# ORION 2.4™

## Non-Linear Junction Detector

## User Manual

**Research Electronics International, LLC**

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www.reiusa.net

# ORION 2.4™

## Non-Linear Junction Detector

This document is intended to provide guidance and instruction on using the ORION 2.4 Non-Linear Junction Detector for finding hidden electronic devices.

This manual contains proprietary information intended solely for use with the ORION 2.4 Non-Linear Junction Detector.

The overall effectiveness of this product, and of any surveillance countermeasure, is dependent on the threat level and the user's ability to properly utilize the appropriate equipment.  REI's Center for Technical Security offers training on technical surveillance countermeasure equipment.

Revision 1.2

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<span style="color:red">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.</span>

This device complies with part 15 of the FCC Rules.  Operation is subject to the following two 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.

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Information contained in this manual including product operation and specifications is subject to change without notice.

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U.S. PATENTS: 5,815,122; 6,057,765; 6,163,259
U.K. PATENTS: GB2344423; GB2351154; GB2381077; GB2381078
Additional Patents Pending

OWNER'S RECORD
The Serial Number of each ORION 2.4 is located on the bottom of the unit near the battery compartment door. Please record this number and refer to it whenever you contact your dealer or Research Electronics International concerning this product.  Note: Removal or alteration of the serial number automatically voids all warranties of this product.

SERIAL NUMBER:  _____

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# TSCM Training

**REI Center for Technical Security:** REI offers the world's largest commercially available Technical Surveillance Countermeasure (TSCM) training facility. Training courses include classroom instruction and hands-on exercises where students perform sweep exercises in "live" environments utilizing "target rich" project rooms. The progressive course curriculum is designed for the beginner or the seasoned TSCM Technician.

Regularly scheduled courses are taught monthly; visit REI's website (www.reiusa.net) or contact REI (sales@reiusa.net) for training dates.
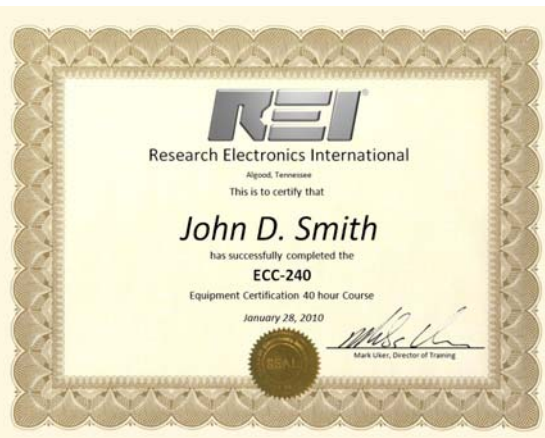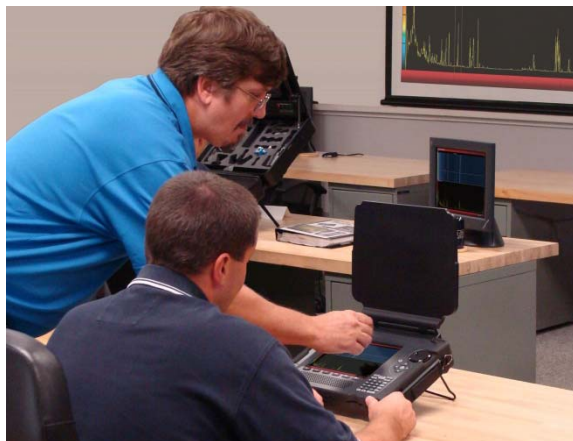




Contact REI for more information about TSCM training and/or other TSCM equipment: www.reiusa.net

## PRECAUTIONS

**ORION 2.4**

- CAUTION: Any changes or modifications not expressly approved by REI could void the user's authority to operate the equipment.

- The ORION is capable of emitting a radio signal between 2.404 GHz and 2.473 GHz.  The ORION meets USA FCC transmission requirements and has been CE marked, 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.
  - Maintain a distance of at least 20 cm between the antenna and the body of the user or nearby persons
  - 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 life support device.

- For your own safety do not use the ORION if:
  - The ORION cables or its plugs become frayed or otherwise damaged.
  - The ORION housing is cracked or otherwise damaged.
  - You suspect that the unit requires servicing

- Only use REI approved power sources, batteries, chargers, and accessories.

- There are no serviceable parts inside.  Contact your dealer or Research Electronics International, LLC for repairs.  Opening the unit will void the warranty.

