

# ORION™

## Non-Linear Junction Evaluator (NJE-4000)

### Operating Manual

**Version 1.5**

Patent No. 5,815,122

Patent No. 6,057,765

Patent No. 6,163,259

U.K. Patent GB234423



RESEARCH ELECTRONICS INTERNATIONAL LLC

ORION™ Version 1.511 Operating Manual

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*This manual contains Proprietary Information intended solely for use with the ORION™ NJE-4000.*

All information contained in this manual is subject to change without notice.

This manual is specifically intended to accompany an ORION™ with the firmware version listed above. Availability and function of some features may vary with other firmware versions.

**WARNING:** It is the responsibility of the user to comply with the appropriate radio communication laws of the country in which the ORION™ is being used.

**OWNER'S RECORD**

The serial number of your unit is located on the transceiver near the antenna cable. The serial number as well as firmware version information may also be determined by pressing **OFF**, then **FNCT** until "Display" is shown, then press **AUTO**. Please record this information and refer to it whenever contacting your dealer or Research Electronics concerning this product.

Model Number: NJE-4000

Serial Number: \_\_\_\_\_

Firmware version: \_\_\_\_\_

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## **SECTION 1: INTRODUCTION**

The ORION™, designed and built by the engineers at Research Electronics International, is the latest advancement in Non-Linear Junction Evaluation. The ORION™ can be used to locate electronic devices whether in furniture, walls, ceiling fixtures or elsewhere. Since the ORION™ is detecting semiconductor junctions, not receiving transmitted signals from a surveillance device, it works even when the bug is turned off.

Countersurveillance receivers are designed to detect signals transmitted from “bugs”, but they have a difficult time detecting chip cameras that may be hard wired or tape recorders that do not actually transmit a signal. The ORION™, however, is designed to find just such threats. Rather than looking for a signal from the device, the ORION™ looks for the hardware itself.

It is important to note that due to the variations in electronic circuitry, the unit will respond differently to different electronic circuits. Therefore, the manufacturer makes no guarantee about the performance of the unit when attempting to detect hidden electronic devices.

### **Background Theory**

Here’s how it works. The ORION™ antenna radiates a signal. When this signal encounters an electronic device, the signal is returned at harmonic frequency levels. (If a signal is radiated at 915 MHz, a 2<sup>nd</sup> harmonic would be found at 1830 MHz, and a 3<sup>rd</sup> harmonic would be at 2745 MHz.) Other situations can also produce harmonic signals. Two dissimilar metals, joined or touching, and corroded metals both return harmonic signals. These we will refer to as false junctions.

The junctions in electronic devices and those in false junctions are quite different. The junctions in electronic devices are well defined, but those created by false junctions are not as well defined or as clean a physical junction. Imagine two perfect cubes joined—this would be a junction found in electronic devices. False junctions are more like two irregularly shaped items touching in places, but not in a smooth, regular pattern.

The following equation describes the electronic characteristics of a basic diode, which is the simplest form of an electronic non-linear junction.

$$I = I_s [ e^{qV/kT} - 1 ]$$

Where  $I$  is the current of the signal,  $I_s$  the leakage current,  $q$  equals the electron charge,  $V$  is the voltage,  $K$  equals Boltzman’s constant, and  $T$  is the temperature.

While more complex semiconductor devices are different, they all produce clean, predictable junction characteristics. For the junctions found in electronic devices, this equation produces a predictable, but unsymmetrical curve. False junctions produce a less regular curve, one that is noisy and unpredictable, yet they are typically symmetrical: their curve is mirrored for negative values. The current/voltage characteristics are illustrated in Figure 1.

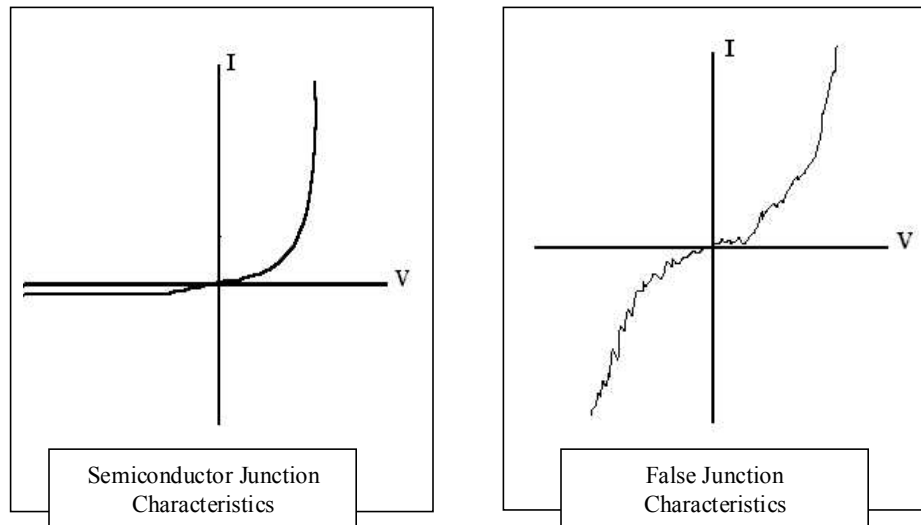


FIGURE 1: SIGNAL CURVE OF JUNCTION IN ELECTRONIC DEVICE

This level of regularity in the junction results in differences in the harmonic signals. When the ORION™ radiates a signal reflected by the junction in electronics, it results in a strong 2<sup>nd</sup> harmonic signal and a weak 3<sup>rd</sup> harmonic. A false junction returns a very weak 2<sup>nd</sup> harmonic and a strong 3<sup>rd</sup>. (See Figure 2)

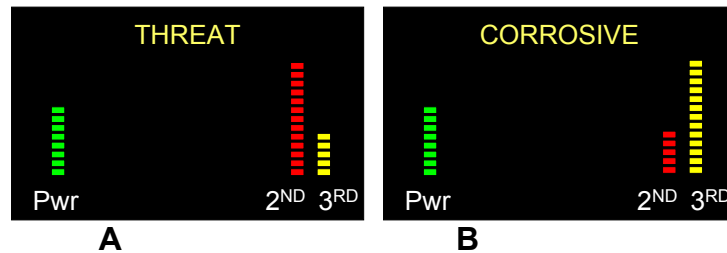


FIGURE 2: ORION™ COMPARISON OF HARMONIC LEVELS

(A – Semiconductor, B – False Junction; Bargraphs on the right are the 2<sup>nd</sup> and 3<sup>rd</sup> harmonic levels)

When the signal is returned as a harmonic, the electronic device produces a regular signal pattern.

