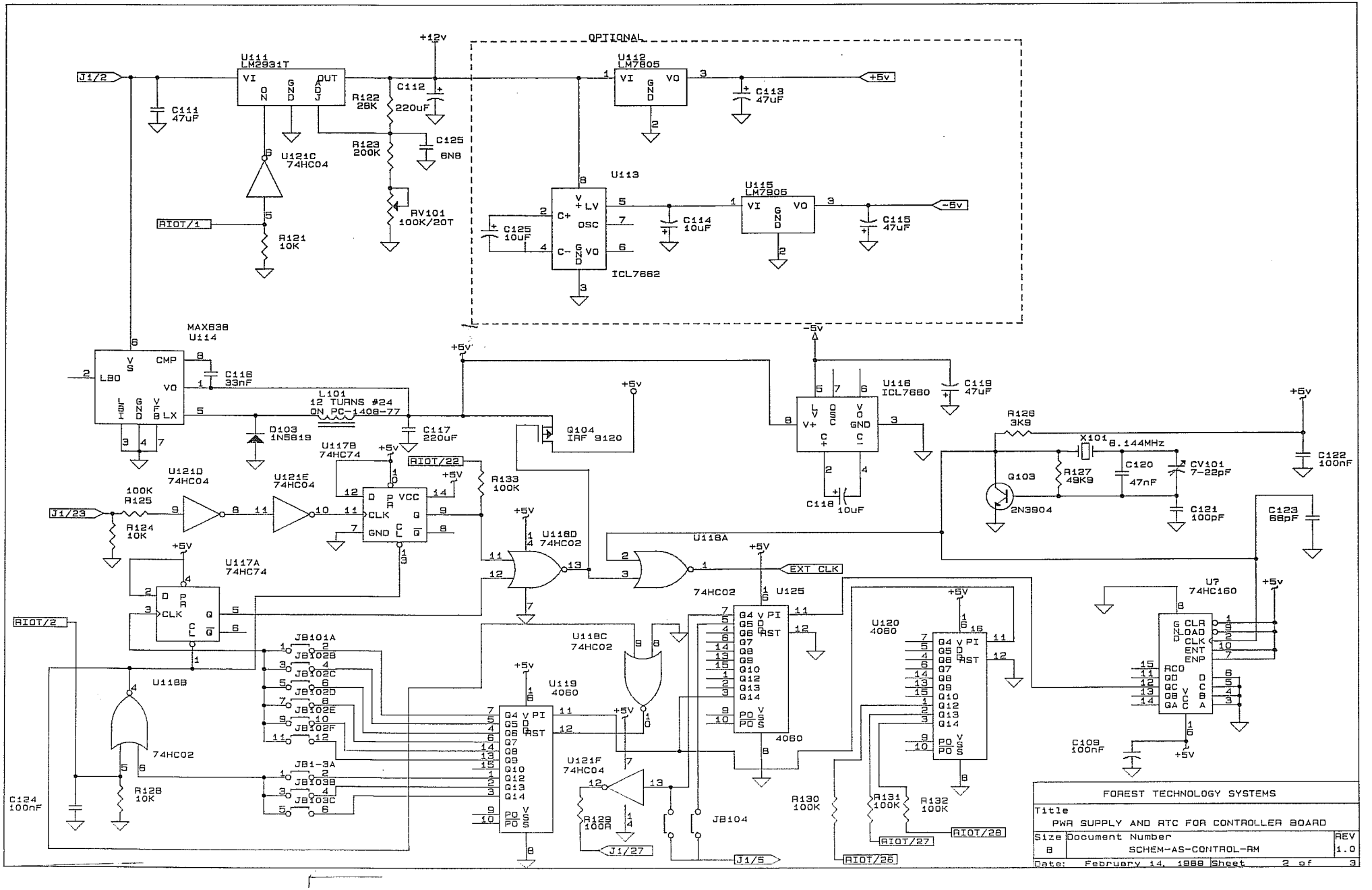
Document Number
SCHEM-AS-RAD-MOD-BDNU
REV
Date: January 5, 1988
Sheet 1 of 4

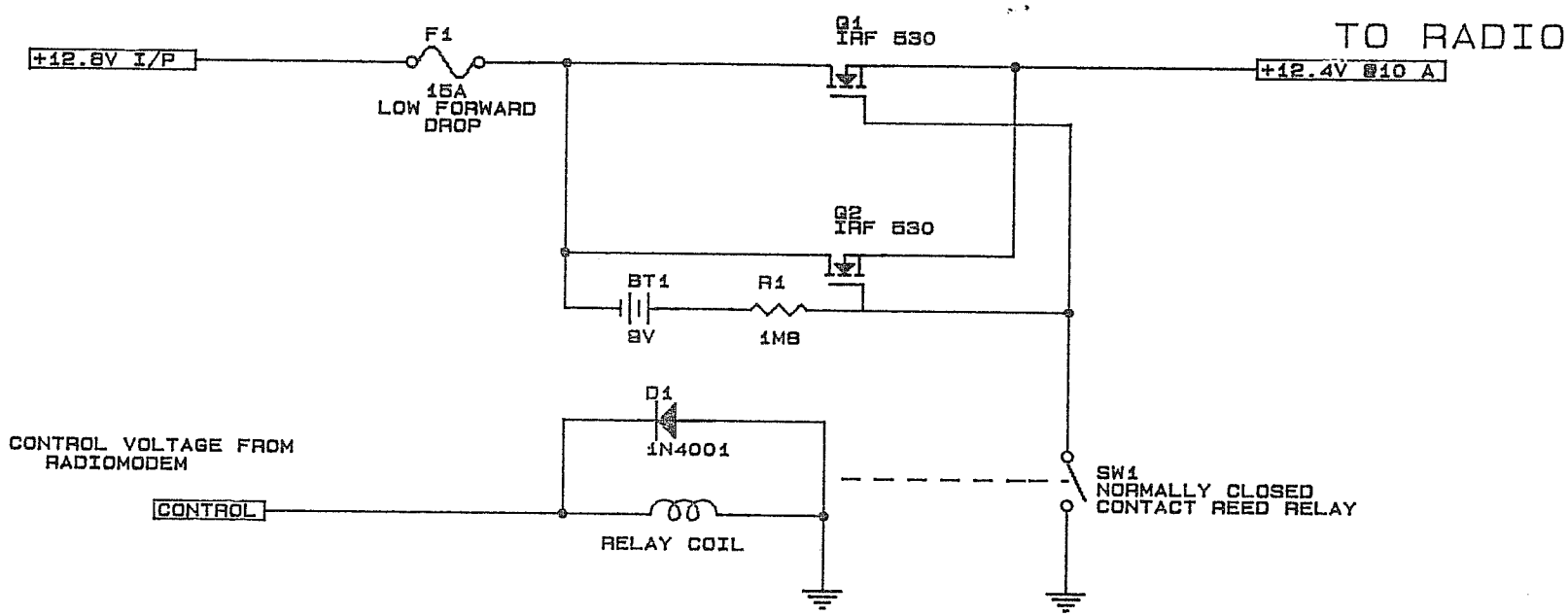

U201 4046
C203 100nF
C205 100nF
U202 4018
U203 4018
C208 100nF
U205A 4013
U208B 4015
C201 1nF
J1/5
1N5237
470pF C204
D201
R201 10K
R203 10K
R202 1K
C202 88nF
U207A 4011
U207B 4011
C212 100nF
U207D 4011
U207C 4011
U204B 4025
U204A 4025
U204C 4025
C241 100nF
C207
U205B 4013
C209 1nF
U208A 4015
R204 57K6
R205 90K4
R208 23K7
R207 22K1
R208 23K7
R209 90K4
R210 57K6
FSK
R212 2K2
BZ201
R211 2.150K
RP202C
RP202D
RP202F
RP202H
RP202I
R213 28K
C214 100nF
+12v
1N4148 D204
R214 10K
U211A
RP201B
RP202B
CD4010B
RP201C
RP202E
RP201D
RP202G
RP201A
RP202A
J1/7
J1/8
JB201
C242 100nF
U210B 4082
D202 1N4148
150K R215
SYL
C213 33nF
R218 10K
+5v
D203 1N4148
U210A 4082
C210 100nF
U208B 4013
U208A 4013
C211 100nF
PHASE
MODEM EN
CVSD EN
FOREST TECHNOLOGY SYSTEM
Title
RADIO MODEM BOARD FOR RM4000
Size B
Document Number SCHEM-AB-RAD-MOD-BDNU
REV
Date: February 10, 1988 Sheet 2 of 4



FOREST TECHNOLOGY SYSTEMS		
Title: TX. FILTER AND DTMF SECTIONS FOR RM4000		
Size: A	Document Number: SCHEM-AS-RAD-MOD-BDNU	REV
Date: October 30, 1989	Sheet 3 of 4	

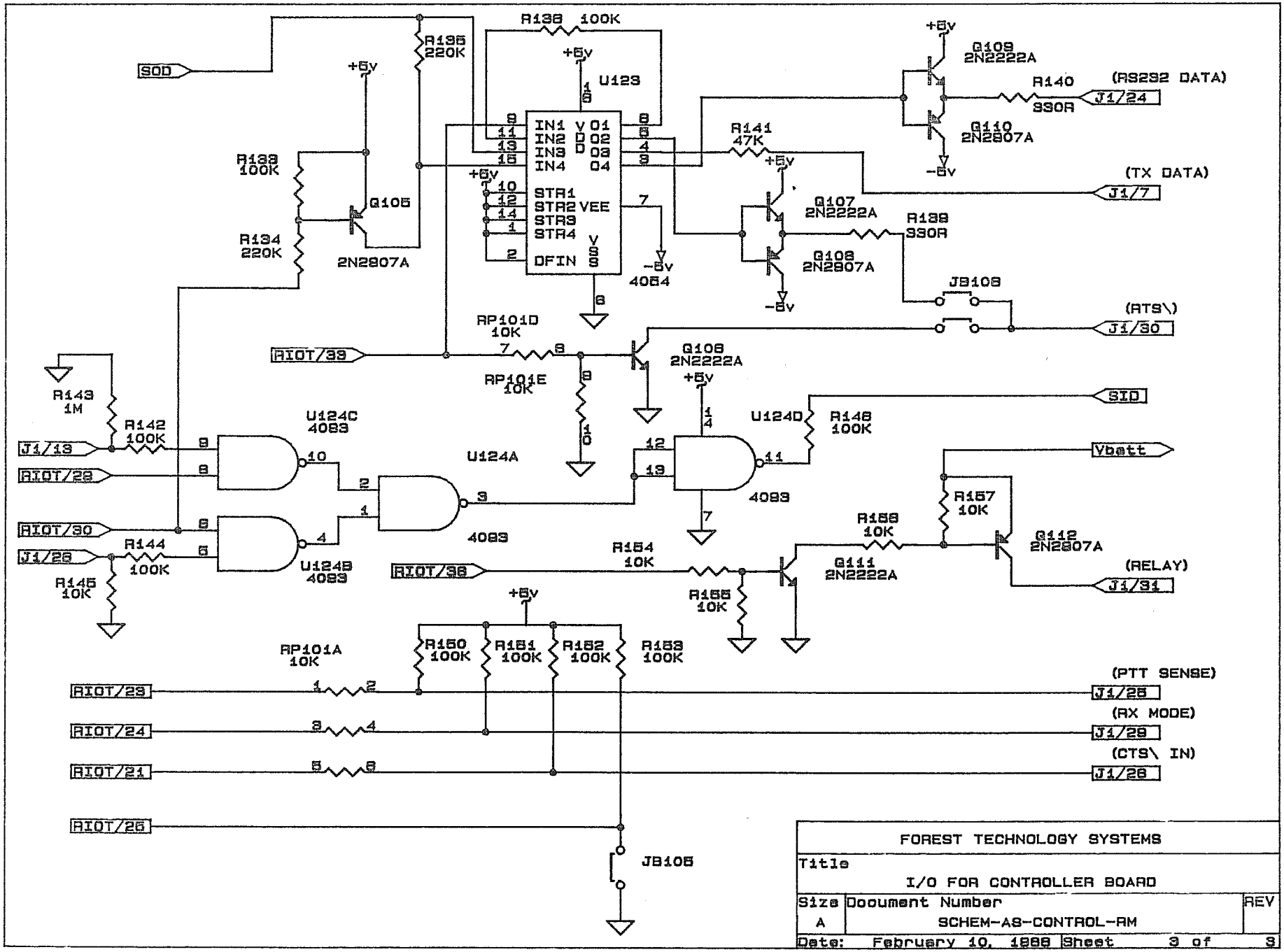

FOREST TECHNOLOGY SYSTEMS
Title
MICROPROCESSOR SECTION OF CONTROLLER BOARD
Size B
Document Number SCHEM-AS-CONTROL-RM
REV
Date: February 11, 1988
Sheet 1 of 3
U101A LM348N
U101B LM348N
U101D LM348N
U102 74HC138
U103A 74HC20
U103B 74HC20
U104 27C256
U105 5584
U106 74HC573
U107 8085
U108 DAC1008
U109 8155
U110 LM311
Q101 2N3904
Q102 2N2222A
D101 1N4148
D102 1N4148
AP101A
JB101
(VOICE SYNTH)
(SYNTH FREQ)
(MODEM)
(VOICE MODE)
BYPASS FOR U109