- For your own safety do not use the AC power battery charger if:
  - The battery charger cables or its plugs become frayed or otherwise damaged.
  - The battery charger housing is cracked or otherwise damaged.
  - The battery charger is exposed to rain, liquid or excessive moisture.

**Lithium-Ion Batteries**

- 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.

- Avoid shorting the battery, immersing in water, or exposing to fire.  Also, avoid excessive physical shock or vibration.
- Only use the specified REI battery chargers or products to charge REI batteries
- There are no serviceable parts inside the battery.  Contact your dealer or Research Electronics International, LLC for repairs.  Opening or puncturing the unit can be dangerous and may result in injury.
- Using the Lithium-Ion batteries in a manner not specified by this user's guide may override the equipment's built-in protection mechanisms.
- Keep out of the reach of children.
- Dispose of Lithium-Ion batteries in accordance with local regulations.

## Equipment Description

### Overview



1.  **ANTENNA** – located on opposite side of head display
2.  **HEAD DISPLAY** – LED Bargraphs for indicating Power level, 2$^{nd}$ & 3$^{rd}$ Harmonic levels and a small informational display for indicating status and displaying the menu.
3.  **KEYPAD** – used for controlling the ORION 2.4
4.  **HEADPHONE JACK** – for connection of headphones to monitor audio from the unit
5.  **USB CONNECTOR** – used for connecting to a PC for software updates
6.  **SPEAKER** – used to monitor audio from the unit
7.  **POWER INPUT** *(under battery door)* – for AC adapter (only use REI supplied AC Adapter)
8.  **BATTERY DOOR / BATTERY DOOR LATCH** – conceals battery compartment

# OPERATION

## Keypad



1. **POWER** – Press to Power on.  Press and hold while the unit is on to Power off.  A quick press of the power button while the unit is on will toggle the Transmit Power Mode (Auto or Manual)
2. **AUDIO** – Press and hold to Mute and Unmute the speaker or headphone.  A quick press will toggle the Audio Modes (Tones, Listen, 500Hz, Off)
3. **TRANSMIT POWER INCREASE / UP ARROW** – Increases Auto Power maximum or Manual Power level depending on current Transmit Power mode (Auto or Manual).  When a menu is on the screen, this button acts as an up arrow, navigating up through sub-items.
4. **TRANSMIT POWER DECREASE / DOWN ARROW** – Decreases Auto Power maximum or Manual Power level depending on current Transmit Power mode (Auto or Manual).  When a menu is on the screen, this button acts as a down arrow, navigating down through sub-items.
5. **VOLUME DOWN / LEFT ARROW** – Decreases the volume.  When a menu is on the screen, this button acts as a left arrow, navigating to the previous menu level.
6. **VOLUME UP / RIGHT ARROW** – Increases the volume.  When a menu is on the screen, this button acts as a right arrow, navigating to the next lower menu level.
7. **SET** – When a menu is on the screen, this button sets the currently active menu item.  Press and hold this button to turn on or off the headlight.
8. **MENU** – Displays the Top Menu.  If the top menu is displayed, this button exits the Menu.  If a sub-item of the menu is currently displayed, this button will return you to the Top Menu.

## SET-UP & BASIC OPERATION

The ORION 2.4 has been designed for quick and easy deployment.  Depending on your application, some adjustments to the default setting may need to be made.

### Battery Usage

Lithium-Ion rechargeable batteries have been included with your unit.



To insert or switch out a new battery:

1. While pressing the latch on the bottom of the grip housing unit, raise the battery door at the rear of the unit.
2. Slide the battery into the battery slot observing proper contact alignment until it latches into place.
3. Close the battery door.

The ORION 2.4 has a built-in battery charger.  To charge the battery in the unit:

1. While pressing the latch on the bottom of the grip housing unit, raise the battery door at the rear of the unit.
2. With the battery already inserted in the unit, connect the provided AC adapter to the jack located just above the battery slot and to an AC source.  The battery will begin charging as indicated by the blinking segments on the gauge visible on the end of the battery.  When the gauge is full, the battery is fully charged.  The OLED display on the head will also show the battery charge status.

After taking the ORION 2.4 out of the case, follow these simple steps to begin using it:

1. Place one of the provided rechargeable batteries in the battery compartment
2. Rotate the head for easy viewing
3. If preferred, extend the telescoping pole to a convenient length

## Procedure

When the ORION 2.4 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 2.4. 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 the ORION 2.4.