After evaluating many NLJDs from around the world, it appears that many units do not have good RF isolation between the 2<sup>nd</sup> and 3<sup>rd</sup> harmonic receiving functions. This means that a pure semiconductor junction may still appear to have a strong 3<sup>rd</sup> harmonic and a pure false junction may appear to have a fairly strong 2<sup>nd</sup> harmonic. Although the unit has the ability to receive both harmonics, it is often very difficult to distinguish between semiconductor and false junctions. If the NLJD has the capability to detect 2<sup>nd</sup> and 3<sup>rd</sup> harmonics, it is very important that the two receive functions are calibrated and do not interfere with each other.

The ORION™ incorporates this important feature by using a unique receiver process designed by the engineers at REI. This process ensures that the two receive functions cannot interfere with each other and provides continuous display of both 2<sup>nd</sup> and 3<sup>rd</sup> harmonics.

## Quieting Effect

Semiconductor junctions produce a receiver quieting effect. Many false junctions do not. (Described in Figure 3.)

If you are listening to the demodulated audio of the return harmonic from a semiconductor junction, you will hear the noise level decrease significantly as you approach the junction. Then, as you move away, the noise level will increase again before it returns to normal. The audio will reach its lowest level directly over the device and swell on either side of it.

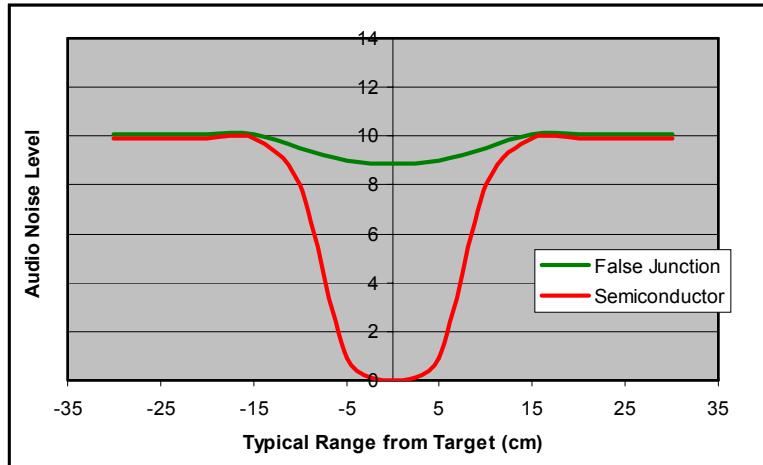


FIGURE 3: NOISE CURVE OF AN ELECTRONIC DEVICE AND FALSE JUNCTION

This is the “quieting effect.” When you are evaluating the demodulated audio, electronic devices actually reduce the noise in their immediate vicinity. For many false junctions the audio noise will not significantly decrease. However, it is possible to detect false junctions that also have some level of quieting; and therefore, it is highly recommended that you also use a physical vibration (see below) and examine the difference between the harmonic levels for discrimination.

## Listening for Physical Break-up of a Non-Linear Junction

If a false junction is detected, one can easily discriminate between semiconductor junctions and false junctions by listening to the audio and providing a physical vibration to the junction. Pounding on the wall with your fist or a rubber hammer provides an effective physical vibration. A rubber hammer is provided in the ORION™ toolkit for this purpose. A false junction will break-up and a crackling sound will be heard. The true junction will remain silent.

## Long Range Detection Using Audible Tones

The ORION™ has several methods of operation. One method uses a Continuous Wave transmit signal with a 1KHz FM modulated tone. With this method, the operator has access to a tremendous detection range. This is utilized by allowing the operator to hear the FM demodulated tone through the high quality receiver. While the visual bargraph display may only show a very small response, which may be interpreted as noise, the

audible tone provides unquestionable detection of a Non-Linear Junction. However, the modulated tone method does not provide any positive discrimination between semiconductor junctions and false junctions.

## Other Uses for Audio Demodulation in an NLJD

Often, when using a NLJD, it is possible not only to detect electronics, but it may also be possible to classify them based on audio demodulation. For example, when detecting some tape recording devices, it is possible to hear the audio from the tape recorder head using the NLJD audio demodulation. Furthermore, if the NLJD provides good audio demodulation, it is often possible to hear the video synchronization pulse when detecting many chip cameras. In addition, by using FM demodulation it is sometimes possible to hear unique, periodic audible sounds resulting from phase-shifts in active electronic devices. It is important to practice using a NLJD so that audio sounds peculiar to specific detected devices can be easily recognized.

## Frequency Issues Associated with NLJD Operation

Most NLJDs on the market today transmit on a single frequency or are limited to a small frequency range. This creates three problems:

1. There is a Null Range associated with operating at a single frequency.
2. Many threatening devices respond differently to an NLJD depending on the Transmit Frequency of the NLJD.
3. While operating at a single Frequency, there is a good potential for interference and degraded performance from one or more of the many wireless devices in use today.

The following sections address these issues in detail.

### **Null Range Effect**

For an NLJD operating at a single frequency, there is a direct correlation between detection range and frequency of operation. This occurs because if the distance between the NLJD and the target is equal to  $\frac{1}{2}$  the wavelength of the transmit frequency then there is a nulling effect in the RF transmit signal that reduces the detection sensitivity associated with that specific range and frequency. Often this effect is not a problem because the user is constantly moving the NLJD and therefore the range to the target is constantly changing. Nonetheless, the ORION™ addresses this issue and essentially eliminates the null Range effect when using the Search Hop Mode because the ORION™ constantly changes frequency and the results are digitally averaged on the display.

### **Target Dependence on Frequency**

When comparing NLJD's of different manufacturers, it is often observed that on one target, one NLJD will perform better, but on another target, another NLJD will have the best performance. This is because detection range is dependent on frequency. One very good example of this effect can easily be seen when using a cellular phone as a potential target. If an NLJD operates at a frequency that is within the operational band of the cellular phone, then the detection range of the phone will be large, however, if the NLJD operates at a frequency range that is outside of the operational band of the cellular

phone, then the built-in filters within the phone will attenuate the NLJD signal and the detection range will be greatly reduced. The ORION™ addresses this problem in two ways. First, the ORION™ has the ability to change the transmit frequency over a rather wide frequency range allowing the user to adjust the frequency depending on the potential threat. In addition, new with firmware version 1.5, the ORION™ has a Search Hop mode in which the transmitted pulse hops over a wide frequency range to ensure good detection ability for a wide range of threats.

