

Wilson 5W Public Safety Bi-Directional Amplifier

User Manual



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1. CERTIFICATION INFORMATION

1.1 FCC Warning States

1.1.1 FCC Part 15.19 Warning Label

The 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.

1.1.2 FCC Booster Warning Label

- 1) Part 90 and Part 20 Signal Boosters – THIS IS A 90.219 CLASS A DEVICE

WARNING: This is NOT a CONSUMER device. It is designed for installation by FCC LICENSEES and QUALIFIED INSTALLERS. You MUST have an FCC LICENSE or express consent of an FCC Licensee to operate this device. You MUST register Part 90 and Part 20 Class A signal boosters (as defined in 47 CFR 90.219) online at www.fcc.gov/signal-boosters/registration. Unauthorized use may result in significant forfeiture penalties, including penalties in excess of \$100,000 for each continuing violation.

1.1.3 FCC Booster Warning Statements

Use of unauthorized antennas, cables, and/or coupling devices not conforming with ERP/EIRP and/or indoor-only restrictions is prohibited.

Home/ personal use are prohibited.

Only 50 ohm rated antennas, cables and passive equipment shall be used with this BDA. Any equipment attached to this device not meeting this standard may cause degradation and unwanted signals in the bi-directional system. All components connected to this device must operate in the frequency range of this device.

1.1.4 FCC Part 15 Class A Label

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.

1.1.5 RF Radiation Exposure

This equipment complies with RF radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of **UL: 80cm, DL: 110cm** between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. RF exposure will be addressed at time of installation and the use of higher gain antennas require larger separation distances.

(UL - LPDA antenna Max. peak gain: 9.0 dBi, DL - Omni directional antenna Max. peak gain: 1.5 dBi)

1.2 ISED Warning States

1.2.1 ISED Warning Label

WARNING: This is NOT a CONSUMER device. It is designed for installation by an installer approved by an ISED licensee. You MUST have an ISED LICENCE or the express consent of an ISED licensee to operate this device.

AVERTISSEMENT: Ce n'est PAS un appareil de consommation. Il est conçu pour être installé par un installateur approuvé par un titulaire de licence d'ISD. Vous DEVEZ avoir une LICENCE d'ISDE ou le consentement exprès d'un titulaire de licence d'ISDE pour utiliser cet appareil.

1.2.2 RF Radiation Exposure

This equipment complies with RF radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of **UL: 80cm, DL: 110cm** between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. RF exposure will be addressed at time of installation and the use of higher gain antennas require larger separation distances.

L'antenne (ou les antennes) doit être installée de façon à maintenir à tout instant une distance minimum de au moins **UL: 80cm, DL: 110cm** entre la source de radiation (l'antenne) et toute personne physique. Cet appareil ne doit pas être installé ou utilisé en conjonction avec une autre antenne ou émetteur.

1.3 RoHS Information

This equipment fully complies with the requirements set out in the RoHS standard.

2. OVERVIEW

2.1 General Information

This document is intended to provide installation methods and step-by-step procedures for installation and service of Wilson Connectivity's Public Safety BDA on the assumption that an experienced technician or engineer understands the basic theories and features associated with wireless signal amplifiers and in-building wireless systems. This document applies to Wilson Connectivity's products.

The BDA is a system that typically supports public safety wireless services indoors, which is necessary for emergency crews and firefighters to communicate with each other in emergencies and normal situations. The BDA is a digital two-way amplifier that supports 700 MHz and 800 MHz bands. The bandwidth is variable based on the FPGA, and the Digital Filter 32 Channel can be selectively serviced through software.

2.2 Functional Description

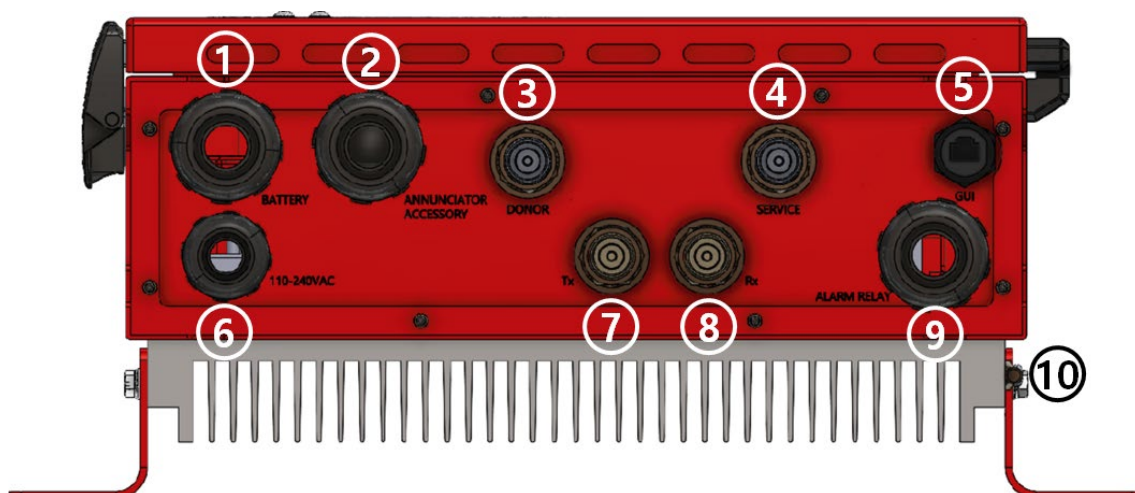
Describe the basic functional operation of the BDA, see [6. SPECIFICATIONS](#) for all specifications.

- 700MHz/800MHz Dual Band
- Support PS-LTE (First-Net™)
- 32 Channels Class A and 4 Channels Class B Filter per Band
- LED for Status Check
- Automatic Gain Control
- DL/UL Squelch
- Oscillation Detection
- Isolation Check
- Auto Shutdown
- Donor Antenna Malfunction and Donor Antenna Disconnection
- Support Web GUI and SNMP V2C/V3.0

3. SYSTEM ARCHITECTU

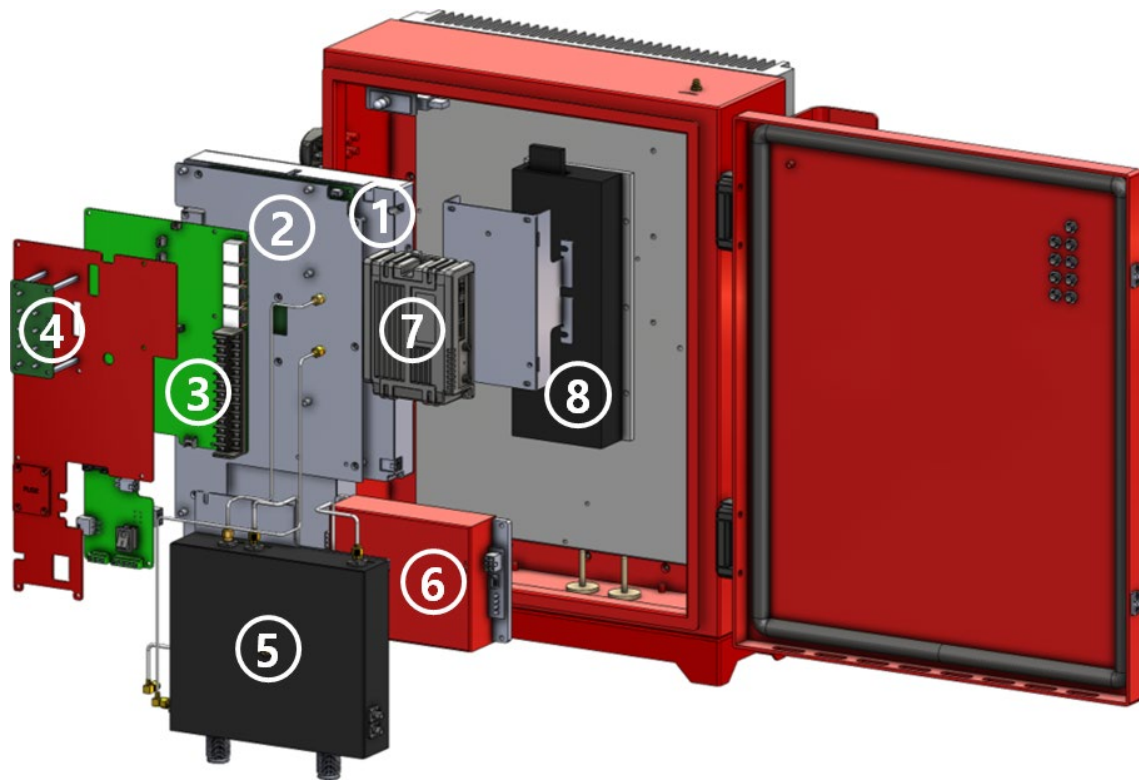
3.1 BDA

3.1.1 BDA Port



No.	Name	Function	Port
1	BATTERY	24VDC external battery power incoming and battery charging	Liquid Tight Conduit Fittings (3/4 inch)
2	ANNUNCIATOR	Provide power and alarm signaling to a remote annunciator	Liquid Tight Conduit Fittings (3/4 inch)
	ACCESSORY	RF, DC power and communication interface for DAS	
3	DONOR	Donor antenna port	4.3-10 Female
4	SERVICE	Service antenna port	4.3-10 Female
5	GUI	Communications with a network	RJ-45
6	110-240VAC	AC power incoming	Liquid Tight Conduit Fittings (1/2 inch)
7	Tx	Downlink coupling port for DAS	4.3-10 Female
8	Rx	Uplink coupling port for DAS	4.3-10 Female
9	ALARM RELAY	Provide wired connection to alarm	Liquid Tight Conduit Fittings (3/4 inch)
10	GND	Connect the ground terminal	Min. 14 AWG wire