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 2.4 can be configured multiple ways to aid in these two processes.

## Basic ORION 2.4 Functions

### Power On/Off

To Power on or off the unit:

1.  With the unit off, press and release the Power button to turn the unit on.
2.  With the unit on, press and *hold* the Power button to turn the unit off.

### Operation/Menu Item: Transmit Power Level

The Transmit Power Level may need to be adjusted depending on several factors, including the target or detection range.

To manually adjust the Transmit Power Level:

1.  Repeatedly press the Up Arrow button to increase the transmit power.  The TX1 Green Bar graph will increase corresponding to the increase in transmit power.  The OLED Display above the bar graphs will display the numerical value of the transmit power level.
2.  Repeatedly press the Down Arrow button to decrease the transmit power.  The TX1 Green Bar graph will decrease corresponding to the decrease in transmit power.  The OLED Display above the bar graphs will display the numerical value of the transmit power level.

*Note: Whenever a menu is on the screen, the Up Arrow and Down Arrow serve as navigation keys for the menu.  To adjust the Transmit Power Level, confirm that no menu is displayed.  To exit a menu, press the Left Arrow button or wait about 7 seconds for the menu to time out.*

### Auto / Manual Transmit

The ORION 2.4 can be operated in either auto transmit mode or manual transmit mode.  In auto transmit mode, the transmit power will automatically reduce whenever the receiver becomes saturated.  In Manual transmit mode, the transmit power remains at the same level unless it is manually changed.

To toggle between Auto Transmit mode and Manual Transmit Mode:

1.  With the unit on & with the Transmit Power adjusted so that the Transmit Power is not OFF, press and release the Power button.

### Volume Level

In addition to bar graphs and the OLED display, which give visual cues whenever a hidden electronic target is detected, the ORION 2.4 also has several audio modes, which give audio cues whenever targets are detected.  For details on the audio modes, see the appropriate sections later in this User's Manual.  These audio cues can be received either through the provided speaker on the unit, through headphones, or through the wireless headphone receiver.

# OPERATION

To adjust the audio level of the ORION 2.4:

1. Repeatedly press the Right Arrow button to increase the volume. The OLED screen will display the volume level as it increases.
2. Repeatedly press the Left Arrow button to decrease the volume. The OLED screen will display the volume level as it decreases.

*Note: Whenever a menu is on the screen, the Left Arrow and Right Arrow serve as navigation keys for the menu. To adjust the Volume Level, confirm that no menu is displayed. To exit a menu, press the Left Arrow button or wait about 7 seconds for the menu to time out.*

## Volume Mute

To quickly mute the volume level:

1. Press and hold the Audio button until the audio silences.
2. Press and hold the Audio button again to return the previous volume level.

## Adjusting the Menu Items

The ORION 2.4 can be configured for multiple situations.  The majority of settings changes are handled through the menu.

To adjust menu items:

1. Press the MENU button.  The Main Menu will appear.
2. Press the Up or Down Arrow to begin scrolling through the Base Level Menu Items: Frequency, Audio, DSP Gain, System, & User.
3. To enter one of the Base Level Menu Items, press the Right Arrow when that Menu Item is displayed.
4. Press the Up or Down Arrow to begin scrolling through the Level 1 Sub-Items.
5. A right arrow next to the name of a menu item indicates another sub-level of menu items.  To access that sub-menu, press the Right Arrow button.
6. Any menu item without a right arrow next to the name or that is displayed with a lit background is a setting.  Press the SET button to activate that setting.
7. Press the Left Arrow to go back up a menu level or to exit the menu if you are already at the Base Level.