OPTIONAL
U111
LM2931T
+12v
J1/2
C111
47uF
R122
28K
C112
220uF
R123
200K
C125
6N8
U121C
74HC04
RV101
100K/20T
R121
10K
RIOT/1
U112
LM7805
+5v
C113
47uF
U113
ICL7662
C125
10uF
C114
10uF
U115
LM7905
-5v
C115
47uF
MAX638
U114
C116
33nF
L101
12 TURNS #24
ON PC-1408-77
D103
1N5819
C117
220uF
Q104
IRF 9120
U116
ICL7680
C119
47uF
C118
10uF
R128
3K9
X101
8.144MHz
C120
47nF
CV101
7-22pF
R127
49K9
Q103
2N3904
C121
100pF
C122
100nF
C123
68pF
U117B
74HC74
RIOT/22
R133
100K
U121D
74HC04
U121E
74HC04
100K
R125
J1/23
R124
10K
U118D
74HC02
U118A
EXT CLK
U117A
74HC74
U125
74HC02
U7
74HC160
RIOT/2
JB101A
JB102B
JB102C
JB102D
JB102E
JB102F
JB1-3A
JB103B
JB103C
U118B
74HC02
U118C
74HC02
U119
4060
U120
4060
4060
U121F
74HC04
R129
100R
J1/27
JB104
J1/5
R130
100K
R131
100K
R132
100K
RIOT/26
RIOT/27
RIOT/28
C124
100nF
R126
10K
C109
100nF
FOREST TECHNOLOGY SYSTEMS
Title
PWR SUPPLY AND RTC FOR CONTROLLER BOARD
Size
B
Document Number
SCHEM-AS-CONTROL-RM
REV
1.0
Date: February 14, 1988
Sheet 2 of 3

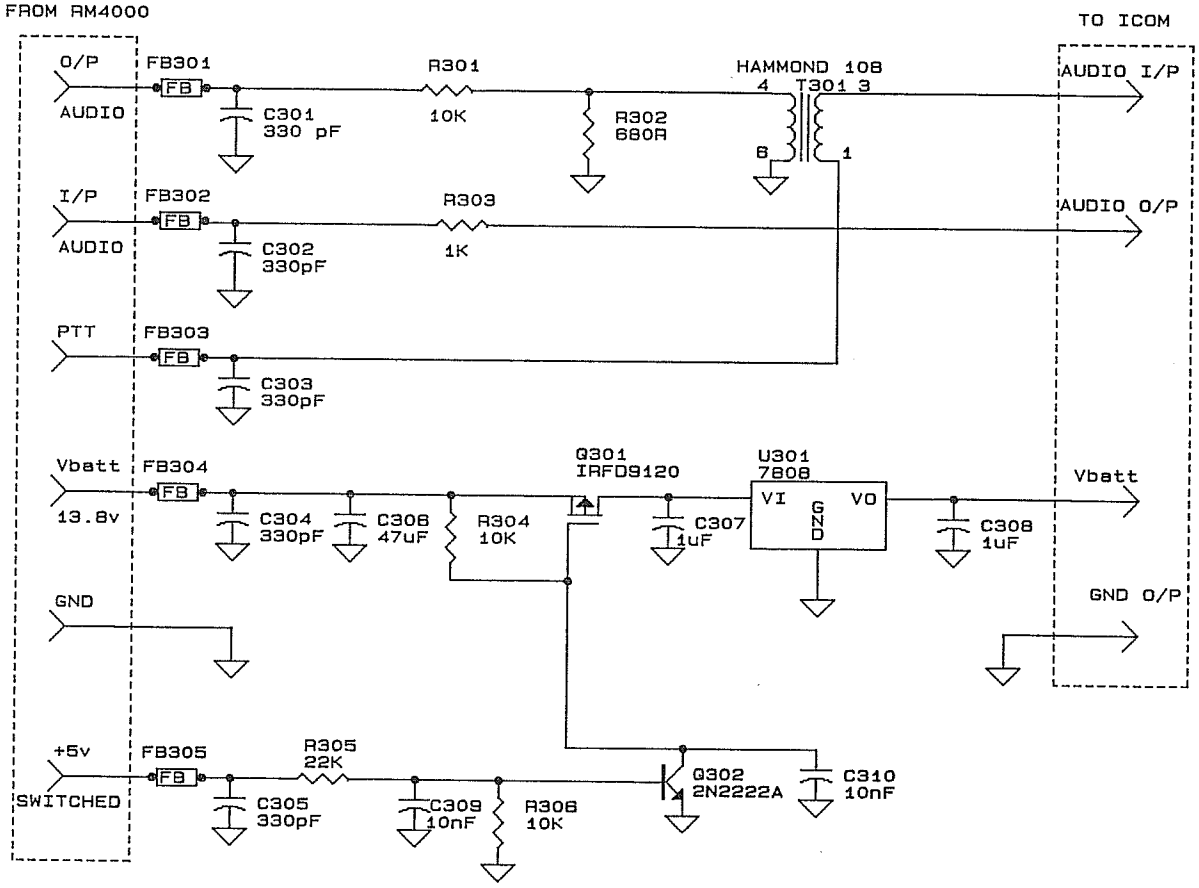


FOREST TECHNOLOGY SYSTEMS		
Title: SOLID STATE RELAY FOR 25W RADIOS		
Size: A	Document Number:	REV:
Date: February 10, 1998	Sheet: 1 of 1	

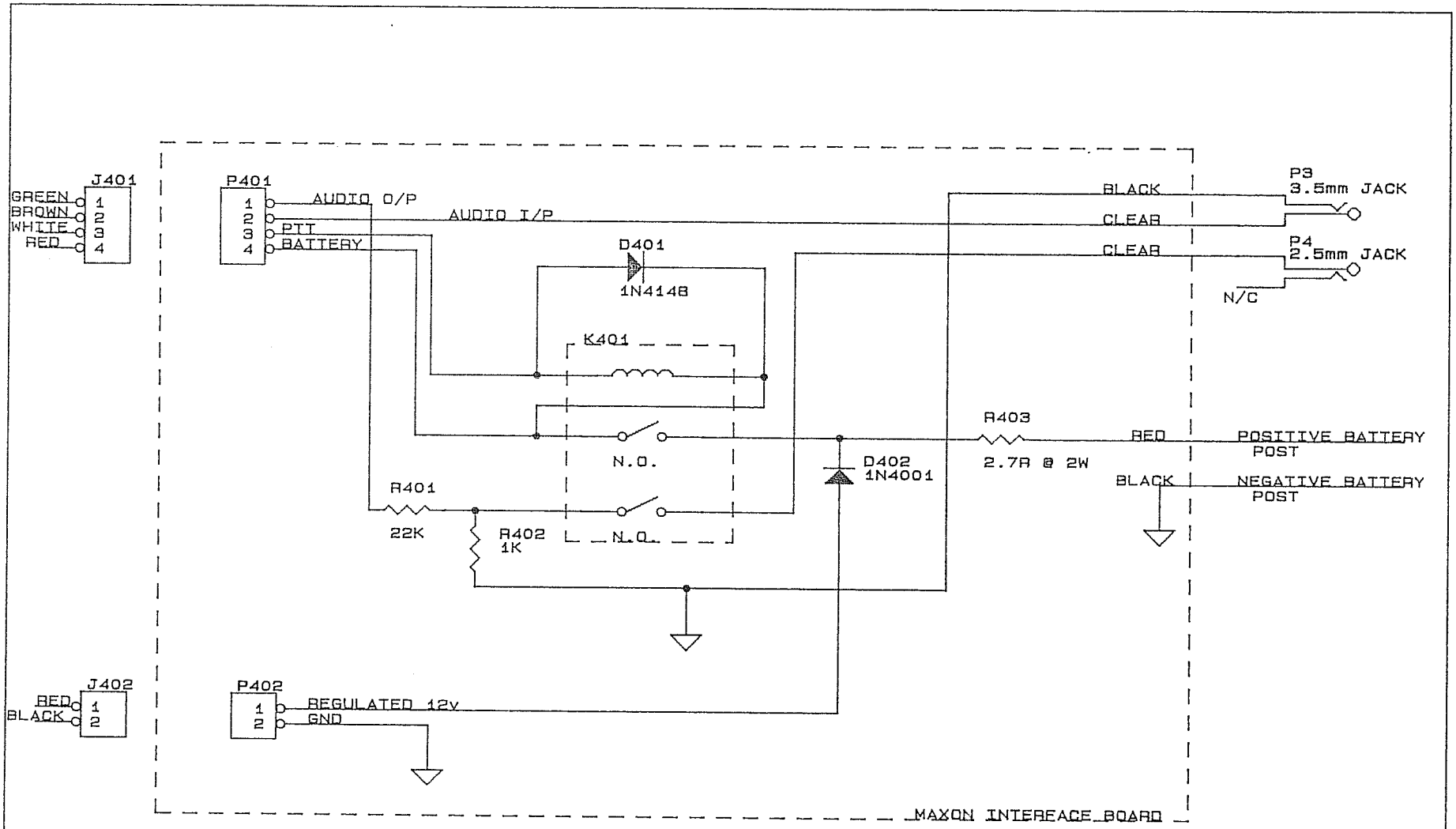
81



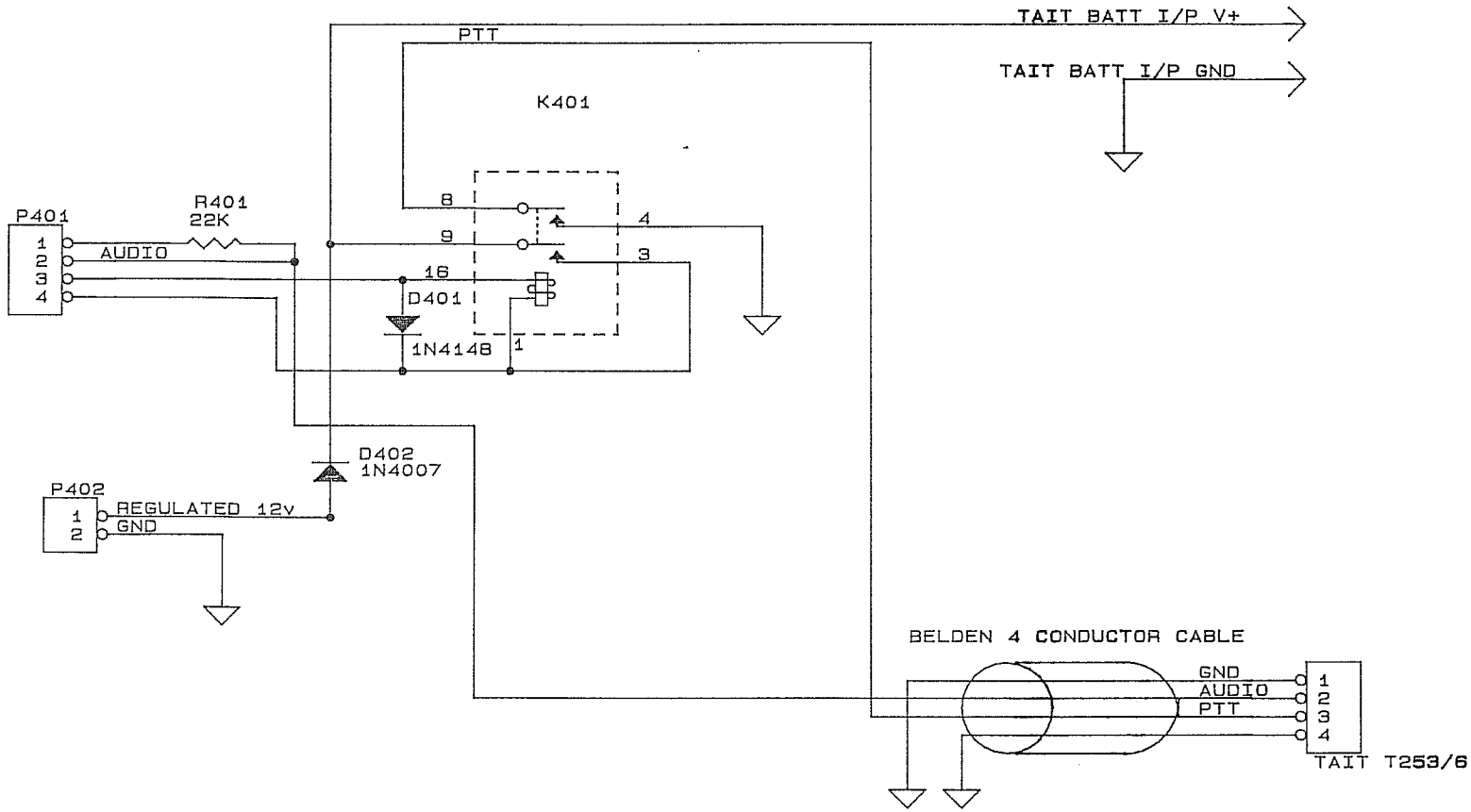
FOREST TECHNOLOGY SYSTEMS		
Title: I/O FOR CONTROLLER BOARD		
Size: A	Document Number: SCHEM-AS-CONTROL-AM	REV
Date: February 10, 1988	Sheet 3 of 3	



