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I General

1-1 Introduction

This technical manual contains information for the installation, operation and maintenance of the RF-TEL RT9000 series rural radio telephone. The RT9000 is a programmable multifunction radio telephone system designed to meet the needs of todays automated operations. It requires a minimum of setup time to change from a Subscriber unit to a Central Office unit or to a Multi Access Remote Unit.
Designed and manufactured to telephone carrier industry standards, it complies with DOC, FCC and CCITT regulations. Using advanced synthesizer technology, the RF-TEL RT9000 series rural radio provides reliable telephone service into remote areas where installation of a hardwired telephone system is economically unattractive or environmentally unacceptable. The system in effect replaces the normal hardwiring and provides full telephone service such as private line dialling, payphone, modem, fax, and E&M communications. The operation of the radio link is fully transparent to the user, operating as if it were wired to a telephone line.

Typical installations were the RT9000 is employed include:

- Telephone service to remote villages
- Island settlements, isolated farms,
- Logging camps, mines,
- Offshore drilling rigs,
- Summer homes and ski cottages,
- Temporary installations.
- Solar powered installations.
- Payphone installations.

1-2 Standard Features of the RT 9000

- One Voice channel or 4800 bps FAX / Modem channel
- Identical Subscriber and Central Office unit (Field programmable)
- 4 Wire E&M operation
- Microprocessor controlled
- 3825Hz out of band FSK signalling
- Programmable companded audio
- Programmable Scrambler, user selectable
- PC or handset programmable RF channels, user ID,
- Two digit signal strength indication from 1 to 32 uV in 1uV steps
- Bar graph signal strength indication in from 1 to 16 uV in 6dB steps
- RS 232 diagnostics
- Self diagnostics
- Rotary or DTMF dialling
- Transparent to payphone signals, Line reversal
- Transparent to 12/16 kHz SPM (Subscriber Pulse Metering)
- Transparent to Coded Ringing and caller identification signals.
- Voltage transient and Lightning protection of Telephone line and Power Supply
- Subscriber Automatic number identification - ANI
- Over voltage line protection
- Remote Subscriber enable / disable from C.O.

1-3 Optional Features of the RT9000

- Built in 110/220Vac / 12Vdc power supply with trickle charge for an external battery
- Built in 48Vdc to 12Vdc converter for Central Office operation
- 4 line concentrator option to operate up to 4 partyline subscribers including automatic revertive call feature for partyline operation
- Dual CTCSS to reduce interference from co-channel users
- Diagnostics, alarm and link polling board

1-4 Equipment Identification

The RT9000 series rural radio telephone system covered in this manual is available in the following models:

RT9150-L VHF Radio Telephone, 138-145 MHz (part # 449-47-605)

RT9150-H VHF Radio Telephone, 145-174 MHz (part # 449-47-606)

RT9450-L UHF Radio Telephone, 400-440 MHz (part # 449-47-607)

RT9450-H UHF Radio Telephone, 435-470 MHz (part # 449-47-608)

RT9300-L UHF Radio Telephone, 310-330 MHz (part # 449-47-609)

RT9300-L UHF Radio Telephone, 355-385 MHz (part # 449-47-610)

1-5 System Configurations

The RT9000 can be programmed to operate as a Single Channel Subscriber unit, a Single Channel Central Office unit, a 4 wire link repeater or a carrier operated repeater.
To change from Subscriber Unit to Central Office Unit requires only the selection of DIP switches.
To the other operations requires only downloading EEPROM personalities via the RS232 port and selection of the appropriate DIP switches on the controller board.

The following table lists the different modes which the RT9000 can be programmed for.:

- Single Channel 2Wire Subscriber Radio
- 2 Wire Central Office Radio with four line concentrator
- Single Channel 4W E&M Central Office Radio
- 4Wire Link Repeater for use with RT9000 system
- 4Wire E&M Base station/Repeater (carrier operated only)
- Payphone 12/16kHz SPM

1-5-1 Single Channel Configuration

The RT 9000 SOLO uses an onboard microcontroller to perform the various signalling and control tasks of the radio link and telephone interface. Out of band 3725/3925Hz FSK signalling is used over the radio link for signalling.

A basic system consists of a Central Office unit connected to the exchange and a Subscriber unit connected to a telephone set at the remote location, providing the user with normal full duplex telephone service. The telephone interface has all the necessary capability such as off-hook or on-hook, dialling, ring detect and ring generate to permit automatic processing of incoming and outgoing calls, and is compatible with most telephone exchanges.

One RT9000 SOLO unit configured as a C.O. connects to the nearest available 2 wire telephone line and one RT 9000 SOLO unit configured as a Subscriber radio connects to a regular dial or touch tone telephone.
The Central Office will detect ringing voltage and signal the Subscriber to generate the same ringing voltage at the subscriber telephone. It also detects off hook and dial pulse signals coming over the radio link in the form of 3825 Hz FSK. It converts these to signals to off hook and dial conditions on the telephone line.

The main components are a full duplex synthesized VHF/UHF radio with adjustable RF power of 5 to 20 Watts, a 6 or 5 cavity duplexer, a microprocessor controller, an optional 4 channel expansion board, and an optional 110/220Vac or 24/48vdc to 12Vdc power supply.

1-5-2 Central Office Radio with four line concentrator

With the optional 4 line extender card mounted at the Central Office unit, up to four Subscribers can share the Radio Channel on a partyline basis. Each partyline Subscriber is connected to his own private line at the C.O. for automatic billing. The 4 line extender option offers full privacy whereby only the phone being called will ring. Each Subscriber unit must have his identification programmed into the appropriate ID box in the setup program. The default for the Subscriber is line 1. If ID #1 has an entry, the Subscriber will ring as line #1. If ID #1 is empty, the Subscriber will ring at the next ID which contains an entry. If none of the ID's are programmed the unit will ring as line 1. If all ID's have and entry, the Subscriber will ring as line #1.

1-5-3 Coded ringing

For coded ringing the four line card extender option is also required. This operation must be specified at the time of ordering the equipment.

1-5-4 Sub and C.O. operation with 4 Wire E&M

The Central Office unit can be connected to the exchange via 4 wire E&M. To setup the RT9000 SOLO for 4 wire operation requires only the selection of appropriate switches on the controller board.

In this mode, the C.O. unit will ring the Subscriber when it receives a ground on the 'E' lead instead of ring voltage as in the 2 wire operation.
An 'off hook' condition from the Subscriber is signalled to the exchange by providing battery (or

ground) on the 'M' lead. Dial pulses are also signalled by pulsing the 'M' lead.
Note: The four line partyline feature is not supported with E&M operation. Only one Subscriber can be connected to the Central Office unit.

1-5-5 Repeater System

If the terrain is such that the SUB and C.O. locations are out of radio range, a considerable extension of range is obtained by employing a repeater.

The repeater consists of two radio units connected back to back so that on detecting a carrier operated relay (COR) the receiver of one keys the transmitter of the other and vice versa. The back to back repeater can be configured by connecting two RT9000 radios together via the optional repeater cable..
A total of four frequencies are required for repeater operation. F1/F2 between the C.O. and the local repeater and F3/F4 between the Subscriber radio and the repeater facing it. Directional antenna systems are employed and frequency allocation has to be chosen to provide sufficient isolation between the two units. To select the repeater function, see the option select switch table.

1-5-6 Payphone Operation

The RT 9000 SOLO is completely transparent to SPM (Subscribe Pulse Metering) signals and line reversals. SPM pulses and line reversal are detected at the C.O. and are reproduced at the Subscriber unit. The SPM payphone operation is optional and it requires the insertion of an integrated circuit. The SPM operation features an auto SPM pulse insertion option which incorporates a programmable pulse duration. For more details consult the programming section of this manual.

1-6 CTCSS

One of the problems sometimes encountered in a rural region where a radio telephone system is used is interference caused by co- channel operation. This interference may be caused by mobiles or other RF radios operating in the vicinity. As a result of this interference, the rural subscriber cannot have access to the Central Office since the transmitter is blocked when it goes “off hook” without a valid ID and a busy tone will be heard.

To overcome this problem, the continuous tone coded sub-audible squelch (CTCSS) option is available. With the CTCSS option, the system becomes largely immune to interference from other users. The C.O. unit will only go “off hook” when receiving the CTCSS tone together with a carrier, while at the remote side, the Subscriber unit will be busied out only from transmissions containing the CTCSS tone.

1-7 Signal Strength Meter

The front panel has 5 LEDS and a dual digit display for signal strength indication. The LED’s light up in increments of 6dB starting at 1 uV and indicate a minimum signal strength of 16 uV when all LED’s are lit. Because the response of these LED’s is without delay, it can provide an instant indication of interfering signals. It can also be helpful to tune in a signal generator if the exact receive frequency is unknown. The two digit display provides signal strength indication from 1 to

32uV in 1uV steps. The response of the display is delayed to prevent flickering of the digits. In normal operating mode the display indicates signal strength. When in “Techmode”, the display indicates the last activated function. (See Techmode for additional description.)
Four other LED’s provide indications of ON, Transmit, COR and Fault. The fault light comes on if the processor detects a malfunction of radio operation such as excessive VSWR or low battery.

1-8 Accessories

Optional accessories available for the RT9000 series Rural Radio include the following:

- Built in RPX-912 Power Supply 220/110VAC/12VDC
- Built in RPX-924 Power Supply 24VAC/12VDC
- Built in RPX-948 Power supply 48VDC/12VDC
- Built in four channel extender board for partyline operation
- 6 element 9dB gain Yagi Antenna
- RG 213 coaxial cable
- Mounting clamps
- 10 ft. aluminium pipe
- Coaxial connectors for antenna mounting
- Stainless steel out door cabinet
- Solar panels
- Standby battery

1-9 Power Supplies

For maximum system performance, it is important to choose a power supply capable of providing a hum and noise free 13.6VDC voltage, <50mVPP.

To operate the RT9000 SOLO Radio Telephone at 20Watts RF output, a 13.6VDC power source rated at 8A continuous duty is required.

To operate the RT9000 SOLO Radio Telephone at .5 to 10Watts RF output, a 13.6VDC power source rated at 5A continuous duty is required.

Various power supplies for operation on 110/220 VAC or 24/48 VDC are available from RF-TEL. All power supplies have a DC input for connecting a stand-by battery. During stand-by, the battery is trickle charged and will switch over to the radio in case of a power failure without interrupting a call.

The RF-TEL power supplies are of a high efficiency switching regulator type dissipating very little power, offering noise free operation of the radio system.

1-10 Duplexer

A band reject duplexer is employed in the RT9000 SOLO radio for use in the 148 to 174 MHz frequency band. It utilises four temperature compensated helical resonators housed in a light weight aluminium extrusion.
The purpose of the duplexer is twofold: It suppresses transmitter noise at the receive frequency

which, since it is on frequency, would otherwise pass directly through the receiver, and it prevents the large off channel transmit signal from desensitising the front end amplifiers of the receiver.

For duplexer tuning instructions see the maintenance section.

1-11 Fault Code Table

The microprocessor continually monitors a number of radio telephone functions and provides a visual indication of malfunctions by means of a fault light on the units front panel and a fault code displayed on the dual digit display. The following fault indications are provided

.

Code	Fault
EB	Low Battery alarm, if battery is below approx. 10.5Vdc
EF	Receive frequency out of lock
EE	EEPROM Checksum failure, EEPROM corrupted or accidentially erase
EC	Main Program Checksum Failure
EA	If RAM checksum does not match, unit resets and reloads info from EEPROM Errors are counted and are stored in EEPROM. # of errors can be examined in prog mode by function *09

1-12 Current Saving Feature

The RT9000 features a current saving operation which drastically reduces standby current requirement. For minimum power consumption, the microprocessor of the RT9000 unit operates in a sleep mode where it checks every few hundred milliseconds for activity on the radio channel or on the telephone line. If it detects any change, it wakes up and activates all other circuitry. The average idle current consumption is the sum of the current in sleep mode plus the current during the time where it checks for activity, multiplied by the respective duty cycle. This way, a very low idle current can be achieved, typically 15mA for a 10 to 1 duty cycle.

1-13 Rear Panel Connections

- 110/220Vac input (If optional power supply is installed)
- 12Vdc input connector or standby battery input
- UHF antenna connection
- Optional 4 modular telephone jacks for four Subscriber (Used only on Central Office unit if the 4 channel extension board is installed)
- DB15 connector for 4W E&M interface, 2W Telephone line and RS 232 interface

DB15 Pinout

1	"M" lead
9	Battery
2	"E" lead
10	4 wire Rx audio
3	4 wire Rx audio
11	Ground
4	4 wire Tx audio
12	4 wire Tx audio
5	Ground
13	Tip
6	Ring
14	N/C
7	DTR
15	RS 232 Rx
8	RS 232 Tx

1-14 Order wire operation

Two RT 9000 Subscribers can be connected to function as an order wire between two points. In this case both radios are configured as a Subscriber. If the handset is lifted in one location, a 3 second ring automatically takes place at the other Subscriber location. When both locations are off hook, normal two way conversation can take place. In the same fashion two fax machines could be connected together.

