BreadCrumb® LX

USER GUIDE

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Note: This device has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the device is operated in a commercial environment. This device generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with this instruction manual, may cause harmful interference to radio communications. Operation of this device in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at their own expense.

This Class A digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de la classe A est conforme à la norme NMB-003 du Canada.

CAUTION: Changes or modifications not expressly approved by Rajant Corporation could void the user's authority to operate the device.

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1.0 PREFACE

1.1 PURPOSE AND SCOPE

This manual refers to the BreadCrumb LX model.

It provides information and guidance to all personnel who are involved with and use Rajant Corporation's BreadCrumb® Wireless Network devices.

The manual begins with an introduction to the BreadCrumb Wireless Network (BCWN) and a brief overview of the BreadCrumb LX.

1.2 USER INFORMATION

The user of this manual is encouraged to submit comments and recommended changes to improve this manual. Please send any comments or changes to support@rajant.com . Be sure to include the version number of the manual you are using and please provide the page numbers related to your comments wherever possible.

2.0 INTRODUCTION

Rajant Corporation's (www.rajant.com) BreadCrumb LX operates on IEEE 802.11a/b/g wireless networking standard to form a wireless mesh network. The network is mobile, self-integrating, self-meshing, self-healing, full-duplex and secure. The focus is on flexibility, adaptability, and simplicity.

The BreadCrumb Wireless Network (BCWN) is intended for rapid deployment of a broadband wireless network into a situation or 'hot zone'. The network can be deployed as a stand-alone wireless network, or bridged to another network (such as the Internet) utilizing available reach-back communication links (such as a DSL, cable, or satellite modem).

The LX provides high bandwidth applications to stream video, audio as well as data over large distances. The network traffic can be secured by using different security features offered by the BCWN. This makes the network optimal for tactical deployments as well as emergency response situations since it offers robustness, stability and ease of setup in mission critical activities.

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment.

This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at their own expense.

2.1 WHAT IS A BREADCRUMB?

A BreadCrumb is an 802.11a/b/g (Wi-Fi) Access Point specifically designed for the following scenarios:

2.1.1 RAPIDLY DEPLOYED WIRELESS NETWORKS

Networks that must be established quickly and with minimal effort for short-term use. (e.g., a network established to provide First Responder support at the site of a disaster).

2.1.2 MOBILE WIRELESS NETWORKS

Networks in which the network infrastructure itself is mobile, in addition to client devices (e.g., a convoy viewing a video stream from a UAV).

2.1.3 WIRELESS NETWORK EXTENSION

Networks in which a wireless network must be quickly extended around or through obstacles that block wireless communications (e.g., urban canyon networks, tunnels/caves, etc.).

2.1 WHAT IS A BREADCRUMB? (continued)

2.1.4 WIRED NETWORK EXTENSION

Networks in which two or more wired networks at different locations must be connected wirelessly (e.g., to securely connect combat service support computers with logistics bases)

2.1.5 ANY COMBINATION OF THE PREVIOUS SECTIONS 2.1.1 to 2.1.4

Most BreadCrumb deployments include elements from more than one of the above scenarios.

In many cases, BreadCrumbs will perform all of the tasks as shipped with no configuration necessary at all, providing an instant TAN -a *Tactical Area Network*. Moreover, because BreadCrumbs use industry-standard 802.11a/b/g communications, client devices such as laptops or handheld computers require no special hardware, software, or configuration to access a BCWN.

2.2 MOBILITY THROUGH MESHING

The key component to a BCWN is a technique known as *Meshing*. While this is generally handled automatically by BreadCrumbs, complex deployment scenarios require a basic understanding of how BreadCrumbs establish and maintain a mesh.

2.2.1 MESH – A DEFINITION

A *mesh* is a collection of network devices (in our case, BreadCrumbs), each of which is connected to one or more other BreadCrumbs. Data can move between BreadCrumbs via these links, possibly passing through several intermediate BreadCrumbs before arriving at its final destination.

The intelligence of a BCWN is in how it adapts rapidly to the creation or destruction of the links in the mesh as devices are moved, switched OFF or ON, blocked by obstructions, interfered with by other devices, or otherwise affected. This adaptation takes place automatically and immediately as needed.

Note: Although all BreadCrumbs can be Access Points, most Access Points do not provide any meshing capabilities. Traditional Access Points simply allow wireless devices within range to connect to a wired network; they do not extend range through other Access Points.