3.1.2 BDA Modules



No.	Name	Function
1	RFM & HPA	RF board and high-power amplifier are built in
2	DTU	Digital board on FPGA
3	Web GUI Board	Web GUI and alarm functionality integrated into one board
4	LED	Display of system and alarm status
5	Triplexer	700 DL, 800 DL, and UL band pass filter
6	Charger Module	Provides battery charging and DC power
7	MODEM	Cellular router
8	PSU	AC/DC converter

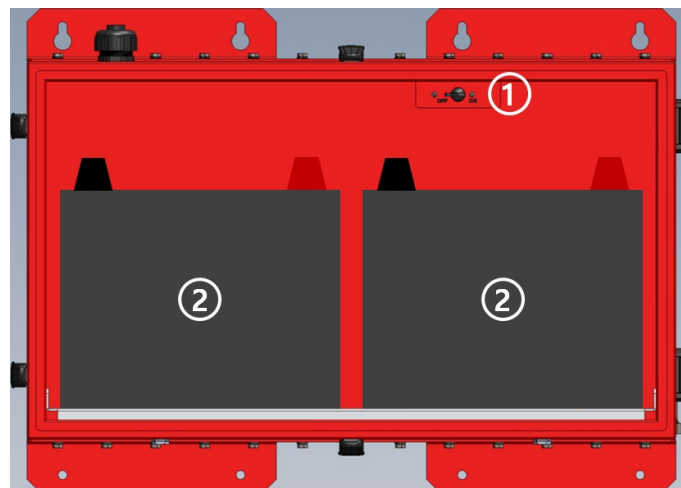
3.2 Battery Back-up Unit

3.2.1 BBU Port



No.	Name	Function	Port
1	BATTERY OUT	Battery power supply and battery charging	Liquid Tight Conduit Fittings (3/4 inch)

3.2.2 BBU Modules



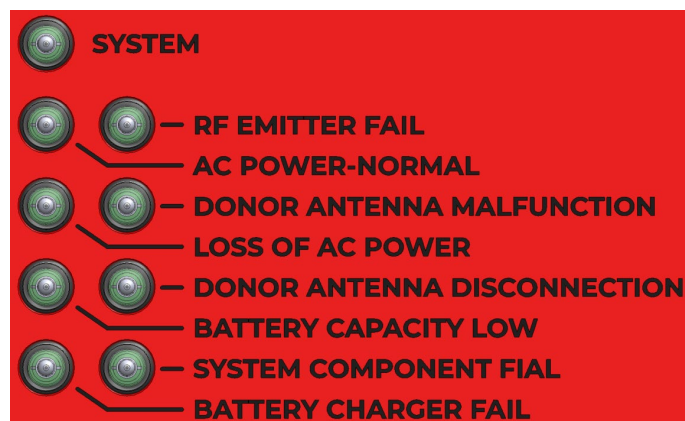
No.	Name	Function
1	DC Switch	Battery DC power On/Off
2	Battery	12V battery

3.2.3 Battery Requirements

- Battery is used for the purpose of supplying power to the BDA in case of AC power failure and the battery capacity must be selected to match the maximum power of the BDA.
- Inspect the battery for abnormalities including cracks, corrosion, or expansion of the battery surface during battery use according to the maintenance schedule and replace the battery with the same battery as the existing product if any abnormalities are found.
- Write the installation date at the time of battery installation for battery maintenance.
- If two 100Ah and 12VDC batteries are connected in series to serve the BDA at full power even in case of AC power failure, it can provide a 12-hour backup time with 20% overhead capacity in preparation for battery aging.
- Battery capacity = $(6.73A \times 12h) \times 1.2 = 96.9Ah$.
- Battery back-up time = $100Ah / 6.73A = 14.86hour$.
- Connecting two 200Ah, 12VDC batteries in series provide a 24-hour backup time with 20% overhead capacity.
- Battery capacity = $(6.73A \times 24h) \times 1.2 = 193.8Ah$.
- Battery back-up time = $200Ah / 6.73A = 29.72hour$.

3.3 Alarm LEDs

The BDA has a built-in Local Annunciator that displays the System Summary status and the alarm status specified in UL2524.



3.3.1 System LEDs

Function	LED Color
System Status Normal – No Alarm Detected or Alarm Masked, Service Properly	GREEN
System Status Warning – Maximum Alarm(s) Warning Detected, Service Not Dead	YELLOW
System Status Critical – Maximum Alarm(s) Critical Detected, Service may Dead	RED
System Dead	OFF

3.3.2 Annunciator LEDs

Function	LED Color
AC POWER NORMAL	Green
LOSS OF AC POWER	Red
BATTERY CAPACITY LOW	Red
BATTERY CHARGER FAIL	Red
RF EMITTER FAIL - DL 700 Amplifier Fail - DL 800 Amplifier Fail - UL 700 Amplifier Fail - Over Temperature - Donor Antenna Disconnection - Oscillation Detection - Service Affecting	Red

DONOR ANTENNA MALFUNCTION	Red
DONOR ANTENNA DISCONNECTION	Red
SYSTEM COMPONENT FAIL - Over Temperature - Oscillation Detection - Reduced Gain - Oscillation Detection - Service Affecting - Link Fail of Remote Annunciator	Red

4. HARDWARE INSTALLATION

4.1 Overview

- The BDA shall be installed within the appropriate environment in accordance with the safety requirements in accordance with the manufacturer's instructions.
- Since the BDA can be quite heavy when fully fitted (up to 26kg), it is recommended that it be installed by at least two properly trained personnel to handle the system at the time of installation.
- BDA installations must be protected from excessive heat, direct sunlight, humidity and high temperatures.
- When connecting all RF cables, it is important to comply with the manufacturer's recommended torque specifications when tightening all connectors.

4.2 Antenna Installation

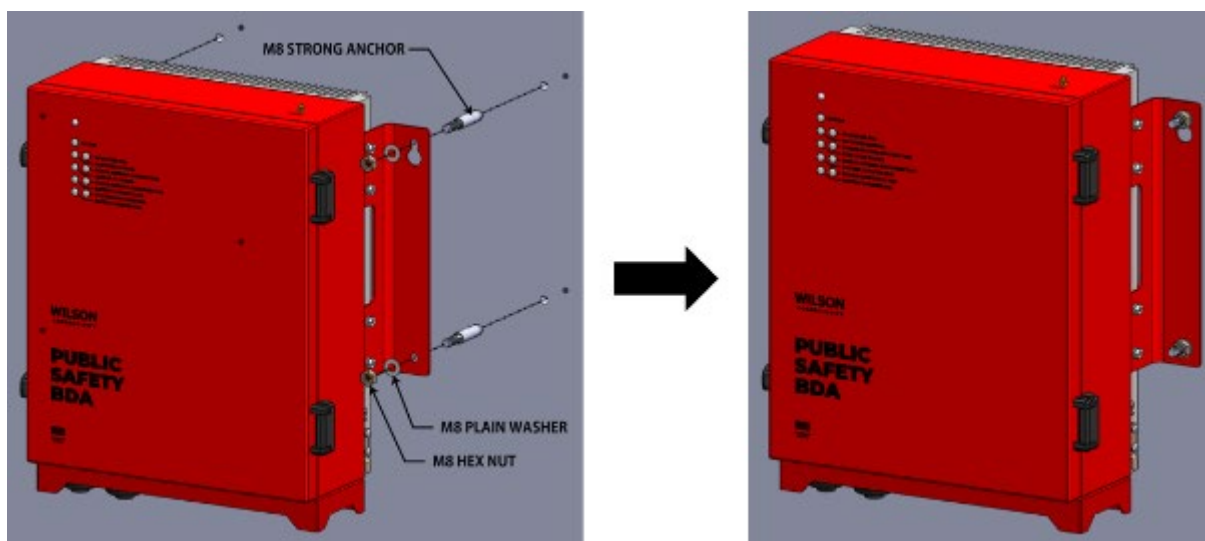
- All antennas should be fitted in such a way that they can remain oriented during normal expected weather patterns in the area.
- The system recommends that Isolation is more than 20 dB above the gain of the system.
- For the system to operate at full gain, the system requires sufficient isolation between the donor antenna and the service antenna. If isolation is not sufficiently guaranteed, the isolation check function will operate to reduce the gain to a level appropriate to the guaranteed isolation.
- The donor antenna should be installed on the exterior of a building with the strongest cell signal. The donor antenna should be mounted as high as possible toward the desired location of the cell tower and in the opposite direction of the expected location of the service antenna.
- The donor antenna must be installed in the direction of the Cell Tower and there must be no obstruction in the radio path between the donor antenna and the Cell Tower to receive a strong signal.
- The wider the gap between the donor antenna and the service antenna, the stronger the signal and the greater the area covered by the BDA.
- A Service antenna must be installed.
- Service antenna installation location and quantity should be determined based on interior structure and wall material.

4.3 System Installation

4.3.1 BDA

The following description is an example of a concrete wall installation.

- 1) Mark where to install the anchor bolts, install the enclosed anchor on the wall, and secure the BDA with nuts.