1-15 Option Select Switch

Different operating modes for the RT9000 Radio Telephone can be selected via an 8 position DIP switch located on the controller board and placing certain links.
The table below shows the switch position and links for various operating modes

SW1	1 2 3 4 5 6 7 8	Additional settings
S1	**Central Office**	
On	x x x	
Off	x x x x x	
S1	**Subscriber**	
On	x x x x x x	
Off	x x	
S1	**4W E&M** (COR operated only)	Activate 4W E&M in advanced setup program
On		
Off	x x x x x x x	
S1	**C.O. Payphone SPM 16kHz**	
On	x x x x	
Off	x x x x	
S1	**C.O. Payphone SPM 12kHz**	
On	x x x	
Off	x x x x	
S1	**Sub Payphone SPM**	Set LK 2 for 16kHz operation
On	x x x x x	
Off	x x	
S1	**Sub Repeater 4W E&M**	Activate repeater in setup program
On		Set LK 2a to pos. ‘A’ on controller
Off	x x x x x x x	
S1	**C.O. Repeater 4W E&M**	Activate repeater in setup program
On	x	Set LK 2a to pos. ‘B’ on controller
Off	x x x x x x	

1-15-1 Link Positions

Link	Description	
1	on = Tx test (not used on 2W unit)	
2 (Sub)	on = SPM frequency 16 kHz	off = SPM frequency 12 kKz
2 (C.O.)	Link 2 must be off on C.O.	
2 (Repeater)	on = For alignment of Repeater only	off = Normal position for Repeater
2A	A = Sub repeater	B = C.O. repeater
3	A = SUB/CO select for normal operation	B = DTMF IRQ for RCS
4	Not used	
5	Not used	
6	A = COR on carrier	B = COR on CTCSS
7	on = ground on 'M' lead	off = 'M' lead open
8	A = FSK Tx tone select normal operation	B = FSK Tx tone select RCS
9	on = CTCSS not installed,	off = CTCSS installed
9A	A = Loop Ringing	B = Ring to ground
10	on = CTCSS not installed,	off = CTCSS installed
11	on = 3825 Hz filter not installed,	off = optional 3825 Hz filter installed
12	A = FSK Rx tone select normal operation	B = FSK Rx tone select RCS
13	on = RCS audible signalling	off = ERTS, or turn off audible sign.

Link	Normal position
1	-
2	-
2A	-
3	A
4	-
5	-
6	A
7	-
8	A
9	on
9A	A
10	on
11	on
12	A
13	-

1-16 Diagnostics, Alarms and Link Polling

1-16-1 Link Polling

An optional alarm board can be installed at the C.O. providing two alarm indications, one for link failure and one to indicate that the Subscriber battery is low.

With the alarm board installed, the C.O. polls the Subscriber radio once every 3 hours to verify the integrity of the radio system. This integrity check is also performed at the end of each ring cycle on a land line call. The C.O. is equipped with a set of dry contacts on the DB 15 connector or on a terminal block when mounted inside the weatherproof housing to signal a radio link failure.

In case the Subscriber battery voltage drops below 10.8V, a low dc voltage alarm is provided via dry contacts at the C.O. radio. The alarm condition will revert to normal when the Subscriber battery voltage is restored. A set of dry contacts are available on the DB 15 connector, or on a terminal block when mounted inside the weatherproof housing.

1-16-2 Accidental off hook

The remote radio reverts to sleep mode if no DTMF or pulse dialing occurs for 30 seconds following an off hook detection. The accidental off hook mode reverts to normal operation when the telephone is placed on hook again thereby preventing unnecessary power consumption.

1-16-3 Subscriber off hook indication

The optional alarm board can also be installed at the Subscriber unit to provide an off hook indication via an optocoupler output. The optocoupler output is available on the DB 15 connector, or on a terminal block when mounted inside the weatherproof housing.

II Theory of operation

2-1 Functional Overview

At the heart of the RT9000 controller is a single chip microcontroller which performs the logic control and operation of the RT9000 controller. The following is a detailed description of how the microcontroller and the various hardware modules interact to produce a dynamic process for controlling the RT9000.

2-1-1 DTMF Transceiver (MT8880)

The MT8880 continuously monitors the transmit side of the telephone hybrid looking for DTMF commands from the telephone and also the receive side looking for DTMF commands from the Central Office unit. A valid DTMF digit will produce an interrupt signal for the microcontroller so that minimal delay exists between commands and their associated functions. DTMF commands are sent from the handset to enter TECHMODE or enable user options such as the scrambler and Compander. Techmode is a restricted operation and is usually only accessed by technical personnel after a security access code is entered. An example of this would be the DTMF sequence of #123. User commands are not restricted and are somewhat shorter for ease of use. An example would be scrambler enable *61.

2-1-2 RS232 Transceiver (MC145407)

The many features of the RT9000 can be configured from a personal computer operating from DOS , Microsoft Windows 3.1 or Windows 95. The RS232 Transceiver provides the hardware interface between the programming port and the serial port on the microcontroller.

2-1-3 Reset Generator (DS1233)

The reset generator provides a reliable and safe way to reset the microcontroller on power up. It also monitors the 5Volt power line continuously to ensure that the microcontroller does not run at too low a voltage.

2-1-4 EEPROM (93C56)

The EEPROM is semi permanent memory which stores the desired configuration of the RT9000. It is programmed and read by an external computer connected to the programming port or via the handset in Subscriber configuration. The programming information is downloaded to the microcontroller which then programs the EEPROM on a serial bus.

2-1-5 CTCSS TX (MX165C)

The CTCSS encoder transmits a continuous subaudible tone on the radio channel to act as an alternative means of carrier detection which is more resistant to noise and interference. The tone frequencies are downloaded on a serial bus from the microcontroller to the MX165C.

2-1-6 CTCSS Rx (MX165C)

The CTCSS encoder receives a continuous subaudible tone on the radio channel to act as an alternative means of carrier detection which is more resistant to noise and interference. The tone frequencies are downloaded on a serial bus from the microcontroller to the MX165C.

2-1-7 Ring Generator

The ring generator consists of Q1, Q2, Q5 and Q6 which are pulsed on and off by the microcontroller on the lines ring 'gen0' and ring 'gen1'. The ring trip circuit consists of an optocoupler U1 which senses the increased load current accross R4 when the phone is off hook.

2-1-8 FSK Tx Modem (XR2206)

Single Channel Operation
Control signals such as ring voltage and dial pulses cannot be transmitted directly on the radio link, they must be encoded before transmission. A dual 3725/3925Hz out of band FSK tone is employed for data transmission. The Tx modem converts transmit data from the microcontroller into an FSK signal of 3725Hz/3925Hz.

Multiaccess operation IMTS
The Tx modem is also used to generate the 1633Hz connect tone and 1336 disconnect tone.

2-1-9 FSK Rx Modem (XR2211)

Single Channel Operation
The Rx modem converts the 3725Hz/3925Hz FSK signal back to digital data for the microcontroller to read.

Multiaccess operation IMTS
The Rx modem is also used to detect the 2000Hz idle tone and 1800Hz seize tone from the IMTS base station.

2-1-10 Scrambler (MX 128)

Voice privacy of the frequency inversion type is provided by the MX 128 scrambler chip.
The scrambler can be activated either permanently via the personality download program or it can be user activated during a call by pressing #*61. The user can also disable the scrambler by pressing #*60. Since activating the scrambler generates some system noise, it is recommended that the scrambler be used only in conjunction with the compander.

2-1-11 Compander (NE571)

With the compander switched in, the overall system noise can be reduced. The compander can be activated either permanently via the personality download program or it can be user activated during a call by pressing #*11. The user can also disable the compander by pressing #*10.

2-1-12 SPM Detector (MX631)

For payphone applications, the SPM detector at the C.O. decodes the 12kHz or 16kHz Subscriber Pulse Metering signals sent by the exchange. The frequency of the SPM pulse detected at the C.O. is selectable via switch S1-8. The frequency of the SPM pulse generated at the Subscriber is selected via link LK2.

2-1-13 Controller board theory

This section describes various circuit functions of the controller board.

- The line power supply consisting of T1 Q3 and Q7 provides the loop voltage and loop current for the telephone set. U3 is a constant current regulator adjusted to provide 30mA or 18mA loop current. The 130Vdc output connects to the ringer circuit consisting of Q2 and Q6. The ringer circuit is driven by the microprocessor through transistor buffers Q1 and Q5.
R4 is the ring trip sensor resistor. When going off hook, the increased current causes a voltage drop accross R4 which signals via optocoupler U1 to the uprocessor that the phone is off hook and to stop ringing.

- The bridge rectifier D21 -D25 and the optocoupler U26 are used on the C.O. only to detect ringing on the line from the exchange.

- U4,5,8 and 9 are latches driven by the uprocessor to activate various functions. The input to the latches is a data bus and a latch enable line. Signal on the databus are difficult to interpret without proper equipment and the only test which could be performed is to test with an oscilloscope if 0-5V pulses on the data bus are present. The outputs of the latches are steady state, they are either on or off.

- The supply voltages on the controller board are controlled by the microprocessor.

UC_VCC is a 5V regulated supply which keeps the microprocessor and some other essential circuits powered during the sleep cycle in current save mode.

The output of Q4 which is switched by BRDEN (Board enable) This voltage is under control of the uprocessor and is normally turned off in current save mode until a call is in progress. This voltage will also be off if no EEPROM is installed of if the EEPROM is not correctly programmed. In this case all the LED's will be off except in certain cases the red TX LED may be on.

2-1-14 Link Radio with 4 Wire E&M

This mode can be activated in the advanced setup programming page by activating the 4W E&M field. In this mode the radio functions strictly as a carrier operated, 4 wire E&M, link radio without any FSK protocol.
A ground on the 'E' lead will cause the radio to transmit and open the audio gates.
COR or CTCSS or opening the squelch will operate the E&M relay and place a ground onto the 'M' lead. It will also open the audio gates.

Note: This mode of operation can be used only for applications which require no out of band signalling. This mode cannot be used in conjunction with an RT9000 Sub or C.O. radio.

2-3 Central Office Mode

2-3-1 General

The RT9000 SOLO is configured as a central office unit and is connected to Tip and Ring of a telephone line from the exchange. The exchange interprets this unit as a telephone set with two states; on hook and off hook. In the stand-by mode the unit is in the onhook state, its transmitter is off and the line coming from the exchange is connected to a high impedance ring detector circuit.

In the Central Office configuration the unit performs the following functions:

- Detects ring frequency between tip and ring on one of the four lines and transmits this information together with the corresponding subscriber ID via FSK signalling to the Subscriber unit.

- Detects a line reversal and 12/16 kHz SPM pulses for payphone applications and transmits this information via FSK signalling to the subscriber unit.

- Decodes the ID and off hook condition of the remote Subscriber unit and seizes the telephone line corresponding to the calling Subscriber.

- Decodes pulse dialling from the subscriber unit and activates the dial pulse relay.

- Decodes Scrambler / Compander enable/disable codes from the Subscriber and activates the scrambler / compander correspondingly.

- Decodes the first DTMF signal sent by a Subscriber unit to determine if a revertive call has been initiated.

2-3-2 Subscriber initiating a call

When the Subscriber goes “off-hook”, his transmitter turns on and a Subscriber ID is transmitted to the C.O. The subscriber carrier and FSK tones are detected and the microcontroller using a software algorithm decides if a valid connect code is present. For valid connects, the off-hook relay corresponding to the calling Subscriber is energized, the line is seized and dial tone from the exchange is transmitted to the Subscriber.

The Subscriber can now dial out using either DTMF or pulse dialing. The C.O. unit is transparent to DTMF dialing. Pulse dialing is decoded via FSK and the microcontroller pulses the offhook relay in relation to the incoming dial bursts. The make-brake ratio at 10 PPS dial speed is set in software for a 60/40 ratio.

2-3-3 Central Office calling Subscriber

Ring voltage on any of the four C.O. lines is detected via an optocoupler, providing a ring detect indication to the microcontroller. This identifies the line which is ringing and a Subscriber ID followed by a ring signal in FSK format is sent to the Subscriber for the duration of the ring cycle. When the Subscriber goes “off hook”, the Sub unit will transmit his ID which will cause the off

hook relay at the C.O. to be energized. This seizes the line from the exchange and causes the ring to stop. The C.O. audio gates are enabled and the radio link is now transparent to voice and normal duplex communication can take place between the remote Subscriber and the exchange through the Central Office unit.
If another Subscriber should try to access the system during this time, he will get a busy tone because he will see a carrier without a valid ID.

When the remote Subscriber goes "on hook", an FSK disconnect tone is sent to the C.O. and the transmitter turns off. The microcontroller at the C.O. de-energizes the off-hook relay disconnecting the line from the hybrid.

The radio link is now idle and ready to initiate a new call.

2-3-4 Revertive Call

After an off hook condition has been established, the C.O. looks for the first dialed digit from the Subscriber to determine if a revertive call is taking place. If the first digit is an asterix (*), the C.O. will disconnect the phone line and switch into a repeater mode. It also decodes the next seven dialed digits to determine which Subscriber is being called. The C.O. will then transmit the ID of the called Subscriber followed by a code indicating a revertive call, followed by ring information.

2-3-5 Payphone Operation with SPM

For payphone operation, the 12/16KHz SPM tones from the exchange are detected by the SPM decoder and translated by the microcontroller to FSK tones that are transmitted over the radio link. At the Subscriber side, after reception and detection of the FSK tones they are translated back to 12/16 kHz tones by the microcontroller and re-injected into the telephone line.

2-3-6 Payphone Operation with line reversal

A line reversal at the exchange side is detected by an optocoupler and is transmitted as a series of FSK pulses to the Subscriber unit which reproduces the line reversal by activating the off hook relay.