2.2.2 BREADCRUMBS MESH BY CHANNEL AND ESSID

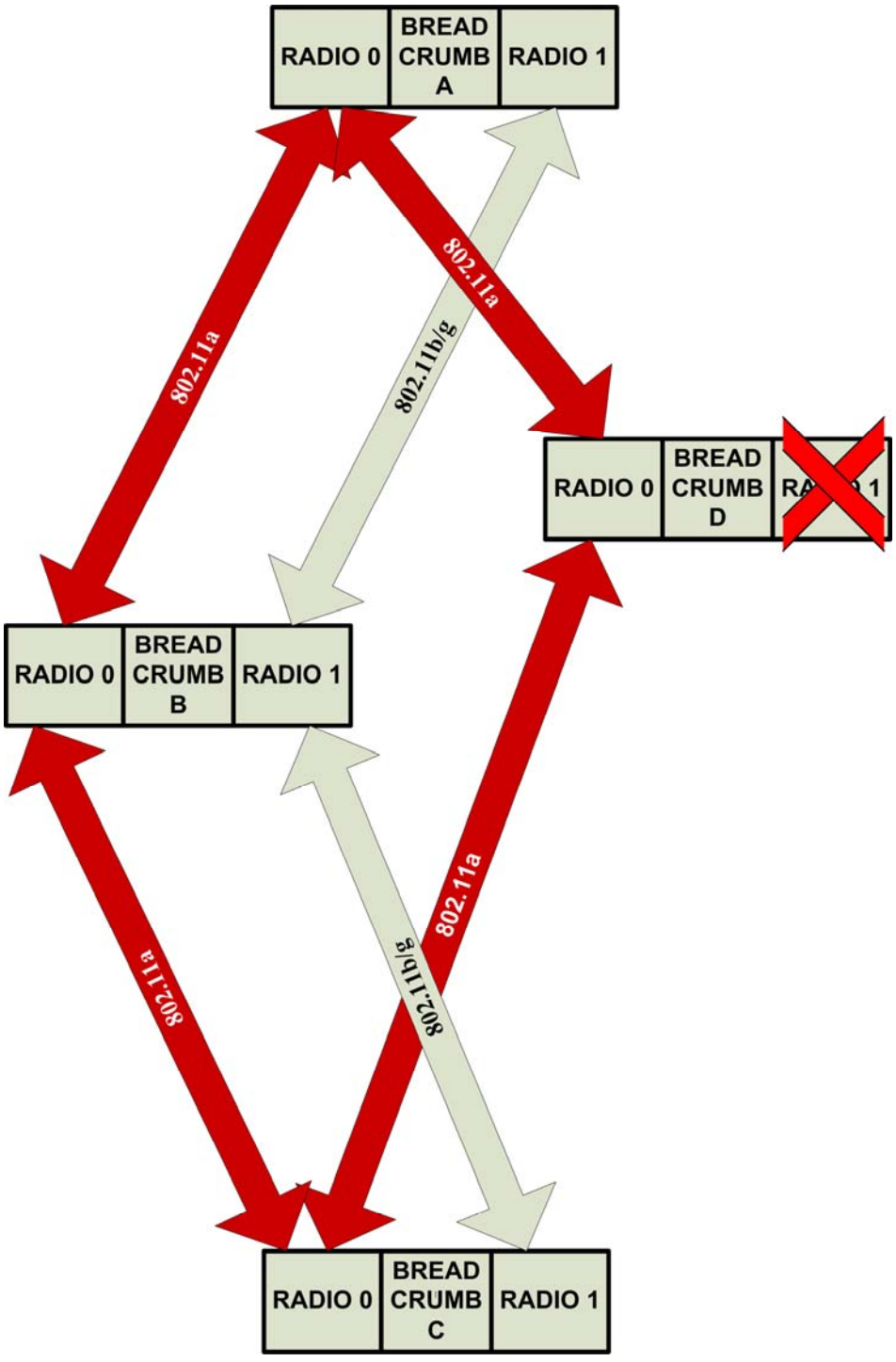
Two BreadCrumbs establish a mesh link to one another when they share both a radio channel and an ESSID. The 802.11b/g radios used by BreadCrumbs support 11 different channels for communication, numbered 1 to 11. The 80211a radios used by BreadCrumbs support 18 different channels: 36, 40, 42, 44, 48, 50, 52, 56, 58, 60, 64, 149, 152, 153, 157, 160, 161 and 165. By default, each 802.11b/g BreadCrumb radio is on channel 1 or 11, while each 802.11a radio is on channel 152.

An ESSID is essentially a name for a wireless network. By default, LX BreadCrumbs use the ESSID "breadcrumb54".

2.2 MOBILITY THROUGH MESHING (continued)

Example 1

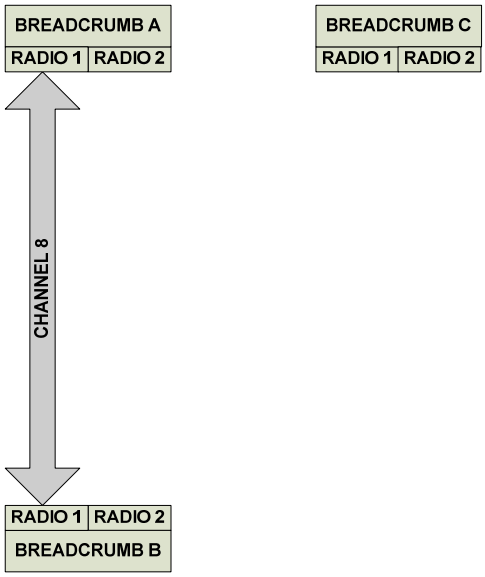
Suppose you have four BreadCrumbs, called A, B, C and D. Each has two radios. All radio 0s are on 802.11a and all radio 1s are on 802.11b/g. All four BreadCrumbs are using the default ESSID of "breadcrumb54". Assuming that all four BreadCrumbs are within radio range of one another and that Radio 1 in BreadCrumb D has lost connection with the network, the network will be connected, as shown below. It can be seen that even with the loss of one radio, the network can still be maintained.



2.2 MOBILITY THROUGH MESHING (continued)

Example 2

Now suppose that you change the ESSID of BreadCrumb C to "lonely". The network will adjust to this change, resulting in the following configuration:



Note that BreadCrumb C can no longer communicate with A or B, and vice versa.

2.3 DESCRIPTION OF BREADCRUMB LX

2.3.1 RADIOS

The BreadCrumb LX uses two radios. The LX only uses one antenna per radio. The LX has N-type connectors for the radios. An 802.11b/g radio is used in the 2.4 GHz band and an 802.11a radio is used in the 5 GHz band. Also, most 5 GHz antennas will only support a subset of the 802.11a 5 GHz channels the Rajant radio is capable of using.

Since the radios operate at different frequencies, you must be careful to use the correct type of antenna with each radio. As an example, a 2.4 GHz antenna will <u>not</u> work with a 5 GHz radio and vice versa.

The user should take care choosing an 802.11a channel from BCAdmin. The available channels are:

U-NII Upper Band (Mesh Only, Mesh/AP):

Channel 149 : 5745 MHz 11a
Channel 152 : 5760 MHz 11a Atheros Proprietary
Channel 153 : 5765 MHz 11a
Channel 157 : 5785 MHz 11a
Channel 160 : 5800 MHz 11a Atheros Proprietary
Channel 161 : 5805 MHz 11a
Channel 165 : 5825 MHz 11a

2.4 POWER/ETHERNET (continued)

2.4 POWER/ETHERNET

The LX is powered by Power over Ethernet (PoE), which is provided by an inline injector. This requires a special PoE power supply. The LX Ethernet port supports automatic MDI/MDI-X. This allows it to handle regular or crossover Ethernet cables.