## Menu Structure

| Base Level | Level 1 | Level 2 | Level 3 |
|---|---|---|---|
| Frequency ➜ | Manual ➜ | ⬆⬇ Adjusts frequency | *  Also MENU + ⬆; MENU + ⬇ |
|  | Hop |  |  |
|  | Auto |  |  |
| Audio ➜ | Audio Off |  |  |
|  | Tones trip set ➜ | ⬆⬇ 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50% |  |
|  | Listen 2$^{nd}$ AM |  |  |
|  | Listen 2$^{nd}$ FM |  |  |
|  | Listen 3$^{rd}$ AM |  |  |
|  | Listen 3$^{rd}$ FM |  |  |
| DSP Gain ➜ | ⬆⬇ Gain 1, 2, 3, 4, 5, 6 |  |  |
| System ➜ | Wireless ➜ | ⬆⬇ On, Off |  |
|  | Settings ➜ | ⬆⬇Save, Recall, Reset |  |
|  | Stats ➜ | Battery |  |
|  |  | About |  |
|  | Clock ➜ | Show Clock |  |
|  |  | Set Clock | ⬅➜ Selects h, m, s, M, D, Y; |
|  |  |  | ⬆⬇ change selected item; |
|  |  |  | ⊙ Completes |
|  | Power Saver ➜ | Standby | Disabled, 1, 2, 5 minutes |
|  |  | Auto Off | Disabled, 5, 10, 20, 30 minutes |
| User ➜ | Headlamp ➜ | ⬆⬇ On, Off | *Also  Set key hold |
|  | Vibrate ➜ | ⬆⬇ Off, 1, 2, 3, 4, 5, 6* | *experimental patterns |

| | Key Light ➔ | ↑↓ Off, On, Momentary | |
|---|---|---|---|
| | Bright ➔ | ↑↓ Low, Medium, High | |

## Menu Items / Operations

### Manual Frequency Adjust

Purpose:    Sets Transmitter Frequency

Menu Access:    Menu > Frequency > Manual > ↑ or ↓ to adjust frequency

Quick Access:    Press and hold MENU button until "Frequency" is displayed, release the MENU button and press ↑ or ↓ to adjust frequency

Range:    2.4040 GHz to 2.4790 GHz, adjustable in 100 kHz steps

Display:    "#.#### GHz"

### Frequency Hop Mode

Purpose:    To avoid transmitting on a single frequency, in frequency hop mode, the frequency is constantly changing transmitter frequency, covering the entire frequency range

Menu Access:    Menu > Frequency > Hop > ⊙ *(press set button)*

### Auto Frequency Mode

Purpose:    Monitors fundamental transmit frequency for ambient noise (including Wi-Fi signals) and automatically changes the frequency if there is interference.

Menu Access:    Menu > Frequency > Auto > ⊙ *(press set button)*

### Audio Output Mode: Tones

Purpose:    To provide an audible component to target detection

Menu Access:    Menu > Audio > Tones > Trip Level - ↑ or ↓ to adjust Trip Level
To turn audio off:  Menu > Audio > Audio Off

Quick Access:    Press the Audio button to quickly access the Audio Sub-menu

Range:    0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%

Display: "Trip: ##%"

### Audio Output Mode: 2nd AM

| | |
|---|---|
| Purpose: | Performs an AM demodulation on the received $2^{nd}$ harmonic signal and outputs the audio through the speakers or headphones |
| Access: | Menu > Audio > $2^{nd}$ AM > ⊙ *(press set button)* <br> To turn audio off:  Menu > Audio > Audio Off |
| Quick Access: | Press the Audio button to quickly access the Audio Sub-menu |
| Range: | "AGC Off" or "AGC On" |

### Audio Output Mode: 2nd FM

| | |
|---|---|
| Purpose: | Performs an FM demodulation on the received $2^{nd}$ harmonic signal and outputs the audio through the speakers or headphones |
| Access: | Menu > Audio > $2^{nd}$ FM > ⊙ *(press set button)* <br> To turn audio off:  Menu > Audio > Audio Off |
| Quick Access: | Press the Audio button to quickly access the Audio Sub-menu |
| Range: | "AGC Off" or "AGC On" |

### Audio Output Mode: 3rd AM

| | |
|---|---|
| Purpose: | Performs an AM demodulation on the received $3^{rd}$ harmonic signal and outputs the audio through the speakers or headphones |
| Access: | Menu > Audio > $3^{rd}$ AM > ⊙ *(press set button)* <br> To turn audio off:  Menu > Audio > Audio Off |
| Quick Access: | Press the Audio button to quickly access the Audio Sub-menu |
| Range: | "AGC Off" or "AGC On" |

### Audio Output Mode: 3rd FM

| | |
|---|---|
| Purpose: | Performs an FM demodulation on the received $3^{rd}$ harmonic signal and outputs the audio through the speakers or headphones |

Access:            Menu > Audio > 3$^{rd}$ FM > ⊙ *(press set button)*
To turn audio off: Menu > Audio > Audio Off

Quick Access:    Press the Audio button to quickly access the Audio Sub-menu

Range:            "AGC Off" or "AGC On"

## DSP Gain Level

Purpose:          Sets the level of digital signal processing integration that is used to process the received signals.