2-3-7 2W/4W Audio Interface

A two wire to 4 wire audio interface is achieved through a conventional hybrid circuit using transformer T3 to transmit and T2 to receive audio signals. Hybrid balance is performed by potentiometer VR7 and capacitors C98 through C101. In the quiescent state the line is connected to a high impedance ring detector. When the "off hook" relay is energized, the hybrid circuit is now loading the line via the relay contacts K2, effecting an "off hook" condition in order to seize the line.

2-4 Subscriber Mode

2-4-1 General

When the radio is configured as a Subscriber unit it interfaces the Subscribers telephone set to the radio link. In this configuration the unit performs the following functions:

- Decodes the Subscriber ID and ring information from the Central Office unit and generates a ring voltage to activate the telephone ringer.

- Transmits a connect signal (Subscriber ID) to the Central Office unit when the Subscriber goes “off hook”.

- Transmits pulse dialing information as FSK format.

- Decodes and duplicates 12/16Khz tones from the Central Office for payphone operation.

- Decodes a line reversal from the exchange and duplicates it at the Subscriber end.

- Generates a constant 30 mA line current (18mA for low power applications) to operate the Subscriber telephone set.

- Decodes the first dialled digit to determine if a revertive call has been initiated which will activate the VOX circuit.

2-4-2 Subscriber Dialling

When the Subscriber goes off-hook, 30 mA of line current flows through the telephone set via Tip and Ring. This line current is sensed by an optocoupler connected to the microcontroller to indicate that the Subscriber has gone off hook.

If a carrier is present without a valid ID at the time of 'off hook', the microcontroller will generate a slow busy tone towards the line.

If the Subscriber unit fails to connect with the C.O. for any reason other than the C.O. being busy, a fast busy tone is generated.

If the channel is free at the time of 'off hook' the microcontroller will turn on the transmitter, enable the audio gates and transmit an FSK ID.

The Central Office validates the Subscriber ID and returns dial tone indicating that a duplex voice path has been established between the Subscriber and the Central Office unit. Dialing can now take place from the subscriber unit either with a DTMF or a pulse dialing phone.
DTMF dialing tones are transmitted directly to the line.
With a pulse dialing phone, the 30 mA line current is interrupted at the rate of dialing. This is sensed by an optocoupler indicating to the microcontroller that dialing is taking place. The microcontroller will key the FSK tones at the same rate for transmission over the radio link.
When the called party answers, normal duplex voice communications takes place via the Rx and Tx

amplifiers. When the Subscriber goes back on hook, a disconnect sequence is sent and the transmitter is turned off. This will restore the C.O. to the idle state and ready to receive a new call.

2-4-3 Subscriber receiving a call

When a carrier is received by the RT9000 SOLO Subscriber, the microcontroller checks for a valid FSK ID followed by ring information. Each ring cycle is preceded by an ID and the subscribers telephone will ring for as long as valid ring data is present.

During the ring on period, a Subscriber off hook condition is sensed by a bridge rectifier driving an optocoupler which indicates to the microcontroller that the Subscriber has gone off-hook and to stop the ring generator. If the subscriber goes off hook during the ring off period, a normal connect sequence follows.

2-4-4 Line Power

The line power circuit is driven from an oscillator operating at 16kHz. Its purpose is to provide the correct voltage and current to the telephone set and to provide -130 Vdc to the ring generator.

2-4-5 Low Battery Voltage Alarm

The low battery voltage alarm warns the Subscriber with an audible tone on the line that the battery voltage is reaching a point (10.8 V) where the unit will not be operating reliable. In addition, the fault light is turned on and and the low battery code will be displayed on the digital display. See fault code table for the applicable fault code.

2-5 Repeater Operation

Two RT9000 radios can be connected back to back via an optional repeater cable part no. 119-47-348 to form a full duplex repeater system.
For repeater operation, both units, the Sub repeater and the C.O. repeater must be configured in the setup program (or via handset programming) and the option select switch on the controller board must be set for 4W E&M.
The C.O. repeater must also have link 2a in position 'B'. This will cause it to transmit when a ground is placed on the 'E' lead.
The Sub repeater must have link 2a in position 'A'. This will cause it to go off hook when a ground is placed onto the 'E' lead.

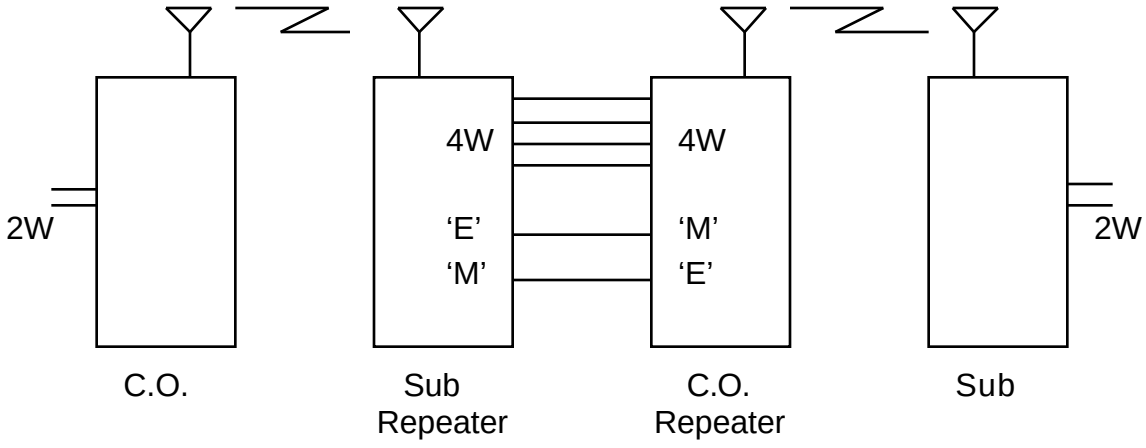
The repeater facing the Subscriber unit functions like a C.O. with the exception that the audio termination is 4 wire E&M. The repeater facing the C.O. unit functions like a modified Sub unit with 4 wire E&M termination. The operation of the Sub Repeater and C.O.Repeater are as follows:

The Sub repeater goes off hook, transmits and opens the audio gates when it receives a ground on the 'E' lead. It also places a ground onto the 'M' lead when it receives ring FSK from the C.O.

The C.O. repeater transmits FSK ring when it receives a ground on the 'E' lead and it places a ground onto the 'M' lead and opens the audio gates when it receives a COR with the Sub's ID.

(The normal C.O. transmits FSK ring when it detects ringing on the telephone line, and it goes off hook and closes the loop when it receives a valid Sub ID)
The normal Sub unit goes off hook when the handset is lifted and it activates the ringer circuit when it receives ring FSK from the C.O.)

Repeater system block diagram



2-5-1 **Subscriber going off hook** (repeater operation)

When the Sub unit goes off hook, it sends carrier and FSK ID. The C.O. repeater will validate the FSK ID, turn on its transmitter and establish a link to the Sub. The C.O. repeater also goes off hook and activates the E&M relay which places a ground onto the 'M' lead. This will place a ground onto the 'E' lead of the Sub repeater, causes it to go off hook and send the Sub ID to the C.O., thereby emulating the Sub unit. The C.O. will validate the Sub ID, go off hook and turn on its transmitter. The entire link is now established and the Subscriber will hear dial tone via the repeater.

2-5-2 **C.O. ringing Sub** (repeater operation)

When the C.O. receives ring from the line, it turns on its transmitter and sends FSK ringing to the Sub repeater. The Sub repeater decodes the FSK ringing and activates the E&M relay which places a ground onto the 'M' lead. This will place a ground onto the 'E' lead of the C.O. repeater and cause it to transmit and send ring FSK to the Sub, thereby emulating the C.O..

III VHF/UHF and 300MHz Radio

3-1 Circuit Description

Note: The RT9000 VHF and UHF 20 Watt radios employ two fully equipped KW transceiver boards. On the receiver only the receive section is used and the corresponding circuits of the schematic diagram apply while on the transmitter only the transmit section is used.
On the low power 2 Watt version and on the 300MHz versions only one KW transceiver board is installed for receive. For the transmit circuits on these models refer to the appropriate transmitter diagrams.

3-1-1 Receiver Section

The receiver section consists of a front end providing selectivity, a VCO/PLL, an IF demodulator chip and associated circuits.
The received signal passes through the band pass antenna filter L10 & L8 which are controlled by variable capacitance diodes to automatically tune the front end on a frequency change. It is then amplified by RF amplifier Q32. The amplified signal passes through L8 and into the first mixer Q21. It mixes the received RF signal and the Local Oscillator (LO) signal and produces the 1st IF signal of 45.05 MHz.

The output signal (1st IF) is further amplified by Q16 and passes through Crystal Filter (XF1 45.05 MHz). The amplified signal enters Pin 16 of IC7.

X2 Crystal (44.595 MHz) forms the oscillator for Narrowband 2nd IF (455KHz) at Pin 1. The output of the 2nd IF signal passes through Band Pass Ceramic Filter 455KHz (CD1). The signal is then internally amplified, limited and detected and is available as an audio signal (AF) at Pin 9. The RSSI (Signal Strength Indication) is taken from pin 13 of IC7.

The de-emphasis circuit for the receiver is on the interconnection board.

3-1-2 Transmitter Section 5 to 20 Watt version

The 20 Watt transmitter uses an identical board as for the receiver whereby only the transmit circuits are used. The power amplifier consists of a wide band module available in high band or low band. The power output and deviation is user programmable. (See programming section) The deviation control on the interface board is used as a factory preset control

3-1-3 TX Section 1 to 2 Watt version (Schematics Main Tx 221-27-358, PA 221-27-357,)

The transmitter consists of a Main transmit board, a VCO (Voltage Controlled Oscillator) and a variable 1 to 2 Watt Power amplifier. The TX RF signal from the VCO (Voltage Controlled Oscillator) is amplified by a MIMIC amplifier U6 on the main Tx board to approximately 120mW and is fed to the power amplifier. The PA output passes through the low pass harmonic filter L1, L2 and L3 to the antenna. The output power is controlled by a comparator circuit on the main Tx board consisting of U1, Q1 and Q2 and can be adjusted by the power control potentiometer on the main Tx board. The deviation is adjusted by a potentiometer on the interface board.

3-1-4 Interface board

The interface board contains the pre-emphasis and limiter circuits for the transmitter and de-emphasis and squelch circuits for the receiver. The transmit audio from the controller board passes through the pre-emphasis and limiting circuit before being fed to the modulator. The pre-emphasis networks is located before the scrambler on the transmit side , while the de-emphasis network is located after the scrambler on the receive side. The two potentiometers on the interface board adjust the squelch and the transmit deviation. The outer potentiometer (towards the front of the radio) is the squelch adjust VR1 and the inside potentiometer is the deviation control VR2.

3-1-5 Voltage Controlled Oscillator (VCO)

The RT9000 contains two independant VCO's, one for transmit and one for receive. They are mounted inside a shielded cover on the receiver board and main transmit board respectively. The frequency of the VCO is determined when a control voltage from the PLL is fed back to the VCO. The output of the transmit VCO is fed to the MIMIC amplifier on the main Tx board for further amplification by the power amplifier. The output from the receive VCO is fed to the first mixer on the receiver board.
The lock status of either VCO can be determined by checking the DC control voltage from the PLL. When the VCO is locked, this control voltage should be in the range of 1 to 5 volts, depending on the operating frequency of the VCO.

3-1-6 PLL Section

Frequency data is stored in the EEPROM. The microprocessor derives this data from the EEPROM and sends it to the PLL in a series format on the DATA, CLOCK and PLL enable lines.

The PLL compares the signal obtained when the 12.0 KHz reference oscillation frequency is divided and the signal obtained when LO signal from VCO is divided according to the DATA from the microprocessor, then generates a dc signal which is fed to the VCO as a control voltage through a low pass filter.

The PLL gives a lock detect output which, in case of unlock, would cause the microprocessor to reprogram the PLL.

3-1-7 TK-860 UHF Radio circuit description

3-1-8 TK-760 VHF Radio: circuit description

IV Programming the RT9000

4-1 General

The RT9000 can be programmed either from a telephone set or via the RS232 port.
This section describes how frequencies and other operating parameters can be programmed into the radio. There are two types of programming, Progmode programming which is permanently stored in EEPROM and Techmode programming which is temporary and is reset to the default values when the radio is powered up again.
In addition, some hardware configuration changes are necessary when converting from Central Office operation to Subscriber operation. This is accomplished via an 8 position DIP switch located on the controller board which allows the radio to be configured for:

- Subscriber operation
- Central Office operation
- RCS operation (IMTS or MASS format)
- 4 Wire E&M operation
- Repeater operation

4-2 Personality Programming

Personality programming is stored in EEPROM and becomes the default mode of the radio on power up. Personality can be programmed in two ways, from a PC via the RS232 port or directly from a DTMF telephone in Progmode.

4-2-1 Programming from a PC

When programming the radio from a PC, all parameters can be entered via RF-Tel's programming software on a graphic layout page in MS DOS and can then be downloaded to the radio via the RS 232 port.

To install the programming software on your computer, insert the install disc into drive a: and copy the file "RFTEL" to your hard disc. To run the program double click "Setup 20".

A settings page appears where the following personalities can be entered.