In most installations, the following specifications should apply.

Input Requirements: 9—28 Vdc (+v for hi/lo margin on input); 5000 W transient suppression (clamp off over-voltages, spikes and surge the output voltages).

Output Requirements: 18—48 Vdc @ 20 W minimum (1.1 A @ 18 Vdc) (The higher the output voltage, the further the power box can be moved remotely from the LX).

2.4 POWER/ETHERNET (continued)

2.4.1 BREADCRUMB LX EXTERNAL CHASSIS FEATURES

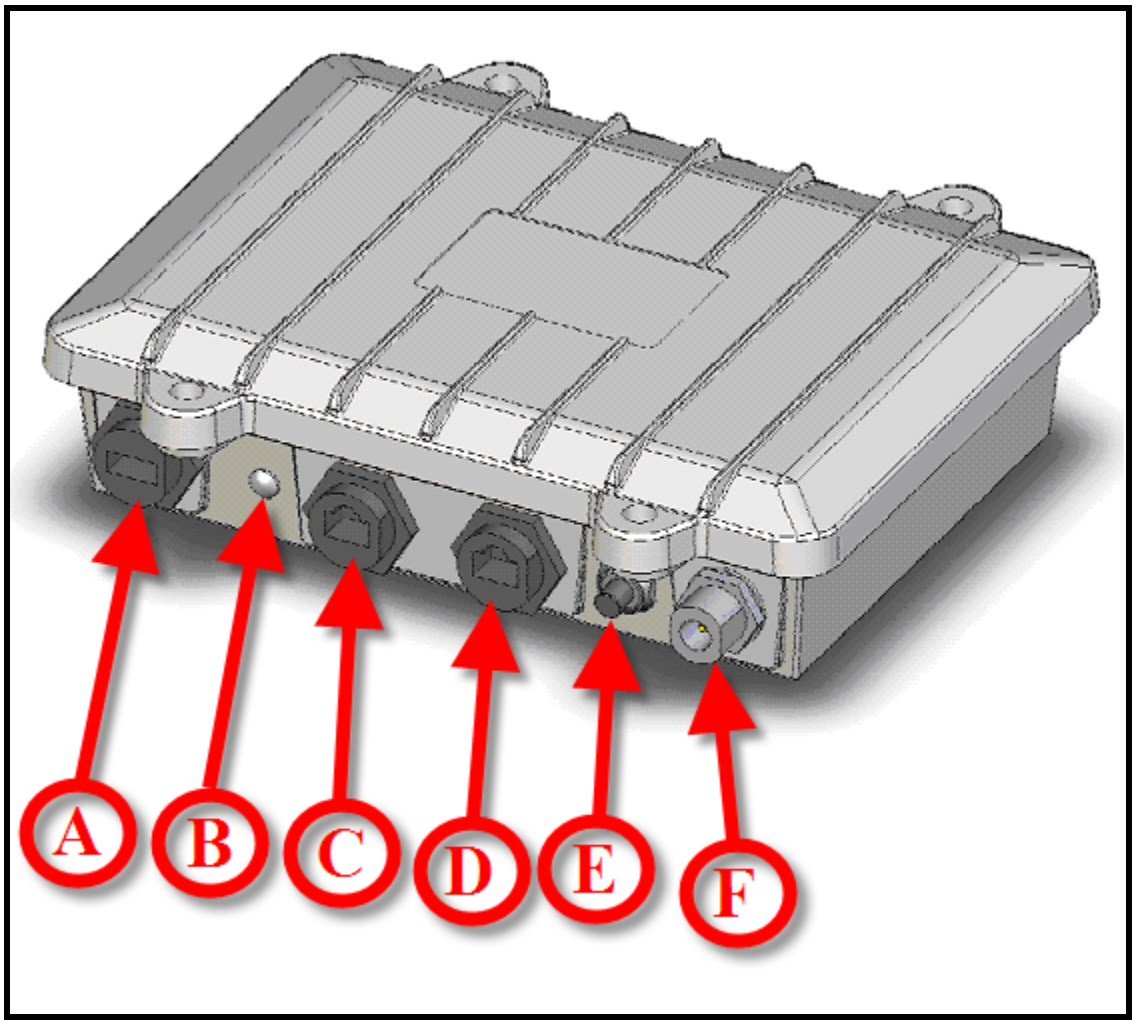


Figure 1. BreadCrumb LX External Chassis Features (Top Side)