Access:            Menu > DSP Gain > ↑ or ↓ to adjust Gain Level

Range:            1 - 6

Display:           "Gain  #"

## Wireless Headset Settings

Purpose:          To turn wireless audio off/on – for use with wireless headset.

Access:            Menu > System > Wireless > ↑ or ↓ to turn off or on

Range:            "Wireless Off" or "Wireless On"

Display:           "Off" "On"

## Reset User Settings

Purpose:          Anytime that the ORION 2.4 is shut down, it saves any user settings that have been changed to memory.  The next time the unit is powered on, it will recall these saved settings.  However at any time the original factory user settings can be recalled.

Access:            Menu > System > Settings > Reset > ⊙ *(press set button)*

## Save/Recall User Settings

Purpose:          For saving the current configuration for recall at a later time.

Access:            To Save current settings - Menu > System > Settings > Save > ⊙ *(press set button)*

To Recall saved settings - Menu > System > Settings > Recall > ⊙ *(press set button)*

## Display Battery Status

Purpose:         To display current battery status to the customer

Access:         Menu > System > Stats > Battery > ⊙ *(press set button)*
                    To exit this screen, press any key

Display:        Current battery status.

## Display About Information

Purpose:         To display general information about the ORION 2.4

Access:         Menu > System > Stats > About > ⊙ *(press set button)*
                    The about screen will time out automatically after about 7 seconds.
                    To exit this screen before then, press any key

Display:        General Information

## Show Clock

Purpose:         To display the current time and date

Access:         Menu > System > Clock > Show Clock > ⊙ *(press set button)*
                    To exit this screen before then, press any key

Display:        Current time and date

## Set Clock

Purpose:         To set the current time and date

Access:         Menu > System > Clock > Set Clock > ⊙ *(press set button)*
                    Press Left or Right Arrow (←→) to select h, m, s, M, D, Y
                    Press the Up or Down Arrow (↑↓) to change the selected item
                    Press the set button (⊙) to complete the change and exit the set clock screen

# OPERATION

### Standby Mode Setup

Purpose: To configure Standby Mode. This feature will automatically put the unit into a low power state after a predetermined period of inactivity. Full operation returns when unit is picked up or handled.

Access: Menu > System > Pwr Save > Standby > Press ↑ or ↓ to adjust timeout

Range: Disabled, 1 minute, 2 minutes, 5 minutes

### Auto Off Mode Setup

Purpose: To configure Auto Off Mode. This feature will automatically shut off the unit after a predetermined period of inactivity. Power Up operation (pressing the power button) is required to return to full operation.

Access: Menu > System > Pwr Save > Auto Off > Press ↑ or ↓ to adjust timeout

Range: Disabled, 5 minutes, 10 minutes, 20 minutes, 30 minutes

### Headlamp Setup

Purpose: To enable the headlamp on the head

Access: Menu > User > Headlamp > ↑ or ↓ to turn off or on

Quick Access: Press and hold the set button (⊙) to toggle the headlamp on and off

Range: "Lamp Off" or "Lamp On"

### Haptic Feedback Setup

Purpose: To configure vibrator/haptic feedback

Access: Menu > User > Vibrate

Range: Off, Target detection only, Keypad feedback only, Both target detection and keypad)

### Keypad Backlight Setup

Purpose: To configure keypad backlight

Access: Menu > User > Keypad backlight

Range: Off, On, Momentary

## Display Brightness

Purpose: To adjust the brightness of the OLED character display and LED Bar Graphs.

Access: Menu > User > Display Brightness

Range: Low, Medium, High

# Wireless Headphone Receiver

The ORION 2.4 Wireless Headphone Receiver provides the ability to listen to the received signal without fighting with cords and plugs.



## Normal Operation

To power on and begin using the wireless headphone receiver:

1. Plug the headphones into the 3.5mm jack on top of the wireless headphone receiver. The wireless headphone receiver will power up when the headphones are detected. The green LED on the headphone receiver indicates that it is powered up and receiving.
2. Once powered the receiver will begin looking for the Orion 2.4. If no audio is present after a few seconds, refer to the section below "Pairing to an Orion 2.4". While the receiver is looking for the ORION 2.4, the LED on top of the wireless headphone receiver will flash red and green. Once the ORION 2.4 has been located, the LED will remain green.

