TYPE OF EXHIBIT:	OPERATIONAL DESCRIPTION
FCC PART:	2.1033 (c) (3)
MANUFACTURER:	RITRON, INC. 505 West Carmel Drive Carmel, IN 46032
MODEL:	SST-144
TYPE OF UNIT:	VHF-FM Handheld Transceiver
FCC ID:	AIERIT13-144
DATE:	May 18, 2001

Included in this exhibit are the operating instructions and theory of operation for the SST-144.

The operating instructions and theory of operation included in this exhibit are excerpts of the Maintenance and Operating Manual for RITRON Model Patriot SST-144 VHF-FM Handheld Transceiver. The complete Maintenance and Operating Manual is included in this application for Certification as a separate exhibit.

Signed: Kevin G. Matson

Kevin G. Matson - Project Engineer

DESCRIPTION OF CONTROLS AND CONNECTORS

Antenna

The flexible antenna radiates and receives radio signals. Before using the radio, be sure the antenna base is threaded fully into the radio's antenna bushing.

Use only the antenna(s) available from RITRON for the SST-144. Do not attempt to substitute with any other antenna.

On/Volume Up

This button switches on the radio, then increases the volume if you continue to press.

Volume Down/Off

This button decreases the volume, then shuts off the radio if you continue to press.

Push-To-Talk

The PTT activates the transmitter, and must be held down while you talk into the microphone. Release the PTT button to receive.

Channel Selector

Pressing this button selects the next channel. When the maximum number of channels is reached and you press this button, the radio resets to channel 1.

Audio Accessory Jack

This jack connects speaker audio to optional accessories, such as a remote speaker/ microphone or an earphone. For accessories that have a two-plug connector, the smaller plug is inserted into the charge jack.

This jack is also used to program the radio using the optional PC programming kit.

Charge Jack

The battery may be charged through this jack using a standard RITRON wall socket charger cube. This jack also connects microphone audio to the optional remote speaker/microphone.

Microphone

The microphone converts your voice into electrical impulses, which are carried with your broadcast to receiving radios. Hold the radio about four inches away and talk into the microphone while transmitting. Shouting does not improve the listener's reception.

Speaker

The speaker allows you to hear calls on your channel.

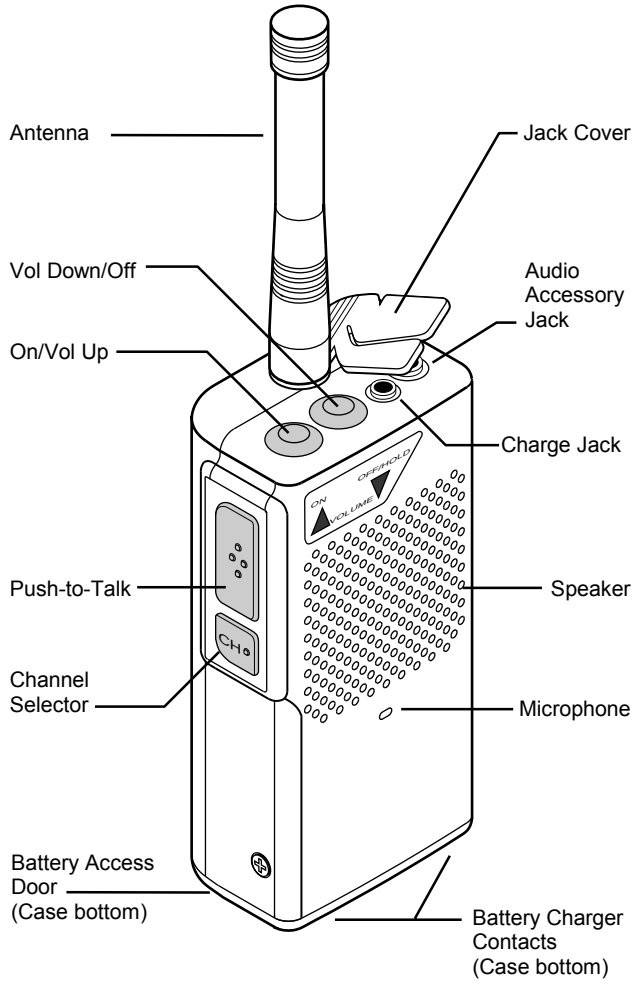

Fig. 2 Controls and Accessory Connectors

Jack Cover

This rubber cover seals out dust and moisture, etc. Snap the cover into the audio accessory and charge jack openings when the jacks are not being used.