### **Frequency Interference**

Most NLJDs on the market today transmit on a single frequency or at best a limited frequency range. As more wireless devices are being assigned to more frequencies, the performance of these limited NLJD units can suffer. Interference from other transmitters may result in erratic and unreliable readings. The ORION™ is the only NLJD that addresses this problem with two REI exclusives: Quiet Channel Search and Frequency Hopping. In normal search mode, the ORION™ automatically searches for the quietest channels on which to operate in the ambient environment. The new frequency hopping search method employs an algorithm that constantly changes the transmit frequency over the full legal range to increase the target hit rate.



## Important Safety Information

For your own safety do not use the AC power battery charger if:

- The battery charger cables or it's plugs become frayed or otherwise damaged.
- The battery charger casing is cracked or otherwise damaged.
- The battery charger is exposed to rain, liquid or excessive moisture.

For your own safety do not use the ORION if:

- The ORION cables or it's plugs become frayed or otherwise damaged.
- The ORION casing is cracked or otherwise damaged.
- The ORION is exposed to rain, liquid or excessive moisture.
- You suspect that the unit requires servicing.

For your own safety do not use any ORION battery if:

- The battery case is cracked or otherwise damaged.
- The battery is excessively hot or warm for any reason.

The ORION is capable of emitting a radio signal between 880 MHz and 1005 MHz. The ORION is offered in models to meet the USA FCC transmission requirements and models to meet the European CE Mark requirements. However, it is the responsibility of the user to practice good safety procedures. In doing so, you should take the following precautions:

- Do not point the antenna at a person's eyes or head.
- Do not leave the antenna in close proximity to any part of the body for more than 5 minutes.
- Do not use near flammable fluids or explosives or in any area where the use of radio communications equipment is prohibited.
- Do not use in close proximity to any person fitted with a heart pacemaker, heart defibrillator, or any other lifer support device.
- Do not use the ORION in close proximity to any person wearing a hearing aid.

## **SECTION 2: TECHNICAL ADVANCES**

The ORION™ incorporates many advanced features that make it more accurate, compact, and easier to use. The following features are intended to make searches more precise and efficient.

**Automatic Power Control** dynamically adjusts power level when receiver is saturated.

**Synthesized Transceiver** provides frequency stability and agility to automatically search for clean operating frequencies. Legal operating frequencies vary from country to country, so ORION™ was designed with a very wide 880 MHz to 1005 MHz operating range. This is adjusted at the factory for the country of operation. For example, all models sold for use in the United States operate between 902.2 MHz and 927.8 MHz.

**Circular Polarized Antenna** eliminates the need to make several passes over an area, and it reduces the risk of missing a threat due to incorrect antenna polarization.

**Lightweight Single-Body Design** contains transceiver, antenna, and display assembly joined with an extending arm. The whole body is collapsible to make it portable and easy to set up. A single cable carries all transmitting, receiving, and digital display control signals. The cable is concealed and stored internally, which eliminates the need to attach cords before use. The hassle of tangled cords will never occur.

**Dual External Charger** and **Rechargeable Batteries** are included with the product. The flashing LED indicates a charge pending, Constant LED indicates a charge is in progress, and dark LED indicates a completed charge. The camcorder-style batteries have an average life of 1 hour at maximum strength, but typical power level settings will yield longer run times. Charging time is approximately 35 to 45 minutes.

**Wireless Infrared Headset** provides the ability to listen to the received signal without fighting with cords and plugs.



FIGURE 4: HEADSET & IR RECEIVER

- The headset can be plugged directly into main unit or plugged into the Infrared Receiver.
- Plugging headset into the main unit turns off the IR transmit function on the main unit.
- Plugging headset into the IR Audio Receiver automatically turns on the IR Audio Receiver.
- Volume levels for wired or wireless headset are controlled via the main unit.

## **SECTION 3: HOW TO USE THE ORION™**

### Preparation

After taking ORION™ out of the case, unfold the antenna/display first, then unfold the transceiver assembly (the main rectangular section with the keypad) 180°. Then extend the telescoping antenna to a convenient length. Rotate the antenna head and tilt the display for easy viewing.

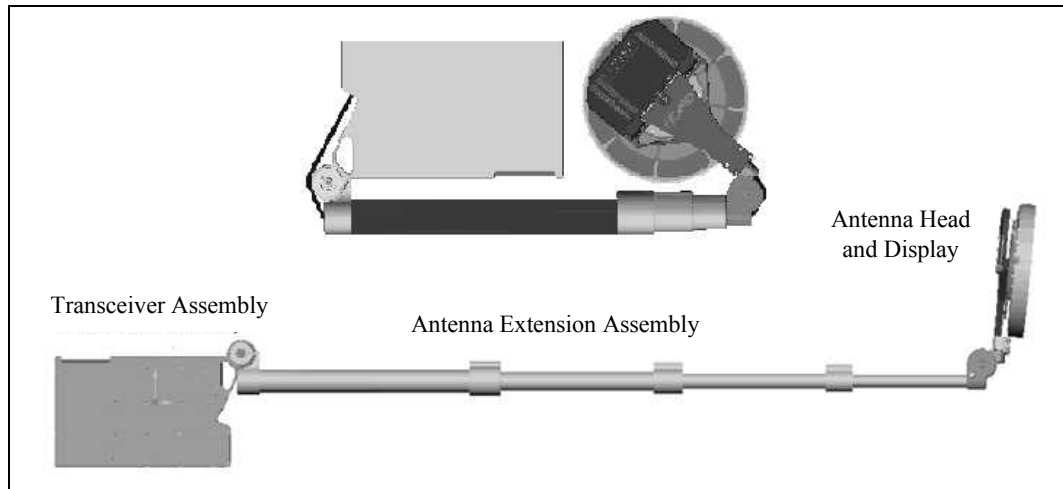


FIGURE 5: FOLDED AND EXTENDED VIEW OF MAIN UNIT.

**ATTENTION:  
TO PREVENT DAMAGE TO CABLE:**

**WHEN OPENING, UNFOLD ANTENNA ASSEMBLY PRIOR  
TO UNFOLDING TRANSCEIVER. REVERSE FOR STORAGE.**

**ALWAYS EXTEND AND RETRACT POLE SLOWLY.**

**Technical Note:** It is advised that prior to each use, the unit is extended at least one length of the telescoping extension assembly. This will minimize the possibility of metal oxidation in the slip-ring assembly in the antenna head.

Procedure

There are two basic procedures to using any Non-Linear Junction Detector:

- (1) Detecting a non-linear junction and
- (2) Discriminating between electronics and false detection.

The ORION™ utilizes three different methods of operation that are optimized for these two processes. These primary methods (referred to as SEARCH, I.D., and LISTEN) have two or more variations as listed below.

