City of Fort Lauderdale

Compliant Two-Way, In-Building Emergency Communications Systems Requirements

Please note that this document is undergoing revisions due to new NFPA regulations and Broward County requirements. Please verify that you are using the current revision prior to system design.

DOCUMENT REVISION : 10-23-2019

PUBLIC SAFETY RADIO SIGNAL BOOSTER SYSTEM
INSTALLATION GUIDANCE AND SPECIFICATION

PURPOSE

This specification describes the requirements of a Radio Signal Booster System, also known as a Bi-Directional Amplifier (BDA), which will correct for a reduction in the radio signal to a level below that required to assure the 95% area coverage reliability needed for public safety communications caused by a new building development.

The terms Public Safety Radio Signal Booster System, Radio Signal Booster System, Bi-Directional Amplifier System and BDA are all referring to the same system and are used interchangeably within this document to refer to a Public Safety radio signal in-building distribution network meeting the requirements of the NFPA, the County, and the City.

The term Distributed Antenna System, or DAS, is typically used to describe a Cellular or other Personal Communications Service in-building signal distribution network. A DAS is not considered to be a Public Safety grade system.

The City of Fort Lauderdale operates a 26 channel trunked, simulcast public safety radio system in the 800 megahertz (MHz) band. The City also utilizes the County's 28 channel 800 MHz trunked, simulcast public safety radio system interconnected with the City's system. The systems were designed to provide clear, intelligible, in-building communication from portable radios with public safety speaker microphones mounted at shoulder height with an area coverage reliability of better than 95%. Broward County is constructing a new 700 MHz trunked public safety radio system that is expected to be available 1st quarter of 2020. Per Broward County Building Code, Chapter 1, Section 118, BDAs within the confines of Broward County shall also include the capability of transporting this new 700 MHz system.

Erection of new buildings affects the radio system coverage. The effect on radio coverage is dependent on location (distance from the radio transmitter and receiver and other buildings in the vicinity), height, and projected frontal area and construction materials. If the City's analysis indicates that there may be a reduction in radio system coverage to a level below that considered acceptable for reliable public safety communications, corrective action will be required to assure radio system coverage reliability is retained. At the minimum, a Radio Signal Booster System will be required. In extreme situations, it may be necessary to install a full transmit and receive site.

SYSTEM DESIGN CRITERIA

- External Antenna, **Must be a high gain directional antenna**
- A bi-directional amplifier system
- Back-up battery power supply capable of supplying 12-hour back-up run time
- In-building antennas and/or radiating cable system
- BDA system shall operate in the 800 megahertz (MHz) band, specifically 806-816

MHz mobile transmit and 851-861 MHz base transmit.

- BDA system shall be capable of operating in the 700 MHz public safety frequencies per Broward County. Specifically 799-805 MHz mobile transmit and 769-775 MHz base transmit
- BDA system shall be able to accommodate digital signals complying with the Association of Public Safety Communications Officials (APCO) Project 25 (P25) standards, both Phase I and Phase II, with no more than 15 µsec of signal delay through the system
- Recommended that the BDA system utilizes a carrier detect or squelch detect circuit keeping the up-link amplifiers off until a subscriber signal within the building activates.
- Engineer shall use 50 channels in the 800 MHz band and 40 channels in the 700 MHz band in their design calculations
- Both bands to be modeled at the same time
- Up-link signal strength leaving the donor antenna shall not exceed -60 dBm for a single carrier
- Noise floor as measured at the donor antenna shall not exhibit any measurable increase with the BDA up-link amplifier turned on
- Up-link signal strength and noise floor measurements shall be taken directly in front of and in the primary direction of the donor antenna main lobe
- Off axis measurements shall have appropriate gain compensation added to the observed signal strength. As an example, the front to back ratio of a typical Yagi antenna is 15 dB. If measurements are taken off axis, this 15 dB shall be added to the measured signal.
- Coaxial cables shall be solid copper shield hardline, either low density foam insulation or air-core construction. Dis-similar metals shall be avoided such as the combination of an aluminum foil and copper or tinned copper braided shield cable type. Aluminum shield hardline should be avoided for the same reasons.