- Tx and Rx frequencies can be entered directly in kHz without the need for conversions.
- CTCSS Tx and Rx frequencies can be activated via a selection box.
- The Subscriber ID can be set. For a single Subscriber system, the Subscribers Telephone number should be entered in the "Private line" box. For multi partyline systems, the Subscribers Telephone number must be entered in the appropriate "Partyline" box. In multi partyline systems, the Central Office unit must also have all Subscriber Telephone numbers programmed into the appropriate "Partyline" boxes for correct identification of each Subscriber.
- The Programming access code can be changed. Since in personality programming the radio's frequency plan can be altered, the programming access code should be known to authorized personnel only. The radios are shipped from the factory with the programming code set to #456.
- The "Techmode" access code can be changed. The default is set from the factory to #123.
- Scrambler on / off default can be selected

- Compander on / off default can be selected
- Current saving mode on / off can be selected
- Repeater on / off can be selected
- The customer Name can be entered

Downloading personalities can be done for approximately 5 seconds during power up of the unit. To proceed, connect the selected computer com port to the DB15 connector of the radio via the supplied interface cable.

To download or store the selected settings in EEPROM memory, turn the radio off. From the menu select **F4 Dnload.** Turn on the radio and observe the front panel display. It will indicate 00 then blank and then AA. as soon as the AA's disappear, press **F7 Start**. After a few moments a dialog box will appear that downloading was successful. This completes downloading of the new radio personalities.

By selecting **F3 Upload** from the menu, it is possible to verify the programmed radio configuration. With the radio turned off, select **F3 Upload** from the menu. Then press **F7 Start** and wait for 'Receiving header' message**.** Now turn on the radio. Up-loading takes place automatically when the radio is being turned on, and a few moments later the currently programmed personalities of the radio are displayed on the settings page. To change any parameters, proceed as described under downloading personalities.

If additional assistance is required, the **Help** file may be consulted.

The following parameters can be programmed from the RS232 port:

- Transmit frequency
- Receive frequency
- CTCSS Tx frequency
- CTCSS Rx frequency
- Scrambler enable / disable
- Compander enable / disable
- Current saving enable / disable
- Repeater mode
- Subscriber ID
- Access code for programming mode
- Access code for techmode
- Customer Name
- Diagnostic mode
- Auto SPM pulse
- 4 Wire E&M
- 1st ring duration (used for caller ID function)

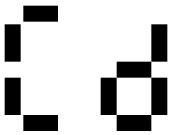
4-2-2 Programming from the Telephone Handset (PROG MODE)

Programming takes place in the so called volatile PERSONALITY memory (RAM), which establishes the operating parameters of the RT9000 radio. At power on, this Personality Memory is normally loaded with pre-programmed values from the Non-Volatile memory (EEPROM).
During programming of the radio, it is the volatile PERSONALITY memory which is being changed and once reprogramming of the Personality is complete, it must be saved to the EEPROM memory by entering *01, otherwise the information will be lost when the unit is switched off.

To program the radio from a DTMF telephone, it is necessary to first configure the unit as a Subscriber by selecting the appropriate DIP switches on the controller board. The radio cannot be programmed on an active link, it can only be programmed if there is no C.O. responding.
Note: Disconnect power before changing DIP switches.
To proceed with programming, go off hook and enter the programming access code. The default code set by the factory is #456. (If the programming access code has been forgotten, it can be read from the RS232 port via the **Upload** function.)

The programming password can be up to 8 characters long and it can only be entered via programming from a PC. The programming password can not be programmed from the handset. If the programming password field is left blank, the handset programming feature is disabled. Once a programming password has been entered, PROG MODE can be accessed from the telephone handset.

1. Entering programming mode can be done during the initial power up of the unit or everytime going off hook. Password entering is similar to TECHMODE. After turning on the radio, or after going off hook, wait a few seconds until a fast busy tone is heard, then type #456. The display will indicate



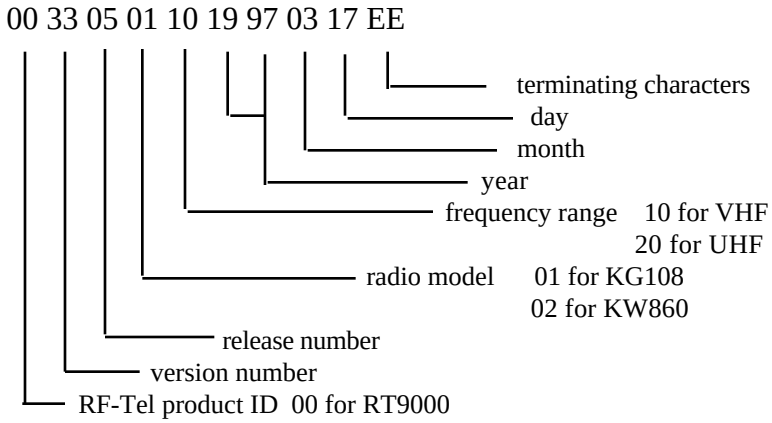
Once the Password has been entered, there are four groups of functions which can be programmed in PROG MODE:

Group 0 (programming functions)

- *00 Erases all current (unsaved) changes to the Personality Memory and restores settings to the values from the EEPROM
- *01 Saves current contents of the Personality Memory to the EEPROM
- *03 Displays radio version information (Read only)

Selecting *03 displays 2 digits to show a series of numbers which identify version, release, radio model, frequency band and release date. Pressing the '#' key lets the user scroll these numbers from the beginning to the end and again until the next function is selected.

The format of the displayed digit pairs is shown below:



Group 1 (parameters which can be toggled on or off.

*11 Selects Compander On
*10 Selects Compander Off

*41 Turns Transmitter On
*40 Turns Transmitter Off

*42 Turns audio gates off
*43 Turns audio gates on

*51 Turns Repeater mode On
*50 Turns Repeater mode Off

*53 Enables automatically generated SPM pulse
*50 Disables automatically generated SPM pulse

*55 Activates straight 4W E&M operation, no signalling
*50 Deactivate 4W E&M operation

*61 Selects Scrambler On
*60 Selects Scrambler Off

*91 Selects Power Saving Mode On
*90 Selects Power Saving Mode Off

Group 1 parameters such as Scrambler, Compander and Current saving mode are directly selected by entering the appropriate command code preceded by a star (*). To permanently store any configuration changes in EEPROM, do not forget to enter *01 before going on hook or switching off the unit.

Group 2 (These parameters require entry of parameters or using the step up/down functions)

*21 Programming Id of User #1
*22 Programming Id of User #2 (For partyline systems)
*23 Programming Id of User #3 (For partyline systems)
*24 Programming Id of User #4 (For partyline systems)
*20 Store entered User ID to Personality Memory followed by *01 to store in EEPROM

*71 Programming Receive Frequency
*73 Programming Transmit Frequency
*70 Store selected frequency to Personality Memory, followed by *01 to store in EEPROM
*81 Selects CTCSS Receive Tone Frequency
*83 Selects CTCSS Transmit Tone Frequency
*85 Selects length of first ring, minimum .8 sec. plus n x 100ms (max 2.3 sec)
*87 Caller ID window length, fixed 1.8 sec. plus n x 200ms (max 4.8 sec)
*89 SPM pulse length, 12kHz minimum 100ms plus 256 x 1ms
16kHz minimum 200ms plus 256 x 1ms

Once a function is selected, the 2 digit display shows the current function number. Pressing any of the following keys changes the display mode.

Enters and continues scrolling mode

When the # key is pressed the display scrolls through the content of the selected parameter. Each time the # key is pressed, the next digit is shown (ex. 9 is displayed as 09) Empty spaces are displayed as EE. After the last entered digit, one or more EE's are displayed before the display returns to the first digit.

0 to 9 Enters first/next digit of the User ID or frequency

Entered digits are displayed preceded with 'E' (ex. E3 when key [3] has been pressed).

***** Abandons programming of the current parameter and allows selection of a new function.

Frequencies or Subscriber ID are entered in the following manner:
Enter the function code for the parameter to be changed. The left display will show the first digit of the function accessed. Repeated pressing of the # key will scroll the display through the current data in memory for that code. Data can now be entered by pressing digits 0 through 9. New data is automatically entered at the first digit location regardless which digit the display shows. To write this data to memory, enter the terminate code (*70 for frequencies and *20 for ID numbers) followed by *01 to store in EEPROM. After 01 has been entered, the radio will reset automatically.

Example: Re-program the transmit frequency from 156.4MHz to 157.68MHz

- Go off hook and wait for the fast busy tone
- Enter the programming access code *456
- The display shows CD to indicate programming mode
- Enter *73 (Selects Tx frequency programming)
- Pressing the # key, the left display will show a 1 which is the first digit of the

currently programmed frequency.

- Repeatedly pressing the # key will scroll the left digit to -5-6-4 0-0-0-E to show the remaining digits. E indicates that these digits are not programmed. If scrolling is continued, the display will return to the first digit.
- At any time during scrolling enter the new frequency as 15768
- Enter *70 to write the new data to RAM memory
- Scroll through the just entered Tx frequency by pressing the # key
  The display will scroll through 1 5 7 6 8 to show the new Tx frequency
- Store the new frequency in personality EEPROM by entering *01

CTCSS Tones are selected as a number from 0 to 47. '0' means CTCSS tone signalling is Off. Corresponding tone frequencies can be found in the table below. When a value is incremented or decremented, the new value is loaded to the radio immediately and the volatile Personality Memory is updated. To permanently save changes to the EEPROM enter *01.

CTCSS Frequency table

	(Hz)		(Hz)
0	Off		
1	67.0	26	156.7
2	69.3	27	159.8
3	71.9	28	162.2
4	74.4	29	167.9
5	77.0	30	173.8
6	79.7	31	179.9
7	82.5	32	183.5
8	85.4	33	186.2
9	88.5	34	189.9
10	91.5	35	192.8
11	94.8	36	196.6
12	97.4	37	199.5
13	100.0	38	203.5
14	103.5	39	206.5
15	107.2	40	210.7
16	110.9	41	218.1
17	114.8	42	225.7
18	118.8	43	229.1
19	123.0	44	233.6
20	127.3	45	241.8
21	131.8	46	250.3
22	136.5	47	254.1
23	141.3		
24	146.2		
25	151.4		

Group 3 (These are special programmable radio functions which do not need to be programmed for normal operation or maintenance of the radio.)

When a value is incremented or decremented in the special functions menu, the new value is loaded immediately to the radio and the volatile Personality Memory is immediately updated.

		Available on
*31	Program Front End Filter tuning	All units
*33	Adjust transmitter Output Level	20W radio only
*35	Adjust Transmit frequency Deviation	20W radio only
*37	Receiver Fine Tuning (Reference Oscillator Adjustment)	All units *
*39	Transmitter Fine Tuning (Reference Oscillator Adjustment)	All units *

Note: The above are special functions and differ on some radios
* On the low power 2 Watt model, *37 adjusts both the Rx and Tx reference oscillator tuning

Once a function is selected, the current function number is shown on the 2 digit display. The illustration below shows the function of each key.

1 (+20)	**2** (+5)	**3** (+1)	Keys 1,2 and 3 increment current parameter values by a value of 20, 5, or 1
4 (-20)	**5** (-5)	**6** (-1)	Keys 4, 5 and 6 decrement current parameter values by a value of 20, 5, or 1
7 (200)	**8** (100)	**9** (50)	Keys 7, 8, and 9 set new parameter value 200, 100 and 50
*****	**0**	#	Key 0 resets parameter values to 0 Key * abandons programming of the current parameter and starts a new selection of PROGMODE functions Key # scrolls through parameter values.

The display shows only the last two decimal digits of the parameter value. For values greater than 100 the two rightmost signal strength LED's are used. If the parameter value is in range of 100-199, the rightmost signal strength LED turns On. For the range of 200-255 the next LED turns On. When both LEDs are off, the value is lower than 100.

Special use of the "Touch Tone" keyboard to step up/down one of the main frequencies.

*75 Step Up/Down Receive Frequency
*77 Step Up/Down Transmit Frequency

These functions immediately place the new value into the Personality Memory and adjust the radio frequency according to the new value.

1 (+20)	**2** (+5)	**3** (+1)	Keys 1, 2 and 3 increment current frequency by a value of 10MHz, 1MHz or 100KHz.
4 (-20)	**5** (-5)	**6** (-1)	Keys 4, 5 and 6 decrement current frequency by a value of 10MHz, 1MHz or 100KHz.
7 (-20) (-12.5)	**8** (+5) (+12.5)	**9** (+20) (+12.5)	Keys 7, 8 and 9 change current frequency by a value of 20KHz, 5KHz for VHF radios. and by a value of 12.5KHz for UHF radios.
*	**0** (-5) (-12.5)	#	Key 0 decrements current frequency by 5 kHz for VHF radios or by 12.5 kHz for UHF radios.

Additional programming notes:

When programming receive or transmit frequency parameters, a correct number of digits must be entered. If less than 7 digits of frequency are entered, the last ones will result as '0'.

In case of User Id, if less than 8 digits are entered, the not entered positions will be empty or blank and are not '0'.

If more than 8 digits are entered, the first digits will be lost and only the last 8 will be retained.

If no digits are entered after selecting *2x for user ID programming and *20 function is selected, the previously selected User Id will be erased and the location will be empty.

The functions (*2n, *71, *73), store input strings of digits to the temporary buffer which is later transferred to the Personality Memory with the corresponding *20, *70 functions.

If this is not done before programming the next parameter, the input data is lost.

To make programmed changes permanent, function *01 must be used to save Personality memory contents to non-volatile EEPROM memory.