NOTE: If the LED on the Wireless Headphone Receiver remains green, but no audio can be heard, ensure that the volume is not muted on the ORION.

## Pairing to an Orion 2.4

The Wireless Headphone Receiver comes paired with the ORION 2.4 it ships with from the factory. Any time that the Wireless Headphone Receiver is powered on, it begins looking for the ORION that it has been previously paired with. To pair the Wireless Headphone Receiver with a different ORION:

1. Make sure that the ORION you wish to pair with is powered on, that the transmit power is not set to off, and that the Wireless setting is turned "On" in the menu. Power off any other nearby ORIONs, as the Wireless Headphone Receiver will pair with the first unit that it finds.

2.  Press the Sync button located on top of the Wireless Headphone Receiver.  The Wireless Headphone Receiver will begin scanning all channels looking for an ORION.  Once the receiver has been paired with an ORION, it will always look for that ORION when it is powered on.

Note:  The wireless receiver will only pair with one ORION 2.4 at a time.  However, it is possible to have multiple wireless receivers listening to the same ORION 2.4.

Note:  When pairing the wireless receiver with an ORION 2.4 unit, the receiver will pair with the first unit it sees as it scans the channels.  If there are multiple ORIONs in the area, confirm that the unit you wish to pair with is the only ORION transmitting while performing the pairing operation.

## Replacing the Wireless Headphone Receiver Battery

The wireless headphone receiver is powered by one, user-replaceable AA battery.



To replace the AA battery:

1.  Locate the battery housing door on the back of the unit below the belt clip and slide it open.
2.  Replace the battery, being careful to observe the polarity markings on the housing.

## Specifications

### TRANSMITTER

**Frequency Bands:** 2.404 GHz – 2.473 GHz center
**Transmit Channels:** Manual or Auto selection, more than 100 available
**Transmit Power:** 3.6 Watts
**Power Control:** Manual or Auto control
**Detection Modulation:** Digital 1.25 MHz BW

### RECEIVER

**Simultaneous 2$^{nd}$ & 3$^{rd}$ harmonic receive**
**Digitally Correlated**
**Frequency Bands:** Transmit Band (2.404 GHz – 2.473 GHz); Second Harmonic (4.808 GHz – 4.946 GHz); Third Harmonic (7.212 GHz – 7.419 GHz)
**Sensitivity:** -140 dBm for both harmonics

### DISPLAY

**Antenna-Mounted Display**
**Bar Graph Display** for transmit power level, 2$^{nd}$ harmonic level, 3$^{rd}$ harmonic level

### MECHANICAL

**Extension Lengths:** 16-51 in (40.6 - 129.5 cm)
**Case Dimensions:** 6.25 in x 14.9 in x 18.5 in (15.9 cm x 37.8 cm x 47.0 cm)
**ORION 2.4 Dim:** 21 in x 3.75 in x 3 in (53 cm x 9 cm x 7.5 cm)
**ORION Weight w/ Battery:** 2.9 lbs (1.32 kg)
**Case Weight including ORION & Accessories:** 10.5 lbs (4.8 kg)

### BATTERY

**Input AC:** 100 - 240 V, 50 – 60 Hz
**Run Time:** 4 hours per battery (typical)
**Charge Time:** 2.5 hours per battery
**Batteries:** 10.8 V Lithium Ion Rechargeable Battery (2 included)

CE

*Product specifications and descriptions subject to change without notice*

## APPENDIX

The $\mathrm{ORION}^{\text{™}}$2.4, designed and built by the engineers at Research Electronics International, is the latest advancement in Non-Linear Junction Evaluation. The $\mathrm{ORION}^{\text{™}}$ 2.4 can be used to locate electronic devices whether in furniture, walls, ceiling fixtures or elsewhere. The $\mathrm{ORION}^{\text{™}}$ detects semiconductor junctions, to alert in the presence of electronics.

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

The $\mathrm{ORION}^{\text{™}}$ radiates RF energy at frequency $f_0$ and receives energy at $2f_0$ & $3f_0$. When the radiated signal at $f_0$ encounters a non-linear junction, some of the energy is re-radiated back at $f_0, 2f_0, 3f_0, ...$ It is the non-linear characteristic of the junction that generates $2f_0, 3f_0, ...$ (the 2nd & 3rd harmonics respectively). By observing the presence of returned signals at $2f_0$, $3f_0$, the user can detect the presence of a non-linear junction.