A. USB Flash Port.

B. STATUS LED.

C. ETH0/PWR RJ45 Port.

D. ETH1 RJ45 Port.

E. ZEROIZE/RESET Pushbutton Switch.

F. Type N RF Connector for the 2.4 GHz Antenna.

2.4.1 BREADCRUMB LX EXTERNAL CHASSIS FEATURES (continued)

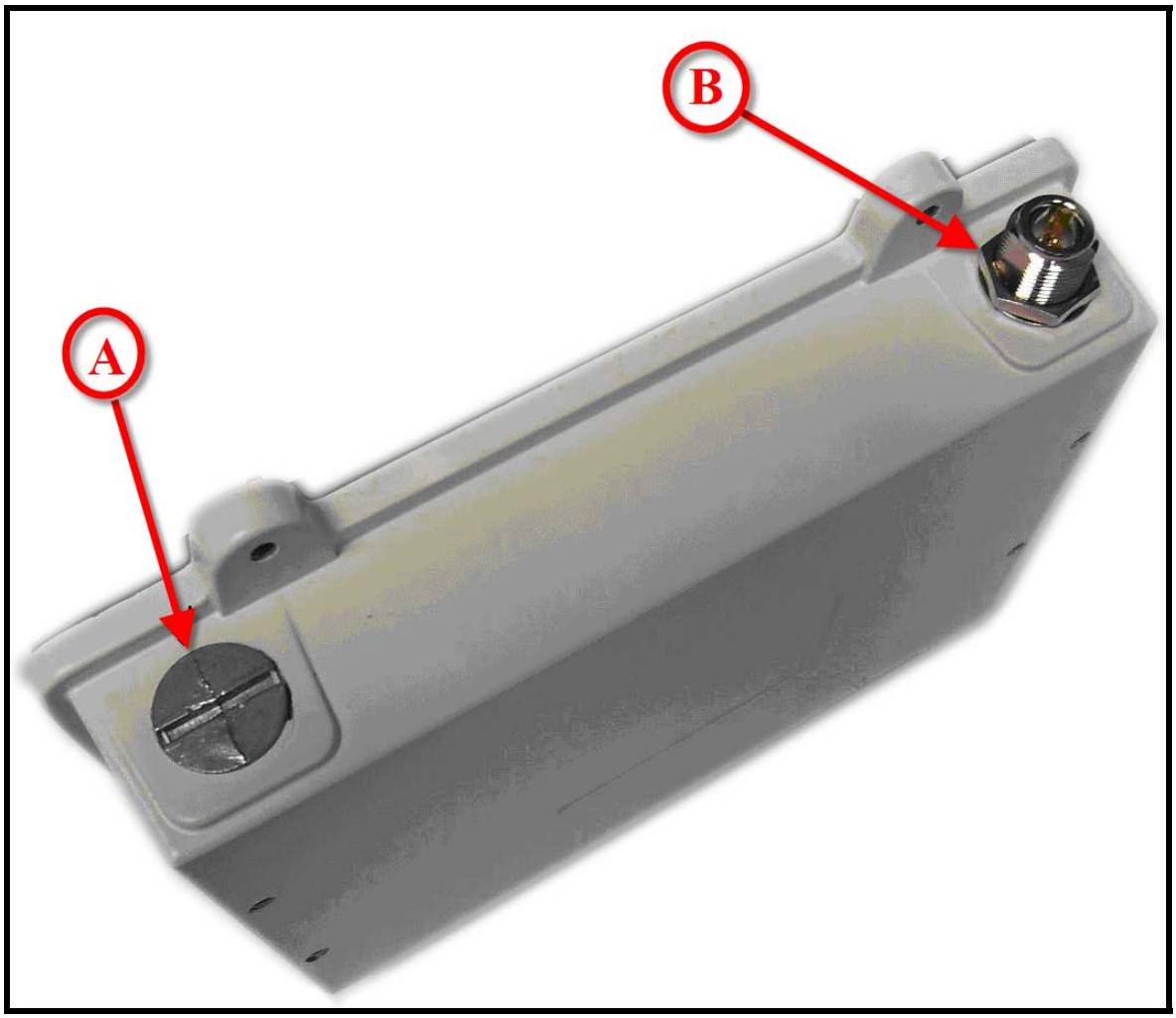


Figure 2. BreadCrumb LX External Chassis Features (Bottom Side)

A. ½" Closure Plug (Not Used)

B. Type N RF Connector for the 5.0 GHz Antenna

2.5 NETWORK FEATURES

Each BreadCrumb LX has one IEEE 802.11b/g wireless NIC (network interface card), one IEEE 802.11a NIC, two externally accessible Ethernet ports and one externally accessible USB2 port. The wireless NICs enable the BCWN components to communicate and form the wireless LAN, as well provide access for wireless clients to connect and communicate. The Ethernet ports provide wired connections to auxiliary network devices and clients. The Ethernet ports also provide a secure connection for some device configuration options which are not available through wireless connections. The USB port is used primarily for upgrading firmware.

2.6 CONNECTIONS

Because the PoE voltage provided by the injector is a fairly high 48 volts, the Ethernet cable between the injector and the LX Breadcrumb should be made **before** powering up the injector. If cable is plugged in with a live injector, a large spark will be produced that is not good for the electronics.

In order to avoid sparking and possible damage to the unit, be sure to connect the powered Ethernet cable to the BreadCrumb LX before applying power to the power supply.

The LX supports two Ethernet ports. Both ports operate in a 100BASE-TX or 10BASE-T configuration and support auto MDI/MDIX for automatically switching twisted pair inputs and outputs. Therefore, any combination of straight-through or crossover Ethernet cable combination can be used.

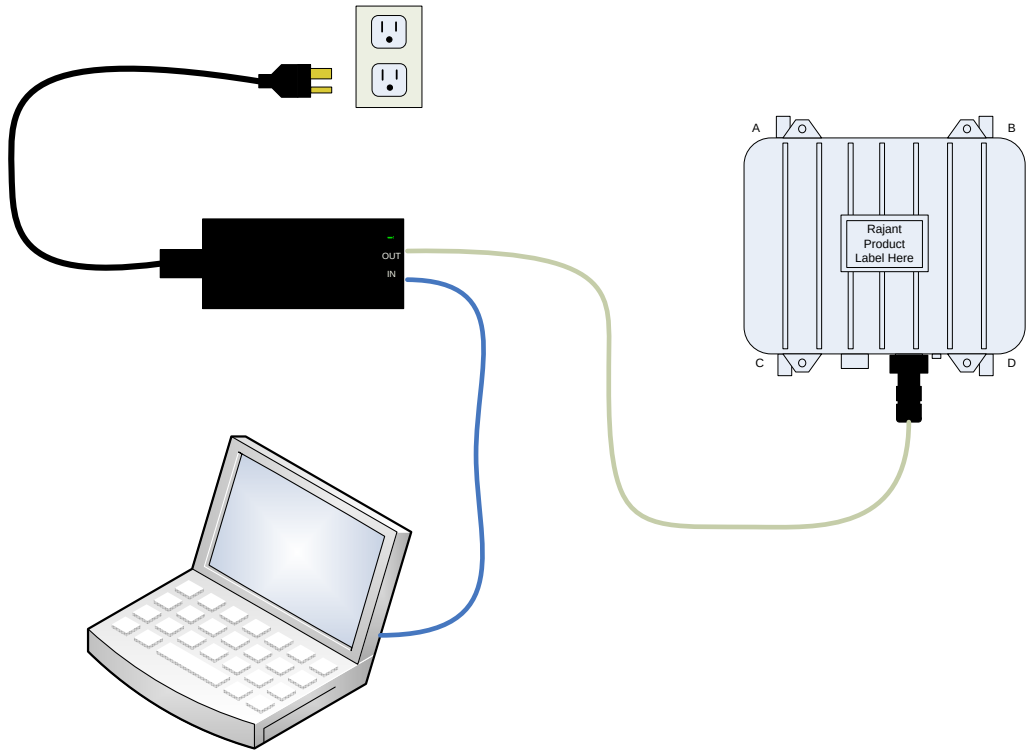


Figure 3. LX – POE Ethernet and Power Connections

2.7 ANTENNA FEATURES

The BreadCrumb LX makes use of two antenna ports, and are used alternately by the BreadCrumb, based on which one has the better signal.