4-3 Techmode Programming (Subscriber mode only)

Techmode programming is done from a telephone in Subscriber mode. Techmode programming is temporary and is restored to the default mode upon power up.
To operate the radio in 'Techmode', the radio must be configured as a Subscriber. Most radio personalities can be programmed in 'Techmode' using a regular DTMF telephone connected to the main telephone jack. To restrict access to authorized personnel, 'Techmode' is activated by first dialing an access code. The 'Techmode' access code is programmable for up to 8 digits in Personality programming. To enter Techmode, dial the access code which is factory set to #123. The display will indicate FC to verify techmode operation. A number of functions can now be activated by dialing an asterix (*), followed by two digits according to the table below. Going on hook will reset the unit to the default parameters programmed in "program" mode.

*10	Compander off
*11	Compander on
*20	Disable audio gates
*21	Enable audio gates
*30	Disable modem
*31	Enable modem
*40	Transmitter off
*41	Transmitter on
*50	Modem Hi tone 3925Hz
*51	Modem low tone 3725Hz
*60	Scrambler off
*61	Scrambler on
*70	960Hz Test tone off
*71	960Hz Test tone on
*80	Disables ring on when going on hook
*81	Enables ring on when going on hook
*90	Current saving disabled
*91	Current saving enabled

4-4 User Programming

User programming allows the Subscriber to activate or de-activate the compander and scrambler from his telephone after a connection has been established.
When going off hook, the radio will initially come up in the default mode (compander on, scrambler off) established in personality programming.
To activate the compander, the user dials #*11, to de-activate the compander he dials #*10.
To activate the scrambler, the user dials #*61, to de-activate the scrambler he dials #*60.
A double audible beep indicates to the user that the function selected has been activated, a single audible beep confirms that the function has been de-activated. When going on hook, the radio system reverts to the default mode.

4-5 Error Codes

The following error codes are displayed on the dual digit display on the front panel:

EB	Low battery	EE	EEPROM error (contents corrupted)
EF	Frequency error (Rx PLL out of lock)	EC	Processor error

V Alignment Procedure

5-1 General

The average audio levels from a telephone set and levels from the exchange can vary considerably. Telephone set levels are typically 0dBm (~2VPP) and levels from the exchange are typically -10dBm (200-~700mVPP). Therefore, when changing the RT9000 SOLO from Subscriber configuration to Central Office configuration, a line level change has to be made.

The RT9000 has a level compensation circuit which automatically increases the TX audio gain by 6 dB when switching from a Subscriber to a Central Office.
Line levels are adjusted in **Subscriber Techmode** with the compander off.

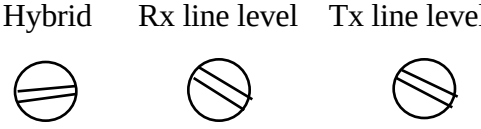
5-2 TESTPOINTS

A number of testpoints are available to assist in the alignment and troubleshooting of the radio telephone. Testpoints are identified by TP-n and are generally found on the controller board for alignment of the telephone interface circuits and line levels. To facilitate testing, all testpoints have been arranged in one place where a connecter could be plugged in for automatic testing.

TP	Description
1	Rx discriminator audio
2	Rx audio before audio gates
3	3825Hz filter alignment
4	Tx FSK data
5	Rx FSK demodulator alignment
6	Tx audio to modulator
7	Rx FSK data
8	Rx audio to line
9	Tx line audio
10	Tx audio after audio gates

5-3 Line Level Adjustments

For reference only, the following are the normal positions of the 3 level control potentiometers for the low power 2 Watt version.



5-3-1 Transmit Line Level

Make sure the RT9000 SOLO is in Subscriber configuration.
Connect a DTMF telephone to the line 1 input and place the telephone off-hook and dial #123. This activates ‘techmode’.
Dial *41 to turn on the transmitter and then *21 to turn on the audio gates.
Inject a 1000Hz audio signal at -6dBm to Testpoint TP-9 via a 1uF capacitor

Adjust Tx level potentiometer VR-5 for +- 3kHz deviation on the service monitor.
Alternatively, if no audio source is available, press one of the DTMF keys on the telephone. A dual tone combination should be observed on the monitor. Adjust the TX level control for +-4kHz deviation on the monitor.
This sets the TX line level for a Subscriber. When switching the unit into a C.O. configuration, the transmit level is automatically increased by 6dB to compensate for the lower line levels from the exchange.

5-3-2 Receive Line Level

Make sure the RT9000 SOLO is in Subscriber configuration.
Connect a DTMF telephone to the line 1 input and place the telephone off-hook and dial #123. This activates 'techmode'.
Dial *21 to turn on the audio gates. Connect a signal generator to the antenna connector with a 1kHz modulated signal at +-3kHz deviation.
Observe testpoint TP-8 with an oscilloscope and adjust the RX line level control for 1.5VPP.
This sets the nominal RX line level for a Subscriber and a for Central Office unit to -8dBm.

5-3-3 Hybrid Adjustment

Optimum Hybrid balance is achieved by compensating the line impedance with a balancing network across the hybrid. A 5 kohm variable resistor and 4 selectable capacitors are available on the controller board for this purpose.
Following the receive line level adjustment, observe testpoint 9 with an oscilloscope and adjust the Hybrid balance potentiometer VR7 for minimum. When the radio is reconfigured as a Central Office unit, it will be necessary to readjust the Hybrid when connected to a telephone line. Depending on the line impedance, it may be necessary to add some capacitance to the balancing network to achieve the required hybrid balance. Different value capacitors can be selected via 4 position DIP switch S2.

5-4 FSK TX Tone Adjust 3725/3925

Place the RT9000 SOLO in Subscriber configuration.
Connect a DTMF telephone to the line 1 input and place the telephone off-hook and dial #123. This activates 'techmode'.
Dial *41 to turn on the transmitter.
Dial *31 to activate the modem
Dial *50 to turn on the 3925Hz modem tone. Monitor the signal at TP 6 and adjust the frequency with potentiometer VR4 for 3925Hz.
Dial *51 to turn on the 3725Hz modem tone. Monitor the signal at TP 6 and adjust the frequency with potentiometer VR3 for 3725Hz.

5-5 FSK RX Tone Adjust 3725/3925

Ensure that the RT9000 is in Subscriber configuration.
Connect a DTMF telephone to the line 1 input and place the telephone off-hook and dial #123. This activates 'techmode'. Connect a signal generator to the antenna connector with a 3725Hz modulated signal at +-3kHz deviation.

With an oscilloscope monitor the signal at TP5.
Adjust VR1 until the signal just starts to clip on the **High** side.
Change the modulating frequency to 3925Hz and verify that the signal is balanced with equal clipping on both sides.

5-6 Duplexer Alignment

The duplexer has a bandwidth of approximately 200 KHz. If a frequency change of more than 100 kHz takes place, it will be necessary to retune the duplexer. The three receiver cavities are tuned for minimum on the transmit frequency and the three transmit cavities are tuned for minimum on the receive frequency.

Exact tuning of the duplexer, as is performed at the factory, can only be accomplished with a Network analyzer. However, since this type of equipment is not normally available in the field, some alternate methods are described here to perform emergency field repair.

5-6-1 Duplexer alignment using a Signal Generator together with an RF voltmeter or a Spectrum analyzer:

Remove all three connections to the duplexer. Connect an RF signal generator to the antenna terminal of the duplexer. Connect a 50 ohm load to the terminal marked receiver. Connect the spectrum analyzer or an RF millivoltmeter to the transmit terminal. Set the signal generator to the receive frequency and the output to 1V, or the maximum it can deliver. Tune the three transmit cavities for a minimum dip.
Connect the 50 ohm load to the transmit terminal and the spectrum analyzer or the RF millivoltmeter to the receive terminal. Set the generator to the transmit frequency and adjust the three receive cavities for a minimum dip.

5-6-2 Duplexer peaking using a Signal Generator only (Not recommended)

Minor repeaking of the duplexer can be accomplished by monitoring the receive audio while transmitting and adjusting the 6 tuning capacitors of the duplexer for minimum desensitization. The PA output power should be set to less than 1 Watt for this to prevent damage to the duplexer while tuning. Do not use this method to retune the duplexer to a different frequency or if the duplexer is severly detuned.

To repeak the duplexer proceed as follows:

Connect a wattmeter to the antenna terminal of the RT9000 radio. Also connect a signal generator modulated with a 1000 Hz signal at 3 KHz deviation via a signal sniffer to the antenna terminal.
Enter Techmode and monitor the receive audio at the telephone line output or at testpoint 2 with an oscilloscope. Adjust the generator output to obtain approximately 12 db SINAD.

Cause the unit to transmit and adjust the six cavities (4 cavities on VHF and 300MHz) on the duplexer for best SINAD. Readjust the generator output to maintain a 12 db SINAD.
It may be necessary to repeat the adjustment several times, tuning all 6 cavities. Do not turn any of the adjusting screws by more than 1/2 turn in either direction
The above proceedure should be used only for minor repeaking of the duplexer. If the duplexer cannot be successfully tuned using this proceedure, a complete realignment will be required.

5-7-1 Deviation adjust (VHF/UHF 20/10Watt versions)

On radios equipped with 2 KW transceiver boards, the transmit deviation is controlled from 2 places; It can be adjusted by programming and also via the deviation control on the interface board. It is recommeded that the deviation is programmed for maximum and then adjusted for 5kHz by the potentiometer on the interface board.

Step 1 To program the deviation for maximum enter the following DTMF sequence from the handset:

Off hook, wait for busy tone
dial #456
dial *43
dial *41
dial *35
dial 1111111
dial *01
On hook

Step 2 Now adjust the deviation control on the interface board for 5kHz as follows:

Off hook, wait for busy tone
dial #123
dial *12
dial *41
Press key #4 on the handset and adjust the maximum deviation for +-5kHz

5-7-2 Deviation adjust (2Watt and 300MHz versions)

The 2Watt and 300 MHz radios do not have deviation programming capability. To adjust the deviation on these models follow only **step 2** above.

5-8-1 RF power adjust (VHF/UHF 20/10Watt versions)

The RF power output on these models must be adjusted by programming from the handset.
To program the power output enter the following DTMF sequence from the handset:

Go Off hook, wait for busy tone
dial #456 to enter ProgMode
dial *41 to turn on Tx
dial *33 to enter power adjust mode
up/down keys to set the required power output
dial *01 to save settings

5-8-2 RF power adjust (2Watt and 300MHz versions)

The output power on these models is controlled from a potentiometer located on the Tx main board. To set the power, proceed as follows:

Go Off hook, wait for busy tone
dial #123 to enter TechMode
dial *41 to turn on Tx
Adjust the output power with VR1 on the Tx main board

5-9 Setting up and testing the repeater link

To test the repeater operation, proceed as follows:

1) Temporarily install Link 2 on the controller board of each repeater. This will make the repeater COR operated without the FSK signalling.
2) Connect the two radios together via the repeater cable.
3) Connect a Signal Generator tuned to the receive frequency of radio #1. Set the Generator output to 100uV and the deviation to 1kHz at 3.5 kHz deviation.
4) Monitor TP8 on the controller board of radio #1 and adjust the receivel level to 1.2VPP
5) Monitor the transmitter of radio #2 and adjust the Tx line level potentiometer of radio #2 for +-3.5 kHz deviation
4) Connect a Signal Generator tuned to the receive frequency of radio #2. Set the Generator output to 100uV and the deviation to 1kHz at 3.5 kHz deviation.
4) Monitor TP8 on the controller board of radio #2 and adjust the receivel level to 1.2VPP
5) Monitor the transmitter of radio #1 and adjust the Tx line level potentiometer of radio #1 for +-3.5 kHz deviation
6) Remove link 2 on both repeater radios.

This completes the repeater setup. The repeater is now setup to re-transmit the same deviation as it receives.

VII SPECIFICATIONS

7-1 General specifications

Frequency range	406-420, 450-470 MHz 310-330 MHz, 355-385MHz
Temperature range	-30 oC to +60 oC
Duty cycle	Continuous
Input voltage	13.6V nominal
Input currents	1.0A Tx @ 1W 4.5A Tx @ 18W VHF 4.0A Tx @ 10W UHF 150mA Idle on hook 20mA Idle on hook (current save) Operation Full duplex
Signalling	FSK 3825Hz out of band
Rx/Tx frequency spacing	5-15 MHz
Dimensions	L 13.5" (34.3 cm) W 10" (25.4 cm) H 3.5" (8.9 cm)
Weight	15 lbs (6.8Kg)
Number of channels	1
Number of Subscribers	1 Private

7-2 Transmitter

Power output	1-2W VHF/UHF/300MHz 1-10W UHF/300MHz 1-20W VHF
Frequency stability	5ppm
Audio distortion	< 3% 1kHz test tone
FM hum and noise	> 50dB
Spurious and harmonics	2 uW maximum
Modulation	16F3

7-3 Receiver

Sensitivity 12 dB SINAD	.25uV
20dB Quieting	.5uV
Selectivity	-85dB
Intermodulation	-75dB
Spurious and image	-90dB
Hum and noise	-50dB
Frequency stability	5ppm
Audio distortion	3% max at +-3kHz dev.

