# USER MANUAL

## SB400M1A

Band Selective Class B Signal Booster

Bi-Directional Amplifier (BDA)

***Patents Pending***

V1.1.0

# FCC ID: 2AHVPSB400M1A

| Part 90 Signal Boosters | THIS IS A 90.219 CLASS B 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 Class B 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.

**For Class A or Class B Unintentional Radiators:**

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, that may cause undesired operation.

**Unauthorized Changes to Equipment -** Changes or Modifications not expressly approved by the manufacturer responsible for compliance could void the user's authority to operate the equipment

**FCC RF Exposure Limits -** This unit complies with FCC RF exposure limits for an uncontrolled environment. To comply with FCC RF exposure limit requirements antennas must be operated at a minimum distance of 51cm or 20" between the radiator and any person's body. This assumes 5W ERP (=8.2W EIRP) with 20% power margin.

§ 90.219 (d) Class B broadband signal boosters are permitted to be used only in **confined or indoor areas** such as buildings, tunnels, underground areas, etc., or in remote areas, i.e., areas where there is little or no risk of interference to other users.

§ 90.219 (e) The licensee is given authority to operate signal boosters without separate authorization from the Commission. Certificated equipment must be employed and the licensee must ensure that all applicable rule requirements are met. (f) Licensees employing either Class A narrowband or Class B broadband signal boosters as defined in §90.7 **are responsible for correcting any harmful interference that the equipment may cause to other systems**. Normal co-channel transmissions will not be considered as harmful interference. Licensees will be required to resolve interference problems pursuant to §90.173(b).

**ERP POWER LIMIT:** FCC regulations limit signal booster ERP (Effective Radiated Power) to 5W. Effective radiated power is calculated as follows: 1.59W - (CABLE LOSSES) – (CONNECTOR AND SPLITTER LOSSES) **-** (ANY OTHER SYSTEM LOSSES) + (ANTENNA GAIN*), where the 1.59W figure is the maximum output power of the signal booster @ 32dBm*. **If a high gain antennas are used, such as a directional Yagi antenna, please reduce the maximum output power of the signal booster so that the ERP (Effective Radiated Power) does not exceed the 5W limit.**

***https://signalboosters.fcc.gov/signal-boosters/***

## Contact Information

**Headquarters, R&D and Manufacturing Facility:**

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Norwell, MA 02061
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### Trademark Notice



***Patents Pending***

**Standard Warranty**

Standard warranty applies for two years from shipping date. Please contact Radio Solutions, Inc. for a copy of the Standard Product Warranty terms and conditions.

**Return and Repair**

The equipment can be returned for repair by the following procedures:

• Call Radio Solutions, Inc. at 1-781-331-1008 or email RMA@radiosolutionsinc.com for a Return Materials Authorization (RMA) number. Please provide serial number and model number.

• Ship the defective part prepaid to:

Radio Solutions, Inc.

ATTN: Service; RMA number: XXXX

70 Accord Park Dr.

Norwell, MA 02061

**Parts and Accessories**

Please contact Radio Solutions, Inc. or an authorized reseller for parts pricing and delivery. When ordering a replacement part, please provide model number, serial number and software version number.

**Safety Instructions**

**Before Use** review this manual and insure that all conditions are meeting the equipment specifications and site requirements. Safe operation may be impaired if this equipment is not used as intended. Radio Solutions, Inc. assumes no liability for the customer's failure to comply with these precautions.

**This is not a consumer device.** It is intended and designed for installation by qualified installers.

**Danger - Electrical Shock Hazard** – Any high voltage and electrical ground connections must be done by a qualified electrician. To prevent electrical shock when installing or modifying the system power wiring, disconnect the wiring at the power source before working with uninsulated wires or terminals. Prior to powering up the unit, please make sure that electrical ground is connected to both the ground DIN-Rail terminals and to the enclosure grounding bolt located on the underside of the enclosure. AC Power and RF Connections should be installed with all standard installation practices for lightning protection. This includes grounding and electrical bonding together of all equipment enclosures and grounding of the primary antenna cable and the installation of proper surge suppression (lightning arrestor) equipment at the entrance to the building or the equipment room.