Both external antennas MUST be connected to the device at all times for proper operation.

Always connect or disconnect external antennas with the power to the BreadCrumb LX off.

Because the two antennas are mounted top and bottom on opposite corners of the unit (as shown in Figure 4), the only viable means of using the LX with both antennas attached is by using the pole mount. Care should be taken to make sure the pole is mounted plumb (or possibly carefully tilted to account for altitude differences) for reasons noted below:

The 802.11a 5 GHz Vertically Polarized Omni antenna (OD5WM-6) has an extremely narrow coverage plane. It only extends 5 degrees above and below the center-line, even at relatively short range. This means that two units using these antennas will have to be at the same altitude with the antennas plumb to see each other.

The 802.11b/g 2.4 GHz Vertically Polarized Omni antenna (OD24M-7) covers a more lenient 18 degrees above and below center at distance and an even wider range up close. So it is much more forgiving of imperfect placement than the 802.11a antenna.

2.7 ANTENNA FEATURES (continued)

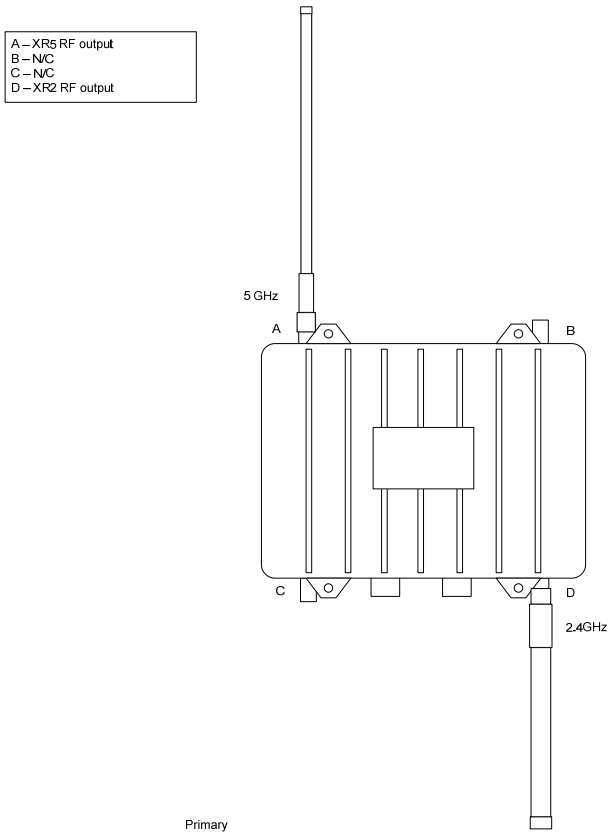


Figure 4. LX Antenna Layout

2.8 POWER FEATURES

Each LX is shipped with a 48 V AC/DC POE power supply. Primary power is provided through the Ethernet port labeled **ETH0/PWR**.

An optional 10 V—30 V DC in/24 V DC out power supply is available.

2.9 MISC. INFORMATION ABOUT THE LX

There is no LED control switch on the LX. The LED will always come on when booted.

The LX supports over the air flashing. The OTA for the LX has minimal downtime because the new image can be installed while the BreadCrumb continues to run. The only downtime occurs while the system reboots onto the newly installed firmware.

The flash images for the BreadCrumb LX are much smaller than those for the BreadCrumb ME2.

2.10 RESET/ZEROIZE THE LX

The software process is done from within BCAdmin. Right mouse click on the LX to be zeroized. Choose 'Diagnostics & Maintenance' from the options on the screen. Then a 'Restore Factory Defaults' screen will appear. Type the word **FACTORY** in the box and then choose the OK button. Reboot the LX to complete the Reset/Zeroize process.

The hardware reset process involves pressing the P4 Zeroize button down and holding it down for up to 8 seconds. The P1 status LED (Refer to Figure 1) will go from the normal color of green or blue, to the USB flash upgrade color of blinking yellow. Make sure that the zeroize button is pressed while the LED is in this state. After a second or two, the LED will blink through all of it's colors in rapid succession (similar to when a USB flash is done). At this point, the zeroize button no longer needs to be pressed. Once the zeroize button has been released, the BreadCrumb will then reboot using the default settings.

3.0 USING BCADMIN™

BCAdmin is Rajant's software package used for monitoring the status of a BreadCrumb Wireless Network (BCWN), configuring the BreadCrumbs and to graphically portray the network topology. BCAdmin typically runs on a laptop PC, but it can be run on any PC that has access to the entire BCWN. Versions are available for Microsoft Windows® and Linux.

Note: Some portions of the BCAdmin User Guide assume a working knowledge of TCP/IP networking, including DHCP, NAT, and DNS. While the network lay person may be able to perform some BCWN management tasks, it is recommended that network configuration be performed by experienced network administrators.

Note: BCAdmin version **9.93 or higher** is required to administer all firmware features, which are covered Rajant's **BCAdmin User Guide**.

Rajant periodically releases updated BCAdmin software. The updated BCAdmin software must be obtained from Rajant. Refer to Rajant's most recent BCAdmin User Guide for instructions on how to install the latest version of BCAdmin on your computer and how to use BCAdmin with Rajant's BreadCrumbs.

4.0 DEPLOYING THE BREADCRUMB WIRELESS NETWORK

4.1 OVERVIEW OF BCWN DEPLOYMENT

There are many factors which need to be taken into account when deploying the BreadCrumb Wireless Network. Section 4.2 details some of the most commonly occurring environmental factors that will have a major impact on the performance of the BCWN. Section 4.6 details guidelines and methodology needed to follow when deploying the BCWN.