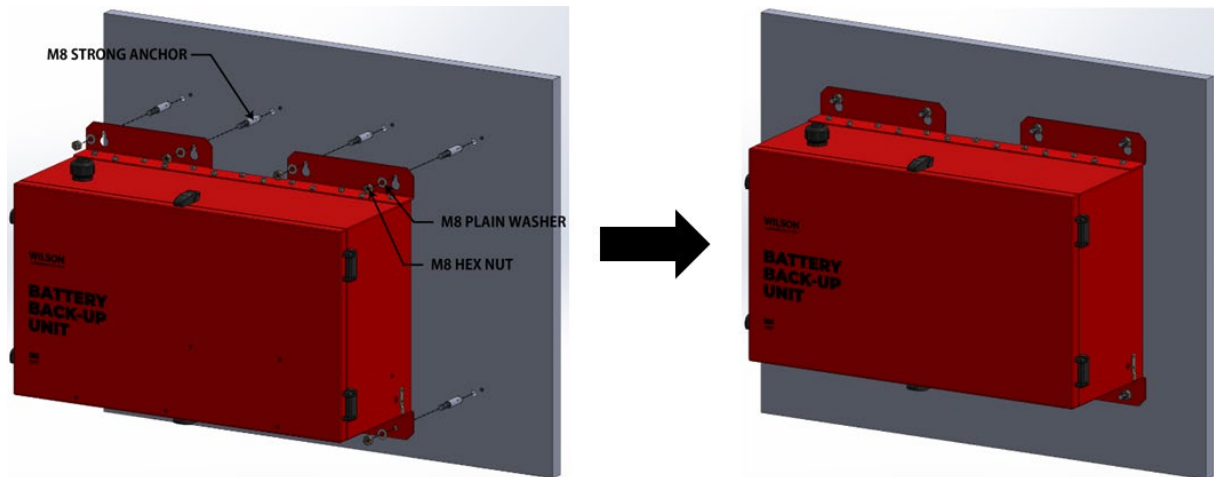


- 2) Connect the single lug frame ground connectors at the bottom of each side of the BDA radiating pin to the building ground using at least 14 AWG wires.

4.3.2 Battery Back-up Unit

The following description is an example of a concrete wall installation.

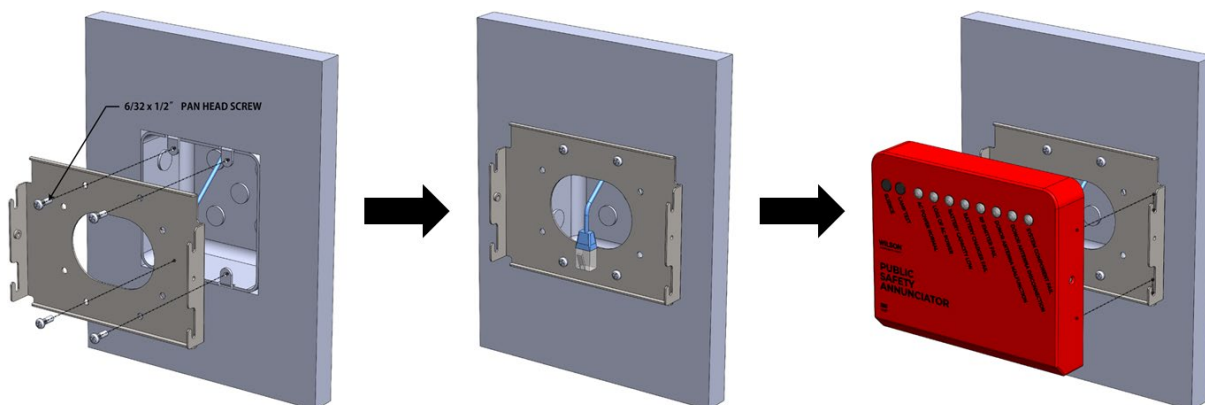
- 1) After marking the location of the anchor bolt to be installed, install the enclosed anchor on the wall and secure the BBU with a nut.



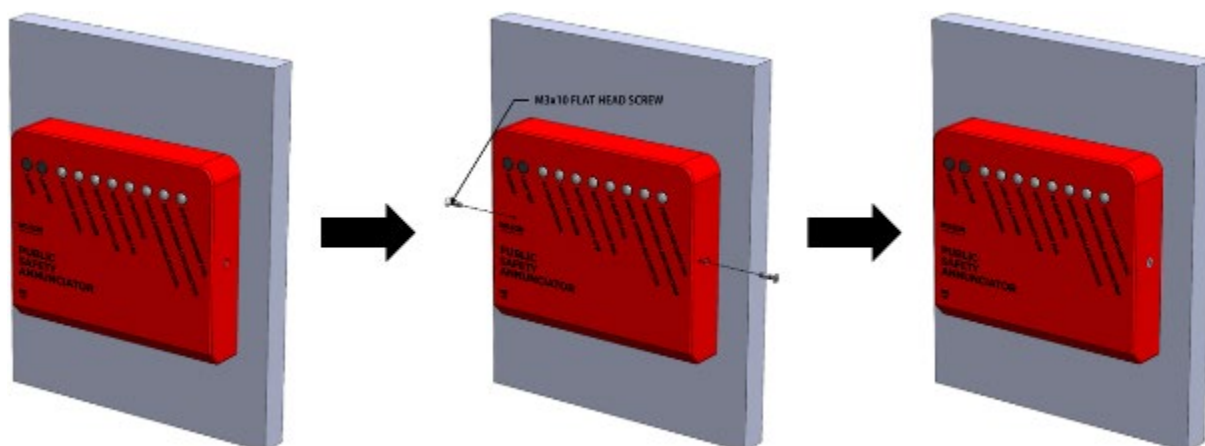
4.3.3 Remote Annunciator

The following description is an example of a concrete wall installation.

- 1) Screw the mounting bracket into the exposed outlet box, connect the standard Ethernet cable to the back of the RA, and attach the RA to the installed mounting bracket.



- 2) Secure the RAID next to both sides.



4.4 Cable Installation

4.4.1 AC Power

Connect to the BDA using the AC power cable provided in the following order.

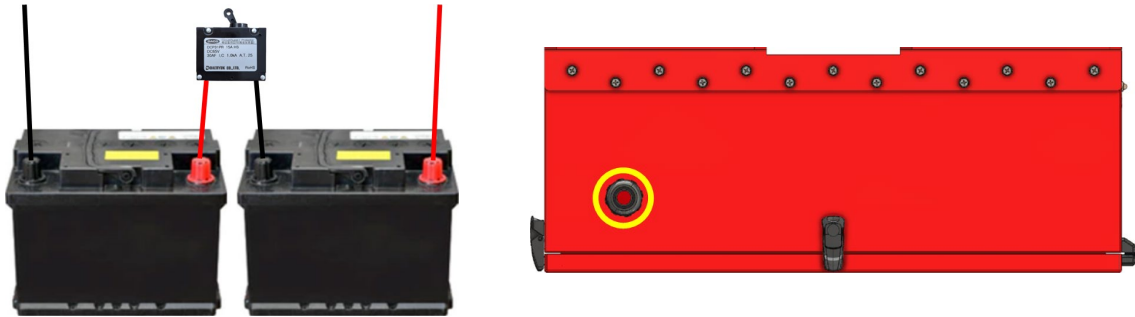
- 1) Insert the AC power cable into the HFC 8402 gland connector on the 110-240 VAC port at the bottom of the BDA, insert it into the BDA, and connect the cladding end to the screw terminal block on the Web GUI board. Be careful that the AC_N (white) / Ground (green) / AC_L (black) connection is correct. Secure the connector screws to prevent the cables from coming off.



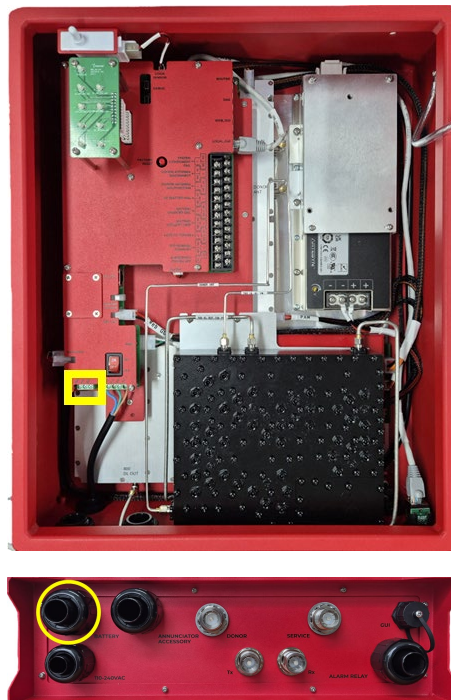
4.4.2 Battery Power

Use the provided DC power cable to connect to the battery in the following order.

- 1) Fasten the provided 50cm long red and black LUG cable to the DC Switch.
- 2) Fasten the O-ring on the other side of the 50cm long red and black LUG cable to the battery polarity. Connect the same color as the battery terminal.
- 3) Fasten the provided 3m long red and black cable O-ring to the same color as the battery terminal for polarity and pull the cladding out of the battery back-up unit through the HFC 8402 gland connector on the BATTERY OUT port at the top of the battery back-up unit.