Battery Access (Case Bottom)

The battery door on the case bottom may be removed to access the battery. (Refer to the Battery Replacement section of this manual.)

Drop-in Charger Contacts (Case Bottom)

Two charger contacts in the bottom of the SST-144 radio case allow the battery pack to be charged using an optional RITRON drop-in charger (model BCC-PS.)

RADIO OPERATION

On-off/Volume

To switch on the radio - press the On/Volume Up button. The radio will beep a number of times equal to the current channel number.

To adjust the volume - press the volume up button until you reach the desired level. You should hear noise and any broadcasts on the channel.

To turn off the radio - press and hold the Off/Volume Down button until two tones sound.

To determine whether the radio is on - press the volume down button. If the radio is on, noise or activity on the channel is heard.

Receive

To hear calls from other users - adjust the volume as desired. The radio can receive broadcasts while the Push-To-Talk button is not being pressed. Whether or not you hear these broadcasts depends upon the squelch settings.

There are two types of squelch used in the SST-144 portable. First is carrier squelch. This lets you hear all broadcasts on your channel strong enough for the radio to detect, and silences noise. Second is one of the selective signaling or “tone squelch” formats available on the SST-144. This allows you to screen out “on-channel” broadcasts that do not carry the correct code programmed for the radio.

Note: It is possible that the beginning of a call might be missed while the radio is in battery saver mode. If this happens, ask the caller to repeat the message.

Selective Signaling Squelch

To activate tone squelch - simultaneously press both of the volume buttons. Hold for a second or two before releasing. When tone squelch is turned on, the handheld sounds one beep. When carrier squelch is on, the radio emits a "double beep."

Note: If you continue to hold down the volume buttons after the beep (or double beep), the radio will start beeping repeatedly. This means that squelch is turned off. Release the buttons. To restore squelch, press and hold both of the volume buttons until the radio sounds a beep or double beep.

Monitor

To monitor the channel - press one of the volume control buttons. When you press the volume up or the volume down button, squelch turns off and all radio traffic on the channel (and noise) sounds in the speaker.

Battery Saver

The handheld has a programmable "battery saver" feature that conserves battery power. The battery saver constantly checks the radio's transmitter, receiver and controls for activity. If a number of seconds pass without the receiver detecting a call, and without the user operating a control, this feature removes power from most of the radio.

During this "off-time," any activity restores full power. Every few fractions of a second, the battery saver applies power to the receiver, checking for broadcasts. It is possible that the first part of an incoming call might go unheard before activity is detected and power restored. If this happens, the caller can repeat his message. Once "radio contact" is made, normal unhurried conversation can follow.

Transmit

Normally, you should not transmit until no one is talking on the channel.

To transmit - hold down the Push-To-Talk button and with the radio four inches away talk into the microphone. Speak in a normal tone, since talking louder will not improve the listener’s reception.

Channel Selection

To change channels - press and release the Channel button. The radio will beep a number of times equal to the current channel number. Pressing the Channel button again will increment the channel and the radio will beep the new channel number. For example, if you select channel 2, the handheld will beep twice. If the highest channel number is selected and you press the Channel button, the radio will reset to channel 1. A one-channel radio will beep only once when you press the Channel button.

WHAT THE RADIO TONES MEAN

The handheld responds to certain instructions by sounding a beep or series of tones. These tones can tell you whether the radio is working as you expect.

Power On/Self Check "OK"

When it is first turned on, the radio runs a quick "self test" to confirm basic functions. The radio then beeps the number of times equal to the channel number selected. The radio is then ready to use.

Error Tones

However, if the "self test" detects a diagnostic error, an error tone sounds. Alternating tones (the second is longer and lower pitched) indicate the radio frequency synthesizer is malfunctioning. Turn off the radio and try again. A long, low-pitched tone means the battery voltage is too low to operate the radio. In this case, recharge the battery. If you cannot correct a problem, consult an authorized Ritron service facility or Ritron.

Channel Select

When the Channel button is pressed, the radio beeps a number of times equal to the current channel number. Pressing the Channel button again will increment the channel and the radio will beep the new channel number.

Tone Squelch

When you press and hold both Volume buttons at the same time, a single beep will sound to indicate that tone squelch is on. A "double beep" means that carrier squelch is on.

Recharge Battery Alert

As the battery voltage approaches the minimum required "operating voltage" the radio will emit a short beep every minute to alert the user that the battery will soon need recharging. Once the battery charge drops below the required "operating voltage," the radio emits a long, low tone and turns itself off. If you turn the radio back on, it will beep again and shut itself off. Recharge the battery.