ORION™ Method Key	Method of Operation Variations	Detection Range	Discrimination Ability
<b>SRCH</b>	Srch 2&3 Search CW Srch Hop	Good	Good
<b>ID</b>	ID FM 2 <sup>nd</sup> ID FM 3 <sup>rd</sup>	Good	Poor
<b>LSTN</b>	CW FM 2 <sup>nd</sup> CW FM 3 <sup>rd</sup> CW AM 2 <sup>nd</sup> CW AM 3 <sup>rd</sup> 20K AM 2 <sup>nd</sup> 20K AM 3 <sup>rd</sup>	Moderate	Good

When the ORION™ is turned on, it automatically searches for and selects the quietest frequencies available in the ambient environment. The operator may also manually select frequencies. Two test tags are included with the ORION™. One is a semiconductor diode to simulate an electronic device. The second is a steel wool pack, to simulate a corrosive metal-to-metal junction. These tags can be used to verify the proper operation of ORION™.

Models sold for use in the USA are configured to comply with FCC maximum average output power and frequency requirements. Models sold for use in other countries may be subject to power and frequency limitations. It is the responsibility of the user to comply with the appropriate radio communication laws of the country in which the ORION™ is being used.

## ORION™ OPERATING METHODS

### 1: SRCH (Search Method)

- Access:** **SRCH** key.
- Purpose:** Search for and locate semi-conductor junctions. This method provides graphical display of the 2nd and 3rd harmonic Relative Signal Strength Indicator (RSSI) levels. This method can utilize maximum peak power of the transmitter.
- Utility:** Best method for comparing 2nd and 3rd harmonic levels. The audio output definitely indicates the presence of a junction, but it is of little value in discriminating between electronic and corrosive junctions.
- Description:** When using the Search 2&3 method, the transmitter is pulsed to obtain maximum peak output while maintaining maximum allowable average power output. Unit alternately monitors and displays 2nd and 3rd harmonic levels, and displays threat warning when the advanced algorithm resolves a Threat or Corrosive junction.
- In addition to the original Search 2&3 pulsing method, REI has enhanced ORION™ with two added search methods. These new search methods, like the original, monitor both second and third harmonic signal return.
- The new Search CW method operates the transmitter as a continuous wave. There is no pulsing, but unlike ID or Listen methods, both second and third harmonics are monitored. This may be desirable if there is concern that a pulsing signal may trigger a device. Because the transmitter is always on, the ORION™ cannot perform background baseline analysis or auto-frequency checks as is done in the standard Search 2&3 method. The continuous transmission also affects battery life.
- The new Search Hop method moves the transmit frequency at a fast rate. The frequency is changed after each second/third harmonic analysis period. As some target devices may be more sensitive at different frequencies, this method may detect devices that might be missed using a single frequency. As ORION™ hops across the frequency range it logs the “hot” frequencies while ignoring those with high ambient levels. Because background noise varies with frequency, ORION™ does not perform background baseline analysis or auto-frequency checks as is done in the standard Search 2&3 method.
- Process:** The transmitter is pulsed (except Search CW) to obtain maximum peak output while maintaining maximum allowable average power output. The microprocessor alternately monitors and displays 2<sup>nd</sup> and 3<sup>rd</sup> harmonic levels, and displays a threat warning when 2<sup>nd</sup> Harmonic RSSI rises above 3<sup>rd</sup> Harmonic RSSI.

**A: SEARCH 2<sup>nd</sup> & 3<sup>rd</sup>**

Transmitter: Pulsed

Modulation: none

Power: Auto and manually adjustable within the legal output power limits.  
Limited to FCC maximum average power requirements for models sold in the USA.  
Limited to CE Mark maximum power requirements for units sold with CE Mark.

Frequency: Auto and manually selectable within the legal frequency range. Auto continuously tests and adjusts for the best frequency to use.

Receiver: Alternates between second and third harmonics each 60-mSec period.

User Audio: The user can select either natural audio or synthesized tones indicating 2<sup>nd</sup> and 3<sup>rd</sup> harmonic variances. The natural received audio using AM demodulation can be used as an aid to quickly and precisely determine the presence and location of a junction, but does not discriminate between electronic and corrosive junctions. Using the Trip Set feature (under the **SET** key), 2nd and 3rd harmonic levels each generate unique synthesized tones providing rapid auditory information about the signal strength of each harmonic.

Display: "Srch 2&3"

Tx1 Bar: (green) Transmit Power Level

Rx2 Bar: (red) Second harmonic RSSI

Rx3 Bar: (yellow) Third Harmonic RSSI

**B: SEARCH CW**

Transmitter: Continuous

Modulation: none

Power: Auto and manually adjustable within the legal output power limits.  
Limited to FCC maximum average power requirements for models sold in the USA.  
Limited to CE Mark maximum power requirements for units sold with CE Mark.

Frequency: Locked, but can be changed manually within the legal frequency range.

Receiver: Alternates between second and third harmonics each 60-mSec period.

User Audio: Same as Search 2&3.

Display: "Search CW"

Tx1 Bar: (green) Transmit Power Level

Rx2 Bar: (red) Second harmonic RSSI

Rx3 Bar: (yellow) Third Harmonic RSSI

**C: SEARCH HOP**

Transmitter: Pulsed

Modulation: none

Power: Auto and manually adjustable within the legal output power limits.  
Limited to FCC maximum average power requirements for models sold in the USA.  
Limited to CE Mark maximum power requirements for units sold with CE Mark.

Frequency: Constantly changing, covering the entire legal frequency range.

Receiver: Alternates between second and third harmonics each 60-mSec period. In Search Hopping, ORION™ monitors peak returns separately for second and third harmonics. The peak level is displayed as a blinking LED, and the frequency at which the peak was detected is stored. To evaluate a captured peak, use either the I.D. or Listen methods, selecting the desired harmonic. ORION™ will return to the frequency that detected the peak for that harmonic. The ambient r.f. environment is monitored. Frequencies with high ambient levels are ignored.

User Audio: Same as Search 2&3.

Display: "Srch Hop" with a moving bar indicating hopping.

Tx1 Bar: (green) Transmit Power Level

Rx2 Bar: (red) Second harmonic RSSI

Rx3 Bar: (yellow) Third Harmonic RSSI

**2: ID (Identify Method)**

- Access: **ID** key. Sequence through second and third harmonics.
- Purpose: To provide detection of a non-linear junction by listening for an audible tone using the ORION™ headset.
- Utility: Good method for long range detection of Non-linear Junctions. The transmitter is modulated with a fixed or variable pitch that is re-radiated by a target. This is received and demodulated for listening. This method does not provide a method of discriminating non-linear junctions.
- Description: This method of non-linear junction evaluation produces an uninterrupted continuous wave output with a FM tone. This tone is selectable (using the Trip Set feature under the **SET** key) as a fixed 1kHz pitch or a variable pitch that corresponds to the strength of the harmonic signal return. The user can hear the return of the tone to make a threat determination.
- Process: Sets transmitter to CW method with 1 kHz or variable pitch FM modulation. Monitor active harmonic channel RSSI Only.