**Battery** - Risk of explosion or fire if battery is replaced with incorrect type. Do not use faulty or degraded batteries. Follow all installation instructions and safety precautions specified in this manual. Replacement fuses and batteries must be the same type and must have identical values to the original ones. Do not short the battery terminals or other power supply lines. Do not leave loose pieces of wire or other conductive material inside the battery or signal booster enclosures. Do not block the battery enclosure vents.

**Electrical Specifications:**

| | |
|---|---|
| Frequency Range | 450-490MHz |
| Channel Bandwidth | 1.8MHz or 150KHz each channel*. *Multiple channels can be combined within the 3MHZ duplexer band-pass. Multiple bands can be combined in the same enclosure.* |
| Maximum Bandwidth, each band | 3MHz |
| Gain (adjustable) | 92dB max. (90dB min) |
| Gain Adjustment, 0.5 dB attenuator increments. | -31dB in LNA module and -31dB in AGC module = 62dB total adjustment range |
| Maximum Composite Output Power (i.e. single carrier) | 32dBm max. 30dBm min. |
| Power Limiter Adjustment (0.5dB increments) | 0 to –13.5dB |
| Impedance | 50 Ohm |
| Maximum RF Signal Input Level for FCC spurious limits compliance | -20dBm |
| Absolute Maximum Input RF Signal Level | 0dBm continuous, +10dBm peak |
| Noise Figure | <6.5dB typ. 8dB max. |
| Alarms: | Two Form C relays for each of the alarms: AC Power Status, Charger Status, Low Battery Capacity, Low Battery Voltage, BDA Trouble, Antenna Trouble and Aux Alarm. Second relay contact set provided for a LED annunciator panel. |
| Alarm Logging: | Standard SD Card up to 16GB. Mini SD with adaptor. Real-time clock time stamp included. |
| AC Power Supply | Two independent power supplies with 110-240VAC/2.1A or 277VAC/0.8A 50/60Hz each. |
| Power Supply Efficiency | 93% (Typ.) |
| DC Power Supply | Supports either 2x75Ah 12V AGM Sealed L.A. Batteries in series for DC UPS Backup or an external 28VDC Supply. Max. Current Draw: 2.3A @ 28VDC |
| Run Time with standard 2x75Ah Battery Backup | >25-30 Hours under full load |
| Battery Charging with the Built-in Charger** | Charging Current Limited to 5A max. Float voltage: 27.4V |
| Operating Temperature Range | -30°C to +65°C |
| Recommended Ambient Temperature*** | -20°C to +35°C (-4°F to +95°F) |

*Other channel bandwidths may be available, please inquire with your specific requirements.

** Only use approved lead-acid batteries. Contact RSI for list of approved batteries.

*** Extended ambient temperatures and outdoor applications may require specialized enclosures. Please inquire with your specific requirements.

*** Operating the device outside the recommended ambient temperature range may void the warranty.

**Mechanical Specifications:**

| | |
|---|---|
| Dimensions | NEMA4 Enclosure: 20”W x 24”H x 7”D |
| | Total Width Including Heatsinks: 24” |
| | Total Height Including Mounting Tabs: 26” |
| Signal Booster Enclosure Type | NEMA-4, Sealed Enclosure, Aluminum with Powder-Coat or Enamel Finish. Red for NFPA-Compliant Mission-Critical BDA Version and Beige for others. UL-Listed enclosure version available. |
| Weight – Standard Enclosure, Single Band Configuration, NFPA Compliant Version with two power supplies | <59lbs |
| RF Connectors | N-Female |
| Booster Shipping Box Size | 30” x 30” x 15” – UPS, FedEx Shippable |
| Backup Battery Enclosure<br>(Applies to NFPA-Compliant Version of the Booster*) | 22”W x 13”H x 8”D<br>Contains two 12V/75Ah Sealed Lead-Acid Batteries.<br>Enclosure Color: Beige<br>Includes Louvered Vents on Both Sides |
| Connections | Four ½” trade size cutouts provided for conduit or strain relief fittings for power, battery backup and alarm lines. |

*Other battery backup configurations are available. Please inquire with your specific requirements.

***Patents Pending***

**Description:**

The RSI SB400M1A is a high gain, high power class B band-selective signal booster (BDA, Bi-Directional Amplifier) that operates in 450-490MHz UHF range. It is intended for enhancing two-way radio signal coverage in buildings, tunnels and other confined areas.