OPTIONAL RADIO TONES

The SST-144 can be programmed using the RITRON PC Programmer for optional alert tones.

Receive Squelch Tone

A short tone sounds at the end of each received transmission to indicate that you may transmit.

Busy Channel Transmit Inhibit

If a user is transmitting on your radio frequency without your tone, you will not be allowed to transmit. The radio will beep a series of long, low tones while the PTT is held down (like a busy signal).

Transmitter Time Out

A low tone followed by a higher-pitched tone sounds and the transmitter automatically shuts off if you hold down the PTT button longer than the programmed Time-out. The radio automatically switches to receive mode. Authorized service personnel can turn off this feature.

BELT CLIP INSTALLATION

If you are going to attach the belt clip to the handheld, follow these instructions:

1. The belt clip is fastened to the radio case back with the Philips head screw provided. Use the screw included, since a longer screw might damage the radio's electronics.

   Do not use petroleum solvents of any kind on the radio. These can corrode the case.

2. Place the belt clip on top of the radio case back, with the screw hole in the aligned with the hole in the radio case.

3. Using the screw that came with this accessory, attach the clip to the radio.

TROUBLESHOOTING

If you have trouble operating the handheld, review the radio controls and operation sections. If you think the radio is malfunctioning, check the following table.

GENERAL

The radio does not work at all.

- Make sure the battery is installed correctly, as shown in FIG-1.
- Recharge or replace the battery. (See note 1.)

Operating features do not work exactly as expected.

- The radio has been factory or dealer programmed for customized operation.

Reception is poor.

- Move to a different location. (Note 2.)
- Confirm that the proper antenna is connected to the radio. (See p. 11, "Antenna.")

You cannot hear calls from other radios.

- Turn off tone squelch. (See Note 3.)
- Be certain your radio receives on the same as the caller transmits. (Note 4.)
- Recharge the battery. (Note 1.)

Your calls cannot be heard in other radios.

- Make sure that your radio transmits on the receive frequency of the radio(s) you want to call. (Note 4.)
- Recharge the battery. (Note 1.)

TONE CODED SQUELCH

You cannot screen out calls from users outside of your tone group.

- Make sure the channel is programmed with tone squelch.
- Activate Tone (coded) squelch. (Note 7.)

You cannot hear Tone coded messages while in Tone (coded) squelch.

- Confirm that the channel is programmed to detect the same code as the calling radio(s) transmits. (Note 7.)

Others in your tone group cannot hear your tone coded messages.

- Verify that you transmit the same code as the radio(s) you call are programmed to detect. (Note 7.)

ERROR TONES

An error tone sounds when the radio is first turned on.

- Replace the battery. (Note 1.)
- See "Error Tones" in the Operation section.

An error tone sounds while you are talking. (and the transmitter shuts off).

- Refer to “Error Tones”

BATTERY

The battery loses its charge sooner than expected.

- Review the battery charging instructions.
- Conserve the battery. (Note 5.)
- If the radio is used in extreme cold, warm the radio under your coat. (Note 6.)

Notes

1. Try a battery pack from a working radio. If the radio in question works with that pack, the original battery is suspect. Charge the suspect battery as recommended in this manual. Then, if the charged original battery cannot power the handheld, try charging again with another charger. If the battery still doesn’t hold a charge, the pack should probably be replaced. However, if the battery appears to be good after you try the second charger, the first charger might be faulty. If you think that an accessory is not operating properly, contact your dealer or RITRON. (Radio accessories come with a 90-day limited warranty.)
2. Reception can often be improved by moving a short distance. This effect is more noticeable inside of buildings. The range of these portables equipped with a standard battery pack is about two miles (line-of-sight).
3. If your radio does not detect calls from other radios on the channel, turn off tone squelch. (Press both Volume buttons at the same time - a double beep means that tone squelch is off.)
4. If you want to hear a call, you must select a channel that is programmed to receive the caller’s transmit frequency. If you want to call another unit, you must select a channel that is programmed to transmit the other radio’s receive frequency. However, if you use a repeater, your channel must be programmed to work with the repeater’s transmit and receive frequencies. (A radio channel can hold two separate operating frequencies, one for Receive, the other for Transmit.)
5. Maximum power drain occurs while the radio transmits, so don’t hold down the Push-To-Talk button more than necessary. Battery power is used while the handheld is left on to receive calls. If practical, switch off the unit.
6. In extreme cold, a battery’s charge capacity is greatly reduced. If you use the radio in very cold weather, periodically warm the portable underneath your coat if possible. An optional remote speaker/microphone would allow you to keep the radio under your coat while transmitting and receiving.
7. In order for radios to communicate using Quiet Call, they must be programmed with the same tone code. Each code is unique, and your radio will respond only to the code programmed. Press and hold both volume buttons at the same time. A single beep means that tone squelch is on. A double beep means that tone squelch is off.