FOREST TECHNOLOGY SYSTEMS		
Title: RADIO MODEM ICOM ADAPTER BOARD		
Size: A	Document Number: SCHEM-AS-ICOM-ADAP	REV:
Date: September 2, 1987	Sheet 1 of 1	

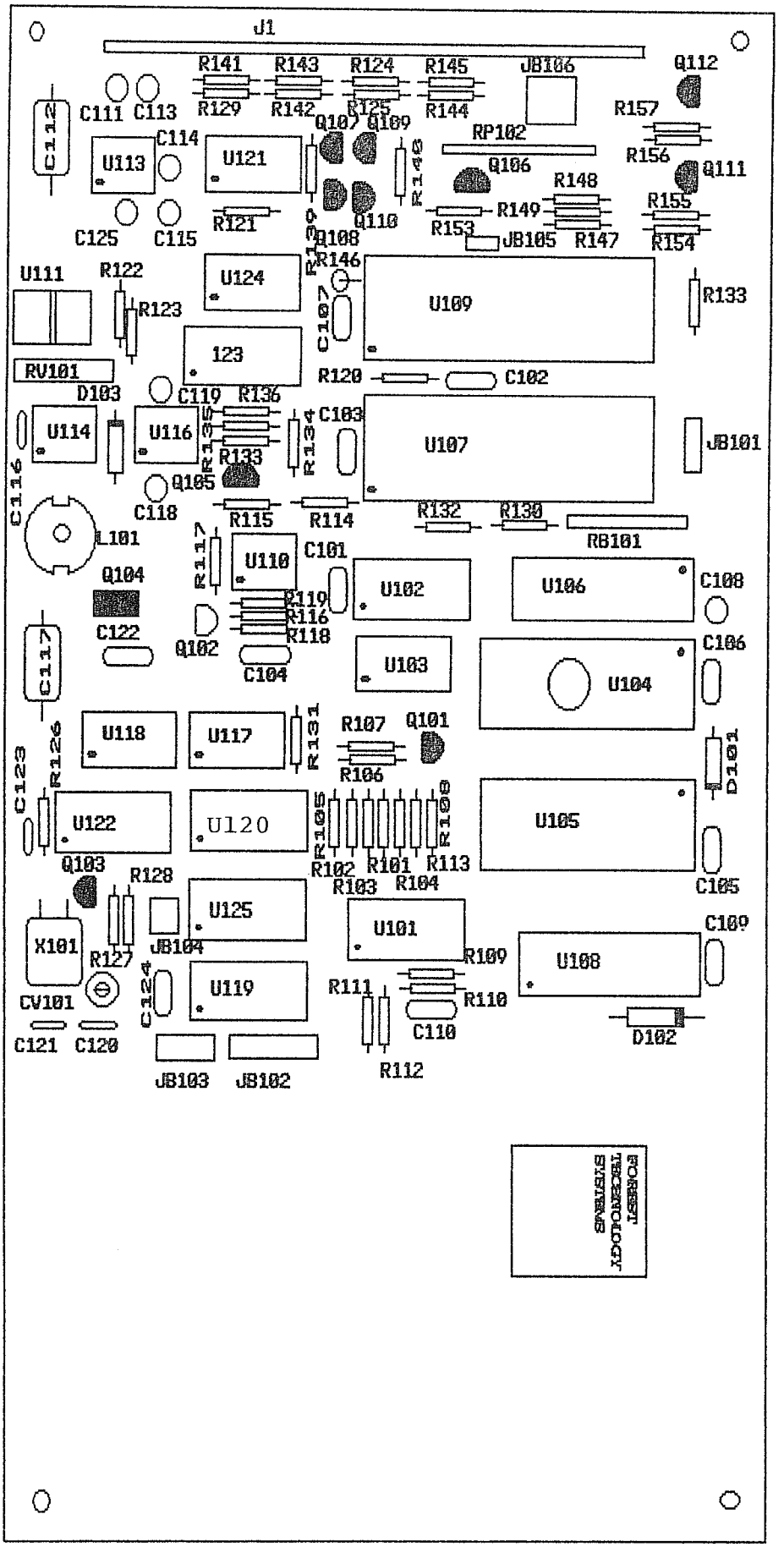


FOREST TECHNOLOGY SYSTEMS		
Title: MAXON INTERFACE BOARD		
Size: A	Document Number: SCHEM-AS-MAXON-INTER	REV
Date: December 18, 1987	Sheet 1 of 1	



TAIT T253/6 LAPEL MIC CONNECTOR CONNECTIONS		
PIN #	COLOUR	FUNCTION
1	GREEN	GND
2	WHITE	PTT
3	RED	AUDIO

FOREST TECHNOLOGY SYSTEMS		
Title: INTERFACE TO TAIT RADIOS FOR TM4000		
Size: A	Document Number: SCHEM-AS-TAIT	REV
Date: September 16, 1988	Sheet of	

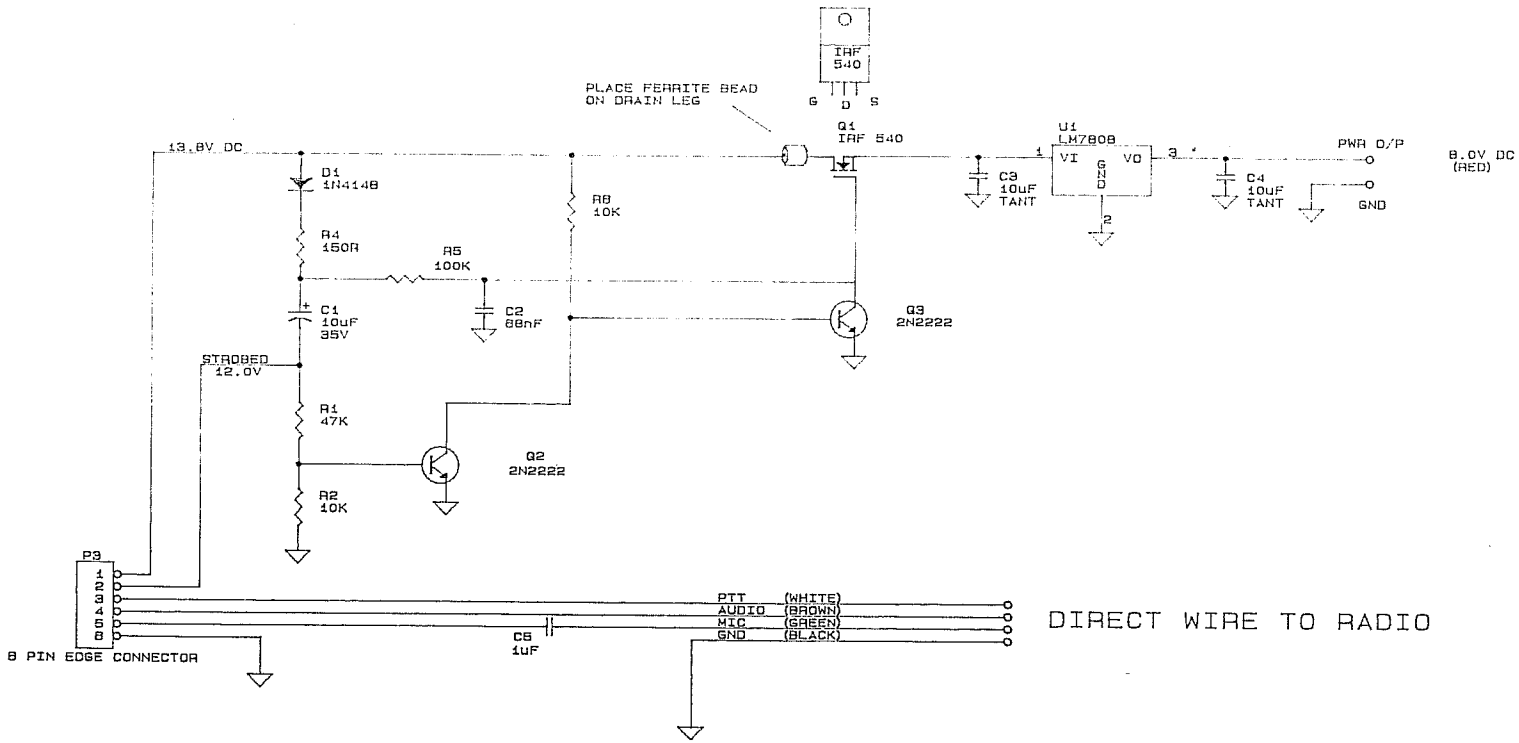


FOREST TECHNOLOGY SYSTEMS

RM4000 CONTROLLER

BOARD LAYOUT

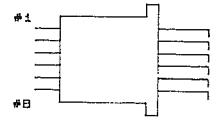
LAYOUT-AS-CONTROL-R



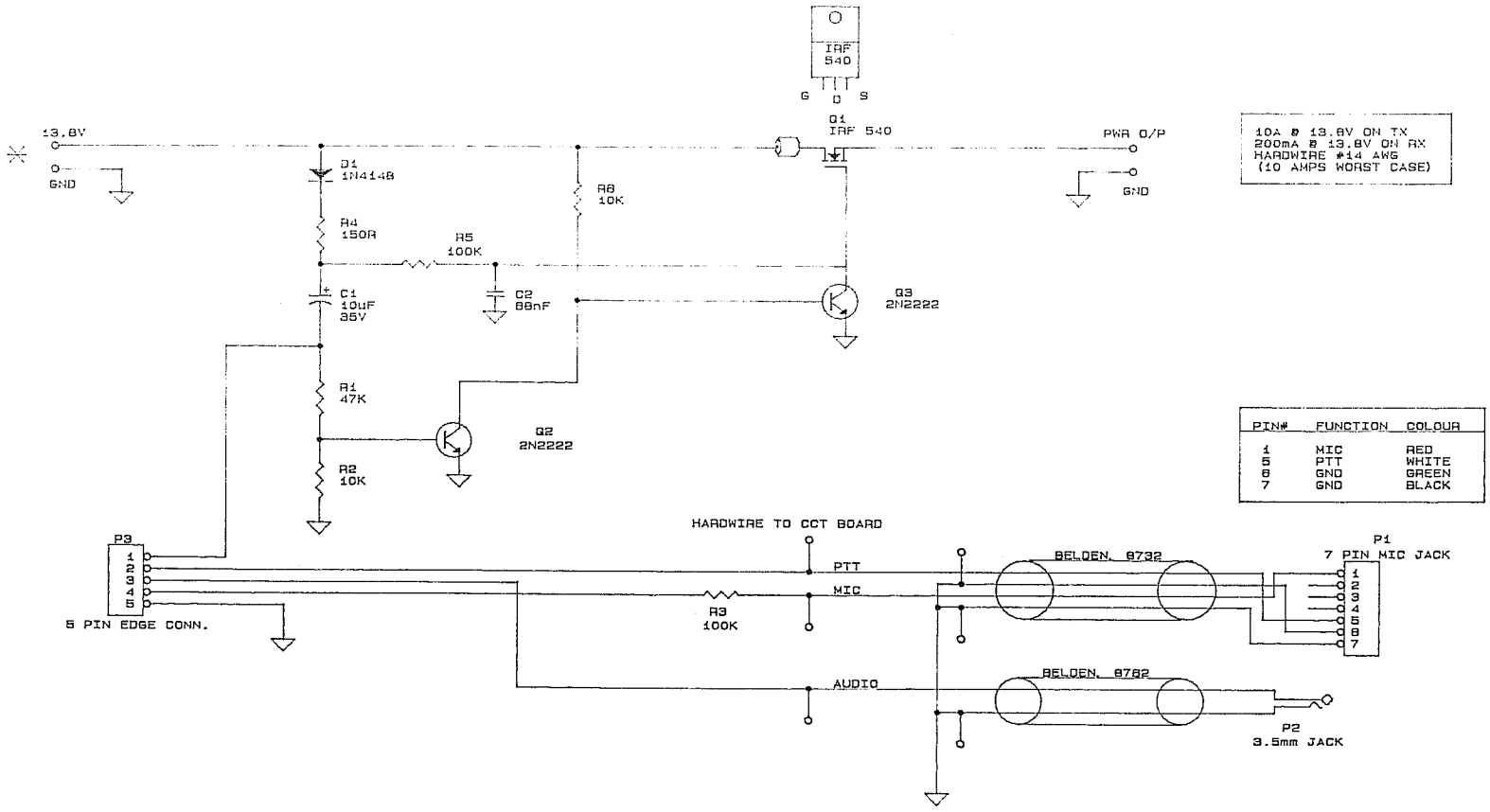
NOTE:

1 - 8 PIN EDGE CONNECTOR, .1 SPACING, RIGHT ANGLE
2.- MAX BOARD SIZE: 5.5" BY 3", 8/32 MOUNTING HOLES

PIN OUT TOP VIEW



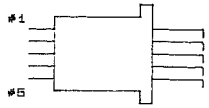
FOREST TECHNOLOGY SYSTEMS		
Title: G.E. HI-POWER TO RM4000 INTERFACE CCT		
Size: B	Document Number: 01-RM4M/380	REV
Date: January 1, 1980	Sheet 1 of 1	



NOTE:

1.- @ 13.8V CONNECTION HARDWIRED #14 AWG
2.- MAX BOARD SIZE: 5.5" BY 3", 8/32 MOUNTING HOLES
3.- 5 PIN EDGE CONNECTOR, .1 SPACING, RIGHT ANGLE

PIN OUT TOP VIEW

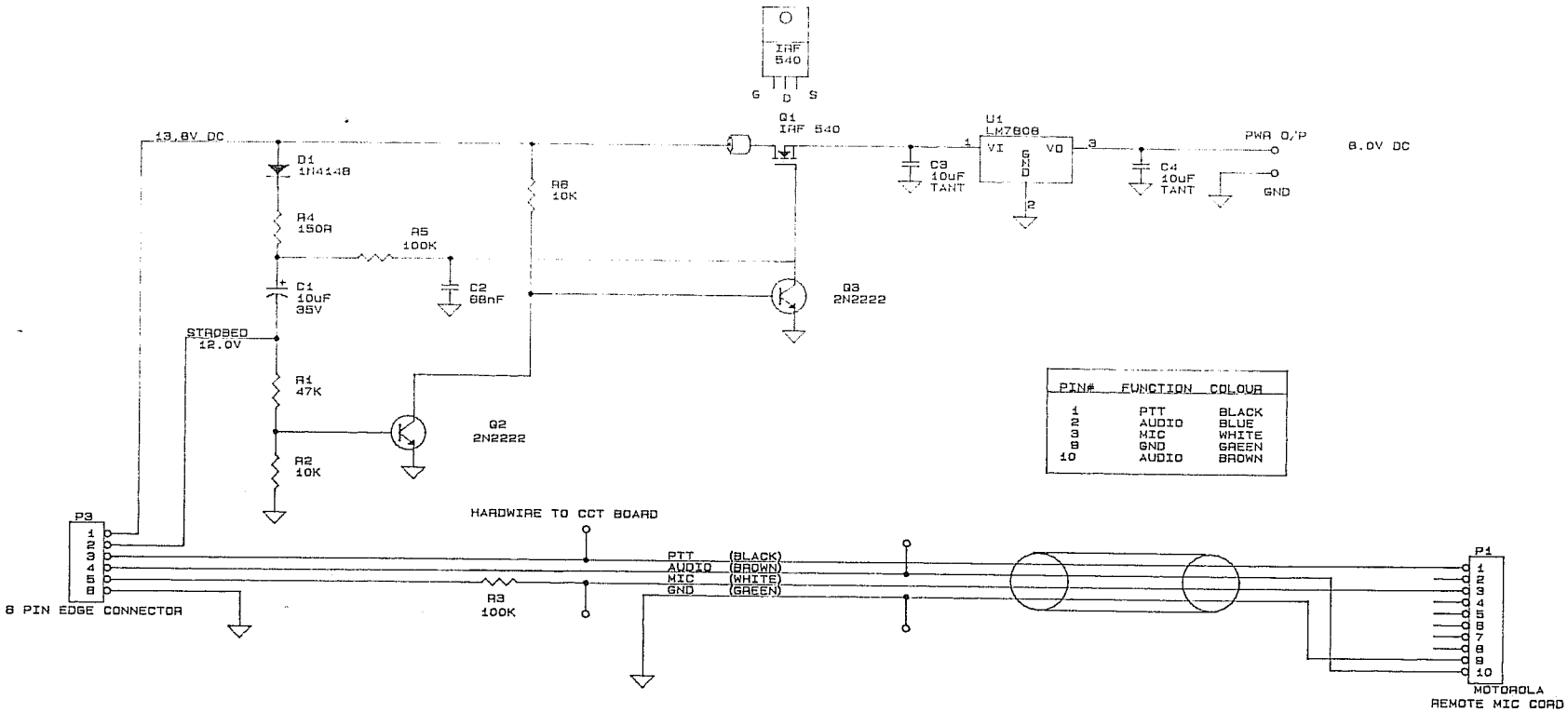


FOREST TECHNOLOGY SYSTEMS

Title
ICOM IC-V200 TO RM4000 INTERFACE CCT

Size	Document Number	REV
B		

Date: January 1, 1980 Sheet 1 of 1

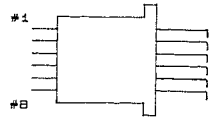


PIN#	FUNCTION	COLOUR
1	PTT	BLACK
2	AUDIO	BLUE
3	MIC	WHITE
8	GND	GREEN
10	AUDIO	BROWN

NOTE:

1 - 8 PIN EDGE CONNECTOR, .1 SPACING, RIGHT ANGLE
2.- MAX BOARD SIZE: 5.5" BY 3". 8/32 MOUNTING HOLES

PIN OUT TOP VIEW



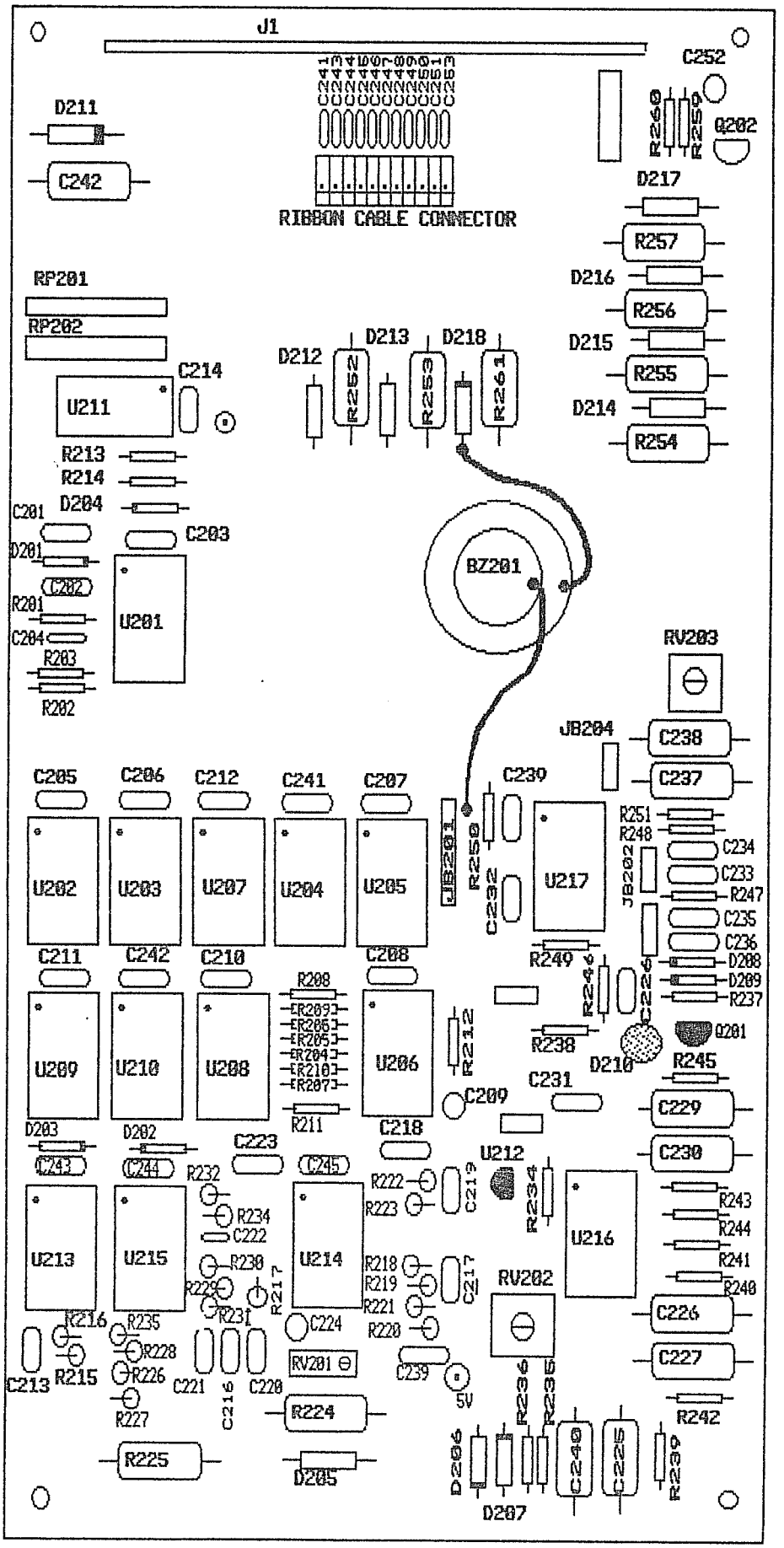
FOREST TECHNOLOGY SYSTEMS

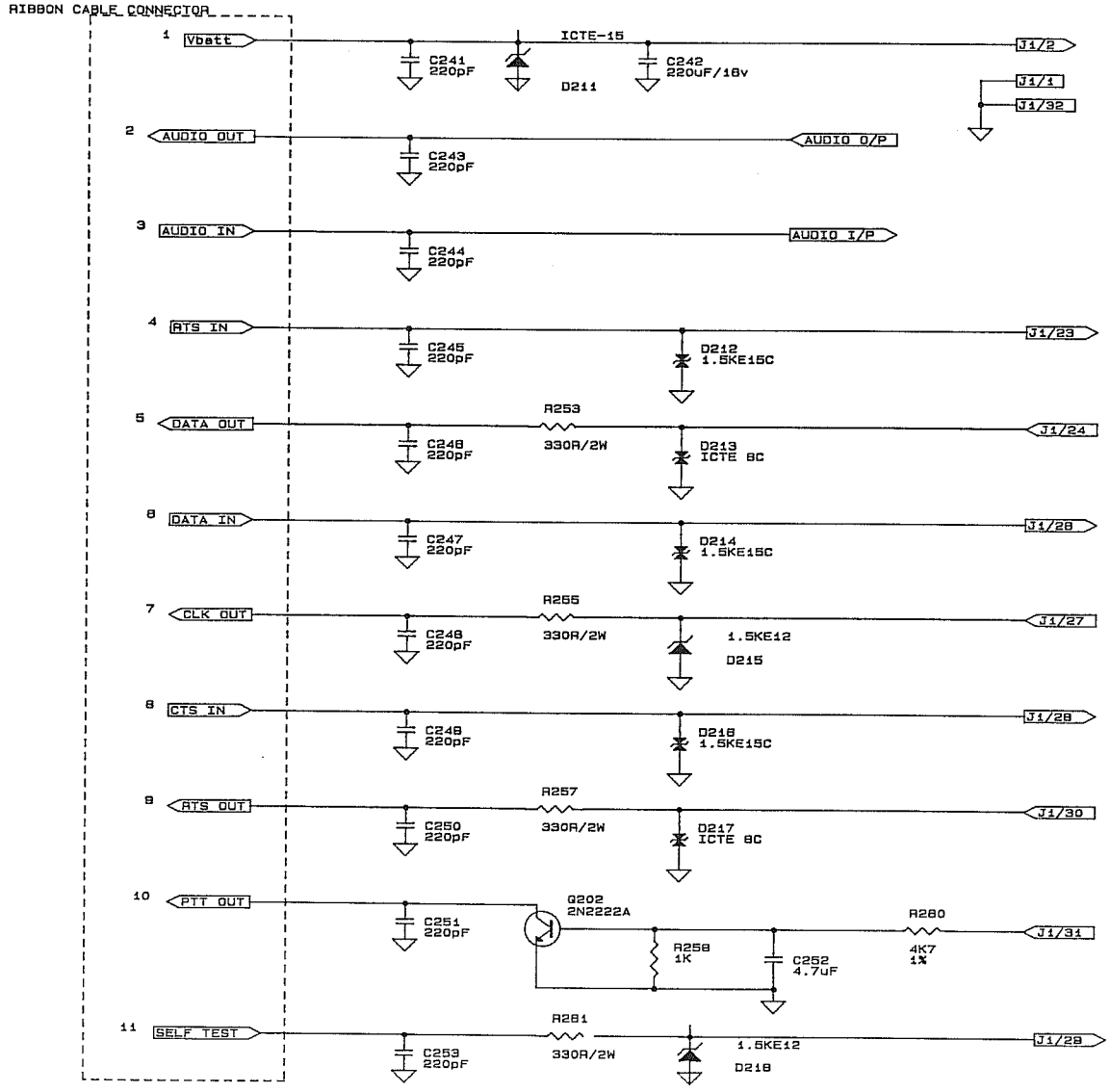
Title
MOTOROLA HX380 TO RM4000 INTERFACE CCT