Now consider a basic diode; the simplest form of an electronic non-linear junction.

$$i = I_s \left[ e^{qv/kT} - 1 \right]$$

Eq. 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 in Kelvins.

A plot of this equation for a typical diode looks something like the following:

**Typical Diode Voltage Curve**
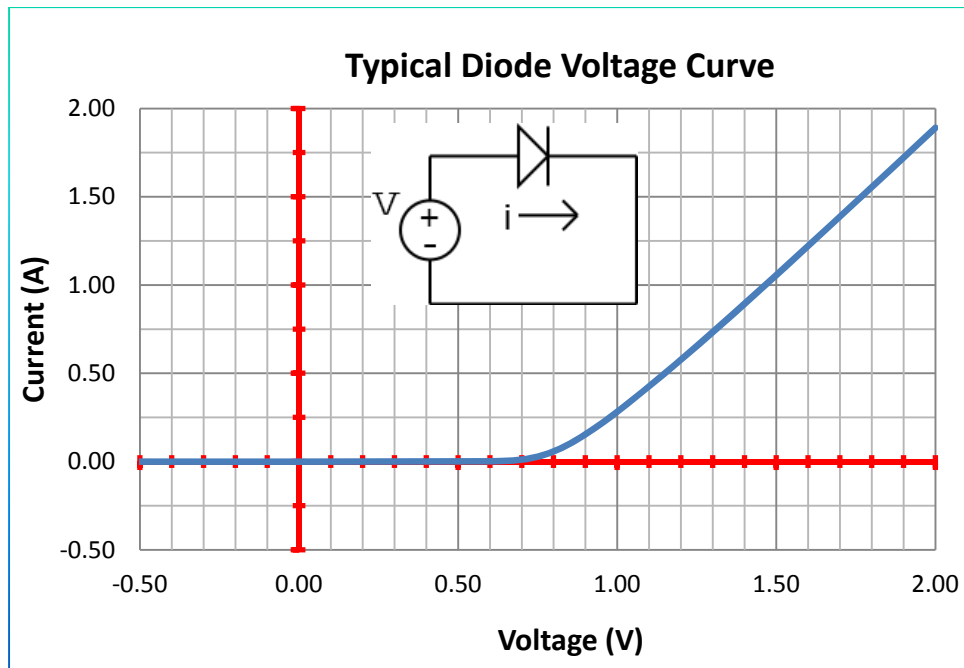
# APPENDIX

If we approximate Eq. 1 near the origin using Taylor Series,

$$i = I_s \left[ \frac{vq}{kT} + \frac{\left(\frac{vq}{kT}\right)^2}{2} + \frac{\left(\frac{vq}{kT}\right)^3}{6} + \ ... \right] \qquad \text{Eq. 2}$$

For small signals across the diodes terminals, we can reduce this to the first three terms,

$$i \sim I_s \left[ \frac{vq}{kT} + \frac{\left(\frac{vq}{kT}\right)^2}{2} + \frac{\left(\frac{vq}{kT}\right)^3}{6} \right] \qquad \text{Eq. 3}$$

In Eq. 3, the second term is responsible for generating the 2nd harmonic and the third term is responsible for generating the 3rd harmonic.

Electronic devices typically have many different non-linear junctions (diodes, transistors, etc.) linked by wires or printed circuit board traces. Therefore energy can be radiated in and out of the device through complex paths. Typically the 2nd harmonic signal is stronger than the 3rd harmonic signal. However, some circuits can re-radiate strong 3rd harmonic signals.

Other situations can also produce harmonic signals. Two dissimilar metals, joined or touching, and corroded metals return harmonic signals (passive intermodulation). These we will refer to as false junctions (Sometimes called "rusty bolt effect" or "environmental diodes".)

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.



http://en.wikipedia.org/wiki/File:Rust_Bolt.JPG

Although there are various different types of semiconductor junctions (PN, PIN, JFET, MOSFET, etc.), 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 below.