The SB400M1A is specifically designed for public safety and other mission-critical applications. The NFPA-compliant version of the signal booster includes a built-in dual power supply system (Fig. 1.1 and 1.2) with a backup battery charging and monitoring system Fig. 1.15). It also includes two sets of alarm connections for status monitoring of the BDA operation(Fig 1.14 and 1.15), antenna systems, battery capacity, power supply monitoring, AC supply, temperatures, RF module status etc. (Fig. 1.14 and 1.15). All alarm conditions are also logged as a simple text file on a removable SD Memory Card.

The two separate circuit breakers (Fig 1.3 and 1.4) are provided for easy power hookup and for the increased reliability. The RF modules (Fig 1.6 – 1.11) are mounted on a DIN rail for easy access and serviceability.

The unit is factory-set for specific frequencies and bandwidths and other than the gain and power settings, it does not require any other field tuning or programming.

Figure 1

**Installation Procedure**:

**1. Secure the signal booster to a solid, vertical surface** such as an interior wall. The signal booster enclosure has two mounting tabs on top and two on the bottom. For optimal airflow, it is best to maintain at least 1" of spacing between the back of the enclosure and the wall. This is best accomplished by mounting the enclosure on a grounded strut channel (i.e. Unistrut, Kindorf etc.).

Please make sure that there is sufficient clearance around the signal booster enclosure to ensure unobstructed airflow.

**2. Connect the AC Power** - The enclosure has 4 ½" trade size cutouts: two for power, one for battery backup and one for alarm circuits. Diameter of the cutouts is 7/8" to allow for easy installation of ½" trade size conduit fittings. The two power supplies have two separate circuit breakers so that either a one shared circuit or two separate circuits can be connected for backup and redundancy in mission-critical applications. Each one of the two dual circuit breakers has the Line, Neutral and Ground connections. Please make sure that the green ground terminal is connected to the ground wire and that is it secured to the DIN-rail. The DIN rail is the ground path for the enclosure.

**Warning** – Live wire terminals on the circuit breakers!

**Danger - Electrical Shock Hazard** – *Any high voltage and electrical ground connections must be done by a qualified electrician. To prevent electrical shock when installing or modifying the system power wiring, disconnect the wiring at the power source before working with uninsulated wires or terminals. Prior to powering up the unit, please make sure that electrical ground is connected to both the DIN-Rail terminals inside the enclosure and to the enclosure grounding bolt located on the underside of the enclosure. AC Power and RF Connections should be installed with all standard installation practices for lightning protection. This includes grounding and electrical bonding together of all equipment enclosures and grounding of the primary antenna cable and the installation of proper surge suppression (lightning arrestor) equipment at the entrance to the building or the equipment room.*

**3. Connect the Battery Backup** – RSI Battery enclosure is designed to be installed directly below the signal booster. Use the provided wire harness to connect batteries to the battery power terminal on the PMU circuit board. Leave the battery fuse out for now. *Please only use the RSI supplied or RSI approved batteries.*

**4. Connect the Antenna system** – Underside of the signal booster enclosure has two N-Type connectors - the DAS system connector on the right side and the connector for donor antenna on the left side, as labeled.

*50 Ohm coaxial cable jumpers for both DAS (distributed antenna system) and for the donor antenna must have solid outside conductor (such as ¼" - ½" Superflex, Heliax, etc.). Coaxial cables with braided outside conductor may have excessive "signal leakage" that can cause feedback and oscillation of the signal booster, especially when high gain settings are used. Please ensure that both DAS and donor antenna systems are tested before they are connected to the signal booster. Bad antenna connections, antenna line breakages etc. can cause poor performance and RF intermod interference.*

**5. Power up the signal booster, insert the battery backup fuse**

**6. Set the signal booster gain for both uplink and downlink chains** – the signal booster ships from the factory with gain set to minimum. Gain can be increased as needed by setting DIP switches on LNA and ALC modules.

Figure 3 shows the LNA module with an example DIP Switch setting of -8dB. This introduces 8dB attenuation to the LNA module. For example, if the rated maximum BDA gain is 90dB then: 90dB – 8dB = 82dB. So the BDA total gain now is 82dB.

Figure 4 shows the ALC module with 8dB gain attenuation.

With both modules settings as shown, BDA gain is calculated as follows: 90dB – 8dB (LNA Attenuation) – 8dB (ALC Attenuation) = 74dB total gain.