INTRODUCTION

The SST-144 is a four-channel handheld transceiver built on a single multi-layer printed circuit board. Both sides of the main printed circuit board are populated with components, with the bottom side containing only surface mounted components.

The SST-144 is frequency synthesized, with all functions of the radio controlled by microcontroller.

POWER SUPPLY AND VOLTAGE DISTRIBUTION

The SST-144 is powered by an internal 6-cell rechargeable battery pack. The battery pack supplies power to the radio via two contact terminals that are connected to the PCB through P302. F301 is a 3A fuse in series with P302 for short circuit protection. The battery pack may be charged through 2.5 mm charge jack J301 via CR302 and F301. Zener diode CR301 prevents the batteries from discharging through the charger accessory, stops a reverse voltage from being applied to the battery pack through J301, and prevents a high voltage from being applied to the radio circuitry.

SW301 ON/VOL UP switch is pressed to turn on the SST-144, turning on voltage pass transistor Q304 via R302 and CR303. Q304 supplies power to IC309, a +5 VDC regulator used to power microcontroller IC301. Pin 13 of IC301 turns on Q303, which keeps Q304 turned on after SW301 has been released. Power is removed from the SST-144 by pressing the VOL DN/OFF switch SW302 until a beep is heard from the speaker, at which time Q304 is turned off.

+5 VDC regulator IC309 supplies power directly to microcontroller IC301, bilateral audio gates IC304, reference oscillator Y302, synthesizer IC401, and PTT detect transistor Q302.

The T/R output at Pin 11 of IC301 lets Q101 switch the regulated +5 VDC to the receiver. Pin 11 of IC301 will also turn on Q202, which turns on voltage pass transistor Q201. With Q201 emitter connected to the +VBATT battery supply, the collector output is connected to the emitter of Q202 through voltage divider R202/R203, whose values are selected to limit the TX+V voltage to +6 VDC.

Power Strobe

The SST-144 handheld includes a power strobe feature, which reduces battery current drain by periodically removing voltage from part of the radio. The strobe off cycle time is programmable using the PC Programming Kit. The +5V SW power strobe output at Pin 10 of IC301 controls Q306, which switches the regulated +5 VDC to the audio processing circuitry and the synthesizer circuitry. This includes IC303A 2.5 VDC (Vag) for bias on audio processing circuitry, IC303C audio high pass filter, IC308 and IC305A audio low pass filter for sub-audible frequencies, IC305B audio limiting amplifier, IC306 digital potentiometers, IC303B audio summing node amplifier, and IC303D audio low pass filter.

Low Battery Voltage Detection

Battery voltage is measured at A/D input Pin 16 of IC301 through voltage divider R303/R305. The radio will emit a periodic beep if low battery voltage is detected, and will turn the radio off if the battery voltage drops below +5 VDC. This is to protect the microcontroller and its EE memory from corruption due to low supply voltage.

REFERENCE OSCILLATOR

Reference oscillator Y302 is a 1.5 ppm temperature controlled, voltage controlled oscillator (TCVCXO) operating at 14.4 MHz. The Pin 4 output of the TCVCXO provides a reference for the frequency synthesizer IC401 at Pin 20. IC401 is programmed to provide an output at Pin 1 that is ¼ of the reference (3.6 MHz), which is applied as a reference oscillator to Pin 27 of IC301 microcontroller. The Y302 pin 4 output is also multiplied up to 43.2 MHz by Q105 and its associated circuitry to provide a receiver 2nd local oscillator signal.

SYNTHESIZER

The SST-144 radio is built around a common phase-locked loop (PLL) that consists of a voltage-controlled oscillator (VCO) and a frequency synthesizer. The PLL generates both the receiver 1st local oscillator and transmitter carrier signals. Control signals from microcontroller IC301 and Reference oscillator Y302 are routed to frequency synthesizer IC401 per the following chart:

Pin Numbers

	IC301	Y302	IC401
Clock	12	-	18
Data	5	-	19
Latch	20	-	17
LD	12	-	2
T/R SW	11	-	-
REF IN	-	4	20
REF OUT	27	-	1
+5 SW	10	-	12
+5V	1, 15, 28	2	5, 14

Q404, CR401, C414 and associated components provide a filtered supply for the VCO oscillator and buffer amplifiers.