EXTERIOR ANTENNA SYSTEM

The roof top donor antenna system:

- Broadband YAGI antenna covering both the 700 and 800 MHz public safety frequency bands
  - **OMNI-DIRECTIONAL ANTENNAS SHALL NOT BE UTILIZED UNDER ANY CIRCUMSTANCE**
- YAGI should have a minimum of 25 dB front to back gain ratio
- Antenna shall be directed to the nearest system repeater site
  - City will provide antenna orientation upon request
- Coax lightning surge suppressor
  - To be installed for each antenna at the building entrance
  - Similar or equal to Polyphaser Model IS-50NX-C2
  - 50 ohm
  - Flange mounted
  - Properly grounded per Motorola R56
- A ½" LDF coaxial cable jumper shall run from the antenna to the coaxial surge suppressor
- ½" type LDF foam core is to be used from the last point inside the building leading to

the exterior antenna system.
- If required by Federal Aviation Agency regulations, obstruction lighting shall be installed
- Antenna installations shall meet the wind loading requirements of the South Florida Building Code, most current edition

IN-BUILDING ANTENNA SYSTEM

The in-building antenna system:
- Consist of a sufficient number of unity gain antennas distributed within the building to meet the -95dBm, or 18 dB above the noise floor, design criteria at all locations within the building
- Generally has a reliable coverage area of roughly 40 feet in diameter per antenna. Depending upon the interior construction materials, it could be significantly less
- Coaxial cable, directional couplers and or splitters to divide the radio signal into its appropriate branch
- Coaxial cables to connect the antennas to the BDA through directional couplers and splitters
- Coaxial cable shall be a minimum of ½" LDF or ½" air core plenum rated. Cables with dis-similar metal construction, commonly known as LMR style, shall not be permitted
- All coaxial cable is to be installed in metallic conduit
- The use of 2 inch metallic conduit is recommended
- Pull boxes shall be installed as required insuring proper cable installation
- Typically there shall be no more than two 90 degree bends between pull boxes
- It is recommended to utilize, at minimum, 12-inch sweeps in conduit bends
- No other wiring or fiber shall be installed within the conduit utilized for the BDA
- Each splitter and connector shall be mounted in a junction box and identified and located for easy accessibility for maintenance while maintaining security from unauthorized tampering

BI-DIRECTIONAL AMPLIFIER SYSTEM – GENERAL CONSIDERATIONS

The BDA system:
- Consists of an ac power supply
- Consists of a battery backup power supply
- Have electrical transient voltage surge suppression
- Shall not be integrated with a Cellular or other type of Personal Communications Service network distributed antenna system
- Fiber distributed architectures are discouraged due to the additional complexity of providing operation status alarms, back-up power for a distributed network design, and the noise generation that causes the ambient noise-floor to rise significantly
- Have Automatic Gain Control, or Output Level Control
- Contains a gain block (a wide band, linear amplitude amplifier)
- Contains a power supply regulator
- Have an isolation between the donor antenna and the distribution antenna network

equal to or greater than 15dB higher than the signal booster's maximum gain in all operational modes.

Multiple BDAs may be connected in series to provide an acceptable radio signal level in multi-story buildings, long tunnels, or separated areas of communications. However, they:

- Shall not cause interference or an undue increase in the radio frequency noise floor
- Require engineering justifications including detailed and specific loss budget calculations
- Will not routinely be authorized without significant detailed engineering support documentation

Electrical power for the BDA and battery charger:

- Have 2 dedicated 20 amp circuits through a suitably sized Transient Voltage Surge Suppressor
- May be wired directly or through a NEMA "Twist-Lock" connector
- Breakers shall be colored RED, marked BDA and have a mechanical lock-out device to prevent inadvertent disruption of the power

Backup electrical power:

- Contain a battery system or Uninterruptible Power Supply capable of 12 hour run time
- Backup electric power unit shall maintain the batteries at the manufacturer's recommended float level and shall recharge the batteries should the charge be depleted.
- Shall be enclosed in a NEMA 4 cabinet with suitable clear space to permit access for servicing the unit

The BDA and battery backup units:

- Shall be installed in a secured environment to prevent tampering
- Shall be installed in a 2 hour fire rated room
- Be painted fire engine red and identified in one (1) inch high reflective white lettering stating:
  - **FIRE COMMUNICATIONS BDA**
  - **POWER PANEL LOCATION NUMBER**
  - **CIRCUIT NUMBER**
  - **PERMIT NUMBER**
  - **SERVICED BY:**
- If the BDA is not located in the Fire Command Room, a permanent sign or placard shall be located in the Fire Command Room next to the BDA Alarm Panel stating, "FIRE COMMUNICATIONS BDA LOCATED ON FLOOR _____ IN ROOM ____". Placard shall be red with white lettering no less than 3/8" high.
- A permanent sign or placard is to be placed on the door of the BDA room indicating that the BDA is located within

INSTALLATION GUIDANCE

The BDA and backup electric power housing shall:

- Be wall mounted side by side or in close proximity and be within NEMA 4 enclosures
- Be mounted on fire treated plywood/backboard

- Be located in an equipment room that has direct access to the building ground halo or electrical ground system
- Be located in a well ventilated room with a maximum temperature of 80 degrees Fahrenheit
- Have 2 dedicated 120VAC, 20 amp branch circuits servicing the BDA and backup power supply
- Be grounded to the building system utilizing a short, direct path with minimum bends
- Ground cables should flow downward from equipment and not reverse direction when connecting to terminating points

Coaxial cables shall:

- Be installed in EMT conduit, 2 inch conduit is recommended
- Have all terminations within a junction box
- Have donor antenna coaxial cable installed in EMT conduit from the BDA to two (2) feet above the roof deck/antenna location with a weather head attached at the end
- For all riser cables, be installed in conduit and shall have two (2) hour fire rated protection. If two (2) hour rated rooms for the riser coaxial cables are not available, a two (2) hour rated chase shall be installed for the riser path per Broward County's Board of Rules and Appeals requirements
- All conduits shall be grounded to the building ground network

SYSTEM OPTIMIZATION

Prior to the start of optimization, notification shall be provided to the City's Radio Systems Manager. A brief inspection will be made utilizing a spectrum analyzer to verify that the BDA installation is not generating an increase in the noise floor when it is turned on. This inspection will also include personnel from the Broward County Radio Shop.

The BDA shall:

- Not be turned on prior to the initial inspection from the City and Broward County Radio Shop
- Be optimized to reduce the level of unwanted intermodulation and increase the level of desired signals
- Use fixed pads or system programming to set the BDA amplifier levels
- An "As-Built" heat map shall be generated that shows ACTUAL signal strengths measured within the building. This document shall be provided to the City's Radio Systems Manager prior to Acceptance testing

COVERAGE REQUIREMENTS

System shall be designed to cover the following;

- BDA system shall be designed to provide a -95 dBm RF signal level over at least 95 percent of each floor.
- BDA system shall be designed to provide a -95 dBm RF signal over at least 99% of the following critical areas per NFPA 72, 2013 edition;
    - **Fire Command Room**
    - **Fire Pump Room**
    - **Stairwells**

- **Elevator Cabs and Lobbies**
- **Exit Passageways**
- **Standpipe Cabinets**
- **Sprinkler Valve Locations**

- Intended signal shall be a minimum of 18dB above the RF noise floor
- There shall not be any excessive leakage outside of the building.
    - Outside of the building at any point 20 feet from the outside wall of the structure, signal levels from the BDA shall not exceed -115dBm.
    - This does not apply to interior courtyards that may have open air access, but are completely surrounded by the building structure
- Delivered Audio Quality (DAQ) standards must be met. A Radio Signal Booster System shall not be accepted that delivers less than a DAQ of 3.4 at all locations in the building. A DAQ of 4 is required within critical areas including the Fire Command room.

Delivered Audio Quality Metrics:

- DAQ 1 Unusable. Speech present but not understandable.
- DAQ 2 Speech understandable with considerable effort. Requires frequent repetition due to noise/distortion.
- DAQ 3 Speech understandable with slight effort. Requires occasional repetition due to noise/distortion.
- DAQ 3.4 Speech understandable without repetition. Some noise/distortion present.
- DAQ 4 Speech easily understood. Occasional noise/distortion present.

ALARMING REQUIREMENTS.