Size	Document Number	REV
B		

Date: January 1, 1980 Sheet 1 of 1

FOREST TECHNOLOGY SYSTEMS	RM4000 RADIO MODEM	BOARD LAYOUT	LAYOUT-AS-RAD-MOD





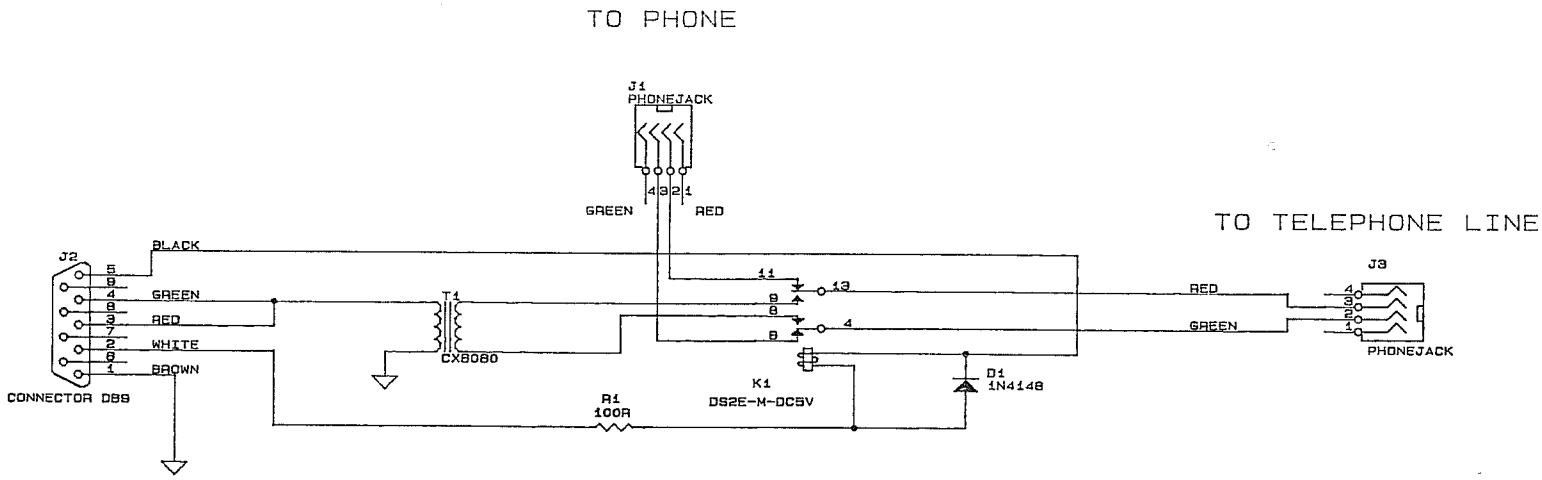
REV	ECN #	DATE	APPROVAL
A	001	28/8/87	
	028	18/3/89	PHIL

FOREST TECHNOLOGY SYSTEMS

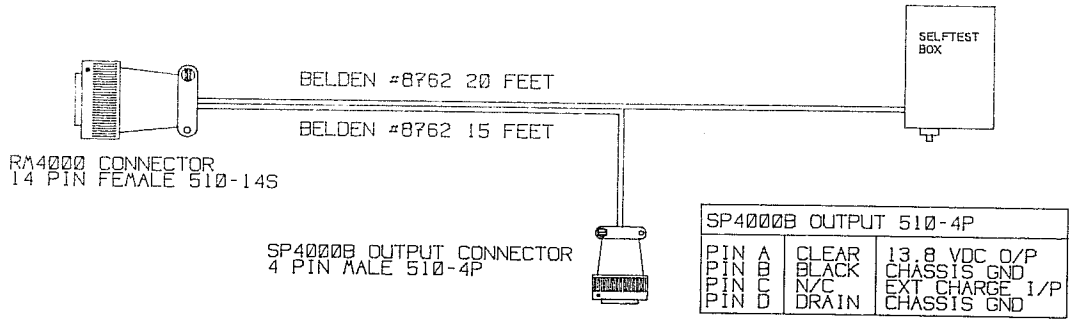
Title
CONNECTIONS FOR RADIO MODEM BOARD ON RM4000

Size	Document Number	REV
B	SCHEM-AS-RAD-MOD-BDNU	A

Date: March 18, 1989 Sheet 4 of 4

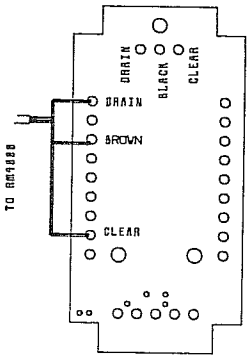


FOREST TECHNOLOGY SYSTEMS		
Title: TEL-4000		
Size: B	Document Number:	REV:
Date: June 27, 1989	Sheet 1 of 1	



SP4000B OUTPUT 510-4P		
PIN A	CLEAR	13.8 VDC O/P
PIN B	BLACK	CHASSIS GND
PIN C	N/C	EXT CHARGE I/P
PIN D	DRAIN	CHASSIS GND

RM-4000 CONNECTOR 510-14S			
PIN #	TO SLFTST	TO SPB	RM4000 FUNCTIONS
PIN A	BLACK	N/C	RM AUDIO O/P
PIN B	N/C	N/C	RM AUDIO I/P
PIN C	N/C	N/C	RTS I/P
PIN D	N/C	N/C	TX DATA O/P
PIN E	N/C	N/C	DSR O/P
PIN F	CLEAR	N/C	SELF TEST I/P
PIN G	N/C	N/C	PTT O/P
PIN H	N/C	N/C	CTS I/P
PIN I	N/C	N/C	DATA I/P
PIN J	N/C	N/C	CLOCK O/P
PIN K	N/C	CLEAR	POWER I/P
PIN L	N/C	BLACK	CHASSIS GND
PIN M	DRAIN	DRAIN	CHASSIS GND
PIN N	N/C	N/C	CHASSIS GND

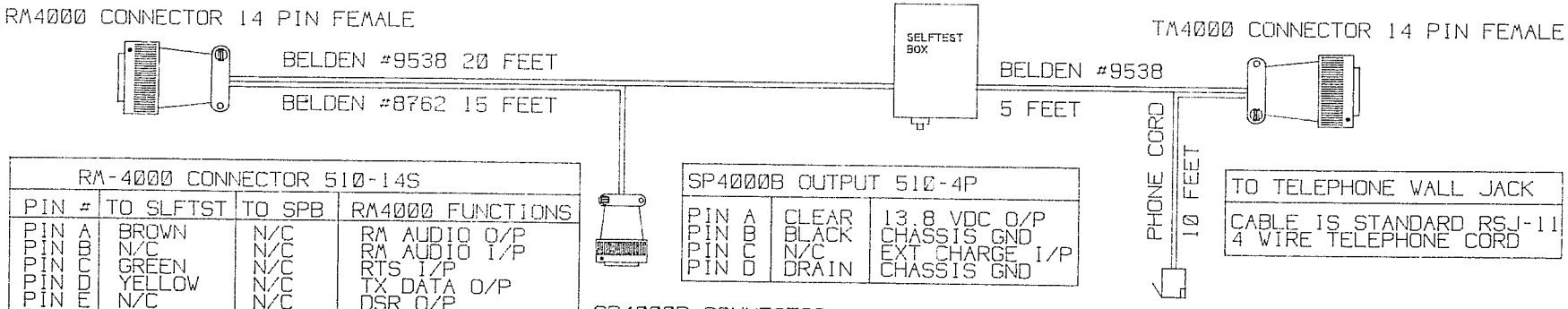


SELFTEST BOARD

FOREST TECHNOLOGY SYSTEMS LTD.

CBL-SP-RM

PHIL JONES FEB 1990

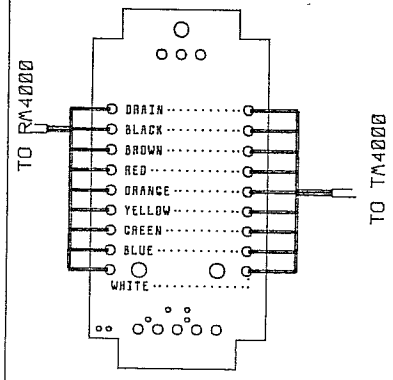


RM-4000 CONNECTOR 510-14S			
PIN #	TO SLFTST	TO SPB	RM4000 FUNCTIONS
PIN A	BROWN	N/C	RM AUDIO O/P
PIN B	N/C	N/C	RM AUDIO I/P
PIN C	GREEN	N/C	RTS I/P
PIN D	YELLOW	N/C	TX DATA O/P
PIN E	N/C	N/C	DSR O/P
PIN F	BLUE	N/C	SELF TEST I/P
PIN G	N/C	N/C	PTT O/P
PIN H	JUMPER I	N/C	CTS I/P
PIN I	WHITE	N/C	DATA I/P
PIN J	N/C	N/C	CLOCK O/P
PIN K	ORANGE	CLEAR	POWER I/P
PIN L	RED	N/C	CHASSIS GND
PIN M	DRAIN	DRAIN	CHASSIS GND
PIN N	BLACK	BLACK	CHASSIS GND

SP4000B OUTPUT 510-4P		
PIN A	CLEAR	13.8 VDC O/P
PIN B	BLACK	CHASSIS GND
PIN C	N/C	EXT CHARGE I/P
PIN D	DRAIN	CHASSIS GND

TO TELEPHONE WALL JACK
CABLE IS STANDARD RSJ-11 4 WIRE TELEPHONE CORD

TM4000 OR TM4000CD CONNECTOR 510-14S			
PIN #	TO SELFTEST	TEL CORD	TM4000(CD) FUNCTIONS
PIN A	N/C	RED	TELPH RING
PIN B	N/C	GREEN	TELPH TIP
PIN C	ORANGE	N/C	PWR I/P
PIN D	N/C	N/C	NO CONNECT
PIN E	WHITE	N/C	DATA I/P (FROM RM)
PIN F	GREEN	N/C	RTS I/P (TM)
PIN G	YELLOW	N/C	DATA O/P (TO RM)
PIN H	N/C	N/C	RESERVED I/P
PIN I	RED	N/C	EXT CLOCK O/P
PIN J	BROWN	N/C	RTS O/P (TTL)
PIN K	N/C	BLACK	TELPH BLACK
PIN L	BLUE	N/C	DATA I/P (WR)
PIN M	N/C	YELLOW	TELPH YELLOW
PIN N	BLACK & DRAIN	N/C	CHASSIS GND



SELFTEST BOARD

NOTE: THIS CABLE CAN BE USED WITH BOTH TM4000 AND TM4000CD.