7-4 Subscriber Interface

Line level Rx	-20dBm to +7dBm
Line level Tx	-20dBm to +7dBm
Loop current	30 mA +- 2mA
Hybrid rejection	-50dB
Loop resistance	1300 Ohms max.
Ringer power	5W
Signalling	FSK 3725/3925 Hz out of band
Ring frequency	20Hz or 25Hz

7-5 Central Office Interface

DC loop resistance	180 Ohms min
2W Line level Rx	-20dBm to +7dBm
2W Line level Tx	-20dBm to +7dBm
4 W Rx level	+7 dBm
4W Tx level	-16dBm
Hybrid rejection	-50dB
Dial pulse rate	8 - 12 pps
Signalling	FSK 3725/3925 Hz out of band

7-6 Power Supply RPX 912

Input voltage	95 to 130 Vac or 190 to 260 Vac, 50/60 Hz
Input current	0.7A @ 110VAC
Output voltage	13.6 Vdc
Output adjustment range	Greater than 1V dc
Output current	8 amps @ 100% duty cycle
Line regulation	0.5% typical
Ripple and noise	50 mV P-P typical, dc to 20 MHz
Load regulation	0.5 % typical
Overshoot	No overshoot on turn on or turn off.
Temperature	-30 to +60 degrees C.
Cooling	Convection cooling
Protection	Input fuse, Reverse polarity Current limiting, Over voltage Over temperature

7-7 Duplexer RDU 450

Frequency range	406-420 MHz, 450 - 470 MHz
Frequency separation	5 - 15 MHz
Insertion loss Tx to antenna	1.3 dB max
Insertion loss Rx to antenna	1.3 dB max
Isolation Tx noise suppression	80 dB min
Isolation Rx	80 dB min
VSWR	1.5 : 1 max
Power rating	50 Watts
Temperature range	-40 to +80 degrees C

Duplexer RDU 150

Frequency range	138-174 MHz
Frequency separation	5 - 15 MHz
Insertion loss Tx to antenna	1.0 dB max
Insertion loss Rx to antenna	1.0 dB max
Isolation Tx noise suppression	60 dB min
Isolation Rx	60 dB min
VSWR	1.5 : 1 max
Power rating	50 Watts
Temperature range	-40 to +80 degrees C

Duplexer RDU 300

Frequency range	310-330 MHz, 355-385MHz
Frequency separation	5 - 15 MHz
Insertion loss Tx to antenna	1.0 dB max
Insertion loss Rx to antenna	1.0 dB max
Isolation Tx noise suppression	60 dB min
Isolation Rx	60 dB min
VSWR	1.5 : 1 max
Power rating	50 Watts
Temperature range	-40 to +80 degrees C

9.0 Pre Installation Checks

9-1 Unit verification

To verify unit operation before installing it in the field, certain functional tests can be done on the bench without requiring any testequipment other than an RF load, by placing the unit into **Techmode.** For techmode to work, the radio has to be configured as a Subscriber unit. Follow the instruction in the manual on how to configure the unit as a Subscriber.

Connect an RF load to the antenna terminal and connect a DTMF telephone to the modular phone plug at the front of the unit.

Go off hook and wait for a fast busy tone. (The fast busy tone will turn on because the unit will not be able to establish a connection without a Base unit.)

Dial #123 which places the unit into **Techmode**. (#123 is the factory default access code for Techmode)

Activate the transmitter by dialing *41. The Tx LED should turn on. Dial *40 to turn off the transmitter.
Dial *91 and hang up. The unit should go into current save mode (if activated) which is indicated by the on LED flashing at a one second interval. Approximately every 30 seconds the radio is also powered up.
Verify that the unit goes off hook when lifting the handset.
Enter Techmode again by dialing #123 and then *90 to turn off the current save mode.
Dial * 81 and hangup. The phone should ring for a few seconds..

To verify the receive and transmit frequencies, it is necessary to know the Programming Access Code (Factory default is set to #456). Go off hook and wait for the fast busy tone. Enter the Programming Access Code #456. Dial *71 and use the # key to scroll and view the stored receive frequency.
Dial *73 and use the # key to scroll the stored transmit frequency.

9-2 Link test bench setup

The following procedure describes how to setup a pair of radios on the bench to perform pre-installation testing.

To setup a link on a testbench, proceed as follows:

1- Identify the Subscriber and the C.O. units by the markings “Sub” or “C.O.” on a small sticker at the back of the radio.
The unit identity can also be established by uploading the personalities from a computer or by the switch positions on the controller board.

2- Make sure that the two units are a pair and match in frequency.

3- Connect 12 Vdc power to the units via the supplied power cable (red +, black -)
or, if the units are equipped with internal power supplies, plug them into the appropriate ac power.

Note: If the unit has an internal ac power supply, it can be operated from either ac or 12Vdc. If the unit has an internal 48Vdc to 12Vdc power supply, it will only operate from 48Vdc, it will not run on 12Vdc.

4- Connect a telephone with a modular connector to the front panel jack of the subscriber radio and a phone line to the modular connector on the C.O.

5- Connect a wattmeter or a dummy load to the antenna connectors of both the Sub and C.O. radios.

6- Ensure that there is at least two meters distance between the two radios to prevent stray RF signals from busying out the Sub unit.

8- Turn on the power switch of both radios. The green "on" lights should turn on.
If current saving has been enabled, the on light will be blinking at the rate of once per second, indicating that it is in current saving mode.

Important: All the other lights, in particular the yellow COR light on the Subscriber radio must be off. If any of the signal strength LED's are on, or if the yellow COR LED is on, it indicates that the units are too close together and are picking up each others signal. A busy tone will then be heard when going off hook at the Subscriber end and a connection cannot be established.
If this should be the case, the units must be physically separated to be further apart. If the COR LED is still on, then the squelch setting must be temporarily tightened. To do this, remove the top cover on the Subscriber radio. Turn the squelch potentiometer clockwise until the Yellow COR led goes off. (The squelch potentiometer is the one closest to the front panel. **Do not adjust the other** potentiometer which controls the maximum Tx deviation.)

After completing the bench tests, the squelch potentiometer will have to be reset to threshold squelch, otherwise sensitivity will be lost. To do this, turn off the C.O. unit. Rotate the squelch potentiometer on the Subscriber unit fully counterclockwise, the COR LED will turn on. While observing the COR LED rotate the potentiometer clockwise until the COR LED just turns off. Note the setting on the squelch potentiometer and increase the potentiometer 1/8 of a turn clockwise.
Turn off the Sub unit and repeat the above squelch setting procedure on the C.O.

9- Now place the Subscriber telephone off hook and the following should happen.

- The Sub should transmit and the Red Tx LED should turn on
- The Yellow COR LED at the C.O. should turn on indicating that the Sub units carrier is being received. (One or more of the signal strength LED's may also turn on, depending on the signal received)
- The C.O. should transmit and the Red Tx LED should turn on.

- Yellow COR LED at the Subscriber unit should turn on along with one or more signal strength LED's

- The connection is now made and dial tone should be heard at the Sub unit.

- Verify the operation by dialing a valid phone number and establishing a connection.

- To test the system the other way, dial up the C.O unit and the telephone at the Subscriber end should ring.

9-3 Installation

9-3-1Antenna Installation

The antenna should be mounted preferably on a tower or, where not possible, at least 3 meters off the ground or roof surface. The antenna elements should be aligned vertically and in the direction of the other radio.
Connect the the antenna cable to the antenna and use a rubber tape to make a water tight connection. A loop of approximately 20 cm should be formed and anchored to the antenna mast to prevent strain on the antenna connector.

A line of sight path should exist between the two antennas with no obstructions in the way. Obstructions near the antenna will cause a higher signal loss than obstructions farther away. If possible, units should be installed equal distance between a major obstruction such as elevation in terrain.
It should also be noted that obstruction losses at UHF frequencies are considerable higher (6dB) than at VHF frequencies.

9-3-2 Radio installation

The RT9000 should be installed in a dry area preferably away from electrical machinery emitting RFI/EMI noise.
The RT9000 can be mounted on a wall or on a 19 inch rack with the use of the Wall/Rack mount bar or can be placed on a level surface.
Connect the antenna cable to the UHF (or type N) connector and make sure the connection is tight. A loose RF connection can be the cause of system noise.
If the unit is not equipped with an internal AC power supply, connect the enclosed power cable to a 13.6Vdc power source, Red to + and Black to -.
Turn on the power and verify the display steps through indications of ‘FF’ , ‘AA’ , ‘00’.

Hints:

- If the display goes off after approx. 5 seconds and only the ‘On’ light blinks, it means the unit is in power save mode.
- If the unit turns off 30 seconds after going off hook, it indicates that diagnostics mode is turned on.

9-3-3 Outdoor installation

The RT9000 can be mounted out doors in a weather proof stainless steel housing. The outdoor housing has provisions for a backup battery which provides approximately 24 hrs standby autonomy with one hour transmitting.
For temperature considerations it is recommended to keep the output power to less than 3 Watts where the radio link is expected to be used continuously.

10.0 User Instructions

The RT9000 radio telephone provides normal telephone service like a regular telephone. However, there are a few differences between a wireline telephone and a Radio Telephone the user should note.

In a wireline telephone service, the telephone set is connected via a pair of telephone wires to the Telephone Exchange Switch which is connected to other Subscribers.

In a Radio Telephone service, a radio link replaces the wireline to the Telephone Exchange; One radio unit is connected to the Exchange and the other unit is connected to the Subscriber's telephone. During a telephone call, the two units are connected via a radio frequency and a normal telephone conversation takes place over the radio link.

Voice Security: Radio transmissions can be received by anyone having a receiver tuned to the same frequency as the Radio Telephone transmitter. Although the transmission of the Radio Telephone is highly directional towards the Central Office unit, it can be received by a sensitive scanner receiver. To safeguard against unauthorized eavesdropping, the RT9000 Radio Telephone incorporates a scrambler unit which can be activated by the user. The scrambler is normally not engaged but it can be activated once a call has been established. To activate the scrambler after a connection has been established, the user dials #*61. This will turn on the scrambler at both ends and provide a secure communication link. An audible double beep in the earphone indicates that the Scrambler has been activated,

To de-activate the scrambler, dial #*60 and a single audible beep confirms that the Scrambler has been de-activated. When going on hook, the radio system reverts to the default mode.

Trouble shooting

For a properly functioning radio link four things are required at the Subscriber location:

- An RT9000 Radio Telephone unit
- A yagi antenna
- A 12V dc power source
- Coaxial cable connecting the Radio Telephone to the antenna

If you encounter a problem with your Radio Telephone, run through the following checklist to verify proper operation.

Is the Battery charged ? The battery voltage should be at least 12Vdc when the telephone is off hook

Is the antenna connected ?

Is the unit turned on ? Check the green LED on the front panel, it should be on or it may be blinking if the current save mode is on. If the light does not turn on, check if the power cord is plugged in or, if the unit is battery powered, verify that the battery is charged.

Go off hook

The red transmit light should turn on and after approximately 1 second one or more of the LED's on the right side of the unit should also light up. If the red transmit light turns on and off again and you get a fast busy tone, it indicates that the transmission to the Central Office unit has failed. This could indicate a problem with the antenna or the antenna cable. It could also be caused by a low battery voltage. If the antenna and the battery check out OK, the problem may be at the central Office site.

If a slow busy tone is heard when going off hook, it indicates that the frequency is occupied by another user. If this happens frequently and if the telephone is not part of a partyline system, contact your telephone company.

12.0 Problem solving guide

Troubleshooting the RT9000 Radio Telephone is done by performing a number of tests to eliminate problems which can be field repaired; Either reprogramming, realigning the radio, or isolating the problem to a module which can then be replaced.

The following troubleshooting guide highlights a list of possible problems in bold letters and their logical investigation. In addition, a number of troubleshooting flow charts are designed to help the service technician isolate various problems.

12.1 Noise in handset

Possible causes
- Insufficient RF signal level causing noisy transmission
- Hybrid not balanced causing squeal
- Compander is activated only at one end causing noisy transmission
- Phone line grounded on one side causing hum

- If a squealing noise can be heard when lifting the handset, this could be caused by improper hybrid balance at the Sub or C.O radio or by excessively high line levels. Try balancing the hybrid by adjusting the hybrid balance potentiometer on the controller board to minimize the squeal. It may also be necessary to switch in different values of capacitors via the 4 position dip switch S2.
If the feedback noise still persists, reduce the Rx and Tx line levels on the controller board.

- If the transmission is noisy, this may be due to insufficient RF signal level. Check the signal strength LED's or the signal strength level on the display. A good signal level would be a reading of 7uV on the display or 3 signal strength LED's lit. If the received signal is weak, a better link quality may be obtained by turning on the companders. This can be done while the connection is made by dialing #*11 from the Subscriber phone. A double beep in the handset will confirm that the compander has been activated. To turn off the compander, dial #*10. A single beep confirms deactivation. To permanently activate the companders it is necessary to either perform a download via the RS232 or by programming both Sub and C.O. units from the handset. (See Programming the RT9000)

12.2 **FAX** operates only at low speed;

This could be due to a high Tx level, causing FM limiting of the amplitude modulated Fax signal. Try lowering the Tx line level by turning the line level potentiometer on the Sub and C.O. controller board counterclockwise 1/8 of a turn at a time.

12.3 Low Handset audio level

The subscriber Tx level is factory set to provide 3kHz deviation with 0dBm input and the Rx level is set for -4dBm output at 3 kHz deviation.
The C.O. Tx level is factory set to provide 3kHz deviation with -10dBm input and the Rx level is set for 0dBm output at 3 kHz deviation. These settings will provide unity gain from Sub to C.O and 6dB gain from C.O. to Sub.
These nominal factory levels may be readjusted to compensate for different exchanges.
If the handset audio level is deemed too low, it can be re-adjusted by the Rx line level potentiometer on the controller board. Turning the potentiometer clockwise increases the line level.