**Transmitter**

- Duty: Duty Cycle is 6% for ORION pulsing modes.
- Power: Auto and manually adjustable within the legal output power limits.  
CW Max power reduced to maintain FCC and CE Mark power requirements for units sold in USA and CE Mark versions
- Frequency: Manually adjustable within the legal frequency range. When ID method is entered from Search Hop, ORION™ will return to the frequency that detected the peak for the selected harmonic.
- Modulation: FM 1 kHz (trip off), or a pitch that varies with signal strength (trip on).

**A: ID 2<sup>nd</sup> FM**

- Receiver: Second harmonic frequency
- User Audio: Received FM Second harmonic.
- Display: **"ID FM 2"**
- Tx1 Bar: (green) Transmit Power Level
- Rx2 Bar: (red) Second Harmonic RSSI
- Rx3 Bar: (yellow) Off

**B: ID 3<sup>rd</sup> FM**

- Receiver: Third harmonic frequency
- User Audio: Received FM Third harmonic.
- Display: **"ID FM 3"**
- Tx1 Bar: (green) Transmit Power Level
- Rx2 Bar: (red) Off
- Rx3 Bar: (yellow) Third Harmonic RSSI



**3: LSTN (Listen Method)**

- Access: **LSTN** key. Sequence through second and third harmonics, CW and 20K methods.
- Purpose: To detect and discriminate Non-linear junctions based on audio characteristics. The quieting effect can be effectively used in this method, and it is sometimes possible to hear audible electronic characteristics from certain devices. For example, it is often possible to hear the video synch pulse when detecting a video chip camera. These methods are also used to listen for physical vibrations that can be used to discriminate between semiconductor and false junctions.
- Method Utility: The listen method is used primarily for discrimination purposes. However, this method can also be used for detecting junctions.
- Description: The CW listen methods provide AM or FM demodulated listening capability using a continuous wave process. The 20K-listen methods of non-linear junction evaluation produce very short (7.5 microsecond) transmit pulses at a repeat rate of 20kHz (50 microseconds period). The 20k process provides the same basic capability as the CW method, but the 20K method provides greater output power while the CW method provides cleaner audio output. In either method, no junction present yields white noise. Corrosive junctions produce uneven noise when using the third harmonic. True non-linear junctions (diodes) cause a quieting effect on the second harmonic audio.
- Power: Auto and Manually Adjustable within the legal output power limits.
- Frequency: Manually adjustable within the legal frequency range. When Listen method is entered from Search Hop, ORION™ will return to the frequency that detected the peak for the selected harmonic.
- Modulation: None

There are six modes of the listen method, two CW AM, two CW FM and two 20K AM, each with second and third harmonic selection. The Trip Set function is not available in this method of operation.

**A: LISTEN CW AM 2<sup>nd</sup>**

- Duty: 100% (Continuous wave transmission)
- Receiver: Second harmonic frequency
- User Audio: AM Second harmonic
- Display: "CW AM 2"
- Tx1 Bar: (green) Transmit Power Level
- Rx2 Bar: (red) Second Harmonic RSSI
- Rx3 Bar: (yellow) Off

**B: LISTEN CW AM 3<sup>rd</sup>**

Duty: 100% (Continuous wave transmission)  
Receiver: Second harmonic frequency  
User Audio: AM Third harmonic  
Display: "CW AM 3"  
Tx1 Bar: (green) Transmit Power Level  
Rx2 Bar: (red) Off  
Rx3 Bar: (yellow) Third harmonic RSSI

**C: LISTEN CW FM 2<sup>nd</sup>**

Duty: 100% (Continuous wave transmission)  
Receiver: Second harmonic frequency  
User Audio: FM Second harmonic  
Display: "CW FM 2"  
Tx1 Bar: (green) Transmit Power Level  
Rx2 Bar: (red) Second Harmonic RSSI  
Rx3 Bar: (yellow) Off

**D: LISTEN CW FM 3<sup>rd</sup>**

Duty: 100% (Continuous wave transmission)  
Receiver: Second harmonic frequency  
User Audio: FM Third harmonic  
Display: "CW FM 3"  
Tx1 Bar: (green) Transmit Power Level  
Rx2 Bar: (red) Off  
Rx3 Bar: (yellow) Third harmonic RSSI

**E: LISTEN 20K AM 2<sup>nd</sup>**

Duty: 20 kHz Pulse, Duty Cycle 6  $\mu$ Sec on, 44  $\mu$ Sec off.  
Receiver: Second harmonic frequency  
User Audio: Second harmonic AM  
Display: "20K AM 2"  
Tx1 Bar: (green) Transmit Power Level  
Rx2 Bar: (red) Second harmonic RSSI  
Rx3 Bar: (yellow) Off

**F: LISTEN 20K AM 3<sup>rd</sup>**

Duty: (red) 20 kHz Pulse, Duty Cycle 6  $\mu$ Sec on, 44  $\mu$ Sec off.  
Receiver: Third harmonic frequency  
User Audio: Third harmonic AM  
Display: "20K AM 3"  
Tx1 Bar: (green) Transmit Power Level  
Rx2 Bar: (red) Off  
Rx3 Bar: (yellow) Third harmonic RSSI

## ORION™ FUNCTIONS

ORION™ functions are user-activated routines used to adjust operational parameters. Some functions may not be accessible in some operating methods. Using a function, such as Volume Adjust, will not interrupt or change the operating method. Most functions are selected with one or more press of either the **SET** or **FNCT** key. The display will indicate the active function. The **▼**, **▲** or **AUTO** keys are then used to change the current setting for that function. The function will cancel a few seconds after no key activity. The default function (while no other function message is displayed) for the **▼**, **▲** and **AUTO** keys is Transmit Power. Press and hold the **ON/OFF** key to turn off ORION™.

### MUTE Headset

**Access:** Successive press and release of **ON/OFF** key toggles headset mute. Activates volume adjust function.

**Purpose:** Single key mute for convenience.

**Range:** Headset audio on or off.

**Display:** "Vol Mute" or "Vol==---"

### Volume Adjust

**Access:** Cycle **FNCT** key to Volume, or single press of **ON/OFF** key. Press **▼** and **▲** Keys to manually control volume to the headset. Press **AUTO** Key to enable or disable the IR wireless headset feature. "IR on" allows use of the wireless headset when the wired headset is not plugged into the ORION™ main unit. For those who use the ORION™ without audio, set this option to "IR off" to increase battery life and/or control infrared emissions.