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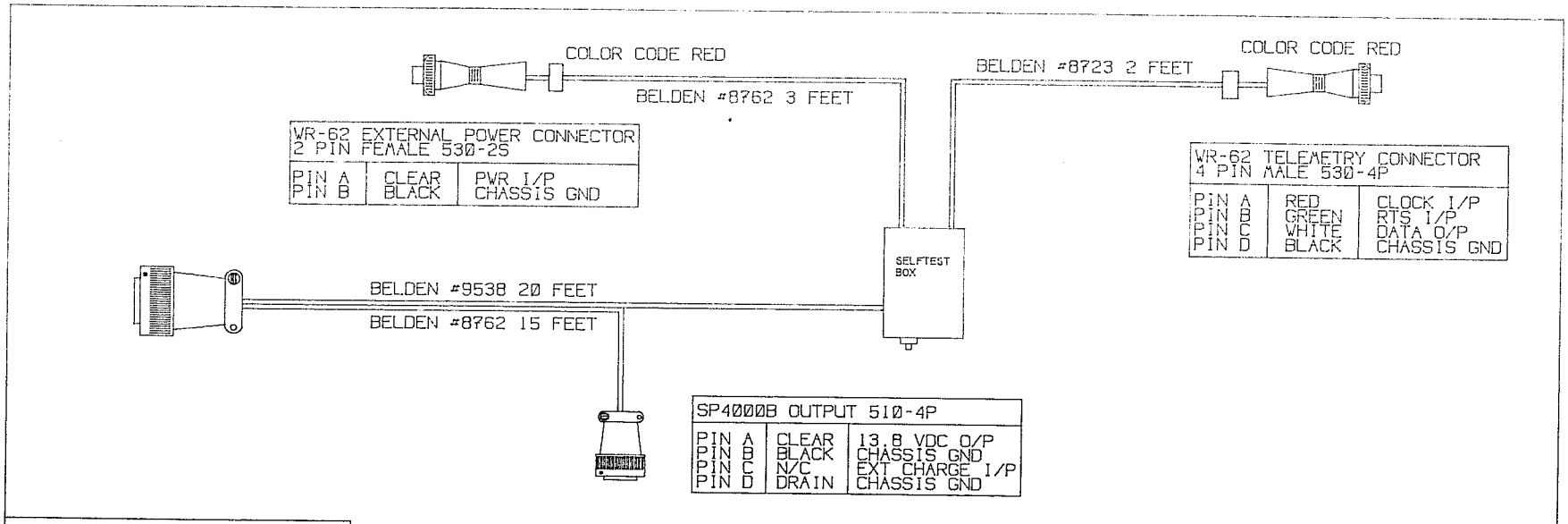
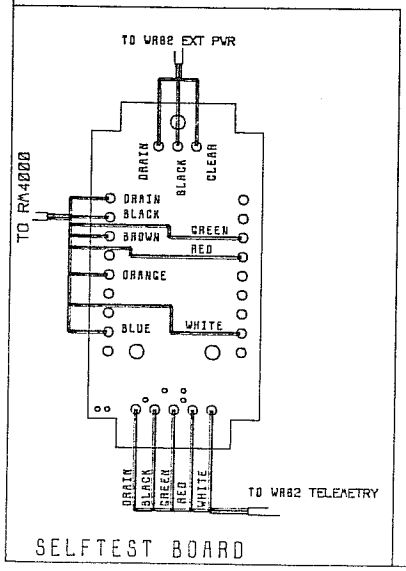


WR-62 EXTERNAL POWER CONNECTOR 2 PIN FEMALE 530-2S		
PIN A	CLEAR	PWR I/P
PIN B	BLACK	CHASSIS GND

WR-62 TELEMETRY CONNECTOR 4 PIN MALE 530-4P		
PIN A	RED	CLOCK I/P
PIN B	GREEN	RTS I/P
PIN C	WHITE	DATA O/P
PIN D	BLACK	CHASSIS GND

SP4000B OUTPUT 510-4P		
PIN A	CLEAR	13.8 VDC O/P
PIN B	BLACK	CHASSIS GND
PIN C	N/C	EXT CHARGE I/P
PIN D	DRAIN	CHASSIS GND



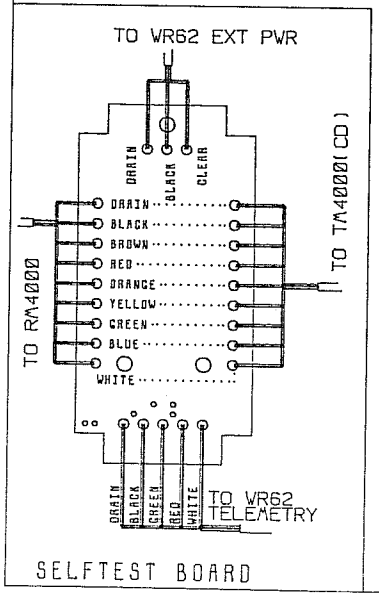
SELFTEST BOARD

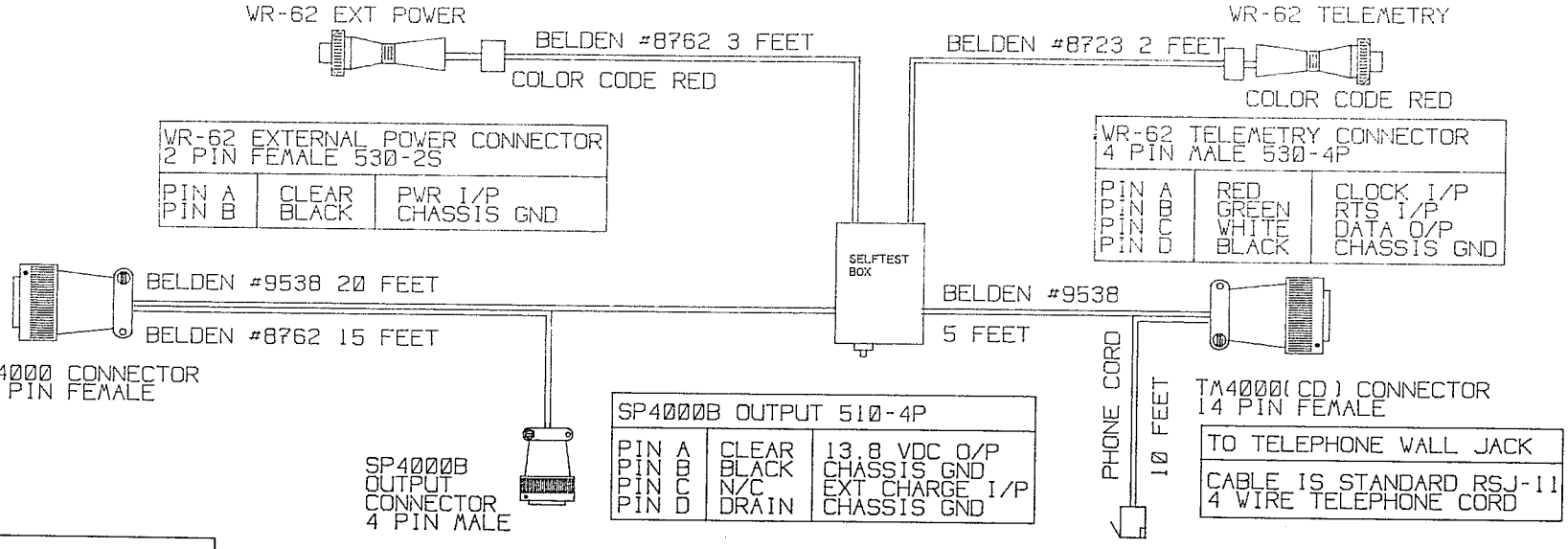
RM-4000 CONNECTOR 510-14S			
PIN #	TO SLFTST	TO SPB	RM4000 FUNCTIONS
PIN A	BROWN	N/C	RM AUDIO O/P
PIN B	N/C	N/C	RM AUDIO I/P
PIN C	N/C	N/C	RTS I/P
PIN D	N/C	N/C	TX DATA O/P
PIN E	GREEN	N/C	DSR O/P
PIN F	BLUE	N/C	SELF TEST I/P
PIN G	N/C	N/C	PTT O/P
PIN H	N/C	N/C	CTS I/P
PIN I	WHITE	N/C	DATA I/P
PIN J	RED	N/C	CLOCK O/P
PIN K	ORANGE	CLEAR	POWER I/P
PIN L	BLACK	BLACK	CHASSIS GND
PIN M	DRAIN	DRAIN	CHASSIS GND
PIN N	N/C	N/C	CHASSIS GND

FOREST TECHNOLOGY SYSTEMS LTD.

CBL-SP-RM-WR

PHIL JONES FEB 1990





WR-62 EXTERNAL POWER CONNECTOR 2 PIN FEMALE 530-2S		
PIN A	CLEAR	PWR I/P
PIN B	BLACK	CHASSIS GND

WR-62 TELEMETRY CONNECTOR 4 PIN MALE 530-4P		
PIN A	RED	CLOCK I/P
PIN B	GREEN	RTS I/P
PIN C	WHITE	DATA O/P
PIN D	BLACK	CHASSIS GND

SP4000B OUTPUT 510-4P		
PIN A	CLEAR	13.8 VDC O/P
PIN B	BLACK	CHASSIS GND
PIN C	N/C	EXT CHARGE I/P
PIN D	DRAIN	CHASSIS GND

TO TELEPHONE WALL JACK
CABLE IS STANDARD RSJ-11 4 WIRE TELEPHONE CORD

RM-4000 CONNECTOR 510-14S			
PIN #	TO SLFTST	TO SPB	RM4000 FUNCTIONS
PIN A	BROWN	N/C	RM AUDIO O/P
PIN B	N/C	N/C	RM AUDIO I/P
PIN C	GREEN	N/C	RTS I/P
PIN D	YELLOW	N/C	TX DATA O/P
PIN E	N/C	N/C	DSR O/P
PIN F	BLUE	N/C	SELF TEST I/P
PIN G	N/C	N/C	PTT O/P
PIN H	JUMPER I	N/C	CTS I/P
PIN I	WHITE	N/C	DATA I/P
PIN J	N/C	N/C	CLOCK O/P
PIN K	ORANGE	CLEAR	POWER I/P
PIN L	BLACK	BLACK	CHASSIS GND
PIN M	DRAIN	DRAIN	CHASSIS GND
PIN N	N/C	N/C	CHASSIS GND

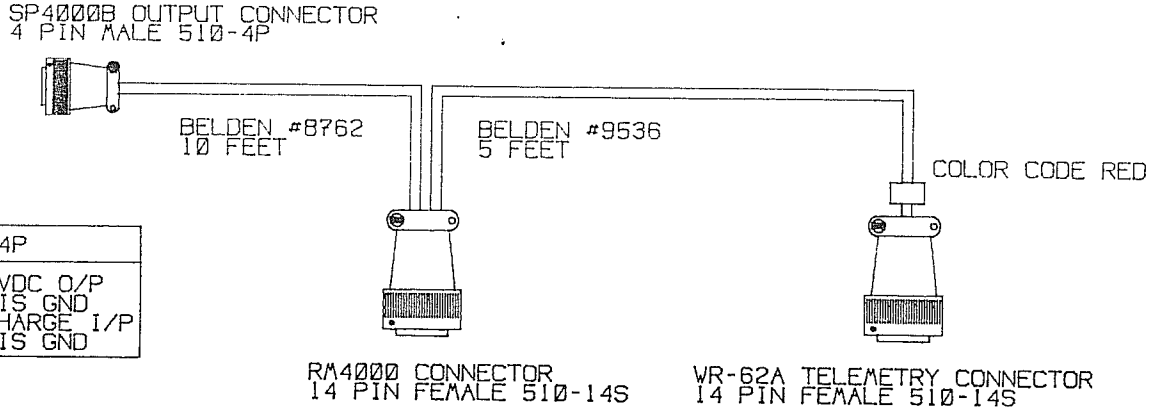
TM4000 OR TM4000CD CONNECTOR 510-14S			
PIN #	TO SLFTST	TEL CORD	TM4000(CD) FUNCTIONS
PIN A	N/C	RED	TELPH RING
PIN B	N/C	GREEN	TELPH TIP
PIN C	ORANGE	N/C	PWR I/P
PIN D	N/C	N/C	NO CONNECT
PIN E	WHITE	N/C	DATA I/P (FROM RM)
PIN F	GREEN	N/C	RTS I/P (TM)
PIN G	YELLOW	N/C	DATA O/P (TO RM)
PIN H	N/C	N/C	RESERVED I/P
PIN I	RED	N/C	EXT CLOCK O/P
PIN J	BROWN	N/C	RTS O/P (TTL)
PIN K	N/C	BLACK	TELPH BLACK
PIN L	BLUE	N/C	DATA I/P (WR)
PIN M	N/C	YELLOW	TELPH YELLOW
PIN N	BLK&DRN	N/C	CHASSIS GND

NOTE: THIS CABLE CAN BE USED WITH BOTH TM4000 AND TM4000CD.

FOREST TECHNOLOGY SYSTEMS LTD.