4.2 DEPLOYMENT CONSIDERATIONS

Commonly occurring environmental factors have a significant impact on performance and behavior of the BreadCrumb wireless network. Line-of-Sight obstructions, distance, weather, and device placement should all be considered when deploying a wireless network.

The *IEEE* 802.11b/g wireless standard 'gracefully degrades' as distance increases between nodes or as interference becomes present. This will be apparent by a data rate reduction between nodes.

The goal in planning and deploying a BreadCrumb wireless network is to maximize data transfer rate between devices. The data rate can be maximized by taking into consideration all of the contributing factors that affect data throughput.

4.2.1 ADDRESSING

When routing to another network or when using its own embedded DHCP servers, the BreadCrumb Wireless Network requires that wireless devices use IPv4 addresses in the Class A network 10.0.0.0/8 (that is, any address that begins with '10.'). If you are not connected to another network, or if you are bridging to one rather than routing to it, your wireless client devices may have any address whatsoever.

Important: Any devices running the BCAdmin management application *must* have an address in the 10.0.0.0/8 range. This may be in addition to other addresses the devices may have configured.

4.2.1.1 BREADCRUMB DEVICE ADDRESSES

Each BreadCrumb radio has one IPv4 address in the Class A network 10.0.0.0/8. These addresses are assigned during manufacturing and cannot be changed in the field. Rajant ensures during manufacturing that these addresses are not duplicated between any two BreadCrumb devices. Addresses assigned to BreadCrumb devices can be viewed using BCAdmin.

4.2.1.2 DHCP

Each BreadCrumb device includes an embedded DHCP server. You may safely enable the DHCP servers of multiple BreadCrumb devices simultaneously, and it is in fact the most common case that all BreadCrumb devices in a BCWN run DHCP servers. Address conflicts among DHCP clients are prevented by using the unique BreadCrumb device addresses assigned at the factory as a base.

A BreadCrumb device determines its DHCP range as follows:

1. Start with the first three bytes of the first radio's IPv4 address.
   Add a low-byte range of 10 to 210.

4.3 CHANNEL ASSIGNMENTS

By default, BreadCrumb LX devices use channels 152 and 11 upon startup. In some cases, however, it is necessary to manually set the radios to different channels as described below.

4.4 PHYSICAL PLACEMENT AND OTHER CONSIDERATIONS

Commonly occurring environmental factors have a significant impact on performance and behavior of the BreadCrumb Wireless Network. LOS (Line of Sight) obstructions, distance, weather, and device placement should all be considered when deploying a wireless network.

IEEE 802.11a/b/g wireless operation degrades gracefully as distance increases between nodes or as interference becomes prominent. This manifests as a data rate reduction between nodes.

The goal in planning and deploying a BreadCrumb Wireless Network is to maximize both coverage and the data transfer rate between devices. These can be maximized by taking into consideration all of the contributing factors described in this section.

4.4.1 LINE OF SIGHT

Unobstructed LOS (Line of Sight) is critical for optimal performance of the BCWN. Partial LOS obstruction results in noticeable network performance degradation. Total LOS obstruction can result in complete loss of network connectivity.

Elevating the device and external antenna will assist in providing better LOS. This can allow the radio waves to propagate over some possible obstructions.

Unobstructed LOS is not necessary from every BreadCrumb and wireless client to every other BreadCrumb and wireless client. However, each device must have unobstructed LOS to the previous and subsequent device.

Client connectivity will degrade, and if significantly dense, drop if LOS to a BreadCrumb can not be maintained.

4.4.2 DISTANCE

- There are many factors to determine acceptable distances to place BreadCrumbs when deploying a wireless network.
- If many devices are placed too closely together, it is possible that interference will degrade the performance of the system.
- Devices placed too far away or in RF ‘shadows’ may experience total loss of connection.
- Device power is important in determining distances that the device will be effective.
- When placing a BreadCrumb, check the connection status to the most available device with BCAdmin. If the connection is poor or non-existent, attempt to relocate the BreadCrumb closer to the available device until acceptable connection is achieved. If poor or no connection is made at even relatively close distances, you should refer to the troubleshooting section of this guide.
- When the connection quality is found to be acceptable from BCAdmin, the distance of the BreadCrumb from the network can be increased until an optimal balance between distance, connectivity and tactical placement is achieved.
- BCAdmin is an administrative software application that can aid in deploying a BreadCrumb wireless network. Refer to section 3.0 of this manual regarding BCAdmin.

4.4 PHYSICAL PLACEMENT AND OTHER CONSIDERATIONS (continued)

4.4.3 WEATHER

Precipitation and fog also act as obstructions blocking the propagation of the wireless network's radio waves.

Light fog or precipitation may result in noticeable degradation of wireless network performance. Heavy precipitation or fog may result in severe performance degradation and possible loss of network connectivity.

If the performance of a well functioning network is degraded by increasing weather conditions, it may be advisable to add BreadCrumb devices into the network to act as short haul repeaters to counter act the effects of the weather. An alternative is to move the devices closer together.

4.4.4 INTERFERENCE

- RF interference can degrade network performance and can come from many different sources.
- Interference can come from other BreadCrumb devices that are placed too closely together.
- Interference can come from many other RF devices such as microwave devices, cordless phone base stations, radio transmitters, other wireless networks, jamming devices, etc.
- Metal surfaces such as fences and building can cause radio waves to be reflected, causing multipath interference.
- Plan the BreadCrumb wireless network to minimize the effects of RF interference.

4.4.5 PLACEMENT OF BCWN COMPONENTS

The placement of BreadCrumb devices has a major impact on maximum effective range, and therefore network performance. The components must be elevated above the surrounding terrain to allow for adequate wave propagation. A device placed directly on the ground has a significantly reduced effective range. Elevating a device above the ground dramatically increased the maximum effective range. Rajant recommends elevating the components a minimum of 6 ft. above the surrounding surface.