**Purpose:** Sets Audio Output Level to the wired or wireless headset.

**Range:** Zero to full volume, indicated by bargraph.

**Display:** "Headset", "Wireless" or "IR OFF" then "Vol==---"

### Trip Adjust

**Access:** Available in Search or ID methods only  
Press **SET** key until display indicates "Trip Set"  
Press **▼** and **▲** keys to manually set the trigger level.  
Press "AUTO" Key to automatically set trigger level.

**Purpose:** Sets Alert Trip Point for audible alert. Available for use with the Search and ID methods, the audible alert tone frequency corresponds to the received signal strength. The varying pitch can assist in locating threats A higher pitch indicates a stronger received signal.

**Range:** Zero to about two-thirds Full Scale

**Display:** "TRG:###%"

### Gain Adjust

- Access: Press **SET** key until display indicates "Gain Set".  
Press ▼ and ▲ Keys to manually set gain level.  
Press **AUTO** Key to toggle Gain between on and off.
- Purpose: Sets amount level of digital signal processing integration that is used to process the received signals.
- Background: The ORION™ firmware utilizes digital signal processing integration techniques to improve the gain of the unit (this may be also referred to sensitivity control). There are five levels of gain control ranging from 1 to 6, which correspond to pre-programmed integration levels. The default level of integration is "2". By increasing the level of integration, the sensitivity of the unit can be greatly increased, but the penalty is that the unit does not respond as quickly to new signals. Therefore, if you increase the gain, it is important to experiment with the unit to be sure that you spending sufficient time on each target to allow the unit display to respond.
- Display: "Gain #"

### Power Adjust

- Access: Default function of the ▼, ▲ and **AUTO** Keys  
Cycle **FNCT** key until display indicates "Pwr Man1" or "Pwr Auto"  
Press ▼ and ▲ Keys to manually control the maximum power level setting.  
Press **AUTO** Key to toggle the unit between manual and automatic power adjust. When in the Automatic power adjustment mode, the unit will automatically reduce the transmit power whenever the receiver becomes saturated. A flashing LED will indicate the manually set maximum power.
- Purpose: Set Transmitter Power Output Level.
- Range: 0 to 100%
- Display: "Pwr: ###%"

### Frequency Adjust

- Access: Cycle **FNCT** key until display indicates "Frq Man1" or "Frq Auto".  
Press ▼ and ▲ keys to manually change frequency.  
Press **AUTO** Key to set automatic selection of the best frequency when using Search 2&3.
- Purpose: Sets Transmitter Frequency Channel.
- Range: The country in which the unit is used determines Frequency allocations.
- Display: "###. #MHz"

**Extended Functions**

Additional functions are available to the user by pressing the **ON/OFF** key once or twice prior to pressing the **SET** or **FNCT** key. These extended functions are generally setup or diagnostic by nature and therefore are used only occasionally.

**Display Brightness Control**

**Access:** Press **OFF** then cycle **FNCT** key until display indicates "Display:"  
 Press ▲ Key to set display brightness to Bright.  
 Press ▼ Key to set display brightness to Dim.  
 Press **AUTO** key to show ORION™ serial number and software version.  
 Press and hold **AUTO** key to show display module software version.

**Purpose:** Sets one of two levels of display brightness. The dim setting will extend battery life.

**Range:** Bright or Dim.

**Display:** "BRIGHT" or "DIM"

**Battery Status**

**Access:** Press **OFF** then cycle **FNCT** key until display indicates "Battery"  
 Press either ▲ or ▼ Key to display battery voltage.  
 Press **AUTO** key to perform battery condition test

**Purpose:** Access to battery status.

**Range:** Measures actual battery voltage under present operating load.

**Display:** Battery voltage

**Save User Preferences**

**Access:** Press **FNCT** key once, **OFF** key twice then press and hold **SET** key for 4 seconds.

**Purpose:** This allows permanent storage of user preferences including audio volume, brightness, power, gain, trip and Auto/Manual settings.

**Display:** Unit briefly indicates "Saved OK" when save is complete.

**Field Service System Peek**

**Access:** Press **OFF twice** then cycle **SET** key until display indicates "Sys Peek"  
 Press either ▲ or ▼ Key to cycle through various internal values.  
 Press **AUTO** key to display detected errors.

**Purpose:** This is intended to allow a service technician to access internal system status. The data displayed will only have meaning to a technician. This feature allows a basic level of field diagnostics.

**Local/Remote Display Control**

- Access: Press **OFF** then cycle **SET** key until display indicates "Display:"  
Press ▲ Key to set display to Dual. Both local and remote displays are active.  
Press ▼ Key to set display to Single. Only the display associated with the last used keypad is active.  
**AUTO** key has no function.
- Purpose: Active only with an ORION™ RCM-4000 remote control installed. This setting selects Single or Dual display modes. Single display mode provides privacy as well as extended battery life using either the ORION™ "Local" display (the one attached to the antenna) or the RCM-4000 "Remote" display. Dual display mode operates both displays.
- Range: Dual or Single.
- Display: "Dual" or "Single"

## **SECTION 4: HARDWARE SPECIFICATIONS**

### **Transmitter**

- Frequency Bands: 880 - 1005 MHz @ 200 kHz steps. USA: 902.2-927.8 MHz. Foreign models are adjustable between 880 and 1005 MHz. CE Mark Version operates at 869.4 MHz and 869.6 MHz.
- Peak Power: 1.4 Watts for unrestricted models (Effective Radiated Power including antenna gain and all system losses). FCC and CE Mark versions meet their respective frequency and power requirements as stated below.
- Power Control: 30 dB range in 2 dB steps. Pulsed to limit average output power to FCC max.
- FCC ID: EIH98NJE4000 – This device complies with Part 15 of the USA Federal Communications Commission Rules. Operation is subject to the two following conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation.
- CE Mark – The ORION is also offered in a CE Mark version. This version complies with the European RTTE standards EN300220 and EN301489 with a maximum transmit power of 500mwatts ERP and frequency operation at 869.4 MHz and 869.6 MHz.

**WARNING:** It is the responsibility of the user to comply with the appropriate radio communication laws of the country in which the ORION™ is being used.