Semiconductor Junction
Characteristics

False Junction
Characteristics
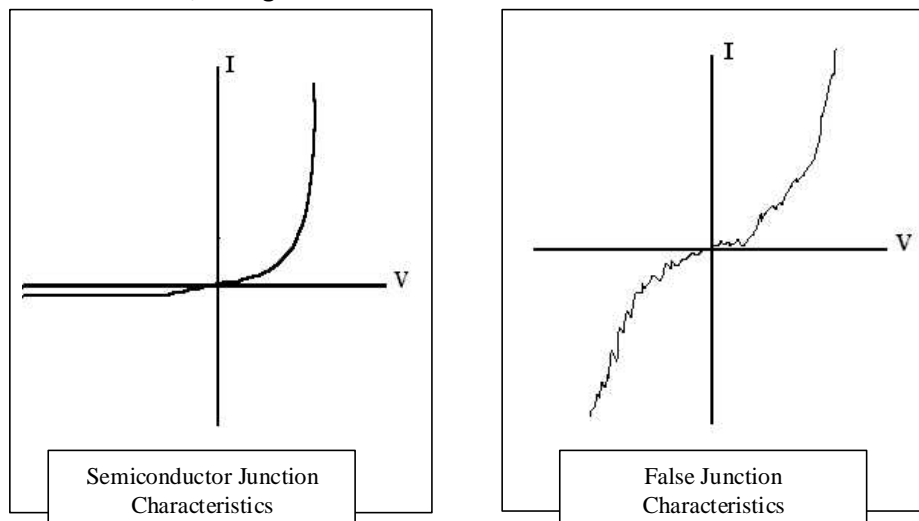
This level of regularity in the junction results in differences in the harmonic signals.  When the $ORION^{™}$ radiates a signal that is returned by the junction in electronics, it results in a strong 2nd harmonic signal and a weak 3rd harmonic.  A false junction returns a very weak 2nd harmonic and a strong 3rd.

**A**                                                                                      **B**
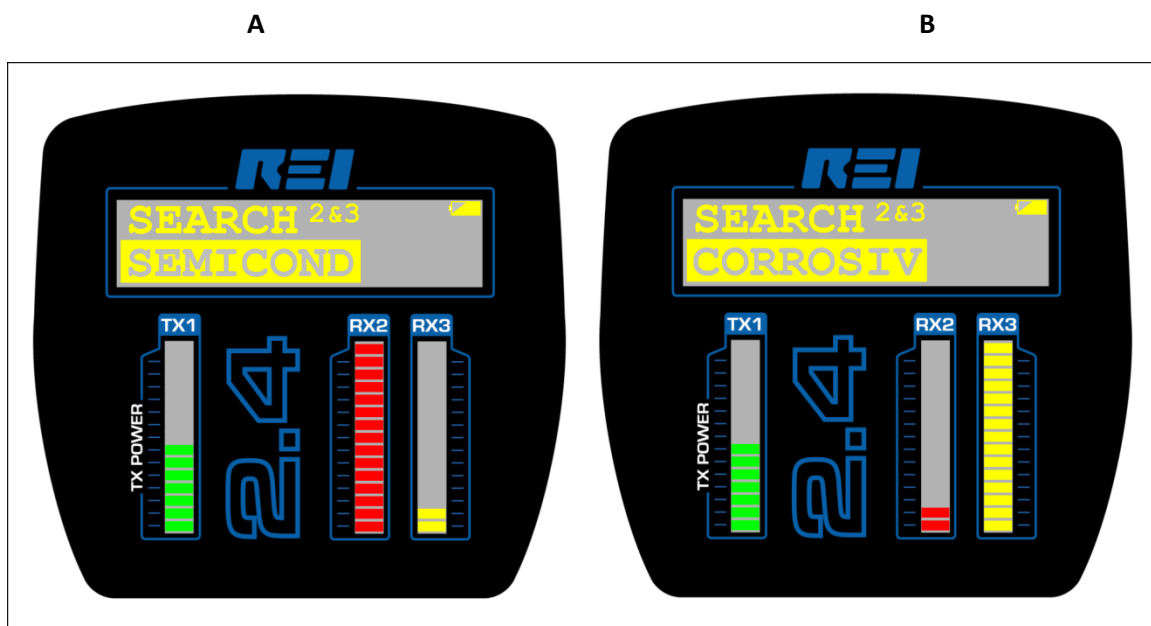


$ORION^{™}$ COMPARISON OF HARMONIC LEVELS
(A – Semiconductor, B – False Junction; Bargraphs on the right are the 2nd and 3rd harmonic levels)

APPENDIX

As mentioned earlier, some semiconductor circuits re-radiate a strong third harmonic signal. For example with two diodes connected back to back (see below), the shape of the voltage curve resembles the symmetry of a false junction and produces a stronger third harmonic than does a single diode.



Back to Back Diode Voltage Curve