System shall comply with NFPA 72, 2013 edition for monitored status of the following alarms;

- **BDA AC POWER FAILURE**
- **BDA BATTERY CHARGER FAILURE**
- **BDA LOW BATTERY CAPACITY**
- **BDA BOOSTER AMPLIFIER FAILURE**
- **BDA ANTENNA MALFUNCTION/HIGH VSWR**
- **NORMAL AC POWER**

These alarms shall be shown on a dedicated annunciator panel located in the Fire Command Room or where the main fire alarm panel is located. The alarm point shall indicate what floor the BDA system is located. An example for an alarm with a BDA on the 27th floor would read “27 FL BDA AC POWER FAIL”

- Alarm tags shall clearly indicate the floor and that it is a BDA alarm as shown in table 1 below.
- Alarms shall also be presented on the fire alarm panel and generate a system trouble alarm
- Fire alarm panel is to be monitored either by a 24 hour manned guard, receptionist,

or by a registered alarm monitoring company

TABLE 1

ALARM DISPLAY	ALARM FUNCTION
nn FL BDA AC POWER FAILURE	AC Power Failure
nn FL BDA BATTERY CHARGER FAILURE	Battery Charger Failure
nn FL BDA LOW BATTERY CAPASITY	Low Battery Capacity
nn FL BDA BOOSTER AMPLIFIER FAILURE	Booster Amplifier Failure
nn FL BDA ANTENNA FAILURE HIGH VSWR	Antenna Failure or high VSWR

nn = the floor number

OUTPUT SIGNAL LEVEL

The Signal Booster System shall amplify all signals within the required frequency bands.

- The effective output power per single channel will change as more channels are amplified.
- The maximum output power level is shared by each input channel.
- The exact proportion of 'sharing' is determined by the number of channels and the power level of each channel in relation to all the other input channels.
- The following chart illustrates the effect of multiple channel amplification.

Number of frequencies in the passband	Maximum output power per single channel
2	24.7 dBm
4	20.0 dBm
6	17.5 dBm
8	15.5 dBm
10	14.1 dBm
20	9.8 dBm
30	7.3 dBm
40	5.6 dBm
50	4.3 dBm

INPUT SIGNAL LEVEL

An input signal level of -60 dBm is generally used as the most desirable input signal level for a signal booster system, although the Signal Booster System may operate at a much lower level with the acceptance of a reduced output signal level. The manufacturer’s specifications will govern input signal levels.

FEDERAL COMMUNICATIONS COMMISSION (FCC) REQUIREMENTS

The following are the FCC requirements for a BDA system:

- The Signal Booster System must be FCC type accepted and labeled as such when operating on any frequency regulated by the FCC.
- The Signal Booster System shall be installed in compliance with FCC 47 CFR Part 90.219
- The FCC also requires that the booster be registered on the FCC web site under the City's listings.
  - **REGISTRATION IS TO BE DONE BY THE CITY**
    - Building owner is to provide the City with the following:
      - **Contact Name**
      - **E-Mail address**
      - **Telephone Number**
      - **Building Address**

RADIATORS

The amount of radio frequency (RF) radiation and signals inside the area served by bi-directional amplifiers can be controlled by selecting appropriate coaxial cables (i.e. "leaky coax") or antennas as radiator elements. In some extremely limited cases both may be used.

Radiating cable provides coverage that can be easily controlled and is especially applicable to tunnels, stairwells, passageways, etc. Radiating cable shall be installed per manufactures' specifications. However, in areas where the cable is accessible to the public or exposed to other hazards, the cable shall be installed within non-metallic conduit. Metallic or EMT conduit is not permitted for use with radiating coax as this would defeat the purpose of using the radiating coax. Please note that Fire Codes do not allow the use of plastic conduit in stairways or other emergency egress areas. Therefor, the use and installation of radiating cable is extremely limited in scope.

Unity gain antennas shall be installed as needed to provide specified in-building coverage. Elevators are a special case that will require additional engineering in order to provide the appropriate signal levels in the elevator cab during its entire travel.