### **Receiver**

- Frequency Bands: Second (1760-2010 MHz) or third (2640-3015 MHz) harmonic of transmit frequency.
- Sensitivity: -135 dBm for both harmonics (see software integration).
- Gain Control: The gain of the unit is enhanced using software integration. Various methods of operation have different integration algorithms for maximum performance. Refer to the description of the gain function on page 20.
- Receiver IF BW: 3 kHz

### **Antenna Polarization**

Circular for both transmit and receiver functions.

### **Physical**

- Weight: 3.4 lbs (1.54 kg) Operational with battery

### **ORION™ Headset**

- The ORION™ headset works with either the main unit or the Infrared Receiver.
- No IR is transmitted when the headset is plugged into the main unit.
- The IR Audio Receiver is turned on whenever a headset is plugged into it.
- The IR audio feature can be disabled. See volume control function on page 19.
- Volume levels for wired or wireless headset are controlled via the main unit.

### **Battery Specifications**

- Externally rechargeable standard type battery
- 7.2v camcorder style NiCad
- Run time 1 hour on full charge when operating at full power. Normal usage should result in run times of 2 hours.

### **Battery Charger**

- Dual battery charger with Automatic Operation.
- Charging Time: approximately 45 minutes to 1 hour depending on battery vendor.
- Sequentially charges both batteries.
- LED Indicator:
  - Flashing LED – Charge Pending (Applies to the situation when two batteries are simultaneously placed in the charger)
  - Bright LED – Fast Charging
  - Dark LED – No Battery or Charge Complete

NOTE: To test for faulty batteries, place a single battery in the charger. If the LED continues to flash and never goes Bright or Dark, then the battery is faulty and should be discarded.



## **SECTION 5: ORION Remote Control**

The ORION™ Remote Control RCM-4000 is an extension of the ORION™ Non-Linear Junction Evaluator. The RCM enables the ORION™ to be placed in a fixed position and the operator to be stationed up to 20 meters away out of sight or in a safe location. Operation using the remote control module is identical to normal ORION™ operating procedures. No additional training needed!



This ORION™ accessory is a direct result of requests from our clients, and many units have already been sold for anti-terrorism applications. The RCM-4000 has many practical uses. Most of these uses involve the pre-screening of packages, suspicious items, luggage, or people for electronics. Using this approach, the presence of electronic circuitry may be evaluated prior to using other detection equipment such as X-ray. Furthermore, this electronic evaluation may be conducted without moving or touching the suspicious item. Some examples are:

- Positioning the ORION™ over a suspicious package using a tri-pod.
- Placing the ORION™ on a robot vehicle with the operator located away from any potential hazard to examine suspicious packages.
- Positioning the ORION™ over a conveyer belt carrying postal packages, and providing long term monitoring from a centralized location.
- Installing the ORION™ in a chair, desk, or conference room table for covert situations in which the technician must be out of sight.

### **Features**

The RCM-4000 provides power for the ORION™ and itself through the use of a standard 7.2V NiCad ORION™ Battery or an External DC input from 9-24 Volts. When connected to an external power source the RCM-4000 is capable of providing a maintenance charge to the Battery on the RCM-4000. Full charging should be done with the Quick Charger provided in the ORION™ Case.



Also available is an optional, heavy-duty, professional tripod (TRI-4000). This useful tool mounts the ORION™ in a fixed position. A custom mounting bracket for ORION™ and a Hakuba soft carrying case is included when ordering the TRI-4000.



The following reference guide describes installation and set-up.

### **INSTALLATION**

Securely mount the ORION™ at the desired location. A tripod and mounting bracket is available from Research Electronics. Replace the standard battery pack from ORION™ with the remote adapter pack on one end of the supplied cable. Close the battery door, with the cable in the notch. Route the cable as desired. Plug the 9 pin sub-D into the remote; use the two screws on the connector to secure. The supplied AC adapter plugs in next to the ORION™ cable. The battery slips into the grooves on the back of the remote and latches into place. Plug in the headset on the unit's edge, to the right of the ON/OFF key, and the unit is ready for operation.

### **OPERATION**

This document uses the term *local* to refer to keypad and display on the ORION™ itself. The term *remote* is used to refer to keypad and display on the RCM-4000 ORION™ Remote Control.

When using the RCM-4000 ORION™ Remote Control, both local and remote keypads are always active. One or both displays can be made active. Both displays, local and remote, are always on when "Dual display" mode is selected. Only the display associated with the keypad being used is active when "Single display" mode is selected. The other display is muted, with only a small flashing diamond to indicate that the system is active. "Single display" conserves battery power. Some users may desire to blank the local display as a security advantage. The display mode choice can be made by this key sequence (local or remote keypad can be used): Press OFF once, then press SET until "Display" is shown. Press UP for dual display, or Down for single. ORION™ retains this display mode setting until it is changed again, or the system is powered down.

The dual/single display selection, as well as other user preferences can be permanently saved. ORION™ will automatically assume these settings when powered on. User preferences that can be saved include remote Single/Dual display, display brightness, default transmit power setting, Search mode Auto/Manual power, Frequency Auto/Fixed, headset volume setting, Gain level and Trip settings.

Set each of the above items to your preferences then save with the following procedure using the *local* keypad only. Press the FNCT key once. Press the OFF key twice, then press and hold the SET key for about 6 seconds. "Saved OK" will briefly appear. Now, even when the battery or power is removed, the settings will be retained.

**Please be aware of the following**

The RCM-4000 ORION™ Remote Control can only be used with an ORION™ designated as remote capable.

Do not extend the cable length over 20 meters. Do not use “off-the-shelf” serial type extension cables, as these do not have the current carrying capacity required.

REI suggests the use of the AC adapter as the primary power supply. Battery life will be reduced compared to normal ORION™ operation without the remote. The Remote may be powered by a properly polarized power supply with an output rating of 9 to 25 VDC at 1.5 amp, center pin positive barrel connector. External DC voltages greater than 25VDC will cause damage to the remote control and/or the ORION™. Application of voltages over 7.8VDC or reversed polarity to the battery contacts will cause damage.

The AC adapter will provide a maintenance charge to the battery installed on the remote, but for full charge, always place the battery in the REI standard ORION™ NiCAD battery charger.