System gain needs to be set for both downlink and uplink

**7. Set the power limit –** signal booster ships from the factory with output power set to minimum. Power limit can be increased as needed by setting DIP switches on the ALC module. Figure 4 shows ALC module with 7dB of power limit deduction. For example, if the maximum BDA power is 32dBm then: 32dBm - 7dB = 25dBm maximum output power.


Figure 3 - LNA Module


Figure 4 – ALC Module

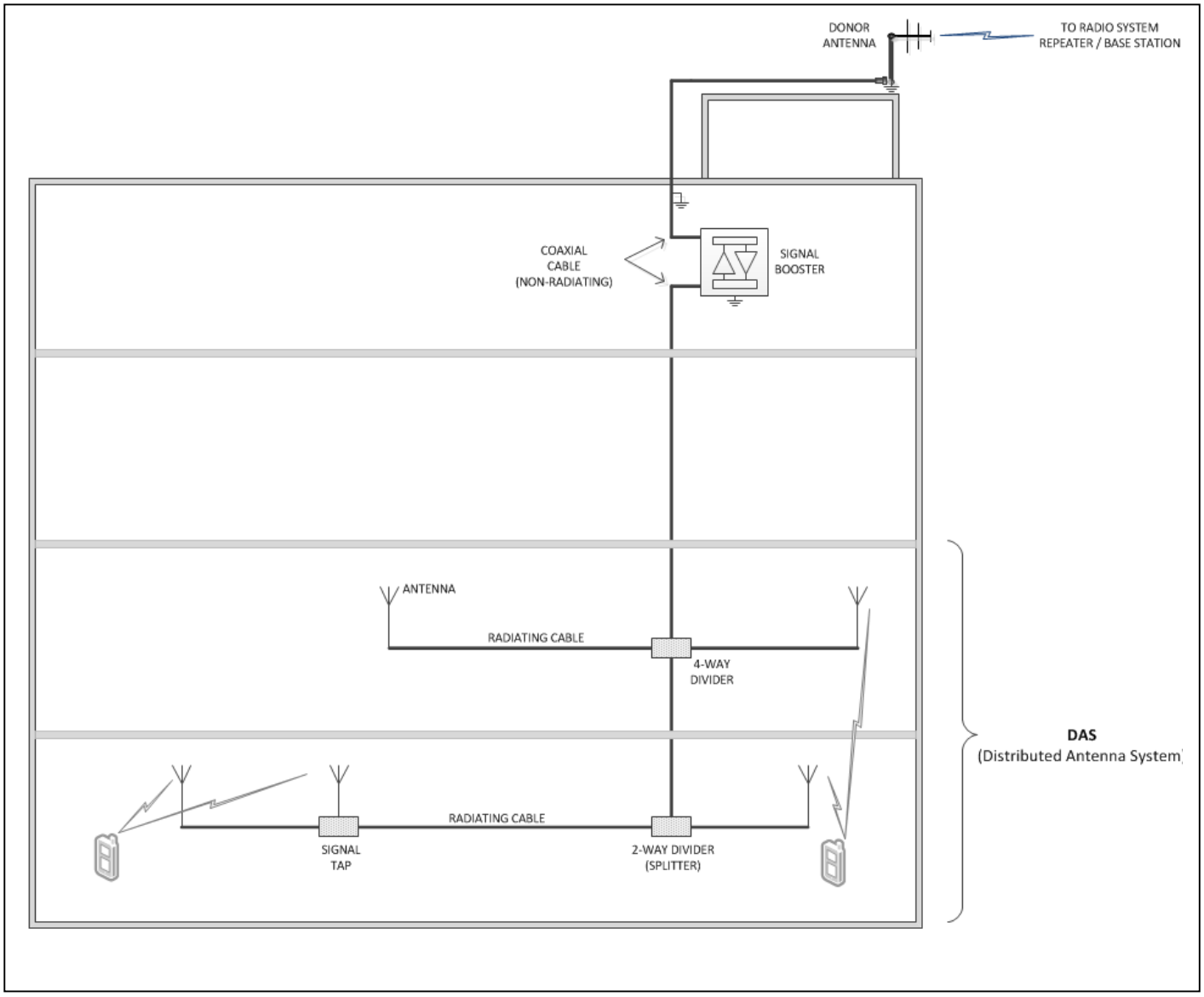
**8. Connect the Alarms and the Booster Monitoring Annunciator panel** (NFPA-Compliant versions olnly)

The LED Light Indications:

Red "Signal" LED's on both modules indicate that the ALC (Automatic Level Control) circuit has been activated – i.e. input signal is high enough where amplifier needs to reduce the gain to limit the output power to 32dBm max.