Note: When readjusting audio levels, care must be given to maintaining a good hybrid balance. If

levels are set too high, it is possible for the system oscillate due to excessive feedback.

12.4 Phone does not ring;

Possible causes:
- Ring circuit at Sub defective
- FSK frequencies out of alignment
- Ring detection circuit at C.O. defective
- Rx/Tx frequencies don't match

First test the Sub ring circuit by placing the Subscriber into Techmode by going off hook and dialing #123 (C.O. must be off for this test) Then dial *81 (ringback) and hang up. The phone should ring for a few seconds. If it does not ring, then the problem is with the ring circuit at the Subscriber.
To find out if the FSK communication is operational try to ring the Subscriber by shorting pins 4 and 5 of U 26 at the C.O. This should turn on the C.O. transmitter and Ring FSK should be sent to the Subscriber.
If the Subscriber phone rings this way, but does not ring when dialed from the landline, then the problem could be with he ring detection circuit of the C.O.
If the C.O. transmitter turns on by shorting pins 4 and 5 but the phone does not ring, check the COR light at the Sub. If it turns on while the C.O. transmits then the problem could be that the FSK tones are out of alignment.
If the C.O. transmitter turns on by shorting pins 4 and 5 but the Sub COR light does not turn on, the problem may be that the Rx/Tx frequencies for the Sub and C.O. don't match. Verify the programmed frequencies either by uploading the personalities to a computer or by checking the frequencies using Prog mode #456, then *71 and the # key to scroll through the receive frequencies and *73 and the # key to scroll through the transmit frequencies.

12.5 Phone rings intermittantly (or rings are missed)

Possible causes:
Improper programming of ring parameters *85 or *87
Ring voltage too low

This could be caused by improper programming of the ring parameters. Standard ring parameters are 2 seconds ring, 4 seconds pause. Standard contents of *85 are 12 and contents of *87 are 11.

12.6 Display Errors

Possible causes:
EEPROM corrupted
Battery voltage low

- Display blinks and shows EE; This indicates that the EEPROM has been corrupted and it will be necessary to reprogram the EEPROM by downloading personalities from a computer via the RS232 port. Although this does not normally happen, it is possible for the EEPROM to loose its contents after a high voltage surge resulting from a lightning strike.

- Display blinks and shows FE, This indicates a frequency error and the EEPROM may be corrupted. Verify the Rx/Tx frequencies by entering program mode #456, then check the Rx frequency by dialing *71 and scrolling through the frequency with the # key. Check the Tx frequency by dialing *73 and scrolling through the frequency with the # key.

12.7 Fault light is on

Possible causes: Receive VCO out of lock
Bad receive frequency programmed

12.8 Sensitivity is reduced when transmitter turns on:

Possible causes:
- Desensitization caused by a mistuned duplexer
- Bad ground contact
- Loose RF antenna connections

Retighten chassis screws, make sure that gaskets between chassis parts make good contact. Check antenna connections. Do not attempt to tune the duplexer unless the proper test equipment is available.

12.9 No RF power output

Possible causes:
- VCO out of lock due to out of range frequency programming
- Duplexer connections interchanged
- Bad coaxial connections

Place the radio into Techmode (#123 in Subscriber configuration) and turn on the transmitter (*41). If the Tx light does not turn on, it indicates that the VCO may be out of lock. Check the programmed Tx frequency either by uploading personalities from a computer or by entering Prog mod (#456) and checking the Tx frequency by entering *73 and scrolling with the # key.

If the Tx light turns on but there is no RF power, check the current drain. If the current goes up significantly when the transmitter is on but there is no power, check all the coaxial connections from the PA output to the Wattmeter. Check that the Rx/Tx cables at the duplexer are connected to the appropriate terminal.

12.10 Low RF output (2Watt PA)

Possible causes:
- DC input voltage low
- Duplexer not tuned
- Power setting potentiometer not adjusted
- PA output transistor defective

Try to readjust the output power with the power control potentiometer on the Tx main board. If it is already at maximum, check the power output directly out of the PA before the duplexer. If the difference in power before and after the duplexer is more than .5 Watt, it indicates a mistuned duplexer.
Check the dc input voltages for the PA driver and PA final amplifier. The dc voltage for the driver should be at least 12 volts when adjusted for maximum power and the final stage dc voltage should be at least 13.6 volts. If the dc input voltages are 12V and 13.6V respectively and the output power before the duplexer is less than 1.5 Watts it indicates a defective output transistor.

12.11 TECHMODE cannot be entered

Possible causes:
- Radio is not in Subscriber mode
- Unit is not squelched causing noise to interfere with DTMF tones
- C.O. unit is not turned off causing the Sub to connect
- Squelch breaking when going off hook causing the Sub to connect
- Antenna is not terminated into an RF load causing the squelch to break
- A signal is received from a signal generator interfering with DTMF tones

If difficulty is experienced placing the unit into techmode, verify that the unit is configured as a Subscriber and that the C.O. unit is turned off. When going off hook, a busy tone should be heard. If the busy tone is not present, it may be that the squelch was breaking slightly when going off hook. Tighten the squelch potentiometer and try going off hook again.
Alternatively the squelch may be opened fully until the COR light is on and then go off hook.
If a signal generator is connected to the antenna, turn of the modulation which otherwise may block the DTMF signal from the telephone.
Remove the bottom cover and check the off hook LED on the controller board. It should turn on when going off hook. If the off hook LED does not turn on, it could indicate a defective line power supply (check the 13.6V line at the 4.7 ohm resistor feeding the line power circuit) or it may also indicate a defective optocoupler IC U21. Swap optocouplers U18 and U21 to verify.

12.12 Link gets busy tone when going off hook:
Possible causes:
There are two busy tones generated. A slow busy tone indicating that the channel is busy (COR light is on at the time of going off hook), and a fast busy tone indicating that the communication with the C.O. unit has failed.
- If a slow busy tone is heard when going off hook, (channel busy) check squelch setting, check for interfering signals. When performing a bench setup make sure that the C.O. signal is not picked up through radiation leaks, to desensitize the receiver temporarily tighten the squelch control.
- If a fast busy tone is heard when going off hook, indicating communication failure, check RF frequencies for correct programming, check frequency of FSK tones generated (techmode *31,*51,*50), check sensitivity of receiver, check power output, check antennas.

12.13 COR LED is on when it should be off: If the COR LED is operating backwards it would indicate that the radio is programmed for CTCSS. (In CTCSS mode the COR logic is reversed) To restore it to normal operation, download personalities from a computer or enter Programming mode #456 (In Subscriber configuration) and turn off CTCSS Rx by dialing *81 and enter 00 into this location. Turn off CTCSS Tx by dialing *83 and enter 00 into this location.

12.14 Radio does not power up: If the display does not turn on when powering up the radio, it could indicate a blown fuse or that the crystal for the uprocessor is not oscillating. If a fuse is blown, carefully investigate the cause before inserting a new fuse. The most likely cause for a blown fuse would be in the power supply / ring circuit section of the controller board where higher currents are present.
If the display turns on during power up and then goes off with only the green on light blinking, it indicates that the radio is in current save mode. See current save mode on how to enable / disable current saving.

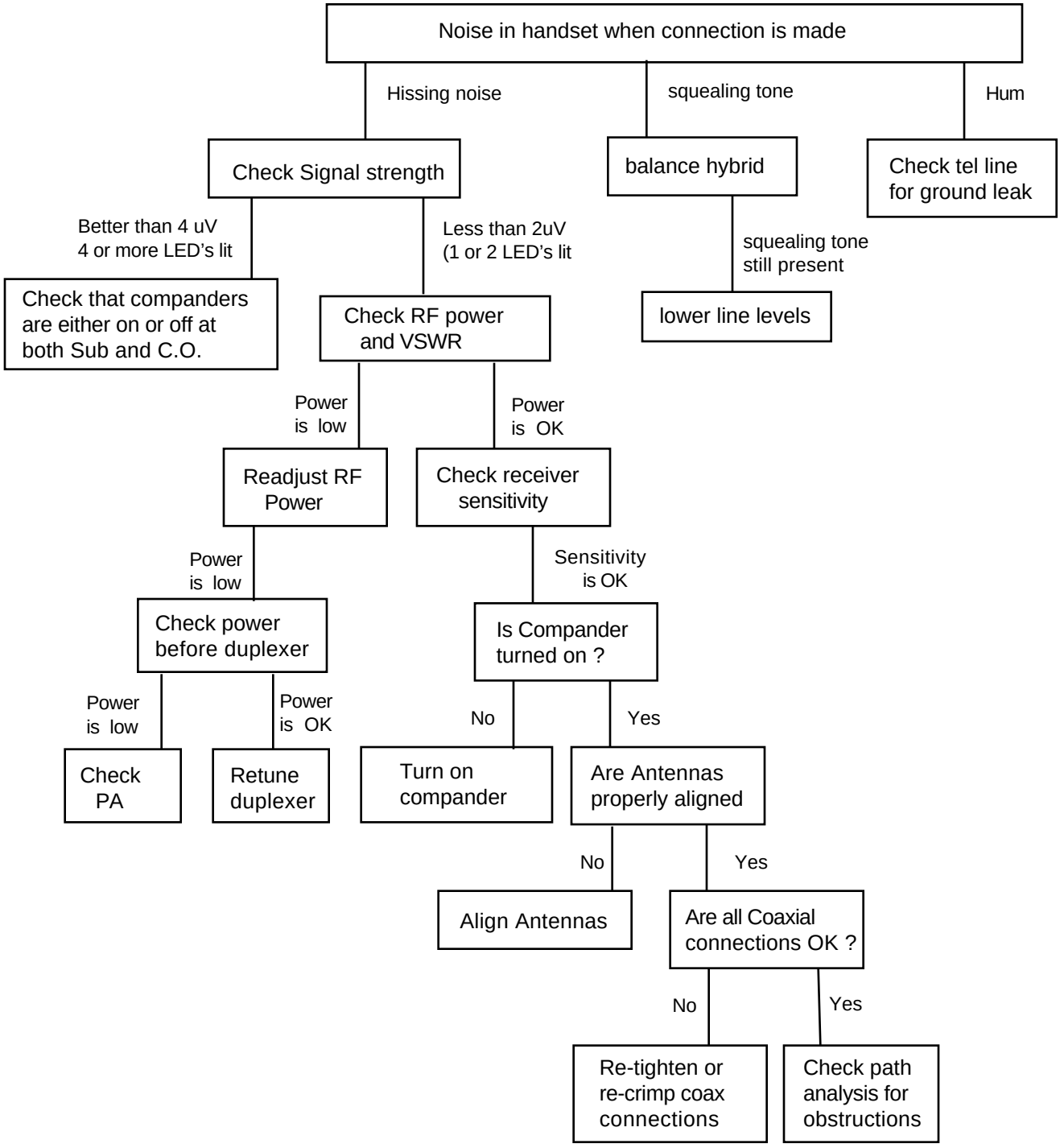
12-15 Additional trouble shooting suggestions

The first step in troubleshooting is to dentify which module is at fault. First try a different controller board. Make sure that a uprocessor and EEPROM are installed and that the EEPROM is programmed with the correct frequencies to match the duplexer.If the problem still persists, plug a different radio to the controller board interface connector.

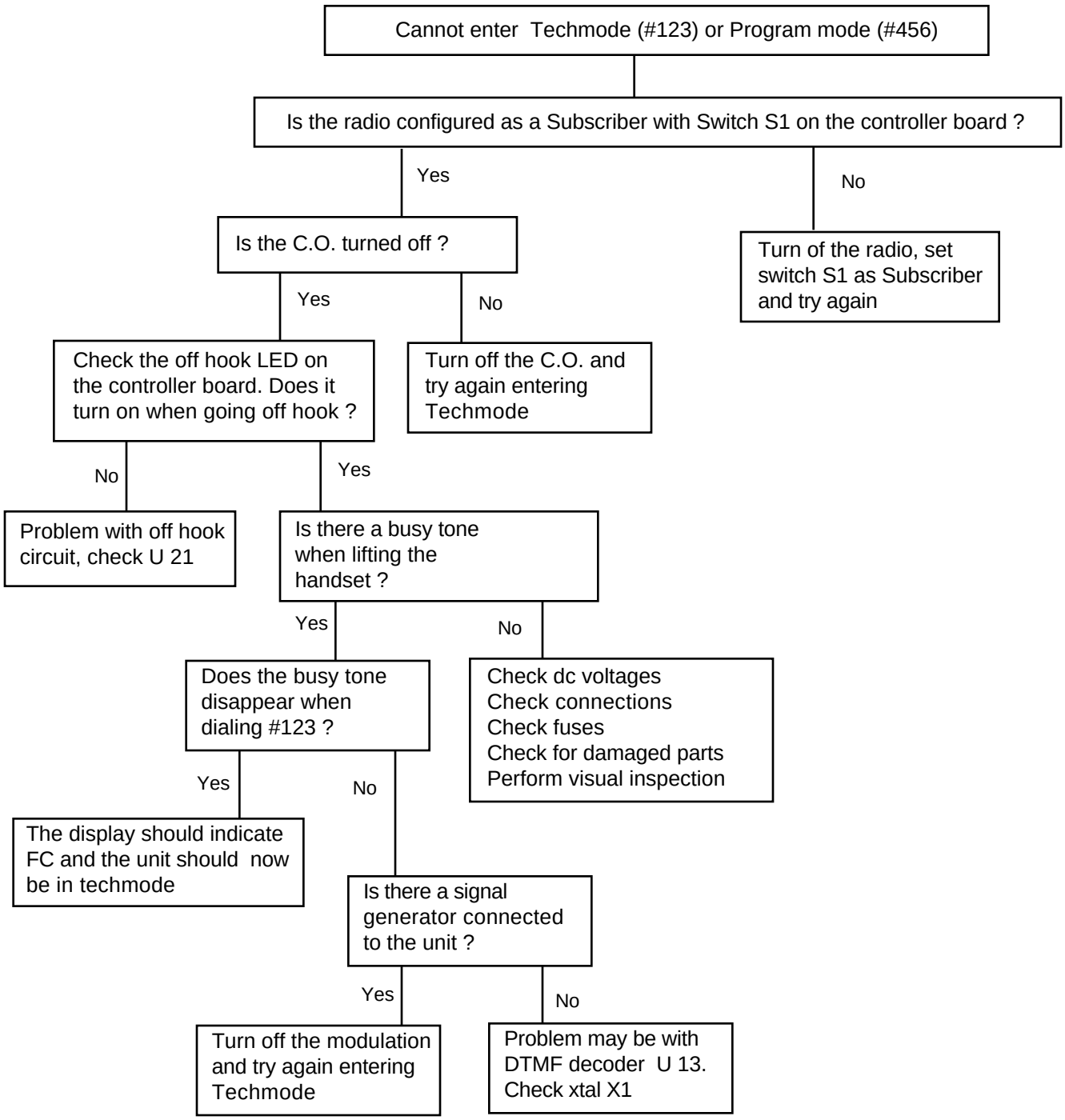
Make sure that the EEPROM is correctly programmed. Perform an upload and examine the information on the settings page.