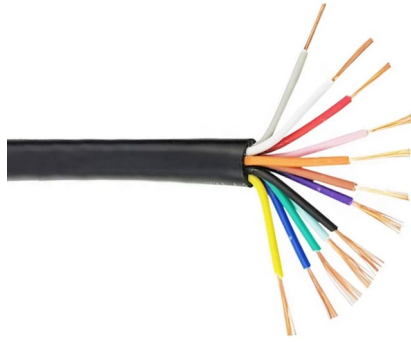
- 4) Connect the 3m long DC power cable connected to the battery to the HFC 8404 gland connector on the BATTERY port at the bottom of the BDA, insert it into the BDA, and connect the cladding end to the screw terminal block on the Web GUI board. Connect the red cable to the (BAT+) terminal, and the black cable to the (BAT-) terminal. Be careful not to change the +/- polarity. Secure the connector screws to ensure that the cables do not come off.



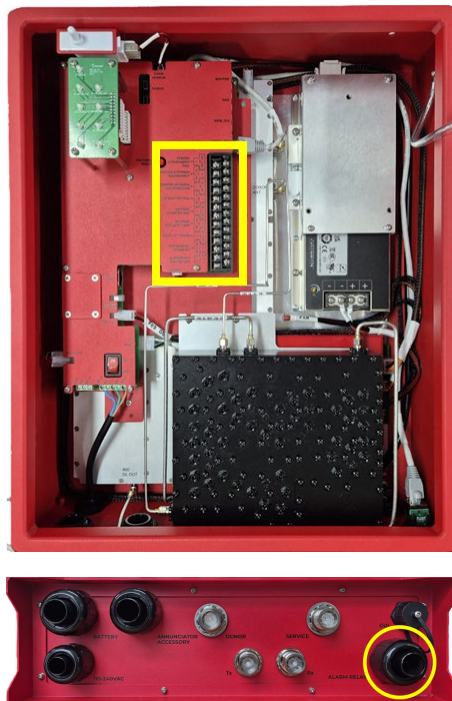
4.4.3 Alarm Relay

Using a multi-stranded alarm cable, connect the alarm board inside the BDA to the alarm relay panel outside the BDA in the following order. Alarm cables are not provided.

- 1) Remove the outer sheath of the alarm cable so that the inner cable is exposed. Work on both sides of the cable.
- 2) Remove the sheath on each internal cable end by 5mm. Work on both sides of the cable.



- 3) Insert the alarm cable into the HFC 8404 gland connector on the ALARM RELAY port at the bottom of the BDA, insert it into the BDA, and connect the cladding end to the screw terminal block for each alarm on the alarm board. Secure the connector screws to prevent the cable from leaking out.

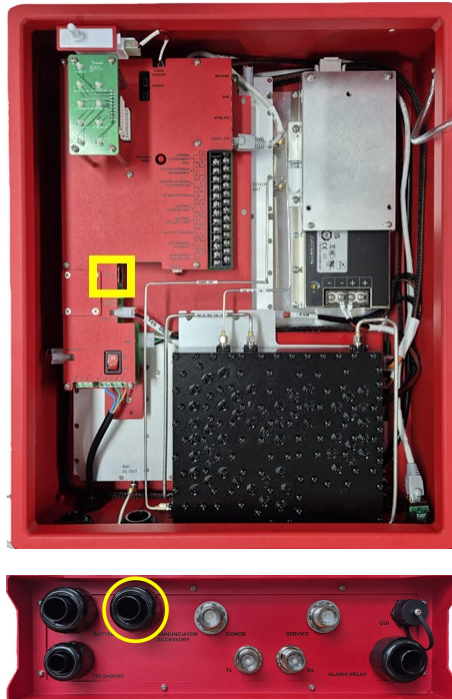


- 4) Connect the other side of the alarm cable connected to the BDA to the alarm relay panel. Secure the connector screws to prevent the cable from being disconnected.

4.4.4 Remote Annunciator

Install the RA in the following order.

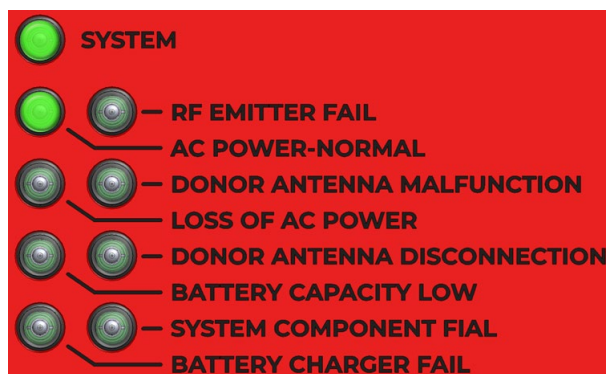
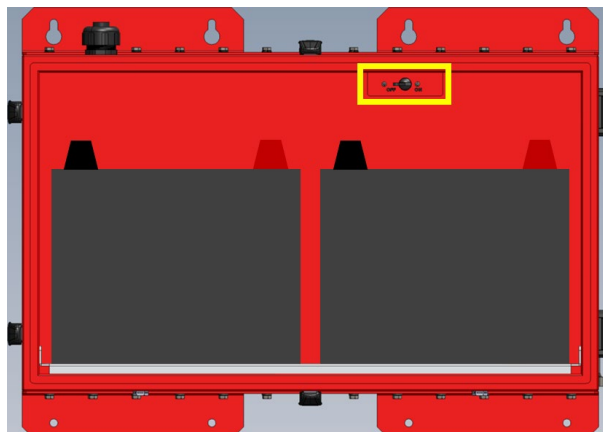
- 1) Connect a standard Ethernet cable to the back of the RA and secure the RA to the installed mounting bracket.
- 2) Insert the other side of the ethernet cable into the HFC 8402 gland connector on the ANNUNCIATOR port on the bottom of the BDA, insert it into the BDA, and connect it to the RS_485 ethernet connector on the alarm board.



4.4.5 Power up the BDA

Follow these steps to supply AC and DC power to the BDA once all equipment is installed.

- 1) Connect the RA before powering the BDA. Connecting the RA with the BDA powered can cause the RA to fail.
- 2) Connect the AC cord to an outlet and turn on the switch on the BDA's power switch board.
- 3) Turn on the DC switch in the battery unit to connect the BDA to the battery.
- 4) When AC power is supplied normally, the AC POWER - NORMAL LED will be lit in Green Color. The SYSTEM LED will be lit in Green/Yellow/Red Color depending on the BDA's Alarm status. After checking the LED Color, refer to the [2.3 Alarm LEDs](#) to check the BDA status.



4.4.6 Set up the BDA

- For BDA setup or maintenance, you must access the Web GUI to check the status of the BDA and to control the settings. The ethernet port on the laptop and the GUI port located at the bottom of the BDA can be connected to the Web GUI by connecting with an ethernet cable.
- For more information on using the Web GUI, see the [4. Web GUI](#).
- When the GUI port located at the bottom of the BDA is used, be sure to remove the ethernet cable and close the cap.



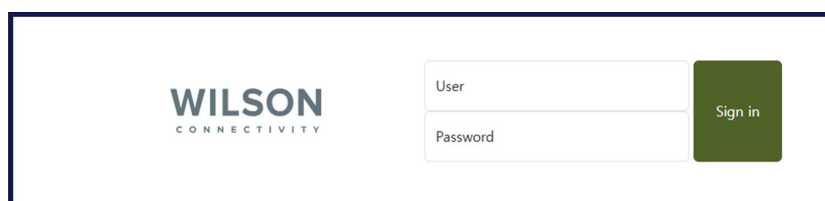
5. WEB GUI

5.1 Web GUI Setup

The Web GUI allows users to communicate with the BDA locally or remotely. To connect to the BDA locally, you need a laptop with an ethernet port. To connect to the BDA remotely, an Internet connection must be enabled.

5.1.1 BDA/PC Connection Using Web GUI

- Verify that the local area connection is set to automatically import IP addresses based on internet protocol (TCP/IP) properties.
- Connect the ethernet cable between the ethernet port on the laptop and the ethernet port on the BDA.
- Run an internet browser.
- In the Internet address bar, type the following IP address: `http://192.168.0.2`
- If you connect to a device remotely, enter the modem's IP address to connect to the BDA.
- The next login screen appears:



- Enter your username and password. There are three levels of permission.

Username	Default Password	Description
viewer	No Password	View system status but cannot make any changes.
basic	installer	View system status and can make only a subset of configuration changes.
advanced	supervisor	View and change all options.

- Click Sign In.
- After successful login, the system status window appears. The left menu provides access to all the other screens of the application.

5.2 Advanced/Basic Mode

5.2.1 System Setup page

- This is a page where you can check the current operation status of the BDA, it can only check the status, and you cannot edit the settings.