Prescaler Divider / Synthesizer Controller

IC401 contains both a prescaler and synthesizer controller. The prescaler squares and divides the VCO output present at pin 11 by either 64 or 65, determined by a synthesizer controller logic signal. The exact number of times the prescaler is instructed

to change divisors is determined by the channel frequency.

IC401 contains a digital phase detector that works as follows: when an operating channel is changed or the receive/transmit mode switched, a new synthesizer operating frequency is selected. Microcontroller IC301 clocks new data into IC401 internal buffer in synchronization with clock pulses. The channel information is stored in EE memory of IC302 and is loaded into RAM when the channel is selected.

Once new data is loaded into the buffer, a single pulse from IC301 appears at IC401 to instruct the synthesizer controller to latch and execute the new data. IC401 utilizes internal circuitry to determine whether the present VCO output frequency is correct by comparing the phase and frequency of the VCO signal at Pin 11 to the 14.4 MHz reference oscillator at Pin 20. IC401 produces an output signal at Pin 6, a single-ended phase/frequency detector output, proportional to the phase difference between the two input signals.

The loop filter C429, C427, R419, R420, R418, and C426 transform the Pin 6 output signal to a DC voltage for application to the VCO tuning varactor CR402. The synthesizer system is “locked” when the phase and frequency of both the reference and the divided VCO signal are the same.

The maximum amount of current this output can sink or source is determined by the value of R421 tied to Pin 8 of IC401, with the output current programmable to 25, 50 or 100% of maximum.

VCO / Buffer Amplifiers

Q403, L401, L406, CR402 and associated components form the VCO (Voltage Controlled Oscillator), a resonant circuit that oscillates at frequencies from 150 MHz in transmit to 205 MHz in receive (receive frequency + 43.65 MHz) to. Varying the voltage at CR402 changes the varactor capacitance, which in turn alters the VCO output frequency.

When in receive mode a +5 VDC T/RSW signal is applied to Q406, which turns on Q405 to draw current through pin diode CR404 and L403. With CR404 biased on, L402 is effectively shorted to ground, shifting the VCO frequency up 43.65 MHz.

Q401 and Q402 are buffer amplifiers, with Q401 feeding in the input of the synthesizer at Pin 11, the receiver 1st local oscillator and the transmitter pre-amplifier.

Oscillator Modulation

When the SST-144 is in transmit, modulation balance control IC306E passes TX audio through to the VCO modulation input at R416. TX audio is applied to varactor CR403 to modulate the VCO. TX audio is also routed to the Pin 1 input of TCVCXO reference oscillator Y302. Low frequency tones modulate the reference oscillator because the synthesizer is not able to track them.

DIGITAL POTENTIOMETERS

IC306 contains 6 digital potentiometers programmed by IC301, sharing the same clock and data outputs used by the synthesizer and a separate Digital Pot Latch signal from Pin 8. The digital potentiometers are used in conjunction with IC303B, a summing node amplifier used for modulating the VCO and reference oscillator. IC306A, B, D, E, and F can only be changed through serial programming, and can only be performed by an authorized licensed RF technician.

IC306A is connected through R352 to the Pin 6 input of IC303B. IC306A adjusts the DC output of IC303B to tune the reference oscillator frequency.

IC306B is connected to the Pin 2 Gate control of RF power transistor Q203 to adjust transmitter power output.

Volume control IC306C applies the processed voice band signals at IC303D to audio amplifier IC307 when in receive mode. Depressing the ON/VOL UP switch SW301 increases the setting of IC306C while VOL DN/OFF switch SW302 decreases it.

Transmitter tone deviation control IC306D applies the output of the selective signaling low-pass filter IC308 to the Pin 6 input of IC303B through R350. IC306D is completely closed in receive mode.

Transmitter modulation balance control IC306E is used to apply the Pin 7 output of IC303B to the VCO modulation input. This will set the ratio of the modulating signal applied to the VCO and the reference oscillator. IC306E is completely closed in receive mode.

Transmitter voice deviation control IC306F applies the processed voice band signals at IC303D to the Pin 6 input of IC303B through R349. IC306F is completely closed in receive mode.

RECEIVER

As mentioned before, Q101 switches the regulated +5 VDC to the receiver. The +VRX receiver voltage is switched at the strobe duty cycle if programmed for power strobe.