4.5 DEPLOYMENT CONFIGURATIONS

Deployment configurations can provide reach back connectivity to the Internet or other network by utilizing a Gateway BreadCrumb and available communication link (such as DSL, cable, or satellite modem).

4.6 DEPLOYMENT GUIDELINES AND METHODOLOGY

This section addresses the actual onsite deployment of the BCWN. While no means an exhaustive treatise, it is intended as a good source of guidelines and methodology for the successful deployment of the BCWN in the field.

4.6.1 DEPLOYMENT GUIDELINES

Referring back to Section 4.2 (Deployment Considerations):

1. Placement of BCWN components
    a. Elevate the BCWN components whenever possible.
        i. Directly on the ground, the maximum distance between any two BCWN components is approximately 300 ft. Also, the maximum distance between a wireless client and the nearest BCWN component is approximately 300 ft.

4.6 DEPLOYMENT GUIDELINES AND METHODOLOGY (continued)

ii. Rajant recommends elevating each BCWN component a minimum of 6 ft. above the surrounding terrain for maximum range. Elevating the BCWN components, as little as 14 inches, has proven to increase the range out to approximately 600 ft.

2. Distance
    a. If you cannot elevate the BCWN components, they can only be approximately 300 ft. apart. Also, any wireless clients can be no farther than approximately 300 ft. from a BCWN component.
3. Line of Sight
    a. Obstructions to line of sight block/absorb/deflect the wireless LAN's radio waves, resulting in poor network performance or total loss of network connectivity.
    b. When placing the BCWN components, scan the area for LOS obstructions. Envision the BCWN's radio waves as a light beam. Look for obstructions that would result in shadows in the light beam, they will most likely weaken or block the BCWN's radio waves.
4. Weather
    a. Light precipitation will reduce the range and performance of the BCWN components and wireless clients.
    b. Heavy precipitation or fog will most likely result in extremely reduced range and frequent or total loss of network connectivity.

4.6.2 DEPLOYMENT METHODOLOGY

The steps detailed in this section should assist you in successfully deploying the BCWN.

1. Scan the terrain on which the BCWN will be deployed.
    a. Determine the initial distances for BreadCrumbs.
    b. Note any LOS obstructions, and plan BreadCrumb placement to work around them.
2. Identify the PC on which BCAdmin will be run.
    a. This PC should have a wireless NIC, as you will need to carry it with you as you deploy the BCWN.
        i. Alternatively, the BCAdmin PC can be stationary with one person monitoring BCAdmin while another deploys the BreadCrumbs. This method requires some form of communication (radio, cell phone, etc.) between the two persons.
3. Determine the location of the first two BreadCrumbs.
4. Power ON the device.
5. Wait approximately 90 seconds for the device to boot.
6. Power ON the BCAdmin PC.
7. Start BCAdmin.
8. The BCAdmin console should display the first BreadCrumb.
9. Proceed to the location for this BreadCrumb, observing the network in BCAdmin as you progress.
    a. If the BreadCrumb loses network connectivity before you reach its destination, backtrack until network connectivity is restored. The point at which network connectivity for this BreadCrumb is restored is most likely the farthest point in this direction at which you will be able to place this BreadCrumb.
    b. If you reach the destination without losing connectivity you can place it there.
        i. At this point, you may choose to proceed farther in an attempt to make optimal use of the available BreadCrumbs.
            1. If so, proceed until network connectivity is lost and then backtrack until network connectivity is restored for this BreadCrumb. The point at which network connectivity is restored for this BreadCrumb is most likely the farthest point in this direction at which you will be able to place this BreadCrumb.

4.6 DEPLOYMENT GUIDELINES AND METHODOLOGY (continued)

10. Determine the approximate location for the next BreadCrumb.
11. Power ON the device.
12. Wait for it to appear in BCAdmin.

4.7 STATUS LED

The LED function on the BreadCrumb indicates the current status of the BreadCrumb. The LED has three colors: Red, Blue and Green. Their color code indicators are given in the table below:

Table 1. LED Color Status

Color	Status
SOLID RED	Booting
BLINKING RED*	Error
SOLID BLUE	Ready, but no peers
SOLID GREEN	At least one 24 MBit or higher peer
BLINKING GREEN	At least one peer
BLINKING YELLOW (at a constant rate)	Progress
BLINKING YELLOW (with short and long pauses between blinks)*	Warning
All LED colors scrolling in succession	Success/Completion

* Refer to Appendix A at the end of this document, for a list of error codes.

Note: The default state of the LED after a power reset is **off** and the LED turns on/off when the status button is pressed.

5.0 BREADCRUMB SOFTWARE MAINTENANCE

5.1 BREADCRUMB FIRMWARE

5.1.1 INTRODUCTION

Each BreadCrumb relies on low-level software known as firmware for proper execution. Rajant periodically releases updated BreadCrumb firmware. The updated firmware must be obtained from Rajant.

For a BreadCrumb to communicate with other BreadCrumbs or a BCAdmin client, the firmware version of the device must be compatible with the version of all other device firmware within the network, and with the version of BCAdmin running on a client PC!

Refer to the procedures to install and upgrade versions of BCAdmin and upgrade BreadCrumb firmware to ensure compatibility.

5.1.2 UPGRADING THE FIRMWARE

5.1.2.1 USING A USB FLASHDRIVE

1. Obtain the desired firmware from Rajant Corporation for the version of your device board type. Create a directory named 'rajant' on a USB storage device (of at least 256 MB) that must be FAT or FAT32 formatted and copy the firmware file into the created 'rajant' directory.
2. Turn **off** power to the BreadCrumb.
3. Insert the USB storage device into the one of the BreadCrumb's two USB ports.
4. Turn on the BreadCrumb.
5. Observe the status LED to monitor progress.
   5.1. When the USB flash upgrade begins, the status LED will start blinking yellow, which identifies progress.
   5.2. When the process nears completion, the blink rate will increase from once per second to several times per second.
   5.3. If the flashing completes successfully, the status LED will start rotating between red, green, blue, cyan, magenta, yellow and white colors.
   5.4. If an error condition is encountered, the status LED will start repeating a particular sequence of long and short blinks in red indicating the error code. If this happens, note the error code. Manually power off and then back on the BreadCrumb, leaving the USB storage device plugged in. Then repeat the procedure starting from step 6. This time, the BreadCrumb will go through a more reliable, failsafe flashing process, which has a greater chance of successful completion. If, during the failsafe flashing process another error occurs, note the new error code and apply for technical support.
   5.5. See APPENDIX A for a list of error codes.
6. When complete, turn off power and remove USB programming cable and USB storage device.