WILSONCONNECTIVITY

Connected to PS-BDA "WILSON-BDA DBG"

advanced

Logout

System Status

RF Setup

Filters Setup

Alarms Setup

Event Log

Network Setup

BDA Setup

Developer Menus

Advance Setup

System Tables

System Status

System Information

Serial Number	WILSON-BDA-DEBUG-001	Model	PSBDA-7837-UAB
Description	700M/800M DUALBAND 5W PSBDA CLASS A&B Supports Fir		

Environment

	Celsius [°C]	Fahrenheit [°F]
Enclosure Temperature	0	32
Module Temperature	0	32

Antenna Status

	VSWR [:1]	Return Loss [dB]
DONOR	0.0	0.0
SERVICE	0.0	0.0

System Isolation

	Donor to Service	Service to Donor
Isolation [dB]	0	0

RF Status

	700MHz		800MHz	
	DL	UL	DL	UL
Mode	Class A			
Channels	15		0	
HPA Status	ON	ON	ON	ON
Gain [dB]	60	50	60	50
Input Power [dBm]	0	0	0	0
Output Power [dBm]	0	0	0	0

NFPA Annunciator

Alarm	Status
LOSS OF AC POWER	[NORMAL]
BATTERY CAPACITY LOW	[NORMAL]
BATTERY CHARGER FAIL	[NORMAL]
RF EMITTER FAIL	[NORMAL]
DONOR ANTENNA MALFUNCTION	[NORMAL]
DONOR ANTENNA DISCONNECT	[NORMAL]
SYSTEM COMPONENT FAIL	[ALARM]

System Alarms

Alarm	Status
FAIL OF DL700 HPA	[NORMAL]
FAIL OF DL800 HPA	[NORMAL]
FAIL OF UL HPA	[NORMAL]
OUT OF TEMPERATURE RANGE	[NORMAL]
OSC - REDUCED SERVICE	[NORMAL]
OSC - SERVICE SHUTDOWN	[NORMAL]
ENCLOSURE OPENED	[WARNING]
EMERGENCY POWER OFF INITIATED	[NORMAL]
FAIL OF REMOTE ANNUNCIATOR LINK	[WARNING]
SERVICE ANTENNA DISCONNECT	[NORMAL]

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- Details of the System Status configuration are as follows.

1) System Information

- Serial Number : Serial number.
- Model : Model name.
- Description : License Description.

2) Environment

- Enclosure Temperature : Display the temperature of the enclosure in degrees Celsius and Fahrenheit.
- Module Temperature : Display the temperature of the Module in degrees Celsius and Fahrenheit.

3) Antenna Status

- DONOR / SERVICE VSWR : VSWR of Donor / Service antenna port.
- DONOR / SERVICE Return Loss : Return loss of Donor / Service antenna port.

4) System Isolation

- Isolation : Isolation checks the result value of Donor to Service path and Service to Donor path.

5) RF Status

- Mode : Display filter mode.
- Channels : Display the number of filters turned on.
- HPA Status : Display the on/off status of the HPA.
- Gain : Display system gain.
- Input Power : Display system input power.
- Output Power : Display system output power.

6) NFPA Annunciator

- Displays the status of the RA alarm connected to the NFPA, which operates the same as the LED on the front of the cover of the BDA, see [3.3.2 Annunciator LEDs](#) for detailed LED operation.

7) System Alarm

- Displays the alarm status of the BDA except for the UL2524 alarm, see the [5.2.4 Alarm Setup Page](#) for detailed operation on the system alarm.

5.2.2 RF Setup Page

- A page where you can edit the RF configuration of the BDA, and you can edit 700 MHz and 800 MHz, respectively.

Wilson CONNECTIVITY

Connected to PS-BDA "WILSON-BDA DBG"

advanced Logout

RF Setup Apply Settings

System Isolation

SERVICE to DONOR [dB]	0	Click to Execute Isolation Measurement	Isolation Test
DONOR to SERVICE [dB]	0		

RF Settings

	700MHz		800MHz	
	DL	UL	DL	UL
TS AGC	ON		ON	
Squelch	ON	ON	ON	ON
Gain	90	80	90	80
Output Level	34	27	34	27
Squelch Level	-90	-90	-90	-90

General Settings

	Config
Mode	Class A
DL700 HPA	ON
DL800 HPA	ON
UL HPA	ON

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- Before setting up the RF configuration, the user must first run an isolation test to ensure proper isolation is ensured between the donor antenna and the service antenna.
- If you click the 'Apply Settings' button to set up the RF configuration without running the isolation test, a warning pop-up window will appear asking you to perform the isolation test first.
- You can run the isolation test by clicking the 'Isolation Test' button at the top right of the page.
- Running an isolation test completes the test within seconds, with Gain and Isolation displayed.
- You can test the isolation level again by clicking the 'Isolation Test' button at any time.
- After editing RF and General Settings, you can apply the edit by clicking the 'Apply Settings' button at the top right of the page.
- The detailed setup of the RF Setup configuration is described below.

1) System Isolation

- SERVICE to DONOR : Displays isolation measurements for downlink.
- DONOR to SERVICE : Displays isolation measurements for uplink.

2) RF Settings

- TS AGC : Displays the TS AGC operation status. You can turn the TS AGC function on or off by clicking the check box on the right. If you want fast AGC control for the APCO P25 Phase 2 TDMA signal, click the check box to activate the TS AGC function.

- Squelch : Displays the status of the squelch operation. You can turn the squelch function on or off by clicking on the value field.
- Gain : Displays gain for downlink and uplink. Gain can be set by clicking on the value field, and the setting range is DL: 90dB to 60dB and UL: 80dB to 50dB.
- Output Level : Displays the output AGC level. The output level can be set by clicking on the value field, and the setting range is DL: +37dBm to +7dBm and UL: +27dBm to -3dBm.
- Squelch Level : Displays the squelch operation level. You can set the squelch level by clicking on the value field, and the set range is from -60dBm to -90dBm for both DL and UL.

3) General Settings

- Mode : Display filter mode. You can select Class A or Class B by clicking the Value field.
- DL 700 HPA : Displays the operation status of the DL 700 HPA, which can be switched on or off by clicking on the value field.
- DL 800 HPA : Displays the operation status of the DL 800 HPA, which can be switched on or off by clicking on the value field.
- UL HPA : Displays the operation status of the UL HPA, which can be switched on or off by clicking on the value field.

5.2.3 Filter Setup Page

- This page allows you to edit the filter configuration of the BDA, and only the corresponding classes set in the RF Setup page can be edited.

Connected to PS-BDA "WILSON-BDA DBG"

advanced Logout

Filters Setup Apply Settings

First Net™ Settings

Center Frequency [MHz]		Bandwidth	Channel Power [dBm]		Enable
DL	UL		DL	UL	
763	793	10MHz	0	0	Enabled

700MHz Settings

CH	Center Frequency [MHz]		Bandwidth	Channel Power [dBm]		Enable
	DL	UL		DL	UL	
1	769 2438	799 2438	25.0kHz	0	0	Enabled
2	769 1438	799 1438	25.0kHz	0	0	Enabled
3	769 6438	799 6438	25.0kHz	0	0	Enabled
4	770 1438	800 1438	25.0kHz	0	0	Enabled
5	770 6438	800 6438	25.0kHz	0	0	Enabled
6	769 7438	799 7438	25.0kHz	0	0	Enabled
7	770 2438	800 2438	25.0kHz	0	0	Enabled
8	770 9938	800 9938	25.0kHz	0	0	Enabled
9	770 8938	800 8938	25.0kHz	0	0	Enabled
10	770 3938	800 3938	25.0kHz	0	0	Enabled
11	770 4938	800 4938	25.0kHz	0	0	Enabled
12	770 8398	800 8398	25.0kHz	0	0	Enabled
13	769 9938	799 9938	25.0kHz	0	0	Enabled
14	769 3938	799 3938	25.0kHz	0	0	Enabled
15	769 4938	799 4938	25.0kHz	0	0	Enabled
16	770 7438	800 7438	25.0kHz	0	0	Enabled

800MHz Settings

CH	Center Frequency [MHz]		Bandwidth	Channel Power [dBm]		Enable
	DL	UL		DL	UL	
1	851 0125	806 0125	25.0kHz	0	0	Disabled
2	851 5125	806 5125	25.0kHz	0	0	Disabled
3	852 0125	807 0125	25.0kHz	0	0	Disabled
4	852 5125	807 5125	25.0kHz	0	0	Disabled
5	853 0125	808 0125	25.0kHz	0	0	Disabled
6	853 5125	808 5125	25.0kHz	0	0	Disabled
7	854 0125	809 0125	25.0kHz	0	0	Disabled
8	854 5125	809 5125	25.0kHz	0	0	Disabled
9	855 0125	810 0125	25.0kHz	0	0	Disabled
10	855 5125	810 5125	25.0kHz	0	0	Disabled
11	856 0125	811 0125	25.0kHz	0	0	Disabled
12	856 5125	811 5125	25.0kHz	0	0	Disabled
13	857 0125	812 0125	25.0kHz	0	0	Disabled
14	857 5125	812 5125	25.0kHz	0	0	Disabled
15	858 0125	813 0125	25.0kHz	0	0	Disabled
16	858 5125	813 5125	25.0kHz	0	0	Disabled

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- The detailed settings for the Filter Setup configuration are described below.

1) First Net™ Settings

- You can enable or disable LTE 10MHz band.
- Only the 700 Class A band is using an additional FirstNet 10MHz.
- Center frequency and bandwidth cannot be edited.

2) 700MHz Settings

- Channel 1 - 16 : Due to the screen configuration characteristics of the Web GUI, Class A Filter is divided into 16 to display.
- DL / UL Center Frequency : Displays the center frequency of the filter. When the center frequency of the DL is set, the center frequency of the UL is set automatically. You can edit the frequency by clicking the value field and you can apply the edit by clicking the 'Apply Settings' button at the top right of the page.
- Bandwidth : Displays the bandwidth of the filter. You can select the bandwidth by clicking the value field and applying the edit by clicking the 'Apply Settings' button at the top right of the page. Class A and Class B have different bandwidths, see the topic [6.1 System Specification – Filter Bandwidth](#).
- DL / UL Channel Power : Displays the individual output power of the filter.
- Enable : You can enable or disable the operation of Filter by clicking on the Value field.

3) 800MHz Settings

- Same configuration as 700MHz Setting.