RF Amplifier

A received signal from the antenna passes through a low-pass filter (L207, C218, C217, L208, C219, and C222) to the receiver headend. L101, L103, and the associated capacitors form a bandpass filter ahead of low-noise RF amplifier Q102. The amplified RF signal is applied to a 2-pole bandpass filter consisting of L104, L105, and associated capacitors.

1st Mixer

The amplified received input signal is applied to the gate of FET mixer Q103. The 1st local oscillator signal from the synthesizer module is applied to the source of Q103. L106, C117 and C118 tune the drain output of Q103 to 43.65 MHz and apply it to YF101, a 43.65 MHz two-pole crystal filter. Q104 and associated components amplify the 43.65 MHz IF signal and apply it to the input of the 2nd mixer at Pin 16 of IC101.

FM Receiver Subsystem

A multi-function integrated circuit, IC101 and associated components for the FM-receiver subsystem. The subsystem performs the following functions: 1) 2nd mixer, 2) 2nd IF amplifier, 3) FM detector, and 4) noise amplifier.

The Pin 4 output of 14.4 MHz reference oscillator Y302 is multiplied up to 43.2 MHz by Q105 and associated components. This signal is applied to the 2nd local oscillator input at Pin 1 of IC101. The 43.65 MHz signal at Pin 16 and the 2nd local oscillator are mixed, with the resulting 450 KHz output signal appearing at Pin 3. This signal is filtered by a 450 KHz 6-pole ceramic filter YF102 and applied to the input of the limiting IF amplifier at Pin 5. IC101 Pin 6 is the de-coupled input to the IF amplifier, Pin 7 the limited IF output signal. An internal quadrature detector, whose center frequency is determined by 450 KHz quadrature coil T101, detects the FM IF signal. One input of the quadrature detector is connected internally to the IF signal at Pin 7, while the other input is the phase-shifted signal from T101 at Pin 8.

Demodulated audio appears at Pin 9, where a low-pass filter (R114, C130) removes spurious quadrature output prior to application to the voice/tone conditioning audio circuitry. Demodulated audio from Pin 9 is applied to the Pin 10 input of a noise filter/amplifier consisting of R112, C123, C124, R110, R111 and R113. The Pin 11 output of the noise amplifier is applied to a biased noise detector CR103, with the output connected to an A/D input of IC301 at Pin 19. The SST-144 is serial programmed to set the squelch threshold and hysteresis.

Voice / Tone Conditioning in Receive Mode

SST-144 audio conditioning filter circuits are shared with the transmitter. The same high-pass filter/amplifier (IC303C and associated components) used in receive voice band conditioning is used in the transmit band. Similarly, the low-pass filter (IC308 and associated components) used for selective signal tone decode filtering is also used for selective signal encoding. Altering circuit configuration with bilateral switches IC304A, B and C permits the use of the same audio filtering system for both transmit and receive modes.

After R114 and C130 remove the 450 KHz element from the demodulated audio output at Pin 9 of IC101, C333 couples the audio signal to bilateral switch IC304C for subaudible tone detection and connection to IC304A for voice band audio processing.

Voice Band

Bilateral switch IC304A passes the received audio signal to the input of IC303C, which along with its associated components for a high-pass filter/amplifier circuit that attenuates audio signals below 300 Hz.

The output of IC303C is applied to the input of IC305B limiting amplifier. Bilateral switch IC304B is switched in receive to insert C351 into the feedback circuit of IC305B, providing de-emphasis of the received audio signal. Bilateral switch IC304B also removes R335 from the Pin 6 input to reduce the gain and prevent limiting.

The output from IC305B is applied to the input of IC303D, which along with its associated components form an 18dB/octave low-pass filter for frequencies above 3000 Hz.

The output of IC303D is connected to IC306C volume control prior to connection to audio amplifier IC307. The output of IC303D is also connected to IC306F voice deviation control, which is completely closed in receive mode to prevent received signals from modulating the VCO and reference oscillators.

Audio frequency tones from Pin 24 of microcontroller IC301 are applied to the Pin 6 input of IC305B to provide the SST-144 alert tones.

Sub-Audible

Bilateral switch IC304C passes the received audio signal to the input of IC305A, which amplifies the signal and applies it to the Pin 2 input of IC308, a 5-pole low-pass filter that attenuates frequencies above 250 Hz.