CBL-SP-TM-RM-WR

PHIL JONES FEB 1990



SP4000B OUTPUT 510-4P		
PIN A	CLEAR	13.8 VDC O/P
PIN B	BLACK	CHASSIS GND
PIN C	N/C	EXT CHARGE I/P
PIN D	DRAIN	CHASSIS GND

RM-4000 CONNECTOR 510-14S			
PIN #	TO WR-62A	TO SPB	RM4000 FUNCTIONS
PIN A	GREEN	N/C	RM AUDIO O/P
PIN B	N/C	N/C	RM AUDIO I/P
PIN C	N/C	N/C	RTS I/P
PIN D	N/C	N/C	TX DATA O/P
PIN E	WHITE	N/C	DSR O/P
PIN F	BLUE	N/C	SELF TEST I/P
PIN G	N/C	N/C	PTT O/P
PIN H	N/C	N/C	CTS I/P
PIN I	BROWN	N/C	DATA I/P
PIN J	N/C	N/C	CLOCK O/P
PIN K	RED	CLEAR	POWER I/P
PIN L	BLACK	BLACK	CHASSIS GND
PIN M	DRAIN	DRAIN	CHASSIS GND
PIN N	N/C	N/C	CHASSIS GND

WR-62A TELEMETRY CONNECTOR 510-14S		
PIN #	TO RM4000	WR62A FUNCTION
PIN A	GREEN	AUDIO I/P
PIN B	N/C	EXT PWR I/P
PIN C	RED	EXT PWR I/P
PIN D	BLACK & DRAIN	CHASSIS GND
PIN E	N/C	RTS JUNCTION (TO M)
PIN F	BLUE	RM SELF TEST O/P
PIN G	N/C	DATA JUNCTION (TO H)
PIN H	N/C	DATA JUNCTION (TO G)
PIN I	BROWN	DATA O/P RS232
PIN J	WHITE	RTS I/P
PIN K	N/C	DATA JUNCTION (TO N)
PIN L	N/C	NO CONNECT
PIN M	N/C	RTS JUNCTION (TO E)
PIN N	N/C	DATA JUNCTION (TO K)

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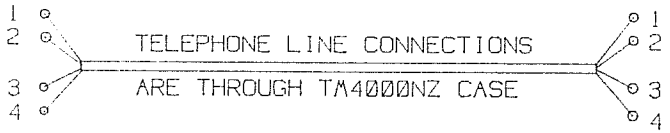
CBL-SP-RM-WRA

PHIL JONES FEB 14 1990

TELEPHONE LINE JACK	
1	NO CONNECT
2	TIP +48 VOLTS DC
3	RING -48 VOLTS DC
4	NO CONNECT



TM4000NZ END:		
TO J1 OF TM5000 CCT BRD		
PIN 1	YELLOW	1 WIRE
PIN 2	GREEN	2 WIRE
PIN 3	RED	3 WIRE
PIN 4	BLACK	4 WIRE

BELDEN #8762 10 FEET

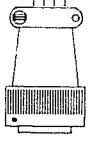
BELDEN #9538 5 FEET

BELDEN #9538 5 FEET

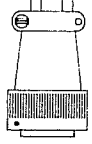
SP4000B OUTPUT CONNECTOR
4 PIN MALE 510-4P

COLOR CODE RED

SP4000B OUTPUT 510-4P		
PIN A	CLEAR	13.8 VDC O/P
PIN B	BLACK	CHASSIS GND
PIN C	N/C	EXT CHARGE I/P
PIN D	DRAIN	CHASSIS GND



RM4000 CONNECTOR
14 PIN FEMALE
510-14S



WR62A CONNECTOR
14 PIN FEMALE
510-14S

TM4000 CONNECTOR
14 PIN FEMALE
510-14S

RM-4000 CONNECTOR 510-14S			
PIN #	TO WR62A	TO SPB	RM4000 FUNCTIONS
PIN A	BROWN	N/C	RM AUDIO O/P
PIN B	N/C	N/C	RM AUDIO I/P
PIN C	WHITE	N/C	RTS I/P
PIN D	GREEN	N/C	TX DATA O/P
PIN E	N/C	N/C	DSR O/P
PIN F	BLUE	N/C	SELF TEST I/P
PIN G	N/C	N/C	PTT O/P
PIN H	JUMPER I	N/C	CTS I/P
PIN I	YELLOW	N/C	DATA I/P
PIN J	N/C	N/C	CLOCK O/P
PIN K	RED&ORG	CLEAR	POWER I/P
PIN L	BLACK	BLACK	CHASSIS GND
PIN M	DRAIN	DRAIN	CHASSIS GND
PIN N	N/C	N/C	CHASSIS GND

TM-4000NZ CONNECTOR 510-14S		
PIN #	TO WR-62A	TM4000NZ FUNCTION
PIN A	N/C (RED) *	TELPH RING
PIN B	N/C (GRN) *	TELPH TIP
PIN C	RED & ORG	PWR I/P
PIN D	N/C	NO CONNECT
PIN E	YELLOW	DATA O/P (RM)
PIN F	WHITE & BROWN	RTS O/P
PIN G	GREEN	DATA I/P (RM)
PIN H	N/C	RESERVED I/P
PIN I	N/C	EXT CLOCK
PIN J	N/C	RTS O/P (TTL)
PIN K	N/C *	TELPH BLACK
PIN L	BLUE	DATA I/P (WR)
PIN M	N/C *	TELPH YELLOW
PIN N	BLACK & DRAIN	CHASSIS GND

WR-62A TELEMETRY CONNECTOR 510-14S			
PIN #	TO RM4000	TO TM4000NZ	WR62A FUNCTION
PIN A	BROWN	N/C	AUDIO I/P
PIN B	ORANGE	ORANGE	EXT PWR I/P
PIN C	RED	RED	EXT PWR I/P
PIN D	BLACK & DRAIN	BLACK & DRAIN	CHASSIS GND
PIN E	WHITE	N/C	RTS JUNCTION (TO M)
PIN F	BLUE	N/C	RM SELF TEST O/P
PIN G	YELLOW	N/C	DATA JUNCTION (TO H)
PIN H	N/C	YELLOW	DATA JUNCTION (TO G)
PIN I	N/C	BLUE	DATA O/P RS232
PIN J	N/C	BROWN	RTS I/P
PIN K	GREEN	N/C	DATA JUNCTION (TO N)
PIN L	N/C	N/C	NO CONNECT
PIN M	N/C	WHITE	RTS JUNCTION (TO E)
PIN N	N/C	GREEN	DATA JUNCTION (TO K)

* NOTE: RESERVED FOR USE IN CANADA

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CBL-SP-TM-RM-WRA

PHIL JONES (TMNZ) FEB 1990

RM-4000 CONNECTOR 510-14S			
PIN #	TO FWS-11	TO SPB	RM4000 FUNCTIONS
PIN A	N/C	N/C	RM AUDIO O/P
PIN B	N/C	N/C	RM AUDIO I/P
PIN C	N/C	N/C	RTS I/P
PIN D	GREEN	N/C	TX DATA O/P
PIN E	N/C	N/C	DSR O/P
PIN F	N/C	N/C	SELF TEST I/P
PIN G	N/C	N/C	PTT O/P
PIN H	JUMPER K	N/C	CTS I/P
PIN I	WHITE	N/C	DATA I/P
PIN J	N/C	N/C	CLOCK O/P
PIN K	RED	CLEAR	POWER I/P
PIN L	BLACK	BLACK	CHASSIS GND
PIN M	DRAIN	DRAIN	CHASSIS GND
PIN N	N/C	N/C	CHASSIS GND

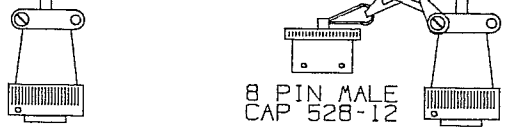
INTERCONNECT TO TM4000 OR FWS-11 TELEMETRY 520-128S		
PIN A	N/C	CTS I/P
PIN B	DRAIN	CHASSIS GND
PIN C	GREEN	DATA I/P
PIN D	WHITE	DATA O/P
PIN E	N/C	RTS O/P
PIN F	BLACK	SIGNAL GND
PIN G	RED	EXT PWR I/P
PIN H	N/C	NO CONNECT

BELDEN #8723
5 FEET

RM4000 CONNECTOR
14 PIN FEMALE 510-14S

BELDEN #8762
10 FEET

COLOR CODE GREEN



SP4000B
CONNECTOR
4 PIN MALE
510-4P

8 PIN MALE
CAP 528-12

FWS-11 TELEMETRY CONNECTOR
8 PIN FEMALE 520-128S

SP4000B OUTPUT 510-4P		
PIN A	CLEAR	13.8 VDC O/P
PIN B	BLACK	CHASSIS GND
PIN C	N/C	EXT CHARGE I/P
PIN D	DRAIN	CHASSIS GND

NOTE: IF CABLE IS USED FOR AN RM4000 STORE AND FORWARD SITE (CBL-SP-RM) BE SURE TO CAP THE FWS-11 TELEMETRY CONNECTOR.

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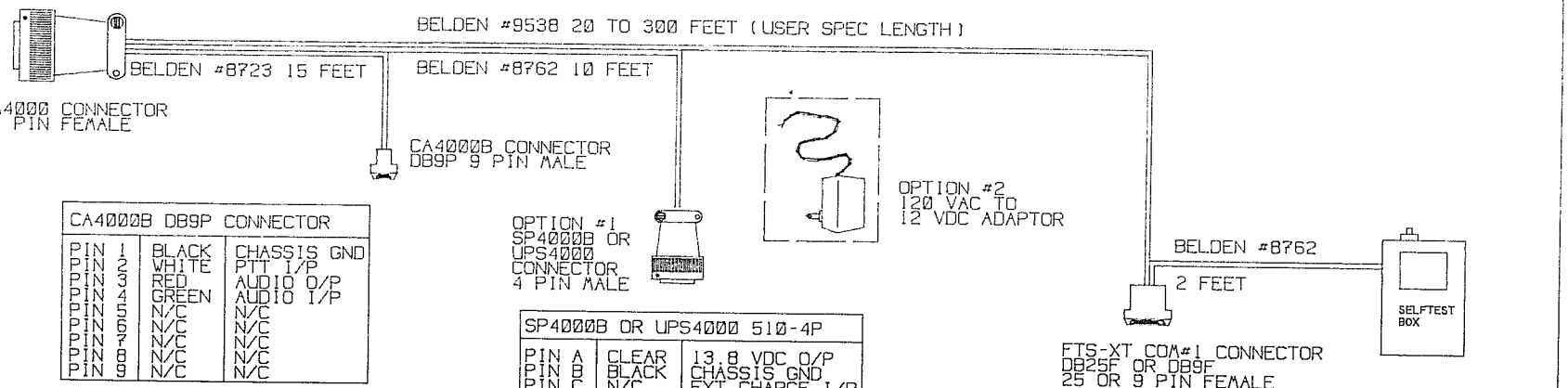
CBL-FWS-SP-RM

MAY 89 T. RHODES



CA4000B DB9P CONNECTOR		
PIN 1	BLACK	CHASSIS GND
PIN 2	WHITE	PTT I/P
PIN 3	RED	AUDIO O/P
PIN 4	GREEN	AUDIO I/P
PIN 5	N/C	N/C
PIN 6	N/C	N/C
PIN 7	N/C	N/C
PIN 8	N/C	N/C
PIN 9	N/C	N/C

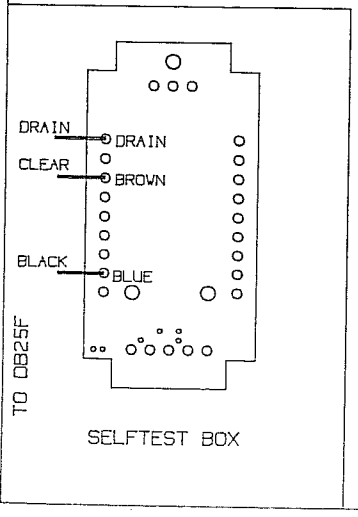
SP4000B OR UPS4000 510-4P		
PIN A	CLEAR	13.8 VDC O/P
PIN B	BLACK	CHASSIS GND
PIN C	N/C	EXT CHARGE I/P
PIN D	DRAIN	CHASSIS GND

FTS-XT COM#1 562-25S OR 562-9S CONNECTOR				
PIN # DB25	PIN # DB9	TO RM4000	TO SLFTST	FTS-XT FUNCTION
PIN 1	PIN 5	DRAIN	DRAIN	GROUND
PIN 2	PIN 3	GREEN	N/C	TX DATA
PIN 3	PIN 2	RED	N/C	RX DATA
PIN 4	PIN 7	BLACK	N/C	RTS
PIN 5	PIN 8	JUMPER	N/C	CTS
PIN 6	PIN 6	JUMPER	N/C	DSR
PIN 7	-----	JUMPER 1	N/C	GROUND
PIN 8	PIN 1	JUMPER	N/C	DCD
PIN 20	PIN 4	WHITE	N/C	DTR
PIN 11	SPLICE	BROWN	CLEAR	RM AUDIO O/P
PIN 25	SPLICE	BLUE	BLACK	RM SELFTEST
DB25 JUMPER PINS:(1 & 7)(5 & 6 & 8)				
DB9 JUMPER PINS:(1 & 6 & 8)				

NOTE: THIS CABLE CAN BE USED WITH BOTH UPS4000 AND SP4000B THE CONNECTIONS ARE THE SAME.