## SECTION 6: QUICK REFERENCE GUIDE

### ORION™ QUICK REFERENCE GUIDE – Version 1.5

#### On/Off Key Functions



Turns unit On	Single press of ON/OFF when off
Turns Unit Off	Press and hold ON/OFF
Volume Mute/Unmute	Single press of ON/OFF toggles mute
Save User Preferences	Press FNCT, OFF, OFF, Hold SET 4 seconds

#### Operating Modes



Mode Key	Display Text	Description	Main Utility
<b>SRCH*</b>	Srch 2&3 Search CW Srch Hop	Display 2 <sup>nd</sup> and 3 <sup>rd</sup> harmonics	Detection and discrimination
<b>ID</b>	ID 2 <sup>nd</sup> FM ID 3 <sup>rd</sup> FM	Single Harmonic detection	Long range detection
<b>LSTN</b>	CW 2 <sup>nd</sup> AM CW 3 <sup>rd</sup> AM CW 2 <sup>nd</sup> FM CW 3 <sup>rd</sup> FM 20k 2 <sup>nd</sup> AM 20k 3 <sup>rd</sup> AM	Listen for junction characteristics	Junction evaluation and discrimination

\*Recommended mode with Trigger function enabled

#### Functions - Use UP, DOWN and AUTO keys to adjust



Function	ACCESS KEY	Description
<b>Set Gain</b>	<b>SET</b>	Controls sensitivity, Range 1-6 default = 2
<b>Set Trip</b>	<b>SET</b>	Alert Tone, UP/DOWN = manual, AUTO = automatic
<b>Power</b>	<b>FNCT</b>	Range 0 to 100% Output power
<b>Volume</b>	<b>FNCT</b>	Headset level, quick mute is ON/OFF key
<b>Frequency</b>	<b>FNCT</b>	Move transmit frequency within limits for optimum detection.
<b>Display</b>	<b>OFF, FNCT</b>	Bright or Dim display, AUTO = system information
<b>Remote</b>	<b>OFF, SET</b>	Selects Single or Dual display with RCM remote
<b>Battery</b>	<b>OFF, FNCT</b>	Read battery voltage, AUTO = battery test

Detailed table of the various functions available and the key or key combination used to access them.

Function	Description	Key	Display	Access	UP	DOWN	AUTO
<b>Power ON</b>	Power on if off.	<b>OFF</b>	ORION	Press <b>OFF</b> key and release.	-na-	-na-	-na-
<b>Power OFF</b>	Power off if on.	<b>OFF</b>		Press <b>OFF</b> key and hold.	-na-	-na-	-na-
<b>Transmit Power</b>	Sets Transmit Output power, displayed as a percentage of the maximum legal output power.	<b>FNCT</b>	PWR Man1 PWR Auto	Cycle <b>FNCT</b> key to Power function. When no other function is active, use <b>UP</b> , <b>DOWN</b> and <b>AUTO</b> directly.	Increase transmit power.	Decrease transmit power.	Toggle between manual (fixed) and auto adjusting transmit power.
<b>Mute/Unmute</b>	Toggle Headset audio on/off.	<b>OFF</b>	Vol MUTE Vol==----	Successive press and release of <b>OFF</b> key.			
<b>Headset volume</b>	Set Headset Volume Level	<b>FNCT</b>	Phones Wireless IR On IR OFF	Cycle <b>FNCT</b> key to Volume function. Also accessed through <b>OFF</b> key Mute/Unmute function.	Increase headset volume.	Decrease headset volume.	The IR wireless headset feature is enabled ("IR On") or disabled ("IR Off").
<b>Frequency</b>	Sets Transmitter Output frequency.	<b>FNCT</b>	Frq Man1 Frq AUTO	Cycle <b>FNCT</b> key to Frequency function.	Increase transmit frequency.	Decrease transmit frequency.	Toggle between manual (fixed) and auto adjusting frequency.
<b>Trip Set</b>	Sets Signal Strength Alert Tone threshold	<b>SET</b>	Trip Set	Cycle <b>SET</b> key to Trip set.	Increases threshold point.	Decreases threshold point.	Auto adjusts threshold point to current signal.
<b>Gain Set</b>	Sets the Integration Gain level.	<b>SET</b>	Gain Set	Cycle <b>SET</b> key to Gain Set.	Increases the Gain setting.	Decreases the Gain setting.	Toggles between Gain Off and On.
<b>Display parameters</b>	Sets display brightness.	<b>OFF then FNCT</b>	Display:	<b>OFF</b> then cycle <b>FNCT</b> key to DISPLAY function.	Set display to full brightness.	Set display to a dimmer, battery saving brightness.	Display ORION™ version and unit information. Press and hold to display version number of display module.
<b>Show Battery</b>	Displays battery voltage.	<b>OFF then FNCT</b>	Battery	<b>OFF</b> then cycle <b>FNCT</b> key to BATTERY function.	Shows battery voltage.	Shows battery voltage.	Performs battery condition test. Displays warning if battery condition is poor.
<b>Recalibrate</b>	Recalibrates 2 <sup>nd</sup> and 3 <sup>rd</sup> harmonic receiver display to current ambient environment.	<b>FNCT</b>	-	Press <b>FNCT</b> key while in ID or CW methods.	-na-	-na-	-na-
<b>Save user preferences</b>	Permanently stores user's volume, brightness, power, gain and tone preferences.	<b>OFF OFF then hold SET</b>	Saved OK	Press <b>OFF</b> key twice, then press and hold <b>SET</b> key for 4 seconds.	-na-	-na-	-na-
<b>Remote Display</b>	With RCM-4000 only: Set the behavior of the local and remote displays.	<b>SET</b>	Dual Single	Press <b>OFF</b> key once, then cycle <b>SET</b> key to "Display:"	Set Dual displays	Set Single display	no function
<b>Field Service System Peek</b>	Allows technician to "peek" at internal values. Permits remote diagnostics.	<b>OFF OFF then SET</b>	Sys Peek	Press <b>OFF</b> key twice, then cycle <b>SET</b> key to Sys Peek Function.	Select peeks at various internal values.	Select peeks at various internal values.	Displays Errors detected by ORION™'s self-diagnostic routines.



The following table lists the various methods available in the ORION™.

<u>Method</u>	<u>Description</u>	<u>Display</u>	<u>Access</u>
<b>Search</b>	Starts Search 2 <sup>nd</sup> and 3 <sup>rd</sup> method	Srch 2&3 Search CW Srch Hop	Press <b>SRCH</b> key to desired search method variation.
<b>Identify</b>	Starts Identify with FM modulated tone method	ID FM 2 ID FM 3	Press <b>ID</b> key to select desired harmonic.
<b>Listen</b>	Starts one of six listen methods: CW (continuous wave) transmission, AM or FM demodulation, 2 <sup>nd</sup> or 3 <sup>rd</sup> harmonic. 20k AM method with 2 <sup>nd</sup> or 3 <sup>rd</sup> .	CW AM 2 CW AM 3 CW FM 2 CW FM 3 20k AM 2 20k AM 3	Press <b>LSTN</b> key to select the desired variation and harmonic.