The output at Pin 5 is applied to an A/D input of IC301 at Pin 18 for tone decoding. An internal digital signal processing routine programmed into microcontroller IC301 is used to decode the correct selective signaling code. The output at Pin 5 of IC308 is also connected to tone deviation control IC306D, which is completely closed in receive mode to prevent received subaudible tone signals from modulating the VCO and reference oscillators.

Audio Amplifier

Receive audio from volume control IC306C is applied to the Pin 2 input IC307, a 1 Watt audio amplifier. C365 couples the Pin 5 output to the internal 8Ω speaker SP301 via audio jack J303.

Microcontroller IC301 Pin 22 switches DC power to the audio amplifier by turning on Q307, which then turns on pass transistor Q308 to apply battery voltage to Pin 6 of the audio amp. CR307 prevents an inadvertent DC voltage at J303 from damaging the audio amplifier.

ANTENNA SWITCHING / LOW PASS FILTER

A low-pass filter comprised of filter L208, C222, C219, C218, C217, L207, and C220 removes harmonics from the transmitter output before applying the RF signal to the antenna. Received signals pass through the low-pass filter before entering the receiver RF amplifier circuitry.

Two PIN diodes (CR201, CR101) and associated components form the antenna switching circuit. With the SST-144 in receive mode, no voltage is applied to the PIN diodes and they do not conduct. This reverse biases CR201 to prevent the transmitter amplifier from affecting the receiver tuning and removes CR101 from the receiver input. Incoming signals from the antenna pass through the low-pass filter, then L206 and C101 to the receiver headend.

When the SST-144 is switched into transmit mode, transmitter supply voltage is switched on by Q201 and Q202 and applied to R207. Current flows through R207, L205, CR201, L206 and then CR101 to ground, forward biasing the PIN diodes. CR201 passes transmitter RF power to the antenna while CR101 shunts the receiver RF amplifier input to ground. L206 provides sufficient impedance to isolate the transmitter power from the receiver RF amplifier.

TRANSMITTER

Keying

The SST-144 transmitter is keyed when PTT switch SW304 is depressed. Electret condenser microphone M301 is connected in series to ground with the PTT switch, which when depressed draws current through M301, SW304, CR304 and R307 to turn on pass transistor Q302. Q302 then turns on Q301 to pull the TX Key Pin 2 input of microcontroller IC301 low. The microcontroller T/R output at Pin 11 then goes high to turn on Q202, which turns on pass transistor Q201 to apply +6VDC to the transmitter as described previously. The transmitter can also be keyed through J301 with an audio accessory that inserts a microphone and PTT switch in series to ground, drawing current through CR304.

+VTX Supply

With the transmitter enabled as described above, the +VTX voltage from Q201 is applied to transmitter RF amplifier Q204. +VTX supply also forward biases the PIN switching diodes CR201 and CR101 as previously described. The transmitter RF final amplifier Q203 is powered by the battery supply.

The Pin 11 T/R output of microcontroller IC301 can be PC programmed to hold the transmitter on after the PTT switch has been released to allow tone related turn-off codes for squelch tail elimination.

Power Amplifier

Q204 and associated components amplify the VCO signal and apply it to the input of RF Final amplifier module Q203 at Pin 1. The 50Ω output of Q203 is matched to the antenna switching circuitry and applied to the antenna through the low-pass filter.

The RF power output is programmable by a licensed RF technician. The SST-144 can be programmed on a channel-by-channel basis for low or high power operation. The power control digital Potentiometer IC306B is used to adjust the Q203 gate voltage and set RF power output.

Voice / Tone Conditioning in Transmit Mode

SST-144 audio conditioning filter circuits are shared with the receiver. The same high-pass filter/amplifier (IC303C and associated components) used in receive voice band conditioning is used in the transmitter voice band. Similarly, the low-pass filter (IC308 and associated components) used for sub-audible tone decode filtering is also used for tone encode. Altering circuit configuration with bilateral switches IC304A, B and C permits the use of the same audio filtering system for both transmit and receive modes.

Voice Band

M301 microphone audio is passes through CR304, C334 and is switched by IC304A to the input of IC303C, which along with its associated components form a high-pass filter/amplifier circuit that attenuates audio signals below 300 Hz. The output of IC303C is applied to the input of IC305B limiting amplifier. Bilateral switch IC304B switches R335 in parallel with R336, raising the gain of limiting amplifier IC305B for full limiting of the transmitter voice audio. The output of IC305B is applied to the input of IC303D, which along with its associated components form an 18 dB/octave low-pass filter for frequencies above 3 KHz. The output of IC303D is applied to voice deviation control IC306F, which sets the level of the processed transmitter audio applied to summing node amplifier IC303B used to modulate the VCO and reference oscillator.