- When setting the center frequency of the filter, the frequency setting field is shown in red if it overlaps with the frequency of another channel or violates the frequency setting rules.
- The frequency setting rule sets the point at which the waveform between adjacent filters is crossed to a point 20 dB below the passing band.

Connected to PS-BDA "WILSON-BDA DBG"

advanced Logout

System Status >
RF Setup >
Filters Setup >
Alarms Setup >
Event Log >
Network Setup >
BDA Setup >
Developer Menus

Filters Setup

Apply Settings

First Net™ Settings

Center Frequency [MHz]		Bandwidth	Channel Power [dBm]		Enable
DL	UL		DL	UL	
763	793	10MHz	0	0	Enabled

700MHz Settings

CH	Filter-Range		Bandwidth	Channel Power [dBm]		Enable
	DL	UL		DL	UL	
1	769 1438	799 1438	25 0kHz	0	0	Enabled
2	769 1438	799 1438	25 0kHz	0	0	Enabled
3	769 6438	799 6438	25 0kHz	0	0	Enabled
4	770 1438	800 1438	25 0kHz	0	0	Enabled
5	770 6438	800 6438	25 0kHz	0	0	Enabled
6	769 7438	799 7438	25 0kHz	0	0	Enabled
7	770 2438	800 2438	25 0kHz	0	0	Enabled
8	770 9938	800 9938	25 0kHz	0	0	Enabled
9	770 8938	800 8938	25 0kHz	0	0	Enabled
10	770 3938	800 3938	25 0kHz	0	0	Enabled
11	770 4938	800 4938	25 0kHz	0	0	Enabled
12	770 8398	800 8398	25 0kHz	0	0	Enabled
13	769 9938	799 9938	25 0kHz	0	0	Enabled
14	769 3938	799 3938	25 0kHz	0	0	Enabled
15	769 4938	799 4938	25 0kHz	0	0	Enabled
16	770 7438	800 7438	25 0kHz	0	0	Enabled

800MHz Settings

CH	Filter-Range		Bandwidth	Channel Power [dBm]		Enable
	DL	UL		DL	UL	
1	851 0125	806 0125	25 0kHz	0	0	Disabled
2	851 5125	806 5125	25 0kHz	0	0	Disabled
3	852 0125	807 0125	25 0kHz	0	0	Disabled
4	852 5125	807 5125	25 0kHz	0	0	Disabled
5	853 0125	808 0125	25 0kHz	0	0	Disabled
6	853 5125	808 5125	25 0kHz	0	0	Disabled
7	854 0125	809 0125	25 0kHz	0	0	Disabled
8	854 5125	809 5125	25 0kHz	0	0	Disabled
9	855 0125	810 0125	25 0kHz	0	0	Disabled
10	855 5125	810 5125	25 0kHz	0	0	Disabled
11	856 0125	811 0125	25 0kHz	0	0	Disabled
12	856 5125	811 5125	25 0kHz	0	0	Disabled
13	857 0125	812 0125	25 0kHz	0	0	Disabled
14	857 5125	812 5125	25 0kHz	0	0	Disabled
15	858 0125	813 0125	25 0kHz	0	0	Disabled
16	858 5125	813 5125	25 0kHz	0	0	Disabled

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5.2.4 Alarm Setup Page

- It is a page where you can check the alarm status of the BDA, and you can set an alarm mask and run an alarm test.
- You can check the alarm status of BDA with LED color.
 - GREEN : Normal
 - YELLOW : Alarm Detected / System Operation / Service Degraded / Warning Alarm
 - RED : Alarm Detected / System Not Operation / Service Affecting / Critical Alarm
 - GRAY : Alarm Masked

Connected to PS-BDA "WILSON-BDA DBG"

advanced Logout

System Status > RF Setup > Filters Setup > Alarms Setup > Event Log > Network Setup > BDA Setup > Developer Menus > Advance Setup > System Tables >

Alarms Setup

Apply Settings

Alarm Settings

Alarm	Status	MASK	Interval [minutes]	
			Sense Delay	SNMP Repeat
LOSS OF AC POWER	[NORMAL]	OFF	0	1440
BATTERY CAPACITY LOW	[NORMAL]	OFF	0	1440
BATTERY CHARGER FAIL	[NORMAL]	OFF	0	1440
FAIL OF DL700 HPA	[NORMAL]	OFF	0	1440
FAIL OF DL800 HPA	[NORMAL]	OFF	0	1440
FAIL OF UL HPA	[MASKED]	ON	0	1440
OUT OF TEMPERATURE RANGE	[NORMAL]	OFF	0	1440
DONOR ANTENNA DISCONNECT	[NORMAL]	OFF	0	1440
DONOR ANTENNA MALFUNCTION	[NORMAL]	OFF	0	1440
OSC - REDUCED SERVICE	[NORMAL]	OFF	0	1440
OSC - SERVICE SHUTDOWN	[NORMAL]	OFF	0	1440
SYSTEM COMPONENT FAIL	[NORMAL]	OFF	0	1440
ENCLOSURE OPENED	[WARNING]	OFF	0	1440
EMERGENCY POWER OFF INITIATED	[NORMAL]	OFF	0	1440
FAIL OF REMOTE ANNUNCIATOR LINK	[WARNING]	OFF	0	1440
SERVICE ANTENNA DISCONNECT	[NORMAL]	OFF	0	1440

Pseudo Alarm Generation

ITEM	Generation
Loss of AC Power	Generation
Battery Capacity Low	Generation
Battery Charger Fail	Generation
RF Emitter Fail	Generation
Donor Antenna Malfunction	Generation
Donor Antenna Disconnection	Generation
System Component Fail	Generation

Audible Alarm Setting

Audible Alarm OFF

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1) Alarm Settings

Details of the Alarm Setup configuration are as follows.

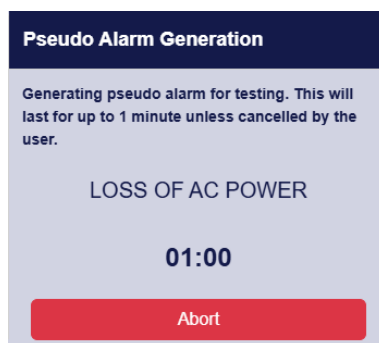
- LOSS OF AC POWER
 - AC power failure due to power failure or poor power cable or outlet.
- BATTERY CAPACITY LOW
 - Battery discharge voltage below 22.8VDC.
- BATTERY CHARGER FAIL
 - Bad battery charge or battery separation.
- FAIL OF DL700 HPA / FAIL OF DL800 HPA / FAIL OF UL HPA

- Shutdown due to high temperature.
- Shutdown due to oscillation detection.
- ⑤ OUT OF TEMPERATURE RANGE
 - High temperature detection above set temperature.
- ⑥ DONOR ANTENNA DISCONNECT
 - Separation of BDA and donor antenna.
 - No input signal due to poor donor antenna or damage to antenna connection cable.
- ⑦ DONOR ANTENNA MALFUNCTION
 - Low input signal or poor VSWR due to poor donor antenna or damage to an antenna connection cable.
- ⑧ OSC – REDUCED SERVICE
 - Reduction of gains from oscillation detection.
- ⑨ OSC – SERVICE SHUTDOWN
 - RF shutdown due to oscillation detection.
- ⑩ SYSTEM COMPONENT FAIL
 - OUT OF TEMPERATURE RANGE.
 - OSC – REDUCED SERVICE.
 - OSC – SERVICE SHUTDOWN.
 - FAIL OF REMOTE ANNUNCIATOR LINK.
- ⑪ DOOR OPENED
 - Enclosure covers open.
- ⑫ EMERGENCY POWER OFF INITIATED
 - External EPO switch turned on.
- ⑬ FAIL OF REMOTE ANNUNCIATOR LINK
 - Communication failure with an externally installed remote annunciator.
- ⑭ SERVICE ANTENNA DISCONNECT
 - Separation of BDA and service antenna.
 - Low input signal or poor VSWR due to poor service antenna or damage to an antenna connection cable.

2) Pseudo Alarm Generation

You can edit the mask status of an alarm, the time it takes to appear after the alarm, and the frequency at which the alarm sends SNMP traps.

You can run an alarm test by clicking the 'Generation' button on each alarm. When you click the alarm button, a pop-up window appears, and a timer displays the end time of the test. The user can stop the test by clicking the 'Abort' button at any time.