AN AC ADAPTOR IS USED WHEN THE RADIO IS EXTERNAL TO THE RM4000.

THE CA4000B CONNECTOR CAN BE USED TO CONNECT THE RM4000 TO THE EXTERNAL RADIO.



RM-4000 CONNECTOR 510-14S				
PIN #	TO FTS-XT	TO SPB	TO CA4B	RM4000 FUNCTIONS
PIN A	BROWN	N/C	RED	RM AUDIO O/P
PIN B	N/C	N/C	GREEN	RM AUDIO I/P
PIN C	BLACK	N/C	N/C	RTS I/P
PIN D	RED	N/C	N/C	TX DATA O/P
PIN E	N/C	N/C	N/C	DSR O/P
PIN F	BLUE	N/C	N/C	SELF TEST I/P
PIN G	N/C	N/C	WHITE	PTT O/P
PIN H	WHITE	N/C	N/C	CTS I/P
PIN I	GREEN	N/C	N/C	DATA I/P
PIN J	N/C	N/C	N/C	CLOCK O/P
PIN K	N/C	CLEAR	N/C	POWER I/P
PIN L	N/C	BLACK	BLACK	CHASSIS GND
PIN M	N/C	N/C	N/C	CHASSIS GND
PIN N	DRAIN	DRAIN	DRAIN	CHASSIS GND

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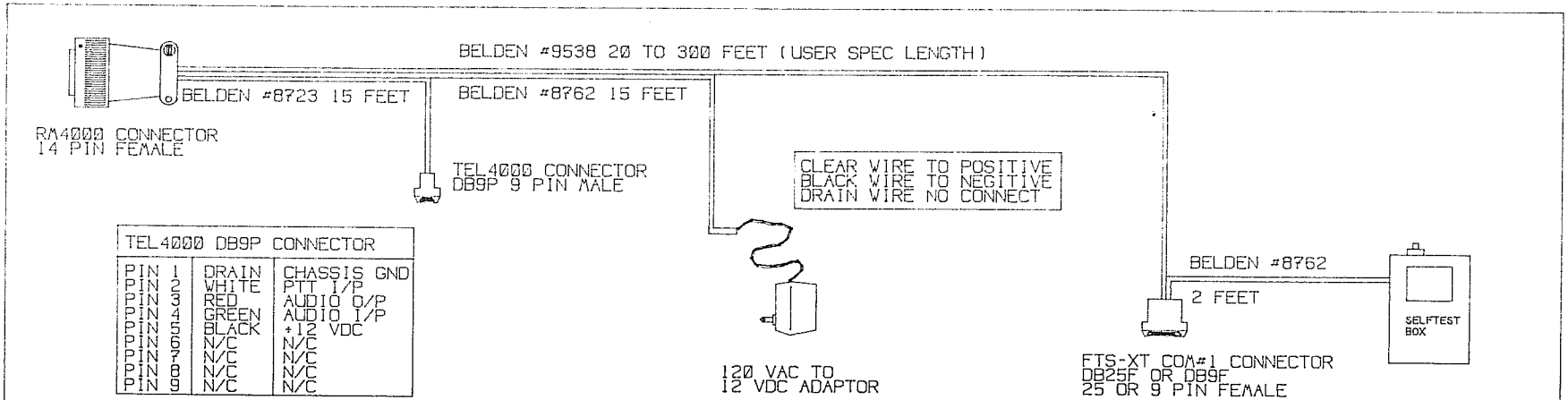
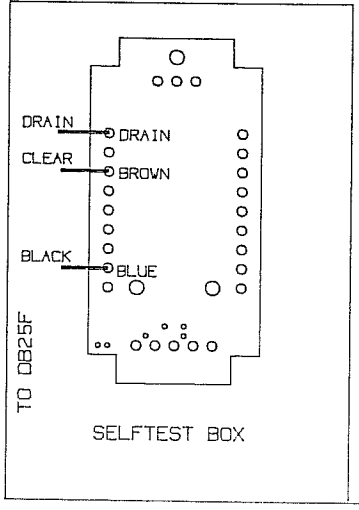
CBL-RM-IBM-UPS-CA

PHIL JONES MARCH 1990



TEL4000 DB9P CONNECTOR		
PIN 1	DRAIN	CHASSIS GND
PIN 2	WHITE	PTT I/P
PIN 3	RED	AUDIO O/P
PIN 4	GREEN	AUDIO I/P
PIN 5	BLACK	+12 VDC
PIN 6	N/C	N/C
PIN 7	N/C	N/C
PIN 8	N/C	N/C
PIN 9	N/C	N/C

FTS-XT COM#1 562-25S OR 562-9S CONNECTOR				
PIN # DB25	PIN # DB9	TO RM4000	TO SLFTST	FTS-XT FUNCTION
PIN 1	PIN 5	DRAIN	DRAIN	GROUND
PIN 2	PIN 3	GREEN	N/C	TX DATA
PIN 3	PIN 2	RED	N/C	RX DATA
PIN 4	PIN 7	BLACK	N/C	RTS
PIN 5	PIN 8	JUMPER	N/C	CTS
PIN 6	PIN 6	JUMPER	N/C	DSR
PIN 7	-----	JUMPER 1	N/C	GROUND
PIN 8	PIN 1	JUMPER	N/C	DCD
PIN 20	PIN 4	WHITE	N/C	DTR
PIN 11	SPLICE	BROWN	CLEAR	RM AUDIO O/P
PIN 25	SPLICE	BLUE	BLACK	RM SELFTEST
DB25 JUMPER PINS:(1 & 7)(5 & 6 & 8)				
DB9 JUMPER PINS:(1 & 6 & 8)				



RM-4000 CONNECTOR 510-14S				
PIN #	TO FTS-XT	TO SPB	TO TEL4	RM4000 FUNCTIONS
PIN A	BROWN	N/C	RED	RM AUDIO O/P
PIN B	N/C	N/C	GREEN	RM AUDIO I/P
PIN C	BLACK	N/C	N/C	RTS I/P
PIN D	RED	N/C	N/C	TX DATA O/P
PIN E	N/C	N/C	N/C	DSR O/P
PIN F	BLUE	N/C	N/C	SELF TEST I/P
PIN G	N/C	N/C	WHITE	PTT O/P
PIN H	WHITE	N/C	N/C	CTS I/P
PIN I	GREEN	N/C	N/C	DATA I/P
PIN J	N/C	N/C	N/C	CLOCK O/P
PIN K	N/C	CLEAR	BLACK	POWER I/P
PIN L	N/C	BLACK	N/C	CHASSIS GND
PIN M	N/C	N/C	N/C	CHASSIS GND
PIN N	DRAIN	DRAIN	DRAIN	CHASSIS GND

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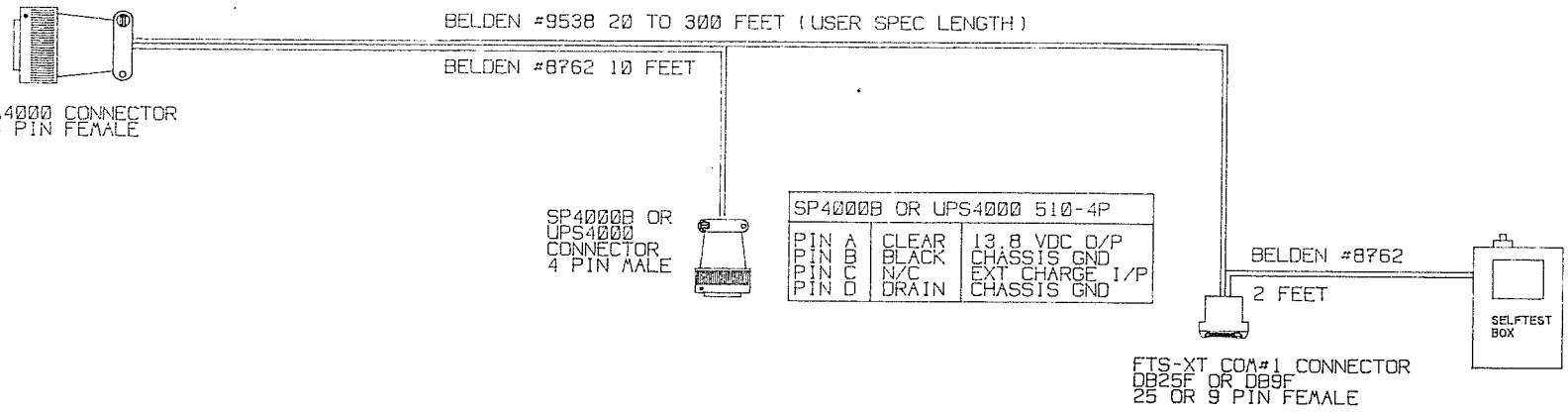
CBL-RM-TEL-IBM-AC

PHIL JONES MARCH 1990

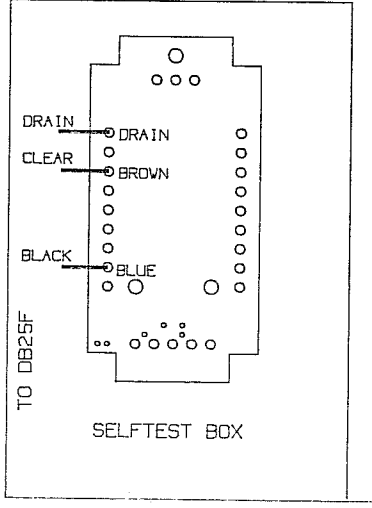


SP4000B OR UPS4000 510-4P		
PIN A	CLEAR	13.8 VDC O/P
PIN B	BLACK	CHASSIS GND
PIN C	N/C	EXT CHARGE I/P
PIN D	DRAIN	CHASSIS GND

FTS-XT COM#1 562-25S OR 562-9S CONNECTOR				
PIN # DB25	PIN # DB9	TO RM4000	TO SLFTST	FTS-XT FUNCTION
PIN 1	PIN 5	DRAIN	DRAIN	GROUND
PIN 2	PIN 3	GREEN	N/C	TX DATA
PIN 3	PIN 2	RED	N/C	RX DATA
PIN 4	PIN 7	BLACK	N/C	RTS
PIN 5	PIN 8	JUMPER	N/C	CTS
PIN 6	PIN 6	JUMPER	N/C	DSR
PIN 7	-----	JUMPER	N/C	GROUND
PIN 8	PIN 1	JUMPER	N/C	DCD
PIN 20	PIN 4	WHITE	N/C	DTR
PIN 11	SPLICE	BROWN	CLEAR	RM AUDIO O/P
PIN 25	SPLICE	BLUE	BLACK	RM SELFTEST
DB25 JUMPER PINS:(1 & 7)(5 & 6 & 8)				
DB9 JUMPER PINS:(1 & 6 & 8)				

NOTE: THIS CABLE CAN BE USED WITH BOTH UPS4000 AND SP4000B THE CONNECTIONS ARE THE SAME.

THIS CABLE IS USED FOR RM4000 WITH INTERNAL RADIOS.



RM-4000 CONNECTOR 510-14S			
PIN #	TO FTS-XT	TO SPB	RM4000 FUNCTIONS
PIN A	BROWN	N/C	RM AUDIO O/P
PIN B	N/C	N/C	RM AUDIO I/P
PIN C	BLACK	N/C	RTS I/P
PIN D	RED	N/C	TX DATA O/P
PIN E	N/C	N/C	DSR O/P
PIN F	BLUE	N/C	SELF TEST I/P
PIN G	N/C	N/C	PTT O/P
PIN H	WHITE	N/C	CTS I/P
PIN I	GREEN	N/C	DATA I/P
PIN J	N/C	N/C	CLOCK O/P
PIN K	N/C	CLEAR	POWER I/P
PIN L	N/C	BLACK	CHASSIS GND
PIN M	N/C	N/C	CHASSIS GND
PIN N	DRAIN	DRAIN	CHASSIS GND

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CBL-RM-UPS-IBM

PHIL JONES MARCH 1990