If the output power is low, replace the PA module. When soldering a new PA module, take care to properly solder the six connections connecting the PA to the Tx main board.

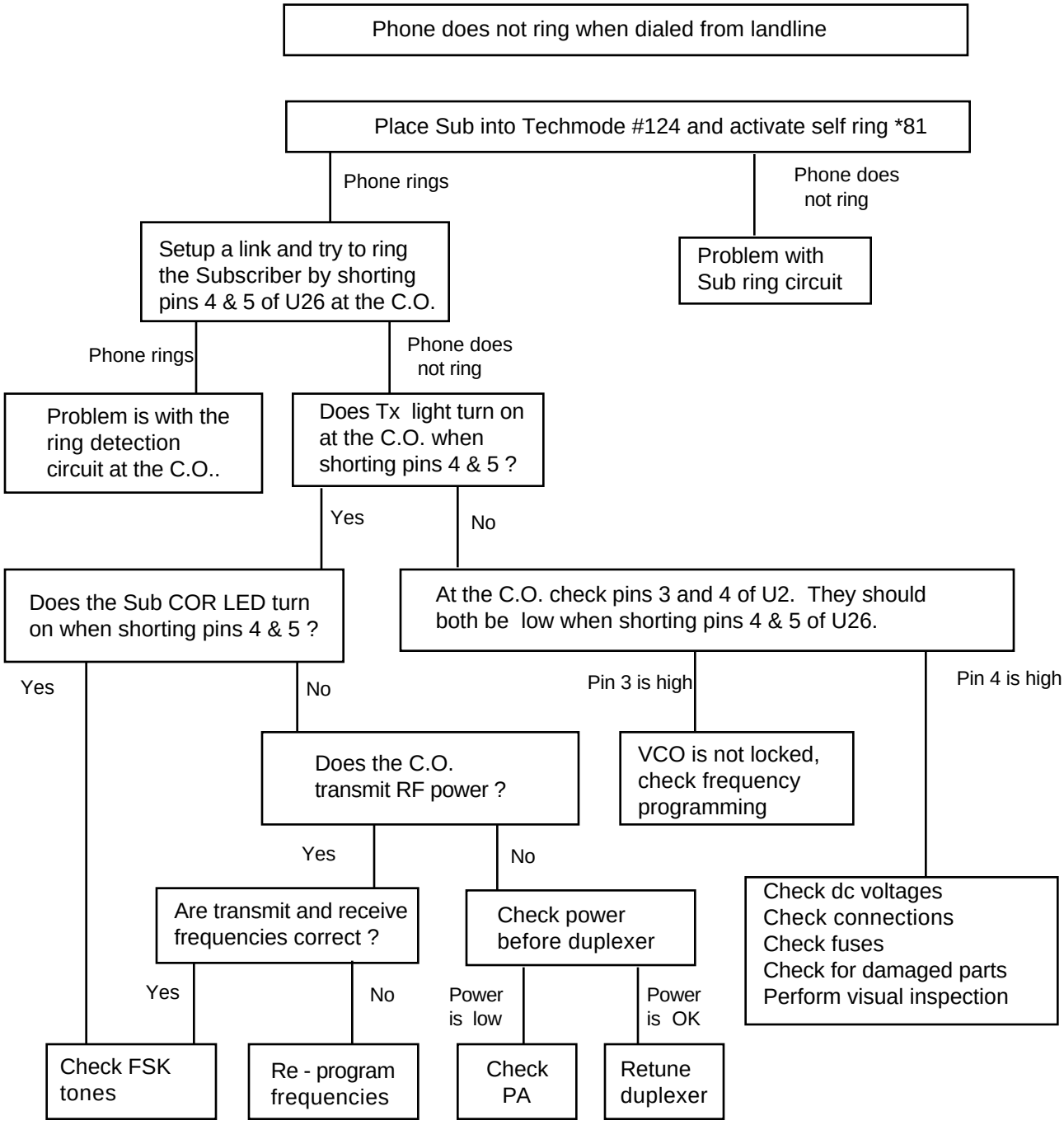
Noisy Connection



Cannot enter Techmode



Phone does not ring



No RF output (2W PA)

No RF output power (2 Watt PA)

Place Sub into Techmode #124 and activate the transmitter *41

Check if the red Tx LED is on ?

Yes

No

Increase the power adjust potentiometer on the Tx board for max. (CW)
How much power does the wat tmeter read at the antenna output ?

VCO is not locked, check frequency programming

Less than 1.5 W

More than 2 W

Check power directly out of the PA before the duplexer

PA is OK
Problem is elsewhere, Check antennas

No power

.5W - 1.2 W

More than 2 W

Check dc voltages on the middle two pins on the PA

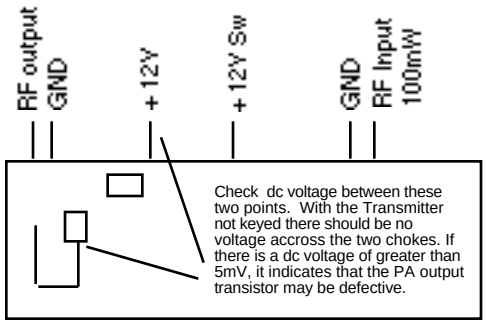
Retune duplexer

Voltage on one or both pins is less than 10V

Voltage on both pins is more than 10V

Check PA

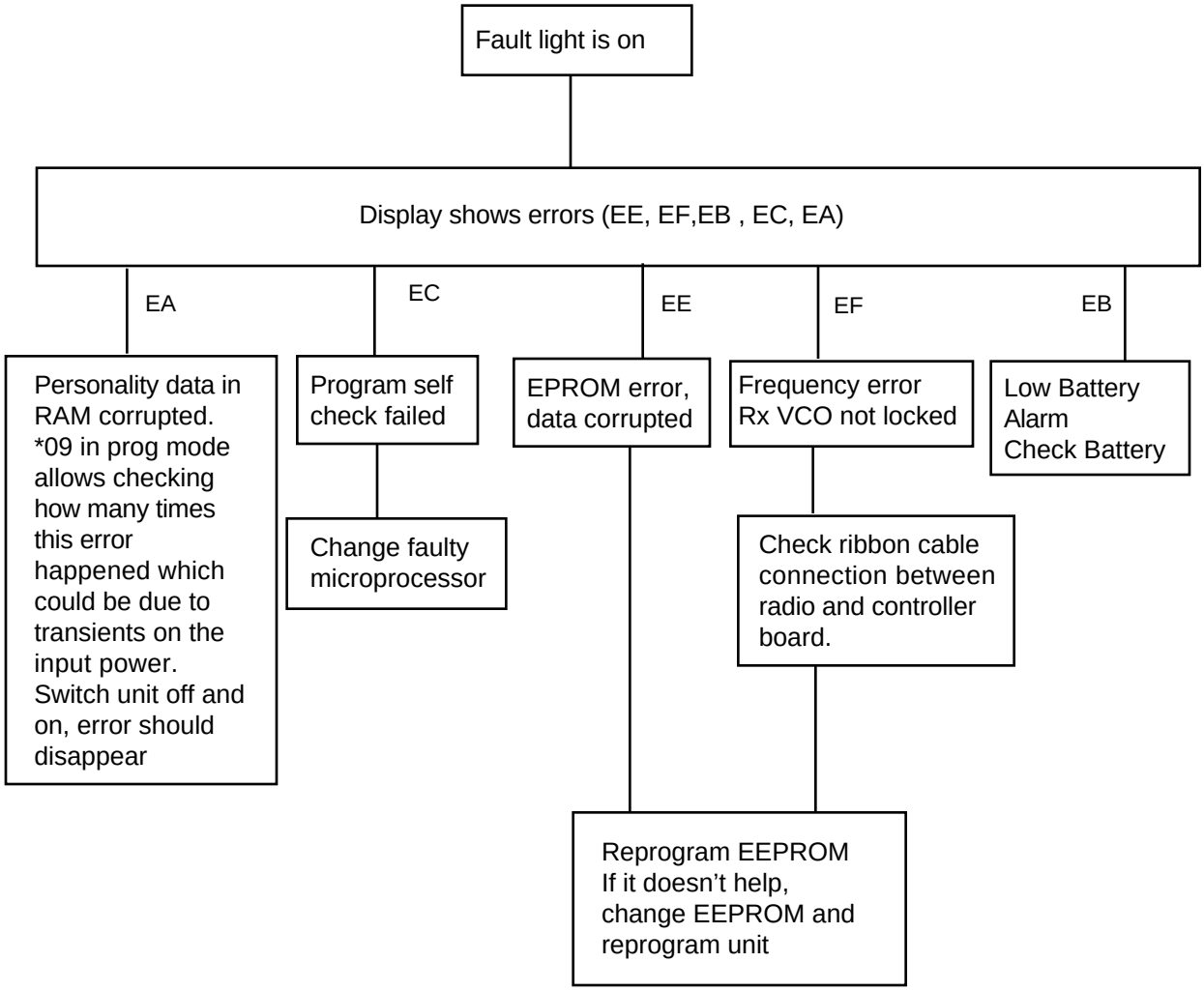
Problem is with Tx main board



Check dc voltages
Check power lead connections
Check fuses
Check for damaged parts
Perform visual inspection

There is a small possibility that the driver output is low. If a suitable RF meter is available you can disconnect the input to the PA (the last pin) and measure the driver output. It should be greater than 100mW. If the driver output is low then the problem may not with be the PA

Display errors, Fault light



VIV Partslists and Diagrams

14-1 Partslists

119-47-330	Antenna cable assy
119-47-332	Ribbon programming cable assy
119-47-337	Power switch cable assy
119-47-341	26 pin ribbon cable assy
119-47-343	Rx coax cable assy
119-47-344	Tx coax cable assy
119-47-345	6 foot power cable sssy
119-47-347	TCXO coax cable assy
339-47-437	Radio chassis assy
339-47-438	Rear panel assy
339-47-439	Radio frame assy
339-47-431	UHF duplexer assy
229-47-329	Controller board assy
229-47-335	Display board assy
229-47-348	UHF 3Watt power amplifier
229-47-349	UHF main Tx board
229-47-339	KW interface board
449-47-512	Radio Assy RT 9000
X57-4940	TK-860 UHF Radio parts list
X57-4950	TK-760 VHF Radio parts list

14-2 Schematic Diagram

631-27-133	ProgMode Quickguide (In front of Manual)
221-27-346	Schematic diagram Dual digit display board
221-27-350	Schematic diagram KW Interface board
221-27-357	Schematic diagram VCO
221-27-358	Schematic diagram UHF main Tx board
221-27-361	Schematic diagram UHF 3Watt Power Amplifier
221-27-363	Schematic diagram UHF 10W transmitter
221-27-364	Schematic diagram alarm board
631-27-127	Connection diagram DB-15 to 16 pin header cable assy
631-27-128	Connection diagram DB-15 to DB-9 programming cable assy
631-27-129	Connection diagram repeater cable
631-27-132	Component layout Main Controller board
221-27-367	Schematic diagram Repeater interface for party line
221-27-368	Schematic diagram Repeater cable for party line
999-99-999	Location of System level adjustments
999-99-999	Location of radio adjustments
221-27-366	Schematic diagram KW 760 VHF Rx/Tx 20W
631-27-130	Component layout KW 760 VHF Rx/Tx 20W
221-27-362	Schematic diagram KW 860 UHF Rx/Tx 20W applies to 406-420MHz, 450-470MHz, 315-330MHz, 355-385MHz
631-27-131	Component layout KW 860 UHF Rx/Tx 20W applies to 406-420MHz, 450-470MHz, 315-330MHz, 355-385MHz
221-27-345	Schematic diagram 4 Line Extender
221-27-348	Schematic diagram Controller board