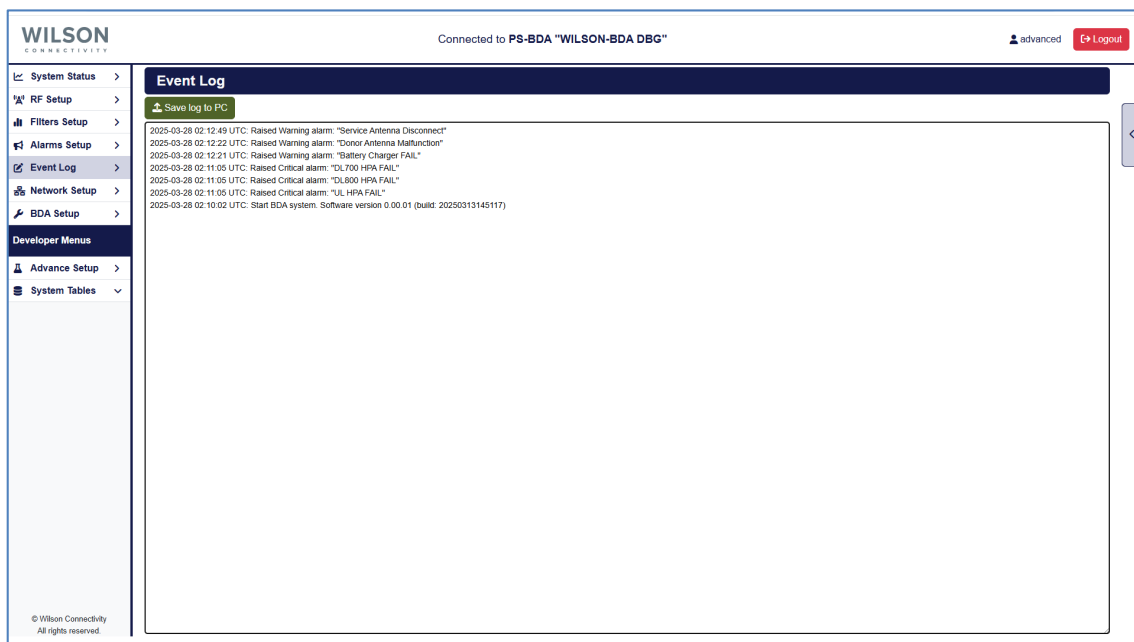


3) Audible Alarm Setting

If any of the seven alarms as defined by UL2524 occur, repeat that the buzzer on the alarm board is set to ring at half-second intervals. The buzzer signal does not sound when the alarm is cleared or the switch on the Web GUI board is pressed. Turning off the audible alarm does not sound the buzzer signal even if the alarm is raised.

5.2.5 Event Log Page

- It is a page where you can check the event log of the BDA, and you can save the event log history as a file by clicking the 'Save log to PC' button.



5.2.6 Network Setup Page

- A page where you can edit the network configuration of a BDA, and you can edit WAN, MODEM, Site, SNMP, User Interface entries, and display LAN Status information.

The screenshot displays the Wilson Network Setup page. The top bar shows the Wilson logo, connection status 'Connected to PS-BDA "WILSON-BDA DBG"', user level 'advanced', and a 'Logout' button. A left sidebar contains navigation links: System Status, RF Setup, Filters Setup, Alarms Setup, Event Log, Network Setup (selected), BDA Setup, Developer Menus, Advance Setup, and System Tables. The main content area is divided into several sections:

- WAN Settings:** A table with fields Status (UP), IP Address (192.168.50.40), Subnet Mask (255.255.255.0), Gateway (192.168.50.1), and MAC Address (10.06.48.7F FF FD). Below the table are buttons for 'Click to Update Settings' and 'Apply Setting'.
- MODEM Settings:** A table with fields Status (UP), IP Address (192.168.50.45), Subnet Mask (255.255.255.0), Gateway (192.168.50.1), and MAC Address (10.06.48.7F FF FF). Below the table are buttons for 'Click to Update Settings' and 'Apply Setting'.
- LAN Status:** A table with fields Status (UP), IP Address (192.168.0.2), Subnet Mask (255.255.255.0), and MAC Address (10.06.48.7F FF FC).
- Site Settings:** A form with fields for Contact, Company, Email, Phone, Address1, Address2, Latitude, and Longitude. Below the fields are buttons for 'Click to Update Settings' and 'Apply Settings'.
- SNMP Settings:** A form with fields for Receiver IP Address, Receiver Port, Version (set to V2C), and Heartbeat Interval [min]. Below the fields are buttons for 'Click to Update Settings' and 'Update'.
- User Interface Settings:** A form with a field for Connection Encryption (SSL) set to Enable(http). Below the field are buttons for 'Click to Update Settings' and 'Update'.

At the bottom left of the page, there is a copyright notice: '© Wilson Connectivity All rights reserved'.

- Details of Network Setup configuration settings are as follows.

1) WAN & MODEM Settings

- Status : Show connection Status (UP).
- IP Address : WAN connection IP Address.
- Subnet Mask : WAN connection Subnet Mask.
- Gateway : Default Gateway.
- MAC Address : MAC address of the BDA.
- Click to Update Settings : Save changed settings.

2) LAN Status

- Status : Show connection Status (UP).
- IP Address : WAN connection IP Address. preset to 192.168.0.2.
- Subnet Mask : WAN connection Subnet Mask. preset to 255.255.255.0.
- MAC Address : MAC address of the BDA.

3) Site Settings

- Contact : Representative.

- Company : Company name.
- Email : Contact e-mail.
- Phone : Contact phone number.
- Address1 : The name of the road.
- Address2 : City / State.
- Latitude : Latitude of the BDA installation location.
- Longitude : Longitude of the BDA installation location.
- Click to Update Settings : Save changed settings.

4) SNMP Settings

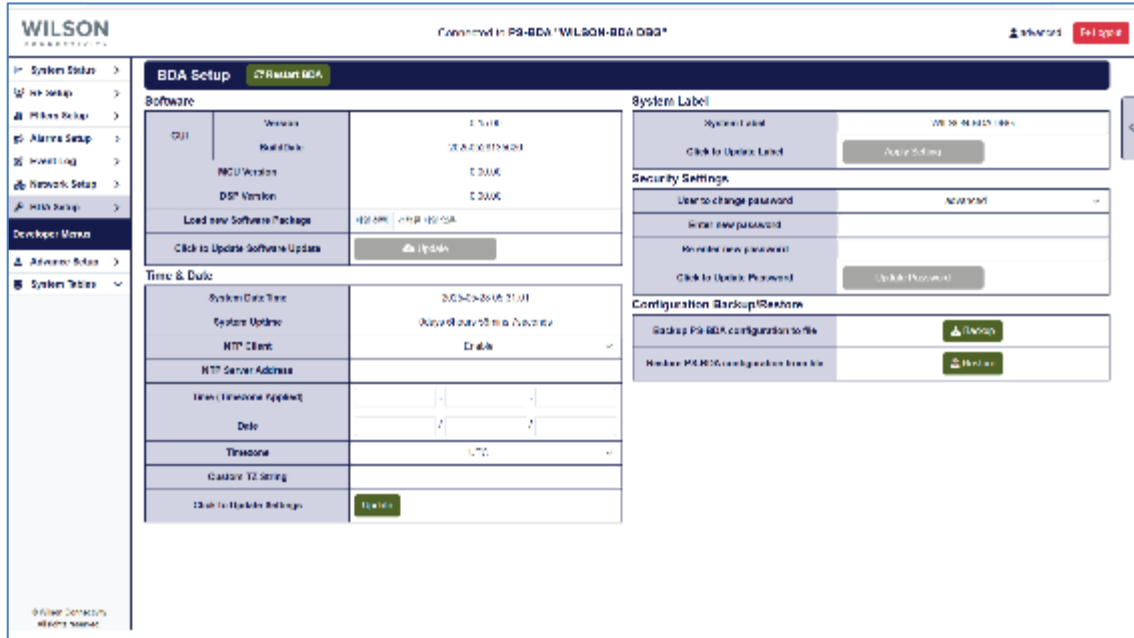
- Receiver IP Address : SNMP server IP address.
- Receiver Port : SNMP server TRAP receiving port.
- Version : V2C or V3 settings.
- Heartbeat Interval : Setting the SNMP heartbeat interval time.
- Click to Update Settings : Save changed settings.

5) User Interface Settings

- Connection Encryption : Set up http or https.
- Click to Update Settings : Save changed settings.

5.2.7 BDA Setup Page

- A page where you can check the software upgrade and version information of the BDA's web GUI, MCU, and DSP, edit Time & Date, and change the user password.



- Details of the BDA Setup configuration are as follows.

1) Software

- GUI Version : Check GUI software version.
- GUI BuildDate : Time to build GUI software
- MCU Version : Check MCU software version.
- DSP Version : Check DSP software version.
- Load new Software Package : Select the file you want to upgrade.
- Click to Update Software Update : Click the 'Update' button to proceed with the upgrade.

2) Time & Date

- System Date Time : Displayed in YYYY-MM-DD HH:MM:SS format.
- System Uptime : Accumulated system run time.
- NTP Client : Enable time synchronization using network time synchronization protocol.
- NTP Server Address : Network time synchronization server address.
- Time : Manual time setting in HH:MM:SS format when NTP client is disabled.
- Date : Manually setting the date in YYYY-MM-DD format when NTP client is disabled.

- Timezone : Setting up an area that adopts the same standard time.
- Custom TZ String : Manual input when setting Timezone to custom TZ string.
- Click to Update Settings : Save changed settings.

3) System Label

- System Label : Alias settings of system.
- Click to Update Label : Save changed labels.

4) Password

- User to change password : Select who wants to change the password.
- Enter new password : Enter the password to change.
- Re-enter new password : Re-enter the password to change.
- Click to Update Password : Save changed password.

5) Configuration Backup/Restore

- Backup PD-BDA configuration to file : Save system setting as a file.
- Restore PS-BDA configuration from file : Importing a file saved system setting and applying it to system.