Sub-Audible

Microcontroller IC301 generates the sub-audible selective signaling encode waveforms at Pin 21 and applies them to the input of buffer amplifier IC305A. The output of IC305A is applied to the input of IC308, a 5-pole low-pass filter that attenuates frequencies above 250 Hz. C342 and C343 set the corner frequency of the low-pass filter, with C342 switched in by Pin 7 of IC301 to lower the corner frequency for lower tones. The output of IC308 is applied to tone deviation control IC306D, which sets the level of the transmitter sub-audible encode tones applied to summing node amplifier IC303B used to modulate the VCO and reference oscillator.

MICROCONTROLLER

The SST-144 handheld transceiver is electronically controlled by IC301, an 8-bit microcontroller. IC301 has four 8-bit A/D inputs for processing analog signals.

PIN DESCRIPTION

1 RESET is connected to the SST-144 +5V to start the radio in a known state on power up.

2 TX KEY input is pulled LOW when either the internal or external PTT switch is pressed to initiate transmitter operation.

3 AUDIO GATE ENABLE controls analog switches IC304A and B to configure the shared audio processing circuitry for receive operation when LOW, and for transmitter operation when HIGH.

4 SERIAL DATA INPUT links the microcontroller to communications from an external data terminal via J303 RING connection. This allows programming of the SST-144 EEPROM memory used to store channel frequency and configuration information.

5 DATA output sends serial data to frequency synthesizer IC401 to program frequency information, IC302 EEPROM memory, and to IC306 to set the digital potentiometers.

6 EECLOCK output sends serial data clock pulses to EEPROM IC302 when reading or writing.

7 LOW-PASS CUT-OFF output goes LOW to lower the cut-off frequency of IC308 when the radio is on a channel programmed for a CTCSS tone below 150 Hz. This output is in a tri-state OPEN condition for all other tones.

8 DIGITAL POT LATCH sends a single positive pulse after data has been sent to IC306 to latch the new data and change the digital potentiometers to the new programmed settings.

9 LED output goes LOW when the radio is on channel 1 and is HIGH for all other channels.

10 +5V SW output goes HIGH at a programmable periodic rate to remove the +5VSW supply from various circuits in the radio, thus conserving battery life. In normal transmit or receive mode this output is LOW.

11 T/R SWITCH output is connected to the Synthesizer circuitry to shift the frequency of the VCO oscillator used in both transmit and receive. The output is HIGH in transmit and LOW in receive. T/R output is also used to switch supply voltage to the transmit and receive circuits.

12 CLOCK output sends serial data clock pulses to frequency synthesizer IC401 and digital potentiometers IC306 when programming these devices.

13 +V SW output is HIGH when the radio is turned on, keeping pass transistor Q304 turned on via Q303 to supply power to the radio.

14 GROUND

15 V_{REFH} sets the upper reference level for the A/D and is connected to the regulated +5 VDC.

16 A/D input BATTERY is used to measure the battery voltage for low and dead battery detection. This input also serves as the ON/VOL UP input, and is pulled LOW when SW301 is depressed to turn on the radio and raise the receiver speaker audio level.

17 A/D input VOL DN/OFF is pulled LOW when SW302 is depressed to lower the receiver speaker audio level and turn off the radio. This input also serves as CHANNEL input, and goes to 2.5 VDC when channel selector switch SW303 is pressed to change the radio to the next programmed channel.

18 A/D input TONE DECODE accepts the received QC (CTCSS) and DQC (DCS) waveforms after signal processing for decode analysis.

19 A/D input RSSI is used to measure the output voltage of the noise filter for squelch detection.

20 LATCH output goes LOW to allow serial data to frequency synthesizer IC401 and goes HIGH to latch the data, allowing the synthesizer to execute the new frequency information.

21 TONE ENCODE outputs generate the QC (CTCSS) and DQC (DCS) encode waveforms for signal processing prior to modulating the VCO in transmit mode.

22 AUDIO AMP ENABLE output goes HIGH to apply power to audio amp IC307 for receiver speaker audio or radio alert tones.

23 RX AUDIO GATE ENABLE switches IC304C for receive operation when LOW, and for transmitter operation when HIGH.

24 BEEP output generate the radio alert tones heard in the speaker.

25 See Pin 4

27 REFERENCE OSCILLATOR INPUT has the 3.6 MHz reference signal from the synthesizer.

28 +5 VDC V_{DD} supply voltage.