The Green "Status" LED's indicates status of the module. Green LED light indicates that the unit is powered up and no faults have been detected. No LED lights or a red status LED light would indicate a problem with the module, such as: over/under voltage, over/under temperature, over/under current draw or other module fault. All alarm conditions are signaled to the central monitoring unit which then displays the alarm condition on the LCD, logs the alarm condition with the current time stamp to the SD card and activates the BDA fault alarm outputs.

**System Planning and Deployment:**




Typical BDA System

**1. Design the Distributed Antenna System (D.A.S)** – Design the D.A.S for optimal signal coverage of the building or other confined area. The D.A.S. system can be designed by using a combination of radiating cable, non-radiating cable, antennas, signal taps, splitters or hybrid couplers. To prevent feedback oscillations, a solid outer conductor, non-radiating cable must be used to connect the booster to the D.A.S. and donor antenna systems. *If high gain antennas are used, it is important to limit the output power of the signal booster so that the maximum ERP does not exceed the 5W limit (see the warning and calculation instructions on page 2).*

**2. Locate the Donor Antenna –** The Donor antenna should be a high-gain, directional type antenna and should be aimed at the nearest radio system repeater site. Location of the antenna should be chosen so that it provides highest possible signal isolation from the D.A.S. system. *It is important to limit the output power of the signal booster so that the maximum ERP does not exceed the 5W limit (see the warning and calculation instructions on page 2).*

**3. Measure the D.A.S. to Donor Antenna Signal Isolation –** Probably the most important step in design and deployment of an in-building signal booster system is to ensure that there is a sufficient signal isolation between the donor antenna and the D.A.S. system. Just like the feedback that occurs when the microphone and speaker get too close together on a public address system, a signal booster can start to oscillate when the gain of the system is higher than the isolation of the antenna system. The oscillations can cause continuous in-band interference to other users that are in the range of the signal booster. To prevent the feedback oscillation from happening it is important to ensure that the amount of antenna isolation is at least 15dB higher than the signal booster gain. Antenna isolation is measured by generating a test signal into the D.A.S. system and measuring the level of the signal received off the donor antenna using a spectrum analyzer or other device capable of accurately measuring RF signal levels. If a directional hybrid couplers are used in the D.A.S. system then the same test should be performed in other direction by generating the test signal into donor antenna and measuring the received signal level from the D.A.S. system. Once the signal separation is measured, deduct 15dB from the figure and the result is the maximum amount of gain that is allowed.

<u>Example:</u>

Test Signal Level generated into the D.A.S. system: 0dBm

Measured Test Signal Level at the Donor Antenna: -70dBm

Signal Isolation = 0dBm – 70dBm = 70dB

Maximum Booster Gain Allowed: 70dB -15 = 55dB

**4. Follow the Good Engineering Practices and be a Good RF Neighbor -** Good engineering practice must be used in regard to the signal booster's noise radiation. Accordingly, the gain of the signal booster should be set so that the ERP of the output noise from the signal booster should not exceed the level of -43 dBm in 10 kHz measurement bandwidth. In the event that the noise level measured exceeds that value, the signal booster gain should be decreased accordingly. Also, please note that in general, the ERP of noise on a spectrum more than 1 MHz outside of the pass band should not exceed -70 dBm in a 10 kHz measurement bandwidth.

**5. Set the Booster Gain** using the procedure described on page 10 to the value as determined by following the step 3 and 4. System gain can be further reduced if required by specific site conditions or factors.

**6. Set the Booster Power Limit** to the desired value using the procedure described on page 10.

**7. Power up the Booster and Test the Coverage**. *Class B broadband signal boosters are permitted to be used only in confined or indoor areas such as buildings, tunnels, underground areas, etc., or in remote areas, i.e., areas where there is little or no risk of interference to other users.*

This product is intended for installation by qualified personnel.

Please contact Radio Solutions, Inc. technical support for information about training, any additional technical information and help with the product installation and deployment.

**DESIGNED AND BUILT IN THE USA**

**From domestic & imported components*

**Headquarters, R&D and Manufacturing Facility:**

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