5.1.2.2 USING OVER-THE-AIR FLASH

1. Obtain A Copy Of the Latest (Over-The-Air) Firmware from Your Rajant Account Representative
2. The latest version of BCAdmin should be on your computer and running. The screen should be showing the BreadCrumb(s) that you intend to upgrade. With your mouse, right click on the BreadCrumb icon. A popup menu will appear on the screen at the BreadCrumb with the different options available. Move the mouse pointer down to the option labeled *Diagnostics and Maintenance*. Several more options will appear. Left click on *Update Firmware*.

5.1.2.2 USING OVER-THE-AIR FLASH (continued)

3. The installation of the firmware can be started immediately, by left clicking on *Open Folder*.

NOTE: Before proceeding any further, make sure that the BreadCrumb(s) that are being updated have been turned on.

4. On the BCAdmin screen, put in the location of where the Firmware Update File was saved to. Left click on *Firmware Update*. If you want to "auto-retry firmware transfer until successful?" The update should be successful on the first update attempt, but just in case, left click *Yes*.
5. On the BCAdmin screen, while the BreadCrumb is being updated, it will show the firmware update percentage transferred, as seen in the figure below.

NOTE: Do **NOT** turn off the BreadCrumb during the firmware update process.

NOTE: Although, a percentage indication is seen while the firmware is being copied to the BreadCrumb, the actual 'installation' does not take place until after the firmware is copied. After the firmware is copied, installation can take up to another two (2) minutes. When firmware installation is complete, the BreadCrumb will reboot. The BreadCrumb reboot can take a little more than one (1) minute.

6.0 TROUBLESHOOTING

6.1 BREADCRUMB WIRELESS NETWORK

6.1.1 SPORADIC NETWORK CONNECTIVITY

Table 2. Sporadic Network Connectivity Issues

Problem	Resolution
Light precipitation or fog beginning after initial deployment of the BCWN can result in sudden sporadic network connectivity for BreadCrumbs and their associated wireless clients.	Increase the density of the network by adding more BreadCrumbs or by moving existing BreadCrumbs closer together.
As a wireless client moves around through the coverage area, LOS to the BreadCrumb can become obstructed resulting in sporadic network connectivity for this wireless client.	Train users to maintain LOS to known BreadCrumb locations. Place BreadCrumbs strategically to ensure coverage of areas through which users are expected to move.
A wireless client that moves beyond the range of the BCWN will experience sporadic, and eventually complete, loss of network connectivity.	Drop more BreadCrumbs as necessary to increase range.
A wireless client cannot join the network.	• Ensure that BreadCrumbs are powered on. • Ensure that the wireless card in the client device (laptop) is enabled. This is usually indicated with a blinking light on the card. • Ensure that the wireless card is in "Infrastructure" or "Access Point" mode, and not in "Ad Hoc" mode. Scan for the ESSID "breadcrumb54" (or the ESSID that you set for the network) using the software accompanying your wireless card. • Ensure that the wireless client's IP address settings are configured properly. • Ensure that the WEP settings on the client device and BreadCrumbs match. • Ensure that the client device is not prevented from connecting by an ACL. • If the BreadCrumbs comprising the network have AirFortress encryption enabled, ensure that the client does as well.

6.1.2 BREADCRUMB CANNOT CONNECT TO BCWN

Table 3. BreadCrumb Cannot Connect to BCWN

Problem	Resolution
Discharged batteries can cause the BreadCrumb to appear to power up, but not be able to establish connectivity to the BCWN.	When deploying the BCWN, ensure that the batteries should be fully charged.
On rare occasions, the PCMCIA cards within a BreadCrumb can work loose, resulting in the BreadCrumb's not being able to establish connectivity to the BCWN.	Open the BreadCrumb's case and verify that the PCMCIA cards are securely seated in the PCMCIA slots.
When using external antennas, faulty cable connections or crimped cables can result in difficulty establishing and maintaining network connectivity.	Check antenna cables and their connections to the BreadCrumb.

APPENDIX A

Error codes are divided into groups. Groups are indicated by the first digit of the error number. A full error code will be formed by prefixing a group number to the error number.

Example: 'Could not mount the USB drive.' error (4) of the 'LX USB Firmware Upgrade' group (1) will be represented by error code 14.

Error codes by group (grouped by first digit)

LX USB Firmware Upgrade Error Codes (1*)

11 - Flash image file rajant/ breadcrumb_${UPGRADE_VERSION}_${PLATFORM}${UPGRADE_ ADDITIONALINFO}.flash does not exist.
12 - Current flash image version is greater than or equal to versions of files found on USB drive
13 - No flash image files found.
14 - Could not mount the USB drive.
15 - Unlocking of /dev/mtd0 failed.
16 - fconfig for SetFailsafeBoot? failed.
17 - Unlocking of /dev/mtd0 failed.
18 - fconfig for SetMainBoot? failed.
19 - Copying of zImage failed!!
111 - Copying of ramdisk failed.
112 - FIS directory update of ramdisk failed.
113 - Copying of etc failed.
114 - FIS directory update of /etc failed.
115 - Copying failed.
116 - flashunbundle failed.
117 - Version information in flash file name and breadcrumb-buildinfo.conf do not match.
118 - Untar failed.
119 - FIS directory update of zImage failed.
121 - Failed to unmount /etc.
122 -.In Failsafe mode, but no USB drive detected.

Self-Test Error Codes. (3*)

31 - Hardware configuration not set. Run factory-init.

32 - BreadCrumb has been zeroized

33 - Radio not detected. Turn the unit off, and then back on. If the problem persist, contact technical support.

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