6. SPECIFICATIONS

6.1 System Specification

Parameter		Specification		Unit	Remark
		DL	UL		
Frequency	700MHz	758 ~ 776	788 ~ 806	MHz	
Range	800MHz	851 ~ 869	806 ~ 824	MHz	
Output Power	700MHz	37	27	dBm	
	800MHz	37	27	dBm	
Gain Range		60 ~ 90	50 ~ 80	dB	
Pass Band Ripple		3		dB	peak to peak
Gain Adjust Accuracy		±1		dB	
Max RF Input Power without Overdrive		-10	+10	dBm	
Max RF Input Power without Damage		+10	+10	dBm	
ALC Range		60		dB	Composite 30dB, Individual Channel 30dB
Noise Figure			≤ 6	dB	Full gain
Squelch		-90 ~ -60		dBm	Per Class A and B Channel, must have a disable
Spurious		≤ -13		dBm	FCC Title 47 Part 90.219
Filter Bandwidth	Class A	12.5, 25, 50, 75		kHz	
	Class B	0.1, 0.15, 0.25, 0.5, 1, 2, 3, 7, 10		MHz	
Delay	Class A	≤ 61.5		us	@ 12.5kHz
		≤ 37.5		us	@ 25kHz
		≤ 26.5		us	@ 50kHz
		≤ 16.5		us	@ 75kHz
	Class B	≤ 16.5		us	@ 100kHz
		≤ 16.5		us	@ 150kHz
		≤ 16.5		us	@ 0.25MHz
		≤ 9.5		us	@ 0.5MHz
		≤ 9.5		us	@ 1MHz
		≤ 7.8		us	@ 2MHz
		≤ 7.8		us	@ 3MHz
		≤ 7.8		us	@ 7MHz
		≤ 7.8		us	@ 10MHz

Roll Off	Class A	≥ 60	dBc	@ Fc±36.25kHz (BW 12.5kHz)
		≥ 60	dBc	@ Fc±62.5kHz (BW 25kHz)
		≥ 60	dBc	@ Fc±130kHz (BW 50kHz)
		≥ 60	dBc	@ Fc±247.5kHz (BW 75kHz)
	Class B	≥ 60	dBc	@ Fc±260kHz (BW 100kHz)
		≥ 60	dBc	@ Fc±285kHz (BW 150kHz)
		≥ 60	dBc	@ Fc±335kHz (BW 0.25MHz)
		≥ 60	dBc	@ Fc±750kHz (BW 0.5MHz)
		≥ 60	dBc	@ Fc±1MHz (BW 1MHz)
		≥ 60	dBc	@ Fc±1.75MHz (BW 2MHz)
		≥ 60	dBc	@ Fc±2.25MHz (BW 3MHz)
		≥ 60	dBc	@ Fc±4.5MHz (BW 7MHz)
		≥ 60	dBc	@ Fc ±6MHz (BW 10MHz)
Dimensions (H x W x D)		378 x 495 x 178 (14.88 x 19.49 x 7)	mm (in)	without Bracket
Weight		≤ 26 (57.32)	kg (lbs)	
Operating Voltage		110 ~ 240	VAC	50/60Hz
Operating Temperature		-30 ~ +50 (-22 ~ 122)	°C (°F)	
Operating Humidity		≤ 95	%	
Enclosure Cooling		Convection		
Enclosure Class		NEMA4		

6.2 Battery Back-up Unit Specification

Parameter	Specification	Unit	Remark
Dimensions (H x W x D)	729 x 424 x 274.5 (28.7 x 16.7 x 10.8)	mm (in)	without Bracket
Weight	≤ 16 (35.3)	Kg (lbs)	
Operating Temperature	-30 ~ +50 (-22 ~ 122)	°C (°F)	
Operating Humidity	≤ 95	%	
Enclosure Class	NEMA3R		

7. TROUBLESHOOTINGS

7.1 Simple Troubleshooting Method

- Check the status of the system by referring to the [3.3 Alarm LEDs](#).
 - System Status Normal – No Alarm Detected or Alarm Masked, Service Properly : Green LED
 - System Status Warning – Maximum Alarm(s) Warning Detected, Service Not Dead : Yellow LED
 - System Status Critical – Maximum Alarm(s) Critical Detected, Service may Dead : Red LED
- Check the external and internal connectors to ensure that all connections are firmly secured. All connectors and cables should be checked regularly.

7.2 Alarm LEDs

GUI ALARM	FRONT PANEL LED	BDA ACTION	TROUBLESHOOTING
NA	AC POWER - NORMAL	SHUTDOWN	- Check the power cable connection.
LOSS OF AC POWER	LOSS OF AC POWER	NONE	- Check AC power line.
BATTERY CAPACITY LOW	BATTERY CAPACITY LOW	NONE	- Check the battery cable connection. - Check battery discharge
BATTERY CHARGER FAIL	BATTERY CHARGER FAIL	NONE	- Check the battery cable connection. - Check battery life.
DL 700 HPA FAIL	RF EMITTER FAIL	700 DL RF SHUTDOWN	- Check HPA is off. - Check BDA shutdown condition.
DL 800 HPA FAIL	RF EMITTER FAIL	800 DL RF SHUTDOWN	- Check HPA is off. - Check BDA shutdown condition.
UL HPA FAIL	RF EMITTER FAIL	700 & 800 UL+DL RF SHUTDOWN	- Check HPA is off. - Check BDA shutdown condition.
HIGH TEMPERATURE DETECTED	SYSTEM COMPONENT FAIL	700 & 800 RF SHUTDOWN	- Check maximum temperature setting. - Check ambient temperature.
	RF EMITTER FAIL		
DONOR ANTENNA DISCONNECT	DONOR ANTENNA DISCONNECTION	NONE	- Check the donor antenna and RF cable connection status.
	RF EMITTER FAIL		
DONOR ANTENNA MALFUNCTION	DONOR ANTENNA MALFUNCTION	NONE	- Check the donor antenna and RF cable connection status.
OSCILLATION REDUCED GAIN	SYSTEM COMPONENT FAIL	NONE	- Check the direction of the donor antenna and the service antenna.
OSCILLATION RF SHUTDOWN	SYSTEM COMPONENT FAIL	700 & 800 RF SHUTDOWN	- Check the direction of the donor antenna and the service antenna.
	RF EMITTER FAIL		
SYSTEM COMPONENT FAIL	SYSTEM COMPONENT FAIL	NONE	- Check maximum temperature setting. - Check the ambient temperature. - Check the direction of the donor antenna and the service antenna. - Check BDA shutdown condition.
	RF EMITTER FAIL	700 & 800 RF SHUTDOWN	
DOOR OPEN	NA	NONE	- Check the door.
USER INITIATED	RF EMITTER FAIL	700 & 800	- Check emergency situation.

EMERGENCY TRANSMIT DISABLE		RF SHUTDOWN	
REMOTE ANNUNCIATOR LOSS OF COMMUNICATION	SYSTEM COMPONENT FAIL	NONE	- Check RA cable connection.
SERVICE ANTENNA DISCONNECT	RF EMITTER FAIL	NONE	- Check service antenna and RF cable connection status.

7.3 NMS

	CHECK POINT	TROUBLESHOOTING
Link Fail	Communication Problem	- Re-connect ethernet cable. - Be sure to check the connection status of the ethernet cable with the BDA powered off. - Verify IP address and DHCP function.

7.4 Replaceable Battery (For RTC on alarm relay board)

- Risk of explosion if battery is replaced by an incorrect type.
- Replace only with the same or equivalent type.
- Dispose of used batteries according to the instructions.

8. MAINTENANCE

- Maintenance is required to ensure smooth operation of the system and maximum performance, which can be maintained through periodic inspection and maintenance.
- The BDA is designed for route-free operation and does not typically require maintenance. Maintenance activities should only be performed by trained technicians and recommended tasks are as follows.

8.1 Maintenance Items

8.1.1 Antennas

- Check the orientation and position of the antenna, re-align if necessary.
- Ensure that the sealing and cable of the antenna cable connector are not damaged.
- Make sure that the antenna cable connector is not loosened.

8.1.2 Battery of Battery Back-up Unit

- Battery inspection and maintenance are recommended in accordance with the battery manufacturer's instructions.
- Write the installation date at the time of battery installation for battery maintenance.
- Check battery surface for abnormalities including cracks, corrosion, or expansion.
- Verify that the battery cable connection is loose or corroded and that the cable is not damaged.
- If a Battery alarm is triggered, check the Battery condition and replace the Battery as necessary.

9. ABBREVIATIONS

AC	Alternating Current
AGC	Automatic Gain Control
Ah	Ampere-hour
ALC	Auto Level Control
AWG	American Wire Gauge
BDA	Bi-Directional Amplifier
cm	Centimeter
DAS	Distributed Antenna System
dB	Decibels
dBc	Decibels relative to the carrier
dBm	Power ratio in decibels(dB) referenced to one milliwatt(mW)
DC	Direct Current
DHCP	Dynamic Host Configuration Protocol
DL	Downlink
DTU	Digital Board Unit
EIRP	Effective Isotropic Radiated Power
ERP	Effective Radiated Power
FCC	Federal Communications Commission(US)
FPGA	Field Programmable Gate Array
GUI	Graphical User Interface
HPA	High Power Amplifier
IP	Identification code for Protection
ISED	Innovation, Science and Economic Development(Canada)
kHz	Kilohertz
LED	Light Emitting Diode
MAC	Media Access Control
MHz	Megahertz
mm	Millimeter
NEMA	National Electrical Manufacturers Association
NMS	Network Management System
PC	Personal Computer
PS	Public Safety
PSU	Power Supply Unit
RA	Remote Annunciator

RF	Radio Frequency
RFM	RF Module
RTC	Real Time Clock
SNMP	Simple Network Management Protocol
TCP	Transmission Control Protocol
UL	Uplink
UL*	Underwriters Laboratories
us	Microsecond
VAC	Volts Alternating Current
VDC	Volts Direct Current
VSWR	Voltage Standing Wave Ratio

UL* : page 13, 26, 33

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