The installation of YAGI antennas at the bottom and top of the shaft may provide adequate signal levels within the elevator cab. There may be additional measures that must be taken depending upon local conditions and construction.
WRITTEN APPROVAL FROM THE ELEVATOR INSPECTOR MUST BE PROVIDED WITH INTIAL DESIGN TO INSTALL YAGI ANTENNAS IN AN ELEVATOR SHAFT

D.C. POWER

The power supply voltage shall be measured to ensure specified levels. The manufacturer will supply a bi-directional amplifier functional block diagram, which will show the D.C. check points.

The backup D.C. battery bank voltage level shall be measured to assure it meets the manufacturer's specifications.

BI-DIRECTIONAL AMPLIFIER GAIN

The bi-directional amplifier gain shall

- Be measured by injecting a -60 dBm test signal at the bi-directional amplifier's lower, middle and upper limits of the operating bandwidth and measuring the level at the -50 dBm sample point using a communications service analyzer.
- The level at this test point shall be 50 dB lower than the unit's output signal level.
- The measured level shall be recorded in the acceptance test document.

SYSTEM SIGNAL LEVEL MEASUREMENTS

The system signal levels shall

- Be measured throughout the building per NFPA 72 2013 specifications for grid size, and in the area outside of the building using a high quality recording spectrum analyzer.
- These measurements will be imported into the same computer program utilized to generate the design heat maps.
- As-Built heat maps shall be generated from this documentation and provided to both the City and the Developer/Owner.
- The minimum measured signal level, at any test location, including inside elevators at all floors, shall be -95 dBm, or 18 dB above the ambient RF noise floor.
- There shall not be excessive signal leakage outside of the building. At any point 20 feet from the outside wall of the structure, signal levels from the internal Signal Booster System shall not exceed -115 dBm.
- In addition to signal strength measurements, Delivered Audio Quality (DAQ) standards must be met. The Radio Signal Booster System must deliver a DAQ of 3.4 at all locations within the building.
- DAQ 4 is required within critical areas, including the Fire Command Room.
- Test equipment used to verify installed system performance shall be provided by the installing contractor.
- Test equipment shall have a current calibration certificate showing calibration to National Bureau of Standards (NBS) references within the past 12 months. A copy of the certificate shall be provided PRIOR to Acceptance testing and as part of the system documentation package.
- Not exceed -60 dBm for uplink as measured at the donor antenna

ACCEPTANCE TESTING PROCEDURE:

The As-Built heatmaps, diagrams showing equipment placement and routing for antennas, coaxial cables, AC power as well as NBS Calibration Certificates shall be provided to the City and the developer/owner prior to acceptance testing.
Absent the above documentation, the acceptance testing shall not proceed.

The Signal Booster System acceptance test shall:

- Be performed by the installing contractor to verify the system has been installed in accordance with these specifications, the system design drawings and meets the system performance criteria.
- This will include inspection, test and measurements of the D.C. power, the bi-

directional amplifier gain, and the signal levels within and outside of the building.

- In addition to signal strength measurements, Delivered Audio Quality (DAQ) standards must be met (See Coverage Requirements, page 6). .
- A demonstration of the system alarms and their proper presentation within the Fire Command Room and to the Fire Alarm Panel will be required.
- The alarm monitoring company shall certify that they have received the BDA alarms as a trouble and have procedures in place to report trouble events to the proper authority.
- A representative of the City's Fire Department may witness these tests.
- The City's Technical Compliance Certificate shall be completed for each active amplifier in the system.
- The building developer/owner shall receive two complete copies of the system documents.
- A Technical Compliance Certificate for the BDA shall be provided to the developer/owner by the City's Telecommunications Management Section at the conclusion of the acceptance testing.
- A copy of Compliance Certificate shall be kept inside the BDA cabinet, with the original kept with the building's maintenance files.

System sign-off will not occur until all documentation is provided to both the developer/building representative and the City.

The City reserves the right to charge for multiple site visits that may be required to certify the installation. Installers and building owners are highly encouraged to ensure everything is ready before calling for an acceptance test.

Contact Bobby Brown, Communications Coordinator via e-mail, bobrown@fortlauderdale.gov or telephone (954) 828-5554 or Gary Gray, Communications Coordinator/Radio Systems Manager, ggray@fortlauderdale.gov, (954) 828-5762 should you have any questions.